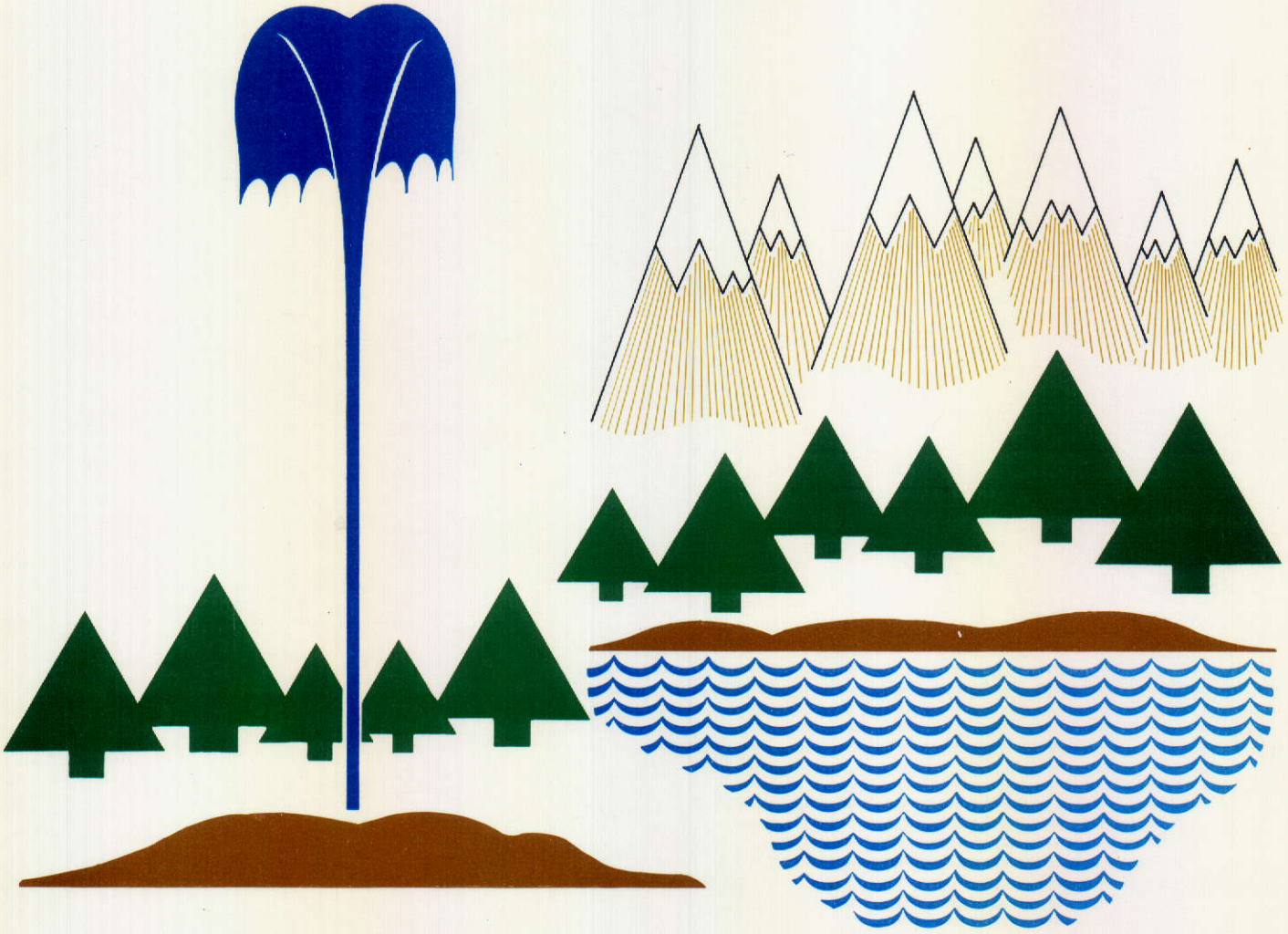
a report
regarding

SOLID WASTE MANAGEMENT, YELLOWSTONE NATIONAL PARK GRAND TETON NATIONAL PARK

May, 1972



YODER - TROTTER - ORLOB & ASSOCIATES
ENGINEERING CONSULTANTS

walnut creek, california

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May, 1972

prepared for

National Park Service
U.S. Department of Interior
contract no. 4970B20014

YODER - TROTTER - ORLOB & ASSOCIATES
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walnut creek, california

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May 19, 1972

National Park Service
7200 West Alameda Avenue
Denver, Colorado 80226

Attention: Mr. George Gallagher

Regarding: Contract No. 4970B20014

Gentlemen:

In accordance with the terms of the subject contract, we submit herewith a report on a comprehensive solid waste management study designed to meet the present and future needs for both the Yellowstone National Park and Grand Teton National Park

We believe that the approaches to solid waste management outlined in this report represent a sound and realistic means of solving impending solid waste problems.

It is with pleasure that we submit this report on solid waste management for your consideration and ultimate action. The opportunity to be of service in this vital capacity is appreciated.

Respectfully submitted,

YODER-TROTTER-ORLOB & ASSOCIATES

M. Carleton Yoder

M. Carleton Yoder
Principal

MCY/dsm

Enclosure

Chapter 1

INTRODUCTION

The ever-increasing awareness that the physical environment, our health, safety, and well-being are being threatened by environmental pollution has aroused demands that abatement programs be initiated for the preservation of our quality of life. This is of nationwide concern and involves the restoration, protection, and control of environmental quality. Because of this, environmental quality control planning has taken on a renewed emphasis and has increased at all levels of federal, state, and local governments.

In past practices in most of the nation, solid wastes have been taken out and disposed of with little thought concerning its effect on the environment. Until now, nature has covered for such a casual attitude toward solid waste handling through natural destruction processes. However, man's technology is rapidly exhausting nature's generosity. Today, we are finding that past approaches to the problem are no longer satisfactory. The solid waste problem arises, in most instances, from the need to protect the land, air, and water environments. They are greatly affected by the terminal disposal techniques we choose for solids, such as landfill and incineration.

The recognition and proper management of the environmental problems associated with solid wastes have been slow in developing. However, with increasing public awareness, the proper management of the entire ecological system is being acknowledged as vital to the protection and conservation of our resources and environment. With this has come a recognition that the management of solid wastes is one that must be adequately planned for if our environmental objectives are to be achieved. Effective mechanisms for the adequate control of the ever-increasing problems associated with solid wastes must be developed. Such development, to be effective, must be accomplished in accordance with total areawide planning which encompasses all environmental control programs and truly coordinates and integrates all planning activities and functions.

The President of the United States, with his complete awareness of the problem, has recognized the need and desirability for governmental agencies to take the lead in promoting pollution control in their own operations in order to achieve an effective control program throughout the nation. The issuance of Executive Order 11507--Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities--clearly spells out the need and requirements. To comply with the President's Executive Order, it was apparent that there was a need for an areawide approach to the problems of solid waste management for both the Yellowstone and Grand Teton National Parks.

AUTHORIZATION

Realizing the foregoing facts, and convinced that the solid waste management program could be of benefit to the surrounding areas as well as the national parks, the National Park Service, United States

Department of the Interior, on the twentieth day of August 1971, engaged the engineering firm of Yoder-Trotter-Orlob and Associates, Walnut Creek, California, to undertake a solid waste management study for both the Yellowstone and Grand Teton National Parks.

OBJECTIVES AND SCOPE OF INVESTIGATION

The primary objective of this study is to examine the total solid waste management needs of Yellowstone National Park and Grand Teton National Park to some reasonable future date, and the development of a plan to meet the needs for that period. The projection of long-range needs is of equal importance, since the formulation of a plan for the short-range needs must take into consideration the possible implementation of more sophisticated systems to which the initial systems must adapt. The need and desirability for reaching an areawide solution to the environmental problems must be kept at the forefront of all planning activities. Provisions for adequate safeguards against degradation and pollution of all environmental factors is fundamental.

To provide the necessary information and data to accomplish the above objectives, a scope of work, prepared by the National Park Service, established the following requirements as guidelines for the study:

Alternative Plans

1. Review solid waste practices.
2. Evaluate adequacy of disposal sites.
3. Identify potential solid waste disposal and processing sites.
4. Formulate alternative waste management plans.
5. Evaluate alternative solid waste management systems.
6. Make draft report on solid waste management plans and recommendations for review by the National Park Service.

Solid Waste Production

1. Review existing and projected permanent and visitor growth patterns.
2. Determine total volume of wastes generated.
3. Determine detailed composition of wastes from various sources within the parks.
4. Project solid waste production and distribution.

Administration and Control

1. Contact all involved regulating agencies regarding regulations pertaining to collection and disposal.
2. Identify administrative agencies and structures governing solid waste practices.

Environmental Factors

1. Public health and environmental aspects of existing facilities.
2. Evaluation of public health aspects and environmental factors.

Evaluation Procedures

1. Review cost data.
2. Develop cost information.

Environmental Impact Statement

1. Assist in its preparation and coordinate with personnel of other disciplines of the National Park Service's staff to develop and complete statement.

Final Report

1. Prepare and submit thirty (30) copies to the National Park Service.

CONDUCT OF INVESTIGATION

Initial phases of the work were concerned primarily with the field evaluation of the volume and composition of the various solid wastes in the two parks. Wastes from the different activities (campgrounds, picnic areas, restaurants, lodges, service stations, etc.) were collected using a random sampling technique. These random samples were deposited in a pickup and hauled to a site where the wastes were segregated and weighed. Records were also kept on a volume basis. In Yellowstone National Park, the most detailed field evaluation was undertaken in the Lake-Fishing Bridge areas, while in the Grand Teton National Park, it was the Colter Bay area. Visitor counts were made each day in these areas. Due to the limited time that remained of the peak season, typical waste generation factors developed from these detailed analyses were used in developing the waste generation rates for the remaining activities within the parks. All privately operated dude ranches throughout Grand Teton National Park were contacted to determine the quantity of their waste, as well as the method used for disposal.

Through representatives of the National Park Service, contacts were made with the neighboring agencies to explore the areawide concept of solid waste management. Contacts were made in Montana with representatives of the communities of West Yellowstone, Gardiner, and Park County. The Shoshone and Gallatin National Forests in the Yellowstone National Park area were also contacted, as were representatives of the city of Jackson, Teton County, the Elk Refuge, and the Teton National Forest in the Grand Teton National Park area. An investigation was made of the solid waste from the Flagg Ranch area for subsequent inclusion in the park collection system.

Based on the information developed during the survey, the existing methods of operation, the projected growth pattern, and all the alternative solid waste management methods were considered with respect to their ability to meet all environmental standards. From these, alternative solid waste management plans were selected for comparison and evaluation on the basis of cost and other factors.

DATA AVAILABLE TO STUDY

Full use was made of the existing reports, maps, collection and disposal system operation and maintenance records, and growth projections furnished by the National Park Service. In determining off-season operating conditions, reliance was placed on the information furnished by the agencies involved. Waste generation rates for the Teton National Forest, the city of Jackson, and the county of Teton were obtained from a study currently in progress at the local offices of the Teton National Forest.

ACKNOWLEDGEMENTS

Throughout the conduct of this investigation, we have had, and appreciate, the cooperation extended us by the various governmental agencies. For their assistance during the survey, we express our appreciation to the following:

Western Service Center, National Park Service

George Gallager

Yellowstone National Park

Jack Anderson - Park Superintendent
Gary Everhardt - Assistant Park Superintendent
Keith Fellbaum - Environmental Engineer
Richard Lake - Naturalist
William Armstrong - Maintenance Superintendent - South District
Donald McCann - Maintenance Superintendent - North District
Charles Tobin - Maintenance Superintendent - West District

Grand Teton National Park

Gary Everhardt - Park Superintendent
Glenn Schultz - Maintenance Superintendent

Teton National Forest

Ernest Hirsch - Assistant Forest Supervisor

Elk Refuge

Don Redfearn - Refuge Manager

City of Jackson, Wyoming

Lester May - Mayor

County of Teton, Wyoming

Arthur Brown - Chairman, County Commissioner

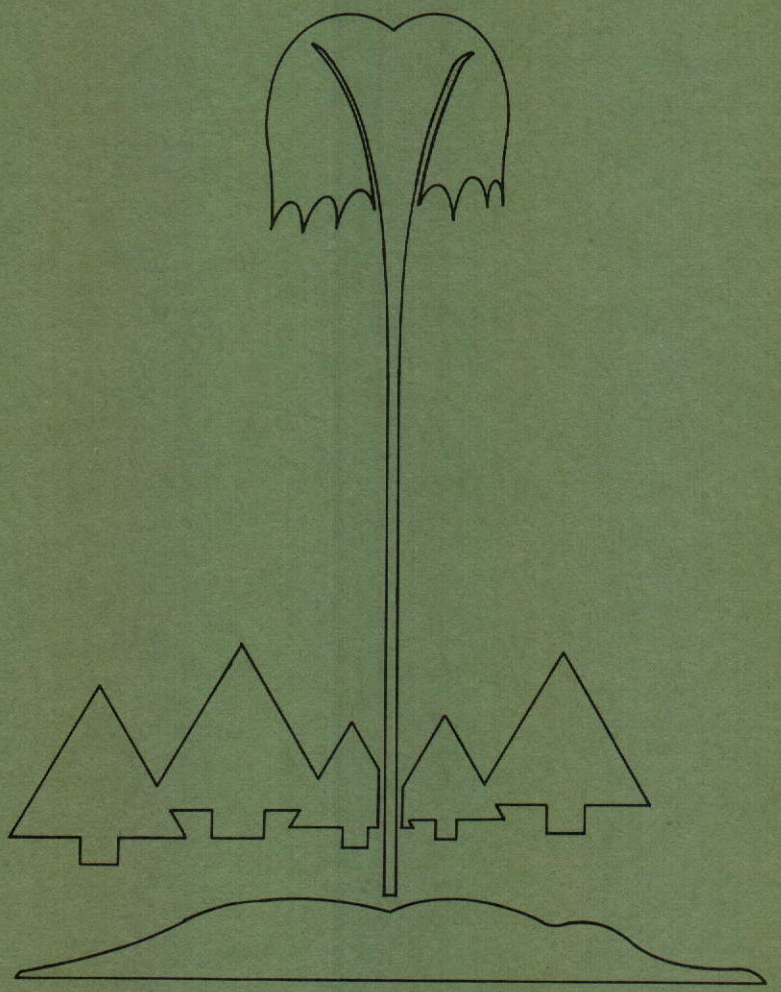
City of West Yellowstone, Montana

Martin Smith - Mayor

County of Park, Montana

Ray Hedrick - County Sanitarian

YELLOWSTONE NATIONAL PARK



Chapter 2

SUMMARY and RECOMMENDATIONS

The body of this report presents the background information and data necessary to the formulation of plans for the present and future management of solid waste for both Grand Teton National Park and Yellowstone National Park. This chapter brings this information together in concise form to permit a cursory review of the important features and to summarize the essential elements of the recommended plans. Specific recommendations relating to the nature and magnitude of the improvements which should be undertaken are presented.

SUMMARY - YELLOWSTONE NATIONAL PARK

Characteristics of the Area

Yellowstone National Park is the oldest and largest national park in the United States. It is located in northwestern Wyoming and is approximately 3,460 square miles in area. Major park roads and entrances are maintained from May 1 through October 31. The park ranges in elevation from 5,700 feet to 12,000 feet and is composed primarily of igneous rocks and their weathered products in the western half and basic volcanic rocks in the eastern half of the park. Some sedimentary deposits also exist in the lower-lying areas. Because of the high elevations and dry air, extremes of temperature in summer and winter are common. Rainfall averages about 20 inches per year. The glacial and alluvial deposits in the valleys are porous and loaded with groundwater, a fact which must be evaluated when considering the use of these lands for solid waste disposal.

EXISTING SOLID WASTE MANAGEMENT PRACTICES

The park is divided into the North, South, and West Maintenance Districts. Each district provides for its own administrative and operational functions, the primary function being solid waste collection and disposal.

Park personnel collect all the solid wastes generated within the park. In general, refuse collection practices include the pickup of all containers in areas of high population density and roadside pickup at viewing locations and along the Grand Loop Road. Most of the refuse is collected during the 100-day peak tourist season extending from Memorial Day through Labor Day. A 32-gallon can is the storage container in general use throughout the park. In the South District, these containers have bear-proof covers, as bears are much more prevalent in this area of the park.

Each district utilizes 13-cubic yard rear-loading packer trucks and 1½-ton stake trucks for collection and litter control. The three districts annually generate a total of 1,920 tons of solid waste comprising a volume of 47,300 cubic yards. In 1971, the cost of collection totaled $155,500 for a per ton cost of $81.00

Similar collection methods and procedures are practiced in the populated areas contiguous to the park. This is as expected since all adjacent areas are tourist-oriented communities facing similar solid waste problems during the same period of time. West Yellowstone is the largest community and its population during the peak season is in the neighborhood of 10,000 persons per day. Solid waste disposal facilities consist of sanitary landfills at Grebe Lake and Madison Junction, each on a 10-acre site, and incinerators at Mammoth, Lake, and Grant Village. Each of the incinerators has a 36-ton-per-day capacity but none have the capability of meeting existing federal emission standards.

Refuse from the community of West Yellowstone is disposed of at a 10-acre sanitary landfill site. Nearby, Gardiner, Jardine, and Corwin Springs dispose of their refuse to open pits on national park property which is now illegal and must be curtailed. The Silver Gate-Cooke City-Cooke Pass area recently formed a disposal district to operate a 3-acre sanitary landfill located on Forest Service property. The Shoshone National Forest is presently developing a solid waste management plan.

LAND DEVELOPMENT POPULATION

Solid waste collection and disposal service is provided in the North District service area throughout the year, while only limited winter operations exist in the other two districts.

Land Use

The North District service area contains three subareas, namely, Mammoth, Norris, and Tower. The permanent park headquarters for the National Park Service is located at Mammoth, the only year-round residential and tourist area in the park, where visitor accommodations include an inn, hotel, tourist cabins, and campground. The Norris and Tower areas have accommodations which include a campground, a ranger station, and a small employee housing area.

The West District service area contains two subareas--Madison and Old Faithful. The Old Faithful area hosts existing guest accommodations at the Old Faithful Inn, the Old Faithful Lodge, and campers' cabins. Facilities at the Madison area include a campground, a ranger station, and employee facilities.

The South District service area consists of the Bay Bridge-Fishing Bridge-Lake subarea, the Canyon subarea, and Grant-West Thumb subarea. Campgrounds are located at Bay Bridge and Fishing Bridge, and major hotel, lodge, and service facilities are at Lake. Accommodations at Canyon consist of motor lodge cabins and a campground, while at Grant they include a campground and a National Park Service trailer court.

Population

In recent years, over two million people visit Yellowstone Park annually, which is an increase of twice that in 1950. Of these visitors, over 90 percent occur during the 100-day peak season between June 15 and Labor Day. About three-fourths of the park accommodations are concentrated in the South District service area. During the peak season, virtually all accommodations are in full use, and in winter, the park facilities cater largely to the snow sports enthusiasts. Because present park philosophy is to limit overnight accommodation at present levels, projected population growth is expected to only increase moderately to a peak annual visitor population of 2,750,000 by the year 2000. In the adjacent communities, the only significant population growth is expected at West Yellowstone where the total summer peak population is forecasted to increase to 35,500 by 1985.

SOLID WASTE PRODUCTION, COMPOSITION, AND PROJECTIONS

A field survey was made to determine the specific composition of the solid waste generated at Yellowstone Park and at Grand Teton National Park. Detailed information pertaining to this survey is presented in Appendix A.

Field survey data indicated that the average loose weight of the refuse was 3 pounds per cubic foot and paper comprised between 70 and 90 percent of the waste by volume and from 40 to 50 percent by weight.

During 1971, about 1,920 tons of solid waste was generated within Yellowstone Park. The community of West Yellowstone generated an additional 1,500 tons, while the Gardiner area added 785 tons. By the year 2000, Yellowstone Park is projected to generate almost 2,400 tons of solid waste, whereas West Yellowstone should increase to 1,860 tons per year and the Gardiner area to 980 tons of solid waste per year.

SOLID WASTE MANAGEMENT METHODS AND CONSIDERATIONS

A solid waste management system consists essentially of storage, collection, transport, processing, salvage, and disposal. Two types of storage methods are generally available. One is the traditional metal can, normally a 20- or 32-gallon size container. The second type is the bulk container which may vary in size from 4 to 40 cubic yards. Collection methods are actually influenced by the type of storage method, pickup point requirements, kind of waste, kind of equipment, and cost. The collection from metal cans is usually provided by a rear-loading or side-loading compaction truck. Bulk containers, however, are normally serviced by a front-end-loading compaction truck.

Secondary Transportation

A secondary transportation system can provide a place for collection vehicles to unload near their routes, thus eliminating the need for long-distance hauling in each small vehicle. A large transport vehicle from 40- to 70-cubic yard capacity could then convey the refuse to the disposal area.

Transfer Stations

A transfer station is a facility designed to transfer refuse from the collection vehicle to a larger capacity transport vehicle to reduce the cost of direct haul from completion of the collection route to the disposal site. Smaller collection vehicles collect and dispose of their refuse at the transfer station where refuse is compacted into larger transfer trailers and hauled to distant disposal sites.

Pretreatment Methods

Many methods have been devised to consolidate the loose solid wastes to reduce the cost of transportation and the space required at the disposal area. These methods include shredding, separation, high-compression baling, and composting.

Disposal Methods

There have been no significant advances in the technology of solid waste disposal, since its inception, that are in common use today. Incineration and landfill are the principal disposal methods employed and may or may not be carried out in conjunction with salvage. The only improvements in these disposal systems have been largely in the areas of management and operation.

Incineration reduces the volume of refuse to less than 15 percent of the total volume of combustible refuse. Advantages of incineration are the reduced land requirements, possibility of a more centralized

location for the facilities, and a residue that contains smaller quantities of organic material with less nuisance than raw refuse. Disadvantages are the comparatively high capital and operating costs.

Sanitary landfill represents a refined method of open dumping and consists of the basic operations of spreading, compacting, and covering the refuse daily. Four common methods of operation in use are area operation, trenching operation, canyon operation, and the pit or abandoned quarry operation.

Salvage or recycling can be divided into four general groups based on the extent to which the material is processed for reuse. These groups include reuse of material in the form in which it occurs in the waste stream, such as returnable bottles; a change in the form of the material; a chemical change in the raw material with the result of an entirely different class of material formed; and those methods leading to the release and use of energy.

PLANS FOR SOLID WASTE MANAGEMENT

Five alternative plans for solid waste management were developed and analyzed for the two basic types of disposal, namely, sanitary landfill and incineration with residue disposal to land.

Plan 1

Each of the three park maintenance districts would haul refuse to separate sanitary landfill sites outside of the park, which would be used jointly with the contiguous communities. Existing collection vehicles would haul directly to each disposal site.

Plan 2A

Waste generation in the West and South Districts would be delivered to a transfer station in each district and transferred to 40-cubic yard transport containers. Every other day, a special transport vehicle would haul transport containers to an areawide sanitary landfill located nearby in the Gardiner area. The waste generated in the North District would be hauled directly to the disposal site.

Plan 2B

This plan is similar to Plan 2A except that the collection vehicles in both the West and South Districts would haul directly to the areawide sanitary landfill.

Plan 3

All waste generated in the park would be disposed of at a central sanitary landfill site located within the park. Collection vehicles from all districts would haul waste directly to the disposal area.

Plan 4A

Similar to Plan 2A except that waste would be hauled to a new incinerator in the North District near Mammoth and residue would be disposed of at a nearby landfill.

Plan 4B

Similar to Plan 2B except that an incinerator would be utilized instead of the landfill area.

Plan 5

Similar to Plan 3 except that solid waste would be hauled to a central incinerator instead of the landfill.

For use in analysis of the above plans, year 2000 sanitary landfill area requirements were estimated to be 11.2 acres for the entire Yellowstone Park service area, 8.7 acres for the community of West Yellowstone, and 4.6 acres for the community of Gardiner.

An economic comparison showed Plans 2A and 2B to have almost equivalent total annual cost with Plans 1 and 3 slightly greater (see Table 7-4). In Plans 4A, 4B, and 5, in which disposal is by means of incineration, the costs are significantly greater. A subjective analysis showed Plan 2A to have the highest ranking (see Table 7-5). Plan 2A has a number of distinct advantages from the subjective point of view and, therefore, was selected as the best plan. Capital cost for both transfer stations would be approximately $493,000, and the 1972 annual transfer and haul costs would be $10,000 for the West District and $19,000 for the South District.

RECOMMENDATIONS - YELLOWSTONE NATIONAL PARK

Based on the findings and analyses developed during the conduct of this study of the solid waste management needs of the park, we make the following recommendations:

1. That Plan 2A, as presented in Chapter 8, page 78, be adopted as the plan for the management of solid waste.

2. That, should a delay be experienced in the development of the areawide sanitary landfill, one of the interim measures set forth on page 94 should be taken to insure compliance with present federal directives.

SUMMARY - GRAND TETON NATIONAL PARK

Characteristics of the Area

Grand Teton National Park is located six miles south of Yellowstone National Park and covers an area of 498 square miles. Elevations vary from 6,000 to almost 14,000 feet. The Continental Divide lies a few miles east of the park. Older hard rocks compose most of the higher elevations and glacial deposits predominate the lower elevations. Alluvial or younger soft rocks are confined to the valley of the Snake River. Primary physical features include the Grand Tetons to the west and Jackson Lake. Extremes of temperature in summer and winter are prevalent because of the high elevation and dry air.

EXISTING SOLID WASTE MANAGEMENT PRACTICES

Two maintenance districts provide for the collection and disposal of solid waste at Grand Teton National Park. Both districts, the North District and the South District, are under the overall supervision of the Maintenance Supervisor who, in turn, is responsible to the Chief of Park Maintenance. Most of the solid waste generated within the park is collected by park personnel, however, solid waste generated at dude ranches, private residences, and cabins within the park boundary are hauled by each individual or establishment to the three available disposal sites. Concessionaires within the park are provided with collection and disposal service during the peak tourist season. General collection practice includes normal garbage pickup of all containers in the high density areas, as well as roadside can pickup at viewing locations. The storage containers in general use in the park are the 32-gallon cans used in the high density areas, and the 25-gallon cans used for roadside litter. Each district has one 14-cubic yard rear-loading packer truck which services the high density areas, and a 3/4-ton pickup truck for roadside service and litter control. Daily collection services are provided during the peak 100-day season and then diminish to a minimum of one day a week as the tourist demand dwindles during the winter season.

Solid waste field studies at Grand Teton Park indicated an average solid waste density of 3 pounds per cubic foot for all standard uses within the park. Total annual solid waste tonnage for the park is estimated at 1,110 tons. In 1971, the cost of collection was estimated to be $29,000 for a total cost per ton of $28.70. All areas adjacent to the park are tourist-oriented and face similar solid waste problems as in the park. The city of Jackson has a peak summer population of 7,000 people and is estimated to generate approximately 3,900 tons of waste per year. The Teton National Forest, whose facilities generate an estimated 100 tons of refuse per year, is currently conducting a study to determine its long-term collection and disposal needs for its service area. The National Elk Refuge generates very little solid waste from its visitors and can easily provide for their long-term needs.

Disposal practices within the park consist of three landfill sites. The Colter Bay sanitary landfill services the North District, and the Timber Island and Kelly sanitary landfills service the South District. The Colter Bay landfill is operated daily during the peak season and the other two landfill sites are operated on an alternate-day basis. The Colter Bay and Kelly landfills are open year-round. Total annual cost of disposal for these three sites is estimated to be $15,000 per year or $13.45 per ton. A solid waste disposal site is maintained by the city of Jackson south of the city, and the National Elk Refuge maintains a small site on its own property.

LAND DEVELOPMENT AND POPULATION

Family campgrounds are available in both the North and South District service areas. There are also many overnight paid facilities and services available within the park from early July through September. A majority of the over three million visitors to Grand Teton Park only tour the park during the day. During the 100-day peak season, campgrounds, as well as concession accommodations, are filled to capacity. Although winter season operations at the park are not large at present, indications are that, in the future, they may increase appreciably.

Daily park visitors are projected to increase to approximately six million by the year 2020. Overnight accommodations, however, are not forecasted to increase.

SOLID WASTE PRODUCTION, COMPOSITION, AND PROJECTIONS

Solid waste characteristics at Grand Teton Park are similar to those at Yellowstone Park, with a few exceptions which are discussed in Appendix A. The park generates a total volume of approximately 10 tons of solid waste per day during the peak season. As in Yellowstone Park, it is expected that there will be an increase in per capita waste generated in the future. The projected solid waste production during the peak season in the year 2000 is estimated to be 12.4 tons per day. Most of this increase is due to increased per capita generation factors. The major portion of solid waste produced is from overnight accommodations and, since these are not projected to increase in the future, the projected total volume will also not increase materially. Although the number of visitors passing through the park is forecasted to almost double, this type of waste comprises less than 7 percent of the total solid waste generated.

SOLID WASTE MANAGEMENT METHODS AND CONSIDERATIONS

The various aspects of solid waste storage, collection, transportation, and disposal previously discussed for Yellowstone Park apply to Grand Teton Park and will not be discussed further. However, the need to protect the stored solid waste from marauding bears is not necessary in this park.

PLANS FOR SOLID WASTE MANAGEMENT

Four alternative solid waste management plans were presented for Grand Teton Park. Each plan considered utilizing either a 14-cubic yard capacity or a 25-cubic yard capacity packer truck for the collection of the solid waste.

Plan 1A

Solid waste generated in both the North and South Districts would be hauled directly to a landfill site located near Moose Junction. Waste generated from the communities contiguous to the park would be hauled directly to the existing Jackson landfill located south of the community of Jackson. This plan would utilize two 13-cubic yard packer trucks for the North District and the existing 14-cubic yard packer truck for the South District.

Plan 1B

This plan is similar to Plan 1A except that one 25-cubic yard packer truck would be used in the North District and another 25-cubic yard packer truck in the South District.

Plan 2A

Direct haul of all solid waste generated in the park to a regional landfill site south of Jackson is contemplated in this plan. All waste generated from nearby communities would be hauled to this regional landfill site. The 14-cubic yard packer trucks would be utilized as in Plan 1A.

Plan 2B

Similar to Plan 2A except that 25-cubic yard packers would be utilized.

Plan 3A

This plan proposed that both the North and South Districts haul directly to a transfer station located near Jackson Lake Junction. Solid waste from the transfer station would then be hauled to the regional landfill site by a transfer vehicle once a day.

Plan 3B

Identical to Plan 3A except that 25-cubic yard packer trucks are used in the North District in lieu of the 14-cubic yard vehicle.

Plan 4A

This plan proposes that an incinerator be located in the park near Jackson Lake Junction. Depending on accessibility and cost, outside entities would also haul either to this incinerator or to the Jackson landfill site.

For use in evaluating the plans, year 1980, 1990, and 2000 sanitary landfill area requirements were developed and presented in Table 14-2, page 142.

As with Yellowstone Park, both an economic and subjective evaluation were made of the alternative plans. Plan 3A, although slightly more expensive than either Plan 1A or 2B, was selected as the best plan. The controlling factor was in the subjective evaluations and its conformance to park philosophy of disposing of all waste outside of the park. This plan also provides for the temporary storage of solid waste during inclement weather.

As proposed, the plan would provide for the construction of a transfer station in the vicinity of Jackson Lake Junction and utilization of the existing 14-cubic yard packer trucks in both districts.

Plan 4B

This plan proposes direct haul of park refuse via 25-cubic yard packers to an incinerator located in the park.

RECOMMENDATIONS - GRAND TETON NATIONAL PARK

Based on the findings and analyses developed during the conduct of this study of the solid waste management needs of the park, we make the following recommendations:

1. That Plan 3A, as presented in Chapter 14, page 141, be adopted as the plan for the management of solid waste.

Chapter 3

YELLOWSTONE NATIONAL PARK CHARACTERISTICS of the AREA

The physical and environmental characteristics of an area have an important influence upon the location and operation of a system of solid waste management. This is particularly true where the use of the area is primarily for recreational purposes. Thus, the description of the characteristics of this park is designed to show the operational limitations of the environment upon the waste disposal system.

LOCATION AND HISTORICAL SKETCH

Yellowstone National Park, the oldest and largest national park in the United States, is located in northwestern Wyoming immediately adjacent to the Montana and Idaho state boundaries, with some limited overlap into the two states (see Figure 3-1). It is approximately 3,460 square miles in area with a very irregular east boundary, perfectly straight boundaries on the west side, and straight with two bulges on the north side. The overlap into Idaho and Montana on the west is about 2.5 miles, while the overlap into Montana on the north is about 2 to 4 miles with some irregularity.

There are five entrance roads leading to the park which are identified as: 1) the west entrance connecting Idaho and Montana; 2) the south entrance connecting to Grand Teton Park; 3) the east entrance connecting to Cody and Sheridan, Wyoming; 4) the northwest entrance connecting to Billings, Montana; and, 5) the north entrance connecting to Gardiner and Bozeman, Montana (see Figure 3-2). Major park roads and entrances are maintained open from May 1 through October 31. The closest air terminal is at West Yellowstone at the west entrance. Other nearby terminals are at Bozeman, Montana, and Cody, Wyoming. Air service is provided from Salt Lake City to the west and Minneapolis-St. Paul to the east.

The Continental Divide extends from the Montana-Idaho line on the west to the southeast corner of the park. Thus, the park occupies the upper portions of two major drainage basins--the Yellowstone River Basin over about 80 percent of the park area, which drains east into the Missouri River Basin, and the Snake River Basin over the remainder, which drains west into the Columbia River Basin.

This area has a fantastic historical background in terms of its geologic, environmental, and cultural development. The cultural history extends some 8,500 years into the past, while the geologic history embraces some 2.5 billion years. Thus, the scope of the park history is almost as sweeping as that of the earth and the solar system.

GEOLOGY AND PHYSIOGRAPHY

The land mass that makes up Yellowstone National Park ranges in elevation from about 5,700 feet in

Figure 3-1. VICINITY MAP OF YELLOWSTONE NATIONAL PARK

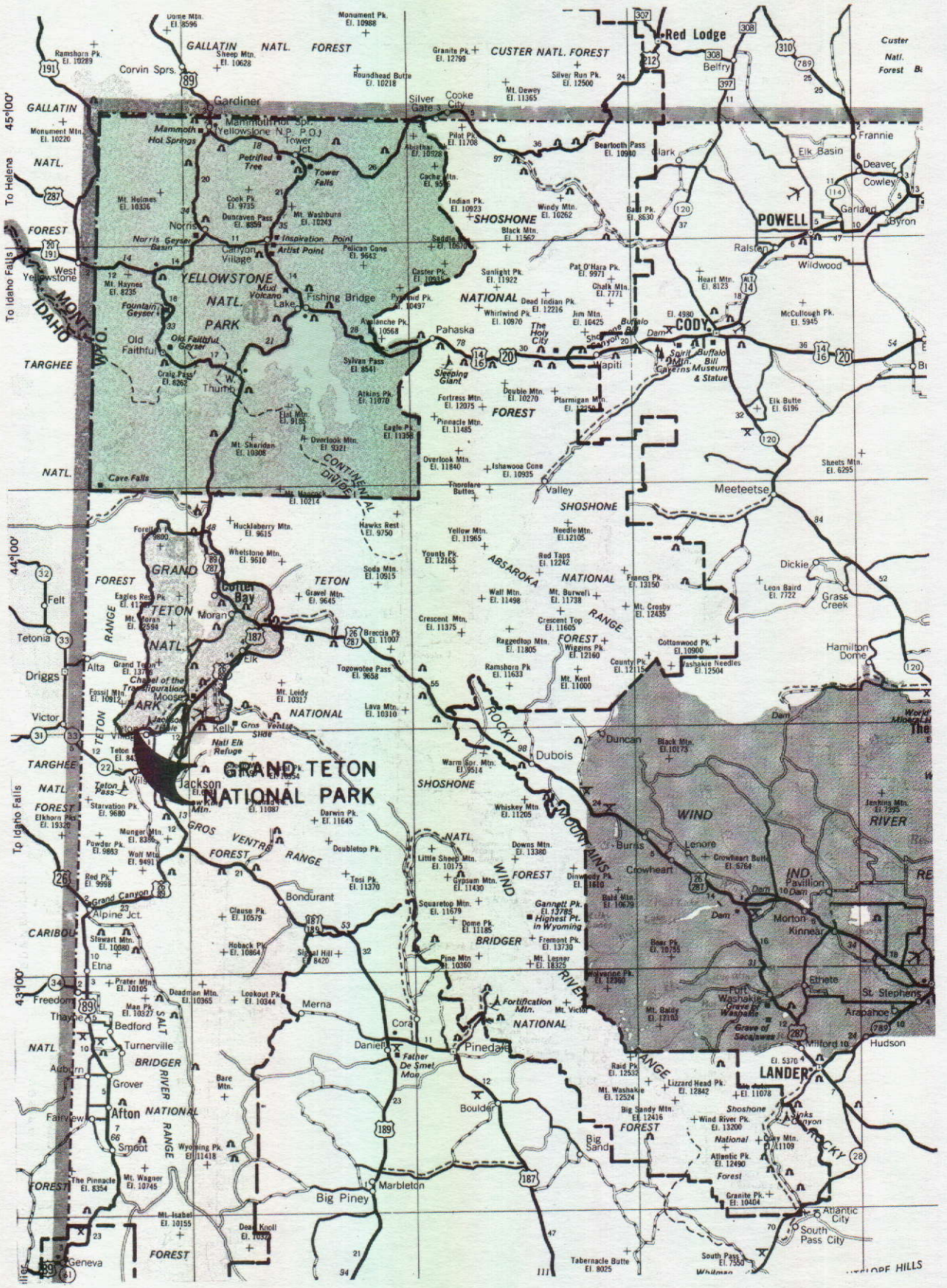
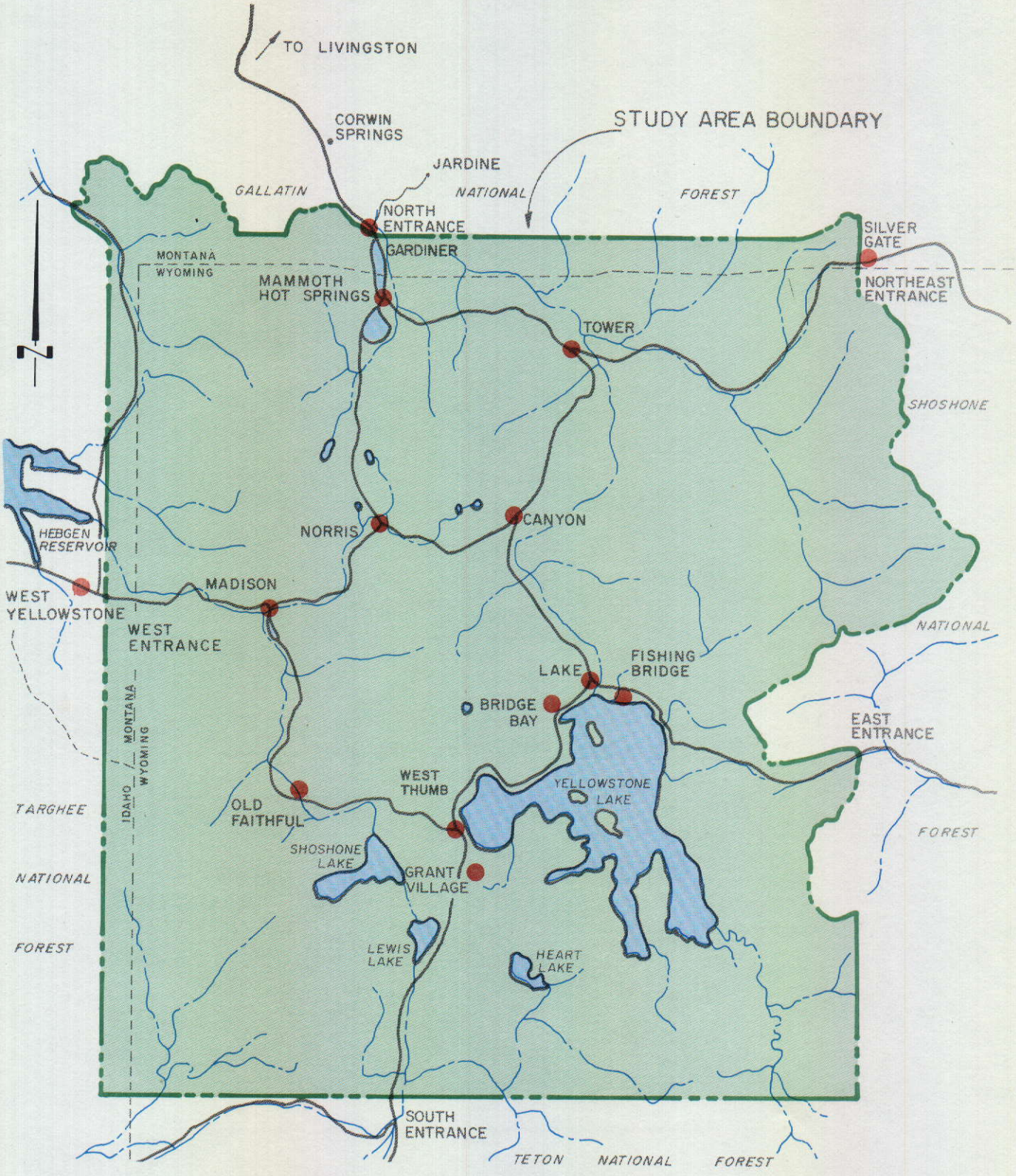


Figure 3-2. STUDY AREA AND OUTLYING COMMUNITIES



SCALE
0 5 10 15
MILES

YELLOWSTONE RESEARCH LIBRARY

the main plateaus to 12,000 feet in the mountains. It is composed of igneous rocks and their weathered products for the most part, with a predominance of acidic volcanic rocks (rhyolite and trachyte) in the west half of the park and basic volcanic rocks (basalt and andesite) in the east half, but the boundary between the two types of flows is very irregular due partly to the vast extent of volcanic breccias.

The remainder consist of sedimentary formations which are of three general age and composition classes. The oldest one is the Laramie sandstone and shale formation of Cretaceous age which is coalbearing, exposed in the north and central portions of the park. The second consists of coarse moraine and outwash sediments from the glaciers. The third is coarse sand deposits in the alluvial valleys that are derived from the older formations plus a large influx of dark volcanic obsidian glass.

The earth movement forces that created the plateau-mountain terrain of the park are very old indeed--part of the larger earth forces that produced the Rocky Mountains. Some volcanic flows covered the ancient forest and animal life and preserved them in fossil form.

