# Water for Nevada

Special Planning Report Summary

WATER SUPPLY FOR THE FUTURE IN SOUTHERN NEVADA

MONTGOMERY ENGINEERS OF NEVADA
1100 EAST SAHARA AVENUE, LAS VEGAS, NEVADA 89105
TELEPHONE: (702) 735-7198

WILLIAM H. BLACKMER
PRESIDENT

December 31, 1970

Mr. Roland D. Westergard
Nevada State Engineer
Carson City, Nevada 89701

Dear Mr. Westergard:

We are pleased to submit the accompanying report entitled "Water Supply for the Future of Southern Nevada." This report describes several alternative plans for alleviating a projected water shortage in southern Nevada near the turn of the century. The plans include importing water from within the state, importing water from outside the state, reducing water use, dispersing population, and limiting population growth.

Unlike most studies of this type, we have not made a recommendation as to which alternative should be selected in the event the projected water shortage occurs. Each of the alternatives involves the Las Vegas Community and, on some projects, outlying communities. Each alternative has negative and positive aspects, the values of which are intangible. Thus, the final selection of alternatives is not entirely an engineering or economic consideration, but rather a matter of how the selected plan affects the people involved. It is for this reason that one of our recommendations emphasizes the need for wide distribution of the report so that a broad spectrum of opinion may be obtained before action is taken to implement any segment of the report.

During the preparation of this report we had the pleasure of working with you and several members of your staff, all of whom were especially cooperative. Also we were the beneficiaries of considerable assistance from numerous public and private organizations. All of this valuable aid and support is greatfully acknowledged. The report was prepared by Edward L. Kostjal, Fred K. Duren, and Dr. A. W. Morgner, consulting economist, under the direction of William H. Blackmer and was reviewed by William J. Carroll.

We have thoroughly enjoyed preparing this report, a portion of the State Water Plan. We wish to thank you for the opportunity of having served the State in this regard.

Very truly yours,

W H Blackmer

W. H. Blackmer

# WATER

# FOR NEVADA

Prepared by the State Engineer's Office
JANUARY 1971

ELMO J. DeRICCO
Director

STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

# DIVISION OF WATER RESOURCES

201 South Fall Street, Carson City, Nevada 89701

ROLAND D. WESTERGARD
State Engineer

In reply refer to
No.

Address All Communications to the State Engineer, Division of Water Resources

TO THE CITIZENS OF THE STATE OF NEVADA:

This Report is one of a series of Planning Reports to be prepared for the people of Nevada to assist them in following and understanding the development of the State Water Plan.

One of the Principles we have established for planning the use of the water and related land resources of Nevada is that early attention will be given to meeting the needs of those areas of the State which are presently experiencing water shortages and those areas which may be water deficient in the near future.

Following this Principle, a consulting engineering firm, Montgomery Engineers of Nevada, was chosen to study and evaluate alternative ways to meet the potential water needs in Southern Nevada over and above those which can be met with the importation of Nevada's allocation of mainstream water from the Colorado River through the Southern Nevada Water Project.

Five alternatives were considered and are described briefly as follows:

1. Importation of Water from sources within Nevada.
2. Importation of Water from sources outside Nevada including desalinization of ocean water and exchange with the Metropolitan Water District.
3. Alleviating water needs through the economization of water.
4. Population Redistribution.
5. Limiting Population Growth.

While this Planning Report deals with future water needs in Southern Nevada the concepts and effects of the alternate courses of action considered are applicable throughout the State.

The Report will be widely distributed for review and public meetings will be held with agencies and groups to discuss the Study. It is our opinion that the Report and such meetings will provide the type of information needed to facilitate the decision making process.

Respectfully,

Roland D. Westergard
State Engineer

# WATER SUPPLY FOR THE FUTURE IN SOUTHERN NEVADA

Special Planning Report

# SUMMARY

1. The Las Vegas Metropolitan Subarea is predicted to have a population of between 1,100,000 and 1,300,000 in the year 2020.

2. The water requirements for Las Vegas Metropolitan Subarea are expected to exceed supply (ground water, Lake Mead water, and reclaimed waste water) by 28 percent to 39 percent in the year 2020 respectively for the low and high population projections.

3. Other subareas near Las Vegas have been investigated in order to ascertain whether the projected deficiency is widespread and whether these subareas might have water available for export. In determining whether water would be available for export, an amount of water equivalent to that contained in the upper 100 feet of the ground water basin was considered to be available for mining. The results for the nine subareas studied follows:

| Subarea with Water Deficiency | Subareas with Water Balance | Subareas with Water Available for Export |
|---|---|---|
| Las Vegas Metropolitan | Fort Mojave | Virgin Valley |
| | LMNRA | Pahrump Valley |
| | Moapa Valley | Amargosa Desert |
| | | Railroad Valley |
| | | Pahranagat Valley |

4. Of the five subareas with water available for export, all but the Virgin Valley have enough water resources to supply Las Vegas' needs through the year 2020, if an amount of ground water equivalent to storage in the upper 100 feet of saturated material is considered available for export to Las Vegas. The water is of acceptable quality except for high fluorides in Amargosa Desert and very high dissolved solids in the Virgin River.

5. The estimated cost of importing water from outside Nevada is as follows:

| Plan | Unit Cost Production $/Ac. Ft. | Unit Cost Production & Distribution $/Ac. Ft.° |
|---|---|---|
| Snake-Colorado Project | 175 | 240 |
| Modified Snake-Colorado Project | 190 | 255 |
| Desalinization | 200 | 265 |

° Cost to ultimate consumer
°° All plans based on utilization of Lake Mead or a terminal reservoir.

6. Instead of constructing expensive facilities for conveying water to Las Vegas, it is believed feasible to reduce water consumption in Las Vegas so that a water shortage would not occur. An estimated increase in water rates of about 100 percent is believed to be sufficient to achieve this.

7. Redistribution of population to subareas with water surpluses may be possible if enough incentives are established by governing bodies. However, the cost of transporting workers between these outlying subareas and Las Vegas greatly exceeds the cost of constructing aqueduct systems.

8. Elimination of the water problem faced by Nevada could result if projected population growth failed to occur; however it is difficult to conceive of a deterrant to population growth which would not adversely affect present residents of Nevada.

