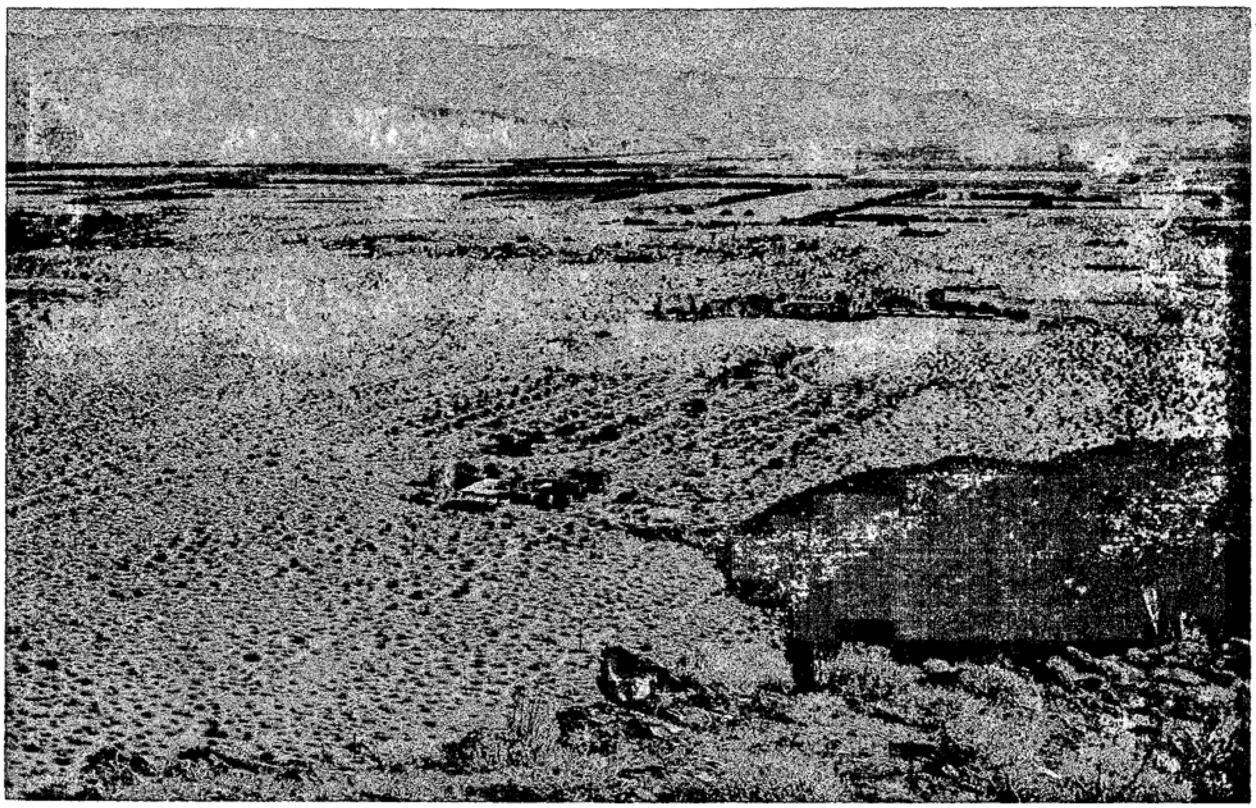
BORREGO VALLEY
WATER MANAGEMENT PLAN



State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Southern District

June 1984

#6

BORREGO VALLEY WATER MANAGEMENT PLAN

Copies of this report at $3 each may be ordered from:

State of California
DEPARTMENT OF WATER RESOURCES
P. O. Box 6598
Los Angeles, CA 90055

Make checks payable to DEPARTMENT OF WATER RESOURCES. California residents add sales tax.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Southern District

June 1984

FIGURES

Page

1 Study Area 3
2 Historic and Projected Population of Borrego Valley 8
3 Borrego Valley Water Use in 1980 9
4 Conceptual Ground Water Recharge Structure (Typical) 34
5 Plan A: Multipond Recharge Facility 35
6 Plan B: Tandem Pond Recharge Facility 36
7 Potential Recharge Sites 39

TABLES

1 Agricultural Land Use in Borrego Valley in 1980 5
2 Historic Population of Borrego Valley 6
3 Population Projections 7
4 Borrego Valley Applied Water Use 8
5 Historic Agricultural Water Use 10
6 Agricultural Water Use in 1980 11
7 Recreational and Landscape Demand 12
8 Future Agricultural Water Use Scenarios 13
9 Projected Municipal Water Demand in Borrego Valley 14
10 Borrego Valley Future Applied Water Demand With Declining Agriculture 14
11 Borrego Valley Future Consumptive Water Use With Declining Agriculture 15
12 Borrego Valley Future Consumptive Water Use With Level Agricultural Activity 16
13 U. S. Environmental Protection Agency Recommended Water Quality Limit on Constituents of Interest in Borrego Valley 18
14 Chemical Analyses of Water from Wells and Streams Collected in 1980 20
15 Project Conveyance Facilities 25
16 Estimated Cost of Development Plans 26
17 Updated Estimated Construction Cost of Development Plans 27
18 Updated Estimated Operation, Maintenance and Replacement + Power Costs of Development Plans 28
19 Updated Costs for Projects to Import Water to Borrego Valley 29
20 Reduction in Demand Through Conservation in Borrego Valley 32
21 Potential Storage in Recharge Ponds 37
22 Estimated Streamflow 38

COVER PHOTO: Looking northeast across Borrego Valley toward the Santa Rosa Mountains. In the foreground is Borrego Palm Canyon Campground. Farmland can be seen in the distance.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SOUTHERN DISTRICT

Jack J. Coe, Ph.D. . . . . Chief, Southern District

This report was prepared under
the direction of

Robert Y. D. Chun . . . . Chief, Planning Branch

by

Kiyoshi Mido* . . . . Chief, Plannned Utilization Section

Assisted by

Harry Iwanaga . . . . Associate Geologist
Peter Louie, Ph.D. . . . . Associate Engineer, W. R.
Kenneth K. Hatai** . . . . Assistant Engineer, W. R.
Phyllis J. Yates . . . . Research Writer
Susie M. Ramirez . . . . Editorial Aid
Maria D. Zamora . . . . Word Processing Technician
Dean Wilson . . . . Senior Delineator
Carl Brockman . . . . Office Assistant II (Typing)

*Retired in November 1983.
**Transferred to Department of Transportation in August 1983.

CONVERSION FACTORS

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit By	To Convert to Metric Unit Multiply Customary Unit By
Length	millimetres (mm)	inches (in)	0.03937	25.4
	centimetres (cm) for snow depth	inches (in)	0.3937	2.54
	metres (m)	feet (ft)	3.2808	0.3048
	kilometres (km)	miles (mi)	0.62139	1.6093
Area	square millimetres (mm^2)	square inches (in^2)	0.00155	645.16
	square metres (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometres (km^2)	square miles (mi^2)	0.3861	2.590
Volume	litres (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons (10^6 gal)	0.26417	3.7854
	cubic metres (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic metres (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekametres (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic metres per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	litres per minute (L/min)	gallons per minute (gal/min)	0.26417	3.7854
	litres per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekametres per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lb)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	metres per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.33456	2.989
Specific Capacity	litres per minute per metre drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per litre (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimetre (uS/cm)	micromhos per centimetre	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8 × °C)+32	(°F−32)/1.8

FOREWORD

In an area with sparse rainfall, such as the Borrego Valley of San Diego County, managing its water resources in a prudent and wise manner is especially important if the area is to prosper.

Recognizing this fact, San Diego County entered into a cooperative agreement with the Department of Water Resources to conduct the study reported here.

From the study, the Department has concluded that Borrego Valley can increase its available water supply if it institutes a water management plan consisting of conservation, reclamation, and use of small recharge ponds to capture and store more of its runoff water following the infrequent rains.

In the conduct of this study, the Department wishes to thank, in particular, the U. S. Geological Survey, Borrego Water District, and DiGiorgio Company for their generous contribution of time and knowledge.

Jack J. Coe, Chief
Southern District

TABLE OF CONTENTS

	Page
I. INTRODUCTION	1
Objective of Investigation	1
Scope and Conduct of Investigation	2
Area of Study	2
II. LAND USE, POPULATION, AND WATER DEMAND	5
Land Use	5
Agriculture	5
Urban and Domestic	5
Population	6
Past and Present Water Uses	7
Municipal Water Use	9
Agricultural Water Use	10
Recreational Water Use	10
Uncultivated Vegetation Water Use	11
Future Water Demands	12
III. WATER SUPPLY	17
Ground Water	17
Geology	17
Ground Water Levels	17
Amount of Water in Storage	17
Average Annual Recharge	18
Ground Water Quality	18
Reclaimed Water	19
IV. COMPONENTS OF WATER MANAGEMENT AND SELECTED PLAN	23
Construction of Dams	23
Importation of Water	23
Water Conservation	28
Irrigation Water Conservation	28
Urban Water Demand and Conservation	30
Water Reclamation	31
Increasing Ground Water Recharge	33
Varying Amount of Ground Water Used	40
Varying Pumping Patterns	40
Selected Water Management Plan	41
V. SUMMARY AND RECOMMENDATIONS	43
REFERENCES	45

I. INTRODUCTION

The Borrego Valley is located in the northeastern portion of San Diego County. It lies along the base of the eastern slope of the Coastal Range of mountains as they descend into the Colorado Desert. The valley is approximately 85 miles northeast of the City of San Diego and is separated from it and the developed coastal area of San Diego County by the Coastal Range. It is approximately 30 miles west of the Salton Sea and is separated from the Salton Sea and the rest of the Imperial Valley by a low range of highly eroded hills known as the Borrego Badlands.

Borrego Valley had little development before World War II because of poor access by road and lack of electricity. Development of both commerical agriculture and residential home sites began shortly after the war when the DiGiorgio Fruit Company obtained electricity and telephone service and improved roads for the valley so that commercial agricultural operations could begin.

The primary commercial crop was grapes. Other commercial crops were asparagus, cotton, flowers, and citrus. Agricultural uses reached their peak in 1958, at which time they used an estimated 22,500 acre-feet of water per year, or about 96 percent of the valley's consumption. The DiGiorgio Company withdrew from agricultural operations shortly after that, and agricultural uses in the valley declined rapidly.

Concurrently, substantial residential subdivision activity took place beginning in 1947 and lasting into the 1960s. This produced approximately 3,000 subdivided lots, of which about 75 percent remain vacant. Residential development is scattered across all the subdivided lots along the western edge of the valley, but is concentrated at the northern end of the valley at the DeAnza Country Club and in the central portion at the Roadrunner Mobile Home Park.

In the mid-1970s renewed interest in large-scale residential development brought reactivation of a 1,000-acre project known as the Borrego Country Club and development of a new resort community known as Rams Hill Country Club on 3,000 acres along the south slopes of the valley. This led to questions about the adequacy of the area's water supply, principally ground water, to handle the expected growth.

Thus, the County of San Diego requested the United States Geological Survey (USGS) to make a geohydrologic study. USGS concluded its study in 1982 and published "Water Resources of Borrego Valley and Vicinity, California Phase I--Definition of Geologic and Hydrologic Characteristics of Basin", USGS Open-file Report 82-855.

Also, the Department of Water Resources (DWR) and the County of San Diego entered into a cooperative agreement to undertake a 30-month study to develop a water management plan for Borrego Valley. That investigation has been completed. Water management information developed in the investigation is presented in this report.

Objective of Investigation

The objective of this investigation, as

stated in the cooperative agreement, is to develop a water management plan, based on indepth studies of significant parameters of the valley water resources.

Scope and Conduct of Investigation

The work performed by DWR under this agreement included:

A. Evaluation of available data to establish the advisability of developing a ground water model. In conjunction with this evaluation, DWR made an assessment of the state of the art of ground water basin modeling.

B. Evaluation of existing and future water supplies, water demand, and land use. Water supply estimates were based on historic periods of record; for projections, the period covered was 1980 to 2000.

C. Assessment of the opportunities for recharging the ground water basin with local runoff.

D. Assessment of the opportunities for using reclaimed water and evaluating the impact on the area's water quality.

E. Formulation of preliminary alternative water management plans in cooperation with the County, local agencies, and USGS.

F. Coordination with the USGS in compiling, collecting, and evaluating hydrologic data for use in the analysis of the alternative water management plans.

G. Assessment of the potential impact of water conservation practices on the water demand.

H. Evaluation of the various water management plans with operational, economic, institutional, and environmental considerations.

I. Review and selection of water management plans in coordination with participants and local agencies.

J. Preparation of technical information records on: (1) annual recharge to Borrego Valley Ground Water Basin, (2) historical and projected water demands, (3) cost of imported water supplies, (4) opportunities for recharging Borrego Valley Ground Water Basin with local runoff, and (5) future operations of the ground water basin. Reports referred to are listed in the appendix.

Area of Study

The main investigation area is Borrego Valley and Clark Valley (Figure 1). In addition, areas outside the main investigation area, such as Coyote Canyon, San Felipe Valley, and Earthquake Valley, in particular, and the watershed in general, were considered to the extent necessary to assess the contribution of water from these areas into the main study area.

Borrego Valley and Clark Valley together cover about 100,000 acres. The study area is accessible from the east and west by Highways S22 and 78. The valley floor, which constitutes much of the study area, is an enclave of privately owned land surrounded by the Anza-Borrego Desert State Park.

Borrego Valley is bordered by the Santa Rosa Mountains on the north and the San Ysidro Mountains on the west. The east boundary is drawn through the Borrego Badlands and the Borrego Mountains. Clark Valley, north of and contiguous to Borrego Valley, lies between the Santa Rosa Mountains on the north and Coyote Hills on the south.

