11-1-1980

Economics of Existing Systems and of Alternatives

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Solid Waste Management Series

Adm New Yes

EC-512

SOLID WASTE MANAGEMENT

ECONOMICS OF EXISTING SYSTEMS AND OF ALTERNATIVES

WEST CENTRAL INDIANA AND EAST CENTRAL ILLINOIS

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COOPERATIVE EXTENSION SERVICE • PURDUE UNIVERSITY • WEST LAFAYETTE, INDIANA

Contents

SOLID WASTE MANAGEMENT

ECONOMICS OF EXISTING SYSTEMS AND OF ALTERNATIVES

WEST CENTRAL INDIANA AND EAST CENTRAL ILLINOIS

What to do with waste material has always been a puzzling problem for mankind. Only a few generations ago, this Nation's inhabitants could simply migrate to another area to alleviate any problem with waste accumulation. However, with an increasing population, limitations on land space, and a decreasing availability of natural resources, waste materials management is becoming an increasingly important concern for elected officials as well as the general populace. As the field of waste management continues to expand, improvements will be needed in this field as technology and society will permit. As in the past, cost and convenience will continue to be dominant factors influencing the management of waste material.

Public officials in West Central Indiana and East Central Illinois establish provisions for the disposal of waste material generated by their communities. In all counties, this method generally consists of collection and then disposal of the refuse in landfills. In many communities, this process often becomes costly and controversial.

This report was developed to make an economic analysis of the solid waste management methods currently being used in the area. It also examines the economics of alternative methods of refuse disposal to determine whether a better, less costly, or more efficient solid waste management system might be implemented.

The following data regarding solid waste generation estimates and the estimates of the alternative refuse collection and disposal costs should be used with caution. From community to community there are wide variations in land, labor, capital, utility, material, and other costs. Also, depending on the source from which data are received, estimates may be subjected to variations and uncertainty.

1. Terminology Commonly Used in Solid Waste Management

Solid Waste—Any garbage, refuse, or sludge, from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities.

Solid Waste Management—The systematic administration of activities which provide for collection, source separation, storage, transportation, transfer, processing, treatment, and disposal of solid waste, including planning and management with respect to resource recovery and resource conservation.

Disposal—The discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters including ground waters.

Hazardous Waste—A solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may—

(a) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness; or

(b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

Hazardous Waste Management—The systematic control of the collection, source separation, storage, transportation, processing, treatment, recovery, and disposal of hazardous waste.

Open Dump—A site for the disposal of solid waste in which, unlike a sanitary landfill, there is reasonable probability of adverse effects on health or the environment from disposal of solid waste.

Recoverable—Refers to the capability and likelihood of a material being recovered from solid waste for a commercial or industrial use.

Recovered Resources—Materials or energy recovered from solid waste.

Resource Conservation—The reduction of the amounts of solid waste that are generated, reduction of overall resource consumption, and utilization of recovered resources.

Source Separation—A method of recycling waste materials by encouraging the generators of the waste to selectively collect, segregate, and separately store desirable components of their waste so that they may be later collected and introduced back into the materials market for recycling.

Resource Recovery—Any systematic recovery and use of values from residuals or discards. The values are usually in the form of recyclable materials (paper, metals, and glass), and the energy derived from burning the combustibles of solid waste.

The types of resource recovery approaches range from what are essentially labor-intensive projects at sources separating recyclables, to capital-intensive facilities to separate materials and energy products from mixed wastes. Also included is the tapping of methane gas from landfills, as well as from mixtures of sewage sludge and solid waste. And the use of humus composted from selected organic discards—mixed, in some cases, with sludge—is a recovery application.

Solid Waste Transfer System—Refuse is dumped or deposited at a central location. It is then transferred to large over-the-road hauling equipment for more efficient transport to the disposal site. Applications include transfer to sanitary landfills, land reclamation areas, resource recovery stations, recycling and conversion to fuel or a variety of uses. These facilities can also help cut vehicle maintenance costs and can increase equipment durability because of their easier access than landfills. Trucks going to landfill sites usually have to cross very tough terrain, which is hard on refuse trucks and their components, particularly tires, engines, and transmissions.

Direct Haul—Refuse is hauled straight from the collection site or sites to the final disposal site. The same vehicle is used both to collect and transport the refuse.

2. County Populations

Many factors affect the amount and type of solid waste generated. Important data needed for solid waste planning and analysis are accurate population estimates and projections.

Data included in this section were obtained from the 1970 Census of Population, U.S. Department of Commerce, Bureau of Census, and from 1980 population projections prepared jointly by the Bureau of the Census and the Indiana State Board of Health. For the Illinois counties the 1970 population was also used as the projected 1980 population.

The total projected 1980 population for the eleven-county area is 319,531 persons.

Table 1. Population of County Subdivision,s 1970 and 1980.

Clay County	1970		1980
1. Brazil Township	8,568		8,638
Brazil City (part)	8,053		
2. Cass Township	298		368
3. Dick Johnson Township	1,136		1,206
Brazil City (part)	20		
4. Harrison Township	2,129		2,199
Clay City Town	900		
5. Jackson Township	1,665		1,735
Brazil City (part)	90		
6. Lewis Township	1,338		1,408
7. Perry Township	939		1,009
8. Posey Township	3,311		3,381
Staunton Town	582		
9. Sugar Ridge Township	865		934
Center Point Town	275		
10. Van Buren Township	2,990		3,059
Carbon Town	344		
Knightsville Town	788		
11. Washington Township	694		763
	23,933	(+767)	24,700

Greene County	1970		1980
1. Beech Creek Township	1,274		1,402
2. Cass Township	426		553
Newberry Town	295		
3. Center Township	1,391		1,518
4. Fairplay Township	651		778
Switz City Town (part)	113		
5. Grant Township	668		795
Switz City (part)	188		
6. Highland Township	513		640
7. Jackson Township	1,182		1,309
8. Jefferson Township	2,116		2,243
Worthington Town	1,691		
9. Richland Township	4,336		4,463
Bloomfield Town	2,565		
10. Smith Township	419		546
11. Stafford Township	535		662
12. Stockton Township	7,383		7,510
Linton City	5,450		
13. Taylor Township	938		1,065
14. Washington Township	1,241		1,368
Lyons Town	702		
15. Wright Township	3,821		3,948
Jasonville City	2,335		
	26,894	(+1,906)	28,800

Owen County	1970		1980
1. Clay Township	1,272		1,491
2. Franklin Township	727		946
3. Harrison Township	253		472
4. Jackson Township	299		517
5. Jefferson Township	751		969
6. Jennings Township	370		588
7. Lafayette Township	378		596
8. Marion Township	730		948
9. Montgomery Township	479		697
10. Morgan Township	540		758
11. Taylor Township	748		966
12. Washington Township	4,400		4,618
Spencer Town	2,553		
13. Wayne Township	1,216		1,434
Gosport Town	692		
	12,163	(+2,837)	15,000

Parke County	1970	1980
1. Adams Township	4,161	4,261
Rockville Town	2,820	
2. Florida Township	2,433	2,533
Rosedale Town	817	
3. Greene Township	470	570
4. Howard Township	204	304
5. Jackson Township	549	649
6. Liberty Township	852	952

Parke County

		1970		1980
7.	Penn Township	887		987
	Bloomingdale Town	391		
8.	Racoon Township	711		811
9.	Reserve Township	1,562		1,662
	Montezuma Town (part)	1,157		
10.	Sugar Creek Township	265		365
11.	Union Township	698		798
12.	Wabash Township	875		975
	Montezuma Town (part)	35		
13.	Washington Township	933		1,033
	Judson Town	35		
	Marshall Town	365		
		14,600	(+1,300)	15,900

Putnam County

		1970		1980
1.	Clinton Township	829		943
2.	Cloverdale Township	2,049		2,162
	Cloverdale Town	870		
3.	Floyd Township	734		847
4.	Franklin Township	1,712		1,825
	Roachdale Town	1,004		
5.	Greencastle Township	11,498		11,611
	Greencastle City	8,852		
6.	Jackson Township	706		820
7.	Jefferson Township	963		1,076
8.	Madison Township	953		1,066
9.	Marion Township	1,871		1,985
10.	Monroe Township	1,393		1,506
	Bainbridge Town	703		
11.	Russell Township	814		927
	Russellville Town	390		
12.	Warren Township	1,884		1,997
13.	Washington Township	1,526		1,639
		26,932	(+1,468)	28,400

Sullivan County

		1970		1980
1.	Cass Township	2,263		2,254
	Dugger Town	1,150		
2.	Curry Township	3,778		3,768
	Farmersburg Town	962		
	Shelburn Town	1,281		
3.	Fairbank Township	699		689
4.	Gill Township	1,083		1,073
	Merom Town	305		
5.	Haddon Township	1,972		1,962
	Carlisle Town	714		
6.	Hamilton Township	6,555		6,545
	Sullivan City	4,683		
7.	Jackson Township	1,899		1,889
	Hymera Town	907		
8.	Jefferson Township	800		790
9.	Turman Township	840		830
		19,889	(-89)	19,800

Vermillion County

		1970		1980
1.	Clinton Township	9,084		9,246
	Clinton City	5,340		
	Fairview Park Town	1,067		
	Universal Town	462		
2.	Eugene Township	2,127		2,289
	Cayuga Town	1,090		
3.	Helt Township	2,819		2,980
	Dana Town	720		
4.	Highland Township	1,694		1,855
	Perrysville Town	510		
5.	Vermillion Township	1,069		1,230
	Newport Town	708		
		16,793	(+807)	17,600

Vigo County

		1970		1980
1.	Fayette Township	2,734		2,499
2.	Harrison Township	69,530		69,295
	Terre Haute City (part)	69,530		
3.	Honey Creek Township	9,079		8,844
	Terre Haute City (part)	14		
4.	Linton Township	1,435		1,192
5.	Lost Creek Township	6,481		6,245
	Seelyville Town	1,195		
	Terre Haute City (part)	679		
6.	Nevins Township	2,200		1,965
7.	Otter Creek Township	7,801		7,565
	Terre Haute City (part)	63		
8.	Pierson Township	1,285		1,050
9.	Prairieton Township	1,063		828
10.	Riley Township	1,976		1,741
	Riley	257		
11.	Prairie Creek Township	1,216		981
12.	Sugar Creek Township	9,728		9,493
	Terre Haute City (part)	----		
	West Terre Haute City	2,704		
		114,528	(-2,828)	111,700

Clark County, Illinois

16,216 - 1970
16,546 - 1960

		1970
1.	Anderson Township	323
2.	Auburn Township	271
3.	Casey Township	3,954
	Casey City	2,994
4.	Darwin Township	379
5.	Dolson Township	390
6.	Douglas Township	183
7.	Johnson Township	387
8.	Marshall Township	4,296
	Marshall City	3,468
9.	Martinsville Township	1,876
	Martinsville City	1,374
10.	Melrose Township	391

Clark County, Illinois

11.	Orange Township	352
12.	Parker Township	235
13.	Wabash Township	1,608
14.	Westfield Township	827
	Westfield Village	678
15.	York Township	744

Crawford County, Ill.

