

# Water for Nevada



APPENDICES

9

FORECASTS FOR THE FUTURE—ELECTRIC ENERGY

W A T E R F O R N E V A D A

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R E P O R T No. 9

FORECASTS FOR THE FUTURE --

ELECTRIC ENERGY

A P P E N D I C E S

ABSTRACT

Generation and use of electric energy require water and related land resources, the amount and distribution of which are related to the following certain factors, each of which is discussed in a separate appendix.

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TO THE CITIZENS OF THE STATE OF NEVADA

This report examines whether Nevada will import, export or be self sufficient with respect to electric energy, together with future water and related land resources questions. The report was edited and prepared by Victor R. Hill, of the Division's planning staff, along with Robert E. Walstrom, Natural Resources Consultant. Many other individuals and agencies provided extensive input for which there is space for only partial acknowledgment herein.

Nevada is currently a net importer of electric energy, and must also import the fuel required for generation within the State. Generation of electric energy in Nevada makes use of scarce water and related land resources. In this regard, generation requires considerable support. Accordingly, a preliminary listing of valleys which might efficiently support electric energy generation has been provided.

There are many things to consider related to Nevada's future electric energy course. Some of the more apparent include pressures building outside of Nevada affecting availability of sites and fuels. Transmission of electric energy is on a regional basis. Therefore, siting of generating facilities cannot escape regional import-export aspects. Inside of Nevada, this report examines methods of efficiently achieving reasonable economic and environmental balance, without a morass of regulations. However, recent and future federal actions may become controlling with respect to regulations.

It should be noted that there is great interest for future development of Nevada's geothermal resources. About 20% of the State is thought to have promise for future geothermal exploration. On a national scale, Nevada is estimated to be second only to California for potential geothermal development.

Additional emphasis in the report has been placed upon factors of efficiency in the use and generation of electric energy. In arid Nevada's future, conservation measures can help to prevent having to face in some areas the hard decision of whether to drink water or use it for coolant in electric energy generating stations.

Respectfully,

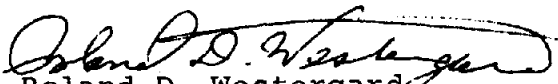
  
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TABLE OF CONTENTS (\*)

	<u>Page</u>
Chapter 1: INTRODUCTION	1
Major Issues	1
Effects Upon Nevada	1
Nevada's Present Internal Position	1
External Factors	1
Alternative Postures	3
Chapter 2: PURPOSES OF THIS REPORT	7
Overview	7
Purposes	7
Chapter 3: AMOUNTS OF ELECTRIC ENERGY GENERATION AND USE	11
Future Meaning	11
Powerful Forces Interacting	11
Listing of Projections	11
Most Probable Basis	11
Growth Patterns Inside Nevada	11
Study Boundaries	11
Nevada Projection Approach	13
Past and Expected Patterns	13
Population - Water - Energy Situation	14
Number of Nevada Generating Stations	14

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\*The entire table of contents is reproduced here for purposes of continuity. However, this addendum consists only of appendices to the separately published text.

CHAPTER 3: (Continued)	<u>Page</u>
Growth Patterns Outside Nevada	14
Interpretation of Outside Pressures	14
Study Boundaries	15
Regional Projection Approach	15
Past and Expected Patterns	15
Prudence of Self Sufficiency	16
Chapter 4: CONSERVATION FOR ELECTRIC ENERGY GENERATION AND USE	33
Limitations	33
Efficiency	33
Factors of Efficiency	33
APPENDICES: FOCUS UPON EFFICIENCY	37
BIBLIOGRAPHY	203

TABLES

Page

1. Projections in this Report.	20
2. Nevada Electric Energy Use Growth Patterns, Historic and Projected, in the Period 1930-2020	21
3. Nevada Growth Patterns for Population, Per Capita Use and Total Use of Electric Energy	23
4. Coolant Water Needs for Nevada's Future Electric Energy Generation	24
5. Projections for Nevada's Population, Municipal and Industrial Water Use and Electric Energy Use, 1970 to 2020.	24
6. Population and Electric Energy Growth Patterns for Groupings of States by Area and Class, 1920-2020	25, 160
7. Important Inflection Times for Long Term Growth	16
(Tables following are in separate addendum to the report)	
8. Listing of Valleys Tentatively Selected	47
9. Large Historic Earthquakes in the Western Basin and Range Province, Nevada and California	49
10. Vegetation General Categories Showing Estimated Amounts	57
11. Known and Listed Archeological Resources Per the Nevada Archeological Survey (NAS), 1974	69
12. Nevada Archeological Survey Basins Corresponding to Division of Water Resources Hydrographic Areas, 1974	70
13. Proposed Buffer Zone for Plant Siting	75
14. Less Favorable Areas for Plant Siting	77
15. Known Geothermal Resources Areas (KGRA) in Nevada	93
16. Exploratory Geothermal Drilling in Nevada Through 1973	95
17. Estimated Future Geothermal Energy Statistics by County	101
18. Estimated Future Geothermal Energy Statistics by Hydrographic Region	102
19. Geothermal Resource Development on Federal Lands	103

