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Planning for Community Services in Rural Areas ... A Regional Approach to Solid Waste Management

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Planning for Community Services in Rural Areas: A Regional Approach to Solid Waste Management

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INTRODUCTION

PROVIDING ADEQUATE community services in cities, towns, and counties is a nationwide problem. Costs associated with the provision of such services have risen to such levels that heavy financial burdens are being placed upon many local governments, yet state or federal laws require that many of these services be provided.

The concepts of regionalism and intergovernmental cooperation in planning for community needs have received much emphasis in recent years. These concepts are being considered in many areas as a possible means for local governments to share and possibly reduce their required expenditures.

The research reported in this bulletin was conducted to determine what economic gains or savings could be realized if counties or other units of local government would cooperate in providing certain necessary services. Intergovernmental cooperation would spread the costs of these services among the individual localities and would possibly reduce the total costs as well.

Solid waste collection and disposal was selected as the specific community service to be studied. This service was chosen because it is a relatively expensive operation and is one which is required by law in all Alabama counties.

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RESEARCH OBJECTIVES

The major objective of this research was to determine the minimum cost solid waste collection and disposal system for a selected multi-county region in Alabama.

The accomplishment of this objective required that the best or least cost system for each individual county and each possible multi-county unit in the study area be derived and then the results compared to determine the least cost system for the region as a whole. The research was designed to determine the best locations and sizes for specified numbers of sanitary landfills for each county, various subregions and the region, determine the least cost routing of pickup vehicles for each locational pattern, and to determine the total investment and annual operating costs for each locational and routing pattern.

STUDY AREA

A five-county area located in northwest Alabama was selected for analysis, Figure 1. The area was selected because of its geographic and demographic characteristics and because the Muscle Shoals Council of Local Governments, a very active regional planning body that has jurisdiction over Alabama Planning Region 1, plans to use the results of this research effort.

The study area encompasses 3,324 square miles and is bordered on the north by Tennessee, on the west by Mississippi, and on the south and east by other Alabama counties. With the exception of a segment of northeast Franklin County and the southern portion of Marion and Winston counties, the area is drained by the Tennessee River. Elevations range from over 1,000 feet in Marion County to around 480 feet along the Tennessee River. Predominant elevations in the area vary between 500 and 700 feet above sea level.[1]

The Quad-Cities area is the commercial hub of the area. It is composed of the city of Florence, in Lauderdale County, and the cities of Sheffield, Tuscumbia, and Muscle Shoals in Colbert County. The cities share common boundaries and form one large metropolitan area.

The Tennessee River is the dominant geographical feature of

[1] Muscle Shoals Council of Local Governments, *Regional Open Space and Recreation Study* (Muscle Shoals, Alabama: July, 1971), p. 27.

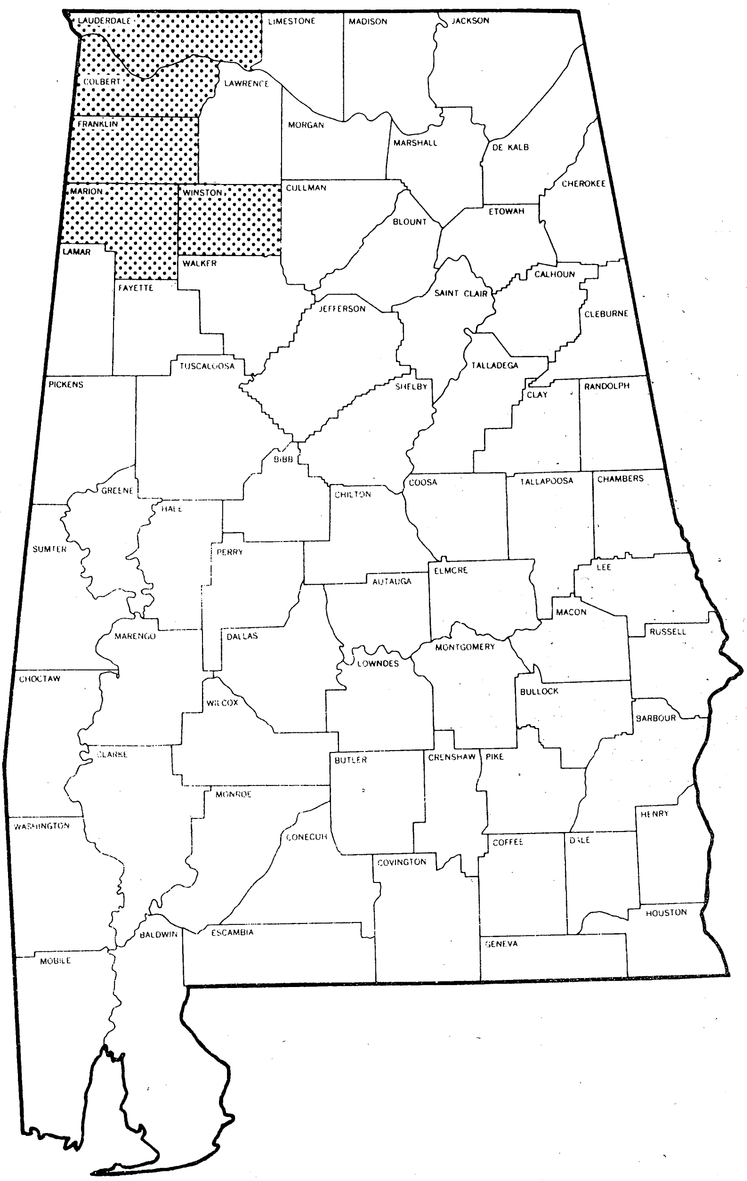

FIGURE 1. Alabama State Planning Region, served by the Muscle Shoals Council of Governments.

TABLE 1. POPULATION BY COUNTY IN ALABAMA PLANNING REGION 1, 1970

County	Total population	Urban		Rural	
	Number	*Number*	*Percent*	*Number*	*Percent*
Lauderdale	68,111	34,031	50.0	34,080	50.0
Colbert	49,632	28,031	58.1	20,782	41.9
Franklin	23,933	7,814	32.6	16,119	67.4
Marion	23,788	6,241	26.2	17,520	73.8
Winston	16,654	4,134	24.8	12,520	75.2
Total	182,118	81,070	44.5	101,048	55.5

the region. A system of dams and locks was established on the river during the 1930's by the Tennessee Valley Authority and since that date, the river has served as the major economic stimulant for the region.

Major highways, including U.S. 43 in a north-south direction, and U.S. 72, 72-A, 24, and 278 in an east-west direction, provide access throughout the region. Air transportation is available at Muscle Shoals and at several smaller airports throughout the region.

In 1970, the five-county area had a population of 182,118.[2] On a rural urban basis (urban being a population concentration greater than 2,500), there were 101,048 (55.5 percent) rural residents and 81,070 (44.5 percent) persons living in urban areas. Of these 81,070 urban residents, 62,881 (77.6 percent) lived in Colbert and Lauderdale counties. Franklin, Marion, and Winston counties were predominantly rural. A summary of the population in the respective counties of the study area is given in Table 1.

METHOD AND SCOPE OF STUDY

The Solid Waste Management System

A complete solid waste management system performs three basic functions: (1) storage; (2) collection; and (3) disposal. Each of the functions may be accomplished by any one of several methods, making it possible to have many variations within a total system.

Storage is normally considered to be the first activity in a solid waste management system, with storage methods being classified

[2] U.S. Bureau of Census, 1970 Census of Population. Volume 1, *Final Population Counts.* Advance Report PC (VI)-2, Alabama. Washington, D.C.: U.S. Government Printing Office.

according to their location. The most common storage location is at or near the site where refuse is generated; that is, at the residence, industry, or firm where waste is initially produced.

In densely populated areas where distances between residences, businesses, or industrial sites are sufficiently short to make pickup at each location feasible, storage in suitable containers at each site becomes the normal procedure. Depending on collection and disposal methods and the location of the disposal site, it may be necessary to provide short term storage at a transfer station. In urban areas, transfer stations may be relatively elaborate and used to collect waste in a sufficiently large volume to make train or large trailer truck hauling feasible. In these systems, collection trucks unload into bins or onto larger trucks or rail cars. The waste is then compacted and transported to the disposal site. This system is normally used when disposal sites are relatively distant from the solid waste producing units.

In rural areas, the transfer station may simply be collection bins where individuals deposit waste. This practice consolidates widely scattered waste into a larger volume for transfer to a disposal site. For this study, it was assumed that this containerized system of storage would be used.

The second activity in a solid waste management system is collection; the process of removing solid waste from storage and transporting it to a disposal site. Collection may be accomplished in different ways, but the method and frequency of collection are directly related to the type of storage process being used. Collection is normally the most expensive phase of solid waste disposal, accounting for as much as 80 percent of the total cost.[3]

This activity involves the use of several pieces of equipment and a large number of personnel. The productivity of each collection vehicle and its crew is dependent upon the amount of time spent in transit. Therefore, the distance between each origin of solid waste and each disposal site is reflected in the collection cost and is thus a primary determinant of the disposal site location.

In this investigation, it was assumed that thirty cubic yard front-end-loader compactor trucks would be used to service the containers. Use of this type of equipment increases initial in-

[3] John M. Huie, *Solid Waste Management: Storage, Collection and Disposal*, (Lafayette, Indiana: Purdue University, Cooperative Extension Service EC-397), p. 5.

vestment costs but reduces labor requirements.

Disposal, the third activity in a solid waste management system, provides for the destruction and final removal of solid waste. Several technically feasible methods of solid waste disposal are permitted within the standards imposed by Alabama law and the Alabama Department of Health, with incineration and sanitary landfills being the most frequently used methods. "The sanitary landfill is presently the only true disposal method and is basic to any solid waste program. Incineration is a volume reduction process and produces residue which should be sanitary landfilled."[4]

Grinding, composting, pyrolysis, and high temperature incineration are other less often used techniques of solid waste disposal. Salvaging, recycling, and the use of waste products for fuels are receiving increased emphasis. These less frequently used methods may be preferred under certain conditions and with improved technology, some of them may become more prominent in the future.

In the sanitary landfill disposal process, solid waste is spread and compacted in layers of not more than 2 feet in thickness. Each of these layers is covered with 6 to 8 inches of soil at the end of a day's operations, or more frequently if required. A completed landfill receives a final 2-foot cover of soil.

For rural areas, the apparent least cost method of waste disposal is by means of a sanitary landfill. Golucke and McGauhey reported an average cost of about \$1.13 per ton for solid waste disposal with cost ranging from \$0.05 per ton to \$2.00 per ton.[5]

Costs of incineration are reported to range from about \$4.00 per ton to over \$12.00 per ton. Clearly, for rural areas with an abundance of possible disposal sites, landfill is the best alternative. The sanitary landfill was assumed to be the method of disposal for this study.

The methods of financing a solid waste management system

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[4] National Association of Counties Research Foundation, *Solid Waste Management—Design and Operation (#5)*, U.S. Department of Health, Education, and Welfare, Public Health Service, Consumer Protection and Environmental Health Service, Environmental Control Administration, Bureau of Solid Waste Management, 1969, p. 10.

[5] C. G. Golucke and P. H. McGauhey, *Comprehensive Studies of Solid Waste Management:* First and Second Annual Reports, (Washington, D.C.: U.S. Public Health Service Publication 2039, 1970), p. 20.

were not considered in this research. The costs for the different variations are presented and the least cost system selected. It was beyond the scope of this study to determine the best ways to meet these costs.

Simulating the Solid Waste Management System

Three quantitative models were utilized to determine the least cost solid waste management system for the five-county study area. The first was used to determine the amount of solid waste expected to be generated. The second permitted determination of the locations for landfills which would minimize the total travel required to dispose of all solid waste. The final model was used to determine the best routes for the collection vehicles for each selected best sanitary landfill location. Results from these three models were combined to aid in deriving cost data and budgets which permitted determination of the least cost solid waste management system for the total region.

Amount of Solid Waste

The waste generation model was used to estimate the total waste expected to be generated in the study area and the amount of landfill area needed for disposal. The amount of household waste generated in the area was calculated by using census enumeration district population data and established figures which indicate the average amount of solid waste expected to be generated by each resident.

The established waste generation coefficients indicated that the quantities of solid waste collected differ according to the area — rural or urban. The average number of pounds of solid waste collected per capita per day in the United States from households, business, and industry during 1967 was 5.72 in urban areas and 3.93 in rural areas. Of these totals, persons in urban households accounted for 1.26 pounds and those in rural areas, 0.72 pounds per day.[6]

It is safe to assume that the total generation of waste has increased since 1967 and will continue to increase in the future. Taking this into consideration, it was assumed for this research

[6] A. J. Muhich, "Sample Representativeness and Community Data," *An Interum Report 1968 National Survey of Community Solid Waste Practices,* Department of Health, Education, and Welfare, p. 13.

that the estimated collection of waste from rural households would be 1 pound per capita per day and 2 pounds per day from each urban resident. Total solid waste, including business and industrial sources, were estimated to be 8.5 pounds per capita per day in urban areas and 6.0 pounds per capita per day in rural areas. Table 2 presents the expected daily generation of solid waste material for each county.

