PDR

# "WRMI PROCESS"
# Water Supply Planning for the Las Vegas Region

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Water Resources Management, Inc.

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# INTRODUCTION

During 1988 and 1989, the Las Vegas region experienced extraordinary growth in water use. By and large this growth resulted from an enormous development boom in the region, one of the fastest growing areas in the United States. By late 1989 it looked as though the Region's current share of the Nevada allocation of the Colorado River might prove to be insufficient to meet its needs in only a few years. Since additional water would be needed sooner than expected, the individual water purveyors immediately began exploring ways to develop additional sources on an independent basis.

The Las Vegas Valley Water District realized that even the entire remaining Nevada apportionment of the Colorado might soon be inadequate to meet projected needs, and that without the active support of other water purveyors in the Las Vegas Region it was unlikely to obtain substantial additional water from other sources. Therefore, it began a multi-faceted approach to the problem. It filed for unused surface and groundwater rights in Clark and three other counties and also began a serious effort to find a regional approach to solving the water supply problem.

In November 1989 the District retained Water Resources Management, Inc. (WRMI) of Columbia, Maryland, a consulting firm specializing in resolving water disputes, to recommend a methodology for developing a region-wide solution to the Las Vegas Region's water supply problems. To that end, WRMI began to guide a series of meetings and working sessions of a technical committee composed of representatives of all the water related agencies in the Las Vegas Region. The meetings were arranged initially by the Las Vegas Valley Water District but soon became a coordinated effort of all the involved agencies. Those agencies included:

- Big Bend Water District/Clark County Sanitation District
- City of Boulder City
- Clark County Department of Comprehensive Planning
- Colorado River Commission
- City of Henderson
- City of Las Vegas
- Las Vegas Valley Water District
- Nellis Air Force Base
- Nevada Department of Conservation and Natural Resources
- City of North Las Vegas
- U.S. Bureau of Reclamation

The meetings became part of a process, often called the WRMI process. In the most general sense, that process has been designed to develop a consensus concerning how to ensure adequate supplies of water for the Las Vegas Region.

In January of 1991, the process completed its first two phases. During the first phase, WRMI staff held extensive meetings, both collectively and individually, with the members of the Technical Committee. The Technical Committee provided invaluable information and guidance. The result of Phase I was a report describing the water supply problem facing the Las Vegas Region, the objectives to be met by a water supply plan, the alternatives which needed to be evaluated, and the tasks to be performed in developing the required analytical tools. This last task was scheduled to be undertaken during the second phase of the work.

Phase II consisted of a major effort designed to build the analytical tools recommended at the end of Phase I. Phase II used the tasks of model building to achieve a consensus about the current and projected future state of the system, as reflected in the data required to run the models. It achieved technical consensus on methods of analysis, including the use of consistent, state of the art methods to forecast demands and evaluate the effects of conservation, the details of the methods to be used for calculating return flows, and the use of optimization techniques to provide operational information about proposed facilities. Phase II saw a consensus develop concerning the overall objectives of the WRMI process, and on the nature, magnitude, and timing of the water supply problem facing the region.

This report is the final report from Phase II. It begins with a summary of Phase I, and continues with a description of Phase II. The major products of Phase II are then described, as follows:

- Monthly Model
- Hourly Model
- Briefing to Local Officials

This report then describes Results and Conclusions, and recommends additional and continuing work. A listing of all the reports produced by the process is given in the List of References.

# SECTION 1

## PHASE I SUMMARY

**Report on Project Objectives**

After several meetings with the members of the Technical Committee, a report was prepared in December 1989 (Reference #1) detailing the committee's consensus on realistically achievable goals for the WRMI Process. This was the first report of the project. These goals bear repeating:

1. Establish a cooperative framework for solving regional water problems

2. Identify and implement beneficial operating policies absent of jurisdictional restrictions. This will include solutions to operational problems such as capacity and short term supply.

3. Identify formulas for the equitable allocation of capital and operational costs for implementing regional solutions to water problems.

4. Develop policies for the joint sharing of water supply shortages.

5. Identify optimal circumstances for reusing treated effluent vs. returning it to the Colorado River for return flow credits.

6. Develop a framework for a regional water supply plan which includes all of Nevada's Colorado River water and all other existing and potential sources of water supply, including periodic Colorado River surpluses.

7. Achieve consensus on realistic levels of conservation measures that should be implemented.

8. Identify feasible, short-term options for water supply and conservation.

9. Identify reasonable scenarios illustrating when temporary or permanent shortages might occur, considering growth, actual and projected supplies, and conservation.

**Report on Methodology**

The final report for Phase 1 is the methodology report, Reference #2. It describes the perceptions of the water related agencies concerning the water supply problem and provides an approach to developing models to address the problem. Section III of that report discusses the overall problem. It contains an assessment of the total amount of additional water likely to be available to the Las Vegas Region in the short term. It points out that the water remaining from the Colorado River might be sufficient to meet the region's expanding demand for perhaps five to six more years. This is an extremely short time period in which to physically develop new sources of supply. It also points out that an aggressive program for instituting water conservation measures could lengthen that time horizon sufficiently to allow for the orderly development of additional water resources. It recommends that a program to provide state of the art demand forecasts and to allow quantitative evaluation of the effectiveness of conservation measures be undertaken.

Section IV of the Phase I report outlines the local and regional objectives that must be achieved by a water supply plan. These objectives include:

1. the equitable allocation of water, or maintaining an adequate supply for all "acceptable" uses;

2. minimizing costs (measured in various ways) or ensuring an equitable allocation of costs;

3. maintaining the institutional independence of existing agencies and jurisdictions; and

4. other objectives, such as maintaining environmental quality and overall quality of life, and minimizing impacts on surrounding counties.

Section V of the Phase I report describes the water supply and conservation alternatives that might be evaluated in developing an overall regional plan. These include:

1. short-term peaking alternatives, such as SNWS capacity sharing, water exchange via additional interconnections, energy demand charge cost sharing, winter use of SNWS capacity to preserve well capacity,

groundwater injection on a local or regional basis with cost sharing, and peak use demand reduction strategies;

2. short-term conservation/supply alternatives, such as local public awareness programs, voluntary/compulsory installation of inexpensive water saving devices, plumbing code requirements, temporary use of unutilized Nevada Colorado River water allocations, obtaining Nevada's share of surplus Colorado River flows, and conjunctive use of Virgin River water;

3. long-term peaking alternatives, such as alternate configurations for groundwater injection Valley-wide, additional finished water storage configurations, expansion of the SNWS, alternate energy supplies, increased capacity for delivery of water from new sources, capability to supply additional peaking from the BMI pipeline, peak period water delivery metering and pricing, and use of non-potable water for landscape and industry; and

4. long-term conservation/supply alternatives such as aggressive water conservation policies, additional, permanent Colorado allocations from the current Nevada allocation or from purchased rights in upper basin States, BMI supply, additional groundwater mining of the Valley aquifer, direct reuse, long-term banking of unutilized Nevada allocation and surplus flows, Virgin River supplies, groundwater imports, alternate Laughlin allocations of Colorado River water, reduced Valley groundwater depletion, and alternate well configurations within the Valley.

Section VI describes the analytical tools and procedures that could be used to evaluate the alternatives developed in Section V. It also details the data required to support the analysis and specifies the ways in which the tools need to be used and integrated. The tools themselves include simulation, optimization, and financial analysis models that must be specially designed and implemented for Las Vegas Valley Region. This section serves as the blueprint for Phase II.

# SECTION 2

## PHASE II DESCRIPTION

Much of the work done during the course of Phase II has focused on the development of two computer models, a monthly model and an hourly model. The models themselves will be described later on in this report. But first it is important to describe the process which was used to develop the models. That process, which was the focal point of Phase II, was aimed at bringing all the participating agencies to a common understanding of the water supply problems facing the region and to a consensus on actions to be taken jointly by the participating agencies.

Phase II began with an agreement among most of the purveyor participants to share in the cost. Phase I had been funded entirely by the LVVWD; however, all parties believed that if the work was to represent a joint effort, at the very least the major water purveyors had to share in the costs. Shared costs increased the agency's stake in a successful outcome for the project. As soon as funding was secured, WRMI staff launched an intensive effort to develop the tools required to meet the goal of forming a coordinated regional position by the beginning of 1991. They began by building models.

There are two distinct reasons why so much effort has been given to modeling. The first is that the models are essential to the development and evaluation of alternatives for meeting the water requirements of the Las Vegas Region. The second reason, while less obvious, is perhaps even more important.

The development of the models was structured to assure the maximum involvement of the staffs from all of the water related agencies in the Las Vegas Region. In fact, the agencies sometimes found that their involvement in the process stretched their staff resources somewhat. The objective of involving the technical staff was to ensure that the models accurately reflected all the aspects of the problem which were considered important by all of the agencies. But, there was also a very important side benefit. By participating in the process of developing the models, technical staff from each agency learned to appreciate the problems and perspectives of their counterparts in other agencies.

They also came to realize that these models were being built to reflect regional as well as individual agency concerns, and that they were indeed "neutral" analytical tools which would provide an unbiased evaluation of differing alternatives.

At the beginning of Phase II, meetings were held with all participating agencies to demonstrate the progress made in developing the models. WRMI staff presented work in progress at these meetings, and received much feedback as to the wishes and desires of the participants. These demonstrations and the ensuing discussion clarified exactly what data would be required to run the models, and how that data would be used in the models.

