CHAPTER 10. WASTE-TO-ENERGY SYSTEMS.[1]

"Waste-to-energy" is the generic term for any system that processes waste to recover usable energy either through direct combustion or by producing a solid or liquid fuel. By the late 1880's, the production of electricity from waste-generated steam was commonplace in many European cities, using essentially the same kind of "mass-burn, waterwall" technology that is now in wide use throughout the world. "Pre-processing" mixed wastes to take out recyclable and/or non-combustible materials to produce a simple sort of "refuse-derived fuel" goes back to the turn of the century, but the use of trommels, magnets, air-classifiers, flotation-separators, and other more sophisticated devices has a relatively recent history. Experiments with pyrolysis and biogasification go back several decades, but have never been proven practical for commercial operation on a large scale. The major technological innovations of the last decades have focussed on improved air-pollution control devices (such as improved fabric filters for particulate control, spray-dry absorbers for acid-gas control, and techniques for controlling nitrogen oxides), and on improved combustion controls and monitoring systems.

Although (as noted in Chapter 1), waste-to-energy incineration systems were not in widespread use in this country throughout most of this century (as they were in Europe), the Public Utilities Regulatory Policy Act of 1978 and the increasing shortage of landfill capacity have combined to make waste-to-energy incineration systems increasingly common. In New York State, as in the rest of the country, an average of 15% of the solid-waste stream is currently disposed of at incineration facilities, and this rate is steadily increasing.

Mass-burn and refuse-derived-fuel systems are suited for burning municipal solid wastes either alone, or in combination with dewatered sewage sludge, regulated medical wastes, and pre-processed wood separated from harbor debris and construction and demolition debris. If sludge is to be burned alone, fluidized-bed combustion is the best-suited technology at present. Pyrolysis and biogasification systems, if they become viable as a result of future developments, may be appropriate in varying degrees for any of these waste-streams, either alone or in combination.

The basic technology options for waste-to-energy systems and their subcomponents are discussed below, and in greater detail in Appendix Volume 4.2.

10.1 Processing Technologies and Sub-Component Systems.

10.1.1 Mass-Burn Systems.

"Mass-burn" systems are designed to accept mixed raw waste; source-separation of particular recyclable and/or non-combustible materials is not necessary, and no pre-processing of waste to remove non-combustible materials, or to reduce the size or moisture content of the raw waste is involved. Most mass-burn furnaces are relatively large, field-erected facilities, but a small proportion are small-scale, factory-assembled modular units. Field-erected facilities consist of one or more furnace "trains," each of which can range in size from 50 to 1,000 tons a day. Mass-burn furnaces are designed to handle any type of material commonly found in household or commercial waste; only oversized bulky wastes such as "white goods" (appliances such as refrigerators and stoves), large amounts of tires, barrels of hazardous or flammable liquids, radioactive materials, and, sometimes, yard wastes (which have a relatively high nitrogren content), must be excluded.

The heat released by the combustion process is captured to produce steam. Most systems operating today use a series of water-filled tubes in the furnace wall for this purpose, although refractory-type furnaces are still used for some applications, such as the incineration of pathological wastes. A variation on the refractory-type furnace is a rotary-kiln. The major differences between the proprietary mass-burn systems offered by various commercial vendors involve the design of the furnace grate, which is the mechanism responsible for agitating the garbage bed to facilitate complete combustion. The design and operation of the grate is one of the ways of controlling the three parameters most directly related to effective combustion -- residence time in the furnace, temperature, and turbulence. The control of air flow into the combustion chamber, and the size and configuration of the chamber itself are the other most important furnace design features of a mass-burn waste-to-energy facility.

Typical mass-burn systems reduce the volume of the incoming waste stream by up to 90 percent, and the weight by up to 75 percent (modular systems produce lesser reductions), leaving a biologically and chemically inert ash residue. (This ash residue, and the alternative methods for handling it, are discussed in section 10.3.) In addition to the ash left on the grate after the waste has been combusted, there is an additional residue stream that consists of the soot particles ("particulate" or "fly ash") that are entrained in the exhaust gases and captured by the air-pollution control devices (about which more detail is presented in section 10.1.9.1.1) and of the alkaline reagent that is used to capture acid gases (see section 10.1.9.1.2). This fly-ash increases the overall residue quantity by about a fifth.

One advantage of mass-burn systems is that they have the longest and most-extensive operating record for large-scale facilities. There are hundreds of mass-burn facilities in operation throughout the world, some of which have been in operation for decades. Over 50 field-erected mass-burn facilities are in operation in the U.S. (eight of which are in New York State), and that many more are under construction or in advanced planning stages (a complete listing of these facilities is in Appendix Volume 4.2, [Table 8.a-3]). There are an additional 50 modular waste-to-energy facilities, which process an average of 40 tons of waste a day, with another half-dozen in construction or advanced planning.

Typical heat-recovery efficiencies range from 65 to 70 percent for waterwall and rotary-kiln facilities, and are slightly lower for refractory-lined furnaces. (Modular-type mass-burn incinerators have a thermal efficiency of roughly 50 to 60 percent.) They typically generate three to four pounds of steam for each ton of waste combusted, or 500 to 600 kilowatt-hours of electricity.

10.1.2 Refuse-Derived Fuel.

Instead of burning refuse in as-received condition, refuse-derived fuel ("RDF") systems involve some degree of pre-processing to remove recyclable and/or non-combustible materials (in typical systems about 20 percent by weight), and to produce smaller, more homogeneously sized pieces prior to the incineration process. More elaborate systems produce a more finely shredded and/or pulverized product that is dryer (which increases the BTU content and enhances combustion efficiency). This finer product is then densified or pelletized (to facilitate storage and handling, and to allow more-efficient fuel-injection in a specially designed combustor) or is prepared in "fluff" or "fine" form that is suitable for suspension-firing in a standard utility or industrial boiler. Most current RDF systems are of the "coarse" RDF type, which requires that the RDF be burned in furnaces designed for the purpose; coarse RDF systems combust a greater percentage of the incoming waste stream, with a greater degree of reliability. Individual RDF furnace trains typically combust 180 to 1,200 tons of RDF a day.

The advantages of RDF over mass-burn systems are that the fuel product (as opposed to raw refuse) can be more easily stored for longer periods of time before combustion, can be transported off-site for combustion elsewhere (sometimes in admixtures with other types of fuel or in furnaces designed for other purposes), and has a higher BTU content than raw refuse, that the furnace chamber can be smaller than a chamber designed to handle the larger, unprocessed waste stream (thus reducing facility capital costs), and that the air-pollution-control devices can be smaller (since there is relatively less exhaust gas to pass through them), and finally, that ash residue volumes are decreased by the amount of non-combustible material removed prior to incineration (RDF systems typically produce 10 percent ash residue by weight, compared to 25 percent for mass-burn systems).

Higher operating costs for RDF systems, however, as well as the capital costs for front-end processing equipment, outweigh the decrease in capital costs for combustion and air-pollution-control equipment, so that the overall costs of RDF systems are somewhat more than the costs of mass-burn systems. Decreased ash residue quantities are largely offset by unrecyclable residue from material diverted in the pre-processing operations. Although the overall volume of air emissions is decreased in relation to the amount of material that is diverted before combustion, <u>per pound</u> emissions from wastes actually combusted are roughly similar both in terms of the range of pollutants and in their concentrations. Energy-recovery efficiencies are typically somewhat lower than for mass-burn systems. Another disadvantage is that the front-end processing facilities required for an RDF facility require more acreage than is saved by the smaller furnace equipment, so that RDF facilities require more acreage overall than do mass-burn systems.

The major problem with RDF systems is that their operating experience has included frequent equipment breakdowns, and a record of explosions; however, the more recently constructed facilities have incorporated changes in facility configurations and simplified processing equipment in order to address these problems, and have largely succeeded in improving the operational reliability of these systems. At least one "fluff" RDF facility has also had significant odor problems.

There are 25 RDF facilities in operation in the U.S., three of which are in New York State; nine more facilities are under construction or being planned. (A list of the U.S. RDF facilities of at least 400 tons a day capacity is in Appendix Volume 4.2 [Table 8.a-6].)

10.1.3 Fluidized-Bed Combustion Systems.

A fluidized-bed furnace is a cylindrical refractory-lined shell containing a bed of sand. As in some RDF combustors, the prepared refuse-derived fuel in a fluidized-bed (FBC) system is burned in fluid suspension, but in an FBC, it is entrained with the intensely hot sand particles in an upward flow of turbulent air, which "fluidizes" the bed of sand. Existing FBC systems are reported to maintain more consistent combustion temperatures than do mass-burn or RDF systems. Although FBC technology has been widely used for years, it has been used primarily for dewatered sewage sludge, industrial waste, and pulverized coal. There are only two waste-to-energy facilities that use FBC technology operating in the U.S.: a 400-ton-per-day plant in Duluth, MN, has burned RDF and dewatered sewage sludge since 1985, and a 400-ton plant in LaCrosse, WI has burned RDF, wood chips, and dewatered sewage sludge since 1988. The largest plant that burns RDF-only is a 165-ton-per-day facility in Japan.

10.1.4 Pyrolysis Systems.

Pyrolysis is the process in which the organic portion of solid waste is decomposed under pressure in a heated, oxygen-deficient vessel to produce a liquid fuel. Close to half of the organic material (in addition to any non-organic non-recyclable residue) is left as a residue that will require disposal either through incineration or landfilling. Although the concept of pyrolizing solid waste is several decades old, and although there are three pyrolysis facilities in Germany, it has not yet been successfully used on a commercial scale in the U.S. Three U.S. companies have conducted failed demonstration projects; a fourth has operated a 50-ton-per-day pilot facility in California since 1985.

10.1.5 Biogasification Systems.

Biogasification is the process through which organic wastes are decomposed by anaerobic organisms to produce methane. Municipal solid waste must first be processed, as in any refuse-derived-fuel system, to remove non-organics, and to reduce the size of the refuse pieces. It is then mixed with liquid sewage sludge or other process water and nutrients, and steam, to produce a homogeneous slurry that is fed into air-tight digesters, where it remains for between five and 30 days. As in pyrolysis systems, nearly half of the organic material processed is left as residue. The operational experience of biogasification systems is relatively limited. Several systems are operating in Europe and Japan, one of which, a 60-ton-per-day French facility, has been operating since 1981. Only one demonstration plant has been built in the U.S.; this plant, in Pompano Beach, FL, operated from 1978 to 1988, when it was closed due to excessively high operating costs.

10.1.6 Ocean-Burning of Harbor Debris.

Until recently, almost all shoreline harbor debris was disposed of through at-sea incineration. Now that at-sea incineration is banned due to the Water Resources Development Act of 1990, upland incineration options -- using chipped harbor debris in waste-to-energy facilities or other power plants -- is the only waste-to-energy alternative for managing these wastes.

A more detailed description of harbor debris incineration issues is presented in Appendix Volume 4.2.

10.1.7 Alternatives for Retrofitting Existing Municipal and Hospital Incinerators.

As noted in Chapters 3 and 4, the Sanitation Department is in the process of retrofitting ~~its existing municipal~~ the Southwest Brooklyn incinerator~~s~~ to comply with new air-pollution control regulations. The Department also plans to add waste-to-energy capability to ~~these~~ this incinerator~~s, which will~~ to reduce ~~the~~ its operating costs ~~of these facilities,~~ and more fully comply with the State's waste-management hierarchy.

The survey of existing hospital on-site incinerators throughout the City (both public and private) conducted by the Health and Hospitals Corporation (see Appendix Volume 8) found 12 incinerators that would be economically and technically feasible to upgrade to comply with the new 6 NYCRR Part 219-3 regulations. These incinerators would have a combined capacity of just over 25 tons a day (only six tons per day of this capacity is currently in use).

10.1.8 Other Technologies.

Instead of being burned directly, RDF can be converted to ethanol. As when bourbon is made from corn mash, the RDF is first chemically broken down into sugar compounds and fermented by enzymes, and is then distilled, leaving one-third of the original material as residue. Although this technique has been tested in laboratories, there are no known MSW-to-ethanol facilities in operation.

10.1.9 Sub-Component Systems.

10.1.9.1 Air-Pollution-Control Devices.

10.1.9.1.1 Particulate Control.

10.1.9.1.1.1 Fabric Filters.

Fabric filters (shaped in cylinders and hung in rows in a "bag house" like giant sausages in a smokehouse) are often likened to a vacuum cleaner bag to explain how they capture dust or soot particles from a stream of flowing air: a handkerchief may provide an even more instantaneously understandable image. Depending on how much "cloth" (the fabric is often woven or felted from fiber glass that has been treated with teflon or similar materials to resist abrasion and corrosion) there is in relation to the amount of air that passes through, fabric filters have been demonstrated to be capable of reducing particulate emissions enough to meet any regulatory requirements yet established (or proposed). (Other factors that affect filtration efficiency are the nature of the filter material, and the degree of particle-build-up, since this "filter cake" accomplishes much of the filtration.) An additional advantage of fabric filters is that the particles that accumulate on the fabric themselves provide alkaline surfaces onto which acid gases can adsorb, thus providing a degree of acid-gas reduction as well.

10.1.9.1.1.2 **Electrostatic Precipitators.**

Electrostatic precipitators remove particulate matter from exhaust gases through electrical attraction: exhaust gases pass between flat, electrically charged plates, across rows of electrodes that impart an opposite electrical charge to the particles that are entrained in them, causing the particles to stick to the plates. Electrostatic precipitation is a technology that pre-dates fabric filters in waste-to-energy (and other industrial) applications, and its use has largely been superseded by fabric filters, since fabric filters more efficiently capture the smallest particulates (which are of greatest importance from public-health, environmental and regulatory perspectives) and in general can produce a greater degree of particulate control, more reliably, at less cost. Electrostatic precipitators continue to offer advantages in certain applications, however -- notably in connection with wet acid-gas-scrubbing systems.

10.1.9.1.2 Acid-Gas Control.

10.1.9.1.2.1 Spray-Dry Adsorbers.

Some acid gases (notably hydrogen chloride and sulfur dioxide, two of the most significant pollutants in exhaust gas from waste-to-energy systems) are soluble in water, so spraying water into the exhaust gas stream reduces acid-gas concentrations to some degree. Most acid gases (nitrogen oxide is the exception) can be adsorbed onto particles of alkalines such as lime. Combining these two reaction effects by mixing lime with water to make a slurry that is sprayed into an exhaust gas stream maximizes the efficiency of acid-gas adsorption, while also reducing the temperature of the exhaust gases enough to condense certain metals (such as lead and cadmium), as well as organic compounds that have been volatilized or formed during the combustion process. If the slurry is sprayed into the exhaust gas in tiny droplets (as opposed to in a steady stream), the efficiency of the reaction processes is enhanced because there is more surface area available for adsorption, and there are the corollary benefits that the water can be completely evaporated, leaving only a dry particulate that can be efficiently captured in either type of particulate-control device.

