Town of Hague Landfill Reclamation Study

Researching Ways to Increase Waste Heating Value and Reduce Waste Volume

Final Report 97-1
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New York State
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NYSERDA

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January 1997

TOWN OF HAGUE LANDFILL RECLAMATION STUDY:
Researching Ways to Increase Waste Heating Value and Reduce Waste Volume

Final Report

Prepared for

**THE NEW YORK STATE
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY**

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ABSTRACT

Monitored composting was studied as a method for reducing the quantity of waste requiring disposal from a landfill reclamation project. After each of two re-screening steps, composted "soil" from a single long windrow of varying depths and moisture content was subjected to analytical testing to determine its suitability to remain as backfill in a reclaimed landfill site. The remaining uncomposted waste was combusted at a waste-to-energy facility to determine if Btu values were improved. Results indicate that a full-scale composting operation could result in a net decrease of approximately 11 percent in disposal costs. The Btu value of the reclaimed waste was calculated to be 4,500 to 5,000 Btu/lb. The feasibility of composting reclaimed waste at other landfill reclamation projects will depend upon site-specific technical and economic factors, including size and nature of the organic fraction of the waste mass, local processing costs, and the cost of waste disposal alternatives.

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A NYSERDA Report in Brief

Report: **Town of Hague Landfill Reclamation Study: Researching Ways to Increase Waste Heating Value and Reduce Waste Volume**
Report 97-1

Project Manager: **James F. Reis, P.E.**

Contractor: ***Town of Hague***

Background: A previous NYSERDA project in Edinburg, New York, demonstrated that landfill reclamation (excavating a landfill and separating the reusable and combustible materials) could be an economically and environmentally beneficial alternative to conventional landfill closure. Separation equipment was used to reclaim part of a landfill, producing reusable soil, recyclable metals, and residual waste with a heating value of 3500 Btu/lb, lower than that of "normal" municipal solid waste (5500 Btu/lb).

For a fee, the residual was taken to a waste-to-energy (WTE) facility where it was burned. Project results showed that more than half the cost of reclamation was for transportation and disposal of the residual waste. It was concluded that decreasing disposal costs and increasing heating value was necessary for landfill reclamation to be more cost-effective. Using additional equipment could help, but would increase project complexity. Simple composting is another option.

Objectives: The project had two objectives: to determine the effect that composting reclaimed waste would have on reducing the volume of waste requiring off-site disposal; and increasing residual waste heating value so it could be used in a WTE facility as fuel.

R&D Results: Screened waste was composted in windrows during reclamation. Windrow temperature and moisture were monitored periodically. After two months, the waste was rescreened, separated portions were weighed and measured. Half was sent to a WTE facility for combustion testing, the remainder was re-piled in a windrow for additional composting. After another two months, the remaining waste was rescreened again and the residual sent to a WTE facility for combustion testing.

Two months of composting was found to be optimal, increasing the heating value of the waste to 4500 Btu/lb, and decreasing weight by 31% and volume by 17%. Net project cost savings were 11%.

Copies Available: The full report is available from the National Technical Information Service. For information on how to purchase it from NTIS, call NYSERDA at (518) 862-1090, ext. 3241.

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SUMMARY

This research project examined the use of monitored composting to reduce the amount of waste requiring disposal from a landfill reclamation project, and to provide an improved, higher Btu fuel for waste-to-energy combustion. Landfilled municipal solid waste from the ongoing Town of Hague landfill reclamation project was excavated, screened and placed in static piles (windrows) on top of the landfill footprint.

Approximately 500 cubic yards of screened reclaimed waste, originally landfilled in 1990, was arranged into a single long windrow of varying depths and moisture content. The internal temperature of the compost windrow was monitored twice each week, and no odor, vector or leachate problems were experienced.

Two months after and again 4 months after the windrow was established, waste was re-screened and the net volume and weight reductions determined each time. The recovered compost soil was subjected to analytical testing to determine its suitability to remain as backfill at the reclaimed landfill site. The resulting waste product after both re-screenings was sent to a waste-to-energy facility for combustion testing.

The composting and re-screening proved to be effective, resulting in a 31 percent average weight reduction in material requiring off site transportation and disposal. Temperature monitoring indicated that most composting activity occurred within 3 months of windrow establishment, declining rapidly thereafter. Other indicators of composting included the darkened appearance of the material at re-screening and the apparent decrease of the presence of paper within the re-screened waste fraction.

Complete composting of the organic waste fraction was not accomplished, as indicated by the presence of un-decomposed paper and cardboard scraps in the compost soil. A low nitrogen level is believed to have been a compost-limiting factor. The addition of water during windrow establishment may not have had a major effect.

The recovered compost soil met 6NYCRR Part 360 analytical standards for Class I compost. However, the presence of waste particles smaller than the 1-inch screen openings limits its application to landfill or other approved uses.

The initial combustion test of composted and re-screened waste indicated a significant improvement in Btu value as compared to past experience with unimproved reclaimed waste. No problems were encountered by plant operators and no operating adjustments were necessary. The Btu value of the reclaimed waste was calculated to be 4,500-5,000 Btu/lb. However, the second combustion test was unsuccessful because of the material's high moisture content. This moisture content was the result of heavy rainfall on the compost windrow in the weeks preceding the final re-screening.

The waste disposal cost savings associated with the composting effort were compared to the costs associated with conducting the operation. These costs included windrow set up and monitoring, which were insignificant, and the re-screening of the composted waste. It was concluded that a full-scale composting operation would result in net decrease of approximately 11 percent in disposal costs.

Implementation of a full-scale composting effort was shown to be feasible at the Town of Hague landfill reclamation project. However, the feasibility of composting reclaimed waste at other landfill reclamation projects will depend upon site-specific technical and economic factors. These factors include the size and nature of the organic fraction of the waste mass, site logistical considerations, local processing costs, and the cost of waste disposal alternatives.

Section 1
INTRODUCTION

Landfill reclamation is the process of excavating a solid waste landfill to recover energy and materials, reduce environmental impacts, restore the land, and, in some cases, extend landfill life. Landfill reclamation can be an economically and environmentally beneficial complement or alternative to conventional landfill closure.

Landfill reclamation procedures typically involve the monitored excavation and separation of soil from waste. Reclaimed waste is then re-disposed in a number of ways: on site as part of a landfill closure consolidation effort, on site in an existing or newly constructed lined landfill cell, or off site at an approved solid waste management facility. NYSERDA-sponsored research at the Town of Edinburg Landfill (Report 1355-ERER-MW-89, 1993) demonstrated the feasibility of recovering energy from reclaimed waste using waste-to-energy facilities. In spite of this energy benefit, the removal of an entire landfill through the reclamation process can generate significant quantities of waste, resulting in potentially prohibitive costs.