With the important exception of demand projections, data development was the direct responsibility of the staffs of the agencies. All data provided was reviewed by all the agencies involved. Many data problems came to light during initial model runs. In fact, it was because the models were designed to combine all data in an organized fashion that inconsistencies and errors became apparent. All participants in the process were involved in finding and correcting the errors in the data. As a result, the data sets now used in the models have substantial credibility with all of the participants.

As soon as the models were capable of runs, intensive working sessions with all of the participants were scheduled. In order to minimize distractions, working sessions were held in Mesquite, NV. The sessions were several days long. During the sessions, the techniques of Computer Aided Negotiation were used to build a common understanding of the models, to improve their function and data, and to enhance the credibility of the results in the eyes of the technical representatives.

The first set of model runs focused on current conditions in the system. These runs served mainly to verify the particular model's function under conditions familiar to those involved. Data errors which surfaced during these runs mainly concerned the representation of the pipe network in the model, and several revisions to the network representation (the schematic) occurred as a result. Additional corrections regarding costs of pumping through the various pipes and from the various sources were also made during the initial runs.

The next set of model runs focused on meeting year 2000 demands, assuming availability of the remainder of Nevada's Colorado River entitlement. These runs highlighted insufficient capacities of the existing pipe networks of the purveyors to meet year 2000 demands, and the critical need for system expansions above and beyond the current capital plans, which are generally designed to meet needs only through about 1995. Many model runs were required before suitable system

configurations were found. A representative schematic is provided in Figure 1 of the monthly model documentation report. During these runs it became apparent that improvements made by one purveyor could be very important to another. For example (and only one of many) the development of recharge facilities in the western portion of the LVVWD service area has the highly beneficial effect of allowing Henderson and North Las Vegas to increase their SNWS withdrawals during peak summer months. These increases are absolutely required if they are to meet its summer peak demands.

Finally, sets of production runs of the monthly model were made in order to estimate, under varying assumptions of availability of water from existing supplies, when all the water available to the Las Vegas Region would be fully utilized. The results of these runs are discussed below. The model and its data sets have been fully documented (Reference #5); the documentation is available in a separate report from the LVVWD.

Two additional data items of great importance were noted during the latter portions of Phase II. The first involved accounting for return flows and return flow credits, the second involved demand projections.

The importance of Colorado River return flow credits to the water supplies in the Las Vegas Region has long been recognized. However, the relative merits of returning flows to the river as opposed to reusing the water directly has been a matter of intense debate. Debate has also raged about the increase in supply, which could be attributed to the adoption of mandated conservation regulations in the region if those regulations also resulted in a reduction of return flows to the Colorado, and thus a corresponding reduction in return flow credits.

While the monthly model developed during Phase II was designed to address the question of reuse vs. return flow credits directly, it was vital that the method used to compute return flow credits be acceptable to the Nevada Colorado River Commission (CRC) and the U.S. Bureau of Reclamation. The methods currently used by those agencies, however, are designed to compute actual return flows rather than projected return flows. A great deal of effort was expended during Phase II in a successful attempt to ensure that the methodology employed to compute return flows in the monthly model was acceptable to the CRC and USBR, and consistent with the currently accepted methodology. Full documentation of the return flow credit methodology is given in the model documentation mentioned above (Reference #5).

Finally, Phase II saw the development of demand and conservation projections for all of the major water purveyors in the Las Vegas Region. This effort was so extensive that it is the subject of separate reports, but the importance of the effort will be

described here. The rationale for developing consistent projections for all purveyors is simple. In a battle for water, each purveyor will naturally seek to gain advantage by stressing its needs. This leads to inconsistent, and in many cases inflated, estimates of future demands. If water agencies in the Las Vegas Region are to cooperate in searching for water, they must be able to believe each other's projections.

The Las Vegas Region is seeking water from many sources, and each of these sources has competing users. Therefore, it is imperative for water purveyors in the Las Vegas Region to have credible, technically defensible demand projections which are consistent with other growth projections (e.g. employment and housing) for the area. Because per capita water use in the Las Vegas Region is among the highest in the nation, it is easy for outsiders to characterize the area as wasteful. Projections of future demand must not only take into account the high water use, they must also explain the causes and evaluate reasonable and rational ways to conserve water in the region, and produce realistic estimates of the impact of conservation on demands. This requires multi-sectoral analysis of current water use in the region and projections based on reasonable (and in the case of conservation, achievable) water use factors for each sector.

As stated above, in the Las Vegas Region it is not only raw demand which is important in determining the adequacy of supply, but also the fraction of supply which is used consumptively, as this reduces return flow credits. Conservation measures which are targeted at outdoor water uses often serve to reduce the fraction of water used consumptively as well as reducing overall demand, which makes them doubly effective.

As a part of Phase II, the major water purveyors in the region contracted with Planning and Management Consultants, Ltd. of Carbondale, IL (PMCL) to produce demand projections and evaluate the impact of conservation programs on demand. The purveyors contracted with UNLV Center for Business and Economic Research (CBER) to produce the socio-economic projections for population growth, housing, and employment by sector required to drive the forecasts to be made by PMCL. PMCL used the forecasting methodology developed for the Institute of Water Resources (IWR) of the U.S Army Corps of Engineers to create the forecasts. The result represents the state of the art in water demand projections, and incorporates information on water use by sector garnered from water use studies across the U.S. Water demands in the Las Vegas Region were explicitly compared to water use in other areas to determine which conservation measures would be most effective. The projections are consistent with other growth projections for the region. This adds substantial credibility to the results of the Phase II analysis. The reports from CBER and PMCL fully document the derivation of projected demands and the estimated effectiveness of conservation measures (References #3 & #4).

# SECTION 3

## PROJECT PRODUCTS

### Monthly Model

The monthly model is the more important of the two models, and most of the effort during Phase II was spent on its development. The monthly model has a number of functions:

- To demonstrate the feasibility of coordinating the operations of major water purveyors
- To demonstrate the economic benefits of coordinated operations
- To find the most efficient pumping schedules for groundwater
- To provide a convenient means of evaluating the performance of various capital facilities aimed at increasing system capacity
- To ensure that such facilities can operate efficiently in the system as a whole
- To estimate return flows, and to compute a region- wide water budget for any alternative evaluated
- To evaluate the extent to which conservation practices could extend supplies, so that additional development in the region could occur
- To prepare estimates of overall costs for a set of proposed alternatives over a period of several years, and to facilitate the evaluation of the annual cost to each agency under a variety of cost allocation schemes.

The monthly model produces output which shows the most efficient operating scheme for a period of 12 consecutive months for the input set of demands (which may be based on some conservation policy) and facilities. It also determines if sufficient water is available to the region to meet demands, including credit for return flows to

the Colorado River. Full documentation on the monthly model is available in a separate document. In brief, the model works as follows:

First, the model solves an optimization problem which minimizes the cost of pumping and treating raw water for water supply. The optimization accounts for:

1. limitations of total annual withdrawals (or groundwater pumping) from all sources;

2. limitations due to facility sizes;

3. electrical cost differentials from month-to-month;

4. availability of groundwater recharge facilities for minimizing peak withdrawals and electrical use; and

5. demands and conservation, as described above.

If supplies or facilities are insufficient to meet demands, the model reports the problems and locations.

Next, the model computes the consumptive use at each demand point (node) for each period, and returns the remaining water to the wastewater treatment plant associated with the node. If the wastewater flow to the treatment plant exceeds its capacity, or if it is less than the direct reuse from that facility, th[illegible] the problem is reported. Finally, return flow credits and then net Colorado River consumptive use is calcula[illegible]d. If the net consumptive use exceeds that allowed for the run, the problem is reported.

The model computes and allocates operating costs for water and wastewater treatment, pumping, and fixed O & M for each run of the optimization. It can also allocate the costs to agencies according to percentages supplied by the user. Moreover, the model allows the input of new facilities for a given time period, their costs, and percentages for allocating those costs. A series of runs made for a set of future years (e.g. 1995, 2000, 2005, 2010) with the appropriate new facilities and demands for each year allows the creation of output fully describing the capital, operating and financing costs for the set of alternatives and their allocation to agencies.

**Hourly Model**

The hourly model has two major functions, one for planning, and the other for operations. The planning function is to produce more refined estimates of energy requirements and costs for use in the monthly model. The operational function is to improve actual operations by allowing operators to look ahead a full week when deciding on choice of water sources and pumping schedules in real time. Like the monthly model, the hourly model is fully described in Reference #6. Program development for the hourly model was delayed in order to meet the deadlines imposed for the initial findings through the monthly model, and so the model is being completed as of this writing.

The hourly model is essentially the same as the monthly model, but with two exceptions. First, of course, is the time step. Instead of months, the hourly model splits the day into many segments as dictated by energy pricing schedules. At a minimum, there are two such periods in a day, on-peak and off-peak. Days with up to six segments based on price can be accommodated.

The second difference is that while the hourly model uses a network transportation algorithm for optimization, the hourly model uses a linear programming (LP) technique. The less computationally efficient but more general LP is required in order to properly account for energy charges related to the maximum use over an entire month.