19,824 - 1970
20,751 - 1960

		1970
1.	Honey Creek Township	1,365
	Flat Rock Village (part)	425
2.	Hutsonville Township	1,195
	Hutsonville Village	544
3.	Lanrotte Township	2,500
	Palestine Village	1,640
4.	Licking Township	392
5.	Martin Township	685
6.	Montgomery Township	758
	Flat Rock Village (part)	79
7.	Oblong Township	3,124
	Oblong Village	1,860
	Stoy Village	199
8.	Prairie Township	678
9.	Robinson Township	9,026
	Robinson City	7,178
10.	Southwest Township	101

Edgar County, Ill.

21,591 - 1970
22,550 - 1960

		1970
1.	Brouilletts Creek Township	343
2.	Buck Township	394
	Redman Village (part)	137
3.	Edgar Township	644
4.	Elbridge Township	689
	Vermillion Village (part)	19
5.	Embarrass Township	921
	Borton Village	349
	Redman Village (part)	114
6.	Grandview Township	667
7.	Hunter Township	376
8.	Kansas Township	1,098
	Kansas Village	779
9.	Paris Township	11,306
	Paris City	9,971
10.	Prairie Township	395
11.	Ross Township	1,576
	Chrisman City	1,285
12.	Shiloh Township	465
	Hume Village (part)	19
13.	Stratton Township	699
	Vermillion Village (part)	314
14.	Symmes Township	860
15.	Young America Township	1,158
	Hume Village (part)	477
	Metcalf Village	269

3. Solid Waste Generation

In solid waste planning and management, many basic questions must be addressed. How much solid waste? Where from? Who from? What is its composition? In this section the question "How much?" is addressed.

A concerted effort was made to survey landfill operators, landfill monitors (the Indiana State Board of Health), public and private collectors, and commercial businesses and industries to determine "how much?" The data obtained, however, were very inconsistent and showed sizable differences. For this reason, it was decided best to use a per capita generation figure derived from records kept at the Tippecanoe County landfill where incoming refuse is weighed daily.

From the landfill monitoring in Tippecanoe County, it was determined that each urban resident generates 5.2 pounds/day and each rural resident generates 3.3 pounds/day of refuse which goes to the landfill for disposal. These figures seem to be in line with other research projects where estimations of solid waste generation have been made. These estimates were then used in conjunction with 1980 population projections to determine the tons/year going to the landfills. These figures are rounded to the nearest hundred.

An Ad Hoc Advisory Committee from Vigo County reviewed this report prior to publication. They disagreed with the solid waste generation guideline as applied to Vigo County and contend that the landfills actually receive 2 to 3 times the estimate used. The conclusions from this report would be the same even if the quantity of refuse was increased accordingly. The next section does reflect a higher landfill cost per ton in Vigo County than in other Indiana counties. Naturally, this would not be the case if the per capita generation is underestimated in Vigo County by a factor of 2 or 3. However, to be consistent, the authors have chosen to use the same per capita generation guidelines for all counties.

The total solid waste going to landfills in the eleven-county area is estimated at 257,312 tons in 1980.

Table 2. Solid Waste Generation by County Subdivision.

Clay County

		Tons/Day	Tons/Year
1.	Brazil Township (urban)	22.5	8,200
	Brazil City	----	-----
2.	Cass Township	.6	200
3.	Dick Johnson Township	2.0	700
4.	Harrison Township	3.6	1,300
5.	Jackson Township	2.9	1,000
6.	Lewis Township	2.3	800
7.	Perry Township	1.7	600
8.	Posey Township	5.6	2,000
9.	Sugar Ridge Township	1.5	500
10.	Van Buren Township	5.0	1,800
11.	Washington Township	1.3	500
		49.0	17,600

Greene County

		Tons/Day	Tons/Year
1.	Beech Creek Township	2.3	800
2.	Cass Township	0.9	300
3.	Center Township	2.5	900
4.	Fairplay Township	1.1	400
5.	Grant Township	1.3	500
6.	Highland Township	1.1	400
7.	Jackson Township	2.2	800
8.	Jefferson Township	3.7	1,400
9.	Richland Township (urban)	11.6	4,200
	Bloomfield Town	---	----
10.	Smith Township	.9	300
11.	Stafford Township	1.1	400
12.	Stockton Township (urban)	19.5	7,100
	Linton City	----	-----
13.	Taylor Township	1.8	700
14.	Washington Township	2.3	800
15.	Wright Township	6.5	2,400
		58.8	21,400

Parke County

		Tons/Day	Tons/Year
1.	Adams Township (urban)	11.1	4,100
•	Rockville Town	---	----
2.	Florida Township	4.2	1,500
3.	Greene Township	.9	300
4.	Howard Township	.5	200
5.	Jackson Township	1.1	400
6.	Liberty Township	1.6	600
7.	Penn Township	1.6	600
8.	Racoon Township	1.3	500
9.	Reserve Township	2.7	1,000
10.	Sugar Creek Township	.6	200
11.	Union Township	1.3	500
12.	Wabash Township	1.6	600
13.	Washington Township	1.7	600
		30.2	11,100

Owen County

		Tons/Day	Tons/Year
1.	Clay Township	2.5	900
2.	Franklin Township	1.6	600
3.	Harrison Township	.8	300
4.	Jackson Township	.9	300
5.	Jefferson Township	1.6	600
6.	Jennings Township	1.0	400
7.	Lafayette Township	1.0	400
8.	Marion Township	1.6	600
9.	Montgomery Township	1.2	400
10.	Morgan Township	1.3	500
11.	Taylor Township	1.6	600
12.	Washington Township (urban)	12.0	4,400
	Spencer Town	----	----
13.	Wayne Township	2.4	900
		29.5	10,900

Putnam County

		Tons/Day	Tons/Year
1.	Clinton Township	1.6	600
2.	Cloverdale Township	3.6	1,300
3.	Floyd Township	1.4	500
4.	Franklin Township	3.0	1,100
5.	Greencastle Township (urban)	30.2	11,000-
	Greencastle City	----	----
6.	Jackson Township	1.4	500
7.	Jefferson Township	1.8	700
8.	Madison Township	1.8	700
9.	Marion Township	3.3	1,200
10.	Monroe Township	2.5	900
11.	Russell Township	1.5	500
12.	Warren Township	3.3	1,200
13.	Washington Township	2.7	1,000
		58.1	21,200

Sullivan County

		Tons/Day	Tons/Year
1.	Cass Township	3.7	1,400
2.	Curry Township	6.2	2,300
3.	Fairbanks Township	1.1	400
4.	Gill Township	1.8	700
5.	Haddon Township	3.2	1,200
6.	Hamilton Township (urban)	17.0	6,200
	Sullivan City	---	---
7.	Jackson Township	3.1	1,100
8.	Jefferson Township	1.3	500
9.	Turman Township	1.4	500
		38.8	14,300

Vermillion County

		Tons/Day	Tons/Year
1.	Clinton Township (urban)	24.0	8,700
	Clinton City	------	------
	Fairview Park Town	------	------
	Universal Town	------	------
2.	Eugene Township	3.8	1,400
3.	Helt Township	4.9	1,800
4.	Highland Township	3.1	1,100
5.	Vermillion Township	2.0	700
		37.8	13,700

Vigo County

		Tons/Day	Tons/Year
1.	Fayette Township	4.1	1,500
2.	Harrison Township (urban)	180.2	65,800
	Terre Haute City (part)	-----	-----
3.	Honey Creek Township	14.6	5,300
4.	Linton Township	2.0	700
5.	Lost Creek Township	16.2	5,900
	Seelyville Town	----	-----
	Terre Haute City (part)		
6.	Nevins Township	3.2	1,200
7.	Otter Creek Township	12.4	4,500
8.	Pierson Township	1.7	6,200
9.	Prairieton Township	1.4	500
10.	Riley Township	2.8	1,000
11.	Prairie Creek Township	1.6	600
12.	Sugar Creek Township	24.6	8,900
	West Terre Haute City	----	-----
		264.8	102,100

Clark County, Illinois

		Tons/Day	Tons/Year
1.	Anderson Township	.5	183
2.	Auburn Township	.5	183
3.	Casey Township (urban)	10.2	3,723
	Casey City	----	-----
4.	Darwin Township	.6	219
5.	Dolson Township	.6	219
6.	Douglas Township	.3	110
7.	Johnson Township	.6	219
8.	Marshall Township (urban)	11.2	4,088
	Marshall City	----	-----
9.	Martinsville Township	3.1	1,132
10.	Melrose Township	.7	255
11.	Orange Township	.6	219
12.	Parker Township	.4	146
13.	Wabash Township	2.7	986
14.	Westfield Township	1.4	511
15.	York Township	1.2	438
		34.6	12,631

Crawford County, Illinois

		Tons/Day	Tons/Year
1.	Honey Creek Township	3.1	1,132
2.	Hutsonville Township	2.0	730
3.	Lanrotte Township	4.1	1,497
4.	Licking Township	.7	256
5.	Martin Township	1.1	401
6.	Montgomery Township	1.3	475
7.	Oblong Township	5.2	1,898
8.	Prairie Township	1.1	402
9.	Robinson Township (urban)	23.5	8,578
	Robinson City	---	----
10.	Southwest Township	.2	73
		42.3	15,442

Edgar County, Illinois

		Tons/Day	Tons/Year
1.	Brouilletts Creek Township	.6	219
2.	Buck Township	.7	256
3.	Edgar Township	1.1	402
4.	Elbridge Township	1.1	402
5.	Embarrass Township	1.5	548
6.	Grandview Township	1.1	402
7.	Hunter Township	.6	219
8.	Kansas Township	1.8	657
9.	Paris Township	29.4	10,731
	Paris City		
10.	Prairie Township	.6	219
11.	Ross Township	2.6	949
12.	Shiloh Township	.8	292
13.	Stratton Township	1.2	438
14.	Symmes Township	1.4	511
15.	Young America Township	1.9	694
		46.4	16,939

4. Inventory of Landfills in Study Area (1979)

A. Area Served by Landfills

Indiana

Clay County

1. *Haviland Landfill* - Serves southern portion of Clay County; Clay City; some areas outside of the county (Coal City).
2. *Staunton Landfill* - Northern third of Clay County; Brazil.
3. *Bedwell Landfill* - North central and northeast Clay County; Brazil.

Greene

1. *Greene County Landfill* - Greene County; some areas outside the county.

Owen

1. *Owen County Landfill* - Owen County, some areas outside the county.

Parke

1. *Parke County Landfill* - Parke County.

Putnam

1. *Putnam County Landfill* - Putnam County.

Sullivan

1. *Sullivan County Landfill* - Sullivan County.