<b>TABLES</b>	<b><u>Page</u></b>
20. Nevada Potential Pumped Storage Sites	112
21. Site Selection Criteria Summary	114
22. Number of People at Hard Manual Labor Equivalent to Electric Energy to Operate Devices and Processes	129
23. Sources of Residential Average Annual Use	131
24. Organization of Appendix to Show Meaning	157
25. Description and Measurement of Focus	161
26. Variables and Combinations as an Identity	163
27. Meanings of Combinations of Variables in the Identity	163
28. Relationships Among Densities	167
29. What It Means to Try to "Control the Whole Thing"	171
30. Major Regulatory Factors and Their Major Effects on the Major Sources of Energy	176
31. Regulatory and Advisory Agencies and Functions with Respect to Energy	179

FIGURES

Page

1. Nevada Electric Energy Growth Patterns by Area	26
2. Nevada Electric Energy Growth Patterns by Class of Usage.	27
3. Nevada Per Capita Electric Energy Growth Patterns	28
4. Coolant Water Needs for Nevada's Future Electric Energy Generation, Assuming No Net Import or Export of Electric Energy	29
5. Percent Increase in Importance Above 1970 Conditions with Time	30
6. Population Growth Patterns for the Nation and Groupings of States by Area and Class, 1920-2020	31, 158
7. Electric Energy Generation Growth Patterns for the Nation and Groupings of States by Area and Class, 1920-2020	31, 158
8. Per Capita Electric Energy Generation Growth Patterns for the Nation and Groupings of States by Area and Class, 1920-2020	32, 159
(Figures following are in separate addendum to the report)	
9. Stages of Siting Process	41
10. Economic - Environmental Balance Mechanism for Siting-Rating System	43
11. Earthquakes in Nevada for 1971	52
12. Provisional Fault Map of Nevada	53
13. Faults in the Reno-Tahoe-Carson City Area	54
14. Proposed Buffer Zone	76
15. Pumped Storage Plant Operation	110
16. Typical Weekly Electric Utility System Load Curve	115
17. Head-Storage Capacity Relationship	116
18. Typical Cross Section of an Earthfill Dam	118



MAPS	<u>Page</u>
1a. Nevada and A Portion of the West, as Viewed from the Pacific Ocean	5
1b. Principal Electric Energy Transmission Lines of Nevada and A Portion of the West	6
2. Nevada Portions of FPC Power Market Areas I, II, III and IV	17
3. Nevada Portions of FPC Power Supply Areas 41, 46B, 47 and 48	18
4. United States of America, the 48 Contiguous States in 4 Regions	19
(Maps following are in separate addendum to the report.)	
5. Nevada Archeological Survey Basins and Resources	71
6. Known Geothermal Resource Areas (KGRA) and Lease Applications Activity in Nevada	97
7. Hot Springs and Geothermal Wells in Nevada	98
8. Nevada Potential Pumped Storage Sites	113

## INTRODUCTORY NOTE

Because this report has been written in sections, by persons from diverse backgrounds and interests, electric generating plants and other facilities are referred to differently. In some sections, the discussion will contain reference to "electric energy generating....." In other sections, the reference will be to "electric power generating.....". For the Division of Water Resources, the focus is mostly upon energy, because annual water use depends upon energy more than power. For utilities, the focus is mostly upon power, because installed electric generating capacity depends upon demand for power more than energy.

Energy and power are related because power is energy expended per unit of time. For a service area, on an annual basis, the total energy generated divided by the time in one year will give the average electric power generated for that year. Of course, power demand varies quite a bit above and below the average on a daily, weekly and seasonal basis -- both predictably and unpredictably.

In this report, we are attempting to focus mostly upon the long term electric energy use and generation, and associated interactions with water and related natural resources.

## A P P E N D I C E S

### FOCUS UPON EFFICIENCY

Generation and use of electric energy require significant support from Nevada's scarce water and related land resources. The following appendices are concerned with the applications of factors of efficiency as conservation measures for the generation and use of electric energy.

There is no question that the factors of efficiency are related among themselves, and some of this interrelation will show up in the appendices. The purpose of treating the factors of efficiency primarily separately, rather than in groupings, is to provide a wider future basis for examining options and their meanings for Nevada and the West. In this manner, it is intended to better provide for the future quality of life for individual citizens of Nevada.

### ORGANIZATION OF APPENDICES

<u>Appendix</u>	<u>Factor of Efficiency</u>	<u>Page</u>
A	Siting	38
B	Alternative Processes	83
C	Rate of Use	128
D	Design	140
E	Natural Limits	148
F	Regulatory Situation	173
G	Technology of Water Use for Energy Processes	184
BIBLIOGRAPHY		203

A P P E N D I X A

S I T I N G

	<u>Page</u>
SITING	39
Reasonable Balance	39
Regulations	39
Siting-Rating System Development, Use and Limitations	40
Listing of Criteria and Tentatively Selected Valleys	42
INDIVIDUAL CRITERIA (refer to Figure 10)	43

## SITING

### Reasonable Balance

Recently, much planning attention has been directed toward examining the combined economic and environmental impacts of production and use of electric energy. The concept of attempting to reach a reasonable and efficient economic - environmental balance has resulted.