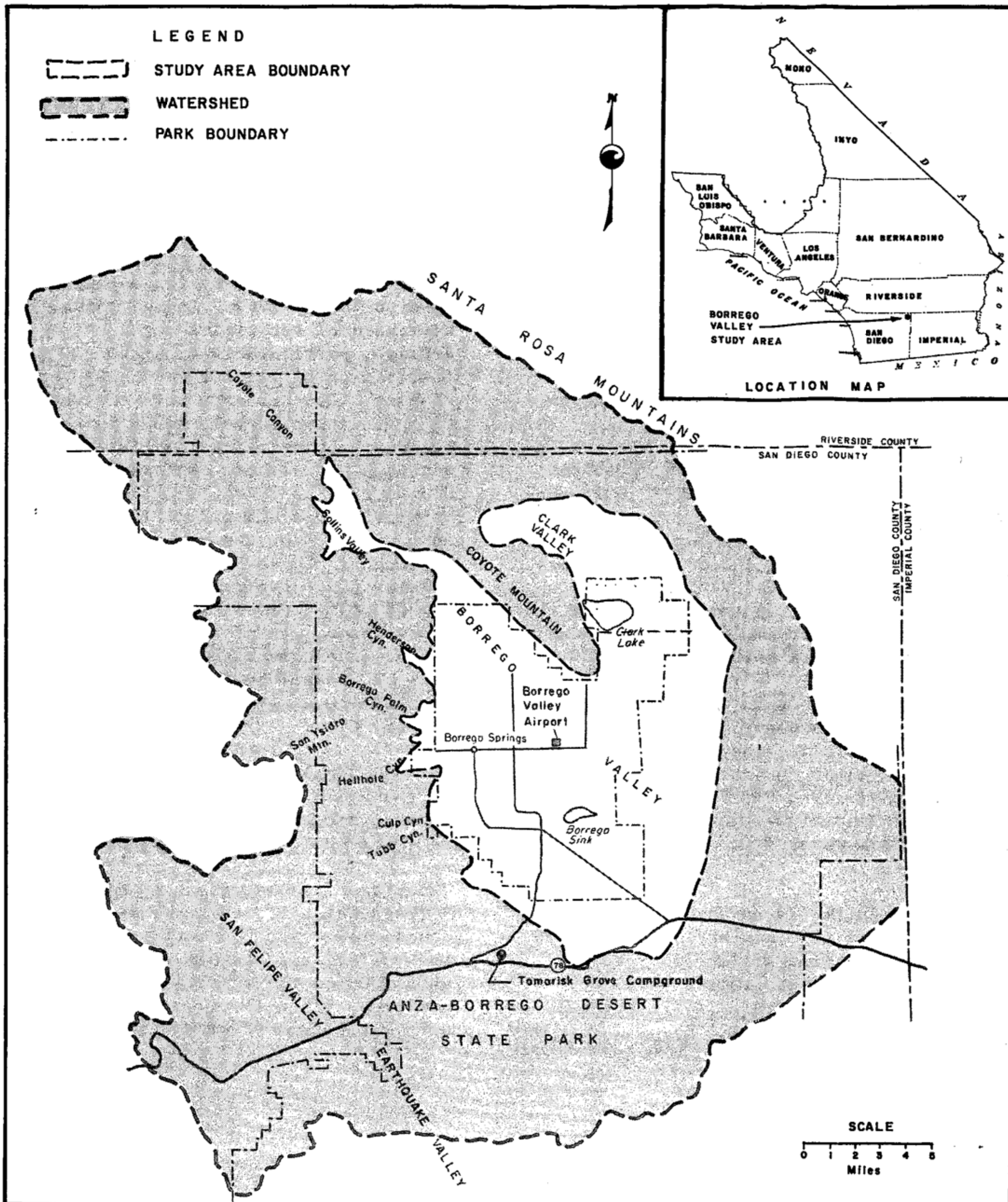


Figure 1 – STUDY AREA

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1984

Borrego Valley comprises 70,000 acres and is about 16 miles long, northwest-southeast, and about 8 miles wide, northeast to southwest. Clark Valley comprises 30,000 acres and is about 8 miles long, northwest to southeast, by 4 miles wide, northeast to southwest. The watershed to Borrego Valley encompasses 398,000 acres and the watershed to Clark Valley, 91,000 acres.

The San Ysidro Mountains, which rise to 6,100 feet on the west side of Borrego Valley, are incised by several large canyons that serve as avenues for most of the runoff to Borrego Valley. The main canyons are Coyote Canyon, Henderson Canyon, Borrego Palm Canyon, Hellhole Canyon, and Tubb Canyon.

Coyote Canyon at the northwest end of Borrego Valley, comprising 95,000 acres of watershed, is the major drainage system into Borrego Valley. The upper canyon has perennial flow and supports abundant plant life, but downstream, the stream flows intermittently and the scene changes to a desert environment as it approaches Borrego Valley.

Two major geographic features in the study area, Borrego Sink and Clark Lake, are playas; they are the surface drainage sumps for runoff in Borrego Valley and Clark Valley, respectively. However, during wet periods, surface and ground water flow out of the valleys.

Borrego Valley is an area of hot summers and mild winters. Based on 20 years of records at Borrego Springs Station 3 North-Northeast (NNE), the average temperature is 70°F; extremes ranged from 19°F to 121°F.

The mean annual precipitation, based on 20 years of records at Borrego Springs Station 3NNE, is 3.37 inches and at Ocotillo Wells Station, based on 21 years of record, is 2.9 inches.

Precipitation in the mountainous watershed is considerably higher, up to 16 inches annually.

As recently as 1940, Borrego Valley was a farm community with a population of 36. In the 1950s, agricultural activity increased and the population rose to 780 by 1960. In the 1960s, agricultural activities began a decline, particularly with the termination of farming by the DiGiorgio Company. Concurrently with the decline in agricultural development, residential subdivision activity began, although actual home construction was slow until the 1970s. In 1970, the population was 828 and in 1980, 1,405, according to the Census. By 1980, Roadrunner Mobile Home Park and DeAnza Country Club development, both centered around golf courses, had been constructed. In addition, two large resort developments have recently been started or approved by the County: Rams Hill Country Club and Borrego Country Club.

Borrego Springs is the only settlement in the study area, although, at other points, accommodations for tourists and retirees have also been built.

Water agencies serving the valley are Borrego Water District, whose boundaries cover the eastern half of the valley, and Borrego Water Company, which serves the western half. In addition, agricultural needs are met with water from privately operated wells.

II. LAND USE, POPULATION, AND WATER DEMAND

Three significant land use components determine water use: agriculture; recreational facilities (golf courses), knd urban developments. Although agricultural acreage has declined substantially since the 1950s, agriculture still constitutes the largest water user. Next in magnitude in terms of water use are the golf courses that use more than four times as much as do urban purposes. The municipal water use is less than 450 acre-feet a year. In addition, the native vegetation surrounding the Borrego Sink uses about 1,200 acre-feet per year.

Land Use

Historically, Borrego Valley has been an agricultural community. But, beginning in the 1960's, the valley has changed gradually to an accumulation of farms, retirement communities, resorts, and large family homes.

Agriculture

Irrigated acreage increased from a few hundred acres in the mid-1940s to a peak of 5,000 acres in 1958. Thereafter, the irrigated acres declined until, in 1965, only about 2,000 acres were being irrigated.

Today there are still approximately 2,000 acres irrigated. Findings in a USGS survey of agricultural water use in 1980 are shown in Table 1.

Whether irrigated acreage will remain at its current level, decline or increase is unpredictable. Currently, because of the increasingly popular use of drip and trickle irrigation systems that conserve water and reduce operating costs, agriculture may be rebounding but is not expected to return to the scale of 1958. The overall operational cost (pumping water, harvesting crops, and shipping) and marketing condition and not just the cost of the water supply will determine the direction that agriculture will take in the future.

Urban and Domestic

About the time that irrigated agriculture was diminishing in the 1960s, interest in Borrego Valley as a retirement and resort area began to grow. The DeAnza Country Club

TABLE 1
AGRICULTURAL LAND USE
IN BORREGO VALLEY IN 1980*
In acres

Crop	Irrigated acres
Citrus	940
Grass (pasture)	425
Alfalfa	140
Tomatoes (hot house)	10
Tree farm**	390
Grapes (abandoned)	655
Date palm (abandoned)	40
Total	2,600

*From W. R. Moyle, Jr., "Water Resources of Borrego Valley and Vicinity, California: Phase 1 - Definition of Geologic and Hydrologic Characteristics of Basin," USGS Open-file Report 82-855, November 1982.

**Predominantly palm trees, but also include other ornamental trees such as olive.

development and the Roadrunner Mobile Home Park, both of which feature residential use around a golf course, were begun in the 1960s and 1970s. The latest large development proposals that have been approved are a revised plan for the Borrego Country Club, a defunct 1960 project which is east of Borrego Springs, and the Rams Hill Country Club, several miles southeast of Borrego Springs.

The Borrego Country Club, which was first developed in the 1960s, was centered on a golf course. The project was only partially constructed when the developer withdrew. The new specific plan approved by the County proposes a community that would ultimately comprise 835 residential units, a 210-unit hotel and three golf courses. The golf courses would consist of two 18-hole courses and one 9-hole course with areas of 78, 51, and 46 acres, respectively.

The Rams Hills Country Club project proposes an ultimate development of 1,585 residential units and a 350-room resort hotel. Already constructed are a medical clinic, an 18-hole 160-acre golf course, a waste water treatment plant, and approximately 50 residential units.

Population

The permanent population in the study area mainly comprises retirees and persons involved in ranching, tourism, and other service occupations. There are substantial seasonal increases in population, especially in November to May. There is also a spillover of tourists from the surrounding Anza-Borrego Desert State Park, which is renowned for its native Colorado Desert scenery.

Historic population data, which were obtained from various sources, are given in Table 2. A reason for the discrepancy between the 1980 population figures obtained by the Census Bureau and USGS is the likelihood that many seasonal residents were absent from the valley during the period the census was conducted or they do not regard it as their primary place of residence. The USGS figure was based on an examination of the local telephone directory and a survey of local schools. Because

TABLE 2
HISTORIC POPULATION OF BORREGO VALLEY

Year	USGS	PRC Toups**	U. S. Census
1940	--	36	--
1950	--	350	--
1960	--	780	780
1970	--	838	828
1979	--	1,620	--
1980	2,131*	--	1,405

*Moyle, W. R., Jr., "Water Resources of Borrego Valley and Vicinity, California," United States Geological Survey, Open-file Report 82-855, p. 21.

**PRC Toups, "Borrego Water District Latent Powers Authorization," Focused Environmental Impact Report, November 1979, p. 29.

domestic water use represents less than 5 percent of the total water use of the area and U. S. Census figures are generally considered to be reliable, the Census figure of 1,405 in 1980 was used in this study as a basis for projecting future population and water use.* Moreover, this number can be used for comparison with future Census figures.

Prior to World War II, the relative isolation of Borrego Valley contributed to the limited influx of population. Since the end of the war, there has been sporadic expansion of local residential developments.

Population projections that have been developed for the area are presented in Table 3 and Figure 2. These projections were made on the assumption that annual growth rates would range between 4 percent and 12 percent. Using U. S. Census data, the annual growth rate for the decade 1970-80 was estimated at about 5-1/2 percent. However, caution must be exercised when extrapolating historic trends, because future growth need not have any direct relationship to past growth. It should be noted that the population growth resulting from the Borrego Country Club and Rams Hill Country Club developments is in the projected population growth.

Past and Present Water Uses

The three major users of applied water in the study area are: municipal, agricultural, and recreational. Also, water is used by uncultivated vegetation. There are no major manufacturers in the area.

Total applied water use is composed of two parts: consumptive use and return water. "Applied water" is defined as the total quantity of water delivered to, among others, municipal,

TABLE 3
POPULATION PROJECTIONS

Year	4 percent growth per year	8 percent growth per year	12 percent growth per year
1980	1,405*	1,405*	1,405*
1990	2,100	3,000	4,400
2000	3,100	6,500	13,600

*U. S. Census

agricultural, and recreational users. "Consumptive use" is that portion of applied water permanently lost to the study area as a result of evapotranspiration. "Return water" is that portion of applied water that percolates to the ground water table and again becomes available for use; thus, consumptive use is equal to applied water use less return water.

Table 4 contains total historic applied water use in Borrego Valley. The values for the years between 1950 and 1978 were developed by PRC Toups and the current (1980) value was developed using USGS and DWR land and water use data. The 1980 breakdown as a pie-chart is given in Figure 3.

The seeming inconsistency of the applied use by agriculture being far higher in 1980 than in 1978 can be attributed to the fact that each investigator uses different techniques for making estimates and that a substantial amount of judgment is involved, especially when much of the agricultural, golf course, and landscape use is not metered. The land use in 1980 was determined by USGS. Using these data, unit water use data determined by DWR for each crop were applied to obtain the total water use by agriculture and golf courses. The municipal demand was determined by

*However, there are 1,000 registered voters in the valley, which suggests that the Census figure may be low.