Vermillion

1. *County Home Landfill* - Vermillion County (mainly north of U.S. 36); some areas outside of the county (Parke, Fountain, and Edgar counties).
2. *Kanizer Landfill* - Vermillion County (mainly south of U.S. 36); some areas outside of the county.

Vigo

1. *Coal Bluff Landfill* - Vigo County.
2. *Southside Landfill* - Vigo County.
3. *Westside Landfill* - Vigo County.
4. *Victory Mine Landfill* - Vigo County.

Illinois

Clark County

1. *Clark County Landfill* - Clark County (Casey; Martinsville, Marshall).

Crawford

1. No landfill in the county.

Edgar

1. No landfill in the county.

B. County Landfill Acreages and Costs

The following is a list of the landfills in the study area (West Central Indiana and East Central Illinois), the number of acres approved by the State Board of Health to be used as a sanitary landfill, and the cost to the counties to use this land. Site acreage is based on the most current construction plan permit application. Capacity limits and lifetimes of landfills will vary considerably, depending upon the incoming volume, compaction, and other factors.

Indiana

Clay County *Cost*

1. Bedwell Landfill—33 ac.—$100/month lease
2. Haviland Landfill—10.6 ac.—$8,000.00 for 8 acres (1977)
3. Staunton Landfill—27.5 ac.—$1.00/year lease with Amax Coal

Greene
1. Greene County Landfill—Tract 1 - 8.15 ac., Tract 2 - 5.49 ac.—$1.00/year lease with Graham Farms

Owen
1. Owen County Landfill—51 ac.—$1.00/year lease with Peabody Coal

Parke
1. Parke County Landfill—73 ac.—$65,000/purchase price

Putnam
1. Putnam County Landfill—30.8 ac.—$400/month lease

Sullivan
1. Sullivan County Landfill—90 ac.—$250/year lease from Peabody Coal

Vermillion
1. County Home Landfill—40 ac.—Land owned by county
2. Kanizer Landfill—40 ac.—Land owned by permittee

Vigo
1. Coal Bluff Landfill—80 ac.—Land owned by permittee
2. Southside Landfill—225 ac.—Land owned by permittee
3. Westside Landfill—70 ac.—Land owned by permittee
4. Victory Mine Landfill—100 ac.—Land owned by permittee

Illinois
Clark
1. Clark County Landfill—40 ac.—Land owned by permittee

Crawford
Crawford County did not, during the time the survey was conducted, have an approved sanitary landfill site. There is a possibility of a landfill opening up in the vicinity of Robinson, Illinois, in the near future. The County's solid waste is presently hauled to surrounding counties.

Edgar
Edgar County does not now have a sanitary landfill. Most of the county's solid waste is hauled to a landfill in the Danville, Illinois, area. This is done with the aid of a transfer station located near Paris, Illinois.

C. Landfill User Rate Structure

Indiana
Clay County
1. *Haviland Landfill*
   (a) Large truck—$1.50 (per load)
   (b) Pickup truck—$1.00
   (c) Automobile—$.50
   *Out of county users only
2. *Staunton Landfill*
   *Only out of county residents are charged to use landfill
3. *Bedwell Landfill*
   *Only out of county residents are charged to use landfill
   (a) Automobile body—$10.00

Green County Landfill—No user charge
Owen County Landfill—No user charge
Parke County Landfill
(a) Garbage truck—$1.00/cubic yard
(b) Large truck—$4.00/1 ton truck, $6.75/2 ton truck
(c) Pickup truck—$2.00/load
(d) Automobile—$1.00/load
(e) Semi—$25.00/load
(f) Tandem axle—$13.50/load

Putnam County Landfill
(a) Garbage truck—$1.00/cubic yard
(b) Large truck—$4.00/1 ton truck, $5.25/1½ ton truck, $6.75/2½ ton truck
(c) Pickup truck—$1.75 (per load)
(d) Automobile—$.75 (per load)
(e) Semi—$25.00 (per load)
(f) Tandem axle—$13.50 (per load)
(g) Appliances—$2.00-$3.00

Sullivan County Landfill—No user charge
Vermillion County
1. County Home Landfill—No user charge
2. Kanizer Landfill—No user charge

Vigo County
1. Coal Bluff Landfill—No user charge
2. Southside Landfill—No user charge
3. Westside Landfill—No user charge
4. Victory Mine Landfill—No user charge

Illinois
Clark County Landfill
(a) Garbage truck—$7.50 (per load)
(b) Large truck—$7.50
(c) Pickup truck—$3.50
(d) Automobile—No charge

Crawford County—No landfill
Edgar County—No landfill

5. Sanitary Landfill Cost

The total annual cost of operating a sanitary landfill includes: (1) planning and designing costs; (2) initial site development costs; (3) land expense; (4) the owning and operating expense of equipment; (5) wages and salaries of personnel; (6) annual site maintenance and development costs; and (7) an administration and overhead expense. These cost components can be combined to provide an expression of total annual cost that assumes the general form:

$$TC = PD + ID + L + E + P + N + AO$$

Where: TC = the total annual cost of disposal at a sanitary landfill
PD = the total annual planning and designing cost
ID = total annual initial site development cost
L = total annual land expense
E = total annual equipment expense
P = total annual wages and salaries of personnel
M = total annual site maintenance and development cost
AO = total annual administration and overhead cost[1]

[1] Clayton, Kenneth C., and Huie, John M. *Sanitary Landfill Cost.* Department of Agricultural Economics, 1970, p. 11.

The costs in the preceding expression could also be separated into fixed and variable components. Fixed costs are not affected by volume except at those increments where more land, bigger equipment, or additional labor is needed. Variable costs tend to be a more direct function of volume. The "planning curve" (Figure 1), developed by Huie and Clayton and updated by the Ohio State University Agricultural Economics Department, shows the relationship between volume and expected costs. Increases in volume give rise to decreases in the average annual per ton cost of disposal. Significant per ton cost savings can thus be expected as the size of a sanitary landfill is increased.

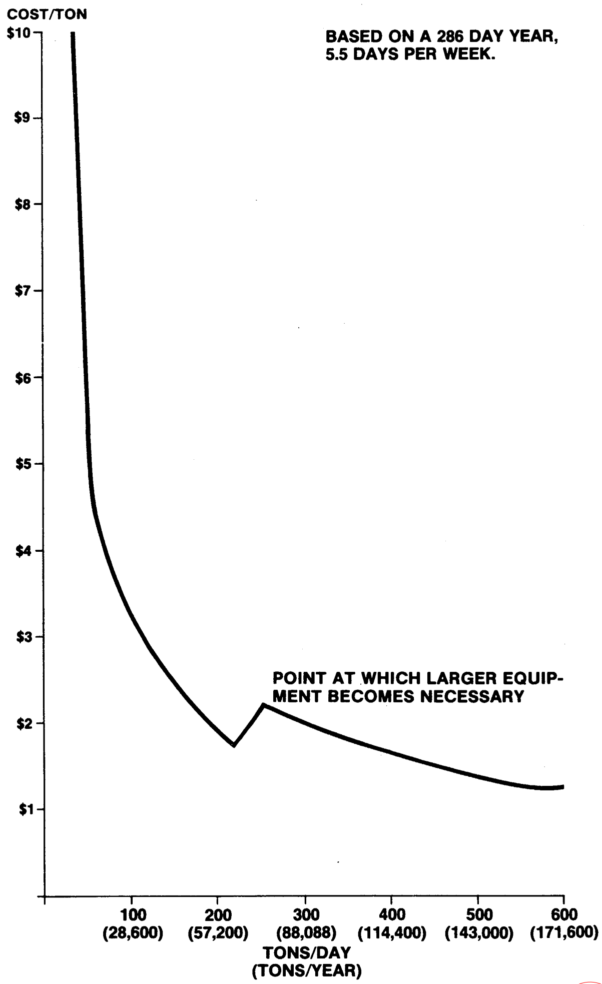


Figure 1. Estimated Average Annual Solid Waste Disposal Cost at a Sanitary Landfill (1978).

In Table 3 the actual or estimated disposal costs by county for 1979 are given. To further explain the estimates, Parke and Putnam counties have similar user rate charges at their landfill sites. Since the Parke County Landfill is operated by the county, the landfill operating costs and the income from user fees may be obtained as public record. From this, the cost per person for Parke County residents to use the landfill was calculated. This figure was in turn used to estimate the cost to Putnam County residents to use the privately operated landfill in Putnam County. This estimate was then added to the $39,765 contract for operation of the county landfill to determine the total disposal cost.

Greene, Owen, and Sullivan Counties all use the rural "green box" collection system. Of the total solid waste management costs in Greene and Owen counties, the "green box" collection system represents 68 percent and 62 percent, respectively, of the total county costs. Sullivan County collection costs were estimated to be 65 percent of the total county solid waste management cost, leaving $34,457 as the estimated disposal cost.

The Clark County Landfill is owned and operatedf by a private individual. The $100,000 disposal figure is the owner-operator's estimate of the annual cost of operating the landfill.

Crawford County currently has no city or county landfill. A landfill close to the city of Robinson is expected to open in the near future. Of the solid waste presently being generated in the county, 75 percent is hauled to a privately owned landfill in Vigo County or to a landfill near Lawrenceville, Illinois, and 25 percent to a landfill near Effingham, Illinois.

The Edgar County Landfill was recently filled to capacity. Refuse is now being hauled, via a transfer station near Paris, Illinois, to a landfill site in Danville, Illinois.

Table 3. Solid Waste Disposal Cost by County (1979).

Location	Disposal Cost	Tons/Year	Cost/Ton	Cost/Person
Clay County, Ind.	$ 75,000	17,600	$ 4.26	$3.04
Greene County	38,400	21,400	1.79	1.33
Owen County	44,850	10,900	4.11	2.99
Parke County	49,650	11,100	4.47	3.12
Putnam County	87,957 (estimated)	21,200	3.72	2.78
Sullivan County	34,457 (estimated)	14,300	2.41	1.77
Vermillion County	47,988	13,700	3.50	2.73
Vigo County	638,000	102,100*	6.25*	5.71
Clark County, Ill.	100,000 (estimated)	12,600	7.94	6.17
Crawford County	188,134 (estimated)	15,400	12.22	9.49
Edgar County	202,113 (estimated)	16,000	12.63	9.36

* The landfill operator estimates the annual tons/year to be 243,400. The cost/ton using this estimate is $2.62

Source: Disposal costs were obtained from county auditors.