9. The estimated cost, based on 1970 construction costs and 7 percent interest, of water from the five subareas of surplus conveyed to Las Vegas is as follows:

# SUMMARY

| Project | High Population Projection | | | Low Population Projection | | |
|---|---|---|---|---|---|---|
| | Capital Cost | Unit Cost Delivered | Unit Cost Delivered & Distributed* | Capital Cost | Unit Cost Delivered | Unit Cost Delivered & Distributed* |
| Pahrump Valley | $237 million | $186/ac. ft | $248/ac. ft | $185 million | $168/ac. ft. | $230/ac. ft |
| Amargosa Desert | $295 million | $270/ac. ft | 332/ac. ft | $227 million | $225/ac. ft. | 287/ac. ft |
| Railroad Valley | $474 million | $252/ac. ft. | 330/ac. ft | $372 million | $268/ac. ft. | 314/ac. ft |
| Pahranagat Valley | $246 million | $214/ac. ft. | 276/ac. ft | $192 million | $178/ac. ft. | 240/ac. ft |
| Virgin Valley | ---*** | $ 63/ac. ft.** | 125/ac. ft | ---*** | $ 63/ac. ft.** | 125/ac. ft |

* Cost to ultimate consumer

** Estimated unit cost based on using Lake Mead for storage, blending and conveyance.

*** The capital cost of the Virgin River project would depend upon the amount of upstream use.

# RECOMMENDATIONS

1. A continuing educational program should be initiated immediately to inform residents of the Las Vegas Metropolitan Subarea of the need to conserve water. The intent of such a program would be to achieve a pattern of voluntary reduction in use so that the need to import water before 2020 would be obviated.

2. A tri-state compact should be consummated with Utah and Arizona concerning rights to the Virgin River. Negotiations should be continued with the U.S. Bureau of Reclamation to obtain credit for flows, both surface and underground, entering Lake Mead from the Virgin River.

3. Nevada should join with other southwestern states to formulate a plan to import water from outside this arid region. The target date for deliveries should be not later than 2020.

4. Nevada should continue to work with other states along the Colorado River to reduce the river's degradation.

5. If development, in an area warrants further investigation of its ground water basin, or if a basin is seriously being considered as a source for export of ground water, then it is recommended that it be investigated in much more detail than has been done to date in order to more clearly define its water resource and the inter relationship of this resource with other basins.

6. This report should be widely distributed for comment. After receiving a broad spectrum views concerning it, the most promising plans to alleviate the projected water shortage in Las Vegas should be investigated further.

# PART 1

# NARRATIVE SUMMARY

Paradoxically, at the time when southern Nevada is anticipating its first deliveries of water from the Southern Nevada Water Project (SNWP) concerned water administrators in the Division of Water Resources are looking ahead to the turn of the century when a water shortage may again occur. This report examines the water requirements and possible sources of a supplemental supply in the period from 1993 to 2020. The first date is the earliest at which a problem is expected. The second is the latest assumed time when additional water will become available from outside Nevada and the problem will no longer exist.

The purpose of this study is to make an overview of the logical alternatives open to water managers of Nevada, estimate the cost of each alternative, and try to forecast the effects of implementing each plan. Needless to say, this study is of reconnaissance grade, but it does delineate the more promising plans for further study.

This report has been divided into two parts so that the casual reader as well as one who is technically oriented may each have a readable and complete account of the findings of the study. Part 1 minimizes details and technical jargon, while Part 2 contains necessary backup material to make the findings understandable and reproducible.

The study area is the populated or soon-to-be populated portion of southern Nevada and five possible areas having a substantial water resource. The study area has been divided into nine subareas as shown on Figure 1. Many small communities have been left out of the study, because it is believed they will not affect its results and to investigate the entire southern Nevada water situation is beyond the scope of the report.

To quantify the extent of the problem, population projections have been made for each subarea. From the population predictions, water requirements for each subarea have been estimated for the year 2020. These water requirements are based on a supply of potable water being available at reasonable prices. Each subarea has some water supply. For the purposes of this study, it has been assumed that the equivalent amount of water contained in the upper 100 feet of the stored ground water also would be available for mining. That supply has been balanced against the subarea's demand in 2020 with the following result.

| Subarea with Water Deficiency | Subareas with Water Balance | Subareas with Water Available for Export |
|---|---|---|
| Las Vegas Metropolitan | Fort Mojave<br>LMNRA<br>Moapa Valley | Virgin Valley<br>Pahrump Valley<br>Amargosa Desert<br>Railroad Valley<br>Pahranagat Valley |

Concluding that only one subarea, Las Vegas Metropolitan, will have a serious water shortage before 2020, various intrastate and interstate schemes for alleviating the projected shortage have been studied. All schemes have been found to be extremely expensive; far costlier than any of today's sources.


LOCATION MAP
SHOWING STUDY AREA BOUNDARIES

## NARRATIVE SUMMARY

In addition to the engineering studies, economic investigations have been made of the possibility of reducing demand, dispersing population or limiting population growth, in efforts to eliminate the shortage.

If we start the 21st century with a water shortage in Las Vegas, it is simply because of people--too many of them. Trying to predict population growth has always been an onerous task as the recent census so capably demonstrated. But even the census bureau has its share of problems. When it released the 1970 figures, the census bureau also released new predictions for United States population in 2000. The new predictions were from 6 percent to 11 percent lower than those previously predicted by the bureau.

Why the decrease? The principal reason is that the birthrate has slumped from an average of 3.24 children per woman of child bearing age in the period from 1945 to 1965 to today's rate of 2.45. This little-noticed trend could affect all long-term population projections. It could materially affect the water demand in Las Vegas. The study, however, has been completed on the basis of no drastic downturn in the rate of population growth.

It has been assumed that reclaimed waste water, to the extent of 30 percent of total water demand of the Las Vegas Metropolitan subarea would be available for use by the time it is needed. Whether the waste water is made available as a credit after discharge into the mainstem of the Colorado River, as a potable water after receiving extensive treatment, or as an increased ground water resource after being used to recharge the ground water basin is immaterial from the standpoint of this study as long as it is cheaper than the importation plans.

A description of each subarea along with its predicted population in 2020, its water requirements, and its water resource is given in the following paragraphs.

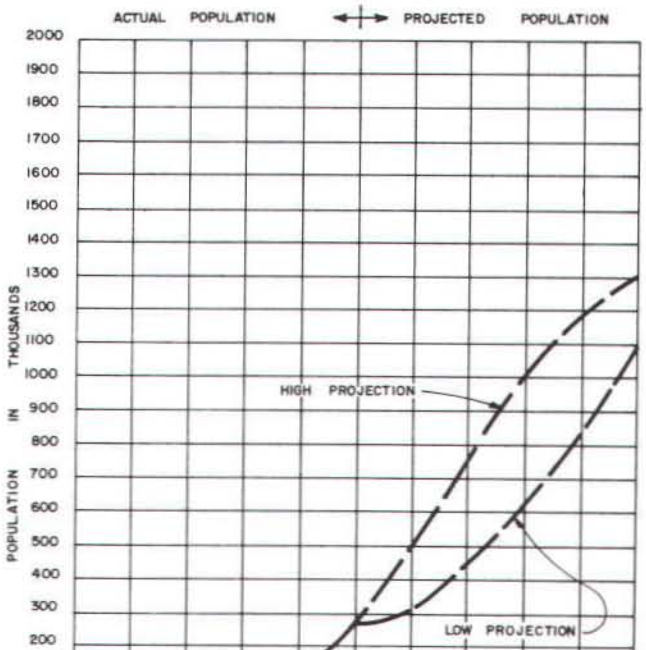
### DESCRIPTION OF STUDY AREA

**Las Vegas Metropolitan Subarea.** The Las Vegas Metropolitan subarea is located in southern Nevada and includes the cities of Las Vegas, North Las Vegas, Boulder City, and Henderson. On the western boundary of the subarea are the Spring Mountains, while along the eastern side are the Las Vegas and Sheep Ranges and Frenchman Mountain. The northern border is formed by the Desert, Pintwater, and Spotted Ranges, and the McCullough Range and River Mountains form the southern border.

