Appendix B

The Composting Process

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This section provides an overview of the typical composting process, and provides a description of the specific types of composting process procedures that would be utilized for the Proposed Project.

Composting is a managed treatment process that transforms biodegradable (organic) material into a soil-like substance called compost. Composting occurs naturally in the soil or forest floor, where various organisms and weather slowly break down organic materials. In the case of the Proposed Project, organic materials will be composted to produce compost-based soil amendments.

The heat generated during the composting process destroys pathogenic organisms, as well as plant diseases, weed seed, insects, and insect eggs that may be present especially in foodwaste materials as well as other organic waste materials and bulking agent materials.

In any well-managed composting facility, natural decomposition processes are accelerated and controlled to produce a quality product that meets applicable standards of use in a relatively short period of time. Typically, clean organic materials are collected and sent directly to the compost facility without becoming mixed with refuse.

Composting typically occurs aerobically (digestion in the presence of oxygen), however a portion of the feedstocks that are anticipated to arrive at the facility may be better suited to anaerobic digestion (digestion in the absence of oxygen). These materials will be digested in an enclosed facility where gases are captured and used either as a heat source or for renewable energy.

Compost Recipe Design

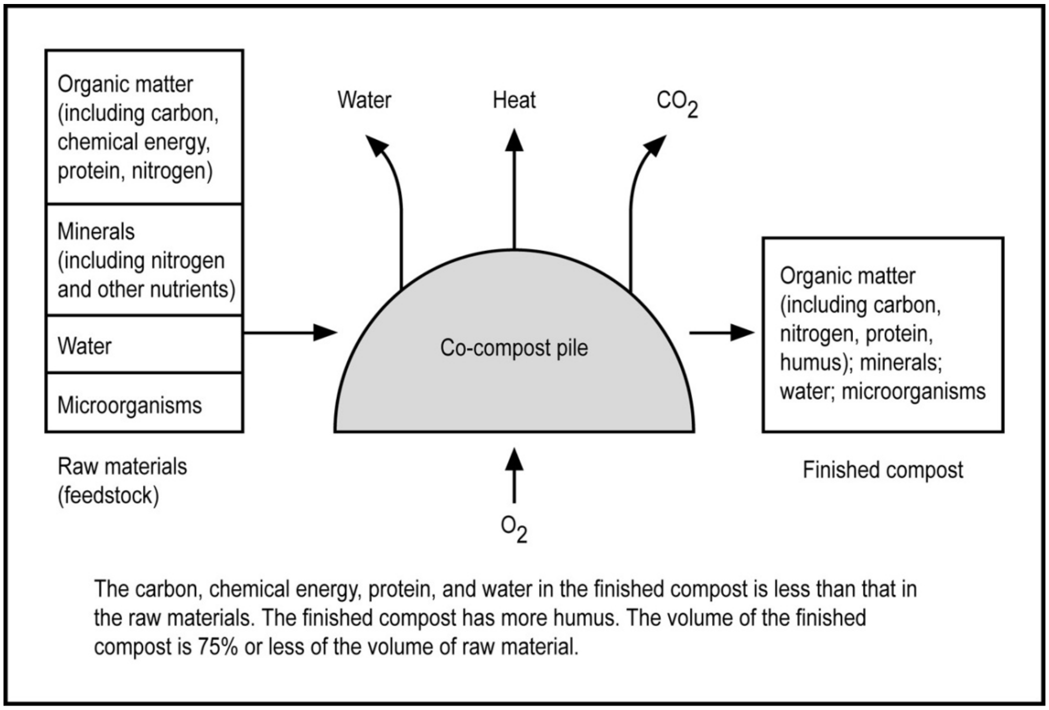
Composting is the aerobic, or oxygen-requiring, decomposition of organic waste by microorganisms under controlled, high temperature conditions. During composting, microorganisms consume oxygen (O2) while feeding on organic matter (see Figure 8). Active composting generates heat and releases gaseous carbon dioxide (CO2) and water vapor into the air. In fact, losses of CO2 and water during composting can amount to half of the weight of the initial feedstock. Composting reduces both the volume and mass of the raw materials while transforming them into a stable soil amendment (see Figure 1).