Most of the acid-gas-control equipment in use in this country is of the spray-dry-adsorber type; all of the facilities now being planned will use spray-dry adsorbers.

Because the addition of lime (or another caustic reagent) to the fly ash that is collected in the particulate-control device increases the alkalinity of the ash, and because hydrophilic metals (lead, for instance) are more easily leached out at increased pH levels, the amount of lime used should be matched as closely as possible to the amount of acids in the exhaust gas, so that no excess lime is used. (This also reduces ash volumes and operating costs.) This matching of lime-to-acid levels is accomplished through continuous inlet-and-outlet monitoring and computerized controls. Even at optimal lime levels, however (depending on the type of ash-disposal or re-use system employed), the resultant ash may need to be chemically treated to reduce its alkalinity, and thus to "fix" these metals to make them less available for leaching. An advantage of this addition of lime to fly ash, on the other hand, is that it reacts with the ash to produce a cement-like material that is more impervious to water, thus reducing the potential for leaching in general.

The disadvantages of spray-dry adsorbers are their relatively high operating and maintenance costs, which are in part due to the high cost of alkaline reagent and to the energy required to power fans to pull the exhaust gases through layers of fabric caked with particulate.

10.1.9.1.2.2 Dry Injection.

Alkaline reagents may also be injected into an exhaust stream in dry form. This technique is less-expensive, but less-effective. More reagent is required, so there is more residue that must be disposed of. Dry injection is also less efficient than spray-dry adsorption in condensing volatilized metals and organic compounds.

10.1.9.1.2.3 **Wet Adsorption.**

There are two kinds of "wet scrubbers." One type of system, called "high-energy wet adsorption," uses high-pressure streams of reagent dissolved in water to remove acid gases (and particulate) from exhaust gas. These systems are inefficient and relatively ineffective, and therefore would not be a reasonable choice for a new waste-to-energy facility. The other type of system, however, called "low-energy wet adsorption," offers the potential for pollutant reductions that equal or exceed those of alternative technologies. In low-energy wet scrubbers, exhaust gases are first cooled in a chamber where they come in contact with a liquid reagent and become saturated with it as it evaporates. In this first stage, hydrochloric acid is dissolved and removed as a liquid, and, due to the lowered temperatures, lead and other volatilized metals and organic compounds are condensed and collected as particulate. The gases then pass into a second chamber, where they are sprayed with a lime solution to remove sulfur dioxide. Finally, they enter the particulate-removal device, which can be either an electrostatic precipitator, or a specialized device which further saturates and condenses the exhaust gases, then passes them through an electrostatic precipitator whose effectiveness is enhanced by a spray of electrically charged water droplets.

The liquid discharged from a wet scrubber can be used to "wash" the bottom ash (as well as the dry flyash if a conventional electrostatic precipitator has been used) to leach out and collect metals from the ash. The liquid is then filtered to remove the solids, which at this point are quite insusceptible to further leaching in a landfill environment. The filtered liquid must then be sent to a dedicated water treatment facility so that the dissolved metals can be precipitated out; these metals must then be handled as a hazardous waste, while the treated filtrate can be re-used in the wet adsorption process.

Low-energy wet scrubbers are more effective than conventional spray-dry adsorbers (i.e., those that do not use activated carbon or sodium sulfide injection) in removing organics and metals, especially mercury. The solid residue from this process is essentially non-leachable, and the residue quantity is less than from spray-dry adsorbers because the reagent-reaction process is more efficient. An additional advantage is that overall energy consumption is less than in a spray-dry system.

The relative disadvantages are their significantly higher capital costs (although these may be partially offset by reduced operating costs), the additional maintenance costs due to handling the discharged slurry, higher water consumption, and cleaned gas that finally emerges from the exhaust stack looking like the cloud of steam that it is. This can cause visibility problems, increase the potential for roadway icing, and significantly reduce dispersion of the "exhaust plume" (a particularly apt expression in such instances, when exhaust gases rise and curve like a proud white feather before disappearing in wisps at a tapered edge), thereby increasing ambient pollutant concentrations. The problems due to a low-temperature plume can be alleviated by re-heating the flue gas before it is released, but this adds significantly to capital and operating costs, and requires the use of more energy.

10.1.9.1.2.4 Activated Carbon Injection.

Activated carbon has been added to the reagent medium at several facilities in Europe. Tests of this process show mercury reductions of about 90 percent,[2] and increased capture of dioxins and furans, but data on the performance of carbon systems thus far are limited.

10.1.9.1.2.5 Sodium Sulfide Injection.

Adding sodium sulfide to the reagent medium has been tested at waste-to-energy facilities in Europe and Canada, producing mercury reductions of 65 to 90 percent. Capital and operating costs of sodium sulfide systems are higher than those of an activated carbon system.

10.1.9.1.3 Control of Nitrogen Oxides.

Nitrogen oxides, a pre-cursor of smog, are a special problem in waste-to-energy systems because they cannot be controlled as other pollutants are through adsorption by alkaline reagents and collection of particulates, and because the high-temperature combustion conditions that are most effective in destroying or preventing the formation of harmful organic compounds cause increased nitrogen oxide levels. Short of using specialized air-pollution-control devices (which are described below), there are several ways to minimize the amount of nitrogen oxides that are produced in a waste-to-energy system. First, since grass and certain other leafy yard and kitchen waste contains a relatively high amount of nitrogen that is released when it is burned, keeping such material out of the incoming waste stream will help to reduce nitrogen oxide concentrations. Maintaining combustion temperatures that are adequate for destroying organic compounds, but no higher than necessary, keeping the amount of air in the furnace at the level necessary to ensure complete combustion, but no higher, and ensuring that there is enough mixing of air and refuse in the furnace to prevent the formation of "hot spots," will minimize the degree to which nitrogen in the combustion air is oxidized to create nitrogen oxides.

10.1.9.3.1 Flue-Gas Recirculation.

Recirculating flue gas from the furnace outlet back into the bottom of the furnace reduces the amount of nitrogen oxide formed from the combustion air. This technique, however, is relatively ineffective.

10.1.9.1.3.2 Selective Non-Catalytic Reduction.

Ammonia (NH_3) is the secret weapon usually used in selective non-catalytic nitrous-oxide reduction systems, which are generally referred to as "thermal de-Nox" ("NOx" being the familiar term for nitrogen oxides and "thermal" referring to the sort of nitrogen oxides that are formed by the oxidation of nitrogen in the combustion air). The nitrogen and hydrogen in the ammonia combine with the nitrogen and oxygen atoms in the nitrogen oxides (NO_2 and NO_3) to form nitrogen (N_2) and water (H_2O). This reaction, however, only takes place in the temperature window between about 1600 and 1800 degrees Fahrenheit; above or below that temperature, the ammonia either does not react with the nitrogen oxides (and thus leaves the stack as ammonia -- an undesirable ingredient in the ambient air) or reacts to produce unwanted compounds (either more nitric oxide, or ammonium sulfate or bisulfate). Under properly controlled operating conditions, it is possible to reduce nitrogen oxide concentrations by 60 percent (40 to 60 percent is a likely range; 80 percent reductions have been achieved by one system), while allowing only 30 parts per million of unreacted ammonia to escape ("slip") up the stack.

The problems associated with this type of system include a tendency for carbon monoxide emissions to increase (presumably due to difficulties in maintaining temperature fluctuations within the acceptable range), and the difficulties inherent in transporting, storing, and handling ammonia, the toxicity of which requires extensive safety precautions to protect both plant workers and the general public.

The only two facilities in the U.S. that have nitrogen-oxide control equipment (the Commerce and Long Beach, California plants) both use this type of system.

A variation on the non-catalytic-reaction theme is the use of urea ($CO[NH_2]_2$) instead of ammonia to convert nitrogen oxides to nitrogen, carbon dioxide, and water. This system can achieve 60 percent NOx reductions while reducing the ammonia slip to only five parts per million. An advantage of this type of system is that urea, unlike ammonia, is not dangerous to handle. Another advantage is that the equipment for injecting a liquid reagent (as urea is) into exhaust gases is less expensive than the equipment for injecting a gas (as ammonia typically is in this application). The injection of urea is also easier to regulate in response to fluctuations in waste composition and to furnace conditions that produce fluctuations in nitrogen-oxide levels.

While this type of system has been used in Europe, it has not yet been used in the U.S. other than in a short-term demonstration at one facility.

10.1.9.1.3.3 Selective Catalytic Reduction.

In catalytic reduction systems, the ammonia-enriched flue gas is passed through a honeycomb-shaped bed of catalysts (typically copper, chromium, iron, and vanadium), which enhance the reaction process through which nitrogen oxides are converted to nitrogen and water. Because the catalysts make this reaction more efficient, only about half as much ammonia is required, while the degree of conversion is increased to as much as 90 percent (70 to 90 percent is the typical range). This system is much more expensive than non-catalytic reduction, however, largely due to the price of the catalysts, which lose their effectiveness and must be replaced on a regular basis.

10.2 Potential Options for Integrating Process Streams in Waste-to-Energy Systems.

There are three potential ways in which MSW and sewage sludge, depending on site-specific circumstances, might be beneficially integrated: by using heat from MSW incineration for sludge drying, by using treated water from water-pollution-control plants as process water in waste-to-energy plants, and by using methane from sludge for auxiliary incinerator fuel. In addition, again depending on site-specific circumstances, sludge and MSW can be co-incinerated. Co-incineration of shredded harbor debris with MSW is the optimal disposal technique for this material. Co-incineration of treated medical waste (i.e., red-bag waste that is sterilized and shredded so that it can be treated as black-bag waste) may also be a desirable disposal technique.

10.3 Ash Treatment/Re-Use/Disposal Alternatives.

Ash residue from waste-to-energy facilities is a glass-and-gravel-like material comprised of minerals, metals, unburned organic carbon, dirt, and grit. Fly ash, as noted above, consists of the light particles that are carried off the grate by turbulence or that condense and form in the flue gas in the boiler system and are subsequently collected by the air-pollution-control devices, and of the lime or other caustic that has been injected into the flue-gas stream to adsorb acid gases. "Bottom ash" is the relatively coarse residue that accumulates on the grate.

As noted above, because of the noncombustible materials that are removed prior to incineration in an RDF system, mass-burn systems typically produce more than twice as much ash as do RDF systems. The composition of this ash is also different. Most ferrous metals are magnetically removed in RDF pre-processing operations, so that there is less ferrous metal in RDF ash than in mass-burn ash. Although about half of the glass is removed by rotary screens, the glass fraction is nonetheless proportionately higher because of the overall reduction in ash volume. Most significantly, fly ash accounts for about two-thirds of the total ash from RDF systems, but only about a fifth of the total from mass-burn systems. Data on the chemical composition of ash are presented in Appendix Volume 4.2 (in Tables 8.a.5-1 through 8.a.5-8).

Leachate is the primary environmental concern associated with landfilled ash. Available leachate data show that the metals and organic compounds in this ash, for the most part, are not readily available for leaching by normal rainwater, but are more susceptible to leaching through contact with solvents. (Leachate data are presented in Appendix Volume 4.2.) Since solvents are generated by raw organic waste in landfills, the recommended practice is to landfill ash and MSW separately. Because ash is moist when landfilled, and rapidly hardens, relatively few airborne particulate emissions are ~~not~~ generated, and unlike raw waste, ash generates no volatile emissions.

Virtually all ash residue is disposed of in landfills. In New York State, disposal requirements vary depending on the type of landfill (monofill or co-disposal) and the type of ash being disposed (fly ash, treated fly ash, bottom ash, or combined ash), but the disposal of any ash requires a detailed ash-management plan, which includes regular testing for hazardous elements and reporting of the results. With the exception of Nassau and Suffolk County landfills, monofills that receive treated fly ash, combined ash, or bottom ash require a single composite liner. Monofills that receive untreated fly ash require a double liner. MSW landfills that receive treated fly ash, combined ash, or bottom ash also require a double composite liner, and may not accept any untreated fly ash. All fills that receive ash must also be equipped with leachate-collection and -monitoring systems. While tests of leachate from actual ashfills indicate that concentrations of metals and organics meet drinking-water standards (although they are exceeded for some inorganic salts), the leachate must be treated before discharge.

A variety of techniques have been proposed for immobilizing the hazarous chemical constituents in ash. These include vitrification (a process in which residue is thermally fused), chemical fixation, biological treatment (mixing ash with sewage sludge to reduce the leachability and solubility of both components), polymerization (coating the ash with a plastic resin), cementation (adding Portland cement or lime and moisture to create a concrete-like product), and embedding ash in asphalt. These techniques have been demonstrated to inhibit leaching. Ash residues treated in these ways may be suitable for use in beneficial ways, such as in road aggregate or the construction of artificial reefs, or they may be suitable for less-stringent landfilling methods, such as co-disposal with MSW. The major concerns about the long-term safety of these alternative disposal techniques include the long-term physical integrity of stabilized ash products, the potential for occupational exposures (such as, for example, during future renovations to structures that contain ash products), and the ability to take remedial action if problems arise. Additional data on all of these techniques is required before recommendations can be made concerning their future use for New York City. The future potential of these management techniques will also depend on regulatory policies that are yet to be formulated.

10.4 Regulatory Requirements.

New incineration facilities are subject to a number of Federal, State, and local regulations that establish permit and performance standards for their siting, construction, and operation. The most significant regulations that are specific to waste-to-energy facilities are requirements that stem from the federal Clean Air Act (Ambient Air Quality Standards, New Source Performance Standards, National Emission Standards for Hazardous Air Pollutants, Prevention of Significant Deterioration, and New Source Review Standards) and from the State's 6 NYCRR Part 360 (waste-management facilities, construction and operation) and Part 219 (incineration facilities) requirements. Ash-management systems must also meet Part 360 standards as well as the requirements of the Resource Conservation and Recovery Act (RCRA).

A detailed description of the regulatory requirements for new waste-to-energy facilities is presented in Appendix Volume 4.2.

10.5 Cost Impacts of Waste-to-Energy Alternatives.

The cost differences between mass-burn and RDF systems have been alluded to above. A second difference between alternative waste-to-energy facilities has to do with the size of the facility: in general, increases in size produce economies of scale. One factor that can somewhat offset these economies, however, is the type of steam-condensing mechanism that is used. Water-cooled condensers are less expensive, but use a great deal of water; they are therefore best-suited for smaller-scale facilities, while the more expensive air-cooled condensers are the most practicable solution for a facility much larger than 2,000 tons a day.