The climate of the subarea is arid, the average annual precipitation being approximately 4 inches. The summers are long and commonly have temperatures of 100 degrees or more, while the winters are short and mild. No perennial streams of any significance cross the basin. The Las Vegas Valley is drained to Lake Mead by Las Vegas Wash which carries a perennial flow consisting mostly of waste water.

Latest population figures indicate that the subarea supports approximately 265,000 residents. The bulk of this population is centered in Las Vegas and North Las Vegas. During the last 20 years the subarea has experienced one of the fastest growth rates in the nation. The 1950 population of about 48,000 has risen more than 400 percent to reach its present level. Two industries, the gaming-entertainment industry and the military-nuclear research-heavy industry, have been the primary factors contributing to this growth. The tourist related industry is the most important, accounting for a direct employment of about 34,000. The other industries involve approximately 16,000 employees.

Water requirements for the Las Vegas Metropolitan subarea have been determined on the basis of the population estimates shown in Figure 2. These water requirements do not include water for any new major power generation installation in the study area. These water requirements,

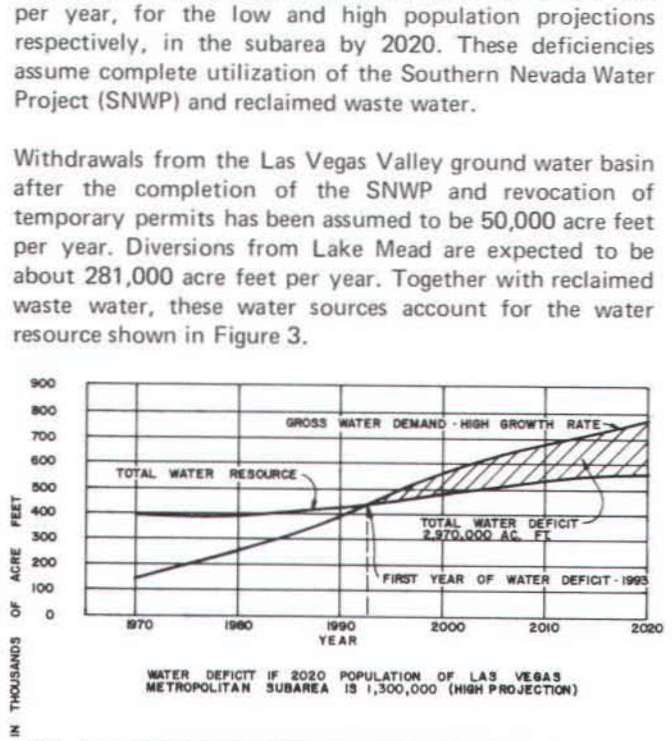



(FIG. 2)

POPULATION PROJECTIONS IN
LAS VEGAS METROPOLITAN SUBAREA

shown graphically in Figure 3, indicate that there will be a deficiency of from 131,000 acre feet to 211,000 acre feet per year, for the low and high population projections respectively, in the subarea by 2020. These deficiencies assume complete utilization of the Southern Nevada Water Project (SNWP) and reclaimed waste water.

Withdrawals from the Las Vegas Valley ground water basin after the completion of the SNWP and revocation of temporary permits has been assumed to be 50,000 acre feet per year. Diversions from Lake Mead are expected to be about 281,000 acre feet per year. Together with reclaimed waste water, these water sources account for the water resource shown in Figure 3.




(FIG. 3) WATER DEFICIT IF 2020 POPULATION OF LAS VEGAS METROPOLITAN SUBAREA IS 1,100,000 (LOW PROJECTION)

COMPONENTS OF TOTAL WATER RESOURCE

1. Withdrawal from Las Vegas Ground-Water Basin 50,000 Ac. Ft./Yr.
2. Nevada's entitlement of Colorado River water which is available for use in Las Vegas Metropolitan Subarea is approximately 281,000 Ac. Ft./Yr.
3. Quantity of reclaimed water is 0.3 times the gross water demand.

GROSS WATER DEMAND BASED ON:

1. Present daily per capita use of 475 gallons
2. Per capita water use will increase at the rate of 2.5 percent each 10 year period.

**Fort Mojave Subarea** The Fort Mojave subarea is located at the extreme southern tip of Nevada approximately 100 miles south and slightly east of Las Vegas. On the east, the subarea is bordered by the Colorado River, while north is the Lake Mead National Recreation Area. The land in the subarea is undeveloped desert with some hills and gullies. Vegetation is sparse in this arid land. As is usual for southern Nevada, the average annual rainfall is low and long, hot summers and short, mild winters are common.

The population of this subarea is almost 100. The Southern California Edison Company recently completed construction of a steam power generating station in the subarea. Land developers have plans to develop the subarea as a second home or retirement place with some modest-size casinos and hotels complementing the usual commerical enterprises. The entire subarea is planned to be water oriented as full use of the Colorado River frontage is anticipated.

The future water requirements of this subarea depend primarily upon whether development materializes. If the developer's plans for the area become reality, then considerable water would be required. The Colorado River Commission of Nevada (CRC), has tentatively allotted 13,000 acre feet of water per year to four development firms which have plans for the subarea. In addition, the CRC has allotted a variable amount to the Edison Company; 30,000 acre feet per year to 1985, a steadily declining amount varying between 30,000 in 1985 and 15,000 in 2000; 15,000 acre feet per year from 2000 to 2006; and nothing after 2006. The allocations for the developers from the mainstem of the Colorado River are sufficient to support an equivalent permanent population of about 50,000; a probable figure for the area by the year 2020. In addition to using water from the mainstem of the river, ground water may also be withdrawn for domestic use. Therefore no water shortage is foreseen for the Fort Mojave subarea.

**Lake Mead Nation Recreation Area (LMNRA).** The Lake Mead National Recreation Area is the subarea encompassing the shoreline of Lakes Mead and Mojave and a portion of the Colorado River running along the easterly boundary of the state. This subarea extends back from the shoreline a few miles and has a boundary that is highly irregular.

The vegetation is very sparse, as is characteristic for all of southern Nevada. Also, the climate is arid, with long, hot summers and short, mild winters. Total permanent population of the area is estimated to be only about 300 although 5.75 million visitor days were spent in the subarea during 1969.