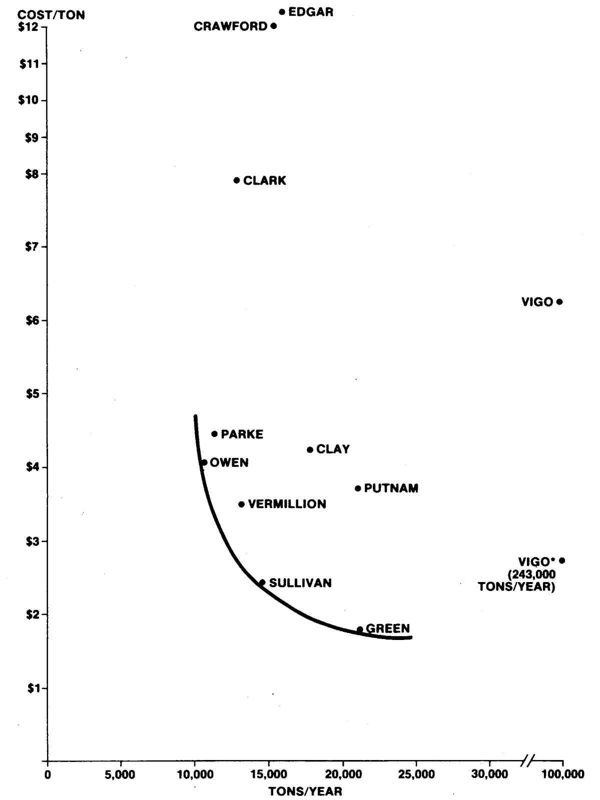
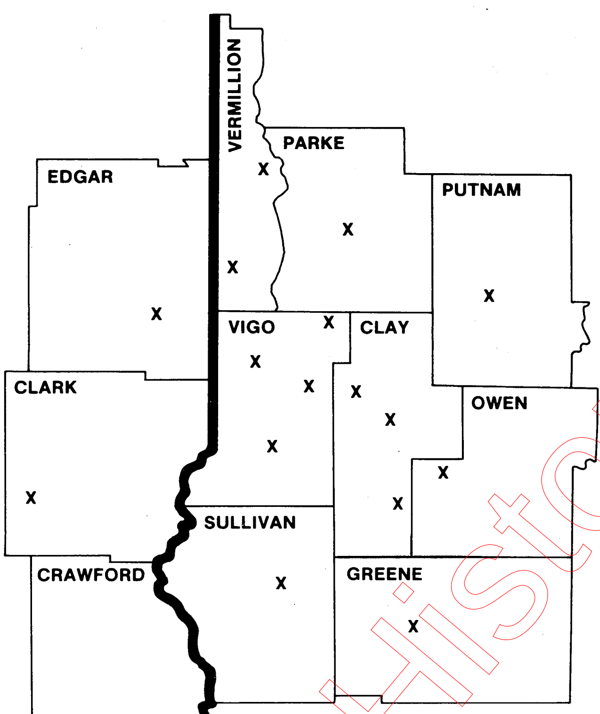


Figure 2. Solid Waste Disposal Costs by County (1979).



X - INDICATES THE LOCATION OF SANITARY LANDFILLS. THE X IN EDGAR COUNTY IS THE LOCATION OF THE TRANSFER STATION. CRAWFORD COUNTY DOES NOT PRESENTLY HAVE A LANDFILL.

Figure 3. Landfill Locations.

The disposal costs for Crawford and Edgar counties are estimates for hauling solid waste using a transfer station system. The estimates were provided by the Ohio State University Agricultural Economics Department.

Figure 2 shows the landfilling cost/ton for each of the eleven counties. The cost/ton for each Indiana county is probably lower than expected, with the exception of Vigo County. As was pointed out, in Part 3, some Vigo County practitioners contend that the tonnage estimates used in Vigo County are too low. The landfill operator estimates an annual tonnage of 243,400. With a total landfilling cost of $648,000 in Vigo County the cost/ton would thus be $2.62 instead of the $6.25 estimated by the authors.

6. Direct Haul and Transfer Station Costs

The cost of transportation is a major part of any solid waste management system. A multi-county system cannot be explored at all without a detailed analysis of transportation. The tables in this section contain the basic costs used and demonstrate one way of determining transportation costs. Cost guidelines in Tables 4, 5, 6, and 7 are from the Ohio State University Agricultural Economics Department.

Table 4. Direct Haul vs. Transfer Station Method for Multi-County Solid Waste Disposal.

Quantity (in tons/day)	Distance (in miles) 20	25	30	35	40	45	50
20	DH	DH	DH	DH	DH	DH	DH
30	DH	DH	DH	DH	TS	TS	TS
40	DH	DH	DH	TS	TS	TS	TS
50	DH	DH	TS	TS	TS	TS	TS
60	DH	TS	TS	TS	TS	TS	TS
70	DH	TS	TS	TS	TS	TS	TS
80	DH	TS	TS	TS	TS	TS	TS
90	DH	TS	TS	TS	TS	TS	TS
100	DH	TS	TS	TS	TS	TS	TS
110 and greater	TS	TS	TS	TS	TS	TS.	TS

"DH" indicates that the direct haul method is the most economical; "TS" indicates that the use of a transfer station is the most economical method.

Note: This table was developed assuming that all urban waste is transported by a rear-load collection vehicle.

Table 5. Comparison of Annual Direct Haul vs. Transfer Station Costs (1978).

Quantity (in tons/day)	Distance (in miles) 20	25	30	35	40	45	50
20	72,344	83,311	94,279	105,246	116,213	12/,180	138,146
30	102,816	119,877	136,939	154,000	159,919	162,309	163,903
40	140,242	157,060	179,972	182,839	184,957	188,134	210,429
50	164,986	193,504	198,134	202,113	224,942	228,921	231,574
60	196,469	216,908	240,261	245,027	248,203	252,969	256,146
70	234,736	265,375	269,087	274,654	278,366	283,934	287,645
80	265,207	296,637	300,873	307,227	311,463	317,817	358,230
90	296,261	317,714	322,485	329,641	334,412	377,744	382,515
100	328,481	339,879	345,174	353,116	394,588	402,530	407,825
110	353,539	362,283	368,113	413,034	418,864	427,609	433,438

Table 4 indicates the point where a transfer station becomes economically more feasible than direct haul. For example, if it is 30 miles from the point of origin to the landfill, then a transfer station would be economically justified at somewhere between 40 and 50 tons/day.

In Table 5 the cost figures above the line are direct haul costs and include the cost of rural collection and the urban waste transportation costs.

The figures below the line represent the addition of a transfer station. These costs include the cost of the transfer station, the cost of transporting the waste from the transfer station to the final disposal or recovery point, and the cost of transporting the waste to the transfer station (assuming rural waste is transported an average distance of 12 miles and urban waste is hauled an average of 7 miles to the transfer station). All urban waste is assumed to be transported by rear-load collection vehicles with a capacity of 20 cubic yards. The push-out trailers used to transport the refuse from the transfer station to the disposal site are assumed to have a capacity of 75 cubic yards.

Table 6. Transfer Station Facility Costs (1978).

Tons/Day	Capital Cost
0-100	\$ 61,400 - \$110,900
100-180	\$ 73,800 - \$128,300
180-325+	\$168,700+

***In the design of many solid waste management systems, it is necessary to include transfer stations as a part of the total system. The facility costs in Table 6 include the building, front loader, steel hopper, truck scale, stationary compactor, auxiliary power unit, and for the 180-325+ton-per-day facility a push pit is also included.**

Is there a more economical way to dispose of solid waste than the current system? One alternative is a regional landfill. Tables 8 and 9 contrast costs for transporting all refuse to two existing centrally located landfill sites in Vigo County, Coal Bluff and South. In both examples, the total transportation costs would be greater than the current costs of operating landfills in each county.

The most feasible alternative (direct haul or transfer station system) of transporting the waste from each county to the Coal Bluff Landfill was selected. The alternative used is indicated after the total costs for each county as either "DH" or "TS" (Figure 8).

It is not considered economically feasible to haul refuse more than 50 miles. Therefore, Crawford County would have to be excluded from consideration if the Coal Bluff Landfill were utilized.

The total cost figure listed for Vigo County is an estimate of what it should cost to operate a landfill with a solid waste load of 660 tons per day. This estimate was derived from the Ohio State University Agricultural Economics Department's cost curve graph showing the estimated average annual solid waste disposal cost at a sanitary landfill (1979).

Again, the "DH" and "TS" listed after the total cost for each county indicate whether direct haul or a transfer station system is the most feasible alternative (Figure 9).

The total cost figure listed for Vigo County is an estimate of what it might cost to operate a landfill with a solid waste load of 700 tons per day. This estimate was derived from the Ohio State University Agricultural Economics Department's cost curve graph showing the estimated average annual solid waste disposal cost at a sanitary landfill (1979).

Table 7. Annual Cost of Transporting Urban Waste (1978).

Quantity (in tons/day)	Distance (in miles) 5	10	15	20	25	30	35	40	45
20	24,378	36,566	48,754	60,943	73,132	85,300	97,500	109,700	121,900
30	36,566	54,849	73,133	91,416	109,699	127,950	146,250	164,550	182,850
40	48,755	73,131	97,509	121,886	146,264	170,600	195,000	219,400	243,800
50	60,945	91,415	121,885	152,358	182,830	213,250	243,750	274,250	304,750
60	73,134	109,698	146,262	182,829	219,396	255,900	292,500	329,100	365,700
70	85,323	127,981	170,639	213,301	255,962	298,550	341,250	383,950	426,650
80	97,512	146,264	195,016	243,772	292,528	341,200	390,000	438,800	487,600
90	109,701	164,547	219,393	274,244	329,094	383,850	438,750	493,650	548,550
100	121,890	182,830	243,770	304,715	365,660	426,500	487,500	548,500	609,500
110	134,079	201,113	268,147	335,187	402,226	469,150	536,250	603,350	670,450

These figures represent the cost of transporting urban waste with a rear-load (20 cubic yard capacity) collection vehicle. Given a certain distance, the annual cost of transporting urban waste varies in direct proportion with the quantity.

Table 8. Direct Haul and Transfer Station Costs to Vigo County Coal Bluff Landfill (1979).

	Tons/Day[1]	Distance (in miles)[2]	Total Cost[3]	Cost/Ton[4]
Clay County, IN	50	20	$164,986 (DH)	$9.04
Greene County	60	50	$256,146 (TS)	$11.70
Owen County	30	40	$159,919 (TS)	$14.60
Parke County	30	25	$119,877 (DH)	$10.95
Putnam County	60	30	$240,261 (TS)	$10.97
Sullivan County	40	45	$188,134 (TS)	$12.89
Vermillion County	40	30	$179,972 (DH)	$12.32
Clark County, ILL.	30	35	$154,000 (DH)	$14.06
Crawford County	---	(70)	-------	------
Edgar County	50	45	$228,921 (TS)	$12.54
	390	35.5 average	$1,692,216	$11.89 average
Vigo County	270 (660)		($301,125)=disposal cost	($1.25)=disposal cost
Total	660 ton/day		$1,993,341	$8.27 average

1) From Table 2
2) From Table 5
3) From Table 5
4) Calculated from Tons/Day and Total Cost Columns

Table 9. Direct Haul and Transfer Station Costs to Vigo County South Landfill (1979).