The Town of Hague in Warren County, New York, conducted a NYSERDA-sponsored landfill reclamation feasibility study in 1993, and concluded that reclamation would be a technically and economically feasible alternative to conventional closure. Even so, over half of the projected reclamation costs were for transportation and disposal fees for reclaimed waste at off site disposal facilities. Reducing the amount of waste requiring disposal would lower project costs to the Town.

This subsequent research project examined the use of monitored composting to reduce the amount of waste requiring disposal and to provide an improved, higher Btu fuel for waste-to-energy combustion. Municipal solid waste recovered from the operating Town of Hague landfill reclamation project was excavated, screened, and placed in a static pile (windrow) on top of the landfill footprint. Two months after and again 4 months after the windrow was established, the waste was re-screened (interim re-screening and final re-screening, respectively) and the net volume and weight reductions measured each time. The recovered compost soil was subject to analytical testing to determine its suitability to remain at the reclaimed landfill site. Finally, the resulting waste product from both the 2-month and then the 4-month test were sent to a waste-to-energy facility for combustion testing.

This research project was cosponsored by the Town of Hague, which supplied equipment, operators, materials, and support services. SSB Environmental, Inc., of Albany, New York, was project contractor for the Town's landfill reclamation effort and also served as project contractor for this research effort. SSB Environmental, Inc., was responsible for project planning, coordination, permitting, operations, and reporting. The Cornell University College of Agricultural and Life Sciences provided technical guidance on establishing, monitoring and analyzing the composting effort.

Also participating in the project was Holt Consulting (engineering services); Precision Industrial Maintenance, Inc., (equipment and operators); Powerscreen Northeast, Inc., (screening equipment); Clough, Harbour & Associates, L.L.P, (analytical sampling); and Adirondack Resource Recovery Associates, L.P. (waste-to-energy combustion testing).

Section 2

METHODS AND ACTIVITIES

The goal of the Town of Hague landfill reclamation project was to completely eliminate the landfill, as an alternative to conventional closure and long-term monitoring. After processing, reclaimed waste was removed from the site for disposal at approved solid waste management facilities. Recovered soil was subjected to an analytical testing program approved by the New York State Department of Environmental Conservation (NYSDEC) and, upon approval, used on site for backfill and grading.

Soil was separated from waste using a Powerscreen Model 830 trommel screen with 1-in. screen openings. Although the trommel separated almost all of the soil, rocks larger than the screen openings remained in the waste. To avoid higher weight-based disposal costs, large rocks were removed using a backhoe stationed near the trommel drum exit. A manual laborer then removed any remaining rocks from stockpiled waste awaiting off site transport.

The research project involved establishing a compost windrow of reclaimed municipal solid waste. Waste was screened using normal landfill reclamation procedures and processing equipment. The windrow was monitored for 9 weeks and a portion of the waste was subjected to interim re-screening, analytical testing, and combustion testing. The remaining waste was re-established into a new windrow, monitored for an additional 8 weeks, and subjected to final re-screening, analytical testing, and combustion testing.

INITIAL COMPOST WINDROW ESTABLISHMENT

Following a work plan approved by the NYSDEC, a single compost windrow of reclaimed waste was established on June 22, 1995. Approximately 1,400 cubic yards (cy) of landfilled material was excavated and screened. The resulting 505 cy of screened waste, as determined through loader bucket counts, was delivered to the designated compost area and arranged into a single long windrow. The screened waste represented 36 percent by volume of the excavated material.

The waste used for this project was originally landfilled in 1990, and is among the most recently-disposed in the Hague landfill. It was selected because its remaining compostable fraction was assumed to be higher than waste that had been landfilled in earlier years. The waste appeared to be similar to waste reclaimed at other reclamation projects (Edinburg) and contained little or no food waste, a high fraction of film plastic and textiles, substantial amounts of paper, cardboard and metals, and some small-to-medium-sized rocks. The excavated waste had a mild odor, though no odor problems were attributed to the excavation and screening operations.

Some of the reclaimed waste delivered to the compost area was spread approximately 3 feet deep and wetted by the Hague Volunteer Fire Department. The waste was then shaped into a continuous 165-foot-long windrow of selected varying depths and moisture content. This shaping was done in an attempt to determine optimum windrow composting configuration and moisture requirements. The windrow sections were as follows:

- A 4-foot-high wet section, which received an estimated 300 gallons of added water
- A 4-foot-high dry section
- A 6-foot-high dry section
- An 8-foot-high dry section
- An 8-foot-high wet section, which received an estimated 1,000 gallons of added water.

The internal temperature of the compost windrow was generally monitored twice each week using a 3-foot-long probe. Each of the five windrow sections was monitored in three different locations. Daily weather conditions, including rainfall, were also monitored. During the first two-month monitoring period, no additional water was added. Precipitation was calculated to have deposited approximately 1,900 gallons of water on the windrow, although it is likely that much of this was not absorbed because of the high plastic fraction of the waste mass. Finally, the windrow was not turned or disturbed during the period.

INTERIM RE-SCREENING AND TESTING

Nine weeks after establishing the windrow, approximately 63 cy of material was removed and re-screened to remove the compost soil fraction. Material was taken from all five sections of the windrow and screened through the normal processing train. The volume and weight of both the separated waste and compost soil fractions were measured.

A composite sample of the screened compost soil fraction was taken and sent to a certified laboratory for Class I and Class II (6NYCRR Part 360) compost parameter testing. Separated samples of newspaper and cardboard (the primary visible organic materials) were taken from the waste fraction, as was a sample of the screened compost soil fraction. These were sent to the project's composting consultant at Cornell University for moisture testing.

A dump trailer containing re-screened waste was delivered to the Adirondack Resource Recovery Facility (ARRF) for combustion testing. The 400-ton-per-day, mass burn, modern waste-to-energy facility is located in Hudson Falls, New York.

Although the waste did not appear wet, it was relatively dense and matted, and some soil and rocks remained. Based upon previous experience in combusting reclaimed waste, plant operators decided not to feed 100 percent reclaimed waste into the boiler. Reclaimed waste was deposited in the plant's waste bunker and mixed with existing waste in a 50:50 ratio prior to loading the boiler. The combined waste was fed into one of the two plant boilers until the supply was exhausted.

RE-ESTABLISHMENT OF COMPOST WINDROW

Immediately after the interim re-screening, the remaining waste was re-established into a windrow 80 feet long and 8 feet high with three distinct sections:

- An 8-foot-high wet section made by re-shaping the remaining original 8-foot-high wet section
- A new 8-foot-high wet section made by combining the remaining 4-foot-high wet, 4-foot-high dry, and 6-foot-high dry sections
- An 8-foot-high dry section made by moving and re-shaping the remaining original 8-foot-high dry section.

