WES..... EGS.....
TCC..... JDW.....
DWS..... DRL.....
✓REF..... PCB.....
DAG..... SGE.....
JGL..... JLB.....
MSA..... PSO.....
GDC..... PLM.....
File.....

STATE OF ARIZONA

ENVIRONMENTAL SERVICES NEEDS STUDY for Greenlee County

Planning Division • Office of Economic Planning and Development

10179

STATE OF ARIZONA

GREENLEE COUNTY

ENVIRONMENTAL SERVICES NEEDS STUDY

1970-1990

Prepared by

PLANNING DIVISION

OFFICE OF ECONOMIC
PLANNING AND DEVELOPMENT

June 1974

The preparation of this report was
financed in part through a study
grant from the U.S. Department
of Agriculture, Farmers Home
Administration

RECEIVED
JAN 3 1975
Arizona Water Commission

ARIZONA DEPT. OF
WATER RESOURCES LIBRARY

ARIZONA WATER COMMISSION

FOREWORD

This study is the result of a financial assistance program administered by the Farmers Home Administration (FHA) to aid planning in small rural areas. The report was organized on a county basis with FHA regulations providing the framework for selections of study areas within the counties. The areas were not required to be incorporated municipalities, however, some semblance of community organization was required and the population could not exceed 5,500 persons.

The report is primarily concerned with the identification and evaluation of existing water systems and sewage and solid waste disposal facilities, and the projection of future needs for these services in rural areas of Greenlee County. In addition, the completion of the study meets the following related objectives:

> The delineation of probable areas of community growth and their concomitant need for "environmental service systems" (see definition).
>
> An appraisal of existing land use patterns and environmental services problems which may result from various types of future use.
>
> The collection and interpretation of data projecting the future needs for environmental services on a county-wide and individual community basis.

Definitions

For the purposes of this report, the following definitions shall apply.

> "ENVIRONMENT" - The aggregate of physical, social, and cultural conditions that influence the life of an individual or community.
>
> "SERVICES" - (1) Contributions to the welfare of others; (2) Facilities supplying some public demand.
>
> "COMMUNITY" - (1) A unified body of individuals; (2) People with common interests living in a particular area.
>
> "WATER SUPPLY SYSTEM" - Wells, surface water collection reservoirs, storage reservoirs and tanks, water treatment equipment, distribution pipelines, water meters and all other appurtenances which serve to supply the public within a community or built-up area with a source of water suitable for drinking.
>
> "SEWERAGE" - Pipelines and/or appurtenances which serve the public within a community or built-up area with a means of disposing sewage wastes from the properties on which they may reside. This term refers to the means by which sewage wastes are transported to some point removed from the community, or built-up area, for treatment.

"SEWAGE TREATMENT SYSTEMS" - Devices or equipment used for the expressed purpose of removing the organic and pathogenic constituents of sewage, and capable of producing an effluent safe for discharge to a water body, stream or disposal by seepage through soil to subterranean water tables.

"SOLID WASTES DISPOSAL METHODS" - Devices and/or means serving, or utilized by, the citizens of a community, or built-up area, for removal or disposal of garbage, trash, grass and brush clippings from places of residence.

"ENVIRONMENTAL SERVICES" - "Water Supply Systems," "Sewerage," "Sewage Treatment Systems" and "Solid Wastes Disposal Methods" utilized by the citizens of a community, or built-up area to serve public welfare and enhancement, enjoyment or maintenance of the environment in which they reside.

TABLE OF CONTENTS

LIST OF TABLES vii

LIST OF FIGURES xi

LIST OF PLATES xiii

SECTION I

CHAPTER I. INTRODUCTION AND SUMMARY 1

CHAPTER II. COUNTY PROFILE 3
Historical Profile 3
Physical Characteristics 3
Natural Resources 4
Population and Economy 11
Land Ownership and Land Use 17
County Needs For Environmental Services 22

CHAPTER III. COMMUNITY PROFILES 27
Community of Duncan 29
Community of Clifton 37

REFERENCES SECTION I 47

SECTION II

CHAPTER I. ENVIRONMENTAL SERVICES ESTIMATED COSTS 1
Sewerage and Sewage Treatment Projects 2
Water Supply and Distribution Systems 5
Solid Waste Management 8

CHAPTER II. FINANCING ENVIRONMENTAL SERVICES 11
Introduction 11
Bonding 11
Special District 12
Federal Grants and Loan Programs 13

REFERENCES SECTION II 17

SECTION III

CHAPTER I. POPULATION PROJECTIONS METHODOLOGY 1
County Population Projections 1
Community Population Projections 2

CHAPTER II. EMPLOYMENT PROJECTIONS METHODOLOGY 5

CHAPTER III. PROJECTION METHODOLOGIES FOR WATER SUPPLY DEMANDS AND SEWAGE PRODUCTION LEVELS 7
General Discussion 7
Specific Procedures 8

CHAPTER IV. PROJECTION METHODOLOGY FOR SOLID WASTES PRODUCTION LEVELS 11
General Discussion 11
Specific Procedure 11

REFERENCES SECTION III 13

GREENLEE COUNTY
List of Tables

Table Number		Page
	SECTION I CHAPTER II	
II-1	Surface Water Records - Streamflow Data, Greenlee County	8
II-2	Selected Storage Reservoirs and Lakes in Greenlee County	9
II-3	Water Quality Standards For Domestic Water Sources	10
II-4	Water Quality of Selected Wells in Duncan Basin	11
II-5	Apache County Labor Force and Employment 1968-1970 With Projection to 1990	14
II-6	Labor Earnings - Greenlee County.	15
II-7	Existing Land Ownership for Greenlee County - 1971	18
II-8	Surface Acreage in Greenlee County By Type of Lease.	19
II-9	Land Use - Greenlee - 1971	20
II-10	Recreation Parcicipation in Arizona in National Forests - 1969. . . .	21
II-11	Participation in Outdoor Recreation, Apache National Forests - Apache County	21
II-12	Existing and Future Water Supply and Distribution Needs in Rural Areas of Greenlee County	23
II-13	Summary of Projected Annual Greenlee Domestic Water Demands for Greenlee County in 1975, 1980, and 1990	23
II-14	Existing and Future Sewerage and Wastewater Treatment Facilities Needs in Rural Areas of Greenlee County	24
II-15	Inventory of Sewage Treatment Facilities in Greenlee County. . . .	25
II-16	Summary of Projected Average Annual Sewage Production Levels for Greenlee County in 1975, 1980, and 1990	34
II-17	Summary of Projected Annual Solid Wastes Production Levels for Greenlee County in 1975, 1980, and 1990	26

CHAPTER III

III-1 Water Quality Data For Wells Serving Duncan, Arizona-City Utilities Company 34

III-2 Projected Average Daily and Yearly Water Demands for Duncan in 1975, 1980, and 1990 34

III-3 Projected Average Daily and Yearly Sewage Flows for Duncan in 1975, 1980, and 1990 35

III-4 Projected Yearly Solid Wastes Production Levels for Duncan in 1975, 1980, and 1990 36

III-5 Water Quality Data for Clifton - Morenci Water and Electric Company 40

III-6 Clifton Monthly Water Use and Distribution Network Connections 1969, 1970 and 1971 41

III-7 Projected Average Daily and Yearly Water Demands for Clifton in 1975, 1980, and 1990 42

III-8 Projected Average Daily and Yearly Sewage Flows for Clifton in 1975, 1980, and 1990 43

III-9 Projected Yearly Solid Wastes Production Levels for Clifton in 1975, 1980 and 1990 45

SECTION II
CHAPTER I

I-1 Major Components of Construction for Sewage Treatment Plants and Sewers - 1970 2

I-2 Estimated Average Unit Cost for Construction of Sewage Collection Lines - 1970 2

I-3 Generalized Cost to Size Relationships of Basic Waste Treatment Processes 4

CHAPTER II

II-1 Major Federal Aid Programs Utilized for Providing Environmental Services 14

SECTION III
CHAPTER I

I-1 Graham County Population Projection 1

CHAPTER III

III-1 Normal Water Consumption 7

GREENLEE COUNTY
List of Figures

SECTION I
CHAPTER II

Figure Number		Page
II-1	Vegetation of Greenlee County	5
II-2	Hydrologic Basins of Greenlee County	9
II-3	Population of Greenlee County and Projections to 1990	13

CHAPTER III

III-1	Population of Duncan and Projections to 1990	32
III-2	Population of Clifton and Projection to 1990	38

SECTION II
CHAPTER I

I-1	Generalized Ranking of Unit Cost and Removal Efficiencies of Conventional Waste Treatment Processes	3
I-2	Application of Economics of Scale Through Consolidation of Waste Sources Producing 10 Million Gallons per Day of Sewage	4
I-3	Relationship Between Lift and Cost Per Acre-Foot of Groundwater Pumped	5
I-4	Sanitary Landfill Operating Costs	10

SECTION III
CHAPTER IV

IV-1	Per Capita Solid Wastes Production Levels for 1946 to 1968 and Projections to 1990	12

GREENLEE COUNTY

List of Plates

Plate Number		Following Page
1	Greenlee County Land Ownership	26
2	Greenlee County Land Use	26
3	Greenlee County Inventory of Facilities	26
4	Duncan Topographic Features	36
5	Duncan Land Use	36
6	Duncan Projected Land Use	36
7	Duncan Water System	36
8	Duncan Sewer System	36
9	Clifton Topographic Features	46
10	Clifton Land Use	46
11	Clifton Water System	46

SECTION 1

CHAPTER I. INTRODUCTION AND SUMMARY

This study is the result of a financial assistance program administered by the Farmers Home Administration (FHA) to aid planning in small, rural areas. The report is organized on a county basis with FHA regulations providing the framework for selection of study areas within the county. The areas were not required to be incorporated municipalities, however, some semblance of community organization was required and the population could not exceed 5,500 persons.

The report is primarily concerned with the identification and evaluation of existing water systems and sewage and solid waste disposal facilities, and the projection of future needs for these facilities and services in rural areas of Greenlee County. The projection of future needs is based upon an analysis of natural resources, social and economic conditions, present and future general land use patterns and existing environmental service facilities within the County. This projection is of a dual nature, focusing at both the community level and the county level. In reviewing environmental service needs, it is intended that this report will be of value as a preliminary study to other more specific planning and engineering studies, and eventually to the development of projects to meet these needs.

Water usage in Greenlee County for domestic purposes is currently estimated at 1100 acre-feet of water per year. The locations of existing water systems are on PLATE 3.

Future water supply demands which will be placed on these utilities, as purveyors of water, are estimated to range from 1201 to 1265 acre-feet per year by 1975; from 1378 to 1525 acre-feet per year by 1980: and from 1771 to 2154 acre-feet per year by 1990. (TABLE II-13) These increasing demands will result, depending on rates of growth in respective areas, in varied modifications, expansions and incorporation of new water supply equipment in utility systems found in the County.

Future water supply demands will correspondingly place increasing demands upon the available water resources of the County. Ground water reserves for the area of the County contained within the Gila River sub-basin of the state are estimated to be substantial.

Considering the above along with factors of climate, topography and soil characteristics in general, water resources appear adequate to meet the future domestic water demands of the County. It should be noted that no effort has been made to define or assess the water needs of agricultural or industrial interests within the County, whose demands exceed domestic demands by a sizeable margin.

Corresponding with the increase in domestic water demands will be the increased production of sewage wastewaters. At present, the smaller rural areas between Duncan and Clifton have marginal needs for centralized sewage collection and disposal facilities. However, as these rural areas develop there will be more need for such systems.

Currently, sewage wastewaters are generated at an estimated rate of 700 acre-feet per year. Approximately 90 percent of this quantity of sewage is provided with some form of treatment prior to discharge to the San Francisco or Gila Rivers. The remaining portions of these wastewaters is treated by septic tank systems. Ultimate disposal of these wastewaters is achieved through percolation and seepage into underlying groundwater reservoirs.

TABLE II-15 provides an inventory of existing wastewater treatment facilities in Greenlee County. The larger communities will experience the earliest need for expansion and/or modification of existing treatment facilities as the result of increasing sewage flows.Sewage production levels are projected to range from 736 to 776 acre-feet per year in 1975; from 829 to 927 acre- feet per year in 1980; and from 1065 to 1298 acre-feet per year in 1990. (TABLE II-16) It is estimated by 1990 that 95 percent of the sewage wastes will originate in communities having centralized sewage collection and disposal facilities.

The production levels of refuse, garbage and other forms of solid waste will increase as a result of population growth in Greenlee County. Currently, solid waste materials are produced at an estimated rate of 9,000 tons per year. The largest part of this tonnage finds its way to sanitary land fills located in the county.

The primary method of waste control at sanitary landfills is by burial. The remaining dumpsites receive periodic maintenance by county road crews through a recently implemented solid wastes management plan.

Solid waste production levels will range from 10,065 to 10,825 tons per year in 1975; from 11,995 to 13,840 tons per year in 1980; and from 16,375 to 21,690 tons per year in 1990. (TABLE II-17) Solid waste production at these levels suggests that the citizens or industrial interests of Greenlee County would be benefited by a coordinated county-wide program of solid waste resource recovery. The accumulated waste materials by 1990 (high projection) will require an estimated 41 acres of land for sanitary land fills. Resource recovery programs could result in a lower land requirement.

Review of solid waste production levels indicates that by 1990, the bulk of solid waste will originate in the larger communities and developed rural areas of the county. In 1975, approximately 90 percent of the solid wastes produced in the county will originate within the Clifton-Morenci urban centers. By 1990, 95 percent of the solid waste produced will originate in these areas of major urban development.

Review of the information contained in this report leads to the general conclusion that Greenlee County will have minor problems related to the proper and timely development of environmental services. This appears evident from the standpoint of existing needs, and more specifically from the projected rate of growth for the County. Assuming that problems will occur with respect to providing future environmental services and that these problems are best handled on a local level. All communities should be provided ready access to information related to federal and state programs which provide assistance for development of environmental services. This functional need is currently handled by the Regional County organization of governments. Representatives of the COG should keep the local communities advised by changes in application procedures and requirements.

CHAPTER II. COUNTY PROFILE

This chapter presents a profile of the physical characteristics, social and economic conditions, and land use and ownership patterns of Greenlee County. The physical structure of the county is discussed in terms of topography, geology, vegetation and climate. Natural resources are considered with respect to their supply, accessibility and quality. Also a review and analysis of social and economic conditions is presented including projections of population and economic growth for the county as a whole. The projections are then utilized in the projection of environmental services needs of the county, and of the individual communities outlined in CHAPTER III.

HISTORICAL PROFILE

Greenlee County was created from the eastern portion of Graham County by an Act of the 25th Territorial Legislature in March, 1909. However, because of political involvement between the two counties, Greenlee did not officially gain county status until 1911. The county was named after Mason Greenlee, an early settler who lived and prospected in the area from 1879 to his death in 1903.

Development in the county has been primarily due to the mining industry, especially copper production. Cattle raising and agriculture, important since early days, are still highly productive industries, especially in the fertile Duncan Valley in southern Greenlee County.

The county, second smallest in Arizona, encompasses 1,199,360 acres of colorful, rugged land. Clifton, a well-known and picturesque mining community, is the county seat. Although considerably modernized, Clifton, like the rest of Greenlee County, has managed to retain some of the distinctive flavor that was the West over one hundred years ago.

PHYSICAL CHARACTERISTICS

Physiography and Geology

Greenlee County is within two physiographic provinces: The Basin and Range Lowlands and the Central Highlands. Many areas in the county are heavily forested, while other portions, especially in the southern areas, are desert lands. Elevations in Greenlee County range from less than 2,800 feet above sea level in the valley areas to over 9,000 feet in the mountain ranges of the Apache National Forest.

The county is composed of alluvial plain and valley areas to the south and moderately rugged, hilly and mountainous terrain throughout most of the central and northern areas. Mountains and rock outcroppings found in these portions of the county consist primarily of volcanic rocks of basaltic composition. Most of these deposits (lava and other extrusive

materials) accumulated during the Cenozoic era, developing from alternating periods of volcanic activity, faulting and erosion processes. These materials reach thicknesses of more than 6,000 feet in some areas. 1/

The alluvial valleys are filled with silt, sand and gravel to depths ranging from approximately 10 feet to perhaps a few thousand feet in some areas. These deposits, primarily unconsolidated, are from the quaternary and upper to middle tertiary periods.

Shallow soils on basalt, granite and schist parent rock cover the central and southwestern portions of the county, while soils in the Duncan Basin are developed from acid igneous alluvium. The northern portion of Greenlee County is covered with forested soils developed on basalt and cinders. 2/

Climate

In general, Greenlee County experiences cool winter and warm to hot summer temperatures. Winter temperatures normally vary from the low thirties at night to the low sixties during the day. The average January temperature is 42°F. Summer temperatures usually vary from the 60°s at night to the low 90°s during the day. The average July temperature is 79°F and the county has an average of 195 frost-free days per year.

Greenlee County generally receives its heaviest rainfall in July and August. Average annual precipitation for the area is 12 inches. However, precipitation rates vary, as do temperatures, with the topography of the county. For example, Duncan experiences approximately nine inches of rainfall each year, while along the Mogollon Rim to the north, the average annual precipitation is approximately 30 inches. Snowfall for the county as a whole is light; generally less than two inches per year.

Natural Vegetation

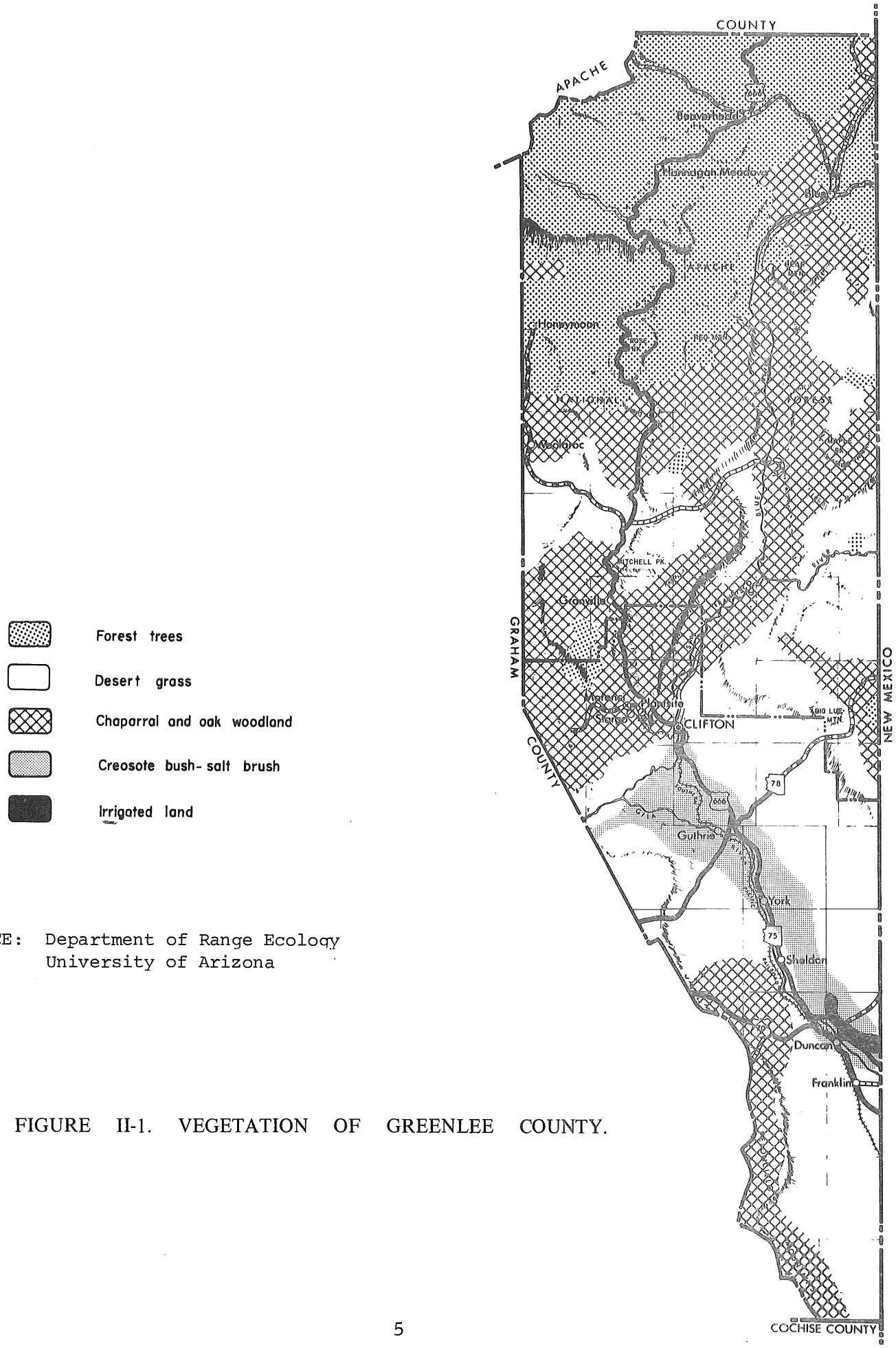
Vegetational cover within the boundaries of Greenlee County consists primarily of forest vegetation such as Chaparral, oak woodland and yellow pine. In the higher mountain elevations forest vegetation consists of Douglas Fir, Pinyon and Ponderosa pines. Mesquite and other desert grasses are found in the lower portions of the county. Palo Verde trees, burr sage, creosote bush, salt brush and various types of cacti are found in the southern portion of Greenlee County, along the Gila River (FIGURE II-1).

NATURAL RESOURCES

Mineral Resources

Copper mining and smelting operations form the major industry and most important economic element in the county. The Clifton-Morenci area is the site of one of the largest copper producing districts in the United States. The value of mineral production in Greenlee County was approximately 151 million dollars in 1970. Copper production accounted for a large portion of this amount, followed by silver, lime, stone, gold, sand and gravel. 3/

Placer gold is found south of Clifton on the San Francisco River. Lode gold is found in disseminated copper deposits in the Morenci district and in siliceous base-metal vein



SOURCE: Department of Range Ecology
University of Arizona

FIGURE II-1. VEGETATION OF GREENLEE COUNTY.

deposits north of Duncan (Ash Peak). Copper deposits and tailings in the Clifton-Morenci area also furnish pyrite for sponge iron. 4/

Molybdenum is found in disseminated copper sulphides at the Morenci mine, along with antimony and other minor metals found in small amounts in the same area.

Silver is mined at Clifton and Duncan (Ash Peak) and occurrences of zinc, lead, manganese and beryllium are found throughout the central and southern portions of the county.

Water Resources

An accurate appraisal of water resources within a region necessitates at least a general understanding of the climate, terrain and geologic characteristics of the area, since these are the factors which determine the occurrence and availability of water. The brief descriptions of these factors presented in the preceding sections should therefore be kept in mind while considering the water resources of Greenlee County.

Surface Water. Arizona is divided into three general geographic regions: the Central Highlands, the Plateau Uplands and the Basin and Range Lowlands. In addition, and for the purpose of water resource studies, the state has been divided into several hydrologic study areas based on its interstate river basin and drainage systems. Greenlee County is located in both the Basin and Range Lowlands (southern 50 percent) and the Central Highlands (northern 50 percent) and contains portions of two major drainage systems: (1) the Upper Gila River Area and (2) the Salt River Area. For the purpose of this report, however, the surface water resources of Greenlee County will be discussed in terms of the Upper Gila River Basin, since this basin encompasses over 90 percent of the county, including its principal rivers and water storage areas (FIGURE II-2).

Water which is found on the surface of the earth exists either as runoff or as storage. Runoff can be defined as "that part of precipitation which appears in surface streams". 5/

Storage is water which has been artificially impounded in surface or underground reservoirs, or water which is naturally detained in a drainage basin.

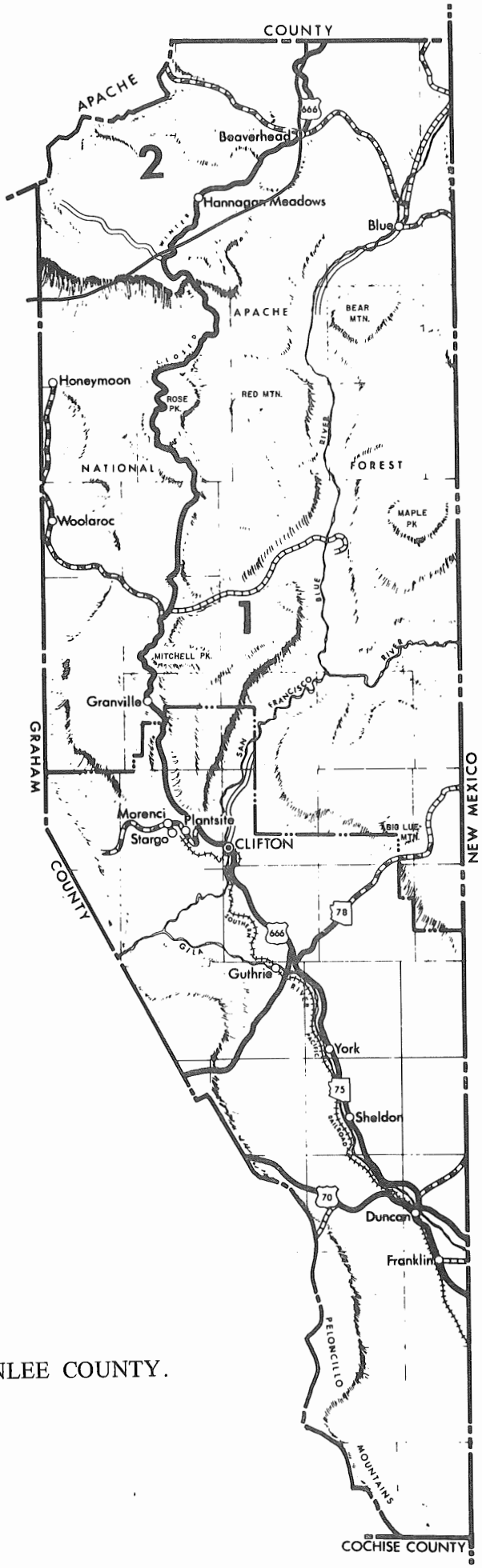
Climatic conditions vary throughout the county influencing to a great extent the amount of runoff made available from precipitation in the area. Although the area receives an estimated 1,000,000 acre-feet of precipitation each year, evapo-transpiration processes reduce the amount of available water by more than 90 percent. Average annual runoff for most of the area is less than 0.5 inches, compared to a national average of 9.4 inches. For the higher elevations of Greenlee County, however, annual runoff figures are as high as 8 inches.