When pre-processing equipment is added to the front end of a mass-burn incinerator, the cost effects are similar to those of RDF relative to "normal" mass-burn systems. That is, like an RDF plant in relation to a mass-burn plant, the pre-processing version has lower capital costs, higher operating costs, and higher energy revenues. Relative to RDF facilities, mass-burn facilities with pre-processing are slightly more expensive in terms of both capital and operating costs, but these facility costs may be offset by higher revenues from recovered materials.

If the City's existing incinerators were retrofitted with heat-recovery equipment, the net reduction in per-ton costs would be about $28. In comparing the existing incinerators to new waste-to-energy facilities, a second factor to consider (besides the apparent advantages of energy recovery) are operating costs. Due to current labor practices, the existing incinerators are not operated as cost-effectively as are standard privately operated waste-to-energy facilities. If labor rates were made more efficient, and energy recovery capability added to the existing incinerators, their costs would be roughly comparable to newly built waste-to-energy facilities.

The relative costs of various waste-to-energy facility types and sizes can be seen in the cost matrices presented in Appendix Volume 5.

10.6 Siting.

Waste-to-energy facilities are appropriate only in industrial areas. As with most types of facilities, a rectangular site for a waste-to-energy plant facilitates site access and operations. The ideal site would be large enough to provide a buffer zone between the roadways and buildings and the site boundary to mitigate the visual and noise impacts of a waste-to-energy facility. As with most facilities that entail large, heavy buildings, the ideal site would be fairly level, and have bedrock that is neither too deep (more than a hundred feet below the surface) nor too shallow (less than ten feet from the surface). The Federal Aviation Administration imposes restrictions on the heights of stacks in areas near airports; a suitable site must allow a stack that is high enough to permit adequate dispersion of air pollutants. (A stack height that conforms to the standard regulatory definition of "good engineering practice" [GEP] is roughly 2.5 times the building height.)

10.7 Environmental Impacts of Waste-to-Energy Alternatives.

The net environmental differences between the major waste-to-energy alternatives -- mass-burn facilities with or without pre-processing systems and refused-derived-fuel facilities -- are relatively inconsequential. Per-ton emission factors are higher for facilities that involve pre-processing, but since fewer tons are burned when some material is removed prior to combustion, the net air impacts even out. A similar phenomenon occurs with ash residue, both in terms of total volumes landfilled (ash and material that is removed prior to combustion) and in terms of toxicity. Higher numbers of employees at facilities with pre-processing generate slightly higher traffic and water usage impacts. These factors, and others, can be readily compared in the reference-facility matrices presented in Chapter 17, and in more detail in Appendix Volume 5. Detailed environmental analyses of all types of facilities, by environmental media, are presented in Appendix Volume 6.

10.8 Viable Program Options.

Mass-burn facilities, with or without pre-processing systems and refuse-derived fuel facilities that are equipped with best-available air-pollution-control technologies (fabric filters, spray-dry-adsorbers, nitrogen-oxide and mercury removal systems, continuous monitoring equipment, and auxiliary burners), coupled with ash monofills or co-fills that comply with regulatory standards, are equally viable technology options. The trade-offs between them in terms of cost and environmental performance may make one type of technology better suited for a particular location or size or waste stream, and both types of systems have factors which recommend them under particular circumstances or policy objectives. Depending on the specific circumstances, it also may be viable to produce a refuse-derived fuel in one facility for shipment off-site for burning in a boiler in another location. Other types of waste-to-energy technologies, such as pyrolysis and biogasification, do not appear viable (now or in the foreseeable future) for New York City.

Sludge-only incinerators are technically, economically, and environmentally viable alternatives to other types of sludge-management technologies. Sludge-and-MSW co-incinerators are also a viable option. Using water or methane from waste-water-treatment facilities in waste-to-energy facilities, or heat from waste-to-energy facilities in waste-water-treatment facilities, is viable from a technical and environmental perspective; the economic viability of such "cross-over" applications will depend on site-specific circumstances.

Incineration is the most appropriate form of treatment for untreated red-bag medical waste, either in regional incinerators, on-site incinerators (there are several on-site hospital incinerators in the City that it would be cost-effective to upgrade to meet the latest air-pollution control regulations), or in incinerators dedicated to pathological wastes. Co-incineration of black-bag medical wastes, either in medical-waste incinerators with red-bag wastes, or with MSW (either in newly constructed waste-to-energy facilities or in upgraded existing municipal incinerators) is also viable.

Endnotes

1. More detailed presentations of the material in this chapter are found in Appendix Volume 4.2 (Waste-Management Components), in the section entitled "Waste-to Energy Technologies," which is divided into the following subsections: Technology Evaluation, Siting Requirements, Costs, Regulatory Requirements and Environmental Impacts, and Ash and Residue Requirements. Data on waste-to-energy facilities are also provided in Appendix Volume 5 (Reference Facilities). Environmental data are provided in Appendix Volume 6 (Environmental Data).

2. Brown, B. and Felsvang, K.S., "Control of Mercury and Dioxin Emissions from United States and European Municipal Solid-Waste Incinerators by Spray Dryer Adsorption Systems," presented at the Second Annual International Municipal Waste Combustion Conference, Tampa, FL, April, 1991; Technical Services Group, American Norit, "Darco FGD Activated Carbon for Removal of Mercury and Dioxin from Flue Gas;" both cited in Carolyn Konheim to Jim Coyle, 1-24-92, in Appendix Volume 7.2.

CHAPTER 11. LANDFILL ALTERNATIVES, WITHIN NEW YORK CITY AND OUTSIDE NEW YORK CITY

11.1 Municipal Landfills.

11.1.1 The Fresh Kills Landfill.

The Fresh Kills landfill has a remaining capacity of approximately 100 million cubic yards. Because one cubic yard can hold about seven/tenths of a ton of compacted refuse (particularly after it has had time to settle and decompose a bit), this equates to about 85 to 90 million tons of capacity.

This capacity estimate, however, is based on some engineering assumptions about stability and other factors that are difficult to guarantee, and therefore, may somewhat overstate the final capacities that can actually be achieved. If these assumptions can be met, the result would be maximum heights of about ~~460~~ 437 and ~~280~~ 270 feet in the two largest sections of the landfill, and heights of between 150 and ~~200~~ 170 feet in the remainder.

Another kind of constraint is the rate at which this filling can take place. A computer-simulated analysis of the bearing capacity of the types of subsoils underlying major portions of the site suggests that there may be cause for concern about the future stability of the fill as the mounds grow significantly higher. If the spongy, water-filled clay and silt structures underlying the fill were loaded more quickly than water could be compressed out of them, there could be a risk of sliding/shearing movements between these geological layers. Stability-monitoring equipment is being installed to measure actual stresses and strains. These data will be used to help predict whether limitations may need to be imposed on the future rate of filling. However, under quite conservative assumptions, rate-of-filling constraints would not be expected to affect the landfill's throughput capacity for at least five to 10 years.

At current rates of filling (about 13,000 tons a day of primarily residential MSW, less than 500 tons per day of commercial waste, and about 300-400 tons a day of incinerator residue), Fresh Kills could be expected to continue to have available disposal capacity until well into the next century. ~~A currently proposed monofill for ash residue at a section of the landfill, if approved by the DEC, would have capacity for up to 1,800 tons of ash per day. If filled only with ash from the three existing municipal incinerators (which, as noted in Chapter 4, will have a higher throughput than at present due to operational improvements currently underway), the proposed monofill would last for about 20 years.~~ To the extent that, as a result of initiatives recommended in this plan, the City succeeds in reducing the need to landfill raw or unprocessed waste --

through waste prevention, recycling, composting and waste-to-energy incineration -- the overall life-expectancy of the landfill would increase~~, while any areas devoted to monofilling ash and/or other types of residue would be filled to capacity more quickly.~~

Fresh Kills is also operated under an administrative consent order between the City and the DEC, as well as under a federal-court consent order between the City and a New Jersey Township, the State of New Jersey, and various environmental groups. These agreements have guided the Sanitation Department's efforts (as described previously in Chapters 3 and 4) to improve environmental controls and operating conditions at the landfill. As noted in Chapter 4, the total estimated cost of these ongoing and planned improvements is about $500 million, roughly 60 percent of which is scheduled to be spent over the next three years. In addition, the direct operating costs of the landfill in fiscal year 1990 (not including the marine transport system or the cost of landfill depletion, but with the cost of the barge-unloading system) were about $93 million, or about $22 per ton of waste landfilled.

Pursuant to the consent order with the DEC, two sections of the landfill must be closed ~~at the end of 1993~~ by November 30, 1992, and the City must submit a complete application for a Part 360 permit for the remaining sections by ~~September~~ March 15, 1995 if operations at these sections are to continue past then. The planned improvements at the landfill are intended to bring the facility substantially into compliance with the regulations. However, variances from some of Part 360's regulatory requirements almost certainly will have to be granted by DEC if Fresh Kills is to be permitted, because certain regulatory conditions are virtually impossible to fulfill at the 45-year-old Fresh Kills site -- an engineered liner system being one of them.

11.1.2 Inactive Municipal Landfills.

The City has ceased operating five municipal landfills since 1979. These inactive landfills have been classified by the State as Class 2 Inactive Hazardous Waste Sites as a result of past illegal disposal of industrial wastes and, therefore, must be remediated in accordance with the State's standards for the clean-up of hazardous wastes sites. In mid-1990, the New York City Department of Environmental Protection assumed responsibility for the remediation activities at four of these sites -- the Pennsylvania Avenue and Fountain Avenue landfills in Brooklyn, the Brookfield Avenue landfill in Staten Island, and the Pelham Bay landfill in the Bronx. The Edgemere landfill, which closed on July 1, 1991, remains under the jurisdiction of the Sanitation Department.

Remedial activities typically will include the same actions that are required for the "final closure" of a municipal waste landfill, as well as additional steps to address problems associated with the disposal of hazardous wastes. These activities are likely to include grading and "capping" the site with impermeable material to preclude water infiltration and further leachate generation, and covering it with topsoil and vegetation to protect the cap from erosion. Gas- and leachate-control measures may also be required as part of these plans, along with continued environmental monitoring and a twenty-year post-remediation maintenance plan.

These landfills will be "closed" in accordance with schedules and procedures contained in consent-order agreements between the City and the DEC. The DEP has proposed the use of de-watered sludge that has been chemically treated to prevent the leaching of metals as final-cover material. This proposed use of sludge products will require approval by the DEC. If this permission is granted, it would allow the City to meet two objectives at once: provide capacity for the disposal of treated sludge, and provide some of the capping material (which otherwise would have to be purchased) for these closed landfills. The use of treated de-watered sludge for this purpose, however, would be likely to create detectable ammonia levels in the areas surrounding these landfills while this material is being applied to the landfills.

Except for portions of the Brookfield landfill, these areas are mapped as parkland, which is their currently intended "end-use." Because they contain decomposing waste that is settling, stability problems would make construction of any buildings atop them problematic and costly (requiring extremely deep pilings as well as other special design features such as gas-controls). Windrow leaf-and-yard-waste composting facilities could be built on properly prepared, graded and drained level surfaces at any one of these facilities. The current windrow facility at Fresh Kills is expected to be relocated to a closed portion of that site in several years. Other types of small-scale waste-management uses (such as a drop-off facility) may be appropriate for these locations. The Department of Sanitation operates one of its "self-help bulk drop-off facilities" at the Edgemere site, where individuals can dispose of bulky objects such as furniture; these materials are then sorted and removed for processing at private facilities elsewhere to recover recyclable materials. A second windrow-composting facilities has been proposed in the same "virgin" (i.e., un-landfilled) area on the entrance portion of the peninsula adjacent to the bulk drop-off facility. If, after the landfilled portion of the site is capped, the windrow facility were to be relocated to that area, the flat unlandfilled "neck" area, consisting of about 25 usable acres, could be suitable for a variety of types of waste-management facilities. A facility in this area is accessible by water, and therefore, potentially could receive or discharge material by barge.

Ferry Point is the one other major City landfill that closed in recent decades. Landfilling operations there ended in 1965, before the current landfill regulations had come into effect; the site therefore was never capped. The City Department of Parks and Recreation took jurisdiction of that facility at the end of active operations there. The Parks Department has not yet developed all portions of the site for any kind of park use.

Although this land is mapped as park, since it is not yet developed, it might also be considered as a possible site for future waste-management activities, such as the "light" uses mentioned above. Also, as with the other closed landfills, it might be considered as a potential location for new/re-newed landfilling, although no determination has been made as to its ability to be redeveloped in conformance with current Part 360 landfill-design requirements. In addition, as with these other inactive landfill sites, approval from the State Legislature would be required to de-map them as parkland. Although Ferry Point is largely undeveloped at present (in spite of numerous proposals for developing it over the past decades by the Parks Department and by private developers), the site offers majestic waterfront views of Long Island Sound, the East River, and the New York City skyline, which could be significantly impaired if Ferry Point reverted to waste-management functions. However, it might be suitable as an additional area -- one with the benefits of shorefront breezes blowing away to Long Island Sound and relatively distant residential populations -- for the placement of products made from de-watered sludge.

11.2 Non-Municipal (Out-of-City) Landfill Alternatives.

The survey of potential out-of-City landfill capacity for the export of New York City waste, which was discussed in Chapter 3, also included a survey of potential new landfills. Most of this potential new landfill capacity consists of planned expansion of existing landfill sites. This survey did not account for the potential for siting new private landfills, which will depend on the market demand for such new capacity. This survey appears to suggest that landfill capacity limitations *per se* are not likely to be a significant constraint over the next 20 years. While this capacity will be available at increasing distances from New York City, the overall costs, even with increasing transport costs, would remain competitive with the costs of some alternative disposal options.

A separate consideration, of course, are increased legal and regulatory obstacles to the export of waste. A more detailed discussion of these possibilities is presented in Appendix Volume 2.

The DEP interim sludge plan (until in-City facilities have been built) proposes the use of out-of-state landfills that may include facilities in Virginia, Arizona, or elsewhere.

Within the past year, a private firm that handles New York City commercial waste proposed the development of a new, large-scale regional landfill in northwestern Massachusetts. That proposal appears unlikely to be approved, due to a recent state environmental agency decision that precludes that area from landfill development.

11.3 Landfill Design and Technology Alternatives.

11.3.1 Description of Alternatives.

More stringent environmental regulations have induced major advances in landfilling practices in recent years. In contrast to the simple dump-and-cover practices of the past, modern landfills must be designed and operated so that their environmental emissions -- leachate and gases -- are effectively contained, controlled and monitored. The standards that these systems must meet are prescribed by regulation, and vary depending on the types of materials being landfilled. A landfill can be designed as a "monofill," which accepts only a single waste material such as incinerator ash, or as a "co-fill," which accepts combined wastes. For non-hazardous wastes, the strictest regulations apply generally to landfills that receive raw MSW.