Subsequently, the area was subjected to three glacial periods which left their own deposits of cobble, gravel, and sand, and the interglacial clay tills. This older Pleistocene period of ice formation and flows should not be confused with the present smaller glaciers of minor size and extent. Underneath all of these complex rock mantles, formed in past ages, are the thermal springs and lakes which result from runoff waters filling the valleys and seeping down into the porous rocks until they encounter hot, deep-seated magmas which heat the water and convert much of it to steam. These hot liquids then rise to the surface where they mix with the new runoff and the process starts all over again. Thus, this unusual phenomena controls much of the hydrology and drainage system for the park.

This is the briefest possible description of the geology of the park area. The important thing to keep in mind is that the hard volcanic lava or tuff is not suitable for disposal of solid wastes and neither are the thermal spring areas and other high water table areas near the lakes, for they could lead to contamination of water supplies.

SOILS AND TOPOGRAPHY

Between these volcanic rock and spring areas are two types of sedimentary deposits which are suitable for solid waste disposal when developed properly, namely, the lower-lying glacial outwash deposits, consisting mainly of coarse sand, gravel, and cobble, and the lowest-lying stream-laid sand and gravel deposits, loaded with obsidian glass particles. The specific location of waste disposal sites depends upon a closer examination of local topography, soil characteristics, and groundwater levels.

As a result of these varied earth forces and movements, the original mountains and valleys have been worn down and levelled several times throughout geologic history. But the present rolling-to-rugged topography results mainly from the three periods of glaciation, the recent period of river and stream cutting and deposition, and the thermal action of deep-seated hot waters that rise to the surface.

The soils developed on the glacial deposits show some transformation of these deposits into surface, subsoil, and subsurface profile horizons, resulting from weathering of the coarse rock particles into clay and soluble substances. But the young alluvial deposits show very little change in mineral weathering, clay formation, and downward movement of clay and calcium carbonate within the soil profile. Therefore, the younger soils have very low water-holding capacities.

Photographs of these two major soil groups would seem to indicate that there is more grass and lower shrubs growing on the older glacial outwash deposits which, in itself, is indicative of more clay in the soil profile and higher water-holding capacities. The younger alluvial soils are more adapted to deep-rooted plants, namely, the forest cover. Of course, the forest cover tends to encroach upon all soil areas below the snow line of the rugged mountain peaks.

Sanitary landfill site possibilities are limited to outwash sedimentary materials from glacial deposits or stream and lake lacustrine deposits. The hot spring formations are not usable. Figure 3-3 shows the general areas of these deposits. A detailed soils and geologic analysis should be made of any site proposed in these areas.

The possible landfill sites near Gardiner may be at two general locations, determined by the position of the canyon a few miles below the town. This canyon restriction means that the choice of sites is limited to the alluvial valley west of the river near Gardiner or the alluvial valley of the river more than 13 miles below Gardiner. The alluvium in each case probably would be better than the glacial outwash deposits because of easier excavation and more favorable topographic slopes. The river is said to be deeply entrenched in the Gardiner area so no serious water table problems should be encountered there. If the river is not deeply entrenched in the lower valley below Yankee Jim Canyon, any landfill site in that valley should be located far enough back from the river to avoid pollution of the water table.

Much of the alluvium in the upper valley is used for crops or pasture but there should be areas at or below the 5,400 contour line that are suitable for landfill. There is an access road on the west side of the valley with two short take-off roads extending away from the main access road, the lower one of which might be the best location for a landfill. The upper take-off road leads to a recreation lake.

The one argument against such a site is its location within the park. There may be a remote possibility of a site outside the park and on the north and east side of the valley, similar to the landing strip in Section 16, but this is doubtful. It should be explored, however. Other arguments favor this upper valley area due to less haul distance from waste accumulation areas. Thus, a decision against a site in the upper valley means that the total haul to reach the closest disposal point below Yankee Jim Canyon is at least 13 miles and possibly more.

The possibilities of sites in the lower valley are much more extensive in both the alluvium and glacial outwash gravels. Although the alluvium is wider in the lower valley, it still is rather narrow, compared with the glacial outwash deposits on its margins. Thus, the best possibilities seem to be in the glacial drift on the east side of the valley at either one of the two small roads that take off in Sections 16, 3, and 10 from the main or an auxiliary highway. The general area of the alluvium, glacial outwash gravels, and two basalt outlyers (in the lower valley) are shown in Figure 3-3.

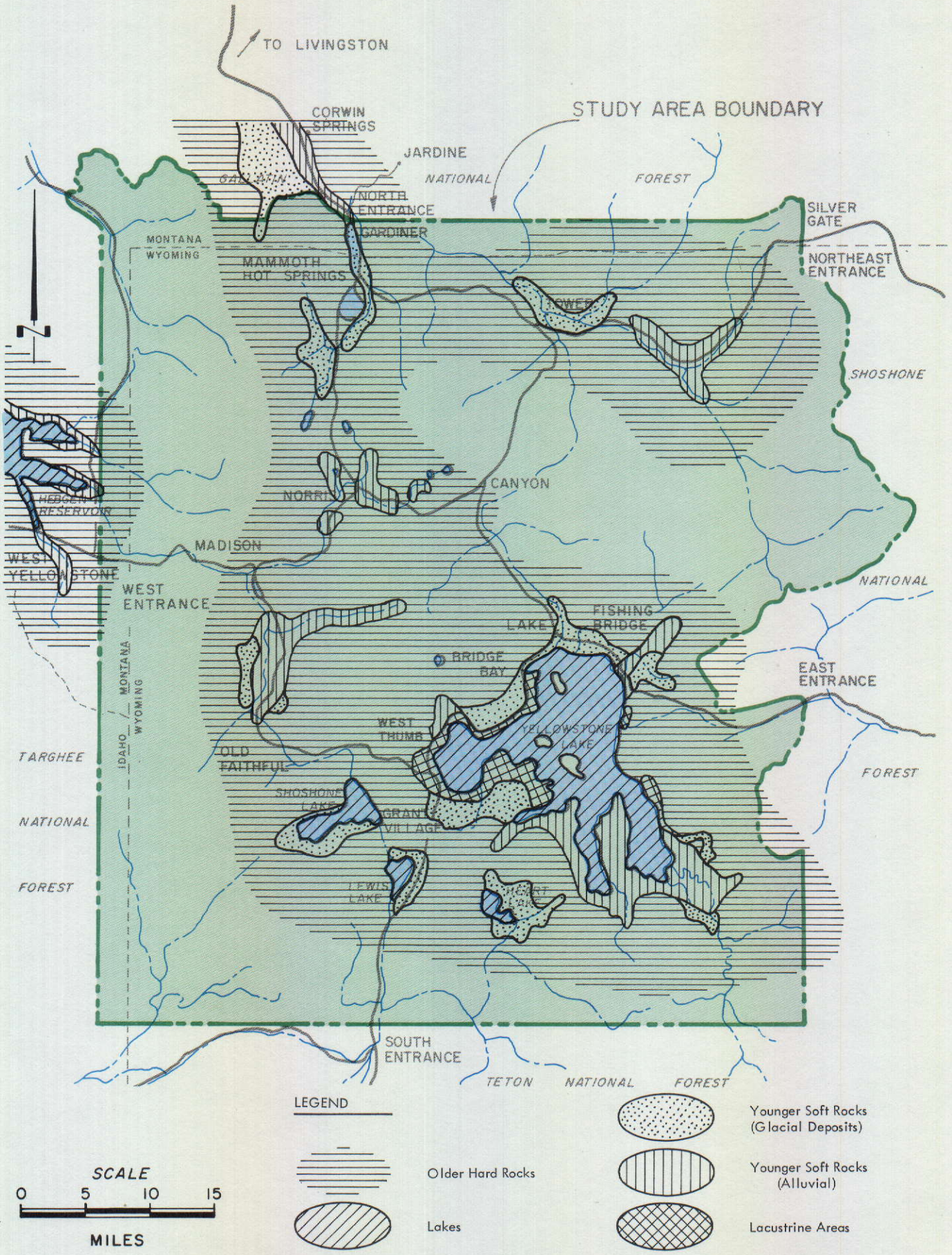
A landfill site in the vicinity of the town of West Yellowstone presents a special problem. The upland areas around the town probably are underlain by volcanic rhyolite or welded tuff. These materials may be too hard to excavate unless there are glacial outwash materials from the surrounding mountains that have been deposited upon the tuff. Field examination would be required to determine their feasibility for landfill.

The other possibility would be the alluvial valley of the Madison River north of the town of West Yellowstone. There appears to be a short road from the west park entrance leading to the valley at a point called Riverside. This is within the park area, however. Another point outside the park but in the valley is about three to four miles due north of the town on either side of the main north-south highway. Care should be exercised that any landfill in the valley does not pollute the river.

CLIMATE

The climate of the park area is dominated by the high elevation and dry air, such that extremes of temperature in summer and winter are common. The lowest recorded temperature occurred in December 1954--52 degrees below zero. Cold air draining down from the mountains keeps the valley cold for several days at a time.

Figure 3-3. GEOLOGY OF STUDY AREA



Summer temperatures rarely exceed 90 degrees with the highest recorded of 101 degrees in July 1934. Snow covers the lower elevations for 80 to 120 days in winter. Sunshine is abundant with low relative humidity higher in winter. Winds are generally not strong. The growing season is about 70 to 80 days with rainfall averaging about 20 inches per year.

The glacial and alluvial deposits of the valleys are porous deposits, loaded with groundwater, such that shallow-driven wells are common. However, this also means that septic tanks are a hazard outside of areas having sewage treatment plants. By the same token, care must be exercised in the use of lands for solid waste disposal near or upon shallow groundwater.

Chapter 4

YELLOWSTONE NATIONAL PARK

EXISTING SOLID WASTE MANAGEMENT PRACTICES

Important to the identification of problem areas that exist or may be developing is an examination and review of existing facilities and practices. Existing conditions occasionally control and always influence the future direction of a solid waste management system and must, therefore, be considered in the development of short- and long-range plans.

DEFINITION OF TERMS

To aid in understanding the discussion on solid waste management, the terms used in the following chapters are defined:

Waste:	Useless, unused, or discarded material. Waste may be solid, liquid, or gas.
Solid Wastes:	All those materials that are solid or semi-solid and that the processor no longer considers of sufficient value to retain. For the purposes of this report, the term solid wastes is all inclusive and considers all types of classifications, sources, and properties.
Refuse:	All of the solid wastes normally handled in any waste management system. This term is commonly used to denote a heterogeneous mixture of solid waste materials from several sources.
Garbage:	Animal, fruit, or vegetable residues resulting from the handling, preparation, and cooking of foods. When stored separately or used as animal feed (more free liquid usually exists), it is sometimes referred to as swill.
Rubbish:	Combustible and noncombustible solid wastes of households, commercial establishments, institutions, etc., exclusive of highly putrescible wastes (garbage). Rubbish consists of such materials as paper, metal, wood, cans, furniture, yard trimmings, and ceramics.
Construction and Demolition Waste:	The waste building material and rubble from construction, remodeling, repair, and demolition operations on houses, commercial buildings, other structures, and pavements

Leachate:	Water flowing from a solid waste landfill into the adjacent soils, groundwater, or surface water or onto adjacent ground surfaces, as a result of supersaturation of the fill. The organic and mineral content of the water may be high and, thus, represent a potential water pollution problem.
Sanitary Landfill:	A land site on which engineering principles are utilized to bury deposits of solid wastes without creating public health or safety hazards or nuisances.

SOLID WASTE COLLECTION

The collection and transportation function of a solid waste management system is composed of facilities and equipment necessary to collect, transport, or transfer accumulated and stored refuse materials from the source of production and generation to the place of final disposal. Collection is the most expensive activity in the solid waste system. It is that part of the handling cycle which most directly affects the inhabitants and visitors.

Administrative and Operational Structure

The park is divided into three separate maintenance districts, namely, the North, South, and West Districts (see Figure 4-1). Each district is under the control of a maintenance superintendent who is charged with the responsibility of maintaining and operating the service utilities of his district. Solid waste collection and disposal is one of the services provided in each district and the practices employed in each district, relative to the same, are primarily formulated by the district superintendent and the operators who are responsible to him.

Uniform records of collection are maintained in each district. These are tabulated annually in a composite form to represent primarily the total number of 32-gallon containers collected. Schedules of and frequency of collection of solid waste in each district vary throughout the park season in accordance with tourist increase or decrease and also in response to anticipated problems with marauding bears, especially in the South District. A discussion of these problems will be presented in the text to follow.

Service Areas

North District:

The North District of Yellowstone Park encompasses the areas of use along the Grand Loop Road from Norris on the south, through Mammoth to the community of Gardiner on the north, where the Yellowstone Park county headquarters are served. Also included in this district is the area between Mammoth and the northeast entrance station, including all the facilities at Tower.

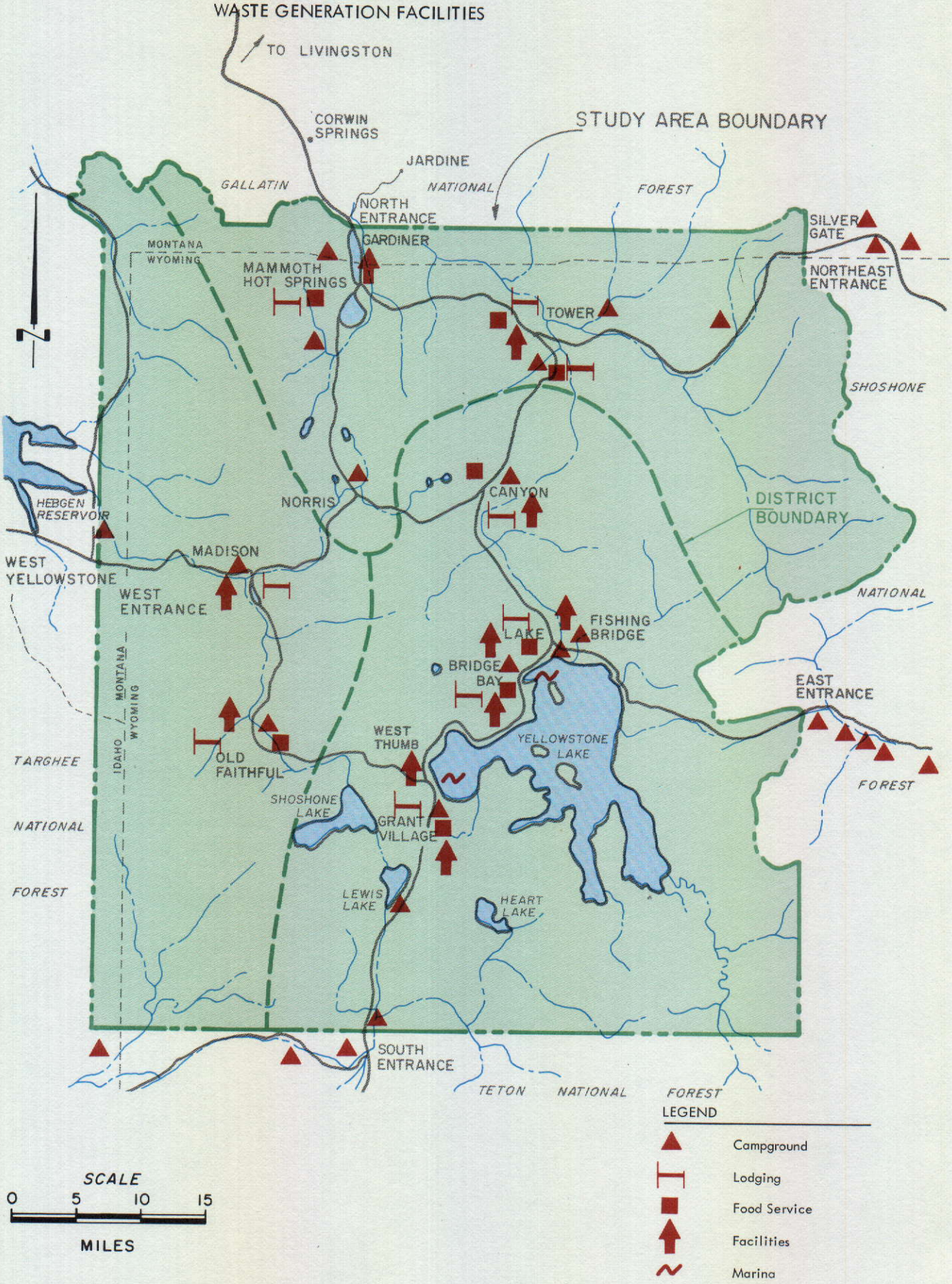
West District:

This district encompasses the Old Faithful area and use areas along the Grand Loop Road south of the Continental Divide and north through Madison Junction to the Norris area. All the use areas west of Madison Junction to the West Yellowstone entrance station are also included.

South District:

The South District covers the largest area of the park and, in terms of solid waste generation, is also the largest contributor. The district encompasses all the use areas along the Grand Loop Road from

Figure 4-1. SERVICE AREAS AND SOLID WASTE GENERATION FACILITIES



Canyon on the north, south to include the Lake, Bridge Bay, West Thumb, Grant Village, and all use areas along the South Entrance Road to the south entrance station. Also included are the use areas east of the Lake area, including Fishing Bridge and areas east to the east entrance station.

Collection Practices Within the Park

All solid waste generated within the park is collected by park personnel. There are no privately owned collection facilities or franchised operators within the park boundary. Concessionaires within the park are provided with collection and disposal service on a daily basis minimally during the peak tourist season, and are charged each season on a per can basis. Where the standard container is not used, an estimate of equivalent cans is used to determine the volume to be charged. No record is kept of cans collected other than concessionaires' except on a random basis.

General collection practice includes normal refuse pickup of all containers in the high density areas, as well as the pickup of cans at roadside viewing locations along the entrance and Grand Loop roads. In each district, regular litter control is provided by routine patrol and pickup of paper, cans, and other trash deposited along the roads of each district. The various solid waste generation areas are delineated in Figure 4-1.

The major difference between solid waste collection practices in Yellowstone Park and practices in parks in other areas of the country is associated with the limited tourist season. In general, the 100-day period between Memorial Day and Labor Day is the peak tourist season and the period when the maximum effort is provided in maintaining sufficient collection services. For a period of 80 days (the light season), 40 days before and 40 days after the above peak season, variable collection frequencies are employed throughout the districts and are regulated primarily by tourist demand.

All park facilities close during the period between November 1 and May 1, with two exceptions. Park Headquarters and some of the service facilities at Mammoth are kept in operation and collection of solid waste continues throughout the year. The other exception is due to the increasing snowmobile population visiting the Old Faithful area during the winter months. At present, solid waste collection from the Old Faithful area is disposed of at the West Yellowstone landfill.

Storage Facilities:

The storage container in general use throughout the park is the 32-gallon can. The cans are made "bear-proof" depending on their locations. Those cans subject to outside exposure and possible bear contact are fitted with a weighty steel top with a tilting chute (see Figure 4-2). These tops are anchored to a steel post mounted in a concrete foundation.

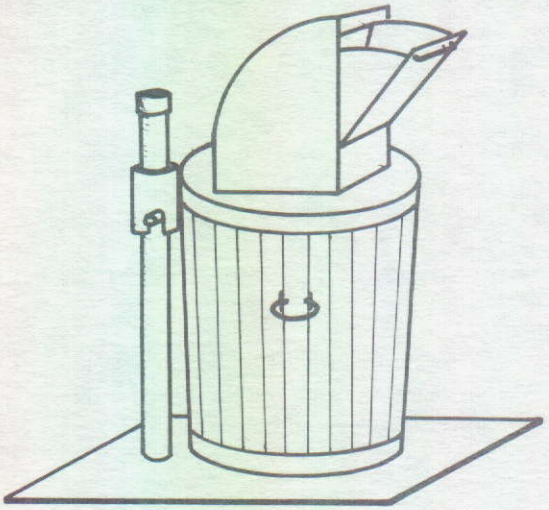
At concessionaire locations where a large number of cans are serviced, 32-gallon cans with regular lids are kept indoors prior to pickup and are then removed outdoors by concessionaire personnel for emptying. The only exceptions to the 32-gallon containers are the containers at housing of park service personnel where they are furnished with 20-gallon containers.

All standard refuse cans are provided with plastic liners at all times. This practice is followed in an effort to reduce collection time and increase the useful life of the containers. The reported annual cost of plastic liners for refuse containers is $2,500.

Collection Equipment:

Equipment used for the collection of solid waste throughout the park is consistent between the three districts of the park. In general, areas of high density tourist population near major park communities are serviced by 13-cubic yard rear-loading packer trucks; picnic areas, remote campgrounds, and roadside pickup are serviced by $1\frac{1}{2}$-ton stake trucks; and litter control is provided by specially adapted $\frac{1}{2}$-ton trucks with box attachment.

Figure 4-2. "BEAR-PROOF" STORAGE CONTAINER



Specific equipment within each of the service areas is as follows:

North District:

Two 13-cubic yard packer trucks are used to service the high density areas--one at Mammoth and one at Tower. Each location is also provided with a 1½-ton stake truck to provide roadside service and litter control.

West District:

Two 13-cubic yard packer trucks provide service for the Old Faithful and Madison campground areas, respectively. One 1½-ton stake truck at each of the above areas provides for litter control and roadside and picnic area collection.

South District:

The South District provides collection equipment at three separate locations. At Canyon, one 13-cubic yard packer truck and one 1½-ton stake truck provide necessary collection and litter control. At Lake, two 13-cubic yard packer trucks, two 1½-ton stake trucks, and one ½-ton pickup truck provide collection services for the Lake-Fishing Bridge-Bridge Bay areas. At Grant Village, one 13-cubic yard packer truck and one 1½-ton stake truck provide similar collection services for the West Thumb-Grant Village areas.

Although the frequency of collection varies throughout the season, during the peak season (100 days), all packer, stake, and pickup trucks operate seven days a week. During the light season, packer operation is reduced to five days per week and the pickups and stake trucks are reduced to three days per week.

Collection Personnel:

All collection personnel work eight hours per day throughout the year. In recent years, however, due to reported bear problems in and around the Fishing Bridge area in the South District, efforts are made to remove all food waste from the campgrounds and at all food service locations in the Lake-Fishing

Bridge area. This requires the need of an additional collection of these areas after the supper hour. One packer truck crew is used for this purpose and works a 12-hour day for this reason. Since disposal in the affected area is by incineration, it is also necessary for that operator to work overtime to burn the collected waste.

The packer trucks in the North and West Districts are two-man crews, whereas the South District uses three men. All stake and pickup truck crews utilize two men.

Collection Services:

Like all services relative to the solid waste management problem within the park, collection services vary in frequency as does the tourist demand.

Table 4-1 cites the collection frequency associated with each of the districts of the park. No distinction is made nor is there any attempt to classify whether refuse be of a domestic or tourist nature, or whether it be classified as rubbish or some other special waste classification. In general, complete collection service is provided to all concessionaires, park housing, and service facilities. Construction debris associated with contractors' operations within the park are excepted from collection service by park personnel. This waste is handled directly by the contractor; disposal to existing sanitary landfills within the park is allowed.

Table 4-1. COLLECTIONS PER WEEK

District	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
North	5	5	5	5	5	7	7	7	7	7	5	5
West	-	-	-	-	5	7	7	7	7	7	2	-
South	-	-	-	7	14	21	21	21	21	14	7	-

Collection Costs:

The cost of solid waste collection within Yellowstone Park has, heretofore, been a best estimate because of the basis on which volumes were estimated. The only record source has been the actual can count of the concessionaires' waste and an estimate of park cans collected to estimate the total tonnage of waste produced. The total tonnage of solid waste collected annually was based on the premise that all cans collected were assumed to be full. A review of past records and reports discussed that the average weight per 32-gallon container differed. For example, in one report, a weight of 40 pounds was assumed and, in another, a weight of 25 pounds was used.

Composition studies, conducted as a part of this report and as fully outlined in the Appendix, have shown an average density of 3 pounds per cubic foot for all standard uses within the park--the only exception being the store where the cans are manually compacted prior to pickup and indicate a density of almost 8 pounds per cubic foot. Based on these findings, the uncompacted volume of a full, standard 32-gallon can would weigh approximately 13 pounds and that an uncompacted cubic yard of refuse would weigh 81 pounds.

This fact, coupled with the additional fact that the count of total can volumes appreciably lowered when an attempt was made to identify degrees of fullness, has significantly reduced the annual tonnage figure to be used in calculating the per ton cost.

A previous report, prepared by the Public Health Service based on the above full can assumption, indicated a total annual tonnage of 5,700 tons; the findings of this report indicate a total annual solid waste tonnage of 1,920 tons or approximately 34 percent of that originally assumed.

The total cost of collection consists of that allocated to labor, operation and maintenance, and depreciation. These costs are discussed briefly below:

Operation and Maintenance:

Each unit of equipment used throughout the park for collection service is charged to the various districts through an internal rental system.

For each 13-cubic yard packer truck, a cost of $1.20 per operating hour is charged to each district. Similarly, for stake trucks and pickup trucks, a charge of $0.08 per mile and $0.555 per mile, respectively, is made for operation and maintenance.

Labor:

Labor used for collection is charged at 8 hours per day exclusively for this purpose. One exception is the packer truck crew in the South District which is on duty for a 12-hour shift to provide the necessary food waste pickup service after the supper meal.

Each packer truck crew in the North and West Districts consists of one driver and one laborer while the South District uses three men--one driver and two laborers.

Labor rates are as follows:

Heavy-duty truck driver	$4.18/hour
Truck driver	$4.08/hour
Laborer	$3.26/hour

Crew cost per operating hour:

Packer:	1 x $4.08 + 2 x $3.26 = $10.70/hour
Stake Truck:	1 x $4.08 + 1 x $3.26 = $ 7.34/hour
Pickup Truck:	1 x $4.08 + 1 x $3.26 = $ 7.34/hour

Depreciation:

Depreciation charges are assessed as part of the operating expense of each collection equipment unit.

In the case of the packer trucks, because they are special-purpose vehicles, a full year's depreciation is charged even though the vehicle is used only a small portion of the year. The amount charged per packer truck is $82.00 per month or $984.00 per year. Since both the stake trucks and pickup trucks can be used at other times of the year for purposes other than solid waste collection, the portion of depreciation assignable to the winter season is not reflected in costs of collection. The depreciation charge for stake trucks is $35.00 per month and for pickup trucks is $18.00 per month.

The total costs of solid waste collection incurred during the 1971 season, using the revised volume and weight figures developed in this study, are delineated in Table 4-2. Collection costs per ton were developed for each of the park districts together with the average cost per ton for the entire park which amounted to $72.50 per ton.

Table 4-2. COST OF COLLECTION

Location	Solid Waste Generated Annually, cubic yards	Tonnage	1971 Cost, $1,000	Cost Per Ton
North District	14,200	580	38,300	$66.00
West District	13,600	560	39,500	$70.00
South District	24,500	1,000	77,700	$77.70
Total	52,300	2,140	155,500	$72.50

Collection Practices Outside the Park

An attempt was made in the conduct of this study to ascertain the collection and disposal practices of areas immediately adjacent to the park in order to ultimately effect a coordinated solid waste management plan for the park and surrounding environs.

All areas adjacent to the park are generally tourist-oriented communities that face the same solid waste problems as the park at identical points in time throughout the park season.

West Yellowstone:

The city of West Yellowstone, Montana, is located at the west entrance to Yellowstone National Park. Collection of solid waste in the city is by a private collector who provides this service to residences once a week, throughout the year. Commercial establishments are provided this service twice a week during the tourist season.

Tourism, the major economy of this community, attracts a summer transient population which has reached as high as 10,000 persons per day. Permanent visitor population amounts to 850 persons, whereas the peak season residential population increases to 2,000 persons.

Collection equipment consists of two rear-loading packer trucks and one dump truck. Total volume collected during the 1971 season amounted to an estimated 1,500 tons of solid waste.

Gardiner-Jardine-Corwin Springs:

The communities of Gardiner, Jardine, and Corwin Springs are located in Montana outside the north entrance to the park. As is the case with other communities adjacent to the park, the major industry of the Gardiner, Corwin Springs, and Jardine areas is tourism. The peak tourist season, during July and August, increases the attendant population of the community of Gardiner to over 3,000 persons. Permanent resident population of Gardiner is estimated to be about 700.

Of the three communities, the only organized collection service exists in Gardiner where collection of garbage is by a private collection agency on a weekly basis throughout the year. Collection equipment consists of a stake truck; disposal is to an open dump which is discussed later in this chapter.

Silver Gate-Cooke City-Cooke Pass:

These communities are located outside the northeast entrance to the park in the state of Montana. Private or public collection practices are nonexistent. Solid waste collection is by each individual resident or commercial establishment on a demand basis. Individuals haul their own refuse to the local disposal site which is administered and operated by the recently formed Silver Gate-Cooke-Cooke Pass Disposal District.

Shoshone National Forest:

The Shoshone National Forest operates and maintains campgrounds, picnic areas, and other tourist-oriented facilities in two separate areas immediately adjacent to the park. The first of these is in the Clarksford district outside the northeast entrance.

In the Clarksford area, there are 12 separate waste-generating areas that are serviced by collection equipment operated by the Forest Service on a semi-weekly basis. Daily collection volume is estimated at 4.6 cubic yards. Pickup of refuse is by a 1-ton truck with a dump bed for the main refuse-generating areas and by a pickup truck for litter control.

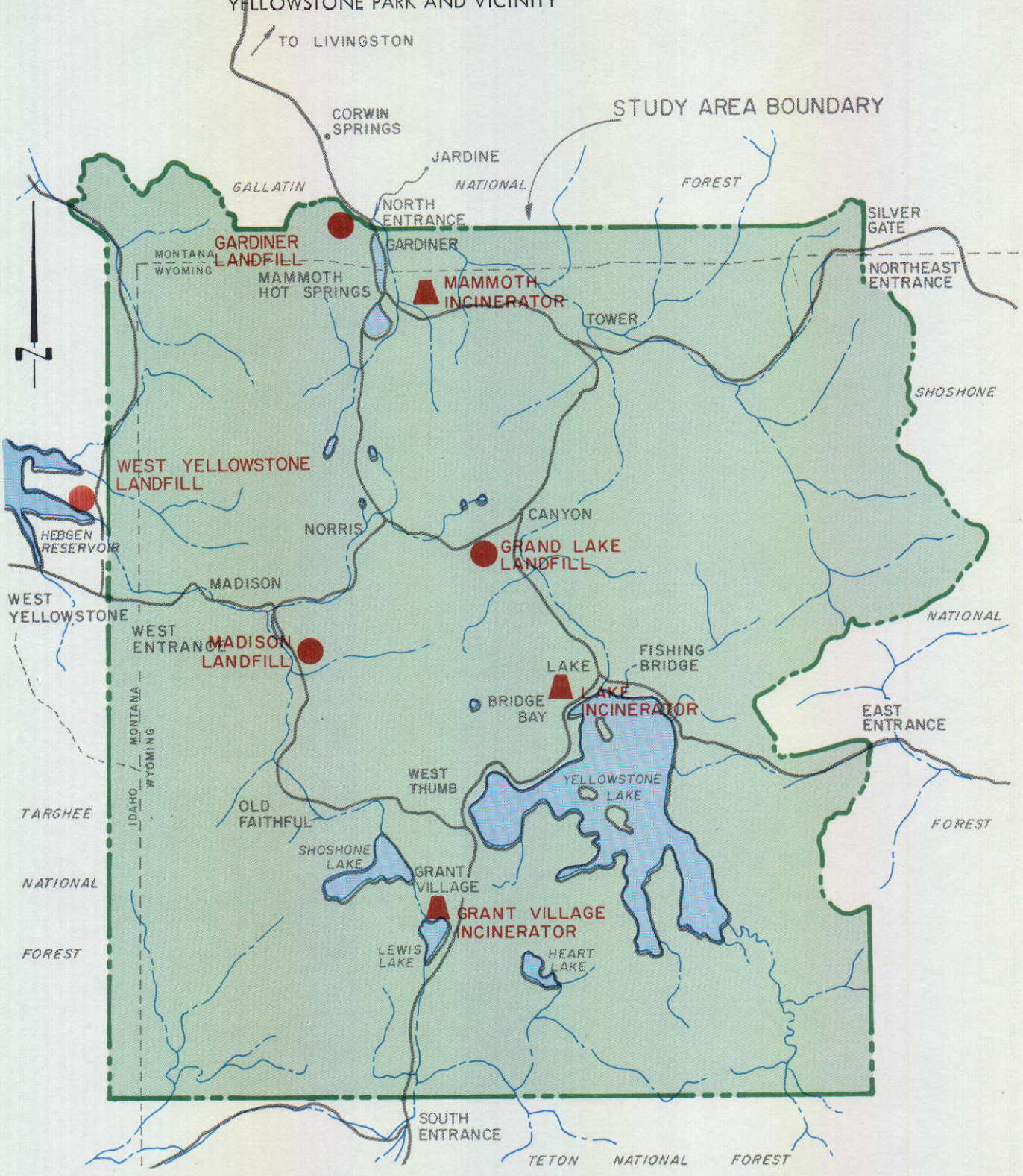
The second area of waste generation inside Shoshone National Forest and immediately outside Yellowstone Park is at the east entrance. This service area is comprised of 24 separate waste-generating facilities including campgrounds, picnic areas, and scenic overlooks. Collection service to this area is on a twice or thrice weekly basis depending on tourist demand. Collection service is provided by a private contractor to the Forest Service. The daily collection volume is estimated at 9.5 cubic yards.

Table 4-3 summarizes the collection practices in the areas outside of the park.

Table 4-3. COLLECTION PRACTICES OUTSIDE YELLOWSTONE NATIONAL PARK

Location	Collection Equipment			Container Pickup		
	Type	No.	Size	Size, gal.	No.	Frequency
West Yellowstone, Montana	Packer Dump Truck	2 1	13 c.y. 5 c.y.	30	1	Weekly
Gardiner, Jardine, Corwin Springs	Stake Truck	1	1½-ton	Varies	-	Weekly
Silver Gate, Cooke City, Cooke Pass	none			none		
Shoshone National Forest	Dump Truck	1	1-ton	30	-	Weekly/2

Figure 4-3. EXISTING DISPOSAL SITES WITHIN YELLOWSTONE PARK AND VICINITY



SOLID WASTE DISPOSAL INSIDE THE PARK

Disposal is the ultimate step in a solid waste management system. All solid wastes, whether raw refuse, sewage sludge, incinerator fly ash and residue, or compost must be utilized in some way or given final disposal. In Yellowstone Park, incineration, together with sanitary landfill, and sanitary landfill alone have been the methods used for disposal of solid waste. Figure 4-3 shows the various disposal facilities within the park. A review of the existing facilities is presented in the following discussions.

Sanitary Landfills

Present practice of solid waste disposal within the park provides for the operation of two sanitary landfill sites. The first site is known as the Madison sanitary landfill and is located on the east side of the Grand Loop Road approximately five miles south of Madison Junction. All of the solid waste generated in the West District is disposed of at this location.

The Grebe Lake sanitary landfill is located approximately five miles west of Canyon, south of the Grand Loop Road between Canyon and Norris. This site provides disposal service for the incinerator residue at Lake and Grant Village, all the solid waste collected at Canyon and Norris, and the roadside pickup along that routing.

Adequacy of Sites:

Of primary consideration in the development or operation of a sanitary landfill is the need to avoid possible pollution of the groundwaters or surface waters of the area. The adequacy of a sanitary landfill is measured not only by the physical housekeeping measures employed in operating the site, but by the maintenance of proper drainage facilities and the avoidance of possible contamination of groundwaters underlying the site.

Both of the sanitary landfill sites in the park are operated with an intense effort to minimize and, if possible, eliminate the bear attraction generally associated with refuse disposal. Not only are all solid wastes completely covered each day, but each of the sites are totally fenced with both a chain link and an electrified wire enclosure located five feet outside the main fence. The combination of these two fences and excellent operation have been extremely successful in reducing the bear contacts at the disposal sites.

Grebe Lake Sanitary Landfill:

This site is located in an area where the geology is essentially a glacial drift material with a fairly high groundwater table. Figure 4-4 shows the representative operation of the site and the typical material of either of the sites in the park. A high groundwater table is evident from the picture and pollution of the groundwater is most certain to occur since no seal or barrier can be provided between the compacted refuse undergoing decomposition and the groundwater.

The site is located reasonably well with respect to drainage and is not subject to heavy storm flows or serious inundation from flooding. This site is inadequate due to a high groundwater table which cannot be effectively isolated from the decomposing waste. The degree of inadequacy can be measured by the usability of the groundwater aquifer. If no identifiable uses are existing or planned for these groundwaters, perhaps some water quality impairment can be tolerated. The decision to continue the use of this site must be made with the knowledge that pollution of the groundwater will be occurring for many years in the future.

Madison Junction Sanitary Landfill:

The geology of this site shows a glacial drift material, primarily an obsidian sand, with a rea-

Figure 4-4. GREBE LAKE SANITARY LANDFILL



sonably low groundwater table during the late summer season. Figure 4-5 shows the representative site and the appearance of the operation of the facility.

Figure 4-5. MADISON JUNCTION SANITARY LANDFILL



Again, this site is located in a highly pervious material subject to high percolation rates which provides no seal or barrier between the waste fill and the groundwater. During the wetter periods of the year, the groundwater rises and comes in contact with the fill material. As with the Grebe Lake site, a decision regarding the continued use of this site should be conditioned with knowledge of the pollution of the groundwater underlying the site.

As mentioned, the soils material at this site is an obsidian sand. Wet weather causes erosion of the cover material at the face of the waste cells and bird and potential bear problems are the result. The angular nature of the sand is also a factor that prevents compaction of the waste since the sand bridges readily and can support normal compaction equipment without further compression. The results of these two problems has been a higher-than-anticipated use of available sites since two feet of cover material is placed over each lift of waste rather than the normally expected six inches of cover.

Size of Sites:

Both the Grebe Lake site and the Madison site encompass an area of ten acres each. Both sites were developed recently; the Grebe Lake site is two years old while the Madison site commenced operation at the beginning of the 1971 season.

General Operation of Sites:

The Madison site is operated eight hours per day, seven days per week from 8 a.m. to 5 p.m. during the peak tourist season and five days per week during the light season. The Grebe Lake site is operated eleven hours per day, seven days per week from 8 a.m. to 9 p.m. during the peak tourist season and five days per week during the light season. The longer operating day at the latter site is to accommodate the disposal of food wastes collected from the Canyon area after the evening meal and to dispose of the residue from the incinerators at Lake and Grant Village. In general, the last hour of the day's operation is spent in providing final compaction and cover of the day's waste cell.

As has been previously mentioned, a great deal of concern is apparent and maximum effort is made to eliminate potential bear problems by providing good operation of the sites. All waste dumped at each site is immediately compacted and, at the end of each day's operation, all waste is amply covered to remove all traces of waste material.

Personnel and Equipment:

Each site is equipped with a dozer as the prime piece of equipment for trenching, compacting, and covering. A pickup truck is provided for the use of the operator, not only for transportation, but also as a protective enclosure in the event a bear comes into the site. There is not sufficient backup equipment available to the sanitary landfill sites in the event of a dozer breakdown as occurred during the 1971 season at the Madison landfill. Here a rubber-tired, front-end loader was being used to compact and spread the waste leading to inefficient use of the site.

The crew at each site consists of a heavy-duty equipment operator and a laborer. Each man works a regular 8-hour shift.

Annual Cost of Disposal:

Table 4-4 shows the respective cost of operation on a per ton basis for the wastes received at both the Grebe Lake and Madison sanitary landfills. The costs presented include all assigned labor, depreciation, and operation of equipment at the sites. No provision has been made for depreciation or maintenance of fixed facilities at the site, such as fencing.

Table 4-4. COST OF SOLID WASTE DISPOSAL AT SANITARY LANDFILLS

Site	Volume Per Season	1971 Amount	Cost Per Ton
Madison	600 tons	$11,900	$20.00
Grebe Lake	565 tons	$11,500	$20.50

Incinerators

Incineration of solid waste is practiced at three locations within the park. These are at Mammoth, Lake, and Grant Village. All are of identical design capacity capable of burning up to 3,000 pounds of solid waste per hour on a 24-hour-per-day basis or 36 tons per day. The Mammoth unit is a front-loading, stationary grate, single-hearth furnace, while the Lake and Grant Village units have movable grates to propel the waste through the furnace. Residue ashes and noncombustibles are collected from the units and disposed of at the sanitary landfills. Furnace draft is by gravity through refractory-lined metal stacks. A typical park incinerator is shown in Figure 4-6.

Figure 4-6. TYPICAL INCINERATOR IN YELLOWSTONE PARK



Adequacy of Incinerators:

It is estimated that the furnaces achieve a reduction of 80 percent in the solid waste burned, leaving 20 percent of the volume to be hauled away or otherwise disposed of at the sites. Residue from the

furnaces primarily consists of ashes and noncombustible items such as cans, other metals, and glass, as well as some food residue that was not properly incinerated.

Charging of the incinerator is through the use of a specially adapted front-loader vehicle which pushes the refuse through a large guillotine-type door directly to the furnace hearth. Each time a packer unit unloads its contents at the incinerator, the loader vehicle quickly dispatches all waste to the furnace. At Mammoth, the only agitation or stirring of the waste during incineration is by manual means and is not effective in attaining complete combustion of all of the solid waste material.

Complaints associated with the operation of the units are generally those of heat buildup behind the charging door causing door warping and binding in the door guides. A more suitable method of charging each furnace and better conveyance through the combustion chamber would reduce this problem.

The incinerators were installed prior to the adoption of exhaust emission standards by the federal government. The standards presently in existence were adopted as Part 466 of Federal Regulations persuant to Section 111 of the Clean Air Act of 1971.

The exhaust emission standard relative and pertinent to the incineration of solid waste deals only with the amount of particulate matter in exhaust gases. Emission standard for federal installations is currently 0.10 grains per standard cubic foot (29.2 inches Hg and 70°F) of dry flue gas corrected to 12 percent carbon dioxide. For the average domestic solid waste, an uncontrolled furnace gas may contain 1.0 grains or more of particulates per standard cubic foot, or approximately ten times the allowable discharge.

Each of the incinerators at the park are essentially uncontrolled furnaces, having only a wire mesh screen and gravity settling chamber between the furnace hearth and the stack and, as such, are not capable of meeting the new standards.

General Operation of Incinerators:

Incinerators at Mammoth and at Grant Village operate on an 8-hour day and each is open between the hours of 8 a.m. and 5 p.m. At Lake, the after-supper collection of food waste is also incinerated and incinerator cleanup takes place thereafter. Operating hours are from 8 a.m. to 8 p.m.

Operation of incinerators includes startup each day for a period sufficient to bring the furnace up to a proper temperature. Loading of the furnace starts with the arrival of the first packer truck. In order to provide a more uniform loading of the incinerator and to encourage a minimum storage of refuse awaiting incineration, the packers do not necessarily fill to capacity prior to a trip to the incinerator. The cost of collection is increased because of the inefficient use of the packer truck in making extra trips to the incinerator.

The use of incinerators throughout the park where a limited tourist season exists and an 8-hour operation is practiced leads to the rapid disintegration of the fire bricks in the hearths. The Mammoth incinerator has been in operation for less than nine years and is in need of major maintenance for hearth replacement.