The general objectives of composting are to:

- Transform biodegradable organic materials into a biologically stable material in a reasonable time (and in the process reduce the volume of original material).
- Destroy weed seeds, pathogens, insect eggs, and other unwanted organisms the may be present in the original feedstock.
- Manipulate useful crop nutrients (nitrogen, phosphorus and potassium) into a more manageable form.
- Produce a product that can be safely used as soil amendment to support plant.

- Prevent growth or inhibit molds and fungi.
- Avoid serious odors and other potential nuisance.

Figure 1 Compost Process Cycle



Like all living organisms, composting microbes require air, water nutrients and a suitable temperature to grow and multiply. Proper management of these four basic needs is necessary to ensure a high rate of decomposition in a compost pile. Too much or too little air, water, nutrients or temperature extremes will hinder the composting process. As microbes successively break down and consume nutrients from complex organic compounds in the feedstock, compost is formed. During composting, the activity of the microbes releases enough heat to destroy pathogens and weed seeds.

Feedstock preparation includes mechanical process control, such as size reduction and mixing, as well as biological controls, such as establishing the right nutrient balance, moisture content and microbial diversity. Mechanical preparation of the feedstock shares an important role with biological preparation in the establishment of proper conditions for composting.

An important requirement for active composting is an appropriate balance between carbon and nitrogen, which is measured by the carbon-to-nitrogen (C:N) ratio – the ratio, by weight of total organic carbon to total nitrogen. Raw materials should be blended to approximately a 30:1 (weight) carbon-to-nitrogen ratio. Carbon and nitrogen are the two most important elements in the composting process carbonaceous material serves mainly as an energy source for the composting microbes. Nitrogen is critical for microbial population growth, since a major constituent of protein (which forms over 50 percent of the dry bacterial cell mass). Many operators refer to the process of balancing a compost feedstock as preparing the “recipe.”

Inadequate nitrogen (a high C:N ratio) results in limited microbial biomass and slow feedstock decomposition. Excess nitrogen (a low C: N ratio) is likely to produce losses of ammonia (as a gas) or nitrate in solution, which may cause odors or other potential environmental problems. In a composting system, microorganisms effectively use nitrate, ammonia and other nitrogen compounds from the compost, thereby greatly reducing the pollution threat. The most effective ratio of carbon to nitrogen depends on the availability of carbon and nitrogen for microbial decomposition. Not all forms of carbon and nitrogen can be immediately used by the microorganisms.

Carbon availability is particularly variable, as it depends on the surface area (determined by particle size) and the extent of lignification of the material. Most decomposition occurs in the aqueous films on the surfaces of the particles, so a greater surface area increases the availability of carbon compounds. Lignin, because of its complex structure and variety of chemical bonds, is resistant to decay. Consequently, the carbon in wood chips is less available than the carbon in straw or paper, and greater quantities of wood chips would be required to balance a high-nitrogen source like grass or foodwaste.

Porosity, the volume of void space in a material divided by its total volume, is closely related to particle size. The initial porosity of mixed feedstock should range from 45 to 60 percent and is set by managing feedstock particle size. If particle sizes are too small, then they will pack together and obstruct air movement in the pile. Bulking agents are often required to achieve the necessary porosity for active composting.

Moisture is also essential to composting, since much of the decomposition in a compost pile occurs within the liquid that covers the particle surfaces. If a mixture is too wet, the water will displace the oxygen supply of respiring microorganisms. If there isn't enough oxygen for respiration, odorous anaerobic conditions will from. The negative impact of excess moisture can be offset in part by setting a high initial pile porosity (about 60 percent) to help ensure free airspace in the pile.

