CHAPTER 5
LEARNING OBJECTIVES AND CONCEPTUAL DESIGN

Summary

This section presents the conceptual design for a theoretical, New York City Research and Development Pilot Materials-Recovery and Composting Facility ("MRC," pronounced *merc*). The chapter presents the basic design considerations and learning objectives of such a facility, and follows with a general description of the theoretical facility configuration and components.

The description of the pilot-facility layout and its components included herein should not be read as an actual design plan, but rather as a general guide to help conceptualize what a pilot MRC might look like and how such a facility might operate, should one be built in New York City.[1]

Materials Recovery and Composting

What is a MRC? A materials-recovery and composting facility is designed to recover as much recyclable and degradable material as possible from the waste stream. Simply stated, a MRC is an MSW-composting facility combined with a mixed-waste materials-recovery facility (MRF).

Recognizing that over half of the municipal solid-waste stream is degradable (even with a curbside, mixed-paper recycling program), a MRC's broad goals are to:

- De-bag and "clean" incoming MSW by removing as many non-degradable materials as possible before composting the larger, degradable fraction of the waste stream
- Focus especially on removing non-degradable items that are perennially problematic for MSW composting, such as plastic bags and glass
- Recover for recycling as many of the non-degradable items as is practically possible
- Produce a quality compost product

As described in Chapter 1, most MSW-composting facilities rely on the tumbling action of the rotating composting drum to break open garbage bags and thereby expose the degradable fraction of the waste stream to the agents of decomposition. The advantage of this approach is that 100 percent of the degradable material entering the facility goes to the composting drum. The disadvantage is that 100 percent of everything (with the exception of certain bulk items) in the waste stream goes to the composting drum as well.

For MSW composting to work, non-degradable material has to be separated from degradable material at some point in the process. As explained in Chapter 4, the current approach to MSW composting—where facilities attempt to screen out non-degradable material *after* it has gone through the composting process—leads to increased residue disposal costs, decreased recovery of non-degradable recyclable items, and increased contamination levels (small pieces of glass and plastic remaining) in the final compost product.

The pilot facility, described in this chapter, would attempt to avoid these problems by segregating and (where possible) recovering non-degradable materials *before* they go through the composting process. Again, this pilot facility can be thought of as a traditional MSW-composting facility with a mixed-waste materials-recovery facility (MRF) on the front end. Mixed-waste MRFs (sometimes referred to as "dirty MRFs") accept mixed waste, rather than source-separated recyclable items. These MRFs debag the incoming mixed waste and accomplish separation and recovery through various screens and sort lines. Much of the design for the pre-composting, materials-recovery process for a pilot Materials-Recovery and Composting Facility comes from these types of MRFs.

Design Considerations

Based upon the results of the MSW-Composting Research Project, this report recommends that, were a pilot Materials-Recovery Composting Facility to be built in New York City, it should include the following design features:

• **Removal of non-degradable items before MSW enters the composting digester drums.** Rather than rely upon a successive series of screens after drum discharge to remove non-degradable items, such materials should be removed *before* they go through the composting process. This would increase facility recovery rates, decrease residue disposal costs, and create a cleaner, final compost product.

• **Recovery of recyclable materials from the waste stream before MSW enters the composting digester drums.** Materials-Recovery Facilities (MRFs) employ technology and systems designed to remove targeted items from the waste stream. MRFs generally separate and bale these items for transport to manufacturers, who will use them as feedstock for production. An NYC Pilot Materials-Recovery and Composting Facility should test the configuration of these recovery technologies in order to remove and recover as many recyclables as possible from the waste stream, before material gets sent to the composting digester drums.

• **Flexible and largely modular design so that different components can be moved, reconfigured, or removed in order to meet learning objectives.** All sort lines should be skid-mounted, and all equipment should rest on a concrete floor, so that facility components could literally be rearranged. Most of the push walls could be recyclable steel, rather than concrete, and could fit into slots in the floor, rather than being permanently cast. The design elements should be reusable and recyclable to the extent possible.

• **Operational redundancy and flexibility.** Each piece of equipment should be paired, so that if one breaks down and requires repairs, the other could take up the slack. Additionally, the different component processes (materials recovery, composting drum loading and discharge, and compost curing) should be operated separately so, for example, material could be received and sorted on one shift and then loaded into the digester drum on another shift.

• **Adequately sized air floor.** One of the primary lessons of DSNY's MSW-composting research project was the need for extended, actively managed, post-digester composting to produce a quality compost product.

• **Sensitivity to neighbors.** Given New York City's dense, urban environment, neighbors will never be far from a potential facility, even in industrial zones. Therefore, the facility should be designed from the very beginning with the goal of being a good neighbor. Such design considerations include: preventing and minimizing odors, minimizing truck queuing, facilitating easy and routine cleaning, and keeping materials moving (not stockpiling them for long periods).

• **Adequate throughput to ensure economies of scale.** The facility should be designed not only to demonstrate the technical viability of the processes involved, but to handle sufficient volumes of waste, such that it is economically sensible to operate.

Learning Objectives

An NYC Research and Development Pilot Materials-Recovery and Composting Facility (from here on referred to as "pilot MRC facility" or "pilot facility") should have a discreet number of learning objectives (summarized in Table 5-1), and a set time period in which to answer some important questions. Another key function of the pilot facility would be to introduce legislators, interested parties, concerned communities, and local regulatory agencies to the process, such that all potential environmental concerns (including odor-control performance) are addressed. If a pilot facility is able to operate successfully in a cost-effective, nuisance-free manner, and produces a quality compost product with viable end markets, then New York City might consider scaling up to a permanent facility. If a pilot facility is unable to accomplish these goals, then the facility should be dismantled, with the component equipment sold for reuse to other solid-waste–handling enterprises.

Facility Layout and Description of Components

In preparing an initial plan and cost estimates for a pilot MRC facility in New York City, the Department worked with a consultant who has long-standing experience both with MSW-composting systems and facility design. This consultant in turn sought assistance from an engineer specializing in MRF design in order to identify successful and proven materials-recovery equipment. The goal was to identify equipment that would both maximize the recovery of non-degradable materials for conventional recycling markets, as well as target items (such as film plastic and small pieces of glass) that regularly cause problems for MSW-composting systems. For projected recovery rates for the various material fractions of the waste stream moving through a pilot facility, see Chapter 6.

Appendix I contains the engineer's recommended equipment list for the materials-recovery component of the theoretical pilot MRC facility, described herein. This list represents the engineer's recommendations only, and is provided primarily as a break-out of equipment costs. This list in no way constitutes equipment that New York City has chosen, or might chose to employ in the future, should it decide to pursue the development of a pilot facility. The engineer's drawings for the materials-recovery component of the pilot MRC facility have been reproduced from the original blueprints and resized for convenience of viewing. These drawings (Illustrations 5-2 through 5-8) accompany the narrative description which follows.

Illustration 5-1 shows a preliminary conceptual layout of a pilot MRC facility, designed to fit in the smallest footprint possible. Building numbers discussed in the text and in subsequent illustrations reference this drawing. The text that follows describes the hypothetical movement of materials from Building 1 (Facility Tipping Floor) through Building 14 (Final Screening and Compost Load-Out). Table 5-2 provides an overview of how a pilot MRC facility might function, and lists the various illustrations and photos associated with each section.

Receiving and Sorting Waste

After weighing in on facility scales, trucks pull up to the doors of the pilot facility and tip their loads onto a depressed, concrete **tip floor**, several feet below the entrance (Building #1 in

Table 5-1

Summary of Learning Objectives for an NYC Pilot Materials-Recovery and Composting Facility

Facility Size and Cost	• Test the pilot facility over the course of a year to determine its ability to handle the peaks and valleys in New York City's degradable waste stream (such as the influx of yard waste during the spring). • Test flow-through times in order to properly size a full-scale facility that would be able to handle the allocated fraction of the waste stream, as managed by the NYC Departments of Sanitation and Environmental Protection (in the case of biosolids). • Closely track recovery rates (including weights of all facility inputs and outputs) and operating and maintenance costs to develop an accurate basis with which to compare materials recovery and composting to other waste-management strategies.
Materials Recovery	• Test and configure different materials-recovery components (including conveying and baling equipment) to determine which are best suited for maximizing the recovery of non-degradable materials for conventional recycling markets, and diverting non-degradable materials that are especially problematic for composting (such as film plastic and glass). • Determine the optimum sorting-station length, number of sorting stations, and speed of the sorting belts for a given amount of material across the pre-processing sort lines, so as to maximize the removal of non-degradables. • Assess potential markets and their capacity to absorb both the compost and other products produced by the pilot facility (such as recovered textiles and standard, baled recyclable commodities).
Compost Quality	• Test input "recipe" formulations and material-retention times, both in the composting digester drum and post-digester composting systems, to optimize decomposition and final compost quality. • Determine the ability of the solid waste to absorb biosolids at different levels of dewatering. • Conduct intensive, independent laboratory analyses to make certain that the compost consistently meets or exceeds New York State and federal quality standards.
Facility Operations	• Assess ability of trucks to weigh in and tip quickly in order to minimize queuing. • Test different operating schedules to provide for adequate material throughput and regular facility cleaning. • Measure odor dilution at the perimeter of the facility to establish a consistent, objective record of odor-control performance through different weather conditions/wind patterns.

Table 5-2
Summary of the Basic Components of a Theoretical, NYC Pilot Materials-Recovery and Composting Facility

Facility Tipping Floor *Illustration 5-1*	• Contains tip floor, where incoming MSW is unloaded, and grapple crane, which removes bulk items (recyclable and non-recyclable).
Materials-Recovery Building *Illustrations 5-1 through 5-8; Photos 5-1 and 5-2*	• Contains primary and secondary sort lines and bag-opening equipment. These lines serve to remove large items not in bags (recyclable and non-recyclable), empty contents of opened bags, and remove film plastics. • Material then passes through a primary screen, a final sort line, and a final screen. • The screens and final sort line remove small, non-degradable items and recover recyclables from the waste stream.
Materials-Recovery Staging Area *Illustrations 5-1 and 5-9*	• Baling and storage area for the recyclables removed from the waste stream. • Staging area for any reusable, salvageable materials removed from the waste stream. • Staging area for the disposal of the non-degradable residue removed from the waste stream. • Potential location for the processing of the glass-and-organics–laden unders from the primary pre-drum screen.
Digester Drum Tipping Floor *Illustrations 5-1 and 5-10*	• Loading area for the sorted and screened MSW to be composted in the digester drums.
Biosolids Storage Bunker and Pumps *Illustration 5-1*	• Stores biosolids and pumps them directly into the digester drums where they will be mixed with sorted MSW.
Three Digester Drums *Illustrations 5-1, 5-10, and 5-11*	• Mix biosolids and sorted MSW to begin intensive decomposition process. • Two main drums handle the "overs" from the Materials-Recovery Building (largely comprised of paper and other degradable materials not picked out or screened away). • The third drum handles only the glass-and-organics–laden "unders" from the primary screen in the Materials-Recovery Building.
Primary Screening Building *Illustrations 5-1 and 5-11*	• Screens the immature compost discharged from the drums to remove large, non-degradable items missed by the materials-recovery process. • "Unders" from the first two drums go to the First-Phase Composting building. "Overs" are disposed as residue. • "Overs" from the third drum are also disposed, and the "unders" are sent to the De-Stoning Building.
First-Phase Composting *Illustration 5-1, Photo 5-3*	• Composts the "unders" from the two main digester drums for approximately 20 days.
Second-Phase Composting & Curing *Illustrations 5-1 and 5-12*	• Continues to compost materials from the First-Phase Composting building for an additional 30 days.
Final Screening & Compost Load-Out *Illustration 5-1, Photo 5-2*	• Screens the compost from the Second-Phase Composting & Curing building. • Staging area for loading final-screen "unders" (finished compost) into transport vehicles for additional curing or end use.
De-Stoning Building *Illustration 5-1*	• Separates the inerts from the immature compost discharged from the third digester drum. • Small, non-degradable material is disposed. • Remaining degradable material is sent back though one of the two main digester drums.
Biofilter and Emissions-Control Equipment *Illustrations 5-1, 5-13, and 5-14*	• Filters and treats process air from the facility to remove odors before release outdoors.