The use of the hourly model will encourage actual cooperative operations among the water purveyors and to provide some experience with the kinds of operating changes that will be needed as additional water supplies are brought into the Las Vegas Region. The hourly model will be available to fulfil this function for the summer of 1992. Runs of the hourly model can also be used to determine the costs or savings that would occur with changes, imposed or negotiated, in the electric rates used to calculate utility charges.

Runs of the hourly model will also be needed to refine the estimates of energy costs used in the monthly model, as explained above.

**Briefing to Local Officials**

The Technical Committee prepared a briefing for local elected officials in late January, 1991, which fully described the magnitude of the water deficits facing the region, the time remaining to act to avert them, and to identify initial, low cost options required for the immediate future. Because of the technical consensus developed during the WRMI process, there was remarkably little disagreement, political or otherwise, on these conclusions. It is important to note that the briefing

signaled the achievement, in part, of many of the goals set out the previous October. The contents of the briefing are described below:

- It was the result of a cooperative regional effort (goal 1).
- It identified that there was little difference in total supply caused by reuse vs. return flow, making the choice a matter of economics (goal 5).
- It called for the immediate allocation of the remaining portion of Nevada's Colorado River Water to the SNWS (part of goal 6).
- It recommended a set of conservation measures for implementation (part of goal 7). These measures were evaluated by PMCL in their report (Reference #4) and the long range implications of adopting the measures were tested using the WRMI model.
- It identified, and recommended for adoption, short term options for water supply and conservation, (goal 8). These were evaluated and tested in the same manner as the long range conservation measures.
- It identified when shortages would occur if no action was taken (goal 9). This was accomplished using the WRMI model.

In addition to the reports mentioned above, Phase II of the WRMI process produced several products in the form of analytical tools and the data sets required to use those tools. All of the products of Phase II are described in this section. These include the monthly model, the hourly model, and results and conclusions to date. When looking at the "products" of the project, it is extremely important to realize that the very process of building the models accomplished more in terms of consensus building than simple model runs could ever have achieved. All of the agencies involved have had substantial input to the models, and therefore have some "ownership" and pride of achievement in the results.

## SECTION 4

# RESULTS AND CONCLUSIONS

There have been a number of highly significant results and conclusions which have been derived from the WRMI process to date. The most basic is the consensus that has developed over the data and methods of the work. Second, the feasibility of regionally coordinated operations to reduce operating costs on a monthly basis has been clearly demonstrated. Finally, a technical consensus has developed concerning the magnitude of the water supply deficit facing the region over the next decade, and the actions which need to be taken immediately to deal with those deficits in the short term.

Of course, the most important outgrowth of the WRMI process has been the formation of the Southern Nevada Water Authority (SNWA). The agreements which underlie the SNWA allow the water purveyors in the Las Vegas Region to operate jointly, and to jointly pursue additional sources of supply. Applications for diversion of Nevada's remaining share of Colorado River Water have already been filed.

Despite these successes, however, much work remains to be done. Some suggested activities are described below. They include continuing the WRMI process to improve the efficiency of water use and water operations throughout the Las Vegas Region.

**Conclusions on Data and Methods**

The need for developing simulation/optimization models for the Las Vegas Region was apparent to all the participants in the WRMI process. A comprehensive water supply and return flow related data base has been developed for the Las Vegas Region. The benefits of the models are presented in Fig. C. The data used in the models is accepted as reasonable by all the agencies involved in the WRMI process. It is expected that improvements will be made to the data as the process continues, but the current data is essentially correct and suitable for use in analysis. The data includes:

- Demand Projections done in a consistent, state of the art manner for the entire region, and a corresponding analysis of the effectiveness of a wide variety of conservation methods. Projections are consistent with other economic projections for the region, and jointly agreed to by the staffs of the region's water

related agencies. The basic process for developing this data is shown in Figure A and explained in detail in References #3 and #4.

- A base pipe network diagram to be used for analysis purposes, and general agreement on the scope of network additions for the next decade. These will prove invaluable in evaluating alternatives as the process continues (Reference #5).

- Current energy requirements per unit of pumping, and other operating costs for facilities (Reference #5).

- Total water available from existing sources. This is shown in Figure B and explained in the model documentation (Reference #5).

The methods of the monthly model have been accepted by the technical committee and the model is available to each of the agencies participating in the process. Three points are of particular note:

- There is agreement that the optimization produces reasonable regional operations for use in the analysis. Automating the determination of operating strategies greatly simplifies the task of using models to compare alternatives.

- Water delivered to nodes in the model is routed to the proper wastewater treatment plants. This is crucial for the evaluation of reuse alternatives and for the computation of return flows.

- The return flow calculations used by the models meet the requirements of the CRC and are consistent with the wastewater generated at each of the plants during the model runs. This makes the treatment of conservation alternatives (which changes the percent of water returned as wastewater), reuse alternatives, and return flows all consistent within the models (Reference #5).

**Physical Feasibility of Regionally Coordinated Operations**

All of the model runs made to date have utilized the operational schedules produced by the optimizer in the monthly model. The optimizer does not consider independent operations by each utility, rather it coordinates all operations to minimize costs. The

general acceptance of the results of the monthly model runs indicates very strongly that such coordinated operations are both feasible and desirable.

**Results and Conclusions from the Modeling Efforts to Date**

As mentioned above, the results and conclusions of the modeling efforts to date were reported to local officials in January 1991. They covered three major issues:

- The magnitude and urgency of the water supply problem. Without any action, the region's available water will not be able to support projected development beyond 1995 (Fig D & E). Prompt allocation of the remainder of Nevada's Colorado River water to the region will extend that time until 2002 (Fig F, G, & H). This is recommended as the first step in an immediate action plan for the Las Vegas Region. Imposition of a responsible program of water conservation measures (Level 1 in Fig I) will further extend that time until 2006 (Fig J & K). Surprisingly, adoption of more severe conservation measures will not further delay the need for additional supply (Fig L). This is because of the reduction in flexibility for short term reductions in demand during emergencies. As a result a "working reserve" of supply is required. After 2006 additional water will be required to support the region's projected needs. The full range of supply and demand options are summarized in Fig M.

- Proposed actions on conservation. Conservation must be an integral part of any water planning for the Las Vegas Region. Reductions in consumptive use of water are most effective in extending supply, however, because much of the water used in the region is returned as wastewater and thus becomes new supply through return flow credits from the Colorado River. The full details of the possible conservation programs are given in the PMCL reports. The recommended options are detailed in Fig I.

- Proposed immediate actions on water supply. The briefing of local officials urges the immediate allocation of the remaining Nevada Colorado River supply to the region. It also recommends that the Las Vegas Region aggressively pursue any possible new sources of water and that planning begin immediately for the construction of facilities to import additional water to the region. (Fig N).

# SECTION 5

## REQUIRED FOLLOW-UP ACTIVITIES

Although much has been accomplished during Phase II of the WRMI process, much remains to be accomplished. Most of what remains concerns goals 2 through 4 developed for the process in the Objectives Report, which concern implementing regional operating policies, allocation of water, and costs from new supplies, and allocation of shortages, should they occur. Some recommended future activities are discussed in the following paragraphs.

These activities can best be carried out by a continuation of the WRMI process, utilizing the existing committees.

**Development of Practical Operating Strategies**

The high cost of pumping water to users in the region dictates that the most efficient pumping schedules be adopted region wide. On an annual basis, this means analyzing the balance between groundwater pumping and Lake Mead deliveries for each month of the year so as to minimize pumping from the Lake when electrical costs are highest, subject to the constraint that all demands are met. For the short term, this means optimizing the use of system storage and other sources of water to minimize pumping charges related to the maximum utilization of energy over the period of a month (capacity charges) and for pumping during "curtailment" periods. It may also mean evaluating the financial impact of modifying the electric rate schedule, or of purchasing power and/or generating capacity from other sources.

The monthly model provides guidance as to when to utilize groundwater over the annual cycle. The hourly model must be run to provide insight as to when to incur capacity charges and when to incur additional expenses for pumping during curtailment periods. Development of operating strategies is at the heart of achieving the joint operations goal of the Technical Committee (Goal 2).

**Testing of Operating Strategies Through Time Using Interactive Simulations**

Before actually implementing new, coordinated operating strategies, it is highly desirable to test them using interactive simulations. These simulations are the water supply equivalent of military war games. During the simulations, operators are given forecasts of demands for the day and month. The output of the hourly models are then used to plan hourly operations, which are input to the interactive simulations. The simulation adds random errors to the forecasts to determine what "actually"

happened during the hour, and then outputs the "actual" demands and the storage left in the system at the end of the hour. The process then repeats.

Using interactive simulations will allow the correction of problems with coordinated operating strategies before they are implemented, will increase operators' confidence in the workability of the plans, and ease the way for interagency agreements. Testing of operating strategies will also lead to meeting the water operations goal of the Technical Committee (Goal 2).

**Water Banking Analysis**

For the next few years, and perhaps for longer if the USBR declares Colorado River surpluses, there will be water available to the Las Vegas Region in excess of its needs. This water can be directly recharged to groundwater basins, for use in future droughts, or to possibly delay the requirement for new sources of imported water, perhaps by as much as a few years. There is, of course, a cost associated with such a strategy, specifically, the extra cost of pumping associated with the operation.

The feasibility of this "water banking" can be tested using the monthly model, and efficient and regionally agreeable operating strategies can be derived. The water banking analysis is essential to fulfill the Colorado River allocation goal (Goal 6) of the Technical Committee.