Unit runoff figures measuring flow in the mainstem of the Gila River (that portion within Greenlee County) show runoff figures ranging between 30 and 35 acre-feet per square mile. For tributary streams, the range in unit runoff is much greater (TABLE II-1), Pan evaporation rates vary from 70 inches per year at Clifton to approximately 42 inches along the county's northern border.

Recent data acquired from the Forest Service for Apache National Forest indicate that from 1944 to the present, flow records show that Eagle Creek yields an average of 42.7

1 UPPER GILA RIVER AREA

2 SALT RIVER AREA



SOURCE: Arizona Bureau of Mines
Bulletin 180

FIGURE II-2. HYDROLOGIC BASINS OF GREENLEE COUNTY.

cubic feet per second or 30,940 acre-feet per year. Of this flow, 6,320 acre-feet per year is diversion from the Black River to augment flow for the Morenci Mine. The Blue River, extending from northern Greenlee County to its central portions, has recorded flow at its gaging station since 1967. Data show an average flow of 26.4 cubic feet per second (19,000 acre-feet per year) at this point within the county. Additional streamflow data can be found in TABLE II-1.

TABLE II-1

SURFACE WATER RECORDS - STREAMFLOW DATA - GREENLEE COUNTY

	Gaging Station and Number	Drainage Area (sq.mi.)	Elevation of Gage (feet above mean sea level)	Streamflow Average Acre-feet	Streamflow Average cfs**	Streamflow Maximum (cfs)	Streamflow Minimum (cfs)	Unit Runoff (acre-feet per sq.mi)	Period of Record (years)
4420	Gila River near Clifton	4,010	3,337	133.200	184	28,200	5.0	33	1911-17 1927-66
4442	Blue River near Clifton	506	4,160			6,290	2.7		1967-71
4445	San Francisco River at Clifton	2,766	3,436	134,700	186	30,500	6.5	49	1913-17 1927-66
4460	Willow Creek near Double Circle Ranch near Morenci	149		9,770	13.5	7,500	0	66	1944-66
4465	Eagle Creek near Double Circle Ranch near Morenci	377		18,800	26.0	13,600	1.5	50	1944-66
4470	Eagle Creek above pumping plant near Morenci	613	3,695	29,250	40.4	21,000	3.2	48	1944-66

*Gaging station numbers are those used in USGS publications of surface water records
**cfs - cubic feet per second

Source: "Bulletin 180," Arizona Bureau of Mines, Tucson, Arizona, 1969. "Water Resources Data" Part 1, U. S. Department of the Interior, 1969.

Principal storage reservoirs and lakes in Greenlee County are listed in TABLE II-2. Some of these facilities retain measurable amounts of surface water only after heavy rains making meaningful data accumulation difficult. Average annual lake evaporation for the county varies between 58 and 62 inches depending on the location of the water body.

Groundwater. Groundwater is a transitory phase of the hydrologic cycle wherein water percolates downward over long periods of time through weakly consolidated and unconsolidated rock, and is stored below the land surface. Most of the groundwater in Greenlee County is found in alluvial deposits consisting of sand, gravel, silt and clay, although some small amounts of stored water can be found in fractures of consolidated rock.

Greenlee County has one major groundwater reservoir: the Duncan Basin, located in the southern portion of the county. The basin is a typical downfaulted sediment-filled trough lying between mountain ranges in the Basin and Range Lowlands province. Duncan Basin trends north-northwest and is approximately 37 miles long. The drainage area of the basin is about 680 square miles and the alluvial valley ranges in width from five to nine miles, encompassing approximately 270 square miles. 7/

Alluvium in the area generally ranges between 40 and 100 feet thick and is capable of yielding between 50 and 2500 gallons per minute (gpm). Irrigation wells drilled in the alluvium generally produce between 100 and 1500 gpm.

TABLE II-2

SELECTED STORAGES RESERVOIRS AND LAKES
GREENLEE COUNTY

Reservoir or Lake	River Basin	Drainage (sq.mi.)	Type of Structure	Use*	Capacity (ac-ft.)	Surface Area (Acres)
Greyhorse Detention Dam	Gila	3	Earthfill	F	100	16
Olney Detention Dam	Gila	8	Earthfill	F	180	28
Rock Tank	Gila	10	Earthfill	K	25	8
Round Mountain Det. Dam #1	Gila	16	Earthfill	F	186	41
Round Mountain Det. Dam #2	Gila	32	Earthfill	F	670	72
Twin Detention Dam	Gila	7	Earthfill	F	250	60

*F = Flood Control
K = Stock Watering

Source: "Water Resources - State of Arizona," Arizona Interstate Stream Commission, October 1967.

Although water in the alluvium is unconfined, some artisian water is available from deep aquifers not directly connected to the flood plain alluvium. This water has an inordinate amount of sodium and is not often used for irrigation.

Groundwater in the Duncan Basin is used to supplement Gila River surface water used to irrigate a specific amount of acreage in the county. Therefore, the amount of groundwater pumped in any given year varies in relation to the amount of surface water available for that year. Groundwater has been pumped for irrigation and agricultural purposes since 1935 and it is estimated that since that time over 500,000 acre-feet have been withdrawn from the Duncan Basin reservoir. 8/ Unlike the conditions which prevail in much of the rest of the state, there has been relatively no change in the height of the water table in the groundwater storage areas in Greenlee County. Depth to water along the flood plain of the Gila River to Duncan Basin varies from approximately 10 to 60 feet. Depth to water in most other areas of the basin rarely exceeds 300 feet. 9/ The U. S. Geological Survey estimates that there are approximately 150,000 acre feet of groundwater available from storage in that portion of the alluvium underlying the flood plain of the Gila River in the Duncan Basin. It is probable that much larger quantities are available at greater depths throughout the basin fill but computation of these amounts has not been carried out to date.

Groundwater reservoirs in the county receive recharge from six major sources: (1) underflow of the Gila River; (2) underflow from tributary washes; (3) direct recharge from penetration of rainfall; (4) seepage from the Gila River; (5) infiltration from irrigation water; and (6) recharge to the alluvium of the inner valley by seepage out of the older alluvium. 10/ Current data with respect to the amount of recharge to groundwater reservoirs from the six sources cited above are unavailable at this time.

Water Quality and Use. No extensive recent studies of water quality and use quantities in Greenlee County were available as of this writing. However, previous analysis (USGS Hydrological Survey, 1962) of groundwater samples from the Duncan Basin show ranges in concentrations of total dissolved solids from 250 to 5,000 parts per million (ppm). Higher concentrations occur in wells at the upstream end of the basin near the state line. A USGS report (1952) further states that in general the waters are suitable for irrigation, except in those areas where faults permit upward seepage of the highly mineralized water from the older alluvium. 11/

Although the quality of water to be used for industry or agriculture may vary greatly with respect to chemical composition and physical properties, the same variance is not possible where domestic use is concerned. All water sources developed for domestic uses must comply with the 1962 U. S. Public Health Service Drinking Water Standards. These standards, which set concentration limits for chemical parameters present in the water sources, are summarized in TABLE II-3.

TABLE II-3

WATER QUALITY STANDARDS FOR DOMESTIC WATER SOURCES

Chemical Parameter	Limiting Concentration milligrams/liter
Arsenic	0.01
Chloride	250.0
Copper	1.0
Cyanide	0.01
Fluoride	0.6-1.7*
Iron	0.3
Manganese	0.05
Nitrate	45.0
Phenols	0.001
Sulfate	250.0
Total Dissolved Solids	500.0

*dependent upon ambient temperature.

Source: USPHS 1962 Drinking Water Standards.

Recent water quality data obtained from wells throughout Greenlee County are listed in TABLE II-4.

TABLE II-4

WATER QUALITY OF SELECTED WELLS IN DUNCAN BASIN
GREENLEE COUNTY, ARIZONA

Location Q TS RE SEC	Depth	Static Level	Date	CA ppm	MG ppm	NA ppm	CL ppm	SO ppm	F ppm	Use
D-7-31 5 AAA	70	25	4/3/67	79	16	96	56	140	1.8	WIID
D-8-31 13 DAA	60	20	4/3/67	184	42	237	236	550	2.6	WDOD
D-8-32 20 CCB	72	10	4/3/67	134	29	160	144	370	2.2	WDOD
D-8-32 20 DDC	72	18	4/3/67	141	9	182	104	330	3.5	WIID
D-8-32 34 BBD	72	10	4/3/67	101	19	137	48	190	3.5	WIID
D-9-31 2 ABD	392	359	4/3/67	16	15	195	96	230	5.5	WLLD
D-9-32 17 AAA	100	45	4/3/67	13	10	148	8	160	6.5	WDOD

Use - Source: W, Well
Used for: L, industrial; D, domestic; I, agriculture; 0, no other use.

Source: "Quality of Arizona's Domestic, Agricultural and Industrial Waters," Agricultural Experiment Station, Report 256, University of Arizona, February 1970.

Ranching and livestock grazing will continue to be the largest land use, by acreage, with both private and public lands being utilized. This activity generally requires few improvements to the landscape and is found in all parts of the county. The number of acres is not expected to change significantly although the number of head may decrease. This is caused by the increased use of "dry lot" feeding techniques rather than running the livestock on open range.

The county is not anticipated to experience any rapid change during the next 20 years except in the mining areas. The central portion of the county is expected to be the most dramatic area of change due to this increased mining activity and the development of the supporting urban activities.

POPULATION AND ECONOMY OF GREENLEE COUNTY

In order to make projections of future water requirements and to plan for sewage and solid waste management, it is essential to have growth and locational information on both the population and industry in the county.

Data are presented in this section on pertinent demographic characteristics of the county such as present and future centers of population density along with projections of population through 1990. Relevant economic facts are presented for each industry in the county including past trends in employment, labor earnings and unique factors which may affect economic development. Employment projections on a broad industry basis are made for 1990 to aid in determining future water needs.

The major determinant of growth in Greenlee County is the mining activity of Phelps Dodge in the Morenci area. Also affecting development is the large amount of federally owned land not available for commercial or residential development.

Population Growth and Projection

Greenlee County, with a 1970 population of 10,108, is the smallest county in the state in terms of population. Given a land area of 1,879 square miles, it has a population density of 5.5 persons per square mile. While this appears small in relation to the state average of 15.4 persons per square mile, six other counties have smaller population densities.

Eighty percent of the population lives in the Clifton-Morenci area near the Phelps Dodge Mines which are the main source of employment in the county. Clifton, with a 1970 population of 5,087, is the largest town in the county followed by Stargo with a population of 1,194 and Plantsite with a population of 1,077.

FIGURE II-3 shows the county's past population and projections to 1990. The figures from 1920 to 1940 reflect the depletion of high grade ores at Morenci and Metcalfe and the effects of the national depression. The decade 1940 through 1950 reflects the beginning of open pit operations at Morenci. Modernization of methods after 1950 resulted in a decline in population for Greenlee over the last twenty years. Population over the next five years is projected to increase by approximately 1,000 persons as Metcalf operations, which have been reopened, are expanded to full size. According to FIGURE II-3 growth is expected to continue through 1990 with support for the growth coming from both mining income and tourist income. The median projection is for a population of 11,483 by 1980 and 12,069 by 1990. Low and high projections are also given. All of the projections are based upon the long-term relationship between the county and state populations.

Most of the projected increase in population will be in the Clifton census division. The town of Morenci is presently being torn down by Phelps Dodge and its population moved to Plantsite and Stargo. These will be the most likely areas of expansion as Clifton has little room for additional people. Development in other parts of the county will be limited since 93 percent of the land is owned by federal and state governments, leaving little for private development. This includes the Apache National Forest which encompasses the northern part of the county.

Employment, Industry Analysis, Labor Earnings

Greenlee County had a civilian work force averaging 4,925 persons during 1970. Annual average employment was estimated to be 4,675. This results in a 3.0 percent unemployment rate compared to the state rate of 4.1 percent. The civilian labor force figure is inflated due to the construction activity at the Phelps Dodge mines. In projecting the 1990 labor force it was necessary to take this temporary expansion into consideration. As a result the 1990 labor force is projected to be 4,975 which is just slightly above the present size of the labor force. This figure is shown in TABLE II-5 which also gives employment projections by sector for the county and 1968 through 1970 labor force and employment data.

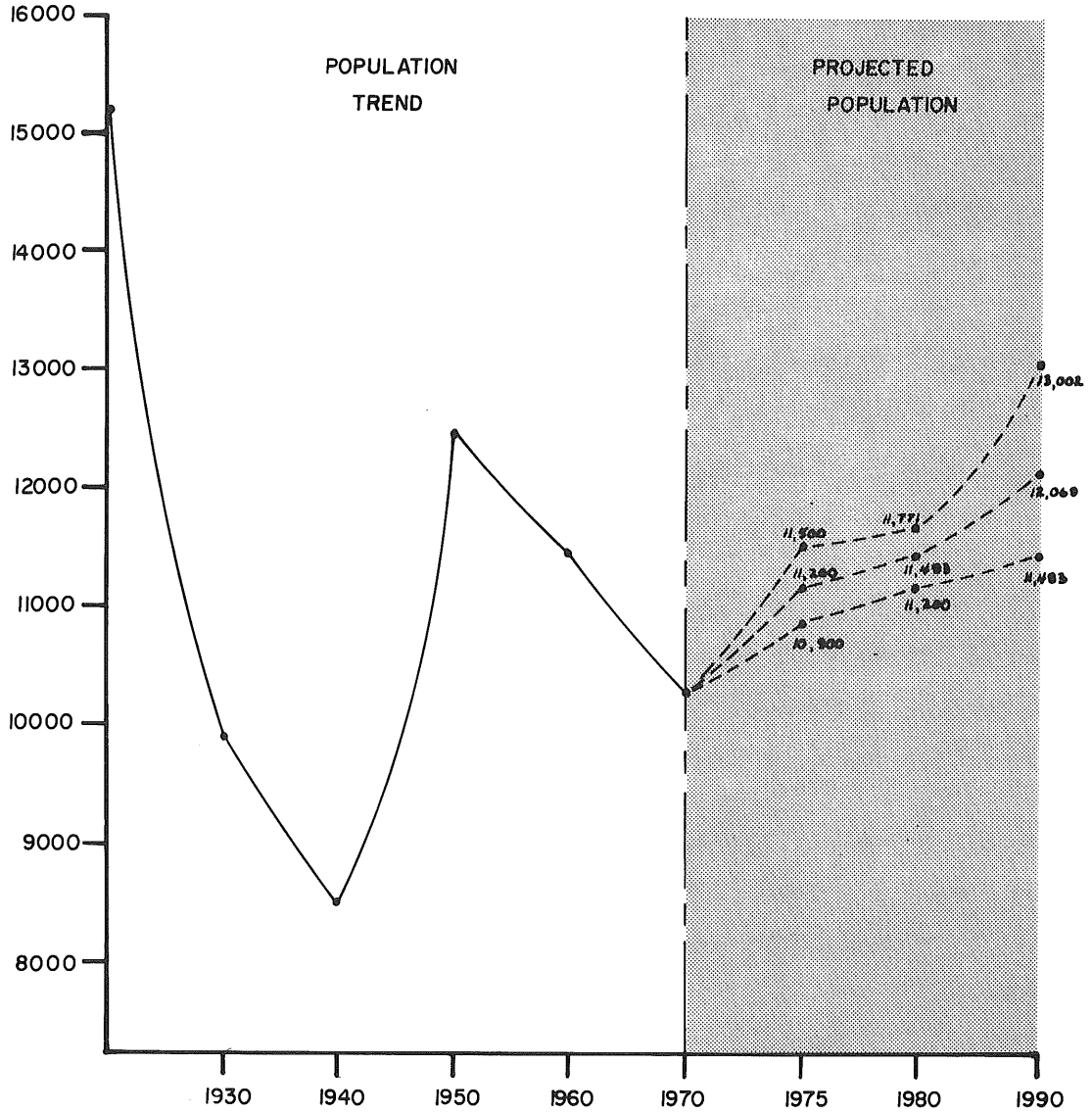


FIGURE II-3. POPULATION OF GREENLEE COUNTY AND PROJECTIONS TO 1990.

TABLE II-5

GREENLEE COUNTY LABOR FORCE AND EMPLOYMENT 1968-1970 WITH PROJECTION FOR 1990

	1968	1969	1970	1990
Civilian Work Force	3,800	4,150	4,925**	4,975
Unemployment	100	100	150	150
Percent Unemployment	3.9	2.4	3.0	3.0
Total Employment	3,325	4,050	4,775	4,825
(a) Non-agricultural Wage-Salary	2,625	3,275	4,025	4,675
Manufacturing	225*	250*	350*	500
Non-Manufacturing	2,400	3,000	3,700	3,575
Mining & Quarrying	1,450*	1,700*	1,850*	2,200
Contract Construction	75*	325	725**	125
Trans., Comm., and Public Utilities	75	75	100	100
Trade	275	325	350	400
Finance, Insurance & Real Estate	25	50	50*	50
Services	50	50	100	125
Government	450	450	525	575
(b) All Other Non-Agricultural Employment	400	475	450	450
(c) Agriculture	300	300	300	300

*Estimated by the Department of Economic Planning and Development in conjunction with the Bureau of Mines data.

Mining was estimated to account for 39 percent of total employment in 1970 making it the largest sector in the economy. It was also estimated to account for most of non-farm labor earnings as 66 percent of labor earnings were withheld for reasons of disclosure and most of these earnings would be attributable to mining. These labor earning figures are shown in TABLE II-6.

The second largest sector of employment was contract construction which accounted for 15 percent of total employment in 1970 mainly due to the construction at Metcalf, Plantsite and Stargo.

TABLE II-6

LABOR EARNINGS - GREENLEE COUNTY
($ X 1000)

	1950	1962	1966	1967	1968
Total Earnings	15,207	13,886	26,763	21,371	26,812
Farm Earnings	914	761	6	33	575
Total Non-Farm	15,293	23,125	26,757	21,338	26,237
Government	1,088	2,528	3,399	3,789	4,278
Total Federal	234	395	357	376	440
Civilian	168	236	202	202	257
Military	66	159	155	174	183
State and Local	854	2,133	3,042	3,413	3,838
Private Non-Farm	14,205	20,597	23,358	17,549	21,959
Manufacturing*	64	79	34	42	40
Mining	D	D	D	D	D
Contract Construction	343	759	442	203	85
Trans., Comm., and Public Utilities	455	512	603	560	665
Trade	1,197	1,564	1,767	1,695	1,648
Finance, Insurance and Real Estate	51	170	243	255	289
Services	697	973	1,420	1,373	1,439
Other	D	D	D	D	D

D - omitted for disclosure problems.

* This data does not include earnings from the Phelps Dodge smelter or mill.

Source: Office of Business Economics.

The projected figures indicate an increase in manufacturing, mining, trades, services and government employment. These increases are related to increased mining activity and increased use of the Apache National Forest and Coronado Trail by vacationers. Agriculture employment is projected to decline as is contract construction. Also other sectors are projected to maintain their current levels as they are judged to be sufficient to meet the needs of the projected population increase.

Agriculture. In 1969 there were 11,041 acres under cultivation in Greenlee County. Alfalfa, sorghums and cotton are the principal crops. Most farming is in the Duncan area. Cattle raising is also of some importance in the county and centers in the northern section. Estimates by the Agriculture Extension Service in Clifton are that cattle sales are twice the value of field crops.

Agricultural employment has been a decreasing percentage of total civilian employment for the past three years. It is projected to continue this trend through 1990 maintaining approximately the same absolute level as in 1970.

Contract Construction. The employment figures for construction in Greenlee County show a significant increase in workers from 1968-1970. This is due in part to work done at Metcalf on an underground mine in 1969 and 1970 before plans were curtailed. It is also related to the expansion of the Morenci mine into the site of the town of Morenci. Phelps Dodge has been moving the town's inhabitants into new housing in Stargo and Plantsite during the past decade.

While construction employment should continue at near its present size until after the Metcalf mine has been completed, by 1990 construction demands are projected to require a smaller work force.

The total employment in construction is projected to be 125 by 1990. This would include workers not only at the mines but also in housing on the private land in the county, particularly for vacationers.

Mining. This is the most important sector in the economic life of Greenlee County. In 1969 Greenlee County with a value of mineral production equaling $92,925,000 was the third highest in the state. Most of those living in the county are tied in some way to the mines--either directly through employment or in providing services to the mines.

The Morenci open-pit mine of Phelps Dodge is the chief mine of the county. It is the largest mine in the state and second largest in the country. Over the past ten years the mine has averaged yearly over 225,000,000 pounds of copper recovered. New land is constantly being made available for mining through moving of the town of Morenci. In 1970, Morenci averaged 170,000 tons of material moved per day which yielded 60,000 tons of ore per day. By 1975 the underground mine at Metcalf is expected to be in full operation yielding 110,000 tons of material moved a day, an increase of 30,000 over its present yield. This will increase copper production in the county.

This optimistic picture for mining is reflected in the employment projection figures. By 1990 employment is projected to reach 2,200.

Manufacturing. Almost all manufacturing employment in Greenlee County is related to mining through the mill and smelter. Employment figures for manufacturing were estimated from Bureau of the Mine figures to reflect smelter and mill operations. Six to seven percent of employment in 1968 through 1970 was attributed to manufacturing. In making employment projections for 1990, the addition of a new mill at Metcalf was taken into consideration. One-hundred fifty additional workers were projected to be in manufacturing by 1990 giving a total of 500 for the sector. This represents ten percent of the projected total employment. The labor earnings data for manufacturing does not include the Phelps Dodge smelter and mill and therefore appears lower than in actuality.

Transportation, Communication and Public Utilities. This has not been a dominant sector in the economy of Greenlee County. Labor earnings have been moderate in comparison to other industries, comprising only two percent of total earnings in the county during 1968.

From 1968 through 1970, employment in the industry group remained fairly constant, increasing only in the last year from 75 to 100 persons. Approximately 50 percent of these people are employed by the public utility companies.

Employment is projected to remain at its present level through 1990. Productivity increases resulting from technological advances should enable the present work force to meet the needs of an expanded population.

Wholesale and Retail Trade. Almost all of the employment has been in retail trade with restaurants, service stations and general stores predominating. These businesses meet the needs of the mining community and also offer services to visitors to the Apache National Forest. As a result, most of these establishments are found in Plantsite, Stargo and Clifton. They are not a major source of labor earnings, providing only six percent of total labor earnings for the county. Employment in the sector has equaled between seven and eight percent of total employment over the past three years. This is low in comparison to the other rural counties of the state, Apache County being the only other county with as low a proportion in retail and wholesale trade. This proportional relationship is explained by the close proximity of Greenlee's towns to larger shopping areas in Graham County. Between now and 1990 a small amount of growth is projected for the sector. A figure of 400 is used as the employment projection. This is 8.3 percent of total projected 1990 employment.

Finance, Insurance and Real Estate. Employment in this sector has averaged about one percent of total employment in Greenlee County in the past three years. These services are concentrated in the Clifton-Morenci area, where most of the population lives.

Although labor earnings in this sector have increased at a rate of 10.1 percent per year since 1950, they were only 1.8 percent of total labor earnings in the county during 1968. Both earnings and employment should remain at about the same levels in the coming decades for existing facilities should be sufficient to meet most of the needs of the projected population increase. As shown in TABLE II-5, employment is projected to be approximately 50 by 1990, the same figure as the 1970 employment in the sector.

Services. Employment in this sector has averaged only two percent of total employment in the past three years. Most of these workers have been employed by motels and rooming houses. Labor earnings in the service industries were only five percent of total labor earnings in 1968. Some growth is expected in the sector over the next 20 years as demands of vacationers and the mining community increase. This is reflected in the projected 1990 employment figure of 150 for the service industry in Greenlee County.

Government. Government was the third largest employer in the county in 1970 with a total of 525 workers. This includes those working in the school system and for the forest service as well as in the county, state and local offices. In 1968 labor earnings in the government sector accounted for 16 percent of total labor earnings, making it the second largest sector in that respect.

Employment and earnings can be expected to stay at about their present levels. Some growth in employment is projected to meet the demands of a larger population and from expected increase use of the Apache National Forest. This is reflected in the employment projection of 575 by 1990.

