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RESOURCE RECOVERY THROUGH COMPOSTING AT ECOLOGY, INC., NEW YORK, NEW YORK.

AN EVALUATION PREPARED BY U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION II

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AN EVALUATION PREPARED BY U.S. ENVIRONMENTAL PROTECTION AGENCY REGION II

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November 15, 1973

PREFACE

One obvious problem facing municipal solid waste disposal is that the spatial distribution pattern of generation is nearly inverse to that of the most cost effective existing techniques for disposal. This suggests widespread, intensive reliance on transportation or on the potential of development of new technology. This report addresses one attempt at development of a technological approach, as is being made by Ecology, Inc. of Brooklyn, New York. The technology involved is composting; the attempt is to develop the economic viability of its use on municipal refuse in an inner city situation.

This report was written in response to our perception of a need for public information for resource recovery technologies which have been developed by private industry as well as those developed by the Environmental Protection Agency. This particular process was selected on the basis of proximity and number of requests for information received. In addition, Corporate Executives of Ecology, Inc. requested that this office review their process. The sources of information for preparation of this paper were site visits and interviews with officials of the developing company, accountants' reports supplied by the company, and interviews with and reports by officials in New York City Environmental Protection Administration.

The plant closed about June, 1973, during the preparation of this report. We were informed by Corporate Executives of Ecology, Inc. that the reason it closed was because of (1) lack of funds, (2) general reorganization of the company, including new refinancing, to allow the construction of larger plants, and (3) need to modify equipment in order to be self-energizing. The plant is scheduled to reopen about June, 1974.

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CONCLUSION

The composting facility owned and operated by Ecology, Inc. in Brooklyn, New York, appears to offer an environmentally sound method of disposal of municipal solid wastes. The facility employs a process which subjects raw municipal refuse to environmental conditions suitable for biological activity in such a way that natural degradation processes are accelerated, achieving effective stability within forty hours. The remains after this activity appear to be environmentally inoffensive. The cost of this process per incoming ton of raw refuse for a 600 ton per day plant is estimated by Ecology, Inc. as $5.34 operating expenses plus capital expenses of $5.80 per rated ton of capacity, amortized for 20 years at 6% plus land costs. These data indicate that the total cost per ton of refuse for the conversion process in New York City, for a 600-1000 ton rated capacity, could be less than $15.00; according to City auditor figures, this is competitive with new or upgraded incineration facilities.

If the Company's cost estimates prove to be correct, the process compares very favorably with incineration. Bulky and large ferrous wastes are removed as usual in incineration; there is little unconverted residue comparable to incinerator ash; there is no reported air pollution, the major gaseous emissions are water vapor and carbon dioxide; there is no water pollution comparable to quench water; and the versatility of the product is much greater. It still retains two thirds of its raw Btu content for subsequent use in energy recovery, and it may be used as a fertilizer carrier, a building aggregate or other saleable raw material. The cost of processing the conversion product for sale as fertilizer will permit a considerable return from sale in subsidy to the whole operation. In the estimation of Ecology, Inc. it will render a net profit as well. Processing for sale as fuel or construction material are less profitable but still self supporting.

It is our conclusion that the refuse conversion process in operation at the Ecology, Inc. facility in Brooklyn offers considerable promise as a candidate system for inner-city disposal of domestic solid waste. This conclusion was based on two assumptions, the verification of which is outside the scope of this assessment: (1) that intracity disposal is in fact desirable, as opposed to regional systems with transhipment and, (2) that the cost estimations of interviewed officials is in fact valid. It is also based upon casual observation of the system, its apparent environmental impact, its product, and on independent analyses of the product. The conclusion of this investigation are as follows:

a. The process receives municipal domestic refuse as collected, removes 15% by weight as bulky rejects and tramp iron salvage, and processes the remaining 85% to an environmentally inoffensive product in a manner compatible with urban industrial land use.

b. The product of this process is useable as a carrier for fertilizer; it also lends itself to separation into fractions which may prove useable as construction materials and as fuel.

c. The economic viability of the conversion process as presented by the Company appears plausible, and the addition of chemical nutrients to the product for sale as fertilizer seems economically sound.*

d. The process is capable of handling domestic refuse without apparent environmental degradation, and subsequent reuse of its product is no more environmentally deleterious than is the use of the materials for which it may substitute.

*No definitive economic conclusions should be based on this investigation, however, since company cost and market projections were used without attempt at validation.

SECTION 1.0 INTRODUCTION

1.1 History

Ecology, Inc. was originally organized in Florida in 1958 under the name National Waste Conversion Corporation. It became a public corporation with its 1969 incorporation under Delaware law and changed its name to Ecology, Inc. In 1961 the company installed the first pilot plant, a one ton a day unit at Manhattan College, Civil Engineering Department, in Riverdale, New York. The College made available their laboratory facilities in conjunction with an experiment they were performing on biological oxidation of liquid wastes, and contracted with the Company to provide equipment for observing biological oxidation of solid waste. The contract ran for eight years, after which the equipment was moved to a spare room at the present facility at 221 Varick Avenue. During that period the Company assessed the feasibility of the process and filed their patents. Some basis for cost estimation were developed during this period, and limited investigations were done into marketability of compost. The conversion process in use today is nearly identical to the early process operated at Manhattan College, based entirely upon the patents that were filed in 1961 and granted in 1966.

In 1969 the Company put together the format for their present operation, including the building layout and facility design for this particular site, and negotiated loans with the United States Economic Development Administration (EDA) and Manufacturers Hanover Trust Company. Ground breaking at the Varick Avenue site (Figure 1) was September 11, 1969, and they began moving equipment into the building in May of 1970, about eight months later. The first load of refuse was received in July of 1970; the next six months were devoted to debugging the flow process. The early periods of operation were devoted primarily to product improvements since the intention was to derive the primary revenue from sales. As metropolitan disposal costs went up, more and more attention was devoted to improving the disposal process. Since June 1972 they have been handling on a fairly consistent basis 25 tons a day of New York City's refuse with a smaller and smaller residue or reject fraction. A contract was signed in September, 1972 with the City of New York to handle up to 150 tons a day, and the intentions are now to approach that figure by 1974.

EDA loans were contingent upon locating within designated impact areas. Site selection was therefore limited to the Brooklyn Navy Yard and some adjacent property. The Company's original selection was Building No. 292 on the Brooklyn Navy Yard but the City did not take title to this property until much later and so their lease was not honored. They then looked for M-3 zoning within the designated area adjacent to the Yard. Zoning and land use maps of the Williamsburg Area are shown in Figure 2. The present location described in Section 2.4 (page 21), was the only site available. It was not originally for sale so they accepted a 21 year lease, which was acceptable to EDA. They later purchased the site. The site has navigable access which could provide direct rail service, delivering additives and transporting the marketable products from the plant. Lighterage is included in the rail haul freight rates throughout the New York Metropolitan Area. The river channel capacity allows 4,000 ton barges to load freight for rail transit south along the Eastern Seaboard so as to spread seasonal demand.

This brief summary of a history reflects an uncharacteristically smooth beginning for solid waste processing facility start-up. Much of this is due to the opportunity afforded by the EDA development of the Brooklyn Navy Yard. There was little or no site opposition during this period of intensive build-up of the area with light and medium industries. Access to capital was facilitated and several other traditional road blocks to the start-up of new industries were avoided.

The purpose of the EDA involvement, of course, was to stimulate the hiring of unskilled workers living in the area. This was willingly done by the Company and has proved to be of little deficit. Every person on the plant staff was brought on originally as an unskilled laborer at minimum wages of $2.50 an hour, including the plant foreman, the mechanics and all the craft trades. During the first year of operation the turnover rate was 40% or less, and nearly all those who remained after the first year are still with the Company.