It was assumed that only household waste from rural areas would be picked up by the collection vehicles. Business and industry would be responsible for either transporting their own waste to the landfill or it would be collected and transported by a municipal system.

In determining the land area needed for disposal, it was assumed that 800 pounds of waste material would occupy 1 cubic yard of space when landfilled. One pound at a bulk density of 800 pounds per cubic yard would occupy a volume of .00125 cubic yards. Therefore, the annual volume of landfilled waste can be estimated by multiplying .00125 by the total pounds of solid waste generated.

Cubic yards of waste per year = [(.00125) (rural population) (6.0) + (.00125) (urban population) (8.5)] [365]

Estimates of the landfill area needed annually were obtained by assuming that the ratio of waste material to cover material would be 4:1.[7] With 1 acre of land, 1 foot deep (1 acre-foot) containing 1,613 cubic yards and filling at the ratio of 4:1, each acre-foot of land area would have a capacity of 1,290 cubic yards of solid waste material. Assuming a landfill depth of 10 feet, divid-

TABLE 2. DAILY RESIDENTIAL AND TOTAL SOLID WASTE QUANTITIES BY COUNTY, ALABAMA PLANNING REGION 1

County	Residential solid waste per day	Business and industrial waste per day	Total solid waste per day
	Tons	*Tons*	*Tons*
Lauderdale	51.07	195.80	246.87
Colbert	39.24	145.71	184.95
Franklin	15.87	65.69	81.56
Marion	15.01	64.15	79.16
Winston	10.39	44.74	55.13
Total	131.58	516.74	647.67

[7] D. H. Carley, *Handling Solid Waste Materials in Urban-Fringe and Rural Communities in Georgia,* (Athens, Georgia: University of Georgia, College of Agriculture Experiment Stations, Research Bulletin 149, 1973), p. 19.

ing the annual estimate of cubic yards of waste by 12,900 provides an estimate of the acre-feet of landfill area needed annually. This factor could be adjusted to account for deeper or more shallow landfills. Multiplying this figure by the planned life of the landfill would give an estimate of the total land needed for a given landfill operation.

Total land needed = [(cubic yards of waste per year) ÷ 12,900 (years of expected life)]

Best Sanitary Landfill Locations

A computerized procedure was utilized to determine the best locations for various numbers of sanitary landfills for each of the five counties, for several combinations of the counties, and for the region as a whole.[8] The locations selected as best were those which minimized the total travel required to dispose of the expected solid waste.

Several sources and types of data were assembled to complete the location analysis. The first step in assembling these data was to select potential locations for sanitary landfills within the study area. Possible sites were established through the use of a general soils map which was constructed by the Soil Conservation Service for the five-county region.[9] The map indicated the soil limitations of the different soil associations in each county. Any area illustrated on the map with slight or slight to moderate limitations for landfill use was considered as a feasible area for a possible sanitary landfill location. The maps in Appendix A illustrate the general areas within the five-county region which could possibly support a landfill operation and the specific points which were selected as potential sites. Thirty-four sites were chosen. Six potential sites were specified in Winston County, seven in Marion County, seven in Franklin County, six in Colbert County, and eight in Lauderdale County.

Six of the specified potential landfill sites lie outside of the areas designated as satisfactory for landfill use. These points are the existing landfills in the counties. The fact that they lie out-

[8] W. E. Hardy, Jr., *A Computer Program For Locating Economic Facilities* (Auburn, Alabama: Auburn University, (Ala.) Agricultural Experiment Station, A. E. Series 24, March 1973).

[9] Muscle Shoals Council of Local Governments, *Regional Open Space and Recreation Study* (Muscle Shoals, Alabama: July, 1971), p. 29.

side the generally accepted areas emphasizes the importance of specific site investigation before landfill establishment.

The next step in assembling data for the location analysis was to specify the locations of collection points and amount of waste to be collected at each. Census enumeration district maps and associated population data were used to determine population density and distribution for the five counties in the study area. These data were multiplied by the established household waste generation coefficients – 1 pound per capita per day in rural areas and 2 pounds per capita per day in urban areas – to determine the total household waste expected from the area.

One or more pickup sites were selected for each enumeration district, giving a total of 237 collection points for the five-county area. These locations were strategically placed at highway intersections and other easily accessible places throughout each county so that they would be convenient for both local residents and travelers. Population density was a major factor considered in specifying the locations.

The exact location of each of the 237 collection points is illustrated on the maps and presented in the tables of Appendix A. The amount of waste to be collected at each point is also presented in the tables with the volume being based upon population numbers and an assumed pickup of twice a week or every 3.5 days.

The tables presented in Appendix A also indicate the number of 4-cubic-yard containers which should be located at each pickup site. Certain assumptions were made in determining how many collection bins to place at each site. These assumptions were supported by preliminary findings for Chilton County, Alabama.[10] Specifically, it was assumed that solid waste is discharged from the collection vehicle at an average density of 400 pounds per cubic yard. Assuming the collection vehicle has a compaction ratio of 3:1, then the non-compacted density of 1 cubic yard of waste is approximately 134 pounds. At this density, a standard 4-cubic-yard collection bin is capable of holding 536 pounds of non-compacted waste.

It was further assumed that only 50 percent of bin capacity will be utilized. This assumption was necessary to allow for pe-

[10] A. M. Alexander, G. D. Smith, and J. V. Walters, *Chilton County Solid Waste Disposal Demonstration Project Detailed Progress Report, Project Clean and Green*, Clanton, Alabama, 1971, pp. 42-45.

riods of peak generation, and to allow a margin of error to ensure against undercapacity. Therefore, at 50 percent capacity, a 4-cubic-yard bin will contain approximately 268 pounds of solid waste.

According to previously established guidelines, the average daily waste produced by each rural resident is approximately 1 pound. Given the average capacity of each 4-cubic-yard bin of 268 pounds, this means that one bin will be able to contain the waste generated by 268 rural residents in 1 day. Assuming a twice weekly pick-up, one 4-cubic-yard bin should be able to serve the disposal needs of 75 people. The number of bins needed in the rural collection areas was calculated by dividing the rural population (1970 Census) in each enumeration district by 75.

It was assumed that all incorporated towns and cities had their own means of solid waste collection. The mechanics of municipal collection was not important to this study, but the quantities of waste collected did have an impact upon the location analysis. Each city was assumed to be a single collection point for the location analysis.

The final step in assembling data for the location analysis was to determine the distances connecting all 271 specified points — 237 collection points and 34 potential landfill sites — to each other. The distance from each point to all directly adjoining points was calculated by using a map measure on county highway maps. A computerized procedure was utilized to determine the shortest distance between each site and other 270 sites. In total, 73,441 different distance measurements were needed to determine the best sanitary landfill locations.

Best Vehicle Routing

After the best sanitary landfill locations were determined for each county and for various combinations of the counties and region, a computerized routing model was utilized to determine the best routes for the collection trucks to follow in picking up the waste.[11] Since costs involved in the collection process are a major component of total operating cost, it is important that all collection vehicles be used as efficiently as possible.

[11] M. C. Hallberg and W. R. Kriebel, *Designing Efficient Pickup and Delivery Route Systems by Computer,* (University Park, Pennsylvania: The Pennsylvania State University, College of Agriculture, Agricultural Experiment Station, Bulletin 782, 1972).

Distance and collection volume data used to determine best location also were used to determine the best routes. It was assumed that 30-cubic-yard compactor trucks would be used to collect waste from containers, and that each would be used for 8 hours a day – 7 hours for travel and pickup and 1 hour for unloading.

Results of the routing analysis provided several types of useful information. In addition to indicating which routes the trucks should follow in picking up the waste, the solution permitted the determination of the number of trucks needed and an estimation of the total travel miles required to serve a given landfill. Such information was very useful in establishing the amount of investment and operating capital needed for the collection process.

Each landfill operation was allotted a certain number of collection trucks based on the total number of routes and the time required to serve each route. Routes were combined so that a given truck would be used as efficiently as possible. The basic goal in combining routes for a given truck was to have it working 8 hours, however, it was virtually impossible to have a work day of exactly 8 hours. Tables 3 and 4 present the basic logic used in determining the number of collection trucks needed for a particular landfill operation. Table 3 illustrates the number of route combinations that a given truck could handle and in what sequence each of these route combinations occurred. For example, three trucks could handle up to nine 8-hour route combinations. With pickup scheduled for 5 days a week, 3 weeks would be required for each route combination to be served five times, for a schedule of 1⅔ pick-ups per week. The three trucks would serve route combinations 1, 4, and 7 on the first day, 2, 5, and 8 on the second, etc.

Table 4 presents the specific guide used for determining the number of trucks needed. If the number of route combinations for a given landfill did not allow for more than one open day per week, then it was assumed that a backup truck would be required for the collection system.

Budgets for Cost Comparison

In satisfying the central objective of determining the least cost solid waste management system for the five-county area, it was necessary to devise complete budgets for each possible sys-

TABLE 3. GUIDE FOR DETERMINING NUMBER OF TRUCKS NEEDED FOR ROUTES ON A THREE WEEK OPERATING CYCLE SHOWING THE NUMBER OF ROUTE COMBINATIONS THAT CAN BE HANDLED BY SPECIFIED NUMBERS OF COLLECTION TRUCKS

No. of trucks	No. of route combinations[1]	Days																				
		M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
		Route Combinations																				
1	1 to 3	1	2	3	1	2	----	----	3	1	2	3	1	----	----	2	3	1	2	3	----	----
2	4 to 6	4	5	6	4	5	----	----	6	4	5	6	4	----	----	5	6	4	5	6	----	----
3	7 to 9	7	8	9	7	8	----	----	9	7	8	9	7	----	----	8	9	7	8	9	----	----
4	10 to 12	10	11	12	10	11	----	----	12	10	11	12	10	----	----	11	12	10	11	12	----	----
5	13 to 15	13	14	15	13	14	----	----	15	13	14	15	13	----	----	14	15	13	14	15	----	----
6	16 to 18	16	17	18	16	17	----	----	18	16	17	18	16	----	----	17	18	16	17	18	----	----
7	19 to 21	19	20	21	19	20	----	----	21	19	20	21	19	----	----	20	21	19	20	21	----	----

[1] A route combination consists of an 8-hour work day.

TABLE 4. GUIDE TO DETERMINING THE NUMBER OF PRIMARY AND BACKUP COLLECTION TRUCKS NEEDED FOR A SOLID WASTE DISPOSAL SYSTEM

No. of route combinations	Open day/week[1]	No. of primary trucks needed	No. of backup trucks needed[2]
1	3	1	0
2	1	1	1
3	0	1	1
4	3	2	0
5	1	2	1
6	0	2	1
7	3	3	0
8	1	3	1
9	0	3	1
10	3	4	0
11	1	4	1
12	0	4	1
13	3	5	0
14	1	5	1
15	0	5	1
16	3	6	0
17	1	6	1
18	0	6	1
19	3	7	0
20	1	7	1
21	0	7	1

[1] An open day is when a primary collection truck is not scheduled to collect on that day.

[2] A backup collection truck is needed when there are one or less open days per week.

tem. The waste generation, location, and routing analyses provided the basic input for the cost comparison budgets. The information illustrated in Table 5 is representative of the cost data used for establishing annual operating costs for each sanitary landfill operation. Size of operation and amount of equipment needed varied for each system.

The budget for each system was divided into two basic parts – cost of collection, and cost of storage and disposal. Each of these parts was further divided into investment costs and annual operating costs, giving four sections to each budget – collection investment costs, annual collection operating costs, storage and disposal investment costs, and storage and disposal annual operating costs. The two investment cost values were combined to show the total initial investment required for each operation and the operating costs were combined to show the total annual operating expense. The total annual operating cost was used for comparison with other derived budgets to establish the least cost solid waste management system for the study area.

The cost rate values illustrated in Table 5 were used for budgets. Some of these values were obtained from previous studies. Others were set at a reasonable value based on the judgement of the researchers.

