BioCycle
ARTICLE SERIES
COMPOST FACILITY PLANNING

Waste Capture Plans

Food waste is a nitrogenous feedstock that generators typically will pay a fee to have processed.
Photo by Nora Goldstein

Guidance helps identify potential waste materials that generators are willing to pay a processing fee to tip within a certain geographic area.

Part I

Craig Coker

PLANNING a new merchant organics recycling facility requires considerable thought and investigation. As the old adage goes, "Proper prior planning prevents poor performance." While organics recycling facilities have a certain "Field of Dreams" cachet about them, i.e., "If you build it, they will come," serious investors will want to see a well thought out business plan. A facility plan is the cornerstone of the business plan for a merchant organics recycling facility.

One of the first steps in the facility planning process is to define, as best as possible, a waste capture plan for the proposed facility — essentially an assessment of potential waste materials where their generators are willing to pay a processing fee within a certain geographic area. The waste capture plan also addresses those compostable materials in that geography that are capturable, but for which processing fees are unlikely (e.g., animal manures), or, for materials that an organics recycler would have to pay for (e.g. kiln-dried sawdust, poultry litter). At this early stage in the process, consider everything. The less favorable feedstocks will fall out in the financial analysis later in the planning process.

How big a geographic area would you search? That depends in large part on the quality of the transportation network in the area you plan to locate in. One rule-of-thumb is that a one-hour travel time (one-way) between either compostable waste sources and/or compost product outlets, and the organics recycling facility, is the upper end of financial feasibility for hauling. This makes sense, if you consider that hauling a 24-ton tractor-trailer load 50 miles adds about $9.38/ton to the cost of transport (this assumes a haul cost of $4.50/loaded mile, which may be low, given the recent run-up in diesel fuel prices). So, if your preferred site is in a rural area of two-lane roads, your geographic search radius is about 50 miles; if your site is within five miles of an interstate highway, that radius might increase to 75 to 100 miles. This is not a hard-and-fast rule; I know of several composters receiving industrial food processing residuals from plants 175 to 200 miles distant from the composting facility.

NITROGENOUS MATERIALS SEARCH

The search should begin with nitrogenous (nitrogen-rich) wastes, as these are the most likely to be materials that generators are accustomed to having to pay a processing fee:

Unstabilized Sewage Sludges

Sewage sludge is composed of both inorganic and organic materials, large concentrations of some plant nutrients, much smaller concentrations of numerous trace elements and organic chemicals, and some pathogens. The composition of sewage sludges vary considerably depending on the wastewater composition and the treatment processes used. Note that the term "biosolids" refers to sewage sludges that have undergone sufficient treatment for stabilization and pathogen reduction (such as composting), and that are of sufficiently high quality to be land applied. In this case, the search would focus on raw (unstabilized) sewage sludges.

Some merchant composting facilities accept sewage sludges as feedstocks, however, merchant anaerobic digestion

Unstabilized sewage sludge from wastewater treatment facility.

Photos courtesy of Craig Coker

(AD) facilities for sewage sludges are rarer, insofar as there are over 1,200 wastewater treatment facilities in the U.S. that have their own AD facilities for sewage sludges. While sewage sludges can command high processing fees, they are the most heavily regulated composting feedstock, which will drive up front-end facility capital costs. Also, sewage sludges are produced 24/7/365, so merchant facilities have to have both adequate capacity and a solid contingency plan in the event of facility problems. As having adequate sludge management capability is critical to the wastewater treatment plant's performance and permit compliance, most wastewater authorities are reluctant to deal with any but the most-seasoned and experienced merchant composters.

All wastewater treatment plants are required to file annual reports on how much sewage sludge is produced and how they are managed. These can usually be obtained by filing a Freedom of Information Act (FOIA) request with the State environmental regulatory agency. Most sewage sludges are recycled or disposed under multi-year contracts issued by the treatment plant or sanitation authority and you may have to wait until the contract is publicly rebid.

Industrial Process Sludges

These sludges are produced by the pretreatment of industrial wastewaters created by the manufacturing processes used. They may or may not include sanitary wastes, which can influence both acceptance feasibility and facility permitting. Process sludges most suitable for recycling via composting or AD are those arising from industrial food processing facilities. Non-food industrial process sludges may be acceptable feedstocks depending on sludge quality. One composter in Virginia accepts a process sludge from a facility that manufactures cellulose acetate from wood chips. These sludges are often the high-moisture content (85%+) residual from dissolved air flotation (DAF), which can be a handling challenge at composting facilities.

Estimating quantities of capturable process sludges can be a challenge as this information is often viewed as proprietary. One place to start is with business directories, either browsing Chamber of Commerce membership listings, or by purchasing a list of industries in particular North American Industrial Classification System (NAICS) codes or from a service like Data Axle. These lists can be purchased for particular geographies. NAICS codes are 6-digit codes; those beginning with 31, 32 or 33 cover manufacturing. Once you have identified a particular industry in your geographic search area, the next step is to contact the wastewater treatment staff to find out more about their wastes and what they do with them. One approach is to talk to salespeople in the wastewater polymers industry (polymers are used to enhance sludge dewatering), as they often know of industries looking for recycling alternatives for process sludges.

Like sewage sludges, these process sludges are often recycled via land application under multi-year contracts. While land application of process sludges is often much cheaper than the processing fee at a composting or AD facility, the need for good weather to apply them, plus nutrient management limitations in water-quality impaired watersheds (along with land development), can make the more reliable outlet of composting or AD more attractive to an industry, even if the cost is higher. Industrial environmental professionals managing a plant's wastes will almost always insist on a site visit to verify that your organics recycling facility is properly operated and free of any regulatory complications. In fact, it is a good practice with industrial feedstocks to engage in mutual site visits, so each can understand how the others' manufacturing processes work.

Industrial Food Processing Residuals

Included in this category are process line start-up and shut-down wastes, spillages, packaging errors, out-of-date foods, and recalled foods. Often, these feedstocks will need to be depackaged prior to recycling. One composter in Virginia had a contract to receive various sized bags of dry dog food; the food was depackaged by hand and incorporated into windrows. The empty bags were taken to the nearby sanitary landfill and photographed as the landfill operator covered the bags with trash. The photos were then sent to the manufacturer of the dog food to certify the destruction. Identifying sources and estimating quantities of these wastes is done the same way as for industrial process sludges.

The U.S. EPA's Excess Food Opportunities Map can be used for an initial approximation of potentially capturable quantities of ICI food waste.

ICI Food Wastes

For sourcing and estimating quantities of industrial, commercial and institutional (ICI) food wastes, I use the U.S. EPA's Excess Food Opportunities Map for an initial approximation of potentially capturable quantities. The map can be adjusted to cover different geographies and provides both a low and a high estimate of potential food waste generation. The generation factors for each category (correctional and educational facilities, hospitality, healthcare, food processors and manufacturers, wholesale and retail food sources and restaurants and food services) are based on industry studies in each sector (EPA, 2020). The ranges between the low estimates and the high estimates can be quite large, reflecting underlying differences in how the original generation studies were performed.

The U.S. EPA's Excess Food Opportunities Map can be used for an initial approximation of potentially capturable quantities of ICI food waste.

The map also provides contact information for each source in each category for individual follow-up. If your new facility is going to locate in a state or community that already has implemented a food waste diversion program affecting ICI generation sources, detailed projections may be available from the local recycling coordinator.

Residential Food Wastes

Residential food waste generation estimates can be compiled from research the NRDC (Natural Resources Defense Council) did in Nashville (TN), New York City and Denver. It estimated food waste generation to be 3.5 pounds (lbs)/person/week or 8.7 lbs/household/week (NRDC, 2017). Updated 2020 population data by state, county or by census tract is available from the U.S. Census. Similar to ICI wastes, detailed projections may be available from the local recycling coordinator if your new facility is locating in a state or community with an existing residential food waste diversion program.

For new voluntary or subscription food waste collection programs, you should adjust your generation estimates for realistic estimates of participation rates and setout rates. Participation rates are the percentage of households who will sign up for the program. This will increase gradually over time, likely from 15% to 20% by the end of year one to ≈ 45% to 55% by the end of year five. Setout rates are the percentage of signed-up households who actually have something to collect on each collection day, which can be influenced by vacation schedules and winter weather. In northern climates, setout rates might be as low as 25% in winter. Setout rates following national holidays will likely be very high.

Animal Manures

Livestock farmers rarely will pay a processing fee for recycling their herds' manures, and, in the case of poultry litter, can command a purchase price of $25 to $30/ton FOB (freight on board) at the poultry farm. In the case of horse manure, there is usually so much bedding mixed in with the manure that it actually has a carbon-to-nitrogen ratio of more than 30:1. Manures vary widely in terms of moisture content, with swine and dairy manure having the highest and poultry litter the lowest. High moisture manures are very suitable for AD. Several poultry litter AD plants have come online in recent years.

Estimating herd and flock counts is available from the U.S. Dept. of Agriculture's National Agricultural Statistics Survey, which is done every five years (the update is scheduled for later in 2022). Herd counts are available by state and county for virtually all forms of livestock, although specific numbers are not reported when there are only a few farms raising particular herds or flocks. The 2017 Survey results can be queried at this website and local Cooperative Extension personnel will likely have interim updated numbers. Manure quantities per head of livestock can be found in references such as the *Livestock Waste Facilities Handbook* ((MWPS, 1985).

In states with yard waste disposal bans, data may be available on the quantities generated in specific localities.

Animal Mortalities

Animal mortalities are very rarely transported off-farm for recycling at merchant composting facilities (they are not suitable for AD) due to animal health and disease transmission concerns. If you are planning an on-farm composting operation, you may find opportunities to help animal agriculture farms with routine mortalities (estimated at about 5% of herd or flock size annually), and you may have opportunities to develop separate composting operations on a farm for catastrophic mortality losses. It is unlikely you will receive any processing fee for routine mortalities, but, in many states, there may be disaster relief funds available for catastrophic mortality composting.

Agricultural Wastes

The vast majority of agricultural wastes are very compostable, but farmers often leave them in the field as they are expensive to collect and transport, and they provide protection against erosion in between crop cycles. One notable exception is cotton gin trash (CGT) — the residual from the first cleaning of cotton from harvested plants. CGT is relatively high in nitrogen; one composter in South Carolina uses CGT to help balance C:N ratios for land-clearing debris they compost. Like animal manures, processing fees are unlikely for agricultural wastes.

CARBONACEOUS WASTES

Waste capture plans should also address carbonaceous (carbon-rich) wastes, which are needed to keep compost pile C:N ratios near the desired 25:1 to 30:1 level. These types of wastes include:

Yard Wastes

Seventeen states ban leaves, grass clippings and/or brush (a.k.a. yard wastes) from landfilling. Another four states ban it unless the landfill has a gas collection system (USCC, 2021). If your planned facility is in one of those states, the environmental regulatory department likely has good data on

The amount of sawdust or shavings (above) produced by sawmills, furniture plants, etc. varies widely depending on tree species, tree sizes, saw blade thickness, etc.

yard waste generation in various counties and cities. Many municipalities in yard waste ban states will have residential curbside collection programs set up. Some run their own mulching and composting facilities while others look to the private sector to handle those materials (usually under contract to the municipality).

In other states, you could use EPA's estimate of 12.11% of the municipal solid waste (MSW) stream being comprised of yard wastes (EPA, 2022). All states track annual generation of MSW. I have used a preliminary generation rate of 0.1 tons/person/year based on tonnages monitored by several municipalities in the mid-Atlantic states.

In states with yard waste disposal bans, data may be available on the quantities generated in specific localities.

It may be possible to get processing fees for yard wastes (some composters will accept them for free just for the carbon). This is most likely if your facility is contracted by a municipality to process its yard wastes. For a purely merchant transaction with commercial landscapers, the processing fee can be based on volume or on weight, if your facility will have scales. If you are not planning on having scales, your volumetric processing fee should be based on size of vehicle delivering the yard waste, not on visual estimates of volume in a vehicle.

Other Carbonaceous Feedstocks

• Land-Clearing Debris: This is a more difficult waste stream to quantify as tonnages or volumes are rarely tracked. In addition, the variations in vegetation on undeveloped sites make it difficult to develop a generation factor such as: "X acres of clearing = Y cubic yards of wood chips." One approach is to try to interview some excavation/clearing contractors in your community to find out what they do with their land-clearing debris now. Keep in mind that this waste stream may require specialty equipment to process, such as shearing attachments for excavators to split open tree trunk stumps. The processing fee considerations noted above for yard wastes also apply to this waste stream.

• Sawdusts/Shavings: This is another waste stream that is difficult to quantify as the amount produced by sawmills, furniture plants, etc. varies widely depending on tree species, tree sizes, saw blade thickness, etc. This is also a feedstock composters often have to pay for; a Virginia composter is currently paying $50/ton ($8.75- $12.50/CY) for kiln-dried hardwood sawdust with a C:N ratio of 308:1.

• Forestry Wastes: Slash is the term used to describe the treetops, limbs and other woody material left behind after a timber harvest. The amount of slash left behind will depend on several factors, including the size and quality of the harvested trees. While this can be a good source of carbon, the cost of collecting, grinding and transporting it may be excessive. Opening dialogues with tree harvesters who precede land-clearing contractors on construction sites may yield some opportunities to capture these wastes. It is unlikely any processing fees can be charged.

• Construction Wastes: Several programs have been attempted over the years to segregate clean wood waste from construction sites for recycling. As most wood-based construction materials are engineered wood products (e.g. plywood, oriented strand board, medium-density fiberboard, etc.), these products have been deemed unsuitable for composting by most state regulators. Several pilot tests I've conducted since the 1990s have proven that the concerns about residual urea-formaldehyde (UF) glues in the final compost are unfounded. Composters interested in this waste stream should conduct their own pilot tests to prove to regulators that composting will degrade the UF glues. These wastes are often landfilled, but if they are source separated properly for composting, a competitive processing fee should be obtainable.

The amount of sawdust or shavings (above) produced by sawmills, furniture plants, etc. varies widely depending on tree species, tree sizes, saw blade thickness, etc.