LAND OWNERSHIP AND LAND USE

Land Ownership

Land ownership is an essential component of land use studies in that it is a major determinant of where various types of land uses occur. The more intensive types of land

uses, i.e., residential, commercial and industrial land developments, occur almost exclusively on privately owned land. Lands administered by federal and state agencies are usually managed under a multiple use concept as defined by the Bureau of Land Management and the U. S. Forest Service and are generally less intensely developed.

Greenlee County encompasses a total land area of 1,199,000 acres. At present 9.6 percent of this area is held under private ownership, 78.8 percent is federal land and 11.6 percent is owned by the State of Arizona (TABLE II-7) (PLATE 1).

TABLE II-7

EXISTING LAND OWNERSHIP FOR GREENLEE COUNTY
1971

Classification	Acres	Total Area
Federal	944,859	78.8
National Forest	749,000	
Bureau of Land Management	192,859	
Other Federal Lands	3,000	
State of Arizona	139,268	11.6
Private & Local Government	114,873	9.6
TOTAL	1,199,000	100.0

Sources: Bureau of Land Management, State Land Department, U. S. Forest Service, and the Agricultural Extension Service, University of Arizona.

Approximately the northern two-thirds of the county is within the Apache National Forest (62.5 percent of the county land area). National forest lands are classified and administered according to resource plans as perscribed under the Multiple Use-Sustained Yield Act of 1960. The forest lands in Greenlee County are primarily used for grazing, recreation, wildlife and watershed conservation.

The Bureau of Land Management (hereafter referred to as BLM) administers 192,859 acres of public lands in Greenlee County. This land is in scattered tracts throughout the central and southern portions of the county. BLM has classified 192,444 acres of these public lands as available for grazing leases. The remaining 400 acres is used for mineral claims, watershed management and wildlife protection. All public land under BLM's administration are used in a manner so as to insure the maximum benefit to the public with the least disturbance of the land and its resources.

The State of Arizona owns 139,268 acres within the county. The State Land Department is responsible for the management of state-trust lands. Most of the state lands in Greenlee County were acquired in lieu of the school sections granted the state by the Enabling Act of 1910; but which were not transferred to state ownership due to their being located within National Forests, National Parks and reclamation withdrawn land areas. These state lands are usually leased for those purposes indicated in TABLE II-8.

TABLE II-8

SURFACE ACREAGE IN GREENLEE COUNTY BY TYPE OF LEASE, STATE LANDS - 1970

Type of Lease	Acres
Agricultural	116.25
Commercial	36.82
Grazing	138,369.74
Rights-of-way	844.25
Special Use Permit	2.00
TOTAL	139,369.06

The remaining 9.6 percent of the county land area is private and is primarily located within the Upper Gila River Valley. There are only two areas of major urban development, Clifton and Duncan, and several small towns and villages. The remaining private land is used primarily for mining, farming, and livestock grazing purposes.

Existing Land Use

Existing land use patterns largely determine future land use patterns. There is a close and predictable relationship between the amount of land utilized for various land uses, especially urban land uses, the rate of population growth and economic mix and the amounts of land required for future urban and rural land development. These same relationships can be extended to evaluate existing and future water supplies, and sanitation facilities.

Urban land uses were defined as those land developments which are primarily for residential, commercial and industrial purposes, including those public facilities required to support the above land uses. This is in contradistinction to those lands which are predominantly rural in character, i.e., agricultural and livestock grazing or lands which are undeveloped outside of urban buildup areas. Urban land uses account for 11.8 percent of the total county land area (TABLE II-9). This figure must be qualified in that it includes both those lands which are undeveloped but have been classified by the County Assessor as being potentially developed for urban land purposes.

Urban land uses are concentrated in the Plantsite-Stargo-Clifton and Duncan areas (PLATE 2). The residents and commercial establishments of Morenci were recently moved to Plantsite and Stargo. This movement was necessitated by the expansion of the Morenci open pit mine.

Plantsite, Stargo and Clifton are all located within three miles of each other along the San Francisco River. Clifton is the county seat and largest town in Greenlee County. Clifton is the older residential and commercial center and is relatively restricted to the area within the canyon formed by the San Francisco River. Due to recent expansion activities of the Morenci Mine the towns of Plantsite and Stargo were expanded to accommodate the movement of residences, commercial establishment and mine related uses.

TABLE II-9

LAND USE GREENLEE COUNTY - 1971

Type of Use		Acres	of Total
Urban		142,486.8	11.8
Residential	1,339.6		
Commercial	444.4		
Industrial	17.2		
Public and Institutional	140,685.6		
Agricultural		11,041.6	0.9
Ranching & Livestock Grazing		37.598.7	3.1
Mining		36,730.4	3.1
Undeveloped Lands[1]		974,902.5	81.1
TOTAL		1,202,560.0[2]	100.0

[1] Computed by subtracting developed lands from county land area.

[2] Calculated by multiplying 1,879 square miles by 640 acres.

Source: Greenlee County Assessor's Office, Arizona Department of Property Valuation.

Plantsite is the newest commercial center in Greenlee County. This small community received the majority of the relocation activity from the old Morenci town site. The new company office building, mercantile and hospital are all located at Plantsite.

Duncan is a center for the agricultural activity in the southern portion of the county (PLATE 2). Duncan and to a lesser extent Franklin, which is a small hamlet south of Duncan, serve as retail trade and service centers for this activity. Duncan also provides roadside commercial conveniences for the tourists traveling U.S. 70.

Ranching and livestock grazing occur throughout the entire county. This activity usually is headquartered on private land with the actual grazing activity being conducted on both leased public lands and fee title land.

Mining activities are concentrated in the Morenci and Clifton areas. The Morenci mine and associated concentrators and smelter is the largest copper mining operation in Arizona. The main mining operation is an open pit mine located at the original site of the town of Morenci and is over 1 1/2 miles in diameter, with a daily production in excess of 156,000 tons daily (60,000 tons of low-grade ore and 96,000 tons of waste).

A new mining operation was recently initiated at the old town of Metcalf, one mile north of the Morenci operations. The stripping of overburden commenced in March of 1970 with a projected date of ore production being in 1975. The Metcalf operation is composed of two open pit mines and an underground mine. The total daily production is projected to be 35,000 tons of low-grade copper ore.

Outdoor recreation in Greenlee County is provided within the communities on a small locally oriented scale and within the Apache National Forest on a county and regional scale. Greenlee ranks tenth in the number of visitor days of recreation participation in Arizona (TABLE II-10). The Apache Trail is one of the most popular attractions with scenic driving, camping, fishing, and picnicking being the most popular activities (TABLE II-11).

TABLE II-10

RECREATION PARTICIPATION IN ARIZONA
IN NATIONAL FORESTS - 1969

County	Visitor-Days* Use (Thousand)	Percent of Total
Apache	583.3	8.6
Cochise	229.1	3.3
Coconino	1,991.1	29.4
Gila	968.1	14.2
Graham	75.3	1.1
Greenlee	113.5	1.6
Maricopa	1,001.2	14.7
Mohave	1.8	.0
Navajo	186.5	2.7
Pima	616.5	9.1
Pinal	82.7	1.2
Santa Cruz	164.9	2.4
Yavapai	757.1	11.1
STATE TOTAL	6,771.1	100.0

*A visitor day is defined as any person participating in the recreation activity for twelve hours or twelve people participating in the same activity for one hour.

TABLE II-11

PARTICIPATION IN OUTDOOR RECREATION
APACHE NATIONAL FOREST - GREENLEE COUNTY - 1970

Viewing Scenery	Visitor Days (Thousands)	Percent of Total
Scenic Drives	15.1	13.3
Hiking	4.0	3.5
Horseback Riding	4.9	4.3
Swimming	.5	.4
Fishing	15.2	13.4
Camping	34.2	30.1
Lodges & Rec. Homes	8.4	7.4
Picnicking	20.0	17.6
Snowplay	1.5	1.3
Hunting	8.7	7.7
Nature Study	.3	.3
Other Activities	.7	.6
TOTAL	113.5	100.0

Generalized Future Land Use

Future land use patterns in Greenlee County are not expected to vary extensively from the established pattern. New urban land development will concentrate around the existing communities (PLATE 3), with the Plantsite-Clifton area experiencing the greatest amount of this growth potential.

The new mines at Metcalf will consist of two open pit operations and an underground mine. The ore will be crushed on site and transported to a proposed new concentrator at Morenci by railroad. The new mine will have an ore output of 35,000 tons daily with approximately 14 pounds of copper produced from each ton of ore.

The employees required for this operation will be housed at Plantsite, Stargo, and Clifton. Presently there are no plans for a new town in the Metcalf or Morenci areas.

Agricultural activity has been decreasing as a factor in the county's economy. This trend has been projected to continue although the amount of acreage will remain approximately the same. The reason for the relative decline is the increased mining activity which is occurring within the county.

There is a great potential for large scale subdividing activity on a speculative basis to take place, but the planning officials are attempting to limit these activities to planned developments in areas which have a justifiable need.

SUMMARY OF COUNTY NEEDS FOR ENVIRONMENTAL SERVICES

This section provides a compendium of existing and projected environmental services needs for Greenlee County. The information presented is a compilation of facts and calculations which are outlined individually in CHAPTER III of this report for the areas surveyed in the county. Opinions related to existing needs were based upon field survey information. Future needs projections were based upon methodologies discussed in SECTION III of this report and qualitative judgments as to life expectancies of existing facilities, if any.

Water Supply and Distribution Systems

Water resources for the county as a whole appear adequate to meet future domestic water needs which could conceivably reach an estimated 2,154 acre-feet in 1990. Present demands are estimated at 1,100 acre-feet per year. As the rural areas of Greenlee County are contiguous to major perennial streams, water supply problems should be minimal.

Existing and future water supply and distribution needs for communities surveyed in Greenlee County are outlined in TABLE II-12. The needs expressed in TABLE II-12 are categorized in terms of varied system modifications and/or expansions, water supply augmentation or additional engineering evaluation of existing or needed systems. Review of TABLE III indicates that there are minimal actual needs within distribution networks.

TABLE II-12

EXISTING AND FUTURE* WATER SUPPLY AND DISTRIBUTION NEEDS IN RURAL AREAS OF GREENLEE COUNTY

Community or Developed Area	Existing Needs**					Future Needs 1975					Future Needs 1980					Future Needs 1990				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Clifton			●			●					●					●				
Duncan				●							●	●				●				●

* Based on high population projection levels.

**Needs classifications:

1. Replacement and/or modifications (expansion) within distribution system.
2. Water storage or additional storage facilities.
3. Detailed engineering evaluation of system and preparation of distribution network schematics.
4. Water supply augmentation.
5. Modification and expansion of equipment utilized in supplying water to distribution network (well motors, booster pumps, etc.).

Source: Staff estimates.

TABLE II-13

SUMMARY OF PROJECTED ANNUAL DOMESTIC WATER DEMANDS FOR GREENLEE COUNTY IN 1975, 1980 AND 1990

(Acre feet per year)

DEVELOPED AREA	PROJECTION YEAR	DOMESTIC WATER DEMANDS PROJECTION LEVELS* LOW	MEDIAN	HIGH
CLIFTON	1975	485	500	510
	1980	540	570	600
	1990	655	725	800
DUNCAN	1975	111	116	120
	1980	118	124	130
	1990	126	140	154
ALL OTHER AREAS OF DEVELOPMENT**	1975	605	620	635
	1980	720	760	795
	1990	990	1,090	1,200
COUNTY TOTAL	1975	1,201	1,236	1,265
	1980	1,378	1,424	1,525
	1990	1,771	1,955	2,154

* Water demands are based on low, median and high population projection levels.

**All Other Areas of Development (AOAD) include Morenci.

Source: Staff calculations.

Sewerage and Wastewater Treatment

Existing and future needs for sewage treatment facilities are presented in TABLE II-14. Most of the developed areas noted have an existing need for more detailed engineering studies related to future development of sewerage and treatment facilities. There are two operating sewage collection and treatment systems in the county (PLATE 3 and TABLE II-15). Of these systems, the Clifton system has current needs related to expansion or modification of their sewage collection network. Existing sewage treatment facilities need expansion in Duncan.

All remaining areas utilize the septic tank system of wastewater treatment.

Wastewater production levels within the county are presently estimated at 700 acre-feet per year. Projected future levels of sewage wastes that may be generated per year by 1990 are presented in TABLE II-16. Currently approximately 90 percent of the sewage originates in Clifton, Duncan and Morenci. By 1990, it is estimated that 90 percent of sewage produced will receive treatment other than by septic tank systems. A high percentage of the sewage generated is provided treatment of a more sophisticated nature than septic tanks, this would suggest that long-range planning related to the ultimate re-use of reclaimed wastewater should be carried out. Using reclaimed sewage for irrigation or industrial applications is currently an accepted practice, provided modern forms of sewage treatment are utilized. Sewage reclamation could augment existing and future irrigation water demands in the region. This particular application should be of interest and value to the Duncan area of Greenlee County.

TABLE II-14

EXISTING AND FUTURE* SEWERAGE AND WASTEWATER TREATMENT FACILITIES NEEDS IN RURAL AREAS OF GREENLEE COUNTY

Community or Developed Area	Existing Needs**					Future Needs 1975					Future Needs 1980					Future Needs 1990				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Clifton	●						●					●						●		
Duncan			●					●				●		●			●	●		

*Based on high population projection levels.

**Needs classification:

1. Detailed engineering design study for future development of sewerage and treatment facilities leading to construction of needed systems.
2. Expansion and/or additions to sewage collection network.
3. Expansion and/or modification of treatment facilities.
4. Consideration of wastewater reclamation for agricultural or industrial uses should be reviewed.

Source: Staff estimates.

TABLE II-15

INVENTORY OF SEWAGE TREATMENT FACILITIES IN GREENLEE COUNTY

Location	Ownership	Type Treatment
Clifton	Municipality	Trickling Filter
Duncan	Municipality	Stabilization Lagoon
Morenci	Private	Trickling Filter
Plantsite	Private	Trickling Filter
Stargo	Private	Trickling Filter

TABLE II-16

SUMMARY OF PROJECTED AVERAGE ANNUAL SEWAGE PRODUCTION LEVELS FOR GREENLEE BOUNTY IN 1975, 1980 AND 1990

(Acre-feet per year)

DEVELOPED AREA	PROJECTION YEAR	SEWAGE PRODUCTION PROJECTION LEVELS* LOW	MEDIAN	HIGH
	1975	340	350	360
Clifton	1980	370	390	410
	1990	425	470	520
	1975	61	62	64
Duncan	1980	65	68	72
	1990	74	81	90
All Other	1975	335	343	352
Areas of	1980	404	424	445
Development**	1990	596	617	638
	1975	736	755	776
County Total	1980	839	882	927
	1990	1,065	1,168	1,248

*Sewage production levels are based on low, median and high population projection levels, as outlined in SECTION III of this report.

**All Other Areas of Development (AOAD) includes Morenci.

Source: Project Staff Estimates.

Solid Waste Disposal Practices and Techniques

The production levels of refuse, garbage and other forms of solid waste materials will grow as population densities increase. Projected levels of solid waste production are presented in TABLE II-19. At present, solid wastes are generated in Greenlee County at an estimated rate of 9,000 tons per year (1970). Levels of solid waste production in 1975, 1980 and 1990 are projected to increase 20, 54 and 141 percent, respectively, over the 1970 level of estimated production.

Solid waste materials are disposed of at three (3) major dumpsites (PLATE 3) and two (2) sanitary landfills. Control of accumulated wastes is accomplished by burning at the dumpsites. The facilities near Clifton and Duncan are operated as sanitary landfills on a full-time basis.

Management of these facilities is carried out by the County Highway Department. Part-time maintenance and operation is provided for the dumpsites at the present. However, full-time management will become increasingly important in future years. A management program involving the development of sanitary landfill disposal sites with regularly scheduled inspections and maintenance would be of benefit to the citizens of Greenlee County.

Planning for site selection and development of centrally or regionally located sanitary landfills and the consideration of associated salvage operations serving all areas would be basic to an effective solid waste management program. Review of existing dumpsite locations and their relationship to projected land use patterns in the county suggests that possibly three (3) regional sanitary landfills could serve the county in the future. Possible area locations for these facilities are: (1) Clifton; (2) York Sheldon; (3) Duncan. Finalizations of actual site locations, land requirements and detailed design could be made a part of a regional program developed by the county.

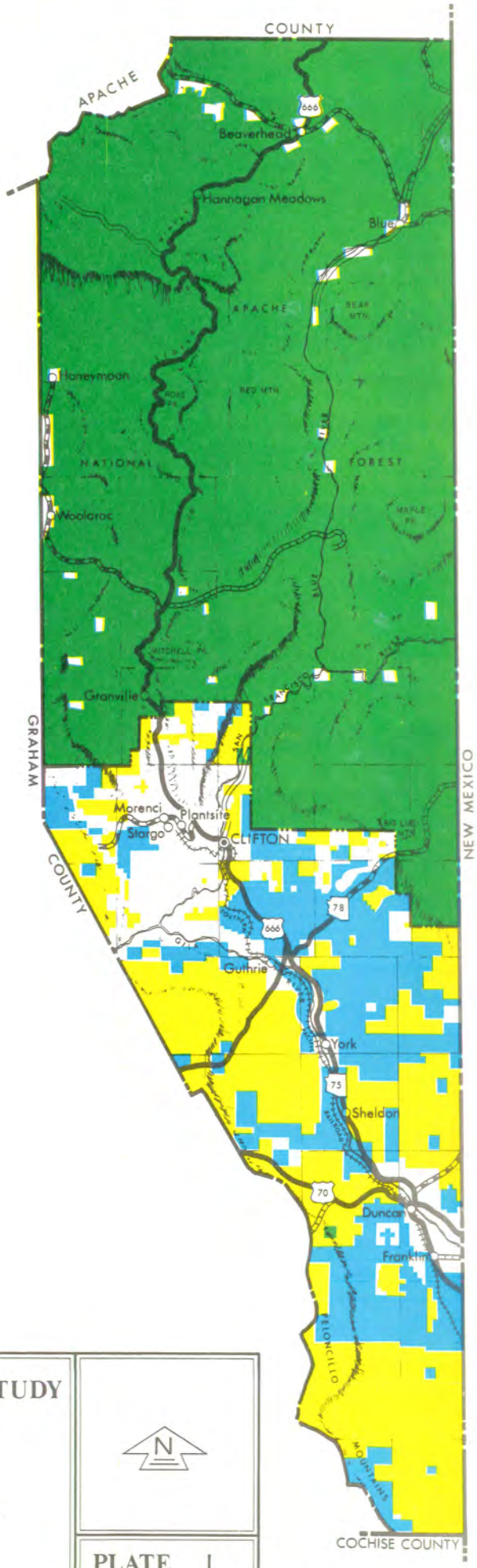
TABLE II-17

SUMMARY OF PROJECTED AVERAGE ANNUAL SOLID WASTES PRODUCTION LEVELS FOR GREENLEE COUNTY IN 1975, 1980 AND 1990
(Tons per year)

DEVELOPED AREA OF COMMUNITY	PROJECTION YEAR	SOLID WASTES PRODUCTION PROJECTION LEVELS* LOW	MEDIAN	HIGH
CLIFTON	1975	4,715	4,830	5,210
	1980	5,350	5,905	6,520
	1990	6,610	8,065	9,820
DUNCAN	1975	715	735	750
	1980	810	855	890
	1990	1,000	1,110	1,220
ALL OTHER AREAS OF DEVELOPMENT**	1975	4,635	4,750	4,865
	1980	5,835	6,130	6,430
	1990	8,765	9,670	10,650
COUNTY TOTAL	1975	10,065	10,315	10,825
	1980	11,995	12,890	13,840
	1990	16,375	18,845	21,690

*Solid waste production is based on low, median and high population projection levels as outlined in SECTION III of this report.
**All Other Areas of Development (AOAD) includes the Phelps Dodge Mining community of Morenci.

Source: Staff calculations.



LEGEND

- Apache National Forest
- State Trust Lands
- Bureau of Land Management
- Private

SYMBOLS

- City, Town, Settlement
- County Seat
- U.S. Highway
- State Highway
- Improved County Road
- Unimproved County Road
- Railroad
- River
- Mountain
- State Line
- County Line
- National Forest Boundary

SCALE—MILES

5 4 3 2 1 0 2 4 6 8 10 12 14 16

ENVIRONMENTAL SERVICES NEEDS STUDY

PREPARED BY

DEPARTMENT OF ECONOMIC PLANNING AND DEVELOPMENT

GREENLEE COUNTY, ARIZONA

LAND OWNERSHIP

N

PLATE 1

LEGEND

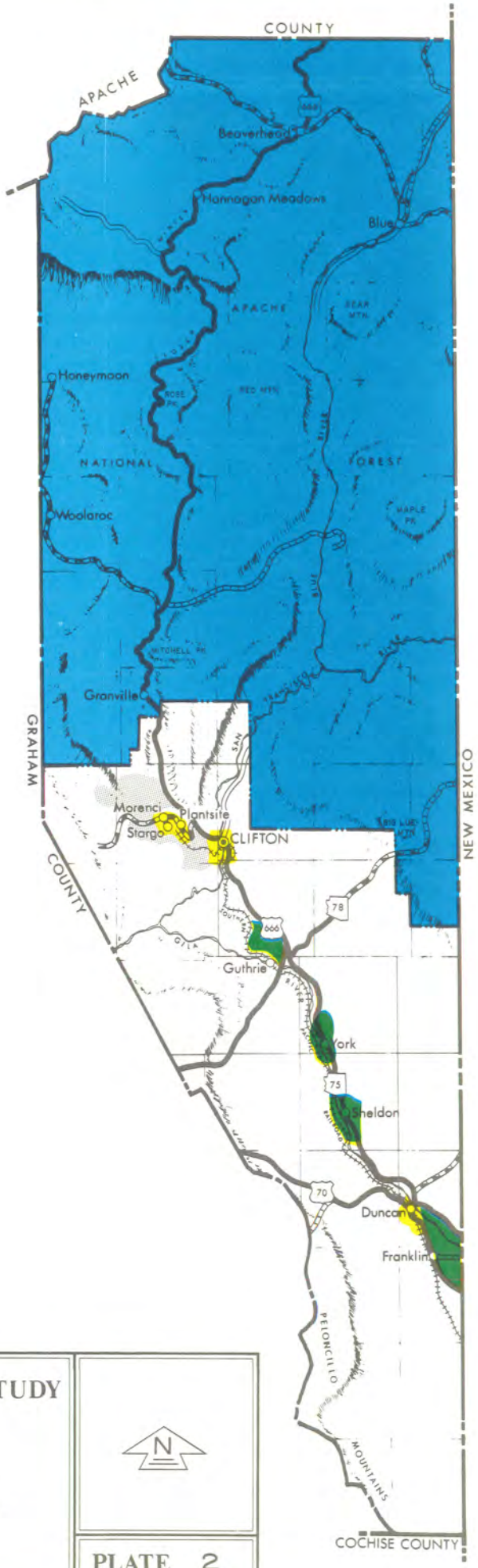
- Urban
- Industrial
- National Forest (Grazing & Recreation)
- Vacant
- Agricultural

SYMBOLS

- City, Town, Settlement
- County Seat
- U.S. Highway
- State Highway
- Improved County Road
- Unimproved County Road
- Railroad
- River
- Mountain
- State Line
- County Line
- National Forest Boundary

SCALE—MILES

5 4 3 2 1 0 2 4 6 8 10 12 14 16



ENVIRONMENTAL SERVICES NEEDS STUDY

PREPARED BY

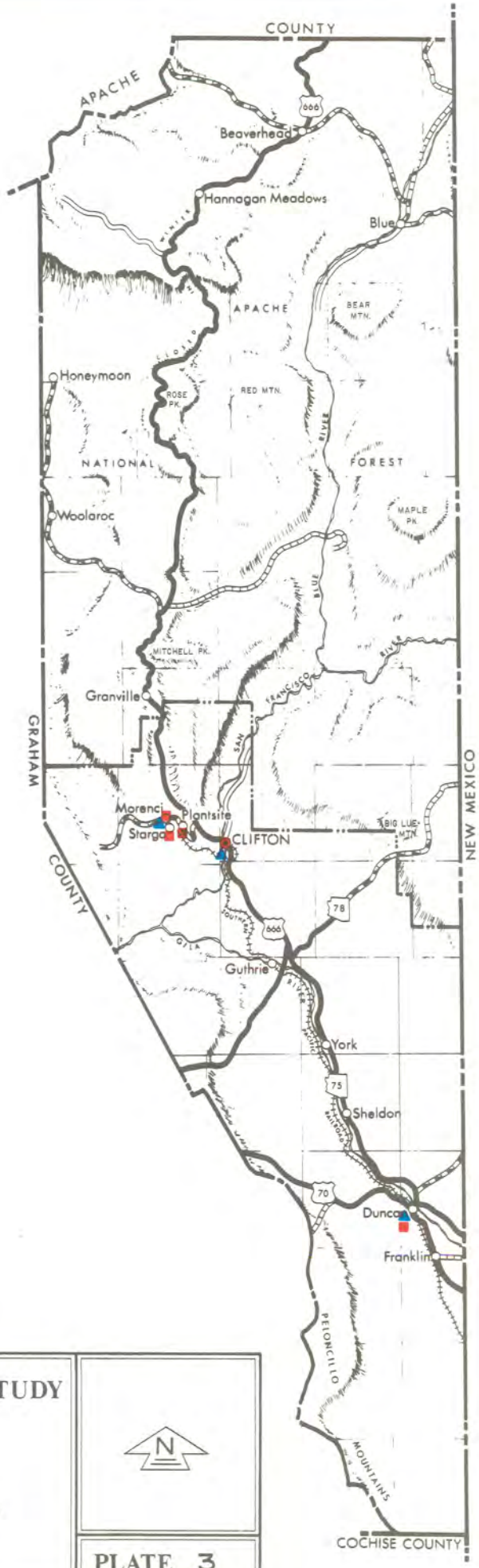
DEPARTMENT OF ECONOMIC PLANNING AND DEVELOPMENT

GREENLEE COUNTY, ARIZONA

LAND USE

N

PLATE 2



SYMBOLS

City, Town, Settlement

County Seat

U.S. Highway

State Highway

Improved County Road

Unimproved County Road

Railroad

River

Mountain

State Line

County Line

National Forest Boundary

Water System

Sewage System

SCALE—MILES

5 4 3 2 1 0 2 4 6 8 10 12 14 16

ENVIRONMENTAL SERVICES NEEDS STUDY

PREPARED BY

DEPARTMENT OF ECONOMIC PLANNING AND DEVELOPMENT

GREENLEE COUNTY, ARIZONA
INVENTORY OF FACILITIES

N

PLATE 3

CHAPTER III. COMMUNITY PROFILES

INTRODUCTION

Socioeconomic activity is related to regional factors such as location, physiography and natural resources. These factors determine the conditions which allow for initial community growth and future development.