Developing a compost recipe can be an ongoing balancing act if the C:N ratio, moisture content and other characteristics of the mix are to be maintained within the recommended ranges shown on Table 3. With wet feedstock materials, the moisture content is particularly critical, because high moisture content (greater than 60 percent) can lead to anaerobic conditions, odors, leachate formation, and relatively slow decomposition. The consequences of a poor C:N ratio is far less troublesome. Therefore, it is usually best to develop an initial composting recipe based on moisture content and then adjust the recipe to achieve an acceptable C:N ratio. With drier feedstocks, the initial recipe can be developed on the basis of the C:N ratio, since it is relatively easy to add water to the mixture.

Odors are the greatest threat to a composting operation. Many odor problems associated with composting come from 1) handling putrescible raw materials and 2) the development of anaerobic conditions in the pile. If anaerobic conditions become prevalent, extremely odorous organic acids are formed. Ensuring the aerobic conditions in the pile occur as soon as possible after receiving the raw materials minimizes these offensive odors. Once a pile is formed, pile porosity and aeration become critical factors for preventing odors. Proper nutrient balance, particle size, moisture content, temperature and bulk density are also necessary for optimum pile performance and odor reduction.

Types of Composting Processes

A variety of methods or technologies have been developed to compost municipal organic feedstock materials. Each method has distinct operational characteristics such as compost pile configuration and level of management and equipment required. The size of the project site, site sensitivity, distance to neighbors and feedstock materials all play a major role in determining the appropriate composting method. The physical and handling characteristics (including odor, moisture and density) also greatly affect the selection of a composting method.

Composting technologies can be divided into four generic types: open piles, turned windrows and piles, aerated piles, and in-vessel systems. Composting of greenwaste feedstock materials in turned windrows and piles is the most common form of municipal composting nationwide. However, as compost facilities are located closer to the urban interface a more positive means of odor control such as aerated piles and in-vessel systems become necessary to obtain community acceptance.

The four composting technologies mentioned above can be placed into two general categories, open-air and controlled-air systems. The first two technologies, open piles and turned windrows and piles, usually take place in the open air, uncovered. There is no provision for collection of odors. Rather, odor is controlled by attentive operation and management. The last two technologies, aerated static piles and in-vessel systems, provide better potential for odor control because they can be easily designed as closed (covered) systems.

Windrow Composting

Windrow composting is the production of compost by piling organic matter or biodegradable waste, such as greenwaste and woodwaste in long rows (windrows). This method is suited to producing large volumes of compost. The piles are generally turned after 30 days to improve porosity and oxygen content, to maintain optimal moisture, and redistribute cooler and hotter portions of the pile. Process control parameters include the initial ratios of carbon and nitrogen rich materials, the amount of bulking agents added to assure air porosity, the pile size, temperature, moisture content, and turning frequency. The Proposed Project windrows would be under controlled conditions using some type of cover with a positive or negative aeration system utilizing a biofilter.

The covering of the windrows helps protect the surface from drying and filters ammonia and other odors from the pile. More recent designs have used a fabric cover material similar to the micro-pore fabric (water-proof and breathable) used in outdoor clothing products. This fabric covering accomplishes the same function as the previous mentioned materials but is also recyclable.

Windrows are covered with a type of tarp or micro-pore cover to retain moisture and reduce active compost time. Windrows are also covered to prevent heavy rains from damaging the compost while maintaining moisture in hot weather. The covers block ultraviolet rays from the sun, protecting the microbial population while helping maintain temperature levels in cooler weather. The use of covers contributes significantly to reducing odor problems. Figure 2 is a photo of an existing covered windrows operation.

Figure 2 Covered Windrows

Compost windrows may also be covered with a layer of finished compost if negative aeration and biofilters are utilized at the site. A 6-inch layer of finished compost placed over active compost windrows, in conjunction with a separate biofilter, has been shown to significantly reduce air emissions that result from the composting process.