PROCESSING FEES

Processing fees should be based on your projected cost of production (on a per ton or per cubic yard) basis but be sensitive to competition. In most cases, your primary competition will be the local landfill, and while their tipping fee rates may be tailored to particular generators, pricing compost processing fees at 80% to 90% of the stated gate rate for MSW tip fees should provide the economic "magnet" to pull wastes towards your organics recycling facility.

A well thought out waste capture plan can provide one of the answers to "How big should my new organics processing facility be?" The other question to be answered is "How much compost/soils/digestate will my market absorb?" That is a topic for another article in this series. ■

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REFERENCES

Hoover, D., et. al., "Estimating Quantities and Types of Food Waste at the City Level", Report No. R-17-09-B, Natural Resources Defense Council, October 2017.

Loudon, T.L., et.al., "Livestock Waste Facilities Handbook", Midwest Plan Service Report MWPS-18, Iowa State University, March 1985.

U.S. Composting Council, "Organics Bans and Mandates", June 2021.

U.S. Environmental Protection Agency, "Excess Food Opportunities Map Version 2.1 – Technical Methodology", EPA 530-R-20-001, April 2020.

U.S. Environmental Protection Agency, "National Overview: Facts and Figures on Materials, Wastes and Recycling", accessed April 13, 2022.

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ARTICLE SERIES
COMPOST FACILITY PLANNING

Product Market Assessments

Within three years of when compost was first used on the fairways and tee boxes, the Meadows of Sixmile Creek golf course in Wanaukee, Wisconsin was able to replace 100% of its synthetic fertilization and 95% of its chemical herbicides. Compost is supplied by Purple Cow Organics.

How much compost/soils will the market likely absorb in your geographic area of influence?

Part II

Craig Coker

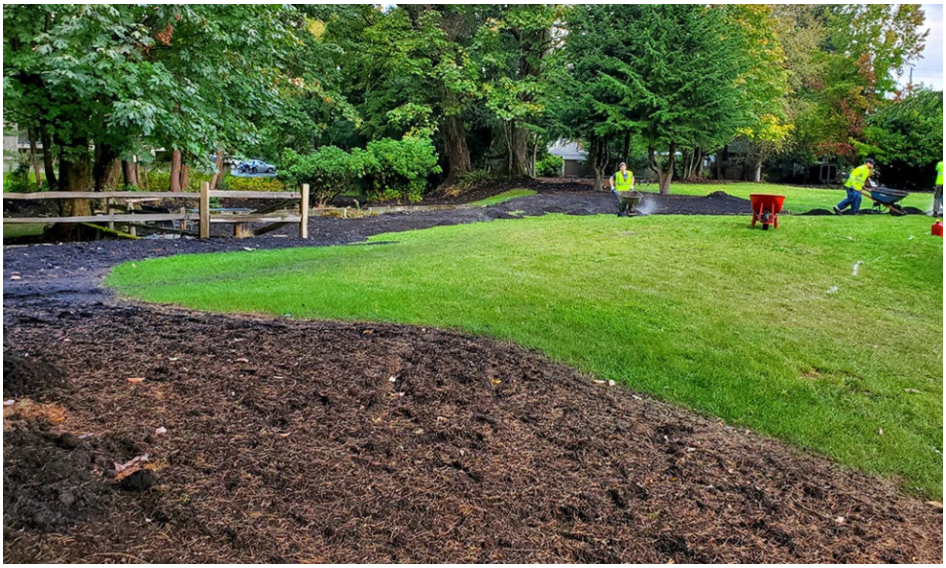
PLANNING a new merchant organics recycling facility requires considerable thought and investigation. As the old adage goes, "Proper prior planning prevents poor performance." This facility planning series is oriented to helping you think through the aspects of proper prior planning. Part I covered developing a Waste Capture Plan. Part II focuses on the other end of compost manufacturing: How much compost/soils will the market likely absorb in my geographic area of influence? At this stage, you are not trying to write your three-year Strategic Marketing Plan, but rather gather research that will feed into and guide that future work.

As discussed previously, your geographic area of influence for compost and soil products is, more or less, about a one-hour hauling travel time for bulk sales from your preferred location for manufacturing compost. As travel time is a function of road network capacity and quality, this generally works out to be 50 miles if your site is in a rural area of 2-lane country roads, or, maybe 75 to 100 miles if you're within five miles of an interstate highway. This rule of thumb applies to bulk sales; bagged product sales have a considerably longer reach of 200 to 250 miles but the added cost of bagging is often a challenge for start-up and first-stage expansion facilities.

ASSESS EXISTING AND EMERGING MARKETS

The first step in assessing potential product demand is to decide what traditional and emerging compost markets are alive and well in your geog-

McGill SoilBuilder Premium Compost was used in construction of practice training fields for the Washington NFL team and the University of North Carolina-Charlotte. The fields were leveled, compost was spread and incorporated into the soil, and sod was laid on top.



Utilization of compost and mulch for landscaping.

Photo courtesy of Cedar Grove

raphy. Residential and commercial landscaping are the bedrock traditional markets for compost and compost-based soils. Agriculture, particularly organic agriculture, is a strong traditional customer, with a growing demand due to increased farmer awareness of the value of soil health coupled with incentive programs for compost use, like the Natural Resources Conservation Service's CPS 808 Soil Carbon Amendment Interim Standard (see references).

Emerging markets might include: Best Management Practices (BMPs) for storm water runoff control, management and treatment; athletic field infrastructure, maintenance and rehabilitation; green roofs, urban forestry and other vegetative practices designed to reduce the carbon footprint of built infrastructure; and development-oriented (or re-development oriented) minimum soil organic matter content requirements to reduce irrigation demand (in western states) and to improve soil infiltration of rainfall and reduce storm water runoff (and its associated pollutants).

RESIDENTIAL AND COMMERCIAL LANDSCAPING

Residential and commercial landscaping is the predominant market for mulch and compost and for some types of compost-based soil blends. Probable uses for compost include ornamental landscape beds, flower and vegetable gardens, and turfgrass establishment and maintenance. Potential methods of compost use are incorporation into the top 6 to 8 inches of soil, incorporation into plant backfill material, loosely spread on the surface of turf as a topdressing, and (more rarely) as a 2-to 3-inch mulch layer. This market has several potential sectors including design professionals (landscape architects and consulting engineers), landscape contractors (installation/maintenance), wholesalers/retailers of landscape soil amendment products, and homeowners/gardeners.

Wholesale landscape material supply yards mainly serve contractors and large residential markets. As such, these businesses often stock bulk inventories of compost-based soils (i.e., manufactured topsoil), some types of rootzone mixes, mulches, gravels, stones, and other similar bulk supplies. The retail landscape material supply distribution chain is heavily dominated by "big-box" stores and generally serves smaller residential customers. As such, these businesses are commonly more interested in bagged products. This is evidenced by local lawn and garden centers increasingly converting the use of their limited space from bulk materials to bagged merchandise.

Homeowners and gardeners represent a significant market share for bulk compost sales. While many residential customers appreciate the convenience of bagged products, there are still a significant number of "pickup truck-load" (1 to 2 cubic yards per purchase) buyers. These buyers are willing to travel some distance to capture cost efficiencies associated with bulk compost purchases, but timely small-scale deliveries and/or more local distribution (through wholesale/retail outlets) are important considerations to sales growth in this market sector.

One method of estimating the preliminary size of the landscape market is to assume that owner-occupied single-family dwelling units (O-O SFDUs) will be the predominant users of compost and compost-based soils. Census data includes the number of owner-occupied SFDU's in your geographic range area (same area as your waste capture plan area discussed in Part I). For each of the cities and counties in the area, assumptions should

Table 1. Calculating size of landscape market for compost

SFDUs = Single-family dwelling units SF = Square feet CY=Cubic yard
CY/1K SF/yr = Cubic yards per 1,000 square feet/year

	Albemarle County	Arlington County	Caroline County	Clarke County	Culpeper County	Essex County	Fairfax County
# owned SFDU's (detached only)	20,363	24,091	7,782	4,061	11,353	2,656	171,424
Avg SF beds (SF/SFDU)	500	250	250	250	250	250	500
Application rate (CY/1K SF/yr)	3	3	3	3	3	3	3
Bed usage (CY/yr)	30,545	18,068	5,837	3,046	8,515	1,992	257,136
Avg SF turf	6,000	3,000	3,000	3,000	3,000	3,000	6,000
Application rate (CY/1K SF/yr)	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Turf usage (CY/yr)	274,901	81,307	26,264	13,706	38,316	8,964	2,314,224
Total usage (CY/yr)	305,445	99,375	32,101	16,752	46,831	10,956	2,571,360
Percent using (%)	10	15	2	2	2	1	15
Market share (%)	30	30	30	30	30	30	30
Potential sales (CY/yr)	9,163	4,472	193	101	281	33	115,711

Table 2. Calculating size of agricultural market for compost

	Grains	Vegetable	Orchards	Soybeans	Total
Crop acreage	223,490	5,170	12,690	207,659	449,009
Application rate (tons/ac/yr)	20	20	5	20	
Percent using (%)	5	5	5	5	
Acreage (ac/yr)	11,175	259	635	10,383	
Compost use (tons/yr)	223,490	5,170	3,173	207,659	
Compost use(CY/yr)	377,517	8,733	5,359	350,775	
Market share (%)	30	30	30	30	
Potential sales (CY/yr)	113,255	2,620	1,608	105,233	222,715

be made about likely landscaped ornamental bed areas (250-500 square feet (SF)/house), turfgrass areas (1,000–3,000 SF/house in cities, 3,000–6,000 SF/house in counties); percentage of homeowners using mulch, compost or compost-based soils (higher closer in and lesser further out in country); and your (conservative) market share capture percentage (30% of market after three years of marketing/sales). Table 1 is from an analysis I did in Virginia in 2019.

Green storm water infrastructure, such as this rain garden in Portland, Oregon, is becoming increasingly common to capture and infiltrate rainwater. Compost is often used in the engineered soil mixes for the rain gardens.

AGRICULTURAL MARKETS

A similar approach can be used with the agricultural market. The quinquennial survey by the U.S. Department of Agriculture's National Agriculture Statistics Service includes data on acreage planted in each crop type in each county. So, using the same geographic radii as in landscaping markets and waste capture markets, estimate the acreage by crop group, make some (conservative) assumptions about application rates (tons of compost spread/acre), percent of farmers using compost, and market share. Then estimate potential sales. Some of the data from a recent Northern California study I did is shown in Table 2.Table 2. Calculating size of agricultural market for compost

STORM WATER BMPS

One emerging market of great interest in some parts of the U.S. is vegetated Best Management Practices (BMPs) for storm water pollution prevention. This includes "green infrastructure" like bioswales, bioretention pond growth media, infiltration basins, etc. These "green basins" need a soil blend that will infiltrate storm water on a long-term basis (e.g. > 1"/hour for 5+ years) yet have enough organic matter in the soil blend to support vegetation. Some composters make up an 80% sand + 20% compost blend that complies with most specifications. One consideration is the type of compost used to make the soil blend. In watersheds with an existing phosphorus (P) water quality problem, like the Chesapeake Bay, soil blends may have to be made with a low-P compost, like leaf compost, to meet the project's specifications on maximum P content.

Estimating demand for these types of soil blends can be challenging. A bioretention pond basin specification normally calls for a 2.5-foot deep layer of a high infiltration soil blend. One approach I have used is to review a community's Municipal Separate Storm Sewer System (MS4) Annual Report, which often includes the number of these new vegetated practices built each year. One reasonable assumption is that, if they built 15 new BMP projects in 2021, they may build 15 more in 2022. Estimating the spatial areas of each installation is also challenging, as it is a function of drainage area, but one conservative estimate would be 0.25 to 0.5 acre each for bioretention ponds. Each pond would have a potential soil blend demand of about 2,000 CY.

MYSTERY SHOPPING

For many, one of the more interesting aspects of compost market research is mystery shopping. Here, in the same 50-mile or 75-mile geography you're using as an "influence zone," the goal is to visit every commercial landscaping product retailer. I will go into the store, wander around looking at prod-

Table 3. Inventory of Placer County, CA commercial landscape product retailers

	Product	Retail price point ($/CY)	What's in it?	OMRI-certified?[1]	CDFA - Organic Input certified?[2]
Nortech	Compost	50.00	Green/food waste	Yes	Yes
Sierra Rock Landscape Materials	50/50 blend	43.00	Sandy loam soil + compost		
	Planters Mix	39.00	50/50[3] + wood fines		
	Super Organic Planters Mix	46.00	Planters Mix w/ org. comp.		
	Compost	27.00	Green waste compost		Yes
	Organic Compost	42.00	Green waste compost	Yes	
	Happy Hippy	85.00	Marijuana blend		
Valley Rock Landscape Materials	Grower's Blend	54.45	Dairy manure + humus	Yes	
	Planters Mix	49.95	Sand, humus, fertilizer		
Roseville Landscape Materials	50/50 blend	44.00	Compost + topsoil		
	70/30 blend	42.00	70% topsoil / 30% compost		
	Platinum Organic Compost	48.00	Green waste compost (1/4")	Yes	Yes
	Gold Organic Compost	46.00	Green waste compost (3/8")	Yes	Yes
	Super blend	44.00	Compost + mushroom substrate		

[1]Organic Materials Research Institute; [2]California Dept. of Food and Agriculture; [3]50/50 compost + topsoil

ucts on shelves (noting brand names and prices) and go out into the yard to see the bulk items. When I can speak with someone, I will say something like "My brother-in-law told me about compost. Do you know anything about it? Do you carry it, and if so, how much is it?" (Note, if you are well-known in your community, you may have to have a friend or relative do this part.) Not only do you learn about competing products and prices, but you learn how knowledgeable their sales staff are, so you can address that in the Product Sales Support portion of your Strategic Marketing Plan.

A lot of this research can be done by phone, asking the same questions as you would on-site, although you often end up speaking with someone who needs to consult with others. Table 3 includes some of the information I gleaned over the phone on that recent Northern California job.