This chapter has been formulated to give detailed descriptions of the communities surveyed as related to their economies and their development potentials. From this information, growth probabilities are developed and utilized in projecting needs for water supply and distribution systems, wastewater treatment and solid wastes management facilities. The projections are related to the existing service systems found in the respective areas.

Although it is not the purpose of this report to discuss flood control the potential dangers of flooding require some comment. The following information has been provided by the staff of the Arizona Water Commission:

"Considerable developed floodplain area exists in Greenlee County. Portions of both the Cities of Clifton and Duncan are within the floodplains of the San Francisco and Gila Rivers, respectively. This was evidenced from the flood of October, 1972, when substantial damages occurred both in the cities and to agricultural developments along the Gila River. During that flood, damage in the Clifton area was approximately $1,357,000. In the Duncan and York Valleys along the Gila River, damages were approximately $2,303,000. The flood that caused these severe changes was not an extremely rare occurrence. Similar flooding can be expected to occur approximately three times each 100 years.

Because Clifton and Duncan are located in a floodplain, future growth will be restricted. Recently enacted state and federal legislation requires that development consider flood hazards. Hazard areas will be identified and new construction controlled. Along the Gila and San Francisco River the flood hazard areas are expected to be extensive."

COMMUNITY OF DUNCAN

HISTORICAL PROFILE

Indian burial grounds and other evidence indicate that the Gila River Valley was occupied even in prehistoric times. When the first white settlers came the only inhabitants were roaming Apaches. Permanent settlement began when the Indians were, at least in part, subjugated by military force. In the early 1880's settlers began organizing irrigation districts and diverting water from the Gila River for irrigation. The Casper-Windham Canal, now greatly extended and known as the Sunset Canal, was begun in 1883. Construction was begun on the Valley Canal in 1886, on the Collminero in 1895 and the Moddle in 1896. Irrigated land included 2,500 acres in 1900 and by 1916 the cultivated acreage was about 3,400 acres. Damaging floods in that year forced many settlers from the lower bottom land and considerably reduced the crop acreage for a time. Because of the extent of the open range, livestock raising was an important aspect to the early agricultural economy of the area. A post office was established in 1883 and in 1884 a narrow-gage railroad was built into the area (Arizona-New Mexico Railroad). Construction work, together with increased nearby mining operations, created considerable demand for agricultural products, especially alfalfa hay for work stock and corn for Mexican laborers. As mining activities at Clifton and Morenci increased, market demands continued to increase. By 1900 standardization and extension of the railroad were necessary and during this period the developing community was known as Prudy. When the railroad was constructed in 1883 the town was named after James Duncan, a director of the Arizona Copper Company. The community gained official status in 1938 through incorporation.

PHYSICAL CHARACTERISTICS

Duncan is situated along the Gila River approximately 180 miles southeast of Phoenix and 115 miles northeast of Tucson in the southern sector of Greenlee County.

The Duncan area forms a part of the Mexican Highland section of the Basin and Range province of the Gila River watershed. The area is characterized by the scattered groups of rugged mountains, volcanic peaks and low lava hills, with intervening broad basins or plains that are traversed in places along the larger streams by narrow deeply incised valleys. Duncan occupies a alluvial flood plain at an elevation of 3,643 feet above sea level (PLATE 4).

The Gila River has a more or less uniform gradient of about 10 to 15 feet to the mile. Its meandering course, which has often shifted, causes considerable bank cutting, and is partly responsible for periodic overflow onto adjacent low lying lands. Floods of 10,000 to 25,000 second feet are relatively frequent and leave quantities of debris on lower areas. At times during the rainy season the flow may reach 40,000 second-feet or more, and seriously damage the agricultural land adjacent to the river. Disastrous floods in 1916 forced many settlers to move to higher land on the alluvial fans and bottoms of the tributary streams. Again in September 1941 and 1972 water rose high enough to flood Duncan causing extensive damage. Although the low-lying alluvial plains in the area are frequently flooded, these lands have sufficiently good underdrainage to prevent extensive areas from becoming water logged or affected by detrimental accumulations of alkali.

Since relatively good quality water can be obtained at shallow depths along the river, it has become a common practice to drill wells for supplementing irrigation water supplies when the river is low during summer months.

In general the Duncan area may be described as arid or semi-arid. The weather is clear and the sunlight intense for the greatest part of the year. The winters are mild with little snowfall. Precipitation and humidity are low and the evaporation rate high. The daily range in temperature is wide with extremely high or low temperatures in common.

A general summary of weather conditions exhibited in Duncan are noted below:

	JAN.	APR.	JULY	OCT.
Average Max. Temperature	59.4	78.2	95.0	80.9
Average Min. Temperature	22.8	37.8	62.0	40.1
Average snowfall per year:		1.9 inches		
Average rainfall per year:		8.9 inches		

The number of frost free days in the area is about 160. Weather records between 1901 and 1906 indicated the average last killing frost in spring to be May 13 and the first in fall, October 14, giving an average growing period of 153 days. During that period, however, killing frosts occurred as late as June 2 and as early as September 30. Winter, hardy, small grain crops grow during the winter, and in late-fall and in early spring lettuce can be raised. The growing season is sufficiently long for short-staple cotton and soy beans. Livestock graze throughout the year.

Mean annual precipitation for the area is about 9 inches. Torrential rains during July, August and September, account for about half of the precipitation. The rest is made up chiefly of gentle winter rains from December to March.

The generally sparse native desert vegetation consists of shrubs, yucca, cacti, annual grasses, herbs, and a few trees. The thickest cover occurs along the river where scattered cottonwood and black willow grow in dense thickets of water motie and arrowweed. In a few permanently well or salty areas salt grass, seepweed, chamiza, water-tolerant grasses and tules grow. The alluvial plains away from the rivers edge support a rather complex and varied association of plants, including mesquite, catclaw, creosote bush, hairy squawberry, lotebush, crucifixion thorn; yucca; Morman-tea, chamiza, broom baccharis, low growing cacti, broom snakeweed, bush mukly, tobosa grass, sacaton, fluff grass, several varieties of grama, alferia, and a number of flowering annuals.

In their virgin state the soils for the Duncan area are similar to those of adjacent valleys and much of the arid southwest. Moisture is the principal factor limiting plant growth. Under natural conditions is such that only desert or semi-desert plants can survive, except along the Gila River, where there is sufficient moisture for trees.

The dominant soils of the area owe many of their important characterisitics to the desert environment. They are comparatively low in organic matter and nitrogen, and high in lime carbonate and salts of potassium, sodium and other alkali (alkalime earth) elements. In a few places these salts are concentrated to the degree of being toxic to plant growth. Although phosphorus apparently is present in sufficient quantity for normal plant growth in most of the soils, it may be largely unavailable in the more calcareous, highly alkaline or puddled soils.

Most of the soils are light in color and many of them have a reddish tinge. This coloring ordinarily is more pronounced in the upper subsoil, where there are unhydrated iron oxides. The soils along the Gila River are the most important soils for agriculture in the area. These soils are dark and rich in organic matter and nitrogen and as a consequence are more fertile.

SOCIO-ECONOMIC PROFILE

Duncan is located in the middle of the principal agricultural area of Greenlee County. It is a small town which derives most of its income from serving the needs of the surrounding farms. The 10,000 acres under irrigation in the valley produce up to 5,000 bales of cotton annually as well as grain, potatoes and melons. Cattle play an important role in the Valley's economy, both in dairy farms and cattle ranches. Much of the town's income is derived directly from meeting the needs of the surrounding agricultural area as most employment is in small retail trade establishments. Another source of income to the town is from the highway traveler since Duncan is on Highway 70 which leads to Lordsburg, New Mexico.

According to the 1970 Census of the population, the population of Duncan has declined from 862 in 1960 to 773 in 1970. The low projection is for the population to remain at its present level. Projected population levels for the community are presented in FIGURE III- 1

Community services and facilities in Duncan consist of a bank, park, swimming pool, five tennis courts, bowling alley, library, two motels, indoor and outdoor theaters and six churches. Communication links consist of two weekly papers in the community and state-wide dailies; and three television channels received from Tucson. Medical services are provided by one MD and one osteopath.

The single elementary school has a faculty of 18 with 550 pupils. The high school has 12 teachers and 270 students.

Transportation links are U.S. 70 and Arizona 75. Freight and cartage services are provided by the Southern Pacific Railroad and three trucking firms.

MANMADE SYSTEMS

EXISTING LAND USE

Duncan has developed linearly along U.S. 70 for approximately 1.8 miles. The town serves as both a retail trade center for the surrounding agricultural activity and as a highway service center for travelers using U.S. 70.

The town has not developed in an orderly manner, the result of no overall land use planning guidelines. The effects of this unorderly development are visible, in terms of inefficient utilization of land, significant amounts of vacant land between developments, and the mixing of incompatible land uses, i.e., residential uses with commercial and industrial uses (PLATE 5).

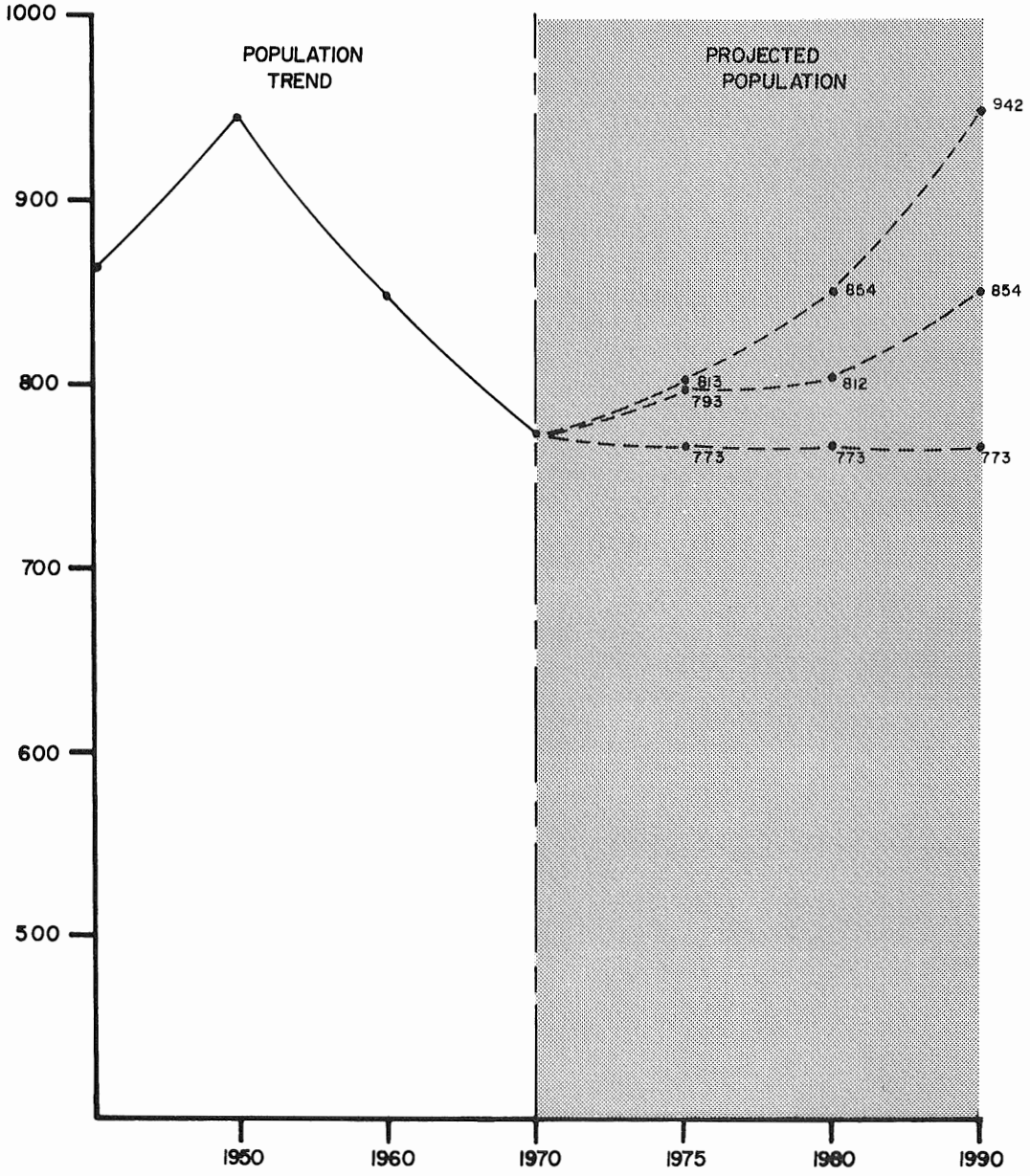


FIGURE III-1. POPULATION OF DUNCAN AND PROJECTIONS TO 1990

Residential uses are scattered throughout the townsite. Commercial land uses in Duncan serve the travelers using U.S. 70 and the local residents and agricultural activities. These commercial uses are scattered throughout the community.

The industrial developments are composed predominantly of warehouses and packing sheds used by the local agriculture industry when shipping their produce to market.

A significant amount of the developed land in Duncan is used for public and quasi-public uses. The land north and east of the community is used primarily for agricultural activities. This land is adjacent the Gila River within the alluvial plain.

The area west and south of the town is undeveloped with the exception of areas used for grazing. The terrain is too rough to be used for agriculture without expensive excavating operations.

Projected Land Use

The population projections for Duncan indicate possible zero growth for the next twenty years. These projections are reflected in the land use projections made on PLATE 6

Any future land development can easily be accommodated within the present town limits. It is projected that any new residential development will locate in those areas of existing development and along established transportation routes. Housing construction is not foreseen as an active area of land development and those areas indicated as residential will probably remain low density, retaining the large vacant areas.

WATER SUPPLY AND DISTRIBUTION SYSTEM

Existing Facilities

Domestic water demands of Duncan are supplied by wells owned and operated by the investor-owned City Utilities Company. The wells are 300, 100, and 90 feet in depth respectively, and are equipped with turbine pumps. Water leaving the well sites is chlorinated prior to storage.

The distribution network contains five storage tanks with a total capacity of 330,000 gallons. Transmission and distribution mains over four inches in diameter total 14,000 and 7,000 feet respectively. Distribution mains with diameters less than four inches total 13,000 feet. (PLATE 7)

Water quality for wells serving the community are presented in TABLE III-1. Concentration levels for sulphates exceed the U.S. Public Health Service recommended limit of 250.0 milligrams per liter.

Future Needs

Future water quality analysis may indicate increasing levels of sulphates in wells serving the Duncan area. If this situation accurs the Arizona State Department of Health will possibly request that a new supply be developed. Projected water supply demands for the community are presented in TABLE III-2.

TABLE III-1

WATER QUALITY DATA FOR WELLS SERVING DUNCAN, ARIZONA-CITY UTILITIES COMPANY

Chemical Constituent	Concentration (milligrams/liter)
Total Dissolved Solids	800.0
Total Hardness	410.0
Calcium	130.0
Magnesium	26.0
Sodium	146.0
Alkalinity	270.0
Chlorides	106.0
Nitrates	0.6
Fluorides	0.56
Sulfates	340.0

Source: Arizona State Department of Health.

TABLE III-2

PROJECTED AVERAGE DAILY AND YEARLY WATER DEMANDS FOR DUNCAN IN 1975, 1980 AND 1990

Projection Level	YEAR 1975 Gallons/day		YEAR 1980 Gallons/day		YEAR 1990 Gallons/day	
Summer High	168,000	120	181,000	130	209,000	154
Winter High	162,500		70,000		87,000	
Summer Median	164,000	116	172,000	124	190,000	140
Winter Median	61,000		67,000		79,000	
Summer Low	160,000	111	164,000	118	172,000	126
Winter Low	59,500		64,000		71,000	

Acre feet per year

SEWERAGE AND WASTEWATER TREATMENT

Existing Facilities

Sewage collection facilities for the community were constructed in 1960 and financed by a 280,000 bond issue. Sewage is carried through the collection network by gravity to a lift station adjacent to the Gila River. From the lift station sewage is pumped through a bar screen to the sewage treatment facility. (PLATE 8) The treatment facility consists of a two-celled stabilization lagoon. Cells have areas of 1.3 and 1.1 acres. No chlorination is provided prior to effluent discharge to the Gila River.

Evaluation of the facility by the Arizona State Department of Health has indicated the lagoon facilities are overloaded. Procedures for increasing the treatment capability of the facility have been recommended by the Arizona State Department of Health. However, to date they have not been implemented.

Problems apparently have occurred with respect to the manner by which the cells are loaded with raw sewage resulting in short circuiting and deposition of sludge. As a result, the facility has produced objectionable odors. In addition, spring runoff in the Gila River flooded the facility in 1972.

Future Needs

The sewage treatment facility should be upgraded to secondary treatment standards. This would first require the preparation of a facilities plan which would delineate a cost effective methodology for achieving adequate sewage treatment for established water quality criteria for the Gila River Basin.

TABLE III-3

PROJECTED AVERAGE DAILY AND YEARLY SEWAGE FLOWS FOR DUNCAN IN 1975, 1980 AND 1990

Projection Level	YEAR 1975 Gallons/day		YEAR 1980 Gallons/day		YEAR 1990 Gallons/day		Acre feet per year
Summer	65,000		73,000		89,500		
High		64		72		90	
Winter	49,000		55,500		71,000		
Summer	63,500		69,100		81,100		
Median		62		68		81	
Winter	48,000		52,900		64,000		
Summer	62,000		66,000		73,400		
Low		61		65		74	
Winter	46,400		50,200		58,00		

Projected sewage flows for the community are noted in TABLE III-3.

Expansion of the collection network will be minimal in the projection period noted.

SOLID WASTE DISPOSAL PRACTICES AND TECHNIQUES

Existing Facilities

The community presently provides trash and garbage pickup service and disposal on a daily schedule. Collected wastes are disposed of at the sanitary landfill noted on PLATE 3. The single collection vehicle has a capacity of 480 cubic feet which is reportedly loaded once a day. This would indicate a solid waste production level of about 1.8 tons per day. The sanitary landfill is maintained once weekly by County Highway Department personnel and equipment.

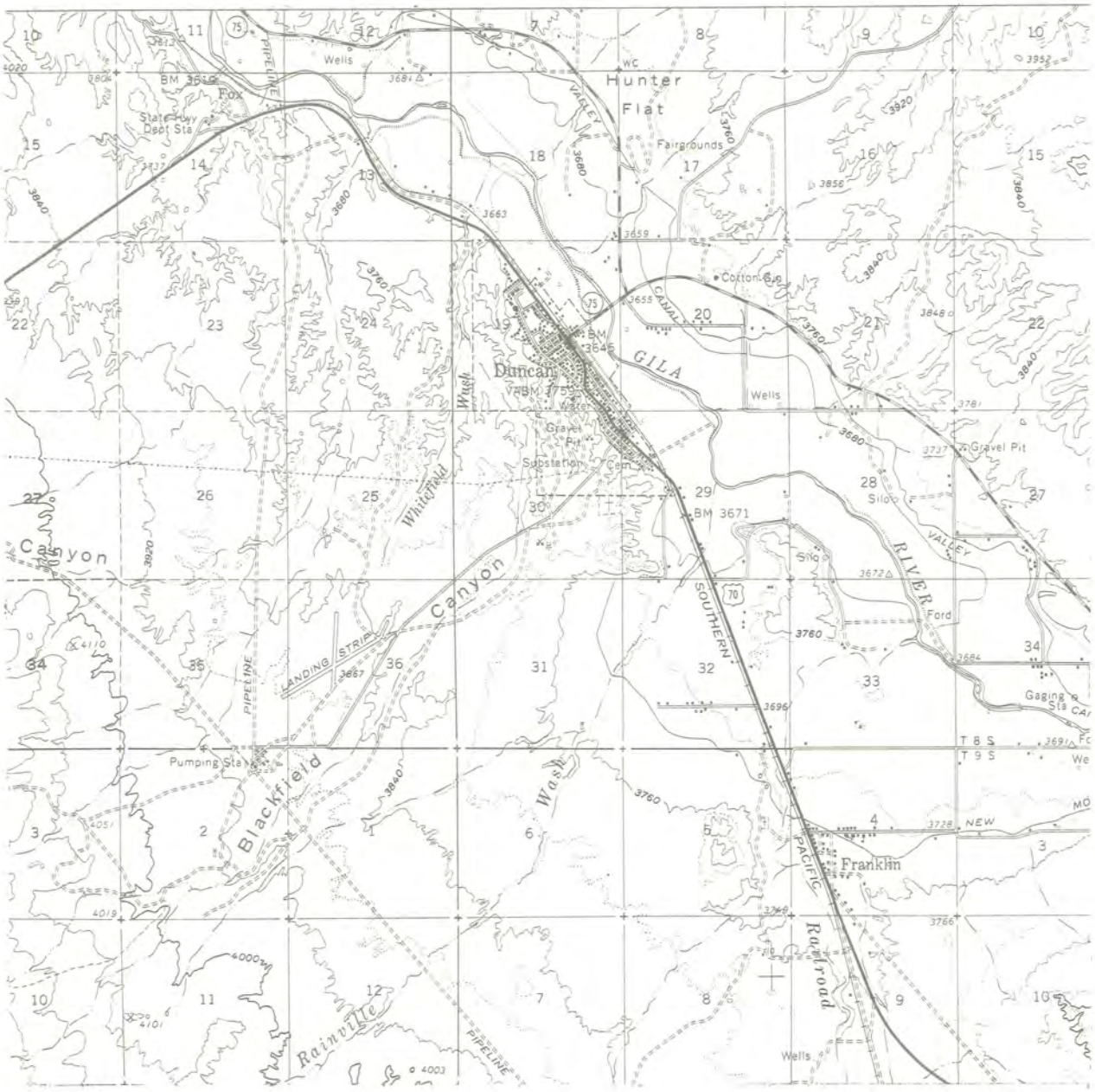
Future Needs

The sanitary landfill has sufficient capacity to meet future disposal needs (TABLE III-4). By 1990 it is estimated that 14,775 tons of solid waste materials will have accumulated at the site. Using a compacted density of 45 pounds per cubic foot and depth of six feet for the accumulated material, approximately 2.5 acres of land would be utilized.