Aerated Static Pile Composting

During the initial stage of composting (12 to 20 days) the Proposed Project would utilize a covered aerated pile process commonly referred to as Aerated Static Piles (ASP) which employs the use of a micro-porous cover positively aerated or a negatively aerated process that include a biofilter for odor control. ASPs are compost piles that are mechanically aerated either by a blower that pushes or a pump that pulls air through the piles. Typically, ASP systems are not turned as frequently as a windrow system. The project proposes a conceptual aerated static pile design that has the air pushed through the static piles from an air collection plenum (or piping network) through the piles and the nature of the micro-porous covers significantly reduces odors and air contaminates. The covers also significantly reduce water requirements and contaminated runoff.

The aerated piles would typically be 10 to 12 feet high. Two of the main advantages of this type of system are (1) that the process air can be collected for odor control and control of other air contaminants, and (2) the footprint of the composting area can be reduced. The disadvantage is lack of flexibility because of the need to have a very homogeneous initial mix of feedstock materials.

Aerated Static Piles

Aerated static piles (ASPs) are closely managed piles that are either outside in the open (in the case of this project) or covered by a structure. The static piles are aerated by fans that either push or pull air through the piles. The Proposed Project would utilize either positive aeration with a micro-porous cover or negative aeration with a biofilter. Positive air systems push air up through the compost pile and a micro-porous covers serves to reduce air emissions and odors. Negative air systems pull air from the bottom of the composting pile to an air collection plenum (or piping network) and then discharge the air to a biofilter to control odors and air contaminants. Figure 3 is a photo of an existing ASP operation.

The pathogen reduction process is shorter for aerated static piles because the pile is covered or insulated (with a layer of wood chips or a membrane cover). In order to meet pathogen reduction requirements the pile has to achieve temperatures in excess of 55° C (131° F) for three days. In practice, the ASP composting achieves high temperatures for longer than the prescribed period.

Figure 3 Overview of an Aerated Static Pile Composting Facility

Figure 4 Aerated Static Pile Biofilter

Unaerated Covered Piles

Following the initial 14 to 20 days composting period, the material would be transferred to unaerated piles.   These piles would be covered immediately for another period of 20 to 40 days. Compost piles would be turned every 7 days and then recovered to maintain aerobic conditions within the piles. A majority of the objectionable odors and air contaminants are reduced by 80% during the first 12-14 days of the composting cycle. Compost piles would remain covered until objectionable odors have dissipated and the compost has met stabilization requirements.

In-Vessel Composting

In-vessel composting generally describes a group of methods that which confine the composting materials within a building, container, or vessel. In-vessel composting systems can consist of metal or plastic tanks or concrete bunkers in which air flow and temperature can be controlled, using the principles of a "bioreactor". Generally the air circulation is metered in via buried tubes that allow fresh air to be injected under pressure, with the exhaust being extracted through a biofilter, with temperature and moisture conditions monitored using probes in the mass to allow maintenance of optimum aerobic decomposition conditions.

This technique is generally used for municipal scale organic waste processing, including final treatment of sewage biosolids, to a safe stable state for reclamation as a soil amendment. In-vessel composting can also refer to ASP composting with the addition of removable covers that enclose the piles.

Offensive odors are caused by putrefaction (anaerobic decomposition) of nitrogenous animal and vegetable matter gassing off as ammonia. This is controlled with a higher carbon to nitrogen ratio, or increased aeration by ventilation, and use of a coarser grade of carbon material to allow better air circulation. Prevention and capture of any gases naturally occurring (volatile organic compounds) during the hot aerobic composting involved is the objective of the biofilter, and as the filtering material saturates over time, it can be used in the composting process and replaced with fresh material.

A more advanced systems design is able to limit the odor issues considerably, and it is also able to raise the total energy and resource output by integrating in-vessel composting with anaerobic digestion. In this approach batches of organic material are first subjected to anaerobic digestion and then later in the same bioreactor the process is switched to composting through the use of forced aeration.