**Water Allocation, Facility Planning, and Capital Budgeting for New Water Sources, and Determination of Formulas for Allocating Water Shortages**

This is the largest task remaining for the WRMI process. Now that the monthly model and its associated financial analysis models are complete and demands have been projected with and without implementation of conservation measures, only the cost data for capital expansion plans must be developed for input to the model.

With this new data in hand, the monthly model can be used by the technical committee to examine a wide range of preliminary physical alternatives for new sources and an equally wide range of cost allocation formulas. Alternatives can be developed using the techniques of Computer Aided Negotiation, since the monthly model was specifically designed to work in such a framework. However, the Technical Committee is not the body required for actual negotiations, and thus must concentrate on developing a wide range of alternatives.

The objectives to be satisfied by alternatives were listed in the final report for Phase 1 of the WRMI process. They fell into the following four broad categories, which are listed in order of relative importance:

1. the equitable allocation of water, or maintaining an adequate supply for all "acceptable" uses;

2. minimizing costs (measured in various ways) or ensuring an equitable allocation of costs;

3. maintaining the institutional independence of existing agencies and jurisdictions; and

4. other objectives, such as maintaining environmental quality and overall quality of life, and minimizing impacts on surrounding counties.

Once the Technical Committee has produced a set of preliminary alternatives, negotiators appointed by the appropriate political bodies can actualiy participate in Computer Aided Negotiations, using those pre-developed alternatives as a point of departure.

It is important that an alternative address all of the following issues in order to be considered feasible:

- a plan for constructing (and staging) capital facilities;

- a plan for implementing conservation measures throughout the region in a coordinated manner;

- a plan for operating those facilities;

- a plan for financing those facilities; and

- a plan for allocating the costs of those facilities. This plan must distribute the costs equitably, taking into account the current water rights of the water purveyors as well as the costs to water users in all of the jurisdictions. Thus the question of water allocation from existing sources will actually be reflected in the negotiations over the cost of new supplies (and in the allocation of future shortages as discussed below). The plan must be flexible, allowing for commitment of funds necessary for initial financing of projects, but ultimately dependent on the actual amount of future water use by each purveyor; and

- a plan for allocating future shortages of water, should they occur. The allocations should be based on the need to maintain public health and safety, the existing water allocations (rights) to the purveyors, the cost sharing for new facilities, and other factors as appropriate.

**Examination of Administrative Alternatives for Integrating Operations and/or Financing New Supplies**

Once a physical, financial and operational plan for meeting the water needs of the Las Vegas Region has been agreed to, the institutional arrangements for implementing the plan will have to be made. These may or may not involve the creation of new, regional institutions. However, the choice of institution and its design should be made in the full light of the alternative chosen. The choice of institutions to implement the plans chosen is also required to meet nearly all the goals set by the Technical Committee.

**Integration of Water and Sewer Planning**

The existence of a monthly model which uses consistent demand forecasts and consumptive use estimates to estimate flows to wastewater treatment plants originating at specific locations throughout the region makes it imperative to integrate water and sewer planning. Any proposals for improvement or expansion of the wastewater collection system which use forecasts which differ from those used in water planning are likely to be challenged.

Integration of the long range water and wastewater planning process can be easily accomplished by modifying the existing monthly model to incorporate the main trunks of the wastewater collection system. In this way, the full costs of providing future water and sewer services can be evaluated in concert. Integrating water and sewer planning is a logical extension of the first Goal of the Technical Committee, setting up a regional framework for resolving water problems.

## SECTION 6

# CONCLUSIONS

Extremely successful Project has lead to several actions:

- Filing for Colorado Water.
- Discussions of Regional Water Agency.
- Credible facilities and demand data developed
- Tools are now in place for rational water planning for the Las Vegas Region

## SECTION 7

# LIST OF REFERENCES

Additional Reports Produced by the WRMI Process


Reference 1. Objectives and Performance Measures for Evaluating Alternative Water Supply Plans for the Las Vegas Valley, Water Resources Management, Inc, Columbia, MD, December 1989.

Reference 2. A Methodology for Developing a Regional Water Supply Plan for the Las Vegas Valley, Water Resources Management, Inc, Columbia, MD, February 1990.

Reference 3. Economic and Demographic Projections for the Major Water Users in Southern Nevada, Center for Business and Economic Research, UNLV, Las Vegas, NV, January 1991 (published February 1992).

Reference 4. Las Vegas Valley Region Water Demand Forecast and Assessment of Water Conservation Savings, Planning and Management Consultants, Limited, Carbondale, IL, January 1991 (published February 1992).

Reference 5. Documentation: Las Vegas Region Monthly Water Supply Planning Model, Water Resources Management, Inc, Columbia, MD, January 1991 (published May 1992).

Reference 6. Documentation: Las Vegas Region Hourly Water Supply Planning Model, Water Resources Management, Inc, Columbia, MD, November 1991 (to be published in 1992).


*Copies of these reports are available from Las Vegas Valley Water District.*

# APPENDIX A

# DATA DEVELOPMENT PROCESS

CENTER FOR BUSINESS AND ECONOMIC RESEARCH AT UNLV (CBER-UNLV)

- Socio-economic data for 1990 - 2030

PLANNING AND MANAGEMENT CONSULTANTS, LTD. (PMCL)

- Water demand projections for 1990 - 2030
  - Unrestricted demands (no conservation)
  - Restricted demands (Level 1 conservation)
  - Restricted demands (Level 2 conservation)

WATER RESOURCES MANAGEMENT, INC. (WRMI)

- Water management model

Figure A

# CURRENT WATER SOURCES
# FOR MAJOR WATER PURVEYORS IN SOUTHERN NEVADA

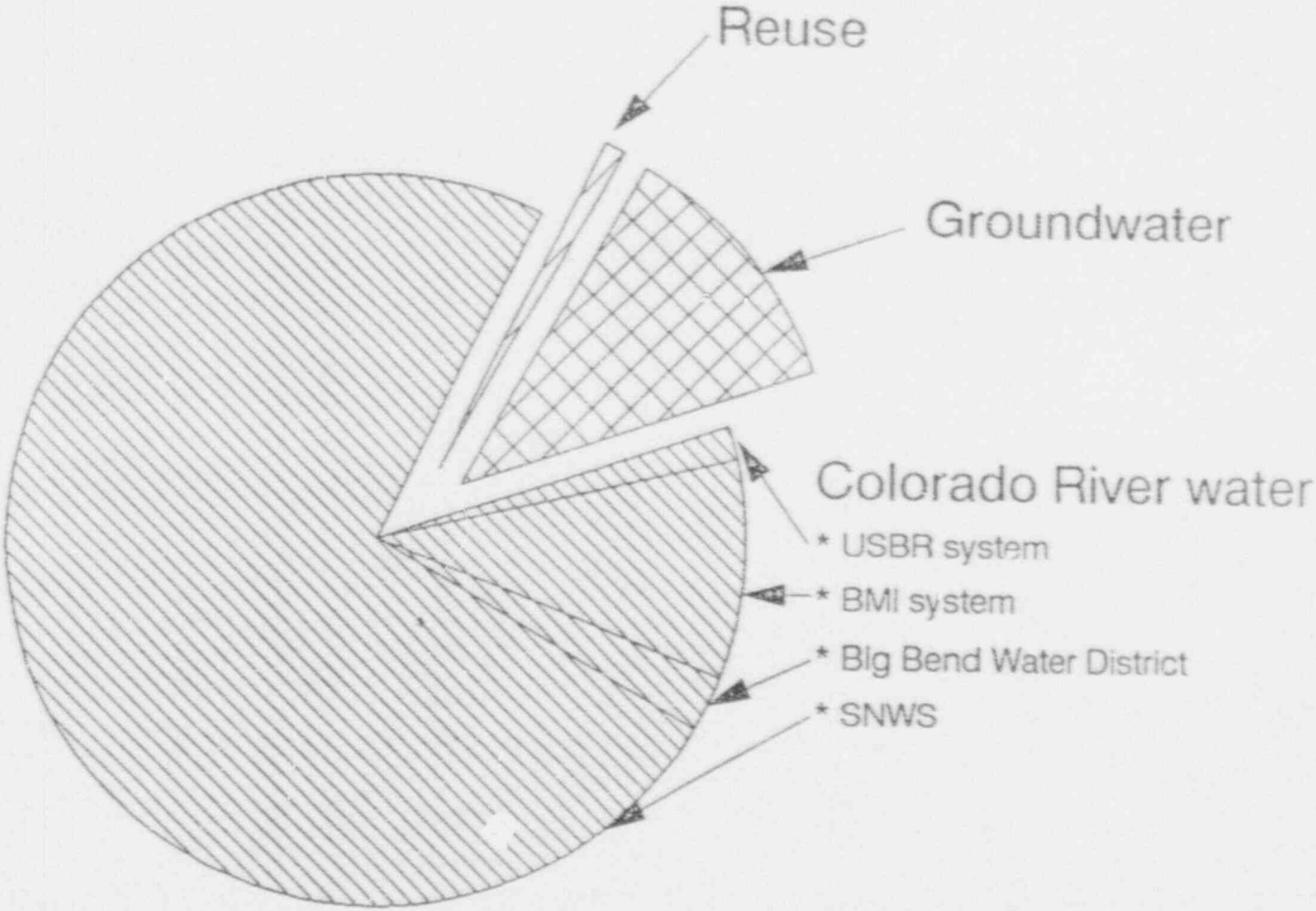


Figure B

# Using the Models

Models and Base Data:

1) Provide a credible basis for consistent evaluation of alternatives

2) Allow rapid and easy evaluation of many alternatives and allocation schemes

3) Assure that operations are feasible and efficient

4) Minimize "bias" in evaluation

5) Allow all parties to participate in negotiations with equal access to technical tools and data

Models have been installed at all agencies participating on the Technical Committee

Models can be distributed to anyone with a PC and adequate knowledge of the system

Figure C

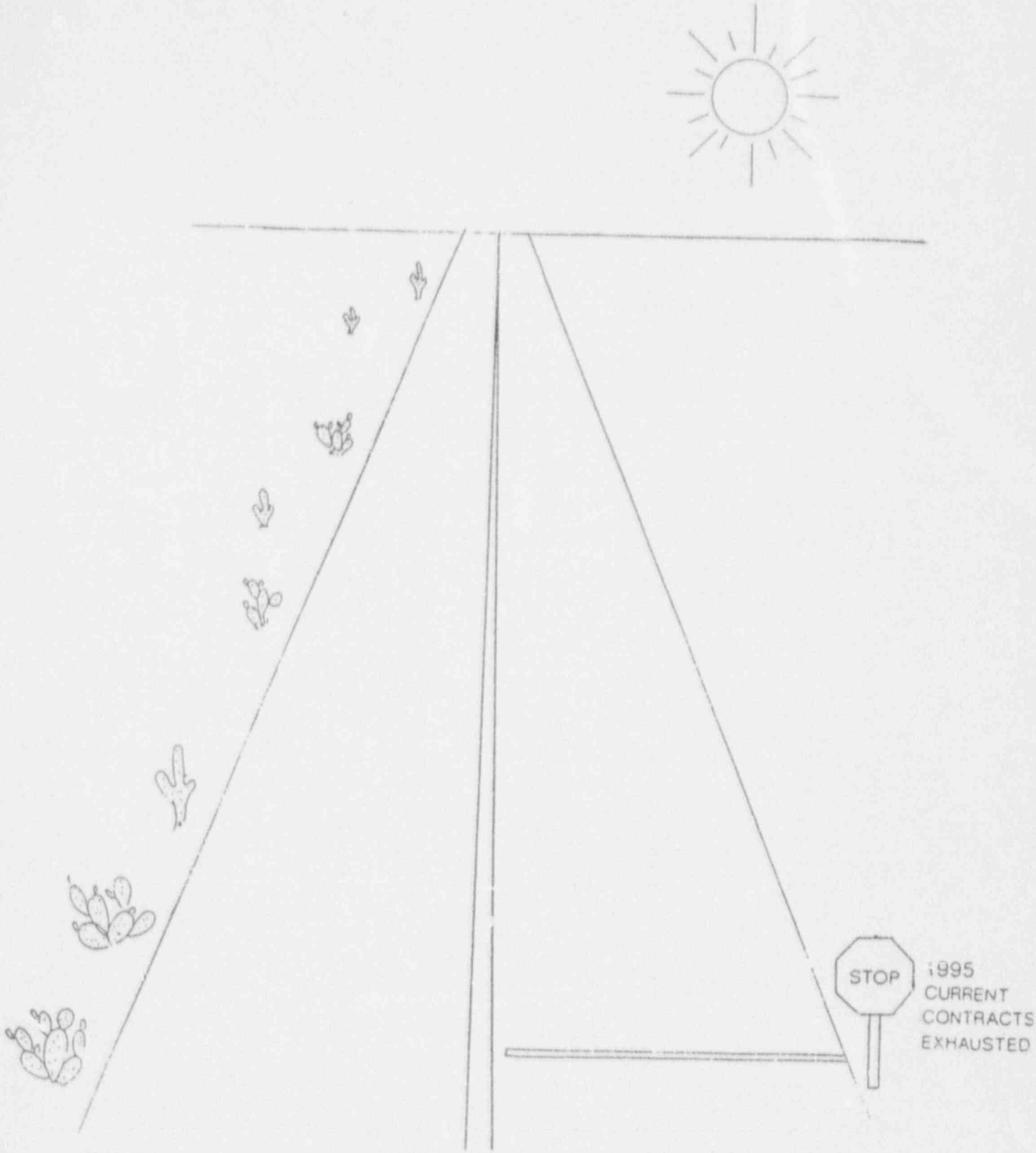


Figure D

# WATER SUPPLY AND DEMAND 1990 - 2030
# FOR MAJOR WATER PURVEYORS IN SOUTHERN NEVADA

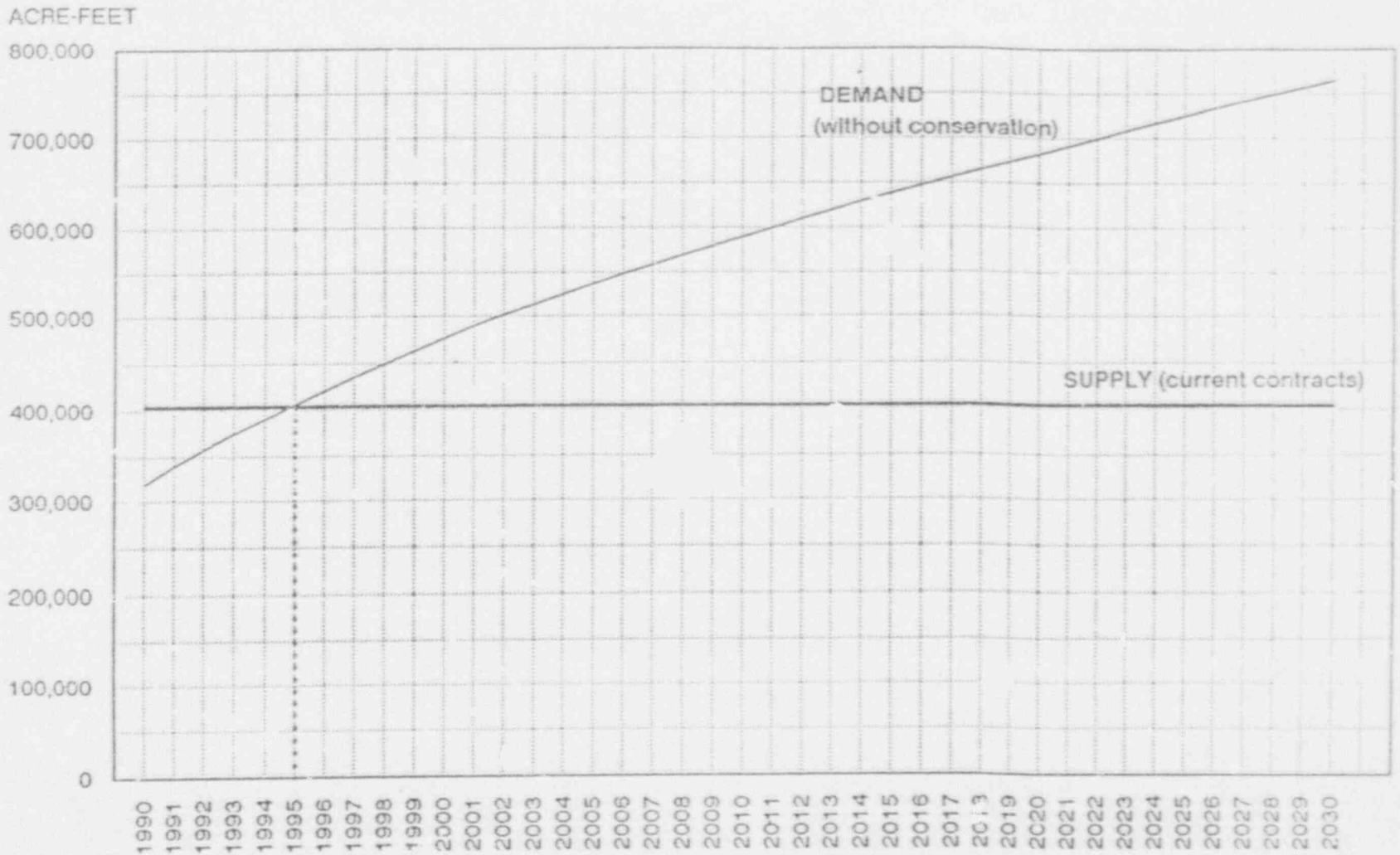


Figure E

# COLORADO RIVER WATER AVAILABLE TO MAJOR WATER PURVEYORS IN SOUTHERN NEVADA

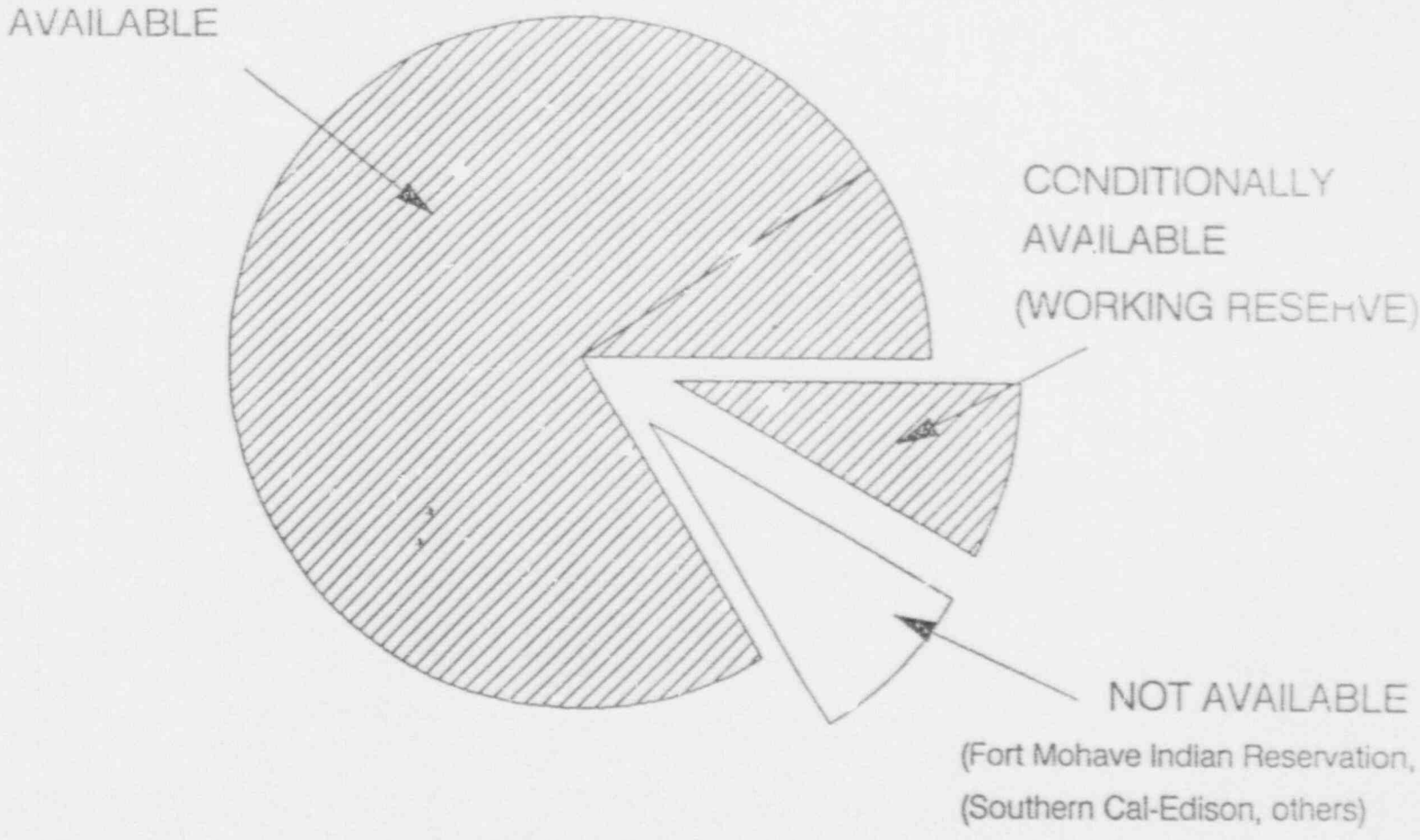


Figure F

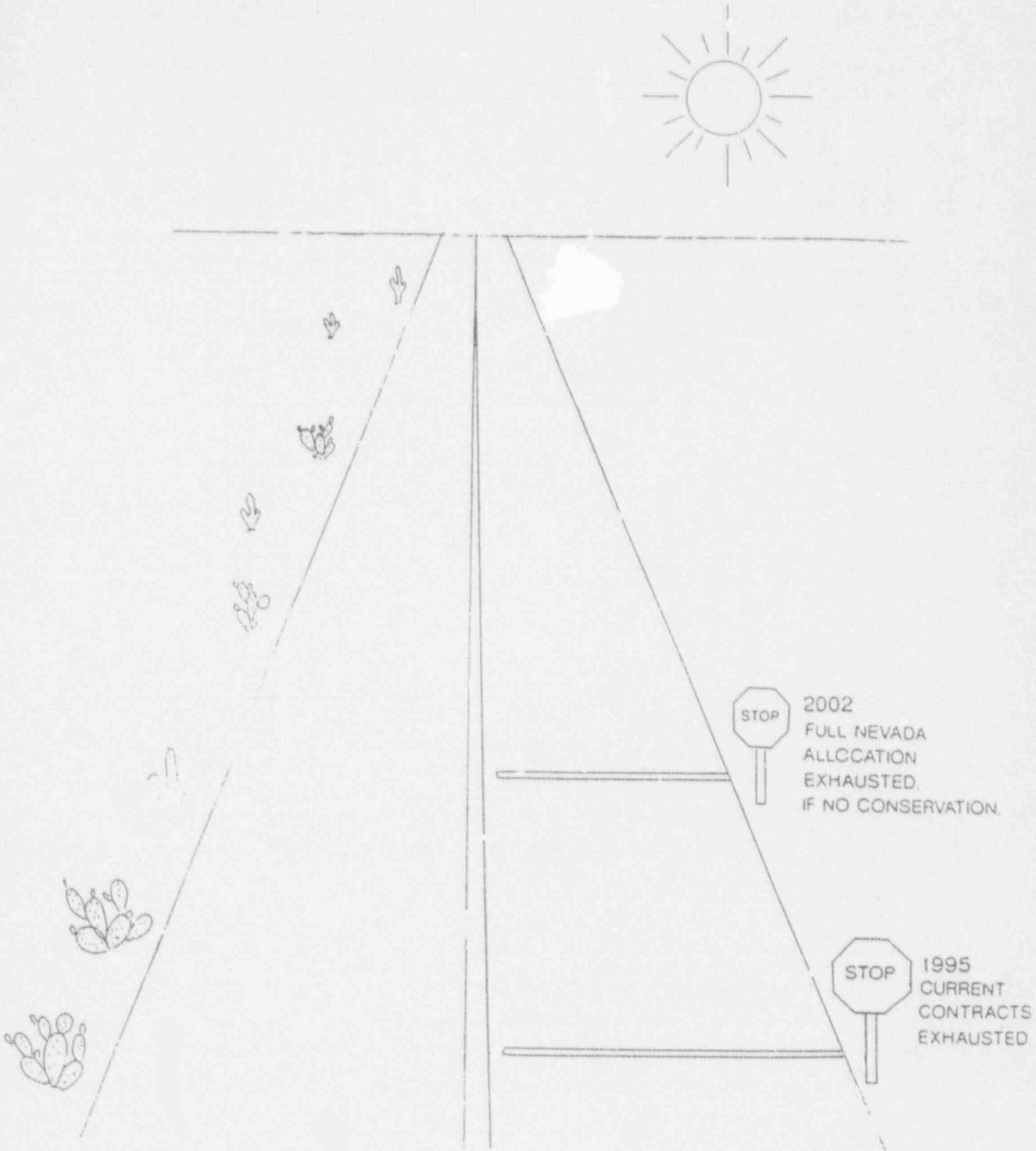
STOP
2002
FULL NEVADA
ALLOCATION
EXHAUSTED.
IF NO CONSERVATION.
STOP
1995
CURRENT
CONTRACTS
EXHAUSTED