Economic conditions would include most importantly four factors, in an order of importance varying with time and place: water availability; fuel availability; proximity to load center; transportation. Environmental conditions would include the integrity of animal, plant and soil relationships. Economic and environmental conditions both include quality of life for people.

People, their economic activity and resource use are the instruments of man made pressures upon the environment. Siting of electric energy generation facilities is an element of these pressures, and has become a subject for regulations in many states.

### Regulations

Discussion of siting regulations for energy generation facilities often revolves around the argument that no region or state should be able to lay its energy burden on others. This "laying on" as a matter regulation might be accomplished by court action, legislation or administrative action and would be described in statement form as:

#### REGULATIONS CONCERNING "LAYING ON"

No state or region should be able to lay its energy burden on others by:

1. Refusing to build generation facilities to produce the energy which is consumed in the area.
2. Importing energy which could be generated in the area.

At first glance, these statements seem reasonable. If all states and regions could be nearly self sufficient in meeting electric energy requirements, "laying on" would not exist as a reasonable subject for argument. However, many regions and states find that they do not have the resources or that it would be grossly inefficient to be self sufficient with respect to energy. Other states and regions barely could be self sufficient with respect to electric energy. A few states and regions easily could be self sufficient many times over.

From both an economic and environmental viewpoint, it seems inefficient to make laws which include or freeze out large blocks of a state or region for siting of electric energy generation facilities. Balanced, efficient siting within any large area is a stepwise process, consistent with many economic and environmental accommodations. Still, restrictive laws are sometimes a needed part of the mechanism when an area such as Nevada attempts to protect itself, should economic and environmental swings set in motion by a neighbor appear to be "laying on" the energy burden.

#### Siting-Rating System Development, Use and Limitations

In this report, analysis of past population and electric energy data has shown the tremendous forces and behavioral stability involved and provided insight into natural limits upon what planners and policy makers may reasonably expect to accomplish. From factual analysis of data, knowledge of planning limitations, and the concept of attempting to reach reasonable economic-environmental balance, criteria were developed for a preliminary "siting-rating" system.

Selecting preliminary criteria was accomplished by research, and particularly by asking for short contributions from experienced people. They were asked to provide opinions about major siting considerations for electric energy generating facilities.

The siting-rating system has been used to tentatively identify a sampling of typical valleys in Nevada. <sup>(1)</sup> These valleys appear to have the best potential for siting future conventional fossil fuel and nuclear electric energy generating facilities. In addition, potential geothermal areas and potential pumped storage sites have been identified. Figure 9 depicts stages of the process of siting prior to actual construction.

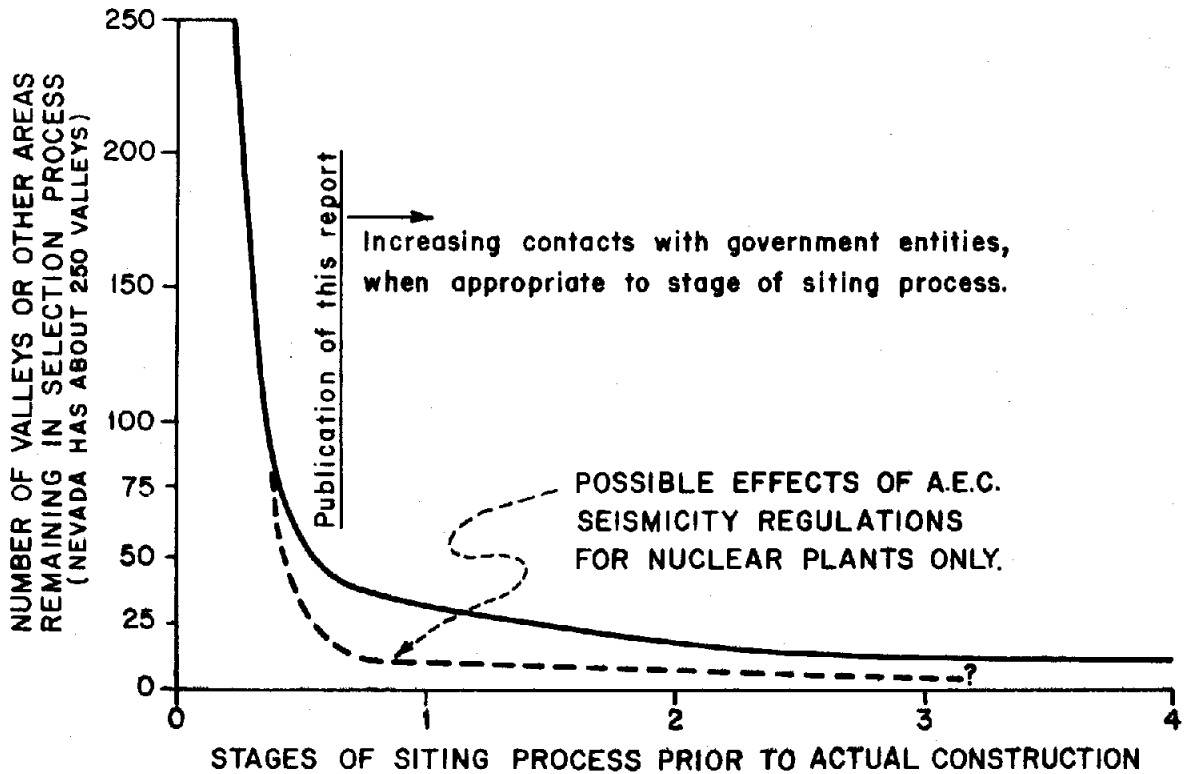
Analysis in this report shows that presently highly determined physical locations for population, economic activity and resource use will dictate the economics of siting for future electric energy generating facilities. Natural processes uncontrolled by planners have caused the physical location of resources needed for electric energy generation, such as water and fuel. Other resource uses, types of vehicle engines and transportation routes have influenced and been influenced by distribution patterns for economic activity and population -- largely uncontrolled by government planners.