Prior to re-shaping the waste into the windrow, the 8-foot-high wet sections were spread on the ground to an approximate 3-foot height and received approximately 2,500 gallons of water from the fire department.

FINAL RE-SCREENING AND TESTING

The re-shaped windrow was monitored in a manner similar to the initial windrow. No water was added and the windrow was not turned or disturbed. Precipitation was calculated to have deposited approximately 975 gallons of water on the windrow during the period. After an additional 8 weeks, the windrow was subject to final re-screening through the normal processing train. Both the waste and compost soil fractions were measured and weighed. A second composite sample of the screened compost soil fraction was taken for compost parameter testing and material. Samples of both fractions were taken for moisture testing and the compost soil fraction was tested for carbon and nitrogen content.

Re-screened waste was delivered to the ARRF for a second combustion test. Reclaimed waste was deposited in the plant's waste bunker and mixed with existing pit waste in a 50:50 ratio prior to loading the boiler.

Section 3
FINDINGS AND RESULTS

WINDROW TEMPERATURE

The condition of the windrow was maintained in accordance with the protocol established by Cornell. The temperature of the compost windrow increased rapidly after establishment, reaching a maximum average section temperature of 144 °F, and an individual high reading of 158 °F. By the third week, average temperatures declined and stabilized in the 106 -115 °F range, except for a period during the seventh week when unusually heavy rains (almost 6 inches) may have contributed to the temporary decline.

Temperatures in the two wetted sections decreased after the interim re-screening and re-establishment of the windrow. However, temperatures rose to well over 100 °F in all three sections within 1 week. After several weeks of average temperatures greater than 100 °F, all sections gradually declined to near ambient temperatures by week 17.

The project took place during summer and fall months and typical weather was experienced. During the first 9 weeks, the weather was generally warm and dry with occasional thunderstorms. The period after the interim re-screening was generally wetter and cooler. Approximately 5.6 inches of rain fell in the 2 weeks preceding the final re-screening, and 3.5 inches of rain fell after the final re-screening but prior to shipping of waste for the second combustion test. Although covered, it is believed that additional moisture infiltrated the waste due the heavy rain.

Temperature, weather data, and other observations are presented in tables 3-1 and 3-2. Figure 3-1 graphically displays average windrow temperature over the project term.

GENERAL OBSERVATIONS

During the 17 weeks of monitoring the windrow, the following general observations were noted:

- There was little appreciable odor associated with the compost windrow.

Table 3-1.

Compost Windrow Observations: Establishment Through Interim Re-screening.

Weeks	Date	High Temp	Rain*	Weather	Average Temperature (degrees F.)** 4' wet	4' dry	6' dry	8' dry	8' wet	Avg. all	Observations
0	thu 6/22	80s	0.0	sun	66	63	63	67	67	65	Piles established, watered, Cornell present
	fri 6/23	80s	0.0	sun							8' wet zone watered, samples taken, slight odor
	mon 6/26	80s	0.1	sun-clouds	104	91	103	102	101	100	Slight odor
	tue 6/27	80s	0.0	sun	140	139	115	125	128	130	Stronger odor, but not objectionable
	wed 6/28	80s	0.0	sun							
1	thu 6/29	80s	0.0	sun	135	144	122	121	144	133	Odor decreasing
	fri 6/30	80s	0.0	sun							
	mon 7/3	na	na	na							
	tue 7/4	na	na	na							
	wed 7/5	80s	0.0	sun	135	132	123	130	134	131	No odor, leachate or vectors, very little blowing
2	thu 7/6	90s	0.0	sun							
	fri 7/7	70s	0.5	clouds/rain	127	136	117	132	139	130	Piles appear to be lower in height
	mon 7/10	80s	0.0	part sun							
	tue 7/11	70s	0.2	sun-clouds	121	103	120	103	131	115	Additional shrinkage since prior report, no odors
	wed 7/12	80s	0.7	sun							
3	thu 7/13	90s	0.0	sun	115	119	112	101	119	113	No noticeable, some blowing papers
	fri 7/14	na	na	na							
	mon 7/17	na	na	na							
	tue 7/18	80s	1.6	clouds-sun	103	100	112	111	125	110	Much stronger odor, difficult to insert temp probe
	wed 7/19	80s	0.0	sun							
4	thu 7/20	80s	0.0	sun-clouds							
	fri 7/21	80s	0.3	part sun	104	115	98	114	110	108	Slight odor, appears damp from rain, no leachate
	mon 7/24	80s	0.1	part sun							
	tue 7/25	80s	0.0	sun	106	117	107	111	113	111	Slight odor, damp
	wed 7/26	80s	0.6	clouds-rain							
5	thu 7/27	90s	0.8	clouds	99	109	112	105	110	107	Waste appears "clean" due to rain, little odor.
	fri 7/28	80s	0.8	part sun							
	mon 7/31	na	na	na							
	tue 8/1	na	na	na							
	wed 8/2	80s	0.1	part clouds							
6	thu 8/3	80s	2.5	clouds							
	fri 8/4	80s	2.0	clouds	92	107	100	103	92	99	Very wet, some leachate stains, many crickets
	mon 8/7	70s	1.3	sun	80	95	101	109	102	97	Still wet, slight odor, some leachate
	tue 8/8	80s	0.0	sun							
	wed 8/9	80s	0.0	sun							
7	thu 8/10	80s	0.0	sun							
	fri 8/11	80s	0.0	part sunny	98	110	109	128	122	113	Drying, little odor, no leachate
	mon 8/14	80s	0.0	clouds-sun							
	tue 8/15	90s	0.0	sun/humid	100	107	106	101	114	106	Dry appearance, no odor, some flies
	wed 8/16	90s	0.0	sun							
8	thu 8/17	90s	0.0	sun							
	fri 8/18	90s	0.0	sun	107	99	107	106	121	108	Dry, little odor, some blowing debris (windy)
	mon 8/21	80s	0.0	sun							
	tue 8/22	70s	0.0	part sun	103	114	98	111	110	107	Some odor, no leachate, some flies
	wed 8/23	70s	0.0	sun							Screened 63 cy and re-established windrow
	Total Rain		11.6								
	Average Temp.				107	111	107	110	116	110	

* Rainfall in inches from close of previous work day through close of day noted.
** Each figure is an average of three individual temperature readings.

Table 3-2.