Forecasting growth in a region requires some research and understanding of historical growth patterns. Traditionally, settled areas in the U.S. tend to grow towards one another along transportation arteries but many communities favor growing in one direction more than others. Local building departments have historical building permit data, sometimes classified by industrial, commercial, and residential. Reviewing these growth patterns, both in time and in space, can give you insights into where to put your marketing resources.

It is also useful to understand larger-scale growth patterns. For example, it is widely reported that the State of Florida is receiving more than 300,000 incoming people from other states (e.g., the population of Orlando) annually. This is driving a huge boom in housing construction in some areas, which, in turn is driving a boom in mulch demand as new homeowners spruce up their yards. This demand jump is so significant, one composter I am working with is changing operations for a while to make more mulch and less compost. If you're planning a new facility in a high-growth area, these considerations can influence equipment and capital expenses decisions. ■

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REFERENCES

U.S. Census Bureau, American Community Survey Data, 2022.

U.S. Department of Agriculture, National Agricultural Statistics Service, 2017

U.S. Department of Agriculture, Natural Resources Conservation Service, Conservation Practice 808: Soil Carbon Amendment (draft), 2021.

BioCycle ARTICLE SERIES
COMPOST FACILITY PLANNING

Compost Process Design

New Earth's composting facility in San Antonio, Texas

A mass-based recipe, a volume-based footprint for the compost manufacturing process, and a site layout to minimize materials handling are used in a compost process design.

Part III

Craig Coker

PLANNING a new merchant organics recycling facility requires considerable thought and investigation. As the old adage goes, "Proper prior planning prevents poor performance." This facility planning series is oriented to helping you think through the aspects of proper prior planning. Part I dealt with how to develop a Waste Capture Plan. Part II covered methods to assess the markets' potential to absorb your compost and/or soils products. This article deals with methods for figuring out "How big should my facility be?"

Compost process design is a somewhat technical analysis of how you are going to convert the capturable wastes you identified in your Waste Capture Plan to meet the potential product demands you identified in your Market Assessment. Compost process design consists of three elements: Developing a mass-based composting recipe; Analyzing the volume-based footprint requirements for each step in the compost manufacturing process; and Arraying all those processing steps in a way that maximizes production at a minimal cost of materials handling. I did say this is somewhat technical.

COMPOST RECIPE

Use of a well-crafted feedstock recipe ensures good process control that results in less malodors, shorter processing times and better product quality. The four main process control variables to be considered in developing a recipe are: carbon-to-nitrogen ratio (C:N), moisture content (%), volatile solids content (%) and predicted free air space (%). Not following these guidelines can have a significantly deleterious effect on process performance in composting. These variables are defined as follows:

- C:N is the ratio of the mass of total carbon in a pile to the mass of total nitrogen, and should be between 25 and 30 to 1.
- Moisture content should be between 50% and 55% (a little higher in the initial mix for aerated static pile composting).
- Volatile solids (VS) are the non-ash solids in a material and they represent the degradability of a feedstock (e.g. sludges/manures high, ash/drywall low). Total VS should be higher than 90%, although only about 70% to 75% of the VS in an organic material will be biodegradable.
- Free air space is the ratio of air volume less the air occupied by water to total volume in a pile and should be between 40% and 60%.

Assuming the feedstocks are acceptable from a metals and hazardous waste perspective, composters should obtain a representative sample of each and have the samples analyzed by a commercial laboratory. Ideally, each sample should be obtained from the point of generation, as this develops an understanding of the source of the waste, how it is generated and handled, and what potential exists for physical or chemical contamination. The analytical lab should be certified under the U.S. Composting Council's Compost Analysis Proficiency Program for methodologies based on Test Methods for the Examination of Compost and Composting (TMECC). Samples should be tested for total nitrogen, total carbon, moisture content, volatile solids, pH, bulk density and soluble salts.

There are numerous computer-based compost recipe models available. I use an Excel spreadsheet that I developed years ago and will make available to those who request a copy. Keep in mind, though, that the laboratory analysis you get back on a feedstock for use in your recipe modeling will report Total Carbon. Not all carbon in a feedstock will be degraded by bacteria in the active composting phase. The carbon in plant tissues (which includes everything from wood chips to leaves to soiled napkins to last week's brussels sprouts) is found in cellulose, hemicellulose and ligno-cellulose. Only the first two are degraded by the bacteria in composting; the ligno-cellulose is degraded by the fungi in curing.

BIODEGRADABILITY ADJUSTMENT

As a result, recipes have to be adjusted for the biodegradable component in the carbon-based feedstock. One method for this is to adjust recipes for biodegradable carbon using a formula developed for anaerobic digestion process design (Chandler, 1980):

Biodegradable Fraction (B.F.) = 0.83 – (0.028) x Lignin Content of Volatile Solids (L.C. VS) Biodegradable-Carbon = Total Carbon x B.F. x Volatile Solids (VS)

An example of this analysis, using yard trimmings, is shown Table 1. Laboratory analyses of yard trimmings samples will likely differ due to the heterogeneity of the feedstock.

The net effect of this biodegradability adjustment is to raise the volumetric ratio of your carbon-rich amendments to your nitrogen-rich amendments from the traditional 3:1 to more like 4 to 4.5:1, which can be a challenge if carbon sources are limited in your region.

The bulk density (BD) measurements are used to estimate the free air space (FAS) in the mixture. Agnew and Leonard (2002) reported a linear relationship between bulk density and FAS:

FAScalc = 100 – (0.09 x BD)

where FAScalc is a percentage and BD is the wet bulk density (in kg/m^3). This is a good approximation of FAS to use in these desktop analyses. Bulk density measurements also offer an easy way for loader operators to know how many buckets of each feedstock to add to the mix.

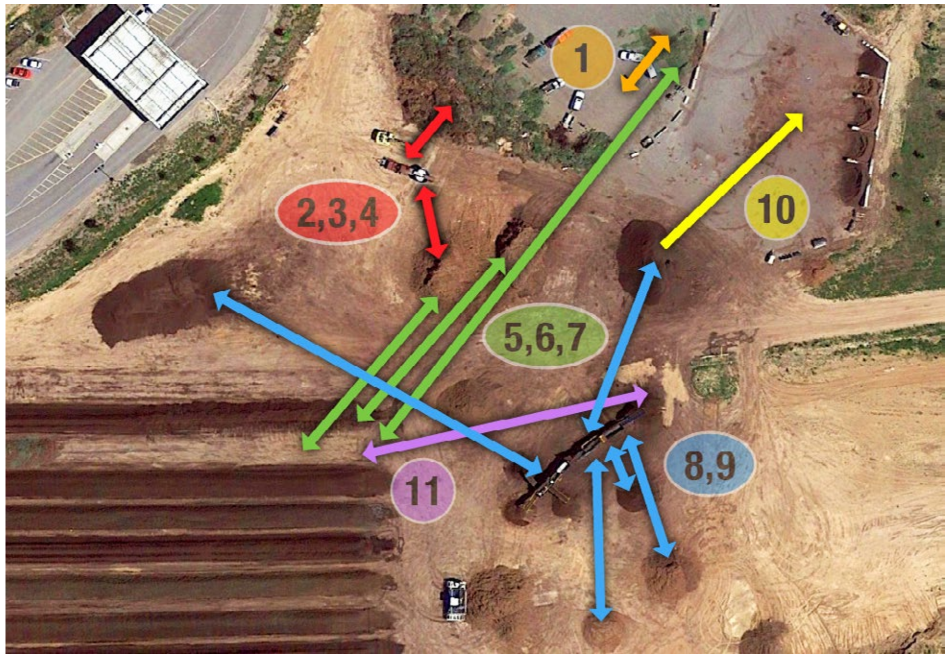

Figure 1. WIWMD Greenwaste Recycling Facility Materials Handling Steps 1. For curbside-collected material, separate grass and garden residuals from brush with rake on loader; 2. Push material toward grinder; 3. Grind material; 4 Pull material from grinder and put in pile; 5. Build windrow with materials from ground mulch, mulch overs, and grass/horse manure piles; 6. Turn windrow; 7. Tear down windrow; 8. Load screen hopper; 9. Pull material from screen conveyor belts and put in piles; 10. Move product from piles to load-out areas; 11. Move mulch overs back into compost windrows.

Base image: Google Earth Pro 7.3.4.8642. Utah, USA. 41° 06' 38.36"N, 111° 55' 49.90"W. DigitalGlobe 2010

FOOTPRINT ANALYSIS

A compost manufacturing facility is a volumetric materials handling exercise — volumes (e.g. cubic yards) of materials are moved from one step to the next and these volumes reside in one spot for each step for a period of time. This requires an analysis of how much area each step in the process will need at various points in the temporal evolution of a composting facility to reach its full capacity. An example of how to do a footprint analysis was covered in a recent *BioCycle* article, "Calculating A Composting Facility Footprint."

Keep in mind that a manufacturing facility must have its outputs (products) move off the production line to make room for new inputs to be converted to products. In composting, this means finished compost has to move off-site at a rate greater than or equal to the volumes coming into the facility. It is very easy for these volumes of organic materials, in varying stages of decomposition, to accumulate at one or more processing steps due to equipment breakdowns, surges in feedstock quantities (e.g. the load of pumpkins coming in during the first week of November), staffing shortages, etc. This can "constipate" a composting facility, which can (and likely will) lead to odor problems, storm water runoff water quality problems, and a deterioration in employee morale.

When you do your footprint analysis, think through how and where constipation can occur and build in some extra "elbow room." This will be important after you design your site layout (see below) and identify "squeeze points" in the materials flows through your proposed layout.

Table 1. Biodegradable component in carbon-based feedstock (in percent)

Feedstock examples	Carbon	Lignin	Biodegradable fraction	Volatile solids	Biodegradable carbon
Yard waste (sample 1)	49.2	4.1	82.89	98.3	40.1
Yard waste (sample 2)	34.5	4.1	82.9	73.7	21.1
Leaves	36.0	18.1	82.5	69.8	20.7
EAB[1] Ash trees	46.4	26.0	82.3	97.4	37.2
Cleaned overs	30.3	12.7	82.6	59.0	14.8

[1]EAB = Emerald ash borer

SITE LAYOUT

The most efficient site layout is a straight line, with the fewest number of materials handling activities during each step in the compost manufacturing process. Few sites can accommodate such pure linearity so site layouts become a balancing act between site constraints and optimized materials

1. Drop-off; 2. Incoming material and grinding; 3. Composting; 4. Screening and finishing; 5. Retail; 6. Drainage pond and perimeter.

Image courtesy of Vermeer

handling. Linearity doesn't mean materials only flow in a single straight line; a linear layout could be "L-shaped" or "U-shaped." You should avoid layouts where material flows cross over each other, as illustrated below. This former layout of a yard waste composting facility (which has since been modified and rebuilt) shows how feedstocks and materials move inefficiently around the site.

Compare that layout and materials flow to the example below. Materials flow in a U-shape around the bounding perimeter of the site.

Using these tools to carefully create a compost process design can convey professionalism and competence to local and state approval authorities — a reward for proper prior planning! ■

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REFERENCES

Coker, C., "Developing Composting Recipes For Process Control," *BioCycle*, December 2011, Vol. 52, No. 12, p. 22.

Chandler, J.A., et.al., "Predicting Methane Fermentation Biodegradability," *Biotechnology and Bioengineering Symposium*, 10, 93, 1980.

Albuquerque, J.A., et. al., "Air Space in Composting Research: A Literature Review," *Compost Science and Utilization*, Vol. 16, No. 3, 2008, p. 159-170.

Agnew, J.M. and Leonard, J.J., 2002, "Using a modified pycnometer to determine free air space and bulk density of compost mixtures while simulating compressive loadings," Proceedings of the 2002 International Symposium: Composting and Compost Utilization, Columbus, Ohio.

Compost Technology Evaluation

An aerated mass bed system is used for composting yard trimmings, and some food waste. A Vermeer elevating face turner moves material 22 feet laterally on the pad in each turning event.

Photo courtesy of the City of Phoenix

How to evaluate different composting approaches or methodologies.

Part IV

Craig Coker

PLANNING a new merchant organics recycling facility requires considerable thought and investigation. As the old adage goes, "Proper prior planning prevents poor performance." This facility planning series is oriented to helping you think through the aspects of proper prior planning. Part I dealt with how to develop a Waste Capture Plan. Part II covered methods to assess the markets' potential to absorb your compost and/or soils products. Part III looked at how to figure out how much room you would need for your new composting facility. This article explores how to evaluate different composting approaches or methodologies.

While deciding what composting system to use is primarily a function of economics (mostly capital costs), influencing considerations include your materials handling experience, feedstocks, size and location of available land, environmental considerations such as storm water and wastewater management, proposed size of facility, potential growth opportunities and need for scalability, your time and budget resources, state and local regulations, and processing time.

ODOR AND TIME CONSIDERATIONS

The degradation potential of various feedstocks is a key factor. Degradation potential can be viewed as odor-producing potential. Some feedstocks, like yard trimmings, are only highly degradable at certain times of year, while others, like food scraps, animal manures and sewage sludges, always have a high degradation potential. Feedstocks with low degradation potential favor low technology, passive aeration, open systems, while high degradation feedstocks favor forced aeration, enclosed or in-vessel systems.

Minimizing the potential for off-site odor impacts is also an important consideration. For smaller area sites within 1,000 to 1,500 feet of a sensitive receptor (such as a home, school, park, shopping center, church or anywhere the public gathers), composting systems should have higher degrees of process and environmental control, which favors enclosed, covered, contained and controlled systems. Large rural sites distant from neighbors can use lower technology open systems. If you are thinking of working with a municipality in a public-private partnership, recognize that some municipal sites have histories of environmental issues, like a landfill, which can influence system selection. Some communities siting composting facilities with other public facilities may insist on a higher level of process and environmental control to mitigate potential additional impacts on residents weary of their public waste management neighbor.