TABLE III-4

PROJECTED AVERAGE YEARLY SOLID WASTES PRODUCTION LEVELS FOR DUNCAN IN 1975, 1980 AND 1990
(tons per year)

PROJECTION YEAR	SOLID WASTE PROJECTION LEVELS		
	LOW	MEDIAN	HIGH
1975	715	735	750
1980	810	855	890
1990	1,000	1,110	1,220



SCALE 1:62500

SOURCE: U.S. Department of the Interior
Geological Survey 1969

ENVIRONMENTAL SERVICES NEEDS STUDY

PREPARED BY

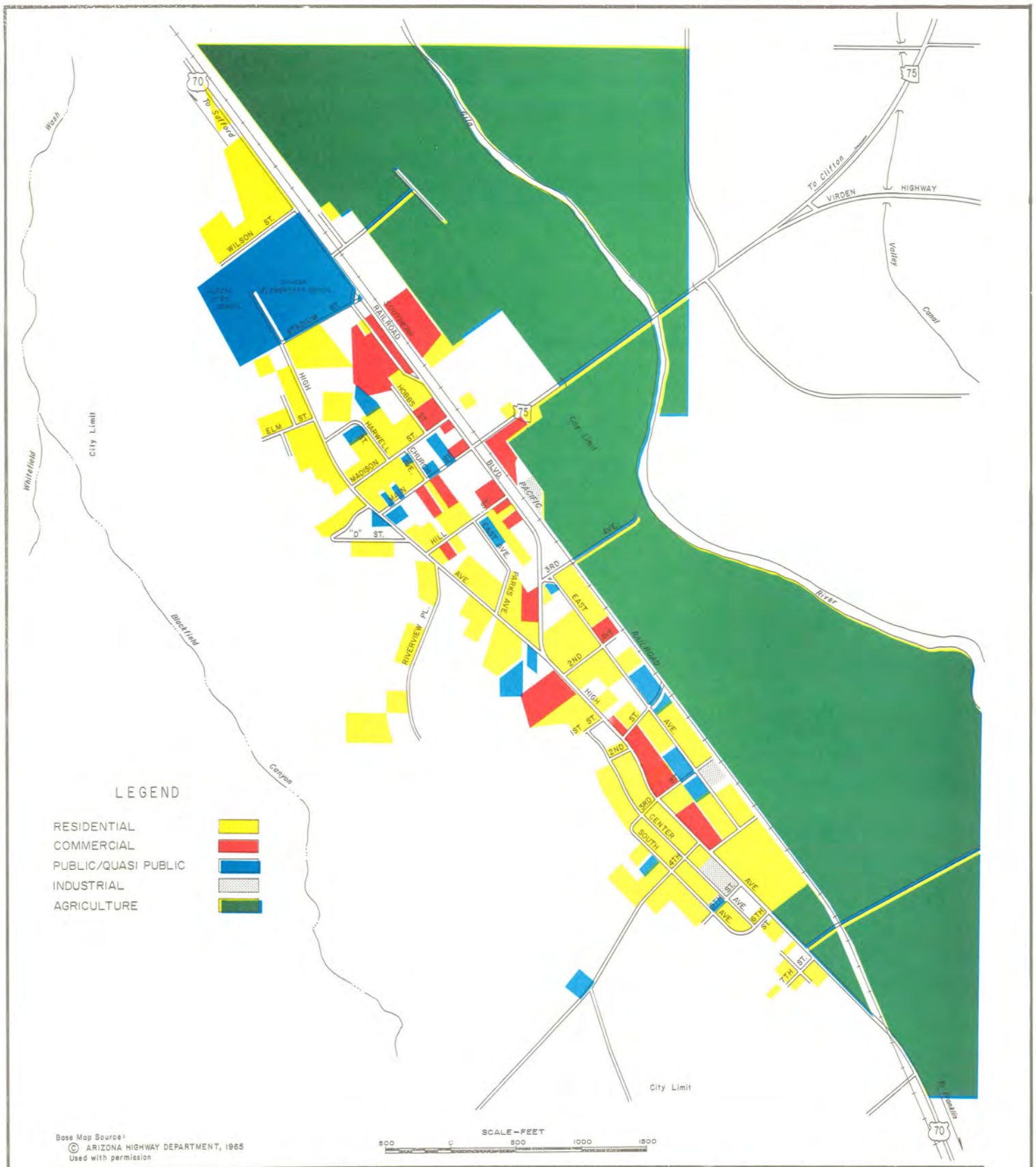
DEPARTMENT OF ECONOMIC
PLANNING AND DEVELOPMENT

DUNCAN, ARIZONA

TOPOGRAPHIC FEATURES

N

PLATE 4



ENVIRONMENTAL SERVICES NEEDS STUDY

PREPARED BY

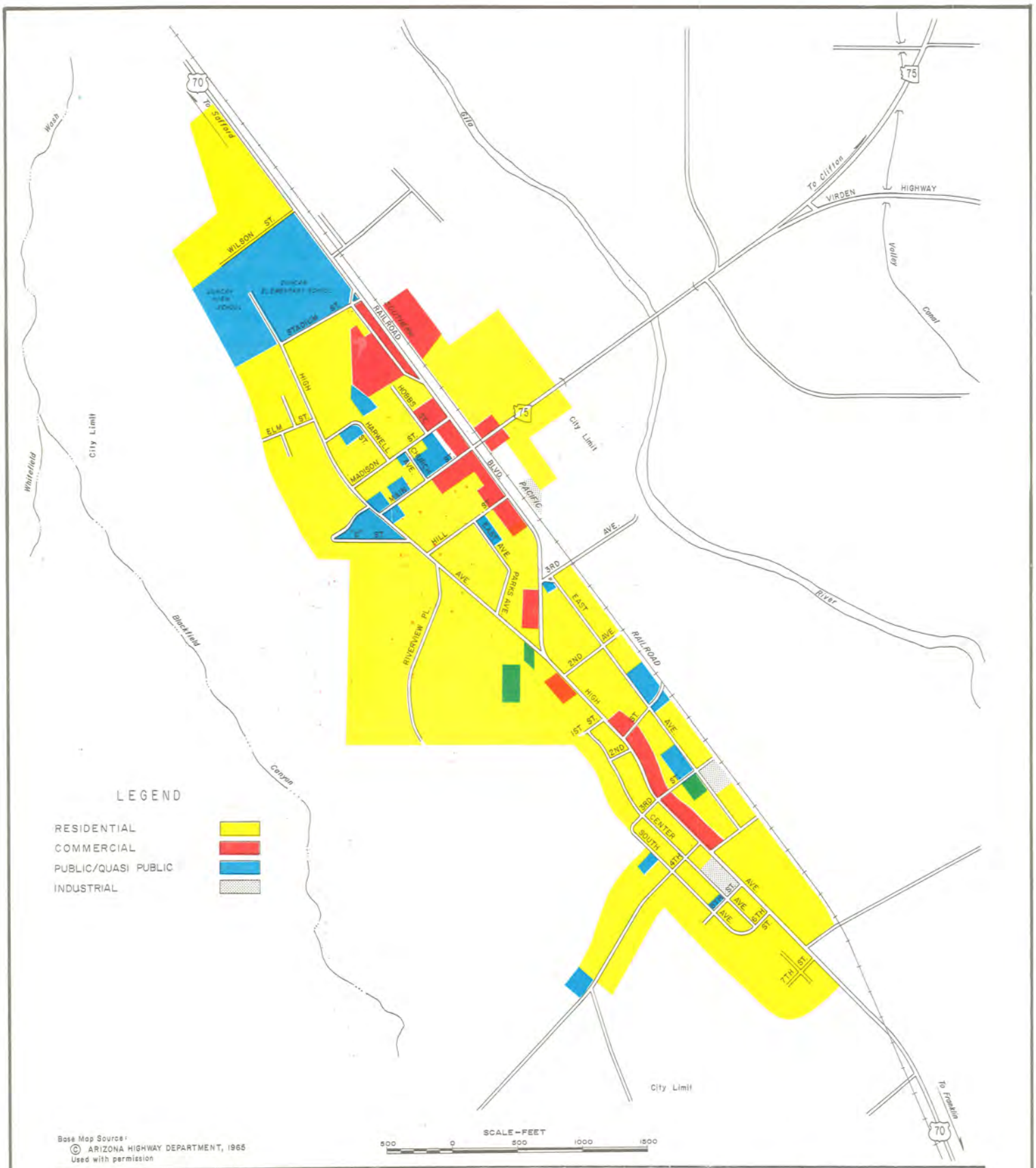
DEPARTMENT OF ECONOMIC
PLANNING AND DEVELOPMENT

DUNCAN, ARIZONA

LAND USE

N

PLATE 5



ENVIRONMENTAL SERVICES NEEDS STUDY

PREPARED BY

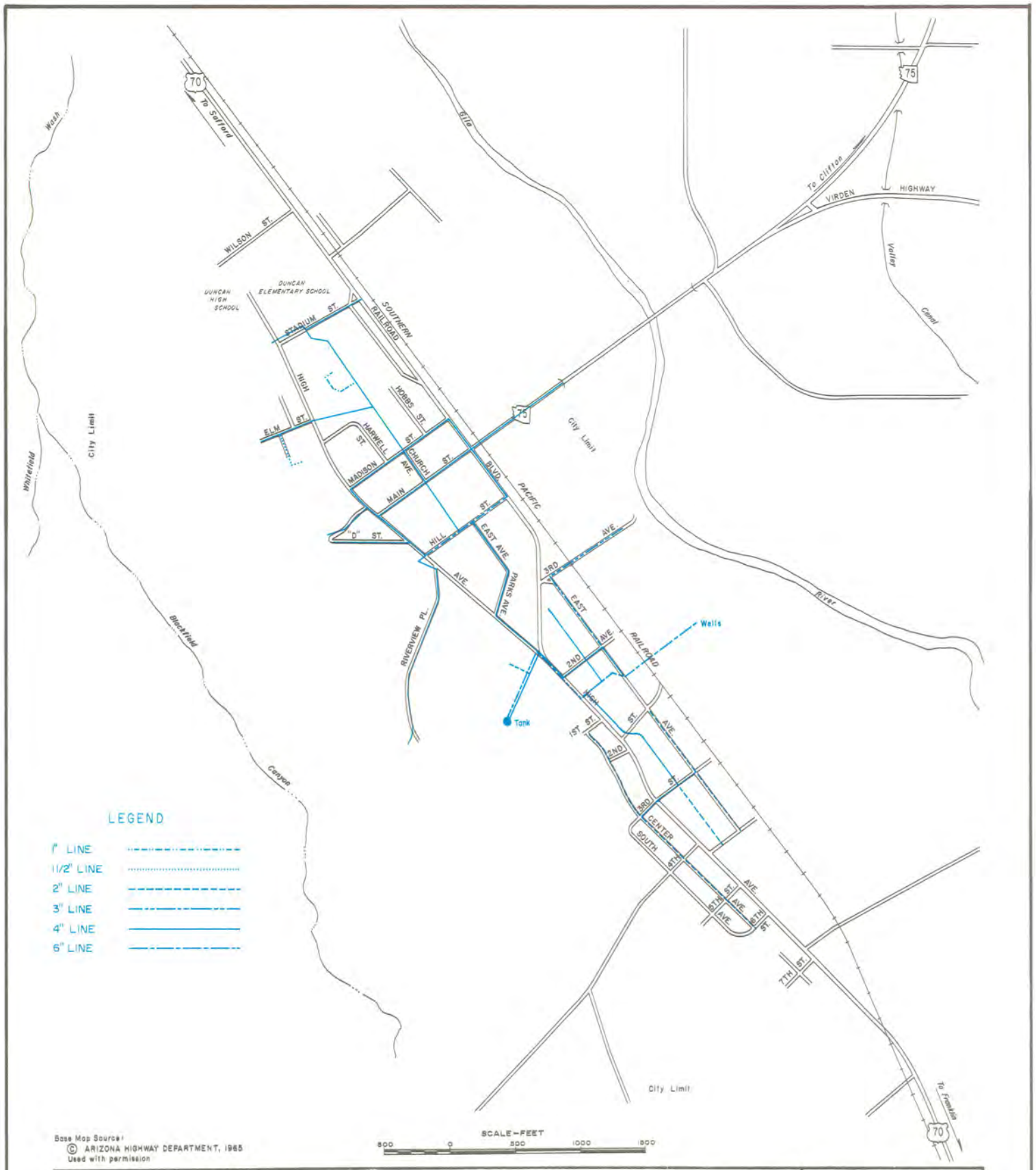
DEPARTMENT OF ECONOMIC PLANNING AND DEVELOPMENT

DUNCAN, ARIZONA

PROJECTED LAND USE

N

PLATE 6



ENVIRONMENTAL SERVICES NEEDS STUDY

PREPARED BY

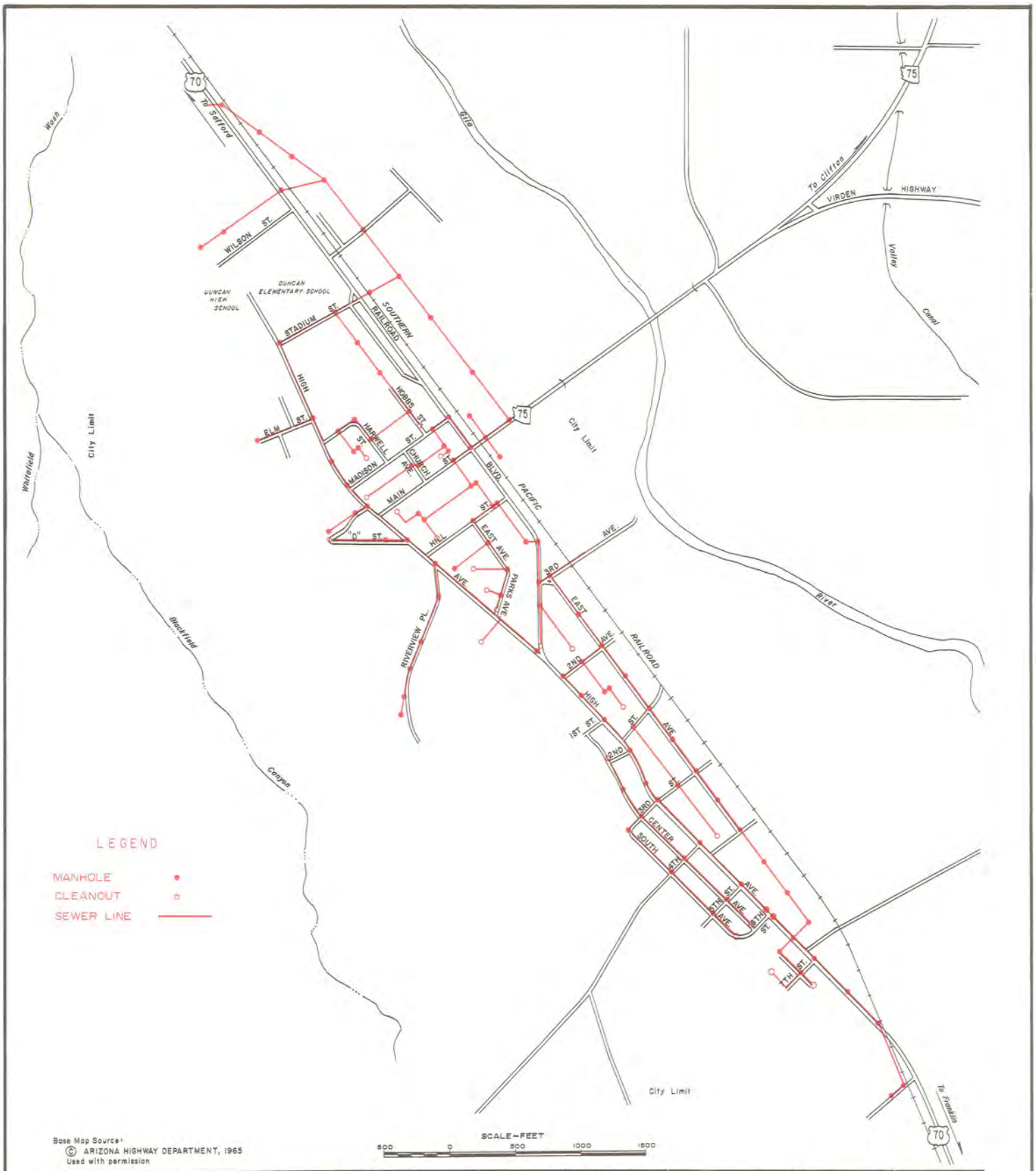
DEPARTMENT OF ECONOMIC PLANNING AND DEVELOPMENT

DUNCAN, ARIZONA

WATER SYSTEM

N

PLATE 7



Base Map Source:
© ARIZONA HIGHWAY DEPARTMENT, 1965
Used with permission

ENVIRONMENTAL SERVICES NEEDS STUDY

PREPARED BY

DEPARTMENT OF ECONOMIC
PLANNING AND DEVELOPMENT

DUNCAN, ARIZONA

SEWER SYSTEM

N

PLATE 8

COMMUNITY OF CLIFTON

Historical Profile

Clifton is believed to have derived it name from its location among the rugged cliffs. In 1872, Clifton was established as a community by a group of prospectors who had explored the area in the early 1870's. The post office was established in 1875, making Clifton the oldest community in Greenlee County. Numerous copper claims were made after problems with the Apache Indians were solved, and the town grew rapidly. The community was incorporated and became the county seat when Greenlee County was established in 1909.

PHYSICAL CHARACTERISTICS

Clifton is situated on the San Francisco River in eastern Arizona about 15 miles west of the Arizona-New Mexico border. The area is characterized by rugged mountainous terrain with elevations ranging from 3,400 to 4,800 feet above sea level (PLATE 9).

Soils to the west, south, southeast and northwest of Clifton are placed upon very steep, deeply dissected old terrace fronts adjacent to the flood plains and bottoms of the San Francisco River, Chase Creek and intermittent drainage courses. The major fraction of these soils are shallow in extent and consist of strongly calcareous gravelly to very gravelly sandy to loamy materials overlying weakly to strongly cemented conglomerate rock, silt-stone and lime. Surface soil adhesiveness is slight which has resulted in many barren escarpments exposing highly stratified subsurface geologic formations. Present vegetation exhibited in these sectors of the Clifton area is a sparce cover of mesquite, creosote, tarbush, cat claw, white thorn and cacti with a scattering of grasses consisting of side oats gramma, bush mukly, tobosa, fluffgrass and three-awns.

East of Clifton the terrain becomes more pronounced with hills and steep mountain foothills evident. The soils, which are developing on materials from a wide variety of rocks, including mixed igneous rocks and conglomerates, are generally shallow to moderately deep. Rock outcrops are common along the canyon walls adjacent to the San Francisco River. Soils northeast of Clifton, formed from materials of volcanic and basic igneous origin on old lava flows, hills, and basalt capped mesas are evident. Vegetation at the higher elevations surrounding Clifton takes on a variable nature consisting of thin and scattered stands of pinyon pine, juniper, and mountain mahogany interspersed with extensive areas dominated by grass. Generally, the soils are calcareous with the exception of the highland areas and along the San Francisco River. As a result, creosote bush grows to the almost total exclusion of other plants.

The relatively shallow depths of soils in the Clifton area coupled with calcareous cemented subsurface geologic formations indicates that septic tank sewage disposal systems will generally have relatively short lifetimes. The predominantly steep slopes of the area also complicates the construction of such systems.

SOCIO-ECONOMIC PROFILE

The economy of Clifton is based mainly upon retail trade and service establishments. The town is the final location of commercial businesses before the start of the Coronado Trail. For this reason it is the center of tourist trade in the county. It also serves as a supplementary shopping center to residents of the Morenci area. County and state government offices as well as a high school and elementary school are located in Clifton.

According to the 1970 Census, the population of the town has increased by almost 900 since 1960. Its present population is 5,087. There is little remaining vacant land in the town at this time. This will serve as a direct limiting factor upon future growth. Any population growth can only result from increased density. This assumption is made in the population projections for 1990 shown in FIGURE III-2. The low projection is for the population to remain at its present level. The high projection is for Clifton to maintain its present rate of growth, giving it a population of 6,210 by 1990. The most probable median projection is for a population of 5,215 by 1975, 5,347 by 1980 and 5,620 by 1990.

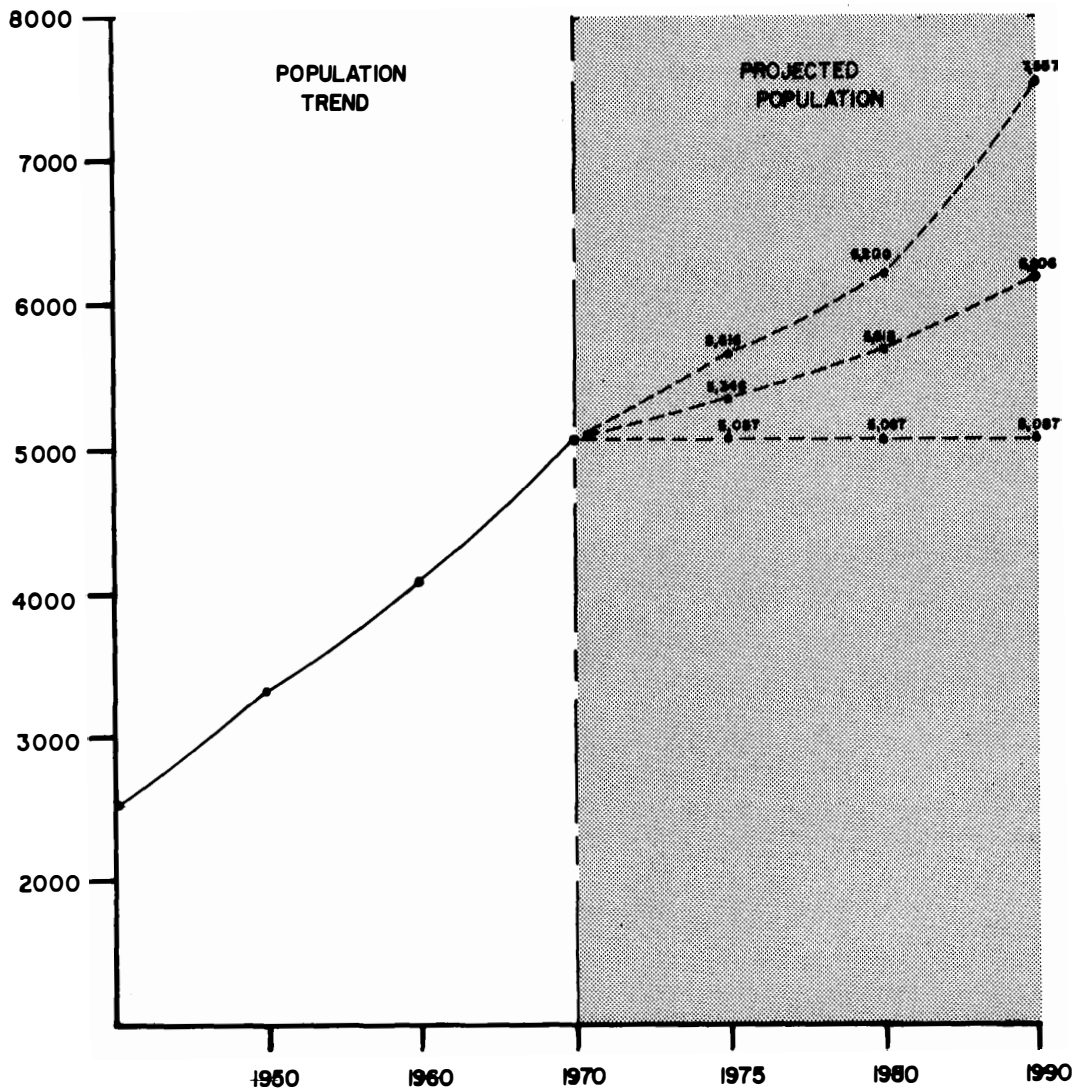


FIGURE III-2. POPULATION OF CLIFTON AND PROJECTIONS TO 1990

Community services and facilities in the Clifton area consist of two libraries, six motels and 14 churches. Recreational facilities consist of three parks, two pools, a nine hole golf course, six tennis courts and a bowling alley. Public safety and law enforcement are provided by a fire department with one full-time fireman and 15 volunteers; a police department with three officers, and the County Sheriff's Department with 9 deputies.

In addition to statewide dailies, two weekly newspapers serve the area. A local radio station and four television channels via cable from Phoenix provide communication services.

Medical and dental services are presently provided by seven doctors and three dentists and a 74-bed hospital located in Morenci.

The educational facilities consist of a public elementary school which currently has an enrollment of about 1,400 pupils with a faculty of 75, and a high school with an enrollment of 756 and a faculty of 44 teachers.

Transportation linkage to outlying areas and communities is primarly via U.S. 666 (Coronado Trail), the main arterial through the community. The Southern Pacific Railroad and two truck lines provide freight and cartage services. The municipal airport has a lighted 4,900-foot runway which serves private aircraft. There are no regularly scheduled airline services into Clifton.

MAN MADE SYSTEMS

EXISTING LAND USE

Clifton is essentially composed of three separate areas of development: Clifton, North Clifton and East Clifton, located within the canyons formed by the San Francisco River and its tributary, Chase Creek.

Land development has occurred in an indiscriminate manner with the inter-mixing of residential, commercial and industrial land uses. This inter-mixing has led to deterioration of certain areas, especially where land uses are incompatible.

Residential land uses occupy the largest amount of land area within Clifton (excluding the mining related activities) (PLATE 10). Single-family dwellings are the predominant form of housing, with mobile homes and apartments accounting for a relatively small percentage of the developed land area.

Most of the housing is located on the hillsides. The housing within Clifton is deteriorating and requires substantial repairs.

North and East Clifton have several small commercial areas. The areas are made up of retail stores, i.e., food, clothing and special shops. There are several secondary highway-oriented businesses located adjacent to U. S. 666.

Public and semi-public land uses include parks, playgrounds, governmental functions, charitable and non-profit organizations, churches, schools and hospitals.

Industrial land uses (with the exception of mining operations) consist of open storage yards and petroleum storage facilities.

The mining operations account for most of the land use and control the direction of growth and rate of development. The mine, concentrator and smelter are located in Morenci, three miles to the west of Clifton. The operations in Clifton are railroad maintenance storage yards and freight depots. Most of the surrounding land owned by the mining company is either vacant or is used for mine and smelter waste disposal.

PROJECTED LAND USE

The land use pattern of the Clifton area is not expected to change significantly during the next twenty years. The land which can be developed for urban purposes is limited to the existing urban areas.

New residential development is limited to the existing vacant land. New housing is being constructed at Morenci, thereby discouraging new residential development in Clifton. Much of the existing housing in Clifton is in need of repair.

The commercial uses within Clifton will probably phase out as the buildings become obsolete and space becomes available in the new retail areas at Morenci. The neighborhood convenience stores will remain.

The highway commercial uses will remain. The Coronado Trail (U. S. 666) is a popular recreational attraction. The volume of traffic on this highway is increasing annually and provides a potential for commercial development.

Industrial uses other than mine-oriented facilities are not expected to change. Mine-oriented industrial uses will probably increase in size and activity. The sites of the additional concentrators and smelter facilities needed to process the additional ore have not been selected.