To protect groundwater from leachate contamination, new landfills generally require some form of engineered liner system to create an impermeable foundation for the fill. The materials used to construct liners can be natural (clays and other soils) or synthetic (various forms of plastics) or combinations of both, and usually consist of a composite of several layers. To drain off leachate that would accumulate at the bottom of the fill, a system of perforated pipes (usually made of plastic to resist corrosion) is incorporated into the liner construction. The leachate is generally pumped to a central collection system via perimeter pipes, and depending on its quality and regulatory requirements, may be treated at an on-site treatment plant before being discharged either to the sewer system or to surface waters.

An alternative, but still innovative, technique for managing leachate involves recirculating the leachate through the fill. This would have the effect of accelerating the decomposition of the waste (thus providing more disposal capacity) and increasing the rate of gas generation (thus improving energy-recovery potential). Recirculation also may tend to remove and/or transform some of the contaminants in the leachate, and, therefore, could reduce the need for and cost of leachate treatment.

Alternatives for controlling landfill gases include active recovery systems and passive venting. Active systems involve pumping gas from wells installed in the fill. The collected gas can be combusted on site to power a turbine, or can be "purified" at a treatment plant so that it can be piped off site for domestic and industrial uses. Passive systems are intended to prevent off-site underground migration of the gases, which can become hazardous if they accumulate in confined spaces such as home basements. This technique uses systems of pipes and perimeter risers or venting trenches to control the release of gases. The vents also can be equipped with flares to burn off the gases.

There are a variety of alternative landfilling procedures, all of which have in common the placement of waste material in "cells," followed by compacting, grading and covering. Clean soil has been the most commonly used operational-cover material, which is intended to control litter, odors, animals, insects, and fires. After sections of the fill reach final design grades and disposal operations cease, an impermeable cap, topsoil, and vegetation (to prevent erosion) are applied as "final cover."

Alternative cover and capping materials are available. However, many of these are still considered innovative and are not yet widely used or approved. They include various tarp-like covers made of synthetic materials such as plastics or textiles, foams or other "spray-on" products, and other processed wastes, such as stabilized sludge, MSW compost, shredded, non-metalic automobile "fluff," dredge spoils, construction-waste screenings, and treated incinerator ash.

In New York City, where suitable sites for major new landfills are non-existent, an alternative technique that involves "mining" old landfilled areas may become a potentially viable option for extending the service life of Fresh Kills, or for creating new capacity at other former landfill sites. The technique, which has been tested at a couple of landfills in Florida and at one in upstate New York, involves excavating well-decomposed, previously landfilled material, screening and separating it into recyclable, compostable and combustible components, and recovering the cover soil for re-use. A liner and leachate-control system could then be installed in the excavated area, making it suitable for further landfilling. The pilot-scale test results have been promising, although a primary concern in the City would be to ensure that adequate provisions can be made to control and mitigate any potential odor problems. Also, the costs of landfill mining in New York City have not been fully assessed, although the alternative -- export to out-of-City landfills -- is likely to be quite costly.

Another landfilling concept that in the past has been proposed in various forms for New York City involves constructing an off-shore containment island with MSW. This technique has been used in Tokyo Bay (with generally unfavorable environmental results -- to prevent unintended "holes in one," a recently constructed golf course atop one prohibits smoking to prevent a patron from lighting up leaking methane), and a similar landfill island is planned for Singapore. The basic technology for constructing such a structure in water is not uncommon, but a number of issues would require further study before a proposal of this sort could be considered a viable waste-disposal option for the City. These include site selection (there are a number of significant navigational, tidal, ecological and other factors that limit the choice of sites for such a structure in New York Harbor), potential water-quality and other environmental impacts, regulatory requirements, impediments and constraints, operational implications, and above all, costs (development, capital and operating).

A more detailed discussion of landfilling alternatives is contained in Appendix Volume 4.2.

11.3.2 Evaluation of Alternatives.

In the near-term, the most viable landfilling alternatives for the City will be related to operational innovations at Fresh Kills, such as using different materials for operational and/or final cover. The proposed environmental improvements at Fresh Kills, particularly the design of the leachate containment and collection system, are a function of site-specific conditions, including the presence of over 40 years of previously landfilled wastes of all types (which precludes the installation of an engineered liner), the geology of the site, ground- and surface water quality, and leachate characteristics.

Because of the size of the site, the amount of in-place waste, the anticipated duration of future filling, and the quantity and quality of gas being generated, an active gas-recovery system, as opposed to passive venting, is the preferred gas-control option. An active gas-recovery facility has been operating for nearly a decade in one part of the site, and another full-service vendor will be selected through an RFP process (a draft RFP was recently released for comment) to develop additional gas-recovery systems.

Landfill-mining techniques may be a viable future option for the City, depending on the results of further studies elsewhere, which could provide the basis for a pilot-scale test at Fresh Kills.

11.4 Regulatory Requirements.

Detailed, design, construction, operating, monitoring, closure and post-closure requirements for landfills in New York State are contained in the 6 NYCRR Part 360 regulations. Also relevant are the Clean Air Act's greenhouse-gas emission limits, and the Clean Water Act's regulation of surface water run-off. These are summarized in Appendix Volume 4.2.

11.5 Costs.

From a cost perspective, landfills are a unique sort of waste-management facility because, once a facility has reached the end of its useful life, it cannot be replaced in the same location. That is (in spite of the opportunities for extending the usefulness of landfills through new techniques such as landfill mining), landfills have a finite capacity, and the only way to replace that capacity is by acquiring access to a new piece of land. Furthermore, a completed landfill, as a piece of real estate, has only limited uses (since it cannot support heavy construction, has a slope, etc.), and it entails permanent maintenance and environmental monitoring costs. All of this means that landfills carry a depletion cost that is significantly greater than the depletion costs for other types of facilities.

Another unique factor is the virtual irrelevance of daily throughput limitations. Landfills can be filled quickly, or slowly, without any significant changes in operating costs. Therefore, capital and operating costs measured on a per-ton-of-daily-capacity basis are not a useful index. Nor -- partly for that reason -- are there particularly significant economies of scale from a capital-equipment or operating-cost perspective. There are, however, very significant life-time economies of scale associated with the size of a landfill's "footprint" (the most significant capital cost), because site geometry dictates volumetric capacity, which increases exponentially as a function of the size of the base.

Because of detailed regulatory prescriptions for the design and operation of landfills for particular types of wastes, there are currently relatively few technology choices that have significant cost impacts. The options available, which will have only minimal cost effects, include the type of cover material used: cost savings are possible by using processed wastes of various kinds -- de-watered dredge spoils, composted sludge or MSW, shredded construction and demolition debris -- in place of other types of material. One technology option that may be available in the future (depending on the solution of technology and regulatory problems) is the construction of landfill islands, although this type of landfill would be significantly more expensive than would be an onshore facility in terms of capital and operating costs.

11.6 Siting Requirements.

The review of potentially suitable land areas in New York City shows that there are not suitable areas of sufficient size to make the development of a new landfill within the City viable. In addition to their very large acreage requirements in comparison to other types of waste-management facilities, other significant siting criteria specific to landfills are the regulatorily-specified minimum distances from an airport (10,000 feet from an airport used by jets and 5,000 feet from an airport used only by propeller-driven planes: a precaution due to the potential danger to aircraft from birds attracted to a landfill), from surface water (100 feet), and from aquifers (they cannot be located above usable aquifer recharge areas). Landfills cannot be sited in areas with shallow groundwater, nor can they be sited on agricultural land.

11.7 Environmental Impacts of Landfill Alternatives.

Relative to other waste-management techniques for handling the same waste components, landfills generally produce the most adverse environmental impacts. Some of these impacts are of the opportunity-cost kind: from an energy perspective, for instance, in spite of the potential for recovery of landfill gas (methane), materials not recycled or processed in waste-to-energy facilities represent a loss of energy resources. The opportunity costs associated with the land on which landfills are located, as discussed above, are another. When organic materials decompose in a landfill, seven times more carbon dioxide (a greenhouse gas) is released than when these materials are burned in waste-to-energy facilities;[1] certain volatilized organic compounds and metals are released as well. Some of these volatilized compounds may be odorous, and may produce a significant nuisance in for nearby residential populations. Although current regulations require that measures be taken to minimize the amount of leachate produced, and to contain it, some degree of leachate is always produced, which must either be treated or pose the potential at some point for escape into the environment. For wastes that cannot be disposed of in any other way, however, controlled landfilling produces the least possible amount of environmental damage. Properly designed and operated landfills pose minimal environmental or public-health risks.

Data on environmental impacts of landfilling are contained in Appendix Volumes 4.2 and 5.

Endnotes

1. Taylor, Hunter F., P.E., "A Comparison of Potential Greenhouse Gas Emissions from Disposal of MSW in Sanitary Landfills vs. Waste-to-Energy Facilities," in Municipal Waste Combustion, Conference Papers and Abstracts from the Second Annual International Specialty Conference, U.S. EPA and Air & Waste Management Association, April 15-19, 1991, Tampa, FL.

CHAPTER 12. ALTERNATIVES FOR COLLECTION, TRANSPORT, AND TRANSFER STATIONS.

12.1 Alternatives for Municipal Solid Waste.

12.1.1 Collection Options.

In the chapters on recycling and composting options (Chapters 8 and 9), collection options were addressed at the materials level; the analysis focussed on the degree of waste segregation **outside** the truck (before it is collected) and on the degree of segregation that is maintained **inside** the truck. The present chapter is concerned with the operational issues involving **labor** and **vehicle** efficiencies -- on how much material can be loaded most quickly with the fewest personnel and the fewest vehicles to minimize capital and operating expenses as well as the environmental impacts (air, noise, energy, traffic, worker safety) associated with collection miles traveled.

These operational alternatives involve relative "sizes" (crew size, vehicle size, route length, length of workday); the type of mechanical equipment (manual, semi-automatic, or completely automatic loading operations); productivity (stops per hour, tons per hour, degrees of compaction); and institutional arrangements (publicly or privately organized labor and ownership of capital equipment).

These issues are reflected in the alternative system arrangements discussed below.

Collection Frequency. One alternative to the current system would be to reduce collection frequency, keeping all other collection parameters the same. The primary advantage of reducing weekly refuse collections by one or more days a week would be somewhat-reduced collection costs, due to a reduced number of truck shifts. (Cost reductions would not be directly proportional to the number of shift reductions, however, since trucks would fill faster, requiring more dumping costs, and more time spent on routes to collect more waste per stop.) There would also be reduced environmental impacts due to reduced collection miles traveled. Disadvantages would include the nuisances created by householders storing more waste for longer periods of time.

In relation to the current system, other modifications to existing procedures would have beneficial cost effects that could be similar to those due to reduced collection frequency. Current recycling collection shifts are simply added onto existing "baseline" refuse collections. If a district receives three-day-a-week refuse collection, collection of recyclables means a fourth or fifth collection each week for that district. Instead, the collection of recyclables could be substituted for one of the refuse collections, so that the district would continue to receive collections only three days a week. Another measure that would improve productivity would be to extend the length of refuse routes to reflect the amount of recyclables that have been diverted to recyclables collections, so that a crew would continue to collect the same amount of refuse per truck shift, but by covering more territory than it did before recycling collections were implemented: such an agreement has recently been reached with the Uniformed Sanitation Workers' Union.

Automated or Semi-Automated Collection. Another type of alternative involves automated or semi-automated collection using 60- or 90-gallon rigid wheeled containers. It is possible that such a system could be used more extensively in New York City for residential waste, as it is in Los Angeles and certain other large cities in this country and abroad, as well as in less-densely populated locales. These sorts of systems require that the generator be able to store a relatively large container, as well as be able to manoeuver it to the curb (this would be difficult for superintendents in many multi-story apartment buildings, who must get waste that is stored in a basement or courtyard up a narrow flight of stairs in order to get it to the street, or for elderly single-family householders who would have to move a container up and down a driveway). They also require that collection vehicles have unimpeded access to the containers on the curb, which would require that there be no parked cars on the street (as is the case in some neighborhoods in low-density areas of the city). However, in homes or buildings where wheeled containers could be gotten to the curb easily, and where on-street parking was not common, or for collection routes that were synchronized with alternate-side-of-the-street parking regulations, such systems could offer significant advantages.

One advantage would be in increased collection efficiency. Fully automated, side-loading systems can be operated by one-person crews; semi-automated two-person trucks can do more than twice as many stops per route.[1] Secondly, larger container sizes could mean fewer collections, particularly for commingled recyclables and/or "dry"/non-putrescible wastes, making once-a-month or twice-a-month collections of recyclables a more viable option in certain areas of the City. Together, these characteristics could have a significant effect on collection costs. The decreased worker fatigue and decreased exposure to lifting injuries would improve working conditions for collection workers. Having a convenient container for dry recyclables would be a convenience for generators, while increases in recycling awareness and participation due to neighbors noticing each others' recycling bins at the curb have been demonstrated in many curbside programs. Another advantage is that such bins could be adapted to a bar-code system, which could be useful in any user-fee-based system or other system that provided economic incentives for recycling, or for enforcement activities, as well as providing useful monitoring data that could be used to increase participation and improve system performance.

The bins, which would need to be provided by the City, would represent a significant expense (depending on the size, a 60 to 90 gallon bin costs between $50 and $60), but there would be off-setting decreases in capital and operating cost due to collection efficiencies, and increased participation rates. Another capital and operating expense would be for the automatic hoisting equipment, which can be purchased on new vehicles, or, possibly, retrofitted onto existing fleets. (A further disadvantage is that collections could be impeded after a snow storm, when ridges of snow interfere with the rolling out of containers.)

Collection trucks involved in such automatic or semi-automatic collections could also accept manually loaded waste, so that individual collection routes could collect waste manually or automatically depending on the way that the generator set it out.

Public versus Private Collection. Although current pay scales for public and private collection forces in New York City are very comparable, productivity -- largely because of relative lengths of routes and of workdays -- is greater for private crews. The competitive advantages of private waste-collection have led many cities across the country to adopt some type of privatized arrangement for at least some portion of their collections. The basic types of privatization systems are contract, franchise, and private subscription. Under a contract system, qualified contractors are chosen through competitive bidding to perform collection services. The contractors are paid by the municipality and may or may not be responsible for setting fees and billing customers. With a franchise system, contractors are also chosen through competitive bidding, and bill and collect payment directly from the customer, but rates are set by municipal officials. With private subscription, generators choose between competing collection companies and subscribe to their services. The private company sets its own rates. Private subscription is the method used by commercial generators in New York City.

The principle advantages of private collection are that competition may increase system efficiency, and improve service. Privatization might also allow for a more flexible management system. The principle disadvantages of a private collection system are that profit-related costs may be passed on to customers, while the advantages of competition may be minimal. Private contractors also require municipal oversight, and may not be as accountable as a public system because financial difficulties and contract problems may hinder service.