Time can be a factor in system selection. If there is no need to get product to market quickly, e.g., if your processing fees for waste management are your major source of revenue, there may be less urgency to rush product to market for cash flow purposes. That favors less capital expense, less equipment, less management and more space, which might favor windrows over ASP or in-vessel. If a composting enterprise needs to get product to the market quickly (for product demand and/or cash flow reasons), then more capital expense, equipment and management, and sometimes less space, are usually necessary.

The availability of resources (e.g., equipment, pavement, buildings, people and money) often influences system selection. Farmers wishing to expand into composting already have resources like tractors they can put to use, as do businesses in related industries that get into composting (e.g., plant nurseries and conventional materials recyclers) and municipal governments with existing public works infrastructure. The economic advantages of sharing land, equipment and labor can be substantial (Platt, 2014).

Composting methods fall into three general categories — passively aerated systems that include static piles and turned windrows; actively aerated systems; and in-vessel. The following section discusses each method, and offers the advantages and disadvantages to each.

PASSIVELY AERATED SYSTEMS

Passively aerated static piles could be called "Nature's original compost pile." This composting method requires patience as it can take months, or longer, for the organics to decompose. Passive aeration is best used for slowly decomposing feedstocks like leaves, brush, bark, wood chips and residues like horse manure and bedding (Rynk, 2022). It is also the primary composting method for livestock mortalities (Figure 1).

Static piles rely on natural convection for aeration, where air heated by microbial decay rises out of the pile and is replaced by cooler air migrating inwards from the sides. Two methods of facilitating natural aeration are:

1. Place perforated plastic pipes cross-wise into the pile with the ends exposed to the atmosphere, which is known as the Passively Aerated Windrow System (PAWS).

2. Build the compost pile on a deep (18-inch thick) bed of coarse wood chips, which is known as the Natural Aeration Static Pile (NASP).

Static Piles

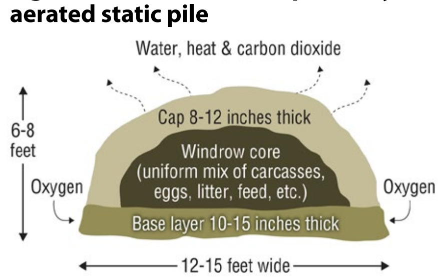
Advantages
- Low capital and operating costs
- Less equipment and staffing requirements
- No electric power needed

Disadvantages
- Large area required
- Not suitable for putrescible materials
- No means of controlling odors
- Slow decomposition rate/long process times
- Some risk of spontaneous combustion fires

The other form of passive aeration is windrow composting — the most common composting system used in the U.S. today due to its suitability to a wide variety of materials and capacities and low capital and operating costs. Windrow composting involves forming your composting feedstocks into long, narrow, low piles known as windrows that are about twice as wide as they are high. The length can be as long as the available space. Windrows are built using front-end loaders, skid-steer loaders and excavators.

Space requirements for a windrow composting pad vary depending on method of turning, as windrows can be turned with a loader, or with a drum turning machine. These turners are either a pull-behind type towed with a loader or a tractor, or a self-propelled straddle-type machine. Turning with a loader or pull-behind turner requires 15 to 20 feet of space between each windrow, where straddle-turned windrows can be as close as 2 to 3 feet apart. If you want to use a tractor-pulled turner, make sure the tractor has an engine with at least 85 hp and that the transmission has an ultra-low speed gear, known as a "creeper gear" to allow it to drive slowly (about 20-25 feet per minute) when pulling a turner through a windrow.

Figure 1. Cross section of passively aerated static pile



Windrow composting is commonly used to process yard trimmings (grass, leaves, brush), and woody materials. Turning the windrow can help break down the particle sizes in these more heterogeneous feedstocks depending on drum design (flail-based are better than auger-based designs for particle size reduction). Food scraps, industrial residuals (i.e. food processing or paper wastes), manures, and biosolids are also composted in windrows, but these facilities are usually located in more arid, warmer regions to minimize impacts from weather and climate, and/or use fabric or compost covers to deter birds, dogs, raccoons, and rodents drawn to the more putrescible feedstocks. An added advantage of covering windrows is to deter possible complaints from neighbors, as people "smell with their eyes."

Windrows

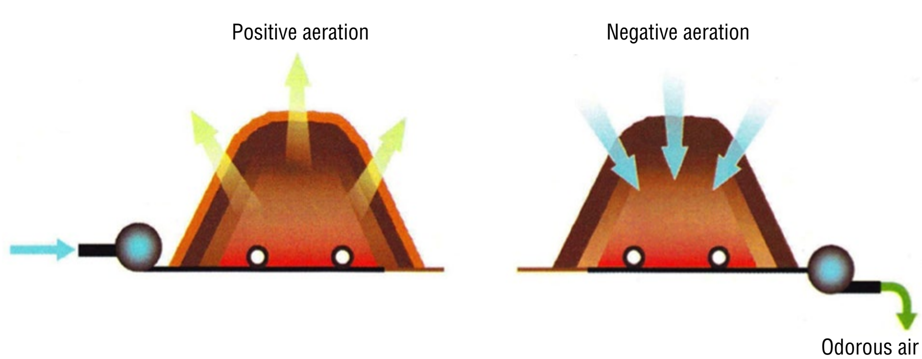
Advantages
- Can handle putrescible feedstocks
- Relatively low capital and operating costs
- Relatively low technology requirements
- No electric power needed
- Extensive industry experience

Disadvantages
- Large area required
- Moderately expensive equipment
- More labor intensive
- Limited means of controlling odors
- Exposure to weather can be problematic

ACTIVELY AERATED SYSTEMS

Actively aerated composting systems use fans and blowers to move air

Figure 2. Positive vs. negative aeration



Aerated Static Piles

Advantages
- Reduced space requirements
- Maintains higher and more uniform oxygen levels
- Negative aeration with biofiltration can help control odors
- Easily scalable
- Significantly shorter composting times

Disadvantages
- Slightly higher capital costs
- Moisture loss is accelerated
- Proper feedstock preparation and mixing needed
- More operator skill needed
- Three-phase electric supply usually needed

Aerated static pile composting takes place in a fabric building. Exhaust air is pulled through the adjacent biofilter.

Photo courtesy of Engineered Compost Systems.

Republic Services is using Sustainable Generation's SG Mobile® System with GORE® Covers at its Otay Landfill composting facility.

through a composting pile to maintain aerobic conditions. There are generally three types of aeration systems: positive (or forced draft), negative (or induced draft), and bi-directional. Figure 2 illustrates positive and negative aeration.

In a positive aeration system, air is introduced through perforated pipes at the base of the pile and allowed to migrate up through the pile, carrying entrapped gases and moisture up and out of the pile. In some positively aerated systems, a layer of compost or a fabric cover is used to help manage odors and retain heat and moisture in the pile.

Negatively aerated systems pull air downward through the pile and into the aeration pipes. This "exhaust" air has high temperature and moisture content, so is usually cooled prior to entering an odor control system. Cooling the air condenses the moisture, so condensate management systems are needed. It is important to have efficient condensate traps between the piles and the air extraction blowers to keep the corrosive condensate moisture out of the blower mechanisms. Odor control systems are usually either biofilters or chemical scrubbers. Bidirectional systems have more advanced ducting and controls and switch between positive and negative air flow to better control temperatures in the piles.

Composting systems using active aeration come in a wide variety of technology options, including simple aerated static piles (ASP) — either out in the open or covered with a pavilion-style or fabric-covered roof — to containerized systems enclosed by concrete bins, inside modified shipping containers, or covered with breathable fabric covers. Some ASP systems fall into a grey area, e.g., composting inside a modified shipping container may be considered in-vessel, as does an agitated bay system inside a building. The reality is that many in-vessel systems have some mechanism for introducing air and many ASP systems are enclosed in some sort of boundary condition (block bunkers, reinforced-concrete wall bunkers, tunnel reactors, modified shipping containers, etc.). As described in the next section, I define in-vessel as some sort of packaged electro-mechanical composting system (e.g. Rocket Composter, FOR Solutions, GMT Earth Flow, B&W Organics rotary drum, etc.), whereas I define ASP as primarily a forced aeration system enclosed in some sort of boundary conditions.

IN-VESSEL SYSTEMS

In-vessel systems can be considered as "bioreactors." A bioreactor is an enclosed, rigid structure or vessel (reactor) used to contain the material undergoing biological processing. These

In-Vessel

Advantages
- Low to moderate space requirements
- High degree of odor control
- Highly automated, so reduced labor costs
- Small sizes allow for modular expansion
- Can be located indoors or outdoors

Disadvantages
- Shorter composting period, longer finishing needed
- Not suitable for large-scale operations
- Capital costs can be high
- May be designated as a "confined space" and thus need health and safety protocols

systems tend to have integrated control systems that monitor process parameters like temperature and oxygen (or carbon dioxide). A mixing and loading hopper/conveyor and a biofilter for exhaust odor management are often included. Material is moved through the bioreactor by various means, including moving floors, spinners, augers, and similar dry materials transport devices. The sizes of these units vary by capacity, with smaller units able to fit into one parking stall, while larger units are 12 feet by 15 feet wide and have lengths greater than 20 feet.

Bioreactors can be classified by their configuration (horizontal, vertical, with channels, with cells, with containers, with tunnels and with rotating drums), by operational mode (continuous or batch), and by static or dynamic movement of material within the reactor (Diaz, 2005). Many bioreactors are dynamic systems, in that forced aeration is supplemented by internal turning or agitation, and typically operated in continuous mode, rather than in batch mode. Some vendors have smaller capacity systems and are modular, so are suitable for community, on-site, and on-farm applications. These systems are suited to capacities of less than 20,000 lbs/day of source separated organics (Environment Canada, 2012). Once capacity is reached, additional vessels will need to be procured.

The Town of Bennington, Vermont built an IPS agitated bay facility in 1992 at its wastewater treatment plant (WWTP) to compost biosolids with yard trimmings. The 4-bay Bennington Compost Facility utilizes equipment supplied by BDP Industries.

The City of Long Beach (CA) composts biosolids in aerated tunnels (above left) supplied by Engineered Compost Systems.

Photo courtesy of ECS

BEFORE YOU BUY

Composting systems, and the mobile equipment used to support them, are all available from various technology providers. If you are going to buy a system or equipment, then do your homework first. Get lists of installations and contact information from the supplier and set up interviews with references. Make up a list of questions and provide it to the interviewed references ahead of time (this signals you are respectful of their time). This approach allows you to evenly compare several references across different systems. Then go out and see a system in operation. Few activities in composting facility planning are as educational as spending time at a facility using an approach to composting similar feedstocks as those you are planning. I have found that much can be learned about how a composting system works by visiting on a cold, wet day in the winter. ■

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REFERENCES

Diaz, L., G. Savage, and L. Eggerth, *Modern Composting Technologies*, The JG Press, Inc., 2005, p. 49.

Environment Canada, "Technical Document on Municipal Solid Waste Organics Processing," 2012, p. 5-13.

Platt, B., et.al., "State of Composting in the U.S.", Institute for Local Self-Reliance, 2014.

Rynk, R., et. al., *The Composting Handbook*, Elsevier Publishing, 2022.

BioCycle ARTICLE SERIES

COMPOST FACILITY PLANNING

Composting Site Selection

Two Particular Acres composting site circa 2004.

Photo by George DeVault

How to evaluate different properties for a potential composting facility location.

Part V

Craig Coker

PLANNING a new merchant organics recycling facility requires considerable thought and investigation. As the old adage goes, "Proper prior planning prevents poor performance." This facility planning series is oriented to helping you think through the aspects of proper prior planning. Part I dealt with how to develop a Waste Capture Plan. Part II covered methods to assess the markets' potential to absorb your compost and/or soils products. Part III looked at how to figure out how much room you would need for your new composting facility. Part IV explored how to evaluate different composting approaches or methodologies. This article discusses issues to consider when looking at possible sites for a composting facility.

Finding the right site for a composting facility that is close enough to feedstock sources, product outlets, and adequate road networks — yet far from sensitive receptors — that will be approved by all levels of government authorities is perhaps the most difficult aspect of facility development…no, it actually is the most difficult aspect. You can spend a lot of time and money chasing sites. Using a methodical approach to siting can make it easier.

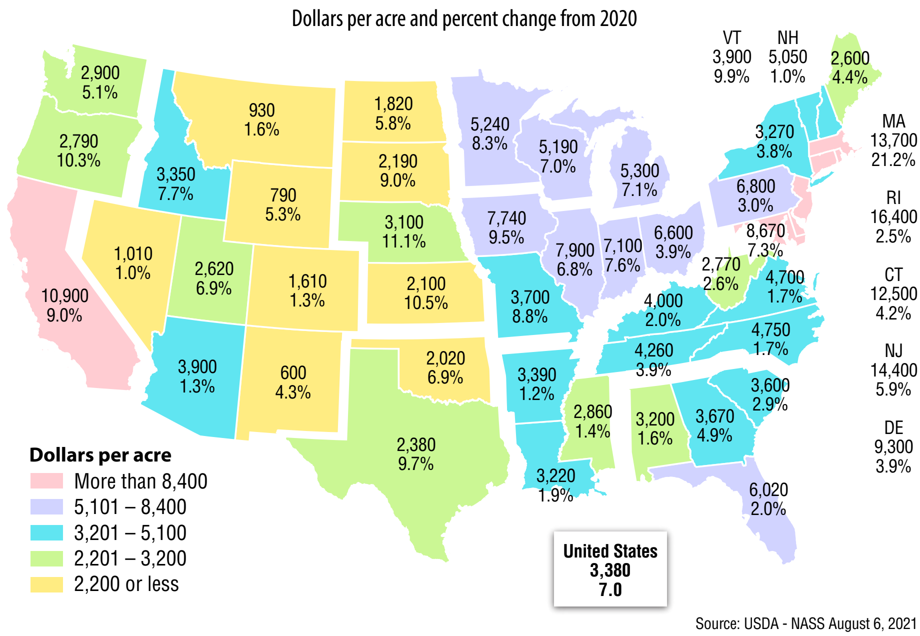
Some composters can find a site easily if they have access to land owned by family or friends. These types of sites usually require a compromise of sorts in terms of proximity, access, neighbors, or approvals, but the cost of leasing that land from Uncle Bob or your old college roommate will be less than the cost of purchasing. Remember, you will need a very long-term lease to justify the capital costs of the improvements you will be making. Leased land is not without risks; there have been several composting facilities shut down and forced to move off leased land when the landlord took issue with an operational malfunction like off-site odors or storm water runoff contamination.