FIGURE 2
HISTORIC AND PROJECTED POPULATION OF BORREGO VALLEY

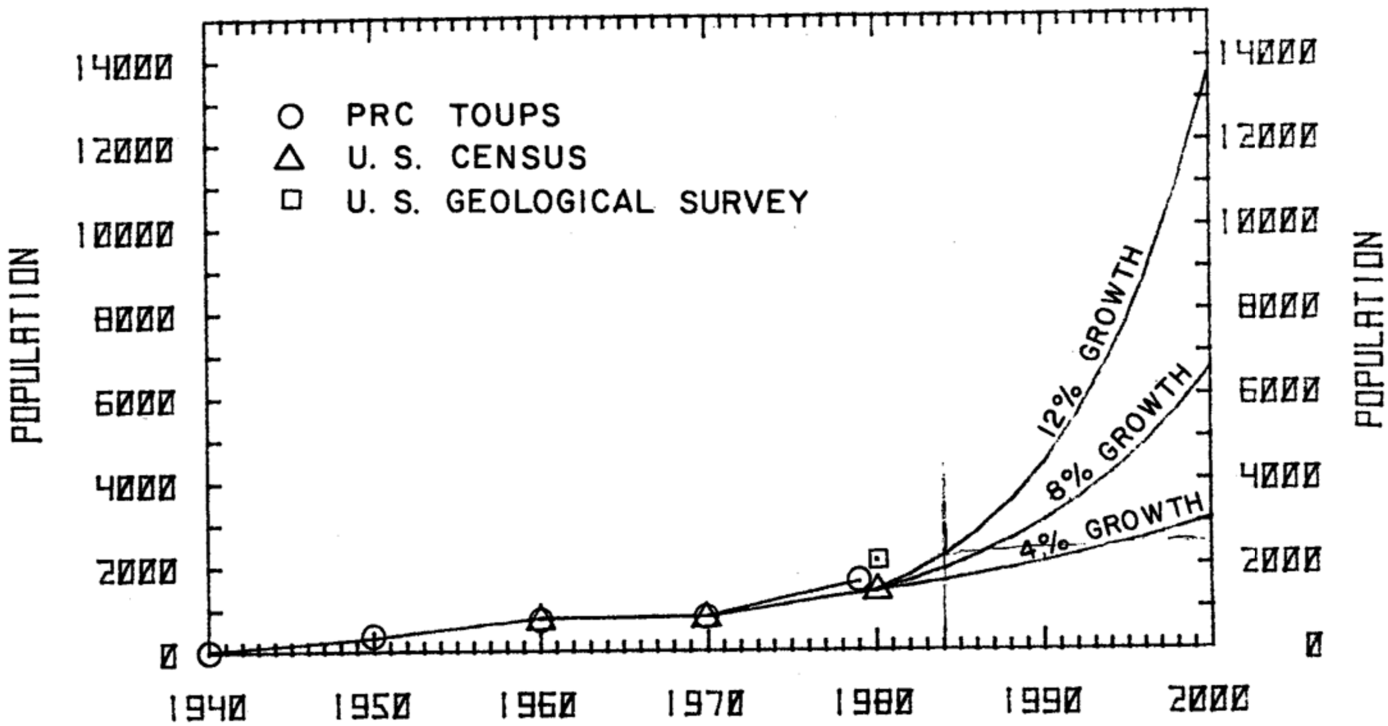
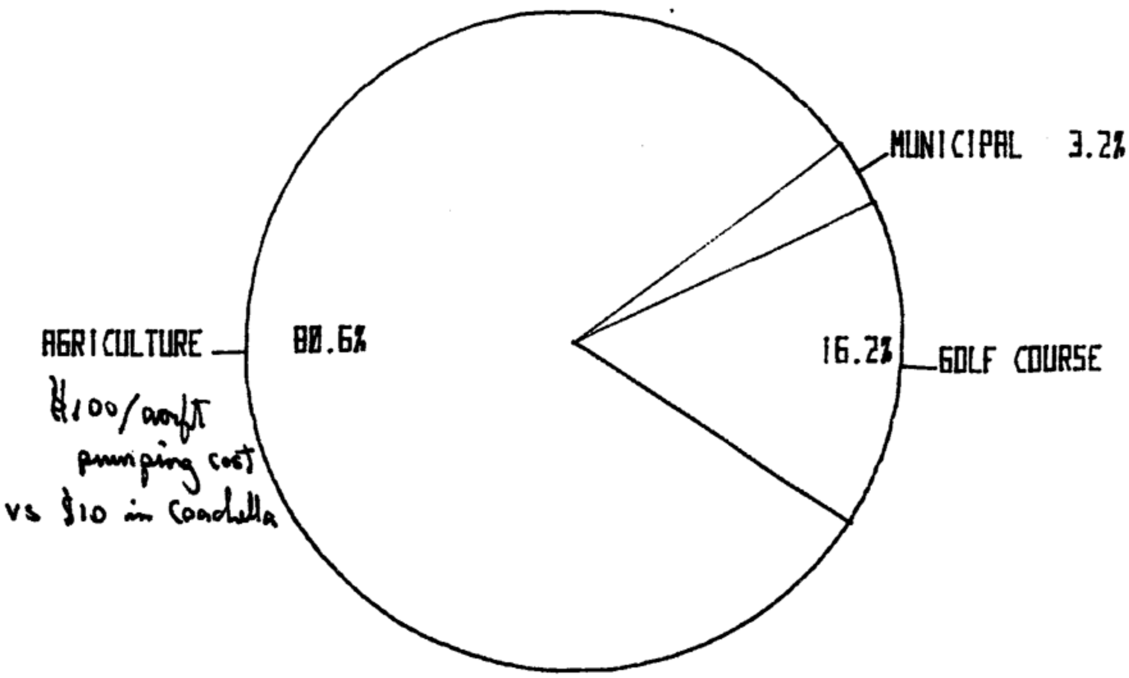


TABLE 4
BORREGO VALLEY APPLIED WATER USE

In acre-feet

Year	Municipal	Agricultural	Golf course and landscape	Total
1950*	170	11,435	190	11,795
1958*	225	22,455	790	23,470
1962*	265	13,830	1,725	15,820
1968*	475	7,260	1,720	9,455
1972*	530	5,320	2,270	8,120
1978*	600	5,705	2,050	8,355
1980**	430	10,600	2,100	13,130

*Applied water use from PRC Toups, op. cit., p. 30.
**Applied water use obtained using USGS, U. S. Census, and DWR population, land use, and water use data.



TOTAL APPLIED WATER USE
IN 1980

Type of use	Water used, acre-feet	
Municipal	430	
Agricultural irrigation	10,600	
Golf course irrigation	2,100	before RHCC
TOTAL	13,130	(~10000 consumptive)

FIGURE 3

BORREGO VALLEY WATER USE IN 1980

multiplying the U. S. Census figure of 1,405 for Borrego Valley in 1980 by 270 gallons per capita per day.*

Municipal Water Use

Historically, municipal use has been a minor constituent of total water demand in the study area.

Using the population of 1,405 for the year 1980, the applied water use would be 425 acre-feet for that year. DWR has also determined that consumptive

*Department of Water Resources, background data developed for Bulletin 160-83 for the Borrego Valley area.

use amounts to about 59 percent of the applied water, which for 1980 would mean that 250 acre-feet were consumed, or 159 gallons per capita per day.*

Agricultural Water Use

Farming has been the most important factor determining the amount of water use in the Borrego Valley. Major growth of the valley's economy and related water use began following World War II, when electrical service was extended into the valley permitting the use of deep well turbine pumps for irrigation of the newly introduced table grapes. Citrus has now replaced grapes as the primary crop, and it is generally irrigated with efficient drip systems.

Increasing competition from the Coachella and Imperial Valleys, which have access to economical imported water, led to a decline in Borrego Valley agriculture from its peak in the late 1950s. Currently, Colorado River water imported to the Imperial Valley by Imperial Irrigation District by gravity costs farmers $9 per acre-foot; for Coachella Valley farmers the cost of Colorado River water imported by Coachella Valley Water District is about $10 per acre-foot. In contrast, for Borrego Valley farmers facing a ground water pumping lift of 250 feet, the power cost alone could exceed $50 per acre-foot at current rates. As a result, agriculture in Borrego Valley is, to a substantial extent, conducted by persons whose primary income is from other sources or who are holding the land for future development for urban uses.

Table 5 contains values of historic use of water by agriculture; PRC Toups' figures are estimates of applied use whereas USGS estimated consumptive use. Table 6 contains two estimates of 1980 agricultural water use. The DWR set includes estimates using unit applied

TABLE 5
HISTORIC AGRICULTURAL WATER USE

In acre-feet

Year	PRC Toups*	USGS**	DWR***
1950	11,435	--	--
1958	22,455	--	--
1962	13,830	--	--
1968	7,260	--	--
1972	5,320	--	--
1978	5,705	--	--
1980	--	6,431	7,475

*Applied water use.
**Consumptive use--USGS Open-file Report 82-855, p. 21.
***Consumptive use with DWR unit use values and USGS Open-file Report 82-855 land use data.

and consumptive use estimates developed for the Anza-Borrego area. The consumptive use estimates developed by USGS utilized its estimates of unit use by each crop. The difference between the two estimates results from the different methods and assumptions used in making the estimates. Information based on direct consumptive use measurements is not available. For this study, the estimates using the combination of USGS land use estimates and DWR unit use values were adopted.

Recreational Water Use

Several residential developments in the Borrego Valley are centered around golf courses. PRC Toups estimated the applied water use by these golf courses, as well as the use by landscaped areas that are held in common by the residents of these developments, from water company

*Ibid.

records. USGS estimated the consumptive use of only the golf courses in 1980; its estimate of water delivered for landscaping was included as a part of domestic use. Consequently, the two series of figures are not, strictly speaking, comparable (Table 7).

In 1983, the golf course for the Rams Hill Country Club was constructed. This course has an area of 160 acres. With the unit water use values of 7.9 and 5.5 acre-feet per acre for applied and consumptive water uses, respectively, it is estimated that an additional 1,260 acre-feet of applied water will be needed and 880 acre-feet of water will be used consumptively. Part of this demand is planned to be met by reclaimed water.

A waste water treatment plant was constructed and turned over to the Borrego Water District. The Borrego Country Club complex specific plan has been approved by the County, but the project is not expected to be developed rapidly. However, when its three golf courses with 175 acres of lawn area are fully developed, an additional 1,380 acre-feet of applied water demand and 960 acre-feet of consumptive use are expected.

Uncultivated Vegetation Water Use

Uncultivated vegetation, which consists mainly of mesquite and tamarisk, consumes a substantial amount of water.

USGS has estimated that consumptive use totals 1,200 acre-feet per year. The USGS figure was used in this investigation.

TABLE 6
AGRICULTURAL WATER USE IN 1980

Type of use	No. of irrigated acres*	DWR applied unit use** ft	DWR applied use** ac-ft	DWR consumptive unit use** ft	DWR consumptive use** ac-ft	USGS consumptive unit use* ft	USGS consumptive use* ac-ft
Citrus	940	5.4	5,076	3.8	3,572	3.26	3,064
Grass (pasture)	425	7.9	3,358	5.5	2,338	4	1,700
Alfalfa	140	7.3	1,022	5.5	770	6.19	867
Tomatoes (hot house)	10	2.5	25	1.5	15	2	20
Tree farm	390	2.9***	1,131	2.0***	780	2	780
Grapes (abandoned)	655	0	0	0	0	0	0
Date palm (abandoned)	40	0	0	0	0	0	0
			10,612		7,475		6,431

*Moyle, W. R., Jr., "Water Resources of Borrego Valley and Vicinity, California," U. S. Geological Survey Open-file Report 82-855, November 1982, p. 21.
**Department of Water Resources, background data developed for Bulletin 160-83 for the Borrego Valley area.
***Estimate.

TABLE 7
RECREATIONAL AND LANDSCAPE DEMAND

In acre-feet

Year	PRC Toups* applied	USGS** consumptive	DWR***	
			Applied	Consumptive
1950	190	--	--	--
1958	790	--	--	--
1962	1,725	--	--	--
1968	1,720	--	--	--
1972	2,270	--	--	--
1978	2,050	--	--	--
1980	--	1,890	2,130	1,480

*PRC Toups, op. cit., p. 30.
**Consumptive use for golf courses alone.
270 acres x 7 acre-feet/acre = 1,890 acre-feet.
Moyle, W. R., Jr., op. cit., p. 21.
***Applied use = 270 acres x 7.9 acre-feet/acre.
Consumptive use = 270 acres x 5.5 acre-feet/acre.
Moyle, W. R., Jr., op. cit., p. 21, and background data for DWR Bulletin 160-83.

Future Water Demands

Future water demands of Borrego Valley in large measure will be affected by what happens to agriculture and recreation-oriented residential developments, which could add many golf courses.

It would seem unlikely that agriculture will expand in the future. More likely, agriculture will decrease. One of the reasons is the increasing cost of pumping ground water as electrical rates rise and ground water levels decline. This will further reduce the competitiveness of local produce in comparison with that from other areas of California, such as Imperial Valley, which have access to cheaper water and well developed transportation systems.

The cost of electricity for pumping within the San Diego Gas and Electric Company service area has risen from slightly under $0.01 per kilowatthour in 1968 to slightly more than $0.12 per kilowatthour in 1983. This cost is expected to continue to rise.

Another reason for the decline in agriculture acreage is the increasing value of valley land for retirement residential development. The desirability of valley lands for residential use is illustrated by the recent development of the sizable Rams Hill residential project in the southern portion of the valley. The continuing population growth in the major urban centers and resort areas of Southern California is likely to be reflected, to some extent, in a further expansion of population in the Borrego Valley.

Because of the uncertainty, water demands were projected under two scenarios with regard to agriculture (Table 8). Under the first scenario, an assumption was made that agriculture of the valley will remain level. Under the second, it will have diminished by 2000.

Even though the likelihood of agriculture becoming zero is small, this scenario was considered to provide ideas as to the extremes. Impacts between extremes can be approximated by evaluating the extremes. For the urban growth, the three different assumptions as to the population growth rate, 4, 8 and 12 percent, which were discussed earlier, were used (Table 9). For the golf courses, it was assumed that current area will not expand for the 4 percent growth and all the currently proposed golf courses will have been developed by 2000 for the 12 percent growth rate. For the 8 percent growth rate, one additional golf course was presumed to be added by 2000.

Applied water demand and total consumptive use in Borrego Valley were projected under declining agriculture (Tables 10 and 11).

Then an assumption was made that the area's agriculture would remain at the 1980 level until 2000. Further, it was assumed that the same degree of development as under the declining agriculture scenario would take place. Table 12 contains the projection of consumptive use under these assumptions.