TABLE 5. SAMPLE BUDGET, ILLUSTRATING INITIAL INVESTMENT AND ANNUAL OPERATION COST FOR A TYPICAL SOLID WASTE MANAGEMENT SYSTEM

Item	Unit	Quantity	Rate	Amount
				(Dollars)
Collection investment costs				
Collection truck	30 cu. yd.	1	35,000.00	35,000.00
Collection truck (backup)	30 cu. yd.	1	23,000.00	23,000.00
Pickup truck	----	1	2,500.00	2,500.00
Dump truck	----	1	5,000.00	5,000.00
Total collection investment costs				65,500.00
Annual collection-operations costs				
Manager-supervisor (½ time)	yr.	1	8,400.00	4,200.00
Secretary-bookkeeper (½ time)	yr.	1	5,500.00	2,750.00
Labor: driver	hr.	2,080	3.25	6,760.00
helper		2,080	2.75	5,720.00
Depreciation	yr.	----	5,895.00	5,895.00
Gas, fuel, oil, repairs, etc.	miles	40,000	.25	10,000.00
Interest on loan	yr.	65,500	8%	5,240.00
Total annual collection operations costs				40,565.00
Storage and disposal investment costs				
Crawler tractor with landfill equipment	----	1	47,200.00	47,200.00
Waste containers	4 cu. yd.	50	300.00	15,000.00
Portable steam generator	----	1	600.00	600.00
Misc. equipment	----	----	2,000.00	2,000.00
Truck scales	50 ton	1	8,300.00	8,300.00
Land	acre	50	300.00	15,000.00
Landfill site preparation	acre	50	150.00	7,500.00
Container site preparation	site	25	85.00	2,125.00
Equipment shed and scalehouse	----	1	10,000.00	10,000.00
Acess road to landfill	----	1	10,000.00	10,000.00
Water supply	----	1	5,000.00	5,000.00
Total storage and disposal investment costs				122,725.00
Annual storage and disposal operation costs				
Manager-supervisor (¼ time)	yr.	1	8,400.00	2,100.00
Secretary-bookkeeper (¼ time)	yr.	1	5,500.00	1,375.00
Labor: operator	hr.	2,080	4.00	8,320.00
laborer	hr.	2,080	2.75	5,720.00
Building depreciation	yr.	----	1,000.00	1,000.00
Site payment and road depreciation	yr.	----	3,962.50	3,962.50
Equipment hire	yr.	----	2,000.00	2,000.00

TABLE 5 (*Continued*). SAMPLE BUDGET, ILLUSTRATING INITIAL INVESTMENT AND ANNUAL OPERATION COST FOR A TYPICAL SOLID WASTE MANAGEMENT SYSTEM

Fuel, oil, grease, repairs, etc.	waste tons/day	50	25.00	1,250.00
Utilities, office supplies	waste tons/day	50	10.00	500.00
Building maintenance	yr.	----	200.00	200.00
Equipment depreciation	yr.	----	6,579.00	6,579.00
Miscellaneous cost	yr.	1	200.00	200.00
Interest on loan	yr.	124,725	8%	9,978.00
Total annual storage and disposal operations costs				43,184.50
Total investment costs				188,225.00
Total annual operations costs				83,749.50

Collection Costs

Collection equipment investment costs were based on approximations of the current market value of the equipment.[12] Thirty cubic yard, front loading packer trucks, costing approximately $35,000 each, were used in the budgets. A used packer truck, of the same size and type, was included as a backup vehicle in those systems where the primary collection trucks operated on a full schedule. The cost of the backup truck was set at $23,000. One pickup truck was allotted to each system, except in the cases where one supervisor was in charge of more than one landfill. In these instances, the cost of purchase and operation of the truck was divided evenly among the systems involved. The cost of a pickup was set at $2,500. A $5,000 dump truck was allotted to each landfill.

The annual operating costs for the collection process consist of the salaries and wages of the workers, equipment depreciation, collection truck operational costs, and interest on the investment loan.

The manager-supervisor's salary was divided between the collection and disposal budgets. For the individual county systems this position was allotted an annual salary of $8,400, a cost of $4,200 to the collection process. For two or more landfills in a county, a single manager-supervisor was used for all landfills and his salary was divided evenly between them. The manager-supervisor on the regional budgets received an annual salary of $9,400, divided equally between collection and disposal costs and between landfills.

[12] Current prices of collection and disposal equipment were obtained from personal interviews with representative of Truck Equipment, Inc., Birmingham, Alabama, and Truxmore Industry, Inc., Richmond, Virginia.

Duties and salaries of the secretary-bookkeeper were allotted to each budget in the same proportion as the manager-supervisor for that landfill. The annual salary for the secretary-bookkeeper was set at $5,500 for county budgets and $6,000 for the regional and subregional budgets.

The annual salary for drivers and helpers was based on a representative hourly wage rate for that type job and a 40-hour work week, 52 weeks per year. The driver's salary was set at $6,760 annually or $3.25 per hour. The helper's salary was set at $5,720 annually or $2.75 per hour.

One of the primary determinants of the least cost system was the cost of operating collection trucks. A rate of $0.25 per mile times the total annual miles traveled by the collection trucks was levied on each system. This made the costs representative of the size collection area a solid waste system covers. The rate was established assuming the truck got 4 miles to each gallon of gas at $0.50 per gallon, or $0.125 per mile. The other $0.125 per mile included the cost of maintenance, repairs, and oil.

The annual collection equipment depreciation was based on a 10-year, straight-line basis, with a 10 percent salvage value placed on the equipment.

The final collection operations cost, assuming that a system had to borrow money to cover the initial investment cost, was in the first year's annual interest that must be paid on the borrowed money. The loan rate was set at 8 percent.

Storage and Disposal Costs

The type and number of bulldozers needed at each location was determined by the amount of waste delivered to the disposal site each day. Guides for determining the size of machine needed for each size landfill were obtained from other studies.[13] A bulldozer capable of handling 50-149 tons per day costs approximately $47,200, while one capable of handling 150-249 tons per day costs approximately $57,000.

Other machines, such as scrapers, draglines, compactors, and front-end loaders are used at many landfill sites. Their use depends on the volume of waste, types of waste, and soil character-

[13] National Association of Counties Research Foundation, *Solid Waste Management,* Volume 5, Design and Operation, 10 volumes, (Washington: National Association for Counties Research Foundation), p. 1.

istics. They were omitted from this study because of the variability of their use.

A standard 4-cubic-yard collection bin was assumed to be the type used because of its ease of handling and convenience to users. Costs of the bins were set at $300 each. A cost for preparation of container sites also was included at $85 per site. The number of pickup sites and the number of containers at each site was set for each system based upon population and expected generation of waste materials.

A portable steam generator, used for cleaning the waste containers, was allotted to each landfill at a cost of $600 each. The cost of miscellaneous equipment needed for each landfill was valued at $2,000. The types of equipment may vary from landfill to landfill because of need.

Truck scales, costing $8,300, also were included in the regional and subregional landfill budgets. They are used to record the amount of waste generated by each county. Scales are not needed at individual county landfills unless the counties prefer them.

The purchase price of land was set at $300 per acre. This amount was based upon the average price of farm land in Alabama. Many governments lease land for sanitary landfill purposes, but for uniformity, all systems were budgeted using the purchase price of land.

The amount of land needed for each landfill was based upon the formula presented earlier. The annual acreage requirement was multiplied by 10 to compute the estimated acreage needed for a 10-year life span. This acreage was used to determine the cost of land acquisition. Once the land has been acquired, it must be cleared and made ready for operation. The rate of $150 per acre includes the cost of fencing, clearing, and other necessary preparations. An allowance of $10,000 was made for constructing an access road to the landfill.

A water supply is needed at each landfill site for sanitation purposes and various other uses. To get a permanent supply, a well must be dug or a connection made to an existing water line. The cost for the acquisition of water was set at $5,000 per landfill.

An equipment shed is needed at each landfill to provide protection for the men and equipment. It also can serve as a workshop, scalehouse, and a place for restroom facilities. The cost of the building and its furnishings was set at $5,000 per landfill.

The storage and disposal operations costs consist of wages, salaries, equipment depreciation, equipment hire, site payment and road depreciation, equipment operational costs, building maintenance, interest on loan, and miscellaneous costs.

The expense of the manager-supervisor was allocated equally between disposal operations costs and collection operations costs, with the salaries the same as previously stated. The only difference appears in the county budgets where the expense for the manager-supervisor on the disposal operations budget is one-fourth of the annual salary. The remaining one-fourth of this salary is assumed to be paid from other funds, because the duties associated with the solid waste management systems in the county should not take up all of the manager-supervisor's time. The salary of the bookkeeper-secretary was allotted at the same rate as the manager-supervisor serving that system.

The annual salaries of the equipment operators and laborers were based on a representative hourly wage rate for that type job and a 40-hour work week, 52 weeks per year. The salary for equipment operators was set at a $8,320 annually, or $4.00 per hour. The salary for laborers was set at $5,720 annually or $2.75 per hour.

The annual disposal equipment depreciation was based on a 10-year, straight-line basis, with a 10 percent salvage value placed on the equipment. The buildings at the disposal site were depreciated on a straight-line basis, with no salvage value.

The operational costs for the equipment at the disposal site also was figured on a rate basis. A rate of $25 per ton multiplied by the average daily tons disposed was levied to estimate the annual cost of fuel, oil, grease, and repairs. This rate was consistent with other studies of solid waste management.[14,15]

Site payment and road depreciation includes the costs of buying the landfill site, the preparation of the landfill site, the preparation of the collection point sites, the access road, and the water supply. These costs were depreciated on a straight-line, 10-year basis, with no salvage value.

There will be times during the year's operation when special

[14] H. B. Strawn, *Factors to Consider in Developing a Solid Waste Management System,* (Auburn University, Cooperative Extension Circular R-30, 1971).

[15] K. Clayton, "An Evaluation of the Economic Feasibility of a Regional Solid Waste System for the Southwestern Indiana and Kentucky Council of Governments Region," (Unpublished M.S. thesis, Purdue University, 1972).

or additional equipment will be needed. A $2,000 per year allowance was made for the renting of this equipment.

Utilities used at the landfill and at the offices of the manager and secretary were included in the budgets. The utility rate was set at $10 per ton and multiplied by the tonnage disposed each day to give an annual cost estimate.[16] Building maintenance and miscellaneous costs were estimated at $200 annually for each system.

The final cost included in the disposal operations was the annual interest that must be paid on borrowed money. It was assumed that the system would have to borrow enough to cover the total investment and that interest would be charged at a rate of 8 percent annually.

RESEARCH RESULTS

General Cost Comparisons

A total of 69 sanitary landfill budgets were prepared to aid in determining the least cost solid waste management system for the total region. The data presented in Table 6 and figures 2, 3, and 4 represent the total annual operating costs for each specified number of sanitary landfills in each county, three multi-county subregions, and the entire five-county region.

The data indicate that size of the solid waste management operation being considered has a direct effect on system cost and that economies of scale are present. The "U" shaped total operating cost curve in Figure 2 clearly indicates this relationship. Each point in the curve represents the cost of storage, collection and disposal for the same amount of waste: the total generated by the region. A single landfill operation appears to be too large and is required to serve too wide an area since the total annual operating cost is greater than with a system operating two landfills. The two landfill operation apparently gives something closer to the optimum size landfill and service area since a higher total cost is also realized if three smaller landfills, each having a smaller service area, are utilized. As the number of landfills increase, the possibility of duplication and underemployment of equipment and manpower becomes more likely, thus increasing system costs.

[16] Ibid.

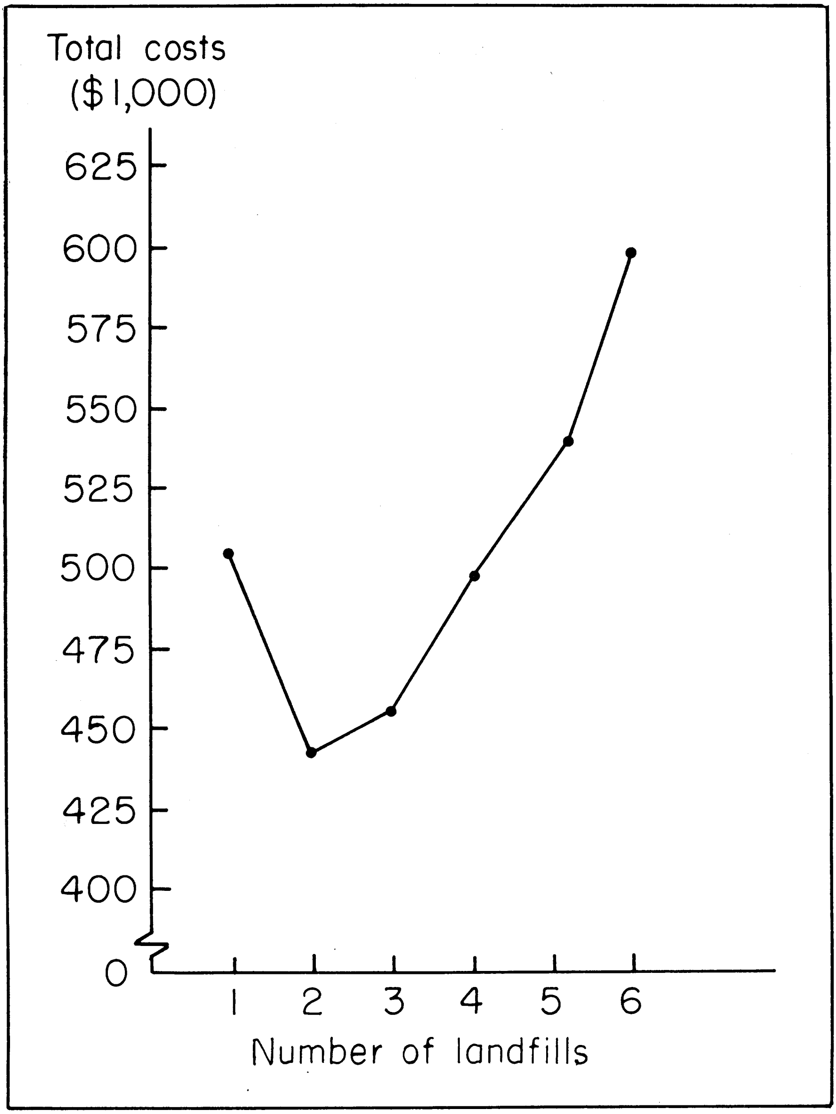

FIGURE 2. Total annual operating costs for specified number of landfills for Alabama Planning Region I.