The assumption has been made that the Nevada portion of the LMNRA, along with other federal users such as indian reservations, will need in the future about 6,000 acre feet per year from the mainstem of the Colorado River. There are so many intangibles associated with the water requirements for the LMNRA that it is hazardous to predict whether a water shortage will occur by 2020. The large proportion of transients consuming water, unquantified needs on federal lands and the varied type of water use all contribute to the difficulty in assessing the future water situation in this subarea. However, it seems that a balance between supply and demand may occur for the LMNRA and other federal users. Consequently, it has been assumed that the LMNRA is a subarea without a water surplus or deficiency.

**Moapa Valley Subarea.** The Moapa Valley subarea is located approximately 50 miles northeast of Las Vegas in the Muddy River drainage basin. Gentle-rolling hills and flat lands predominate in this subarea of moderate relief. The elevation varies only about 500 feet from a low of nearly 1200 feet. As is typical for the southern region of Nevada, the land is desert with sparse vegetation. Precipitation averages less than 5 inches a year, most of which occurs in short intense storms. The climate is characterized by long, hot summers and short, mild winters, which are common to all of southern Nevada.

This subarea is identical to numerous other undeveloped southern Nevada regions in its sparsity of population. Total population of the four primary towns, Moapa, Glendale, Logandale and Overton is about 2,200. Agriculture and tourism are the base industries. The subarea also serves as a bedroom community for a few workers employed in Las Vegas and at the Nevada Test Site.

Moapa Valley is supplied water from the Muddy River which is fed by numerous small springs. The springs collectively discharge water at an almost constant rate of 46.5 cubic feet per second (34,000 acre feet per year). While the top 100 feet of the ground water basin has 800,000 acre feet of water in storage, it is of poor quality.

It appears that the water resources available within this subarea will be sufficient for its needs through the year 2020. If the water now being utilized for agricultural use is diverted to municipal and industrial use, Moapa Valley could support a total population of 50,000 far more than the 20,000 considered to be the most probable population. The water would have to be treated to reduce the fluoride content before being used for domestic purposes. Excessive fluoride causes discoloration of teeth if it is persistently used.

**Virgin Valley Subarea.** The Virgin Valley subarea is located northeast of Las Vegas, approximately 80 miles distant. It includes the portion of Nevada along the lower Virgin River. The climate of this subarea is characterized by the usual southern Nevada long, hot summers and short, mild winters. Average annual precipitation is near 5 inches, accounting for the sparsity of vegetation.

Total population of the subarea is probably less than 1,100 with 700 residing in Mesquite and 300 in Bunkerville. Farming is the base industry. About 3,000 acres are currently under cultivation. There are also dairy and range cattle in the subarea. Highway 91 passes through Mesquite and tourist-related services are prevalent there.

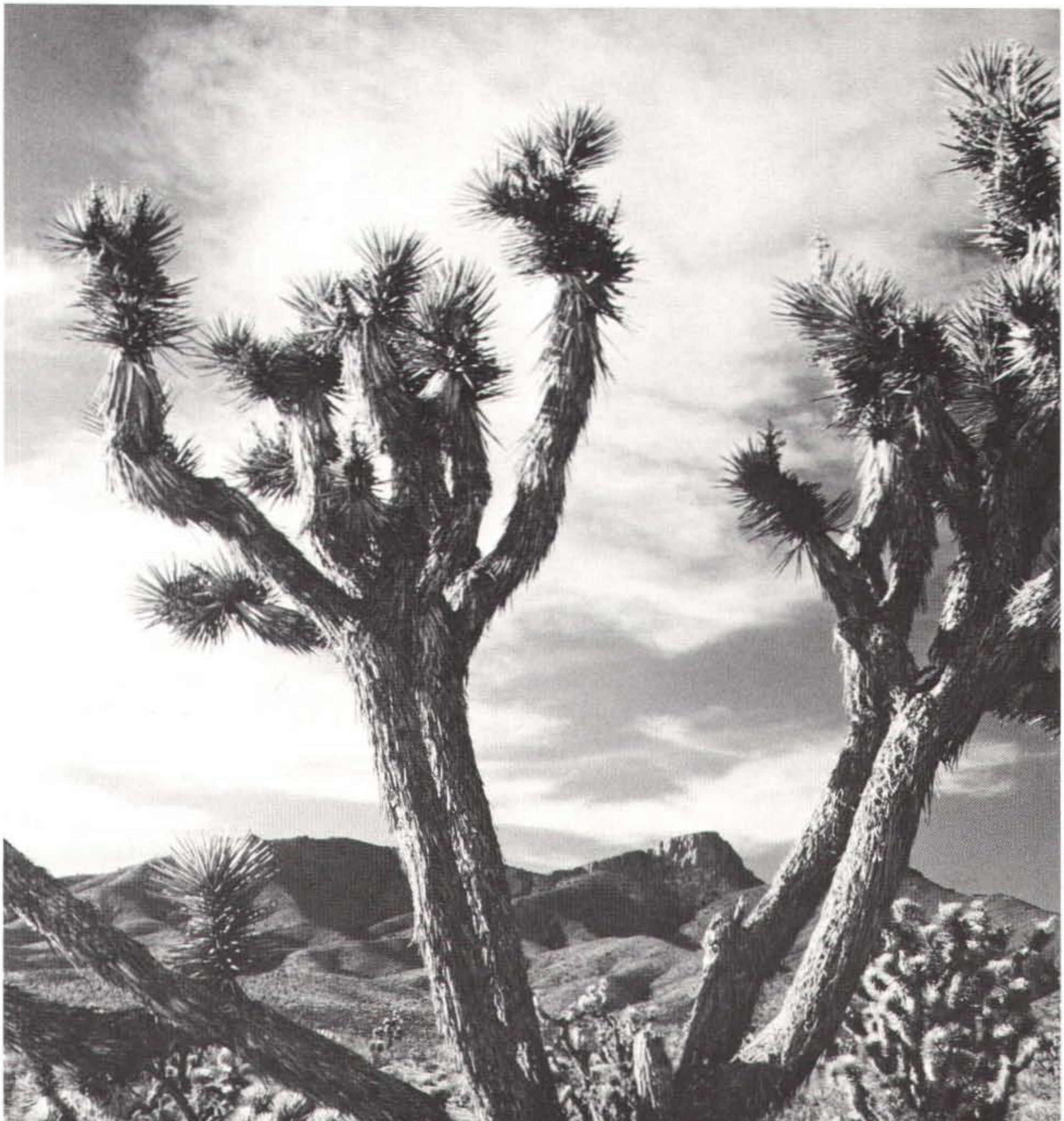
The assumption has been made that this subarea is too far removed from Las Vegas to become an important commuter community, it is estimated that the population in 2020 will be about 10,000.