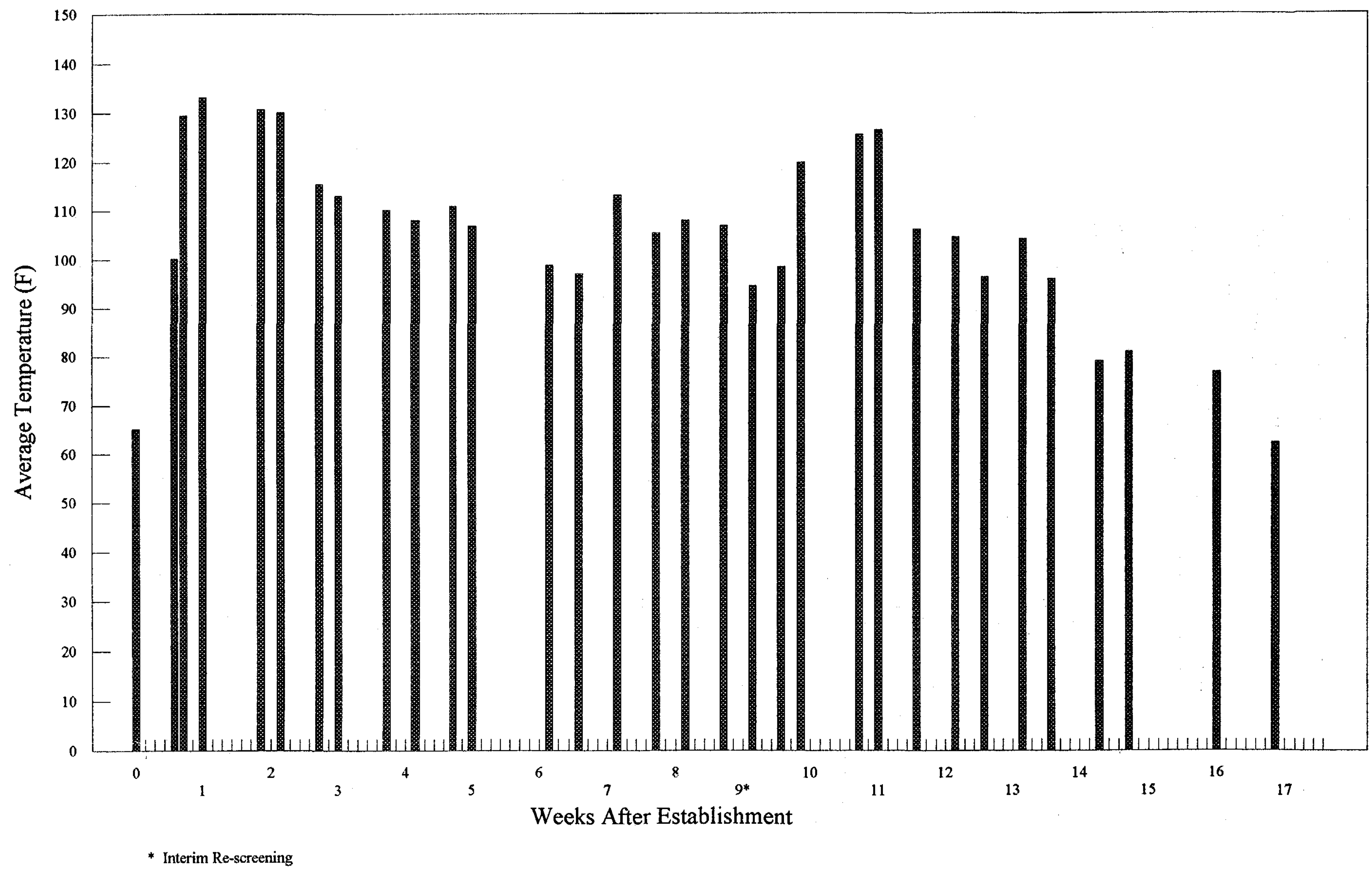
Compost Windrow Observations: Interim Re-screening Through Final Re-screening.

Weeks	Date	High Temp	Rain*	Weather	Avg. Temp. (degrees F.)** 8' wet orig.	8' wet new	8' dry new	Avg. all	Observations
9	thu 8/24	80s	0.0	sun					
	fri 8/25	70s	0.0	sun	79	87	117	95	No noticable odor, no leachate, some flies
	mon 8/28	70s	0.5	sun	93	94	109	99	Little odor, no leachate, some flies and blowing
	tue 8/29	80s	0.0	part sun					
	wed 8/30	70s	0.0	sun	105	117	137	120	Little odor, no leachate, some flies and blowing
10	thu 8/31	70s	0.4	clouds-rain					
	fri 9/1	70s	0.2	sun					
	mon 9/4	na	na	na					
	tue 9/5	70s	0.0	sun	117	123	136	126	No odor, no leachate, some flies and crickets
	wed 9/6	80s	0.0	sun					
11	thu 9/7	80s	0.0	sun/wind	116	131	133	126	Little odor, no leachate, seems more compact
	fri 9/8	60s	0.6	sun					
	mon 9/11	60s	1.1	sun	110	113	95	106	Little odor, no leachate, some flies, bees and crickets
	tue 9/12	70s	0.0	sun					
	wed 9/13	60s	0.0	clouds-rain					
12	thu 9/14	60s	0.7	clouds					
	fri 9/15	60s	0.0	clouds	87	108	119	105	Little odor, no leachate, many flies and crickets
	mon 9/18	60s	0.0	sun	80	99	110	96	Little odor, no leachate, some flies, bees and crickets
	tue 9/19	60s	0.0	sun					
	wed 9/20	60s	0.0	clouds					
13	thu 9/21	60s	0.0	clouds					
	fri 9/22	60s	0.5	rain	85	113	115	104	Raining, no visible leachate
	mon 9/25	50s	0.0	clouds	77	114	97	96	Wet appearance, no odor, leachate or vectors
	tue 9/26	60s	0.2	rain					
	wed 9/27	60s	0.4	part sun					
14	thu 9/28	50s	0.0	sun					
	fri 9/29	60s	0.0	sun					
	sat 9/30	60s	0.0	sun	67	78	93	79	No noticable odor, some flies and bees
	mon 10/2	70s	0.0	sun					
	tue 10/3	60s	0.0	sun	75	76	92	81	Windrow seems more compact, no odor or leachate
	wed 10/4	60s	0.9	rain					
15	thu 10/5	50s	0.1	clouds					
	fri 10/6	na	na	na					
	mon 10/9	50s	2.3	cloudy					
	tue 10/10	60s	0.0	sun					
	wed 10/11	60s	0.0	sun					
16	thu 10/12	70s	0.0	sun	62	71	98	77	No leachate, some crickets
	fri 10/13	80s	0.0	sun					
	mon 10/16	30s	2.0	rain					
	tue 10/17	50s	0.3	sun					
	wed 10/18	na	0.0	sun	63	58	67	62	No odor or leachate, some crickets
17	thu 10/19	60s	0.0	sun					Pile rescreened, very wet
	fri 10/20	60s	0.0	sun					
	mon 10/23	60s	3.5	sun					Transport to plant and combustion test
	Total Rain		13.7						
	Average Temp.				87	99	108	98	

* Rainfall in inches from close of previous work day through close of day noted.
** Each figure is an average of three individual temperature readings.