Compost Management

At build-out, the Proposed Project would process up to 1,000 tons per day. However, at this time it is uncertain if the facility would receive sufficient feedstock to actually reach the full build-out volume. The facility would process organic material utilizing a covered windrow system that would be a combination of ASP and covered windrow composting technology. One of the biggest advantages of the ASP is the ability to collect and treat odors, so this technology is well suited to localities where odor is a primary concern, assuming all other site conditions are equal. As previously noted, emissions control is typically one of the major environmental concerns associated with composting operations. The aerated static pile composting method proposed for this project has historically demonstrated effective odor control. Emissions generated during the project's active composting and compost curing processes will be filtered through a micro-porous water-proof breathable membrane or through a biofilter which significantly reduces emissions.

The delivered compost mixture from the receiving/mixing building will be deposited on the composting pad. An aeration channel or perforated pipe located under the compost windrow will serve to force air through or from the piles and will also serve as a leachate collection system by capturing the moisture and transporting the leachate to a collection area via a piping system. Each aerated static pile will be covered with an insulating cover that retains air and moisture. Cross-sections for a typical aerated static pile are shown on Figure 6.

Once delivered to the composting pad, the mixed organic materials and amendment mixture are stationary (static) during the first 14 to 20 days of the composting process. Following this initial composting phase the material would be transferred to an unaerated covered pile for an additional 20 to 40 days. Total composting time for each pile or zone is approximately 40 to 60 days or until the compost material achieves standards consistent with the state and federal composting regulations. As such, on an approximate 40 to 60 day cycle, all decomposable organic feedstock materials enter the composting process to produce an intermediate stage of compost based soil amendments. At the end of this intermediate stage of the compost process, all active composting processes are complete, and any necessary pathogen reduction/elimination will have been achieved.

Necessary aeration and temperature control of each static pile composting zone or pile is provided by an aeration blower that cycles air through the compost pile to an air collection system buried within the composting pad.

At the completion of the composting cycle, the intermediate compost product is moved out of its zone or pile with front-end loaders (FEL's) and delivered to the curing piles. The approximately 20-40 days aerated curing process produces finished compost that is now suitable for delivery to wholesalers and other possible end users. At the completion of the curing process, the finished product is transported by FELs to the product screening area and then to a finished storage and load-out area.

During the ASP process, NOx emissions and ROG emissions from the compost piles would be greatly reduced (approximately 95 percent lower) in comparison to conventional open windrow processing because emissions are captured by the covers or biofilter. PM10 emissions would be significantly reduced under the ASP alternative because the covered ASP technology eliminates the need for windrow turning during active composting. Diesel particulate matter and ammonia emissions would be reduced because the technology eliminates the use of operating loaders and windrow turners during active composting.

Because the compost piles would not be turned during the initial composting process, and because the covered ASP process significantly reduces emissions, this alternative would result in reduced potential for odor generation in comparison to the conventional open windrow technology.

Aerated static piles are not turned during active composting, so pile porosity must be maintained by structural integrity of the material. Amendments such as ground wood chips or green waste (shredded tires may also be used to accomplish the same purpose) are commonly used to help maintain pile structure. A benefit of ASP is that it allows for larger windrows. The size of the ASP piles will be approximately 170 feet long, 12 feet in height and 26 feet wide. In aerated static pile technology, the active composting time is reduced from 70 days to approximately 45 days which allows for a larger volume of materials to move through the facility in a smaller space.

Odor Control

Odor management is vital to successfully siting and maintaining composting facilities. Odor complaints are common near open-air facilities and have sometimes resulted in facility shutdown. The first step in odor control is an understanding of the process and how to minimize odor generation. The Proposed Project would utilize a controlled technology that has demonstrated that emissions and odors can be reduced by as much as ninety-five (95) percent.