The domestic water requirement for that population will be about 4,500 acre feet per year. Even with the present agricultural water use of 13,000 acre feet per year added, the total water demand in 2020 falls short of the 123,000 acre feet per year expected to reach Lake Mead, as surface flow and ground water movement. If the proposed Dixie Project on the Upper Virgin River is constructed, the quantity of water reaching Lake Mead would be reduced to 60,000 acre feet per year.

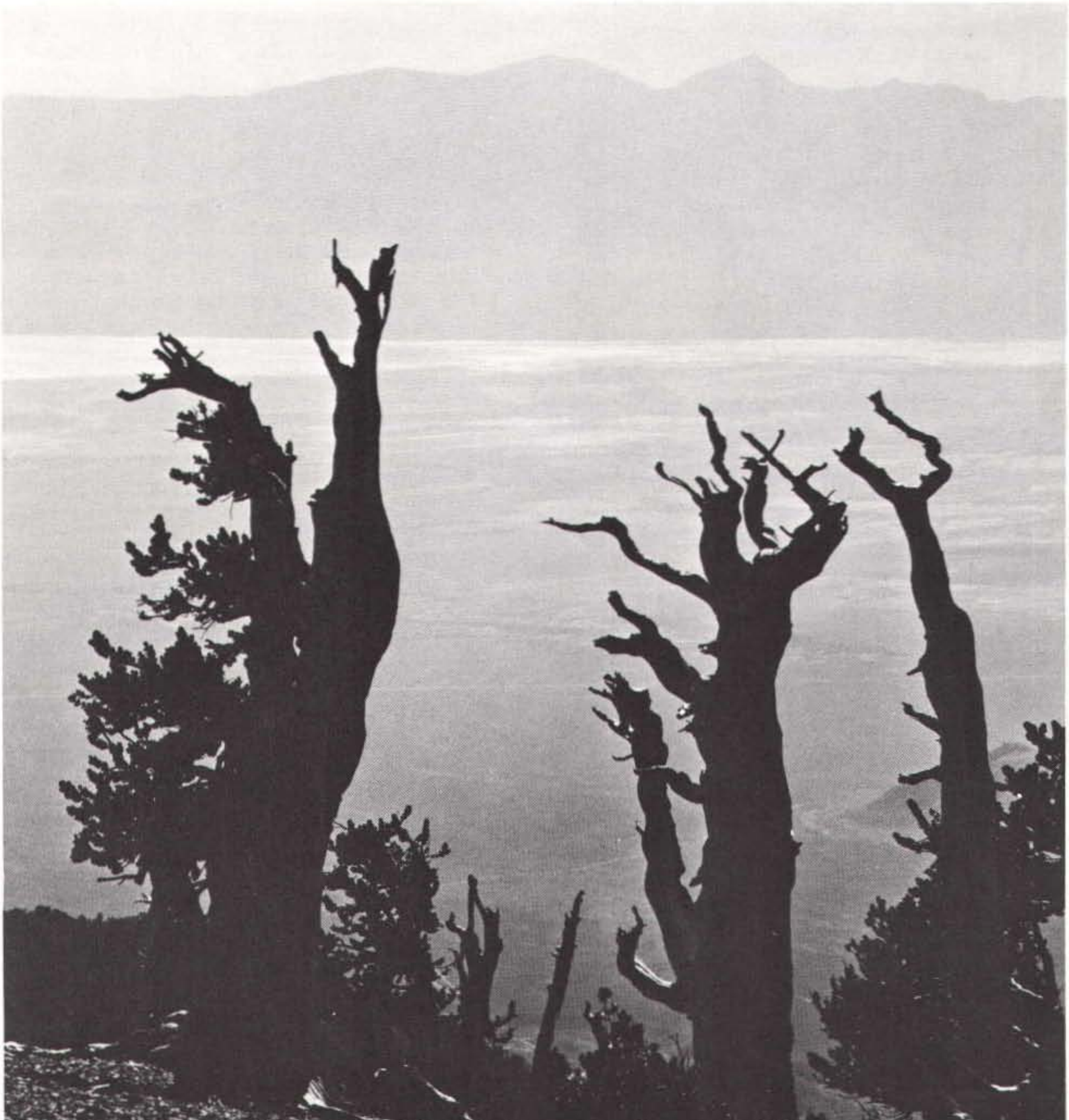
Without very expensive storage and treatment, the Virgin River cannot be considered a good source of water for exportation to Las Vegas because of its irregular flow and very poor quality (very high dissolved solids which can impart taste to the water and act as a cathargic). Since the United States Supreme Court has held that the Lower Basin states are entitled to exclusive use of the tributaries of the Colorado River within each state, the possibility exists that an entitlement could be obtained for the surface and subsurface inflow to the mainstem of the Colorado River from the Virgin Valley. This combined outflow to Lake Mead has been estimated to be about 123,000 acre feet per year, two-thirds being surface water and one-third ground water. By claiming that the introduction of Virgin Valley water into Lake Mead creates an entitlement by the State to increase diversions of water from the mainstem of the Colorado River over and above the 300,000 acre feet per year apportioned to Nevada, the State might use Lake Mead as a conduit and divert the subject tributary water from the lake at any convenient location. The quality of water would be greatly improved by its being blended with Lake Mead water.

**Pahrump Valley Subarea.** The Pahrump Valley subarea is situated about 60 miles west of Las Vegas. The valley is approximately 42 miles in length trending northwest-southwest between the Spring Mountains on the east and the Nesting Spring, Nopah, and Kingston Ranges on the west. Pahrump Valley is a closed topographic basin since there is no outlet for streams to flow from the valley.