Illustration 5-1
Conceptual Layout of an NYC Pilot Materials-Recovery and Composting Facility

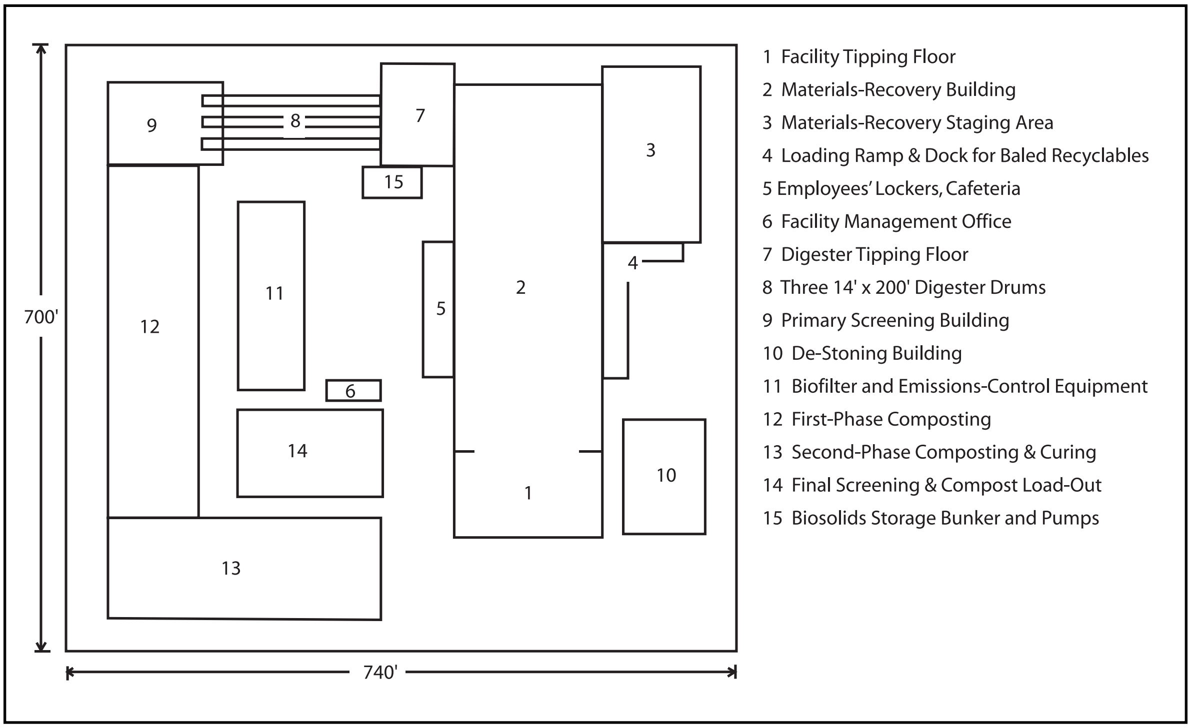


Illustration 5-1). With a depressed tip floor, trucks do not actually enter the facility, which reduces the amount of diesel fumes (and chances for accidents) inside the building. Since collection trucks often tip their loads in convoys, a pilot facility should be designed to accommodate many trucks tipping at once, in order to avoid queuing and delays. Installing high-speed doors would minimize the chance of odors escaping the building during unloading.

An operator in a electrically driven, **fixed-mount grapple crane** (#1A in Illustration 5-2) on the facility tipping floor removes bulky items (such as couches and plumbing fixtures) and places them into containers, and loads all other waste into the infeed hopper of a large conveyor belt (Conveyor #2). Electrically driven cranes are proposed for a pilot facility, instead of front-end loaders, again, to reduce diesel fumes inside the building. When the bulk-item containers are full, a truck transports them to the **Materials-Recovery Staging Area** (Building #3 in Illustration 5-1) for either recovery or disposal.

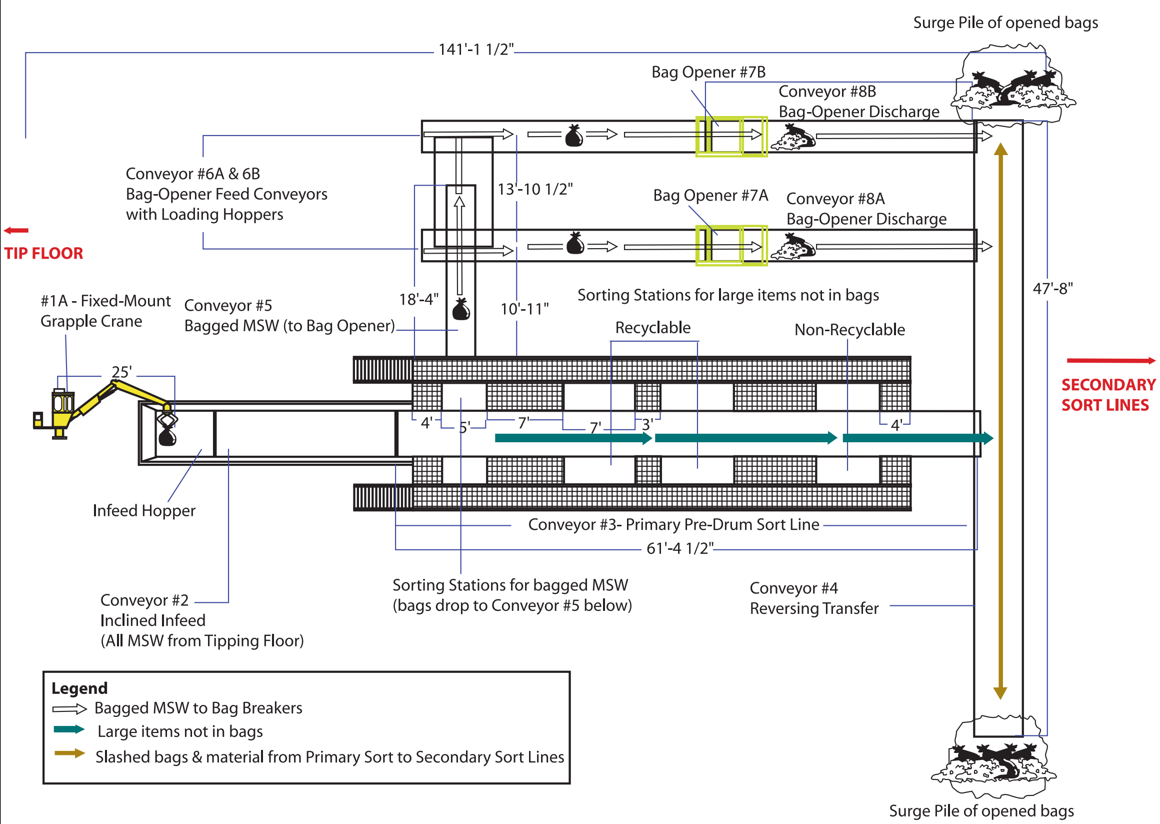
Conveyor #2 rises on a slight incline and moves past the elevated, **primary pre-drum sort line** (Conveyor #3 in Illustration 5-2) in the **Materials-Recovery Building** (Building #2 in Illustration 5-1), where workers in environmentally controlled housing perform the following tasks:

- Sort materials that arrive in plastic bags
- Sort bulky items that do not arrive in plastic bags

The first set of workers on the primary sort line picks all garbage bags, big or small, off the belt and drops them through a chute to a separate conveyor (Conveyor #5), running below the first

Illustration 5-2

Overhead View of Primary Pre-Drum Sort Line and Bag-Opening Process



See Illustration 5-3 for side view of bag-opening process, and Illustration 5-4 for side view of primary pre-drum sort line.

large conveyor (Conveyor #3). Conveyor #5 feeds into two conveyor lines (Conveyor #6A & 6B in Illustrations 5-2 and 5-3), which lead to **bag openers** (#7A & 7B) that slash open all of the garbage bags. Slashed bags then move by a discharge conveyor (Conveyor #8A & 8B) to a **reversing transfer conveyor** (Conveyor #4), and are deposited into two surge piles, which are ready to be loaded onto the **secondary pre-drum sort lines** (Illustration 5-5).

The second set of workers on the **primary pre-drum sort line** removes bulky, potentially reusable or recyclable items that do not arrive in garbage bags. This would include materials such as lumber, large sheets of corrugated cardboard, bulk metal, and electronics. Workers pick such materials off of the conveyor (Conveyor #3 in Illustration 5-2 and 5-4), and drop them into separate, designated

Photo 5-1: Example of an enclosed, climate-controlled sorting station
Photo taken at the materials-recovery facility, located adjacent to the MSW-composting facility in Rapid City, South Dakota—one of the facilities surveyed by DSNY for this report.