Because the estimates of water use are not based on the measurement of actual water use, they are subject to considerable error, as indicated by the difference in numbers generated by different investigators. However, it is obvious that future water demands will largely depend on what happens to the agriculture of the area. That uncertainty overshadows any inaccuracy in the estimates of urban, golf course, and uncultivated vegetation water use.

The trend of change in agriculture should be observed closely and a practical method of estimating agricultural water use should be implemented.

In the meantime, the assumption that the area's agriculture will decline appears to be consistent with economic and other indicators. Until contradictory information becomes available, the urban growth rate of 4 percent with declining agriculture should be used as the basis of water planning of the area.

It should also be noted that an application by United Energy Corporation was approved in October 1983 for development of a solar energy farm. An additional 160 acre-feet of applied water demand would result from this development.

TABLE 8
FUTURE AGRICULTURAL WATER USE SCENARIOS

In acre-feet

Year	Level agriculture		Declining agriculture	
	Applied	Consumptive	Applied	Consumptive
1980	10,612	7,475	10,612	7,475
1990	10,612	7,475	5,306	3,738
2000	10,612	7,475	0	0

TABLE 9
PROJECTED MUNICIPAL WATER DEMAND IN BORREGO VALLEY*

In acre-feet

Year	4% growth per year			8% growth per year			12% growth per year		
	Pop.	Applied use	Consumptive use	Pop.	Applied use	Consumptive use	Pop.	Applied use	Consumptive use
1980	1,405	425	250	1,405	425	250	1,405	425	250
1990	2,100	640	370	3,000	910	530	4,400	1,330	780
2000	3,100	940	550	6,500	1,970	1,160	13,600	4,110	2,420

*Applied use = 270 gallons per capita per day.
Consumptive use = 159 gallons per capita per day.

TABLE 10
BORREGO VALLEY FUTURE APPLIED WATER DEMAND
WITH DECLINING AGRICULTURE

In acre-feet

Year	Municipal	Agricultural	Golf course	Total
		4% annual population growth		
1980	430	10,600	2,100	13,160
1990	640	5,300	3,390*	9,330
2000	940	0	3,390	4,330
		8% annual population growth		
1980	430	10,600	2,100	13,130
1990	910	5,300	3,390	9,600
2000	1,970	0	3,750	5,620
		12% annual population growth		
1980	430	10,600	2,100	13,130
1990	1,330	5,300	4,410	11,040
2000	4,110	0	4,740	8,850

*In 1983, a 160-acre 18-hole golf course was constructed in the Rams Hill Country Club development.

TABLE 11
BORREGO VALLEY FUTURE CONSUMPTIVE WATER USE
WITH DECLINING AGRICULTURE

In acre-feet

Year	Municipal	Agricultural	Golf course	Uncultivated vegetation	Total
		4% annual population growth			
1980	250	7,480	1,480	1,220	10,430
1990	370	3,740	2,360	1,220	7,690
2000	550	0	2,360	1,220	4,130
		8% annual population growth			
1980	250	7,480	1,480	1,220	10,430
1990	530	3,740	2,360	1,220	7,850
2000	1,160	0	2,610	1,220	4,990
		12% annual population growth			
1980	250	7,480	1,480	1,220	10,430
1990	780	3,740	3,070	1,220	8,810
2000	2,420	0	3,300	1,220	6,940

TABLE 12
BORREGO VALLEY FUTURE CONSUMPTIVE WATER USE
WITH LEVEL AGRICULTURAL ACTIVITY

In acre-feet

Year	Municipal	Agricultural	Golf course	Uncultivated vegetation	Total
		4% annual population growth			
1980	250	7,480	1,480	1,220	10,430
1990	370	7,480	2,360	1,220	11,430
2000	550	7,480	2,360	1,220	11,610
		8% annual population growth			
1980	250	7,480	1,480	1,220	10,430
1990	530	7,480	2,360	1,220	11,590
2000	1,160	7,480	2,610	1,220	12,470
		12% annual population growth			
1980	250	7,480	1,480	1,220	10,430
1990	780	7,480	3,070	1,220	12,550
2000	2,420	7,480	3,300	1,220	14,420

III. WATER SUPPLY

Extracted ground water is the only water supply of Borrego Valley, and about 13,000 acre-feet of ground water was used in 1980. The rapid decline in ground water levels ceased with the reduction in irrigated acreage from 5,000 acres in 1958 to 2,000 acres in 1965. Today, municipal and recreational demands are increasing and a close look is needed to evaluate the role ground water will play in meeting the area's future water demands. As the urban water use increases, the opportunity for using reclaimed waste water will also increase.

Ground Water

The Borrego Valley Ground Water Basin is approximately 70,000 acres in area; it is an alluvium-filled valley underlain by crystalline bedrock.

Geology

USGS classified the valley fill into three categories: upper, middle, and lower aquifers. The upper aquifer ranges in thickness from 0 to 1,000 feet, the middle aquifer 0 to 700 feet, and the lower aquifer 0 to 1,800 feet. The upper aquifer is thickest at the north end of the valley, the middle aquifer near the center of the valley, and the lower in the south-central part of the valley.

Relative aquifer characteristics were estimated by USGS in terms of specific capacity of wells constructed in the thickest saturated section of each aquifer. Specific capacities range from 92 gallons per minute (gpm) for a foot of drawdown in the upper aquifer to less than 1 gpm for the lower aquifer.

The upper aquifer is composed of alluvial and windblown deposits and includes younger alluvium, younger fan deposits, playa deposits, sand dunes, older alluvium, and older fan deposits.

Hydraulic conductivity of this aquifer is 50 feet per day with a specific yield of 20 percent.*

The middle aquifer is composed of the upper part of the continental deposits. These deposits are assigned a conductivity of 5 feet per day and a specific yield of 10 percent.

The lower aquifer is composed of the lower part of continental deposits and marine rocks. A hydraulic conductivity of 1 foot per day and a specific yield of 5 percent are assigned.

Ground Water Levels

Ground water levels vary considerably, in 1980, they ranged between about 18 feet and 305 feet from ground surface.*

Amount of Water in Storage

The total amount of ground water in storage in 1945 was estimated to have been 5.5 million acre-feet and, in 1980, 5.2 million acre-feet as the result of 330,000 acre-feet depletion during the 35 years.

---

*W. R. Moyle, Jr. "Water Resources of Borrego Valley and Vicinity, California, Phase I - Definition of Geologic and Hydrologic Characteristics of Basin", U. S. Geological Survey, Open-File Report 82-855, November 1982.

Of the total amount of ground water in storage, it would be reasonable to assume that at least two-thirds, or 3.4 million acre-feet, can be used. As mentioned before, specific capacities range from 92 gpm per foot of drawdown in the upper aquifer to less than 1 gpm in the lower aquifer.

Average Annual Recharge

As to the average annual recharge to the Borrego Valley Ground Water Basin, numerous investigations had been conducted prior to the current study, and estimates ranging from 1,700 acre-feet a year to 16,000 acre-feet a year have been made.

During the USGS geohydrology study, DWR participated in estimating the average annual replenishment of the area by using geohydrology data developed by USGS. Three different approaches were used by DWR: (1) hydrologic balance, with estimates ranging between 6,800 acre-feet per year and 8,700 acre-feet per year; (2) subsurface flow under a steady-state method, which produced an estimate of 13,000 acre-feet; and (3) a mathematical model method, 7,700 acre-feet a year.

USGS also made two estimates of average annual recharge to Borrego Valley Ground Water Basin. One estimate, based on a water yield method, gave an estimated recharge of 2,200 acre-feet year. Another estimate was based on a chloride method; with it, the amount was 13,000 acre-feet per year.

By taking an average of the estimates made by DWR and USGS, USGS arrived at an annual recharge of approximately 8,300 acre-feet per year. USGS has prepared a summary as part of a report on the mathematical model of the basin providing details of its estimates as well as the derivation of the average recharge. This estimate is adopted for use in this study as representative of average annual recharge to Borrego Valley.

It should be noted, however, that currently there are two items that reduce the amount of the annual recharge that can be used for beneficial purposes. They are the consumptive use by phreatophytes, 1,220 acre-feet a year, and subsurface outflow at the southeastern end of the basin, which is 3,600 acre-feet a year. Both losses would decrease if the ground water levels decline.

Ground Water Quality

In November 1980, USGS took samples of water from 27 wells in Borrego Valley. In Table 13 are the limits recommended by the U. S. Environmental Protection Agency. Results of analyses of the samples taken by the USGS are reproduced as Table 14 from USGS Open-file Report 82-855, November 1982.

As comparison of the two tables shows, except for the total dissolved solids (TDS), the quality of water in general is adequate for domestic and agricultural uses without special treatments. From the chemical analyses of water from wells and streams

TABLE 13
U. S. ENVIRONMENTAL PROTECTION AGENCY RECOMMENDED WATER QUALITY LIMIT ON CONSTITUENTS OF INTEREST IN BORREGO VALLEY

In milligrams per litre

Constituents	Upper limit
Sodium	250
Sulfate	250
Chloride	250
Nitrate	45
Nitrogen	10
Total dissolved solids	500

collected in 1980 (Table 14), it was found that most of the wells sampled in the basin have shown high concentration of TDS: (a) up to 2 440 mg/L near the Tamarisk Grove Campground area (southeast of the basin, see Figure 1), (b) above 1 000 mg/L in four wells scattered throughout the basin; and (c) in a few wells along the Coyote Creek fault, which runs northwest to southeast through the basin. (See Figure 7 in Chapter IV.) Moreover, two of the sampled wells, 10S/6E-34D1 and 11S/6E-18R1, had higher levels (30 and 11 mg/L, respectively) of total nitrogen content and well 11S/7E-32Q1 had 6.7 mg/L. These are located on the west side of the basin -- west of the Borrego Valley Airport. (See Figure 1.) The limiting level for total nitrogen is set at 10 mg/L.

The Environmental Protection Agency recommends a limit of 500 mg/L TDS concentration in water for human consumption. However, the use of water with higher concentrations of TDS is permitted when better quality water is not available.

As people's activities continue, the total amounts of minerals added to the area's ground water will increase, which cannot be avoided. However, the concentration will not be distributed evenly throughout the ground water basins. Rather, there will be plumes of high mineral concentration and diffused sources. Usually, those plumes will move slowly downgradient close to the ground water surfaces. TDS concentration in extracted ground water can be maintained at acceptable limits in most cases either by drilling wells away from the flow paths of these plumes or by placing discharge points of waste water treatment plants so that the resulting plumes will not be intercepted by wells.

The concentrations of nitrate in water from some wells are reported to be over the limit of 45 mg/L. The source of high nitrate concentration is considered to be septic tanks and leach lines, effluent of waste water treatment plants, irrigation return water containing fertilizer, and decomposition of native vegetation. However, some high nitrate ground water was reported before irrigated agriculture and concentration of septic tanks began.

USGS postulated that the high nitrate concentration of ground water is often associated with improper placement and perforation of well casing. When a well is placed away from the flow paths of high concentration plumes, with perforations well below anticipated ground water levels, the nitrate problem is minimized. In general, nitrate concentration is higher in the upper aquifer than in the lower aquifer.

In considering water quality problems, it should be remembered that:

1. Constituent concentrations by samples indicate, more often than not, localized quality problems as affected by the location of perforation of well casings relative to ground water levels;

2. There are methods of treating water, some expensive and some inexpensive, that can improve the quality to bring it within the allowable limits; and

3. By appropriate construction and operation of water wells, many quality problems can be overcome.

Reclaimed Water

Because waste water disposal in Borrego Valley is predominantly by individual septic tanks and leach fields today, the opportunity for using reclaimed water is negligible. However, as urbanization expands and sewage treatment plants are constructed, the use of reclaimed water should receive

TABLE 14

CHEMICAL ANALYSES OF WATER

Values are in milligrams per

Local Identifier	Date of sample	Specific conductance (µmho /cm at 25°C)	pH (units)	Water temperature (°C)	Hardness, as $CACO_3$	Hardness, noncarbonate	Dissolved calcium	Dissolved magnesium	Dissolved sodium	Sodium percent	Sodium adsorption ratio
Coyote Creek near Borrego Springs	11-04-80	1,305	8.2	20.0	440	270	130	29	110	34	2.3
Palm Canyon Creek near Borrego	11-05-80	574	8.3	15.0	190	45	50	17	37	28	1.2
9S/6E-31E1	11-04-80	1,021	7.9	27.0	300	150	90	19	91	38	2.3
9S/7E-28N2	11-06-80	1,195	8.9	24.5	15	0	5.2	.6	230	95	25
10S/5E-25R1	11-20-80	693	7.6	21.0	220	83	58	19	47	31	1.4
10S/6E-5F1	11-07-80	1,129	7.9	22.5	360	190	110	20	100	37	2.3
	11-20-80	1,095	7.7	24.0	300	120	92	18	99	41	2.5
10S/6E-7A1	11-20-80	1,100	8.0	25.0	320	140	100	18	110	42	2.7
10S/6E-10M1	11-20-80	1,400	7.7	19.0	340	220	110	15	140	47	3.3
10S/6E-14G1	11-06-80	1,235	8.9	29.0	170	150	61	4.4	190	69	6.3
10S/6E-16E1	11-20-80	1,125	7.7	27.0	310	150	99	16	110	42	2.7
10S/6E-18R1	11-19-80	990	7.7	33.0	110	62	44	.9	150	72	6.1
10S/6E-24K2	11-06-80	1,460	7.8	29.0	250	220	93	3.3	210	64	5.8
10S/6E-29K2	11-19-80	550	7.9	28.0	87	13	30	3.0	70	62	3.3
10S/6E-34D1	11-20-80	1,800	7.7	22.0	430	340	140	19	180	47	3.8
10S/6E-36Q1	12-03-80	815	7.7	27.5	94	46	33	2.8	130	74	5.8
10S/7E-30F1	11-06-80	1,770	8.6	27.5	220	180	86	1.5	280	72	8.2
11S/6E-1C1	11-06-80	1,130	7.9	27.5	54	0	14	4.6	200	83	12
11S/6E-3D3	11-20-80	925	7.9	24.0	310	180	98	17	71	32	1.7
11S/6E-7K3	11-19-80	750	7.7	27.0	96	0	33	3.2	120	72	5.3
11S/6E-9B1	12-03-80	1,750	7.7	23.0	350	110	98	25	250	60	5.8
11S/6E-11D1	12-03-80	490	8.6	28.5	57	8	20	1.7	76	73	4.4
11S/6E-18R1	12-03-80	1,130	7.7	16.0	230	92	73	12	120	52	3.4
11S/6E-23E1	11-05-80	972	8.0	26.0	160	54	53	7.8	130	62	4.4
11S/7E-30G4	11-05-80	1,840	8.0	27.0	460	410	150	20	230	52	4.7
11S/7E-32Q1	11-05-80	615	9.3	27.0	25	0	9.6	.3	110	88	9.5
12S/6E-17C3	11-05-80	3,230	7.7	21.5	1,100	960	300	96	340	39	4.4

From USGS Open-File Report 82-855, November 1982.

careful consideration. Any amount of reclaimed water used for irrigation of farms and golf courses would make a like amount of potable ground water available for domestic purposes.