For the purposes of this article, let us assume you don't have access to family or friends' land and will be looking for land to purchase for your new composting facility. At this point in your facility planning process, you should have finished your footprint analysis and sketched out how your facility might fit on a site with the most cost-efficient materials handling layout.

WHERE TO LOOK, FACTORS TO CONSIDER

Most composters in search of land will look for farmland first, insofar as it is generally cheaper than suburban and urban land, is farther from sensitive receptors (usually), and can be easier to develop as the land is already cleared. The average price for farm real estate in the U.S. is $3,380/acre, with cropland averaging $4,420/acre and pasture land averaging $1,480/acre (USDA, 2021). The average cost of farmland has risen 68.2% over the past

Figure 1. 2021 U.S. farm real estate value by state



15 years, and, not surprisingly, there are substantial variations from state to state, as shown in Figure 1.

Needless to say, the cost of suburban or urban land is much higher. I am helping a client locate a site for their second composting facility in a largely agricultural area in Virginia with a university town as the county seat and an interstate highway bisecting the county. Land prices close enough to be within the sewer envelope are getting $35,000 to $50,000 per acre. As my client is looking for at least 20 acres for a 50,000 ton/year aerated static pile (ASP) composting facility, that means a land acquisition budget of $7,000,000+. If your business model is built around urban and suburban feedstock sources like commercial and residential food scraps, then looking for and renovating an older industrial building may be more cost-effective.

All sites have a prevailing wind direction and you should understand this before you buy land and use that knowledge to lay out your site. You can develop a "wind rose" for any land you are considering, using data from the National Centers for Environmental Information (NCEI) and freeware software called WRPLOT View from Lakes Environmental. You should get at least five years worth of hourly wind observation data from the nearest airport to your site of interest. Uploading the hourly wind direction and speed data into WRPLOT View will take some manipulation, as the NCEI spreadsheet data will have some empty cells where data is missing and the software will not accept a spreadsheet with missing data cells. An example of output from the model is shown in Figure 2. If your site is in more mountainous terrain, your wind rose may only be partially accurate, as mountain terrain makes the wind move around a lot more.

The composting method you choose will have a very direct effect on the amount of land you will need. For example, consider a small facility handling 5,000 cubic yards (CY) per year. Using a tractor-pulled windrow turner will require about 78,000 square feet (SF) (1.8 acres) for the composting pad. Using a self-propelled straddle turner drops that footprint requirement to 32,600 SF, while using turned trapezoidal mass bed composting drops it further to 20,200 SF. Using an extended ASP configuration is the most space-saving of all, needing only 18,700 SF (USCC, 2014).

Look for a site that has a consistent grade in one direction, and that grade, ideally, should be less than 4% to 6%. Sites with grades in two directions are said to have cross-slopes. Grading away one of the slopes is necessary for your composting pad to have efficient storm water runoff drainage with lesser potential for rainwater ponding (which is an odor source and a breeding ground for flies). Grading with a 100-hp bulldozer in Allentown, PA will cost you about $1,380/acre, so for the 1.8 acre composting pad in the above example, your construction costs will go up by $2,500. You could also use a gravel fill to negate one of the cross-slopes prior to an asphalt top layer, but again, that will add construction costs.

Remember to budget enough money and space for a densely vegetated buffer zone as people smell with their eyes. If they can see you, they will think what they are smelling is your facility, even if the cause is something else. A vegetated buffer zone is not just a row of small

Figure 2. Wind rose for a composting site

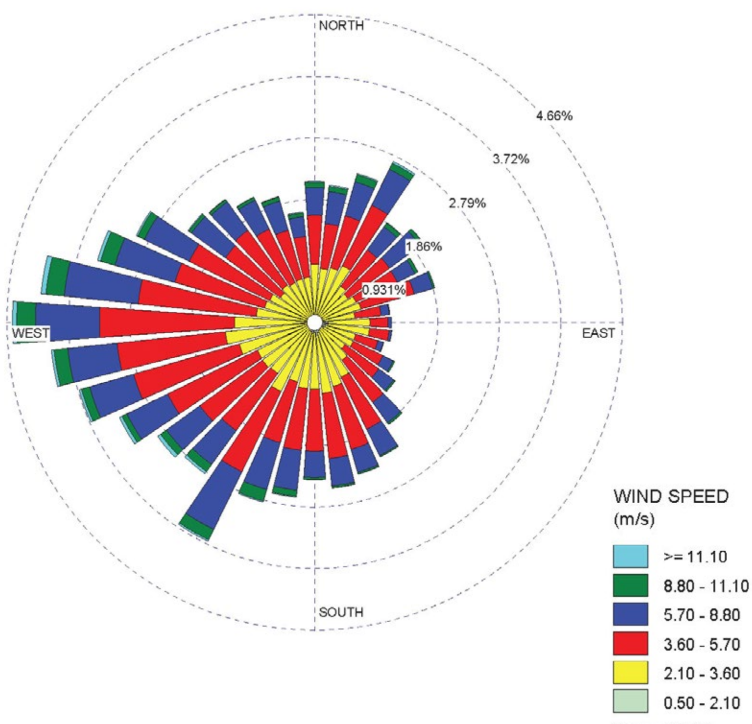
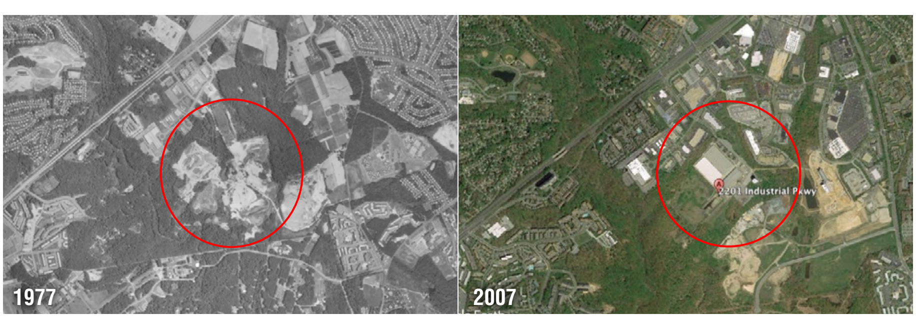


Table 1. Weighted criteria decision matrix for municipal siting study[1]

Evaluation criteria	Meaning
Project development	
Ownership	Publicly-owned sites = higher than privately-owned sites
Current site use	Vacant sites = highest; unused developed sites = lower and developed sites in use by others = lowest
Zoning	Sites in favorable zoning categories = higher
Compatible land uses	Sites in areas with compatible land uses = higher
Topography	Sites with lesser grade = higher
Site buffer/proximity to neighbors	Sites with greater buffer distances to neighbors = higher
Utilities infrastructure	
Availability of 3-phase power	Sites currently served by 3-phase power = higher than those without service
Access to sewer	Sites with access to sanitary sewer = higher than those without service
Access to potable water	Sites with access to potable water = higher than those without service
Access to MS4 stormwater system	Sites not in the priority ranking for water quality-impaired subwatersheds/outfalls = higher than those within those priority areas
Access to natural gas distribution and transmission pipelines	Sites in closer proximity to natural gas transmission and distribution lines = higher than those more distant (for anaerobic digestion options)
Transportation infrastructure	
Access to arterials	Sites with good access to 4-lane arterials (e.g. < 1 mile) = higher than sites with less access
Levels of Service (LOS)	Sites adjacent to roads with Level Of Service (LOS) scores of C, D or E = lower than sites with LOS scores of A or B
Truck queuing length	Sites with inadequate space for truck queues that would impact public streets = lower than those with more space
Road system improvements needed	Sites that needed road improvements to support truck traffic = lower than sites that did not
Social	
Environmental Justice Areas (M= minority, I= income, L= language)	Sites in M+I+L EJ areas = lowest; sites in M+I, M+L, or I+L areas = slightly higher; sites in M or I or L areas = slightly higher
Environmental	
Prior environmental impacts	Sites with known prior environmental impacts = lower than sites without prior impacts
Proximity to sensitive receptors	Sites with longer distances to sensitive receptors (e.g. schools, parks, churches, hospitals, homes) = higher
Floodplains	Sites near 100-year and 500-year floodplains = lower than more distant sites
Wetlands	Sites near jurisdictional wetlands = lower than more distant sites
Historical/archaeological resources	Sites closer to known historical and/or archaeological resources = lower than more distant sites

[1]The phrase "would score" is abbreviated with an "=" sign, e.g., "would score higher" is "=higher"

Figure 3. WSSC Calverton sludge composting facility, 1977 vs. 2007



trees or vertically-oriented shrubs (think Leyland cypress) as it will take years for that to grow into a buffer. The buffer should be planted with an upper tree canopy and a lower shrub canopy for complete screening. A good buffer needs to be 30- to 50-feet deep, so it will take up a sizable footprint.

SITE EVALUATION TOOLS

Geographic Information Systems (GIS) modelling is very useful for doing larger-scale siting studies and online versions of GIS models are easy to use, e.g., ArcGIS. You can map a travel time radius from a site of interest to see if your feedstock sources or product distributors might be too distant to cost-effectively service given the quality of the road network. There are literally hundreds of downloadable GIS model geodatabases that cover environmental considerations (e.g., floodplains, wetlands, etc.), social issues like environmental justice areas, and some elements of infrastructure. (Note that locations of three-phase power, water mains and sewer lines are often not publicly available for security reasons.)

Remember also to study historical community growth patterns. Often these patterns follow roads, railroads or waterways linking two or more historically separate areas of population and industry. You may find the perfect site, but 15 to 20 years later you could be surrounded by development that intensifies awareness of your operation. My first project in composting, in 1977, was an Environmental Impact Statement on a proposed biosolids composting facility between Baltimore, MD and Washington, D.C. The selected site was not far from U.S. Route 29 and is shown in the left-hand photo in Figure 3. The right-hand photo shows that same area 30 years later.

If you have found more than one potential site in a favorable area, then a more formal evaluation/ranking system can be a helpful tool. I use a weighted-criteria decision matrix (WCDM) model, which was discussed in BioCycle a few years ago (Coker, 2016). The weighted criteria matrix is a decision-making tool to evaluate sites (in this context) based on specific criteria weighted by the importance of each criterion. Each site is scored against each evaluation criterion on a scale of 1 to 5, where 1 means the site did not meet the criterion well, 3 means it met it fairly well and 5 means the site met the criterion very well.

The score of each site against each evaluation criteria (known as the "raw score") is then multiplied by the weighting factor for that criterion, then the scores are summed. The alternative with the highest weighted score is the suggested alternative. Table 1 shows a WCDM model for a municipal siting study we are currently working on in Boston, MA.

Taking the time to carefully look for a good site is well worth it. This is going to be a long marriage so you want it to be the right one. ■

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REFERENCES

U.S. Department of Agriculture, "Land Values – 2021 Summary", August 2021

Coker, C., "Weighting Factors in Organics Recycling Facility Development", *BioCycle*, January 2016

U.S. Composting Council, "Site Selection and Design", Compost Operator Training Course, 2014

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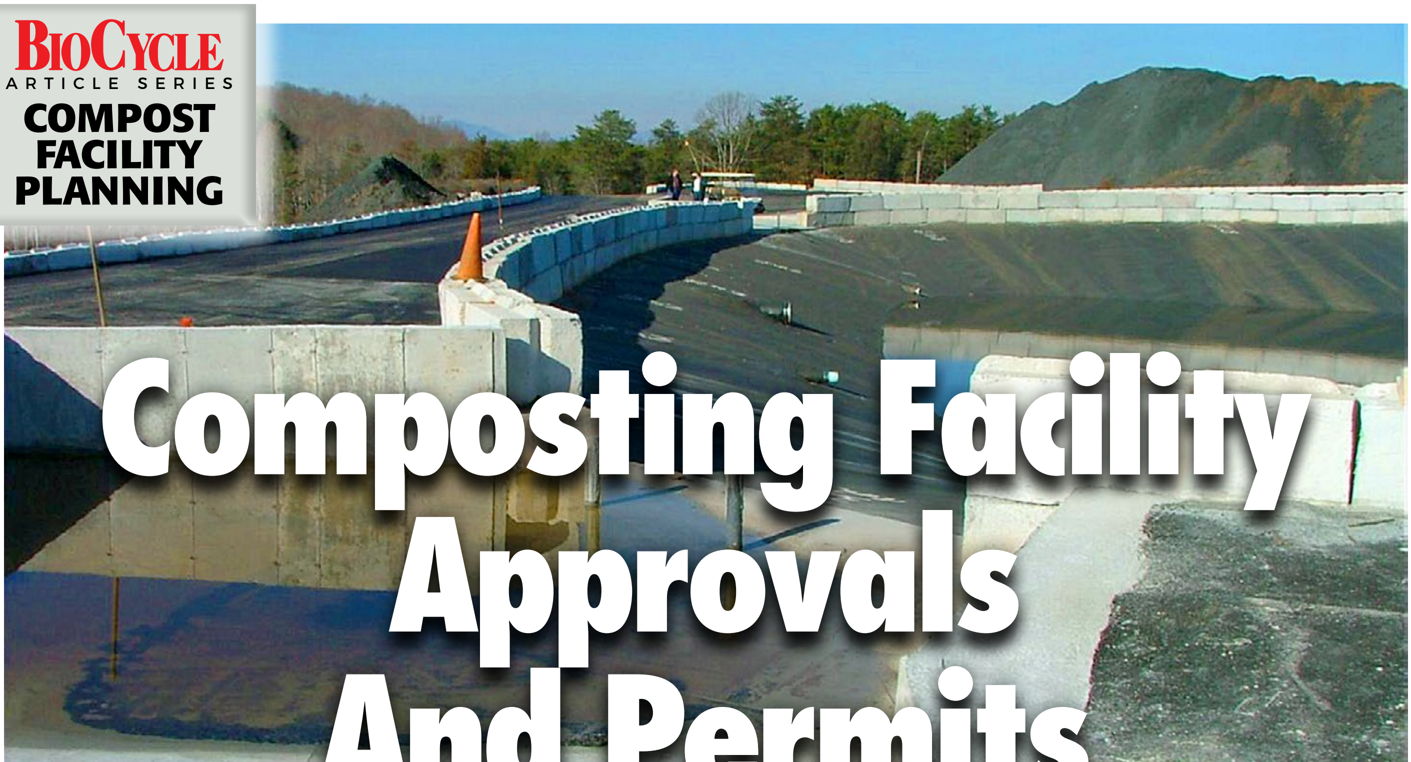
COMPOST FACILITY PLANNING



Composting Facility Approvals And Permits

Storm water collection pond at Royal Oak Farm.