Illustration 5-3
Side View of Bag-Opening Process

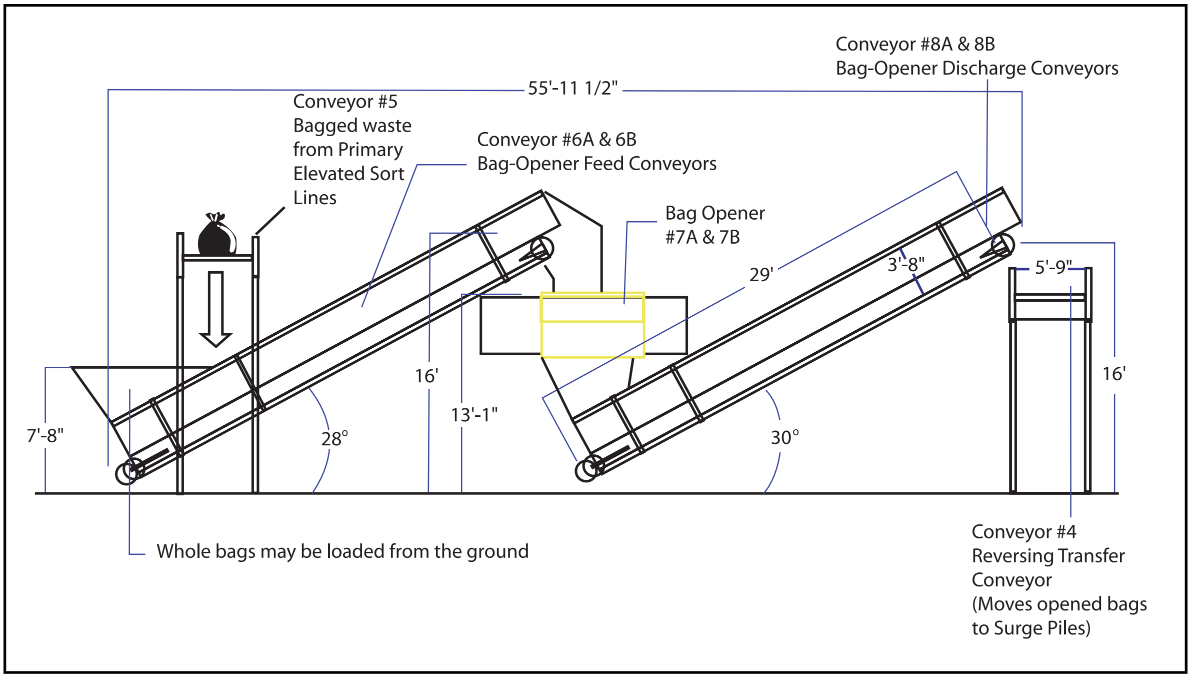


Illustration 5-4
Side View of Primary Pre-Drum Sort Line

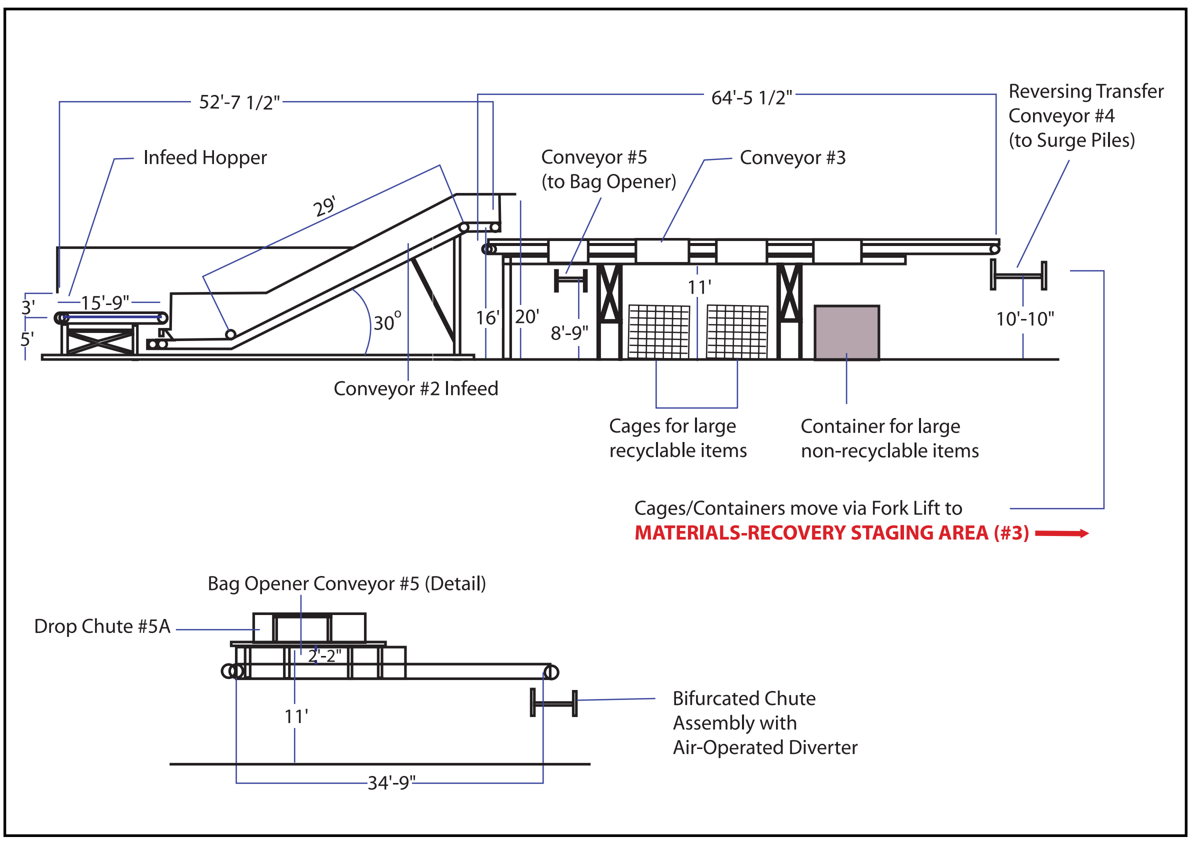
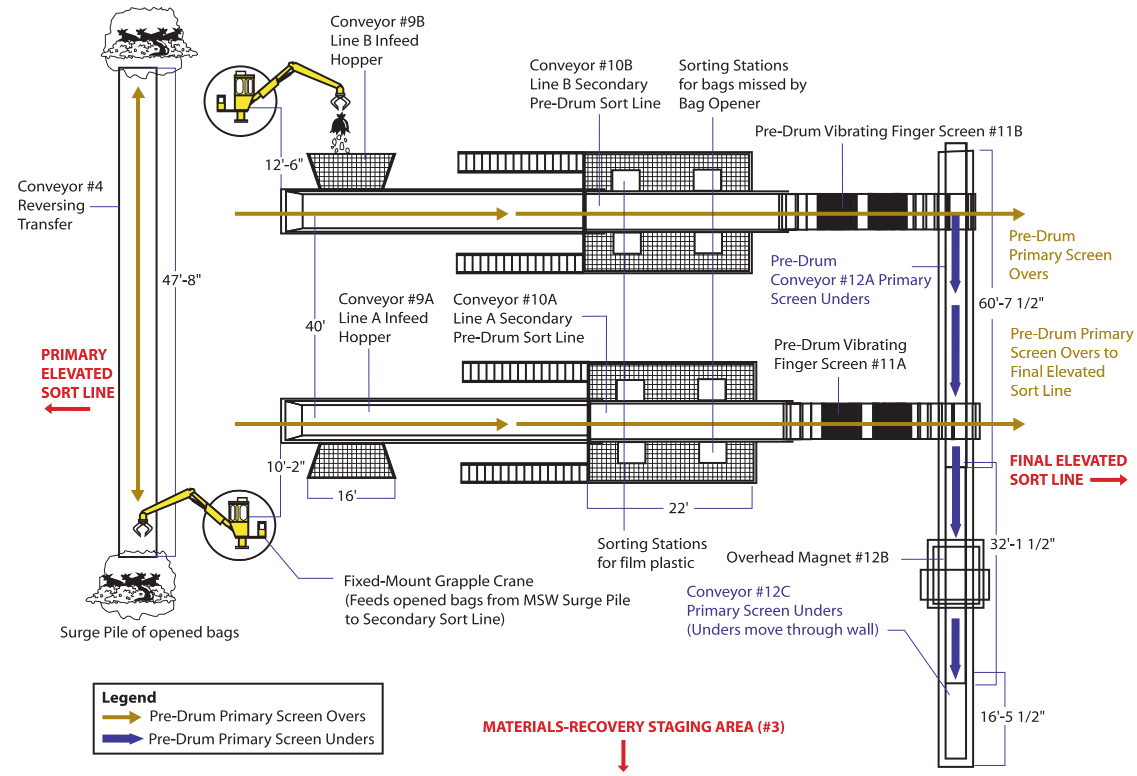


Illustration 5-5
Overview View of Secondary Pre-Drum Sort Lines



See Illustration 5-6 for side view of Secondary Pre-Drum Sort Line, and Illustration 5-7 for movement of pre-drum, primary screen unders.

cages or containers below. The last workers on this line pick any large miscellaneous, non-recyclable items that did not arrive in bags and drop them into a container below for disposal. All other materials continue onto the **reversing transfer conveyor** (Conveyor #4), joining with the opened bags of MSW to be loaded onto the **secondary pre-drum sort lines** (Illustration 5-5).

Operators in a second set of electrically driven, fixed-mount grapple cranes pick up the slashed bags and other material from the surge piles formed by Conveyor #4 (Illustration 5-2) and load them into one of two hoppers.

The hoppers (Conveyor #9A & 9B in Illustration 5-5) feed into the elevated, **secondary pre-drum sort lines** (Conveyor #10A & 10B), where workers separate the materials into the following categories:

- Film plastic from the slashed garbage bags
- Unopened smaller bags, or unopened bags missed by the bag opener
- Clean, dry textiles

The first set of workers on the secondary sort lines picks up the slashed garbage bags, empties the contents onto the conveyor belt, and drops the film plastic into a cage below for baling (Illustration 5-5 and 5-6).

The second set of workers on the secondary sort lines picks unopened, smaller bags that were inside larger bags, and any bags missed by the bag opener (#7A & 7B in Illustration 5-2 and 5-3), and drops them into separate containers below (Illustration 5-5 and 5-6). When full, a forklift or front-end loader transports the containers with the unopened bags and deposits the bags onto the ground-level infeed conveyors, which lead to the bag openers previously described (Illustration 5-3). This step in the process is designed to address the way waste is generally set out for collection in multiple-unit apartment buildings (for instance, many smaller bags within larger bags).

A final set of workers, located in between these two stations, would assist in both tasks, but would also pick out all clean, dry textiles and drop them into separate containers below, before they became contaminated with other fractions of the waste stream.

Pre-Drum Screening

The material that remains on the secondary sort line continues over **pre-drum vibrating finger screens** (#11A & 11B in Illustration 5-5 and 5-6). These screens remove as much broken glass as possible from the material and can be equipped with different decks, which feature various sized openings. The pilot facility might start with a two-and-a-half-inch (2.5") screen setting, but could experiment with both a three-inch and four-inch setting. Testing different screen settings would help determine the optimal size to capture the maximum amount of broken glass, while minimizing the amount of degradable material also removed in the process.

Illustration 5-6
Side View of Secondary Pre-Drum Sort Line

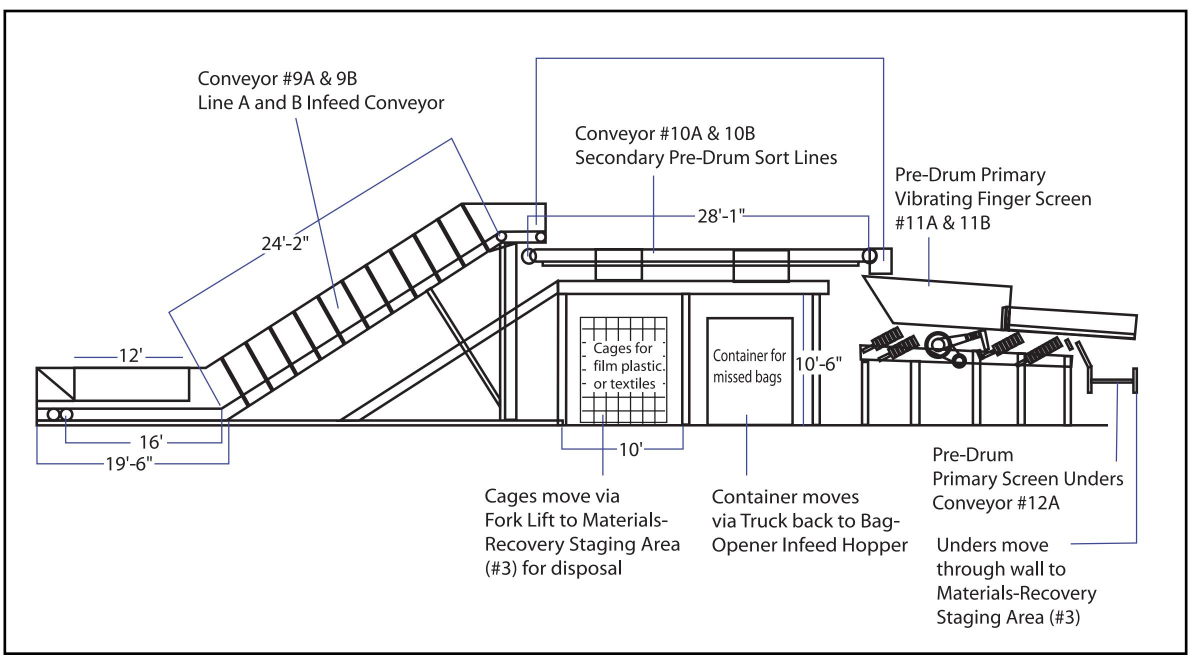
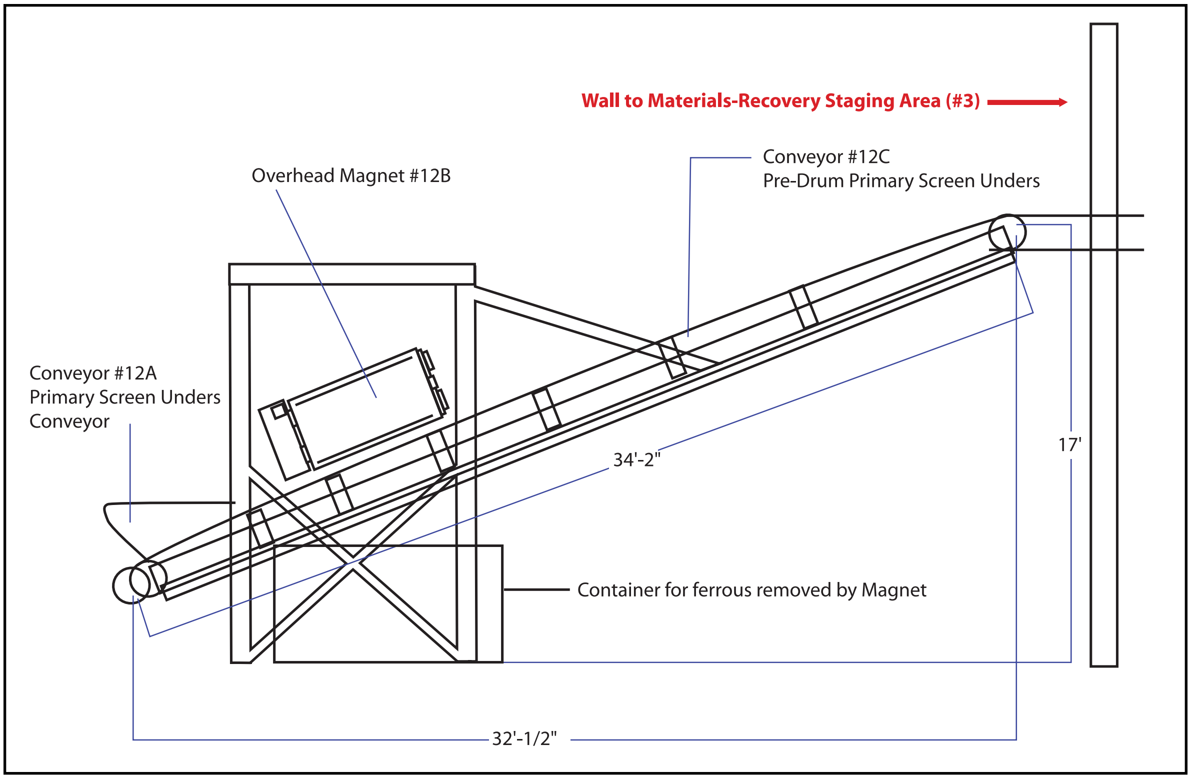