Auxiliary Equipment and Personnel:

As previously mentioned, solid waste arriving at the incinerators is dumped in an unloading area near the guillotine door on the furnace. The equipment used in conveying waste to the furnace is a specially adapted front loader. This unit is equipped with a fabricated steel plow mounted on an extension attached to the loader bucket (see picture, Figure 4-7). A regular daily problem is the disposal of residue produced at each of the incinerators. Each day, as a bear management policy, all residue produced at Lake and Grant Village is disposed of at the Grebe Lake sanitary landfill site. The crew associated with the operation of each of the incinerators consists of one operator and one laborer.

Figure 4-7. FRONT-END LOADER CHARGING OPERATION



Annual Cost of Incinerators:

The accounting records of cost to operate the incinerators provide for all costs excepting those of depreciation of the fixed equipment associated with the installation. The cost of operation, including labor, fuel, equipment, and supplies for the incinerators of the associated districts, is shown in Table 4-5. Previous reports have estimated the per ton cost of incineration at $20.00. The actual cost per ton of waste incinerated during the 1971 season averaged $33.00. If consideration of depreciation of the fixed investment of facilities over a 10-year period is considered, the average cost per ton to incinerate solid waste in the park is $59.00 which is similar to costs found elsewhere.

Table 4-5. COST FOR INCINERATION OF SOLID WASTE

Incinerator Site	Volume Per Season, tons	1971 Amount[a]	Cost Per Ton[a]
Mammoth	405	$11,589	$29.00
Lake and Grant	760	$26,372	$35.00
Total	1,165	$38,231	$33.00 (avg.)

[a]Does not provide consideration for depreciation cost of existing facilities

SOLID WASTE DISPOSAL OUTSIDE THE PARK

As previously reported, solid waste-generating areas outside the park are of special concern when attempting to develop an integrated and effective long-range solid waste management system. Solid waste disposal practices in the area of study vary from individual disposal in open pits to privately owned collection and disposal companies using sanitary landfills.

West Yellowstone, Montana

Waste collected in West Yellowstone is disposed of at a sanitary landfill located approximately five miles north of the city on Forest Service property. The site is approximately 10 acres in size and has been in use since the spring of 1971. Operation of the site is through a contract with a private individual who also provides for the collection of solid waste in the city. Because the site is on Forest Service property, it is also used by that agency for disposal of solid waste collected from various campgrounds, picnic areas, and roadside rests in the immediate Forest Service area.

The site is subject to bear encroachment and, because of this problem, has been fenced with a 6-foot-high chain link fence and an electric fence five feet outside the main fence. Such provisions seem to be successful in discouraging bears from attempting to enter the disposal sites here, as well as in the park.

The site is in geologically similar material to that found inside the park. The material is primarily obsidian sand, extremely permeable and pervious. Although the site is above the water table, no seal is provided below the waste cells and leachate could pollute the aquifer immediately below the site. The proximity of the Madison River to this site poses another consideration of potential pollution.

Gardiner-Jardine-Corwin Springs, Montana

Disposal practices for these communities at the north entrance to the park consist of disposal to open pits on national park property. This practice is now illegal according to both Montana state law and federal law. In view of the Federal Executive Order relative to compliance with state standards, the Park Service has ordered the closing of the site for disposal operations. Some of the citizenry of Gardiner have organized a committee to explore the possibility of the formation of a refuse disposal district with the primary goal of obtaining and operating a new well-managed sanitary landfill site.

Silver Gate-Cooke City-Cooke Pass, Montana

The Silver Gate-Cooke-Cooke Pass Disposal District was recently formed for the express purpose of operating and maintaining a sanitary landfill for solid waste collected throughout the area. The sanitary landfill is approximately three acres in size, unfenced, and is located on Forest Service property. Operation is irregular at the present time, but being planned to provide operation during normal service hours.

Shoshone National Forest

Of concern in this report are those campgrounds, picnic areas, and scenic overlooks near the boundary of Yellowstone National Park where solid waste problems are those associated with tourism. Outside the northeast entrance to the park, an area administered by the Shoshone National Forest, is the Clarksford district. In this area, campgrounds, picnic areas, scenic overlooks, and a boat dock are serviced for solid waste collection and disposal by Forest Service crews. Disposal as presently practiced is to open pits that are covered several times during the peak tourist season.

Outside the east entrance of the park in the forest area, 19 campgrounds and picnic areas are serviced for solid waste collection by a private company under contract to the National Forest Service. Disposal is to the facilities at Cody, Wyoming.

Of general interest, the Shoshone National Forest is presently engaged in a project to define the solid waste volumes generated throughout its area and, during 1972, plans to develop a solid waste management plan within their area of control.

Chapter 5

YELLOWSTONE NATIONAL PARK LAND DEVELOPMENT and POPULATION

The type of development in Yellowstone Park is strictly that associated with the need to accommodate the annual tourist population by providing them with supplies, lodging, and recreation. In order to predict solid waste production in the park, it is necessary to know the type of development, a determination of existing and future permanent and tourist population, and the associated land use. Populations and land development patterns should be on the optomistic side in order to avoid undersizing facilities that are costly to duplicate.

EXISTING DISPOSAL SERVICE AREAS

In connection with the determination of existing solid waste production and the projection of future solid waste loadings, it is essential to identify the waste production potential by areas and subareas. For the purpose of this report, the three established maintenance districts (North, South, and West) shown in Figure 4-1 and discussed more fully in Chapter 4, will be used as service areas. In the North District, solid waste collection and disposal is practiced throughout the year while in the other two districts, limited winter operations forego the need for a regular service except during the main tourist season.

LAND USE

North District Service Area

Within the North District, there are three subareas--Mammoth, Norris, and Tower.

Mammoth Hot Springs is located along the northern section of the Grand Loop Road at its junction with the northern entrance (see Figure 4-1, Chapter 4). The village is the permanent park headquarters for the National Park Service and is the only year-round residential and tourist area in the park. Visitor accommodations include the Mammoth Inn with hotel and tourist cabins and the campground. Employee accommodations include a trailer village, several dormitories, and both seasonal and permanent apartments and residences. Types of visitor service facilities are delineated in Table 5-1.

The Norris area is located along the western portion of the Grand Loop Road near its junction with the Norris Canyon Road. Accommodations include the Norris campground and ranger station and a small government employee area. Other visitor facilities are delineated in Table 5-1.

The Tower area consists of two small developments, Tower Junction and Tower Fall, located on the Grand Loop Road in the vicinity of the junction with the Northeast Entrance Road. Visitor accommo-

dations include a campground at Tower Fall and lodge cabins at Tower Junction. Employee accommodations include a dormitory at Tower Fall and bunkhouse at Tower Junction. (See Table 5-1 for other visitor facilities.)

Table 5-1. VISITOR SERVICE FACILITIES

Facilities	Area									
	Mammoth	Norris	Tower	Old Faithful	Madison	Bridge Bay	Fishing Bridge	Lake	Canyon	Grant West-Thumb
Amphitheater	X		X	X	X	X	X		X	X
Marina						X				X
Cabins	X		X	X			X	X	X	
Campgrounds	X	X	X		X	X	X		X	X
Hotels-Motels	X			X				X		
Trailer Park							X			
Restaurants	X		X	X			X	X	X	X
Service Station	X		X	X			X	X	X	X
General Store	X		X	X			X	X	X	X
Laundry			X	X			X		X	X
Hospitals	X							X		
Post Office	X		X	X			X		X	X
Ranger Stations	X	X	X	X	X	X	X	X	X	X
Visitor Centers	X	X	X	X			X		X	X

West District Service Area

Within the West District, there are two subareas--Madison and Old Faithful.

The Old Faithful area, located on the northwest corner of the Grand Loop Road (see Figure 4-1), is the most heavily visited attraction in Yellowstone Park. The existing guest accommodations are the Old Faithful Inn, the Old Faithful Lodge, and the campers' cabins. (See Table 5-1 for other types of visitor facilities in the area.)

The Madison area is located on the Madison River at the intersection of Grand Loop Road and West Entrance Road. Existing facilities include a campground, a ranger station, an employee apartment building, a dormitory, and an employee trailer park.

South District Service Area

The South District consists of the Bay Bridge-Fishing Bridge-Lake subarea, the Canyon subarea, and the Grant-West Thumb subarea.

The Bridge Bay-Fishing Bridge-Lake area is located along the East Entrance Road and the southeast section of Grand Loop Road and occupies four miles of shoreline on the northern boundary of Yellowstone Lake as shown in Figure 3-1. Campgrounds are located at Bridge Bay and Fishing Bridge, and major hotel, lodge, and service facilities are at Lake (see Table 5-1).

The Canyon area, as shown in Figure 4-1, is located on the Grand Loop Road close to the geographical center of the park. Existing accommodations consist of motor lodge cabins and a campground. (Other service facilities are indicated in Table 5-1.)

The Grant-West Thumb area, located along the western projection of Yellowstone Lake near the intersection of the South Entrance Road and the Grand Loop Road, is shown in Figure 4-1. Recreational facilities at Grant are water-oriented. Overnight accommodations at Grant include a campground and a National Park Service trailer court. The Grant Village area is the newest visitor accommodation center in the park.

POPULATION WITHIN PARK

Over two million visitors have passed through Yellowstone Park each year since 1965. Figure 5-1 delineates the annual visitors to the park since 1900 when 8,928 persons viewed its scenic beauty. Since 1950, the number of visitors had doubled. Over 90 percent of the visitor attendance is concentrated between June 15 and Labor Day, the first Monday in September. Visitor attendance drops rapidly prior to and after this period and is almost negligible from November through April except for snow visitation.

Peak Season Population

The average length of stay for visitors in the park during the peak season is between one and two days. Activities during these stays include trips to the Grand Canyon of the Yellowstone, the several geysers (especially Old Faithful), and Mammoth Hot Springs. A tour along the 142-mile Grand Loop Road is also of considerable significance from the scenic and wildlife aspects. Accommodations are available at all the major population centers throughout the park. Table 5-2 delineates the overnight visitor accommodations in terms of population in each area, as well as the resident and permanent accommodations. Almost three-fourths of the accommodations are in the South District service area. During the peak season, particularly during July and August, virtually all of these accommodations are in full use. Figure 5-2 graphically shows the typical concentration of the visitor population during the peak months.

Winter Season Population

Winter season use of the park is largely for snow visitation. This is particularly true of the Old Faithful area. Table 5-3 shows the use of the park for winter sports for each entrance during the 1969-70 winter season. The west entrance, with 11,635 oversnow visitors, amounted to approximately 75 percent of the total. By far the largest use was by the small individually operated snowmobile. Table 5-4 summarizes the total annual snowmobile use in the park from the 1966-67 winter season through the 1969-70 winter season. Since the 1967-68 winter season, the number of passengers travelling on large passenger-carrying snowmobiles has remained almost stable while individually operated snowmobiles have enjoyed a rapid increase during the 4-year period with an 80 percent increase from the 1968-69 to the 1969-70 winter season and a 500 percent increase over the 4-year period.

Figure 5-1. PAST, PRESENT, AND PROJECTED POPULATION GROWTH

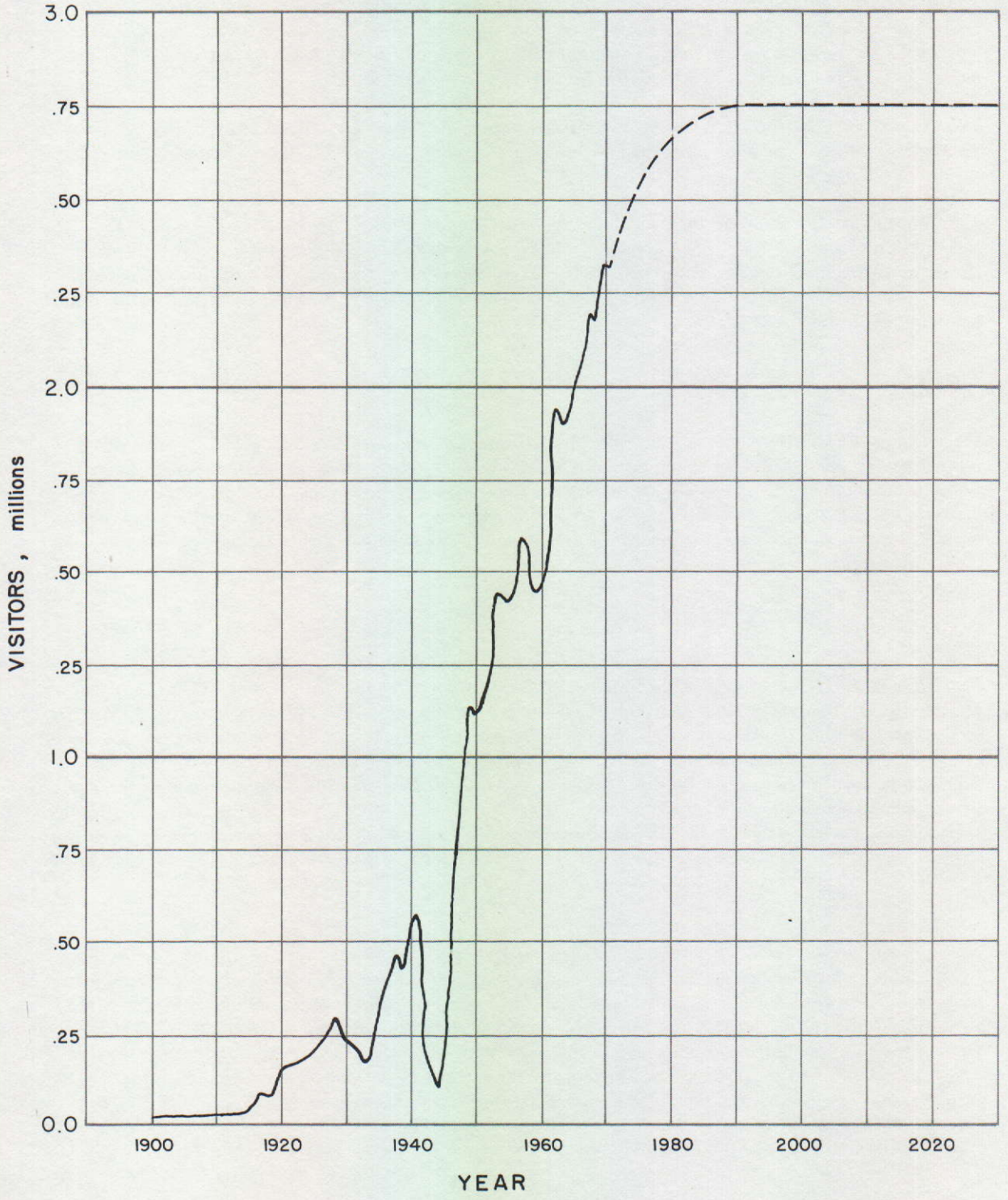


Table 5-2. VISITOR AND RESIDENT POPULATION THAT CAN BE ACCOMMODATED OVERNIGHT AT EXISTING FACILITIES[a]

Area	Population										Total Visitor Population	Total Resident Population
	Visitors					Residents						
	Campgrounds	Trailer Parks	Cabins	Hotels & Lodges	Other	Trailer Parks	Dormitories & Cabins	Residences & Apts.	Bunkhouses	Other		
North Service Area												
Mammoth	440	-	230	270	-	125	297	368	-	-	940	790
Norris	600	-	-	-	-	18	-	-	-	-	600	18
Tower	325	-	-	250	25	-	25	20	-	6	600	51
Subtotal	1,365	-	230	520	25	143	322	388	-	6	2,140	859
West Service Area												
Old Faithful	900	-	1,900	850	320	200	520	35	15	-	3,970	770
Madison	1,230	-	-	-	-	26	-	20	-	-	1,230	46
Subtotal	2,130	-	1,900	850	320	226	520	55	15	-	5,200	816
South Service Area												
Bay Bridge	2,200	-	-	-	-	-	-	4	-	-	2,200	4
Fishing Bridge	1,600	1,470	1,050	-	-	42	150	9	-	-	4,120	201
Lake	-	-	605	440	385	75	63	85	65	9	1,430	297
Canyon	1,300	-	-	1,400	-	165	560	84	8	-	2,700	817
Grant-West Thumb	2,000	1,000	-	2,400	-	55	1,025	80	-	85	5,400	1,245
Subtotal	7,100	2,470	1,655	4,240	385	337	1,798	262	73	94	15,850	2,564
Total	10,595	2,470	3,785	5,610	730	706	2,640	705	88	100	23,190	4,239
											Grand Total	27,429

[a]Source - Master Sewerage Study Yellowstone National Park, Wyoming Contract No. 14-10-7-971-137, November 1968

Table 5-3. OVERSNOW TRAVEL STATISTICS 1969-70 WINTER SEASON

Entrance	Snowmobiles				Skiers, Snowshoers, etc.	All Oversnow Visitors
	Passenger-Carrying Vehicles		Individually Operated Vehicles			
	No. of Vehicles	No. of Passengers	No. of Vehicles	No. of Passengers		
North	182	1,530	301	367	18	1,904
West	320	2,697	6,934	8,915	15	11,635
East	0	0	756	1,473	177	1,642
South	2	11	215	223	0	234
Northeast	0	0	0	0	0	0
Total	504	4,238	8,206	10,978	210	15,415

Figure 5-2. SEASONAL VISITOR POPULATION AT YELLOWSTONE NATIONAL PARK- 1969

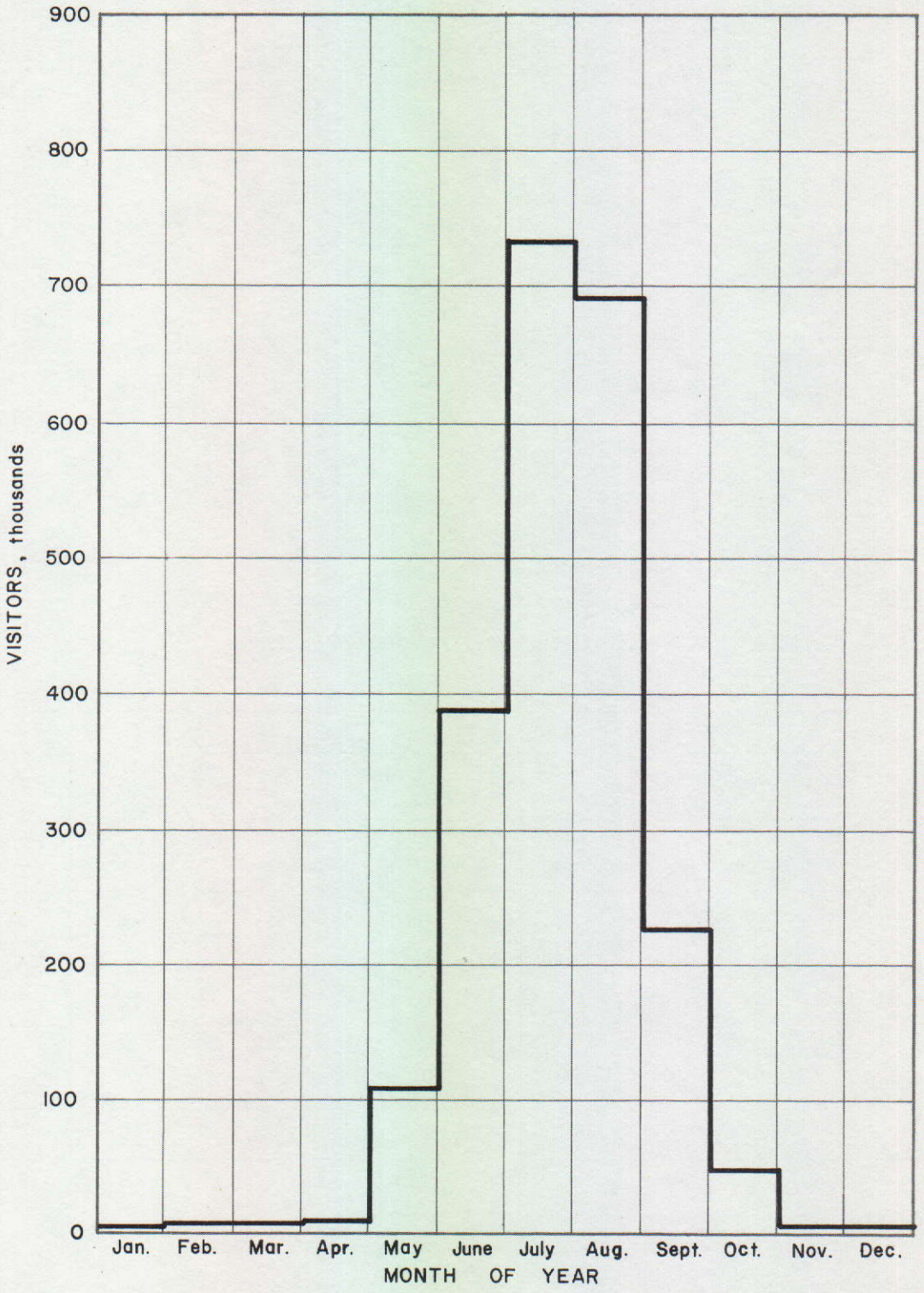


Table 5-4. SUMMARY RECORD OF SNOWMOBILE USE

Winter Season	Passenger-Carrying Vehicles			Individually Operated Vehicles		
	No. of Vehicles	No. of Passengers	Percent[a] Inc. or Dec.	No. of Vehicles	No. of Passengers	Percent[a] Inc. or Dec.
1966-67	349	3,045		1,544	2,173	
			+43.0			+58.0
1967-68	748	4,359		2,352	3,425	
			- 2.0			+77.0
1968-69	728	4,259		4,726	6,076	
			- 0.5			+80.0
1969-70	504	4,238		8,206	10,978	

[a]Persons only

Projected Population Growth

The National Park Service has placed maximum emphasis upon the protection of the environment in order to insure its unimpaired preservation. Conservation and management of the natural, historical, and recreational resources for their highest use is paramount. With respect to overnight accommodations, the present philosophy is to at least limit it to the current level. The replacement of obsolete facilities as necessary would continue, together with improvement of visitor use accommodations. The construction of bypass roads around villages will permit a gradual increase in the day visitor population. No increase in the overnight visitor population, as shown in Figure 5-1, is predicted, however, a gradual increase in day visitors is contemplated throughout the ensuing years. The population projections, as well as the projections of solid waste, reflect the current park philosophy of maintaining a "status quo" of most of the park facilities.

POPULATION OF ADJACENT COMMUNITIES

For the purpose of projecting solid waste productions in the communities adjacent to the park, per capita production factors will be employed since no historical records of production are available. Therefore, an estimate of past and projected population within these communities is essential.

Information relative to the community of Gardiner was abstracted from a water study prepared for the area by Morrison-Maierle, Inc. in January 1966. A design population, taking into consideration permanent residents, seasonal residents, and tourists, was estimated for the year 1987. These figures were reviewed and updated by Metcalf and Eddy Engineers in the 1968 report to the National Park Service on a Master Sewerage Study Yellowstone National Park, Contract No. 14-10-7-971-137. These updated projections for the year 1987 are used in this report and are as shown in Table 5-5.

For the community of West Yellowstone, the 1971 and the estimated 1985 populations are shown in Table 5-6.

Table 5-5. GARDINER POPULATION PROJECTIONS

Gardiner Population	1987
Permanent Residents - Town Proper	965
Yellowstone Park Company & National Park Service	35
Seasonal Residents - Town Proper	405
Yellowstone Park Company & National Park Service	110
Tourists	1,510
Total Peak Summer Population	3,025

Table 5-6. WEST YELLOWSTONE POPULATION PROJECTIONS

West Yellowstone Population	1971	1985
Permanent Residents - Town Proper	850	2,500
Seasonal Residents - Town Proper	2,000	8,000
Tourists	10,000	25,000
Total Peak Summer Population	12,850	35,500

Chapter 6

YELLOWSTONE NATIONAL PARK SOLID WASTE PRODUCTION, COMPOSITION, and PROJECTIONS

A knowledge of the diversity and kinds of solid waste generated is essential to the planning of any kind of associated facilities. However, in Yellowstone Park, as in most areas, there is almost a lack of detailed records pertaining to the quantities and composition of solid waste. Conclusions reached are not dependable unless such basic data is obtained. Recognizing this, the National Park Service authorized a field survey of the solid waste generated at Yellowstone National Park and Grand Teton National Park as part of this solid waste management study. Detailed information pertaining to these surveys is presented in Appendix A and the information presented in this chapter reflects the results obtained.

PRESENT WASTE PRODUCTION

A summary of the waste production factors for the various facilities within the park is shown in Table 6-1. The average loose weight of the refuse is in the neighborhood of 3.0 pounds per cubic foot or 81 pounds per cubic yard. By volume, the field sampling showed paper to comprise between 70 and 90 percent of the waste, whereas on a weight basis, it comprised about 40 to 50 percent of the waste. These production factors, together with the additional information gathered from the park refuse collection crews on quantity as part of the 4-day field survey (see Appendix A), were used in developing the daily peak season waste generation rates for the various areas and subareas within the park. Figure 6-1 shows graphically the distribution of refuse production in cubic yards throughout the park and Table 6-2 tabulates the quantities, both in cubic yards and tons.

PROJECTED WASTE PRODUCTION

The expected impact of new packaging materials on solid waste disposal, increase in use of nonreturnable containers or disposable packages, and the ever-changing consumer buying habits which increase the consumption per capita, indicate the desirability of revising waste generation factors in order to effect a more realistic projection of future wastes. It has been the experience throughout the nation that projections of solid waste production for planning purposes are usually underestimated. For the purpose of projecting needs for disposal, the waste generation factors shown in Table 6-3 were utilized and reflect an expected increase. The increases shown are somewhat below the expectation nationally, however, this is justified since park refuse contains only a limited portion of the waste included as part of the total solid waste picture.

Although per capita generation rates have been increasing in recent years due partly to the factors described above, a reduction in this rate of increase is indicated based on several fundamental ideologies.

Table 6-1. SOLID WASTE GENERATION FACTORS AT VARIOUS FACILITIES

Facility	Solid Waste Generated		
	pounds per cubic foot	pounds per capita per day	cubic feet per capita per day
Campgrounds	3.52	1.00	0.29
Cabins	2.82	1.34	0.46
Lodge Rooms	2.62	0.62	0.24
Employee Housing	2.62	1.20	0.46
Trailer Village	3.22	1.58	0.49
Construction Trailers	3.31	2.43	0.73
Ranger Station	2.66	1.17	0.44
Picnic Area	3.61	0.41	0.11
Hospital	2.89	2.15	0.75
Visitor Center	3.61	0.05	0.01
Restaurant[a]	3.36	0.76	0.23
Marina[b]	2.90	1.25	0.43
Service Station[c]	2.87	0.02	0.01
General Store	7.87	-	-
Roadside Rest	3.98	-	-
Roadside Litter	2.98	-	-

[a]per meal served instead of per capita per day
[b]per berth rented instead of per capita per day
[c]per gallon instead of per capita per day

First, there must and will be a reversal in the trend which permits the discard of our abundant resources. Discovery of beneficial uses through salvage, recycle, and reuse of the various ingredients in solid waste will eventually be realized. The awareness of the enormity of this problem is now in the process of emerging. Realizing this, it is logical to assume that annual per capita increases in generation rates will decrease in the ensuing years.

Secondly, the increasing awareness and sensitivity of the populace to the solid waste problem will bring about a change in the public attitude. Educational efforts directed toward industry and the consumer will assist in the awareness and enhance the trend toward the decrease in per capita waste generation rates.

Utilizing the generation factors shown and discussed above and the population estimates presented in Chapter 5, total annual production rates through the year 2000 have been developed and are shown in Table 6-4. Annual monitoring of waste loadings should be made to check the projections and to insure that no great change has taken place.

Figure 6-1. PEAK DAILY WASTE GENERATION VOLUMES IN YELLOWSTONE PARK AND AT NEARBY COMMUNITIES

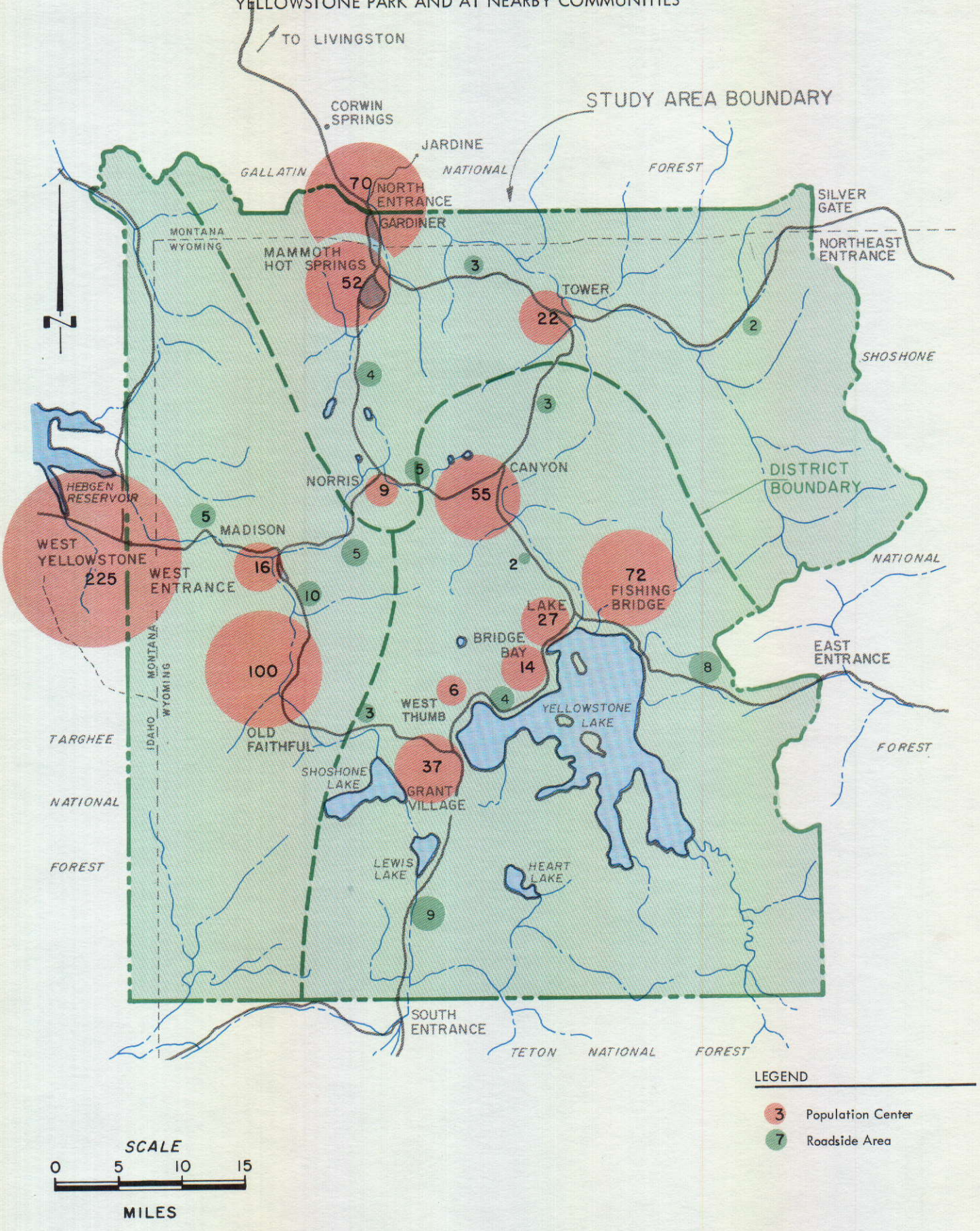


Table 6-2. PRESENT DAILY REFUSE PRODUCTION DURING PEAK SEASON

Facility	Refuse Produced	
	Cubic Yards[a]	Tons
North District Service Area		
Mammoth	52	2.1
Tower	22	0.9
Norris	9	0.4
Roadside	9	0.4
Total	92	3.8
West District Service Area		
Madison	16	0.7
Old Faithful	100	4.0
Roadside	20	0.8
Total	136	5.5
South District Service Area		
Fishing Bridge	72	2.9
Lake	27	1.1
Bridge Bay	14	0.6
Canyon	55	2.2
West Thumb	6	0.2
Grant Village	37	1.5
Roadside	34	1.4
Total	245	9.9
Total Volume Per Day	473	19.2

[a]Based on 81 pounds per cubic yard

Table 6-3. PROJECTED WASTE GENERATION FACTORS

Year	Increase in Generation Factor, percent per year
1971 to 1976	1.5
1976 to 1981	1.0
1981 to 2000	0.5

Table 6-4. PROJECTED SOLID WASTE PRODUCTION

Year	North Service Area		West Service Area		South Service Area		Park Total	
	cu. yd.[a]	tons	cu. yd.[a]	tons	cu. yd.[a]	tons	cu. yd.[a]	tons
1971	92	3.8	136	5.5	245	9.9	473	19.2
1972	93	3.9	138	5.6	249	10.0	480	19.5
1973	94	3.9	140	5.7	253	10.2	487	19.8
1974	95	4.0	142	5.8	258	10.3	495	20.1
1975	96	4.0	144	5.9	262	10.5	502	20.4
1976	97	4.1	145	5.9	264	10.6	506	20.6
1977	98	4.1	146	6.0	266	10.7	510	20.8
1978	99	4.2	148	6.0	268	10.8	515	21.0
1979	100	4.2	149	6.1	270	10.9	519	21.2
1980	101	4.2	151	6.2	273	11.0	526	21.4
1981	101	4.3	151	6.2	275	11.0	527	21.5
1982	102	4.3	152	6.3	276	11.1	530	21.7
1983	103	4.3	153	6.3	277	11.2	533	21.8
1984	104	4.3	154	6.3	278	11.3	536	21.9
1985	104	4.4	155	6.4	279	11.3	538	22.1
1986	105	4.4	156	6.4	280	11.4	541	22.2
1987	106	4.4	157	6.4	282	11.5	545	22.3
1988	107	4.4	158	6.4	283	11.5	548	22.3
1989	107	4.5	159	6.4	284	11.6	550	22.5
1990	108	4.5	160	6.5	285	11.6	553	22.6
1991	109	4.5	161	6.5	286	11.7	556	22.7
1992	110	4.5	162	6.5	288	11.8	560	22.8
1993	111	4.6	163	6.5	289	11.8	563	22.9
1994	111	4.6	164	6.6	290	11.9	565	23.1
1995	112	4.6	165	6.6	292	12.0	569	23.2
1996	112	4.6	166	6.6	293	12.1	571	23.3
1997	113	4.7	167	6.7	294	12.2	574	23.6
1998	113	4.7	168	6.7	296	12.2	577	23.6
1999	114	4.7	169	6.7	297	12.3	580	23.7
2000	114	4.8	170	6.8	298	12.3	582	23.8

[a]Based on 81 pounds per cubic yard

The present and the projected solid wastes for Yellowstone National Park and the nearby communities are presented in Table 6-5.

Table 6-5. PRESENT AND PROJECTED SOLID WASTES FOR YELLOWSTONE NATIONAL PARK AND NEARBY COMMUNITIES - TONS PER YEAR

Service Area	1971	1980	1990	2000
Yellowstone Park				
North District	380	420	450	480
West District	550	620	650	680
South District	990	1,100	1,160	1,230
Yellowstone Total	1,920	2,140	2,260	2,380
West Yellowstone	1,500	1,700	1,780	1,860
Gardiner	785	890	935	980

Chapter 7

YELLOWSTONE NATIONAL PARK

SOLID WASTE MANAGEMENT METHODS and CONSIDERATIONS

Many national parks throughout the United States were established with the objective of preserving the natural scenic beauties for present and future generations. These parks are areas where wildlife can roam without fear of being harmed or molested; where man can enjoy the natural environment in as near a pristine state as possible. The National Park Service has the responsibilities for maintenance and protection of the physical surroundings and environment of the national parks. Constant vigil is exercised to insure that the wildlife, such as bears, will not become dependent on food sources other than those normally found in their natural habitat. Any physical features that pose a threat to the environment are viewed as being in conflict with park philosophy. The disposal of solid waste within the confines of the park poses a threat of indeterminable magnitude which must be considered in the development of any such planning program. The National Park Service contends that, if at all possible, the ultimate solid waste management plan should point toward removal of the wastes from the confines of the park. To do otherwise would be incompatible with national park philosophy.

The plans presented in the following chapter investigate such an approach as well as continued disposal within the parks. Analysis of the plans should not be based strictly on monetary aspects but should be strongly influenced by any detrimental effects that might be placed on the park environment.

SOLID WASTE MANAGEMENT SYSTEMS

A solid waste management system consists essentially of storage, collection, transport, processing, salvage, and disposal. The goal of such a system is to maintain a healthful and aesthetically pleasing environment by providing for the regulation and operation of the best and most efficient system. In the discussions which follow, the various aspects of the systems and their criteria will be reviewed as they relate to the project.

Storage Methods

Storing solid wastes properly while they await collection is necessary to protect them from marauding bears, to prevent unsightliness, and keep them from attracting rats and flies. The responsibility for defining "proper storage" and enforcing standards rests with the National Park Service within the confines of the parks and with the Forest Service and the local governments in the areas surrounding the parks.

Metal and Plastic Cans:

The traditional tapered, galvanized steel can is the solid waste container most widely used throughout the park. The cans are limited to 20-gallon and 30-gallon containers, as they should not weigh more

than 80 pounds when loaded. Fifty-five-gallon drums are unacceptable because they are cumbersome and, when loaded, are too heavy for one man to lift safely. The use of plastic containers has found acceptance in many areas throughout the country due to their lighter weight, ease of cleaning, and rust resistance. However, within the park, they have found little use as they are susceptible to damage by marauding bears. Their inability to withstand freezing temperatures without cracking and their susceptibility for fire damage are other negative factors against their use in the park. As currently practiced, where necessary to prevent marauding bears from feeding on the refuse, metal cans would be provided with elaborate "mailbox" hoppers locked to each can (see Figure 4-2, Chapter 4). Plastic liners would continue to be provided in all instances. Their use increases the efficiency of collection and reduces the time required for cleaning the cans.

Bulk Containers:

Where large quantities of solid waste are produced and for wastes which are difficult to handle, the 20-gallon and 30-gallon cans may be replaced with large detachable metal containers varying in size from 4 to 40 cubic yards. Containers 4 to 10 cubic yards in size are used primarily with either a lift-and-carry or a packer loading-type vehicle, while 20- to 40-cubic yard containers are used with a truck that has a mechanism for pulling the container onto the bed of the truck for direct transport. Such container storage systems speed collection of large amounts of waste from commercial and industrial establishments.

To save storage space, some containers are equipped with their own compaction devices which, when full, are usually hauled piggyback on a truck to the disposal area.

Collection Methods

The collection system is influenced by the storage method, pickup point requirements, kind of waste, kind of equipment, and cost. Factors such as size of truck crew, truck capacity, and travel time are greatly influenced by the extent of service provided.

Metal Cans:

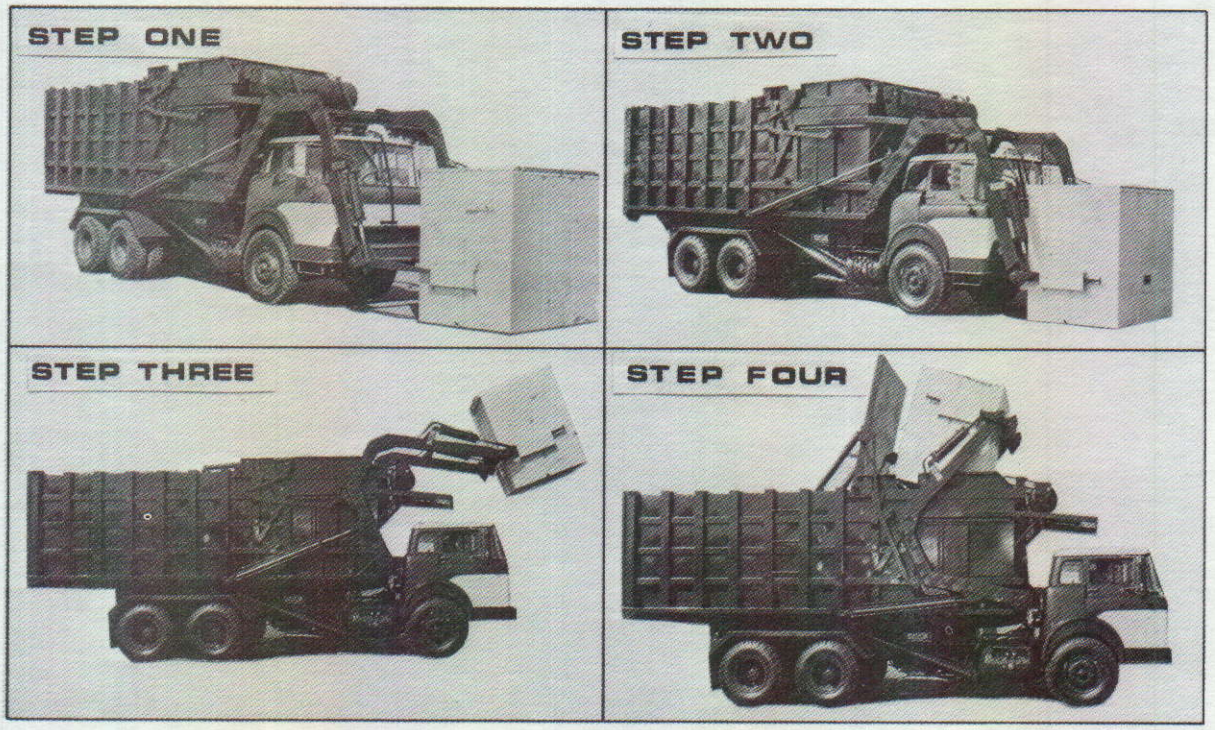
The collection of refuse from 20-gallon and 30-gallon cans is usually provided for by a rear-loading or side-loading, enclosed compaction truck. In operation, cans with plastic liners are picked up and dumped into a receiving compartment. After each deposit, a compaction blade is actuated and the refuse compressed into the packing compartment before the truck proceeds to the next pickup point. The collection truck continues this procedure until it has a full load, whereupon it proceeds to the disposal area where the load is dumped.

Open-body pickup trucks are not normally used in the collection of refuse from areas of high population. However, where storage areas are scattered, such as for roadside service, this means of collection may be the most economical in certain situations.

Bulk Containers:

Front-end-loading compaction trucks are used to handle metal containers ranging in size from 1 to 12 cubic yards. Containers for such use have lifting sleeves mounted on the sides. The truck, shown in Figure 7-1, approaches the loaded container from the front and engages the lifting sleeves of the container with its lifting arms. It then raises the container overhead and above the top opening in the body of the compactor causing the refuse to fall into the unit where the material is compacted by the action of a hydraulic packer plate. The empty container is spray-washed in the top position and then lowered to the ground and placed in position ready for more storage service. The collection truck then continues this procedure until it has a full load, whereupon it proceeds to the disposal area where the load is ejected.