Hence, government siting controls appear to be subject in normal situations to a high degree of predetermined natural and economic limits which define their efficiency. These same limits define the efficiency of industry when siting facilities. Constraints upon government and industry must overlap sufficiently

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(1) See pages 42 and 46 for listing of criteria and valleys identified.

**FIGURE 9**  
**STAGES OF SITING PROCESS**



**DESCRIPTION OF SITING PROCESS STAGES**

**CONCEPTUAL ESTIMATES  
 OF PERCENTAGE  
 OF AREAS REMAINING  
 UNDER CONSIDERATION**

- 0. Projections have indicated time frame of need and management initiates selection..... 100 %
- 1. Broad siting selections completed ..... say 15 %
- 2. Advanced siting selections involving economic studies and some exploratory work within valleys ..... say 6 %
- 3. Finer site investigations involving environmental and detailed surveys within valleys ..... say 5 %
- 4. Single site surveys for final design ..... say 4 %
- 5. Construction at site or sites ..... up to ? %

to achieve agreement, otherwise there will be no investment for electric energy generation facilities in the area and time interval involved. Further, given uncertainty about agreement for a place and time, investment will be almost completely curtailed.

## Listing of Criteria and Tentatively Selected Valleys

### Criteria

Facilities must be sited to meet future needs for electric energy. Figure 10 shows how major criteria for use within the siting process may be classified as part of an economic-environmental balance mechanism. Where appropriate to cover throughout this report, page numbers in parentheses beside a criterion indicate where that criterion is most fully discussed.

In carrying out the siting process, a balance sheet listing the criteria would be made up for each valley. Then the siting-rating system would be used to select the most efficient combinations of economic and environmental criteria believed to be possessed by only a few valleys out of 250 valleys in Nevada. Probably, a mathematical modeling technique called "linear programming" would be used to weigh criteria and complete tentative selections.

The linear programming technique is described in the last article of this appendix. It has been put there to show how what appears to be hopeless complexity, at first reading, may be tied together and coped with to reach a reasonable solution. Description of the newly developed aircraft and earth satellite remote sensing capabilities precedes description of linear programming. This was done to indicate that there is a well organized source of basic water, vegetation and related land data increasingly available for use in the near future.

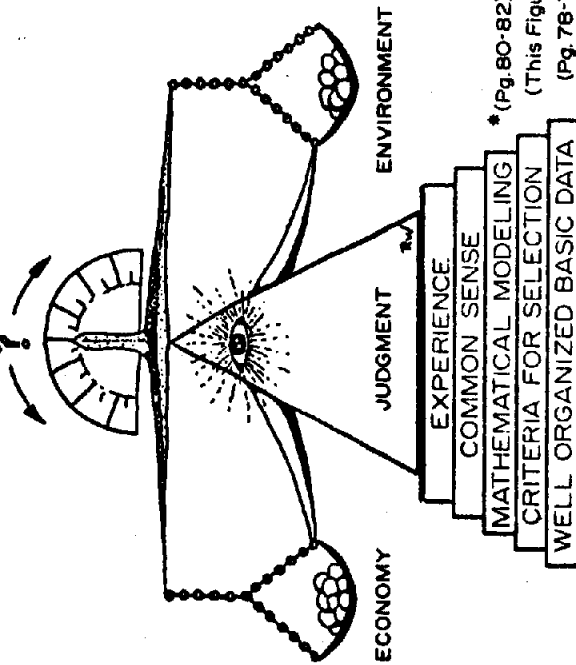
Seismic constraints have been described first in this appendix because they may prove to be more important than water and related land resources in siting of nuclear electric energy generation facilities. Under the heading of safety, the Atomic Energy Commission (AEC) has adopted stringent limits upon how close a nuclear plant may be located to certain types of faults. Thus, available sites would become very scarce indeed.