	Tons/Day[1]	Distance (in miles)[2]	Total Cost[3]	Cost/Ton[4]
Clay County, IN	50	25	$193,504 (DH)	$10.60
Greene County	60	35	$245,027 (TS)	$11.19
Owen County	30	35	$154,000 (DH)	$14.06
Parke County	30	40	$159,919 (TS)	$14.60
Putnam County	60	45	$252,969 (TS)	$11.55
Sullivan County	40	20	$140,242 (DH)	$ 9.61
Vermillion County	40	30	$179,972 (DH)	$12.32
Clark County, ILL.	30	25	$119,877 (DH)	$10.95
Crawford County	40	45	$188,134 (TS)	$12.87
Edgar County	50	30	$198,134 (TS)	$10.86
	430	33 average	$1,831,778	$11.67 average
Vigo County	270 (700)		($319,375)=disposal cost	($1.25)
	700 ton/day		$2,151,153	$ 8.42 average

1) From Table 2
2) From Figure 5
3) From Table 5
4) Calculated from Tons/Day and Total Cost

Table 10. Current Disposal Costs vs. Regional Disposal Costs (1979).

	Current Method		Coal Bluff Landfill[1]		South Landfill[2]	
	Total Cost	Cost/Ton	Total Cost	Cost/Ton	Total Cost	Cost/Ton
Clay	$75,000	$4.11	$164,986	$9.04	$193,504	$10.60
Greene	$129,600	$5.92	$256,146	$11.70	$245,027	$11.19
Owen	$72,178	$6.59	$159,919	$14.60	$154,000	$14.06
Parke	$49,650	$4.53	$119,877	$10.95	$159,919	$14.60
Putnam	$87,957	$4.02	$240,261	$10.97	$252,969	$11.55
Sullivan	$98,450	$6.74	$188,134	$12.89	$140,242	$ 9.61
Vermillion	$47,988	$3.29	$179,972	$12.32	$179,972	$12.33
Vigo	$638,000	$6.47	($301,125)= disposal cost	($1.25)	($319,375)= disposal cost	($1.25)
Clark	$100,000	$9.13	$154,000	$14.06	$119,877	$10.95
Crawford	$188,134	$12.89	-----	----	$188,134	$12.87
Edgar	$202,113	$11.07	$228,921	$12.54	$198,134	$10.86
	$1,689,070	$ 6.61(average)	$1,993,341	$ 8.27 (average)	$2,151,153	$ 8.42(average)
	$153,551 (average)		$199,341(average)		$195,559(average)	

1) From Table 8
2) From Table 9

Table 10 compares the current disposal cost of the 11 counties vs. the cost of the two regional disposal alternatives, were they to be implemented.

Since rural collection costs are included in the direct haul and transfer system cost estimates, those counties (Greene, Owen, and Sullivan) which already have rural collection systems have the cost for their rural collection systems included in the current total disposal costs. This will make for a better comparison with the other two alternative methods.

Once again, the cost figures for Vigo County listed under the Coal Bluff and South Landfill columns (in parenthesis) represent the estimates of operating a regional landfill with a daily solid waste input of 660 and 700 tons per day, respectively.

Figure 4 shows costs for current and regional disposal alternatives, and Figure 5 locations.

7. Resource Recovery

A. Cost Estimates

A major problem in projecting resource recovery costs has been the general lackof comparable cost estimates. There are two apparent causes for this. First, the different cost-accounting methods employed by various designers make it difficult to compare cost projections in proposals from companies bidding on the same contract.

Second, most estimates have been site-specific and reflect a wide range of factors which vary from site to site. Capital costs on a 1,000 ton-per-day plant may range from $10 to $35 million depending on the type of system chosen, land and site preparation costs, and construction costs, including labor, materials, and equipment.

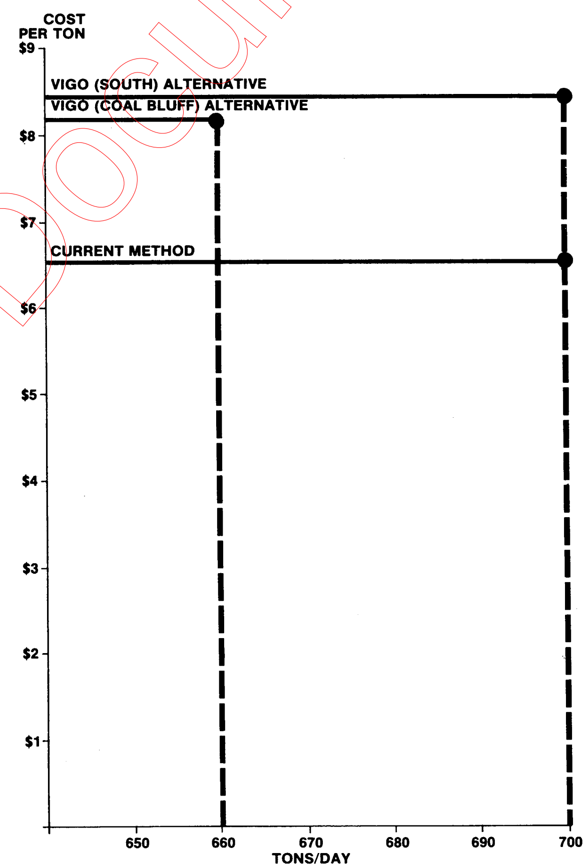
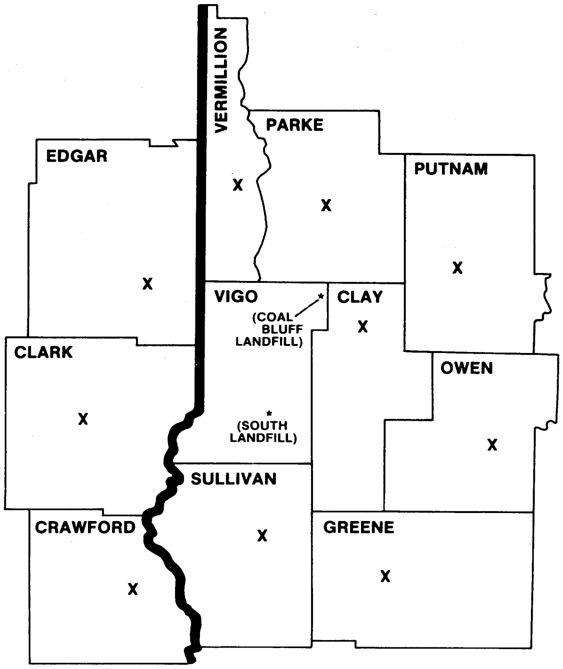


Figure 4. Current Disposal Costs vs. Regional Disposal Costs (1979).

MILEAGES USED IN TABLES 8 AND 9 WERE DERIVED FROM HIGHWAY MAPS. SHOWN BELOW IS THE APPROXIMATE LOCATION OF THE TRANSFER STATIONS AND LANDFILLS USED IN THIS REPORT.



X - INDICATES THE LOCATION OF THE TRANSFER STATIONS
* - INDICATES THE LOCATION OF THE DISPOSAL SITES

Figure 5. Location of Transfer Stations and Regional Landfills.

Annual costs, which include amortized capital cost and operating and maintenance costs, may vary from $11 per input ton to $24 per input ton, depending on, among other things, the utilization of capacity, the interest rate on borrowed funds, wage rates, utility rates, fuel prices, local taxes, and residual waste disposal costs.

Selling prices for the recovered products also contribute a great source of uncertainty. Selling prices will vary greatly among geographic regions and have been subject to extreme fluctuations over time. Future negotiable prices for recoverable fuels and materials are subject to additional uncertainties because of technical questions about product quality and alternative raw material costs.

Product revenues could range from $4 to $16 per input ton, depending on the types and quality of materials and energy recovered, the current market prices, and the cost of transporting the materials and energy.

Using these estimates for annual costs and product revenues, the annual net results may range from a profit of $5 per ton to a cost of $20 per ton. If these extremes were applied to the counties in this study, the resulting estimates would be as shown in Table 11.

For comparison the annual costs and product revenue estimates used here may be contrasted to the actual expenditures and revenues of the Ames, Iowa, solid waste resource recovery plant and to the reported capital costs of the resource recovery facilities in the U.S., as listed by the National Center for Resource Recovery, Inc.

In the Ames project, the city is separating burnable refuse for use as boiler fuel in the Ames Municipal Power Plant and recovering as much of the non-burnable refuse as possible for recycling. The two following pages present a financial summary of the Ames, Iowa, solid waste recovery system for the calendar years 1976 to 1978.

Those interested in the status of the existing resource recovery plants around the nation could obtain this information by contacting: National Center for Resource Recovery, Inc., 1211 Connecticut Avenue, N.W. Washington, D.C. 20036.

Although there are undoubtedly projects not included in the Center's periodic summary, those listed give the location of the project, key participants, process, output, reported capacity, tipping fee (per ton), reported capital costs (millions of $), status, and contact persons.

Table 11. Estimated Range of Net Costs for Resource Recovery by County.

Location	Tons/Day	Current Disposal Cost	At a Profit of $5/Ton	At a Cost of $20/Ton
Clay County	50	$75,000	(+) $91,250	(-) $365,000
Greene County	60	$38,400	$109,500	$438,000
Owen County	30	$44,850	$54,750	$219,000
Parke County	30	$49,000	$54,750	$219,000
Putnam County	60	$78,957 (estimated)	$109,500	$438,000
Sullivan County	40	$34,457 (estimated)	$73,000	$292,000
Vermillion County	40	$47,988	$73,000	$292,000
Vigo County	270	$638,000	$492,750	$1,971,000
Clark County	30	$100,000 (estimated)	$54,750	$219,000
Crawford County	40	$188,134 (estimated)	$73,000	$292,000
Edgar County	50	$202,113 (estimated)	$91,250	$365,000
	700	$1,496,899	(+) $1,277,500	(-) $5,110,000

FINANCIAL SUMMARY
SOLID WASTE RECOVERY SYSTEM
CALENDAR YEARS
1976, 1977, 1978

PER TON COSTS

REVENUE:	1976	1977	1978
REFUSE SALE FOR FUEL	$319,453.00	$353,326.99	$322,344.03
SALE OF METALS	97,885.43	102,323.23	89,270.45
PUBLIC FEES	9,376.37	11,841.62	12,595.38
REGULAR CUSTOMERS	12,528.43	13,653.26	15,206.65
WOODCHIPS	2,262.40	2,792.23	962.24
PAPER RECYCLING	2,112.34	7,416.00	2,225.34
SANITARY LANDFILL	10,281.68	24,124.74	33,590.00
C.I.R.A.L.G.	4,904.82	--0--	--0--
REIMBURSEMENTS & REFUNDS	5,689.13	7,273.39	9,570.32
EPA FUNDS APPLIED	--0--	--0--	75,000.00
TOTAL REVENUES	$464,493.60	$522,751.46	$560.764.41
EXPENDITURES:			
OPERATIONS	$572,287.51	$638,717.60	$637,345.87
START-UP CHARGES	54,383.77	52,183.45	52,183.45
BOND INTEREST	299,519.46	265,352.51	263,595.63
BOND PRINCIPAL	183,333.69	200,000.00	200,000.00
EQUIPMENT RESERVE	12,500.00	12,500.00	12,500.00
TOTAL EXPENDITURES	$1,122,024.43	$1,168,753.56	$1,165,624.95
NET COST OF PROCESSING	$657,530.83	$646,002.10	$604,860.54
TOTAL TONS OF REFUSE	40,936.02	48,294.30	37,719.93
NET COST PER TON	16.06	13.38	16.04