In 1959 the Corporation made their first overture to the City of New York. The discussion lasted for three years, and by 1961 they had a fairly detailed contract negotiated, but the City was not faced at that time with the same pressures and prices for disposal services that they are today. Also there was no evidence that the process was reliable. All that was in existence was a pilot plant at Manhattan College. During the intervening ten years the discussions remained

Figure 1

Plant Location

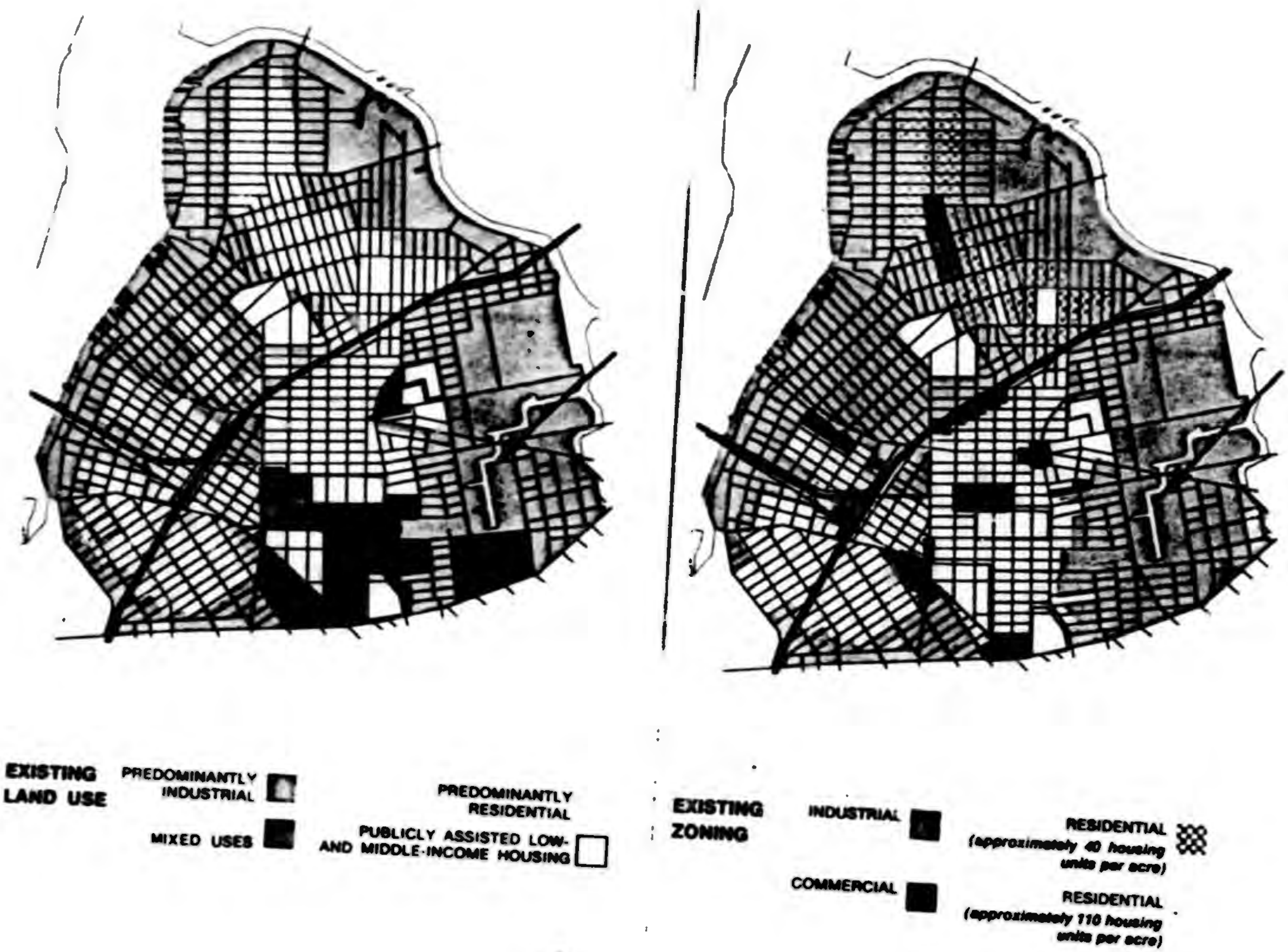
open but no refuse was received from New York City. In fact they imported their refuse from Broomall, Pennsylvania where a shredder manufacturer was paid to pick up raw domestic refuse from a local incinerator, shred it, and ship it fresh to New York. The first shipment of New York City refuse was received by the Company in July 1970; the arrangement at that time was an on-call basis with no money involved. When the Company needed refuse they called the City and deliveries were made. This system stayed in effect until August, 1972, when they signed their present contract. It provides payment of $4.50 per ton up to 150 tons per day, with the City providing free pick-up for the 5% bulky extract. The City has computed this fee on a basis of the reduction in haulage cost from the immediate vicinity of the plant to the nearest disposal site. This contract went into ef ect for payment in October 1972. There is a verbal understanding between the Company and the City that when capacities of the system have reached a point of 1,000 tons a day that the Company will be eligible for the same offer that Monsanto was made, that is, $12.50 a ton on a guaranteed receipt basis. A request for proposal dated February 13, 1972 from the City confirms that the system is under consideration as one of several 1,000 TPD systems be demonstrated under an arrangement wherein the City would purchase the facilities and lease them back on a service fee basis.

1.2 Present Status of the Organization.

Ecology, Inc. is today a corporate entity established under the laws of the State of Delaware. It is wholly self sustaining, attempting to support itself solely by sales receipts and disposal contracts. It employes 49 full time personnel plus four part time or temporary employees. The Company is authorized by charter to issue 3,600,000 shares of which 1,527,540 have been issued. At the end of 1972 the Company had current liabilities of $3.2 Million and current assets of $100,000, and had intentions of offering for sale $2.75 Million worth of shares. A successful return on this offering will permit Company continuation. Much is dependent upon a profitable market situation during the next season. The Company spends a considerable portion of its time and energy upon market analysis and product research. The plant appears to have been considerably debugged during the period of closure in the Spring of 1972. Since the commencement of the New York City contract in the Fall of 1972, the plant has had an increasingly stable operation and production schedule.

Figure 2

Williamsburg Development Plan



Ecology, Inc.

Chemical additives and other supplies are purchased by the Company on an as needed basis, COD. Fertilizer distribution is handled essentially through area distributors both wholesalers and retailers. Although market analyses have indicated a potential demand for the conversion process product, called Stabilate, as a fuel, and as an aggregate for construction materials, the Company has as yet received no proceeds from the sale of Stabilate for these uses. The Market potential does appear favorable, however, for production for specific use fuel, for instance, institutional boiler fuel. Pelletized for use as a fuel, the material is fairly light weight, clean, and has reasonably good burning characteristics. While not as high as coal or oil in Btu content, the ash residue, and particulate emissions are likely to be similar to coal and it will have a low (0.1%) sulfur content; its fuel value has been estimated at around $3 to $4 per ton. Its utility as paper board aggregate is nearly identical with that of paper, and its value as a paper replacement is estimated to be about $25 per ton; its value as a construction material aggregate on the same basis is estimated by the Company at about $19 per ton.

While the productivity of this plant seems to have stabilized, it was impossible to determine, in the few site visits made in connection with this paper, the reliability of the system. The Company states that there have been no periods of significant duration during which the system was inoperable, and claims that the preventive maintenance activities, the standardization and stockpiling of parts, and the on-site ability to disassemble, repair and reassemble all components without serious process disruption preclude unscheduled down time.

At the end of March 1973, General Electric acquired a process license from the Company for the use of the Company's biological oxidation process. Under the agreement General Electric and the Company will submit joint proposals for construction of the Company's solid waste conversion plants throughout the United States. The plants will be operated and the products will be marketed by General Electric. The Company granted General Electric options to purchase up to 30% of the Company's outstanding shares. This involvement dates back to June 1972, when General Electric made a preliminary review of the Company's plant operations, products and market development. At that time General Electric made a proposal to the Company to analyze the markets and the plant operation; under the terms of this agreement, General Electric sent teams of plant operations and marketing specialists to work with the Company's staff to assess as well as to attempt to improve the operation. The General Electric employees worked on-site throughout the Fall of 1972 in cooperation with the Company's staff, making suggestions for improvement of the operation, and analysing the propects of the facility in the context of its national potential. The General Electric staff has also accompanied the Company's personnel on trips to several communities including the Town of Greenwich, Connecticut, and New York City; presumably General Electric will direct some portion of their activities in the field of resource recovery towards investigating the potential of the Company's system.

1.3 - Market, Constraints, and Corporate Posture.

The Company's intention is to produce saleable products which use domestic municipal refuse as a raw product. The intended market presently is the retailing of fertilizer, fuel, and construction materials. Refuse is received and rendered inoffensive by stimulating biochemical action, producing Stabilate, which is used as a vehicle for chemical nutrients, as a fuel, or as a fine aggregate for construction materials. This Stabilate is classified into five categories by the Company according to its characteristics and intended use. Some characteristics are given in Table 1 on page 10. Generally, Stabilate I is the untreated product of the digester and may be used directly as a fertilizer carrier or may be processed into Stabilate II or III. Stabilate II may prove to be useful as an aggregate in bricks or blocks. Stabilate III is used as fuel or soil conditioner or may be separated into Stabilate IV for heavy fiber board, and Stabilate V for light. See the Flow Diagram in Figure 4, page 17.