The small sewage treatment plant, one of the two in the valley, in the Club Circle Golf Course served only 12 homes in 1980. A new 250,000-gallon per day sewage-disposal plant has been completed southeast of Borrego Springs.

Effluent from the treatment plants, the amount of which would remain comparatively small for some time to come, could be suitable for irrigating a part of nearby golf courses or farm lands. Close coordination would be needed to meet requirements set by the Regional Water Quality Control Board and State and County health departments

FROM WELLS AND STREAMS COLLECTED IN 1980

litre; except where noted

Dis-solved potas-sium	Alka-linity	Dis-solved sulfate	Dis-solved chlo-ride	Dis-solved fluo-ride	Dis-solved silica	Dis-solved solids, sum of consti-tuents	Dis-solved nitro-gen, NO_2+NO_3 as N	Dis-solved phos-phorus, ortho-phos-phate	Dis-solved boron (µg/L)	Dis-solved iron (µg/L)	Total arsenic (µg/L)	Dis-solved solids (ton/acre-ft)
12	170	430	78	1.5	35	930	0.35	0.09	250	40	1	1.26
6.2	150	100	30	.4	42	373	.02	.21	40	70	1	.51
11	150	270	66	.8	29	669	.52	.03	170	10	0	.91
9.9	120	.1	290	.1	1.9	611	.00	.00	1,400	20	1	.83
7.2	140	130	43	.3	35	425	.19	.03	60	420	1	.58
11	170	310	70	.9	27	757	1.2	.00	190	10	1	1.03
10	180	240	68	1.0	25	664	.67	.06	230	20	1	.90
9.8	180	250	81	.9	25	708	1.1	.06	280	<10	1	.96
10	120	370	99	.7	20	850	2.8	.03	270	20	1	1.16
9.2	25	450	82	.5	4.6	817	.00	.00	230	30	0	1.11
10	160	310	72	.6	25	745	.95	.03	230	1,300	1	1.01
10	52	320	61	.5	14	634	.43	.03	290	10	1	.86
12	23	380	220	.5	14	947	.00	.00	290	<10	1	1.29
5.9	74	120	31	.2	19	327	.80	.03	70	20	3	.44
10	89	360	210	.2	23	1,130	30	.03	120	20	0	1.54
5.7	48	220	62	.8	9.0	493	.11	.06	210	30	4	.67
10	38	420	270	.7	13	1,100	.04	.00	150	40	2	1.50
30	360	4.2	150	.4	3.4	624	.07	.00	290	30	0	.85
5.0	130	160	140	.2	30	605	1.3	.00	80	50	0	.82
4.8	110	110	100	1.4	26	468	.69	.03	190	10	2	.64
6.8	240	350	200	.7	64	1,150	1.3	.00	360	150	2	1.56
3.0	49	130	33	.9	17	312	.08	.06	150	20	7	.42
5.5	140	28	210	.5	26	608	11	.03	210	10	0	.83
6.8	110	110	170	.4	22	572	1.2	.00	220	10	2	.78
9.6	52	560	240	.2	17	1,260	1.1	.00	110	<10	1	1.71
6.7	29	100	83	.3	12	369	6.7	.00	70	20	1	.50
20	180	1,200	340	.5	36	2,440	.13	.00	130	40	1	3.32

IV. COMPONENTS OF WATER MANAGEMENT AND SELECTED PLAN

The contract under which this study was conducted specifies that alternative water management plans shall be developed. However, as the study progressed, it became apparent that the area really has no viable alternatives to the only practical plan that the area must pursue in managing its water resources. In the following section, the various components of the alternative management plans and finally a management plan selected for recommendation are described.

Construction of Dams

Annual flow data are available for San Felipe Creek, Borrego Palm Canyon, and Coyote Canyon for determining runoff into the valley. Except for the wet years of 1979 and 1980, the flows from those canyons were small, ranging from 65 to 763 acre-feet a year for San Felipe Creek, 9 to 981 acre-feet for Borrego Palm Canyon, and 353 to 2,410 acre-feet for Coyote Canyon. In contrast, during the wet year of 1980, the flows were 4,820, 5,640, and 11,260 acre-feet for San Felipe Creek, Borrego Palm Canyon, and Coyote Canyon, respectively.

Of the three, Coyote Canyon appears to provide a reasonable opportunity for intercepting storm flows--a 27-year average (1951-1978) of 1,310 acre-feet. However, to contain flood flows of wet years--11,260 acre-feet in 1980, for example--the dam needed would be substantial and thus expensive.

For the following reasons, it would be reasonable to conclude that the construction of the dam should be considered only when the financial basis of the area has grown much larger.

In 1980, less than 700 family units resided in the valley with a commensurately small financial basis and the cost of the dam would be in the range of millions of dollars. The site is within the Anza-Borrego Desert State Park and thus recreation and environmental factors would need to be addressed. Even though the amount of water used each year exceeds the amount of annual replenishment, the amount of usable water in storage is several hundred times greater than the difference.

Also, there is a strong probability that agriculture will diminish to the point that the area's water demands could be reduced to approach if not equal the annual replenishment.

Importation of Water

The cost of various plans for importing water to the Borrego Valley was examined by the United States Bureau of Reclamation (USBR) in 1968 and their findings were published in a report.* It contains their appraisal of the area's water needs in the future and presents several alternative plans for importing water to meet the projected demand. Capital, operation, and maintenance costs are presented for projects to import water from the

*United States Department of the Interior, Bureau of Reclamation, "Inland Basins Projects, Borrego Valley, California," Reconnaissance Investigations Interim Report, June 1968.

system of either The Metropolitan Water District of Southern California (MWD), the Coachella Valley Water District, or the Imperial Irrigation District.

The USBR water demand estimates were based on a projection that there would be extensive municipal, industrial, and recreational development of the Borrego and Lower Borrego Valleys. They projected that yearly demand for these purposes would rise to 10,100 acre-feet in the year 2000 and 17,000 acre-feet in 2020.*

USBR assumed three different conditions in preparing estimates of future agricultural water demand. Condition 1 contained the assumption that imported water would be unavailable; consequently, irrigation demand would decline from 13,000 acre-feet per year to 11,375 acre-feet per year in 2020. Condition 2 represented maximum agricultural development with an increase in irrigated acreage from 2,500 acres in 1970 to 31,200 acres in the year 2020. Under Condition 3, a moderate expansion of agriculture was envisioned, in which acreage would expand from 2,500 acres in 1970 to 3,700 acres in 2020; the corresponding water demand would rise from 16,200 acre-feet in 1970 to 24,100 acre-feet in 2020.**

USBR developed several alternative plans to deliver two different levels of imported water. Under Development Plan A, pipelines capable of delivering 25 cubic feet per second were designed using three different routes: Escondido-Borrego (originating from Escondido on the west side of San Diego County, extending to Lake Henshaw, and terminating at the proposed Borrego Springs Reservoir, which is about 6 miles northeast of the Borrego Sink), Oasis-Borrego (starting near Oasis in the northwest corner of the Salton Sea, and extending southerly and westerly to the proposed reservoir), and Westside-Borrego (starting from about 12 miles northwest of El Centro in Imperial County, which is southeast of the study area, and extending northwesterly to the proposed reservoir). This plan would meet projected municipal and industrial, as well as recreational, demands. Development Plan B, with a Westside-Borrego route, would, in addition, take care of year 2020 agricultural demands assuming maximum expansion of irrigated acreage. Pipeline capacity would be 725 cubic feet per second. In Table 15 is a description of each plan.

All plans include a terminal reservoir near Borrego Springs with a maximum storage capacity of about 1,700 acre-feet.

Reconnaissance-level costs for the alternative plans by USBR included right-of-way acquisition, engineering, and supervision, as well as construction, costs. The cost of purchasing the water from the wholesaler, whether it be MWD, Coachella Valley Water District, or Imperial Irrigation District, was not included (Table 16). To update costs to current price levels, each construction and operation and maintenance component was multiplied by a factor developed using USBR cost indexes (Tables 17 and 18). To obtain annual costs using the escalated values, the contruction costs were amortized over 50 years using a typical current revenue bond interest rate of 12 percent. Power costs were escalated using data provided by San Diego Gas and Electric Company. Not included is the cost of developing an environmental impact report for each project; neglecting this cost should have little impact on the total project costs developed for this preliminary report.

*U. S. Bureau of Reclamation, 1968, op. cit., p. 33.
**Ibid, pp. 30-32.

TABLE 15
PROJECT CONVEYANCE FACILITIES

Plan of development	Conveyance system route	Design capacity, in cubic feet per second	Type	Length, in miles	Number of pumps	Total static lift for pipeline, in feet
Plan A	Escondido-Borrego	25 (17,000 acre-feet per year)	Steel pipeline (57-inch diameter)	52	9	7,200
	Oasis-Borrego	25 (17,000 acre-feet per year)	Steel pipeline (57-inch diameter	20		
			Concrete pipeline (57-inch diameter)	21	3	980
	Westside-Borrego	25 (17,000 acre-feet per year)	Steel pipeline (57-inch diameter)	13		
			Concrete pipeline (57-inch diameter)	40	1	800
Plan B	Westside-Borrego	725 (525,000 acre-feet per year)	Open channel	40		
			Steel pipeline (180-inch diameter)	13	1	800

*U. S. Bureau of Reclamation, "Inland Basins Projects, Borrego Valley, California", Region 3, Reconnaissance Investigations, June 1968, p. 43.

TABLE 16
ESTIMATED COST OF DEVELOPMENT PLANS*

IN 1968 DOLLARS

Plan of development	Conveyance system route	Total construction cost	Annual OM&R	Annual power cost
Plan A	Escondido-Borrego	$53,402,000	$318,300	$1,980,000
	Oasis-Borrego	$30,122,000	$ 87,000	$ 267,000
	Westside-Borrego	$33,427,000	$ 45,000	$ 220,000
Plan B	Westside-Borrego	$50,523,000	$152,000	$4,004,000

*U. S. Bureau of Reclamation, "Inland Basins Projects, Borrego Valley, California," Region 3, Reconnaissance Investigations, June 1968, p. 45.

TABLE 17
UPDATED ESTIMATED CONSTRUCTION COST OF DEVELOPMENT PLANS

Plan of development	Conveyance system	Total construction cost,* 1968	USBR construction cost ratio**	Total construction cost, 1983	Annual cost, 1983***
Plan A	Escondido-Borrego	$53,402,000	151/47	$171,568,000	$20,660,000
	Oasis-Borrego	$30,122,000	151/47	$96,775,000	$11,653,000
	Westside-Borrego	$33,427,000	151/47	$107,393,000	$12,932,000
Plan B	Westside-Borrego	$50,523,000	151/47	$162,319,000	$19,546,000

*U. S. Bureau of Reclamation, "Inland Basins Projects, Borrego Valley, California", Region 3, Reconnaissance Investigations, June 1968, p. 45.
**U. S. Bureau of Reclamation, "Construction Cost Trends", Engineering and Research Center, Division of Construction, October 1982, pp. 14 and 17.
January 1968 index was about 47 and October 1982 index (approximately January 1983) stood at about 151.
***Annual cost was obtained by amortizing project over 50 years at an interest rate of 12%.

In the summary of updated estimates (Table 19) are unit costs for conveying imported water that may range from $2,100 per acre-foot to $6,700 per acre-foot for the various alternatives under Development Plan A. Under Development Plan B, the unit cost of water would be $400 per acre-foot. These unit conveyance and storage costs do not include the cost of purchasing imported water.

The cost of importing water even under Plan B would greatly exceed the current cost of pumping ground water, which is estimated to be less than $100 per acre-foot. This is for pumping water from a depth of 300 feet, plus a delivery pressure of 50 pounds per square inch. (The average depth to water in most production wells in the valley is only about 150 feet.)