It has been suggested that these limits may be overly stringent considering the present ability for taking the necessary offsetting design precautions. The degree of stringency could affect Nevada's import-export posture and consequently, its economic-environmental balance. This is because in the short term, there is no practical, efficient and large scale alternative to largely replacing the use of petroleum and coal by nuclear energy. Additionally, if these AEC seismic constraints prove to be overly stringent, they may be completely overthrown. This situation has so much weight for Nevada



# QUALITY OF LIFE

FIGURE 10



\* Basis of common system of measurements of weights

## ECONOMIC-ENVIRONMENTAL BALANCE MECHANISM FOR SITING-RATING SYSTEM

### MANAGEMENT OF THE BALANCE MECHANISM (1)

- Essential Energy (85-86, 150-154, 165-168)
- Government Regulations (39-42, 130, 141, 150, 153, 156, 164, 168-183)
- Seismic Constraints (48-54)
- Other Hazard Constraints (55)
- Buffer Zone (74-77)
- Water Use (44)
- Private Operations (39-42, See) (Govt. Reg.)

## MAJOR NATURAL RESOURCES CRITERIA FOR SITING-RATING SYSTEM

WATER AND RELATED LAND RESOURCES		HUMAN RESOURCES		OTHER RESOURCES	
Surface		Archeological		Flora (Plants)	
Climate	(16, 55)	Historical and Cultural	(67-71)	Rare and Endangered	(56)
Surface Water	(See Mgt.)	Present and Future	(72-73)	Critical Populations	(57-58)
Fragile Environments	(65-66)	Population and Activities		Fauna (Animals)	
Pumped Storage Sites	(109-127)	Associated Economic Resource Use	(24, 25, 160) (167)	Rare and Endangered	(59-60)
Underground				Critical Populations	(61-62)
Ground Water, incl.	(See Mgt.)			Activities	
Geothermal Steam	(88-107)			Migratory Habitat and Breeding Grounds	(63-64)

(1) Achievement of reasonable economic-environmental balance may be connected with prudently paying an insurance premium. Cost of the premium can be weighed against quantities and associated qualities of life which could be lost without insurance. With this approach, final position of the balance mechanism is determined by individual payments, although the apparatus is "managed" by public and private entities. Focus of management upon efficiency will cut the size of premium required to achieve reasonable balance.

and the West that the future quality of life depicted by Figure 10 could be set to greatly swinging.

Surface water in Nevada has been substantially appropriated in the past. Ground water use has been administered under the concept of perennial yield, which provides reasonable balance state-wide between net withdrawals and natural recharge. Mining of ground water on the scale which has been practiced in other Western States has been avoided in Nevada.

During more than 100 years of surface and ground water use in Nevada, a system of water rights has developed. Beneficial use has been defined by custom and statute as the basis, measure and limit of the right to use water.

One of the bedrocks upon which the siting-rating system must stand is continued recognition of established water rights. The manner of use, place of use and point of diversion of these established rights may be changed. Rights may be purchased with land or they may be specifically purchased separately from the land. Thus, through purchase, combinations of sources of water with uses of water may undergo change with conditions, within the historically determined system of established water rights.

Criteria described in this appendix are presented first to indicate how the energy related facilities to be constructed might be damaged by natural and man made conditions. Then, the impacts of the proposed energy related facilities upon natural and man made environments are examined. Finally, as previously mentioned, techniques for remote sensing and mathematical modeling are presented to show how the siting conditions might fit together for both facility and environment.

Criteria described are presented in the following order:

ORDER OF PRESENTATION  
FOR CRITERIA  
IN THIS  
APPENDIX

	<u>Page</u>
1. Seismic Constraints	48
2. Other Hazard Constraints	55
3. Flora - Rare and Endangered	56
4. Flora - Critical Populations	57
5. Fauna - Rare and Endangered	59
6. Fauna - Critical Populations	61
7. Fauna - Migratory Habitat and Breeding Grounds	63
8. Fragile Environments	65
9. Archeological Resources	67
10. Historical and Cultural Resources	72
11. Proposed Buffer Zone	74
12. Remote Sensing	78
13. Mathematical Modeling	80

Where appropriate, the individual, agency or organization making principal contribution to the write-up on a criterion has been acknowledged on the title page in this appendix for that criterion.

## Valleys

In Table 8, valleys are referred to as hydrographic areas. Tentative selection was partly based upon adequate ground water to support 1,000 megawatts of electric generating capacity. In the neighborhood of 15,000 acre-feet of perennial yield would be required.(1) Valleys in developed urban and rural areas have been temporarily set aside from consideration, pending study beyond this report. Included in the set aside classification are the Las Vegas Valley, as well as other valleys in the Carson, Truckee, Humboldt and Walker River systems.

Electrical generating capacity close to larger electric load centers is economically efficient. Planners often say, "Keep the people and the facilities to serve them close together" -- so as to cut down on the total facilities required. However, there are limits to closeness where quality of life has been built and will continue to depend upon use of scarce water and related land resources.

If there is intense competition for existing water resources in an urbanized valley or area, it would probably be necessary to site generating facilities which would use additional water in a nearby but not water short location. The same would be true for agricultural areas, if generating facilities would infringe upon existing rights. Each situation should be judged on its own merits.

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(1) Refer to Appendix G for discussion of water consumption by electric energy generation and other energy processes.