Vehicle/Crew Configurations. Another issue is the relationship between crew size and vehicle design. This issue relates to the discussion of semi-automatic and automatic collection above, but also includes such things as one-person vs. two-person vs. three-person crews. Truck designs can facilitate smaller crew sizes, which in turn may reduce system costs. When New York City in the early 1980's reduced standard collection crews from three workers to two, with the introduction of modified trucks, costs were reduced.

Table 12.1.1-1: Summary of Alternative Collection Systems

ALTERNATIVE SYSTEMS (& APPLICABLE HOUSING DENSITIES)	COLLECTION METHOD	CREW SIZE	VEHICLE TYPE	VEHICLE COMPACTION	PURCHASE PRICE (1990$)	CONTAINER	TONS/HR	USER SET OUT
Existing System w/ Reduced Collection Frequency (l,m,h)	Manual	2	25 cy rear ldr	4:1	$115,000	Bags	1.8 (l) 2.2 (m) 2.8(h)	1 day (l) 2-3 days (m, h)
Semi-Automated (l,m,h)	Semi-automated	2	25 cy side ldr 20 cy rear ldr	3:1	$130,000 (new) $105,000 (new)	60 & 90 gal carts (l,m) ($55, $75) 1 cy cont. (h) ($200)	1.7(l) 3.7(m) 4.2(h)	1 day (l) 2-3 days (m, h)
Automated (l,m)	Automated	1	25 cy side ldr	4:1	$140,000 (new) $35,000 (retrofit)	60 & 90 gal carts ($55, $75)	1.9(l) 3.2(h)	1 day (l) 2-3 days (m)
Increased Containerized Collection (m,h)	Automated Containerized	2	47 cy front ldr	3:1	$124,000	1-8 cy containers ($150-$690)	2.4	on-call
Private Collection (commercial sector)	Manual & Semi-automated	2	31 cy rear pkr 40 cy front pkr	5:1 (31 cy) 4:1 (40 cy)	$120,000 (31 cy) $140,000 (40 cy)	5 cy dumpster	3	2-5 days

Note: l = low density, m = medium density, and h = high density

12.1.2 Transfer Alternatives for Municipal Solid Waste.

Evolutions in technology, and in the role of transfer stations in contemporary solid-waste-management systems, are rapidly changing how transfer stations function; options for configuring transfer stations now range from the simple to the all-but sublime. Depending on the material that is delivered to the transfer station (i.e., on the degree of source separation, as well as the type of material) as well as on the transport mode onto which the waste is being loaded (semi-trailer truck, open-top trailer truck, container on truck or rail or barge, open barge), and the type of processing or disposal facility to which the material will be delivered, various processing operations may occur at the transfer station. Transfer stations generally bale incoming waste for more efficient transport. Steps prior to baling to further increase density often involve shredding or pulverizing (sometimes by techniques as simple as running a front-end-loader over piles of construction and demolition debris). Finally, there may also be some degree of mechanized- or hand-sorting operations to recover recyclable materials, greatly blurring the formerly-distinct line between transfer stations and materials-recovery facilities.

Descriptions of generic options for rail, barge, and truck transfer facilities, along with their capital and operating costs, labor requirements, water usage and discharge, air emissions, site requirements, and traffic and noise impacts are presented in Appendix Volume 5 ("Reference Facilities.")

The most significant decision factors concerning transfer stations have to do with their role within the overall waste-management system, rather than on facility-specific considerations. The modeling of scenario options in NYC WastePlan (presented in Chapters 15-17), for instance, demonstrates that minimizing transport distances is almost always much more significant from a cost perspective than are any economies of scale associated with facility size; given the enormous space constraints in New York City, transfer stations in many situations will offer the most effective means of reducing overall vehicle mileage.

12.1.3 Export Transport Options for Municipal Solid Wastes.

Municipal solid wastes can be exported by three transport modes: truck, rail, and water. Conventional truck transport is cost-effective for relatively short distances of up to 400 miles, and rail transport is more cost-effective at distances between 400 and 1,500 miles. For appropriate locations at even greater distances, barging of waste becomes most cost-effective. Rail and water transport, however, faces significant infrastructural impediments that do not affect truck transport. Table 12.1.3-1 summarizes the cost of the three export options for municipal solid wastes.

Table 12.1.3-1: Cost Comparison of Truck, Rail, and Marine Transport

	Cost per Ton	Optimal Transport Distance (miles)
Truck Transport	$70 (w/ dedicated transport) $55 (w/ back- hauling)	225 (w/ dedicated transport) 250-300 (w/ back-hauling)
Rail Transport	$55-58 per ton for distances between 400 and 1,200 miles	400 - 1500 miles
Marine Transport	$46 per ton for 2000 mile transport	>1500 miles

Truck Transport: Truck transport provides the greatest flexibility of any transportation method. It can be used alone, or in combination with other forms of transportation. Trucks can provide point-to-point transportation service, which allows for flexibility in final disposal destinations. There are, however, hidden costs such as increased roadway- and bridge-maintenance costs, congestion, accidents, and air and noise pollution associated with truck transport.

The average total cost of truck transport with back-hauling is $55 per ton, with an optimal distance from New York City of 250 to 300 miles. The one-way per-ton cost rapidly increases to $70 per ton if dedicated trucks must return empty back to the City, and if a carter must pay for such a return trip, the optimum distance is reduced to 225 miles. Use of double- and triple-trailer trucks that accommodate heavier loads, if allowed by Congress and the states, would extend the competitive range of trucks to about 1,000 miles.

Rail Transport: Rail transport is less labor-intensive than is truck transportation, has minimal impacts on public rights-of-way, and is generally more economical for distances between 250 and 600 miles. One 60-foot boxcar can carry 80 tons of refuse, while a transport truck can carry only 22 tons. The resulting rail transport costs are in the range of $55 to $58 per ton for distances between 400 and 1,200 miles. These cost estimates include the cost of a New York-harbor crossing, along with trans-shipping from the rail head to the landfill.

There are three major obstacles to rail transport. One is an insufficient number of in-city transfer stations located adjacent to rail spurs. The second are the poor rail connections to and within New York City. Rail traffic must go to Albany before crossing the Hudson River, or be ferried across the harbor to New Jersey. Both alternatives are costly, and may delay shipments by as much as three days. The third obstacle is that few landfill sites have rail spurs, which necessitates costly trans-shipment of the waste. Transfering waste from rail to truck at the landfill-end of the trip, coupled with trucking costs, can add as much as $12 per ton to the cost of exporting waste.

At least three New York City transfer stations have in-city rail heads. In the New York City region, rail transport opportunities exist via Conrail, the Long Island Railroad, the South Brooklyn Railway, the New York Cross Harbor Railroad, and the Staten Island Railroad Corporation (formerly the Delaware and Ostego line). These operators have indicated that plenty of rail capacity is available or could be made available.

Rail transport has fewer environmental impacts than does truck transport. Rail transport causes less air pollution and traffic congestion, and does not increase roadway maintenance costs.

Marine Transport: The principle advantage of barge transport are the economies of scale that result from transporting large quantities of waste by water. Although no municipal solid waste is currently exported by barge, operators claim that it would be possible for an ocean-going tug to tow up to 24,000 tons of waste on two barges. Estimated disposal costs are about $45 per ton for a three-week trip to Houston, including fuel and tug rental, tipping fees, off-loading, and the return trip to New York City. Barge transport does not create the traffic congestion and air and noise pollution that are associated with trucks.

A major obstacle to water transport is the almost-universal need for costly waste-transfer and truck-hauling from the destination port. This is a result of current environmental regulations which limit the siting of landfills near shoreline areas. Other potential drawbacks are the potential for accidental spillage of wastes into waterways, especially from the breakage of bales during loading and unloading. Barge transport is also limited on northern waterways, such as the Hudson River, during winter months.

Waterway facilities that are currently owned by New York City include: the South Brooklyn piers, the 25th Street pier, Red Hook (which, though currently operating at capacity, will be expanded by 50 percent), Howland Hook (which has excess capacity), and Pier 42 in Manhattan.

For a more detailed analysis of export transport options for Municipal Solid Waste see the "Export Study" in Appendix Volume 2.

12.2 Alternatives for Transporting Dewatered Sewage Sludge.

Truck transportation is the most economical way to transport dewatered sludge for distances up to 200 miles. Rail and barge transport are most cost-effective for distances over 200 miles. Rail or barge transport can be more economical than truck transport at distances between 100 and 200 miles if the ultimate destination is in the vicinity of a rail line or barge wharf and extensive rehandling and distribution costs are avoided. Pipeline transport is possible for liquid sludge, but is not a viable alternative for dewatered sewage sludge.

Since trucks can go anywhere, trucking is the most flexibile transport modality. Rail transportation is possible only if a rail spur is located at the facility or if the containerized sludge is shipped by barge or truck to existing rail lines. Dewatered sludge is transported by rail in either high-sided gondola cars or in containers on flat cars. Barge transport is most cost-effective if both the dewatering facility and the disposal site can be accessed directly. Barge transport may be limited on northern waterways in the winter months.

For a more detailed analysis of alternatives for transporting de-watered sewage sludge, see the Department of Environmental Protection's, "Task 5 Sludge Management Plan" and the "Sludge Management Report" in Appendix Volume 4.2.

12.3 Alternatives for Collecting and Transporting Medical Waste

Few regulatorily permissible alternatives exist for the collection, containment, and transport of regulated medical wastes. Shipping regulated medical waste (RMW) requires specialized packaging, such as sharps containers, RMW liners, and RMW shipping containers.

Non-regulated medical waste is collected and transported in the same ways as are other institutional wastes. Separated organic materials and recyclables are usually collected in large re-usable containers and processed at compost and materials-recovery facilities. Depending upon the quantity of recyclables generated, certain recyclables, such as white paper, may be collected in separate containers.

A more detailed presentation of alternatives for moving medical waste is presented in Appendix Volume 8.

12.4 Alternatives for Collecting and Transporting Harbor Debris

Harbor debris is collected by a variety of New York City agencies and private contractors. There are three types of harbor debris: shoreline piers, floatable debris, and New Jersey beach debris.

Shoreline piers are demolished by both land- and water-based methods. First, as much non-wooden material as possible can be removed from the structures and recovered. Second, the structure is pulled apart by an overhead crane and the wood loaded directly onto a transport barge. Under the most practicable alternative, the barge would then transport the debris directly to a harbor-debris processing facility where the debris would be unloaded by a knuckleboom crane. At the facility, recyclable metal material would be recovered and the remaining material incinerated. The transport barges would be much smaller than those commonly used by contractors located in the harbor region today. The use of smaller barges probably would allow more contractors to enter the field, which would result in the expansion of competition for harbor demolition contracts.

The second type of harbor debris, harbor floatables, are collected by skimmer boats. Until recently, most floatable debris was incinerated with the pier debris at sea. Now, as a result of more stringent regulations, floatable debris is transported to Fresh Kills.

Harbor debris is also collected along New Jersey beaches in their shoreline beach clean-up programs. The debris is collected in dumpsters, front-end loaders and other collection vehicles and transported to a local landfill.

For more detail on alternatives for moving harbor debris, see "Harbor Debris -- Current and Future Management, Collection, and Disposal" in Appendix Volume 4.2.

12.5 Alternatives for Transporting Dredge Spoils

Dredge spoils are transported by barge. Dewatered spoils can be transported by truck, rail, or barge, or a combination of these modes, depending upon the location of the dewatering facility, of the transfer station (if used), and of the landfill. Most dewatering facilities are built with water access so that marine transport of the de-watered sludge is possible. Marine, rail, and truck transport have the same relative benefits as outlined in section 12.1.3.

A more detailed presentation of alternatives for transporting dredge spoils is found in Appendix Volume 4.2.

12.6 Alternatives for Collecting, Transferring, and Transporting Construction and Demolition Debris.

Most construction and demolition debris is generated by private construction contractors and collected by private carters in open-box roll-off containers. The containers are taken to a transfer station, where recyclable materials are recovered, and the remaining material is densified for transport.

A more detailed presentation of alternatives for moving construction and demolition debris is presented in Appendix Volume 4.2.

Endnotes

1. According to pilot tests done in Los Angeles. World Wastes, February, 1991, p. LAS12.

CHAPTER 13. SITING CONSIDERATIONS.

Selecting specific sites for specific facilities is not among the purposes of this generic environmental impact statement: individual facilities that will be developed pursuant to the present planning effort and that have the potential to create significant environmental impacts will each be the subject of project-specific supplemental environmental impact statements. It is a central goal of the present planning effort, however, to develop, on the one hand, detailed siting criteria related to the technical requirements of particular types and sizes of facilities and to their environmental impacts on surrounding populations and land-uses, and, on the other hand, to develop an understanding of how these siting criteria relate to sites potentially available within the city. Put differently: in order for this plan to be implemented, there must be a realistic congruence between the system of facilities proposed in it and the enormously stringent constraints on available space within New York City.

In this respect (only), developing New York City's waste-management plan is like designing a butterfly, whose two wings, when lifted together, must match. One wing is a detailed matrix of siting criteria, developed from an engineering understanding of the requirements for building and operating particular types of facilities, and from an environmental analysis of their effects on surrounding areas. The other wing is a computerized map of the city which allows the identification of areas that fit relevant siting criteria, such as: zoning and land-use categories, transportation access (to designated truck routes, rail lines, shipping channels), terrain elevations, high-rise buildings, wetlands, and Federal Aviation Administration height restrictions.

The New York Zoning Resolution currently includes all waste-management facilities in Use Group 18, an industrial-use group, either under the subcategories of Use Group 18 A (Manufacturing Uses) or under Use Group 18 B (Storage or Miscellaneous Uses -- Open or Enclosed). Waste-management uses which are not specifically included are accomodated by interpretation under currently listed uses. For example, a sludge-processing facility is interpreted as a "fertilizer" manufacturing establishment, which is a Use Group 18 use. Other waste-management uses which are commercial in character, such as buy-back and redemption centers, are not listed either.

Use Group 18 uses are permitted in the heaviest of manufacturing districts (M3) as-of-right. However, when the facility meets the performance standards of the lighter manufacturing districts (M1 or M2), it is permitted to locate in these districts as well. Although the Resolution does require enclosure of certain uses, the performance standards and the enclosure requirements are separate and not entirely congruent.

Since 1961, when the Resolution was comprehensively amended, there have been many technological changes in the waste-management industry. In addition, there have been increasing efforts by the State and City to control the potential environmental impacts of these uses through regulation. The outdated system of categorization of waste-management uses in the Zoning Resolution makes it difficult to regulate those uses appropriately, since several distinct uses with different potential land-use impacts can be grouped together. Moreover, the New York City Zoning Resolution is not consistent with the permit requirements set forth by the State or by the City. In addition, the City has embarked upon a major recycling program. Uses associated with the recycling program need to be included in the Zoning Resolution.