The primary sources of odor generation at composting facilities are:

1. Delivery and handling of raw feedstocks
2. Active composting process
3. Screening operations
4. Curing process

Controllable factors that impact the potential to generate odors during the composting process include feedstock quality, aeration, moisture, porosity, pH, temperature and time. Most of the odorous compounds are generated during the first 14 days of active composting. To reduce the potential odors generated by anaerobic metabolism, the process is kept in an aerobic state.

Potential emission control systems include: chemical scrubbers, granular activated carbon (GAC), trickling filters (biofiltration towers) or biofilters. Key decision-making factors considered for the Proposed Project in comparison with the different odor treatment technologies included:

1. Industry experience and success
2. Permitting requirements
3. Capital costs, replacement costs and operation and maintenance (O&M) costs
4. Water supply availability for trickling filter technologies

The biofilters proposed for the project act to neutralize odor producing agents present in the air discharged from the Receiving/Mixing Building. Biofiltration uses microorganisms to break down organic compounds (or to transform some inorganic compounds) into carbon dioxide, water and some salts. When the biofilter is constructed, the microorganisms are already on the material that is used as the filter bed. The biofilters themselves are comprised of stockpiled loose organic materials. Approximately every 2 to 3 years the biofilter material may require replacement. The spent biofilter material is an inert, innocuous organic compound that will require disposal in a landfill or may become part of the bulking agent used in the composting process. Air from the receiving/mixing building will be piped to, and filtered through these biofilter materials.

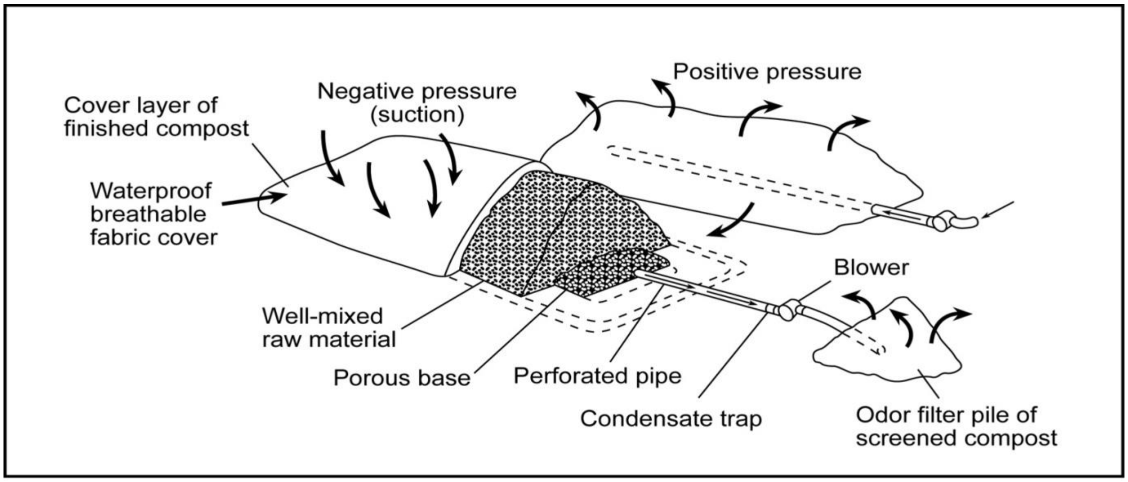
In a cover ASP system the aeration blowers operate on a computer-controlled system that using temperature sensors and oxygen sensors to ensure proper aeration of the piles. Positive aeration blowers typically operate for less than 20 minutes per hour. Odor control collection blowers will operate continuously. The composting and curing aeration blowers are assumed to operate 30 percent of the time.

Forced Aeration

Forced aeration provides more direct control of the compost process and permits larger piles. It also allows more aggressive management of pathogen destruction and biological activity. Positive forced-air systems (which blow outside air in through the bottom of the pile by fans) are used for both temperature control and odor collection. See Figure 5 below.