TABLE 8: LISTING OF VALLEYS TENTATIVELY SELECTED

<u>Hydrographic Area Name</u>	<u>Number</u>	<u>Hydrographic Area Name</u>	<u>Number</u>
Dixie Valley	128	Pahranagat	209
Smoke Creek Desert	21	Snake	195
Kobeh Valley	139	Black Rock Desert	28
Frenchman Flat	160	Diamond Valley	153
King's River Valley	30	Amargosa	230
Newark Valley	154	White River Valley	207
Coyote Spring Valley	210	Muddy River Springs Area	219
Fish Lake Valley	117	Railroad Valley	173
Lower Reese River and Whirlwind Valleys	59, 60	Ruby Valley	176
Clayton Valley	143	Quinn River Valley	33
Clover Valley	177	Big Smoky Valley (North)	137b
Pahroc Valley	208	Steptoe Valley	179
		Spring Valley	184

Acknowledgement: Dr. Alan Ryall  
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## SEISMIC CONSTRAINTS

During the historic period since about 1840, ten earthquakes with magnitude greater than about  $6\frac{1}{4}$  have occurred in the western Nevada/eastern California region (Table 9). In 1872, the great Owens Valley earthquake destroyed the principal buildings in nearly every town in Inyo County. The 1872 earthquake was felt over a larger area than was the 1906 San Francisco earthquake, and probably had magnitude of at least 8.3. Five of the other ten events had magnitude of 7 or greater.

In comparing the current distribution of approximately 500 small earthquakes per year in the Nevada region, with that of larger shocks during the last century, we have come to the following conclusions: In areas where large historic earthquakes have occurred (Owens Valley, 1872; Pleasant Valley, 1915; Cedar Mountains, 1932; Fairview Peak, 1954), aftershock activity appears to decay exponentially, and to die out almost completely about 90 years after the main shock. In some areas, like Death Valley, California, and Granite Springs Valley in northwest Nevada, fresh fault scarps and very low seismicity suggest that large earthquakes probably occurred just prior to the historic period, and that these areas are seismically "dead" for the time being. In several areas that have been noted previously as gaps in the historic seismic zone<sup>(1)</sup>, higher seismic potential is suggested by the combination of moderate seismicity and the lack of recent faulting. These include: (1) Owens Valley north of Big Pine, to Benton; (2) Fishlake Valley north to the Excelsior Mountains; and (3) a northwest trending zone from Carson City, Nevada, to Sierraville.

Maps of current earthquake activity (Figure 11) and of faulting over the last approximately 10,000 years (Figure 12) indicate that very much less activity has been occurring in northern and eastern Nevada. This may, however, be misleading, for the following reasons:

(1) There is a tendency for large earthquakes in Nevada not to recur in the same place for very long periods of time, probably on the order of several centuries or tens of centuries. Thus, the historic record may be helpful in determining where earthquakes will not occur in the near future, but probably not where they are most likely to occur.

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(1) See reference 3 at end of this section.

TABLE 9: LARGE HISTORIC EARTHQUAKES IN THE WESTERN BASIN AND RANGE PROVINCE, NEVADA AND CALIFORNIA

Year	Magnitude	Location	Remarks
1845?	7?	Near Stillwater	Reported by Indians. Knocked people down, changed the course of a river near Stillwater.
1860	6½?	Northwest Nevada?	Reported felt from Yreka, California, to Utah, over 200,000 sq. mi. "Very violent" at Carson City, suggesting epicenter may have been in that vicinity.
1872	8½?	Owens Valley	Terrain disturbed for seventy miles, 27 killed at Lone Pine, principal buildings in nearly every town in Inyo County thrown down, felt over 640,000 sq. mi.
1915	7 3/4?	Pleasant Valley	Faulting for more than 20 miles with vertical offsets up to 15 feet, felt over 500,000 sq. mi.
1932	7½	Cedar Mountains	Ground breakage in area 38 miles long and 4-9 miles wide.
1934	6.3	Excelsior Mountains	Damage in Mina, felt from California to Utah.
1954	6.8	Rainbow Mountain	Two shocks. Felt over 150,000 sq. mi., damage to canals and drainage system of the Newlands Project.
1954	7.2	Fairview Peak - Dixie Valley	Two shocks. Felt over 200,000 sq. mi., spectacular surface faulting in a zone 60 miles long, vertical offset up to 20 feet. Acceleration about 0.015g at Bishop, 210 km from the epicenter.

(2) In a number of other areas of the world, large earthquakes are preceded by an increase in seismicity several years or decades before the large shock. This is the basis for identifying several areas in the Nevada region which appear to have high potential for future earthquakes. However, the San Fernando earthquake on 9 February 1971 was not preceded by any buildup of activity, but occurred in an area of low-to-moderate seismicity, not unlike many other parts of southern California; and no buildup of activity was observed in the years prior to 1971. Thus, our picture of earthquake potential for Nevada is tentative at best, and the possibility of a large earthquake anywhere in the region cannot be ruled out.

(3) In general, earthquakes tend to occur along previous zones of weakness in the earth's crust. Historically, most of the largest shocks have occurred along well defined range-front faults (Owens Valley, Pleasant Valley, Fairview Peak), but the 1932 Cedar Mountains earthquake had a complicated zone of fracturing in an area of complex geology and low topographic relief. Thus, although the potential for large earthquakes is higher along well developed fault zones, they can also occur in areas where faulting is complicated or poorly defined.