Photos courtesy of Royal Oak Farm.

The keys to getting your new facility approved by local and state governments are to pack a lot of patience, and be absolutely factual and documented about everything.

Part VI

Craig Coker

PLANNING a new merchant organics recycling facility requires considerable thought and investigation. As the old adage goes, "Proper prior planning prevents poor performance." This facility planning series is oriented to helping you think through the aspects of proper prior planning. Part I dealt with how to develop a Waste Capture Plan. Part II covered methods to assess the markets' potential to absorb your compost and/or soils products. Part III looked at how to figure out how much room you would need for your new composting facility. Part IV explored how to evaluate different composting approaches or methodologies. Part V examined issues to consider when looking at possible sites for a composting facility. This article discusses the various local and state-level approvals and permits that will likely be needed.

LOCAL GOVERNMENT APPROVALS AND PERMITS

There are two types of local government sign-offs you will likely need: upfront approval of the site from a land use and zoning perspective, and post-design permits for buildings, construction-phase sediment and erosion control and storm water management. This article focuses on upfront approval of the site. In some states, the local government must include your proposed facility in their 10-year Solid Waste Management Plan and get that Plan approved by state regulators (this will add 6 to 9 months to your project's gestation period).

Land use and zoning laws involve the regulation of the use and development of real estate. Zoning regulations and restrictions are used by municipalities to control and direct the development of property within their borders. Since New York City adopted the first zoning ordinance in 1916, zoning regulations have been adopted by virtually every major urban area in the United States.

The basic purpose and function of zoning is to divide a municipality into residential, commercial, and industrial districts (or zones) — for the most part separate from one another with the use of property within each district being reasonably uniform. Within these three main types of districts, there generally will be additional restrictions that can be quite detailed.

Land-use regulation is not restricted to controlling existing buildings and uses; in large part, it is designed to guide future development. Municipalities commonly follow a planning process that ultimately results in a comprehensive or master plan, and in some states the creation of an official map for a municipality. The master plan is then put into effect by ordinances controlling zoning, regulation of subdivision developments, street plans, plans for public facilities, and building regulations.

Zoning approvals can be classified as "permitted by right," "permitted by variance," "permitted subject to Special Exception," "permitted subject to a Conditional Use permit," and "not permitted." A shoe store operating in a commercially-zoned district is an example of "permitted by right," as is farming in all agricultural zones (Coker, 2014). A variance is a license to do some act contrary to the usual rules, often justified by existence of hardship. Variances can be use-based (e.g., a dentist office in a residential area) or area-based (e.g., a garage closer to the property line than ordinance allows). A special exception is a permitted use under the zoning ordinance so long as the conditions for its availability stated in the ordinance are met and the proposed use does not seriously infringe upon the health, safety and welfare of the community (e.g., a day care center in a commercial district). Special exceptions often require special criteria to be met (e.g., fencing of play areas at the day care center).

CUPs FOR COMPOSTING AND AD FACILITIES

A land use subject to a Conditional Use Permit (CUP) is a Special Exception that has to be approved by a governing body. This is the approvals process that most composting and anaerobic digestion (AD) facilities go through. CUPs give local governments a sense of control over the application, and as most governing body deliberations are public events, CUP hearings give neighbors and other affected parties a voice in the approval process. CUPs can be (and have been) revoked if the facility operation consistently violates one or more conditions of the permit. They can impose reasonable conditions and safeguards. Conditions that have been imposed on composting facilities have included no work on Sundays before 12 noon, no truck traffic on certain streets, and all windrows must be kept covered by fabric covers, among other requirements.

The zoning approval process for CUPs usually requires an application, a scaled site plan, and a description of proposed facility operations. The application and supporting documents are reviewed by zoning staff and in many cases, are reviewed by a standing committee that includes representatives from utilities, public works, transportation, and fire marshal's offices. The applicant provides answers to questions and provides other requested documentation. The application then goes to the community's Planning Commission for approval, which usually requires at least one public meeting where the public can make comments on the application. Following Planning Commission approval, the application goes to the elected governing body of the community, where another public hearing is held. The governing body either approves the Planning Commission's approval, or remands (sends back) the application to the Commission with questions or issues to be addressed. The entire process can take about four to six months, although it can be somewhat faster in smaller communities.

WASTE MANAGEMENT ACTIVITY

Composting (or digestion) facilities are very rarely defined in local zoning ordinances and rules. As a result, land use planners and zoning officials tend to classify it as a waste management activity, which is usually a highly restricted land use. One approach that I have successfully used was to get a zoning text amendment passed, which specifically defined and allowed composting in a particular zoning category.

Another issue that often occurs is that zoning ordinances make no distinction between large-scale commercial and small-scale community composting, which is viewed as an impediment to the expansion of community-scale composting facilities (ILSR, 2014). To address this issue in Ohio, the Ohio EPA prepared the document, "Urban Agriculture, Composting and Zoning: A Zoning Code Model for Promoting Composting and Organic Waste Diversion Through Sustainable Urban Agriculture," in response to various requests for guidance coordinating the state's composting regulations and local zoning codes. The document is meant to serve as a guide for planners, zoning officials, municipalities, community groups and all urban agriculture stakeholders in developing local zoning that encourages the establishment of community gardens and composting activities in compliance with related local land use and state environmental regulations (Arroyo, 2012).

Even attempts to expand on-farm composting of food scraps brought in to the farm from commercial and residential sources has run into the buzzsaw of zoning opposition. In 2015, the Maryland Department of Environment adopted new composting regulations that exempted four types of on-farm composting from state regulations as they were considered "an adjunct to farming." Howard County, a suburbanizing county between Baltimore MD and Washington DC adopted an ordinance to regulate wood mulch and composting activities, which added extensive additional conditional uses on any on-farm composting operation (Johnston, 2017). Public hearings about the County's ordinance degenerated into heated arguments that lasted hours. Some of the more disturbing testimonies included one claiming to link composting/mulching to drinking water contamination and cancer, and a local Sierra Club representative expressing disbelief and disgust at animal waste being included in compost.

The U.S. Composting Council (USCC) has developed a Model Composting Ordinance (Zbinden, 2019). The intent, states the document's Introduction, "is to provide baseline ordinance language collected from research into existing zoning ordinance and land use classification tables across the U.S. as a 'best practice' for zoning ordinances,

Royal Oak Farm solid waste composting facility in Evington, Virginia.

to help municipalities who do not have ordinances in place to address applications for industrial (also often called commercial) composting, small-scale (also often called 'community' or 'decentralized') composting, and on-farm composting. The assumption is that each community will apply its own geographic, cultural, political and environmental situation to the template and modify it as needed. To assist with this process, this document includes background discussion to assist with decisions in areas covered by the ordinance."

Getting local approval for your planned composting facility is generally required before state environmental regulators will even consider, much less approve, any permit application for a solid waste composting permit. The key to success is to pack a lot of patience, be absolutely factual and documented about everything, and recognize that you only need a majority vote on the Planning Commission and City/County Council to win approval.

STATE ENVIRONMENTAL PERMITS

Now that you've secured your local approvals (and washed off the tar-and-feathers from that last public hearing), you will need to apply for state composting permits. There are generally three types of permits you will need: a solid waste composting permit, an operations-phase storm water discharge permit, and, less frequently, an air pollutant emissions permit (yes, composting facilities do emit air pollutants, albeit in very small quantities usually).

All states have regulations now that guide the development, design and operation of solid waste composting facilities, although some are more rigorous than others. There are several webpages that document where to find the regulations in each state, such as the USCC's site, and the site available from the Institute for Local Self-Reliance. I realize reading state regulations is slightly more exciting than watching paint dry, but you should make an effort to understand your state's regulations at a very great level of detail and understanding.

Until the mid 2000s, most state regulations and permit requirements for solid waste composting facilities treated the applications as if they were applying for a new sanitary landfill as they had no other regulatory guiderails. The permit we got for the 60,000 tons/year turned windrow facility at Royal Oak Farm in Virginia in 2006 was the first solid waste composting permit issued by the Virginia Department of Environmental Quality and the permit application preparation and submittal costs were in six figures. Since then, many states have updated their regulations to focus on registrations and "permits-by-rule" rather than full-blown permits. The USCC has a Model Composting Regulations template, which has been used by some states as a guiding document as they have revised their regulations.

Most state regulations now are "tiered," i.e., they assign more rigorous siting, design and operations requirements to feedstocks with higher "pathogenicity" (e.g. sewage sludge is regulated more heavily than yard wastes) and to larger scale facilities — a recognition that on-farm and community composting facilities, with their smaller throughputs and footprints, are not a major environmental hazard. As it can be an expensive and time-consuming hassle to upgrade a permit to handle more heavily-regulated feedstocks, your Waste Capture Plan (see Part 1) should anticipate that potential so you apply for the right facility size and feedstock class. The more rigorous design standards for higher pathogenicity feedstocks have been applied to food waste composting in some states. In New Jersey, for example, a food waste composting pad must meet an impermeability standard of 1 x 10(-7) centimeters per second, which is the impermeability standard protecting groundwater from a hazardous waste landfill.

STORM WATER MANAGEMENT PERMIT

Storm water runoff from operating composting facilities is regulated by states. There are two types of storm water discharge permits — individual and general discharge. Of the two, the general discharge permit is preferred. Individual permits contain effluent discharge limits, expressed as monthly averages and daily maximums, which require intensive (and expensive) monitoring and reporting for compliance. Avoid an individual discharge permit if you can.

General storm water discharge permits were developed by U.S. EPA under the Clean Water Act's National Permit Discharge Elimination System (NPDES) program as it made sense to group the storm water discharges from facilities in the same Standard Industrial Classification (SIC) code as similar to one another. EPA has delegated authority to most states to administer the program. Currently, solid waste composting facilities are lumped together under the Agricultural Chemicals sub-sector, SIC Code 2875 – Fertilizers, mixing only (this may change in the future once the composting industry gets its own North American Industrial Classification System (NAICS) code). NAICS is the successor to SIC.

Figure 1. Example of a discharge monitoring report

An Industrial General Storm Water Discharge Permit requires the permittee (you) to prepare and implement a Storm Water Pollution Prevention Plan (SWP3) and to do periodic benchmark monitoring against that state's defined storm water quality criteria. These criteria vary from state-to-state, for example, in Virginia, composters must monitor for biological oxygen demand, total suspended solids, chemical oxygen demand, total phosphorus, total nitrogen, ammonia-nitrogen and, in some watersheds, *Escheria coli* bacteria. You have to take a grab sample of runoff discharging from your composting facility property (at the most downstream point) and report it on a discharge monitoring report (Figure 1). Your sampling must occur during a rainfall event producing a discharge and at least 72 hours must have passed since the previous discharge-inducing storm (to capture the "first flush" of runoff pollutants). If you have an exceedance, you are supposed to more rigorously enforce the elements of your SWP3. In some states, repeated violations of benchmark standards allow states to switch your permit from a general discharge permit to an individual discharge permit, which you will want to avoid.

AIR EMISSIONS PERMIT

The third category of emissions permit you might need is an air emissions permit, which is, by far, the most confusing set of federal and state regulations. Federal regulations require each major source of air pollutant emissions to obtain an "operating permit" (known as a Title V permit) that consolidates all of the air pollution control requirements into a single, comprehensive document covering all aspects of the source's air pollution activities. Very few composting facilities qualify as "major" sources of air pollutants. A State Operating Permit (SOP) is most often used by stationary sources to establish federally enforceable limits on potential to emit to avoid Title V permitting and/or major source Maximum Available Control Technology MACT applicability. When a source chooses to use a SOP to limit emissions below major source permitting thresholds, it is commonly referred to as a "synthetic minor" source. I told you this is confusing.

Air pollution permits are also required for businesses that build new pollution sources or make significant changes to existing pollution sources. These are sometimes referred to as "preconstruction" or "new source review" permits. Operating permits document how air pollution sources will

Figure 1. Example of a discharge monitoring report

TYPE: SWI GP
Benchmark Monitoring

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF ENVIRONMENTAL QUALITY
VIRGINIA POLLUTANT DISCHARGE ELIMINATION SYSTEM (VPDES)
DISCHARGE MONITORING REPORT (DMR)
NOTE: READ PERMIT AND GENERAL INSTRUCTIONS BEFORE COMPLETING THIS FORM.