Figure 7-1. CONTAINER HANDLING PROCEDURES



Rear-end-loading compactor trucks will also handle bulk containers in sizes up to 10 cubic yards. This type would probably adapt better to the collection conditions in the park. Container handling procedures for this type unit are shown in Figure 7-2.

For the 20- to 40-cubic yard open, enclosed compaction, and self-contained compaction containers, another method of collection and transport is practiced. This provides for a truck equipped with a special tilting frame carriage which provides for the loading and unloading of the containers. The containers are pulled up onto the tilted frame carriage by a chain, cable, bail, or loading arms. The frame is then lowered to the horizontal position, the container pulled forward, and locked in position for transport to the disposal area (see Figure 7-3). After discharge of its contents, the empty container is then returned to its original location and put off for further use. Enclosed containers of 40-cubic yard capacity are used with stationary compactor units in small transfer stations and transported when full with a unit of the type mentioned above.

Secondary Transportation

When the distance or travel from the collection route to the disposal site is great, the transfer of wastes from the collection vehicles to larger transport vehicles may be desirable. In such instances, direct hauling of refuse to the disposal area can create a number of problems. Much valuable equipment is ineffectively employed in taking collections directly to the place of final disposal. Frequently, the

Figure 7-2. REAR LOADER CONTAINER HANDLING





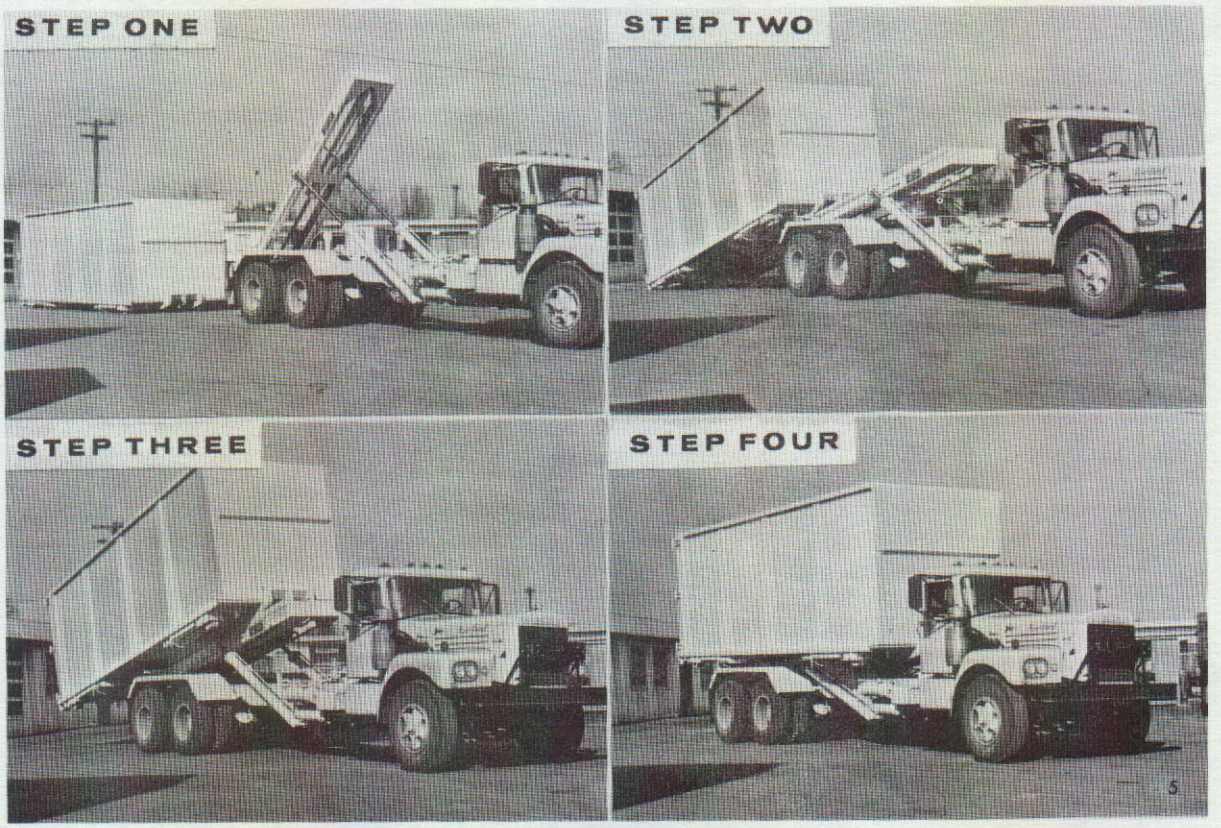


men working the collection route accompany the refuse truck to the disposal site, further increasing the ineconomies of using route trucks for long-distance haul. A secondary transportation system can provide a place for collection trucks to unload near their routes and eliminate the need for long-distance hauling in small vehicles. A few large transport vehicles (40, 65, and 75 cubic yards) would then convey the refuse to the disposal area.

Transfer is justified when it saves more in collection costs than the transfer itself costs. Secondary transportation costs, including amortization of facilities and operational costs, are dependent on the sophistication and capacity of the transfer facility. Haul costs also vary depending on the sophistication and capacity of the transport equipment. Considering the many variables involved in a secondary transportation system, the determination of whether direct haul (these costs also vary depending on vehicle capacity) or transfer and transport is most economical should be based on an analysis of each particular case. Secondary transportation costs quoted in the literature are often misleading since most often the specifics of the secondary transportation system are not known and many times miscellaneous costs of operation are not included.

A graphic representation of the comparison of direct haul versus transfer and haul is shown in Figure 7-4. A transfer station having a unit transfer cost of $1.50 per ton is compared with direct haul by collection vehicles of various capacities. Also shown is the comparative cost of transport vehicles with 10- and 20-ton capacities. The average speed of all vehicles was assumed to be 40 miles per hour. This graph indicates that, for a 10-ton transport vehicle, the transfer system would become economically feasible at 30 minutes and 70 minutes round-trip haul times, respectively, when compared to direct haul by 4-ton and 6-ton collection vehicles, respectively. For a 20-ton transport

Figure 7-3. HANDLING PROCEDURE FOR 40-CUBIC YARD CONTAINER



vehicle, round-trip haul times of 22 minutes and 39 minutes become economical when compared to direct hauls by 4-ton and 6-ton collection vehicles, respectively.

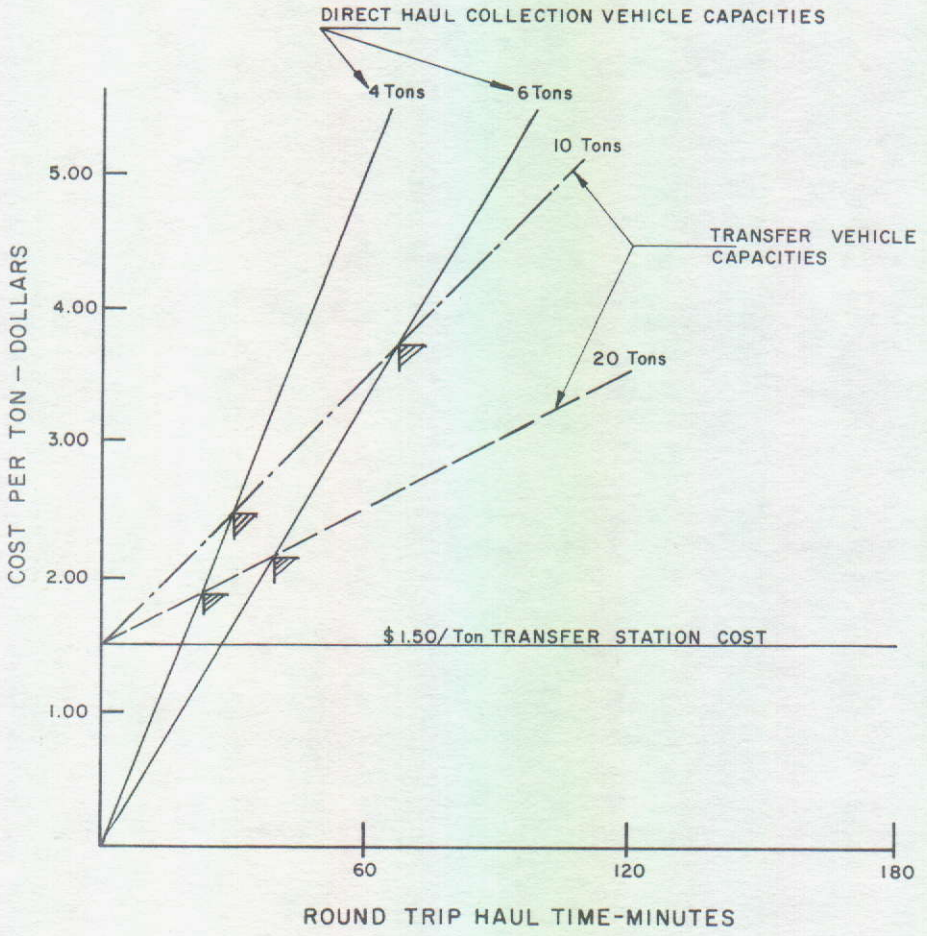
The above graphic presentations of cost of direct haul versus transfer and transport was presented as evidence of the general relationship of these cost factors. The costs of transfer systems for specific applications were determined on the basis of the specific equipment and facilities required. Comparisons with direct haul systems were made to determine the most economical method of hauling wastes to the disposal site.

Transfer Stations:

A transfer station is a facility designed for the transfer of refuse from the collection vehicle to a larger capacity transport vehicle for the express purpose of reducing the cost of the "direct haul" from completion of the collection route to the disposal site. When a transfer station is utilized, transport is identified as the round-trip driving time from the transfer station to the disposal site.

Station efficiency is a primary design consideration. The number of vehicles entering a station at any given period of time must be able to unload with a minimum of delay. Station and transportation

Figure 7-4. TRANSFER STATION VERSUS DIRECT HAUL COST RELATIONSHIP

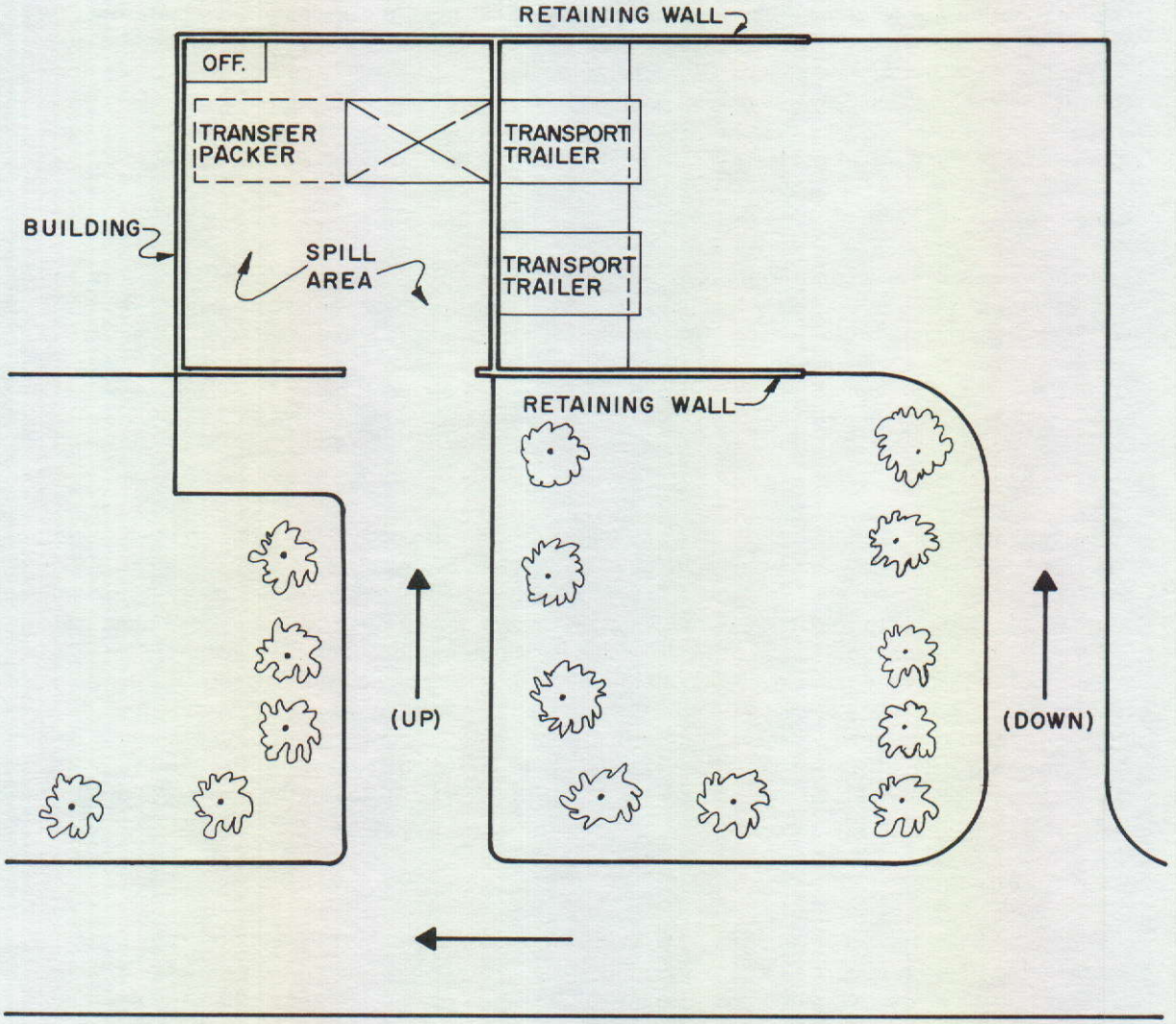


equipment must be reliable and adequate reserve or standby equipment must be available to handle emergencies. In the northern climates, the station should be roofed and enclosed. Enclosure prevents the accumulation of rainwater or snow on the dumping floor. It also helps prevent unsanitary conditions and restricts the blowing of paper. Dust control facilities should be provided. The transfer station should be kept as simple as possible. Simplicity provides a system more reliable than a complicated station and is easier to maintain. The layout of a typical transfer station which might be acceptable for use in the park is shown in Figure 7-5.

There are two basic types of transfer station designs--those which load the waste directly into the transport vehicle and those which deposit wastes into a storage area before loading them into transport vehicles. The former type is the one proposed for use in the park with a limited area provided for the temporary storage of loose refuse.

The location of a transfer station should be as near the center of production of its service area as possible. The ultimate consideration in locating a transfer station or deciding if one is needed at all is

Figure 7-5. TYPICAL PARK TRANSFER STATION



economics. If the cost of driving route trucks to the disposal site is greater than the cost of operating a transfer station and transport system, then the secondary transportation system is justified.

Transport Vehicles:

Transport vehicles, in the past, have been open semitrailers into which the refuse is dumped directly. Some compaction was obtained using a stationary backhoe machine to push loose refuse down into the trailers. In recent years, the use of compactor trailers as transport vehicles has been gaining popularity. Weight restrictions on highways limit the amount of the load. For transfer facilities of the capacity proposed, 40-cubic yard containers equipped for use with a stationary compactor would be provided. A truck equipped with a special tilting frame carriage for loading and unloading, as previously described and shown in Figure 7-3, would be used as the transport vehicle.

Pretreatment Methods

The light weights and low densities of many types of solid wastes have resulted in the transportation of large volumes of waste at relatively high cost per ton. Likewise, these wastes, because of their low densities, occupy large initial volumes in landfills and are subject to a high degree of settlement. Numerous efforts have been made to consolidate these wastes in order to reduce the cost of transportation and the space required at the disposal area. The methods discussed below have been used to prepare solid waste for disposal.

Shredding:

The pulverizing of refuse to reduce its size and increase its density and, thus, reduce subsequent settlement in a landfill has been under extensive investigation. Shredding changes the appearance of refuse so that areas may be filled with shredded refuse which otherwise would be unacceptable. Shredding is also particularly useful for reduction of the volume of garden trash, oversized waste, and other materials for which disposal is a problem at landfills and for which introduction of the material into an incinerator is a problem. In connection with the use of shredding equipment at landfills, operational problems have been largely due to failure of the compaction equipment hauling the refuse from the shredder to the disposal area. Recent installations have employed conveyors to minimize such problems. Noise and dust are problems in connection with the use of shredding equipment. Cost for this pretreatment process ranges from $1.50 to $2.50 per ton. Justification for its use in the proposed project depends upon land premium and odor control.

Separation:

In order to reclaim recyclable materials, they must first be separated from the bulk refuse. Currently, most recycled material is separated by hand. Newspaper, cardboard, glass, and metals are either segregated at the production source for separate collections or hand-separated at the central disposal area. Because the former is labor-intensive, it is too costly for large-scale recycling operations. Automatic separation of recyclable materials is presently under investigation on pulverized or shredded refuse at a full-scale experimental plant. Several automatic sorting systems have been developed for the separation of specific materials. Ferrous metal can be separated from shredded refuse by magnets. Fiberous materials, for use in making paper, are separated by pulping, screening, and washing bulk shredded refuse; this method is costly and has not been satisfactorily proven. A stepped vortex chamber is being developed at the Massachusetts Institute of Technology to separate shredded refuse into its many constituents based on their density and drag characteristics. The Zig-Zag air classifier developed at Stanford Research Institute separates shredded refuse into light and heavy fractions. The light fraction can either be incinerated or composted. Metals, glass, and heavy plastics can be readily separated from the heavier fraction by magnets and floatation methods. The Zig-Zag system has proved more efficient than any other type of air classification to date.

The recycling of salvageable materials is currently not justified in the park due to the limited quantity and lack of established markets within reasonable distances.

High-Compression Baling:

The packaging of municipal refuse in compressed bales with and without an outer wrapper has been proposed as a pretreatment step to the disposal of refuse by landfill and ocean disposal. The primary objective of baling is, of course, a reduction in the volume of the refuse. The manufacturers claim volume reductions varying from 3 to 1 to 30 to 1 and bale densities from 1,100 to 2,500 pounds per cubic yard, dependent upon the type of refuse. When applied to municipal refuse without gleaning, a volume reduction of 6 or 7 to 1 is probably realistic with a compacted density of 1,600 to 1,800 pounds per cubic yard (60 to 70 pounds per cubic foot). The cost of baling has not been well-established. It is estimated that the disposal cost for a 250-ton-per-day facility may be in the order of $5.50 per ton.

The proposed uses of baled waste, such as covering them with asphalt or concrete for use in building blocks or for ocean disposal, have not proven acceptable. In landfills, a compacted density of 1,000 pounds per cubic yard should be consistently realized. Therefore, baling presents the potential of increasing volume reduction by 30 to 35 percent over that attainable in a sanitary landfill. Based on the indicated cost of baling, it is doubtful that this reduction in land requirement could establish economic feasibility. However, other advantages accrue from baling, and outstanding in this regard is the fact that refuse loses its identity when compressed into a package of the densities noted. None of the objectionable characteristics normally associated with refuse remain. The moisture content is sufficiently reduced so that odors and insect problems are eliminated. The bale is sufficiently dense to prevent rodents from boring and, thus, breeding; the problems of litter in transport and handling are eliminated; and, fire hazards are essentially nonexistent. Baling could very likely become a pretreatment element in future disposal schemes where the volume is large. There is not sufficient volume of refuse produced in the park to establish economic feasibility for a facility of this type.

Composting:

Composting is the process in which aerobic bacteria break down organic wastes to a relatively stable, inoffensive humus under controlled conditions. This process is only suitable for certain types of waste matter. Noncompostables, such as bottles, glass, plastics, ceramics, rags, tin cans, etc., must be separated from the incoming refuse. The compostables must be ground or shredded to reduce the particle size to a point at which the material is readily susceptible to bacterial attack. Two classes of composting are mechanical digestion and modified windrowing. Mechanical digestion involves the use of enclosed devices which include provisions for maintaining the composting mass at a suitable moisture contact, temperature, and degree of aeration. No such mechanical devices are used in windrow composting. Instead, the shredded material is stacked in windrows in the open. Periodically, the material is turned for the purpose of aeration.

The lack of a continuous market for the composted material has been the primary cause of failure in this county. There may be some future application of composting in an integrated recovery process. The unit cost of composting ranges from $5.00 to $14.00 per ton for mechanical composting. Lower unit values reflect inclusion of salvage operations.

Disposal Methods

The technology of solid waste disposal has not realized any significant advancement since inception of the disposal methods in common use today. Incineration and landfill are the principal disposal methods employed and may or may not be carried out in conjunction with salvage. The improvements in these disposal systems have been largely in the area of management and operation. Sanitary landfills have progressed, in some localities, from unsupervised open dumps with open burning to well-managed and

-operated sanitary landfills totally acceptable in close proximity to residential developments and properly planned to protect environmental values during the operational phase while yielding useful land which enhances the aesthetics of the area when completed. Incineration similarly has progressed from unsupervised, intermittently charged, single-chamber furnaces to properly planned, designed, managed, and operated incinerators capable of meeting the most stringent air pollution requirements and presenting the potential for recovery of thermal energy. The improvements in each case resulted not from the development of new technology, but the need to apply good design, management, and operation techniques to the basic system in order to protect and preserve our environmental values. The "cheapest method of disposal" can no longer be the basic criteria for selection of a disposal system and the manner in which it is operated. Economics is a proper consideration, but the comparison of alternatives must be on the basis that each method affords equal protection of the environment and the conservation of resources.

Protection of Air and Water Quality:

The impairment of air and water quality by processes associated with solid waste disposal should be considered in the selection of a disposal method. Possible harmful effects of solid waste disposal on water quality are summarized as follows: (1) depletion of dissolved oxygen caused by oxygen-demanding materials; (2) bacteriological contamination; (3) physical impairment of surface streams by sediments and floating debris; (4) increased mineral content (increases in ion concentrations of constituents such as chloride, sulfate, bicarbonate, sodium, and potassium) caused by discharge of mineral salts; (5) increase in hardness stimulated by carbon dioxide gas; (6) nutrient enrichment; (7) change in pH resulting from carbon dioxide gas; and, (8) hazards of deleterious concentrations of uncommon constituents and toxic compounds. The processes which are involved in producing these harmful effects are: (1) physical removal; (2) leaching; and, (3) gas production.

Good judgement and sound engineering practices are essential in site selection which should include a knowledge of the physical environment of the site. A sanitary landfill properly located, designed, and operated can dispose of solid waste without creating a nuisance or a hazard to public health or safety. To protect against the contamination of surface waters, provisions must be provided for adequate drainage. If proper drainage is not provided, the percolation and resultant runoff can cause deterioration of the physical characteristics, biological quality, and chemical composition of the surface waters with which it comes in contact. Areas subject to storm flow or flood hazards should be avoided.

To protect against the contamination of groundwater, a solid waste disposal site should be located so that there is no possibility of pollutants gaining access to an aquifer of a useable groundwater supply. Solid waste disposal may adversely affect groundwater quality by two processes: the percolation of leachate and the migration of carbon dioxide gas from the disposal site into the underlying groundwater. The effects that these two processes may have on the quality of the groundwater are greatly controlled by the geologic and hydrologic characteristics of a disposal site. The geologic factors include the type of materials underlying the site (gravel, sand, silt, clay, rock) and their competence as a barrier or retardant to the movement of the leachate or carbon dioxide into the groundwater. The hydrologic factors include the position of the groundwater and its proximity to the disposal site and the rate and direction of groundwater movement.

The geological and hydrological factors constitute a very complex three-dimensional zone underlying a disposal site. This zone can be basically divided into two portions which are separated by the groundwater table. Technically, these portions are referred to as the "zone of aeration" and the "zone of saturation". The "zone of aeration" is that part of the soil sediments between the land surface and the water table. The "zone of saturation" is comprised of the sediments saturated with groundwater and extends downward through the waterbearing sediments beneath the water table. Solid waste materials placed in the upper zone above the water table remain in the position where they are placed undergoing the various processes of decomposition. One threat to the groundwater arises if a landfill becomes saturated by infiltration causing leachate to discharge from the lower part of the landfill. The greatest

possibility of discharge of leachate to groundwater occurs at disposal sites underlain by highly permeable materials such as sand or gravel. At disposal sites located where sediments, such as shale or clay, of extremely low permeability lie between the solid wastes and the groundwater body, a low degree of hazard exists.

Biological decomposition of the organic material in a landfill produces gases, primarily methane and carbon dioxide. Studies of gas production in landfills indicate that the rate of gas production rises to a peak level (referred to as a "bloom") during the early life of the landfill. From that point in time, the rate of gas production slowly decreases, trailing on until decomposition processes cease many years later. Gas production is affected by various environmental conditions occurring in the landfill. One of these, the moisture content of the landfill, substantially regulates the rate of gas production. The addition of water increases the gas production while low moisture levels will deter decomposition processes, therefore resulting in lower gas production rates.

Movement of landfill gases horizontally and vertically away from the landfill is largely unimpeded due to the small size of the gas molecules compared to the size of the pore openings of the adjacent soil. Because the molecular weight of the carbon dioxide gas is higher than air, it tends to sink, resulting in a downward movement which may cause it to contact the capillary fringe of the groundwater and the groundwater itself. Due to the low solubility of methane in water, it presents no threat to water quality; however, it is a significant threat to the environment because of the hazards of explosion. The carbon dioxide is of consequence since it can be dissolved in water possibly leading to deterioration of water quality. The undesirable effects of carbon dioxide dissolved in water are due to secondary reactions produced under the weak carbonic acid conditions resulting from the reaction of the water and the gas. The theoretical effects include hardness of the water and increased corrosiveness of the water. An attitude of uncertainty prevails regarding the actual effect that carbon dioxide gas migrating from a landfill has on underlying groundwater.

Effective control of atmospheric pollution is extremely important. Entrained particulates and some gaseous products are the major air pollutants from the incineration of solid waste. Gaseous emissions for which attention has been directed toward their control are sulfur oxide, nitrogen oxides, carbon monoxide, hydrogen chloride, and total hydrocarbons. In the specific case of solid waste incineration (except open burning), emission of all these gaseous contaminants is well below present and contemplated criteria.

Gas-suspended particulate emissions have been subject to restrictive quantitative limits by the federal government in the operation of federal facilities. Particulate emission standards for federal installations are 0.10 grains per standard cubic foot (29.92 inches Hg and 70°F) of dry flue gas corrected to 12 percent carbon dioxide. Any proposed incinerator should be capable of meeting this requirement.

Incineration:

The term "incineration" describes the disposal process whereby refuse is reduced in volume by burning before final disposal. The residue generally represents less than 15 percent of the total volume of combustible refuse and may reduce the land disposal requirements for this fraction of the waste by 90 percent. Modern incineration accomplishes this by combining the process of drying wet refuse and burning it in a single chamber within a furnace. The refuse moving slowly through the furnace is consumed, the residue being disposed on land, whereas gaseous by-products of combustion are discharged to the atmosphere. Incineration reduces the volume of material to be handled but is not a complete method of disposal.

Some of the advantages that are attributed to incineration are that: (1) it requires less land than the landfill method of disposal; (2) a more central location for the facilities is possible; and, (3) a residue is produced that contains small quantities of organic material and has less nuisance than raw refuse. A disadvantage is that the comparative capital and operating costs are high. Depending on the size



and type constructed, the initial cost will generally vary from $4,000 to almost $10,000 per ton of rated daily capacity, whereas the operating cost can range from $5.00 to $9.00 per ton of rated daily capacity, including residue disposal and amortization. Also, skilled employees are required to operate, repair, and maintain the incinerator.

For incinerators under 200-tons-per-day capacity, refractory-lined furnaces are generally used. One of the major operating and maintenance costs of such units is refractory replacement. Furnace relining is a costly operation ranging in cost from $30 to $35 per square foot. Damage to the refractory is caused by overheating, slagging, chemical reactions, erosion of the furnace lining by materials in contact with the brick, and by heating and cooling of the furnace. The employment of personnel competent to understand the problems involved in refractory furnace operations is necessary. This type of incinerator is the one considered for use in the park.

Due to the relatively small tonnages of refuse produced within the park, it would be necessary to use a batch loading incinerator with guillotine-type charging doors. The units would be multichambered and the exhaust gases cleaned with modern air pollution control equipment adequate to meet federal emission requirements. Ash hoppers would be provided large enough to store residue for several hours.

The two types of air pollution control devices capable of meeting the required standards are the wet scrubber and the electrostatic precipitator. In the wet scrubber, the gases may be bubbled through a water bath or water injected into the gas stream. The water traps the dust particles, which are removed, and the water treated if it is to be recirculated. Electrostatic precipitators are a high-efficiency dry dust collector. The precipitator consists of a series of plates between which are suspended wires. Dust particles receive an electric charge from the wire and are attached to the oppositely charged plates and, thus, removed from the gas stream. The material which collects on the plate is removed to a receiving hopper by automatic rappers which vibrate the plate and dislodge the dust. Operating costs between the two type units show the wet scrubber to cost almost double that of the electrostatic precipitator.

Operating personnel is an important consideration in incinerator costs. Many incinerators are understaffed, having insufficient manpower to adequately maintain the plant and grounds. Considering the need for controlled operation to reduce refractory replacement costs, the additional manpower costs would be more than offset by savings in maintenance and replacement costs.

Sanitary Landfill:

A sanitary landfill represents a refined method of open dumping where problems related to health and safety, water pollution, and public nuisance common to open dumping are minimized or eliminated. It consists of the basic operations of spreading, composting, and covering the refuse daily. There are four methods used for sanitary landfilling which are summarized as follows:

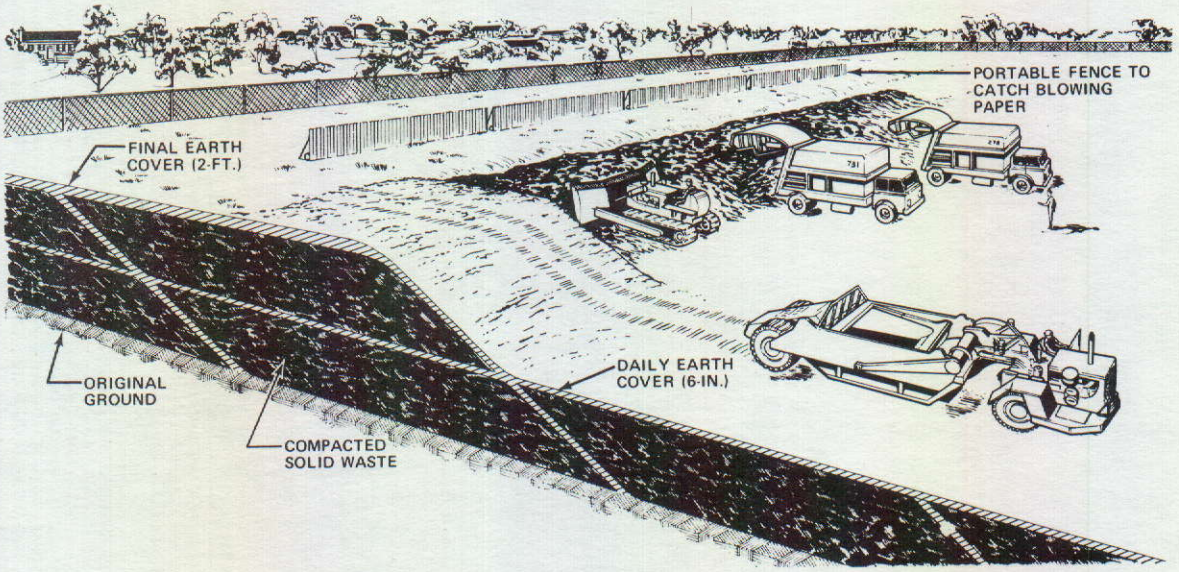
Area Operation:

Earth is excavated in front of the continuously progressing fill and is placed over the top of the deposited refuse as cover (see Figure 7-6).

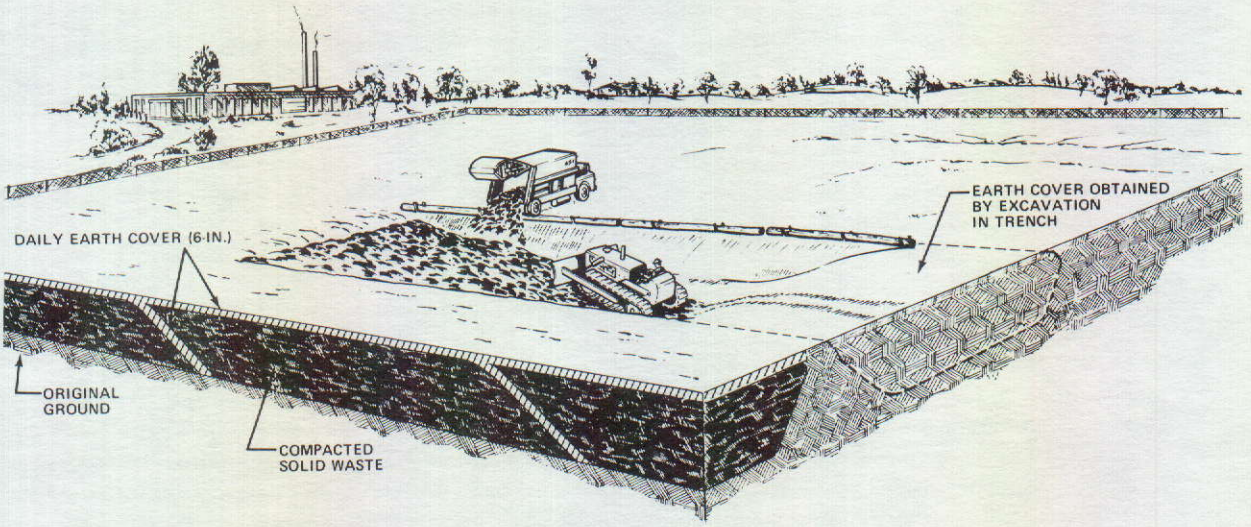
Trenching Operation:

Similar to the area operation except that a trench is completely excavated and the material is stockpiled for future use as cover. The trench is filled with refuse, compacted in cells, and covered with a seal of the stockpiled earth (see Figure 7-6).

Figure 7-6. SANITARY LANDFILL METHODS



AREA METHOD



TRENCH METHOD

Canyon Operation:

A canyon is filled with alternate layers of refuse and cover material. The sides of the canyon are usually used as the source of cover material.

Pit or Abandoned Quarry Operation:

This method is similar to a canyon operation. The pit or abandoned quarry can be filled with alternate layers of refuse and dirt by either dumping from the top of the pit or by building from the bottom up. No high degree of compaction is possible except by building up. Drainage may be a problem in a pit or canyon operation and surface diversion ditches are usually needed to carry surface water from the disposal site.

Selection of a site involves consideration of topography, accessibility, haul distance, cost, pollution potential, cover material, proximity of residences, and ultimate usage. Sites should be selected to meet the needs for at least a 10-year period, but preferrably for a 20- to 30-year period. It is important to select a site that can be easily reached on highways or major streets. Roads to the site should be of such width and construction to handle all sizes of trucks when fully loaded, during all weather conditions. The availability of cover material is another economic factor to consider in choosing a site for the cost of hauling cover material to the site can be excessive. A field investigation of the potential site should include soil analysis to determine the suitability and quantity of soil availability for cover material. Soil with good workability and compaction characteristics is the most desirable cover material.

The potential danger of surface and groundwater pollution from the landfill should be given primary consideration. Site selection should include a geological investigation of the site to determine the pollution potential. Information should be obtained on the historical high groundwater levels and on the general movement of the groundwater, as well as potential flooding conditions on the site during heavy rains or snow melts. Generally, a landfill should not be located in a flood plain due to the flood hazard and usability during these periods.

Climatic conditions are important considerations in site selection and may even dictate the method of operation. In an extremely cold locality such as in the Yellowstone National Park, a site requiring excavation of trenches and cover material may become a problem because of the frost during the winter months. However, a site requiring excavation operations can be used in such a locale if special operating procedures are planned in advance to cope with the expected problems. Trenches should be excavated and cover material stockpiled during the months preceding the extreme weather conditions in sufficient quantity to handle the waste to be disposed of during freezing weather. Calcium chloride can be admixed into the soil to prevent freezing or it can be covered with tarpaulins or leaves. Tarpaulins should be dark to absorb the sun's heat. The bottom of the trench should be sloped to one end to collect rainfall, which should be pumped out before it freezes.

Operation of a sanitary landfill involves a thorough knowledge of such factors as compaction, working face, depth of cells, and cover. Solid waste should be placed at the top or base of the working face, spread in thin layers of about 2 feet thick, and compacted. In general, better compaction will normally result if the wastes are spread and compacted from the base upward. The degree of compaction is dependent on the character of the solid waste, the weight and type of compaction equipment, and the number of passes the equipment makes over the material. The working face should be kept as narrow as possible to minimize the exposed area, but not so small as to interfere with the unloading operations and movement of landfill equipment. The depth of cell or the thickness of the solid waste layer is determined largely by the size and conditions of operation. Eight feet is generally accepted as the maximum single cell depth because deeper cells usually result in fills that have excessive settlement and surface cracking. Cover material applied at the end of each day's operation, or more frequently if necessary, should be with a minimum of 6 inches of compacted earth. Soils of a more sandy nature

may require a greater depth. For intermediate cover on lifts, a minimum of 12 inches of compacted earth is recommended. Final earth cover over the completed site should be a minimum of 2 feet of compacted earth unless the soil is of a sandy or granular nature.

A wide variety of equipment is on the market from which to select the proper size and type needed for the particular operation. The most common equipment used on sanitary landfill is the crawler or rubber-tired tractor equipped with a dozer or trash blade. It is versatile and can normally perform most of the operations--the spreading, compacting, covering, and trenching. Other equipment normally used only at large sanitary landfills are scrapers, compactors, draglines, rippers, and graders. The size of the equipment is dependent primarily on the size of the operation. In general, for the size of operation proposed at the park, a 10- to 15-ton crawler tractor would be provided. Accessories provided for use with this equipment should be a dozer blade, a 2-cubic yard front-end loader, and a trash blade. A building should be provided for maintenance and storage of the equipment and sanitary facilities. The total cost of disposal at a properly designed, managed, and operated sanitary landfill, including amortization of all capital costs, varies with the fill rate and sophistication of the facility. A site receiving 400 tons per day can dispose of refuse at about $1.00 per ton, while the total cost of disposal at a site receiving 50 tons per day could cost as much as $6.50 per ton. The cost of operation used in the report is based on the particular situation, taking into account any peculiarities in operation.

Salvage:

Salvage or recycling and reuse is the recovery of waste material and goods. Recycling can be divided into four general groups based on the extent to which the material is processed for reuse. Those methods which involve the reuse of material in the form in which it occurs in the waste stream constitute the first group. This is the type which generally brings to mind the use of the returnable bottle. The second type includes those methods which involve a change in the form of the material. The residue in the form in which it exists in the waste stream is subjected to processing whereby it is reduced to a state such that it can be fabricated into objects having the original form or into totally different forms. Use of scrap iron in steel making of grounded glass and of paper fiber are the most common examples. In the third group are those which involve a chemical change in the raw material with the result that an entirely different class of material is formed. This change can be brought about by physical, chemical, or biological means. Formation of chemical compounds through pyrolysis of solid wastes is one example. The hydrolysis of cellulose to glucose through bacterial activity is another. In the fourth group are those methods which lead to the release and use of energy. An obvious example is the use of thermal energy from incineration to convert water to steam and then to electricity.

The feasibility of reclamation as an alternative means of disposal is dependent on the material to be salvaged, the market value of the salvaged material, the reclamation process used, and the attitude of those who bear the cost. One of the problems in the area of the park is its nearness to a possible market and the quantities involved. Current efforts to develop schemes that would make recycling or salvage economical could materialize in the future. Therefore, disposal methods should be designed to permit future incorporation of such operations in the waste stream.

BASIS OF COST ESTIMATES

In order to properly evaluate each alternative, it was necessary to establish the criteria upon which they would be compared and evaluated. Those include price base, construction cost, annual costs, and rated capacity.

Prices used were based on the cost of labor and material for mid-1972 when the Engineering News Record Construction Cost Index (20-City) is estimated to be 1,650. Alternative plans were compared on the basis of total annual cost with depreciation being compared on a straight-line basis. Rental

charges and labor costs were those in current use at the park. Life of buildings and structures was taken at 35 years and for equipment, 9 years. For incinerators, the rated capacity was taken as three times the 8-hour-per-day refuse production rate. Design and construction of incinerators and transfer stations provide for first-class construction.

Chapter 8

YELLOWSTONE NATIONAL PARK

PLANS for SOLID WASTE MANAGEMENT

The preceding chapter of this report indicate that the solid waste disposal needs of Yellowstone Park can be met by utilization of the sanitary landfill method or incineration plus a reduced-size sanitary landfill for disposal of residue. Disposal could be carried out independently or in conjunction with the various communities surrounding the park. Sites could be located in certain areas within the park which would protect the groundwater from impairment. However, the continued use of land within the park for such purposes might be considered as "land pollution" from a conservation point of view. Certainly such usage does not lend itself totally to the maintenance of the park environment in a pristine state. Whether the usage of small acreages within the park for sanitary landfill purposes is in concert with long-range park philosophy is the crucial point and not that of strict economics. The alternatives presented in this chapter consider both possibilities and the evaluations cover the various facts associated with selection of a recommended plan.

SOLID WASTE MANAGEMENT PLANS

Plans for solid waste management were developed and analyzed for the two basic possibilities of disposal, namely, sanitary landfill and incineration with residue disposal to land. Both methods of disposal were investigated for both a singular and an areawide approach. An analysis was made of direct haul by the collection vehicle to the disposal area versus transfer from the collection vehicle to a transport vehicle and transport to the disposal area. In analysis of the plans, it was necessary to develop certain assumptions to form the basis for proper comparisons of alternatives. The following criteria were used in the analyses.

1. All collection or transport trucks hauling refuse to the disposal area would proceed only when they had a full (or nearly full) load. One and one-half-ton pickup trucks (and sometimes $1\frac{1}{2}$-ton stake trucks) would transfer their loads to the packer trucks in case of direct haul or to the transfer station, depending on the plan under consideration.

2. In cases of collection vehicles to the disposal area, it was assumed that the entire collection crew (driver plus laborers) would accompany the vehicle to the disposal area when such trip is during the normal 8-hour shift. When the trip required time beyond the normal 8-hour shift, only the driver would accompany the vehicle to the disposal area. Any overtime pay was assumed on a straight-time basis at the regular hourly rates.

3. When a transfer station was used in the West District, the number of collection vehicles was reduced to one packer truck and one $1\frac{1}{2}$-ton stake truck with a corresponding reduction in operating personnel. Although, in some of the alternatives, it is conceivable that the

number of trucks might be reduced in the South District, this was not done in view of the additional problems associated with the bears in this area.