Figure 3-1.

Windrow Temperature.



- The waste material was tightly bound and, as a result, there was little litter blowing off of the windrow.
- There were a few flies and crickets, but otherwise no vector problems.
- There were a few leachate stains, probably iron, emanating from the windrow after the period of heavy rain.
- Settling of the windrow was readily noticeable approximately 2 weeks after establishment.

Interim Re-screening

Nine weeks after establishment, some material was removed from each of the five windrow sections for interim re-screening. The material in each section had the following appearance:

Section	Moisture	Color	State of Decomposition
4' Wet	damp	medium	partial
4' Dry	damp	medium	partial
6' Dry	slightly damp	medium	partial/mostly
8' Dry	lightly damp	medium/dark	partial/mostly
8' Wet	damp	medium/dark	partial/mostly

The following other observations were noted:

- Significant steaming and a mild earthy odor were observed upon digging into each of the five windrow sections.
- All sections were damp. None were dripping wet.
- The re-screened waste fraction appeared cleaner than once-screened waste. Nevertheless, because of the dampness of the waste, a fine coating of soil adhered to the material. There was no apparent food or yard waste remaining in the re-screened waste. It appeared to be primarily film plastic and textiles, with some metals and small rocks. Some paper and cardboard material was present, although it was difficult to identify because of its deteriorating condition and very few large pieces were apparent. Although damp, the material did not contain excessive moisture, which could significantly affect its Btu value.
- As compared to soil reclaimed during normal operations, the recovered compost soil appeared to have more scraps of paper and globules of wetted cardboard and paper. Waste particles smaller than the 1-inch screen openings (eg, broken glass, bits of plastic and metals) also remained in the compost soil.

Final Re-Screening

Eight weeks after the interim re-screening, and 17 weeks after the initial establishment of the windrow, the remaining material was subject to final re-screening. The material in each section had the following appearance:

Section	Moisture	Color	State of Decomposition
8' Wet (original)	very wet	dark	mostly
8' Wet (new)	very wet	dark	mostly
8' Dry	damp	medium/dark	mostly

The waste in the windrow was significantly damper and wetter than during the interim re-screening, most likely due to the wetter and colder fall weather. The bottom portion of most of the windrow was so wet that screening was impossible and not attempted. Some material that was placed in the trommel screen was too wet to be screened effectively and was discharged with considerable soil and mud adhered. This material was re-landfilled and not used for the combustion test. Only relatively clean material was used. Also:

- Some steaming was observed, although less than during the interim re-screening. A mild earthy odor was again observed in each disturbed section.
- The re-screened waste fraction appeared wetter, darker, and not as clean as that produced by the interim re-screening. There was no apparent food or yard waste remaining in the re-screened waste, and scraps of paper and plastic were almost impossible to find or identify.
- The recovered compost soil again contained small scraps of waste material and small globules of wetted cardboard and paper.

MOISTURE TEST RESULTS

Samples of cardboard and newspaper taken during the initial construction of the windrow indicated that the sections were between 43 percent and 61 percent moisture, which is in the optimum range for waste paper composting. Sections of the windrow that were wetted tested drier than the sections where no water was applied. This result is probably a statistical anomaly caused by 2 dry cardboard samples but suggests that the addition of moisture may not have had a major effect.

The moisture level of samples taken during the interim re-screening remained in the optimal range, averaging 59.7 percent. This percentage indicates that moisture was not a limiting factor during the composting experiment. The compost soil that was screened out was considerably more moist than that initially recovered, which may be an indication of a higher organic matter content.

The moisture levels at final re-screening were very high, probably due to the heavy rainfall in the preceding 2 weeks. Moisture data are summarized in Table 3-3.

QUANTITATIVE RESULTS

During both the interim and final re-screenings, the screened compost soil was loaded directly by conveyor into a dump truck and its volume measured. The truck was then sent to a local scale house to obtain the weight of the compost soil. In both cases, some re-screened waste was loaded into a dump trailer(s) for delivery to the waste-to-energy facility for combustion tests, where it was also weighed. Some unused re-screened waste was re-landfilled after its volume was measured.

Interim Re-Screening

The following data were recorded during the interim re-screening operation:

Fraction	Volume (cy)	Weight (tons)	Density (lb/cy)
Loaded into screen	63	-	930*
Re-screened waste:			
- To ARRF	50	20.05	802
- Re-landfilled	2	-	
Compost soil	11	8.45	1,536

* Calculated by assuming that the unweighed re-screened waste had the same density as re-screened waste weighed at ARRF.

Table 3-3.

Results of Moisture Sampling.

Sampled Material	Mean Moisture (%)		
	Initial Mix 6/22-23	At Interim Re-screening 8/23	At Final Re-screening 10/19
Screened soil	13.5	39.2	45.0
4' wet section	58.1	-	n/a
4' dry section	-	-	n/a
6' dry section	60.7	-	n/a
8' dry section	60.8	-	59.8
8' wet section	43.0	-	66.7
8' wet section (new)	n/a	-	60.4
Average of all waste	55.6	59.7	62.3
Waste sampled directly from trench	57.9	-	-

Based on the above figures, the composting and re-screening of waste resulted in a 17 percent decrease in the volume of waste requiring off site disposal and, more importantly, a 29 percent decrease in weight.

The composted and interim re-screened waste material had a lower density (802 pounds per cy) than waste reclaimed during normal processing of the landfill (project average of 1,087 pounds per cy with a general range of 950 - 1,200 pounds per cy).

Final Re-screening

The following data were recorded during the final re-screening operation:

Fraction	Volume (cy)	Weight (tons)	Density (lb/cy)
Loaded into screen	159	-	1,171*
Re-screened waste:			
- To ARRF	80	37.43	936
- Screened/re-landfilled	21	-	
- Poorly screened/ re-landfilled	32	-	
Compost soil:			
- Truck #1	16	-	
- Truck #2	6	7.12	2,373
- Conveyor spillage	4	-	

* Calculated by assuming that the unweighed re-screened waste and soil fractions had the same density as weighed fractions.

In this case, the composting and re-screening of waste resulted in a 16 percent decrease in the volume of waste requiring off site disposal, and a 33 percent decrease in weight as compared to the volume and weight of the original screened waste.

The density of both the final re-screened waste and compost soil was significantly higher than that of the interim re-screening, likely due to their higher moisture content. The decreased screening efficiency caused by the high moisture levels also contributed to the increased density of the re-screened waste.