When the Company originally began their investigations, the disposal fees for domestic municipal refuse were low. Subsequently increases in intra-city disposal costs and in the cost of pollution control tend to offset the increases in cost of production due to inflation, and for over-estimation of the market demand for the products. It is presently anticipated that disposal service will form a major portion of the Company's revenues. The realization of this has precipitated the only change in the Company's intentions since its early inception. It is now the Company's intention to accept all domestic refuse and process it as completely as possible. The corporate posture regarding each of the four potential sources or revenue now being considered will be discussed in the following paragraphs:

a. Disposal Fees. The facility's compatibility with heavy industry land uses is an important factor in determining locational acceptability. Unlike many traditional forms of disposal, these resource recovery facilities do not require a disproportionately large land area, they have no visible effluent, and they are not generally obnoxious neighbors in land zoned for heavy industry. This would permit inner city locations, achieving a competitive advantage in terms of haulage and transportation fees over those types of disposal facilities which require larger area. For instance, the present location of the Company's facility enables New York City to pay the present contract amount of $4.50 per ton without reliability. Since the intermittent nature of the contract would not permit New York City to reduce its necessary disposal capacity, the only basis upon which a fee could be negotiated was upon the City's own computations of the haulage costs between the end of the collection route and transfer or disposal facilities. It is upon this basis that $4.50 per ton was decided as a fair rate for the small interruptable service presently provided.

The design of the facility and its modular composition do not permit great economies of scale beyond one thousand tons per day capacity according to the Company, so that dispersion of these plants is, at this point in their investigations, feasible. This dispersed municipal configuration in an intensely developed megalopolis will permit the most flexible provision of disposal services; this process may be incorporated with others in a city's system. The corporate posture regarding provision of disposal services is in full recognition of the flexibility provided by the economies of the 1,000 ton a day plant capacity. Since characteristics of a 1,000 ton a day plant are nearly indistinguishable in a heavy industry land use pattern, it is superficially evident that much of the 26,000 tons a day disposal capacity of New York City or that of any major metropolitan area with a fair distribution of industrial zoning would lend itself to relief by this approach. Those metropolitan areas whose spatial distribution patterns are less adaptable for these purposes could discover through analysis some lesser extent of dependence upon the method, integrating it into their existing system, while retaining alternative disposal techniques where existing land use is incompatible or when markets are not identifiable.

As shown in Table 1, page 10, the true specific gravity is greater than one. This could be significant if marine disposal were contemplated, but obviously the material would need some form of restraining cover since many particles (e.g., styrofoam) would not sink. It should not be anticipated that any appreciable quantities of Stabilate will require disposal, however, since there are cheaper methods of pretreating refuse for disposal.

While no attempt has been made to provide sludge disposal at this facility, the credit to composting at the Environmental Protection Agency's Johnson City, Tennessee, plant was estimated at $0 to $1 per ton of re-refuse processed. The prospects for including sludge handling appear favorable at future facilities.

b. Fertilizer. The conversion process end product, Stabilate I, is basically clean, easily stored and transported. It is enriched so as to contain specified minimum percentages of nitrogen, phosphorous and potassium and qualifies under most state laws as organic in that a certain part of the nitrogen is in slow release form. The Company intends to produce a whole range of fertilizers, ranging from manure substitutes through high-analysis compounds such as would be used on lawns, gardens and shrubbery. The flexibility of formulation extends from unenriched compost (less than 1-1-1) to highly enriched organic fertilizer with nitrogen units covering the entire range of the intermediate formulae. The production will be determined by market requirements independent of the content of the raw material or the refuse handled. The average fertilizer product bulk density is 35 pounds per cubic foot.

Tests performed at the Department of Agronomy, of Penn State University* indicate that this fertilizer compares favorably with Scott's Turf Builder and Borden's as a lawn fertilizer. Three Ecology formulae were tested and found to prodice no appreciable "fertilizer burn" and, as shown in Figure 3 on page 11, very comparable color and growth (measured in clipping weights).

c. Fuel. The conversion process as presently configured produces five classifications of Stabilate. The characteristics of these classifications are shown in Table 1 on page 10. Only the designation of Stabilate III has been proposed for use as fuel. According to General

*Waddington, Duich and Moberg, Progress Report 327 Evaluation of Fertilizer Containing Composted Refuse, Penn State University, May 1972.

TABLE 1

STABILATE CHARACTERISTICS

Stabilate Grade	Bulk Density (lb./cu. ft.)	Moisture	% Retained on Sieve No. 6	8	10	12	20	pan
I	15-20	4-6	15	5	10	40	10	20
II	30-40	8-10	15	10	5	60	5	5
III	8-12	3-4	30	35	5	5	5	10
IV	To be determined for product specifications.							
V	Dependent upon IV. (V=III-IV)							

Results of the calorimetic tests run on Stabilate III by New York University's Civil Engineering Department are as follows:

BOMB CALORIMETER

Gram Sample	Charred Residue	Btu Per Pound	Moisture
.0556	.0245	7566	7%
.2470	.0538	7500	7%
.4065	.0890	7725	7%

BARNETT TEST

Washed Sample: 7841 Btu per pound

Ash Weight: 0.0897

Sample Weight: 0.0178

Whatman Filter Paper: 7,445 Btu per pound

OTHER CHARACTERISTICS

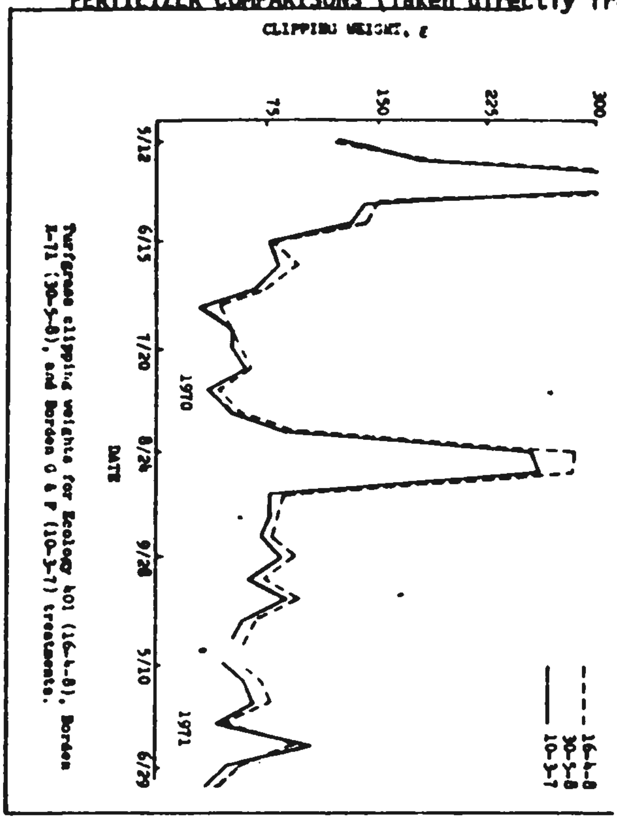
Specific Gravity: 1.66

Moisture: 6.5%

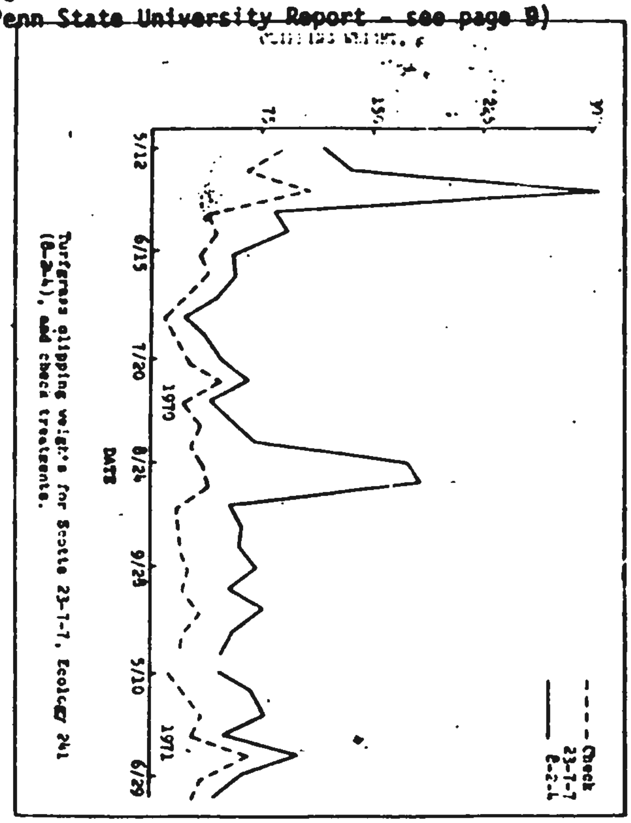
Fiber Length: 0.6 to 1.0 mm average
20 to 35% is less than 0.2 mm
20 to 40% is between 1.0 mm and 3.0 mm