4. In plans employing transfer stations, it was assumed that the containers used for transfer would be held no more than three days before transporting them to the disposal area or until filled. This extended period could be reduced if it caused any problems with odor or associated bear attraction.

5. In all plans, costs were based on efficient use of equipment and personnel.

Description of Solid Waste Management Plans

The solid waste management plans considered for Yellowstone Park are described briefly in the following paragraphs.

Plan 1:

This plan proposes that each of the three maintenance districts within the park haul the refuse to separate sanitary landfill sites outside the park (see Figure 8-1). The disposal sites would be used jointly with the communities in the contiguous areas. The existing collection vehicles would haul direct to the disposal sites. In this plan, the bear problem in the South District and the related need to collect refuse after the evening meal, as well as after the two day meals, creates a problem with respect to the additional time required for haul from the collection route to the disposal area. It currently takes between 9 and 9½ hours to provide three collections per day and dispose of the waste at the existing sites. If the same service were to be provided, the additional time required to haul the refuse to the disposal sites proposed in this plan would be 2, 3, and 2½ hours for the Canyon, Lake-Fishing Bridge, and Grant Village areas, respectively. This is indicated in Table 8-1 which also shows the time requirements assumed for collection and haul for the various plans. Collection times were those indicated as currently required to complete the necessary pickups.

Providing larger collection vehicles would not correct this problem as the existing equipment has sufficient capacity to handle the quantities of waste generated in each area without the need to haul the waste to the disposal site more than once a day. Therefore, in the analysis of this plan, it was assumed that the drivers would work whatever additional hours were required to provide the necessary services.

Plan 2A:

This plan proposes that the waste generated in the West and South Districts would be delivered to a transfer station in each district and transferred to 40-cubic yard transport containers (see Figure 8-2). Every other day, a special transport vehicle, described in Chapter 6 under Secondary Transportation, would haul the 40-cubic yard transport containers to an areawide sanitary landfill outside the north entrance to the park in the Gardiner area. Solid waste generated in the North District would be hauled direct to the disposal site as would those from the community of Gardiner. The use of a transfer station in the South District would minimize the problems discussed in Plan 1 in connection with direct haul of refuse to the disposal site. Haul times would be 1, 0, and 1½ hours for Canyon, Lake-Fishing Bridge, and Grant Village areas, respectively (see Table 8-1). Wastes generated by winter operations at the Old Faithful area would be retained in the storage recepticals until spring or disposed of to West Yellowstone and would be the same in all plans considered.

Plan 2B:

This plan is similar to Plan 1 except that the collection vehicles in the West and South Districts would haul direct to the areawide sanitary landfill outside the north entrance of the park (see Figure 8-2).

Figure 8-1. SOLID WASTE MANAGEMENT PLAN 1

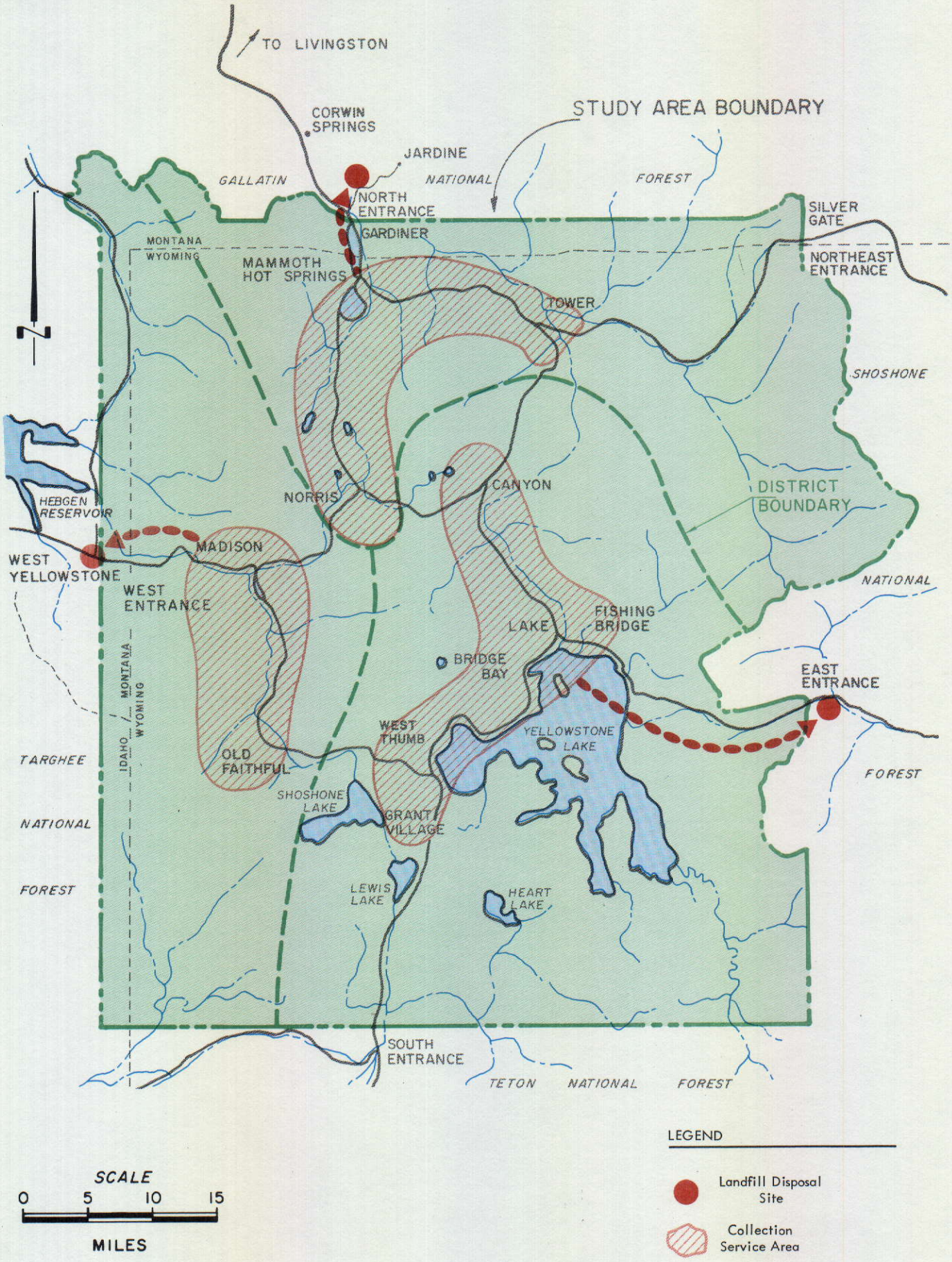
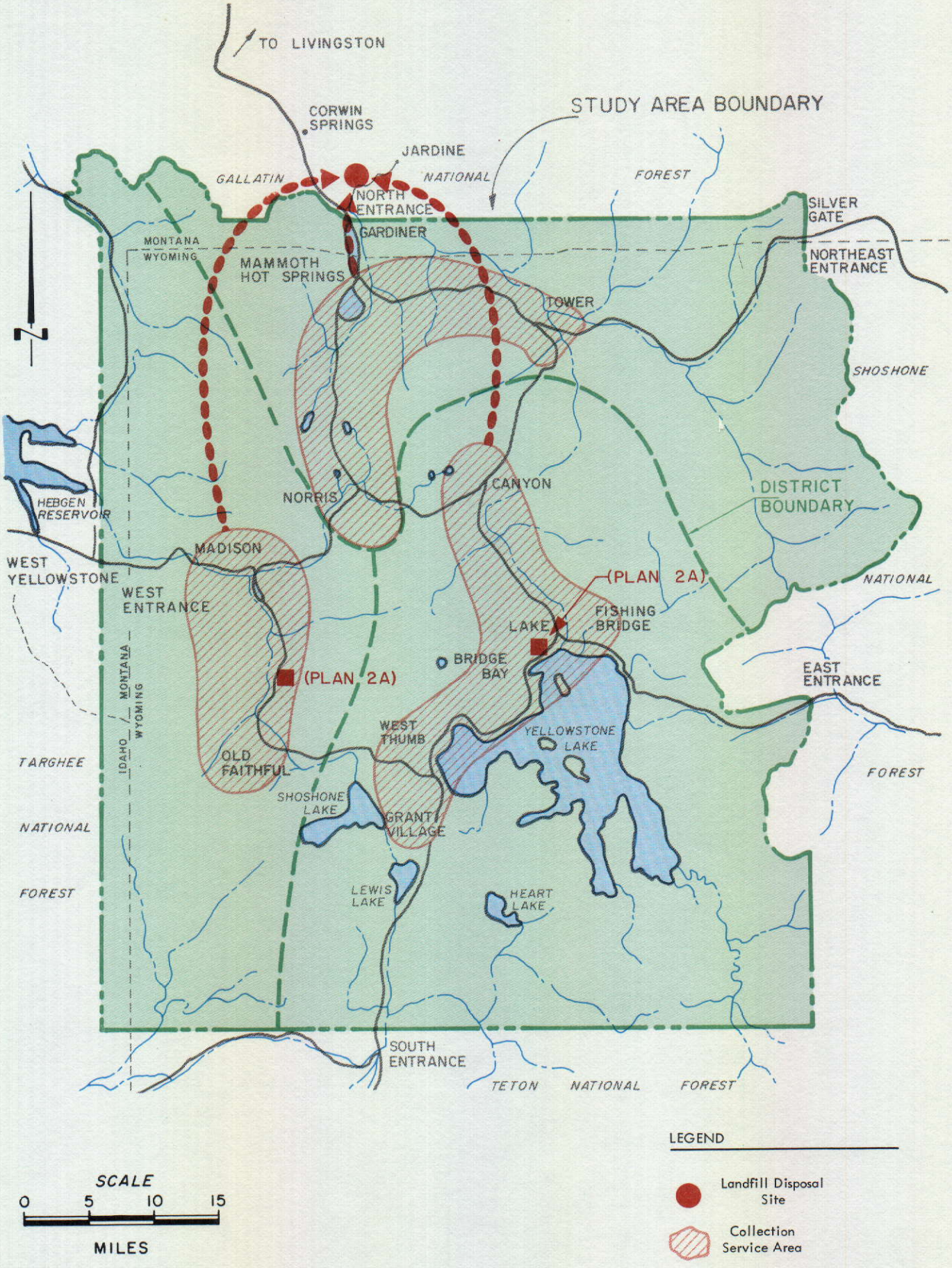


Figure 8-2. SOLID WASTE MANAGEMENT PLANS 2A AND 2B



Problems related to the time required for direct haul to the disposal area would be as described in Plan 1 and shown in Table 8-1 only more severe.

Table 8-1. TIME REQUIREMENTS FOR COLLECTION AND HAUL DURING PEAK SEASON IN THE VARIOUS PLANS

Plan	District	Packer Trucks				1½-ton Stake Trucks				Pickup Trucks
		No.	Collection, hrs.		Haul, hrs.	No.	Collection, hrs.		Haul, hrs.	Collection, hrs.
			Actual	Extra			Actual	Extra		
1	North	2	5	2	1	2	5	2	1	-
	West									
	Madison	1	3½	3½	1	1	3½	3½	1	-
	Old Faithful	1	6	½	1½	1	4	2½	1½	-
	South									
	Canyon	1	9	-	2	-	-	-	-	10
	Lake	2	9½	-	3	2	7	-	1½	10
	Grant	1	9½	-	2½	1	7	-	2½	-
2A & 4A	North	2	5	2	1	2	5	2	1	-
	West									
	Madison Old Faithful	1	9½	1	-	1	7	1	-	-
	South									
	Canyon	1	9	-	1	-	-	-	-	10
	Lake	2	9½	1	0	2	7	1	0	10
	Grant	1	9½	-	1½	1	7	-	1½	-
2B & 4B	North	2	5	2	1	2	5	2	1	-
	West									
	Madison	1	3½	2	2½	1	3½	2	2½	-
	Old Faithful	1	6	-	3	1	4	2	3	-
	South									
	Canyon	1	9	-	2½	-	-	-	-	10
	Lake	2	9½	-	3	2	7	-	3	10
	Grant	1	9½	-	4½	1	7	-	4½	-
3 & 5	North	1	6	½	1½	1	6	½	1½	-
		1	4	1½	2½	1	4	1½	2½	-
	West									
	Madison	1	3½	3½	1	1	3½	3½	1	-
	Old Faithful	1	6	-	2	1	4	2	2	-
	South									
	Canyon	1	9	-	½	-	-	-	-	10
	Lake	2	9½	-	1½	2	7	-	1½	10
	Grant	1	9½	-	2½	1	7	-	2½	-

Plan 3:

This plan proposes that all waste generated in the park be disposed at a central sanitary landfill within the park. Collection vehicles would haul the waste direct to the disposal area (see Figure 8-3). Problems with respect to the time required for direct haul to the disposal area are greater than in Plan 2A but less than Plans 1 and 2B (see Table 8-1). During winter, waste generated in the Mammoth area would be disposed of at a small landfill located inside the park.

Plan 4A:

This plan is similar to Plan 2A except that the waste would be hauled to a new incinerator in the North District near Mammoth (see Figure 8-4). Residue would be disposed of at a landfill in the area.

Plan 4B:

This plan is similar to Plan 2B except that the solid waste would be hauled to an incinerator in the Mammoth area (see Figure 8-4). Residue would be disposed of as in Plan 4A.

Plan 5:

This plan is identical to Plan 3 except that the solid waste would be hauled to a central incinerator and the residue disposed of at an adjacent landfill (see Figure 8-5).

Land Requirements for Sanitary Landfill

The land requirements for sanitary landfill over any period of time will depend upon the planning and management of the disposal site, as well as the total quantities received. For the purpose of determining land requirements, compacted densities of 600 pounds per cubic yard were assumed. In all cases, an average fill depth of 16 feet was assumed. For lesser fill depths, land requirements would increase and for greater fill depths they would decrease.

Utilizing the solid waste projections from Chapter 5, the cumulative quantities shown in Table 8-2 were developed. The land area requirements are tabulated in Table 8-3. The required areas include an allowance of 1 part earth per 3 parts solid waste by volume (compacted).

Table 8-2. CUMULATIVE SOLID WASTE PROJECTIONS - TONS

Service Area	Year		
	1980	1990	2000
Yellowstone Park			
North District	4,040	8,410	13,040
West District	5,870	12,130	18,750
South District	10,490	21,840	33,870
Yellowstone Total	20,400	42,380	75,660
West Yellowstone	16,000	33,400	51,600
Gardiner	8,380	17,510	27,090

Figure 8-3. SOLID WASTE MANAGEMENT PLAN 3

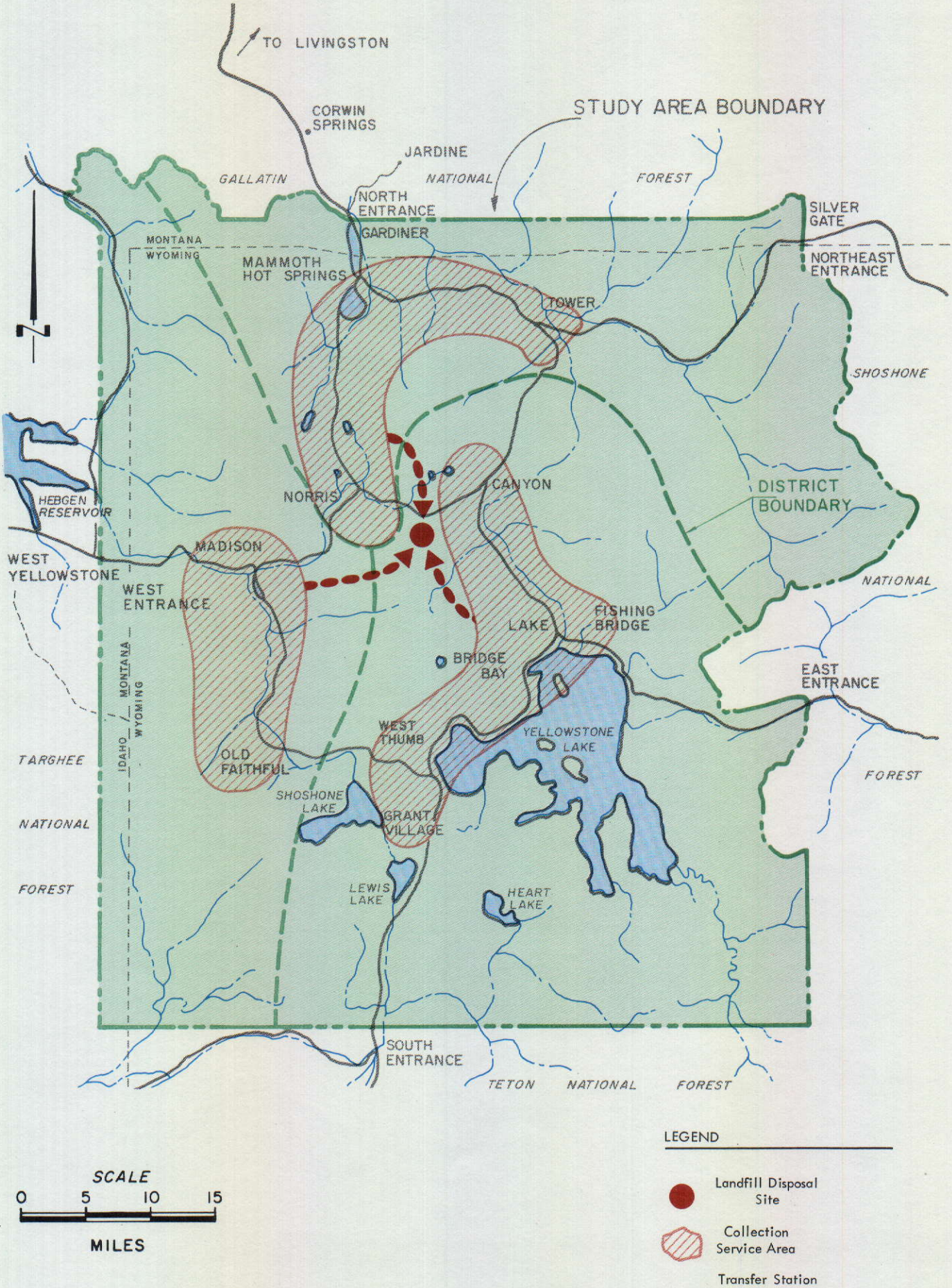


Figure 8-4. SOLID WASTE MANAGEMENT PLANS 4A AND 4B

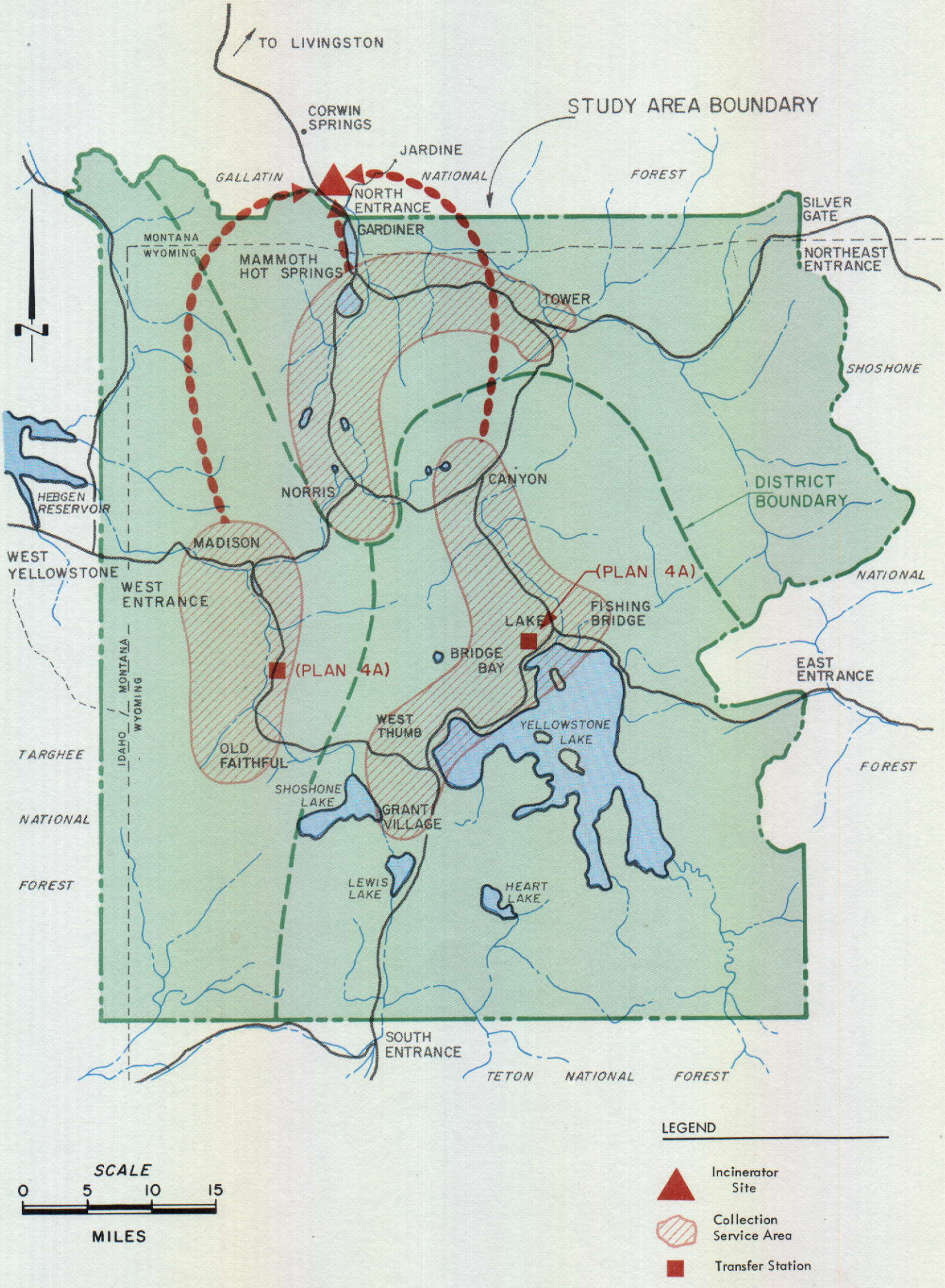


Figure 8-5. SOLID WASTE MANAGEMENT PLAN 5

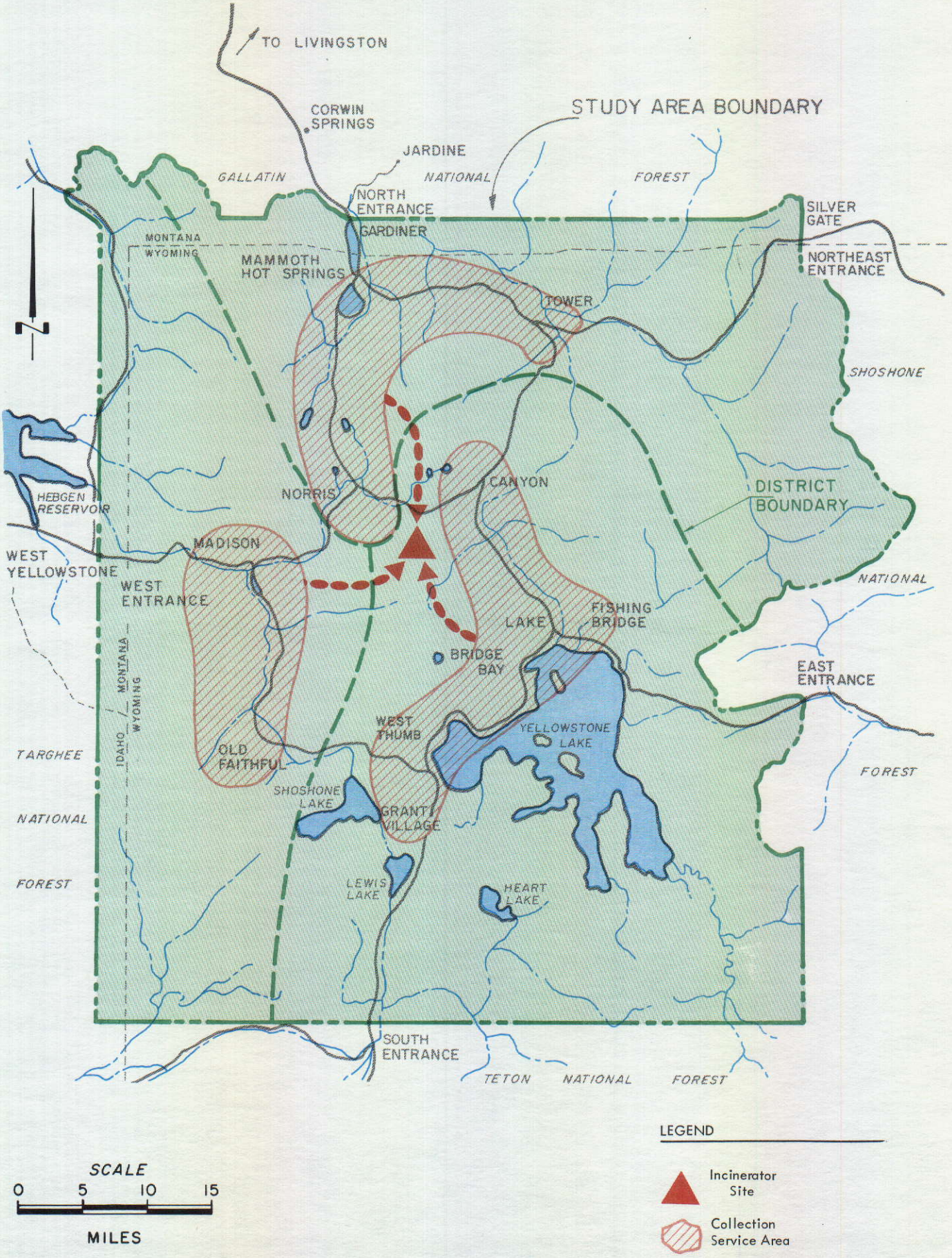


Table 8-3. SANITARY LANDFILL AREA REQUIREMENTS - ACRES[a]

Service Area	Year		
	1980	1990	2000
Yellowstone Park			
North District	0.7	1.5	2.3
West District	0.9	2.2	3.2
South District	1.8	3.8	5.8
Yellowstone Total	3.4	7.4	11.2
West Yellowstone	2.7	5.6	8.7
Gardiner	1.5	3.0	4.6

[a]Landfill area requirements based on a completed fill depth of 16 feet and compacted densities of 600 pounds per cubic yard.

Capacity Requirements for Incinerators

The capacity of an incinerator is based on its 24-hour rated capacity. Since operation of an incinerator in the park is based on an 8-hour day, the required capacity of the incinerator would be three times the maximum solid waste production rate with allowance for future growth. For Plan 4, the incinerator was rated at 100 tons per day and for Plan 5, it was 90 tons per day.

Evaluation of Solid Waste Management Plans

The solid waste management plans previously described were developed in detail and evaluated on the basis of economics and subjectivity. Capital costs of equipment and improvements were developed for each plan from which the annual operation and maintenance costs for the various plans evolved (see Table 8-4). The time requirements for collection and haul in the various plans, shown in Table 8-1, were used in this analysis.

Comparison of Solid Waste Management Plans

In general, the principal factor to be considered when comparing plans is cost. However, in many cases, cost alone is not sufficient to permit a valid comparison and other subjective factors must be considered. In the comparisons which follow, all such factors were investigated and analyzed.

Economic Comparison:

Table 8-1 shows Plans 2A and 2B to have almost equivalent total annual costs with Plans 1 and 3 just slightly greater. From the standpoint of economics, there is no major difference between the four plans. Plans 4A, 4B, and 5, in which disposal is by means of incineration, the costs are significantly greater. These higher annual costs accrue primarily to the greater capital cost for an incinerator and its attendant operation and maintenance costs.

Table 8-4. SUMMARY OF ANNUAL OPERATION AND MAINTENANCE COSTS[a]

Plan	District	Collection Cost,$	Haul Cost,$	Transfer Cost,$	Disposal Cost,$	Total Cost,$
1	North	28,610	3,554		8,100	40,214
	West	23,317	5,057		4,000	32,374
	South	89,045	9,446		12,790	111,281
	Total	140,972	18,057		24,890	183,919
2A	North	28,610	3,554		2,700	34,864
	West	14,835		10,080	4,000	28,915
	South	90,110	2,355	19,060	7,250	118,775
	Total	133,555	5,909	29,140	13,950	182,554
2B	North	28,610	3,554		2,700	34,864
	West	20,317	11,394		4,000	35,711
	South	88,700	12,791		7,250	108,741
	Total	137,627	27,739		13,950	179,316
3	North	27,910	7,884		3,600	39,394
	West	25,507	6,235		5,350	37,092
	South	88,520	7,719		9,650	105,889
	Total	141,937	21,838		18,600	182,375
4A	North	28,610	3,554		12,400	44,564
	West	14,835		10,080	18,500	43,415
	South	90,110	2,355	19,060	33,500	145,025
	Total	133,555	5,909	29,140	64,400	233,004
4B	North	28,610	3,554		12,400	44,564
	West	20,317	11,394		18,500	50,211
	South	88,770	12,791		33,500	135,061
	Total	137,697	27,739		64,400	229,836
5	North	27,910	7,884		16,500	52,294
	West	25,507	6,235		24,700	56,442
	South	88,520	7,719		44,500	140,739
	Total	141,937	21,838		85,700	249,475

[a]Based on 1971 conditions

Subjective Evaluation:

Seven subjective criteria have been used in the comparison of solid waste management plans. These are: (1) public health, (2) ease of operation, (3) conformance to National Park Service philosophy, (4) aesthetics, (5) reliability, (6) safety, and (7) regionalization. These criteria were ranked numerically for

each of the selection criteria listed above. When this was done, the invididual rankings of each plan were totaled and their relative standing determined. The results are shown in Table 8-5.

Table 8-5. SUBJECTIVE EVALUATION OF SOLID WASTE MANAGEMENT PLANS

Selection Criteria	Plan						
	1	2A	2B	3	4A	4B	5
Public Health	6	9	10	6	8	8	6
Ease of Operation	5	8	8	10	2	3	3
Conformance to National Park Service philosophy	10	10	10	0	10	10	0
Aesthetics	6	8	10	8	8	8	8
Reliability	5	10	8	8	5	4	4
Safety	3	8	3	5	8	3	5
Regionalization	1	8	8	3	8	8	3
Total	36	61	57	40	49	44	29

From the standpoint of public health, Plan 2B ranks highest because all solid wastes are directly removed from the park and only one disposal site is required. Plan 2A has a slightly lower ranking since solid wastes are retained for a brief period at the transfer stations. Plans 4A and 4B were given a lower ranking due primarily to possible effects of emissions on the atmosphere.

With respect to ease of operation, Plan 3 ranks highest because it has the least amount of equipment and facilities to maintain. In Plan 2B, the additional time required for haul in the South District complicates the operation and, therefore, must be given a lower rank in this category. Plan 2A is ranked lower in this category since it has a transfer station to operate and maintain. Plans 4A, 4B, and 5 are more difficult to operate because of the incinerator.

From the standpoint of reliability, Plan 2A has the decided advantage of having the transfer station which would provide a space for storage of solid waste in case of equipment breakdown. It is dependent on only one landfill which is located in the North District service area where year-round operations require the availability of disposal facilities at all times. Plan 2B is not as reliable due to its full dependence on collection equipment for transport, whereas Plan 3 does not fulfill the winter needs as well as Plans 2A and 2B. Plans 4A, 4B, and 5 depend on considerable equipment to operate successfully.

From the standpoint of conformance with National Park Service philosophy, all plans removing waste from the park were given maximum ranking and those disposing of solid waste within the park zero ranking.

With respect to aesthetics, Plan 2B was ranked highest because all solid wastes are immediately removed from the park and only one disposal site must be maintained. All other plans were given a slightly lesser rank due either to the physical presence of an incinerator, a transfer station, or a greater number of disposal sites to maintain.

From the standpoint of safety, Plans 2A and 4A received the highest ranking because they had the least requirements for vehicles to be on the park roads during the busy hours of the day. Plans 1, 2B, and 4B received the lowest ranking because of the requirements for direct haul.

With respect to regionalization, Plans 2A, 2B, 4A, and 4B rank highest because these four alternatives all allow for the greatest singular control of the largest possible solid waste. The singular control established by regionalization generally does lead to greater economy of operation, maximum reliability, and lower unit costs. Plans 3 and 5 have a lower ranking due to utilization of two sites and Plan 1 is the lowest due to the utilization of three separate sanitary landfill sites, in addition to a separate sanitary landfill site for Gardiner.

Selection of Solid Waste Management Plan

On the basis of economics, Plans 2A and 2B are lowest. However, Plan 2B would complicate operations in the South District due to the added time required for direct haul of the collection vehicles to the disposal area.

Plans 4A, 4B, and 5 offer advantages from the standpoint that less land is required for disposal than the landfill method of disposal. The incinerator itself can be situated on a relatively small parcel of land. Residue disposal requires less land than for landfilling raw refuse. A more central location is possible. The operation of the incinerator is generally not affected by climate or unusual weather conditions. In contrast, an incinerator is expensive in capital cost as well as operating cost. Skilled employees are required to operate and maintain an incinerator. Maintenance and repair costs are higher due to the equipment and construction of an incinerator. The incinerator does not complete the job of disposal since residue and fly ash must be transported to a landfill site for disposal. The high capital and operation and maintenance costs rule out these alternatives.

Based on the subjective analysis shown in Table 8-5, Plan 2A received the highest ranking and has a number of distinct advantages from the standpoint of safety, reliability, and ease of operation.

On the basis of both the economic and subjective evaluations, Plan 2A is recommended as the plan for implementation.

Recommended Solid Waste Management Plan

In the recommended plan, transfer stations would be constructed in the Old Faithful and the Lake-Fishing Bridge areas. The facilities would consist of a building to cover the unloading area. The building would house the hopper feeding a stationary compactor beneath the loading level. Outside and to the rear, a ramp would be provided for the trucks to load and unload the 40-cubic yard containers. Space would be provided for two containers. One space would be for storing the empty container and the other for the container receiving the refuse from the stationary compactor. A truck equipped with a special tilting frame carriage, which provides for the loading and unloading of the containers (see Figure 7-2, Chapter 7), would be provided and used for transporting the loaded containers to the disposal area. A used truck equipped as above would be kept at each transfer station for moving the containers at the transfer station for convenience in operation. The estimated capital and annual costs for the recommended plan are delineated in Table 8-6.

Disposal is dependent on development of an areawide sanitary landfill in the Gardiner area. Since the park does not have control over the establishment of this facility, it is probable that some measures might be necessary to provide for the disposal of solid waste generated in the park during the period of program implementation. Interim measures that might be taken to insure compliance with the Presidential directive are:

1. During the peak season, solid waste generated in the park could be hauled directly to the landfill site at Grebe Lake. Solid waste from the Gardiner area could be hauled to this

Table 8-6. ESTIMATED TRANSFER AND HAUL COSTS FOR RECOMMENDED PLAN

Item	Capital Cost, dollars	Life, years	1972 Annual Cost, dollars
West District Transfer Station			
Transfer Station	203,000	35	5,800
Equipment			
Compactor	18,000	9	2,000
Containers			
1	8,000	9	880
1/3 (shared)	2,700	9	300
Share of Transfer Vehicle (1/3 x $28,000)	9,250	9	1,020
Haul to Regional Landfill North of Park			1,880
Total Annual Transfer and Haul Cost			10,080
Cost Per Ton			18.30
South District Transfer Station			
Transfer Station	203,000	35	5,800
Equipment			
Compactor	18,000	9	2,000
Containers			
1	8,000	9	880
2/3 (shared)	5,300	9	600
Share of Transfer Vehicle (2/3 x $28,000)	18,800	9	2,100
Haul to Regional Landfill North of Park			7,680
Total Annual Transfer and Haul Cost			19,060
Cost Per Ton			19.20

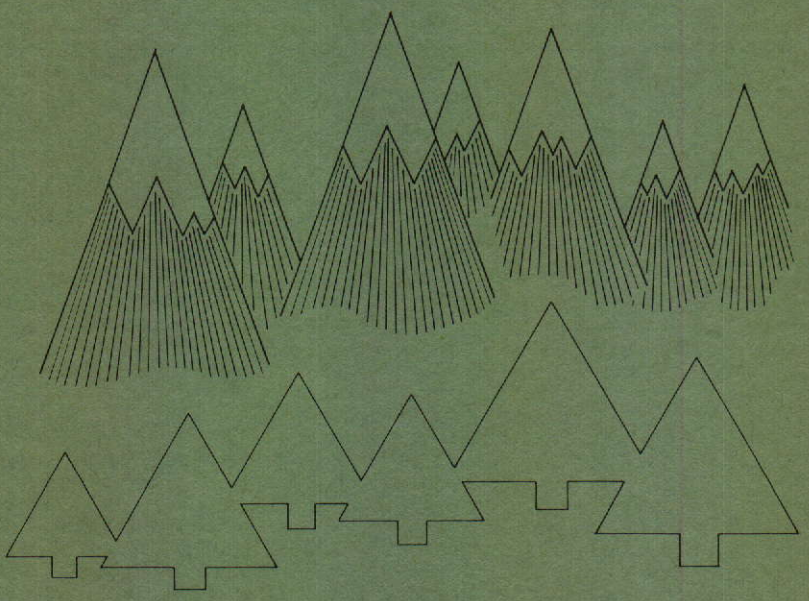
landfill as an interim measure. During the winter season, a small temporary landfill could be developed in the northern extremities of the park for winter use only. An area of less than one-half acre would be required.

2. All areas in the park but Mammoth could haul direct to the Grebe Lake sanitary landfill during the peak season. An incinerator could be constructed at Mammoth to provide for the disposal of solid waste generated at both Mammoth and Gardiner. As a step toward implementation of the long-range plan, the transfer stations could be constructed in the West and South Districts and transport equipment purchased. This would provide for ready

implementation of the recommended plan as, once these facilities are constructed, all that remains is the cooperative development of the regional landfill site.

Costs to construct such an incinerator at Mammoth would be approximately $395,000. This would include the cost of site preparation, landscaping, fencing, lighting, utilities, and building. Total capital cost for the transfer stations and equipment is estimated to be $666,000. All the above costs include an allowance for engineering, administration, and contingencies.

GRAND TETON NATIONAL PARK



Chapter 9

GRAND TETON NATIONAL PARK

CHARACTERISTICS of the AREA

The physical and environmental characteristics of an area have an important influence upon the location and operation of a solid waste management system. This is particularly true where the use of the area is primarily for recreational purposes. Thus, the description of the characteristics of this park is designed to show the operational limitations of the environment upon the waste disposal system.

LOCATION AND HISTORICAL SKETCH

The Grand Teton National Park, as shown in Figure 9-1, is located about six miles south of Yellowstone National Park. As originally established, it was 27 miles long and 3 to 9 miles wide, covering some 150 square miles of rugged mountainous terrain. Subsequent to its establishment, the Jackson Hole National Monument on the east, of 348 square miles, was added making up an area of 498 square miles. The valley area is 48 miles long and 6 to 8 miles wide.

Air travel is provided at an airport located south of Moose Junction within the park. Service is provided from Salt Lake City, Utah, and Billings, Montana. Entrance roads serve the park from the south, east, and north (see Figure 9-2).

The Continental Divide lies a few miles east of the park and, thus, the Snake River constitutes the drainage system for the area. This park also has a fantastic geologic, environmental, and cultural history but it differs somewhat from Yellowstone Park due to differences in geologic history and development.

GEOLOGY AND PHYSIOGRAPHY

The land mass making up this park varies in elevation from 6,000 to almost 14,000 feet. This is due to the fact that the lower east portion of the park is a downdropped fault block, tilted to the west, while the west block with its steep, jagged face, is tilted sharply to the west. Jackson Lake lies in the west edge of the east block and the combination of faulting and the lake gave the area its original name of Jackson Hole. There are several small lakes that extend north and south on both sides of the fault line.

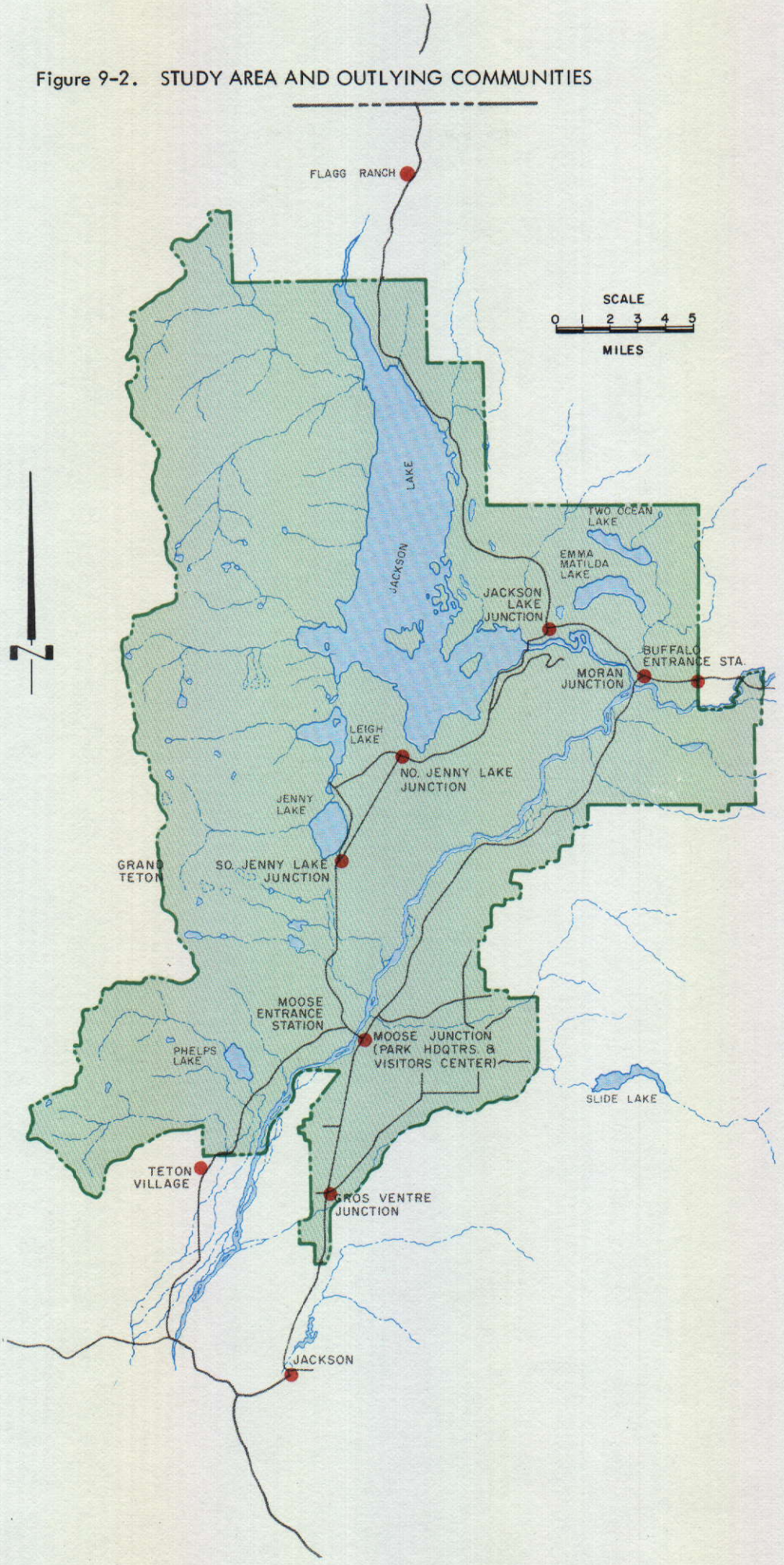
The main north-south Teton fault took place during Tertiary time and before the formation of the main glacial period. The displacement reached some 7,000 feet. The east edge of the west block was very steep and narrow, giving rise to a series of high peaks as the block was worn down by erosion and glaciation. In sharp contrast, the east block carried no outstanding physical features except that of a depression, forming the large Jackson Lake.