Additional information presented in Table 6 and on figures 3 and 4 indicates that a single landfill would provide the best size operation for each of the individual counties and for two of the three sub-regional multi-county combinations. The four-county combination of Winston, Marion, Franklin, and Colbert could realize some savings if the solid waste management system were expanded to include two sanitary landfills.

TABLE 6. ANNUAL OPERATING COSTS FOR SOLID WASTE MANAGEMENT SYSTEMS IN EACH COUNTY, THREE MULTICOUNTY SUB-REGIONS, AND THE REGION

Area	Number of landfills	Best locations	Operating cost
	(Number)	*(Site number)*	*(Dollars)*
Winston County	1	1	83,461
Winston County	2	1, 3	118,342
Winston County	3	1, 3, 6	171,948
Marion County	1	8	100,630
Marion County	2	8, 7	139,596
Marion County	3	7, 10, 11	180,298
Franklin County	1	14	95,317
Franklin County	2	17, 15	134,457
Franklin County	3	17, 15, 19	179,737
Colbert County	1	21	114,375
Colbert County	2	21, 26	149,350
Colbert County	3	21, 26, 23	211,981
Lauderdale County	1	30	167,072
Lauderdale County	2	30, 28	171,836
Lauderdale County	3	30, 28, 27	248,895
Col., Lau.[1]	1	30	239,971
Col., Lau.	2	30, 21	255,098
Col., Lau.	3	30, 21, 28	278,402
Win., Mar., Fkl.[2]	1	10	215,370
Win., Mar., Fkl.	2	13, 17	240,445
Win., Mar., Fkl.	3	17, 1, 11	275,712
Win., Mar., Fkl., Col.[3]	1	22	301,219
Win., Mar., Fkl., Col.	2	9, 21	300,859
Win., Mar., Fkl., Col.	3	9, 21, 11	309,474
Region[4]	1	21	505,480
Region	2	21, 9	442,755
Region	3	21, 9, 29	456,197
Region	4	21, 9, 29, 11	502,621
Region	5	21, 9, 29, 11, 17	538,313
Region	6	21, 29, 11, 17, 7, 6	594,192

[1] Colbert and Lauderdale counties.
[2] Winston, Marion, and Franklin counties.
[3] Winston, Marion, Franklin, and Colbert counties.
[4] All five counties.

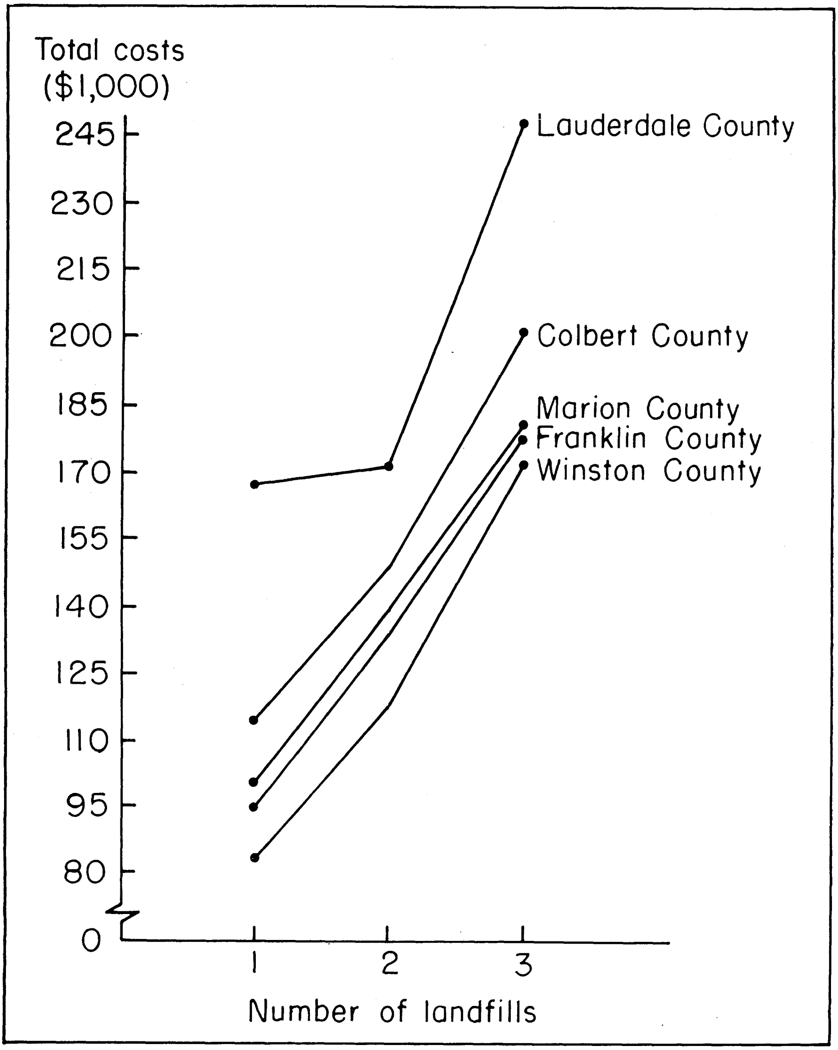

FIGURE 3. Total annual operating costs for specified numbers of landfills in each county of Alabama Planning Region I.

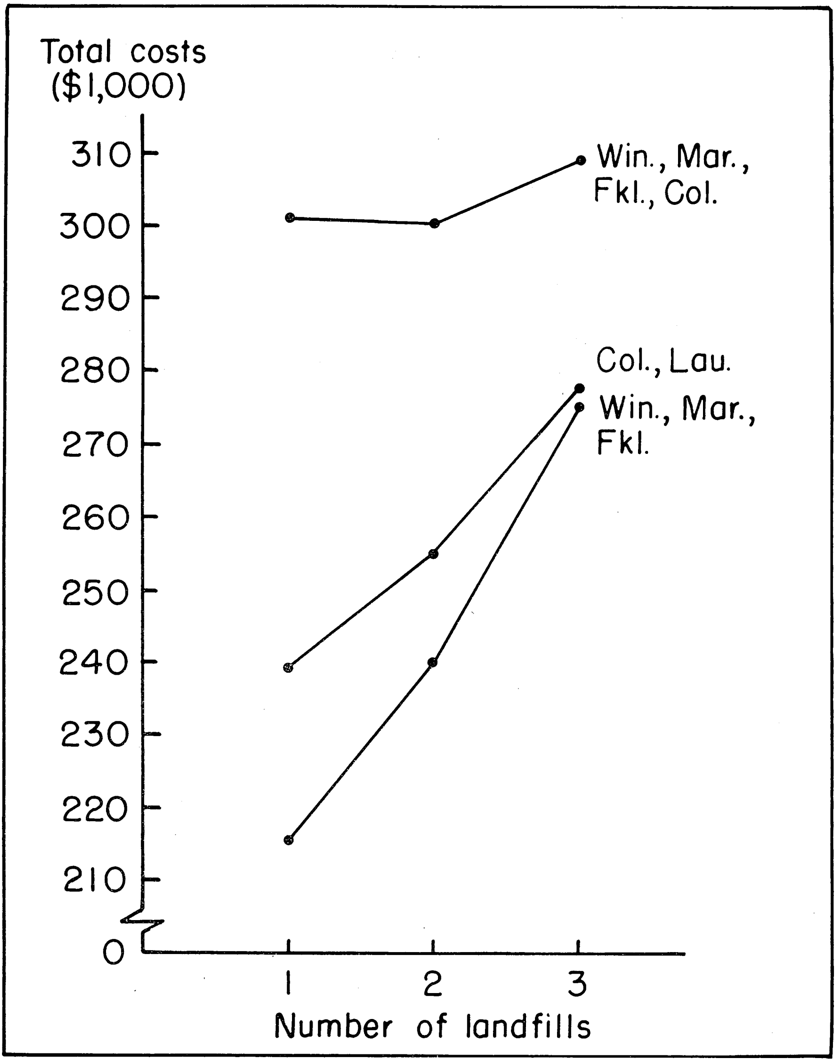

FIGURE 4. Total annual operating costs for specified numbers of landfills in selected sub-regions of Alabama Planning Region I.

The Least Cost System

The total annual operating costs for eleven solid waste management systems in the total five-county region are presented in Table 7. Comparison of the data reveals that the least cost system calls for operation on a regional basis, with two sanitary landfills. The estimated annual operating cost for this system is $442,755, representing a savings of $12,586 over the next best system, and $118,100 over the system where each county operates its own landfill. At least 10 regional or subregional systems serve the entire five-county area with lower total annual operating costs than the combined individual county systems.

Budgets representing the investment and operating costs for the two landfills in the least cost system are presented in Appendix B. The cost data presented in these budgets are based on the results of the waste generation, location and routing analyses. As indicated, the two sites selected as best for the least cost regional

TABLE 7. TOTAL ANNUAL OPERATING COSTS FOR VARIOUS SOLID WASTE MANAGEMENT SYSTEMS FOR ALABAMA PLANNING REGION I

Combination	Number of landfills	Annual operating cost	Total annual operating cost
Region	2	$442,755	$442,755
Win., Mar., Fkl.[1]	1	215,370	455,341
Col., Lau.[2]	1	239,971	
Region	3	456,197	456,197
Win., Mar., Fkl., Col.[3]	2	300,859	467,931
Lauderdale County	1	167,072	
Win., Mar., Fkl., Col.	1	301,219	468,291
Lauderdale County	1	167,072	
Win., Mar., Fkl.	1	215,370	470,468
Col., Lau.	2	255,098	
Win., Mar., Fkl., Col.	3	309,474	476,546
Lauderdale County	1	167,072	
Region	4	502,621	502,621
Region	1	505,480	505,480
Region	5	538,313	538,313
Winston County	1	83,461	560,855
Marion County	1	100,630	
Franklin County	1	95,317	
Colbert County	1	114,375	
Lauderdale County	1	167,072	

[1] Winston, Marion, and Franklin counties.
[2] Colbert, and Lauderdale counties.
[3] Winston, Marion, Franklin, and Colbert counties.

system are sites 21 and 9. Site 21, located in east central Colbert County, is the larger of the two. It would handle 505 tons of solid waste per day produced in Lauderdale County, Colbert County, and part of Franklin County. The acreage needed to handle the annual waste of 184,325 tons for 10 years was estimated to be 358 acres. Site 9, located in the northeastern part of Marion County would serve all Marion and Winston counties and part of Franklin County. The 161 tons of solid waste produced each day in this area would require 114 acres of land for a 10-year life.

Site 21 serves 152 pickup points along 22 routes. These 22 routes were combined to form 10 route combinations, with each route combination scheduled to take no more than one 8-hour day for its completion with four primary collection trucks serving these routes. The low number of trucks required is attributed to the establishment of optimum travel routes which decrease the amount of wasted time the truck spends in transit. The individual routes for site 21 and a descriptive table giving a more complete analysis of the routes, showing pickup points served, quantity of waste pickup, distance traveled, and the time necessary to complete the routes are presented in Appendix B.

Site 9, the smaller of the two landfill sites, serves 75 pickup points along 13 routes. These 13 routes, which run through predominantly rural Winston County and Marion County, and rural Franklin County, were combined into seven route combinations requiring three primary collection trucks. The routing patterns for site 9 and a detailed route explanation giving the pickup points served, quantity of waste delivered, distance traveled, and the time necessary to complete each route are presented in Appendix B.

The cost data for the landfills at sites 21 and 9 – the least cost system – illustrate why a regional approach to solid waste management is more economical. Having two landfill sites reduces the duplication of many of the fixed facilities at each landfill. Also, less equipment is needed and each landfill can be operated more efficiently because of the increased daily tonnage. This decreases idle working hours and increases returns to equipment and labor investment.

The investment and operating costs for the collection process are reduced as a result of the regional routing. Collection routes were established without regard to county boundaries preventing many unnecessary deadends and turnarounds. More efficient routes require fewer trucks, reducing the investment in vehicles and labor.

SUMMARY

The information presented in this bulletin is the result of a study designed to objectively analyze the possibility of economic gains from regionalization or inter-county cooperation in the provision of a given service. Solid waste collection and disposal was the service chosen for study. Five northwest Alabama counties – Colbert, Franklin, Lauderdale, Marion, and Winston – were selected as the study area.

Three separate simulation models were utilized to determine the least cost solid waste management system for the entire five-county region. The first model was used to establish the expected quantity of waste that would be generated in the study area, the location of this waste, and the size of sanitary landfill needed to dispose of the waste. The second basic model employed a computerized procedure to determine the best sanitary landfill locations from specified potential sites. The final model was used to establish the best routes for collection trucks to travel in picking up solid waste.