Figure 3

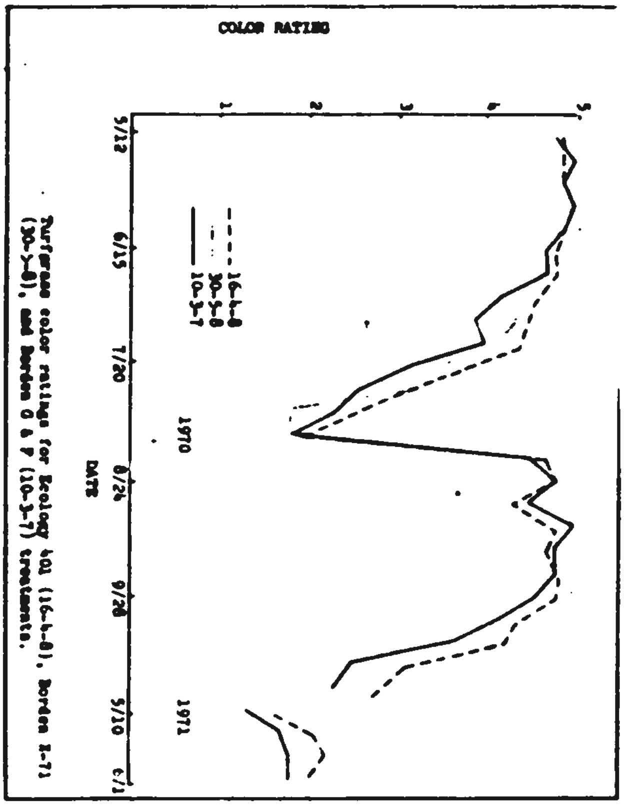
FERTILIZER COMPARISONS (Taken directly from Penn State University Report - see page 9)



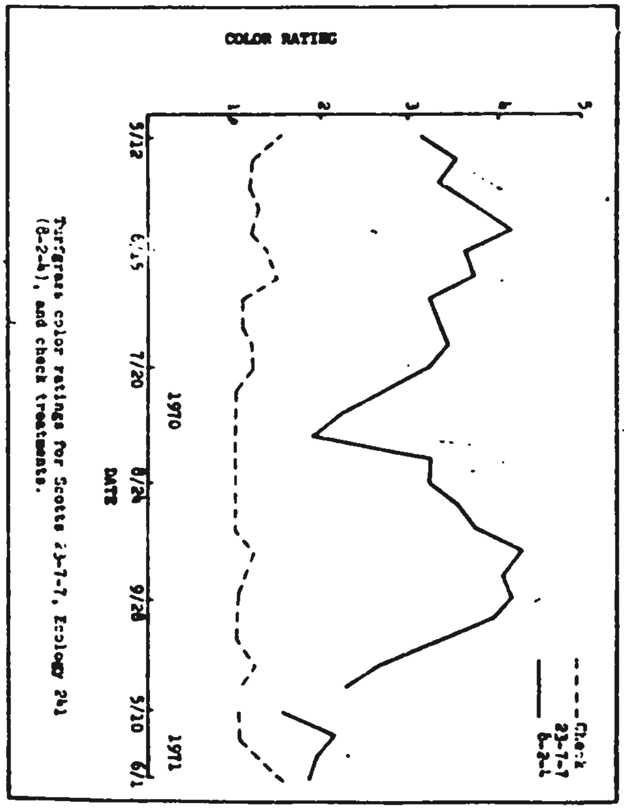
Turfgrass clipping weights for Ecology 401 (16-4-8), Borden Z-71 (30-3-8), and Borden G & P (10-3-7) treatments.



Turfgrass clipping weights for Scotts 23-7-7, Ecology 241 (8-2-4), and check treatments.



Turfgrass color ratings for Ecology 401 (16-4-8), Borden Z-71 (30-3-8), and Borden G & P (10-3-7) treatments.



Turfgrass color ratings for Scotts 23-7-7, Ecology 241 (8-2-4), and check treatments.

Electric computations, if all of the refuse collected in the United States were to be converted to Stabilate III, less than 5% of the electric power demand could be satisfied.

On the basis of calorimetric tests performed by New York University for Ecology, Inc., Stabilate III as produced by the existing plant has an average heating value between 7,000 and 7,500 Btu per pound. The raw municipal refuse as received has an average of 4,700 Btu per pound. Stabilate retains 2/3 of the total heating value of the raw incoming refuse and 1/2 its weight. This compares with approximately 12,000 Btu per pound for anthracite coal, and 18,000 Btu per pound for fuel oil. Stabilate III's combustion characteristics seem most adaptable to the market comprising institutional and large scale residential boilers now served by coal, since only at such smaller furnaces would storability be worth the processing costs. Storage and handling facilities would be similar, and pollution abatement problems would be less expensive, as would the cost per Btu. The effluent loadings would be low in sulfur and most other gaseous pollutants, but as high or higher in particulate content. Ash residue would be greatly increased, and provisions for its handling may be difficult in some facilities. Stabilate III's utility for large power plants and other burners with high performance fuel requirements would be notably less than that of coal and oil. It is not clear that its advantage over shredded refuse would even warrant investigation, considering processing costs.

Matching these limits to the market for the use of Stabilate III as fuel, the Company projections indicate a higher return for the use of Stabilate I as fertilizer and II, IV and V as paper board and construction materials. Therefore, the Company's intentions are to satisfy the demand for fertilizer and aggregate, first and then produce fuel. General Electric studies show, for instance, that for the economic situation in New York City, Hartford, Philadelphia and Los Angeles in 1965, the outputs should be allocated as follows: Seven 1,000 tons per day plants would produce fertilizer, 20 would produce paper board and construction materials and 130 would provide fuel. If each of these 130 plants were to generate 500 tons per day of bio-stabilized refuse, the net megawatt output would be 20 per plant; thus, the total for these 130 plants would be 2,600 megawatts, only a fraction of the power demanded in these areas. In terms of heating energy supplied, with a heating value of 7,000 to 7,500 Btu per pound at 7% moisture, with 130 plants generating 1,000,000 pounds per day each, or a total of 130 million pounds per day, the total energy produced would be 910×10^9 Btu. For comparison purposes the City of New York at present has over 400 schools and other city facilities which purchase at least $4,736 \times 10^9$ Btu per year of coal. This alone would count for three times the quantity produced by the 130 plants. Large apartment building complexes with their own boiler facilities, hospitals, and many smaller industries would be prime targets for sales efforts in this regard. It is important to note, however, that to date there has been no attempt to burn Stabilate III outside the laboratory. Trial runs will certainly be needed to determine suspension and ash characteristics, handling problems, and the adaptability of coal storage and feed mechanisms.

The value in terms of heat of this Stabilate III is estimated at $14 per ton delivered. This revenue would have to cover any portion of the conversion process not covered by the disposal fee, yet permit the user to meet the cost of transportation to the furnace, plus any storage fee at strategically located storage areas within the City, plus the cost of conversion of coal storage hoppers to larger compost storage and larger ash storage, and the cost at each facility of converting so that Stabilate III could replace coal or oil or whatever is now being used. The cost of emission control equipment which would have to be upgraded or adjusted to handle particulate emissions anticipated would have to be weighed against the cost of upgrading some or most of these sites to conform with sulfur emissions control requirements. An engineer with the New York City Environmental Protection Administration has calculated that this usage of the refuse is competitive with the usage of raw refuse directly as a fuel in these smaller facilities. His rational is based on computations showing the net value of bio-stabilized refuse FOB plant would be between $3 and $5 per ton (or $1.50 to $2.50 of originating raw refuse) considering the cost of transportation, storage and conversion. The value of raw shredded refuse is between $2 and $3.30 per ton, which is the price that Consolidated Edison is offering to New York City for the heating content of raw refuse for steam generating facilities.

d. Construction Materials. The Company has investigated the use of Stabilate as aggregates for such products as fiberboard, cardboard and paper. The total annual demand for which Stabilate is competitive in paper board and construction materials is estimated to be 4,343,000 tons in New York City, Hartford and Philadelphia. If it is felt that 15% of the market is within the reach of these plants, then five of them would be able to handle the market in these three cities altogether. General Electric has also done some quantity estimation which indicates that nationally and regionally the amount of Stabilate available for paper board and other construction materials, if all the refuse were to be converted to Stabilate, would greatly exceed the demand. For instance, in 1970 nationally 752,000 tons of Stabilate would be required to produce construction materials in the range of 70% to 80% Stabilate by weight. The annual supply of Stabilate, however, would be 37,609,000 tons. Little other data is available at this time for analysis.

SECTION 2.0 - PROCESS TECHNOLOGY

The raw refuse presently received and processed at the plant is collected by the City for incineration. The routes served are primarily the residential routes in the areas adjacent to the plant. No unusual attempt is made to exclude bulky items, but rather anything that is left on the street for collection which the collectors are willing to pick up and put into the hopper of a compaction truck is brought to the facility. The City has chosen to hold itself responsible for retrieving and disposing of whatever miscellaneous bulky wastes are not marketable (usually 5% by weight). The tramp iron (usually 10%) is removed by a dealer without reimbursement. Hopper dimensions and other hardware constraints at the present facility limit the entry size of bulky waste receipts to a maximum dimension of 3' x 2' x 1'. In the present facility the truck loads are dumped on to a platform, and the refuse is pushed into the hoppers using a small front end loader. This arrangement permits extraction of refrigerators, large rugs, bowling balls, or other items which may damage the hopper and the shredding mechanism, but any preferred system could be adopted for use compatible with the process.