The fault system took place over a long period of geologic history and is complicated by many minor faults. One of these, called Buck Mountain fault, follows the west base of the peaks and forms an

Figure 9-1. VICINITY MAP OF GRAND TETON NATIONAL PARK



Figure 9-2. STUDY AREA AND OUTLYING COMMUNITIES



uplifted block with the Teton fault, called a horst. This uplifted block has been carved into alpine peaks by water and ice erosion. These faults and their dissection by erosion tend to determine the position of the streams and the river. In similar manner, the major eastern fault block was, in turn, broken into smaller fault blocks which left a series of outlier buttes and small lakes. At one time, the glacial moraines blocked the Snake River Valley at Burned Ridge but stream-cutting has since cut through this barrier.

The rocks which were exposed or produced by these gigantic earth forces consist of three groups. The oldest pre-Cambrian rocks are crystalline and metamorphic, occupying the core of the Teton Mountains. The intermediate rocks in age are the Paleozoic sedimentary formations of limestone, sandstone, quartzite, and shale, some 3,000 feet thick. These encircle the alpine area.

Volcanic rocks of Tertiary age overlap both of these older rock formations and were part of the great rhyolite and basalt lava flows of the Yellowstone Park area. They originally covered the whole Teton Mountains but have subsequently been eroded down so as to expose the older underlying rocks. Erosion has left some flat tops in the alpine area where the older sedimentary formations are exposed.

The present physiographic character of the park has its major origin in the three glacial moraines of Pleistocene age and their interbedded till deposits. The oldest moraine deposits of Buffalo age left only two small outliers at Blacktail Butte, near Park Headquarters at Moose, and Lozier Hill next to Emma Matilda Lake. This oldest glaciation may have covered the entire park area, but evidence of it is limited. However, the outwash deposits and moraines of the two other glacial stages were very extensive on both sides of the Snake River Valley and Jackson Lake.

The glaciers of this Pleistocene period carved out the valleys and U-shaped the canyons of the Teton range, depositing the erosional debris or moraines around the lake and in the river valley. Burned Ridge and the ridges around Jackson Lake to the north are two main moraines with their outwash deposits to the south. These deposits consist of porous, quartzite gravels which are treeless, supporting only sagebrush, in contrast to the forest cover of the moraines. However, the sagebrush may indicate more clay in the soil and thus more soil formation.

The northern Jackson Hole was occupied by glaciers at two different time intervals. The first was more extensive, as shown by the outwash deposits of Baseline Flat, Antelope Flat, and the Pothole Country. The second glacier seems to have been more restricted because its deposits are confined to the area around the lake, north of Burned Ridge, the Flats, and the Pothole Country. These influences have determined the soil materials that will be encountered in any solid waste disposal plans.

SOILS AND TOPOGRAPHY

The recent alluvium in the park is confined to the valley of the Snake River, along a rather narrow stretch from the southwest park corner to the point where Burned Ridge moraine once blocked the valley. Above this point, the alluvium broadens out to several times its lower width of $\frac{1}{2}$ to 1 mile (see Figure 9-3). Most of this material is composed of loose, angular quartz or obsidian sand and gravel with little or no developed soil horizons, except for the incipient stratification left by stream sedimentation. Any location in the alluvium of solid waste disposal sites would be satisfactory, provided they are not close to the river or tributary streams where flood flows or high water tables could lead to physical or pollution damages. However, none of the three existing disposal sites seem to be located in the alluvium. The closest one is the site west and south of Kelly.

The Kelly site appears to be in the glacial outwash plain of the early Bull Lake glacier on the north edge of Gros Ventre River Valley. If this is correct, then the deposit is composed of shallow-to-deep glacial clays, sands, or gravels, underlain by other sedimentary beds of old age. The present location appears to be on a low terrace above the river alluvium.

The Timber Island site also appears to be located in the same type of Bull Lake glacial outwash at the very edge of the plain where it is close to the Bull Lake moraine, shown on the map as Timber Island. This site is 1½ miles from Snake River and, so, should be satisfactory from the standpoint of groundwater impairment. To the west of this site, coarse boulders may be encountered in the Timber Island moraine.

The Colter Bay site, located one-half mile east of the junction of Teton Park Road and the turnoff to the Colter Bay campgrounds, appears to be located in the moraine left by the Pinedale glacier. It should be composed of sand, gravel, and cobble, and satisfactory if not loaded with boulders.

CLIMATE

The climate of the park area is dominated by the high elevation and dry air, such that extremes of temperature in summer and winter are common. The lowest recorded temperature was 52 degrees below zero which occurred in December 1924. Cold air draining down from the mountains keeps the valley cold for several days at a time.

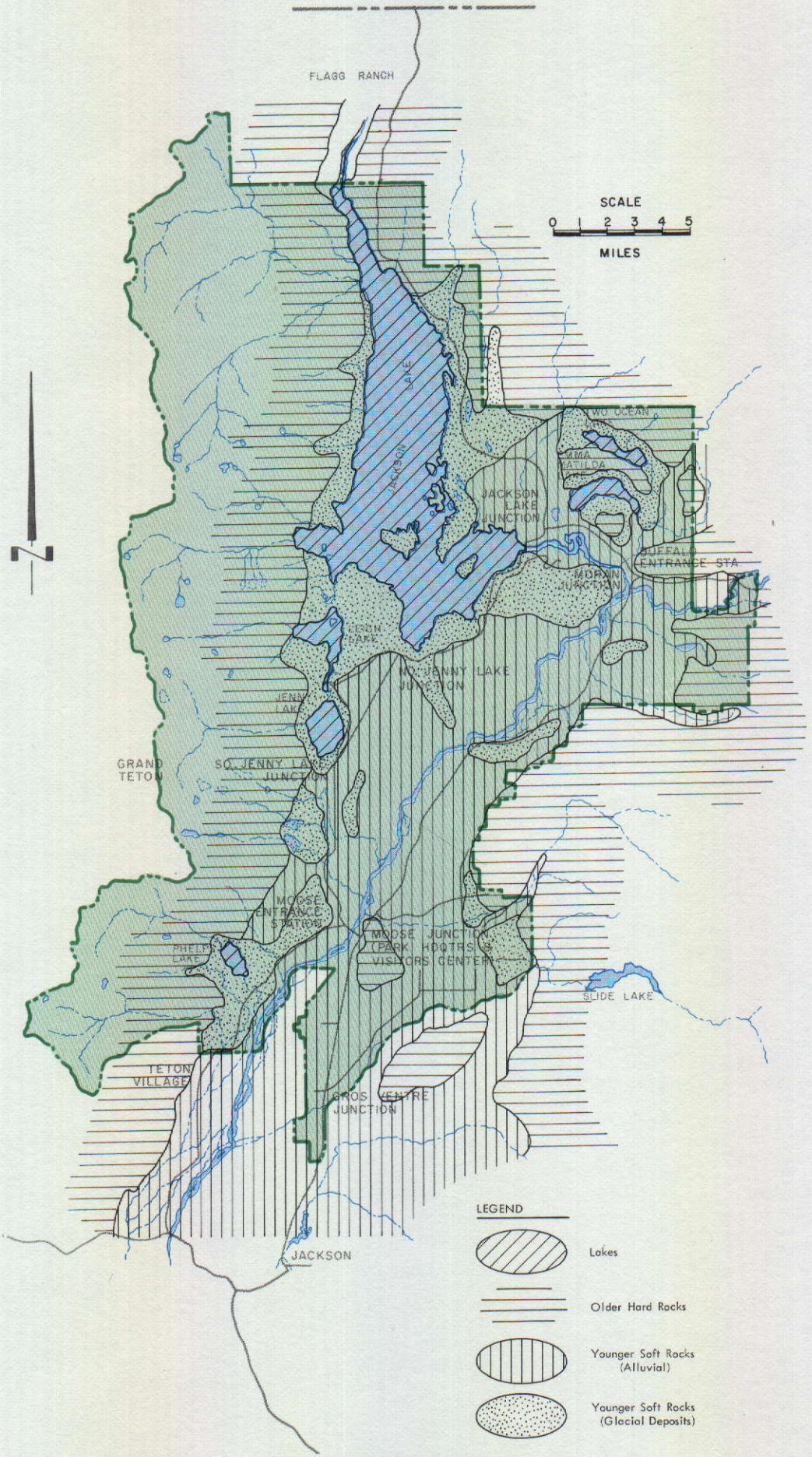
Summer temperatures rarely exceed 90 degrees with the highest recorded of 101 degrees in July 1934. Snow covers the lower elevations for 80 to 120 days in winter. Sunshine is abundant with low relative humidity higher in winter. Winds are generally not strong. The growing season is about 70 to 80 days with rainfall averaging about 20 inches per year.

HYDROLOGY

The average annual runoff from streams in Teton County is about 3,120,000 acre-feet. These waters are discharged through Hoback, Gros Ventre, Buffalo, and Snake Rivers.

The glacial and alluvial deposits of the valleys are porous deposits loaded with groundwater, such that shallow-driven wells are common. However, this also means that septic tanks are a hazard outside of areas having sewage treatment plants. By the same token, care must be exercised in the use of lands for solid waste disposal near or upon shallow groundwater.

Figure 9-3. GEOLOGY OF STUDY AREA



Chapter 10

GRAND TETON NATIONAL PARK

EXISTING SOLID WASTE MANAGEMENT PRACTICES

As previously discussed in Chapter 4, Existing Solid Waste Management Practices at Yellowstone Park, it is important that the existing solid waste facilities and practices be investigated to identify the problem areas that do exist or may be developing. The existing conditions may greatly influence the direction taken in the development of short- and long-range solid waste management plans.

DEFINITION OF TERMS

Terms used in the preceding, as well as the following chapters, were defined in Chapter 4 to aid in understanding the discussions on solid waste management.

SOLID WASTE COLLECTION

Because collection is the most expensive part of the solid waste system, it is important to review and understand the present solid waste handling practices of the area. It is also the only part of the solid waste handling cycle with which the inhabitants come in direct contact. As we become increasingly aware of the importance of protecting our environment, as well as our health, solid waste handling takes on even greater significance.

Administrative and Operational Structure

Two maintenance districts provide for the needs of the Grand Teton National Park in terms of solid waste collection and disposal. These two districts, shown in Figure 10-1, are designated the North District and the South District. The North District of Grand Teton Park encompasses the area north of Jenny Lake and includes such major recreation facilities as Jackson Lake Lodge, Leek's Lodge, Colter Bay, and the Signal Mountain area. The South District encompasses the remaining southern half of Grand Teton Park and includes such major recreational areas as Jenny Lake and Moose, where the Park Headquarters is situated.

Solid waste collection and disposal practices at Grand Teton Park are under the overall supervision of the Maintenance Supervisor, who is in turn responsible to the Chief of Park Maintenance. The Maintenance Supervisor is responsible for two separate divisions, namely, "Roads and Trails" and "Buildings and Utilities". The North and South Districts each have a Roads and Trails Maintenance Division and a Buildings and Utilities Division to handle all solid waste collection and disposal in each district.

The Roads and Trails Division is responsible for collection of roadside pickup, litter, and a number of the picnic areas. The Buildings and Utilities Division handles the buildings, concessions, campgrounds, and the remaining picnic areas.

Each district maintains uniform records of collection which are tabulated annually in a composite form to represent primarily the total number of 25- and 32-gallon containers serviced. Frequency of solid waste collection and scheduling of collection in each district vary throughout the peak summer season in accordance with tourist increase or decrease.

Collection Practices Within the Park

Most of the solid waste generated within the park is collected by park personnel. However, the solid waste generated at the dude ranches, private residences, and cabins within the park is hauled by each individual or establishment to the three available disposal sites. A number of the dude ranches bury their waste on their own lands. There are no privately owned, franchised operators within the park boundary. Concessionaires within the park are provided with collection and disposal service mostly on a daily basis during the peak tourist season, although some are only provided with bi-weekly or weekly service. Private residences pay a monthly service charge of $3.00 based upon an average of three cans per home. This service charge includes pickup and disposal. An annual solid waste disposal fee of $10.00 is charged to any private resident or dude ranch that hauls privately to the site. Motels and concessions are charged $25.00 per year for disposal only. Two exceptions are the Moose Enterprises and Highlands Lodges' concessions which are charged $100.00 and $50.00 per year, respectively, for disposal because of their unusually high waste generation. Records are kept of cans collected for resident pickups, concessions, campgrounds, and roadside litter.

General collection practice includes normal garbage pickup of all containers in the high density areas, as well as roadside can pickup at viewing locations. In the North District, regular litter control is provided by routine daily patrol and pickup of paper, cans, and other trash deposited along the roads of each district. Litter control within the South District is accomplished on an alternate daily basis because of the relatively smaller volume of solid waste generated as compared to the North District.

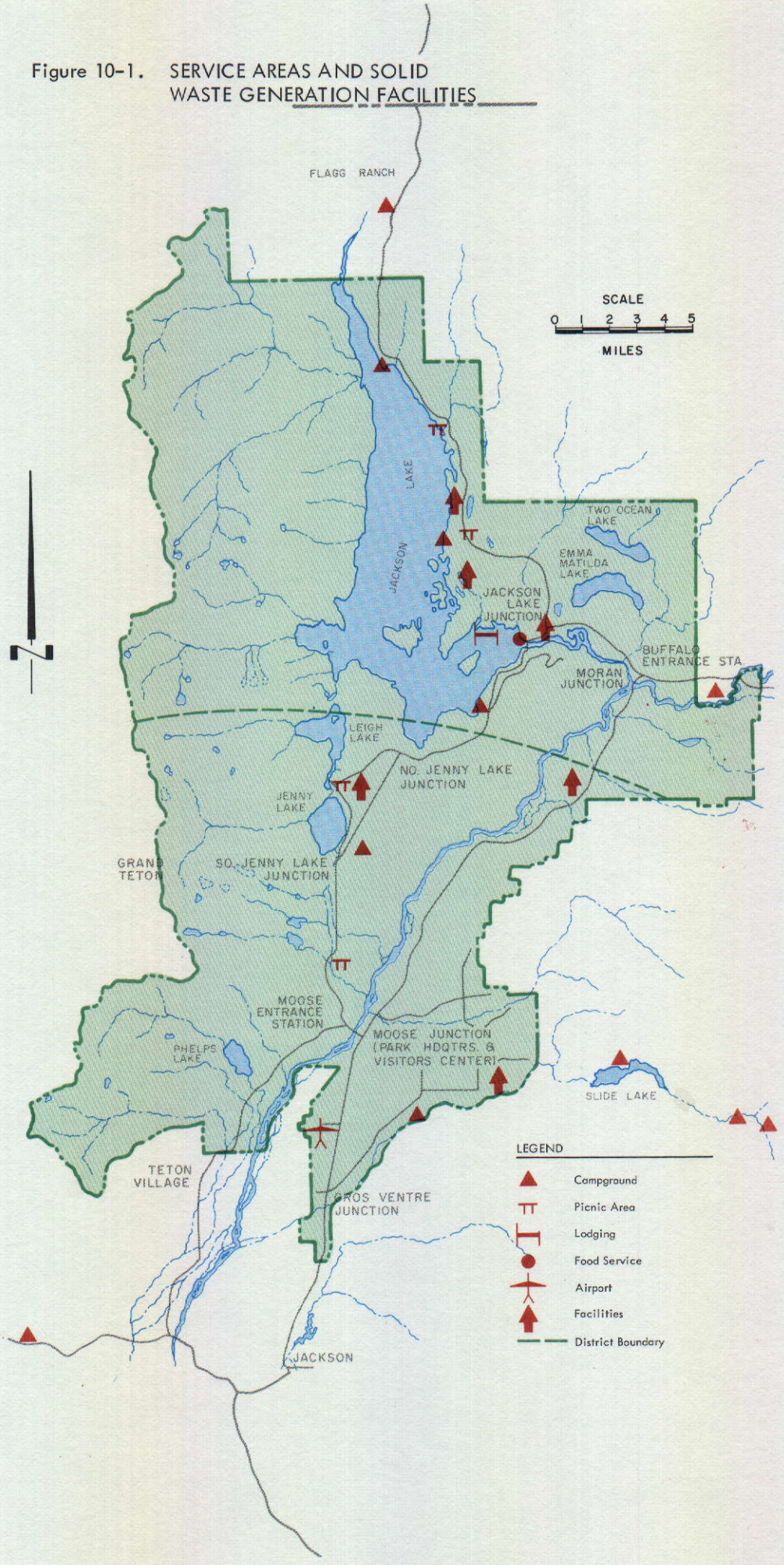
A significant factor in the solid waste collection practices in Grand Teton Park is the limited tourist season. In general, the 100-day period between Memorial Day and Labor Day is the peak tourist season when maximum effort is provided to maintain sufficient collection services. For a period of 80 days (the light season), 40 days before and 40 days after the above peak season, variable collection frequencies are employed throughout the districts and are regulated primarily by tourist demand.

Most park facilities and the dude ranches operate during the period from June 1 through October 15 with some exceptions. Park Headquarters and some of the service facilities at Moose Junction remain in operation throughout the year. Another exception is due to the increasing snowmobile population during the winter months. In addition, there are some concession accommodations and campgrounds open throughout the winter. The Triangle X accommodates hunters through November, with a few guests throughout the winter. The Elbo Ranch and Signal Mountain Lodge have cabins open during the winter. Disposal during the winter is to an open pit located at the Kelly landfill site or at the Colter Bay landfill site. At both sites, new pits are dug each season for disposal of the waste during the winter season.

Storage Facilities:

Two sizes of storage containers in general use throughout the park are the 25-gallon and the 32-gallon cans. The smaller, 25-gallon cans are used primarily for roadside litter, picnic areas, and campgrounds, while the larger, 32-gallon cans are used mainly in the dense Colter Bay and Jackson Lake Lodge complexes. Many of the other dude ranches and lodges that generate a considerable amount of solid waste utilize the 25-gallon containers. Bear-proof covers for the exposed cans are not necessary in Grand Teton Park. Standard refuse cans are provided with plastic liners at all times in an effort to reduce collection time and increase the useful life of the containers. The reported annual cost of plastic liners for refuse containers is $6,000.

Figure 10-1. SERVICE AREAS AND SOLID WASTE GENERATION FACILITIES



Collection Equipment:

The type of equipment used for the collection of solid waste throughout the park is consistent in each district. In general, areas of high density tourist population near major park communities are serviced by 14-cubic yard rear-loading packer trucks, whereas picnic areas, remote campgrounds, litter control, and roadside pickup are serviced by specially adapted 3/4-ton pickup trucks with a box attachment.

In the North District, one 14-cubic yard packer truck services the high density areas. The district also has a 3/4-ton pickup truck for roadside service and litter control.

The South District has one 14-cubic yard packer truck to provide service for the campground areas and also services the heavily used roadside rest areas alternately with the 3/4-ton pickup truck. One 3/4-ton pickup truck provides for litter control and roadside and picnic area collection.

During the peak 100-day season, each of the packer and pickup trucks operates seven days a week. During the winter season, packer truck operation is reduced to one day per week and the pickup trucks are reduced to one-half day per week for each district. A gradual reduction takes place in the collection operation proportional to the reduction in the park activity.

Collection Personnel:

All collection personnel work eight hours per day, seven days per week during the peak months. As the winter season approaches, the collection and disposal operation is gradually curtailed proportional to the activity and the employees are directed to different tasks within the park. During periods of least activity in the winter, one 8-hour man-day of work per week is all that is required for collection of the waste of both the North or South Districts. All 14-cubic yard rear-loading packer trucks use three men--one driver and two laborers. Each of the pickup trucks have a crew of two men--one driver and one laborer.

Collection Services:

Collection services within the park are directly related to the tourist demand. During the peak 100-day season, all portions of the park's North District are provided with daily collection services. In the South District, the eastern and western portions of the district are serviced on alternate days. As tourist demand diminishes, collection services diminish accordingly to a minimum of one day a week during the winter season for both districts.

No distinction is made nor is there any attempt to classify whether refuse be of a domestic or tourist nature or whether it be classified as rubbish or some other special waste classification. In general, complete collection service is provided to all concessionaires, park housing, and service facilities. Construction debris associated with contractors' operations within the park are excepted from collection service by park personnel. This waste is handled directly by the contractor; disposal to existing sanitary landfills within the park is allowed.

Collection Costs:

As with the case at Yellowstone, the cost of collection of waste within Grand Teton Park has been an estimate because the only record source has been the actual can count of the concessionaires' waste and an estimate of park cans collected to estimate finally the total tonnage of waste produced. Although these can counts were an accurate indication of the number of cans that were collected, the percentage of fullness of each can could only be estimated. In addition, there was no accurate way to determine what quantity of solid waste was privately hauled directly to the disposal sites. The park personnel assumed that each can collected was 60 percent full.

Composition studies were conducted for Grand Teton Park as well as for Yellowstone Park as a part of this report and are fully outlined in the Appendix. As in Yellowstone Park, the composition of solid waste shows an average density of 3.0 pounds per cubic foot for all standard uses within the park--the only exception being the restaurant where over 50 percent of the refuse is composed of food waste indicating a density of almost 5 pounds per cubic foot. The studies indicated that the uncompacted volume of a full standard 25-gallon can would weigh approximately 10 pounds and that an uncompacted full standard 32-gallon can of refuse would weigh 13 pounds.

In addition, as part of this report, an accurate count of the total volume of solid waste generated in the park for a 4-day period was obtained and is also fully discussed in the Appendix. Based upon the aforementioned data collected, the findings of this report indicate a total annual solid waste tonnage of 1,110 tons.

The total cost of collection consists of that allocated to labor, operation and maintenance, and depreciation. These costs are discussed briefly below:

Operation and Maintenance:

Each unit of equipment used throughout the park for collection service is charged to the various districts through an internal rental system. For each of the 14-cubic yard packer trucks, a cost of $1.20 per operating hour is made. Similarly, for pickup trucks, a cost of $0.06 per mile is charged for operation and maintenance.

Labor:

Labor used for collection services is charged at eight hours per day. Each 14-cubic yard packer truck crew consists of a truck driver and two laborers while the pickup truck crews consist of a driver and one laborer.

Labor rates are as follows:

Truck driver (packer)	$4.00/hour
Truck driver (pickup)	$3.45/hour
Laborer	$3.20/hour

Crew cost per operating hour:

Packer:	1 x $4.00 + 2 x $3.20 = $10.40/hour
Pickup trucks:	1 x $3.45 + 1 x $3.20 = $ 6.65/hour

Depreciation:

Depreciation charges are assessed as part of the operating expense of each piece of collection equipment. In the case of the packer truck, because they are special-purpose vehicles, a full year's depreciation is charged even though the vehicle is used only a small portion of the year. The amount charged for one packer truck is $57.00 per month or $684.00 per year and the amount charged for the other packer truck is $99.00 per month or $1,188 per year. The lower monthly depreciation of the first packer reflects the age of this vehicle which is about ready to be replaced. Since the pickup trucks can be used at other times of the year for purposes other than solid waste collection, the portion of depreciation assignable to the winter season is not reflected in costs of collection. The depreciation charge for pickup trucks is $30.00 per month.

In order to arrive at the total cost per ton incurred during the 1971 season for solid waste collection within the park, all the tonnages and the costs associated with collection must be identified and tabulated. In the previous paragraphs, the weights and costs were identified and are presented in Table 10-1.

Table 10-1. COST OF COLLECTION

Location	Solid Waste Generated Annually		1971 Cost, $1,000	Cost Per Ton, dollars
	Cubic Yards	Tons		
North District	21,000	850	-	-
South District	6,400	260	-	-
Total	27,400	1,110	29	28.70

Collection Practices Outside the Park

An attempt was made in the conduct of this study to ascertain the collection and disposal practices of areas immediately adjacent to the park in order to ultimately effect a coordinated solid waste management plan for the park and the surrounding environs.

All areas adjacent to the park are tourist-oriented communities that face similar solid waste problems to the park.

City of Jackson:

The city of Jackson, located just south of Grand Teton National Park, has a permanent population of 3,474 people. In addition, it has a summer population of approximately 3,600 people for a total of 7,074 people during this period. The waste generated from this city is estimated to be approximately 3,870 tons per year or 100,000 cubic yards annually. At the present time, a private collector provides daily solid waste collection service to the city of Jackson. This system adequately fulfills the needs of the city at the present time.

Teton National Forest:

Completely surrounding the eastern portion of Grand Teton National Park is the Teton National Forest. The Teton National Forest has a large number of campgrounds and picnic areas within its dominion. It currently has an adequate collection system to retrieve the solid waste refuse generated from all of these sites. At present, the Forest Service is conducting a study to determine the long-term collection and solid waste disposal needs for its service area. Preliminarily, the Forest Service estimates indicate an annual solid waste generation of 100 tons. Present practice is to collect the waste from the various campsites, lodges, and picnic areas and deliver the waste to seven sites within the Forest Service area.

Elk Refuge:

The National Elk Refuge is located on the southeastern corner of the Grand Teton National Park. Although many people visit this elk refuge, very little solid waste is generated from these visitors because of the very short interval of time that each visitor stays at the Elk Refuge vantage points. Therefore, the solid waste generated from the National Elk Refuge is insignificant. The present practice at the refuge is to collect the solid waste and bury it on their property. This solution can meet their long-term needs for many years to come based upon their present waste generation.

SOLID WASTE DISPOSAL

Disposal is the ultimate step in a solid waste management system. All solid waste, whether raw refuse, sewage sludge, incinerator fly ash, or residue, must be utilized in some way or given final disposal. In the last several decades, development of the sanitary landfill has become an accepted method of disposing of refuse on land without creating nuisance or hazards to public health or safety by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation.

Disposal Practices Within the Park

There are three landfill sites within the park. The Colter Bay sanitary landfill services the North District and the Timber Island and Kelly sanitary landfills service the South District (see Figure 10-2). As discussed in Chapter 9, the Colter Bay site shown in Figure 10-3 appears to be composed of sand, gravel, and cobble. However, due to its distance from the lake shore, it does not appear to be causing any impairment of water quality.

The Timber Island landfill does not appear to be creating any problems relative to water quality impairment as long as the site is not expanded west into the island moraine where boulders could be encountered. As previously mentioned, the small creek running between the site and the road may create a problem. Since this creek is tributary to Cottonwood Creek leading to the Snake River, the disposal must be kept above the water table and away from this creek to avoid any possible pollution of the Snake River.

The Kelly landfill site appears to be composed of shallow-to-deep glacial clays, sand, and gravels underlined by other sedimentary beds of old age as discussed in Chapter 9. The present location seems to be on a low terrace above the river alluvium and no drainage problems should be anticipated. Again, as with all the sites, the exact location of the groundwater level is of extreme importance with respect to water quality impairment. Such information was not available but depth to water below the fill should be kept to a minimum of 20 feet. Determination of water table information would be desirable to firmly establish whether a hazard exists.

General Operation of Sites:

The Colter Bay landfill is operated daily during the peak season. The hours of operation decrease as the park population dwindles from the summer peak to the winter minimum. The Colter Bay landfill, as well as the other two landfill sites, is closed during the winter. In the South District, the Timber Island landfill and Kelly landfill are operated on an alternate-day basis for eight hours at each site. Again, as in the case of the Colter Bay landfill, the hours of operation dwindle as the winter approaches.

At any time during the year, private individuals can haul their solid waste to either the Colter Bay or Kelly landfill sites. The Timber Island landfill can only be utilized during the summer period. Most refuse from the dude ranches and private residences is hauled by individuals to the sites. Each private hauler is issued a key upon request which permits them them to enter the disposal sites at any time during the day. As previously mentioned, charge for use of the disposal facilities is $10.00 per year. Some of the dude ranches have their own solid waste disposal pits which they maintain. This is also true for some of the private residences.

Personnel and Equipment:

At the Colter Bay landfill, the disposal equipment consists of one payloader and one operator. A track-mounted standard bulldozer is also available and used whenever it is required. In the South District, another payloader is utilized for both the Timber Island the Kelly landfills. The track-mounted

Figure 10-2. EXISTING DISPOSAL SITES WITHIN GRAND TETON PARK AND VICINITY

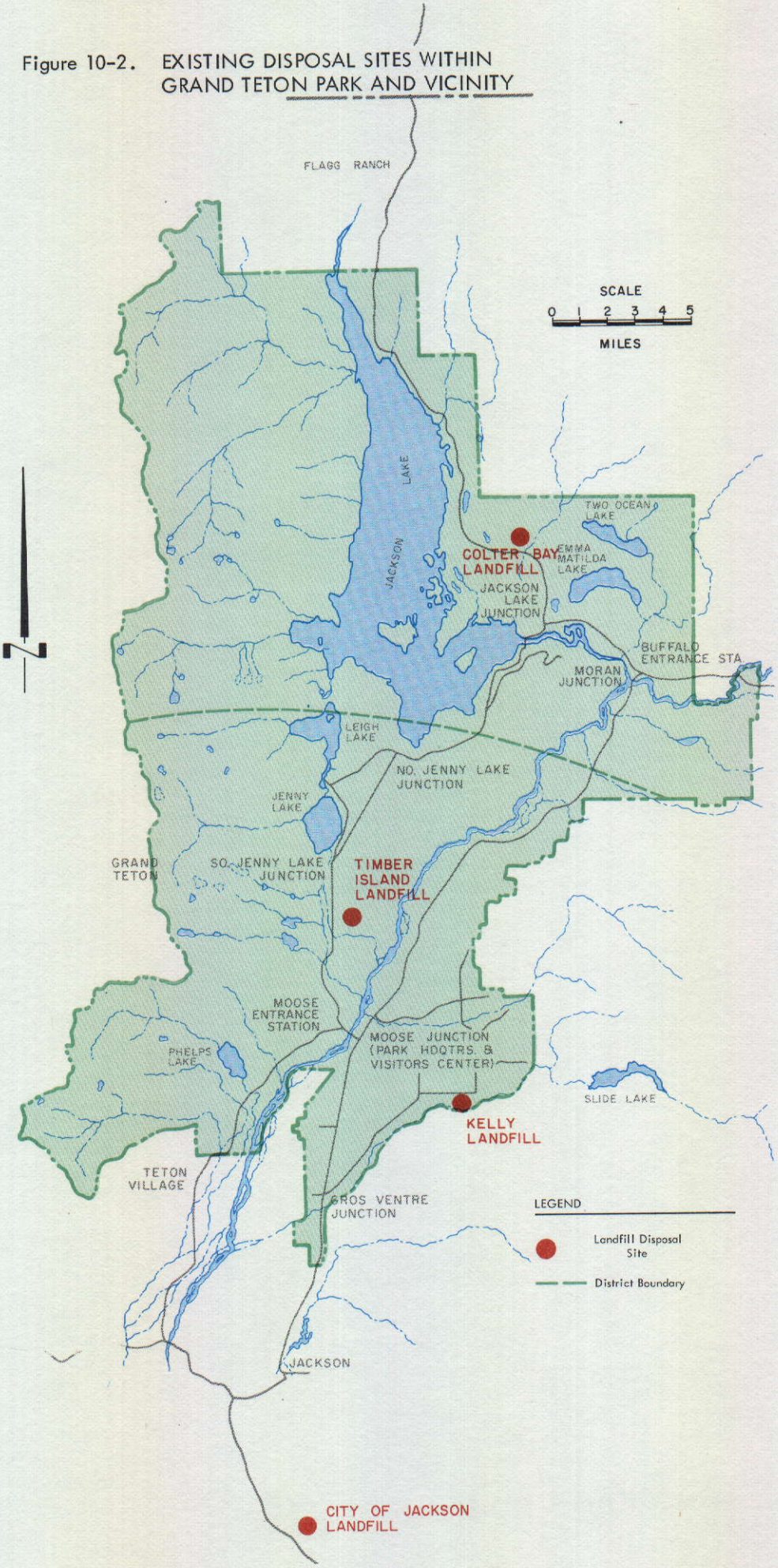


Figure 10-3. COLTER BAY SANITARY LANDFILL



bulldozer also is utilized at these two sites as needed. Each of these sites is surrounded by a fence to contain the refuse.

Annual Cost of Disposal:

Labor, operation and maintenance, and depreciation comprise the total cost of disposal. They are discussed below as they relate to the solid waste disposal facilities:

Operation and Maintenance:

As with vehicle use for collection, each unit of equipment used for disposal service is charged to each of the two districts through an internal rental system. Each of the payloaders are charged a cost of $2.00 per operating hour. The track-mounted bulldozer is similarly charged $6.00 per operating hour.

Labor:

There is one operator for each piece of disposal equipment used. During the peak season, each piece of disposal equipment is considered to be used eight hours per day, seven days per week. As with the collection equipment, this use decreases proportional to the decrease in park use from summer to winter operations. None of this disposal equipment is utilized during the winter. Labor rates for each equipment operator are $4.00 per hour.

Depreciation:

Depreciation charges are assessed as part of the operating expenses of each piece of disposal equipment. Since each piece of equipment can be used at other times of the year for purposes

other than solid waste disposal, only a portion of the depreciation is assigned to the cost of disposal. That cost of depreciation assignable to the winter season is, therefore, not reflected in the cost of disposal. The depreciation charge for one of the payloaders is $87.00 per month. The depreciation charge for the other payloader is $107.00 per month, reflecting the increased cost of the new piece of equipment. The bulldozer is depreciated at $182.00 per month.

The annual cost of disposal, based on the above system of cost allocation, is estimated to be $15,000 per year or $13.45 per ton.

Disposal Practices Outside the Park

The city of Jackson maintains a solid waste disposal site about seven miles south of the city on Forest Service property and is located in a canyon named "Horsethief Canyon". There is a need to improve the operation of the site for both winter and summer operations. The Teton National Forest also utilizes the site for the disposal of its refuse generated from the nearby areas. The existing site is estimated to have the capacity to serve the city for at least ten more years.

The National Elk Refuge maintains a small disposal site on its property which is adequate for their long-term needs because of the small quantities of waste generated.

Chapter 11

GRAND TETON NATIONAL PARK

LAND DEVELOPMENT and POPULATION

The type of development in Grand Teton Park is strictly that associated with the need to accommodate the annual tourist population by providing them with supplies, lodging, and recreation. In order to predict solid waste production in the park, it is necessary to know the type of development, a determination of existing and future resident and tourist population, and the associated land use. Populations and land development patterns should be on the optomistic side in order to avoid undersizing facilities that are costly to duplicate.

EXISTING DISPOSAL SERVICE AREAS

In connection with the determination of existing solid waste production and the projection of future solid waste loadings, it is essential to identify the waste production potential by subareas within the park. For the purpose of this report, the two established maintenance districts (North and South), shown in Figure 10-1 and discussed more fully in Chapter 10, will be used as service areas.

LAND USE

Campgrounds

In the North District service area, there are three family campgrounds, namely, Lizard Creek, Colter Bay, and Signal Mountain, plus a group campground at Colter Bay. In the South District service area, there are campgrounds at Jenny Lake and Gros Ventre. All campgrounds are open from early June to late September. House trailers are permitted at all campgrounds except Jenny Lake, which is for tent camping only. Off-season camping is available at Colter Bay which has the largest number of campers. Groceries, supplies, and other services are available at the Colter Bay, Signal Mountain, and Jenny Lake campgrounds.

Concession Accommodations

There are many overnight paid facilities and services available within the park from early June through September. These facilities include the Jackson Lake Lodge, Leek's Lodge, and Signal Mountain Lodge in the North District service area and the Jenny Lake Lodge in the South District service area. In addition, there are cabins, tent cabins, and trailer accommodations at Colter Bay in the North District service area, and there are many dude ranches in the South District service area. Year-round lodging, restaurants, and other services are also available in nearby Jackson or Teton Village. Grocery stores and service stations are located at Colter Bay, Moose, Kelly, and Signal Mountain. Colter Bay is open in summer only.

Daytime Activity Accommodations

The majority of the over three million visitors to Grand Teton Park only tour the park during the day. For their convenience and enjoyment, park facilities include a multitude of picnic areas, observation sites, a visitor center at Moose Junction, the Colter Bay information station, and a museum at Jenny Lake.

Government Facilities

The National Park Service, U. S. Department of the Interior, is the agency which administers the activities of Grand Teton Park. The administrative offices of the National Park Service are located at Moose Junction, in addition to the visitor center and the entire maintenance facilities of the park. The permanent resident housing facilities are located nearby.

POPULATION WITHIN PARK

Because of the seasonal extremes in climate throughout the year, a decidedly large percentage of the visitor population visit the park during the summer months, although an increasing number of people are beginning to visit the park during the winter season. Table 11-1 shows the total number of visits by month to Grand Teton Park for years 1968 through 1970. The past and present number of visitors travelling through the park annually is shown in Table 11-2. A summary of the type of visitor use in the past five years is shown in Table 11-3. With the ever-increasing number of park visitors, there is an increasing number of people participating in such activities as hiking, Snake River float trips during summer seasons, and oversnow visitors during the winter season.

Table 11-1. VARIATION IN SEASONAL POPULATION THROUGHOUT THE YEAR

Month	Number of Visitors		
	1968	1969	1970
January	4,320	4,150	5,400
February	9,500	10,200	10,980
March	10,450	12,125	12,200
April	47,340	50,570	35,070
May	122,173	134,597	147,150
June	553,432	511,589	529,920
July	962,870	1,030,990	1,094,328
August	820,951	881,834	954,573
September	268,545	306,256	352,458
October	97,470	109,298	123,462
November	68,328	66,960	67,554
December	4,875	15,727	17,370
Total	2,970,254	3,134,354	3,352,464

Table 11-2. TOTAL VISITS FOR YEARS 1951 THROUGH 1970 AT GRAND TETON PARK

Year	Total Visitors
1951	640,973
1952	785,343
1953	942,966
1954	1,003,489
1955	1,104,725
1956	1,197,241
1957	1,306,340
1958	1,428,497
1959	1,529,638
1960	1,429,905
1961	1,492,434
1962	1,799,441
1963	2,158,767
1964	2,450,836
1965	2,507,047
1966	2,673,090
1967	2,643,708
1968	2,970,254
1969	3,134,354
1970	3,352,464

Campground Accommodations

Campgrounds are filled to capacity during the months of July and August. The more popular campgrounds are usually filled by midmorning. Space is often available at the Gros Ventre campground until late afternoon. The number of campsites and the estimated capacity of the various campgrounds is listed in Table 11-4. The number of persons accommodated in 1970 and 1971 in the various campgrounds is shown in Table 11-5.

Concession Accommodations

Most of the concessionaire accommodations are filled to capacity during the months of July and August. Table 11-6 shows the total number of persons accommodated in concession accommodations for 1970 and 1971.

Permanent Population

Park Headquarters and the visitor center facilities located at Moose Junction are open all year. Permanent housing quarters for the park personnel and their families is situated nearby. Many of the private residents reside in the park year-round and a few concessionaires maintain four-season operations. Permanent population living in the park throughout the year, including park service employees, residents, and dude ranch personnel, approximates 200 persons.

Table 11-3. VISITOR USE DATA 1965-1970 SUMMARY

Activity	1965	1966	1967	1968	1969	1970
Total Park Visitors	2,507,047	2,673,090	2,643,708	2,970,255	3,134,354	3,352,464
Visitors from South	1,150,438	1,163,689	1,189,753	1,504,320	1,523,041	1,565,910
Visitors from North	880,765	958,061	959,490	924,444	1,041,116	1,180,346
Visitors from East	475,844	551,340	494,465	541,491	570,197	606,208
Overnight Paid Facilities[a]	211,724	255,084				
Concessionaire	190,668	235,455	204,668	227,168	255,735	273,452
Privately Owned	21,056	19,629	18,926	23,521	21,386	15,812
Campers[a]	321,226	376,369	411,786	296,423	330,130	376,653
Hiking[b]	57,481	68,991	65,828	74,800	84,500	116,000
Horseback Riding[b]	53,200	60,136	57,370	54,600	45,200	34,700
Boat Permits Issued	2,293	2,416	2,787	2,773	3,170	3,593
Snake River Float Trips[a]						
Grand Teton Lodge Company	10,659	12,000	11,900	10,975	10,477	13,171
Other Commercial Float Trips	2,802	4,610	11,755	10,800	22,162	34,418
Other Float Trips	1,021	1,564	2,476	7,848	7,950	3,808
River Boating Days[b]	14,482	18,174	40,296			
Lake Boating Days[b]	116,000	119,000	23,458	25,804	36,500	38,000
Fisherman Days[b]	34,333	30,800	51,302	56,325	58,750	46,550
Swimming[a]						
Jackson Lake Lodge Pool	13,568	13,746	16,359	18,150	17,450	16,270
Other Swimming Areas	23,280	28,446	27,937	28,950	32,850	28,600
Oversnow Vehicle Permits Issued	65	144	277	426	838	837
Oversnow Visitor Days	1,475	1,548	2,815	2,905	4,567	4,800
Concessionaire Trips				274	303	270

[a]Number of persons accommodated or served
[b]Estimated use figures

Winter Season Operations

As in the case at Yellowstone Park, only small-scale winter season operations exist at Grand Teton Park, however, indications are that, in the future, winter operations could increase appreciably. Table 11-3 indicates a threefold increase in the number of oversnow visitor days from 1965 to 1970. Oversnow vehicle permits have increased from 65 in 1965 to 837 in 1970. Some of the concession accommodations are open in the winter. The Triangle X Ranch accommodates hunters, usually through November, with a few guests throughout the winter. The Elbo Ranch has been open year-round for the past three or four years and the Signal Mountain Lodge has housekeeping cabins open during the winter months.