Even if the assumed interest rate were reduced--for example, from 12 percent to 9 percent -- the unit cost of water would still be high compared with the current cost of pumping ground water. Under Development Plan B, a reduced interest rate of 9 percent would reduce the annual construction cost from $19.5 million to $14.8 million. Combining this with an annual OM&R cost of $513,000 and annual power cost of $56.1 million gives a total annual cost of $71.4 million. For a total annual delivery of 184,000 acre-feet, the unit cost declines from $410 per acre-foot

TABLE 18
UPDATED ESTIMATED OPERATION, MAINTENANCE AND
REPLACEMENT + POWER COSTS OF DEVELOPMENT PLANS

Plan of development	Conveyance system	USBR annual OM&R*	USBR machinery & equipment cost ratio**	Updated annual OM&R, 1983	USBR annual power cost*	Power cost index***	Annual power cost, 1983
Plan A	Escondido-Borrego	$318,300	162/48	$1,074,000	$1,980,000	0.1218/0.0087	$27,720,000
	Oasis-Borrego	$87,000	162/48	$294,000	$267,000	0.1218/0.0087	$3,738,000
	Westside-Borrego	$45,000	162/48	$152,000	$220,000	0.1218/0.0087	$3,080,000
Plan B	Westside-Borrego	$152,000	162/48	$513,000	$4,004,000	0.1218/0.0087	$56,056,000

*U. S. Bureau of Reclamation, "Inland Basins Projects, Borrego Valley, California", Region 3, Reconnaissance Investigations, June 1968, p. 45.
**U. S. Bureau of Reclamation, "Construction Cost Trends", Engineering and Research Center, Division of Construction, October 1982, pp. 14 and 17.
***Electrical rates: approximately $0.0087 per kilowatthour in 1968 and $0.1218 per kilowatthour in 1983. Source: San Diego Gas and Electric Company, telephone conversation with Ken Clay, January 25, 1983.

using a 12 percent interest rate, to $387 per acre-foot.

A comparison of costs (Table 19) shows that the cost of imported water is high. Plan B appears to have a reasonable cost, but this assumes large agricultural uses of water and the cost, for that reason, is unrealistic. The costs of Plan A probably are within the right range.

When the total annual cost of the Oasis-Borrego conveyance system is divided by the approximate number of persons in the valley (1,400) an annual per capita financial burden of $11,203 is obtained. Obviously, an imported water project for the valley will remain financially infeasible for many years to come.

Water Conservation

Agricultural water uses still provide opportunities for conservation because of the comparatively large volume involved. However, the municipal water use of the area is still small, and therefore, water conservation associated with this use will remain small. Opportunities for water conservation should be explored as the area's population grows.

Irrigation Water Conservation

Irrigation is application of water to the soil for the benefit of growing crops. The optimum irrigation system would deliver little more water than the amount needed to induce maximum yield from the plant at the least cost to the farmer.

TABLE 19
UPDATED COSTS FOR PROJECTS TO IMPORT
WATER TO BORREGO VALLEY*

(1) Plan of development	(2) Conveyance system route	(3) Construction cost	(4) Annualized construction cost 12 percent, 50 years	(5) Annual OM&R cost	(6) Annual power cost	(7) (4)+(5)+(6) Total annual cost	(8) Annual water delivered, acre-feet	(9) (7)/(8) Unit cost, $/acre-foot
Plan A	Escondido-Borrego	$171,568,000	$20,660,000	$1,074,000	$27,720,000	$49,454,000	7,400	$6,680
	Oasis-Borrego	$96,775,000	$11,653,000	$294,000	$3,738,000	$15,685,000	7,400	$2,120
	Westside-Borrego	$107,393,000	$12,932,000	$152,000	$3,080,000	$16,164,000	7,400	$2,180
Plan B	Westside-Borrego	$162,319,000	$19,546,000	$513,000	$56,056,000	$76,115,000	184,000	$410

*Costs were updated to January 1983 using cost indices given in the U. S. Bureau of Reclamation publication, "Construction Cost Trends", October, 1982. Energy costs were updated using data provided by San Diego Gas and Electric Company. The cost does not include the cost of buying water from water wholesalers such as The Metropolitan Water District of Southern California or Imperial Irrigation District.

In the process of meeting the water demand of a crop, a certain amount of water is invariably lost to surface runoff, evaporation, percolation past the root zone, wetting of the surrounding area, and seepage out of the delivery system. Conservation is the process of meeting the crop growing needs, while minimizing these losses.

Conservation begins with selecting the appropriate irrigation system and operating it efficiently. No system is best for all crops; each has its advantages for a particular crop or for a particular set of circumstances. Including within the efficiency ratings are normal operational losses from leaky systems and common wasteful practices.

The appropriate irrigation system must then be designed and operated efficiently to take full advantage of its potential to conserve water. An efficiently run operation would take into account all the factors that divert water from the crops or unnecessarily consume water. The amount of water applied would be governed by taking into account such things as the amount of moisture present in the soil, daily temperature, time of day, type of soil, leaching requirements, etc.

The conservation effort in Borrego Valley should concentrate on disseminating new and useful information to the farmers. The farmers should work closely with the University of California Cooperative Extension Service, which is deeply involved in promoting the conservation of water through improved farming techniques.

Urban Water Demand and Conservation

In May 1976, DWR published Bulletin 198, "Water Conservation in California", which described the many ways in which water could be conserved in an urban environment. Bulletin 198 has been updated; the updated Bulletin 198-84 is in the State printing plant and will be released in the near future. DWR Bulletin 160-83 also updates Bulletin 198 redefining the means and estimates of savings attainable through conservtion measures. The total potential conservation has been divided into two categories. The first category, "anticipated", contains those quantifiable items that were already governed by State law or regulation or were expected to be in the immediate future. The second category, "additional potential", contained those items that were influenced by State and local programs, but voluntary in implementation. The categories and the elements under each are shown below.

- Anticipated

A. Required by State Law or Regulation

1. Tank toilets. New construction: 3.5 gallons per flush or less.

2. Shower. New construction, rehabilitation, and normal replacement: 2.75 gallons per minute or less.

3. Faucets. New construction, rehabilitation, and normal replacement: 2.75 gallons per minute or less.

4. Hot water pipe insulation. New construction and rehabilitation: R-3 or greater.

5. Water-saving flushometer toilets and urinals: 3.5 and 1.5 gallons per flush or less, respectively (State Legislation SB 643 pending).

B. Established by Observable Trends

1. Clothes-washing machines. New installations and normal replacement: 15 percent

reduction from previous applied water use.

2. Dishwashing machines. New installations and normal replacement: 25 percent reduction from previous applied water use.

3. Residential landscaping. Existing, 10 percent reduction; new development, 20 percent reduction.

4. Commercial. Existing and new, 15 percent reduction.

5. Industrial. Existing and new, 15 percent reduction.

o Additional Potential

A. Retrofit existing toilets and showers.

B. Increase water system efficiency.

C. Promote desert-type landscaping.

"Anticipated" and "additional potential" water conservation percentages used in recent DWR planning studies and those used for the upcoming Bulletin 160-83 are given in Table 20. The anticipated savings that could be expected in Borrego Valley under the different categories are shown. The estimated reduction in water demand through conservation is based on a percentage of expected savings in the Anza-Borrego Hydrologic Unit, of which Borrego Valley is a part. Current urban and domestic water demand in Borrego Valley (USGS) is one-third of that for the Anza-Borrego Hydrologic Unit. Anticipating that growth in Borrego Valley may be more than the average for other parts of the Anza Borrego Hydrologic Unit, future savings in water were calculated at one-third to one-half of the savings projected or of the whole unit.

The installation of new and the protection of existing desert-type, low-water-using ground covers, shrubs, and other ornamentals used in conjunction with appropriate natural materials (such as rocks and earth) can substantially reduce exterior water demand. This is achieved by utilizing plants with minimal evapotranspiration requirements and reducing or eliminating the need for landscape irrigation.

Useful guides are DWR Bulletin 209, "Plants for California Landscapes", September 1979, and Coachella Valley Resource Conservation District and Desert Water Agency publication "Drought Tolerant Ornamental Plants for the Coachella Valley", 1983.

In addition, the University of California, Riverside, is continuing research on turf irrigation and turf substitutes. Its report "Irrigation of Turfgrass for Water Conservation", June 1982, is currently available, and an additional report is under preparation.

As can be seen in Table 20, the amount of water that can be conserved in Borrego Valley is small. Nevertheless, attempts should be made to promote water conservation through an educational program.

DWR can assist in formulating a conservation program. The services of a specialist in conservation can be provided to advise on specific measures that would apply under the unique circumstances in the area.

Except for the regulation on new construction, conservation activities are entirely voluntary.

Water Reclamation

As previously discussed, only a small amount of the total waste water is treated in a waste water treatment plant. The remaining amount is

TABLE 20
REDUCTION IN DEMAND THROUGH CONSERVATION
IN BORREGO VALLEY
In acre-feet

Anticipated	1980	1990	2000	2010
Required by law				
Tank toilets - new	*	6-10	12-20	18-30
Showers - new and rehab.	*	6-10	9-15	15-25
- replacement	*	6-10	12-20	12-20
Faucets - new and rehab.	*	3-5	3-5	3-5
- replacement	*	*	3-5	3-5
Hot water pipe insul. - new & rehab.	-	*	3-5	3-5
Flush valve toilets - new & replace.	-	*	6-10	6-10
Subtotal	*	21-35	48-80	60-100
Observable trends				
Clothes washers - new	-	*	3-5	3-5
- replacement	-	*	3-5	3-5
Dishwashers - new	-	*	*	*
- replacement	-	*	*	*
Residential exterior - existing	0	6-10	6-10	6-10
- new	0	6-10	12-20	18-30
Commercial	0	3-5	6-10	9-15
Industrial	-	-	-	-
Subtotal	0	15-25	30-50	39-65
Total required by law and trends	*	36-60	78-130	99-165
<u>Additional potential from other State programs</u>				
Retrofit - toilets	-	*	*	*
- showers	-	*	*	*
Improvement in water systems	-	6-10	18-30	21-35
Total additional potential	0	6-10	18-30	21-35
GRAND TOTAL	0	42-70	96-160	120-200

*Less than 10.

disposed of in septic tanks and leach lines and percolates to the ground water. Thus, under the current situation, the opportunity for the direct use of reclaimed water is limited.

However, in a newly approved development, such as Rams Hill Country Club where a centralized waste water treatment plant has been constructed, serious consideration should be given to the use of reclaimed water for irrigating golf courses or nearby farms to reduce the use of ground water.

Increasing Ground Water Recharge

Precipitation within the watershed is a major source of natural recharge to the Borrego Valley Ground Water Basin and is the primary source of the water supply of the valley. Most of the precipitation during the summer is lost to evaporation. Under the present condition, the annual 3 to 4 inches of rain that falls on the valley floor may do little more than wet the surface before evaporating.

The mountains receive up to 16 inches of rain in the higher elevations. Most of it occurs as thunderstorms of short duration. Because the terrain is steep and rocky and composed of rocks of low permeability, runoff quickly accumulates in the canyons and flows into Borrego Valley. In the valley it spreads out into numerous drainage courses enroute to Borrego Sink.

Runoff from small storms spreads thinly over a large area, wetting the surface soil; most of the moisture eventually evaporates without reaching the ground water table. Some of the runoff from larger storms infiltrates to the ground water table, but some reaches the Borrego Sink and is lost as a potential potable water supply when it mixes with the salts left behind by evaporation of previous storm runoffs. Conserving even a small portion of this water that is routinely lost to evaporation and to the dry lake would be a significant addition to the local water supply.

Runoff is most often captured and stored for later use through the construction of dams and reservoirs, but such water supply projects are expensive, and the financial burden would normally be too great for small communities with a limited tax base such as Borrego Valley. There are, however, alternatives to reservoir storage that can be both effective and affordable.

Runoff can be captured for recharge to the ground water basin for storage underground through the construction of a large number of small and inexpensive recharge ponds. The basic idea would be the exact opposite of the present flood control concept, in which overland runoff is lead away as soon as possible through gutters, ditches, and lined channels.

Under the approach proposed, runoff would be retained in local depressions, natural and artificial, as long as possible, so that the opportunity for deep percolation to the ground water table is increased. Replenishment from these low-cost ground water recharge facilities could add significantly to the local ground water supply with minor environmental changes.

The recharge facilities would consist of ponds formed by constructing dikes downstream of natural or man-made depressions or in drainage channels. A typical recharge pond is shown on Figure 4. An arbitrary height limit of 4 to 5 feet is suggested at this time to limit the size of the ponds and make them less obtrusive. The spillway in the sidewall or an overflow pipe would limit the storage capacity of the pond and minimize erosion of the dike except during the large storms. A facility at one location can consist of a single pond or several ponds.