ANALYTICAL TESTING RESULTS

Composite samples of the screened compost soil fractions (interim and final re-screenings) were analyzed for Class I and Class II (6NYCRR Part 360) compost parameters. Results are shown in Table 3-4 and compared to applicable standards. For those parameters that have regulatory standards, all results were below limits. Parameters without regulatory limits (eg, total kjeldahl nitrogen, ammonia, nitrates) appear elevated but typical for compost material.

Because the compost contains particles greater than 10 millimeters in size, it would not qualify as Class I compost and, as Class II compost, it would be limited to specific, nonfood-chain approved uses.

The carbon to nitrogen (C/N) ratio of the compost soil produced by the final re-screening was approximately 20/1. This is higher than expected for many finished compost products (below 15/1) and soil organic matter (10/1 to 13/1).

COMBUSTION TESTING RESULTS

Combustion tests were conducted using re-screened waste generated during both the interim and final re-screenings. Both took place at the ARRF waste-to-energy facility and both were conducted using an approximate 50:50 mix of reclaimed waste and normal pit waste.

Interim Combustion Test

The 20.05 tons of reclaimed waste was mixed with pit waste and fed into Boiler B. The mix was exhausted after a period of 4 hours, during which time a total of 40.6 tons was loaded. Boiler A was loaded with 100 percent normal pit waste. Waste was combusted uneventfully: no problems were encountered and no operating adjustments were necessary.

Table 3-4.

Results of Analytical Testing on Screened Compost Soil.

Parameter	NYS Part 360 Standard	Units	Interim Re-screening	Final Re-screening
Mercury	10	ppm	0.07	0.088
Cadmium	10	ppm	<0.3	<0.25
Nickel	200	ppm	<3	10
Lead	250	ppm	49.7	<0.25
Chromium-total	100	ppm	3.06	13.1
Copper	1000	ppm	37.5	18.0
Zinc	2500	ppm	98.6	87.5
PCBs Total	1	ppm	<1	<1
pH	na	su	7.7	7.6
Total Solids	na	%	72	56
Total Volatile Solids	na	%	10	13
Total Kjeldahl Nitrogen-N	na	ppm	2740	2300
Ammonia-N	na	ppm	34	3.6
Nitrate-N	na	ppm	14	45
Nitrite-N	na	ppm	1.8	3.6
Phosphorous Total	na	ppm	403	807
Potassium	na	ppm	368	245

During the run, the average Btu value of the 50 percent reclaimed waste mix loaded into Boiler B was 5,265 Btu/lb. The 24-hour average Btu value for Boiler B was 5,468 Btu/lb and for Boiler A was 5,567 Btu/lb. Based on these values and waste loading data, the value of reclaimed waste was calculated to be in the 4,500-5,000 Btu/lb range. A more precise Btu value cannot be calculated because the precise Btu value of the specific pit waste that was mixed with reclaimed waste cannot be known, and because of the relatively short duration of the test run. Because of the heterogeneous nature of mixed waste, a precise Btu value may not be possible to obtain under any available testing method other than combusting 100 percent reclaimed waste.

Final Combustion Test

The 37.42 tons of reclaimed waste was mixed with pit waste and fed into Boiler A. After 1 hour, dropping combustion temperatures and upset conditions resulted in plant operators switching to a 25 percent mix of reclaimed waste. At 1.5 hours operators started natural gas burners in an attempt to raise temperatures, and at 2.25 hours the test run was aborted. Remaining reclaimed waste was mixed through the waste pit and eventually combusted at low ratios without further problems.

As a result, Btu values for the reclaimed waste cannot be calculated but can be assumed to be low. This low heating value is a direct result of the material's high moisture content, as discussed above. In addition, the landfill site received 3.5 inches of rain between the time the waste was re-screened and shipped to the plant. Although the pile was covered with a tarp, additional moisture may have infiltrated the waste.

DISCUSSION

Composting Effectiveness

Based upon the results, it was apparent that composting of reclaimed waste had occurred. Indicators of composting included the elevated internal temperatures of the compost windrow; the darkened appearance of the material at re-screening; the apparent decrease of paper within the waste fraction; and the large volume of compost soil removed during the windrow re-screenings.

However, it was also apparent that complete composting of the organic waste fraction had not occurred. This fact was evidenced by the increased quantity of paper and cardboard scraps and globules in the recovered compost soil. Results of the carbon and nitrogen testing of the recovered compost soil suggest that a low nitrogen level may have been a compost-limiting factor. This low level of nitrogen could be remedied by the addition of sewage sludge to the initial compost windrow. Based on moisture test results, it is believed that moisture was not a compost-limiting factor, and that the addition of water during windrow establishment may not have had a major effect.

No individual quantitative measurements were made of the individual windrow sections upon interim and final re-screening. Thus, no conclusions can be reached concerning optimum windrow size and moisture. However, all sections exhibited comparable indicators of composting.

The compost soil that was produced cannot be considered a high-quality product. It contained a large percentage of scraps of undecomposed waste, deteriorating materials, and bits of glass, plastic, metals, and other wastes. The product is best suited for use as daily landfill cover, backfill, or other limited applications. Use of a finer screen would improve the product but would also reduce the quantity of the compost fraction removed from the reclaimed waste.

Waste Combustion

Mixed results were obtained from the two combustion tests. The waste fuel produced from the initial re-screening showed significant improvement over waste combusted from typical reclamation operations in a number of areas. The waste had a Btu value of 4,500 to 5,000 Btu/lb as compared to unimproved reclaimed waste combusted at Edinburg (2,200 to 4,000 Btu/lb) and Lancaster, Pennsylvania (3,000 to 3,200 Btu/lb). The significantly lower waste density also was an indicator of the effectiveness of the composting process in improving the fuel quality of the reclaimed waste. Finally, the waste was easily combusted with no problems encountered by plant operators.

The lower Btu value of the waste produced by the final re-screening can be attributed to excessive moisture. As compared to the initial re-screening, the final re-screening effort produced a comparable removal of compost soil and should have produced a comparable test result. However, the rains that fell upon the compost windrow during the final weeks caused an incomplete separation of soil from waste during final re-screening, and added enough moisture to render the waste too difficult to combust.

Other Considerations

The effectiveness of composting reclaimed waste at different sites will depend, in part, upon the organic fraction of the waste. This organic fraction will be affected by several factors:

- Wastes types accepted and landfilling practices. Landfills accept varying waste streams with differing organic fractions. In addition to municipal solid waste (MSW), some sites accept construction and demolition debris, non-hazardous industrial wastes, ashes, sludges, etc. The composition of these wastes also may be affected by local recycling programs. Finally, landfills may have different burial practices with different waste types co-mingled in one landfill cell or disposed in separate landfill areas.