Table 11-4. CAPACITY OF CAMPGROUND ACCOMMODATIONS

Campground	No. of Sites	No. of Persons[a]	Limit of Stay, Days
North Service Area			
Lizard Creek	60	216	14
Colter Bay	525	1,890	14
Signal Mountain	86	310	14
Group Camping Area	6	210	
South Service Area			
Jenny Lake	85	306	10
Gros Ventre	410	1,480	14
Total	1,172	4,412	

[a]Estimated at 3.6 persons per campsite

Table 11-5. TOTAL CAMPGROUND ACCOMMODATIONS

Campground	Number of Persons	
	1970	1971
North Service Area		
Lizard Creek	21,588	14,328
Colter Bay	142,884	159,944
Signal Mountain	45,604	27,772
Colter Bay Group	8,532	3,985
Subtotal	218,608	206,029
South Service Area		
Jenny Lake	36,120	37,140
Gros Ventre	119,254	85,152
Subtotal	155,374	122,292
Total	373,928	328,321

Projected Population Growth

The National Park Service has placed maximum emphasis upon the protection of the environment in order to insure its unimpaired preservation. Conservation and management of the natural, historical, and recreational resources for their highest use is paramount. With respect to overnight accommodations, the present philosophy is to at least limit it to the current level.

Table 11-6. TOTAL CONCESSION ACCOMMODATIONS

Facility	Number of Persons	
	1970	1971
North Service Area		
Colter Bay Cabins	20,784	25,918
Colter Bay Tent Cabins	8,212	7,958
Jackson Lake Lodge	85,092	83,144
Leek's Lodge	4,353	4,316
Signal Mountain Lodge	20,067	18,098
Colter Bay Trailer Village	41,096	42,424
Subtotal	180,604	181,858
South Service Area		
Jenny Lake Lodge	5,842	7,856
Elbo Ranch	1,119	921
Triangle X Ranch	6,055	5,967
Bar BC Ranch	3,791	5,320
Grand Teton Climbers Ranch	2,161	3,021
R Lazy S Ranch	647	2,848
Whitegrass Ranch	1,140	1,220
Subtotal	20,755	27,153
Total Concession Accommodations	201,359	209,011

Although there are no plans to increase overnight accommodations, the number of daytime visitors should increase appreciably during the summer months because the existing roadway system is adequate to accommodate a much greater flow of traffic. Visitor use accommodations, such as boating and camping, will not accommodate a greater use than at present, however, the number of visitors passing through the park will increase. Such an increase may require expanding the existing customer service facilities. Figure 11-1 delineates past, present, and projected population and reflects the current philosophy of maintaining a "status quo" of most park facilities.

POPULATION OF ADJACENT COMMUNITIES

For the purpose of projecting solid waste productions in the communities adjacent to the park, per capita production factors were employed since no historical records of production are available. Therefore, an estimate of past and projected population within these communities is essential.

Information relative to these areas is presented in Table 11-7.

Figure 11-1. PAST, PRESENT, AND PROJECTED POPULATION GROWTH AT GRAND TETON NATIONAL PARK

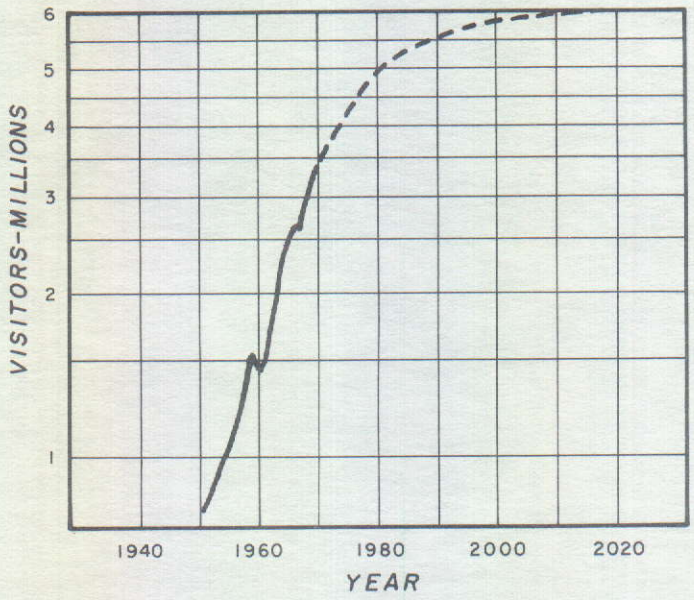


Table 11-7. POPULATION OF ADJACENT COMMUNITIES

Entity	Number of People
City of Jackson	3,474
City of Jackson (summer)	7,000
Teton County	4,900
Flagg Ranch	1,300
Elk Refuge	5

Chapter 12

GRAND TETON NATIONAL PARK SOLID WASTE PRODUCTION, COMPOSITION, and PROJECTIONS

Fundamental to the planning and design of solid waste collection and disposal facilities is a knowledge of the quantity and composition of the wastes. Both the volume and composition of wastes vary from one area to another; therefore, it is essential that design factors be based on actual conditions rather than on experience of nearby or similar communities. The information presented in this chapter is based on surveys, interviews, and waste composition analyses conducted within Grand Teton National Park and presented in Appendix A.

BASIS OF SOLID WASTE PRODUCTION

Solid waste production is most practically reported in terms of pounds per person per day. In this particular case, the available literature reported the results of solid waste production in terms of pounds per camper per day or pounds per visitor per day. These results were based upon data from recreational forest areas throughout the United States. There were no studies available from any other national park. Since solid waste production is basically a function of the socioeconomic characteristics and population of a particular area, it was imperative to gather accurate data regarding solid waste production and characteristics of Grand Teton Park. Field studies presented in Appendix A developed production factors for the various types of facilities within the park, such as pounds per capita, cubic feet per capita, and pounds per cubic foot. These factors are presented in Table 12-1. The average loose density of the refuse is in the neighborhood of 81 pounds per cubic yard. These factors, together with the additional information gathered during the 4-day field survey, were used in developing the daily peak season waste generation rates for the various areas within the park.

PRESENT SOLID WASTE PRODUCTION

The estimated daily solid waste volume generated within Grand Teton National Park during the peak season is shown in Table 12-2. The data was collected during a period when the park was close to typical peak summer capacity. This data was then modified to reflect the peak summer generation rate. Figure 12-1 shows graphically the distribution of refuse production in cubic yards throughout the park during the peak season. Quantities hauled directly to the disposal area by private individuals were included with roadside quantities. The portion from the South District service area amounted to about 12 cubic yards.

PROJECTED SOLID WASTE PRODUCTION

The expected impact of new packaging materials on solid waste disposal, increase in use of nonreturnable containers or disposable packages, and the ever-changing consumer buying habits which increase the consumption per capita, indicate the desirability of revising waste generation factors in order to

Table 12-1. SOLID WASTE GENERATION FACTORS AT VARIOUS FACILITIES

Facility	Solid Waste Generated		
	pounds per cubic foot[e]	pounds per capita per day	cubic feet per capita per day
Campgrounds	3.06	2.90	0.95
Cabins	2.43	0.42	0.17
Employee Housing	2.40	3.85	1.62
Employee Dormitories	2.79	0.55	0.20
Trailer Village	3.24	1.38	0.42
Tent Village	2.84	2.55	0.90
Picnic Area	2.90	1.13	0.39
Visitor Center	2.80	0.04	0.01
Resturant[a]	4.85	0.69	0.14
Marina[b]	2.78	0.83	0.31
Service Station[c]	1.90	0.01	0.01
General Store	3.10	0.20	0.06
Laundry[d]	1.92	1.20	0.63
Roadside Rest	3.45	----	----
Roadside Litter	3.22	----	----

[a]per meal served instead of per capita per day
[b]per berth rented instead of per capita per day
[c]per gallon instead of per capita per day
[d]per machine instead of per capita per day
[e]loose density

effect a more realistic projection of future wastes. It has been the experience throughout the nation that projections of solid waste production for planning purposes are usually underestimated. For the purpose of projecting needs for disposal, the waste generation factors shown in Table 12-3 were utilized and reflect an expected increase. The increases shown are somewhat below the expectation nationally, however, this is justified since park refuse contains only a limited portion of the waste included as part of the total solid waste picture.

Although per capita generation rates have been increasing in recent years due partly to the factors described above, a reduction in this rate of increase is indicated based on several fundamental ideologies.

First, there must and will be a reversal in the trend which permits the discard of our abundant resources. Discovery of beneficial uses through salvage, recycle, and reuse of the various ingredients in solid waste will eventually be realized. The awareness of the enormity of this problem is now in the process of emerging. Realizing this, it is logical to assume that annual per capita increases in generation rates will decrease in the ensuing years.

Figure 12-1. PEAK DAILY WASTE GENERATION VOLUMES IN GRAND TETON PARK AND VICINITY

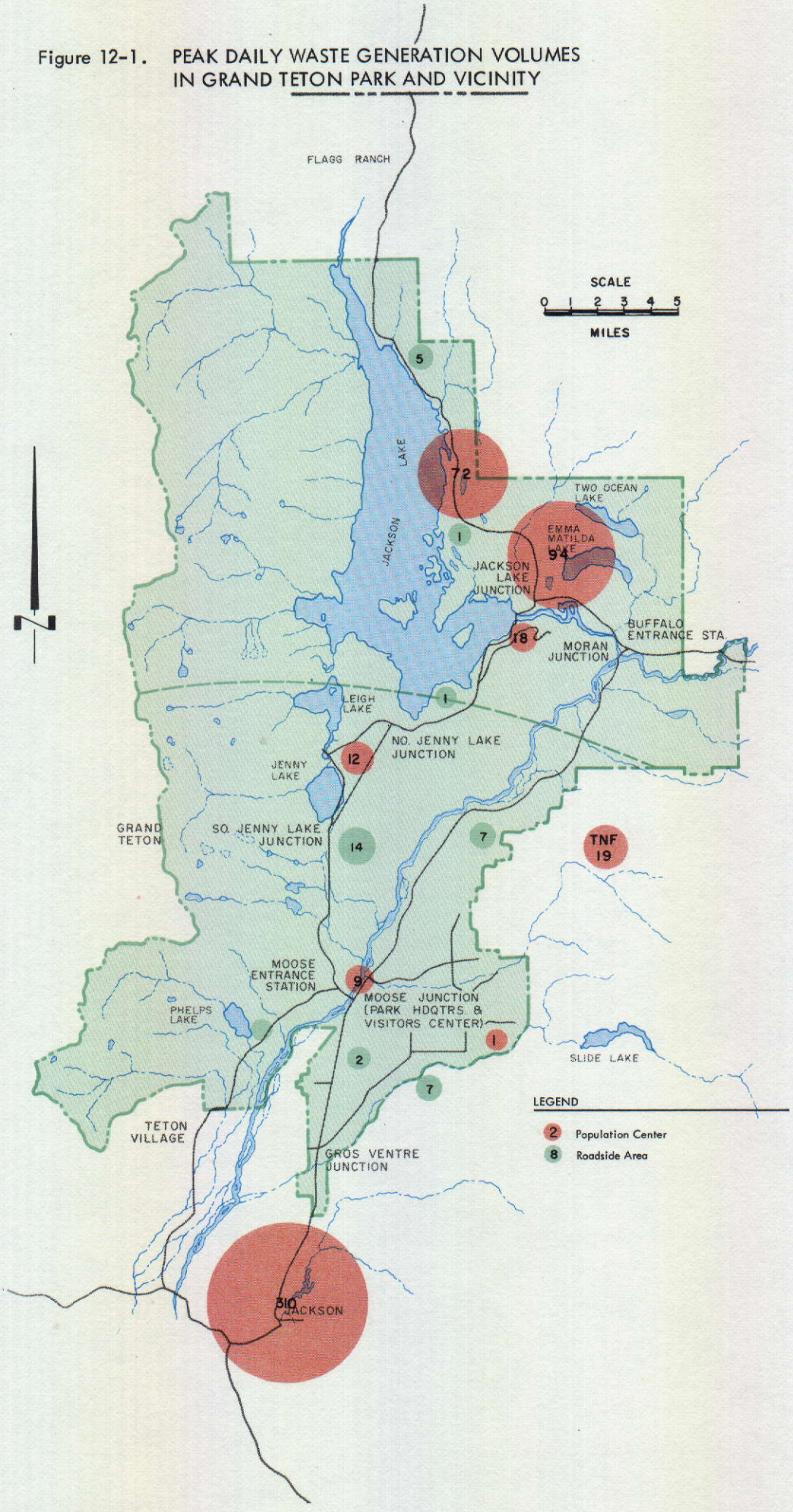


Table 12-2. PRESENT DAILY REFUSE PRODUCTION DURING PEAK SEASON IN GRAND TETON PARK

Facility	Refuse Produced	
	Cubic Yards[a]	Tons
North District Service Area		
Jackson Lake Lodge	94	3.8
Colter Bay	72	2.9
Signal Mountain	18	0.7
Roadside	6	0.3
Total	190	7.7
South District Service Area		
Jenny Lake Area	12	0.5
Moose	9	0.3
Kelly	1	0.1
Roadside	36	0.4
Total	58	2.3
Total Volume Per Day	248	10.0

[a]Based on 81 pounds per cubic yard

Table 12-3. PROJECTED SOLID WASTE GENERATION FACTORS

Year	Increase in Generation Factor, percent per year
1971 to 1976	1.5
1976 to 1981	1.0
1981 to 2000	0.5

Secondly, the increasing awareness and sensitivity of the populace to the solid waste problem will bring about a change in the public attitude. Educational efforts directed toward industry and the consumer will assist in the awareness and enhance the trend toward the decrease in per capita waste generation rates.

Utilizing the generation factors shown and discussed above and the population estimates presented in Chapter 10, total annual production rates through the year 2000 were developed and are shown in Table 12-4. Annual monitoring of waste loadings should be made to check the projections and to insure that no great change has taken place.

Table 12-4. PROJECTED SOLID WASTE PRODUCTIONS

Year	North Service Area		South Service Area		Park Total	
	cu. yd.	tons[a]	cu. yd.	tons[a]	cu. yd.	tons[a]
1971	190	7.7	58	2.3	248	10.0
1972	193	7.8	59	2.4	252	10.2
1973	196	8.0	60	2.4	256	10.3
1974	199	8.1	61	2.5	260	10.5
1975	202	8.2	62	2.5	264	10.7
1976	204	8.3	62	2.5	266	10.8
1977	206	8.3	63	2.5	269	10.9
1978	208	8.4	63	2.5	271	10.9
1979	210	8.5	64	2.6	274	11.1
1980	213	8.6	65	2.6	278	11.2
1981	214	8.7	65	2.6	279	11.3
1982	215	8.7	65	2.6	280	11.3
1983	216	8.7	65	2.6	281	11.4
1984	217	8.8	66	2.7	283	11.4
1985	218	8.8	66	2.7	284	11.5
1986	219	8.9	66	2.7	285	11.5
1987	220	8.9	67	2.7	287	11.6
1988	221	8.9	67	2.7	288	11.6
1989	222	9.0	67	2.7	289	11.7
1990	224	9.1	67	2.7	291	11.8
1991	225	9.1	68	2.8	293	11.8
1992	226	9.2	68	2.8	294	11.9
1993	227	9.2	69	2.8	296	12.0
1994	228	9.2	69	2.8	297	12.0
1995	229	9.3	69	2.8	298	12.1
1996	230	9.3	70	2.8	300	12.1
1997	231	9.4	70	2.8	301	12.2
1998	232	9.4	70	2.8	302	12.2
1999	233	9.4	71	2.9	304	12.3
2000	235	9.5	72	2.9	307	12.4

[a]Based on 81 pounds per cubic yard

Chapter 13

GRAND TETON NATIONAL PARK SOLID WASTE MANAGEMENT METHODS and CONSIDERATIONS

As in the case of Yellowstone National Park, Grand Teton National Park was established with the objective of preserving the natural scenic beauties for both present and future generations. Any change in the physical features of the park would also be viewed as being in conflict with the park philosophy. Such changes in physical features are, of course, directly related to the present solid waste disposal practices at the three solid waste landfill areas in the park. Such practices pose a threat to the maintenance of the "status quo" of the physical surroundings and environments in those particular areas. As previously stated, the National Park Service contends that, if at all possible, the ultimate solid waste management plan should point toward removal of the waste from the confines of the park. Any other solution would not be compatible with the philosophy of the National Park Service. In the following chapter, solid waste removal from the confines of the park was investigated in addition to continued disposal within the park. It must be remembered that, although monetary aspects are an important aspect of the analysis of the plans, it is not the only aspect that should be considered. Any possible detrimental affects that may be placed on the park environment should have a strong influence in the final selection of the recommended plan.

SOLID WASTE MANAGEMENT SYSTEMS

In Chapter 7, the various aspects of a solid waste management system were discussed in detail. These aspects included storage methods, collection methods, secondary transportation, pretreatment methods, and disposal methods. Except for the following, the same criteria that was presented in Chapter 7 also applies to the solid waste management considerations for Grand Teton National Park.

Storage Methods

In Grand Teton National Park, it is not necessary to protect the solid wastes that have been collected from marauding bears as is the case for Yellowstone Park. However, the stored waste must be protected to prevent unsightliness, and from attracting rats and flies.

Metal and Plastic Cans:

As previously mentioned in Chapter 10, two standard-sized cans are used in the park. The 25-gallon container is utilized for roadside litter and the 32-gallon container is used for picnic areas and concessionaires. In addition, a 55-gallon capacity container is used on a much smaller scale. These larger containers are normally used by the concessionaires. All the cans are made of galvanized steel and utilize plastic liners. These liners, which are similar to those used at Yellowstone Park, have been found to increase the efficiency of collection and reduce the time required for cleaning the cans.

Chapter 14

GRAND TETON NATIONAL PARK

PLANS for SOLID WASTE MANAGEMENT

It was determined in the preceding chapters that the solid waste disposal needs of Grand Teton National Park can be met by utilization of either the sanitary landfill method or by incineration with a small sanitary landfill. As with Yellowstone Park, disposal could be carried out independently or in conjunction with the various entities which encompass the park. These entities include the city of Jackson, Teton National Forest, Teton County, and Flagg Ranch, all of which were discussed earlier in Chapter 10. Disposal could be provided through use of suitable landfill sites located in certain areas within the park which would not impair the aesthetics of the environment or groundwater quality. However, the National Park Service is dedicated to conserving the scenic, scientific, and historic heritage of the United States for the benefit and enjoyment of the people. As with Yellowstone Park, whether the utilization of a small amount of land for sanitary landfill purposes really conflicts with the basic national park philosophy is a point that must be considered on other than economic values. The alternatives presented in this chapter consider first their selection on strictly an objective evaluation of basic economics and then on a subjective evaluation by the author of other intangible factors. The final recommended plan is chosen after consideration of all factors.

SOLID WASTE MANAGEMENT PLANS

Two basic disposal methods were considered in developing and analyzing the following plans for solid waste management. These were (1) sanitary landfill and (2) incineration with residue disposal to land. Each method was investigated for the park on a regional approach that included all outside park entities. A comparison was made between direct haul by the collection vehicle to the disposal area versus transfer from the collection vehicle to a transfer station then to a transport vehicle and transport to the disposal area. The criteria used to form the basis for proper comparisons of alternatives in the analysis of the various plans is presented below:

1. All collection or transport trucks hauling refuse to the disposal area would proceed only when they had a full (or nearly full) load. Three-quarter-ton pickup trucks would transfer their loads to the packer trucks.

2. In cases of direct haul via collection vehicles to the disposal area, it was assumed that the entire collection crew (driver plus laborers) would accompany the vehicle to the disposal area when such trip could be made during the normal 8-hour shift. When the trip required time beyond the normal 8-hour shift, only the driver would accompany the vehicle to the disposal area. Any overtime pay was assumed on a straight-time basis at the regular hourly rates. It was assumed that all personnel would work at least eight hours per day. Any nonproduction, "free", time was added to the collection costs.

3. In plans employing transfer stations, it was assumed that the transfer containers would be held no more than two days before transporting them to the disposal area or until filled.

4. In all plans, the costs are based on efficient use of equipment and personnel.

5. Plans 1A, 2A, 3A, and 4A utilized existing 14-cubic yard capacity packer trucks, whereas Plans 1B, 2B, 3B, and 4B used 25-cubic yard capacity vehicles for collection of the solid waste.

Description of Solid Waste Management Plans

Solid waste management plans are described briefly in the following paragraphs.

Plan 1A (Figure 14-1):

This plan proposes that the waste generated in both the North and South Districts of Grand Teton Park would be hauled directly to a landfill site located near Moose Junction. The waste generated from the outside entities, namely, Teton National Forest, the city of Jackson, and Teton County, would all be hauled directly to the existing Jackson landfill. The waste generated from Flagg Ranch would be hauled directly to the park landfill located at Moose Junction. In this plan, the existing 14-cubic yard packer truck at the North District will be used in addition to another newly purchased 14-cubic yard packer truck. The round-trip haul from the North District is estimated to take $1\frac{1}{2}$ hours per trip and the distance is approximately 50 miles. The South District would be able to use the existing 14-cubic yard packer truck currently available. Only one crew would be utilized in the North District for the two packer trucks. The packer truck crew will interchange trucks when one is full and one additional haul driver will be required to drive the full packer truck to the disposal site and back. This extra haul driver will be required to make two round trips a day for a total of three hours. The packer crew would be able to make the other two trips that will be required in their packer trucks.

Plan 1B (Figure 14-1):

This plan is similar to Plan 1A wherein both districts still direct haul to the Moose Junction landfill site. The basic difference is that, in the North District, one 25-cubic yard packer truck has been purchased in lieu of the existing 14-cubic yard packer truck which has now been abandoned. Operations in the South District remain the same. The estimated collection time for the North District still remains at five hours with the 25-cubic yard packer. The estimated haul time with the 25-cubic yard packer is again three hours total for two round trips. The significant difference with utilization of the 25-cubic yard packer truck is that only two round-trip hauls will be required for the entire day instead of the four trips required for Plan 1A. A major constraint associated with any of the "B" plans involving the use of the 25-cubic yard packers is mobility through the campground areas. If the additional-sized container inhibits collection and causes unsafe operation, the use of these packers cannot be justified.

Plan 2A (Figure 14-2):

This plan proposes a direct haul to a regional landfill site south of Jackson which is now the landfill site utilized by the city of Jackson. In this plan, all waste generated, both inside and outside of the park, would go to this regional landfill site. As in Plan 1A, two 14-cubic yard packer trucks would be utilized in the North District and one 14-cubic yard packer in the South District. In the North District, each packer truck would collect for $2\frac{1}{2}$ hours and make two round-trip hauls. Each round-trip haul is estimated at $2\frac{1}{2}$ hours per trip and the distance is estimated at 90 miles. The South District collection time is five hours and the haul time is estimated at two hours. The remaining one hour of the working day has been added to the collection time associated with this plan.

Figure 14-1. SOLID WASTE MANAGEMENT PLANS 1A AND 1B

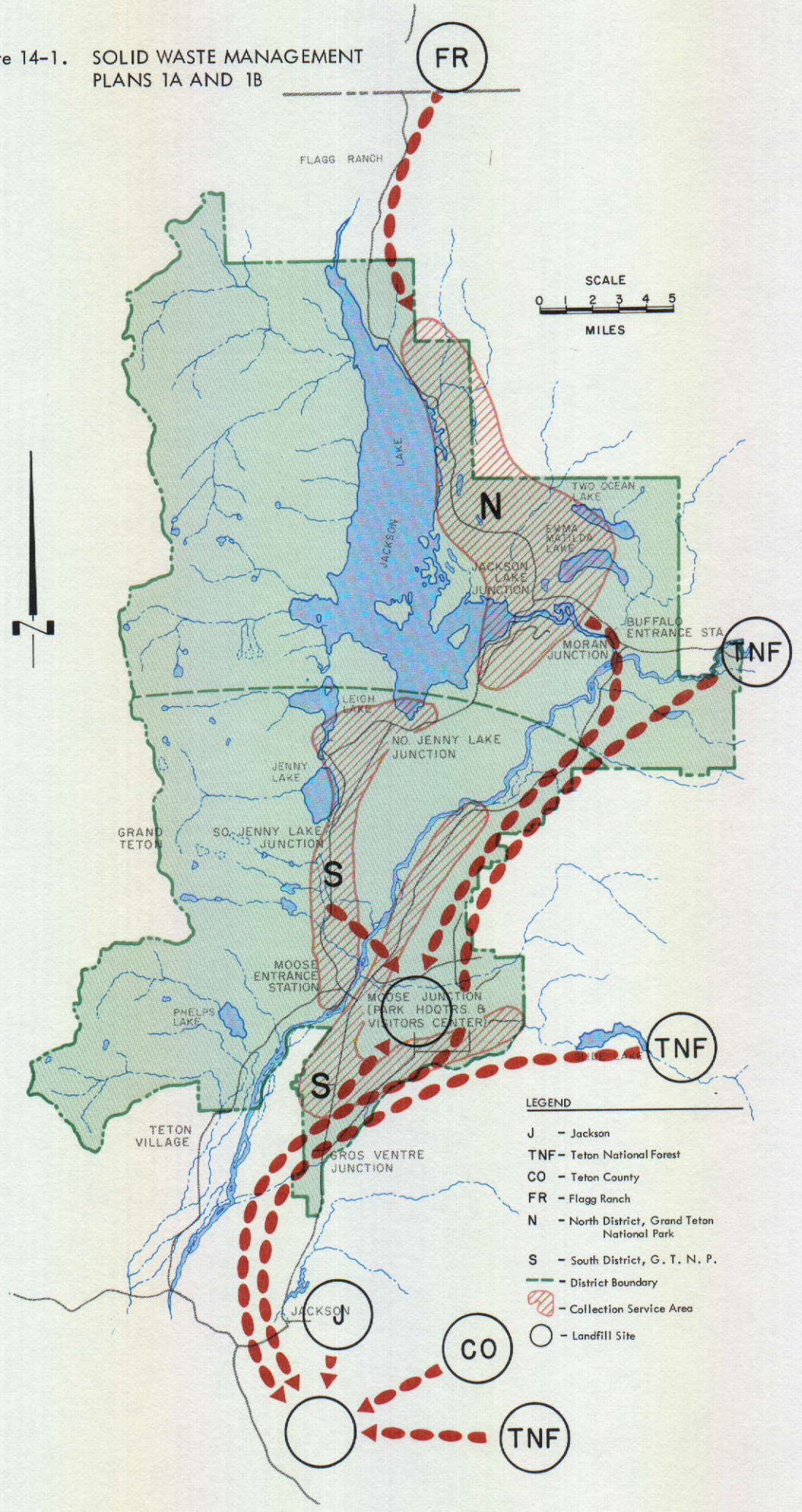
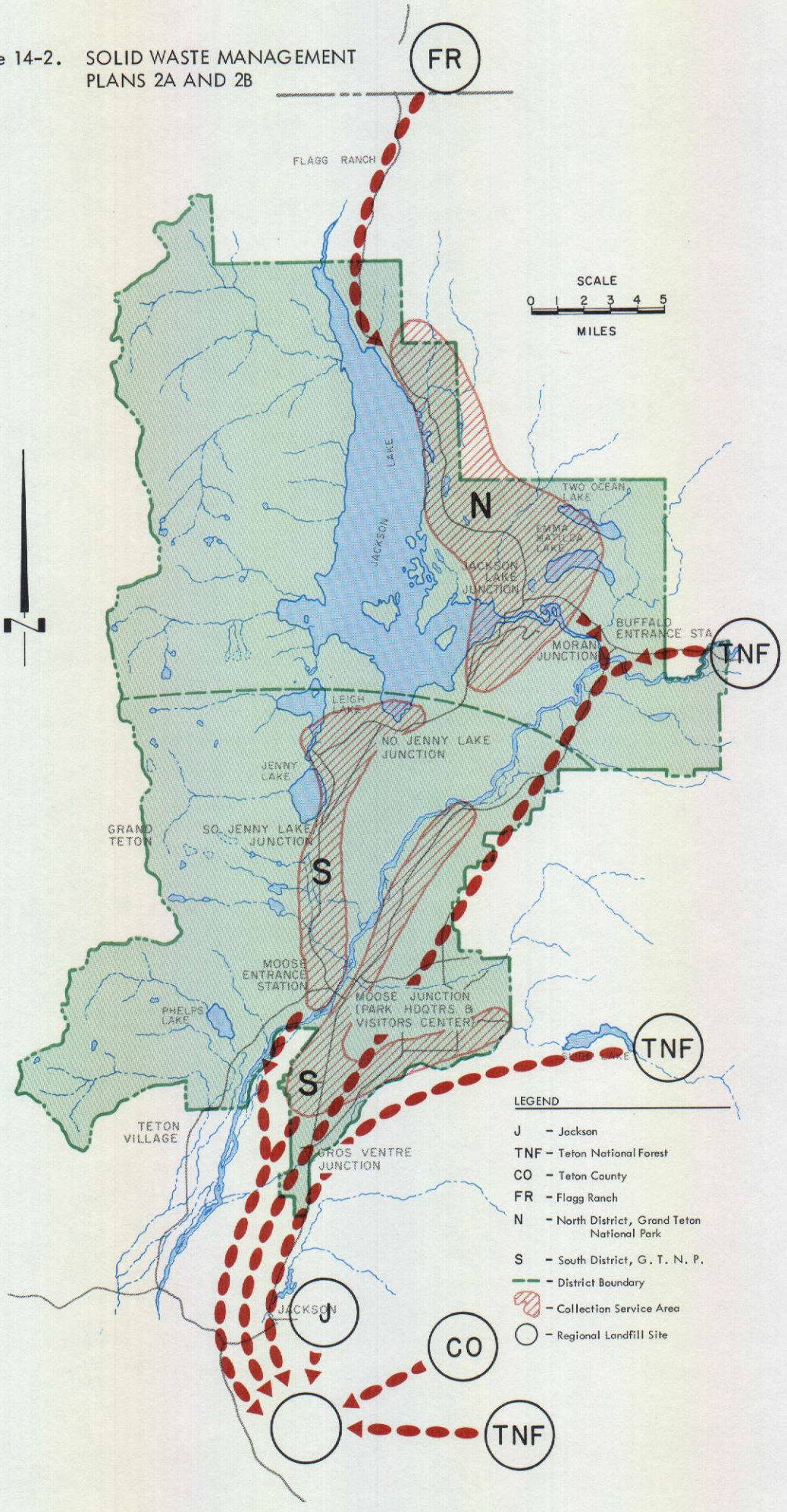


Figure 14-2. SOLID WASTE MANAGEMENT PLANS 2A AND 2B



Plan 2B (Figure 14-2):

This plan is similar to Plan 2A except that two 25-cubic yard packers are being used in the North District instead of the existing 14-cubic yard packer truck. One 14-cubic yard packer truck will be used in the South District as in Plan 2A. As in Plan 1A, only one packer crew will be utilized in the North District for the two trucks. One additional packer driver will be required in the North District to haul one of the full 25-cubic yard packer trucks each afternoon. In the North District, only half the haul time is required for Plan 2B as that required for Plan 2A, whereas collection time remains the same. The collection and haul times in the South District for Plan 2B are the same as for Plan 2A.

Plan 3A (Figure 14-3):

This plan proposes the North and South Districts direct haul all collected wastes to a transfer station located near Jackson Lake Junction. The Flagg Ranch wastes will also be included. The solid waste from the transfer station would be hauled to the regional landfill site by a transfer vehicle once per day. It should take this transfer vehicle approximately three hours for the round trip. The collection and haul times to the transfer station are similar to those presented in Plan 1A. The transfer station would utilize a 40-cubic yard container which should accommodate approximately 250 cubic yards of uncompacted solid waste. In the cost analysis for this alternative, all outside park entities have been assumed to haul all solid waste directly to the regional landfill site; in the case of Teton National Forest, a more economical consideration for wastes generated east of the park would be to haul that waste to the transfer station.

Plan 3B (Figure 14-3):

This plan is identical to Plan 3A with the exception of using 25-cubic yard packer trucks in the North District. Collection and haul costs are similar to those presented in Plan 1B. The most significant difference in this plan as compared to Plan 1B is that only one 25-cubic yard packer truck will be required, made possible because of the short haul distance in this plan.

Plan 4A (Figure 14-4):

Plan 4A proposes to have an incinerator located in the park at the location proposed for the transfer station. The outside entities would still use the landfill near Jackson; all park solid waste, including the solid waste generated from Flagg Ranch, would be hauled directly to this incinerator site. The collection and haul costs are identical to those presented in Plan 3A--the difference being in the higher disposal costs for the utilization of an incinerator. A variation on this plan could be the incorporation of solid waste from areas east of the park to disposal at the incinerator site.

Plan 4B (Figure 14-4):

This plan proposes direct haul of park solid waste refuse via 25-cubic yard packers to a park incinerator. The collection and haul costs for Plan 4B are identical to those presented in Plan 3B. Disposal costs are the same as those presented in Plan 4A.

Land Requirements for Sanitary Landfill

The land requirements for sanitary landfill over any period of time will depend upon the planning and management of the disposal site as well as the total quantities received. For the purpose of determining land requirements, compacted densities of 600 pounds per cubic yard were assumed. In all cases, an average fill depth of 16 feet was assumed. For lesser fill depths, land requirements would increase and for greater fill depths, they would decrease.

Utilizing the solid waste projections from Chapter 12, the cumulative quantities shown in Table 14-1 were developed. The land area requirements are tabulated in Table 14-2. The required areas include an allowance of 1 part earth per 3 parts solid waste by volume (compacted).

Table 14-1. CUMULATIVE SOLID WASTE PROJECTIONS IN GRAND TETON PARK

Service Area	1980	1990	2000
North District	8,190	17,020	26,320
South District	2,480	5,150	7,970
Grand Teton Total	10,670	22,170	34,290

Table 14-2. SANITARY LANDFILL AREA REQUIREMENTS - ACRES

Service Area	1980	1990	2020
North District	1.1	2.2	3.4
South District	0.3	0.7	1.0
Grand Teton Total	1.4	2.9	4.4

Capacity Requirements for Incinerators

The capacity of an incinerator is based on its 24-hour rated capacity. Since operation of the incinerator in the park is restricted to eight hours per day, the required capacity of the incinerator would be three times the maximum solid waste production rate with allowance for future growth. For the plans proposed, the incinerator was rated at 35 tons per day.

Evaluation of Solid Waste Management Plans

The solid waste management plans described previously in this chapter were developed in detail and evaluated on the basis of the criteria established in Chapter 10, which include the capital costs of the equipment and improvements of the recommended plan and are presented in Table 14-3. The annual operation and maintenance costs for each plan are shown in Table 14-4.

Comparison of Solid Waste Management Plans

In general, the principal factor usually considered when comparing alternatives is cost. In some cases, costs alone are not sufficient to permit a valid comparison and other factors must be considered. In this comparison of alternatives, other intangible factors not directly related to cost bear heavily in making a final selection of a solid waste plan for implementation. Factors such as conformance to park service philosophy, aesthetics, reliability, safety, ease of operation, regionalization, and minimization of the public health risk all are considerations of a subjective nature which must also weigh in the selection of the final plan. The comparisons which follow establish the basis for selection of the recommended solid waste management plan.

Figure 14-3. SOLID WASTE MANAGEMENT PLANS 3A AND 3B

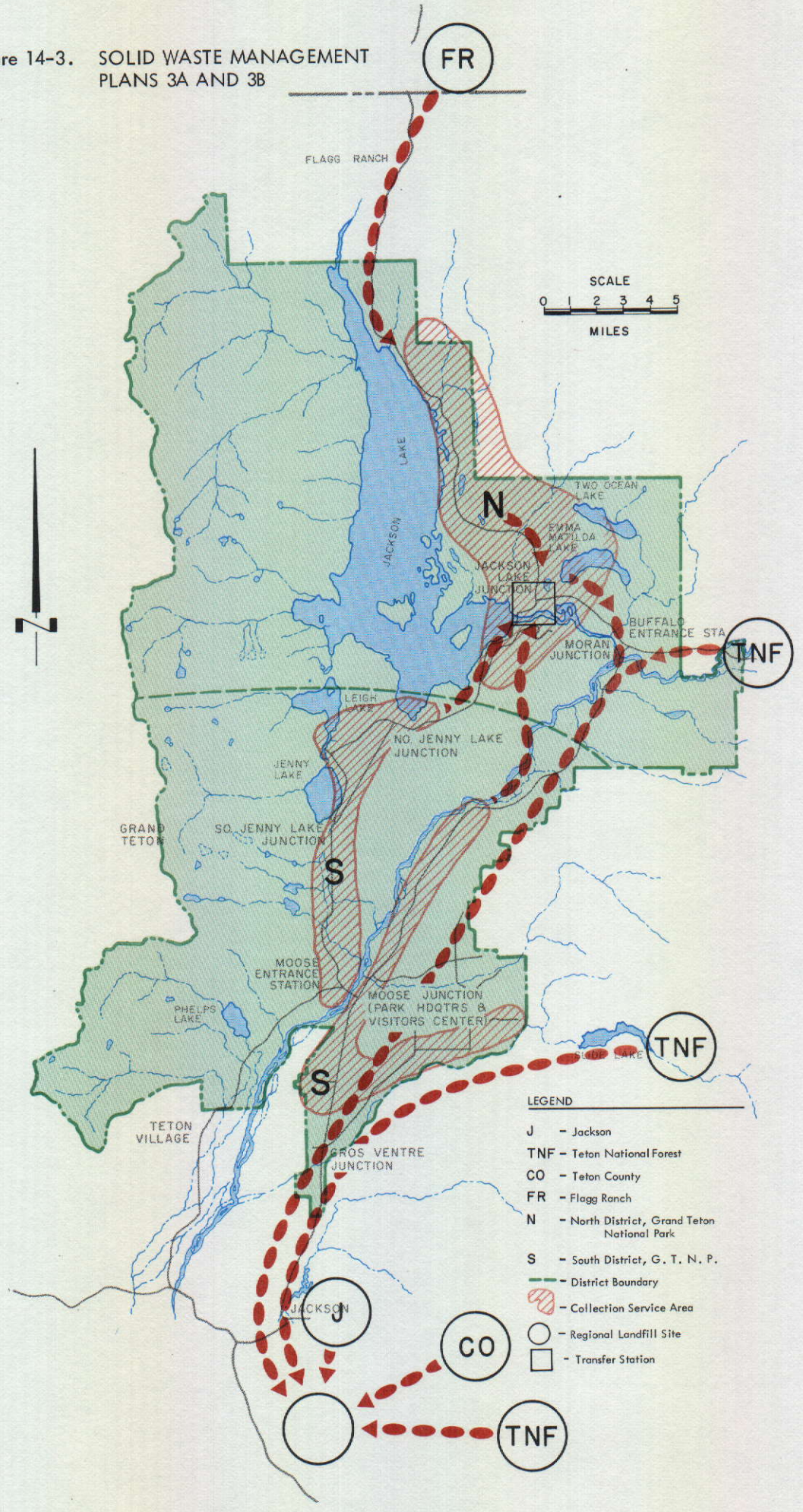


Figure 14-4. SOLID WASTE MANAGEMENT PLANS 4A AND 4B

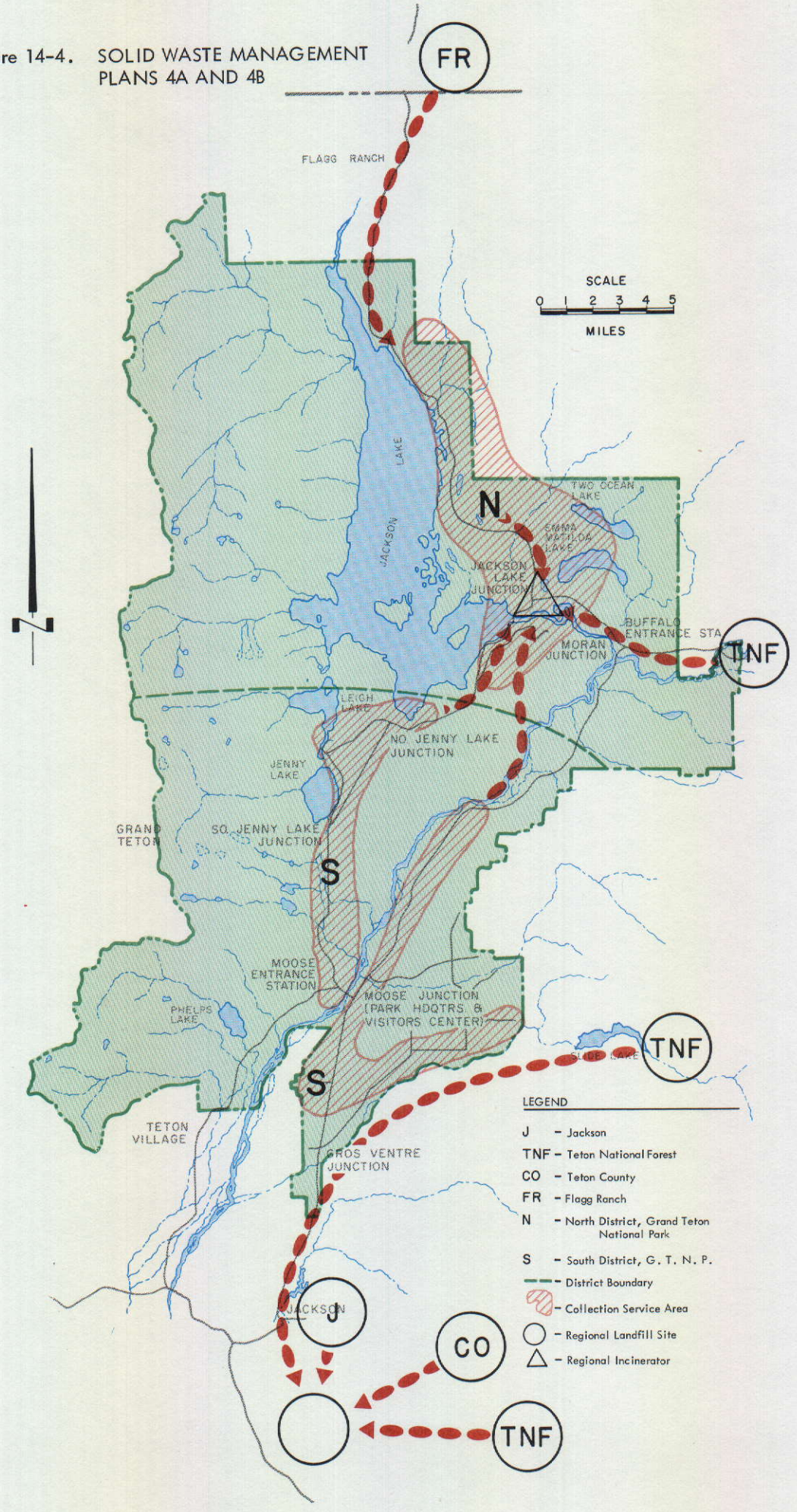


Table 14-3. FREQUENCY OF COLLECTION AND HAUL

Plan	District	Packers (3-man crew)						Pickup Truck (2-man crew)
		Collection				Haul, hr.	Total, hrs.	Collection, hrs.
		No.	Cap.	Actual hrs.	Extra hrs.			
1A	North	2	13 cy	5	0	2 @ $1\frac{1}{2}$=3 2 @ $1\frac{1}{2}$=3	8 +3 (driver)	8
	South	1	13 cy	5	2	1 @ 1 =1	8	8
1B	North	1	25 cy	5	0	1 @ $1\frac{1}{2}$=3	8	8
	South	1	13 cy	5	2	1	8	8
2A	North	2	13 cy	$2\frac{1}{2}$ $2\frac{1}{2}$	$1\frac{1}{2}$ $1\frac{1}{2}$	2 @ $2\frac{1}{2}$=5 2 @ $2\frac{1}{2}$=5	8 8	8
	South	1	13 cy	5	1	2 @ 1 =2	8	8
2B	North	2	25 cy	5	$\frac{1}{2}$	1 @ $2\frac{1}{2}$=$2\frac{1}{2}$ 1 @ $2\frac{1}{2}$=$2\frac{1}{2}$	8 +$2\frac{1}{2}$ (driver)	8
	South	1	13 cy	5	1	2 @ 1 =2	8	8
3A & 4A	North	1	13 cy	5	2	4 @ $\frac{1}{4}$=1	8	8
	South	1	13 cy	5	$1\frac{1}{2}$	1 @ $1\frac{1}{2}$=$1\frac{1}{2}$	8	8
3B & 4B	North	1	25 cy	5	2	2 @ $\frac{1}{2}$=1	8	8
	South	1	13 cy	5	$1\frac{1}{2}$	1 @ $1\frac{1}{2}$=$1\frac{1}{2}$	8	8

Economic Comparison:

A review of Table 14-4 indicates that Plans 1B and 2B, which involve either direct haul to either a landfill site within the park or to a landfill site south of Jackson, will be the least expensive. Both of these plans involve the use of the larger 25-cubic yard packer vehicles for the North District. Because of the previously mentioned constraint associated with the use of 25-cubic yard packer trucks in the campground, it may not be feasible to implement either of the "B" plans. In this case, the least cost plan is Plan 1A which utilizes 14-cubic yard packers in the North District and maintains sanitary landfill operations within the park.