Update

RESOURCE RECOVERY:

THE AMES EXPERIENCE

FINANCIAL SUMMARY
SOLID WASTE RECOVERY SYSTEM
CALENDAR YEARS
1976, 1977, 1978

PER CAPITA COSTS

REVENUE:	1976	1977	1978
REFUSE SALE FOR FUEL	$319,453.00	$353,326.99	$322,344.03
SALE OF METALS	97,885.43	102,323.23	89,270.45
PUBLIC FEES	9,376.37	11,841.62	12,595.38
REGULAR CUSTOMERS	12,528.43	13,653.26	15,206.65
WOODCHIPS	2,262.40	2,792.23	962.24
PAPER RECYCLING	2,112.34	7,416.00	2,225.34
SANITARY LANDFILL	10,281.68	24,124.74	33,590.00
C.I.R.A.L.G.	4,904.82	--0--	--0--
REIMBURSEMENTS & REFUNDS	5,689.13	7,273.39	9,570.32
OTHER GOVERNMENTAL UNITS	6,295.30	5,817.79	8,925.48
ISU PARTICIPATION	88,353.60	91,494.48	116,309.13
TOTAL REVENUES	$559,142.50	$620,063.73	$610,999.02
EXPENDITURES:			
OPERATIONS	$572,287.51	$638,717.60	$637,345.87
START-UP CHARGES	54,383.77	52,183.45	52,183.45
BOND INTEREST	299,519.77	265,352.51	263,595.63
BOND PRINCIPAL	183,333.69	200,000.00	200,000.00
EQUIPMENT RESERVE	12,500.00	12,500.00	12,500.00
TOTAL EXPENDITURES	$1,122,024.43	$1,168,753.56	$1,165,624.95
TO BE SHARED	$562,881.93	$548,689.83	$554,625.93
PER CAPITA (54,432)	$ 10.34101	$ 10.08028	$ 10.1893
EPA FUNDS APPLIED			-1.3779
			$ 8.8114

B. Existing Facility Costs and Product Revenues

Of the incoming waste in the Ames project, 84 percent is used as refuse derived fuel; 7 percent ferrous metals; 1.5 percent woodchips, glass, and grit; and 7.5 percent rejects. From these figures and the two financial summary tables on the Ames recovery system, the per ton revenues for the sale of refuse for fuel and the sale of metals (the two major sources of product revenues) are calculated and shown in Table 12.

Table 12. Revenue from Fuel and Metal, Ames, Iowa.

	1976	1977	1978
Total tons of refuse	40,936	48,294	37,720
Refuse sale for fuel	$319,453	$353,326	$322,344
Revenue (per ton)	9.29	8.71	10.17
Sale of metals	97,885	102,327	89,271
Revenue (per ton)	34.15	30.27	33.81

The National Center for Resource Recovery, Inc., as a monthly feature in the *NCRR Bulletin*, lists resource recovery facilities and gives a summary of each. In March 1979, 37 facilities were listed. See Table 13. Within each of these ranges in the table, the average tons per day, facility cost, and facility cost per ton were calculated. Costs for those facilities constructed prior to 1978 were adjusted to compensate for inflation.

Product Revenue Estimates

A 1975 Environmental Protection Agency Report, *Resource Recovery from Mixed Waste,* estimates the composition and monetary value of refuse components. The estimate for a ton of municipal refuse in a mechanical processing facility is given in Table 14.

C. Recommended Recyclable Materials

The Indiana State Board of Health has developed a list of recommended recyclable materials for this area (*A Guide To Recycling,* Indiana State Board of Health, 1979). It has been limited to those materials that constitute a significant portion of the refuse, are easily collected and sorted, and are marketable at this time. The following is a list of these materials, with brief comments on each:

1. *Aluminum* - Markets for scrap aluminum in Indiana generally are favorable. There are approximately five smelters in the state, and many secondary dealers throughout Indiana are also interested in purchasing the scrap. Aluminum has a relatively stable market value which has been on the increase.

2. *Glass* - The resale value of glass scrap ("cullet") is relatively low but more stable than many other scrap markets. Markets need to be relatively close, i.e. (studies have indicated that shipping glass more than 100 miles is usually not economical).

Table 13. Average Costs, Resource Recovery Facilities.

Number of Facilities	Range (tons/day)	Average Tons/Day	Average Facility Cost	Average Facility Cost/Ton
8	20 to 199	103	$ 2.41 million	$23,398
7	200 to 499	343	10.72	31,253
6	500 to 999	677	17.33	25,598
9	1,000 to 1,999	1,306	44.01	33,698
7	2,000 to 3,000	2,457	89.77	36,536

Table 14. Composition and Monetary Value of Municipal Refuse.

Product	Percent in total waste input[1]	Percent recovered	Recovery as percent of total waste input	Estimated gross price per ton[2]	Approximate potential gross revenue per ton of solid waste
Glass	9.9	70	6.93	$ 16	$1.10
Ferrous metal	8.2	95	7.80	50	3.90
Aluminum	0.7	60	0.42	300	1.26
Other non-ferrous metals	0.3	80	0.24	350	.84
Total	19.1	—	15.39	—	7.10
Paper fiber[3]	30-35	—	20.00	$25-65	—

[1] Based on national average composition.

[2] Excludes costs of transporting to markets. Transport costs could significantly reduce the net revenue from glass and ferrous metals.

[3] Arella, D.G. EPA's Franklin, Ohio, Resource Recovery wet processing demonstration project. U.S. Government Printing Office, 1974. SW-47d.

3. *Ferrous metals* - Ferrous metals constitute approximately 8.5 percent of the municipal refuse stream. About 13 percent of this is in the form of steel cans, and the rest is in various other forms; usually large and bulky such as barrels, appliances, etc.

Many landfills in Indiana have successful steel scrap recovery operations which consist merely of loading large steel pieces into a bin or truck bed on-site as they are introduced.

Tin coated or bi-metal cans are normally the form of steel recovered in municipal source separation recycling operations.

The steel industry normally recycles about 50 percent of the steel scrap. Only about 4 percent of this comes from consumer wastes; most is from industrial sources.

Markets for scrap steel cans are limited in Indiana. The most viable market is the detinning industry. Tin is available only from foreign sources or from guarded government stock piles in the United States. Steel industries within Indiana have shown little interest in purchasing this form of scrap metal.

4. *Paper* - Paper is normally the most important material handled in a source separation project. It is plentiful, easy to separate, easy to handle, and has been successfully recycled from past-consumer waste for decades. In short, it represents a tried and true materials recovery method with established markets. The biggest challenge in this form of recycling is mastering or living with unstable market conditions.

5. *Plastic* - Plastics are made from petroleum resources. They are composed of complex molecular structures which make them essentially non-biodegradable. This same structure also makes recycling very difficult.

Although plastic accounts for 60 percent of the packaging waste in the waste stream, the price paid for scrap plastic does not make the venture economically attractive in most cases.

Plastics generally have a high BTU content. They, therefore, make a welcome addition to energy recovery projects.

6. *Wood, trees, brush, and other organics* - Instead of testing landfill equipment against the strength of trees, most can be processed into desirable products in a short time. Tree chippers can reduce branches into mulch material. Large logs can be cut into firewood and allowed to dry until winter months. These products may then be either sold or given to the public. Used Christmas trees may be spread throughout wildlife preserve areas to provide ground cover for small animals. The leaf and small cuttings recycling problem is a more complicated one. An ideal set-up for a community would be to have an organic center where leaves and such could be brought by citizens for composting. Branches and tree trunks could be brought for processing into mulch or logs for future use.

8. Current vs. Regional Solid Waste Management System Costs (1979)

The following tables represent a financial summary of the current solid waste disposal costs in the study area, compared to the costs of implementing a regional solid waste management system. The costs for the regional method are estimates using the Vigo County South Landfill as the location for a resource recovery facility and/or the final disposal site. Included in Table 15 are: (1)

Table 15. Current Disposal Method Costs vs. Regional Method Costs.

A. Total Annual Cost

County	Tons/Day	Current Disposal Cost (1)	Hauling Cost To Vigo South Landfill (2)	(3) Resource Recovery: $5/Ton Profit	(3) Resource Recovery: $20/Ton Cost
Clay	50	$75,000	$193,504 (DH)	(+) $91,250	(-) $365,000
Greene	60	$129,000	$245,027 (TS)	$109,500	$438,000
Owen	30	$72,178	$154,000 (DH)	$54,750	$219,000
Parke	30	$49,650	$159,919 (TS)	$54,750	$219,000
Putnam	60	$87,957	$252,969 (TS)	$109,500	$438,000
Sullivan	40	$98,450	$140,242 (DH)	$73,000	$292,000
Vermillion	40	$47,988	$179,972 (DH)	$73,000	$292,000
Vigo	270 (700)	$638,000	($319,375)=disposal cost	$492,750	$1,971,000
Clark	30	$100,000	$119,877 (DH)	$54,750	$219,000
Crawford	40	$188,134	$188,134 (TS)	$73,000	$292,000
Edgar	50	$202,113	$198,134 (TS)	$91,250	$365,000
	700	$1,689,070	$2,151,153	(+)$1,277,500	(-)$5,110,000

B. Annual Cost/Ton

County	Current Disposal Cost	Hauling Cost To Vigo South Landfill	Resource Recovery $5/Ton Profit	Resource Recovery $20/Ton Cost
Clay	$4.11	$10.60	(+) $5.00	(-) $20.00
Greene	$5.92	$11.19		
Owen	$6.59	$14.06		
Parke	$4.53	$14.60		
Putnam	$4.02	$11.55		
Sullivan	$6.74	$9.61		
Vermillion	$3.29	$12.33		
Vigo	$6.47	($1.25)=disposal cost		
Clark	$9.13	$10.95		
Crawford	$12.89	$12.87		
Edgar	$11.07	$10.86		
	$6.61 average	$8.42 average		

C. Annual Cost/Person

County	Current Disposal Cost	Hauling Cost To Vigo South Landfill	Resource Recovery $5/Ton Profit	Resource Recovery $20/Ton Cost
Clay	$3.04	$7.83	(+) $3.66	(-) $14.78
Greene	$4.48	$8.50	$3.80	$15.21
Owen	$4.81	$10.27	$3.65	$14.60
Parke	$3.12	$10.06	$3.44	$13.77
Putnam	$3.10	$8.90	$3.86	$15.42
Sullivan	$4.97	$7.08	$3.69	$14.75
Vermillion	$2.73	$10.23	$4.15	$16.59
Vigo	$5.71	($2.86)=disposal cost	$4.25	$16.99
Clark	$6.17	$7.39	$3.38	$13.51
Crawford	$9.49	$9.49	$3.68	$14.73
Edgar	$9.36	$9.18	$4.23	$16.91
	$5.29 average	$6.73 average	(+)$4.00 average	(-)$15.99 average

the current costs to counties for disposing of their solid waste, (2) the estimated cost to each county to hauling their solid waste to the Vigo County South Landfill, and (3) the estimated capital and operating costs each county would incur if a regional resource recovery plant were utilized. These expenditures are expressed in Tables 15 A, B, and C as total annual costs, annual costs per ton, and annual costs per person, respectively. The figures in Table 15 may be further clarified by referring back to Tables 3, 9, and 11.