Results of the three simulation models were assimilated into budget form so that the costs (both investment and operating) for various ways of serving the entire region might be compared. These cost comparisons indicated that economies of scale are present in solid waste management operations. The least cost system for the five-county region is comprised of two regional sanitary landfills. Expected annual operating cost is $442,755 or $12,000 less than the next best alternative. The least cost regional system would permit annual savings of $118,100 over the system with each county having a single landfill. In fact, at least ten regional or combined subregional systems serve the entire five-county area for a lower cost than the combined individual county system.

The results of the study clearly indicate that there are gains to be realized from regional cooperation and coordination in the provision of services. In times of increasing accountability for public dollars and increased demand for public services, regionalization is a possible answer.

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APPENDIX A

Distribution and Location of Pickup Sites and Landfill Sites by County

TABLE A.1. DISTRIBUTION AND LOCATION OF PICKUP SITES BY CENSUS ENUMERATION DISTRICTS, WINSTON COUNTY

ED No.	Population[1]	Pickup site No.	Number of four cubic yard bins[2,3,4]	Waste/site 3.5 days (cubic yards)[5]	Pickup site location[6]
1	692	33	--	12.1	[7]
2	164	29	--	2.9	[7]
3	1,046	26	4	2.6	33-
		34	6	3.9	14-
		35	4	2.6	41-
4	1,425	25	8	5.3	278-35
		27	5	2.5	63-
		28	6	3.7	41-
5	1,258	30	4	3.1	22-
		31	5	3.7	77-
		32	6	4.3	278-77
6	957	23	--	16.7	[7]
7	1,418	15	6	3.9	195-
		16	7	4.4	195-
		36	6	4.1	278-
8	838	21	5	3.1	195-21
		22	5	3.0	195-
		24	2	1.3	----
9-12	4,134	11	--	72.3	[7]
13	1,078	9	7	4.8	195-93
		10	9	6.1	195-19
		12	5	3.0	19-32
14	943	7	7	4.4	7-
		8	7	4.4	243-
15	997	13	6	3.7	5-
16	286	18	--	5.0	[7]
16	1,418	14	5	3.0	5-17
		17	4	2.8	5-
		19	5	3.5	278-5
		20	5	3.1	278-17
	16,654	30	139	200.3	

[1] Based on 1970 Census data.

[2] Bins are not allocated to incorporated enumeration districts since collection service is not provided.

[3] Some enumeration districts are not alloted collection bins because of their small population.

[4] There is not a set number of bins for each pickup site due to differences in population densities.

[5] Waste generation is expressed in volume per 3.5 days because twice a week collection is assumed.

[6] The pickup site locations are specified by the identification numbers of the federal state, or county highways and roads which intersect at that point. In cases where only one or neither of the road numbers is given, the road numbers were unavailable.

Federal roads: 278
State roads: 5, 33, 195, 243
County roads: 7, 14, 17, 19, 21, 22, 32, 35, 41, 63, 77, 93

[7] Incorporated town see Figure A.1. for name.

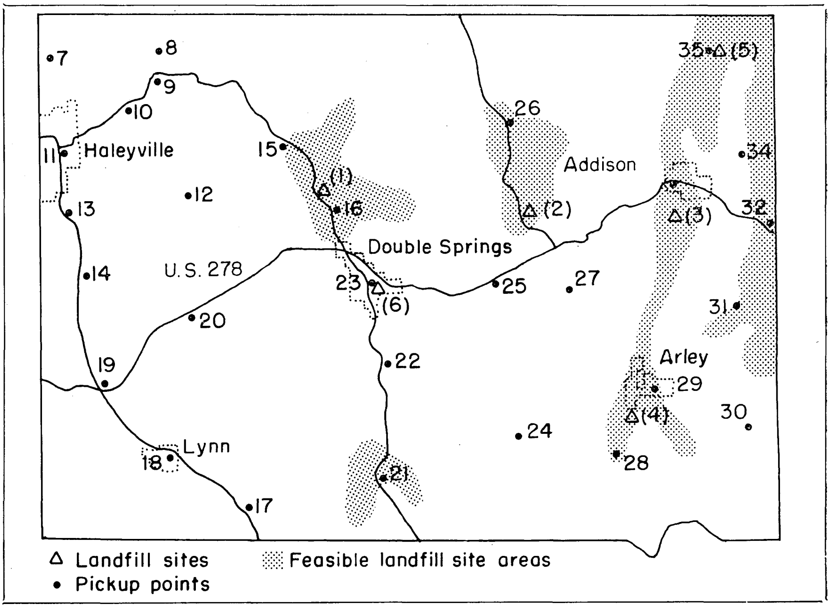


FIGURE A.1. Waste pickup points and potential landfill sites in Winston County.

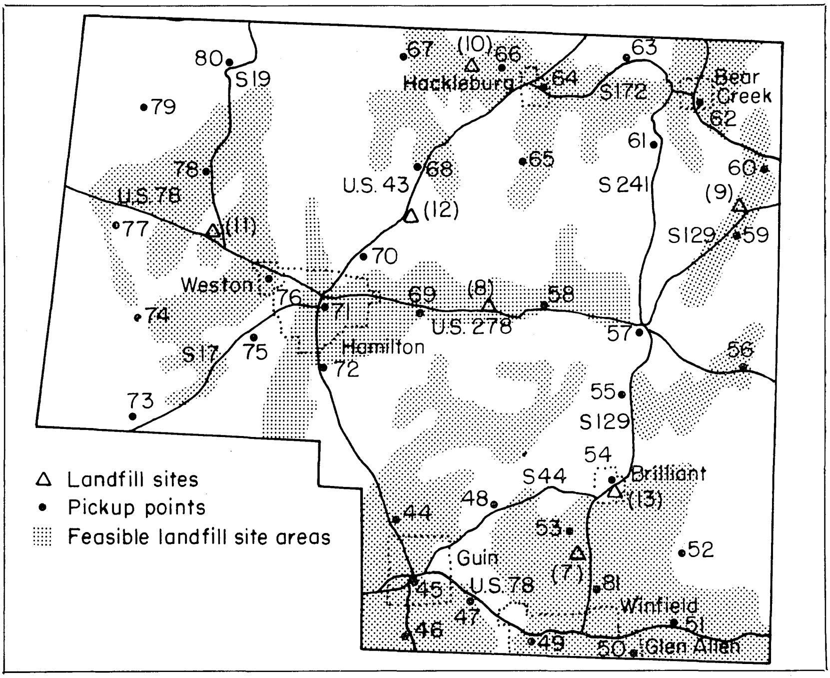


FIGURE A.2. Waste pickup points and potential landfill sites in Marion County.

TABLE A.2. DISTRIBUTION AND LOCATION OF PICKUP SITES BY ENUMERATION DISTRICTS, MARION COUNTY

ED No.	Population[1]	Pickup site No.	Number of four cubic yard bins[2,3,4]	Waste/site 3.5 days (cubic yards)[5]	Pickup site location[6]
1	336	62	--	5.9	[7]
2	1,035	63	9	6.1	237-172
3	1,014	60	9	6.1	5-34
		61	4	2.9	241-12
4	757	57	8	5.5	278-241
		59	6	3.8	129-
5	726	64	--	12.7	[7]
6	978	66	10	6.3	172-
		67	5	3.4	187-
7	511	65	5	3.2	253-
8	1,082	78	7	4.4	19-
		79	4	2.5	56-
		80	6	3.9	19-
9	527	77	5	3.3	----
10-11	3,088	71	--	54.0	[7]
12	187	76	--	3.3	[7]
13	876	68	7	4.4	17-
		70	5	3.3	17-
14	802	73	6	3.8	19-17
		74	5	3.1	19
15	933	72	6	4.2	278, 35
		75	6	4.0	17-11
16	778	58	6	3.7	278-45
		69	5	3.1	278
17	726	54	--	12.7	[7]
18	638	56	7	4.4	278-
19	1,129	48	9	6.3	44-253
		55	7	4.8	129-
20	79	50	--	1.4	[7]
21-23	3,153	49	--	55.2	[7]
24	1,226	51	4	2.4	78-233
		52	5	3.1	233-38
		53	3	1.8	----
		81	5	3.5	129-
25-26	2,220	45	--	38.8	[7]
27	231	47	--	4.0	[7]
28	756	44	5	3.5	278-45
		46	5	3.1	107-
	23,788	38	174	301.9	

[1] Based on 1970 data.

[2] Bins are not allocated to incorporated enumeration districts since collection service is not provided.

[3] Some enumeration districts are not alloted collection bins because of their small population.

[4] There is not a set number of bins for each pickup site due to differences in population densities.

[5] Waste generation is expressed in volume per 3.5 days because twice a week collection is assumed.

[6] The pickup site locations are specified by the identification numbers of the federal, state, or county highways and roads which intersect at that point. In cases where only one or neither of the road numbers is given, the road numbers were unavailable.
Federal roads: 78, 278
State roads: 5, 17, 19, 44, 107, 129, 172, 187, 233, 237, 241, 253
County roads: 11, 12, 34, 35, 38, 45, 56

[7] Incorporated town, see Figure A.2. for name.

TABLE A.3. DISTRIBUTION AND LOCATION OF PICKUP SITES BY ENUMERATION DISTRICTS, FRANKLIN COUNTY

ED No.	Population[1]	Pickup site No.	Number of four cubic yard bins[2,3,4]	Waste/site 3.5 days (cubic yards)[5]	Pickup site location[6]
1-8	7,814	104	--	136.8	[7]
9	1,187	99	5	3.1	----
		100	6	4.2	----
		101	6	3.8	----
10	1,097	102	6	3.8	----
		103	5	3.7	43-
11	899	110	4	2.4	----
		111	3	2.0	----
		112	3	2.2	24-
12	808	108	5	3.5	187-
		109	6	4.2	24-187
13	894	95	5	3.5	43-
		105	5	3.5	----
14	838	96	5	3.1	----
		97	5	3.1	24-
		98	6	3.9	24-
15-16	2,464	117	--	43.1	[7]
17	655	118	7	4.5	24-247
		120	6	3.7	----
		121	6	3.1	----
18	1,132	119	6	4.3	24-
19	207	113	--	3.6	[7]
20	366	115	--	6.4	[7]
21	1,080	114	9	5.9	172-
		116	5	3.5	----
22	1,230	91	--	21.5	[7]
23	1,098	92	6	3.9	243-
24	1,011	89	6	3.8	----
		90	8	5.1	5-
		93	8	5.3	----
25	1,153	94	6	3.9	43-5
		106	6	3.9	43-
		107	4	2.6	187-
	23,933	33	158	314.9	

[1] Based on 1970 Census data.
[2] Bins are not allocated to incorporated enumeration districts since collection service is not provided.
[3] Some enumeration districts are not alloted collection bins because of their small population.
[4] There is not a set number of bins for each pickup site due to differences in population densities.
[5] Waste generation is expressed in volume per 3.5 days because twice a week collection is assumed.
[6] The pickup site locations are specified by the identification numbers of the federal, state, or county highways and roads which intersect at that point. In cases where only one or neither of the road numbers is given, the road numbers were unavailable.
Federal roads: 43
State roads: 5, 24, 174, 187, 243, 247
[7] Incorporated town, see Figure A.3. for name.

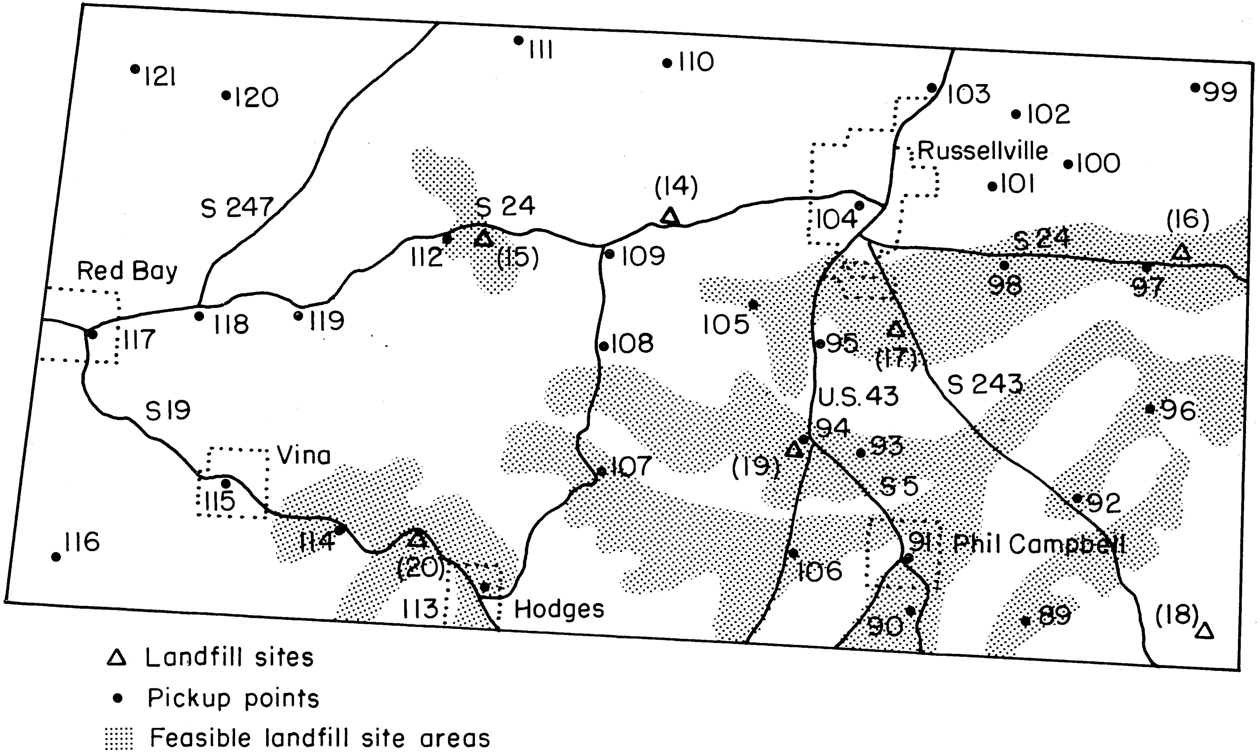


FIGURE A.3. Waste pickup points and potential sanitary landfill sites in Franklin County.