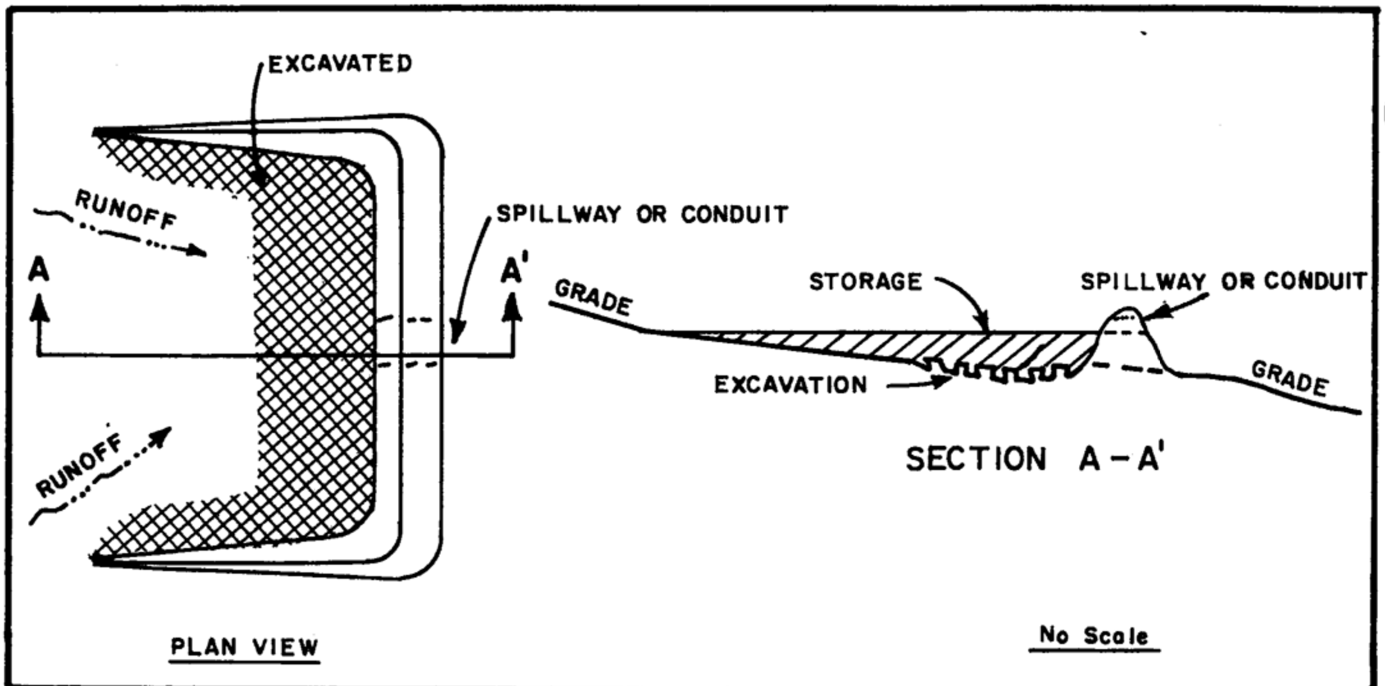


FIGURE 4-CONCEPTUAL GROUND WATER RECHARGE STRUCTURE (TYPICAL)

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1984

A single recharge pond may be adequate to capture and infiltrate runoff from a small drainage area, but large canyons would require several to accommodate the larger volume of runoff and at the same time to acquire the required infiltration area. Two conceptual plans, A and B, with multiple recharge ponds are shown in Figures 5 and 6. Each plan would be applicable under a different set of circumstances. In Plan A, the ponds are staggered over a wide area at the foot of the mountains to capture runoff from several drainage channels. As one pond fills, the overflow would be directed to one or two other downsteam ponds and eventually to an established flood control drainage course. In Plan B, the impoundments are built in tandem in a large drainage channel. Side channels divert local runoff into the recharge ponds to accumulate runoff from small storms. As one pond fills, the overflow is directed through large conduits to the next downstream pond; any excess would be directed to an established flood control drainage course.

These projects, which would be more compatible with the limited financial base of Borrego Valley, would provide increased opportunities for runoff to infiltrate to the ground water. The size of the ponds would be limited to avoid a large buildup of water that could pose a threat to lives and property downstream. These facilities would be inexpensive when compared with constructing dams and reservoirs of concrete and compacted fill. They can also be built as needed, thereby affording further cost control and flexibility to the recharge program.

However, the larger storms, perhaps in the magnitude of 10- to 20- year frequency and greater, would probably wash out parts of the system. This would be expected and is consistent with the overall scheme to keep construction costs down by not building sturdier more expensive structures.

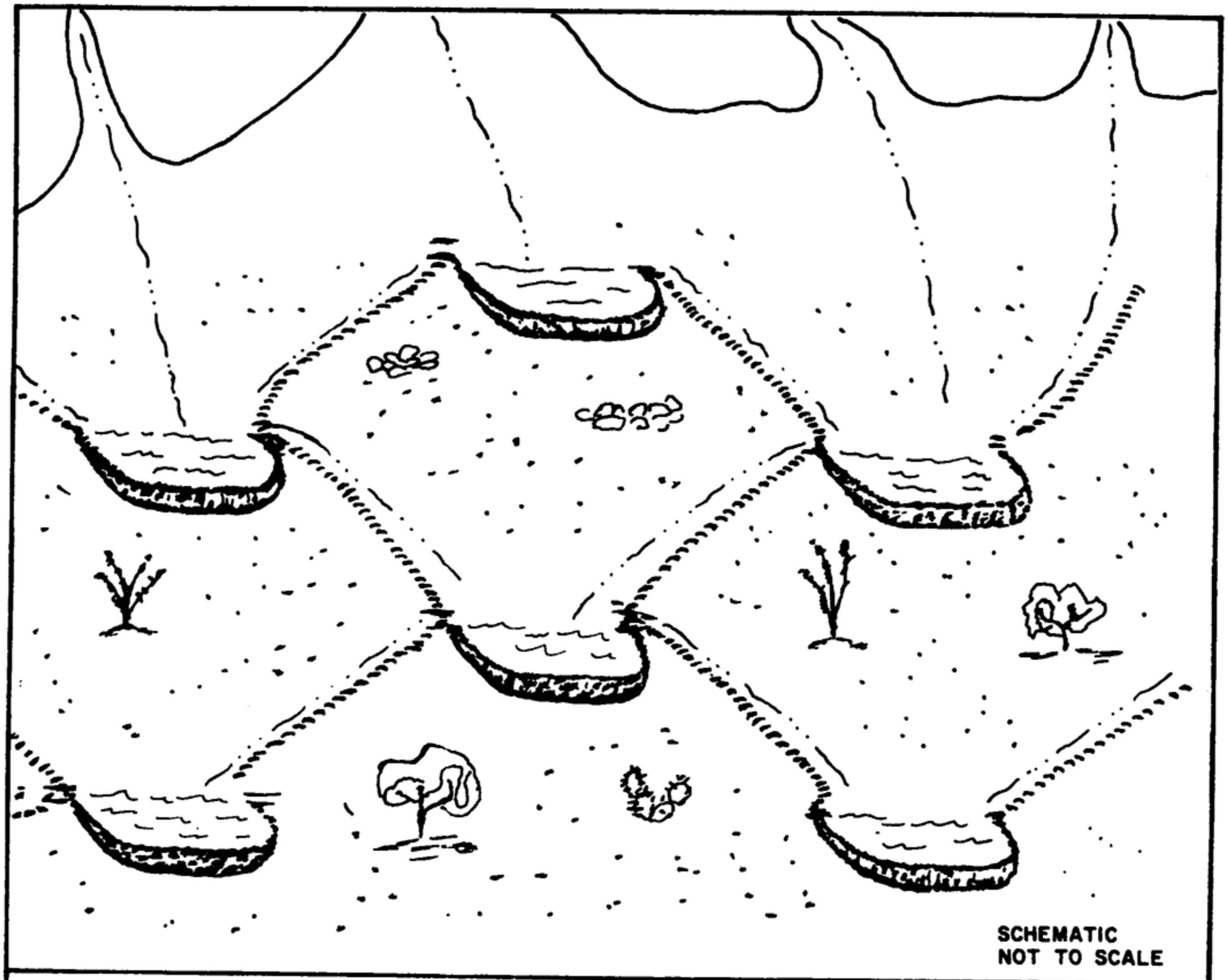


FIGURE 5 — PLAN A: MULTIPOND RECHARGE FACILITY

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1984

The size, configuration, and other features of each of the facilities would be determined by the circumstances at each site. Some of the factors that need to be considered in designing the ponds are: the anticipated volume of runoff, local terrain, local sediments, flood control accommodations downstream, proximity to developments, and environmental constraints.

Because the recharge facilities would reduce the runoff that requires consideration by flood control engineers, these structures should be planned and built in close coordination with the San Diego County Flood Control District.

A crawler-type tractor with a blade would probably be the only equipment required for constructing the ponds and diversion system. No reinforcing of the structures is needed, other than paving of spillways and compaction with the tractor treads during construction.

To minimize disturbing the natural conditions, existing depressions and

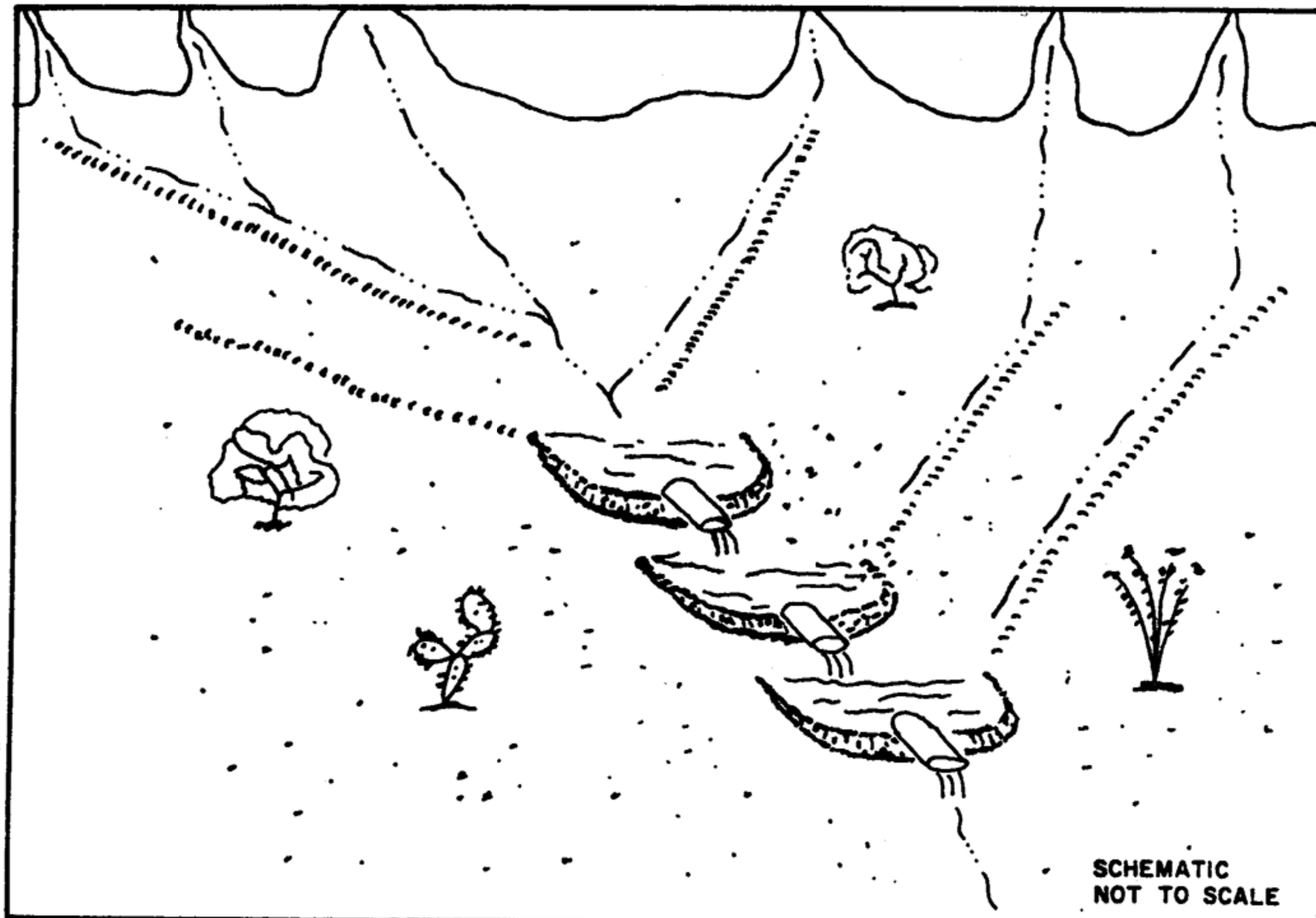


FIGURE 6 – PLAN B: TANDEM POND RECHARGE FACILITY

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1984

streambeds should be utilized, wherever possible, to make the recharge ponds. Where these natural sites are not available, shallow depressions should be scooped out in the landscape. Ditches leading to the depressions should follow the contour as much as possible to minimize the velocity of flows that could cause erosion.

In the construction of the recharge ponds, if dikes are needed, they should be no higher than 4 feet to minimize the impact on the environment. The size of pond and infiltration area that would be created behind a 4-foot wall on various slopes has been determined (Table 21). As the data show, the pond and infiltration area would be smaller as the gradient increases. More ponds would be required to obtain the same infiltration area on steeper slopes.

The amount of recharge to the basin that could be expected from the low-cost ground water recharge facilities will depend upon the amount of runoff, size of the facility, permeability of the underlying materials, depth of ponds, and amount of sediments carried into the ponds by the runoff.

Fine sediments will clog the pore space and thus reduce the infiltration capacity of the pond bottom. Dikes may be installed when appropriate to convey water out the sides of the ponds and to the underground, avoiding sediment-clogged areas at the bottom of the pond.

TABLE 21
POTENTIAL STORAGE IN RECHARGE PONDS

Slope, in percent	Surface area per 100 feet of dike (infiltration area), in square feet	Storage, in acre-feet			
		100-ft. dike	200-ft. dike	300-ft. dike	400-ft. dike
2					
3					
4	10 000	0.46	0.92	1.38	1.84
5	8 000	0.37	0.73	1.10	1.47
6	6 600	0.30	0.61	0.92	1.22
7	5 700	0.26	0.52	0.79	1.05
8	5 000	0.23	0.46	0.69	0.92

Infiltration rates based on field tests are not available for the Borrego Valley area. The Water Encyclopedia by Dr. David Keith Todd gives a range of seepage rates for canals. Assuming that those rates are applicable to the recharge ponds in Borrego Valley and knowing that the material in the potential recharge sites is a composite of clay, sand, gravel, and larger sediments, a range of about 3 to 5 feet per day under ideal conditions can be estimated.

Potentially, a recharge pond with one acre of surface area could infiltrate between 3 and 5 acre-feet of water a day. Under actual conditions, however, the infiltration would be reduced by clogging of pore spaces by fine materials and some evaporation.

Because Borrego Valley is a typical desert with highly localized storms and precipitation varying considerably from storm to storm, year to year, and area to area, the average annual runoff from the mountainous watershed cannot be predicted with any degree of accuracy. Runoff estimates based upon precipitation data obtained from weather stations separated by several miles would be unreliable. There are, however, three gaging stations in the study area with data that could provide a clue to the amount of runoff that could be expected in the nearby ungaged canyons. The gaging stations are located in Coyote Creek, Borrego Palm Canyon, and San Felipe Creek.