(4) When detailed field mapping is carried out in this region, the picture that emerges is much more complicated than that shown on Figure 12. An example of this is shown on Figure 13, for the Reno and Carson City area. In a typical example, detailed mapping would produce hundreds or thousands of potentially active small faults within a radius of several tens of miles.

For nuclear power plants, the AEC siting criteria are very stringent in respect to the evaluation of "capable" faults. Faults a mile or more in length have to be considered within a radius of 20 miles from a reactor site, and within 50 miles all faults five miles or greater in length must be investigated. A "capable" fault is any fault which exhibits one or more of the following characteristics: (1) movement at or near the ground surface at least once within the past 35,000 years, or movement of a recurring nature within the past 500,000 years; (2) macro-seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault; (3) a structural relationship to a capable fault according to characteristics (1) or (2) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

In a region like Nevada, with many thousands of faults, what these criteria boil down to in practice is a search for a site where faulting can be dated by one or another means, and where it can be shown that no "capable" faults exist within perhaps five miles of the site. Further studies then have to be carried out to determine the Safe Shutdown and Operating Basis Earthquakes for that site, based on the most severe earthquakes that could be associated with tectonic structures or tectonic provinces in the region surrounding the site.



The regional studies that have to be carried out before a site is tentatively selected are not trivial, and it is not currently possible for us to evaluate the seismic conditions for each of the more than two dozen hydrographic areas being considered at the "phase one" stage of the preliminary siting procedure. A mistake that has been made in the selection of power plant sites in the past is that of choosing a site because of availability of water or other, non-geologic considerations, and then trying to prove that the site meets the AEC's seismic and geologic siting criteria. In the western United States, sites that can be shown to meet these criteria are rare enough that geologic and seismic investigations should be viewed as a primary, rather than secondary, level of site selection.

For conventional power plants, seismic considerations would be the same as for any other large structure in an active seismic region. The plant would have to be designed to satisfy the minimum requirements of any applicable building codes. Additional studies of earthquake risk would be at the option of the owner, for the purpose of minimizing financial loss, hazards to plant facilities or power distribution systems, etc., during earthquakes.

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**FIGURE 11  
EARTHQUAKES IN NEVADA FOR 1971**