In Plan 2B, where a direct haul distance involves a $2\frac{1}{2}$-hour round trip, the haul costs are substantially lower resulting in a substantially higher total cost for Plan 2A. In Plans 3A and 3B, a comparison of the combined total of collection cost, haul cost, and disposal cost for these two plans is shown to be substantially lower than any of these three combined costs for Plans 1A, 1B, 2A, or 2B. However, when the transfer station cost is added to the collection, haul, and disposal costs, the total cost of Plans 3A or 3B become high. The reasons for the relatively low collection and haul costs for Plans 3A

Table 14-4. SUMMARY OF ANNUAL OPERATION AND MAINTENANCE COSTS[a]

Plan	District	Collection Cost, $	Haul Cost, $	Transfer Cost, $	Disposal Cost, $	Total Cost, $
1A	North	14,440	5,932		8,637	
	South	16,320	1,308			
	Total	30,760	7,240		8,637	46,637
1B	North	16,545	4,010		8,637	
	South	16,320	1,308			
	Total	32,865	5,318		8,637	46,820
2A	North	13,420	13,080		4,900	
	South	15,010	1,980			
	Total	32,668	14,768		4,900	52,336
2B	North	16,145	5,080		4,900	
	South	15,010	1,980			
	Total	31,155	7,060		4,900	43,115
3A	North	15,998	1,310	9,580[b]	4,900	
	South	15,665	1,965	9,360[c]		
	Total	31,663	3,275	18,940	4,900	58,778
3B	North	16,520	1,335	9,580[b]	4,900	
	South	15,665	1,965	9,360[c]		
	Total	32,185	3,300	18,940	4,900	59,325
4A	North	15,998	1,310		30,850	
	South	15,665	1,965			
	Total	31,663	3,275		30,850	65,788
4B	North	16,520	1,335		30,850	
	South	15,665	1,965			
	Total	32,185	3,300		30,850	66,335

[a]Based on 1971 condition
[b]Transfer station costs
[c]Transfer haul costs

or 3B is because the transfer station is located at a central point between the North and South Districts. In analyzing Plans 4A and 4B, we again note the relatively low collection and haul costs. However, the cost of disposal by incineration is high and, when this cost is added to the collection and haul cost, the total costs for Plans 4A and 4B are the highest of all plans in Table 14-4.

Other Considerations:

As previously mentioned, the least cost plan does not necessarily represent the best solid waste management plan for the park. Other factors bearing consideration involve the following:

Conformance to Park Service Philosophy:

Being dedicated to the preservation of the park in its natural and unaltered state is incongruous with development of one or more sanitary landfills within the park. Any plan that encourages the preservation of the park without restricting the use of the park by the general public should be treated more favorably than one not meeting that criteria.

Aesthetics:

Any solid waste management plan must include every consideration for maintaining a pleasingly aesthetic environment within the park. Those plans that accomplish the most in confining the waste and controlling the accumulation of unsightly areas in the park should be weighed more favorably than other plans that do not.

Safety:

The operation of equipment and facilities leads to a potential of operator safety problems. Any solid waste management program that minimizes roadway travel, the operation of dangerous equipment, etc., should be weighed with favor over a plan, for example, that would include direct haul to an incinerator.

Ease of Operation:

This factor is one that somewhat parallels reliability but again, due to the nature of operation in the park wherein peak summer demands create the need for new and, perhaps, untrained personnel, any system selected must be sufficiently unsophisticated to allow for effective and continuous ease of operation.

Regionalization:

Although not paramount in importance, regionalization allows for singular control of the largest possible solid waste problem. The controls established by regionalization generally lead to more effective operation, lower unit costs, and maximum reliability.

Public Health Risks:

A properly maintained solid waste collection and disposal operation eliminates any of the associated public health risks. The potential of public health problems is increased by every contact of man and solid waste. Any plans that minimize this contact should be weighed in favor of those that do not. As an example, the operation of three sanitary landfills presents a more serious public health problem than does the operation of one regional landfill.

Table 14-5 presents a subjective evaluation of the various plans on the basis of the factors presented above. In this table, we have attempted to summarize and evaluate the important subjective factors

for environmental and cost consequences. It is recognized that the entire format of this analysis is arguable, nonetheless, the table reflects the subjective judgement of the consultant regarding available alternatives. The results of the analysis show that Plan 3A is marginally better from a judgement viewpoint than other plans.

Table 14-5. SUBJECTIVE EVALUATION OF ALTERNATIVE PLANS

Item	Plan							
	1A	1B	2A	2B	3A	3B	4A	4B
Public Health	5	5	8	8	7	7	7	7
Ease of Operation	5	5	8	8	7	7	3	3
Reliability	5	5	7	7	10	10	5	5
Conformance to National Park Service philosophy	0	0	8	8	6	6	6	6
Aesthetics	2	2	10	10	8	8	8	8
Safety	5	5	3	3	10	10	5	5
Regionalization	3	3	8	8	8	8	3	3
Total	25	25	52	52	56	56	37	37

SELECTION OF SOLID WASTE MANAGEMENT PLAN

Recommended Solid Waste Management Plan

It is recommended that Plan 3A be implemented as the solid waste management plan for Grand Teton National Park. This plan would be consistent with the park philosophy in disposing of all waste outside of the park and, in addition, would minimize the haul cost involved during collection and the number and frequency of haul vehicles that would be required to haul to the disposal site. It would also provide a means for temporary storage during inclement winter weather conditions when the waste could not be hauled to the disposal site south of Jackson.

In the recommended plan, a transfer station would be constructed near Jackson Lake Junction. The existing 14-cubic yard packer truck in the North District and the existing 14-cubic yard packer truck in the South District would be utilized for collection. The transfer facilities would be similar to those described in Chapter 8 for the Yellowstone transfer facilities.

Disposal to the regional landfill site would only be required once a day during the peak summer season. During the winter season, disposal to the regional site would only be required occasionally. In addition, this transfer station would provide an ideal means of solid waste storage in case of periods of inclement weather when haul to the regional site would not be practical.

APPENDIX

APPENDIX A

SOLID WASTE PRODUCTION, COMPOSITION, and PROJECTIONS

Fundamental to the planning and design of solid waste collection and disposal facilities is a knowledge of the quantity and composition of the wastes. Because both volume and composition of wastes vary from one area to another, it is essential that design factors be based on actual conditions rather than on experience of other similar areas. In order to obtain an accurate appraisal of the composition and quantities of solid waste generated from the Grand Teton National Park, a field investigation was conducted at both parks. Results of the composition and quantities of solid waste generated by both parks are described in this appendix. Solid waste production data was obtained from interviews and field surveys of the quantities and composition.

FIELD INVESTIGATION

The field survey team consisted of two men--one conducting the "refuse survey" and the other simultaneously conducting the "population survey". The survey team was trained to obtain the required information in the shortest possible time space which, in this case, was four days.

The "refuse survey" consisted of obtaining the total amount of refuse (volume and weight) generated in the park and in separate facilities over a 4-day period and determining the composition of that garbage.

The "population survey" consisted of obtaining the total population in the park and facilities correlated to the refuse survey for the same 4-day period that the refuse was collected.

Thus, by combining the information obtained from both surveys, the amount of refuse one person generates per day in the park was determined for various facilities such as a campground, lodge, general store, etc.

Areas of Study

Since the two parks were too extensive to study completely in the time allocated, an area was selected from each park that would typify solid waste collection and disposal throughout the park. Representative samples of various facilities were also taken. In addition, areas were selected in localities of high population densities.

In Yellowstone National Park, the Lake-Fishing Bridge-Bridge Bay area was selected and in Grand Teton National Park, the Colter Bay-Jackson Lake Lodge area was selected. Each area was studied for four days, Thursday through Sunday. The weekends were chosen to insure heavy population densities and, therefore, more refuse.

Refuse Survey

The purpose of the refuse survey was to determine: (1) the total amount of refuse collected in the park each day of the 4-day sampling period; (2) the amount of refuse collected at each facility; (3) the composition of the refuse; and, (4) weight/volume relationships.

To determine the total amount of refuse collected throughout the parks during the survey, each driver of a refuse collection vehicle on each collection run was given a form on which was recorded the number of cans and the size of the cans collected at each facility. From this, the survey team was able to determine the amount of refuse collected at a certain campground or general store, etc., for each day of the 4-day survey period. This phase of the survey was conducted throughout both parks and the total volume of refuse was thus obtained.

In the areas in each park selected for intensive study of the refuse characteristics, refuse samples were collected for each type of facility (campgrounds, hotels, restaurants, etc.) and separated into four categories: food, paper, metal, and glass. Weights and volumes of each category of each sample were determined so that loose densities (pounds per cubic foot) could be calculated for each facility in the study area.

Other random samples were taken outside of the intensive study area in each park to insure that the sampled areas were representative of facilities throughout each park. Among the random samples taken in Yellowstone National Park to verify study area data were the campground and administration building at Mammoth, the campground at Tower, and the cabins and hotel at Old Faithful. These samples were each separated into the four categories and analyzed in the same manner as the samples collected in the areas of intensive study. Results showed almost identical characteristics.

Population Survey

A population survey was conducted to correlate the amount (volume and weight) of refuse generated to the number of people generating the refuse. In this survey, the manager of each facility, including concessions, in the areas of intensive study, was contacted and information obtained relative to the number of people using the facility during each day of the 4-day study period. All managers actively participated and accurate results were achieved.

Information obtained in this survey, together with that obtained in the refuse survey, provided the basis for an accurate determination of the quantity and composition of refuse from each type facility on a per capita basis. For facilities built in the future, the unit quantities would serve as an accurate guide for the quantities of refuse generated.

RESULTS OF INVESTIGATION

Refuse collection haul routes were obtained from the drivers as well as size and number of cans at each facility to aid in volume determinations. In general, Yellowstone National Park almost exclusively uses 32-gallon cans with plastic liners and, where bear problems prevail, bear-proof cans were utilized. Grand Teton National Park, on the other hand, generally uses 25-gallon cans with plastic liners.

As mentioned previously, both parks are divided into maintenance districts. Yellowstone Park has three districts (North, West, and South) and Grand Teton has two districts (North and South). Tables A-1 and A-2 show the volume of waste collected in both parks per day in each maintenance district. Figures A-1 and A-2 for Yellowstone and Grand Teton, respectively, show the weight and volume generated per person per day for different type facilities. For service stations, restaurants, and the marina, the amounts shown were based on per gallons of gas sold, per meal served, and per berth rented, respectively, instead of on a "per person" basis. This was done because more logical and better correlations were obtained in these instances.

Table A-1. DAILY WASTE VOLUME GENERATION RATE IN VARIOUS MAINTENANCE DISTRICTS IN YELLOWSTONE PARK (AUGUST 19 - 22, 1971)

Facility	Uncompacted Refuse Volume, cu.yd./day
North District	
Mammoth	52
Tower	20
Norris	8
Roadside	8
Total	88
West District	
Madison	15
Old Faithful	80
Roadside	18
Total	113
South District	
Fishing Bridge	58
Lake	22
Bridge Bay	14
Canyon	55
West Thumb	6
Grant Village	34
Roadside	31
Total	220
Total Volume Per day	421

Figures A-3, A-4, A-5, and A-6 present the weight and volume percentages of categorical samples from each type facility in both parks. The first two categories, food and paper, are combustible items, whereas the last two, namely, metal and glass, are noncombustible. Tables A-3, A-4, A-5, and A-6 present the same data in tabular form.

Rates of waste generation varied from one type facility to another within each park as expected. But for a few exceptions, comparisons of refuse densities in both parks were reasonably consistent. Figures A-7 and A-8 graphically present the loose density of waste generated for each park. Variations of densities did arise in comparing like facilities in the two parks, namely, in the campgrounds, the picnic areas, the rental cabins, and employee housing. These variations were noted and the studies repeated in these four areas. The results confirmed the previous variations. An analysis of these variations showed that they were influenced by the different characteristics of the two parks.

Table A-2. DAILY REFUSE VOLUME GENERATION IN VARIOUS MAINTENANCE DISTRICTS IN GRAND TETON PARK (AUGUST 26 - 29, 1971)

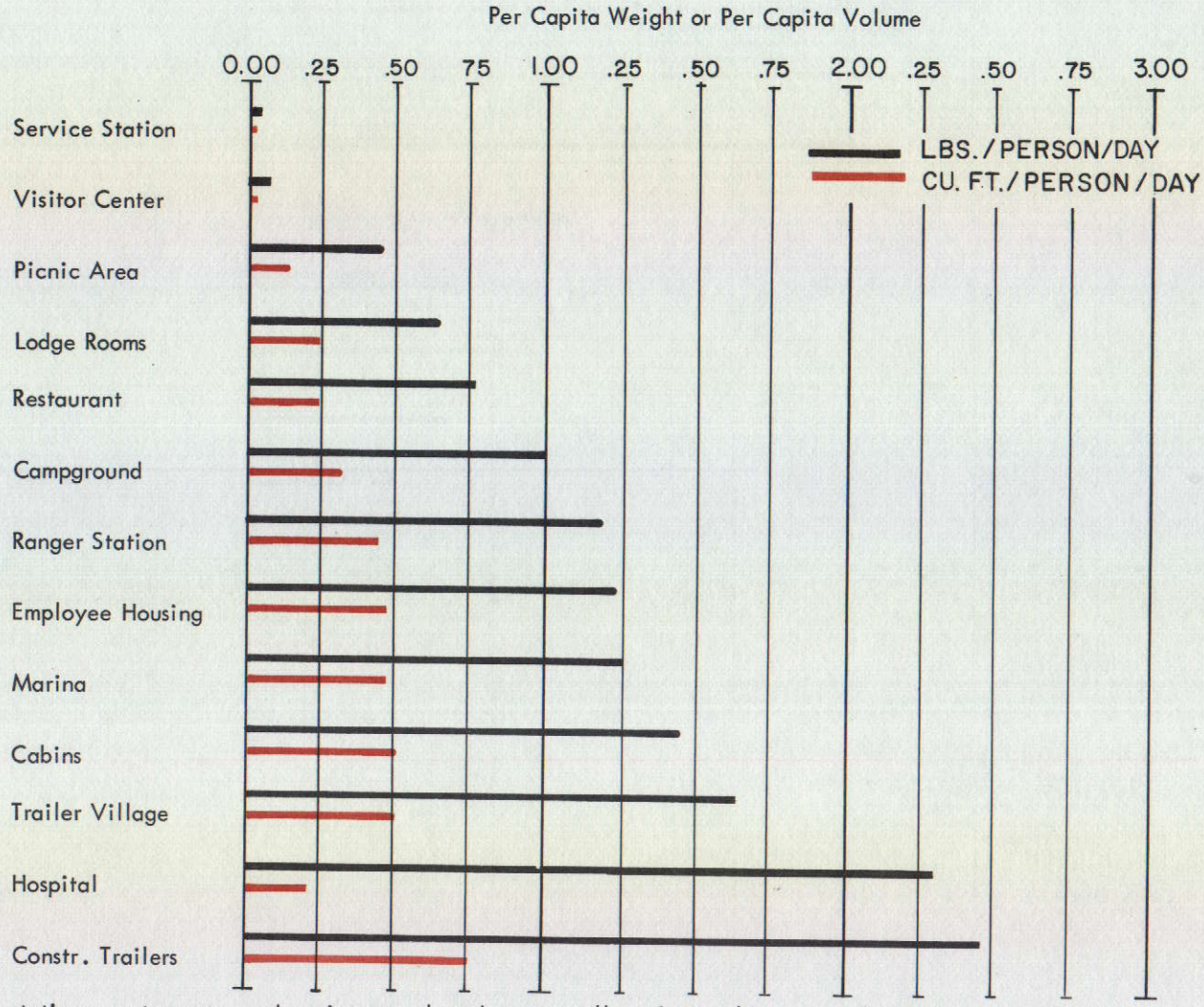
Facility	Uncompacted Refuse Volume, cu. yd./day
North District	
Jackson Lake Lodge	94
Colter Bay	72
Signal Mountain	9
Roadside	6
Total	181
South District	
Jenny Lake Area	12
Moose	9
Kelly	1
Roadside	32
Total	54
Total Volume Per Day	235

An examination of the refuse data developed for campgrounds (Tables A-3 to A-6) showed the loose density of waste in the two parks to be close, however, both the weight and volume generation rates for Grand Teton Park were almost three times that of similar type waste in Yellowstone Park. An analysis of factors contributing to the higher per person rate indicated that campers at Grand Teton Park spent more hours at their campsites, thus preparing more meals and generating more refuse. On the other hand, campers at Yellowstone Park had more tendency to prepare only one or two meals at their campsite and spend the better part of the day travelling throughout the park. This was exemplified by the larger quantities of refuse generated at roadside rests and restaurants in Yellowstone Park.

Picnic areas indicated the same variation in refuse generation with Grand Teton Park showing higher volumes and weights on a per person basis than Yellowstone Park. Once again, this can be attributed to the difference in characteristics of the two parks. The major picnic areas at Grand Teton Park are located on Jackson Lake and Jenny Lake and have about 95 tables and cater more to all-day family outings, whereas Yellowstone Park provides about 5 to 15 tables per picnic area and shorter visitation periods are the result. The Yellowstone Park picnic areas compare more favorably to roadside rest areas.

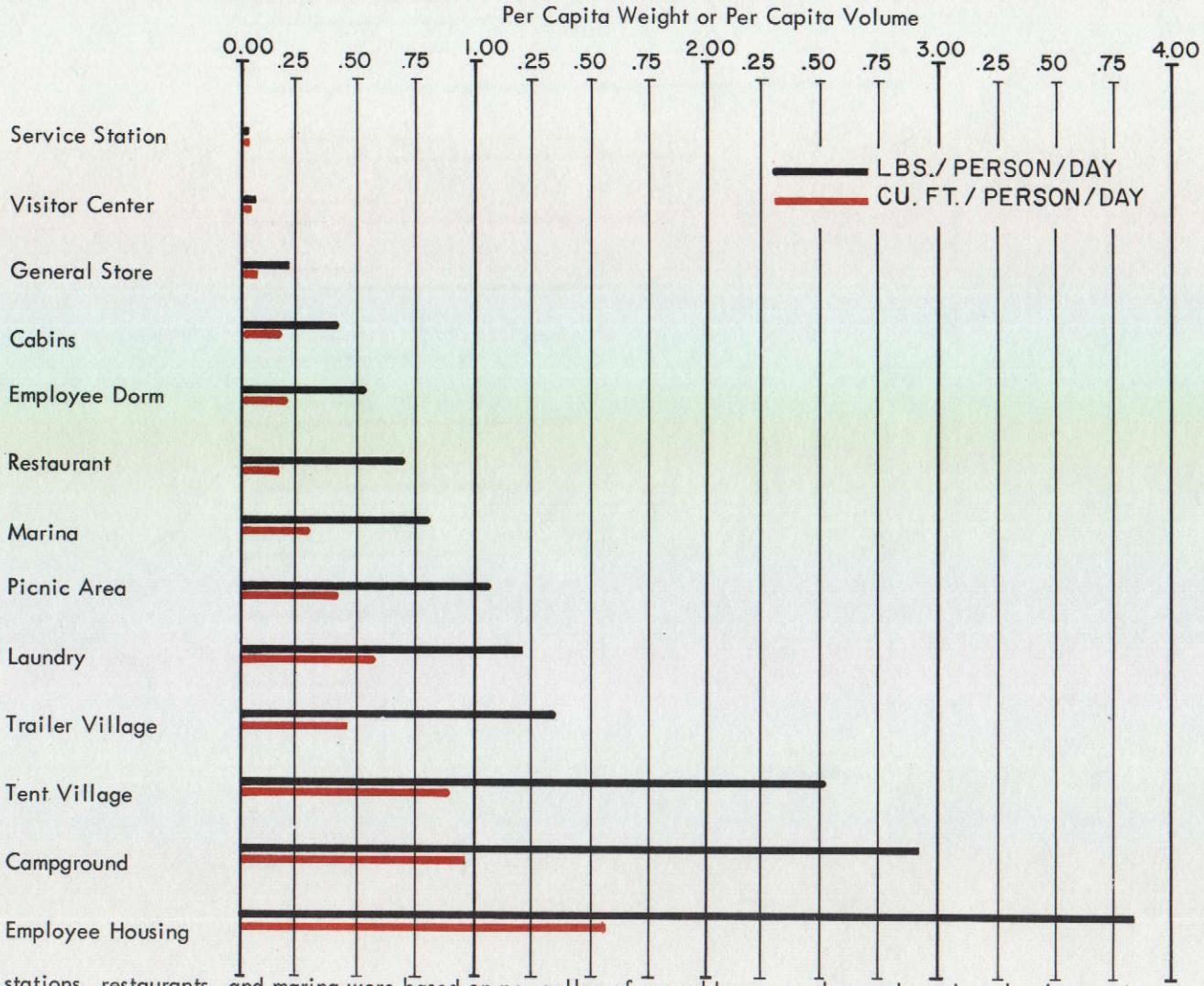
Comparisons of refuse generation at rental cabins showed a wide variance between the two parks. Yellowstone Park recorded only a 14 percent higher refuse density measurement (2.82 pounds per cubic foot to 2.43 pounds per cubic foot), but almost a 300 percent higher refuse volume generation rate (0.48 pounds per person to 0.17 pounds per person), and over 300 percent higher refuse weight generation rate. The greater weight of refuse generated at cabins in Yellowstone Park was attributed to a higher percentage of heavier food, metal, and glass in the refuse. The much higher volume of refuse produced at cabins in Yellowstone Park could be attributed to the type of occupant using the facilities.

Figure A-1. DAILY PER CAPITA WEIGHT AND PER CAPITA VOLUME OF WASTE GENERATED FOR VARIOUS FACILITIES AT YELLOWSTONE PARK[a]



[a]Service stations, restaurants, and marina were based on per gallon of gas sold, per meal served, and per berth rented, respectively, and not on a per capita basis.

Figure A-2. DAILY PER CAPITA WEIGHT AND PER CAPITA VOLUME OF WASTE GENERATED FOR VARIOUS FACILITIES AT GRAND TETON PARK[a]



[a]Service stations, restaurants, and marina were based on per gallon of gas sold, per meal served, and per berth rented, respectively, and not on a per capita basis.

Table A-3. SOLID WASTE COMPOSITION AND PER CAPITA WASTE GENERATED BY BY WEIGHT FOR VARIOUS FACILITIES WITHIN YELLOWSTONE PARK

Facility	Waste Generated, lbs/person/day	Percent Weight				Loose Density, lbs/cu. ft.
		Combustibles		Noncombustibles		
		Food	Paper	Metal	Glass	
Construction Trailers	2.43	23.3	42.8	17.2	16.7	3.31
Hospital	2.15	17.2	50.4	8.3	24.1	2.89
Trailer Village	1.58	26.2	44.6	17.0	12.2	3.22
Cabins	1.34	18.2	54.4	12.3	15.1	2.82
Marina (per berth rented)	1.25	25.1	39.2	19.8	15.9	2.90
Employee Housing	1.20	17.7	55.7	14.1	12.5	2.62
Ranger Station	1.17	40.0	40.8	10.0	9.2	2.66
Campground	1.00	23.5	39.7	21.4	15.4	3.52
Restaurant (per meal served)	0.76	49.3	41.9	7.8	1.0	3.36
Lodge Rooms	0.62	5.4	71.9	13.2	9.5	2.62
Picnic Areas	0.41	26.7	37.1	21.5	14.7	3.61
Visitor Center	0.05	23.0	49.2	16.5	11.3	3.61
Service Station (per gallon)	0.02	2.3	42.2	42.7	12.8	2.87
General Store	-	44.7	16.9	10.5	27.9	7.87
Roadside Rest	-	14.3	43.5	20.4	21.8	3.98
Road Litter	-	1.6	52.7	28.8	16.9	2.98

For example, the cabins in Yellowstone Park cater more to the family-type vacationer with large "per room" occupancy, whereas at Grand Teton Park, most of the rooms are occupied by fewer persons spending most of the day away and eating most of their meals out. For example, during the survey, the park was hosting a doctor's convention and most of the rooms were occupied by single persons who spent most of their time at the convention and ate their meals at the lodge.

Significant variance in waste generation rates occurred at the park service employee housing facilities. Over 300 percent higher rates were recorded at Grand Teton Park. This was due primarily to the fact that the area studied (Park Headquarters at Moose) consists of permanent, all-year housing comparable in quality and size to the Mammoth area in Yellowstone Park, whereas the area sampled at Yellowstone Park (Lake) is a smaller seasonal development with many trailers. Many of the occupants at Park Headquarters at Moose are families, whereas most of the housing at Lake consists of single occupancy. Also, many Grand Teton employees eat lunch and "family dinners" at home, where many Yellowstone Park employees bring their lunch to work and eat dinner out. This accounts in a large measure for the 50 percent higher refuse generation rates of employees housing units in Grand Teton Park.

Table A-4. SOLID WASTE COMPOSITION AND PER CAPITA WASTE GENERATED BY VOLUME FOR VARIOUS FACILITIES WITHIN YELLOWSTONE PARK

Facility	Waste Generated, cu.ft./person/day	Percent Volume				Loose Density, lbs/cu.ft.
		Combustibles		Noncombustibles		
		Food	Paper	Metal	Glass	
Construction Trailers	0.75	4.5	78.8	13.8	2.9	3.31
Trailer Village	0.49	4.6	81.8	11.8	1.8	3.22
Cabins	0.48	6.3	83.1	7.4	3.2	2.82
Employee Housing	0.46	2.4	86.1	9.0	2.5	2.62
Marina (per berth rented)	0.44	1.6	83.0	13.3	2.1	2.90
Ranger Station	0.42	6.6	85.4	6.7	1.3	2.66
Campground	0.28	4.8	76.9	15.2	3.1	3.52
Lodge Rooms	0.24	1.4	90.8	6.7	1.1	2.62
Restaurant (per meal served)	0.23	8.8	80.9	9.3	1.0	3.36
Hospital	0.17	3.4	86.2	6.3	4.1	2.89
Picnic Area	0.12	5.7	72.4	19.3	2.6	3.61
Service Station (per gallon)	0.01	2.6	72.6	23.4	1.4	2.87
Visitor Center	0.01	8.7	77.8	12.1	1.4	3.61
General Store	-	16.7	48.9	22.6	11.8	7.87
Roadside Rest	-	3.5	73.6	18.4	4.5	3.98
Road Litter	-	1.0	78.4	17.6	3.0	2.98

Table A-5. SOLID WASTE COMPOSITION AND PER CAPITA WASTE GENERATED BY WEIGHT FOR VARIOUS FACILITIES WITHIN GRAND TETON PARK

Facility	Waste Generated, lbs/person/day	Percent Weight				Loose Density, lbs/cu. ft.
		Combustibles		Noncombustibles		
		Food	Paper	Metal	Glass	
Employee Housing	3.85	34.1	46.1	11.1	8.7	2.40
Campground	2.90	24.4	46.7	15.7	13.2	3.06
Tent Village	2.55	34.3	43.5	16.7	5.5	2.84
Trailer Village	1.38	31.1	45.5	14.5	8.9	3.24
Laundry (per machine)	1.20	0.0	100.0	0.0	0.0	1.92
Picnic Area	1.13	38.0	33.9	17.9	10.2	2.90
Marina (per berth rented)	0.83	24.2	52.5	11.5	11.8	2.78
Restaurant (per meal served)	0.69	51.0	33.4	9.2	6.4	4.85
Employee Dorm	0.55	16.5	58.6	4.9	20.0	2.79
Cabins	0.42	12.6	62.6	9.1	15.7	2.43
General Store	0.20	3.5	52.9	3.4	40.2	3.10
Visitor Center	0.04	15.3	47.0	22.0	15.5	2.80
Service Station (per gallon)	0.01	6.0	59.8	32.5	1.7	1.90
Roadside Rest	-	38.7	34.1	21.6	5.6	3.45
Road Litter	-	13.7	38.5	15.5	32.3	3.22

Table A-6. SOLID WASTE COMPOSITION AND PER CAPITA WASTE GENERATED BY VOLUME FOR VARIOUS FACILITIES WITHIN GRAND TETON PARK

Facility	Waste Generated, cu.ft./person/day	Percent Volume				Loose Density, lbs/cu. ft.
		Combustible		Noncombustible		
		Food	Paper	Metal	Glass	
Employee Housing	1.62	6.3	86.1	6.5	1.1	2.40
Campground	0.95	5.0	82.9	10.6	1.5	3.06
Tent Village	0.90	5.9	84.5	8.2	1.4	2.84
Laundry (per machine)	0.63	0.0	100.0	0.0	0.0	1.92
Trailer Village	0.42	7.0	82.0	9.3	1.7	3.24
Picnic Area	0.39	6.0	85.0	7.3	1.7	2.90
Marina (per berth rented)	0.31	4.0	87.5	7.5	1.0	2.78
Employee Dorm	0.20	7.5	87.5	2.2	2.9	2.79
Cabins	0.17	1.8	92.7	3.8	1.7	2.43
Restaurant (per meal served)	0.14	12.8	71.4	13.6	2.2	4.85
General Store	0.06	1.0	90.3	1.8	6.9	3.10
Service Station (per gallon)	0.01	1.5	78.4	19.7	0.4	1.90
Visitor Center	0.01	2.9	78.5	14.8	3.8	2.80
Roadside Rest	-	8.0	74.4	16.8	0.8	3.45
Road Litter	-	1.0	82.0	12.0	5.0	3.22

Figure A-3. SOLID WASTE COMPOSITION BY PERCENTAGE WEIGHT IN YELLOWSTONE NATIONAL PARK

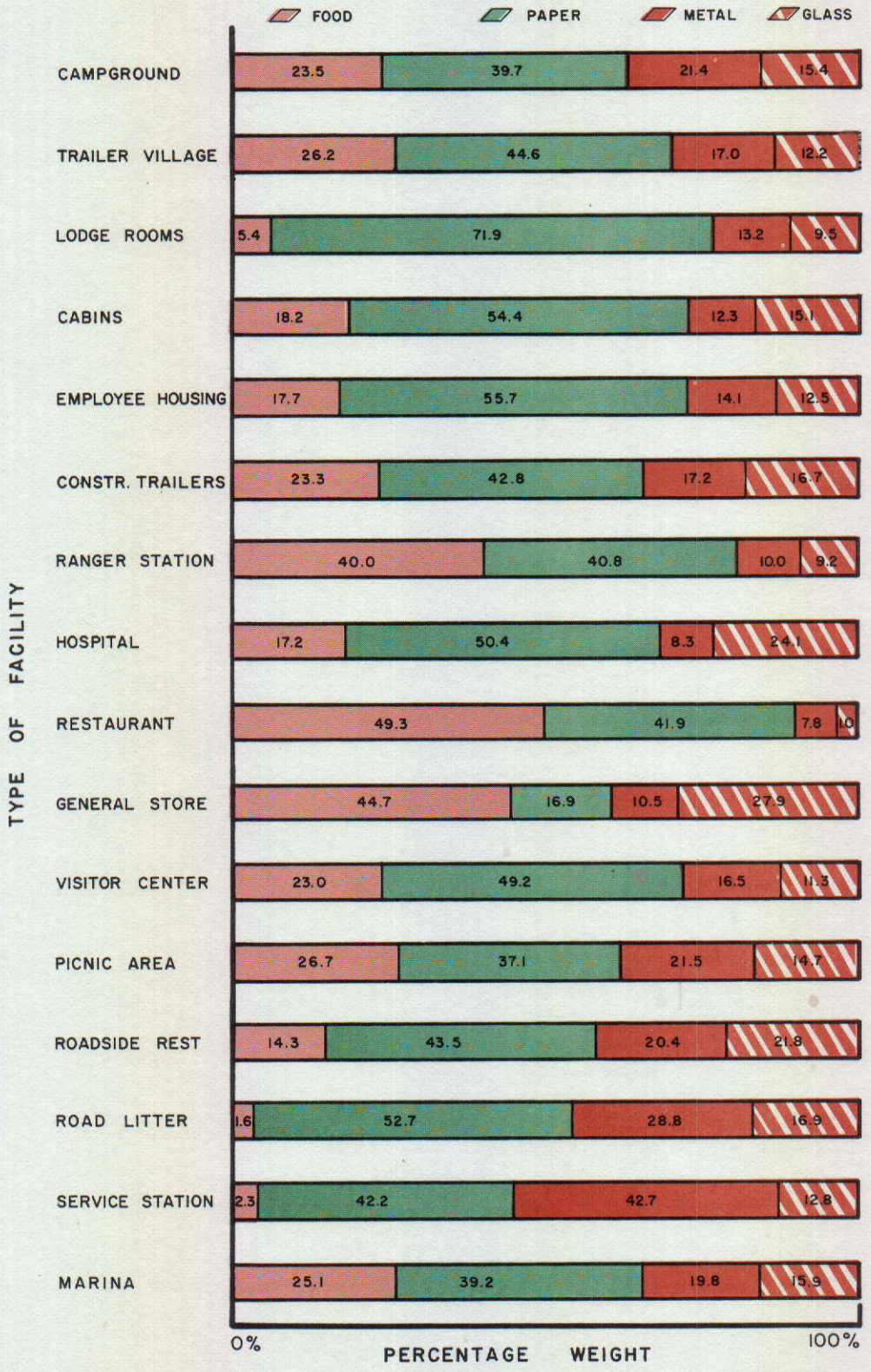


Figure A-4. SOLID WASTE COMPOSITION BY PERCENTAGE VOLUME IN YELLOWSTONE NATIONAL PARK

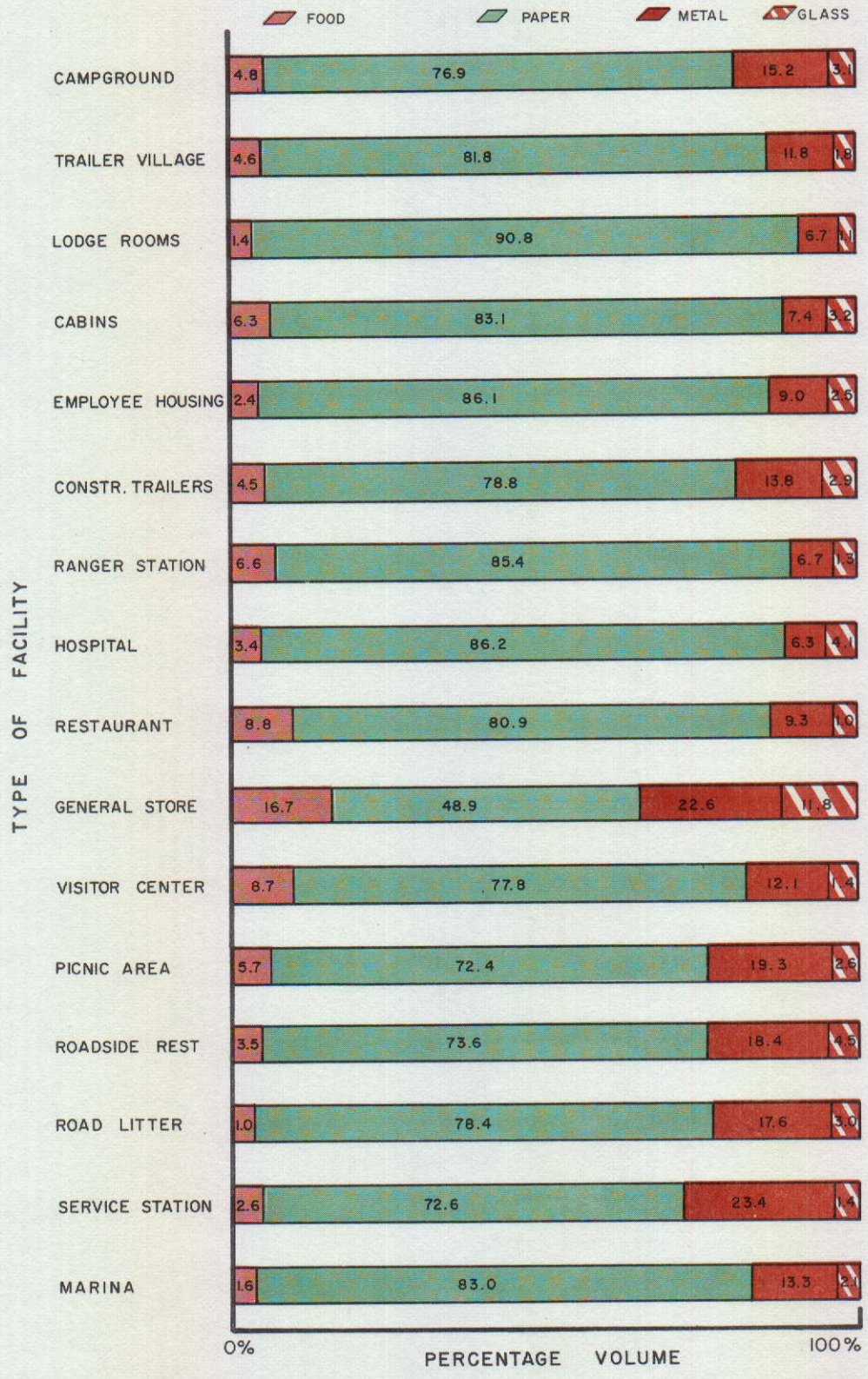
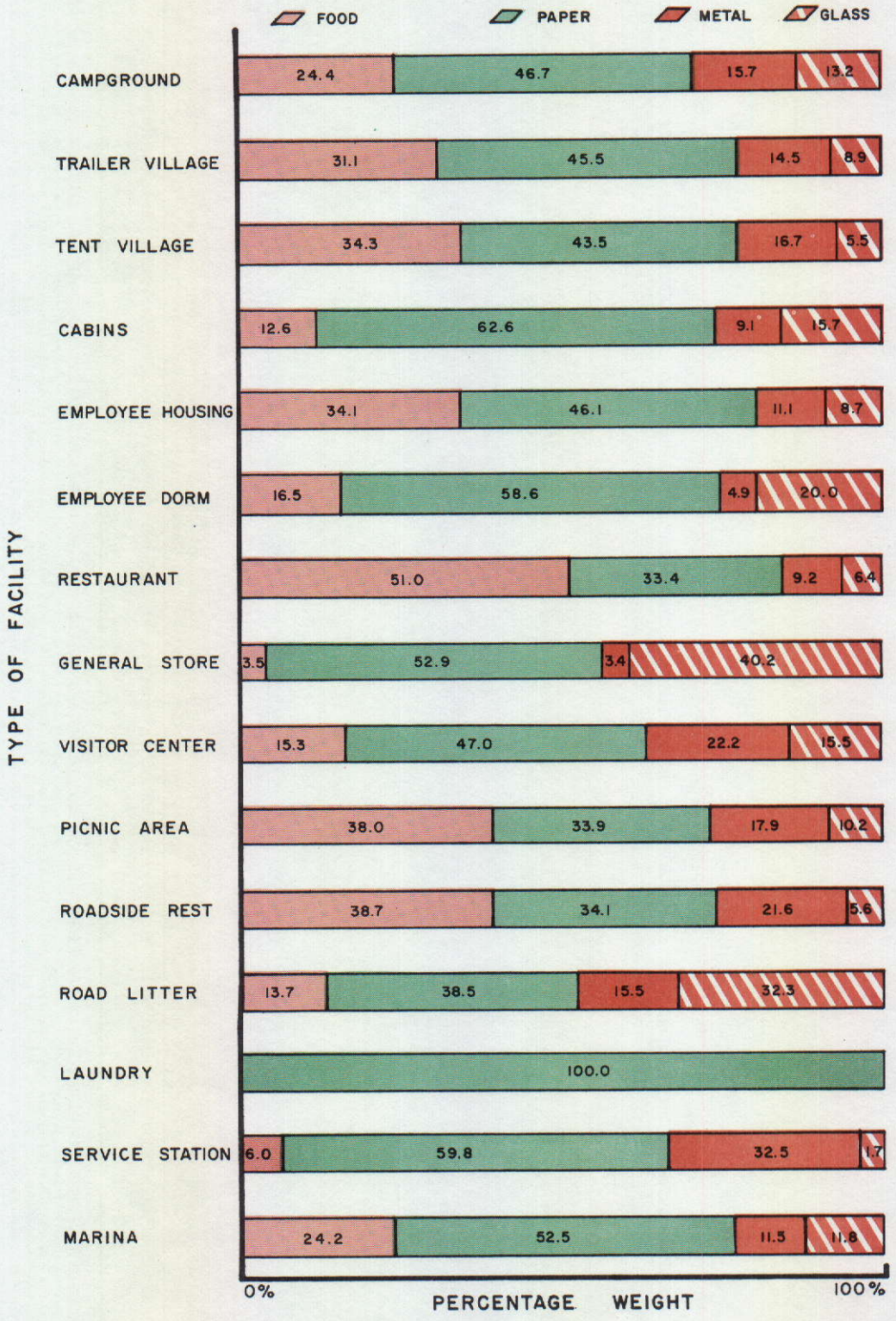


Figure A-5. SOLID WASTE COMPOSITION BY PERCENTAGE WEIGHT IN GRAND TETON NATIONAL PARK



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Figure A-6. SOLID WASTE COMPOSITION BY PERCENTAGE VOLUME IN GRAND TETON NATIONAL PARK