TABLE A.4. DISTRIBUTION AND LOCATION OF PICKUP SITES BY ENUMERATION DISTRICTS, COLBERT COUNTY

ED No.	Population[1]	Pickup site No.	Number of four cubic yard bins[2,3,4]	Waste/site 3.5 days (cubic yards)[5]	Pickup site location[6]
1	1,231	139	--	21.5	[7]
2	2,066	128	5	3.5	40-
		129	5	3.5	40-
		130	6	3.9	40-48
		131	7	4.4	40-
		134	6	4.1	184-
3	1,569	133	5	3.1	184-
		135	6	3.8	184-
		137	6	4.2	24-
4	808	138	6	3.7	72-
		140	7	4.4	72-
		144	5	3.4	157
5	810	145	6	3.9	157-48
		146	5	3.5	48-
6	816	147	6	3.8	57-
7-12	6,907	154	--	120.9	[7]
13	408	132	8	5.0	40-
14	373	------	--	----	----
15	------	------	--	----	----
16	------	------	--	----	----
17	698	136	6	4.2	184-
		141	5	3.5	72-133
18	722	143	3	1.8	157-
		149	3	2.0	----
		150	4	2.8	57-
19-31	13,115	155	--	229.5	[7]
32	14	------	--	----	[7]
33	1	------	--	----	----
34	------	------	--	----	----
35	------	------	--	----	----
36-45	8,828	156	--	154.5	[7]
46	858	151	--	15.0	[7]
47	9	------	--	----	----
48	65	------	--	----	----
49	387	142	6	4.1	72-43
50	76	------	--	----	----
51	2,416	148	8	5.1	----
		152	10	6.3	55-
		153	9	5.9	55-
		158	5	3.1	51-
52	1,370	157	5	3.5	51-65
		159	5	3.5	65-
		160	4	2.6	49-65
		162	6	3.8	72-
53	1,556	161	5	3.1	----
		163	3	2.2	247-72
		164	3	1.8	247-33
		166	4	2.6	72-33
		167	6	3.9	72-
54	1,484	169	--	26.0	[7]
55	1,043	168	6	3.7	72-

(Continued)

TABLE A.4 *(Continued).* DISTRIBUTION AND LOCATION OF PICKUP SITES BY ENUMERATION DISTRICTS, COLBERT COUNTY

ED No.	Population[1]	Pickup site No.	Number of four cubic yard bins[2,3,4]	Waste/site 3.5 days (cubic yards)[5]	Pickup site location[6]
		173	5	3.6	72-
		174	6	3.8	15-
		175	5	3.1	----
56	1,099	171	5	3.0	1-
		172	5	3.6	----
57	903	165	5	3.0	247-
		170	4	2.9	15-
	49,632	48	230	718.1	

[1] Based on 1970 Census data.

[2] Bins are not allocated to incorporated enumeration districts since collection service is not provided.

[3] Some enumeration districts are not alloted collection bins because of their small population.

[4] There is not a set number of bins for each pickup site due to differences in population densities.

[5] Waste generation is expressed in volume per 3.5 days because twice a week collection is assumed.

[6] The pickup site locations are specified by the identification numbers of the federal, state, or county highways and roads which intersect at that point. In cases where only one or neither of the road numbers is given, the road numbers were unavailable.

Federal roads: 42, 83

State roads: 133, 157, 184, 247

County roads: 1, 15, 24, 33, 40, 48, 49, 51, 55, 57, 65.

[7] Incorporated town, see Figure A.4 for name.

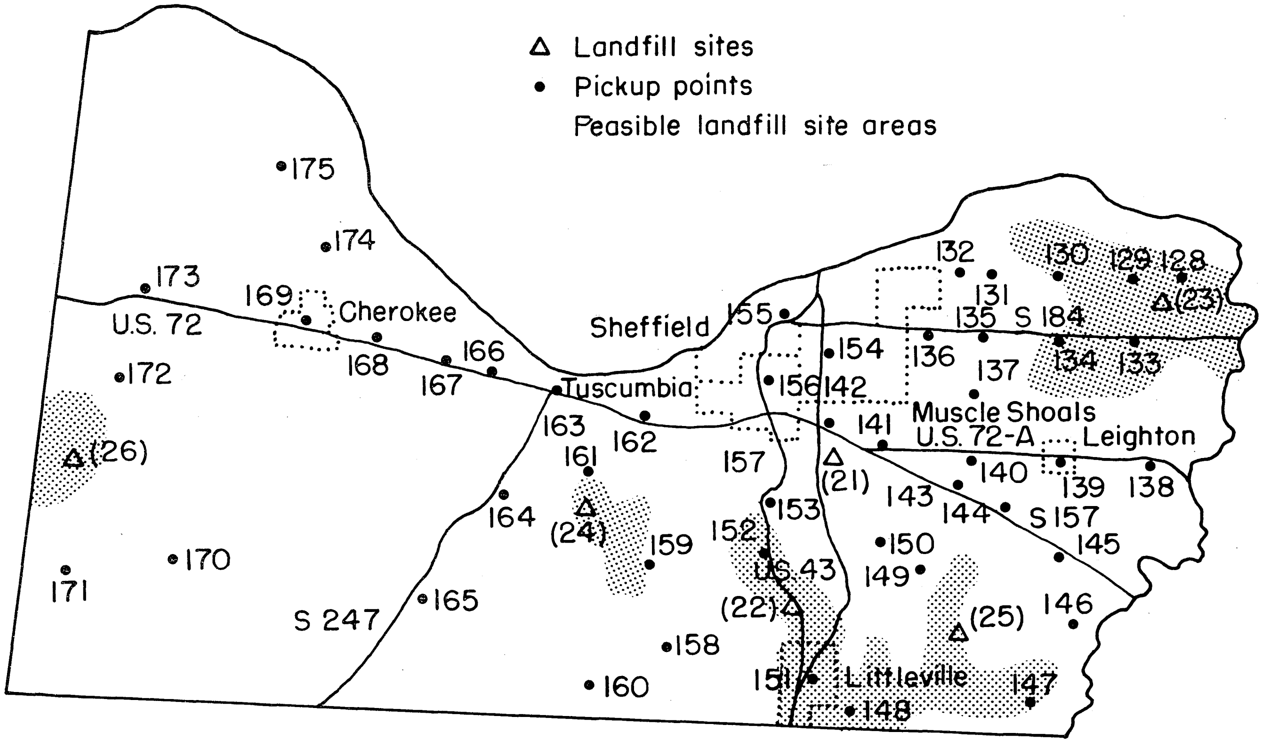


FIGURE A.4. Waste pickup points and potential sanitary landfill sites in Colbert County.

TABLE A.5. DISTRIBUTION AND LOCATION OF PICKUP SITES BY ENUMERATION DISTRICTS, LAUDERDALE COUNTY

ED No.	Population[1]	Pickup site No.	Number of four cubic yard bins[2,3,4]	Waste/site 3.5 days (cubic yards)[5]	Pickup site location[6]
1	950	189	--	16.6	[7]
2	1,156	194	5	3.1	64-207
		195	5	3.3	64-89
3	1,006	196	6	3.7	----
		197	5	3.5	----
4	289	193	6	3.8	207-50
5	1,284	188	6	3.7	72-
		190	4	2.8	26-
		191	5	3.6	207-
		192	5	3.3	207-
6	1,188	185	5	3.1	207-
		186	5	3.2	207-
		187	5	3.1	----
		198	4	2.9	72-
7	278	204	--	4.9	[7]
8	1,350	202	5	3.0	101-50
		203	5	3.1	101-
		205	5	3.1	64-
		208	5	3.3	71-
9	1,368	199	4	2.9	43-
		200	5	3.6	72-101
		201	4	2.3	101-
10	683	215	--	12.0	[7]
11	1,076	206	4	2.9	----
		219	5	3.5	43-
12	541	218	9	5.9	47-
13	1,093	220	6	4.2	43-47
		221	5	3.5	----
14	1,607	222	5	3.4	47-
		223	5	3.6	----
		224	6	3.8	43-72
15	1,048	207	5	3.5	64-
		214	5	3.5	72-
		216	5	3.3	----
		217	5	3.3	64-
16	1,383	209	5	3.5	71-
		210	5	3.5	72-
		211	5	3.5	72-
		212	5	3.3	----
		213	6	3.7	----
17	5	------	--	----	----
18	1,468	234	4	2.6	61-
		235	4	2.8	61-
		237	5	2.8	17-
		238	5	3.0	17-
		239	5	3.1	17-
19	1,192	231	5	3.1	----
		232	4	2.5	47-
		240	5	3.0	17-
20	636	233	5	3.5	47-
20-B	306	------	--	----	----
21	1,390	225	5	3.3	72
		226	6	3.8	----

(Continued)

TABLE A.5 (*Continued*). DISTRIBUTION AND LOCATION OF PICKUP SITES BY ENUMERATION DISTRICTS, LAUDERDALE COUNTY

ED No.	Population[1]	Pickup site No.	Number of four cubic yard bins[2,3,4]	Waste/site 3.5 days (cubic yards)[5]	Pickup site location[6]
		227	5	3.3	72
		228	5	3.3	72
22-63	34,031	254	--	595.5	[7]
64	663	236	5	3.5	47
65	417	230	6	3.7	133
65-A	------	------	--	----	----
65-B	508	242	5	3.5	17-
65-C	571	241	6	3.7	17-
		243	5	3.6	157-
65-D	260	244	5	3.5	----
66	126	245	5	3.5	157-
67	88	253	6	3.8	----
67-A	------	------	--	----	----
67-B	9	------	--	----	----
68	------	------	--	----	----
69	317	------	--	----	----
70	37	229	6	3.7	72-133
71	321	------	--	----	----
72	5	------	--	----	----
73	------	------	--	----	----
74	9	------	--	----	----
75	------	------	--	----	----
76	------	------	--	----	----
77	------	------	--	----	----
78-A	1,105	248	6	3.8	157-
		249	5	3.5	157-
		250	5	3.3	----
		251	6	3.7	----
78-B	1,208	247	6	3.7	157-
		259	4	2.9	20
		260	6	4.0	20-8
79-A	744	257	6	3.9	20-
		258	6	3.7	20-
79-B	1,148	246	6	3.7	157-
		252	5	3.4	----
80	1,237	263	5	3.1	----
		265	5	3.2	14-
		266	5	3.1	14-
		267	5	3.2	14-
		269	5	3.1	----
81	799	255	5	3.6	20-14
		261	5	3.1	----
		262	5	3.2	----
		264	5	3.4	14-
82	1,368	256	6	3.7	20-
83	339	------	--	----	----
84	262	271	--	4.6	[7]
85	1,242	268	4	2.6	14-
		270	4	2.8	14-8
		272	4	2.6	14-
	68,111	88	425	912.5	

(*Continued*)

TABLE A.5 *(Continued)*. DISTRIBUTION AND LOCATION OF PICKUP SITES BY ENUMERATION DISTRICTS, LAUDERDALE COUNTY

[1] Based on 1970 Census data.
[2] Bins are not allocated to incorporated enumeration districts since collection service is not provided.
[3] Some enumeration districts are not alloted collection bins because of their small population.
[4] There is not a set number of bins for each pickup site due to differences in population densities.
[5] Waste generation is expressed in volume per 3.5 days because twice a week collection is assumed.
[6] The pickup site locations are specified by the identification numbers of the federal, state, or county high ways and roads which intersect at that point. In cases where only one or neither of the road numbers is given, the road numbers were unavailable.
Federal roads: 43, 72.
State roads: 17, 20, 64, 101, 133, 157, 207.
County roads: 8, 14, 26, 47, 50, 61, 71, 89.
[7] Incorporated town, see Figure A.5 for name.