Figure G

# WATER SUPPLY AND DEMAND 1990 - 2030
# FOR MAJOR WATER PURVEYORS IN SOUTHERN NEVADA

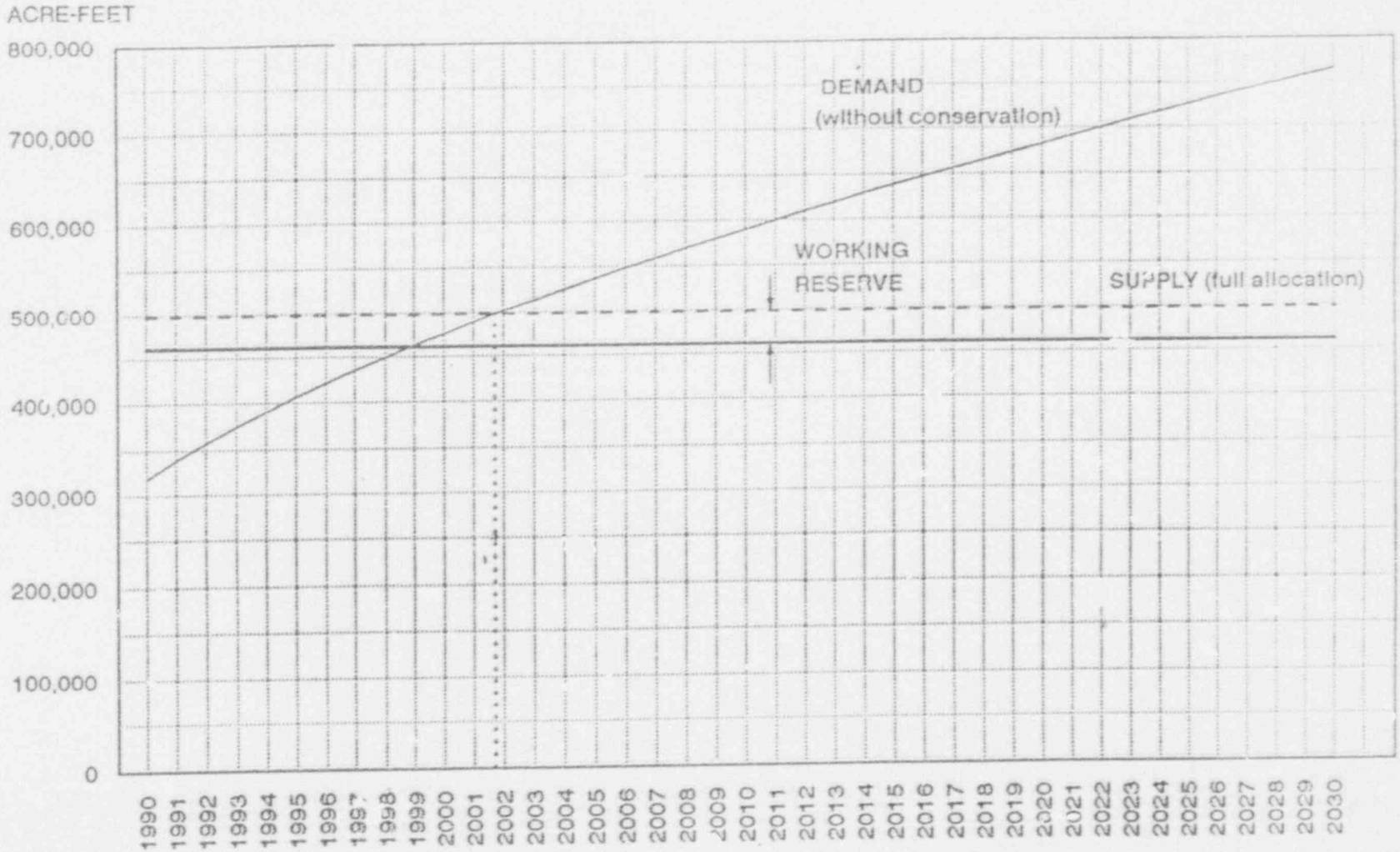


Figure H

# CONSERVATION MEASURES

## LEVEL 1

- Plumbing code for new development
- Volunteer commercial/industrial water audit
- Water waste ordinance
- Pricing policy I (incentive)
- Volunteer plumbing retrofit
- Conservation education

## LEVEL 2

- Plumbing code for new development
- Aggressive commercial/industrial water audit
- Watering restrictions
- Pricing policy II (aggressive)
- Aggressive plumbing retrofit
- Conservation education
- Limit residential and commercial lawn size
- Landscape audit for major irrigation

Figure 1

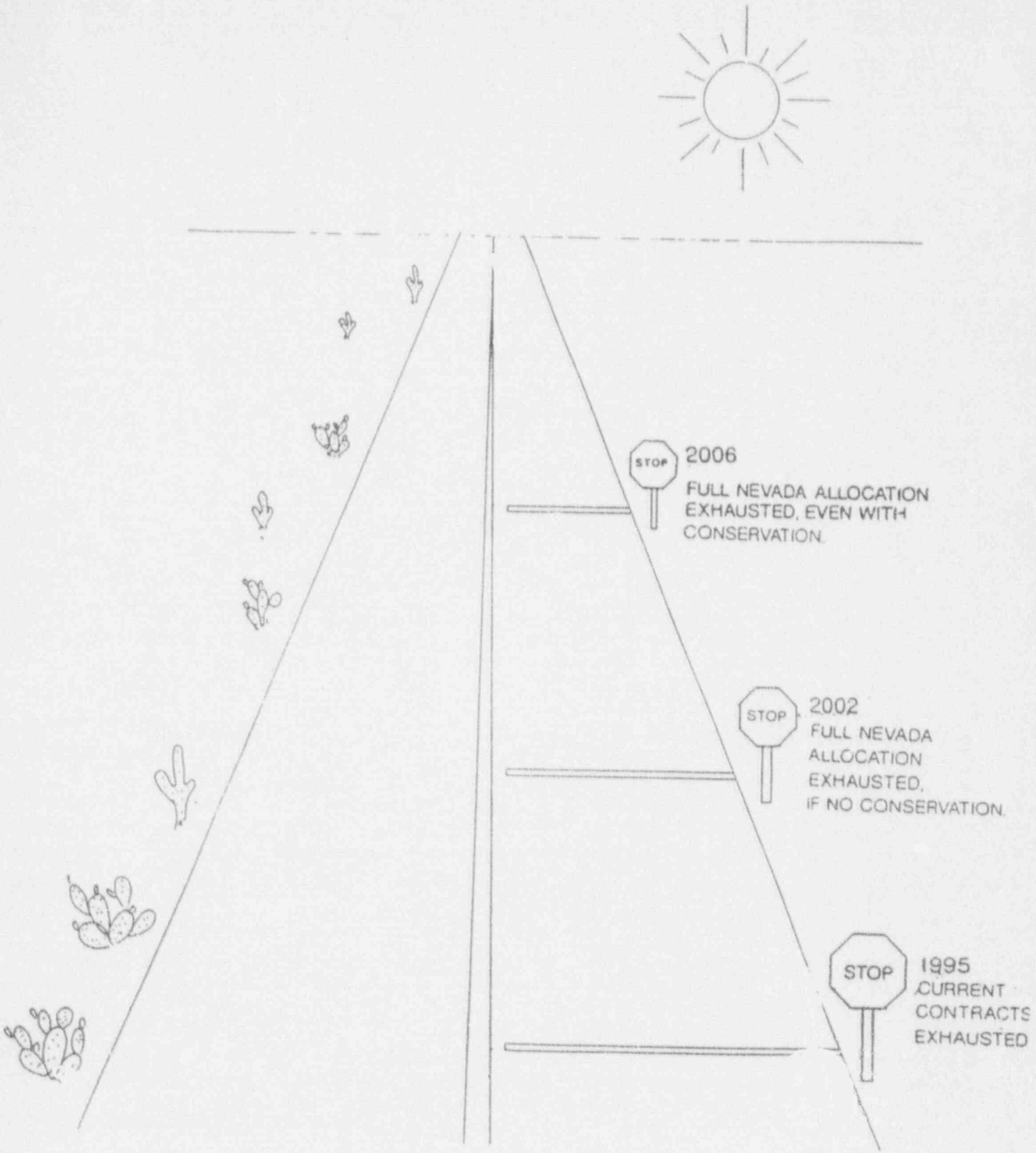
STOP
2006
FULL NEVADA ALLOCATION EXHAUSTED, EVEN WITH CONSERVATION.
STOP
2002
FULL NEVADA ALLOCATION EXHAUSTED, IF NO CONSERVATION.
STOP
1995
CURRENT CONTRACTS EXHAUSTED