Illustration 5-7

Side View of Movement of Pre-Drum Primary Screen Unders



The material that passes **under** the vibrating finger screens—material smaller than 2.5 inches (or depending on the screen size, smaller than three or four inches)—drops onto a conveyor (Conveyor 12A) and moves under an **overhead magnet** (#12B in Illustrations 5-5 and 5-7), which removes small ferrous items for recovery.

The Edmonton Facility employs a similar technology to remove ferrous materials from their post-digester, primary screen unders. (See Chapter 3, Photo 3-14.) At a pilot MRC facility, the unders stream would be fairly light and spread out on the conveyor at this stage of the process. Therefore, a magnet should be more effective located here than post-digester discharge, as it is currently (and problematically) employed in Edmonton. (See the Edmonton section of Chapter 3 for details.)

After passing under the magnet, the **unders** from the finger screen continue on a conveyor (#12C) through the wall and are deposited in a surge pile (Illustration 5-9) on the floor of the **Materials-Recovery Staging Area** (Building #3 in Illustration 5-1).

To get an idea of the size and composition of the **unders** stream from the **vibrating finger screens**, DSNY's consultant visited a 1,900-ton-per-day, mixed-waste MRF in City of Industry, Los Angeles. This MRF processes non-source-separated, residential garbage from a substantial part of L.A., and runs the debagged material directly over a three-inch, vibrating finger screen. The facility reports that about ten percent by weight of the total incoming material passes under the three-inch screen and is largely comprised of broken glass, small pieces of yard and food waste, plastic, and other small, degradable and non-degradable fines.

Since one of the goals of a pilot facility is to keep as much glass as possible out of the composting drums, it would be better to segregate and dispose of this approximately ten percent as residue. However, as a large fraction of the unders stream would also be degradable, it is important to experiment with ways to separate the degradable from the non-degradable fraction. While existing de-stoning equipment could be used at this stage for such a purpose, it would be better to see what this stream actually look likes in New York City (including important seasonal variations) before designating any specific piece of equipment. Space in the Materials-Recovery Staging Area is allocated in the theoretical pilot facility for such pre-processing of these unders.

Another option that a pilot facility could test would be to compost these unders from the vibrating finger screens in a separate **designated digester drum**, and then screen and/or de-stone the resulting compost separately upon discharge. Depending on how glass-free the resulting screened, post-drum compost was, the material could either proceed to the **First Phase Composting** building, or be sent back through one of the **general digester drums**. (See *Composting Digester Drums and Post-Drum Composting*, which follows).

The material that passes **over** the vibrating finger screens—material larger than 2.5 inches—continues via conveyor (Conveyor #13A & 13B in Illustration 5-8) to the elevated, **final pre-drum sort lines** (Conveyor #14A & 14B). In addition to dropping out fines, the vibrating finger screens also serve to spread material out evenly on the conveyor belt, so that the sorters have a good visual presentation of the material.

On the **final pre-drum sort lines**, sets of workers would pick out small, potentially reusable or recyclable, non-degradable items such as:

- Certain hard plastics
- Certain plastic food and beverage containers
- Metal items
- Large pieces of glass
- Intact glass bottles and containers (sorted by color)
- Clean, intact toys
- Electronics

Workers drop these items into separate cages below the sort lines (Illustration 5-8). When the cages are full, a forklift transports them to the attached **Materials-Recovery Staging Area** (Illustrations 5-1 and 5-9). The last workers on the sort lines pick out any miscellaneous, non-reusable, non-recyclable items and drop them into containers below for disposal.

Material remaining on the sort lines then passes over **final pre-drum debris roll screens** (#15A & 15B, Illustration 5-8, and Photo 5-2), which are designed to drop out any small pieces of glass or plastic missed by the first screen. The overs from these screens move via conveyor (Conveyor #16A & 16B) to another conveyor (Conveyor #18), which deposits the material into a surge pile on the **digester tipping floor** (Illustrations 5-1 and 5-10).

Illustration 5-8

Overhead View of the Final Pre-Drum Sort Line for the Primary Screen Overs

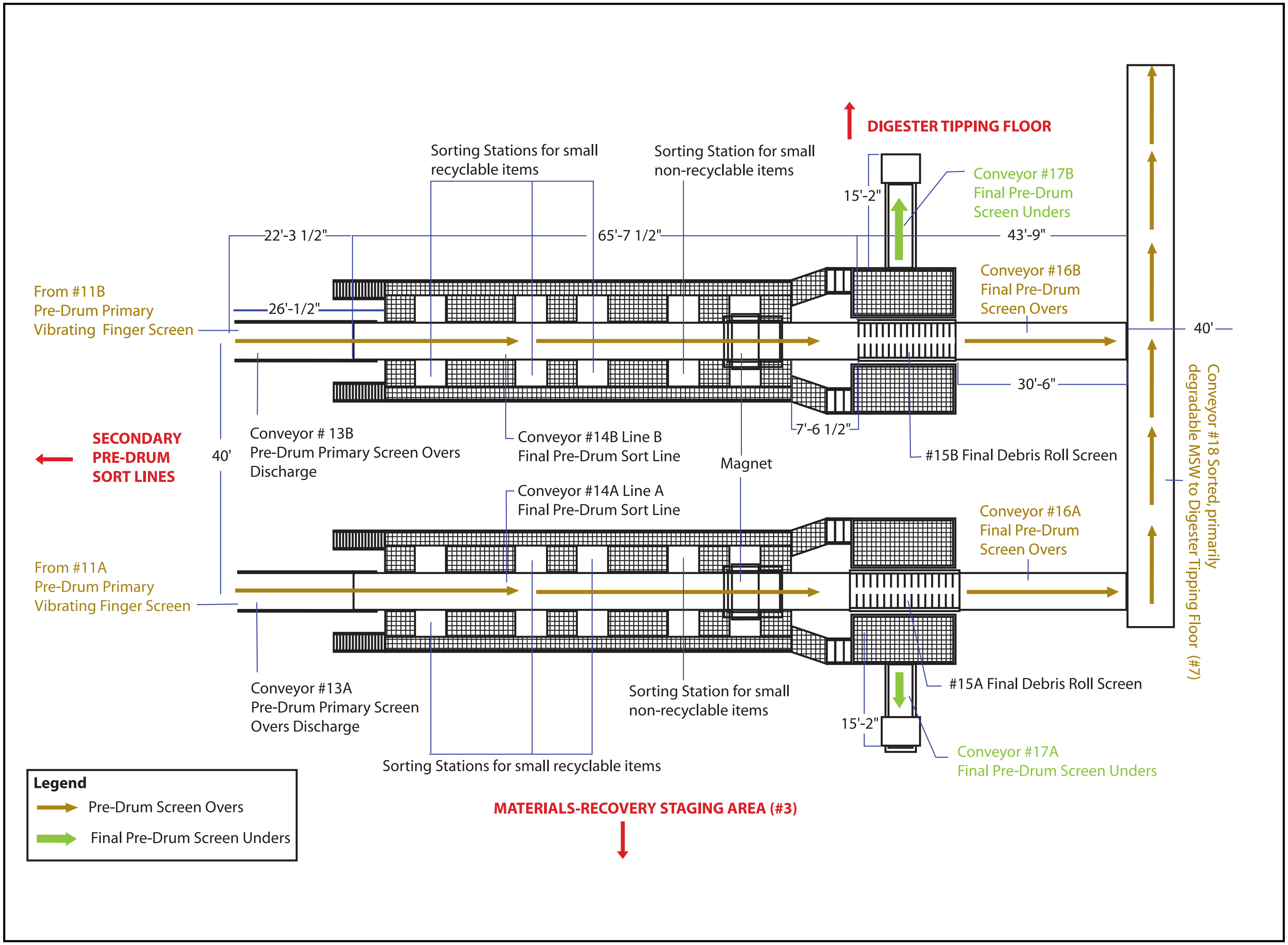
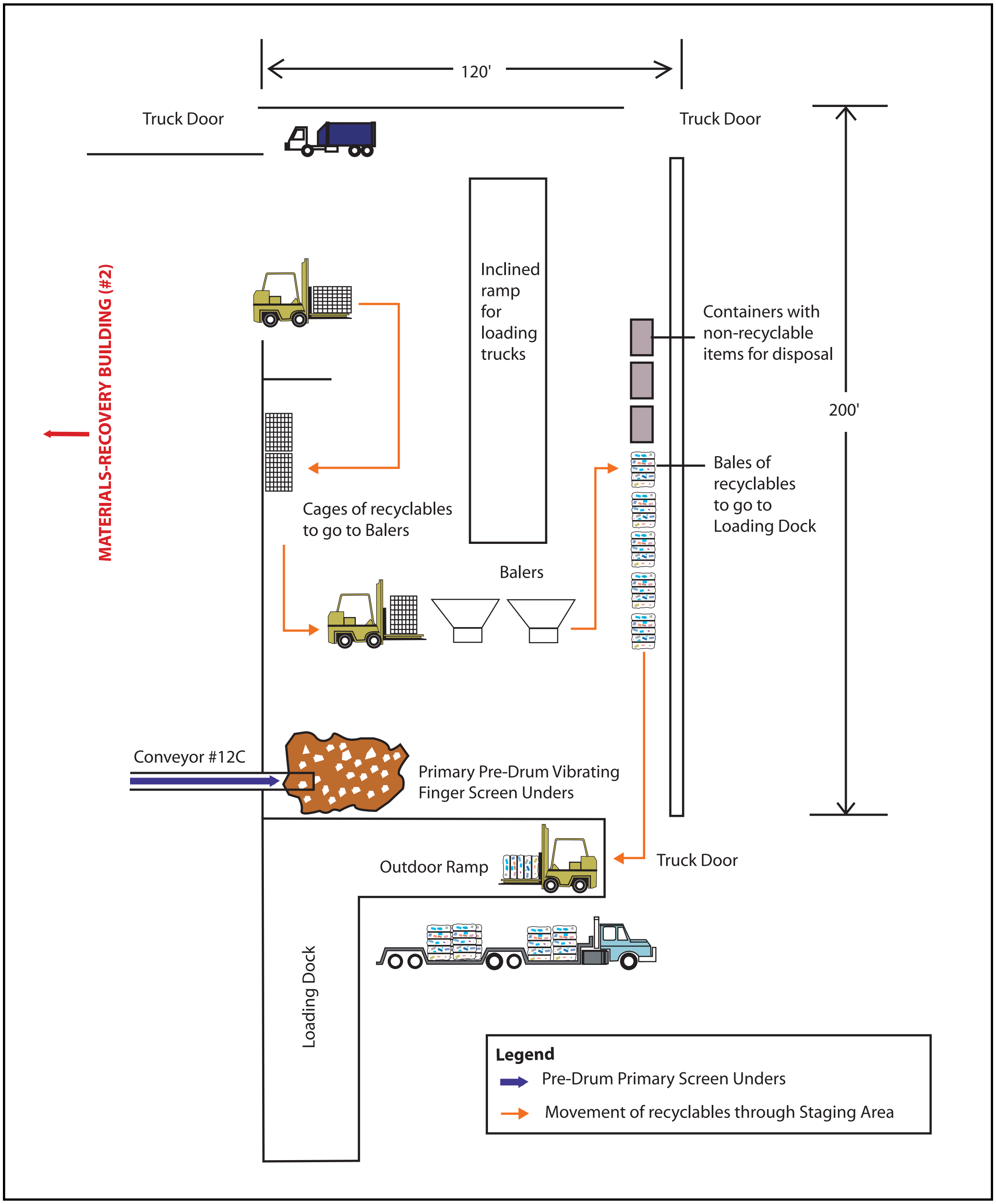