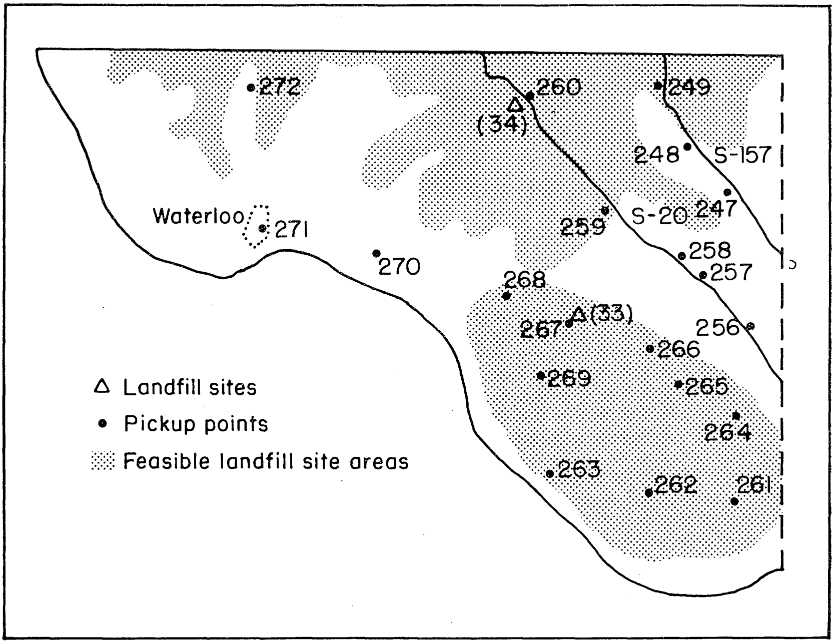


FIGURE A.5. Waste pickup points and potential sanitary landfill sites in Lauderdale County.

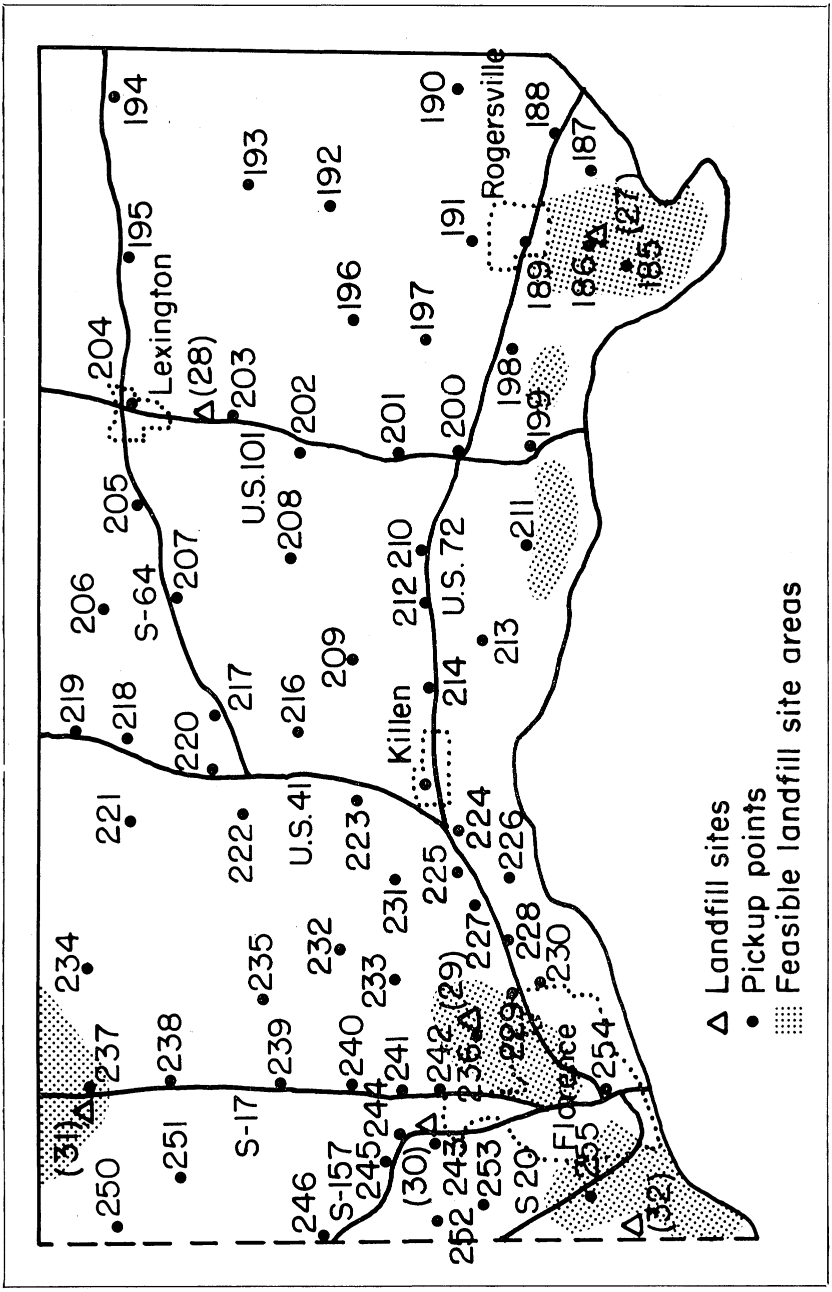


FIGURE A.5 (Cont.). Waste pickup points and potential sanitary landfill sites in Lauderdale County.

APPENDIX B

Budgets and Collection Vehicle Routes for Least Cost Solid Waste Management System

TABLE B.1. BUDGET, SITE 21 OF TWO REGIONAL LANDFILLS

Item	Unit	Quantity	Rate	Amount
Collection equipment costs				*Dol.*
Collection truck	30 cu. yd.	4	$35,000.00	$140,000.00
Collection truck (backup)	30 cu. yd.	0	23,000.00	----
Pickup truck	----	1	2,500.00	2,500.00
Dump truck	----	2	5,000.00	10,000.00
Total collection equipment costs				$152,500.00
Annual collecting operations cost				
Manager-supervisor (½ time)	yr.	1	8,400.00	4,700.00
Secretary-bookkeeper (½ time)	yr.	1	6,000.00	3,000.00
Labor: 4 drivers	hr.	8,320	3.25	27,040.00
6 helpers	hr.	12,480	2.75	34,320.00
Depreciation	yr.	----	13,725.00	13,725.00
Gas, fuel, oil, repairs, etc.	miles	114,608	.25	28,652.00
Interest on loan	yr.	152,500	8%	12,200.00
Total annual collection operations costs				$123,637.00
Storage and disposal equipment costs				
Crawler tractor with landfill equipment	----	2	47,200.00	94,400.00
Waste containers	4 cu. yd.	754	300.00	226,200.00
Portable steam generator	----	2	600.00	1,200.00
Misc. equipment	----	----	2,000.00	2,000.00
Truck scales	50 tons	1	8,300.00	8,300.00
Land	acre	358	300.00	107,400.00
Landfill site preparation	acre	358	150.00	53,700.00
Container site preparation	site	152	85.00	12,920.00
Equipment shed and scalehouse	----	1	10,000.00	10,000.00
Access road to landfill	----	1	10,000.00	10,000.00
Water supply	----	1	5,000.00	5,000.00
Total storage and disposal equipment costs				$531,120.00
Annual storage and disposal operations costs				
Manager-supervisor (½ time)	yr.	1	$ 9,400.00	4,700.00
Secretary-bookkeeper (½ time)	yr.	1	6,000.00	3,000.00
Labor: 2 operators	hr.	4,160	4.00	16,640.00
2 laborers	hr.	4,160	2.75	11,440.00
Building depreciation	yr.	----	1,000.00	1,000.00
Site payment and road depreciation	yr.	----	18,902.00	18,902.00
Equipment hire	yr.	----	2,000.00	2,000.00
Fuel, oil, grease,				

(Continued)

TABLE B.1 *(Continued)*. BUDGET, SITE 21 OF TWO REGIONAL LANDFILLS

Item	Unit	Quantity	Rate	Amount
				(Dollars)
repairs, etc.	waste tons/day	505	25.00	12,625.00
Utilities, office supplies	waste tons/day	505	10.00	5,050.00
Building maintenance	yr.	----	200.00	200.00
Equipment depreciation	yr.	332,100	29,889.00	29,889.00
Miscellaneous costs	yr.	1	200.00	200.00
Interest on loan	yr.	531,120	8%	42,490.00
Total annual storage and disposal operation cost				148,136.00
Total investment costs				683,620.00
Total annual operations costs				271,773.00

TABLE B.2. ROUTES AND PICKUP POINTS SERVED FROM THE LANDFILL LOCATED AT SITE 21

Route	Pickup points served	Quantity picked up	Distance traveled	Hours spent
		Cu. yd.	*Miles*	
1	103, 95, 105 98, 97, 100 101, 102	29.5	59.4	3.40
2	108, 108, 112 119, 118, 116 115	28.6	89.4	4.32
3	132, 131, 130 128, 129, 133 134	27.5	34.0	2.43
4	137, 135, 136 243, 244, 241 242	26.5	33.2	2.37
5	140, 138, 139	29.6	22.4	2.22
6	142, 120, 121 153, 152	23.1	33.6	2.23
7	143, 144, 145 146, 147, 99 149, 150, 141	27.8	31.6	2.37
8	151, 148	20.1	18.8	1.60
9	162, 161, 164 165, 111, 110 160, 159, 157 158	28.8	60.0	3.38
10	168, 175, 174 173, 172, 171 170	29.8	76.2	4.47
11	169, 166	28.6	33.6	2.52
12	195, 194, 193 192, 190, 188 187, 185, 186	29.4	82.2	4.25

(Continued)

TABLE B.2 (*Continued*). ROUTES AND PICKUP POINTS SERVED FROM THE LANDFILL LOCATED AT SITE 21

Route	Pickup points served	Quantity picked up	Distance traveled	Hours spent
		Cu. yd.	*Miles*	
13	189, 191, 196 197, 201	29.7	61.2	3.47
14	199, 198, 200 202, 203, 204 205, 207, 206	29.6	71.0	3.70
15	213, 211, 210 212, 209, 208 216, 217	27.4	57.4	3.22
16	226, 214, 215 225, 229	26.3	34.6	2.43
17	222, 221, 218 219, 220, 223 224	27.9	48.8	2.93
18	235, 234, 238 237, 250, 251 249, 248, 247	29.2	61.6	3.47
19	236, 233, 239 240, 232, 231 227, 228, 230	29.0	39.2	2.67
20	245, 246, 257 266, 265, 263 262, 261	26.8	46.4	2.87
21	255, 264, 256 252, 253	17.9	26.8	1.73
22	267, 269, 268 270, 271, 272 260, 259, 258	29.5	80.6	4.13
	152	602.6	1,102.0	66.17

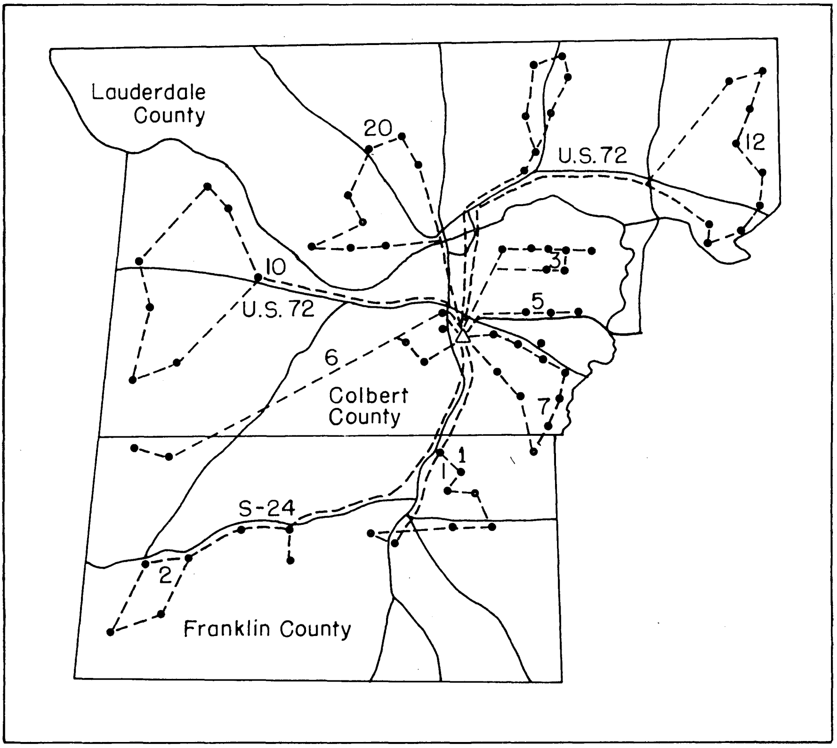


FIGURE B.1. Routing patterns for site 21.