WATER SUPPLY AND DISTRIBUTION

Existing Facilities

Water supply services for the community of Clifton are provided by the Morenci Water and Electric Company which also provides water to the Phelps Dodge mining operations.

The water is supplied by three wells located 2 1/2 miles northeast of Clifton on the San Francisco River. These wells have depths of 460, 260 and 160 feet with a total pumping capacity of 12,000 gallons per minute. The overall system has three storage reservoirs which have a capacity of 26,500,000 gallons. Six storage tanks have a total capacity of 30,000,000 gallons. Water used domestically is chlorinated prior to distribution. Water quality for this water is noted in TABLE III-5.

TABLE III-5

WATER QUALITY DATA FOR CLIFTON MORENCI WATER AND ELECTRIC COMPANY

Chemical Constituent	Concentration (milligrams/liter)
Total Dissolved Solids	308.0
Total Hardness	214.0
Calcium	58.0
Magnesium	17.0
Sodium	47.0
Alkalinity (total)	168.0
Chlorides	57.0
Nitrates	1.0
Sulfates	30.0
Fluorides	0.74

Source: Arizona State Department of Health.

The distribution network serving the area within the Clifton city limits is old. The distribution system was originally started when the community was incorporated in 1909. During the course of community surveys it was determined that a schematic map of the distribution network was not available and that the exact location of all mains within the community were not known.

TABLE III-6 presents recent total water supply use and customer data for the Clifton system.

TABLE III-6

CLIFTON MONTHLY WATER USE AND DISTRIBUTION NETWORK CONNECTIONS 1969, 1970 AND 1971

	Gallonage (Customers)		
Month	1971	1970	1969
January	8,149,400 (926)	7,303,000 (904)	6,462,800 (882)
February	8,275,000 (922)	8,045,400 (907)	6,776,000 (884)
March	8,641,400 (921)	6,648,600 (909)	7,002,300 (879)
April	12,269,000 (915)	10,278,800 (911)	10,373,600 (888)
May	12,020,200 (910)	11,618,600 (914)	10,705,600 (887)
June	15,800,500 (910)	15,519,500 (915)	16,295,000 (891)
July	15,253,800 (910)	15,988,500 (917)	16,995,300 (893)
August	15,111,800 (905)	14,188,500 (919)	13,673,600 (899)
September	13,730,300 (903)	14,054,100 (925)	12,404,400 (901)
October	10,515,900 (911)	10,299,900 (927)	11,242,700 (908)
November	6,998,100 (908)	9,582,200 (930)	8,875,000 (907)
December	--	8,719,200 (925)	6,525,300 (905)

Source: Clifton Town Clerk.

Future Needs

Water supply needs in Clifton are minimal, as the Morenci Water and Electric Company has sufficient delivery capabilities to meet future domestic demands. Projected water demands for the community are presented in TABLE III-7.

In the past few years problems have occurred in the distribution network with ruptured or accidentally damaged mains. Ruptures and breaks have primarily occurred in the older sectors of the community and suggests that new mains should be installed.

Adequate maintenance and operation of the distribution network would be facilitated through the development of an up-to-date network map or schematic. A map delineating all pipe locations and sizes would benefit the fire department, in addition to providing an essential element for planning system improvements and modifications.

TABLE III-7

PROJECTED AVERAGE DAILY AND YEARLY WATER DEMANDS FOR CLIFTON IN 1975, 1980 AND 1990

Projection Level	YEAR 1975 Gallons/day	1980 Gallons/day	1990 Gallons/day	Acre feet per year
Summer High	609,000	697,000	894,000	
	510	600	800	
Winter	375,000	450,000	621,000	
Summer Median	595,000	663,000	809,000	
	500	570	725	
Winter	365,000	428,000	562,000	
Summer Low	580,000	630,000	732,000	
	485	540	655	
Winter	356,000	407,000	509,000	

SEWERAGE AND WASTEWATER TREATMENT

Existing Facilities

The northern and western sectors of the community are served by septic tank-leach field sewage disposal systems. As a result of the calcareous soils and lack of available topsoil, this form of disposal system has a short lifetime. As a consequence, overflowing inoperative septic tank systems are a common problem.

South Clifton has a sewage collection network which was installed during the 1940's. Sewage was transported via a 15-inch outfall to an Imhoff tank sewage treatment system south and adjacent to the San Francisco River. In 1954, the outfall was extended further south to a new plant site where a trickling filter was installed. In 1958, this segment of the outfall was washed out by unseasonably high runoff in the San Francisco River. Again in 1970, high runoff threatened the integrity of the outfall. At that time, a lift station and bar rack was installed at the Imhoff tank site and a force main constructed to the trickling filter headworks above the high water level of the river. In 1973, the lift station was modified with new pump and control equipment.

The trickling filter plant was inoperative between 1968 and 1970 due to a breakdown of an integral part of the facility. During this period, raw sewage was discharged to the San Francisco River. The plant did have chlorination facilities. However, they were in a state of disrepair due to improper maintenance. At present the treatment plant is working satisfactorily and is providing relatively good sewage treatment prior to discharge. Recent sampling of the facility by the Arizona State Department of Health, Bureau of Water Quality Control indicated average biochemical oxygen demand (BOD) and suspended solids levels of 25 and 53 milligrams per liter, respectively. Residual fecal coliform levels averaged about 306 organisms per 100 mililiter sample. Raw sewage in 1966 had a BOD of 204 mg/liter. Coupled with the recent effluent data above, the treatment plant appears to provide 88 per cent removal of BOD.

Present sewage flows for south Clifton are estimated at about 145,000 gallons per day in the winter and 260,000 gallons per day in the summer. In 1973, Phelps Dodge Corporation installed a lift station at Plantsite and now pumps the sewage effluent to copper processing operations east of Morenci. It should be noted that the above sewage flows do not represent the sewage generated in the eastern and northern sectors of Clifton. These two sectors are physically separated from south Clifton by the San Francisco River and extremely steep (cliff-like) topography. Because of these features, it has been difficult to plan and implement sewage collection networks in the eastern and northern sectors of the community.

Community surveys resulted in the determination that there was no schematic map of the collection network. An old map was found in City Hall. However, it was faded to such an extent that location and sizes of sewer mains could not be determined.

Future Needs

Present needs are: 1) a detailed investigation of the collection network serving south Clifton; and 2) the development of sewage collection facilities in east and north Clifton.

Detailed evaluation of the south Clifton network would result in a map of the system and establish the feasibility of expansion to include the unsewered portions of the community. The feasibility analysis would also be directed towards estimating increased sewage treatment capacity needed to maintain discharge water quality criteria established for the water shed. Projected sewage flows for the community are noted in TABLE III-8 .

TABLE III-8

PROJECTED AVERAGE DAILY AND YEARLY SEWAGE FLOWS FOR CLIFTON IN 1975, 1980 AND 1990

Projection Level	YEAR 1975 Gallons/day		YEAR 1980 Gallons/day		YEAR 1990 Gallons/day		Acre feet per year
Summer	401,000		450,000		559,000		
High		360		410		520	
Winter	267,000		309,000		404,000		
Summer	391,000		428,000		506,000		
Median		350		390		470	
Winter	261,000		294,000		365,000		
Summer	382,000		407,000		458,000		
Low		340		370		425	
Winter	254,000		280,000		331,000		

A breakdown of the eastern and northern sectors of the community where sewage collection facilities should be implemented are: 1) Wards Canyon, 2) Okie Town, 3) Patterson Addition, 4) McCormack Canyon, and 5) Reyes Canyon. The Shannon Hill area of the community is two-thirds completed to date.

SOLID WASTE DISPOSAL PRACTICES AND TECHNIQUES

Existing Services

Solid waste collection and disposal services are provided by the community. The municipal service generally has biweekly pickup in the residential areas and daily pickups in commercial zones. Problems have occurred recently with collection trucks which has resulted in sporadic pickup schedules at times.

Collected materials are hauled to a sanitary land fill on Phelps Dodge property west of Clifton. Maintenance of the site is provided by Phelps Dodge equipment and personnel. The associated costs for maintenance are shared with Phelps Dodge Corporation absorbing two-thirds of the costs and the community one-third.

Salvage of metal and tin cans is undertaken at the landfill with reclaimed materials used in the leaching technique of copper extraction at the Phelps Dodge Morenci mine.

An old dumpsite exists on the east bank of the San Francisco River adjacent to the sewage treatment plant south of the community. The location of the dumpsite presents a water pollution source from rain runoff which passes over the waste materials on the way to the river.

Future Needs

New solid waste collection equipment is a current need in Clifton. As Clifton and Morenci are sister cities, it is suggested that a jointly operated collection service would be advantageous to both communities. More efficient operation could result while realizing lower limit costs. Projected levels of solid wastes for Clifton are noted in TABLE III-9.

From the solid waste tonnages in TABLE III-9 it is estimated that for the high projection level in 1975, 1980 and 1990; 3, 4, and 6 truck-loads per day would be required respectively to remove wastes from the community to the sanitary landfill (assuming the use of a 10 cubic yard compactor collection truck).

Cumulatively, the community of Clifton could conceivably produce 150,300 tons of solid waste material by 1990 for the high projections level.

TABLE III-9

PROJECTED AVERAGE YEARLY SOLID WASTES PRODUCTION LEVELS FOR CLIFTON IN 1975, 1980 AND 1990 (Tons per year)

PROJECTION YEAR	SOLID WASTE PROJECTION LEVELS		
	LOW	MEDIAN	HIGH
1975	4,715	4,830	5,210
1980	5,350	5,905	6,520
1990	6,610	8,065	9,820

SCALE 1:62500

SOURCE: U.S. Department of the Interior
Geological Survey 1969

ENVIRONMENTAL SERVICES NEEDS STUDY

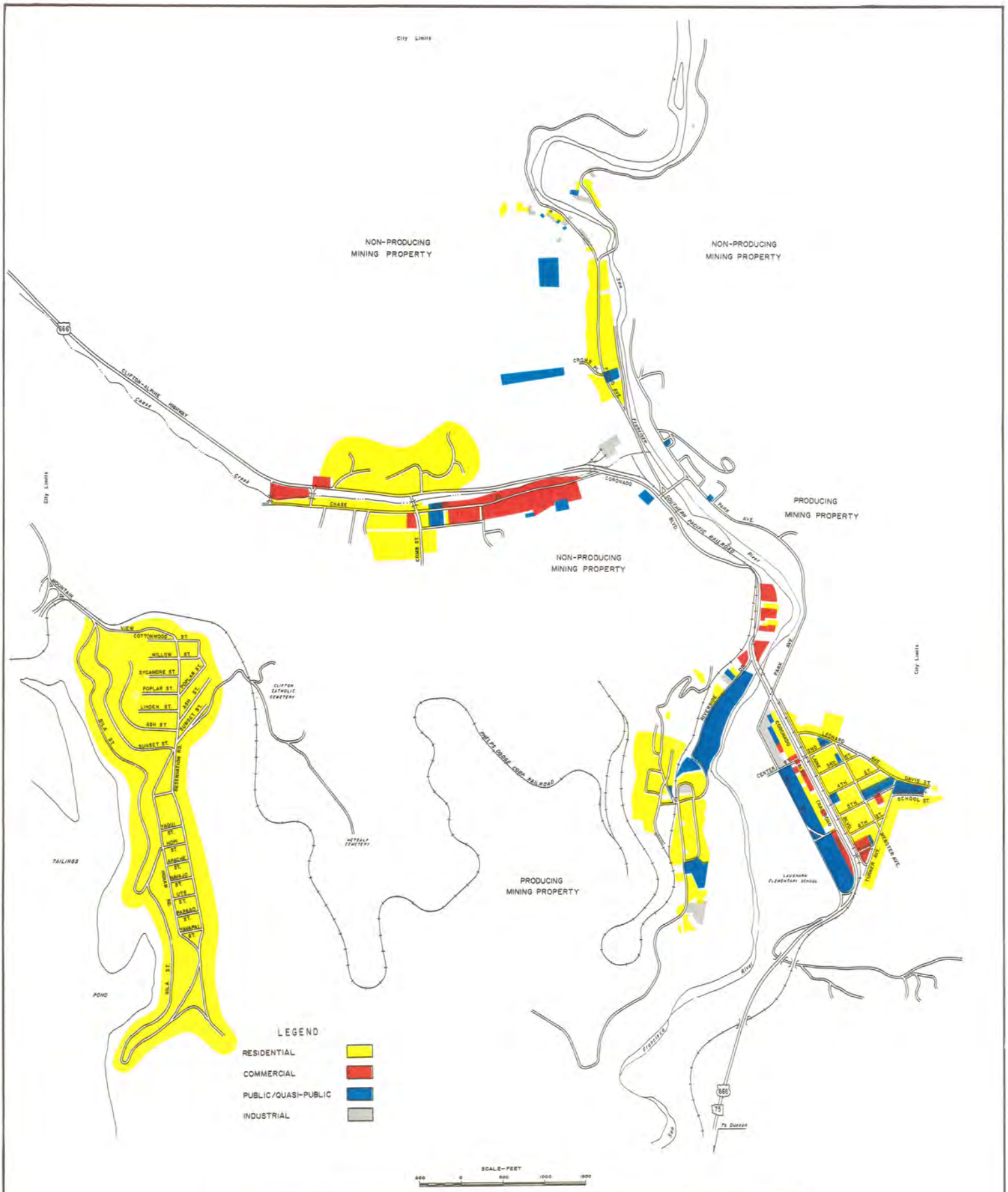
PREPARED BY

DEPARTMENT OF ECONOMIC
PLANNING AND DEVELOPMENT

CLIFTON, ARIZONA

TOPOGRAPHIC FEATURES

PLATE 9

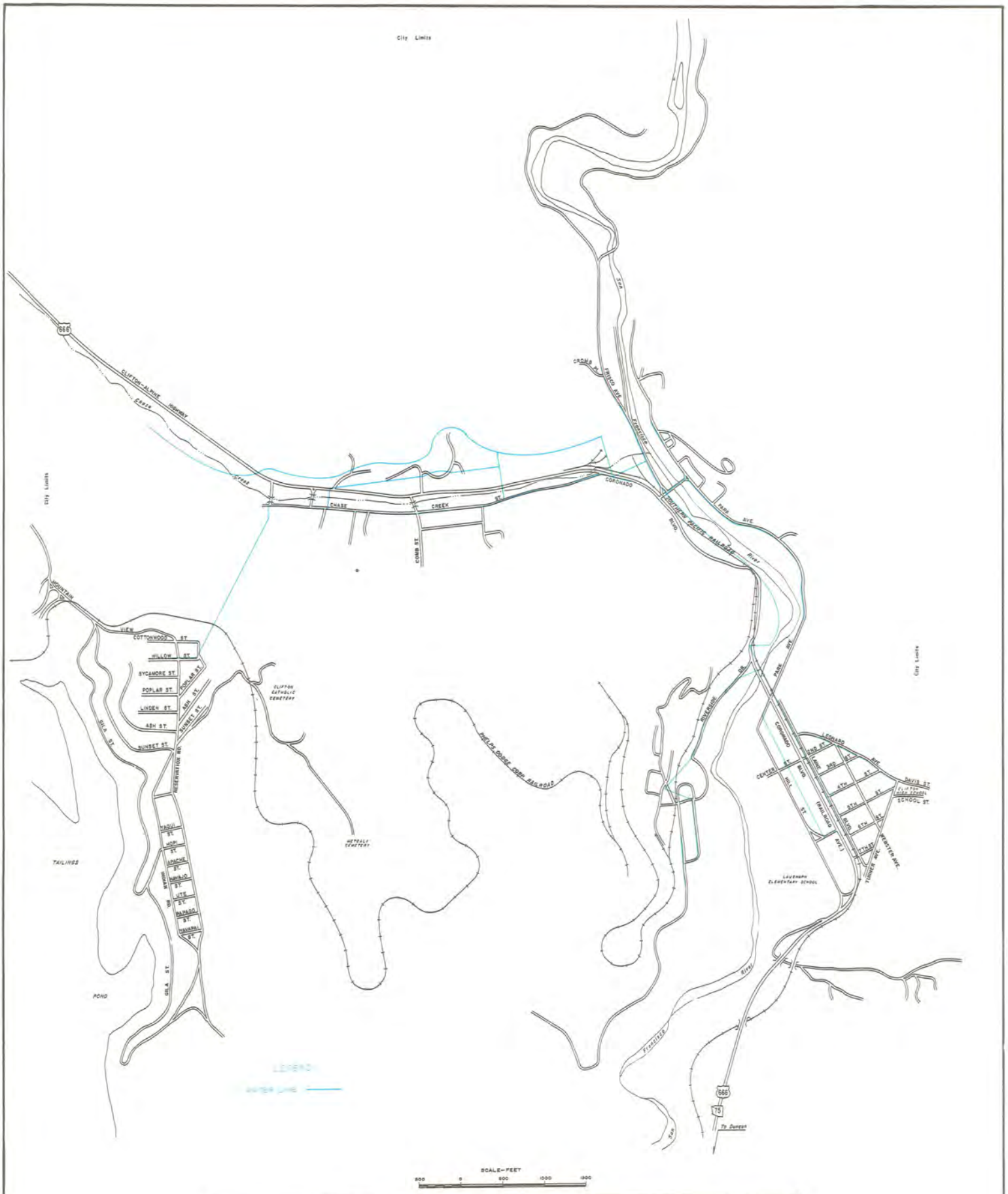


ENVIRONMENTAL SERVICES NEEDS STUDY

PREPARED BY
DEPARTMENT OF ECONOMIC
PLANNING AND DEVELOPMENT

CLIFTON, ARIZONA
LAND USE

PLATE 10



SCALE-FEET

500 0 500 1000 1500

ENVIRONMENTAL SERVICES NEEDS STUDY

PREPARED BY

DEPARTMENT OF ECONOMIC PLANNING AND DEVELOPMENT

CLIFTON, ARIZONA

WATER SYSTEM

N

PLATE 11

REFERENCES

1. Mineral and Water Resources of Arizona, Arizona Bureau of Mines, Bulletin 180, University of Arizona, Tucson, 1969, P. 475.

2. National Forest Service Report - Region 3, June 30, 1971.

3. U.S.G.S. Water Supply Paper 1541-A, 1960.

4. Computed by C. W. Thornwaite method as reported in An Approach Toward a Regional Classification of Climate, 1948.

5. Little Colorado Plateau, RC&D, 1971.

6. U.S. Forest Service, Apache National Forest 1971.

7. U.S.G.S., Groundwater in Gila River Basin and Adjacent Areas, Arizona, 1952.

8. Bulletin 180 Arizona Bureau of Mines Tucson, Arizona, 1969.

9. U.S.G.S. Groundwater in Gila River Basin and Adjacent Areas, Arizona, 1952.

10. U.S.G.S. Water Supply Report, Duncan Basin Greenlee County, 1952.

SECTION II

Editor's Note

Section II of this report projecting the costs of environmental services are based on estimates from 1970. Because of the high inflationary pressures over the past four years and the increasingly higher interest rates the original estimates must be projected upward. Current estimates from a qualified engineer would be necessary to accurately determine the costs of a project.

CHAPTER I. ENVIRONMENTAL SERVICES ESTIMATED COSTS

It is the responsibility of municipal officials faced with the need for environmental services to know how much suggested installations should cost. Actual project costs do not become available until plans and specifications have been completed and approved, bids for construction work, materials and equipment received, and contracts let. Yet there is need for preliminary concepts of what the eventual cost will be long before finalization steps have been taken. In short, there is need for valid "measuring sticks" or guidelines which will supply preliminary cost estimates for projects.

There is no substitute for actual cost information, but costs estimates play an important role in the preliminary stages of environmental services planning, despite the fact that decisions often must be based on needs within a community or the availability of funds. While the size of a project may be firmly established by the population to be served or regulatory requirements, knowledge of what the project may cost will be of great value:

–Cost estimates may dictate whether construction should be phased out in stages rather than on a single project basis.

–Cost estimates may ascertain the future period for which capacity will be provided or for which actual construction will be scheduled on a long-range plan.

–Cost estimates can help municipal and county officials develop planning for rational long-range financing.

–Cost estimates can serve as a guide in judging the validity of competitive bids.

–Cost estimates can help guide bond issue referenda and assure investors in such bonds of the stability of the offerings.

These examples of the serviceability of construction cost estimates point up the responsibility in establishing guidelines. They demonstrate the need for using cost statistics of known validity in offering cost estimating guidelines and for clear interpretation of such data in terms of their limitations as well as their proven values. It should be noted the above examples can also serve as warnings in that estimates are no more than estimates; that the estimates must be used by persons versed in their application; that estimates are no substitute for actual cost experiences by public officials; and that estimates cannot and do not reflect total project costs.

The cost data found in the succeeding sections do not cover certain important items in the overall cost of the actual completion of a constructed project. Non-covered items include administrative, engineering, financing and other services, and land costs. These factors should be kept in mind during review of the following costs data.

SEWERAGE AND SEWAGE TREATMENT PROJECTS

The difference between sewerage and sewage treatment plant projects is best illustrated by a comparison of the percentage breakdown of their four major components of construction – material, labor, contractor's plant, and overhead and profit – as shown in TABLE I-1.

TABLE I-1

MAJOR COMPONENTS OF CONSTRUCTION FOR SEWAGE TREATMENT PLANTS AND SEWERS (1970)

Item	Material	Labor	Contractors Plants	and Profit
Sewage Treatment Plants	54.49	25.33	6.45	13.73
Sewers	35.42	18.48	31.30	14.70

Source : U. S. Department of Interior, Federal Water Pollution Control Administration.

The costs estimates for sewer lines installed in trenches (TABLE I-2) includes (a) excavation, (b) cost of pipe, (c) placing and joining of the pipe, and (d) backfilling of the trench. Sheeting and shoring, gravel foundation cradle or encasement of pipe and surface restoration are excluded. The ranges of costs depicted are based on construction cost indexes for July, 1972. It should be understood that the range of prices indicated here are influenced further by the size of the project and the inplace soil characteristics. Definite economics of scale result with larger sewer projects.

TABLE I-2

ESTIMATED AVERAGE UNIT COSTS FOR CONSTRUCTION OF SEWAGE COLLECTION LINES - 1970 (For Illustrative Purposes)

Vitrified Clay Pipe		Asbestos Cement Pipe	
Diameter, inches	Cost/foot	Diameter, inches	Cost/foot
8	$3.87 - $4.82	8	$3.98 - $4.86
10	$6.36 - $7.95	10	$5.23 - $6.54
12	$8.49 - $10.63	12	$6.66 - $8.32
15	$12.78 - $16.02	15	$9.83 - $12.31

Source: Project Staff Estimates.

Consideration should also be given to the type of pipe to be used in a project. Factors such as life expectancy, durability, unit weight, strength and ease of assembly, and inclusion of service connections all influence final cost figures in sewerage projects.

Costs for wastewater treatment facilities are primarily based on the degree of treatment which may be required by regulatory agencies. As the degree of treatment moves from primary to secondary to tertiary, the costs increase correspondingly (FIGURE I-1). 1,8/

Generalized costs for basic wastewater treatment processes are presented in TABLE I-3. The costs for wastewater treatment facilities are also influenced by economies of scale. The possibilities of areas joining together in regionally organized waste treatment projects can be advantageous for communities in proximity to each other. Economies of scale through consolidation of waste sources and the resulting cost advantages are exemplified in FIGURE I-2. 2/

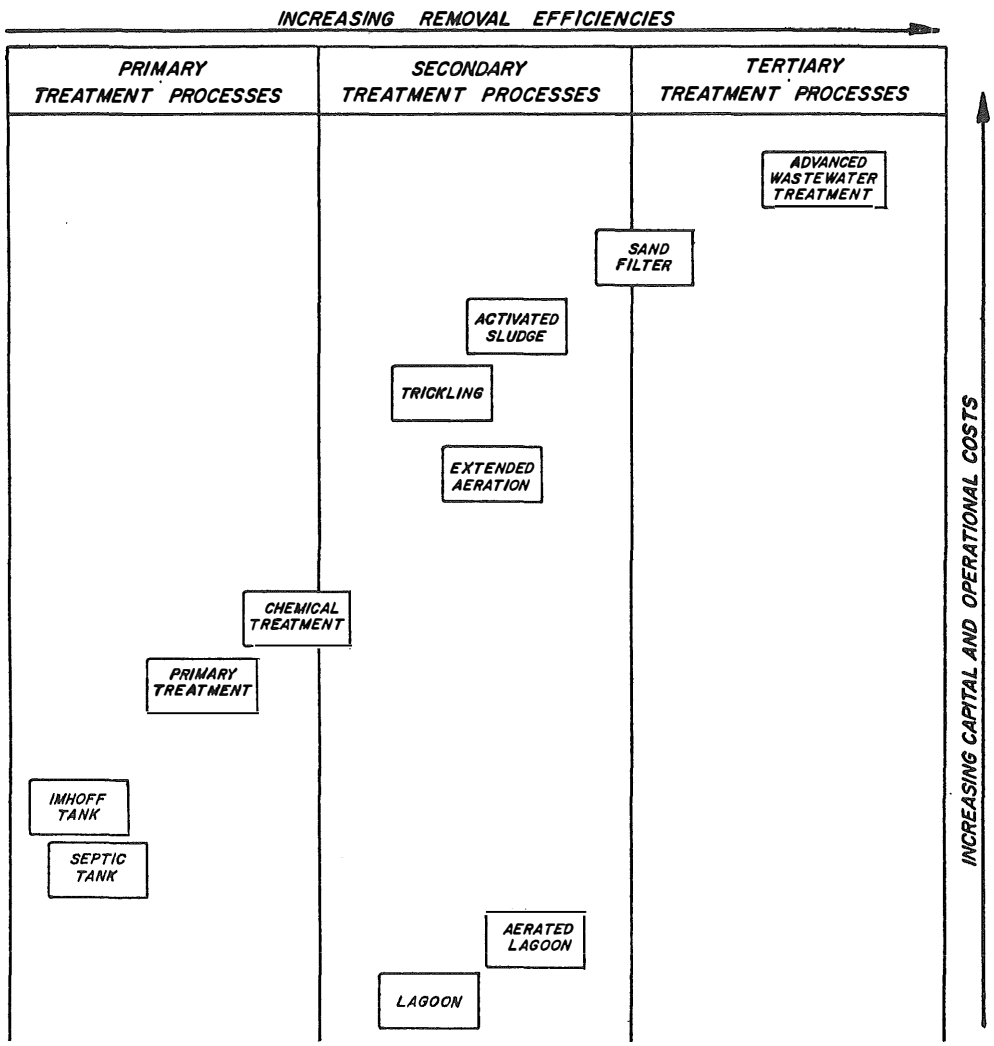


FIGURE I-1. GENERALIZED RANKING OF UNIT COST AND REMOVAL EFFICIENCIES OF CONVENTIONAL WASTE TREATMENT PROCESS.