Illustration 5-9

Overhead View Inside Materials-Recovery Staging Building



Depending on the amount and composition, the final debris roll screen **unders** (Conveyor #17A & 17B, Illustration 5-8) would either be disposed as residue or sent to the Materials-Recovery Staging Area for processing with the unders from the first set of primary pre-drum vibrating finger screens (Illustration 5-9).

Pre-Drum Materials Recovery

A **Materials-Recovery Staging Area** (Building #3 in Illustration 5-1), accessible through a large, interior door from the Materials-Recovery Building (Building #2), would serve several purposes:

- Storing and baling **designated recyclables** removed from the waste stream
- Storing any **reusable, salvageable materials** removed from the waste stream
- Staging area for the disposal of the **non-degradable residue** removed from the waste stream
- Potential location for equipment to process **unders** from the primary **vibrating finger screens**

Cages full of **designated recyclable materials** picked off any of the materials-recovery sort lines—such as scrap metal, aluminum, and certain plastics—enter this building via a forklift and are stacked against a wall (Illustration 5-9). From here, workers bale the material (using the balers inside the building) and then stockpile the bales for shipment. When tractor trailer trucks arrive to take the baled material to processors, forklifts move the material to an outdoor loading ramp and deposit the bales into the awaiting vehicles.

A Materials-Recovery Staging Area also would serve as storage for any **reusable, salvageable items** (such as clean, intact furniture, toys, bicycles, and appliances) removed from the waste stream during the sorting procedures described earlier.

While known markets do exist for scrap metal, clean textiles, color-separated glass, dirty film plastic, and plastic bottles, it is less clear if outlets could be found for certain, recovered electronics, clean toys, and furniture. Part of the research associated with a pilot facility would be to investigate outlets for such materials, and to work with those entities to arrange for regular collection. In order to be conservative, however, the cost estimates for the pilot facility in Chapter 7 assume that all of recovered materials without established, secondary-use outlets would require disposal. Furthermore, the cost estimates conservatively assume that materials with established secondary-use markets would generate no revenue, but processors would pick up these baled items at no cost (freight-on-board at the facility).

A ramp within the Materials-Recovery Staging Area would be used for loading non-degradable, non-recyclable, non-reusable items (**residue** from the materials-recovery process) onto trucks for disposal.

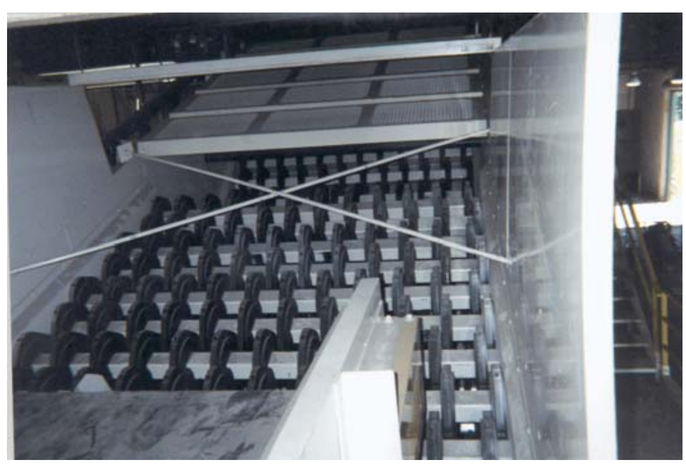


Photo 5-2: Debris Roll Screen at a Mixed-Waste MRF in Oakland, CA. Debris roll screens could be used in a pilot NYC facility to remove any small pieces of glass or plastic that were missed by the first screen.

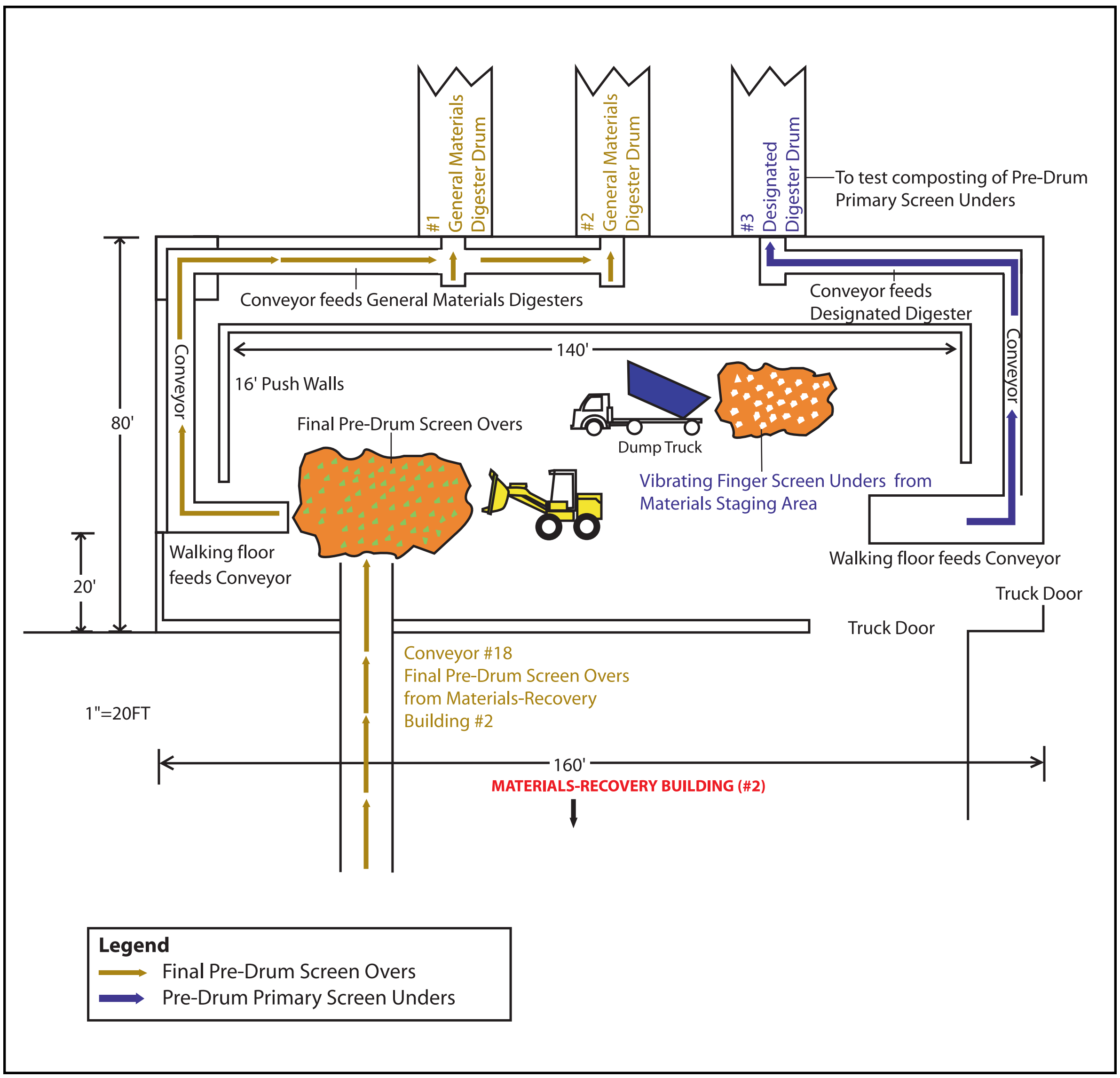
Composting Digester Drums

The material that passes over the **final pre-drum debris roll screens** (#15A & 15B, Illustration 5-8) in the **Materials-Recovery Building** moves via conveyor to form a surge pile on the **digester tipping floor** (Illustration 5-10). This material consists primarily of various types of paper and cardboard, diapers, and the larger pieces of yard and food waste that passed over the material-recovery screens.[2] There would also presumably be a very small amount of non-degradable material missed by the pre-drum sort lines and screens.

The **digester tipping floor** (Building #7 in Illustration 5-1) would be accessible by separate facility doors, so that clean, degradable material—such as landscaper waste—could bypass the materials-recovery process, and go directly to the digesters.

Illustration 5-10

Overhead View Inside Digester Tipping Floor Building



The theoretical pilot facility would employ three, 14-foot-wide by 200-foot-long **digester drums** (Building #8 in Illustration 5-1). Two of the drums (**general materials digester drums**) would be for loading overs from the materials-recovery process (such as degradable material that was not picked out or screened away). The third drum (**designated digester drum**) would be reserved for composting the glass-and-organics–laden unders from the primary vibrating finger screens in order to further segregate this problematic stream.

Digester Drum Sizing and Flowthrough Rates
The theoretical pilot facility would operate six days a week, processing 150 tons of MSW per eight-hour shift, for two shifts a day (300 tpd total). Facility operators would fill the two, general materials digesters on alternative shifts, so that one drum would be loaded on the day shift (8 am to 4 pm) and the other drum would be loaded on the night shift (4 pm to 12 midnight), Monday through Saturday.

The pilot facility would be closed to deliveries from some period between 12 midnight to 8 am, during which time a night crew would clean the entire plant. At this loading rate, material loaded on Monday, Tuesday, and Wednesday would have a three-day retention time in the digester drums, and material loaded on Thursday, Friday, and Saturday would have a four-day retention time.[3] For a description of how material moves through an MSW-composting drum, including retention times, and the continuous nature of the loading and discharge process, see the *Drum Discharge* section of Chapter 1.

In order to accommodate this facility flowthrough time, the digesters must be sized appropriately. Table 5-3 presents the estimate of the amount of material that would go to the two main digester drums per shift, after the incoming MSW had already passed through various materials-recovery processes.