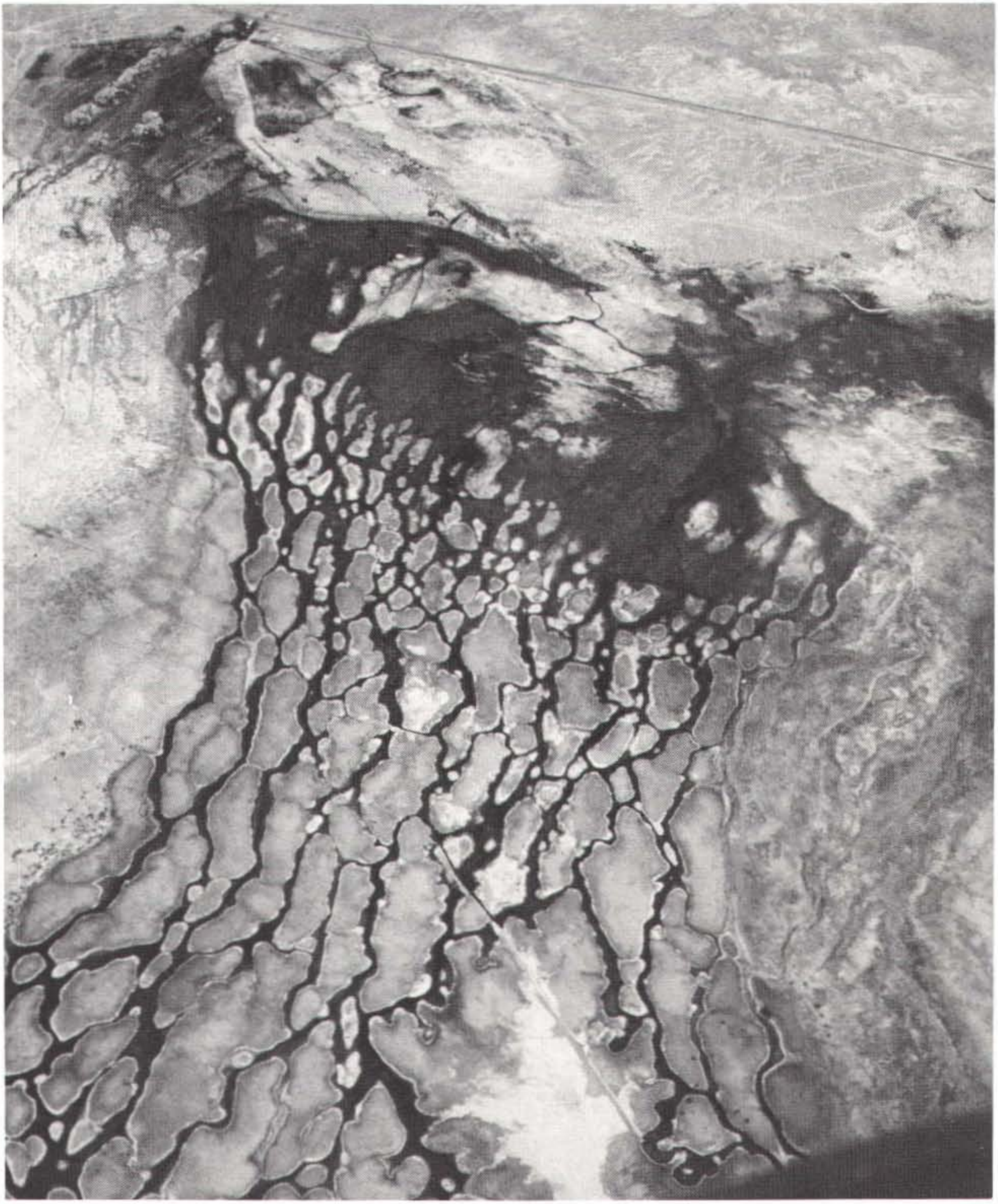
The topography of this subarea is typical of the basins in the Basin and Range Province. The valley is characterized



VIRGIN RIVER COUNTRY – NEVADA



PAHRUMP VALLEY – NEVADA FROM MT. CHARLESTON



AERIAL – SPRINGS AT LOCKES – RAILROAD VALLEY – NEVADA

The present population of Railroad Valley is less than 100, consisting wholly of people on a few farms in the area. Current is the one small community located in the valley.

No population growth is expected in the area in the future. Existing farms may continue; however, most likely no sizeable population increase above the present population is expected, unless federally-controlled lands are made easily available for development.

The Railroad Valley ground water basin is large and contains water of good quality. The volume stored, 7 million acre feet in the top 100 feet, is more than adequate to satisfy Las Vegas' needs past 2020. Exportation from Railroad Valley would affect residents of the subarea of origin the least of any intrastate plan.

**Pahranagat Valley Subarea.** The Pahranagat Valley subarea is situated about 90 miles north of Las Vegas. The valley trends north-south for about 30 miles. The northern boundary is formed by the junction with Pahroc Valley. The north end of the Sheep Mountains marks the southern boundary of the subarea. On the east the Hiko Range forms the boundary and on the west is the Pahranagat Range.

An arid climate is characteristic of Pahranagat Valley. The winters are cool while the summers are hot. A large range in daily and seasonal temperatures is common. Average annual precipitation is about 6.5 inches. Vegetation is sparse except for a green strip about a quarter of a mile wide down the middle of the valley.

Total population of the subarea is less than 500, of which 300 reside in Alamo. Ash Springs, Crystal Springs, and Hiko are three very small communities in the subarea north of Alamo. Farming is the economic base with about 6,000 irrigated acres. The non-farming population is generally engaged in work with the Nevada Highway Department or local service activity; some also work in Las Vegas and at the Nevada Test Site.

The water requirements of the valley are approximately 25,000 acre feet per year. The estimated increase in population to 2,500 in 2020 will not have much affect on the water requirements. With an annual recharge of 25,000 acre feet and 2.2 million acre feet in the top 100 feet of ground water storage, this valley is a likely candidate as an area of origin. If irrigation water rights are purchased and the ground water basin is used as a supplemental water supply for Las Vegas, two effects could materialize. The springs feeding the Muddy River could reduce their flow and the Pahranagat Lakes could become dry. The former would have an adverse effect on Moapa Valley. The latter would have a serious effect on the wildlife using these lakes.

## ALTERNATIVE WATER SUPPLY PLANS

There have been eight alternative water supply plans considered in this study. Five of the plans import water to the Las Vegas subarea from areas within Nevada, and the other three alternatives bring water from out-of-state areas. Although the eight plans considered are not intended to be an all-inclusive list of the possible water supply alternatives for supplying additional water to southern Nevada, they are a representative sample of the most feasible alternatives. Each plan considered has been analyzed singly and not in combination with any other plan.

**Intrastate Water Plans.** Four of the five plans studied require pumpage of ground water from one of the following subareas: (1) Pahrump Valley, (2) Amargosa Desert, (3) Railroad Valley, and (4) Pahranagat Valley. In each plan it is proposed to transport ground water from the subarea by aqueduct to a reservoir near Las Vegas. From there, the water could be treated and conveyed by gravity to the Las Vegas Metropolitan subarea. The fifth plan involves the use of Virgin River outflow to Lake Mead. Water from that river would use Lake Mead for conveyance, blending, and storage.

All five plans have been designed for both the high and low population estimates. The analysis for each population estimate includes a paper layout of the physical components of the water collection and supply systems and an estimate of the cost of the facilities. The cost analyses have been done on the basis of a 7 percent interest rate on capital investment and 1970 construction costs. Reparations for obtaining water rights have been included as a capital cost. The amortization period (useful project life) varies for each of the plans.

It should be emphasized at this point that all of the intrastate water plans, except importation from Virgin Valley, are interim projects. Once the end of the useful project life has been reached, it has been assumed that the projects would cease to supply water to Las Vegas. For each of the plans, the useful life has been assumed to be the amount of time required to withdraw an amount of ground water equivalent to that contained in the upper 100 feet of saturated valley fill or 50 years, whichever is shorter.