TABLE I-3

GENERALIZED COST TO SIZE RELATIONSHIPS OF BASIC WASTE TREATMENT PROCESSES

	Million Gallons Per Day Capacity				
	.01	.10	1.0	10.0	100.0
	Construction Cost, $1000*				
Primary		58.7	308.6	1,247.7	6,559.0
Primary, Separate Sludge Digestion		85.2	305.1	1,092.2	3,084.0
Activated Sludge	11.7	70.8	417.3	2,458.9	14,487.6
Trickling Filter		101.8	288.9	1,374.4	5,045.2
Lagoons	6.2	23.4	88.0	330.3	1,080.0
	Annual Operating and Maintenance Charges,$1000's**				
Primary		4.5	19.7		
Primary, Separate Sludge Digestion		5.5	20.6		
Activated Sludge		6.3	31.3	172.3	
Trickling Filter		5.1	18.3	83.3	
Lagoons	0.1	0.6	3.0		

*Source: Modern Sewage Treatment Plants, How Much Do They Cost and Sewage Treatment Plant Cost Index for June 1969.

**Source: R. L. Michels, et al "Operation and Maintenance of Municipal Waste Treatment Plants," Journal of the Water Pollution Control Federation, March 1969. 1962-64 dollars raised to 1968-1969 conditions by use of BLS Craftsmen's median earning, 1968 + craftsmen's median earnings, 1963 x table value.

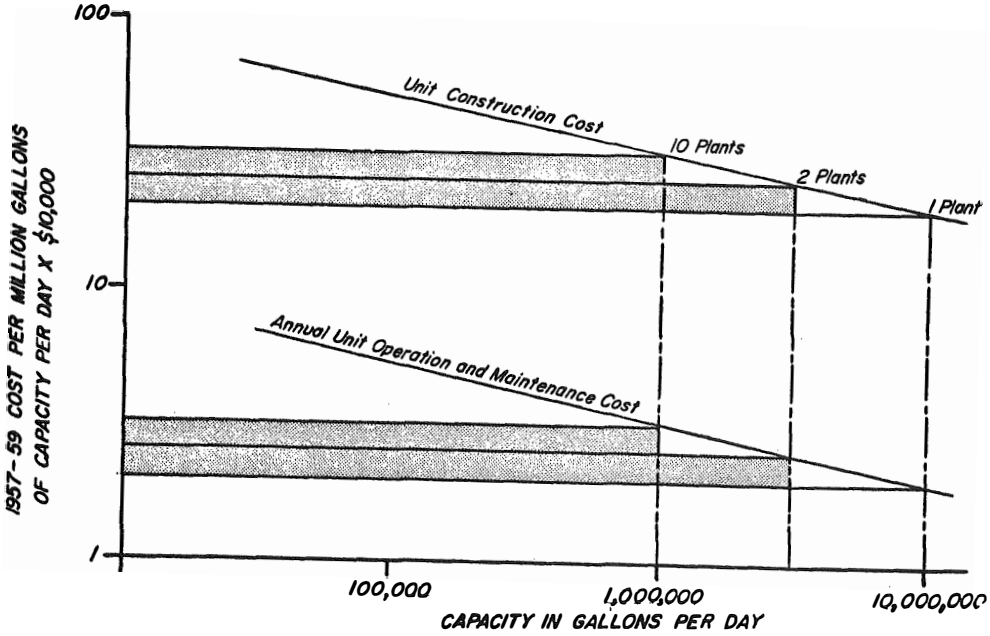


FIGURE I-2. APPLICATION OF ECONOMIES OF SCALE THROUGH CONSOLIDATION OF WASTE SOURCES PRODUCING 10 MILLION GALLONS PER DAY OF SEWAGE'.

WATER SUPPLY AND DISTRIBUTION SYSTEMS

Predicting costs for capital improvements in water systems is difficult, in part because of the variety of equipment and techniques utilized in providing domestic water. Water chemistry and bacteriologic quality of a raw water source also influence total costs related to development of a water supply. Bacteriologic quality of a public water system must adhere to rigid criteria for the public welfare.

The means by which water quality standards are approached is dependent upon the initial characteristics of the water to be used in a water distribution system. These inherent characteristics establish the basic capital costs for water treatment facilities. For well water meeting chemical criteria, captial outlay generally involves pumping equipment, pressure tanks and reservoirs, etc., with provisions for protection against bacteriologic contamination in the system. The larger the distribution system, the more sophisticated chlorination equipment becomes as well as the construction cost.

Well systems have basic operational costs in power consumption for pumps utilized in the system. FIGURE I-3 gives a generalized presentation of pumping costs versus depth to water on the supply end of a system. 3 /

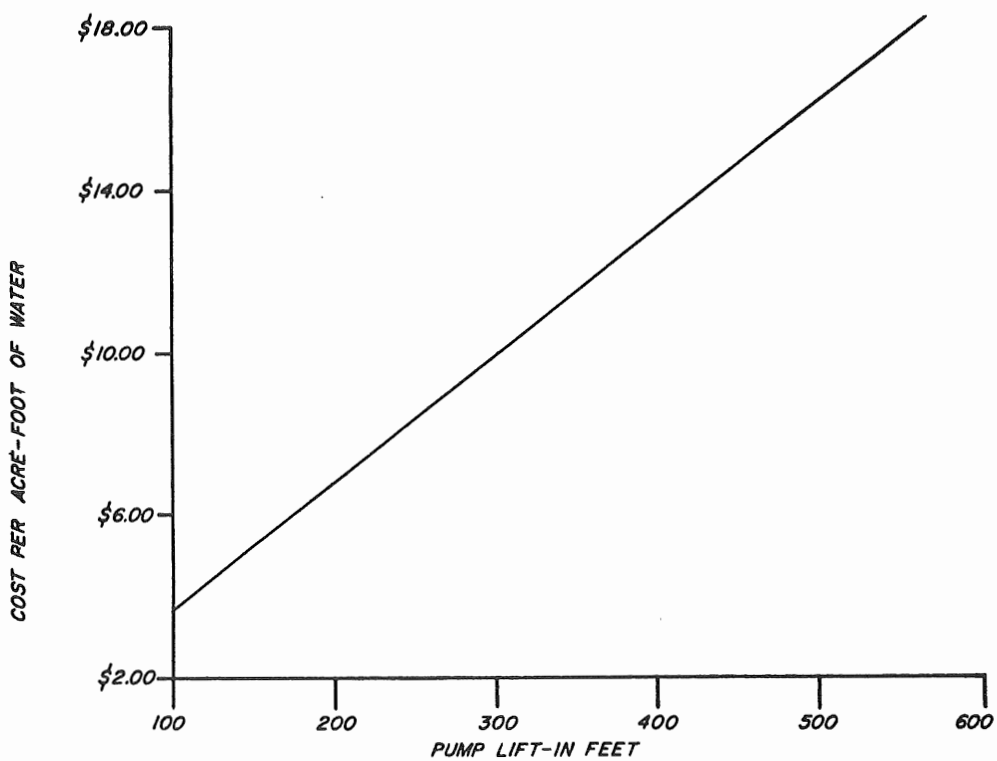


FIGURE I-3. RELATIONSHIP BETWEEN LIFT AND COST PER ACRE-FOOT OF GROUNDWATER PUMPED.

Another major consideration for costs in water systems development is the amortization of equipment to be used. These costs will be reflected in water service rates, particularly if a community is served by a private utility corporation.

The cost of water treatment by coagulation and sedimentation followed by rapid sand filtration for thirty water treatment plants across the country are noted in TABLES I-4 & 5. 9/The costs presented are the result of comparative cost engineering audits made in 1965. (The term "cost engineering audit" means a detailed investigation and analysis of the physical characteristics, the operating data, and the costs of a plant or other operating installation and the presentation of these in a standardized manner so that internal and external comparisons can be made.)

TABLE I-4

WATER TREATMENT PLANT DESIGN FACTORS

Plant No.	Design Capability (Qd) mgd	Year Of Last Major Addition To Plant	Mixing Basin Detention min	Flocculation Basin Detention min	Sedimentation Basin or Clarifier: Detention min	Surface Loading gpm/sq ft	Average Transport Rate fpm	Clarifier Loading gpm/sq ft	Basins Housed or Covered **	Filters Rate gpm/sq ft	Filters Housed or Covered **	Design Manpower man-hr/mg	Days 32° and Below days/year
1	6.00	1959	1.3	30	391	0.651	0.102		o	1.70	o	3.1	11
2	9.00	1953	5.0	30	240	0.313	0.430		o	1.65	½o	9.8	17
3	8.00	1950	0.6	40	283	0.333	0.588		o	1.85	½o	6.6	48
4	6.00	1952	-	65	288	0.366	0.327		o	2.00	h	10.0	33
5	0.500	1953	Ml‡	51	305	0.329	0.199		o	1.93	h	48.0	81
6	0.500	1951	Ml‡	52	346	0.386	0.221		o	1.93	h	48.0	63
7	0.500	1950	10.0	43	315	0.273	0.144		o	1.72	h	48.0	63
8	0.500	1939	with floc	20	240	0.345	0.184		o	1.93	h	48.0	80
9	6.00	1957	-	57	447	0.225	0.278		o		h	4.0	37
10	0.300	1962	with floc	18	220	0.284	0.251		o	1.64	h	15.0	85
12	12.00	1958	-	17†	206† 81†#	0.290# #	0.580		o	3.31	h	2.53	94
13	4.00	1946	Ml‡	10	212	0.495	1.16		o	1.96	h	7.5	100
14	0.432	1947	†	†	67†	†		1.59	h	1.85	h	23.1	148
15	12.00	1960	†	†	102†	†	0.161†	1.10	h	1.87	h	5.1	144
17	12.00	1961	with floc‡	23	202	0.778	0.448 0.262†		c	1.54	h	9.6	144
18	0.300	1948	†	†	47†	†	0.262	2.19	h	0.075	c	12.0	144
19	8.00	1946	1.6	33	125	0.702	0.925 0.127		o	1.93	½c	7.9	144
21	7.50	1955	0.7	51	335	0.321			o	1.94	o	6.8	11
22	6.81*	1955	†	†	102†	†	0.800†	1.18	o	2.00*	c	5.0	65
23	0.576	1938	-	7	327	0.177	0.566 0.352		o	1.94	h	42.0	65
24	0.504	1930	Ml	22	249	0.326			o	1.82	h	47.0	83
25	0.504	1937	Ml	20	283	0.298	0.340		o	1.82	h	48.0	73
26	0.500	1965	†	†	229†	†	0.092†	0.491	o	1.62	h	28.0	70
27	0.486	1948	1.1	142	6960	0.011	0.033		o	3.00*	h	18.0	70
28	1.00	1964	†	†	280†	†	0.161† 0.427	0.354	o	1.49	o	26.6	66
29	8.00	1958	2.4	39	261	0.457			o	1.95	o	7.9	59
30	6.81*	1955	0.18		102		0.80		o	2.00*	c	5.0	65

*Based on an arbitrary design filter rate as shown.
†Suspended solids contact clarifer.
‡Ml signifies mixing basins detention could not be computed because mixing is done in the line. "With floc" indicates mixing basin not separated from floculation basin and floculation detention includes both.
#This plant operates sedimentation basins and a clarifer in parallel. Data applicable to the clarifier are shown in the right hand column. Certain dimensions of the Clarifier were not available.
**Housed, covered, open.
SOURCE: After 9/

The data illustrated in TABLE I-5 can give a general idea of the costs associated with the different operational functions of a water treatment facility.

TABLE I-5

WATER TREATMENT PLANT COSTS

	Investment, ¢/gpd of Qd		Labor			Energy			Chemicals, ¢/lb							
									Coag.		Alkali		Dis-infect.	Taste and Odor		
Plant No.	Adjusted to 1964	Deregion-alized and Adjusted to 1964	Super-visor, $/hr	Operator and Maint. $/hr	General Labor, $/hr	Elec. ¢/KWH	Oil (for heat) ¢/gal	Gas (for heat ¢/Kcf	Alum	Iron Sulfate	Hy-drated Line Equiv.	Type	Cl	Carbon	$KMnO_4$	$NaClO_2$
1	15.1	16.6	3.64	2.05	1.54	0.92	-	-	2.76	2.60	0.88	h	4.9	9.6	36	
2	-	-	3.99	2.01	1.17	0.77	-	-	2.61	1.81	1.20	h	6.5	-		
3	16.0	17.3	3.72	1.79	1.19	1.71	-	33.3	2.51	-	0.78	q	6.5	-		
4	34.5*	37.3	3.14	2.05	1.24	1.00	-	-	2.43	-	1.19	h	9.6	12.5		
5	-	-	1.91	1.62	-	1.40	-	-	3.40	-	2.90	s	8.7	-		
6	32.2*	32.2	-	1.24	-	1.40	-	-	3.78	-	0.33	h	9.0	-		
7	48.6	48.6	-	1.63	-	1.00	-	-	3.55	-	1.50	h	9.0	-		
8	39.0	42.2	-	1.55	-	2.00	-	-	4.92	-	1.65	h	12.7	-		
9	-	-	2.31	2.26	-	1.04	-	-	2.48	-	1.50	h	4.7	-		
10	65.3	63.7	-	2.03	-	2.00	-	-	4.10	-	3.33	s	13.0	12.0		
12	5.6	5.5	5.50	3.38	-	1.00	-	-	4.79	-	4.55	c	3.7	-	32	
13	10.4	10.1	3.03	2.84	-	1.30	-	-	2.58	-	1.10	h	7.0	10.0		
14	54.9	47.0	2.70	1.83	-	1.90	15	-				none	17.5	-		
15	18.0*	17.7	11.10‡	3.19	-	0.77	9.6	705#	2.56	-	-	none	5.4	-		
17			4.70	2.84	2.23	0.69	10.5		2.68	-	-	none	7.9	-		70
18	30.1	29.5	3.08	2.62	2.15	2.00	16.9		4.1	-	-	none	12.5	-		
19	14.0	13.7	3.32	3.05		0.91	9.9		2.37	-	-	none	5.6	11.6		70
21	12.5	24.6	4.47 =	3.14	2.07	0.89		76		2.60	0.54	q	4.9	7.5	40	
22	12.5	13.7	1.91	1.70	-	0.70	-		2.92	-	1.27	h	8.2	14.7		
23	-	-	1.93	1.93	-	1.33	-	-	3.25	-	1.70	h	13.5	12.2		
24	21.8	23.8	1.51	1.38	-	-	-	-	4.10	-	3.80	s	12.5	-		
25	29.0	30.0	-	1.55	-	-	-	-			-	h		-		
26	28.4	31.0	-	1.72	-	1.20	-	-	4.00	-	3.50	h	13.5	-		
27	37.6	41.2	-	1.72	-	1.20	-	-	4.00	-	3.50	h	13.5	-		
28	24.8	27.1	1.93	1.70	1.54	1.04	-	30	3.35	-	0.80	h	13.5	-		
29	20.7	22.6	3.74	2.18	1.92	0.91		47	2.34	-	1.23	h	4.8	13.6		
30			1.91	1.70	-	0.70	-	-	2.92	-	1.27	h	8.2	14.7		

*The cost of a pipeline of length to constitute and appreciable fraction of plant plus pipeline cost was estimated from author's data and removed from total cost.

†A raw water pump station exists but costs for it were not obtainable. Quantity shown is for cost of plant plus pump station estimated.

‡Plant at present operating without a supervisor, but this role is filled by a consultant. The rate shown is the consultant's rate.

#Plant uses LPG and price is per liquid cubic foot.

SOURCE: After 91

SOLID WASTE MANAGEMENT

One of the most popular means for control of solid wastes is the sanitary landfill. Other forms of processing or disposal are, incineration, composting, salvage and reclamation and open burning. Land filling and salvage operations appear the best suited operations for environmental control and service to small communities.

Sanitary landfills have the advantages of being inexpensive and applicable to a wide variety of terrain. Land requirements are the only limiting factor for use of this form of disposal. Sanitary landfills have relatively low capital outlay and cost of operation and are traditionally accepted by the public. They are adaptable and flexible to accept a wide variety of wastes of varying composition and amount with no pretreatment required.

The cost of a sanitary landfill consists of the initial investment for land, equipment, and construction features, and the operating costs.

The magnitude of the initial investment depends on the size and sophistication of the landfill. A typical breakdown of the major items that normally constitute the initial investment is as follows:

1. LAND

2. PLANNING AND DESIGNING

    a. Consultant
    b. Solid Wastes Survey
    c. Site investigation
    d. Design, plans, & specifications

3. SITE DEVELOPMENT

    a. Land development – clearing, landscaping, drainage features, etc.
    b. Access roads
    c. Utilities – water, electricity, telephone
    d. Fencing, signs

4. FACILITIES

    a. Administration
    b. Equipment maintenance
    c. Sanitation
    d. Weight scales

5. EQUIPMENT – TRACTOR, SCRAPER, ETC.

Generally, the major portion of the initial investment is for the purchase of the land and equipment. Often a sizable part of the initial investment for land and equipment can be recovered through the development or use of the land and the salvage value of the equipment or recycling of waste materials such as metals and glass.

If funds are not available for the proposed investment, consideration should be given to leasing land or equipment, or both, to spread the cost over the life of operation.

The operating cost of a sanitary landfill depends on the cost of labor and equipment, the method of depreciation, and the efficiency of the operation. The principal items in operating cost are:

1. PERSONNEL

2. EQUIPMENT

    a. Operating expenses – gas, oil, etc.
    b. Maintenance and repair
    c. Rental, depreciation, or amortization

3. COVER MATERIAL – MATERIAL AND HAUL COSTS

4. ADMINISTRATION AND OVERHEAD

5. MISCELLANEOUS TOOLS, UTILITIES, INSURANCE, MAINTENANCE TO ROADS, FENCES, FACILITIES, DRAINAGE FEATURES, ETC.

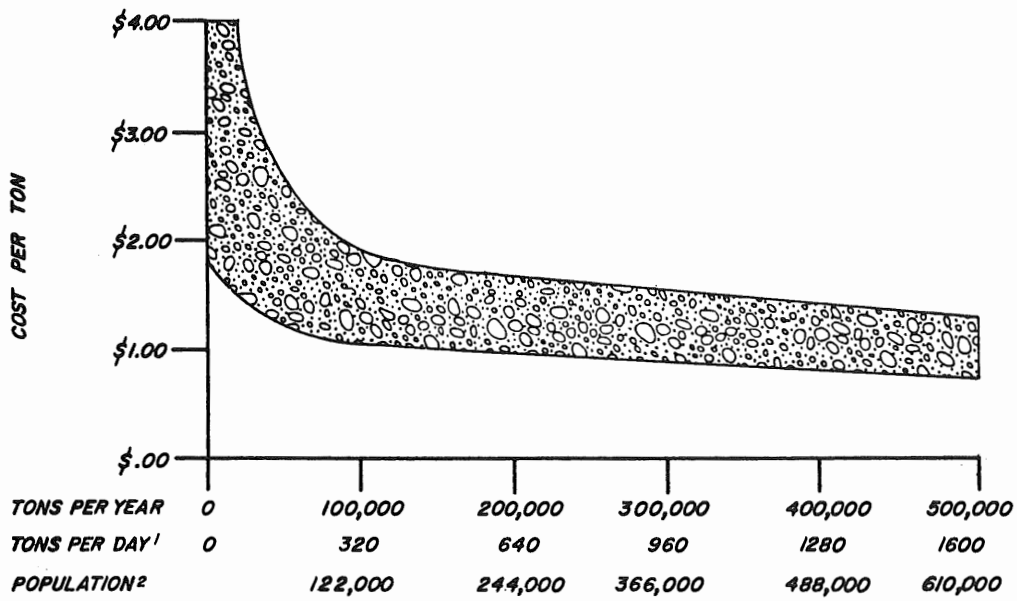
Wages ordinarily make up about 40 to 50 percent of the total operating cost. Equipment equals 30 to 40 percent; cover material, administration, overhead, and miscellaneous amount to about 20 percent.

Operating costs per ton versus the amount of solid wastes handled in tons and the population equivalent may be charted (FIGURE I-4). Operating costs for a small sanitary landfill handling less than 50,000 tons per year varies from $1.25 to approximately $5.00 per ton. This wide range is primarily due to the low efficiency of the smaller operations which are usually operated on a part-time basis.

Full-time personnel, full-time use of equipment, specialized equipment, better management, and other factors that lead to high efficiency are possible at large sanitary landfill operations. The increased efficiency results in lower unit cost of disposal. The unit cost of a large landfill handling more than 50,000 tons per year will generally fall between $1.25 to $2.00 per ton.

To compare the true cost of sanitary landfilling with that of incineration or composting, it is essential that the costs and returns of the initial investments and the hauling costs of a collection system that uses the sanitary landfill disposal method may be higher than the hauling costs of a system using incineration or composting, since sanitary landfills are generally located farther from the waste-generating area than are incinerators or compost

plants. A sanitary landfill, however, may increase the value of a plot of unusable land by converting the site to a playground, golf course, park..., thereby obtaining a major investment cost advantage over incineration and composting.



[1] Based on 6-day work week

[2] Based on national average of 4.5 lbs. per person per calender day

FIGURE I-4. SANITARY LANDFILL OPERATING COSTS

CHAPTER II. FINANCING ENVIRONMENTAL SERVICES

INTRODUCTION

The intent of this chapter is to acquaint community officials with the different means available for financing environmental services systems. The descriptions are meant only as references and not as a substitute for either the opinions of city and county attorneys, the advice of qualified federal program specialists or bond council.

Local communities have found it necessary to construct improve and expand their water and sewer systems, sewage treatment facilities, and solid waste disposal facilities. However, due to the growing complexities of municipal and county finance, careful examination must be made of the various sources of funding to insure that each dollar is spent cost effectively.

BONDING

Cities and towns often find it necessary to incur a large debt to finance capital improvements, i.e., water and sewage facilities. The state has authorized incorporated cities and towns to issue various kinds of bonds to finance this debt. There are a number of bond types which can be used for financing capital improvements for environmental systems. Examples are: general obligation bonds, revenue bonds and special improvement bonds.

General Obligation Bonds

The most common method of bonding for municipal purposes is the general obligation bond. These bonds are retired from revenues generated from property taxes, which are part of the municipalities general revenue sources. These bonds are often referred to as "full faith and credit" bonds because they are guaranteed by the taxing authority of the issuing governmental unit.

Because these bonds are backed by the taxing powers of the issuing governmental body and are based on municipal revenues for retirement, the local government is limited to the amount of debt incurred and the interest rate paid. The Arizona Revised Statutes (ARS) allow a maximum interest rate of nine percent per annum. Also, the amount of debt incurred with general obligation bonds cannot exceed four percent of the total assessed valuation of the taxable property.5/

This type of bonding is generally not encouraged for water and waste disposal projects. The debt limit as defined by the Arizona Revised Statutes is often very low for small communities. This type of bonding is usually reserved for other types of capital expenditures which cannot be financed by other forms of bonding or federal assistance.

Communities may find that mixing general obligation bonds with revenue bonds can be advantageous in marketing the bonds and acquiring federal backing. This is a decision which is dependent upon the bond market, current interest rate and the community's financial planning.

Revenue Bonds

Revenue bonds are used to finance revenue generating facilities. This form of bond is secured by the revenues of the facilities for which they were issued. If these revenues are not sufficient to repay the bonds, the related governmental unit is not obligated to provide tax revenues for the repayment. Because these bonds are not secured by the taxing power of the government, they usually bear a higher interest rate than general obligation bonds.

A lower interest rate may be achieved through the assistance of federal insurance and support. The Federal Government (in the case of rural areas the Farmers Home Administration) will buy issues which cannot be sold at a reasonable rate of interest. These issuing communities must meet specific conditions to qualify for support, one of which is that the project will reduce the user costs for required services to a level equal to the average of the surrounding communities.