Therefore, the Department of City Planning is proposing an amendment of the New York City Zoning Resolution which would do the following:

- Reorganize the existing classification of uses under Use Group 18 to create a separate category (Use Group 18B) for Waste-Management Facilities.
- Separate uses and recategorize them to reflect their different land-use impacts.
- Impose siting and enclosure requirements on facilities with similar potential impacts, such as putrescible-solid-waste transfer stations, regulated-medical-waste transfer stations (including autoclaves), asbestos-waste transfer stations, and radioactive-waste transfer stations. Locational restrictions preventing the siting of some of these facilities within 300 feet of a residence district would apply. In addition, all putrescible solid-waste-transfer stations would be subject to minimum lot-size requirements, to assure ample on-site space for truck queuing and maneuvering, to reduce potentially negative traffic impacts on surrounding streets.
- Add "buy-back or redemption center" as a separate use to Use Groups 8 and 16, and permit these facilities, with size restrictions, to locate widely in commercial districts C2, C4, C6, and C8, to facilitate the City's recycling program.
- Non-putrescible-waste transfer stations, including recyclables processing facilities, if enclosed, would be permitted to locate in light manufacturing districts (M1) and within 300 feet of a residence district. They would be

permitted unenclosed in M2 and M3 districts, and if enclosed, they could locate within 300 feet of a district which permits residences.

The proposed amendment will undergo an environmental review, and then be issued by the City Planning Commission for public review and comment. A City Planning Commission hearing on the proposed amendment will be held, after which the Commission will consider the proposed amendment for adoption. After adoption, the Commission would refer it to the City Council for consideration and adoption. This process is expected to be concluded by the summer of 1993.

Detailed criteria related to building and operating specific types of facilities of specific sizes are presented in the siting matrix in Appendix Volume 5. The most significant considerations are:

Compatible adjacent land-uses. From most to least restrictive: medium- to large-scale waste-management facilities that involve composting, waste-to-energy (and/or thermal processing, e.g., autoclaves for medical wastes); facilities that involve transfer, or processing of recyclables; or landfilling are most compatible with manufacturing land uses; drop-off or buy-back centers for non-putrescible recyclables would be appropriate for commercial areas and commercial areas within residential areas.

Acreage requirements. Landfills require far and away the most acreage of any type of waste-management facility. (Their acreage requirements are so great, in fact, that the mapping analysis shows that the ~~two~~ existing landfill~~s~~ and several of the more-recently-closed landfills are the only areas with appropriate land-use characteristics that are of sufficient size for a landfill in New York City.)[1] Compost facilities are the next-most land-intensive type of facility (requiring on the order of 16 acres per 1,000 tons of daily capacity); followed by waste-to-energy facilities (on the order of 12 acres per 1,000 tons of daily capacity); and materials-recovery facilities (seven acres per 1,000 tons of capacity). Additional acreage requirements for buffer areas are a regulatory requirement for landfills (6 NYCRR 360-2.13); a buffer area may also be desirable for certain other types of facilities to lessen odor impacts, and for reasons of visual aesthetics.

Transportation access. Large-scale facilities require non-congested access to a designated truck route, a rail line, a navigable barge channel, or to some combination of these. Of the potentially suitable manufacturing and "heavy commercial" areas of the city, all had suitable access to at least one of these transport modes, but analysis of the number of vehicle trips that would be generated by truck-related facilities, in relation to existing and projected traffic levels, indicated that about half of these areas of the city would have difficulty sustaining facilities of over 2,000 tons a day.

Generally speaking, other environmental impacts -- beyond the need for appropriate adjacent land-uses, as noted above -- were determined not to pose significant additional siting constraints.

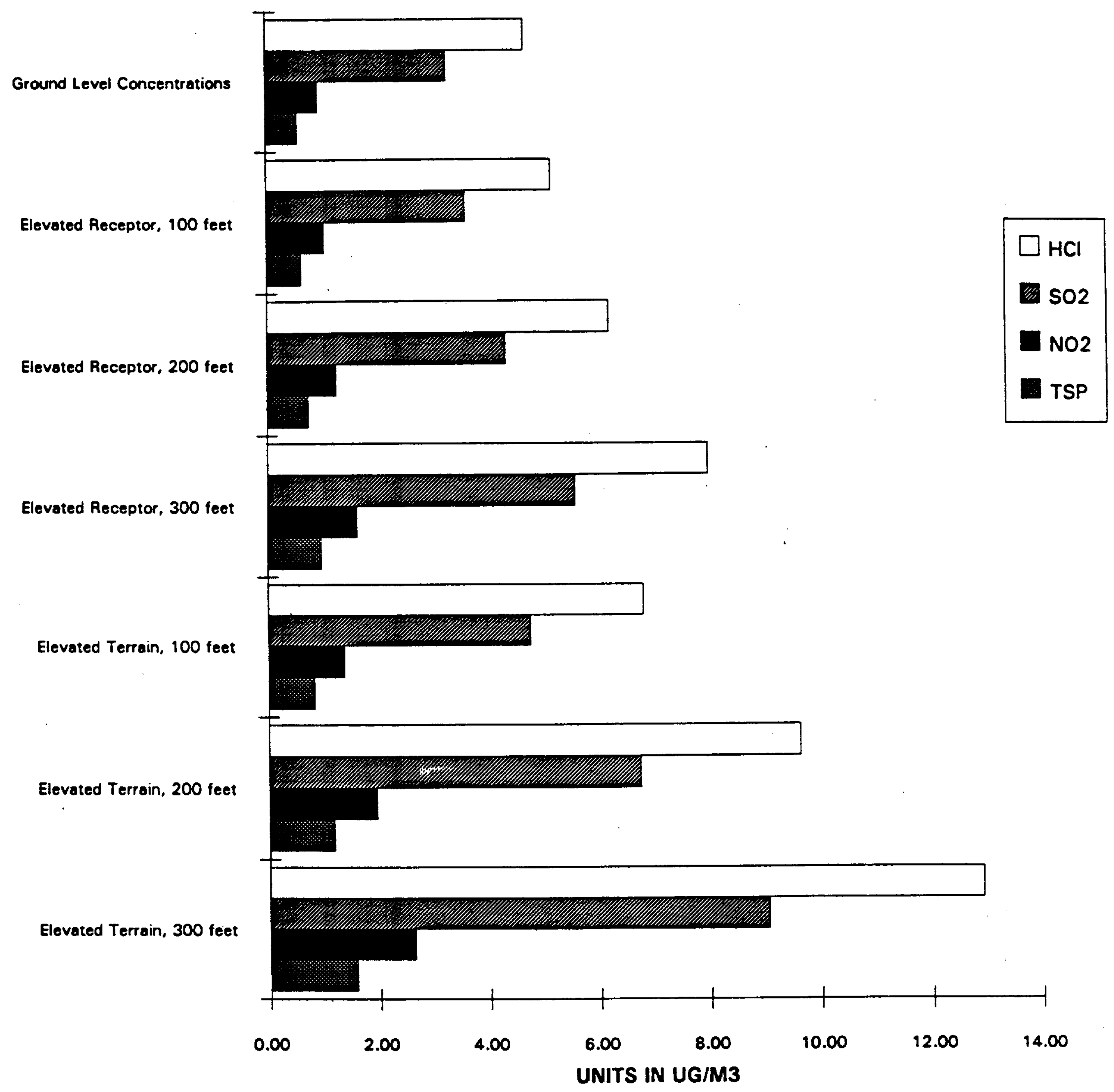
Potential siting constraints related to air-quality -- terrain heights, high-rise buildings, and density of built structures (a factor related to air turbulence in a region) -- were shown by the "prototypical modeling runs" described in Chapter 6 to be relatively insignificant in terms of limiting the availability of suitable facility sites within the city. Figure 13-1 shows (for the facility type that produces the highest ambient pollutant concentrations -- a 2250 ton-per-day waste-to-energy facility) the differential effects at ground-level, at high-rise buildings, and at elevated terrain levels.

Figure 13-1 demonstrates that there are no exceedances of regulatory standards or guidelines at any terrain or receptor elevation modeled, but it also demonstrates the relative improvements in ambient concentrations that could be achieved by siting such facilities with relation to terrain and building elevations. (The effects of a shorter exhaust stack -- which would be necessary if the facility were built in an area within the flight paths to one of the region's three major airports -- are depicted in tables in Appendix Volume 6. These tables compare the conditions that produce the highest ambient pollutant concentrations in the case when the height of the stack is limited by Federal Aviation Administration height restrictions, to the case when stack height is not constrained.)

Due to readily achievable performance standards for noise-attenuation, the need for buffer areas to mitigate the effects of noise is not a significant siting constraint.

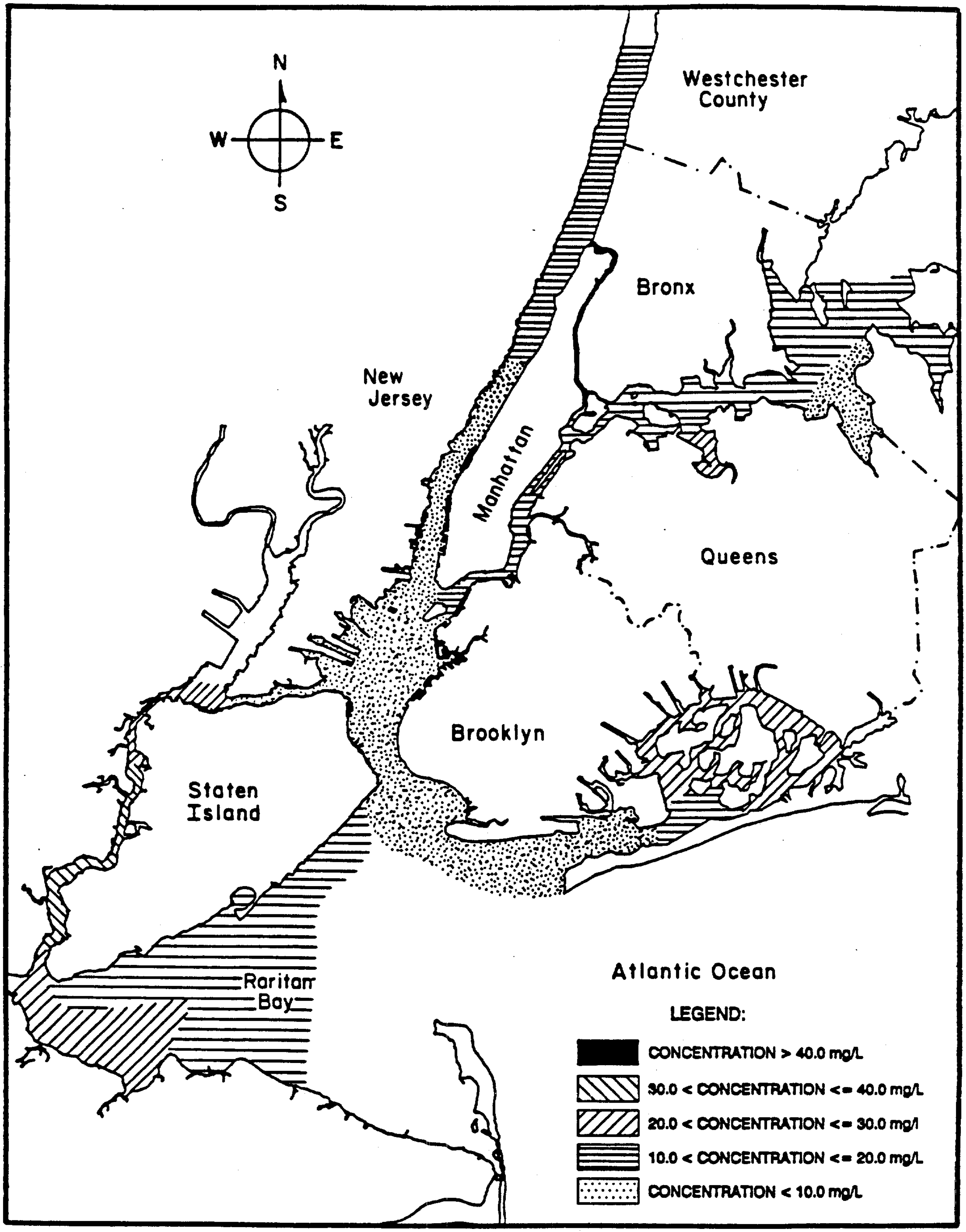
The only facility type among those considered in the universe of feasible alternatives for this planning effort that has direct discharges to surface water other than normal runoff is a dredge-spoils-dewatering facility. Landfills, however, in spite of regulatory requirements for design and operating procedures to completely contain leachate, nonetheless pose the potential for inadvertent discharges to ground and surface waters. These are the only facility types, therefore, that could have any differential effect on the quality of surface waters in the New York Harbor/estuarine region that depend on the location

Figure 13-1: Comparison of Maximum Ambient Air-Quality Impacts for a Prototypical Waste-to-Energy Facility Under Varying Terrain and Receptor Elevations



GEP Stack Height (100 meters); Ring Distance = 900 meters; Urban Dispersion Coefficients.

Figure 13-2: Differential Water-Quality Impacts in New York Harbor System Due to Unit Pollutant Discharges.



where they are sited. In order to understand the differences that different sites would pose for such facilities (as well as for facilities that produced air-borne particulate that could be deposited onto surface waters), a water-modeling analysis was conducted (as described in Chapter 6) to quantify any differences in dispersion/dilution effects that would create differences in peak pollutant concentrations. The maximum pollutant concentrations produced by a unit discharge (one million pounds per day) into each of 41 reaches as depicted on the map that follows, shows that, on average, facilities sited in areas that discharged to the Outer Harbor region would produce the lowest overall surface-water pollutant concentrations. When the remaining areas are ranked on the basis of lowest to highest pollutant concentrations produced by a unit loading, they would be, in order of preference: the Inner Harbor area, the Hudson River area, the East River area, the Raritan Bay area, the Jamaica Bay area, the Kill Van Kull/Arthur Kill area, and the Harlem River area. (This ranking from highest-dilution areas to least-dilution areas also roughly corresponds to the State DEC's existing water-quality classifications for these areas.) (A more detailed presentation of this water-modeling analysis is presented in Appendix Volume 6.)

The relationship of other factors to siting considerations has been discussed in Chapter 6 ("Environmental Evaluation Criteria") and is discussed in Chapter 17 ("Environmental and Economic Impacts"). Such factors include utilities, odor, visual impacts, and public health constraints: although they may pose significant potential siting constraints, for most types and sizes of MSW facilities, adverse impacts due to these factors can be mitigated to an acceptable degree.

Figures 13-3 and 13-4 provide an overall perspective on zoning in the city, and highlight the areas that have zoning suitable for waste-management facilities (M-1, M-2, M-3, and C-8).