The aqueducts have been sized to convey 120 percent of average annual demand for imported water in the year 2020 as far as the terminal reservoirs. This results in a design flow of 350 cubic feet per second for the high population projection and 216 cubic feet per second for the low projection. Downstream of the terminal reservoirs, the aqueducts have been sized to deliver 135 percent of average flow. The terminal reservoir has been determined to be either 11,000 acre feet or 14,000 acre feet in size in order (corresponding to the FY1971 rate on federal loans for water projects) had been used the effect would have been to reduce the unit price of water about 20 percent in the case of Railroad Valley and Virgin Valley plans and about 15 percent in the case of Pahrump, Amargosa and Pahranagat plans.

**Interstate Plans**

In addition to the alternative intrastate water supply plans, there are several interstate alternatives considered in this study. Two different categories of interstate water plans have been investigated. One category consists of regional water plans which were developed to transfer large quantities of water from one region of the country to another. All of these plans involved interstate movement of water. The second category pertains to developing a desalinization plant. Although the interstate plans investigated in this study have not been intended to be an all-inclusive list, they are a representative sample of the best known alternatives.

Since the regional water plans were proposed in the middle 1960's, their cost analysis had to be adjusted to reflect 1970 construction costs and an assumed interest rate of 7 percent. Also, it has been necessary to add to the construction cost the following costs in order to make the economics comparable to those for the intrastate plans: contingencies, engineering, legal, administration, and financing costs. These three adjustments have been made and the costs for the regional plans have been recomputed accordingly.

**Snake-Colorado Project.** This plan was presented by Samuel B. Nelson of the Los Angeles Department of Water and Power in 1963. Nelson proposed to diver 2.4 million acre feet per year from the Snake River and transport it to Lake Mead, a total distance of about 520 miles. From Lake Mead, some of this water could be diverted for use in the Las Vegas Metropolitan area.

The unit cost for water delivered to Lake Mead was shown to be $32 per acre foot in Nelson's economic analysis. This cost was updated to reflect 1970 costs, a 7 percent interest rate, contingencies and non-construction costs. Finally a cost of $63 per acre foot has been added as an estimate of the cost of treating and transporting the water from Lake Mead to the Las Vegas Metropolitan subarea. The total up-dated unit cost has been determined to be $175 per acre foot of treated water delivered to the Las Vegas Metropolitan subarea.

**Sierra-Cascade Project.** The Sierra-Cascade Project was presented in 1964 by E. Frank Miller. This plan was larger in scope than the Snake-Colorado Project since it proposed to divert up to 30-million acre feet per year from the lower Columbia River and eventually transport it to Lake Mead.

The economic analysis presented in this project was very complicated. An adjusted cost analysis for this project has not been made because the time required for this analysis was beyond the scope of this study.

**Modified Snake-Colorado Project.** The last regional water importation plan investigated in the study was the Modified Snake-Colorado Project. This plan was proposed in its final form by William G. Dunn in 1965. In this plan Dunn proposed to divert 15-million acre feet per year from the lower Snake River and the Columbia River and transport it to Lake Mead through a 1,016-mile aqueduct. This plan was claimed to provide eleven western states with adequate water supplies for a period of 50 to 60 years.

The economic analysis presented by Dunn indicates that the cost for water in this plan would be $37.60 per acre foot. This cost was based on a 3 percent interest rate and 1965 construction costs. By making the same adjustments as before, the adjusted unit cost has been determined to be $128 per acre foot. After adding the $63 per acre foot for transportation and treatment of the water from Lake Mead to Las Vegas, the total unit cost has been computed to be $191 per acre foot of treated water delivered to the Las Vegas Metropolitan subarea.

**Desalinization.** The second category of interstate water plans investigated in this study is desalinization of sea water. In this analysis it has been assumed that a desalinization plant would be built on the Pacific Coast in southern California. The potable water from this plant would be delivered to the Metropolitan Water District of Southern California (MWD) in exchange for an equal amount of MWD's share of Colorado River water.

Costs associated with this analysis can be separated into two divisions. The first is the cost of producing the potable water and transporting it to the MWD system. The second division includes the cost of delivering and treating the exchanged MWD water from Lake Mead to the Las Vegas Metropolitan subarea.

A cost analysis has been made to determine the approximate cost of constructing and operating a desalinization plant along the California coast near Los Angeles. This economic analysis indicated that for a 7 percent interest rate and 1970 construction costs the unit cost for desalinization and delivery to MWD would be approximately $149 per acre foot. The cost of delivering and treating the water from Lake Mead to the Las Vegas Metropolitan subarea has been estimated to be $63 per acre foot. It has been assumed that the cost saved by MWD in treatment and transportation costs would be nearly $12 per acre foot of treated water. The net unit cost has been determined to be $200 per acre foot of treated water delivered to the Las Vegas Metropolitan subarea.

## ALLEVIATING WATER SHORTAGE BY REDUCING CONSUMPTION, REDISTRIBUTING POPULATION, OR LIMITING POPULATION

### Reduction of Per Capita Consumption

One alternative solution to the impending water shortage of the Las Vegas Metropolitan subarea is to reduce the consumption of water. By reducing the per capita water consumption it would be possible to completely avert a water shortage through 2020. It has been estimated that if the per capita consumption could be reduced by 28 to 39 percent the water shortage problem would be solved for the study period.

Water consumption rates exhibit a great variation across the country, ranging from around 50 gallons per capita per day (gpcd) to over 500 gpcd. The Las Vegas Metropolitan subarea consumption rate has been estimated at approximately 475 gpcd. This can be compared with the corresponding current consumption rate in Tucson, Arizona, which has a similar climate of about 200 gpcd.

The affluence of the residents and the climate of the area are largely responsible for the great range in per capita consumption rates. In the Las Vegas Metropolitan subarea, approximately 70 percent of the summer water use is devoted to uses outside of the home. Watering lawns and other green areas accounts for the bulk of this outside use, and it is in these areas of water use where the greatest curtailment can be realized.

In order to curtail water consumption in the Las Vegas Metropolitan subarea, it would be necessary to provide an economic incentive to the water users or to create a sense of conservation among users. Increased water rates to cover the cost of obtaining water from the next supply source would have a two-fold beneficial effect. First, it would generate revenue for financing additional water projects; and second, the economic factor of increased water rates would result in reduced consumption.

It appears feasible to reduce per capital water consumption by increasing rates about 100 percent. The effects of this alternative would be to change the pattern of water use. In a large measure, the acceptance by the population that the southern Nevada area is arid and hence not as able to maintain the greenery they might have been accustomed to in more humid environments would greatly help to reduce consumption. The residents of Tucson have, to a large degree, adapted to the desert climate, as evidenced by their water consumption of 200 gpcd. A reduction in the Las Vegas Metropolitan subarea to about 325 gpcd would be sufficient to avert the predicted water shortage problems.