Issuance of revenue bonds are authorized for specific purposes, including electric, water, gas, transportation waste disposal systems, and airport and off-street parking facilities. Revenue bonds do not have to meet the debt limitation required for general obligation bonds. They do have to meet the following statutory requirements; they must be approved by a majority of the voters in a referendum; they must mature within thirty years of the date of issue; they may not bear an interest rate over nine percent and may not be sold for less than par. 6 /

Special Improvement Bonds

Special improvement bonds are issued to finance capital improvemetns on projects such as streets and sewers. The bonds are secured by assessments levied against the properties which are receiving benefits by the improvements. 6 /

SPECIAL DISTRICTS

Special Improvement Districts

There are two types of special districts which may be formed to finance environmental improvements. The first is the Special Improvement District. This type of district is formed by the County Board of Supervisors for a defined geographic area and for special functions. The creation of a special improvement district is easy and straightforward, however, each district has its own set of required procedures for initiation. 7/ To determine what functions each special district may perform and the required procedures for delineation, a review of the appropriate statutes and legal precedent should be carried out.

Special Assessment Improvement District

The second type of special district is the special assessment district. This is the common method of financing required capital improvements, especially for small areas. 7 /The basic premise of this type of district is that the individual properties receiving the primary benefits of the improvement should pay for the improvement. An improvement district may be formed by a city or town council by its own initiative or by petition of the local property owners.

FEDERAL GRANTS AND LOAN PROGRAMS

The Federal Government has a multitude of programs for assisting local governments in financing public facilities. There are five federal agencies which make monies available specifically for water systems and waste disposal facilities.

Rural communities with a population of up to 5,500 are eligible to receive federal assistance from the U.S. Department of Agriculture, the Farmers Home Administration (FHA). FHA provides assistance in the form of loans and grants and technical assistance to rural communities, nonprofit organizations, new towns, and under special conditions, responsible land developers. Eligibility and grant approval is on an individual project basis within the guidelines established by the administrating agency. (See TABLE II-1.)

Communities in excess of 5,500 population must apply to HUD for federal community services assistance. Also included under HUD's jurisdiction are councils of government, counties, special districts, state and nonprofit organizations serving urban communities.

To encourage the expansion and development of a designated areas' economy, the Economic Development Administration (EDA) of the Department of Commerce also provides grants and loans for water and waste disposal facilities. To qualify, a state, county or community must be designated an economic redevelopment district or area. In certain cases, these EDA grants can be used to supplement other federal grant-in-aid programs which may be received by the applicant.

The Environmental Protection Agency (EPA) provides grants for the development of solid waste disposal projects which demonstrate new techniques of disposal or recycling. At the present time, Arizona does not have a state agency designated to administer this program nor a statewide solid waste disposal plan. The EPA also administers grants for the construction of sewage treatment facilities and outfalls which are needed to prevent inadequately treated sewage from being discharged into the environment.

TABLE II-1 provides an overall outline of the federal programs available to assist rural communities in procuring the basic environmental services facilities required by their residents.

TABLE II-1

MAJOR FEDERAL AID PROGRAMS UTILIZED FOR PROVIDING ENVIRONMENTAL SERVICES*

Program Title	Authorizing Legislation	Administering Agency	Program Description
Rural Water & Waste Disposal Assistance	Consolidated Farmers Home Administration	Farmers Home Admin., U.S. Dept. of Agri. Andrew J. Mayberry Rm.6026, Federal Bldg.,230 N. 1st Ave., Phoenix Arizona 85025	Loans, grants & technical assistance are made available to towns under 5,500 population or profit & non-profit organizations for the engineering, construction, repair or expansion of domestic water, sewage treatment & solid waste disposal facilities.
Public Works Planning Advances	Section 701 Housing Act	Community Resources Develop. Admin., Dept. of Housing & Urban Development 2500 Wilshire Blvd. Los Angeles California 90056	Interest-free advances are to states, municipalities & other public bodies to aid in financing the engineering & architectural design work which is preliminary to the construction of a public works project.
Advance Acquisition of Land	Section 704 Housing & Urban Dev. Act	Community Resources Dev. Admin., Dept. of Housing & Urban Dev., 2500 Wilshire Blvd., Los Angeles California 90056	Grants for interest charges on funds borrowed to provide for the propitious acquisition of land needed up to five years in advance of public works projects.

TABLE II-1 (Continued)

Program Title	Authorizing Legislation	Administering Agency	Program Description
Public Works & Econ. Dev. Facilities	Public Law 89-136 Title II	Economic Dev. Admin., Dept. of Commerce 522 N. Central Phoenix, Arizona 85025	Grants up to 50% of project costs & loans up to 100% of land acquisition & improvements for public works and service facilities to encourage industrial or economic expansion. Only projects designated "redevelopment areas" eligible.
Basic Water & Sewer Facilities Grants	Section 702 Housing & Urban Dev.	Community Resources Dev. Admin., Dept. of Housing & Urban Development 2500 Wilshire Blvd. Los Angeles, Calif. 90056	Direct grants up to 50% of the cost of land & construction are made to assist communities in the construction of basic water & sewer facilities, excluding sewage treatment, necessary to improvement of health and living standards.
Public Facility Loans	Title II Housing Admendments of 1955	Community Resources Dev. Admin., Dept. of Housing & Urban Development 2500 Wilshire Blvd. Los Angeles California 90056	Long-term, low interest loans are made to finance local public works projects where credit is not otherwise available on reasonable terms.

TABLE II-1 (Continued)

Program Title	Authorizing Legislation	Administering Agency	Program Description
Grants for Waste Treatment Works Construction	Section 8, FWPC Act 33 U.S.C. 466 et seq	Environmental Protection Agency c/o Ariz. State Dept. of Health, Water Supply and Water Pollution Control Div. Bob Follett 4019 N. 33rd Ave. Phoenix, Arizona	Grants are made to states & municipalities to assist in the construction of waste treatment works, including outfall & Interceptor sewers, which are needed to prevent discharge of inadequately treated sewage.
Solid Waste Disposal	Solid Waste Disposal Act	Bureau of Solid Waste Management, Environmental Protection Agency 100 California St. San Francisco California 94101	State and local agencies may receive grant support for demonstrations relating to the application of new or improved methods of solid waste collection, storage, processing & ultimate disposal.
Grants & Loans Waste Treatment Works, Solid Wastes Planning, Pollution Abatement, Planning Grants Water Improvements	Rural Development Act of 1972	Farmers Home Administration	Grants and loans made to rural communities for essential environmental services.

REFERENCES

1. U.S. Department of Interior, FWPCA, The Economics of Clean Water - Vol. I, April 1970.

2. Shah, K.L. and G.W. Reed. "Technique for estimating Construction Costs of Waste Treatment Plants," Water Pollution Control Federation Journal, May, 1970.

3. Nelson, A.G. and Busch, C.D., Cost of Pumping Irrigation Water in Central Arizona, University of Arizona, Technical Bulletin 182, April 1967.

4. U.S. Department of Health, Education and Welfare, Public Health Service Environmental Health Bureau of Solid Waste Management, Sanitary Landfill Facts, Publication 1792, Second Edition, 1970.

5. Constitution of Arizona, Article IX, Sec. 8 and ARS 35-451 through 475.

6. Arizona Revised Statutes 9-521 through 9-540.

7. Arizona Revised Statutes 9-692 and 9-731.

8. "Cost of Conventional and Advanced Treatment of Wastewater," Smith, R. Water Pollution Control Federation Journal, September 1968.

9. "The Cost of Water Treatment by Coagulation Sedimentation and Rapid Sand Filtration." Koenig, L. American Water Works Association Journal, March 1967.

SECTION III

CHAPTER I. POPULATION PROJECTIONS METHODOLOGY

In this study, population projections are presented for the county and all well-defined communities with less than 5,500 residents. In general, county projections are easier to make, and wider choice of method is available than for communities. A lengthy time series is available for Arizona county populations and these data are sufficient to lend themselves to several different approaches for population projections. Community data, however, are quite often difficult to find, and this limitation constrains the choice of projected population methods that can be utilized. For these reasons, different methodological approaches are used for the county and the community level.

COUNTY POPULATION PROJECTIONS

The method used to project county population growth was based on a ratio of the county population to the state total. The method is explained below with Graham County used as an example.

TABLE I-1

GRAHAM COUNTY POPULATION PROJECTION

Year	Arizona Population	Graham County Population	County as a % of State	Annual Average Rate of Growth
1950	749,857	12,985	1.73	-4.6
1960	1,306,161	14,045	1.08	-1.48
1970	1,777,482	16,578	0.93	-0.98
1975	2,081,500	18,525	0.89	-0.48
1980	2,381,500	21,195	0.89	-0.15
1990	3,108,500	27,355	0.88	

Table I-1 shows the data used to project Graham County's population. The first row shows the population of the state and below that is the population of Graham County. The third row shows Graham County's population as a percent of the state's and the fourth row shows at what rate that ratio has declined over time. For instance in 1950 Graham County had 1.73 percent of the state's population and by 1960 it had only 1.08 percent.

Over the ten-year period, Graham County's share of the total state population declined at an average annual rate of -4.82 percent per year. Likewise, the rate of decline of the county's share of state population between 1960 and 1970 was -1.48 percent per year. That is, the ratio of the county's population of the state still declined, but not as fast as it did from 1950 to 1960. The projected annual average rate of growth of the ratio between 1970 and 1975 is -0.98 percent per year and seems to be in line with the past trend. If the ratio between 1970 and 1975 does decline at this annual rate (-0.98 percent per year) then in 1975 Graham County will contain 0.89 percent of the state's population as seen in row three, column four. That percent is then applied to the projected state population for 1975 to get a county projection for that year of 18,525. (The state population projection has previously been made by the U.S. Bureau of Census.) The same method is then used to project the county's population for 1980 and 1990. One final refinement is then made. After each county's population was projected in the above manner, the projections were forced (proportionally increased or decreased) to sum to the projected total for the state.

COMMUNITY POPULATION PROJECTIONS

Small Arizona communities for which good population time series are available seem to be the exception rather than the rule. Payson, for instance, is one of the communities under study in Gila County and a Payson population projection is required. However, no census population data have ever appeared for that particular community, thus eliminating the use of the ratio method in projecting Payson's population. Other communities, for which good historical data are available, have demonstrated wide population swings in past years and there often appear to be no close relationships between the community population and the county. Once again, the ratio method is inappropriate.

The method that has been chosen for community population projections is based upon annual average growth rates. Where a good community time series is available, the annual average rate of growth over the previous twenty years is calculated. If there are no apparent factors that are expected to cause the community to deviate from that rate, then the population is simply extrapolated into the future using the historical rate. If dynamic factors are apparent that can cause a significant deviation from past trends, then the judgment of the researcher is required to anticipate the magnitude and direction of these changes. There is no "formula" available to accomplish this, and often times local knowledge, plans and judgment are the most important factors in the projection. Judgment is usually preferable to a strict adherence to a rigid methodology.

Judgment also plays an important role in projecting population for a community such as Payson. Where no officially documented current population data are available, estimates by local sources (banks, utilities, post offices, etc.) are used as a base. If no past trends are available to indicate future growth, then judgment is again called for and potential growth rate that seems appropriate for the community must be selected and extrapolated to the future. Again this rate is based upon knowledge of local resources and plans for development.

Rates of growth based upon the above method are designated the medium projection and are thought to be the most probable. But, since a high degree of error is possible, a projection range is desirable. By reviewing the historical growth of a cross section of

small Arizona towns, it appears that the growth rate for a short period (ten years, for instance) may deviate by as much as two percentage points from the long-term growth rate. Thus a community may have increased in population at an annual rate of growth of four percent per year over a thirty-year period. But in one particular decade of that period it may have increased as little as two percent per year or as much as six percent. This range of plus or minus two percent could, then, be taken as the high and low projections for the community and the probability should be quite high that the actual future population will fall somewhere in that range. The problem is that by ranging the high and low projections by plus or minus two percent from the median rate, the resultant projections are so wide as to be practically meaningless. An alternative range was therefore chosen.

The majority of the small communities in the state have not exhibited deviations significantly greater than plus or minus one percentage point in terms of the annual average rate of growth. The exceptions are those that annexed large numbers of persons in a particular decade and those that either gained or lost population due to dramatic changes in employment opportunities. But, it is felt that these types of dramatic population changes cannot be accurately incorporated into a twenty year projection. Therefore, the range of plus or minus one percent is utilized herein.

CHAPTER II. EMPLOYMENT PROJECTION METHODOLOGY

In this study an employment projection has been prepared for the county on an industry by industry basis for 1990. The projection of total employment in Greenlee County is related to the 1990 median population and labor force projections. The labor force is projected as a percentage of the population. In 1970 the labor force participation rate was 48.7 percent mainly due to heightened construction activity at the mines. Eliminating this block of employment leaves a participation rate approximating 43 percent. A participation rate of 41.2 percent was used for the 1990 projections.

The percent of the population which might be unemployed was applied to the projected civilian work force to obtain an estimate of unemployment. A 3.0 percent unemployment rate was used which assumes full employment in the economy. This results in a projection of 4,825 total employment in Greenlee County in 1990.

The distribution of employment among the broad industry groups is based primarily on the 1968 through 1970 trends of employment data by industry and the 1950 - 1968 labor earnings distributions. However, knowledge of local plans and conditions and the judgment of the analyst have been used to modify statistical trends.

The finance, insurance, real estate, transportation, communication and public utilities industries, government, and agriculture reflect a reasonably stabile employment to population ratio; therefore, the ratio is projected forward with some confidence. In the case of trades and services, the absolute increase obtained through the approach is modified to provide what is believed to be a reasonable estimate in the judgment of the researchers as related to changes occurring in the economic structure.

In the remaining sectors, mining, manufacturing, contract construction, and dynamic factors are apparent from industry analysis which are certain to cause significant deviation from 1968-70 employment trends. Both mining and manufacturing were increased significantly to reflect expected increases at the Metcalf and Morenci mines, mills and smelters. The proportion of employment in contract construction was decreased to make allowances for the present work at Metcalf and Morenci.

CHAPTER III. PROJECTION METHODOLOGIES FOR WATER SUPPLY DEMANDS AND SEWAGE PRODUCTION LEVELS

GENERAL DISCUSSION

Good management and design of water-supply and wastewater treatment systems demand a knowledge of the volumes and flows involved and their relation to population and time. An idea of water demands is obtained by review of past and current rates of water use stated in terms such as gallons per day per capita or gallons per day and month, etc. The per capita and related figures generalize the experience and are, therefore, useful in comparing the use records of different communities and in estimating future needs of individual communities and areas (county).

The quantities of water delivered in North American Communities tend towards values shown in TABLE II - 1, but with wide variations, because of differences in (1) climate, (2) standards of living, (3) extent of sewerage, (4) type of commercial and industrial activity, (5) cost of water, (6) chemical quality of water, (7) distribution system pressures, and (8) irrigation practices.

TABLE III-1

NORMAL WATER CONSUMPTION

	Quantity, gpcd*	
Class of Consumption	Normal Range	Average
Domestic	15-70	50
Commercial & Industrial	10-100	65
Public	5-20	10
Water Unaccounted for	10-40	25
TOTAL	40-230	150

*Gallons per capita per day.

Source: Fair, G.M.; D.A. Okun, Water and Wastewater Engineering, Volume 1, Water Supply and Wastewater Removal, 1966, John Wiley and Sons.

The "normal range" of variations noted in TABLE I - 1 are complicated, with respect to projecting future needs, in that water use practices of people over time have been increasing. 1,2 /

Concomitant to water use will be the production of sewage wastes. These wastes are disposed of by some form of individual facility or, if available, in a sewage collection system. The quantities of wastewaters produced are related to the factors stated above with the exception of irrigation practices. Sewage flows are usually 60 to 70 percent of domestic water use rates and sometimes greater where sewage collection systems are relatively new and moderate climates prevail. 3,4 /

SPECIFIC PROCEDURES

Future water demands for small rural communities were based on review and analysis of current and past water use data obtained through public works directors or private water utilities. Data obtained for long periods of time were considered as most reliable, while, in some cases, where limited amounts of data were available, generalizations had to be made. Water use for a years time and the variations for the time of year were tabulated. From this information, each month of the year was quantified as a percentage of the maximum month of water use which in all cases occurred during the summer. From these monthly percentages an average was obtained for the year's average monthly use which for most areas surveyed, was in the range of 60 to 80 percent of the maximum month.

From the maximum and minimum month consumption data, which corresponds basically to the summer and winter periods of the year respectively, per capita water consumption rates were calculated. These figures were calculated for each year in which past data were available. Those communities with long series of data, i.e., 10 years, indicated an increasing trend in per capita water use. In some cases where a definable industrial sector of economic activity was present, the increasing trends for domestic water use were, in a sense, overshadowed by the industrial water use rates. For example, the community of Fredonia, Arizona has an industrial classed water user which demands 1,600,000 gallons of water per month while residential classed users demand an average of 18,500 gallons per month.

Considering the increasing trends exhibited by the rural communities under study and information derived from a limited literature review, an assumption of increasing per capita water use amounting to an average of two (2) gallons per capita per year was used in this report.

Although there are definite possibilities of variation in this figure, depending on the local situations, it was felt that for rural areas with populations less than 5,000, two (2) gallons per capita per year is indicative.

Determination of present per capita water use rates and the expansion of these rates to the years 1975, 1980 and 1990; and then multiplying by the population projections for the area results in projected water needs for the respective years above.

Determination of county needs for the years 1975, 1980 and 1990 were obtained by averaging the per capita summer and winter demands for all areas of development in the county. In Coconino County for example, water use rates for the community of Flagstaff were included in the determination of present average county per capita water uses. These figures were again expanded by use of the two (2) gallons per capita per year and multiplied by the residual population figures determined by subtracting from the projected total population figures for the county, the population of selected communities outlined individually. A summation was then carried out to arrive at a total county demand estimate for water supply capabilities. These figures were developed in terms of total yearly water needs in acre-feet.

Sewage production rates levels were assumed proportionate to the domestic water use rates. Sewage flows during winter within an individual community were estimated as being 70 to 75 percent of the water used. Summer sewage flows were estimated at 60 - 65 percent of the water used in the community. 4 / The lower percentage during summer months is indicative of more fresh water used for irrigation and cooling purposes which would correspondingly decrease the contribution to sewage flows by residents of an area.

CHAPTER IV. PROJECTION METHODOLOGY FOR SOLID WASTES PRODUCTION LEVELS

GENERAL DISCUSSION

The measurement of rates of solid wastes production for rural areas in Arizona have never been attempted. Some studies have been prepared for the major metropolitan areas of Arizona on solid waste disposal problems and rates of production. Smaller urban areas and rural communities in Arizona have not been a part of any form of study related to defining disposal problems and techniques or actual rates of waste production.

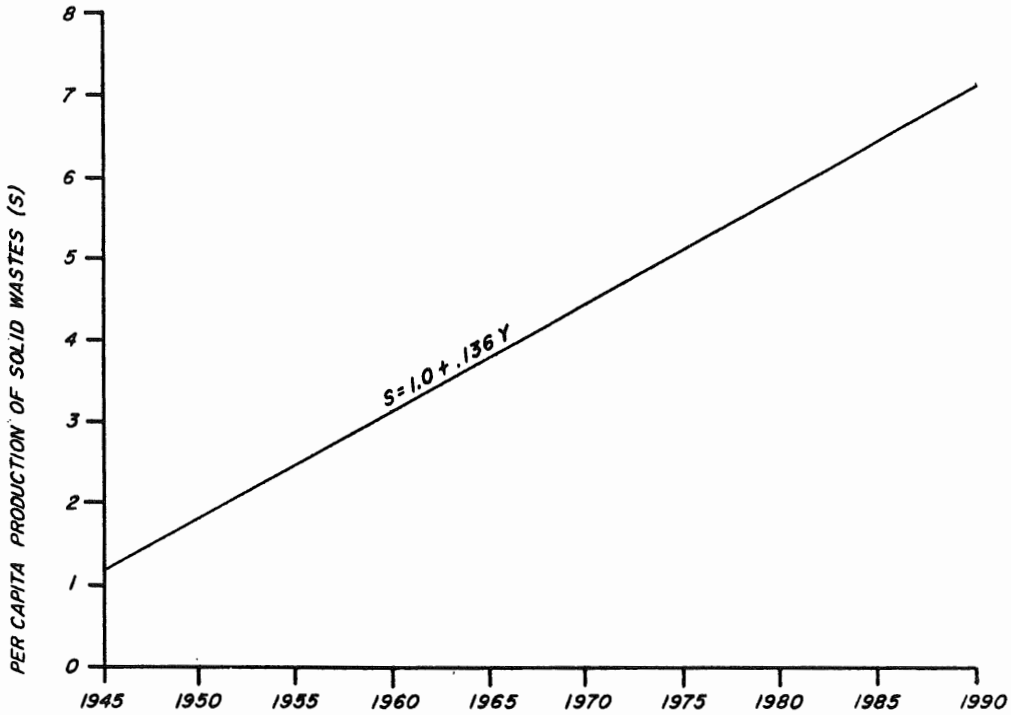
Generally solid wastes are defined as those materials that are solid or semi-solid consisting of refuse, garbage and rubbish. Solid wastes and by-products related to their breakdown constitute one of the forms of environmental pollution that is growing at an alarming rate. It is estimated that per capita quantities of garbage produced in the 1970's will increase 50 percent and that by the 1980's production is estimated to double. 5.6 /

SPECIFIC PROCEDURES

As no valid indicators of solid waste production levels were available with which to quantify levels of production, a literature review was undertaken to develop per capita solid waste production figures. Articles and publications were reviewed which made some reference to rural areas or small communities. Waste production levels on a per capita basis were used to develop an equation which would give an idea of the future solid waste production levels and the anticipated increasing trends.

FIGURE IV - 1 depicts the increase of per capita solid wastes production levels according to the equation indicated which was obtained from regression analysis of data for the 23-year period from 1946 to 1968.

Production levels in tons per year outlined for individual communities and county totals were obtained by multiplying population figures by the per capita production levels obtained from FIGURE IV - 1 for the respective projection years.



S = Solid wastes production, lbs. per capita per day

Y = (A - 1945)

A = Year for which "S" is to be determined from 1946 thru 1990

FIGURE IV-1. PER CAPITA SOLID WASTES PRODUCTION LEVELS FROM 1946 TO 1968 AND PROJECTIONS TO 1990.

Source: Reference 5 through 21.

REFERENCES

1. Proges, R. "Factors in Per Capita Water Consumption," Water and Sewage Works, Sept., 1958.

2. Anon "Present and Future Estimates of Water Consumption," Public Works, Dec., 1956.

3. Fair, G.M.; J.C. Geyer and D.A. Okun, Water and Wastewater Engineering, Volume 1. Water Supply and Wastewater Removal, 1966, John Wiley and Sons.

4. Sewage Treatment Plant Design, American Society of Civil Engineers, Manual of Practice No. 36, 1959.

5. Restoring the Quality of Our Environment, Report of the Environmental Pollution Panel Presidents Science Advisory Committee - 1965.

6. Future Solid Waste Accumulation, Report by the U.S. Department of the Interior, Bureau of Mines, Washington, D.C., 1968.

7. Anon "Plastics Pose a Solid Waste Disposal Problem," Environmental Science and Technology, 2:89, February 1968.

8. Anon "Per Capita Figure of 5.1 pounds of Matter Daily Indicated By National Survey," Solid Wastes Management - Refuse Removal Journal, 11:14, March 1968.

9. Eliot, G.F. "Garbage is a Nasty Word....But" Reprint - Suburbia Today, May 1961.

10. Mix, S.A. "Solid Wastes: Every Day Another 800 Million Pounds," Todays Health, p. 46, March 1966.

11. Anon "Refuse Quantities and Characteristics," In, Municipal Refuse Collection and Disposal, pp. 6-10, Issued by Office for Local Government, New York State Executive Department, 1964.

12. Rogus, C.A. "Refuse Collection and Refuse Characteristics," Public Works, 97:96, March 1966.

13. Kunsch, W.M. "Planned Refuse Vehicle Replacement: Better Service, Lower Maintenance," Public Works, 95:105, March 1964.

14. Hayden, I.L. "Incinerator Model Convinces Public," Public Works, 95:94, July 1964.

15. Gruenwald, A. and J.A. Reynolds, "Less than $3,000 Per Ton," The American City, 80:99, October 1965.

16. Kaiser, E.R., I. Halitsky, M.E. Jacobs, and L.C. McCabe, "Performance of a Flue Fed Incinerator," Air Pollution Control Association Journal, 9:85, February 1959.

17. Cohn, Morris M., "Effect of Food Wastes on Sewers and Sewage Treatment," Sewage Works Journal, 18:477, 1946.

18. Status of Solid Waste Management in California, California State Department of Public Health - 1970.

19. A Program Plan for Solid Waste Management in California, California State Department of Public Health - 1970.

20. Weaver, L. "Refuse and Litter Control in Recreation Areas," Public Works, 98:4, April 1967.

21. Munich, A.J., A.J. Klee, P.W. Britton, Preliminary Data Analysis; 1968 National Survey of Community Solid Waste Practices. Public Health Service Publication No. 1867, 1968.

STATE OF ARIZONA

OFFICE OF ECONOMIC PLANNING AND DEVELOPMENT

ACTING EXECUTIVE DIRECTOR
William F. Kane

DIRECTOR OF PLANNING DIVISION
Harry F. Higgins

ASSOCIATE DIRECTOR OF PLANNING DIVISION
Dennis N. Thompson

STUDY DIRECTOR
Jeffrey K. Kracht, P.E.

STUDY STAFF
Perry L. Wiseman
Diana L. Kenney
Judith Storms
Vicki Schuckert
Ron Ross