- Waste age. The organic fraction of waste that is buried will undergo decomposition. The degree to which this occurs will vary with age, local weather conditions, soil type, moisture content, waste depth and compaction, etc. In addition, older wastes may have been buried before the implementation of recycling programs, and some older landfills may have utilized open waste burning.

Thus, site specific evaluation of a landfill's organic waste fraction is recommended prior to undertaking a reclaimed waste composting operation. Feasibility also may vary among various landfill areas within the same landfill.

The logistics of undertaking a composting effort as part of a landfill reclamation operation should also be carefully considered. Several considerations are as follows:

- Operating space. Establishing windrows of composted waste can require a significant area. Because of potential leachate contamination, this area ideally should be established over an existing landfill area or paved area with runoff controls. A large buffer space between the windrow and the nearest residences is desirable should odors become a problem.

- Field conditions. Seasonal and daily weather conditions are a factor in the composting process. As demonstrated during this research project, field conditions also affect the re-screening process and the quality of the reclaimed waste. Of particular concern are composting operations in which re-screened reclaimed waste is disposed at waste-to-energy facilities. Because of plant capacities, regularly scheduled waste deliveries may be required. However, the variable nature of field conditions can produce a product of variable and sometimes unacceptable quality.

- Time frame. The effective composting of reclaimed waste takes several months to accomplish. However, windrow monitoring and compost re-screening are accomplished most efficiently as part of an ongoing reclamation operation. Returning to a site to re-screen compost after project closure could entail additional equipment mobilization and rental costs. A possible solution is to commence operations in the landfill sections containing the most recently landfilled wastes. Composting of waste from older landfill sections during a project's closing months should not be undertaken. Depending on the age and decomposition of the older waste, those sections would likely benefit the least from a composting effort.

The area required to sustain an ongoing, full-scale composting effort will vary with these considerations. For example, if 500 cy/work day of screened waste are generated, and a composting period of 2 months is needed, then an area large enough to accommodate up to 20,000 cy of windrowed waste at a time is necessary. If 8-foot-high windrows were established with little or no spacing in between, then approximately 3 to 4 acres would be required for the operation, depending on access considerations. If waste was reclaimed at a faster pace, or if a longer composting period was needed, then more space would be required.

Section 4
ECONOMICS

Project results have shown that composting reclaimed waste followed by re-screening to remove the compost soil fraction can result in decreased waste transportation and disposal requirements. However, associated cost savings are offset by the costs of conducting the composting effort, primarily the re-screening of the composted waste. Whether the benefits outweigh the costs for a particular project will be a function of several key variables: the compostable organic fraction of the reclaimed waste, the cost of re-screening the composted material, and the avoided cost of waste transportation and disposal.

COST COMPONENTS

Windrow Set Up Costs

The establishment of a windrow of reclaimed waste incurs an insignificant incremental project cost. As a normal component of a reclamation project, material is excavated, screened, and reburied or set aside for transport. Placing the screened waste into onsite compost windrows presents only a minor change in the work plan with little or no cost implications. The addition of sewage sludge or water to facilitate composting, however, would increase the effort and associated costs.

Windrow Monitoring Costs

Experience at Hague suggests that significant, although incomplete composting can be accomplished with minimal effort. However, attention must be given to the regular monitoring of the compost windrow. Temperature monitoring will indicate whether composting is occurring. Inspection for potential problems (odors, vectors, leachate, and blowing papers) is recommended. These tasks are not significant cost items if there is an ongoing reclamation project at the site. Several factors could increase the cost of windrow maintenance, including turning the windrow, the addition of water, and contingency events, such as odor or leachate controls.

Compost Re-screening

The most significant cost item is the re-screening of the finished compost to remove the compost soil fraction. This requires the dedication of the reclamation processing train and, as a result, the interruption of reclamation operations. Thus, costs for this effort are essentially the same as that of the ongoing reclamation project.

The cost of processing reclaimed waste will vary based upon several site-specific factors, including the number and types of equipment used, the local cost of equipment and labor, and the material processing rate. Table 4-1 indicates monthly costs for the reclamation operations at Hague, which include a combination of Town forces and contracted equipment and labor. These costs, at $99,000 per month, are typical for landfill reclamation work.

Because reclamation operations are limited by the volume of material that can be screened in a given period of time, processing costs are typically noted in dollars per cubic yard. Processing rates at landfill reclamation projects vary with the type of material screened, weather conditions, and equipment and manpower utilized. The above costs at Hague translate to a processing cost of as little as $5 per cy at a 1,000 cy/day processing rate, to as much as $8 per cy at 600 cy/day.

Waste Transportation and Disposal Costs

The increased costs of a landfill reclamation composting operation must be compared to the resulting avoided waste transportation and disposal costs. These widely varying costs depend upon the reclamation site's distance from the selected disposal facility and regional waste disposal market economics.

The reclamation project at Hague utilized off site waste disposal capacity. However, some reclamation projects may re-bury reclaimed waste on site. Reclaimed waste can be relocated as part of a landfill consolidation effort, where the area requiring a conventional landfill cap is reduced; or waste may be placed in a lined landfill cell newly constructed or existing at the reclaimed site. For reclamation operations utilizing such on site waste disposal, the cost of conducting a composting operation can be compared to the avoided costs associated with constructing a smaller landfill cap or lined cell.

Table 4-1.

Landfill Reclamation Processing Costs.

Item	Monthly Cost
Trommel screen/conveyor	$17,000
Other equipment (excavator, loaders (3), backhoe and dump truck)	27,000
Labor (equipment operators (6), health and safety monitoring, and inspection)	30,000
Project management and engineering	15,000
Miscellaneous costs*	10,000
Total Monthly Cost	$99,000

* Miscellaneous costs include utility vehicle, monitoring equipment, protective equipment, per diem, fuel and miscellaneous supplies.

NOTE: Costs are for excavation, screening and material movement. Does not include costs of planning, permitting, laboratory fees, and equipment mobilization/demobilization and maintenance. Costs reflect a combination of contracted and town-supplied equipment and labor.