### Population Redistribution

Another possible solution to the impending water shortage problem which requires no additonal water supplies for the Las Vegas Metropolitan subarea is population redistribution to subareas where excess water would be available if stored ground water were to be mined. Two possible stimulations might attract population dispersion. In the first case, industrial activity in outlying areas could be encouraged by offering industry economic advantages. This type of activity would result in development of supporting activities and consequent population growth. The second stimulation would be to provide economic advantages to people to live in the subareas away from Las Vegas. In both of these cases, population dispersion could be accomplished; and there would be no need to import water into the Las Vegas Metropolitan subarea.

The growth effects of large cities are such that as a city expands in population the cost of living rises while the standard of living falls. As more and more people take up residence, congestion leads to all the consequent problems of air pollution, uncleanliness, crime, etc., while at the same time rents and other living costs tend to get higher. In light of this reasoning, it is evident that a dispersed population in a certain sense results in a more desirable way of life. However, there are numerous advantages to urban life, some of which include a wider range of services and a wider economic base.

There are many difficulties related to accomplishing an effective program of population dispersion. No sure method exists since people cannot be forced into dispersing against their wills. Encouragement must be offered through economic advantages to disperse, and the amount of economic advantage needed to induce people to move is open to question. Based on the high population estimate, it has been estimated that as many as 450,000 people might be located somewhere outside the Las Vegas Metropolitan subarea by the year 2020. All of the subareas, excepting remote Railroad Valley, appear to offer potential sites for increased population. Should population dispersion be effected and an increase in population experienced at the various subareas, the economy of these subareas is expected to realize a drastic change since in most cases, the existing base industry for the subareas is small and is related to tourism and agriculture.

In order to accommodate the expansion attendant with population dispersion, a quick and convenient means of traveling between the outlying subareas and the Las Vegas Metropolitan subarea would be desirable for the approximately 80,000 people who would commute to Las Vegas each work day. On that basis, a mass transportation study has been made to determine its feasibility. For this study, it was assumed that 15,000 commuters would travel by car. A total round trip 120 miles has been taken as representative of the distances to the potential subareas for accepting dispersed population. Four different modes of travel were investigated: bus, automobile, tracked air cushion vehicle (TAVC) and airplane, Using current fares and an estimated fare in the case of the TAVC, daily commuting costs were computed. It was found that the total annual costs of commuting would be more than double the annual costs of an aqueduct system to bring sufficient water to Las Vegas. Hence, it appears that factors other than economic must be used to justify population dispersion.

**Limiting Population Growth**

If it were possible to limit the population of southern Nevada, or more specifically the Las Vegas Metropolitan subarea, to 72 or 61 percent of the projected low and high populations respectively in the year 2020, a water shortage could be averted. Projected populations for the Las Vegas Metropolitan subarea for year 2020 range from 1,100,000 to 1,300,000. The water supply available to the Las Vegas Metropolitan subarea (50,000 acre feet from wells, 281,000 acre feet from the mainstem of the Colorado River, and 30 percent recovery and reuse of the two previous sources) would support a population of 800,000 people in the manner to which they are presently accustomed. While there are conceivable methods of controlling population growth, there are a few which would not adversely affect present residents. One possibility for controlling growth would be to encourage a reduction in the birth rate within the State. This policy if accepted and adopted by Nevada could conceivably control growth from within the State but would be inaffective against controlling migration to the State.

A possibility for controlling growth which would be effective against migration is to control or limit economic growth. This could be accomplished by zoning, excessive taxes, severe anti-pollution requirements, etc. This approach to population control presupposes that people would not locate in an area in which it would be impossible to find employment. While such economic measures may effectively inhibit population growth it cannot be pursued without adversely affecting the present residents.

## COMPARISON OF ALTERNATIVES

Several solutions to the impending water shortage in the Las Vegas Metropolitan subarea have been studied. Cost analyses are given for water importation plans; but because of the intangible economics involved in population dispersion and reduction in per capita consumption and limiting population growth, no cost analysis is given for these alternatives. Table 2 gives a summary of the unit costs for the various water importation plans. This table indicates that the cost for the needed additional water supplies for the Las Vegas Metropolitan subarea will be much higher than today's water costs regardless of the alternative plan chosen.

A significant difference exists between the intrastate and interstate water importation plans. The intrastate plans are not dependent upon an agreement for interstate movement of water. In other words, the State of Nevada has within its boundaries the wherewithal of choosing and implementing one of the intrastate water plans. However, Nevada must depend on the acceptance of other states of a regional water plan before any of the interstate plans can be implemented.

The first alternative plan which did not involve water importation is the reduction of per capita consumption. This alternative appears to be the most economical solution because it creates funds for financing water supply plans, while at the same time reducing the demand for water. In addition, this alternative would cause a greater awareness by the population of the value of water in an arid climate, thereby promoting a more efficient use of this valuable resource by curtailing wastage and excessiveness.

It appears that population dispersion is not an economic means of solving the water problem. Transportation costs would be high and difficulty would be encountered in trying to attract people to the outlying areas.

If definitive action were taken to inhibit the projected population increases and these actions were successful in reducing the projected population at least 28 or 39 percent for the low and high projected populations respectively, then southern Nevada would not experience a water shortage. Although there are advantages associated with restricting population growth it is difficult to conceive of a deterrant to population growth which would not also adversely affect the present residents of Nevada.

As mentioned earlier, the plans investigated in the study are not intended to be all-inclusive of every conceivable solution of southern Nevada's impending water shortage problem. They represent what is believed to be a representative sample of the possible solutions. Based on the analyses given in this report, it should be possible to eliminate the least desirable plans and proceed with a more detailed analysis of those which appear most desirable.

TABLE NO. 2

COMPARISON OF UNIT WATER COSTS
IN $/AC. FT.

| Plan | Cost Delivered to Las Vegas Valley L.G.R.* | Cost Delivered to Las Vegas Valley H.G.R.* | Cost of Water Including Distribution Costs*** L.G.R. | Cost of Water Including Distribution Costs*** H.G.R. |
|---|---|---|---|---|
| Cost of Water in L.V.V. today | | | 90 | |
| Intrastate Plans | | | | |
| Pahrump Valley | 168 | 186 | 230 | 248 |
| Amargosa Desert | 225 | 270 | 287 | 332 |
| Railroad Valley | 252 | 268 | 314 | 330 |
| Pahranagat Valley | 178 | 214 | 240 | 276 |
| Virgin Valley | 63 | 63 | 125 | 125 |
| Interstate Plans ** | | | | |
| Snake Colorado Project | 175 | | 240 | |
| Modified Snake-Colorado Project | 190 | | 255 | |
| Desalinization | 200 | | 265 | |

* A unique unit cost is specified by one population estimate, range of unit cost indicates the range expected on the basis of high and low population estimates.
H.G.R. = High Growth Rate L.G.R. = Low Growth Rate

** Price for water for interstate plans is unaffected by population growth rates of Nevada.

*** Cost to ultimate consumer.

State of Nevada

WATER PLANNING REPORT