Forced aeration takes the piped system one step further, using a blower to supply air to the bottom of the pile. The selection and initial mixing of raw materials are critical to the success of the process. The pile must have a good structure to maintain porosity throughout the entire composting period. This generally requires a fairly stiff bulking agent such as wood chips or mature straw, especially if the materials composted have relatively high moisture content such as wastewater treatment biosolids. The porous base material contains a perforated aeration pipe that can be intermittently pushed (with positive pressure), pulled (with negative pressure) or alternated. Temperature sensors can be used to automatically control the frequency of aeration to prevent excessively high or low pile temperatures.

Figure 5 Aerated Static Pile Schematic



Adapted from *On-Farm Composting Handbook*, NRAES-54

Feedstock Preparation

Arriving materials are consolidated in a receiving area prior to being processed. The first phase for material entering the compost facility is to prepare the feedstock materials for the composting process by grinding or shredding and then screening the materials. A combined grinding and screening phase precedes placement of materials in the windrows. The grinder would be electrically or diesel powered. Material is temporarily stored in the vicinity of the processing equipment until it is convenient or necessary to remove/relocate the materials for composting or bulk storage. Materials are managed by a FEL. Processed feedstock materials may be loaded directly into a trailer or dump truck or stockpiled in the processing area.

Materials to be composted are either premixed prior to being formed into a windrow, or are layered (e.g., typically on a bed of ground yard trimmings, wood chips or sawdust) and then mixed with the turner.

Windrow Management - A truck or conveyor system is used to deliver the feedstock from the stockpiles to the composting area. The feedstock will be formed into windrows with side slopes approximately 1:1. Compost residence time is generally 8 to 10 weeks for stabilization.

In general, the compost windrows are constructed and then aerated for a period of twenty days. Aeration is provided by piping under the windrows to maintain oxygen content and prevent anaerobic conditions that would create odors. After 20 days, the material is moved to a new location and covered for an additional 20 days. A mechanical windrow turner is used to mix the pile in place. After turning a windrow, which takes approximately 15 minutes, the cover is placed back over the pile. If water is required to be added to the compost pile it is done during the turning process. Onsite stored water or leachate pond water is utilized for any additional water requirements.

Monitoring Moisture Content – The structure of the windrow cover is semi-permeable to produce a constant microclimate within the compost pile. The cover is waterproof and windproof to protect the material from the elements. The cover can be anchored to protect it from heavy winds. The cover is permeable to oxygen, carbon dioxide, and water vapor and can shed 100 percent of rain during storm events. The cover is also permeable to gas exchange and is ultraviolet light stabilized, durable and reusable, thereby reducing the volume of waste generated at the facility.

Moisture may be added to windrows during their formation and as needed during maintenance. Moisture content is controlled after initial formation with a target of 50 to 55 %. The amount of water used varies depending on the moisture content of the compost and on wind, temperature and humidity conditions. Very little water runs off the windrows and what does run off is and will be collected in a compost leachate drainage control system and will either evaporate or subsequently drain into the stormwater retention pond and be reapplied to the compost operation. One of the benefits of covered windrows is a reduction in the loss of moisture.

Pile turning introduces oxygen, accelerates physical degradation of feedstocks and provides an opportunity to adjust the moisture content to the optimum level. Many windrow turners have a watering attachment, which enables moisture to be added to the pile while turning. Generally speaking, the total composting time can be managed by the aggressiveness of the turning regime. More frequent turning breaks particles down more quickly, and provides an opportunity to optimize composting conditions, thus accelerating the composting process. This enables a windrow composting facility to increase its annual throughput capacity. Prior to turning, the cover is removed.

Monitoring Temperature – In ASP, monitoring and documentation data of temperature is accomplished with the automated aeration and control and monitoring system (i.e., CompTroller). Batches of compost are tracked through the facility from start to finish and a compliance record is automatically created.