Table 5-3
Estimate of the Amount of Material Going to the Two Main Digester Drums

Processing Stage	Tons per Shift (two 8-hour shifts)	Tons per day	Percent of Incoming Total
MSW Across the Facility Scale	**150**	**300**	**100**
Removed on Tipping Floor & Primary Pre-Drum Sort Line	15	30	10[1]
Material Available for Additional Pre-Drum Sorting and Screening	**135**	**270**	**90**
Material Removed by Vibrating Finger Screen on Secondary Pre-Drum Sort Line	16.2[2]	32.4	11
Material Available for Additional Pre-Drum Sorting and Screening	**118.8**	**237.6**	**79**
Material Removed by Final Pre-Drum Sorting and Screening	35.64[3]	71.28	24
Material Available for Two Main Digester Drums	**83.16**	**166.32**	**55**

1. Based on the percent of bulk material recovered during the NYC Composting Trials.
2. It is assumed that this screen will drop out 12 percent of the material, based on the California mixed-waste MRF experience, but adjusting for greater rainfall and wetter yard waste in New York City.
3. Assuming, based on the experience of other surveyed MRFs, that these sort lines and screens will recover 30 percent of the total material.

The approximately 83 tons of sorted MSW and 100 tons of dewatered biosolids would fill one of the 14-foot-wide by 200-foot-long digesters. Facility operators would pump dewatered biosolids directly to the drums from an adjacent **Biosolids Storage Bunker** (Building #15 in Illustration 5-1) at an initial ratio of 1.2 parts biosolids to one part sorted MSW. As noted, one of the learning objectives of a pilot facility would be to determine the optimal "recipe" for composting biosolids with sorted MSW (primarily paper and other degradable waste).[4]

Pilot facility operators would initially add no biosolids to the Designated Digester. This is because the unders stream from the primary materials-recovery screens should contain adequate moisture due to the presence of food and yard waste (especially when grass clippings are present). Also, facility operators would want to keep this stream on the drier side to facilitate separation of the degradable from the non-degradable as the material moves through the post-digester screening and de-stoning equipment.

Post-Drum Screening

All three digester drums discharge into a separate, post-drum **Primary Screening Building** (Illustrations 5-1 and 5-11). Material discharged from the digester drums drops onto a conveyor, which feeds material onto one of two incline conveyors that lead to a post-drum **primary trommel screen** (Illustration 5-11).

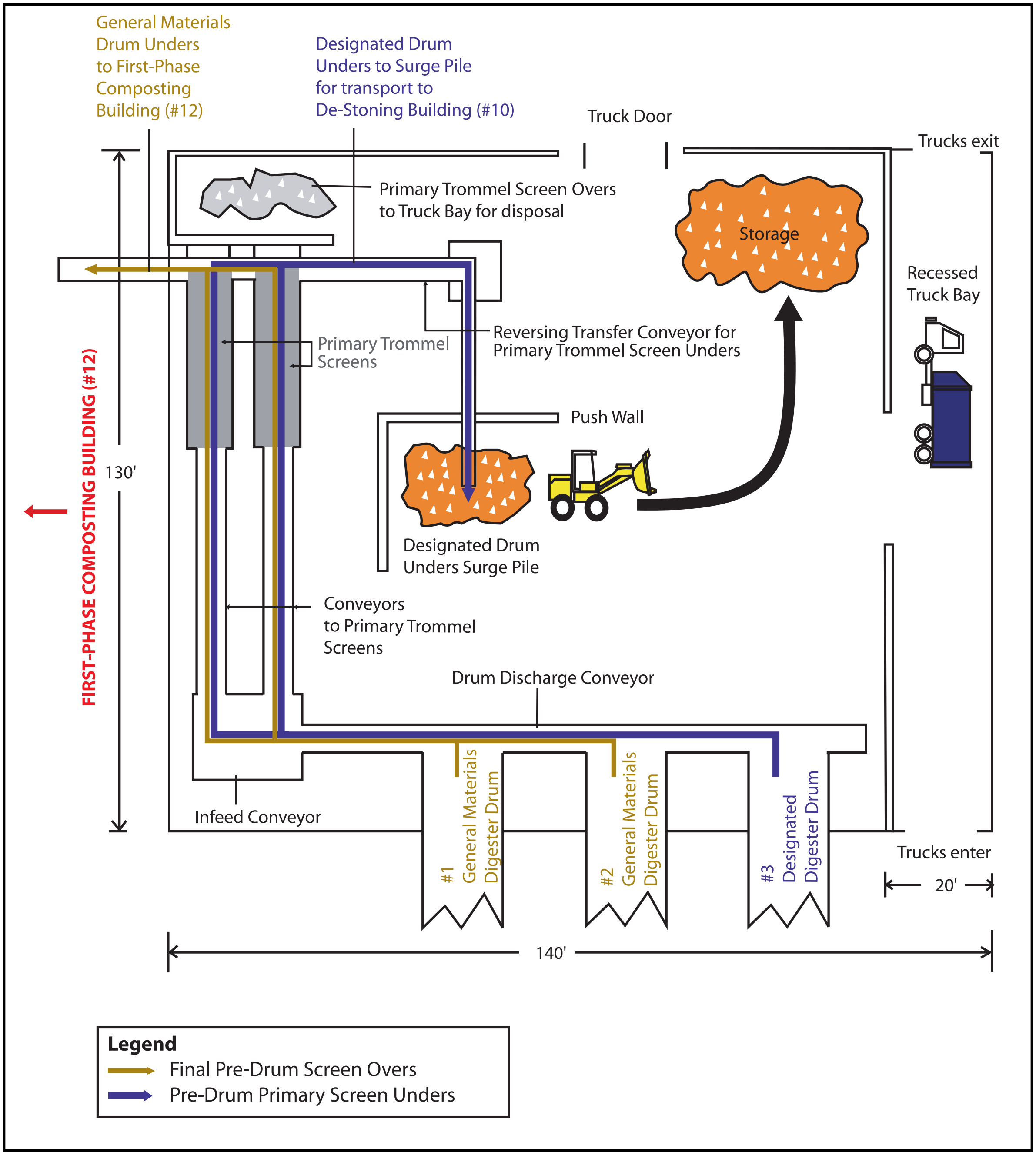
To review, this material is comprised of the largely degradable items (such as soiled paper, food and yard waste, and diapers, etc.) that were present in the incoming MSW. It was composted in one of the two general materials digester drums with biosolids and has begun the initial decomposition process. This immature compost should be relatively free of non-degradable materials, including small pieces of glass and plastic, as these would have been removed in the materials-recovery stage. However, it will require extended composting on an air floor to complete the decomposition process and create a stable, useful end product.

Facility operators discharge material from the third, **designated digester drum** separately, once the discharge from the other two drums is complete. Again to review, this material is comprised of the organics-and-glass–laden fines that passed under the first screen (the vibrating finger screen) in the materials-recovery process. Based on the experience of other MRFs processing mixed waste, this stream consists of small pieces of yard and food waste, dirt, gravel, and unclassifiable fines, but also contains a lot of broken glass, small pieces of plastic, bottle caps, and other small, miscellaneous, non-degradable items.

The goal would be to segregate this inert material from the other "cleaner" stream of degradable material moving through the facility. However, a pilot MRC facility would want to experiment with different ways to recover the considerable organic fraction from this "dirty" stream. As described earlier, one of the ways a pilot MRC facility could attempt to separate the degradable from the non-degradable would be to compost this "dirty" stream separately in its own designated digester. Through the composting process organics would become more uniform and easier to remove through subsequent screening and/or de-stoning.

Illustration 5-11

Overhead View Inside Post-Drum Primary Screening Building



This immature (inert-laden) compost from the designated drum would pass through the post-drum, **primary trommel screens**, with the **unders** falling onto a conveyor that then drops the material into a separate surge pile on the floor (Illustration 5-11). This material would then be loaded onto trucks and taken to the **De-Stoning Building** (Building #14 in Illustration 5-1) to further segregate the degradable from the non-degradable. Depending on the composition of the immature compost from the designated digester, facility operators may decide to forego screening these unders and send this material directly to the De-Stoning Building.

De-stoning equipment is used in a number of industries for the continuous separation of stones and other dense objects from a stream of granular material. De-stoners stratify material according to its specific gravity by the oscillating motion of a screen and by air flowing through the material from the bottom to the top. The light particles (**"lights"**), in this case the immature compost, collect at the top, and the heavy ones (**"heavies"**), including pieces of glass, stones, metal, and other small inert materials collect at the bottom. The lower layer with the "heavies" flows upward and is fed to the final separation zone of the bottom de-stoning screen. Final separation is accomplished by a countercurrent flow of air.

The **"lights"** (immature compost) from the de-stoner would either be sent back through one of the general materials digester drums, or be placed directly onto the conveyor feeding the **First-Phase Composting** building. A front-end loader scoops up the **"heavies"** (inert materials) and places them onto a truck for disposal.

Facility operators at Marlborough (the location of the New York City Composting Trials, described in Chapter 1) found that the de-stoning equipment did an excellent job of removing heavy inerts from a stream of compost. However, they faced two problems that forced them to abandon de-stoning, which a pilot facility design should attempt to resolve. Marlborough facility operators reported that the de-stoner worked best when the compost was relatively dry and operators passed it through the equipment slowly. The compost coming off of the Marlborough air floor to the de-stoner (and final screen) after only 21 days was very wet and therefore jammed the equipment (see Table 4-3 for moisture-level data). In addition, as Marlborough operators were attempting to run all of their compost through the de-stoner (before it went to the final screen and was loaded out of the facility in trucks), it was important to move material quickly or potentially back up the whole facility.

The de-stoner at a pilot MRC facility should be used exclusively to process unders from the primary screening of the designated digester drum discharge. As this is a relatively small fraction of the total MSW processed by the facility, it would be possible to run material in small batches, slowly through the de-stoner. The processing of this separate stream should take place apart from the main movement of material through the facility and would therefore not cause delays to the larger facility operations. Additionally, pilot facility operators would be able to control the moisture level of the material that they send to the de-stoner by experimenting with input "recipes"and retention times in the designated digester drum.

The **overs** from the **post-drum primary screening** of all three digester drums (the two general materials drums and the designated drum) drop into a separate surge pile on the floor (Illustration 5-11). This material, consisting of non-degradable items missed by the materials-recovery process, is then loaded onto trucks and disposed as residue.

Post-Drum Composting

The importance of post-drum composting to produce efficiently a quality end product represents one of the key findings of the Department's research on mixed-waste composting. As discussed in Chapters 3 and 4, facilities with automated, highly regulated air floors produced a better, final compost in terms of important compost-quality and process parameters, such as carbon-tonitrogen ratio, volatile-organic-acid production, and organic matter loss. In short, these air floors optimized the decomposition process.

Another important consideration when designing post-drum composting capacity is the DEC's requirement that compost in New York State be produced from a process with a minimum detention time of 50 days (including active composting and curing). This means that unlike the Marlborough facility, for example, which composts the material on-site for 21 days and then cures the material elsewhere, an NYC pilot facility design would require a post-drum composting system with the throughput capacity to actively manage the material on-site for 50 days. As Chapter 4 summarized, the Department's MSW Research Project determined that at least 50 days of active composting is necessary to achieve high loss of moisture and mass, as well as a reasonable degree of maturity in the material. Moisture loss is especially important as drier material screens more effectively.

One of the overarching objectives of any pilot facility should be to experiment with different types of equipment to determine the best system for sorting and composting New York City's waste stream. The hypothetical pilot MRC facility would therefore employ a **two-phase, post-drum composting and curing process**, in order to both meet the detention time requirements, as well as to compare the efficacy of different, automated air-floor approaches.

Both phases would be fully automated, with material moving through the first and second phases in approximately 27 and 31 days, respectively. Combined with the three-day retention time in the digesters, the total detention time would meet and exceed the DEC's 50-day detention requirement.

If 83 tons of sorted MSW plus 100 tons of dewatered biosolids were loaded into each of the two general materials digester drums (Table 5-3), then after composting and post-drum, primary screening, an estimated 272 tons of immature compost would go to the First-Phase Composting building per day (Table 5-4).