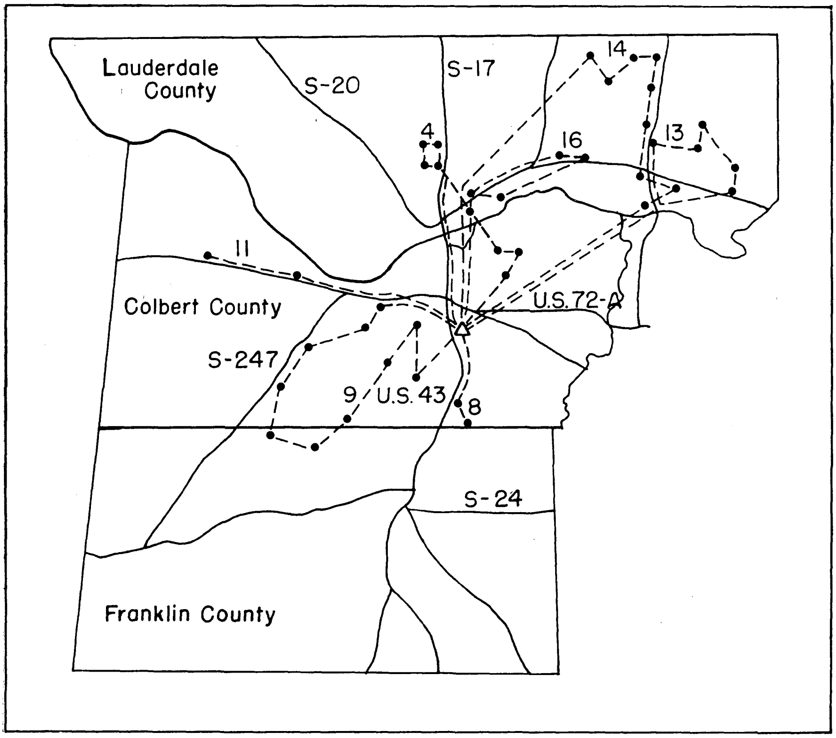


FIGURE B.1. (Cont.). Routing patterns for site 21.

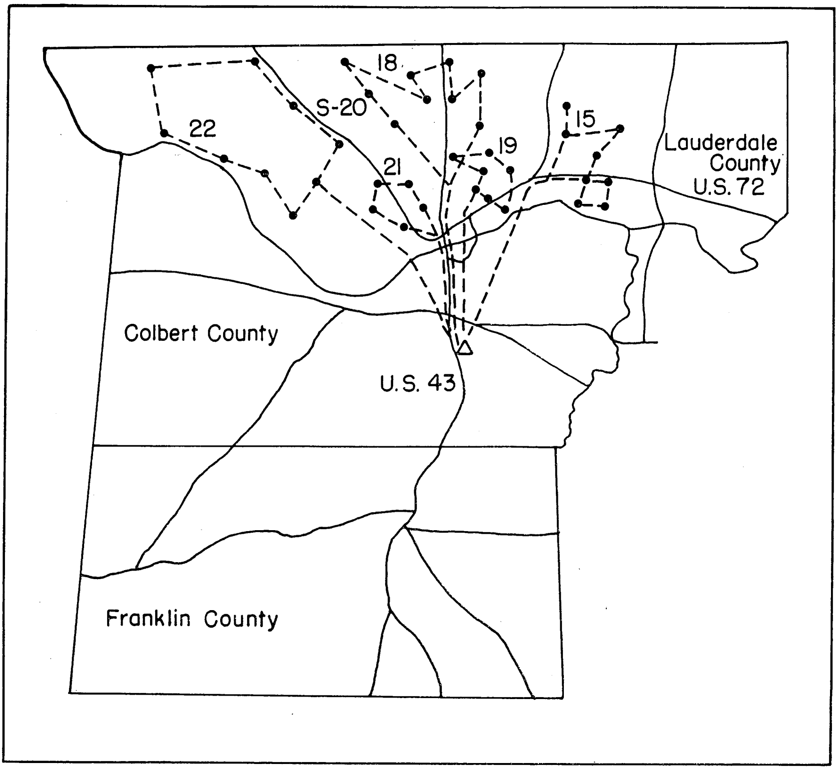


FIGURE B.1. (Cont.). Routing patterns for site 21.

Table B.3. Budget, Site 9 of Two Regional Landfills

Item	Unit	Quantity	Rate	Amount
				Dol.
Collection equipment costs				
Collection truck	30 cu. yd.	3	$35,000.00	105,000.00
Collection truck (backup)	30 cu. yd.	0	23,000.00	
Pickup truck	----	1	2,500.00	2,500.00
Dump truck	----	1	5,000.00	5,000.00
Total collection equipment costs				112,500.00
Annual collecting operations costs				
Manager-supervisor (½ time)	yr.	1	9,400.00	4,700.00
Secretary-bookkeeper (½ time)	yr.	1	6,000.00	3,000.00
Labor: 3 drivers	hr.	6,240	3.25	20,280.00
3 helpers	hr.	6,240	2.75	17,160.00
Depreciation	yr.	----	10,125.00	10,125.00
Gas, fuel, oil, repairs, etc.	miles	85,270	.25	21,318.00
Interest on loan	yr.	112,500	8%	9,000.00
Total annual collection operations costs				85,583.00
Storage and disposal equipment costs				
Crawler tractor with landfill equipment	----	1	57,000.00	57,000.00
Waste containers	4 cu. yd.	372	300.00	111,600.00
Portable steam generator	----	2	600.00	1,200.00
Misc. equipment	----	----	2,000.00	2,000.00
Truck scales	50 tons	1	8,300.00	8,300.00
Land	acre	114	300.00	34,200.00
Landfill site preparation	acre	114	150.00	17,100.00
Container site preparation	site	75	85.00	6,375.00
Equipment shed and scalehouse	----	1	10,000.00	10,000.00
Access road to landfill	----	1	10,000.00	10,000.00
Water supply	----	1	10,000.00	5,000.00
Total storage and disposal equipment costs				262,775.00
Annual storage and disposal operations costs				
Manager-supervisor (½ time)	yr.	1	$ 9,400.00	$ 4,700.00
Secretary-bookkeeper (½ time)	yr.	1	6,000.00	3,000.00
Labor: operator	hr.	2,080	4.00	8,320.00
laborer	hr.	2,080	2.75	5,720.00
Building depreciation	yr.	----	1,000.00	1,000.00
Site payment and road depreciation	yr.	----	7,268.00	7,268.00
Equipment hire	yr.	----	2,000.00	2,000.00
Fuel, oil, grease, repairs, etc.	waste tons/day	161	25.00	4,025.00
Utilities, office supplies	waste tons/day	161	10.00	1,610.00
Building maintenance	yr.	----	200.00	200.00
Equipment depreciation	yr.	----	26,334.00	26,334.00
Miscellaneous costs	yr.	1	200.00	200.00
Interest on loan	yr.	262,775	8%	21,022.00

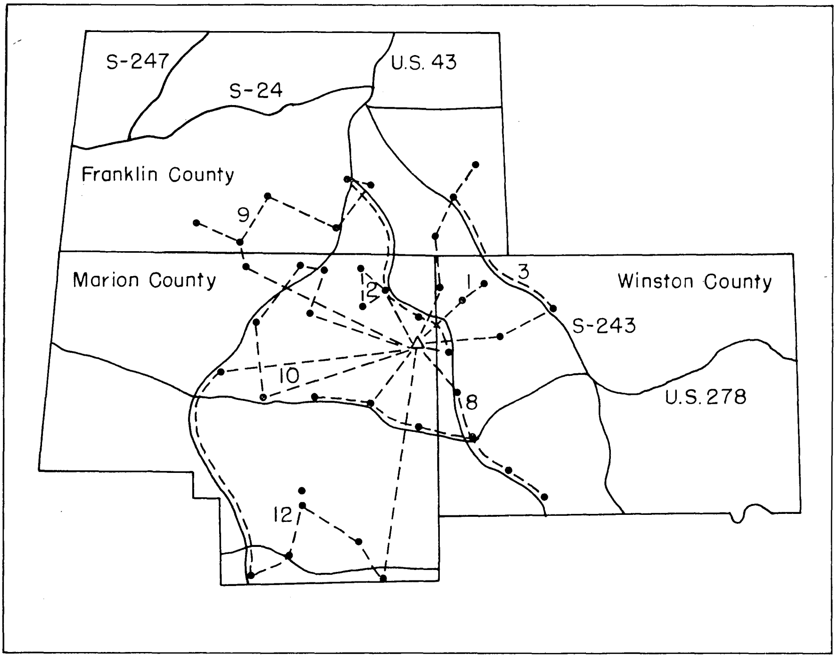
(Continued)

TABLE B.3 *(Continued)*. BUDGET, SITE 9 OF TWO REGIONAL LANDFILLS

Item	Unit	Quantity	Rate	Amount
				Dol.
Total annual storage and disposal operation cost				$ 85,399.00
Total investment costs				$375,275.00
Total annual operations costs				$170,982.00

TABLE B.4. ROUTES AND PICKUP POINTS SERVED FROM THE LANDFILL LOCATION AT SITE 9

Route	Pickup points served	Quantity picked up	Distance traveled	Hours spent
		Cu. yd.	*Miles*	
1	10, 9	10.9	16.4	1.07
2	13, 60, 62 63, 61	24.7	28.2	2.12
3	15, 12, 8 92, 96, 89, 7	26.5	62.6	3.40
4	20, 36, 16, 23	28.3	50.2	3.07
5	33, 35, 25 21, 22, 24	27.4	111.4	5.05
6	34, 32, 31 30, 29, 28 27, 26	27.7	103.6	5.30
7	55, 54, 53 51, 52, 59	28.6	46.8	2.98
8	57, 58, 56 18, 17, 19, 14	27.9	63.8	3.43
9	67, 113, 114 107, 106, 93 94	28.6	70.2	3.72
10	69, 68, 66 64, 65	29.7	51.6	3.17
11	75, 73, 74 77, 78, 80 79, 76	28.3	102.8	4.82
12	50, 81, 48 47, 46, 44 72, 70	29.3	83.5	4.17
13	90, 91	26.6	28.8	2.27
	75	344.5	819.9	44.55



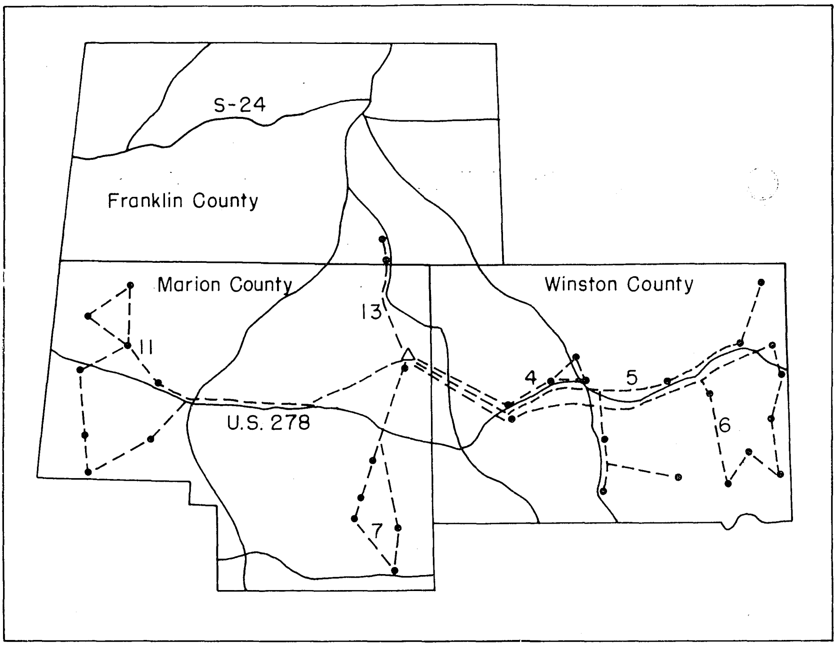
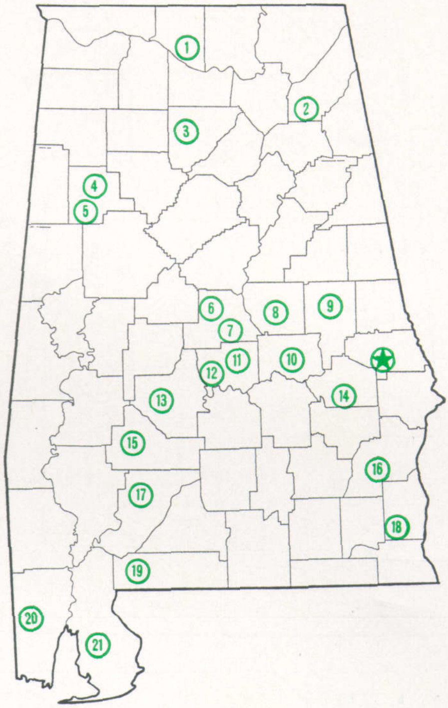


FIGURE B.2. Routing patterns for site 9.

Alabama's Agricultural Experiment Station System
AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.