The following is a loose description of the apparatus contained in the present facility, which is designed so that it may be increased in capacity through modular addition of standard size units. Essentially there are three basic elements to the process, the first being the shredding segment, the second being the digester or the bacteriological segment and the third being the product finishing portion of the plant. The first and third segments are designed for eight hour operation per day, the middle stage, of course, is designed for a twenty-four hour operation. The first segment is composed of the above-mentioned feeder process, with the dumping platform and front end loader, and two parallel lines, each with a hopper and two shredders in series connected by conveyors and magnetic separation devices. The second segment, the digester apparatus, consists of superposed, stationery decks on which the composting material is turned over by mechanical rakes which move it along the deck horizontally where it drops to the next lower deck. The height of the composting layer on the decks is maintained at an average of 12 inches; the decks are composed of a basic unit of eight stacked decks ten feet long and twelve feet wide. Each modular unit holds 14 tons for a design maximum retention time of 72 hours. The minimum effective length of a digester, determined by through-put/cost ratio, is eight modules, or 80 feet. Structurally it is considered by the Company to be uneconomical to go beyond 200 feet. The third segment is presently devoted to the manufacture of finished organic fertilizer; it consists of a screen, a dryer, compost storage, a mixer, a compactor, a granulator, a product screen, and a product storage and bagging area.

2.1 - Shredding Segment.

Access to this particular facility is awkward and not clearly marked. Trucks entering pass over an automatic truck scale where weight, tickets and billing paper work is handled, and then up a ramp around to a charging platform. Queueing space is confined; the ramp will allow only one truck at a time. Two parallel feeders, 60 feet by 8 feet and two apron conveyors 30 feet by 6 feet carry the wastes past two manual sorting stations to the primary shredders. Manual separation is designed to remove large chunks of metal, mattresses, springs, rugs, and other hard to handle items which could damage or bind the machinery; the purpose of removal is not for salvage, the wastes removed (approximately 5% by weight) are simply stored for Sanitation Department removal. Approximately 10% of the refuse is magnetically separated for removal by a broker at no fee. The two primary shredders, arranged in parallel, each have 250 horsepower motors. They shred the refuse so that about 85% is 1/2 inch or less according to tests performed by the Company, increasing the incoming refuse bulk density from 15 lbs. per cubic foot to about 25 lbs. per cubic foot, the Company claims. Particle size determinations are run on 5 pound grab samples of the product of both sets of shredders and grate adjustments can be made to achieve the optimal particle size for composting.

Conveyors transport the shredded refuse across magnetized head pulleys which remove 90 to 95% of the tramp iron, and discharge the remaining material to the secondary shredders. These shredders further reduce the particle size to the point where approximately 90% is 3/8 inch or less, further increasing bulk density to about 40 pounds per cubic foot according to the Company's estimation.

Both pairs of Pennsylvania Crusher Company shredders, similarly constructed and operated, have a single horizontal rotor shaft with swinging hammers. The design rate of all four shredders is 20 tons per hour. Each is powered by a 250-horsepower, open, drip-proof, electric motor that powers the rotor shaft by means of a flexible coupling.

Refuse is crushed between the swinging hammers and the grates. The refuse is pounded until it is small enough to pass through the grates, located below the rotor shaft. The grates are adjusted after every 200 tons so that they almost touch the swinging hammers. These adjustments tend to improve the efficiency of the shredders in reducing the particle size.

The grate openings in the primary shredder are 6" x 8". The grates of the secondary shredder, have openings that are 1" x 6". The secondary shredder grates were extended from 135^{o} to 180^{o} when it was found that no bulky by-pass was occurring. Each shredder is provided with a cover for access to the hammers and grates. Some additional data on these units as provided by the Company is shown in Table 2, below:

Table 2

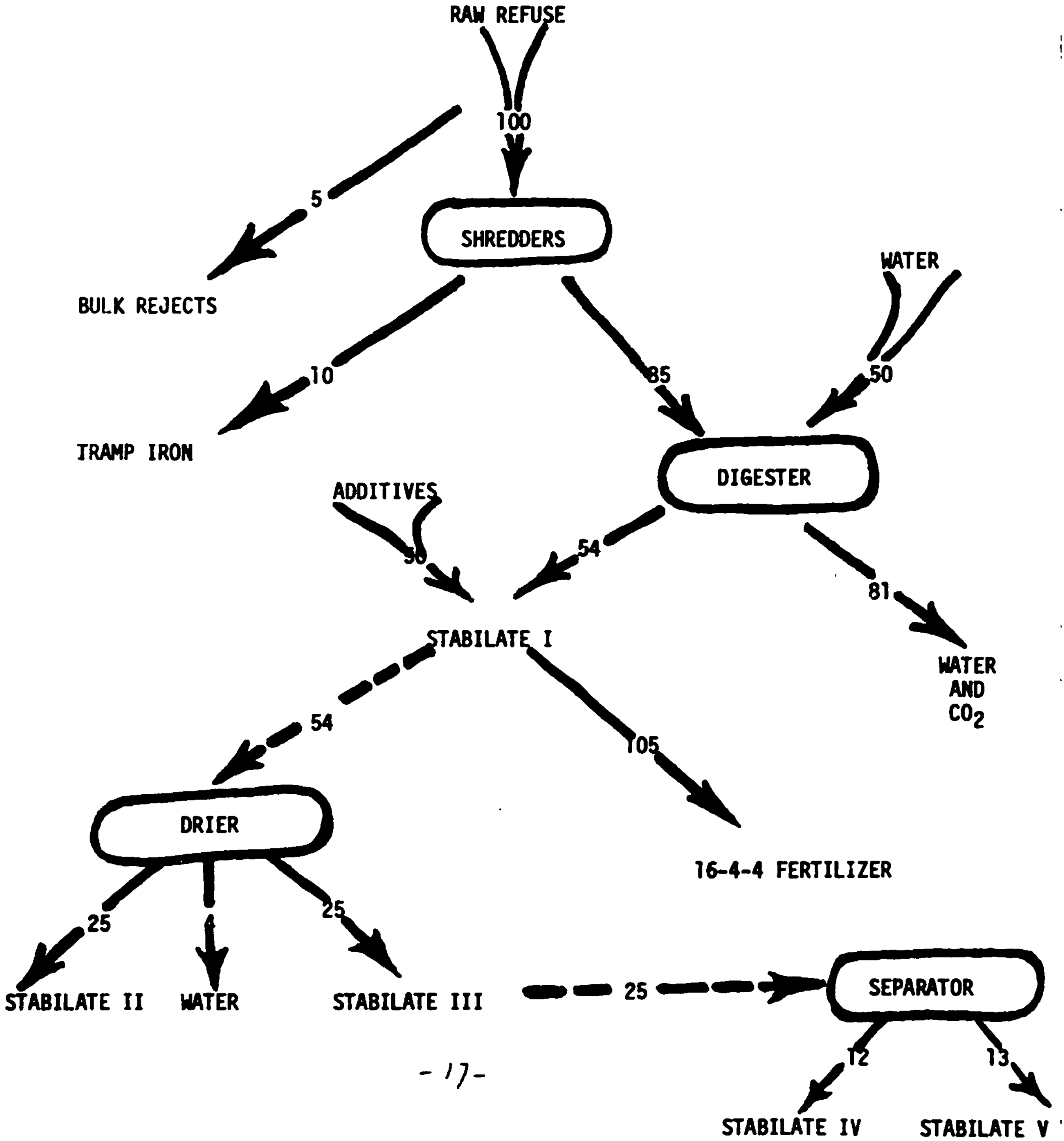
Item	Primary	Secondary
Manufacturer	Pennsylvania Crusher Company	
Number	2	2
Rotor Speed (rpm)	720	720
Capacity, each (rated)	20 tons/hour	20 tons/hour
(Operating)	12-16 tons/hour	16 tons/hour
Rotor Inertia (lbs.)	11,500	7,000
Number of Hammers	36	48
Weight per Hammer (lbs.)	70	35
Feed Opening (in.)	44 x 78	44 x 54
Grate Opening (in.)	6 x 8	1 x 6
Installation Date	May 70	May 70
Hammer Replacement Frequency:		
tons processed	1,000	1,000
Total Installed Cost ($)	72,500	68,900
Repair Cost, 1972: labor ($)	9,000	7,500
Parts & supplies	4,200	6,000

The extrapolated costs per ton shredded during 1972 is approximately $7.79. The costs per rated ton of capacity is $5.46. For the primary shredders, the hourly costs are as follows:

	$/Hr.
Operation (power, labor, etc.)	23.00
Repair & Parts Replacement	30.00
Amortization & Interest	1.50
Total for Primary	54.50

Figure 4. MATERIALS FLOW

by weight



2.2 - Digestion Segment.