DEPT. OF ENVIRONMENTAL QUALITY
(REGIONAL OFFICE)
South Central Regional Office
7705 Timberlake Rd

Lynchburg, VA 24502

FACILITY NAME: Royal Oak Farm Solid Waste Composting Facility
ADDRESS: 1223 Royal Oak Farm Drive
Evington, VA 24550
FACILITY LOCATION: 1223 Royal Oak Farm Drive
Evington, VA 24550

VAR051649	001
PERMIT NUMBER	OUTFALL NUMBER

MONITORING PERIOD

	YEAR	MO	DAY		YEAR	MO	DAY
FROM	2022	01	01	TO	2022	06	30

☐ No Discharge
☐ Adverse Weather Conditions
☐ Representative Outfall
☐ Substantially Identical Outfall

Parameter		QUALITY OR CONCENTRATION				NO. EX.	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		MINIMUM	AVERAGE	MAXIMUM	UNITS			
BOD5	REPORTD	*****	*****	**2**	MG/L		1/6M	GRAB
PARAM CODE: 003	REQRMNT	*****	*****	30			1/6M	GRAB
TSS	REPORTD	*****	*****	**35.8**	MG/L		1/6M	GRAB
PARAM CODE: 004	REQRMNT	*****	*****	100			1/6M	GRAB
COD	REPORTD	*****	*****	**25**	MG/L		1/6M	GRAB
PARAM CODE: 008	REQRMNT	*****	*****	120			1/6M	GRAB
PHOSPHORUS, TOTAL (AS P)	REPORTD	*****	*****	**0.07**	MG/L		1/6M	GRAB
PARAM CODE: 012	REQRMNT	*****	*****	2.0			1/6M	GRAB
NITROGEN, TOTAL (AS N)	REPORTD	*****	*****	**1.17**	MG/L		1/6M	GRAB
PARAM CODE: 013	REQRMNT	*****	*****	2.2			1/6M	GRAB
AMMONIA, AS N	REPORTD	*****	*****	**0.10**	MG/L		1/6M	GRAB
PARAM CODE: 039	REQRMNT	*****	*****	2.14			1/6M	GRAB

STORM EVENT INFORMATION			
DATE	YR	MO	DAY
	2022	06	17
DURATION	HRS	MINS	
	144	0	
RAINFALL TOTAL (IN.)	1.42		
PRECEDING EVENT	DAYS	HRS	
	9	2	

VA DEQ COMMENTS:
GENERAL PERMIT REQUIREMENTS OR COMMENTS:
OUTFALL-SPECIFIC COMMENTS::
PARAMETER-SPECIFIC COMMENTS:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.	PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT		
			2022-07-11 15:22:02
	TYPED OR PRINTED NAME	SIGNATURE	Date

Page 1

demonstrate compliance with emission limits and with other "applicable requirements" such as work practices (e.g., periodically watering a dirt road to prevent dust emissions). Operating permits also document how air pollution sources will monitor, either periodically or continuously, their compliance with emission limits, and all other applicable requirements on an on-going basis.

The permitting process starts with an evaluation of the "potential to emit" (PTE). This is defined as the maximum capacity of a stationary source to emit under its physical and operational design. The calculation is based on uncontrolled air emissions emitted 24 hours per day, seven days per week. If the PTE for one of the criteria or hazardous air pollutants exceeds regulatory thresholds, a permit is required. PTE calculations can be based on actual emissions measurements or on referenceable literature citations.

Literature values are often used as actual emissions testing is very expensive, but there is a downside. For a proposed 115,000 tons/year compost-covered aerated static pile (CASP) source separated organics composting facility in Minnesota, a PTE analysis of Volatile Organic Compound (VOC) emissions from the facility is required to use an emissions factor (3.58 lbs. of VOC per ton of material in the CASP bunkers) that the California Air Resources Board reported in one of their analyses of VOC emissions from windrow composting of green waste — even though more recent field emissions testing at a food and yard waste CASP facility in Napa CA showed a much lower VOC emissions rate (0.3 lbs./ton). Minnesota regulators insisted that the higher emissions factor be used in the PTE analysis as it was a referenceable number in a regulatory document, not unpublished data from a technology provider. In the case of this Minnesota facility, the biofilters treating the air from the CASP when operated in negative air mode will become permitted "air pollution control devices" (APCDs), as will the biolayer over the CASPs when operated in positive mode.

Air emissions permits come in two parts: a "permit to construct" and a "permit to operate." You cannot begin substantial construction of an APCD until the air permit-to-construct is issued (you can do some minor site work, like clearing and grading). And you cannot get a permit-to-operate until you have proven, via source testing, that your APCD is indeed removing pollutants at the removal efficiencies you indicated in your permit application. Source testing to prove pollutant removal efficiencies is expensive.

In some cases, air emissions permits are needed for large horsepower diesel-fueled machines, particularly grinders, although other equipment that is not moved very often may fall under permitting rules (truly mobile equipment, like trucks, are exempt from permitting). This can lead to restrictions on operating hours per day in order to limit emissions to the applicable "pounds per day" permit limit.

Dealing with local and state approval processes can be frustrating, time-consuming and expensive. But complying with all these rules is what separates professional composting from the "bottom-feeders" that have plagued this industry for years. ■

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REFERENCES

Arroyo-Rodriguez, A., "Zoning Model for Agriculture and Composting", *BioCycle*, July 2012.

Coker, C. "Organics Recycling Facility Siting", *BioCycle*, August 14, 2014.

Institute for Local Self-Reliance, "State of Composting in the U.S.: What, Where, Why, and How", 2014.

Johnston, M., "On-Farm Composting Hits Zoning Hurdle", *BioCycle*, October 2017.

Zbinden, M., "USCC Seeks Comments on Model Zoning Ordinance", *BioCycle*, November 10, 2020.

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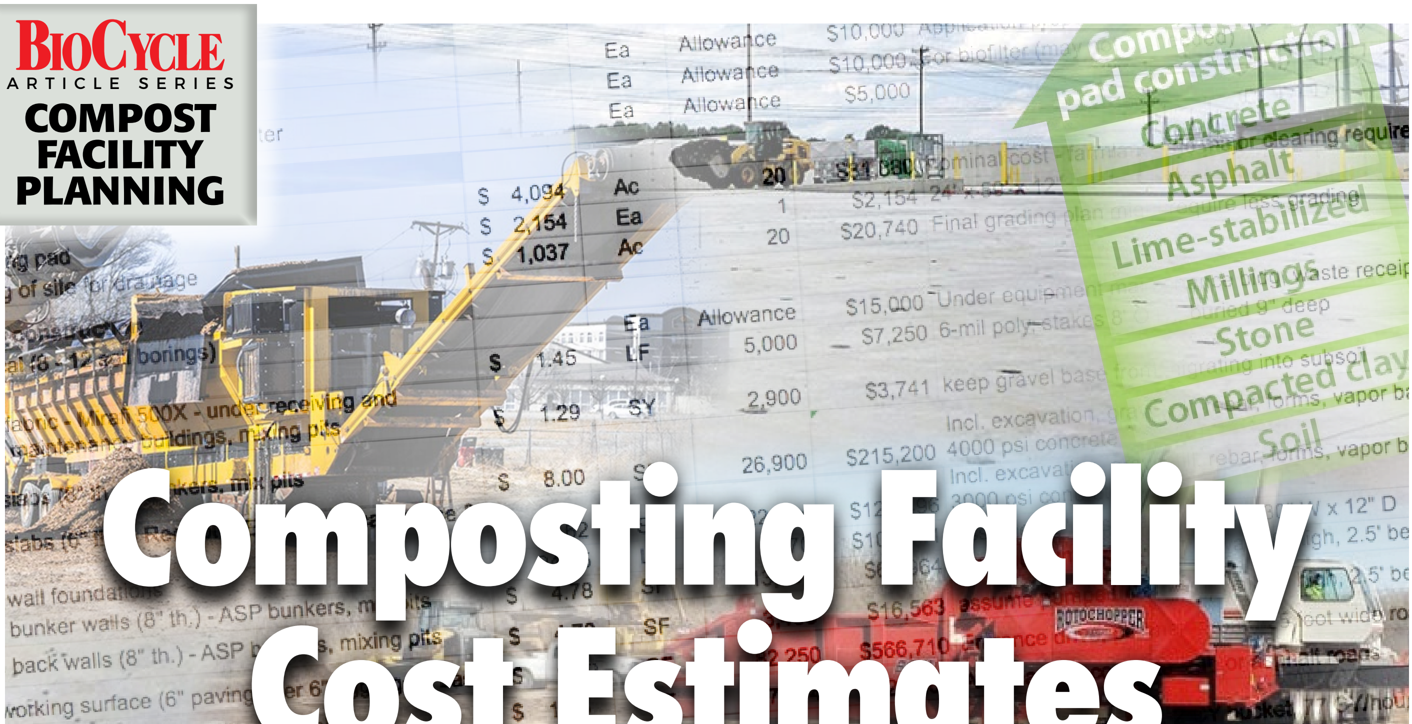
COMPOST FACILITY PLANNING



Composting Facility Cost Estimates

Guidance on how to estimate costs and revenues, evaluate alternatives on the basis of their long-term costs, and assess the impacts of costs on cash flows and budgets.

Part VII

Craig Coker

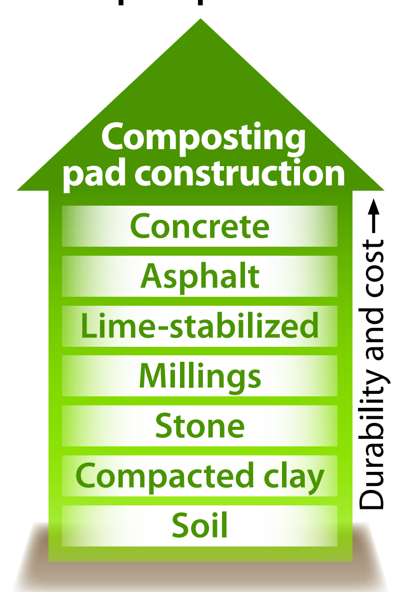
PLANNING a new merchant organics recycling facility requires considerable thought and investigation. As the old adage goes, "Proper prior planning prevents poor performance." This facility planning series is oriented to helping you think through the aspects of proper prior planning. Part I dealt with how to develop a Waste Capture Plan. Part II covered methods to assess the markets' potential to absorb your compost and/or soils products. Part III looked at how to figure out how much room you would need for your new composting facility. Part IV explored how to evaluate different composting approaches or methodologies. Part V examined issues to consider when looking at possible sites for a composting facility. Part VI discussed the various local and state-level approvals and permits that will likely be needed. Part VII covers how to estimate capital and operating costs for your new facility.

Developing sound cost estimates is critical in securing financing for any business enterprise or funding for any municipal operation. While composting is certainly a more environmentally conscious means of handling biodegradable materials than landfilling, the simple reality is that everything revolves around costs. It is necessary to learn how to estimate costs and revenues, evaluate different alternatives on the basis of their long-term costs, and assess the impacts of costs on cash flows and budgets.

CAPITAL COST ESTIMATING

Capital cost estimating for building, expanding or upgrading a composting facility varies in precision as a function of the extent of detailed design and construction bids. The main categories of capital costs to be estimated include site development, processing equipment (both stationary and mobile), and process monitoring equipment. In early facility planning, site development estimates will have an accuracy of

Figure 1. Composting pad options



+50%/-30%; following detailed design, accuracy will improve to +25%/-15%; after bid receipts, accuracy improves to +10%/-5%. To accommodate that varying accuracy, you should budget for contingency funds to cover any unforeseen expenses.

Site development costs are, obviously, very site-specific. Wooded sites will need more clearing; hilly sites will need more grading. Ultimately, what you want to end up with is a gently graded site (≈ 2-3%), with no cross-slope, that is cleared, graded and compacted. The facility's working surface will be defined, partly, by regulation, partly by operator preference (I have yet to meet a composter who prefers a bare earth site in rainy or wintry weather), and mostly by budgetary realities. Figure 1 illustrates the relative capital costs of different types of working surfaces.

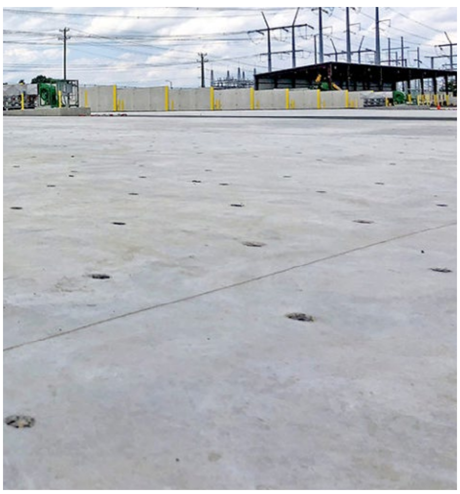
Utilities are part and parcel of any site development costs. If you are planning on aerated static pile (ASP) composting, you will need three-phase power. Extending three-phase power can be expensive if you are considering a farm-based or rural site for composting. Water and sanitation services will also be needed, which will mean a water well and septic system if your site lies beyond a water and sewer-serviced en-