Table 16 illustrates the combined costs to each county (transportation plus resource recovery) for the aforementioned regional solid waste management system, as opposed to the current solid waste disposal system. The "Regional Method Costs" column represents the transportation cost for each county united with each respective recovery extreme, i.e. (in Table 15 A, the resource recovery $5 per ton projected profit is subtracted from and the $20 per ton projected cost added to the hauling cost for each county). The "Cost Difference" column in Table 16 A shows the possible cost range, i.e. the difference between the "Regional Method Costs" and "Current Method Costs" each county would incur if the regional solid waste management system were carried out.

When a $5 per ton profit is projected for resource recovery, Sullivan, Vigo, and the three Illinois Counties, as well as the region as a whole, would realize a financial gain over the current disposal method. However, when a $20 per ton cost is projected for resource recovery, the entire region would be subjected to a cost of $5,527,189.

These expenditures are categorized in Tables 16 A, B and C as total annual costs, annual costs per ton, and annual costs per person.

Figure 6 displays the current cost to the 11 counties for refuse disposal vs. the high and low cost for implementing a regional solid waste disposal system.

Table 16. Current Method vs. Regional Method Cost Differences.

A. Total Annual Cost

County	Current Method Costs	Regional Method Costs $5/Ton Profit to $20/Ton Cost	Cost Differences $5/Ton Profit to $20/Ton Cost
Clay	$75,000	$102,254 to $558,000 (DH)	$27,254 to $483,000
Greene	$129,000	$135,527 to $683,027 (TS)	$ 6,527 to $509,027
Owen	$72,178	$ 99,250 to $373,000 (DH)	$27,072 to $300,822
Parke	$49,650	$105,169 to $378,919 (TS)	$55,519 to $329,269
Putnam	$87,957	$143,469 to $690,060 (TS)	$55,512 to $603,012
Sullivan	$98,450	$ 67,242 to $432,242 (DH)	(+)$31,208 to $333,792
Vermillion	$47,988	$106,972 to $471,972 (DH)	$58,984 to $423,984
Vigo	$638,000	(+)$173,375 to $2,290,375=disposal	(+)$811,375 to $1,652,375 = disposal
Clark	$100,000	$ 65,127 to $338,887 (DH)	(+)$34,873 to $238,887
Crawford	$188,134	$115,134 to $480,134 (TS)	(+)$73,000 to $292,000
Edgar	$202,113	$106,884 to $563,134 (TS)	(+)$95,229 to $361,021
	$1,689,070	$1,036,653 to $7,260,659	(+)$814,817 to $5,527,189

B. Annual Cost/Ton

County	Current Method	Regional Method	Cost Difference
Clay	$4.11	$5.60 to $30.60	$1.49 to $26.49
Greene	$5.92	$6.19 to $31.19	$0.27 to $25.27
Owen	$6.59	$9.06 to $19.06	$2.47 to $12.47
Parke	$4.53	$9.60 to $34.60	$5.07 to $30.07
Putnam	$4.02	$6.55 to $31.55	$2.53 to $27.53
Sullivan	$6.74	$4.61 to $29.61	(+)$2.13 to $22.87
Vermillion	$3.29	$7.33 to $32.33	$4.04 to $29.04
Vigo	$6.47	(+)$0.69 to $8.96=disposal	(+)$3.18 to $6.47=disposal
Clark	$9.13	$5.95 to $30.95	(+)$3.18 to $21.82
Crawford	$12.89	$7.87 to $32.87	(+)$5.02 to $19.98
Edgar	$11.07	$5.86 to $30.86	(+)$5.21 to $19.79
	$6.61 average	$4.06 to $28.42 average	(+)$3.19 to $21.63 average

C. Annual Cost/Person

County	Current Method	Regional Method	Cost Difference
Clay	$3.04	$4.17 to $22.61	$1.13 to $19.57
Greene	$4.48	$4.70 to $23.71	$0.22 to $19.23
Owen	$4.81	$6.62 to $24.87	$1.81 to $20.06
Parke	$3.12	$6.62 to $23.83	$3.50 to $20.71
Putnam	$3.10	$2.35 to $24.32	(+)$0.75 to $21.22
Sullivan	$4.97	$3.39 to $18.44	(+)$1.58 to $13.47
Vermillion	$2.73	$6.08 to $26.82	$3.35 to $24.09
Vigo	$5.71	$0.54 to $7.17=disposal	(+)$2.54 to $5.17=disposal
Clark	$6.17	$4.01 to $20.90	(+)$2.16 to $14.73
Crawford	$9.49	$5.81 to $24.22	(+)$3.68 to $14.73
Edgar	$9.36	$4.95 to $26.09	(+)$4.41 to $16.73
	$5.29average	$3.24 to $22.72 average	(+)$2.55 to $17.30 average

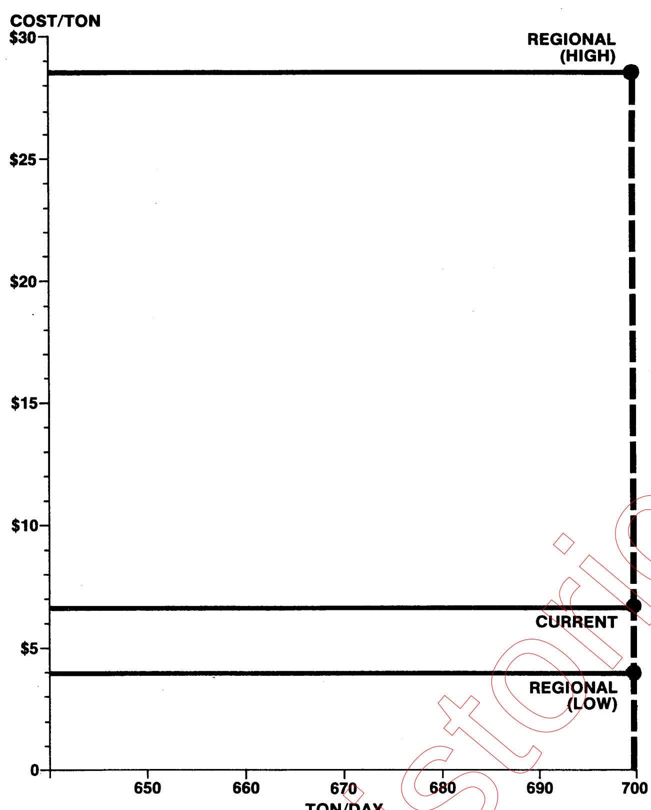


Figure 6. Current Method vs. Regional Method (1979).

9. Summary of Economics of Resource Recovery

With economic pressures and environmental restrictions, there is increasing need to look at recycling of waste materials as a way to conserve valuable resources and to help alleviate a refuse disposal problem. Resource recovery, as is true of all options, has both costs and benefits. Large capital expenditures are required for most resource recovery facilities and for other methods of reducing refuse volume such as baling, incinerating, and shredding. Any public or private entity considering various resource recovery options needs to carefully examine these costs and benefits. In some local communities the costs for these various options may exceed financial capability.

This report indicates this to be the case in East Central Illinois and West Central Indiana. In addition to the financial obstacles, based on the actual operating experience of existing resource recovery facilities, there are problems with gaining commitment of a waste stream; viability of the market for recycled materials; and the successful application of resource recovery technology. When these details are taken into account, high technology resource recovery does not currently appear to be an economically feasible alternative to landfilling in the study area.

Although resource recovery does not seem to be economically attractive at this time, more stringent environmental controls are expected to cause increases in the cost of waste disposal over the next few years. As disposal becomes more difficult and expensive; as energy costs continue to rise; as the world's supply of natural resources becomes more limited; and as new and more efficient methods of solid waste handling and recycling become available, resource recovery may evolve as a more viable alternative to landfilling.

As for now, both public and private sectors should encourage energy and resource conservation along with source separation projects for residential, commercial, and industrial refuse. In addition, existing and potential source separation and recycling centers might be beneficially expanded with additional local support.

10. Quantitative Technique for Choosing the Most Cost-Efficient Landfill Site

Locating a county landfill is often controversial, difficult, and sometimes nearly impossible. The same can be said for private landfills and difficulties might even be further intensified for a multi-county landfill. Geotechnical requirements, political pressures, and the image of a landfill as an "undesirable neighbor" are usual siting difficulties.

When alternative sites for a landfill location exists, an economic analysis of each site should be helpful to decision-makers. One aspect of the analysis would be a comparison of the transportation costs of refuse from point of origination or collection to the landfill. The analytical tool known as the average weighted distance (AWD) can be an aid in selecting the most cost-efficient site when a finite set of alternative sites exist.

$$AWD = \left[\sum_{i=n}^{N} WG \times D \right] \div TWG$$

AWD = Average Weighted Distance
WG = Tons of waste generated or stored at a collection point
D = Distance in road miles between the point of collection and the landfill
TWG = Total waste generated

To apply this equation, (1) collection points must first be identified, (2) road distance from the collection points to each potential landfill site must be measured, and (3) an estimation of the solid waste generated and stored at each collection point is needed.

For counties with rural collection systems, it can be assumed that the results of a comparison of the average weighted distance of all the alternative landfill sites when refuse is collected using the container ("green box") system, will be identical to the results of a comparison when refuse is collected using the house-to-house ("mail box") system. The "green box" system involves collecting refuse at designated storage sites in rural areas or adjacent to unincorporated and small incorporated communities. When the "mail box" system is used, solid waste is placed by the householder at the curb and/or near the mail box in front of his home and it is then picked up at the individual households.

Example of the Average Weighted Distance Formula

The following example will determine whether the Center Point or the Staunton Landfill in Clay County is the most cost-efficient landfill site in that county. Taking into consideration the layout of the Clay County highway system, a collection point was identified within each of the county's townships. It is from these selected points that the distance to the two landfills is measured. See Figure 7.