The shredded refuse which contains about 30 to 40% moisture is then carried by conveyor to a storage tank, and then to the top deck of the digestor. A chain loop arrangement provides drive for a series of parallel bars which tow rakes through the compost pile. Four rakes are spaced about 24" apart on each bar. These bars are about 20 to 25 feet apart on the chain and travel on one chain south bound on one platform, drop down to a lower platform and travel the return north bound trip. The normal operating speed of the rakes is between 30 and 45 feet per minute. These rakes provide the only means of physical agitation that the composting material receives in the digester, both for forward motion and for aeration and mixing. The spacing between the furrows on a bar is such that consecutive furrows travel in slightly offset paths, providing thorough agitation in this continuous flow process. The process provides considerable flexibility for independent control and measurement of the determining factors of composting. Some of the techniques for providing these controls are proprietary, but a general description follows:

(a) Aeration. The supply of oxygen is maintained by the forced air heating system; the rate of aeration is then determined by the particle size, the height of the pile and the agitation. The bed agitation is controlled separately for each pair of decks by the speed and the position adjustment of the raking apparatus (see (f) below). While the control of neither supply nor contact is completely independent, the range of operating requirements is such that both may be adequately achieved without disrupting the other factors such as detention time or the air temperature.

(b) Particle size may be optimized by adjustment of primary and secondary shredder grates. Experimentation has determined optimal adjustment for given agitation, temperature and moisture ranges.

(c) Moisture recording sensors are set in probes in each of the decks to measure moisture content of the compost pile. Water may be sprayed at the beginning of each deck as needed for increasing moisture. There is no provision for downward adjustment other than stopping the spray and increasing the air temperature. The optimal moisture content on the top deck is 50 to 55%.

(d) pH is measured by the same deck-mounted probes. It can be controlled by the addition of buffering agents to the moisturizing spray, separately for each deck. pH is thus not independent of moisture controls in that it may not be controlled when no moisture is needed, but in routine operation that is not a problem. Initially, as microbial action commences, pH will drop quickly due to carbohydrate breakdown into organic acids. After the consumption of the acids, the pH tends to rise to 7.5 but seldom higher.

(e) Temparature can be controlled by an air heating system separately adjustable for each deck. Probes are used to measure air temperature and pile temperature. While air temperature can be controlled directly, pile temperature adjustments can only be influenced through air temperature or other controls such as addition of hot water or agitation. The air heating system is presently adjusted to maintain ambient air temperature about 10°F above pile temperature on the top six decks and at 150°F on the bottom two decks.

(f) Detention time. The speed that the pile travels across the decks can be adjusted separately for each pair of decks, since a single chain drives the rakes for two decks. Leveling bars which travel in front of each rake assembly can be adjusted between a minimum pulp layer height of 8" and a maximum of 16". Chain speeds can be adjusted between 3 feet per minute minimum and 45 feet per minute maximum. The rake delivery can be measured with automatic impact sensors which feed back instructions to the drive chain. These may be adjusted by overrides which provide for temperature control or mixing or the other parameters.

Table 3, following indicates the optimal parameter settings. The detention time is normally adjusted to 40 hours.

Table 3

PARAMETER SETTINGS

Deck	pH	% Moisture	Pile Temperature °F	Air Temperature °F
I	5.5-6.2	50-55	90-120	125-130
II	5.5-6.2	45-50	130	135-140
III	5.5-6.2	40-45	120	125-130
IV	5.7-6.4	35-40	115	120-125
V	5.9-6.6	30-35	110	115-120
VI	6.1-6.8	25-30	110	115-120
VII	6.8-7.0	15-20	90-100	150
VIII	7.0	10-15	90-100	150

The Warburg respirometer test, similar to BOD tests, is used to determine the degree of degradation of available carbon. The Company claims that these tests indicate no adverse effect due to normal fluctuation in paper content.

As noted above, much of the system is automated. Further automation provides safety control devices such as flow sensors and, oxygen sensors, excessive binding or torque demands, as well as fire and system component breakdown alarms.

2.3 - Product Segment.

The third segment, the product treatment apparatus, is arranged for fertilizer production in the existing facility. It is described as follows:

> The compost screen (Number 4 mesh) is fed by conveyors from the bottom of the digester. It removes approximately 10% of the oversized material for regrinding, mostly undecomposed substances, including plastics and nonferrous metals. This is followed by a compost storage tank, which holds some biologically stable material in stockpile for process flow equilibrium. Several compartments may be required depending upon chemical consistency needed in the various product specifications. This is followed by a mixer, fed by a conveyor

belt, through which solid additives are incorporated. The next process uses a compactor, granulator and product screen. They are adjustable to achieve various particle size and other physical characteristics in the product. It is followed by another storage tank which feeds the bagging operation. The processing of construction materials and/or fuel has not yet been described in detail by the Company since it is still in research stages.

Automatic additives control is also provided in the production of fertilizer for the nitrogen enrichment. The final N-P-K enrichment is accomplished by the addition of solid additives after the composting process. Quality control sensors are used for gross indicators of carbon and nitrogen in the raw material, and in the composting pulp.

2.4 - Facility, General.

The plant is situated on a five acre site. Thirty percent of the property is devoted to vehicular access, twenty percent to storage of the product and fifty percent to the building which houses the process. Of the 42,000 square feet of building on the site, ten percent is administrative, twenty-five percent is in the shredder segment, forty percent is in the digesting segment and twenty-five percent is in the production of fertilizer. Intentionally, there is no unprocessed refuse holding capacity other than the shredder hopper, and the apron upon which the vehicles dump. Today there is holding capacity provided in two 18 cubic yard open top metal boxes for separated bulky and ferrous wastes, and another for digester residue which has been removed by screening and is hauled away to disposal. The Company's intentions are to phase out the use of this latter need for disposal by regrinding the screening for inclusion in the Stabilate. These screenings, however, are largely made up of glass, plastic, and non-ferrous metals which do not enhance the quality of the Stabilate for fuel or soil conditioning uses. The purpose, however, is that eventually there will be absolutely no residue which is not processed for subsequent sale or reuse.

As mentioned in Chapter 2, General Electric has provided some amount of staff time on market analyses and to investigate the operation and to provide recommendations for its improvement. They determined that 25% of the personnel man/hours are involved directly in production, 30% are devoted to supervisory capacity, and 45% are involved in maintenance. Detailed findings have not been released.

At one point, the Department of Public Health of the City of New York required placing of rodenticide and other rodent control procedures on a monthly basis; this was discontinued after a period of several months in which no rodents were observed. Operating personnel have noted rats on the top (undigested) deck, however. Casual site inspection does not indicate any inordinate amount of noise or odors or other displeasant emissions from the operation in its present location in an industrial area on the waterfront of the East River.

A backup equipment inventory is maintained at a level of 7% of the number of items of operating equipment, and the total maintenance and tool inventory value combined with the backup equipment inventory is $28,000, estimated at 1% of the capital inventory. Nearly all maintenance is performed on-site; each of the components of the facility is modular and replaceable. There is a twenty percent scheduled down time for maintenance. The Company claims to have nearly no non-scheduled down time, declaring that there is sufficient redundancy in the system to permit by-passing nonfunctioning components during their removal and replacement so that continuous non-disrupted operation is virtually assured. (The only serious disruption to plant operations occurred as a result of zero degree weather during which the plant had been closed. Several burst pipes occurred, seriously hampering the operation during subsequent startup.) The present operation has the flexibility to permit scheduled down time during operating hours since the City does not require receipt of the materials and the Company can simply call the Sanitation Department on any day and request that truck deliveries not be sent.

Table 4 gives operating data for much of 1972-3. Some of the smaller aberrations are due, of course, to the logistics of municipal delivery. Now that relative stability has been achieved, the intentions are to begin demonstration of reliability.