SAVINGS CALCULATIONS

The economic feasibility of composting reclaimed waste at the Hague landfill is calculated using the average effectiveness of the composting trials and actual project costs as follows:

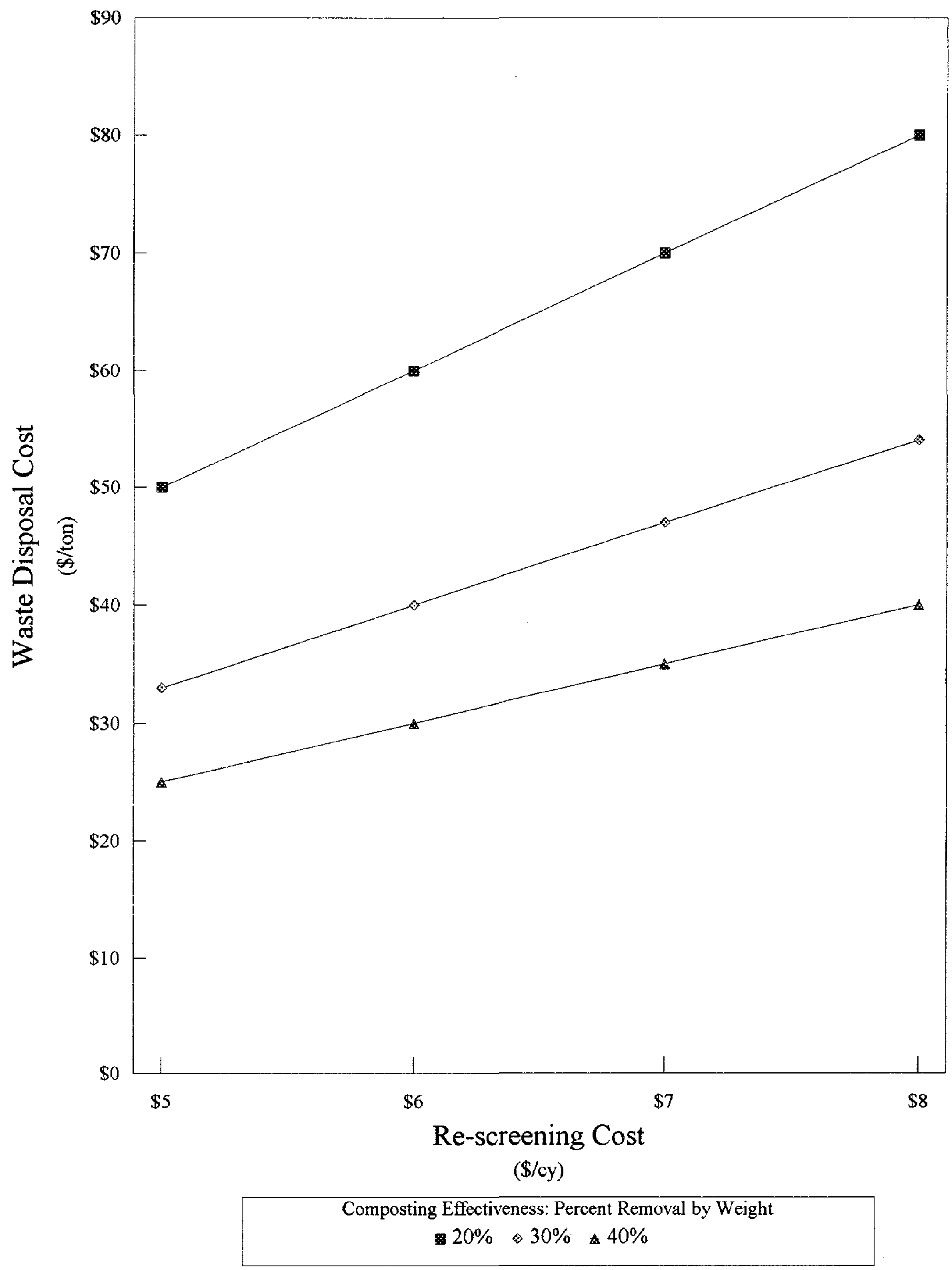
Transportation/disposal cost per ton of waste	$63.39
Composting savings:	
- Percent weight removed by composting	31%
- Tons saved/ton reclaimed waste	0.310
- Cost savings/ton reclaimed waste	$19.65
Composting costs:	
- Reclaimed waste density (lb/cy)	1,087
- Cy per ton of waste	1.840
- Re-screening cost ($/cy processed)	$7.00
- Re-screening cost ($/ton processed)	$12.88
Net savings/ton reclaimed waste	$6.77
Net percent savings in waste disposal costs	10.7%

Thus, composting reclaimed waste at the Hague landfill would result in a decrease of approximately 11 percent in waste disposal costs. Applied to the entire estimated 10,400 tons of MSW in the landfill, the savings would reduce disposal costs by $70,400 from the projected $659,300. However, this assumes that a comparable reduction in the organic fraction would be obtained from all waste in the landfill which, as discussed in Section 3, may not be the case.

Figure 4-1 indicates the break even waste disposal cost for landfill reclamation composting scenarios. Variables include re-screening costs from $5/cy to $8/cy and compost-associated weight reductions from 20 percent to 40 percent. A reclaimed waste density of 1,000 pounds per cy is assumed. In these scenarios, the break even cost of waste disposal ranges from $25/ton to as much as $80/ton, demonstrating the site-specific nature of economic feasibility.

Figure 4-1.

Breakeven Waste Disposal Costs for
Various Landfill Reclamation Composting Scenarios.



Note: Assumes 1,000 lb/cy reclaimed waste density

Section 5

CONCLUSIONS

1. Waste reclaimed from a landfill reclamation operation was successfully composted. The composting and re-screening process resulted in a 31 percent average weight reduction in material requiring off site transportation and disposal.

2. Establishment and maintenance of the compost windrow was accomplished with minimal effort. No odor, vector, or leachate problems were experienced. Removing the compost soil after the composting period required the re-screening of waste through the normal reclamation equipment processing train.

3. The initial combustion test of composted and re-screened waste indicated a significant improvement in Btu value and combustibility as compared to past experience with unimproved reclaimed waste. However, a subsequent combustion test on composted and re-screened waste was unsuccessful because of the material's high moisture content. This content was the result of heavy rainfall on the compost windrow in the weeks preceding the final re-screening.

4. Temperature monitoring indicated that most composting activity occurred within 3 months of windrow establishment, declining rapidly thereafter. However, complete composting of the organic waste fraction had not been obtained. A low nitrogen level may have been a compost-limiting factor. The addition of water during windrow establishment may not have had a major effect.

5. The recovered compost soil met New York State analytical standards. However, the presence of waste particles smaller than the 1-inch screen openings limits its application to landfill or other approved uses.

6. The efficacy of composting reclaimed waste at other landfill reclamation projects will depend upon site-specific factors. Of major importance are the size and nature of the organic fraction of the waste mass, and site logistical considerations. The moisture

content and resulting quality of reclaimed waste as fuel for waste-to-energy combustion can be affected by local weather conditions unless precautions are taken.

7. Implementation of a full-scale composting effort was shown to be economically feasible at the Town of Hague landfill reclamation project. However, feasibility is site specific and can only be determined upon investigation. Major factors affecting feasibility are the effectiveness of the composting operation, available space for establishing the windrows, local processing costs, and the cost of waste disposal alternatives.