The watershed for the Borrego Palm Canyon Station most closely resembles the terrain and the vegetative cover in the ungaged watersheds of the study area. Based upon this similarity, storm flow was estimated for the ungaged canyons by increasing or decreasing the runoff data from the Borrego Palm Canyon Station in direct proportion to the relative area of the ungaged watershed. The 30-year record of stream flow at the Borrego Palm Canyon Station and the calculated estimates of the flow from selected ungaged watersheds have been compiled in Table 22. These estimates give an indication of the recharge potential at the mouth of these canyons (Figure 7).

In selecting recharge sites, it should

TABLE 22
ESTIMATED STREAMFLOW
(Based on that at Borrego Palm Canyon Station)
In acre-feet

Calendar year	Borrego Palm* Sta. 10255810 (15,620 acres)	Tubb Canyon** (7,550 acres)	Hellhole Canyon** (4,770 acres)	Henderson Canyon** (3,300 acres)
1951	273	132	83	58
1952	981	474	300	207
1953	238	115	72	50
1954	303	146	93	64
1955	357	173	109	75
1956	225	109	69	47
1957	152	73	46	32
1958	718	347	219	152
1959	139	67	42	29
1960	149	72	46	31
1961	38	18	12	8
1962	128	62	39	27
1963	59	29	18	12
1964	115	56	35	24
1965	174	84	53	37
1966	166	129	81	56
1967	115	56	35	24
1968	122	59	37	26
1969	716	346	219	151
1970	127	61	39	27
1971	55	27	17	12
1972	9	4	3	2
1973	258	125	79	55
1974	47	23	14	10
1975	65	31	20	14
1976	97	47	30	20
1977	312	151	95	66
1978	770	372	34	162
1979	2,460	1,189	751	520
1980	5,640	2,726	1,722	1,192

*Gaged streamflow.
**Estimated streamflow.

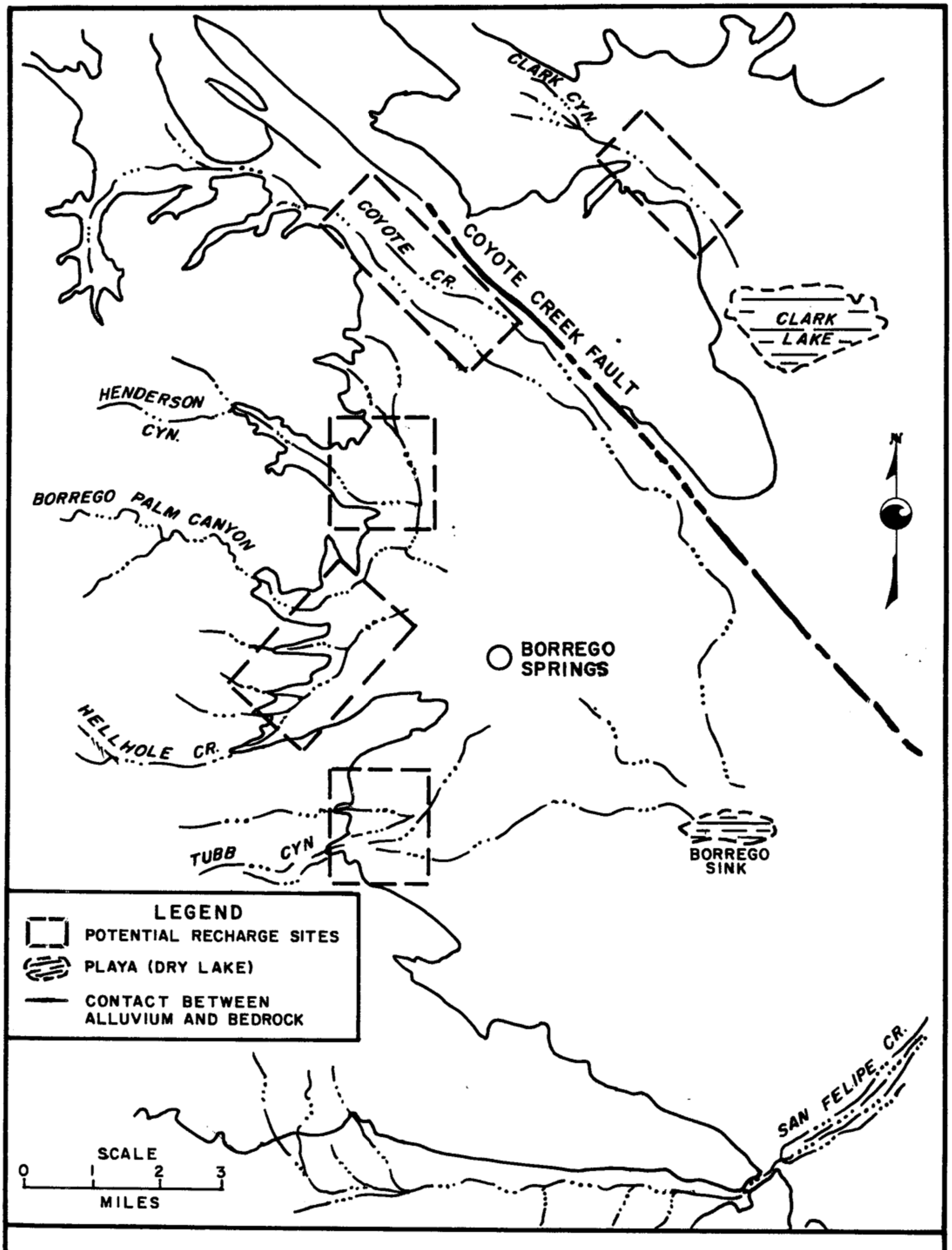


Figure 7 - POTENTIAL RECHARGE SITES

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1984 be remembered that sediments generally grade from coarse to fine with distance from the mountains. Therefore, the better recharge areas would normally be in the fringe areas of the valley, particularly downstream from the canyons, where the coarser materials are concentrated.

Unfortunately, specific data are not available for making dependable estimates of the increase in the amount of ground water recharge from any specific recharge sites. Therefore, it would be advisable to conduct a pilot study by constructing a recharge pond and observing how it behaves under actual conditions. This would point out specifics, such as environmental issues, as well as factors that need particular attention in constructing and maintaining recharge ponds and the approximate amount of recharge that can be expected from a project.

Based on the information obtained, the valley's decision makers can decide on the location and the extent of subsequent recharge projects.

Varying Amount of Ground Water Used

As indicated previously, ground water will constitute the only significant water supply for many years to come. The amount of reclaimable water is small. Thus, it can be concluded that varying the amount of ground water used annually cannot be considered a practical water management measure.

Varying Pumping Patterns

Existing wells are located where the water demands and the best aquifers are. Because current water demands are scattered, pumping ground water where it is needed appears to be the best approach from the standpoint of keeping the cost of supplying water as low as possible.

As was pointed out earlier, two scenarios for agricultural water demand were projected. Under the first, agricultural acreage was assumed to remain unchanged to year 2000. Under the second, it would be diminished by 2000.

Each of these agricultural projections was then paired with three population growth rates -- 4 percent, 8 percent, and 12 percent. These six scenarios are described in detail in Technical Information Record 1335-11-B-2, entitled "Evaluation of Future Operations of Borrego Valley Ground Water Basin", February 1984.

To determine the effect that implementing each of these scenarios would have on the ground water in storage, appropriate pumping patterns were developed, and USGS was asked to analyze them by means of its mathematical model of the basin. A TIR by DWR describing results of the analysis of the six scenarios made by USGS on its preliminary model will be available within the next few weeks. Final results of the detailed descriptions of the finite element model will be published in a USGS report, which is scheduled to be released in June 1985.

Variation of the areal pumping pattern would be useful for avoiding extraction of ground water with specific quality problems such as high concentrations of, nitrate or TDS. Unfortunately, however, adequate data are not available for making specific studies to indicate where new wells should be constructed. Until adequate data become available, " location of wells to avoid "poor-quality water will remain a matter of judgment.

It is generally known that ground water quality problems due to return water tend to be worse in upper aquifers than in lower aquifers. Thus, problems such as high nitrate concentration could be alleviated by deepening wells to lower the perforated section.

Selected Water Management Plan

As previously pointed out, the study area's financial base is small and such expensive alternatives as the construction of large dams and water importation projects are beyond the area's financial means. Furthermore, because of the large volume of ground water in storage, occurrence of critical water problems is extremely unlikely in the foreseeable future. Thus, the only practical water management plan is to: (a) continue to use ground water; (b) maximize the capture and recharge of natural runoff into the ground water basins; and (c) maximize water conservation and reclamation.

Specific steps involved in this management plan are:

1. Commence, as soon as practicable, a pilot study of a spreading pond as part of a water salvage and flood control facility in cooperation with the San Diego County Flood Control District. If the pilot study indicates that significant recharge can be effected inexpensively, the recharge program should be expanded in cooperation with the County Flood Control District.

   The pilot recharge and any expanded program will very likely be located within the boundary of the State park. Close coordination would be needed with the State Department of Parks and Recreation so the program is compatible with recreation use and to minimize adverse impacts on the environment;

2. Institute an inexpensive water conservation education program for both urban and agricultural water uses in cooperation with appropriate County and State organizations;

3. Encourage the use of reclaimed water for irrigation of golf courses and farmlands where waste water treatment plants have been constructed;

4. Implement data collection programs to determine the amount of ground water extraction by urban and agricultural users. This will give an estimate of water use to compare with ground water recharge. Also, this may take the form of a voluntary cooperation by water users that will provide information on the efficiency of their well systems and amount of energy consumed for extracting ground water;

5. Continue compilation of ground water level data and conduct periodic assessment of ground water conditions to ensure identification of problems that must be mitigated or eliminated early; and

6. Solicit assistance from the County, USGS, Regional Water Quality Control Board, and DWR for a water quality monitoring program designed to define the areas of high concentrations of nitrates and TDS and to identify the steps necessary to minimize the adverse effects.

The above management actions will require some funds, even though the amount required would be small. Borrego Water District, as a public agency formed under the State Water Code Section 30200, is empowered to levy a tax for legitimate purposes (Water Code Section 31650). Also, it may be possible to obtain a share of the San Diego County tax revenue to fund the management actions. This possibility should be pursued first.

V. SUMMARY AND RECOMMENDATIONS

Significant growth of Borrego Valley has taken place since 1945, the end of World War II. The valley's population, which mainly consists of retirees, vacationers, and recreationists, is still about 2,000. Family units comprise less than 1,000. Its financial base is small, and any large projects, such as the construction of a dam or a water importation project, would be beyond the area's financial capability.

The area's ground water levels have been stable during the last two years. The rate of ground water level decline seems to have been reduced. Agriculture, the area's major water user, may continue to decline if its competitive disadvantage worsens.

Even if ground water use continues to exceed annual replenishment, the usable amount of ground water in storage is large enough to sustain the present rate for several hundred years.

Even the localized high nitrate concentration problem need not be considered a potentially critical problem; there are many methods, some expensive and some inexpensive, that would minimize the adverse impact.

In other words, Borrego Valley does not have imminent and critical water problems.

Against this backdrop. the valley is in a position to take conservative steps in implementing a water management plan as its growth continues.

It is recommended that the actions be taken to implement the "Selected Water Management Plan" described in the last chapter.

Also, it is recommended that Borrego Water District serve as a valley-wide water management agency. For this the boundaries of the district will have to be extended to cover the entire valley.

REFERENCES

Boyle Engineering Corporation, "Supplemental Environmental Impact Data for Flood Control, Water, and Sewerage Facilities", January 1980.

California Department of Water Resources, "Water Wells and Springs in Borrego, Carrizo, and San Felipe Valley Areas, San Diego and Imperial Counties, California", Bulletin 91-15, January 1968.

----."Vegetative Water Use in California, 1974", Bulletin 113-3, April 1975.

----."Water Conservation in California", Bulletin 198, May 1976.

----."A Preliminary Evaluation of Recharging the Borrego Valley Ground Water Basin with Local Runoff", Technical Information Record 1335-4301-A, by Harry Iwanaga, December 1981.

----."A Preliminary Evaluation of Cost of Imported Water Supplies to the Borrego Valley", Technical Information Record 1335-12-C-3, by Kenneth K. Hatai, March 1983.

----."A Preliminary Evaluation of Historical and Projected Water Demand for Borrego Valley", Technical Information Record 1335-12-C-1, by Kenneth K. Hatai, March 1983.

----."Preliminary Evaluation of Annual Recharge to the Borrego Valley Ground Water Basin", Technical Information Record 1335-11-B-1, by Kenneth K. Hatai, March 1983.

----."Evaluation of Future Operations of the Borrego Valley Ground Water Basin", Technical Information Record 1335-11-B-2, by Peter Louie and Harry Iwanaga, February 1984.

Moyle, W. R., Jr., "Water Resources of Borrego Valley and Vicinity, California". U. S. Geological Survey Open-file Report 82-855. November 1982.

Phoenix, David A., " An Appraisal of the Groundwater Resources in the Northern Subbasin of the Borrego Valley Reservoir, San Diego County, with Emphasis on the Recovery of Groundwater from the Borrego Springs Park Area", for Federated Development Company, July 1979.

PRC Toups Corporation. "Borrego Water District Latent Powers Authorization", Focused Environmental Impact Report, November 1979.

San Diego County, Department of Sanitation and Flood Control, "Borrego Valley, General Plan for Flood Control Improvements", July 1972.

----."Construction Cost Trends", Engineering and Research Center, Division of Construction, October 1982.

Todd, David Keith. "The Water Encyclopedia", Port Washington, N.Y.: Water Information Center, 1970.

United States Department of the Interior, Bureau of Reclamation, "Inland Basins Projects; Borrego Valley, California", Reconnaissance Investigations Interior Report, June 1968.