Table 4

Operating Data

	Number of Days Available for Operatior	Number of Days of Operation	Tons of Refuse Taken In		Tons of Fertilizer Produced	
			Daily Average	Period Aggregate	Daily Average	Period Aggregate
9/19-30, 1972	9	7	22.4	157	-	-
Oct.	22	15	7.9	119	3.6	55
Nov.	20	18	7.5	135	9.2	167
Dec.	20	17	5.8	100	2.8	49
1/1-7, 1973	4	4	15.7	63	10.7	43
1/8-14	5	5	3.0	15	10.8	54
1/15-21	5	5	8.6	43	13.6	68
1/22-28	5	5	13.6	68	16.2	81
1/29-2/4	5	5	7.8	39	17.6	88
2/5-11	5	5	26.5	113	18.6	93
2/12-18	4	3	28.3	85	17.0	51
2/19-25	4	3	36.6	110	22.3	67
2/26-28	3	3	28.0	84	24.3	73
3/1-4	2	2	21.	42	28.5	57
3/5-11		5	15.3	78	18.2	91
3/12-18	5	5	22	110	26.4	132
3/19-25	5	3	28	84	28.3	85
3/26-31	5	3	31	105	31.0	93
4/2-8	5	5	32.5	162	34.2	171
4/9-15	5	4	27	108	38.3	153
4/16-22	5	5	23	115	36.2	181

SECTION 3.0 - ECONOMICS

The economics of this process is based primarily upon the premise that disposal fees will support to some extent the conversion of a municipal refuse to a commercially competitive raw material. Obviously if the net cost of the raw material produced is greater than an acceptable equivalent, this venture will fail economically. Thus, the economic test is the identification of end products whose raw material specifications are most nearly met by the conversion process product. A corporate decision has been made not to segregate any materials for salvage. Thus, the only sales revenue potential are the disposal revenues, and the direct marketing of unrefined converted wastes, under the trademark Stabilate, or the internal sale of Stabilate for refinement or subsequent processing. As mentioned in Chapter 2, the Company presently sees three potential products of such processing; construction materials, fertilizer, and fuel. Each of these has some situational advantages which enhance its competitive advantage for some markets. For instance, the inner city market for aggregates for construction materials is more accessible to this process than it is to the typical quarry or forest.

This chapter of the report will address (a) the financial status of the enterprise, (b) the operational costs, (c) the revenues, and (d) the prospects for this enterprise.

3.1 - Financial Status.

Ecology, Inc. has total assets, as of November 30, 1972 of $6,336,191; as shown in the balance sheets, this comprises essentially $400,000 in land, $800,000 in land improvements, and $2 million in building and $3 million in equipment. Liabilities on that date totaled $6,102,770 comprising largely a U.S. Economic Development Administration loan of $1,300,000 at 4 1/2% interest, and a working capital, mortgage, and other loans from a Commercial Bank of $1,600,000 and accounts payable and accrued expenses of $1.3 million; loans and short term notes payable make up the remainder, and shareholders equity on that date was $234,000. In this connection, the Company has a $3.8 million accumulated deficit and a working capital deficiency of $2.5 million. $1.5 million shares have been issued at a par value of $.10 per share; 35% are held by Company Chairman and Directors. An audit in September 1972 found that a successful consumation of a current offering of almost $3 million worth of common stock would permit resolution of current deficiencies and continue operation. Reasonably profitable future operations should produce stability.

The Company has been engaged primarily in process development and in market analysis since inception. Total proceeds received by January 1, 1973 were $96,000, disposal fees constituting only 3% of that since the contract only became effective in October 1972. At the present facility, the estimated maximum annual proceeds are anticipated by the Company as:

Disposal fees (150 TPD X 300 days X $4.50/ton)	$ 200,000
Sale of fertilizer (150 TPD X 300 days X $20/ton)	900,000
Total	$1,100,000

It is not the Company's intention to derive self sustaining revenues from the existing facility. It has been designed as an operational prototype in order to demonstrate system effectiveness. Modular insertions will permit the existing facility to be developed to a final plant capacity of 300 tons per day. It is the present corporate intention to proceed with the existing facility in this manner.

The Company is entirely dependent upon private capital for its existence to date. The total investment, almost $10 million, is split evenly between debt and equity. The only outright cash grant amounted to $150,000 for training. This was funded by New York State and by the NABS program, and did not go towards plant support, but entirely went into the training and upgrading of indigenous hard core unemployed members of the surrounding community.

3.2 Operating and Capital Costs.

Net costs of mechanical digestor types of composting facilities were estimated to range from $12.46 per ton at 250 TPD to $4.14 per ton at 2,000 TPD operations in a recent survey by the Midwest Research Institute.* Tables 5 and 6 were developed by Midwest Research Institute on a 1,000 TPD basis using gross assumptions such as $5 per hour labor wage rates plus 30% fringe, $0.01 per kwh, $0.50 per million Btu's and municipal ownership; they are shown here to provide a framework for comparison of this plant.

*Resource Recovery, The State of Technology, Midwest Research Institute - U.S. G.P.O. Washington, D.C. - February 1973.

Table 5
ANNUAL OPERATING COSTS FOR COMPOSTING PROCESS
(300,000 TPY Raw Waste Input)

Taken directly from (MRI)

Annual Costs		Total	Per Ton of Waste Input
Operating Costs		$ 915,000	$3.05
Fixed Costs		217,000	0.72
Capital Charges			
Amortized Investment	$ 439,000		
Fixed Investment	1,385,000		
Recoverable Investment	31,000		
Total Capital Charges		$1,855,000	6.19
Total Annual Cost of Operation		$2,987,000	$9.96
Value of Recovered Resources			
Humus	$ 450,000		
Ferrous Metals	245,000		
Nonferrous Metals	240,000		
Glass	168,000		
Gross Value of Recovered Resources		$1,103,000	$3.68
Net Annual Cost of Operation		$1,884,000	$6.28

Effect of System Capacity on Disposal Costs

	250 TPD	500 TPD	1,000 TPD	2,000 TPD
Total Annual Cost	$1,211,000	$1,902,000	$2,987,000	$4,699,000
Resource Value	276,000	552,000	1,103,000	2,206,000
Net Annual Cost	$ 935,000	$1,350,000	$1,884,000	$2,484,000
Net Cost Per Ton	$12.46	$9.00	$6.28	$4.14
Net Gain Over Conventional Incineration Per Input Ton	($2.09)	($0.02)	$1.40	$2.51

Table 6

(Table Taken Directly From MRI)

TOTAL CAPITAL REQUIREMENTS FOR COMPOSTING PROCESS
(1,000 TPD Raw Waste Input Capacity)

Amortized Investment	
Engineering, R&D	$ 1,748,000
Plant Startup	153,000
Total Amortized Investment	$ 1,901,000
Fixed Investment	
Waste Handling, Preparation and Storage	$ 1,730,000
Waste Conversion	5,500,000
Resource Recovery Processes	940,000
Auxiliary and Support Facilities	6,400,000
Total Fixed Investment	$14,570,000
Recoverable Investment	
Land and Site Improvements	$ 400,000
Working Capital	229,000
Total Recoverable Investment	$ 629,000
Total Capital Requirement	$17,100,000
Total Capital Requirement at:	
250 TPD Capacity	$ 6,940,000
500 TPD Capacity	$10,900,000
2,000 TPD Capacity	$26,850,000

Tables 7 and 8 have been developed by Ecology, Inc. for general distribution. They give the Company's projection of costs on a basis of private ownership at 6% interest but exclusive of land cost. Just for comparison purposes, the 500 TPD plant cost may be interpolated at $6.27 per ton; converted to 5% interest, it would be $5.77 per ton, nearly identical with the average investigated by Midwest Research Institute. Company estimates for 1,000 TPD and 2,000 TPD were not available at the time of writing for comparison and economies of scale. The 500 TPD "operating" costs may be interpolated at $816,000, which is approximately the same as the Midwest Research Institute figure for "operating plus fixed" costs for that size plant. It was concluded by Midwest Research Institute that in general the economy of scale regarding plant size for these high rate digestors is more pronounced than in alternative systems. This is in apparent contradiction to the conclusions of the Company, who feels the optimal scale is around 1,000 TPD.

It should be noted that the operating costs, Table 7, submitted by the Company are the costs only of the conversion process, not the production of fertilizer. The cost of chemical additives, the largest single item in fertilizer production, varies considerably according to market condition and formulation. For instance, June, 1973, seasonally adjusted, showed a 20% price increase for additives. The cost of additives for one ton of 12-3-3 is $35, for one ton of 16-4-4 is $50 and for one ton of 20-5-5 is $70. The cost of processing is an additional $30 per ton. The Statement of Expenses given in Table 9 was prepared by an independent C.P.A. for submission to the Securities Exchange Commission. It gives a fairly good picture of the aggregate cost of the several categories of actual plant operation, again with the glaring absence of the cost of chemical additives. Evidently these costs had not been incurred at the time of audit. They should substantially affect the total.

Table 7

ECOLOGY, INC.

SOLID WASTE DISPOSAL PLANT COST ESTIMATES (CAPITAL)

PLANT CAPACITY			
TONS OF REFUSE		COST	
Daily	Yearly	Plant	Per Ton of Refuse
100	30,000	$ 4,000,000	$11.70
150	45,000	5,000,000	9.70
200	60,000	5,800,000	8.50
250	75,000	6,500,000	7.60
300	90,000	7,000,000	6.80
450	135,000	10,000,000	6.50
600	180,000	12,000,000	5.80

- Plant cost figures do not include cost of land or preparation, but do include all construction costs.

- "Per Ton" cost is estimated on the basis of 20 years amortization 6% p.a. straight line.