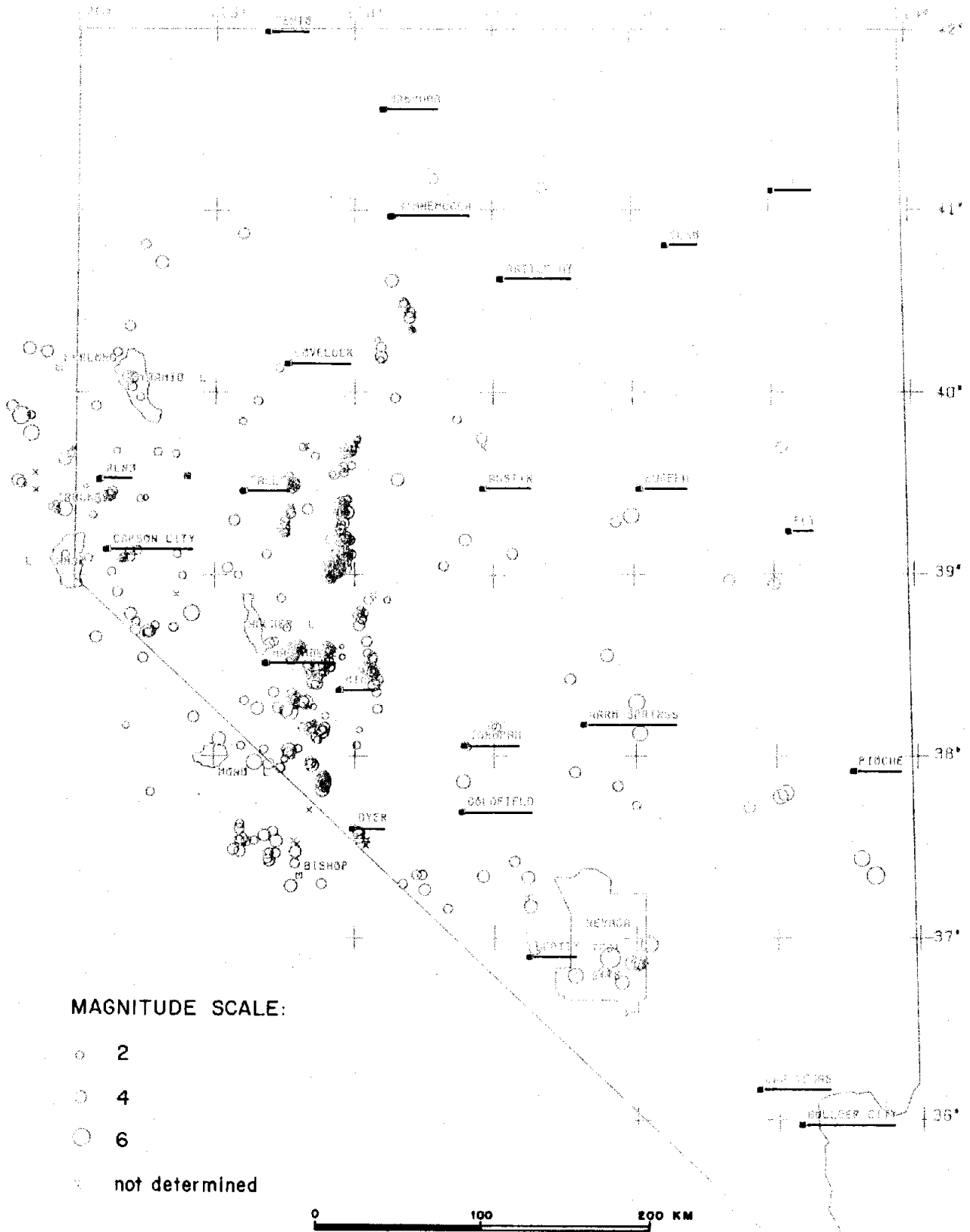
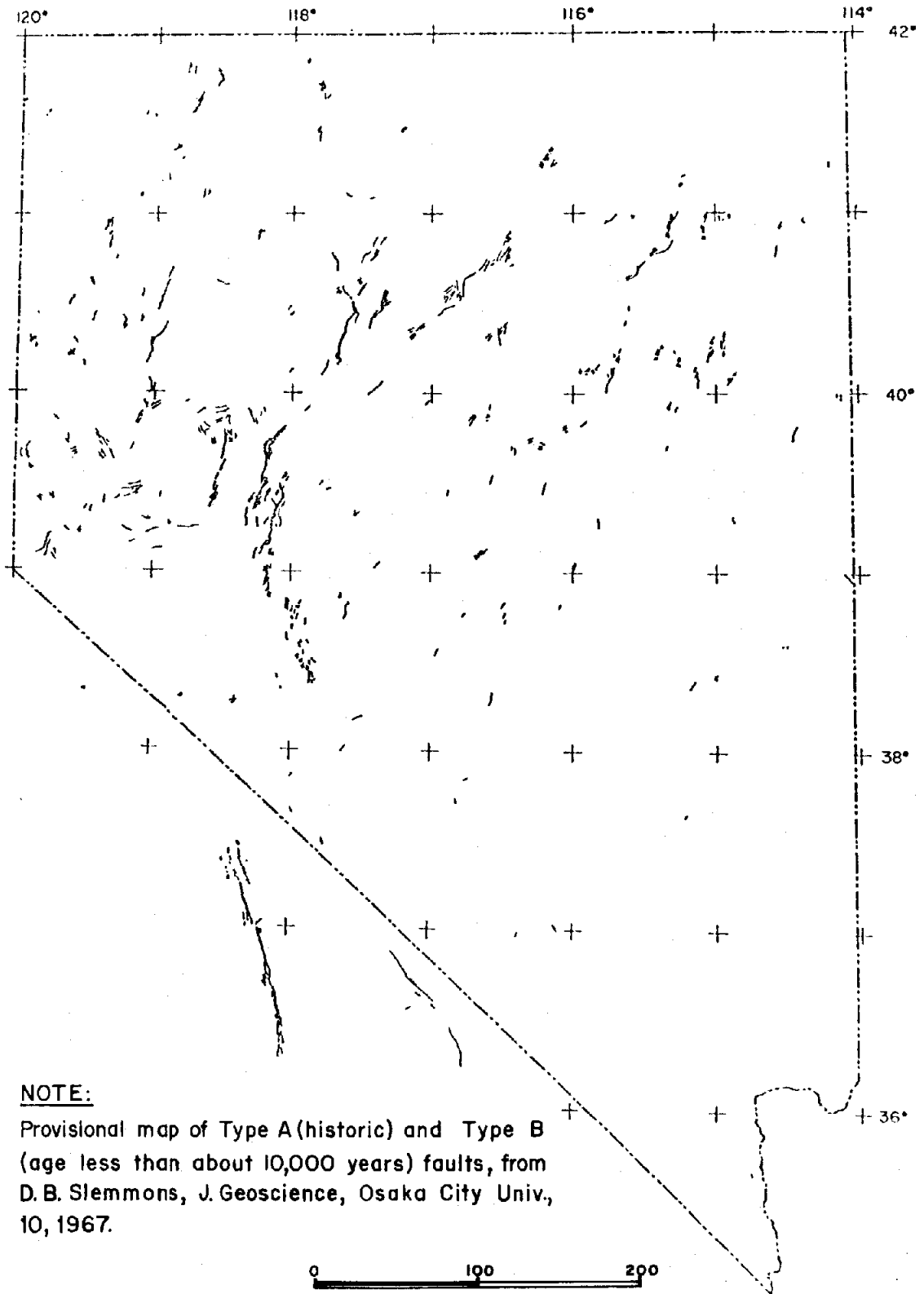


FIGURE 12  
PROVISIONAL FAULT MAP OF NEVADA



**NOTE:**

Provisional map of Type A (historic) and Type B (age less than about 10,000 years) faults, from D. B. Slemmons, J. Geoscience, Osaka City Univ., 10, 1967.