Table 5-4

Estimate of the Amount of Material Going to the First-Phase Composting Building

Processing Stage	Tons per drum	Total tons for both drums	Percent of Incoming Total
General Materials Digester Drums			
Sorted and Screened MSW[1]	83	166	45
Dewatered Biosolids[2]	100	200	55
Total	**183**	**366**	**100**
Immature Compost Discharged from General Materials Digester Drums[3]	146	292	80
Material Removed by Post-Drum, Primary Trommel Screen ("overs")	10	20	7
Material Available for First-Phase Composting ("unders")	**136**	**272**	**73**

1. From Table 5-3. One drum would be loaded during the first 8-hour shift and the other drum would be loaded during the next 8-hour shift.
2. Biosolids added at a ratio of 1.2 parts biosolids to one part sorted MSW.
3. The 37-ton-per-drum difference is due to the inevitable loss of mass that takes place during composting inside the drums.

Photo 5-3: Pictures of the proposed first-phase composting technology
The proposed first-phase composting technology would resemble that employed by Edmonton, with its automated bridge cranes and augurs that mix, add moisture, and move the immature compost over the course of 27 days.

First-Phase, Post-Drum Composting
First-phase composting in the proposed pilot facility would resemble the air floor at the Edmonton facility: a fully automated, agitated-bay curing module. (See Edmonton section in Chapter 3 for more information.) The conveyor carrying the post-drum, primary trommel screen unders from the post-drum, Primary Screening Building (Illustration 5-11) would feed a **tripper trolley** in the **First-Phase Composting** building (Building #12 in Illustration 5-1). The tripper trolley rides along tracks above each of the bays and spreads the immature compost along the length of the loading side of the bay. An **augur**, attached to overhead **bridge cranes**, then mixes the compost and moves it forward over the course of 27 days. Sprays attached to the bridge crane provide moisture to the composting material (Photo 5-3). As discussed in Chapter 4, additional water is especially effective in the beginning of the air-floor process to “kick-start” decomposition.

Air, a critical component of post-digester composting, is drawn down through the piles of composting material to the floor through perforated pipes. Different air-floor technologies handle this critical step in varying ways. The air floor at Edmonton uses this negative aeration technique (sucking air down), while others use positive aeration (blowing air up). The air floor is generally divided into zones, each with an automated, adjustable air-flow rate, so that facility operators can set a general temperature goal, and then the sections self-regulate based on the ambient temperature of the composting material.

The attractiveness of automated air floors is that once facility operators determine a good composting recipe (determining the ratio of solid to liquid waste, bulking-agent requirements, etc.) and the aeration needs of that recipe, then they can set the general parameters for the air floor and "walk away." Compost facility operators currently employing this type of equipment report that once things are up and running, the air floor "takes care of itself." This is important because it means that other than monitoring and making minor adjustments, operators do not need to spend all of their time on the actual composting process and are free to attend to other needs in the facility.

After 27 days, the augurs turn and push the composting material onto an unloading shelf, where it is automatically discharged onto a conveyor. The conveyor moves the material through the wall of the First-Phase Composting building and deposits it onto the floor of the **Second-Phase Composting and Curing** building (Building #13 in Illustration 5-1).

Second-Phase, Post-Drum Composting and Curing

The **Second-Phase Composting and Curing** technology is a similar concept to the first, but with a few key differences. Where the first phase employs active aeration (in this case using motorized fans to draw air down through the compost), the second phase will use **passive aeration**. Passive aeration relies on the principles of convection, or the transfer of heat by movement of a substance such as air or water. When compost gets hot, warm air rises naturally and the resulting convective currents cause a slow but steady movement of heated air upward through the composting material and out the top of the pile.

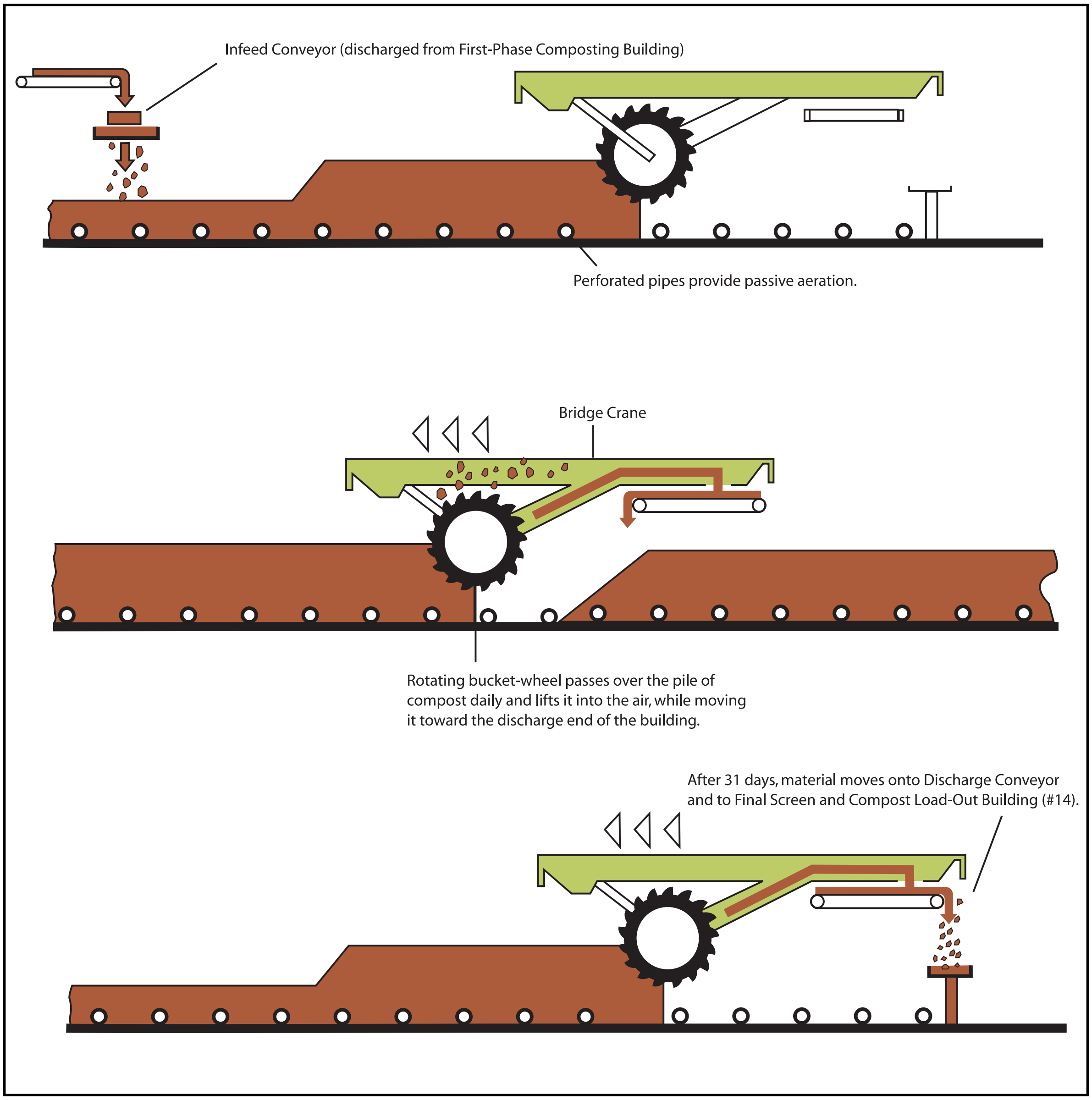
In the Second-Phase Composting and Curing building, the floor is traversed by a series of pipes with many air holes drilled around all sides. The in-feed conveyor (the discharge conveyor of the First-Phase Composting building) deposits material onto the floor of the Second-Phase Composting and Curing building and forms a stack of compost (approximately six feet deep) over the perforated pipes. The ends of the pipes, however, are not covered by compost. Convection again serves to draw the cooler ambient air in through the pipes up through the composting material.

This composting process (with a 31-day detention time) would employ passive aeration, as well as an automated, bucket-wheel mixer to continue to provide air to the decomposing material.

This kind of passive aeration is less electricity-intensive, and therefore less expensive, than the active aeration proposed for the First-Phase Composting building. It is anticipated that this "lower tech" solution will provide adequate aeration and extend the number of days that the material is composted, without adding undue cost.

In addition to passive aeration, the second-phase composting process also provides the essential air and moisture to the decomposing material through a mixer that passes over on a bridge crane. The mixer in this case is not an auger, like in the first-phase process, but a rotating wheel, made of a series of small buckets. The bucket-wheel passes over the stack of compost (to a depth of approximately six inches above the pipes) and lifts it up into the air, while simultaneously moving it toward the discharge end of the building. This motion "fluffs" the material and breaks up any clumps, while introducing oxygen. As in the first-phase process, the bridge crane, to which the bucket-wheel is attached, is also fitted with nozzles to provide water to the piles of compost as needed.[5]

Illustration 5-12
Second-Phase Composting Process



However, it is during this stage of the process that facility operators would want to let moisture levels drop in the compost. As discussed in Chapter 4, the “ideal” compost moisture levels that facilitate effective final screening seem to be somewhere between 25 and 30 percent. Therefore, water would be used in the second-phase composting process, especially in the last 15 to 20 days, to suppress dust, rather than to aid decomposition.

Post-Drum Final Screening

After 31 days, a discharge conveyor moves the compost through the wall of the Second-Phase Composting and Curing building and deposits it in a large surge pile on the floor of the post-drum,

Final Screening and Load-Out building (Building #15 in Illustration 5-1). A front-end loader scoops up the compost from this pile and loads it into an infeed hopper connected to a conveyor. The conveyor moves the material up to the **final facility screen**, sized at ten millimeters (10mm or .4 inch) to meet DEC requirements that particles in a finished compost be no larger than this size.

Photo 5-4: Finished compost after final facility screen

The overs, particles larger than ten millimeters, are deposited in a bunker within the Final Screening and Load-Out building. If this material proves to contain a lot of compost and other degradable material (such as small piece of paper and wood), facility operators would load it into a truck and deposit it directly on the digester tipping floor for reintroduction into the digester drum. If the material is primarily comprised of small, non-degradable material, it will be loaded onto trucks destined for disposal. As described in Chapter 4, reintroducing final screen overs into the composting process is an effective way of lowering facility residue rates. However, in order to be conservative, the theoretical pilot facility cost estimates presented in Chapter 7 assume that all of this material would require disposal.

The **unders** from the final screen are the finished compost product (Photo 5-4). Based on the experience of other successfully operating MSW-composting facilities, after 50-plus days of active, aerated composting, the material does not have any odor associated with it, other than the pleasant, earthy smell of topsoil. At this point, therefore, the material can safely be loaded onto vehicles, and leave the facility without the risk of generating odors. Table 5-5 shows a breakdown of the estimated amount of compost the pilot facility would produce, based on loss-of-mass projections for both phases of post-drum composting, and estimates for final screening overs and unders.

Table 5-5

Estimate of the Amount of Finished Compost Produced by the Pilot Facility

Processing Stage	Tons per day (two 8-hour shifts)	Percent of Incoming Total
Material Sent to First-Phase Composting[1]	**272**	**100**
Loss of Mass During This Process[2]	108	40
Material Going to Second-Phase Composting	**164**	**60**
Loss of Mass During This Process[2]	25	9
Material Going to Post-Drum Final Screening	**139**	**51**
Material Removed by Post-Drum, Final Screen ("Overs")	12	4
Final Compost ("Unders" from Final Screen)	**127**	**47**

1. From Table 5-4.
2. Due to the release of moisture and carbon dioxide during composting on the air floor.

The New York City Composting Trials (held at the Bedminster, Marlborough MSW-composting facility in Marlborough, Massachusetts) demonstrated through extensive testing that it is possible to make a compost with waste generated in New York City that meets New York State Department of Environmental Conservation (DEC) standards. One of the primary goals of a pilot MRC facility in New York City would be to establish a record of that quality over an extended period of time. A testing protocol would be developed according to DEC guidelines. Once the DEC made a designation as to the quality of the compost produced by the pilot facility and acceptable end uses, the City might begin to use the material in such projects as final landfill cover, roadside erosion control, and construction projects. Once the pilot facility consistently produced a quality compost, outside markets could be sought for the material, such as large-scale, regional soil-blending and landscaping operations.