<u>Siting sludge facilities.</u> The siting process for the sludge-management facilities that will be developed by or on behalf of the Department of Environmental Protection is somewhat different than the more generic approach to the larger set of facilities that is described above. The DEP has proposed specific sites for its "intermediate" and "long-range" plans; this site-selection process is described, and the proposed sites are evaluated in the Final Environmental Impact Statement II, issued by the DEP in December, 1990, and Draft Environmental Impact Statement III, issued in December, 1991. The DEP siting study included an analysis of sites outside of New York City elsewhere in New York State.

Figure 13-4: Generalized NYC Zoning: Commercial and Industrial (M and C-8)

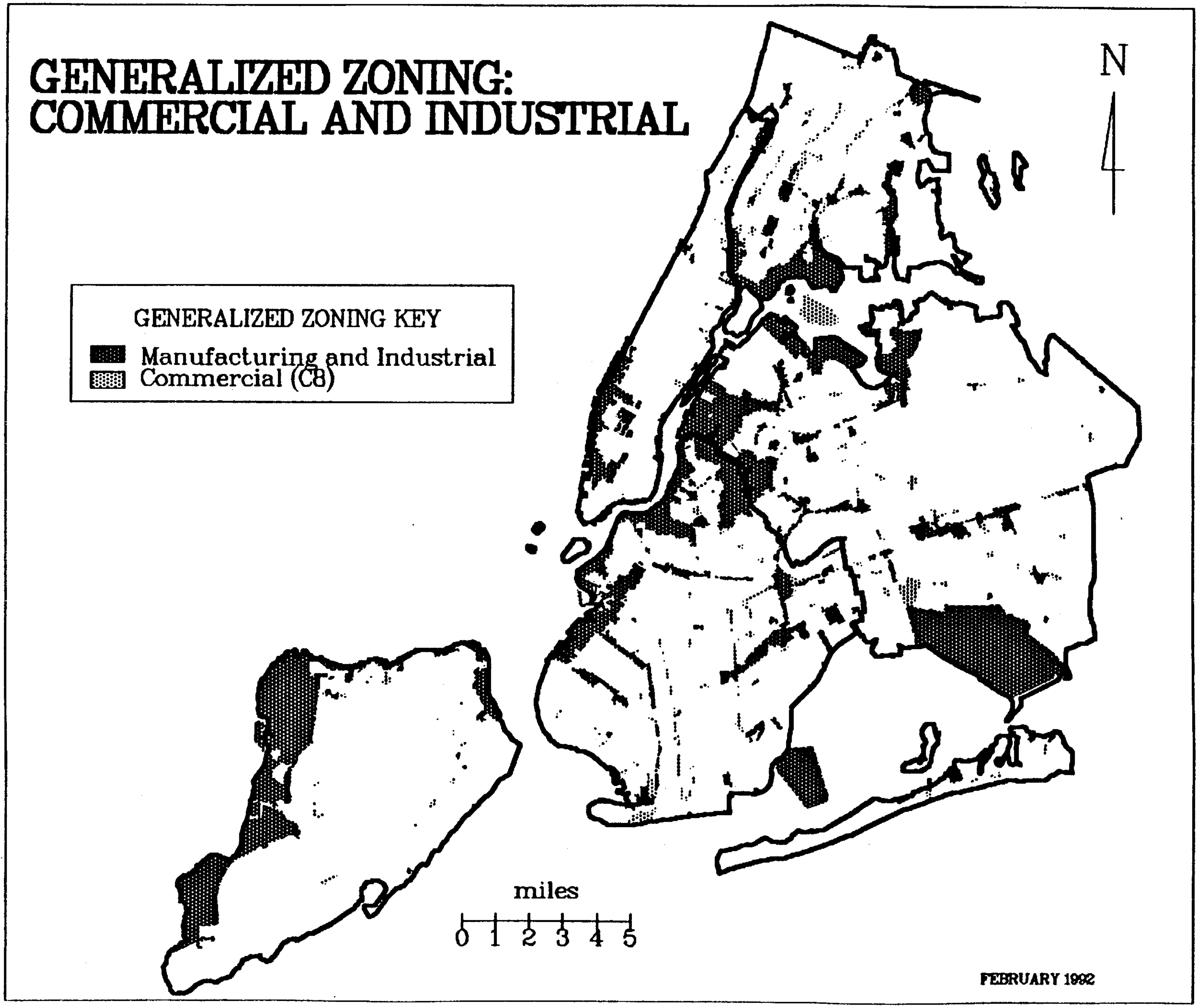
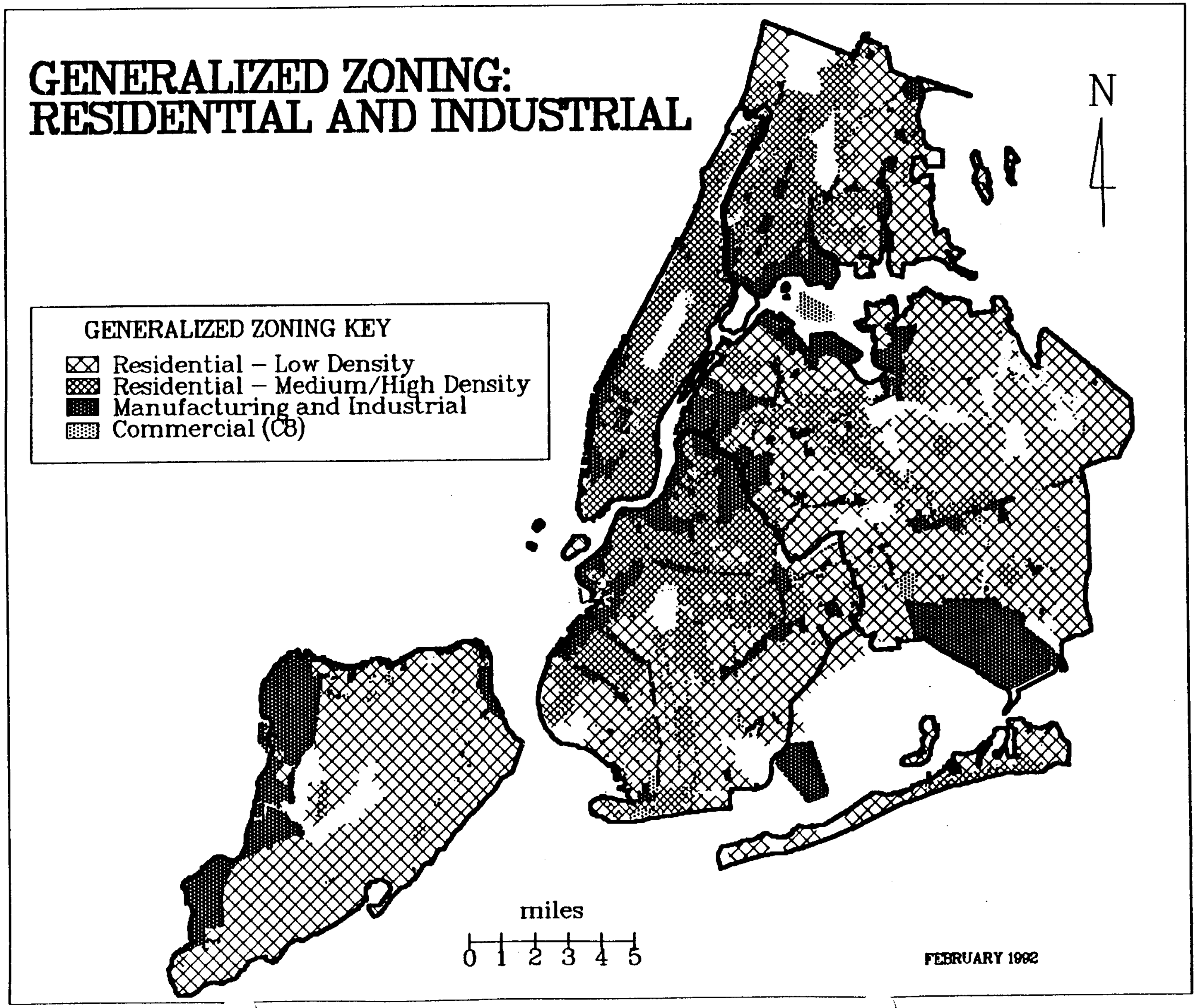


Figure 13-3: Generalized NYC Zoning: Residential and Industrial.



The DEP siting analysis used a combination of two techniques: a "top-down" approach, in which the entire New York State region within two days' driving distance of New York City was "screened" through layers of siting criteria (in a way analogous to the generic approach described above), and a "bottom-up" approach, in which a pool of specifically identified candidate sites was evaluated to determine their relative suitability.

In its evaluation of sites within New York City, the DEP focussed on industrially zoned sites. (The evaluation was limited to processing sites -- as opposed to "final deposition" sites -- because, as in the more general assessment described above, it was determined that there were no appropriate areas in New York City large enough for siting a landfill or other type of "land-application" facility.) Vacant industrial sites over three acres in size (the size determined to be the smallest feasible site, including requisite buffer areas, for any New York City processing facility) were ranked by three criteria. From most- to least-important, these were: category of industrial zoning (M-3 was preferred over M-2, which was preferred over M-1); ownership (public ownership was preferred over private); and size (the bigger, the better). 73 such sites were identified in the city. More of these are in Staten Island (33) than in any other borough; the Bronx has the next-highest number, followed by Queens, Brooklyn, and Manhattan (which has only 2).

In its evaluation of sites outside the city, the DEP likewise used both an inventory-evaluation approach and a "top-down" screening approach. The inventory of candidate areas included those identified in previous studies and those identified by canvassing government agencies and private firms in the State. The original universe screened in the "top-down" analysis included all areas in New York State that could be reached within two days by truck, or that were on transport corridors served by rail lines or barge access. On the basis of criteria related to sensitive land uses (areas of high population density, airports, government land, parks, and mineral and energy resource areas were all avoidance criteria), hydrology (primary water supply areas, principal aquifiers, surface water), geology (depth to bedrock), soils (agricultural districts, prime agricultural soils, soil characteristics, slopes), wetlands, and areas with endangered species, 35 U.S.GS quadrants (representing 11.5 million acres) were identified for more detailed analysis. These 35 were then narrowed to a pool of 12 preferred regions.

Waste-sheds. A final set of siting considerations concerns the cumulative or interactive effects of a network of facilities. The most fundamental siting unit, for waste-management purposes, is a waste-shed. A waste-shed, an analogue of a drainage district for a sewage-treatment plant, is the geographic area "feeding" a particular facility for a particular type of waste. Each waste type requires its own waste-shed. Fundamental decisions flow from the division of the universe of waste generators in the City into waste-sheds: the number of facilities of a particular type that must be sited, the regions within which each facility should be located, the sizes of the facilities, and the transport distances involved. But this "flow" of decisions is not at all one-way; rather, decisions about the size of waste-sheds are based on all available information concerning technology requirements, facility economies of scale, the availability of suitable sites, and environmental impacts. Waste-shed decisions, then, are an attempt to make the "best fit" between all of these factors: they are the outcome of compromises made to balance competing objectives.

The model used for creating waste-sheds was the following:

Step One, as in all other phases and aspects of developing this plan, entailed assembling the necessary and feasible universe of building blocks, e.g., the viable facility types and sizes, an understanding of waste generation and composition patterns with reference to the geographic location of generators, an understanding of collection and transport logistics and costs, and an inventory of potentially suitable regions from a land-use and environmental-impact perspective.

Step Two involved assembling these blocks with a view to maximizing the attainment of the most fundamental objectives. The most fundamental objectives for this plan overall are minimizing costs and adverse environmental impacts. In the creation of waste-sheds, these general objectives together create one focussed priority: minimizing transport distances, since transport is the single most costly and environmentally degrading element of the overall waste-management system, and since, in general (though not in every specific instance, which can vary depending on site-specific circumstances as well as on facility types and type of impact) smaller-scale facilities may create lesser environmental impacts. Sensitivity analyses conducted in the course of scenario evaluation show that the economic benefits of reducing travel distances far outweigh the economies of scale associated with larger, more centralized facilities. (Collection costs could be on the order of 20 percent higher, while the economies associated with larger facilities would be on the order of five percent.)

Step Three involved trying to "fit" this impulse for disaggregated waste-sheds onto the geographic and environmental constraints of the city. The awesome competition for space in New York City creates constraints that greatly limit the number of potentially appropriate sites. And acreage requirements for relatively small-scale facilities could be about 15-20 percent greater than for larger-scale facilities. These factors make desirable a system of transfer facilities as intermediate nodes between collection vehicles and processing facilities, since transfer stations provide a way of mediating between the desirability of short transport distances and the difficulties of finding a sufficient number of sites.

The fact that the city already has a system of marine-transfer stations thus became an important "given" in the creation of proposed waste-sheds. A barge-transport system has the further considerable advantage, in a multi-facility, "utility-type" system, of being a cost-effective way of absorbing an "overflow load" at a particular facility in a "surge" time by "distributing" it to other facilities. (It is much easier to "micro-control" daily shipments of waste by barge than by truck.) In this way, the amount of excess facility capacity that is required at any one facility can be reduced. An additional advantage of barge transport (as is also the case with rail transport, which makes access to rail lines another siting consideration) is that flexibility of transport modes can reduce costs and make the system less vulnerable to specific problems related, for example, to accidents, construction, adverse weather, or labor disruptions.

<u>Step Four</u> involved "checking" these proposed waste-sheds with an analysis of their cumulative or interactive environmental impacts, the most important of which (since certain impacts, e.g., noise and odor, do not, by their nature, lend themselves to the generation of cumulative concentrations) are traffic and air. These analyses showed (as described in Chapter 17, "Environmental Impacts") that, largely due to the dispersed nature of facilities in this combination of waste-sheds, the impacts from "overlapping" facilities would be negligible.

Maps of the proposed waste-sheds for various types of waste are presented in Chapter 15.

Endnotes

1. Another siting requirement that would preclude the development of new landfills within New York City is that landfills must be sited 10,000 feet -- nearly two miles -- from an airport runway used by jet aircraft, in order to minimize the hazards to aircraft posed by birds.

CHAPTER 14. IMPLEMENTATION FACTORS AND ALTERNATIVES.

A detailed discussion of the legal and institutional issues pertaining to procurement, permitting, financing, contracting, and scheduling is presented in Appendix Volume 2. So is a discussion of the various institutional alternatives for particular programs and facilities and for overall systems (i.e., public versus private operating, ownership, and financing structures; the use of authorities). A more general discussion of the most significant issues from a planning perspective (as opposed to a project-specific implementation perspective) follows.