Figure J

# WATER SUPPLY AND DEMAND 1990 - 2030
# FOR MAJOR WATER PURVEYORS IN SOUTHERN NEVADA

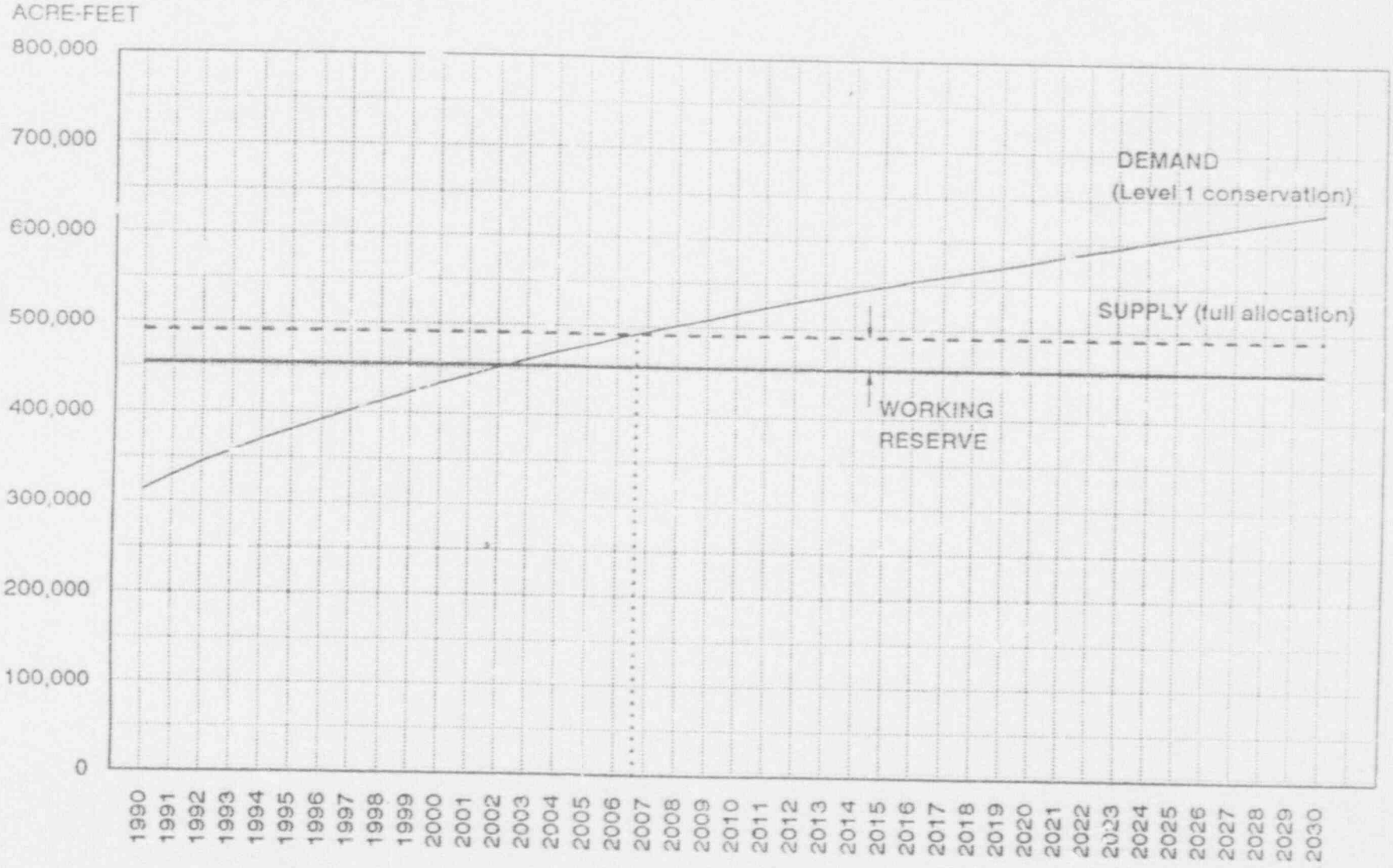


Figure K

# WATER SUPPLY AND DEMAND 1990 - 2030
# FOR MAJOR WATER PURVEYORS IN SOUTHERN NEVADA

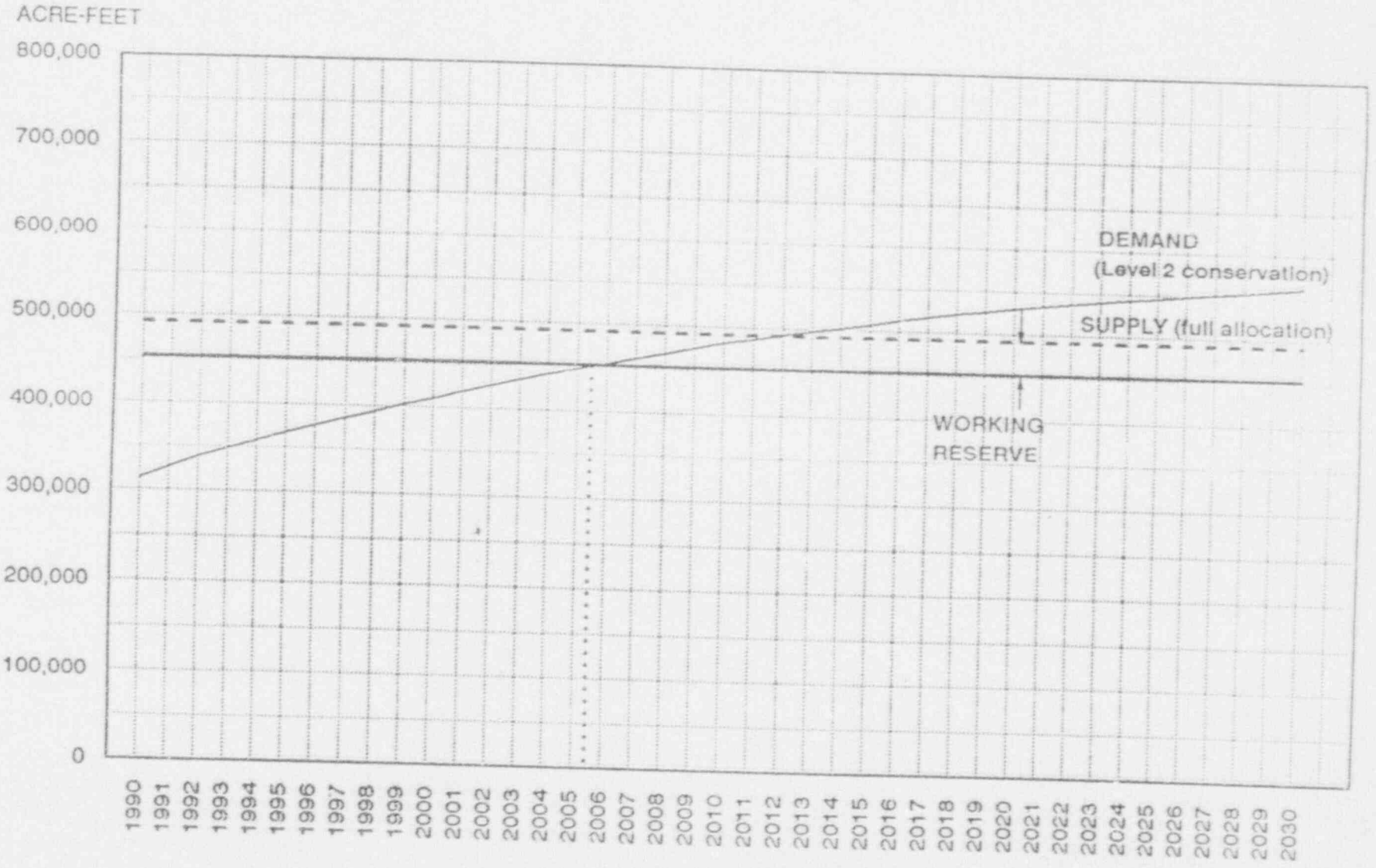


Figure L

# WATER SUPPLY AND DEMAND
# FOR MAJOR WATER PURVEYORS IN SOUTHERN NEVADA

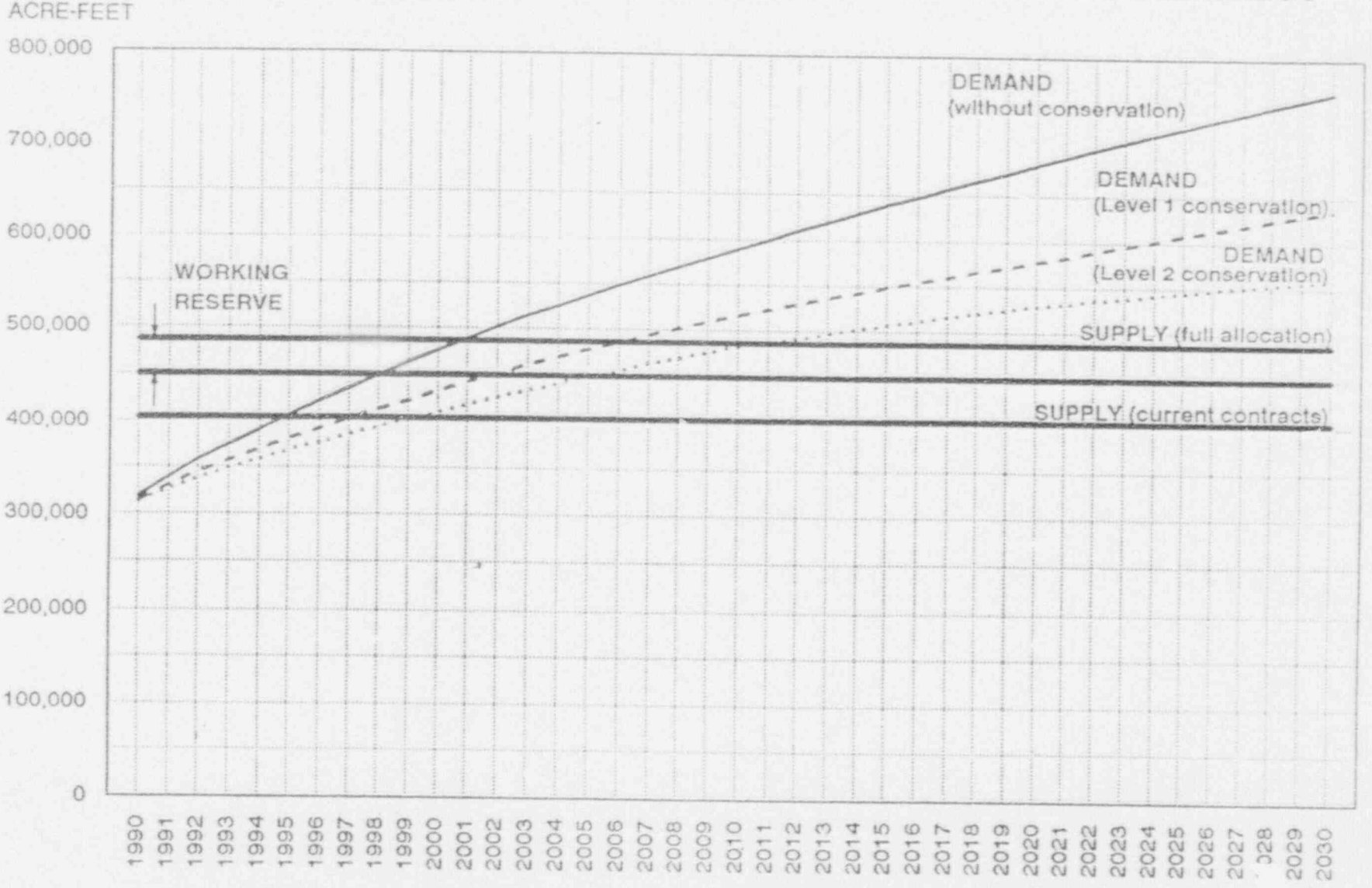


Figure M

# IMMEDIATE ACTION PLAN
# 1991

1. Obtain allocation of Nevada's remaining Colorado River water, and construct necessary capital improvements to deliver that water.

2. Implement conservation measures now.

3. Obtain additional water sources.

Figure N