Although compost in the region usually commands between $10 to $15 per ton, to be conservative, the cost estimates in Chapter 7 for the hypothetical pilot facility assume zero revenue for the final compost product. Furthermore, additional funding is allocated for extensive laboratory testing, and the transportation costs that would initially be incurred when shipping compost off-site to various test locations.

Air Handling and Odor Control

Without question, the most important task of any pilot facility should be air handling and odor control. Many of the early set-backs in the MSW-composting industry (as well as in the waste-water-treatment industry) were due to lack of attention to this critical facility component. The current generation of MSW-composting facilities have zero tolerance for odor emissions and thus, operate in a nuisance-free manner in close proximity to neighbors. If this were not the case, namely if the problem of odor control had not essentially been solved, then the Department would not even be evaluating this technology.

The air-handling system at the pilot MRC facility would be designed to treat process air from all the buildings where odors pose a potential concern. Air would enter these buildings through a centrifugal fan (as well as doors when they are opened) and then be dispersed through air distribution outlets running along the respective roofs. Air would then be extracted from the buildings by a general ventilation system. In the First- and Second-Phase Composting buildings, air would also be extracted through various aeration systems that draw air through the composting material (described earlier). In general, air-handling systems at these types of facilities are designed to provide a specific number of interior “air changes” in a given amount of time, both to ensure odor control and worker safety.

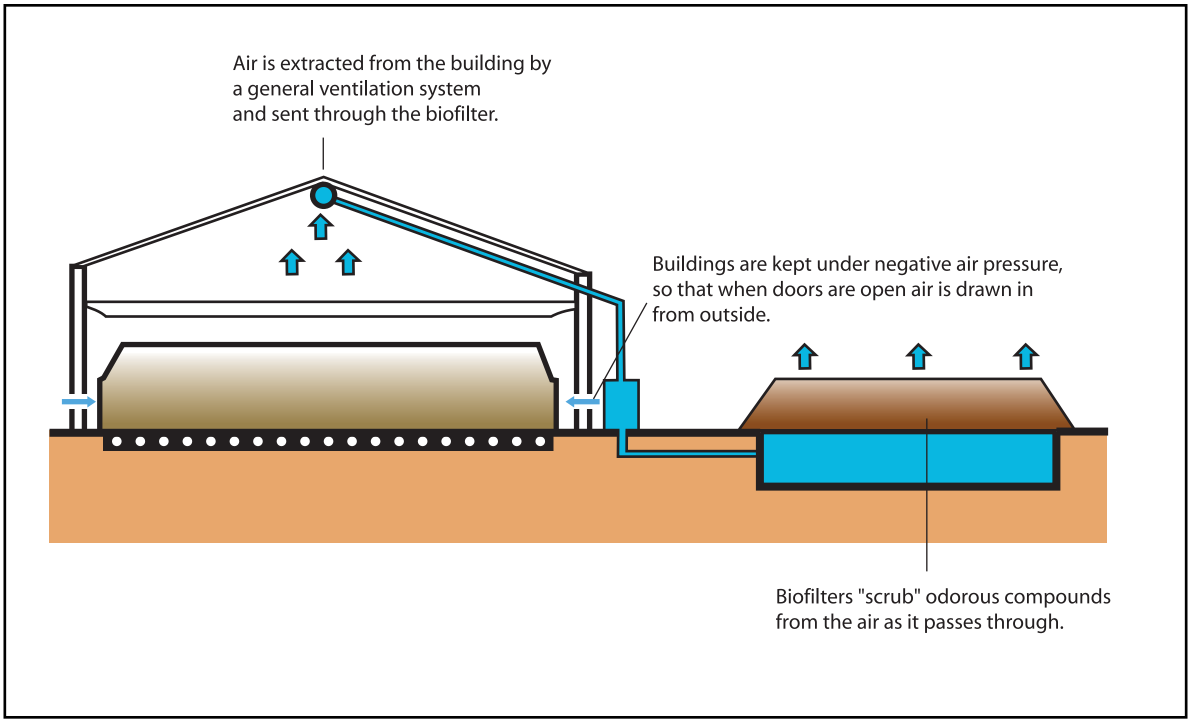
Air would enter and exit each building at slightly different pressures, which would serve to create a negative overall pressure condition in the building. This essentially means that when any doors are opened, air is drawn in from the outside, rather than escaping to the outside, as happens under normal pressure conditions. Maintaining buildings under negative air pressure is another, standard safeguard against odors emissions. (See Illustration 5-13.)

Actual air-handling processes are proprietary of the companies who design them, and a detailed description of their functioning would be out of place in this preliminary design discussion.

Illustration 5-13

General Air-Handling Schematic

A ventilation system removes process air from buildings and sends it to a biofilter for odor-suppression treatment.



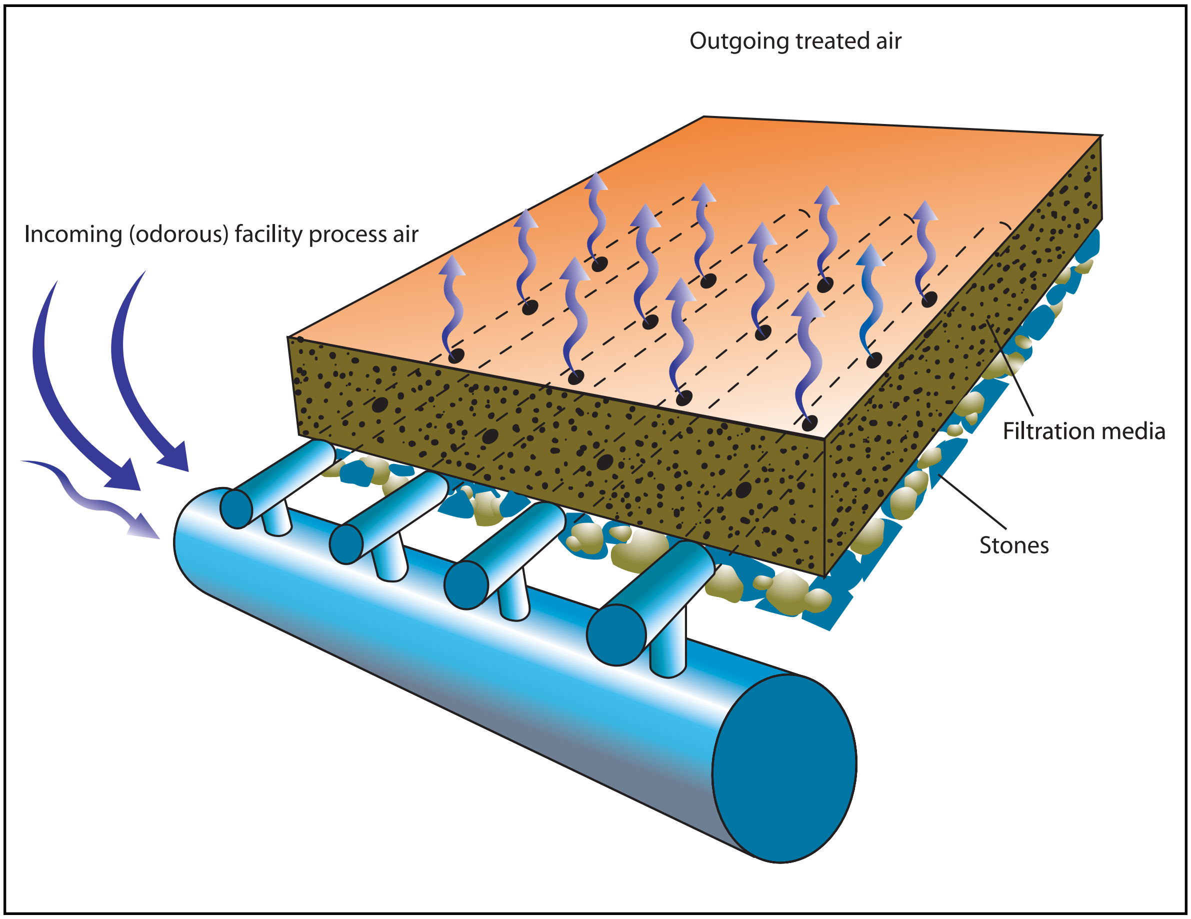
However, it is important to understand the basic concept behind **scrubbers** and **biofilters**. Scrubbers do not actually serve to reduce odors, which are known to be produced by a large number of organic and inorganic volatile compounds. The scrubbers instead use water to “wash” the air of ammonia and ammonia-derived volatile compounds and humidify the airstream before it reaches the biofilter, as high concentrations of these compounds and/or excessive dryness can reduce the biofilter’s efficiency. In essence, the scrubbers are used to prolong the life and effectiveness of the biofilter, as well as safeguard against peaks in ammonia concentration.

Biofilters are standard equipment at all enclosed composting facilities. Recently, other solid-waste-management facilities, such as transfer stations, have also installed biofilters as they have proven to be an effective means to combat odors. A biofilter is a living system that microbially consumes odorous compounds from the air as it passes through. The biofilter is typically composed of compost and wood chips that have been blended in a prescribed ratio. It may also include soil, limestone, or other ingredients. The biofilter is constructed, above or below ground, over a series of perforated pipes through which process air is pumped and distributed. Biofilters are engineered to retain air in the media for a specified time in order to ensure odorous compounds in the air are degraded. (See Illustration 5-14.)

In addition to the formal systems and technologies designed to capture and treat all process air from the facility before releasing it outside, there are other means to prevent odors before they occur. The first is to keep aerobic conditions in the composting material at all times. The microbes that flourish during the anaerobic decomposition of organic material produce

Illustration 5-14

Cross-Section of a Biofilter



undesirable odors as by-products, including the rotten-egg smell of hydrogen sulfide gas. An adequate flow of air through the digesters, as well as during the first- and second-phase, post-drum composting processes, helps ensure that the recycling of the organic fraction of the waste stream will not generate undesirable odors within a pilot facility.

Other means of preventing odors can be built right into the facility design. High-speed, roll-up doors mean that when incoming trucks tip their loads, the doors to the facility are open for the shortest amount of time possible. Also, large doors can be fitted with blowers to create “air curtains” to prevent odors from escaping when the doors are open. Simple design considerations, like minimizing the use of interior columns, small corner spaces, and other areas where debris can accumulate can facilitate easy clean-up. A pilot facility should have heavy-duty concrete floors and be equipped with a system to hose down all equipment on a regular basis. Facilities should employ non-corroding fiberglass duct work, rather than metal, to better withstand the corrosive conditions produced by composting material. Corroded duct work provides a means for odors to escape. Sizing a facility correctly so waste never backs up in any place, and keeps moving through the facility, is another way to prevent odors from occurring.

The updates to New York State DEC regulations, which oversee composting facilities, include a new requirement for an odor-management plan. Such a plan formalizes and “institutionalizes” odor-prevention steps, making them an essential part of a facility’s daily operation and maintenance procedures. The Department and the facility design team should take all necessary steps to make sure such a plan is crafted to the satisfaction of the DEC, as well as concerned members of the community. A facility’s ability to prove itself as a good neighbor, especially in the field of odor prevention and control, will be critical to its success as a waste-management strategy for New York City.

The next chapter presents the estimated facility recovery rate, based on the projected recovery rate for each material fraction of the waste steam as it moves through the hypothetical pilot facility. Chapter 7 presents cost estimates for the theoretical, pilot MRC facility described in this report.