14.1 Collection-System Implementation Alternatives.

There are two fundamental issues related to collection-system alternatives. One is whether the collection system should be publicly or privately controlled. The other is how collection fees to the waste-generator should be structured. Within each of these "macro-alternatives" are a myriad of "micro-choices."

With regard to the choice between public and private collections, these micro-choices concern:

- how the line between public and private is drawn (by waste-generator sector, type, or size; by geographic area);
- the level of disaggregation of generator units and the degree of geographic overlap between collection routes for different types of generators;
- the degree of competition between private firms and/or between public and private operations; and
- whether private collection operations should be based on franchises, contracts, or subscriptions.

With regard to the choices for structuring user fees, the micro-choices involve:

- how charges are tied to the amount and kind of wastes generated (e.g., quantity-based user fees versus flat rates) and to how the wastes are set out for collection; and
- how these charges are assessed, collected, and monitored (e.g., "bag and tag," computerized bar codes, taxes, oversight bodies).

14.1.1 Public versus Private Collection Systems.

Since 1916 (after decades of flip-flopping between either/or systems of municipal or private MSW collection), the City of New York has simultaneously maintained two types of collection operations: public collections for residential and non-profit waste generators, and private collections for commercial waste generators. Many arguments have been advanced over the years for the efficiencies of private collection systems; their effectiveness is reflected in the tide of privatization that has risen in the rest of the country. New York City not only has by-far-the-largest municipal collection force, but it is the only city in the country that offers collection service to high-rise residential buildings, and one of the relatively few cities that offers free collection to non-profit institutions.

New York City does not charge waste-generators directly for refuse-removal or -disposal services; instead, these services are funded out of general tax revenues. Since the many non-profit entities in the city (churches, schools, hospitals, nursing homes, etc.) do not pay City taxes, their collection services have been free. In 1988, however, in connection with new regulations for handling medical wastes, the City began to charge hospitals on a volume basis for the non-regulated ("black-bag") wastes that it collected from them. In 1991, the City extended those charges to nursing homes as well. There are reasons that would argue for extending these charges further, to all non-profit institutions. In 1991, the City considered imposing waste disposal charges on those non-profits receiving municipal sanitation services. However, after weighing the benefits to the City versus the cost to the non-profits, the City decided not to impose these charges at this time.

Another waste-generating sector that might be severed advantageously from the current municipal operations might be high-rise residential buildings over a certain size, or residential buildings that also receive commercial collection service due to the fact that commercial establishments are included in the building. Other alternatives for providing a split between public and private collections would be: to allow private collection in certain geographic areas of the city (either high-density or low-density, depending on the relative economics of the different collection systems); to divide between types of collection routes (automated collections could be handled by one force and manual collections by the other); or to divide on the basis of refuse types (one force could pick up certain types of source-segregated materials, or from generators that produced waste composed of predominantly one type of material, such as food waste from restaurants).

Alternatively, public collections could be extended to commercial waste-generators, again, by generator type, size, type of material, type of collection system, geographic area, or on routes that could be made more efficient by combining formerly distinct routes.

Decisions about which type of collection system should be used in which instance should be based on an analysis of which system is most efficient in terms of cost, and in terms of environmental impacts (which will largely be a function of the relative number of miles travelled). Another factor is how well the systems correspond to the structure of user fees that is in place. In Chapters 3 and 12, the relative collection efficiencies and costs of current public and private collection systems were compared. This comparison shows that there are clear efficiencies under present conditions in private collections over public collections.

Another factor in decisions on this issue should be a more general evaluation of the relative advantages and disadvantages of the structure and functioning of the public versus the private sector, so that decisions on collection systems can be structured to allow each sector to do what it does best in meeting the City's goals. One goal is minimizing fixed City capital and operating costs. Another goal is ensuring that City collection (and/or processing and disposal) costs do not increase overall, or on a per-unit basis, because only the most efficient or the least costly types of collection services have been privatized, while leaving only the most difficult services as a municipal responsibility.

The second major type of issue associated with private collection is whether it should be by:

- franchise, the system of letting one or more bidders compete for the exclusive rights to collect waste from a particular geographic area (or other distinctive "territory," as discussed above), and to directly collect the user fees for this service; by

- contract, the system by which one or more private firms is awarded a competitive contract for a fixed period of time to provide specified collection services; or by

- subscription, the system in use in New York City, whereby private carters are selected by the waste-generator, who pays a fee directly to the carter for this service.

There are advantages and disadvantages to each type of system. The primary advantage of subscription systems is the potential competition between carting firms, which theoretically should keep costs down while keeping the level of service up. The primary disadvantage with this type of system as it is presently practiced in New York City, however, is that competition between carting firms is limited (carters in many cases traditionally treating "stops" -- as their customers are known -- as proprietary acquisitions). Another disadvantage is that there may be substantial inefficiencies to having multiple firms collecting the same types of wastes on one block or from one building. Franchises offer the advantage of minimizing the degree of governmental involvement -- thus minimizing municipal costs -- while also taking advantage of the efficiencies inherent in distinct routes or types of routes. Contract systems allow the highest degree of governmental monitoring and control.

As previously noted (in section 4.1.2), the Department of Consumer Affairs is proposing legislation to authorize the establishment of a contract system in yet-to-be-determined areas of the City (although mid-town Manhattan has been proposed as the first exclusive-contract area).

14.1.2 Alternatives for Structuring, Collecting, and Monitoring User Fees.

As noted in Chapter 7, there are clear advantages to structuring user fees to reflect the quantity of waste set out, as opposed to simplying levying flat charges that do not provide the waste-generator with an economic incentive to reduce the amount of wastes generated. There also may be advantages with rates that reflect the types of waste set out, the frequency of set out, or the form in which they are set out -- any or all of which could affect collection efficiency or costs, or net processing or disposal costs. Some of these advantages might be achieved through building modifications, to create storage areas for certain kinds of collection equipment (e.g. large containers for automated collection), for sorting (e.g., separate areas for different colors of glass or grades of paper), for processing (e.g., compaction or crushing equipment), or for access (e.g., truck docks or transport chutes).

User fees could be structured and collected in ways that relate to these factors. Buildings that comply with "enhanced collection" criteria, for example, could receive discounted collection service.

The technique for collecting user fees presents another range of choices: Should charges in multi-unit buildings be levied directly against tenants, or against building owners/management? Should the fees be reflected in a special line on property tax forms?

Techniques for monitoring waste generation present additional choices. One choice is a "bag and tag" system. In these systems, marked bags or tags are sold for a price that includes a fee for collection services, or a limited number of bags are distributed for free and only those bags are collected. Another choice is a "bar code" system, in which bins bearing bar-codes are weighed and the weights recorded by computer.

14.2 Alternative Institutional Structures for Developing and Operating Waste-Management Facilities.

Decisions on whether waste-management facilities should be publicly or privately owned and/or operated likewise should be made with a view to the system that offers the greatest efficiencies and lowest costs, minimizes the risks for municipal government while also minimizing fixed capital and operating costs, and apportions to each sector the roles that it is best-situated to fulfill (private-sector firms may be best situated, under certain circumstances, for instance, to market the energy or material products recovered from wastes).

Procurement options can range from the provision of private architecture/engineering services only, to "turn-key" facilities (in which a private firm takes full responsibility for designing and constructing a facility, and turns it over to the municipality for operation when the facility is completed), to "full-service" arrangements, in which a private entity is responsible for design, construction, and operation. Or a municipality can contract with a private firm simply to operate a new or existing facility that it has developed.

The full-service approach is now the most common method for developing solid-waste-processing facilities. This is largely due to the need for close integration of the design, construction, and operating phases, and the desirability, therefore, for having one central entity bear responsibility for the overall facility. A primary benefit of this approach -- a benefit for which the contracting entity pays a premium -- is the ability to establish a variety of performance guarantees for facility operation. The operating entity then assumes the risks associated with meeting these guarantees. A further benefit is that construction and operating charges are generally negotiated on a fixed basis (with adjustments for inflation).

The architect/engineering approach once was the method most governments used to procure public-works projects. In this approach, the governmental entity assumes most of the responsibilities for facility performance, and for any financial risks thus entailed. This method generally is coupled with public ownership and operation.

The turnkey approach, a sort of intermediate between the prior two approaches, allows the government entity to obtain certain performance guarantees from the private vendor, who has more latitude in developing the specifications for a facility that will meet those guarantees, and consequently bears more risk. Turnkey facilities are generally publicly owned and operated.

One of the major factors upon which a procurement decision must depend is the technological complexity of the type of facility at issue (and on whether any of the technology involved is proprietary). The architect/engineer (A&E) approach is most appropriate for low-technology facilities such as landfills or transfer stations, which generally do not involve proprietary technology nor complex operations with which a government entity does not have prior experience.

Another factor to be considered is whether to procure facilities individually or to procure more than one facility within the same process. Ordinarily, solid-waste facilities are procured one-at-a-time; in the case of A&E and turnkey facilities, design, construction, and operation contracts are awarded separately, in staged sequence. For the ensemble of facilities needed for New York City's waste-management plan, however, there may be benefits to procuring a number of facilities within the same process.

14.3 Alternative Over-Arching Institutional Structures.

In addition to the basic division between "public" or "private" ownership and operation, there are more complex alternatives for project or system financing, operation, and control.

The three fundamental financing options available to New York City are:

- government-obligation (GO) bonds (which represent the "full faith and credit" of the City, and which are paid out of the general municipal tax-levied budget);
- private equity (or privately issued project-revenue bonds); and
- industrial-revenue bonds issued by a non-profit, publicly chartered, independent agency (the NYC Industrial Development Agency, the NYS Environmental Facilities

Corporation, the NYS Energy Research and Development Authority, the New York State Power Authority, the Port Authority of New York and New Jersey, or a newly created City solid-waste-management agency or authority).

Among the other advantages of using an authority structure for facility financing is that an authority could issue bonds based on revenues from the full range of facility types within the integrated solid-waste-management system, rather than bonds that were tied to single facilities.

An advantage of GO bonds is that they minimize transaction expenses and, since they are tax-exempt, they generally provide the lowest interest rates. Another advantage is that they give the government entity the most control over the project, allowing it to terminate contracts at its convenience, or even to stop construction or operation of a facility at any point it chooses to do so, without infringing on the rights of bond-holders. A disadvantage of GO financing is that it leaves the government entity with the greatest proportion of risks.

Project-revenue bonds largely shield the government entity from financial risks, leaving it primarily responsible only for supplying a specified quantity of wastes and for paying a service fee for processing it. Most waste-to-energy facilities to date have been financed by project-revenue bonds.

System-revenue bonds have the advantages of project-revenue bonds, with the additional advantage of allowing the issuing agency to control the flow of waste between different types of facilities, as circumstances change, without penalizing the bond-holders, since their bonds are not dependent on the rate of throughput at any single facility or type of facility. They also allow the imposition of a more flexible pricing structure for tip fees at various types of facilities, so that the controlling agency can use market forces to direct wastes of certain types to certain types of facilities, or use revenues from one type of facility to subsidize the operations of another. Such a fee structure, for instance, could smooth out the fluctuations in market price for recyclable materials over an extended period. Finally, from a financing perspective, system-revenue bond issues are not limited by the bonding limits imposed on GO bonds.

Aside from financing issues, authorities offer a range of other potential advantages. One such is that an authority might be created with powers to by-pass procedural constraints such as those imposed by the City's Uniform Land-Use Review Process (as is the case with the School Construction Authority, the Urban Development Corporation, and specific projects of the Triborough Bridge and Tunnel Authority), which could facilitate facility development. A regional authority would facilitate inter-jurisdictional cooperation, and perhaps facilitate siting, as would a more limited type of institutional structure: a siting board.

An authority might also provide more flexible institutional mechanisms for instituting user fees (the advantages of which, from a waste-prevention perspective, are discussed in Chapter 7).

14.4 Alternatives for Site Acquisition.

The process of site acquisition involves the completion of three distinguishable phases: 1) obtaining a title or some lesser interest in the site, generally through purchase of condemnation; 2) clearing the way for the planned use of the site, generally through zoning changes and/or demapping; and 3) complying with the review processes governing the first two steps, which are generally the Uniform Land-Use Review Procedure (ULURP) and the City Environmental Quality Review process (CEQR).

Property may be acquired either through purchase or condemnation. Condemnation is the act by which the state or a municipality asserts its inherent police power to acquire a parcel of land to be used for a public purpose (such as solid waste management) from a recalcitrant property owner. The property owner must be compensated for the loss of the property. The City may only condemn property within its jurisdiction, and has no power to condemn land owned by the state or federal government. Both the power to purchase and the power to condemn are held by the Commissioner of General Services.

A parcel of land may not be used as a solid-waste-management-facility site if such use is inconsistent with local zoning ordinances. Zoning ordinances can be changed by an amendment, a zoning variance, or a zoning override. A zoning amendment is used to revise an old zoning plan and create a comprehensive new plan. A zoning variance is used to implement an exception to the original plan, often in the case of hardship. A zoning override is a mechanism that allows a government entity, in certain circumstances, to disregard a zoning regulation for a project that serves the public interest.

Parkland is subject to further restrictions on use, in addition to zoning ordinances. In many cases, a state legislative act (commonly called "demapping") is required to authorize the use of parkland for solid-waste-management purposes.

Any site acquisition for solid-waste-management purposes would be likely to require review under ULURP (the Uniform Land Use Review Procedure) and CEQR (the City Environmental Quality Review).

For more detailed information on alternatives for site acquisition, see Appendix Volume 2.

14.5 Scheduling Alternatives for Implementing this Plan.

Since it will not be possible to flick some switch and have all of the programs and facilities proposed by this plan up and running at the same time -- particularly since the integrated program that is proposed in the following chapters requires not only the development of many new facilities, but many substantial operational changes as well -- the elements of this plan must be developed sequentially, in an order that makes the most rational sense, and at a pace that is possible from both a capital and a logistical standpoint.

There are two basic types of scheduling alternatives. One concerns the pace of implementation. The other concerns whether different types of programs (e.g., recycling and waste-to-energy) are developed simultaneously or sequentially. And there are two primary consequences attached to decisions between these alternatives (provided that the universe of choices is narrowed to those that are practically achievable and that present no more than an acceptable degree of disruption to the existing system). The first is the effect on overall landfill requirements. (Landfills, for reasons enumerated in Chapter 11, are the one type of facility the capacity of which is limited in a way that presents other-than-financial constraints.) The second is the effect on cumulative costs.

Both of these factors were modeled using NYC WastePlan. The general conclusion of this analysis is simple: the more quickly new disposal capacity of any type is developed, the less landfill capacity is expended; net-present-value costs will also decrease, but costs are much less sensitive to the rate of disposal-capacity development than are landfill requirements. That said, there is still sufficient flexibility between alternative feasible scenarios to allow informed public-policy choices that favor alternatives which may not be the least costly or have the least effect on landfill capacity.