To summarize, AWD is calculated by multiplying the quantity (usually expressed in tons) of waste generated each day at each collection point by the distance (in miles) to the disposal or recovery site. The summation of these products (expressed as ton miles) divided by the sum of the waste generated at each collection point daily, is a coefficient representing the AWD from the collection points to the landfill site.

When comparing two or more alternative sites, the smaller the coefficient, the more cost-efficient the landfill site. The above example shows that the Staunton Landfill is more cost-efficient than the Center Point Landfill in Clay County.

CENTER POINT LANDFILL

Location	Quantity of Refuse Generated	Distance	Total
1. Brazil Township	22.5 tons/day	10 miles	225.0 ton miles
2. Cass Township	.6	8	4.8
3. Dick Johnson Township	2.0	14	28.0
4. Harrison Township	3.6	13	46.8
5. Jackson Township	2.9	5	14.5
6. Lewis Township	2.3	21	48.3
7. Perry Township	1.7	9	15.3
8. Posey Township	5.6	10	56.0
9. Sugar Ridge Township	1.5	2	3.0
10. Van Buren Township	5.0	14	70.0
11. Washington Township	1.3	8	10.4
	49.0 tons/day	114 miles	522.1 ton miles

STAUNTON LANDFILL

Location	Quantity of Refuse Generated	Distance	Total
1. Brazil Township	22.5 tons/day	6 miles	135.0 ton miles
2. Cass Township	.6	15	9.0
3. Dick Johnson Township	2.0	10	20.0
4. Harrison Township	3.6	18	64.8
5. Jackson Township	2.9	7	20.3
6. Lewis Township	2.3	27	62.1
7. Perry Township	1.7	8	13.6
8. Posey Township	5.6	1	5.6
9. Sugar Ridge Township	1.5	12	18.0
10. Van Buren Township	5.0	13	65.0
11. Washington Township	1.3	16	20.8
	49.0 tons/day	132 miles	434.2 ton miles

$$AWD = \left[\sum_{i=n}^{N} WG \times D\right] \div TWG$$

Center Point Landfill - AWD = (522.1) ÷ 49.0 = 10.66

Staunton Landfill - AWD = (434.2) ÷ 49.0 = 8.86

11. Procedure for Estimating Cost of a County-Wide Container ("Green Box") Rural Solid Waste Collection System

The most widely used method of solid waste collection in the rural areas of Indiana is the container, or "green box" system. Both public and private arrangements have been utilized for the operation of this system. As its name implies, this system employs a strategic dispersion of storage containers (similar to those commonly used at commercial establishments) throughout a county. The containers are typically located at major highway intersections, at schools or other institutions, and near or within residential developments. Transporting waste from the home or rural business to one of the system's storage containers is the responsibility of the individual. The containers are then regularly emptied by one or more collection trucks. If a "green box" system is well planned and managed efficiently, it can be a valuable asset to a community by helping to alleviate the problem of open dumping. However, a system that is poorly planned and operated can become unsightly, expensive and, in general, have a detrimental effect on a community.

In this section, a series of steps that could serve as a guide for planning a "green box" system and estimating the cost of hypothetical system will be briefly outlined.

Procedure for Planning a Rural "Green Box" Collection System

1. Locate sites for the storage containers. Population density and traffic-flow patterns need to be carefully examined when selecting sites. In rural counties, one site strategically placed in each township may provide adequate convenience for its residents.

2. Estimate the quantity of refuse that will be disposed of at each site. The population in the area surrounding the collection site and refuse which may already be collected at households in the area (via a "mailbox" collection system) should be taken into account.

3. Determine the number of storage containers that will be required to handle the solid waste stream at each collection site. Consideration should be given to the capacity per storage container (containers usually range from 3 to 8 cubic yards) and the frequency of collection. One cubic yard of refuse weighs approximately 125 pounds, although there can be some variation depending on the composition of the refuse.

4. Determine how often the storage containers will be emptied. Frequency of collection will be influenced by the capacity of storage containers, the capacity of the collection vehicle, labor availability, labor costs, and the road distance from the collection site to the disposal site.

5. Determine what size collection vehicle (compactor) can best be utilized. One cubic yard of compacted refuse weighs approximatley 500 pounds, although this figure may also vary depending on the composition of the refuse.

6. **Determine how many trips will be required to haul the refuse from the collection sites to the disposal site.** This will be influenced by the quantity of solid waste at each collection site and the capacity of the collection vehicle. The layout of the county highway system and the quantity of solid waste in contiguous collection sites should be carefully examined to try and minimize the number of trips necessary to empty the storage containers. The number of trips can possibly be lessened by collecting refuse at storage sites which are located along fairly similar routes.

7. After the collection routes have been determined, the total road distance from the collection sites to the disposal sites should be measured.

8. Determine the time required for collection and disposal of the refuse. The traveling speed of the collection vehicle will probably average around 35 miles per hour.

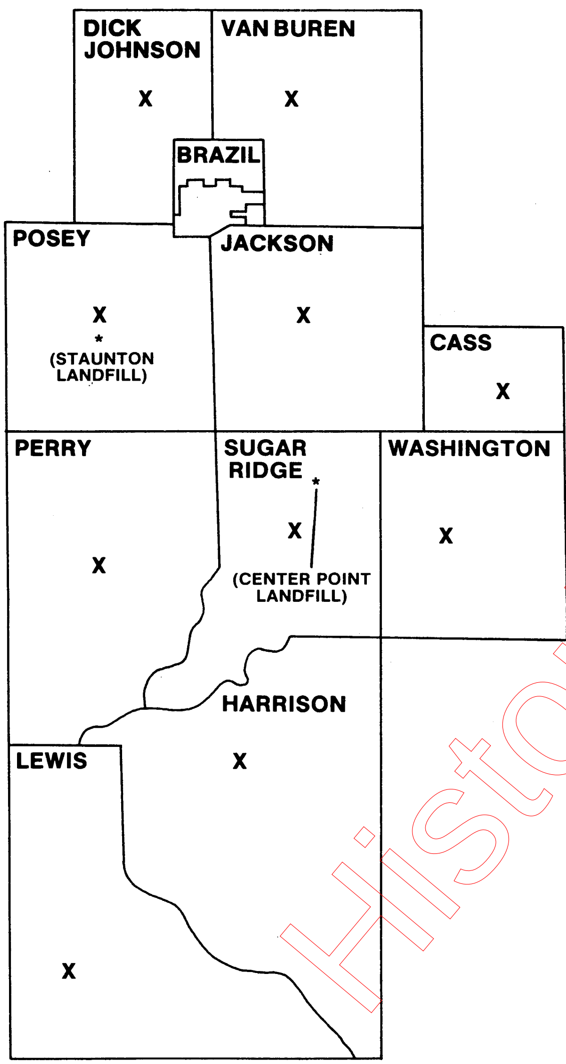
9. Determine the labor requirements for the collection system.

These steps are a very brief synopsis of what needs to be considered in the planning or revision of a "green box" collection system. A more detailed step-by-step illustration is available from the authors.

What Would a "Green Box" System Cost?

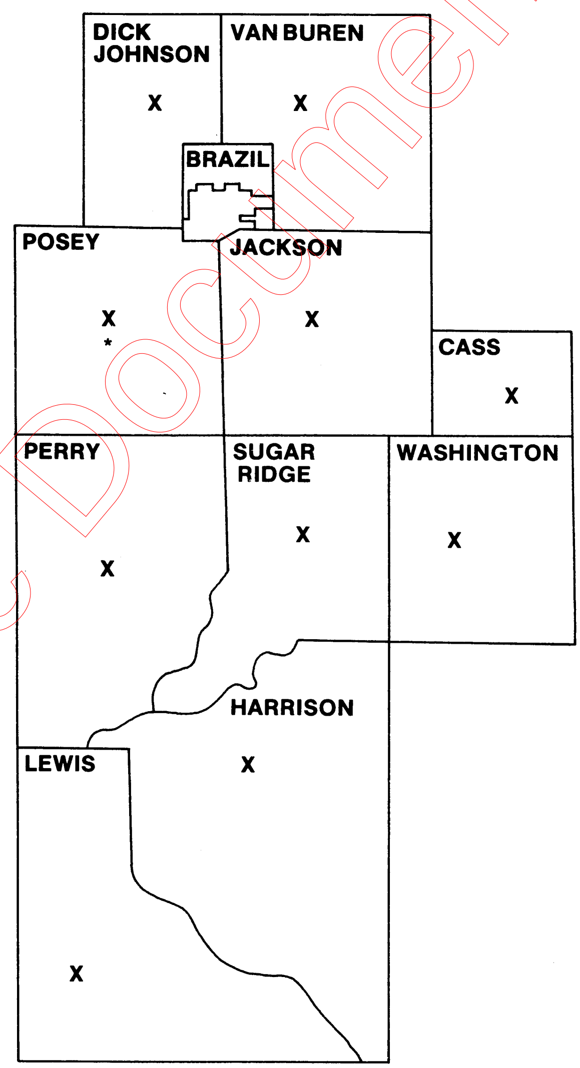
Using Clay County as a hypothetical example, Table 17 illustrates the costs of a "green box" system. Collection and storage sites were placed in all townships except

Figure 7. Clay County Collection Sites and Alternative Disposal Sites.



X - INDICATES THE LOCATION OF THE TRANSFER STATIONS
* - INDICATES THE LOCATION OF THE DISPOSAL SITES

Figure 8. Example of Possible Locations for Storage and Collection Sites for a Rural "Green Box" Refuse Collection System for Clay County.



X - INDICATES COLLECTION AND STORAGE SITES
* - INDICATES DISPOSAL SITE (STAUNTON LANDFILL)

Brazil. Brazil Township was excluded in the example since the city of Brazil makes up most of the township's population and because the city has a refuse collection system in operation. The Staunton Landfill was used as the final disposal site. See Figure 8.

It may be desirable in some cases to have a flatbed or dump truck to haul large bulky items (refrigerators, etc.). If so, an allowance should be made for the cost of this vehicle.

The collection vehicle cost and the operating cost of the collection vehicle are estimates from the Ohio State University Agricultural Economics Department and are expressed in 1978 dollars.

Table 17. Estimated Capital and Operating Costs for a "Green Box" Solid Waste Collection System for Clay County.

	Number	Investment	Life Expectancy	Annual Operation
1. Collection Vehicle (30 yd^3 compactor-front load)	1	$73,100	3 yr.	$24,367
2. Storage containers (8 yd^3)	185	$96,200 ($520 each)	8 yr.	$12,025
3. Maintenance on storage containers		$21 each		$3,885
4. Site preparation for storage containers		$4,000 ($400 per site)	8 yr.	$500
5. Truck driver for collection vehicle (including benefits)	1			$12,500
6. Laborers (including benefits)	2	$10,500 each		$21,000
7. Operating cost for collection vehicle	1	(6 hours per day x 260 days @$5.60 per hour)		$8,752
8. Miscellaneous		5% Contingencies		
				$83,029

NEW 11/80

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