Table 1. Site development costs

	B	C	D	E	F	G
1	Site Development Cost Estimates - Industrial Residuals Composting					
2	**Item**	**Unit Price**	**Units**	**Quantity**	**Costs**	**Notes**
3	**Permits and Approvals**					
4	Composting Permit		Ea	Allowance	$10,000	Application preparation and submittal
5	Air Permit		Ea	Allowance	$10,000	For biofilter (may not be needed)
6	Stormwater Permit: Individual Stormwater		Ea	Allowance	$5,000	
8	**Clearing and Grading**					
9	Clearing	$ 4,094	Ac	20	$81,880	nominal cost - farmland - no major clearing required
10	Stone tracking pad	$ 2,154	Ea	1	$2,154	24' x 50' x 12"
11	Fine grading of site for drainage	$ 1,037	Ac	20	$20,740	Final grading plan might require less grading
13	**Hardscape construction**					
14	Geotechnical (8 - 12 soil borings)		Ea	Allowance	$15,000	Under equipment maintenance bldg, waste receipt bldg, mixing pits
15	Silt fence	$ 1.45	LF	5,000	$7,250	6-mil poly, stakes 8' O.C., buried 9" deep
16	Geotextile fabric - Mirafi 500X - under receiving and equipment maintenance buildings, mixing pits	$ 1.29	SY	2,900	$3,741	keep gravel base from migrating into subsoil
17	Concrete slabs (8" th.) - bunkers, mix pits	$ 8.00	SF	26,900	$215,200	Incl. excavation, gravel fill, rebar, forms, vapor barrier, wire mesh, 4000 psi concrete
18	Concrete slabs (6" th.) - Receipt & EM bldgs, scalehouse & scales	$ 5.62	SF	22,864	$128,496	Incl. excavation, gravel fill, rebar, forms, vapor barrier, wire mesh, 3000 psi concrete
19	Concrete wall foundations	$ 94.15	LF	1,070	$100,741	Assume 42" frost depth, footers 30" W x 12" D
20	Concrete bunker walls (8" th.) - ASP bunkers, mix pits	$ 4.78	SF	13,800	$65,964	assume pumped concrete, walls 8' high, 2.5' below grade
21	Concrete back walls (8" th.) - ASP bunkers, mixing pits	$ 4.78	SF	3,465	$16,563	assume pumped concrete, walls 8' high, 2.5' below grade
22	Asphalt working surface (6" paving over 6" aggregate base)	$ 6.89	SF	82,250	$566,710	Entrance drive, perimeter road: 25 foot wide road, 3,290 ft of road
23	Crushed aggregate working surface (8" thick)	$ 1.25	SF	657,014	$821,268	All areas not concrete slab or asphalt roads
24	Excavation and backfill for leachate tank (10' W x 50' L x 10' D)	$ 2.02	CY	185	$374	Backhoe excavation, 2 CY bucket, 77 CY/hour excavation rate
25	Waste Receipt & Mixing Building	$ 45.00	SF	14,400	$648,000	Agricultural hoop building on 6" concrete slab
26	Equipment Maintenance building	$ 45.00	SF	7,200	$324,000	Agricultural hoop building on 6" concrete slab
27	Scalehouse building	$ 75.00	SF	320	$24,000	10' x 32' construction trailer
29	**Water management**					
30	Vegetative buffer around perimeter (50' W)				$586,700	See details below
31	Run-on berm (8" high compacted earth)	$ 2.00	LF	1,000	$2,000	Width of site only
32	Runoff swales (24" W x 24" D)	$ 3.00	LF	1,000	$3,000	Width plus half of length
33	Solids separator	$ 25,000	Ea	Allowance	$15,000	Prevents fines from washing into the detention pond
34	Wet detention pond	$ 2.00	ft3	202,917	$405,834	
36	**Utilities**					
37	Small utility shed	$ 1,500	Ea	1	$1,500	
38	Extension of 3 phase power & data line from WWTF	$ 55.00	LF	1,500	$82,500	Bring 3-phase over from WWTF
39	Extension of sewer from WWTF	$ 35.00	LF	1,500	$52,500	4" PVC, includes excavation, installation, backfill, road patching
40	Extension of water from WWTF	$ 30.00	LF	1,500	$45,000	1.25" copper pipe, includes excavation, installation, backfill, road pat
42	**Subtotal**				$4,163,613	
44	Design Fee	5.0%	Ea		$208,181	
45	Contingency	25%	Ea		$1,040,903	
46	**TOTAL**				**$5,412,697**	
47	**Notes**					
48	Cost factors from National Construction Cost Estimator software (Craftsman, 2022) based on Zip Code 56007 (mat'ls 0%, labor -5%, equipment 0%) & Research					
49	Vegetative buffer planting guide (source: Town of Wellesley, MA)					
50	Assume 50' W X 4,000' L		SF	# plants	Unit cost	Cost
51	1 tree sapling (6' - 8' tall) per 100 square feet		200,000	2,000	$221.07	$442,140
52	4 shrubs (24") tall per 100 square feet		200,000	8,000	$17.97	$143,760
53	10 herbaceous plants per 100 square feet		200,000	20,000	$0.04	$800
54						$586,700
55	Storm water pond					
56	Assume capture of 24-hr, 10-yr storm	4.3	inches			
57	V = runoff volume = 6.3" x 65% runoff rato x area (SF)	202,917	ft3			
58	Assumed depth	6	ft			
59	Pond footprint	33,820	SF			

Table 2. Equipment costs

◇	B	C	D	E	F	G	H	I	J
1	**Equipment Cost Estimates**								
2	*All equipment is priced new. Some items may be purchased used and/or financed. Asset depreciation with residual values & finance options to be prepared.*								
3							Schedule		
4	**Item**	**Specifications**	**Unit Price**	**Units**	**Quantity**	**Costs**	**Year 1**	**Year 2**	**Notes**
5	Vendor-supplied equipment	Covered Aerated Static Pile Technology				$ 1,500,000	$ 1,500,000		Equipment, Installation & Consulting Support
6	Electrical (total installed)					$ 20,000	$ 20,000		Estimate
7	Weather station		$ 2,200.00	1	1	$ 2,200	$ 2,200		Estimate
8	Trash pump for water/leachate	2.5 hp pump, 1.5" outlets	$ 200	Ea	1	$ 200	$ 200		
9	Leachate tank	25,000 gal double-walled fiberglass tank	$ 75,000	Ea	1	$ 75,000	$ 75,000		Estimate from National Storage Tank
10	Suction/discharge hoses	1.5" hoses	$ 1.00	LF	100	$ 100	$ 100		to connect to WWTF sewer extension
11	Trommel screen	Vermeer TR53000 electric trommel	$ 305,000	Ea	1	$ 305,000	$ 305,000		Estimate including $5k for shipping & installation
12	Front end loaders	180 hp front end loader	$ 250,000	Ea	4	$ 1,000,000	$ 500,000	$ 500,000	
13	Grinder	Rotochopper B66	$ 550,000	Ea	1	$ 550,000	$ 550,000		Estimate
14	Mixer	Rotamix 920-18	$ 200,000	Ea	1	$ 200,000	$ 200,000		
15	Weigh scale	Cardinal Scale	$ 125,000	Ea	1	$ 125,000	$ 125,000		
16	Water truck	Northstar 200-gal skid sprayer	$ 4,000	Ea	1	$ 4,000	$ 4,000		Estimate
17	Pressure washer	Northstar gas cold water 4200 psi, 3.5 gpm	$ 2,000	Ea	1	$ 2,000	$ 2,000		Estimate
18						$3,783,500	$3,283,500	$ 500,000	
19						TOTAL	Y1	Y2	



Newly built sparger type floor for the positive aeration mass bed used for curing (foreground). Active composting bunkers and preprocessing building (on far right) are in the background.

Photo courtesy of Freestate Farms and Engineered Compost Systems

velope. Data communication and internet service are increasingly important in any new facility development, along with adequate cell phone coverage, so plan for those costs (e.g., satellite dish) as well if needed. Storm water runoff management is another necessity, so plan for on-site runoff treatment using vegetated Best Management Practices — even if you can connect your site to a municipal separate storm sewer system (often called a MS4).

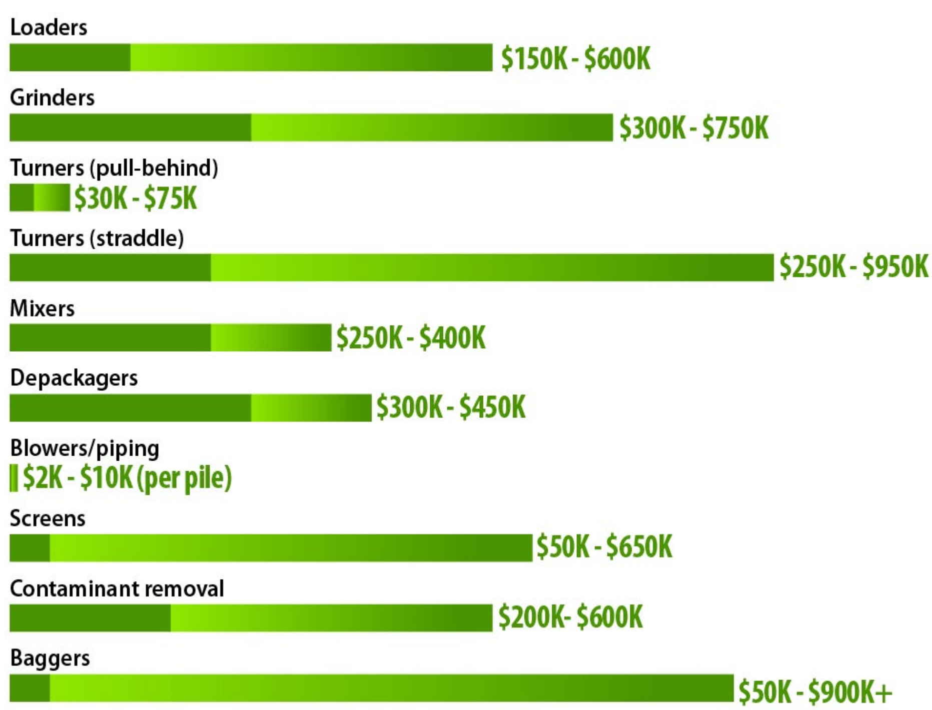
Site development costs can be estimated with construction estimating software. Because those software programs are intended to be used by construction contractors preparing bids from detailed design drawings and specifications, they can be quite detailed. Programs I have used include Craftsman Cost Estimating Software and R.S. Means. Table 1 shows the projected site development costs for a conceptual 40,000 tons/year municipal composting facility using ASP for industrial food processing residuals in the upper Midwest.

The other big capital cost estimating element to consider is equipment. Processing equipment includes front-end loaders, grinders, turners, mixers, depackagers, blowers and piping, screens, contaminant removal and bagging. Multiple companies in the U.S. offer various types of equipment and most exhibit their wares at composting and solid waste trade shows around the country. Equipment costs vary by size, capacity and technological sophistication. Equipment can be purchased, or, in many cases, leased for several years. If leased, those costs get reflected in your operating costs, not your capital costs. Table 2 shows the projected equipment costs for the conceptual composting facility noted above.

Most of this equipment is available in the used equipment market where capital costs are much less. However operating costs are higher, with larger expenditures due to wear in components.

Process monitoring equipment will include the basic essentials such as a 36-inch dial-face temperature probe ($150-$200) and a tablet ($750-$1,000). More sophisticated monitoring systems include wireless temperature probes ($2,000+) and Supervisory Control and Data Acquisition (SCADA) computer interfaces. Many composting facilities have a weather station to record wind speed and direction and rainfall amounts ($700–$2,000) and a small

Figure 2. Composting equipment cost ranges



Vermeer trommel screen (left) and Rotochopper horizontal grinder (right) are examples of equipment purchased or leased for compost manufacturing.

on-site laboratory for measuring bulk density and free air space, microwave measurement of moisture content, pH tests, and similar process monitoring measurements.

OPERATING COST ESTIMATING

Composting is essentially a materials handling exercise. It takes a certain amount of time, at a certain cost, to perform each task in the compost manufacturing process. For new facilities, those costs can be estimated with a time-and-motion projection. For existing facilities, operating expenses can be measured in a similar manner along with detailed cost accounting of equipment costs.

An example of performing a costing exercise is shown in Table 3. This estimates the total annual cost of operating the proposed 40,000 tons/year industrial residuals composting facility noted above.

These types of costing exercises can be used to help make equipment decisions, e.g., one composting facility used this approach to decide whether to keep moving compost into the curing area with loaders, or to invest in a dump truck to move the compost. This calculation step is repeated for each task in the compost manufacturing process, then summarized to provide a projection of the entire facility's annual operating cost.

For operating facilities, this same time-and-motion approach can be used to pin down your actual operating costs. As with projections, the actual cost analysis is based on your actual loaded labor rates plus your measured machine costs. Loaded labor rates include the pay actually paid to the worker, plus amounts needed for employer Federal taxes and State Unemployment Insurance, plus any fringe benefits you pay your workers. The machine rate is the cost of owning or leasing and operating a particular piece of equipment. The machine rate is a compilation of fixed costs, operating costs and labor costs that are expressed over a particular unit factor, usually dollars per hour. The machine rate multiplied by the actual or estimated hours of use in a budget year gives the annual projected cost for that piece of equipment.

Table 3. Operating cost estimate

	A	B	C	D	E	F	G	H	I
1	**Composting Operating Cost Estimate**								
3	Assumptions								
4	Blended Labor rate (loaded) per hour							$35.00	per hour
5	Loader, screen machine rate (fuel + insurance + maintenance)							$55.00	per hour
6	Grinder machine rate							$110.00	per hour
7	Mixer machine rate							$65.00	per hour
8	Facility is open 5 days/week, 52 weeks/yr							260	days/yr
9	Neglects any overlap of labor functions between tasks								
10									
11	**Processing Volumes**								
12				**Avg Annual Vol.**		**Average Daily Volume**			
13	Carbon Amendments			57,475	CY/yr	221.1	CY/day		
14	Nitrogenous wastes - solid			19,257		74.1			
17	Nitrogenous wastes - liquids			2,288		8.8			
18	Overs from screen			18,517		71.2			
19			Totals	97,536	CY/yr	375.1	CY/day		
21	**Materials Handling Assumptions**								
22		Assume wastes & products handled by loader with separate buckets							
23			Bucket capacity of loaders					6	CY
24		Grinding done by horizontal grinder							
25		Mixing done by mechanical mixer							
26		Materials moved to composting and curing with loaders							
27		Materials moved to storage (overs and compost) by loaders							
29	**Scalehouse operations**								
30		Assume scalehouse open 8 hrs/day, 5 days/week							
31		Time spent managing scalehouse						8	hrs/day
32						Labor cost/year		$ 72,800	

NET PRESENT VALUE ANALYSIS

One method of comparing alternatives such as site development costs for one site versus another, or for one model of specific equipment versus another, is to compute the Net Present Value (NPV) of each alternative over the expected life of the alternatives. To keep the math simpler, I normally use a 10-year economic life. These analyses are relatively simple with an Excel spreadsheet.

NPV analyses are often used in financial investment analyses as they model cash flows in and out over the anticipated life of the investment. In engineered facility projects, they can be used to model only the outgoing cash flow of several alternatives, provided all alternatives have the same economic life and produce the same quantities of outputs. The calculation includes initial capital cost, capital costs of replacements during the modeled economic life, operating costs inflated by the Congressional Budget Office inflation forecast, and avoided costs (if any).

These costs are then expressed in current dollar terms using a discount factor equal to the average weighted cost of equity vs. debt capital (for municipal projects, the bond rate for the municipality can be used). If these assumptions hold true, then the alternative with the least NPV is the best financial alternative. Alternatives with less than a 10% difference between them are considered financially equal at this level of analysis. ■

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