Table 8 JAN 73

ECOLOGY, INC. PROJECTION OF OPERATING COSTS

PER MONTH	100-150 T/D	200-300 T/D	450 T/D	600 T/D
(Men)	(16)	(30)	(40)	(50)
PLANT LABOR	$13,000	$24,000	$32,000	$40,000
PLANT SUPERV'N	3,000	4,000	4,000	5,000
UTILITIES	5,000	10,000	14,000	20,000
MAINTENANCE	2,000	3,000	4,000	6,000
SERVICES	2,000	2,000	2,000	2,000
INSURANCE	2,000	3,000	4,000	5,000
OFFICE	2,000	2,000	2,000	2,000
TOTAL MONTHLY:	29,000	48,000	62,000	80,000
X 12 = YEARLY	348,000	576,000	744,000	960,000
PER TON OF REFUSE:	7.72 to 11.60	6.40 to 9.60	5.51	5.34

Table 9 - Statement of Expenses

	Five Months Ended November 30		Year Ended June 30		
	1972	1971	1972	1971	1970
	(Unaudited)				
Interest income	$ 2,750	$ 2,750	$ 7,100	$ 10,131	$ 79,160
Costs and expenses:					
Salaries and wages	117,360	237,416	413,755	143,643	54,043
Employee benefits	5,028	24,084	34,216	49,264	
Plant maintenance and pre-operating expenses	67,024	153,130	416,663	202,630	
Prototype equipment and operating expense				93,569	152,149
Market development		3,701	9,068	53,720	90,582
Lease of plant site, office and storage facilities	13,219	8,083	23,950	40,236	41,000
Travel and related costs	9,011	20,385	37,844	45,078	27,474
Depreciation of plant and equipment	128,000	106,657	287,218		
Amortization of patents, royalty rights and debt discount and expense	26,788	19,300	46,767	26,065	22,033
Legal and accounting fees	33,935	21,517	91,794	44,882	19,366
Interest	107,144	96,075	263,527	47,490	
Insurance	19,520	27,445	46,481	19,608	
Taxes (other than federal income taxes)	29,000	19,299	90,245	32,846	19,178
Office expenses	7,717	9,414	20,016	13,545	13,914
Miscellaneous	3,076	7,464	22,499	20,598	11,353
	566,822	753,970	1,804,043	833,174	451,092
Net (loss)	(564,072	(751,220	(1,796,943)	(823,043)	(371,932)

3.3 - Revenues.

Officials in the New York City Environmental Protection Administration indicate that the final price for disposal services would be established through negotiations prior to contract award, but that they are presently suggesting $10 to $12 as a target for proposals. It has been publicly stated by the Administration that their present intention is to select several processes and contract at 1,000 TPD capacities with each. Using that volume for projection of revenues, the Company has indicated that fertilizer production exclusively will be the most profitable. The volume produced would probably have a significant impact on the market, saturating the lawn fertilizer market and reaching into commercial uses. Detailed investigations are being conducted by General Electric and the Company at present, but no findings have been made available.

Extrapolating company projections appear unreasonable for 1,000 TPD operations. The $12 per ton disposal fee yields $3.6 million per year. This appears to cover projected operating expenses of the conversion process. The company estimates a return of approximately $20 per ton of incoming refuse. A ton of refuse is converted to one-half ton of Stabilate to which is added one-half ton of chemicals to produce a ton of fertilizer; the estimated profit of $20 per ton for fertilizer is presumably the proceeds accruing to the disposal operation, or the net proceeds from manufacture of fertilizer from Stabilate I. The retail suggested price for the lawn market is $5.95 for a 28 pound bag as printed on the label. The suggested wholesale price is $3.00 per bag, or $200 per ton of incoming refuse; the difference, $180 per ton, is the cost of additives ($35 to $70 per ton), processing ($30 per ton), transportation to the wholesaler, and advertising and marketing ($25 per ton). Each of these figures is likely to change when the commercial use market is entered, so until General Electric marketing studies are made available for analysis, no conclusions should be drawn on projected revenues.

4.0 Assessment

4.1 - Process & Technology.

The technology involved seems to be fairly well developed. The stability of the product has not been rigorously determined. New York City engineers have reported faint odors while experimenting with the product submerged in sealed containers of sea water, suggesting possible degradation. Strobel and Rongved, with a similar product, has proposed sterilization by irradiation, indicating that they doubt the effectiveness of the pasteurizing effect of the composting process. The health effects of the use of compost for edible crops has not been well researched at present. The Company is continuing to investigate product characteristics, of course, since they will affect all of the products' useability. Otherwise, the general technology of composting is commonly considered well developed. This specific process is still in developmental stages, and should be considered as such until successful operation on a scale of 1,000 TPD.

4.2 - Economics

The costs as projected by the Company do not appear unreasonable. The revenues, however, appear soft without having the results of General Electric's detailed analysis. Only time will tell, of course, if the system is economically viable, but historical data indicate that there should be no aspect of market analysis overlooked. Of all the compost plants operating in the United States, only a few are still in operation. The U.S. Environmental Protection Agency has recently selected the State of Delaware as the recipient of a resource recovery demonstration grant; the funded portion of this project focuses on the marketing aspects. Present indications are, however, that there may be health hazards associated with Delaware's use of the compost for raising mushrooms.

The use of the conversion system product as a raw material for more readily marketable products greatly enhances the economic profile, if the costs can be covered. A major apparent softness of previous market analysis was the failure to properly assess the impact of expanding supplies of a commodity of marginal utility. Fuel, fertilizer and construction material compose more definitive markets than humus or soil conditioner. What remains to be determined, therefore, is whether the economics of the use of a slightly inferior raw component at greatly reduced costs to produce a highly marketable commodity is preferable to the direct marketing of that component as a commodity of marginal demand.

The environmental ethos may tend to offset quality as a demand factor. The Company's advertising emphasizes the ecological advantage accruing to this process. They have advertised their willingness to underwrite advertising by retailers at $25 per ton sold.

The evidence for a more conclusive economic assessment was not apparent. In principle the concept of marketing the compost internally in a system whose products are more widely consumed is attractive. Data on revenues suggests circumspection, but on the other hand there is little negative evidence to suggest assuming timid or unenterprising posture.

4.3 - Environmental Influence.

Assessment of the influence on the environment of proliferation of this concept must compare the impact of the system with the systems it would replace not only at the point of processing or disposal but also at the point of intended usage of the products. No lasting environmental degradation was observed at the facility from either the conversion process or the subsequent processing. Noise, configuration, and potential odors confine potential locational choices for aesthetic reasons, but properly located, environmental degradation appears negligible. The impact of this system, then, would be positive to the extent that it relieved the need for usage of alternative polluting methods.

Solid outflow from the plant is in four categories: bulky rejects, ferrous scrap, non-compostable residue, and Stabilate. The bulky, such as appliances, rugs, etc., constitute 5% of the waste stream received and are the only major fraction of the incoming stream not intended for reuse. It is extracted without alteration and is removed by the City for land disposal at present; it is typically non-putrescible and can be mixed with demolition wastes or other "clean" fill. The ferrous scrap, 10% by weight of the incoming, is shredded and extracted for removal by scrap dealers. Presumably, most of this material is recycled. The residue comprises plastics, non-ferrous metals, glass fragments and other particles which have passed through shredding and digesting segments of the process and are subsequently removed by screening. At present, this fraction is being reshredded and/or reprocessed for inclusion in the Stabilate with minimal loss of quality. The success is of course dependent upon degree of reprocessing and on the subsequent use of the Stabilate; at present the volumes are not significant. Stabilate is wholly intended for subsequent usage. To the extent that its use is not demanded at any price, it may be satisfactorily landfilled. Its characteristics in landfill are only speculative at this point. There is presently no removal of heavy metals or of many of the components of leachate except for ferrous extraction and pasteurization of most pathogens. Some of the potential for gas production has been exhausted, but some doubt remains that on a volumetric basis, in place, there would be significant improvement over raw or shredded refuse. There would be a definite improvement, of course, on a basis of refuse handled. It was estimated by an engineer with the New York City Environmental Protection Administration that only 1/3 the volume of the raw refuse landfill would be required, not including any reduced cover requirements. Carbon Dioxide, methane, water vapor and other gaseous emissions will occur, of course, but testing is needed to determine the degree of problem, if any.

Subsequent usage of Stabilate as a component of fertilizer adds to the soil some trace amounts of whatever miscellaneous elements were present in the waste stream. Considerable mixing occurs during the handling process, however, and the small dosages applied in fertilization of soil make investigation of resulting environmental damage seem futile.

Utilization as fuel produces a potential air pollutant which must be weighed against usage of alternative fuels. Particulate emissions will be high. The presence of heavy metals, plastics or whatever chemicals comprised in that day's collection could become the component of the day's emissions. Experience in monitoring existing incinerators' emissions will be useful in determining the environmental impact from specific solid waste streams. It is not anticipated that this impact will be considerable.

The nature of the product of the construction materials is such that little human or environmental contact will occur during usage or upon discard. Other miscellaneous uses, such as for "kitty litter," appear likewise to offer no particular pollutant threat.