White Pine Power Project

GROUNDWATER INVESTIGATION
PHASE 1

TECHNICAL REPORT

EXHIBIT #7
FOR:
- [ ] STATE OF NEVADA
- [ ] PROTESTANT
- [x] APPLICANT
- [ ] ______________ OTHER

DATE 8-17-83

GROUNDWATER INVESTIGATION

PHASE 1

Technical Report
For The
WHITE PINE POWER PROJECT

Prepared For

Los Angeles Department of Water and Power

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SUMMARY

The White Pine Power Project (WPPP) is a proposed 1500-megawatt coal-fueled, steam-electric generating facility to be located in White Pine County, Nevada. The project consists of two 750-megawatt units, with Unit 1 scheduled for commercial operation in mid-1989.

A water supply of 25,000 acre-feet per year (afy) is required by the WPPP for cooling purposes. The purpose of this report is to describe surface and groundwater resources in White Pine County which might provide such a supply and to establish a priority ranking of valleys for further more detailed investigations.

This Phase 1 report is a reconnaisance level report which relies on data and information developed by others. It will be followed by Phase 2 and Phase 3 studies in which a specific water supply plan will be developed. The key findings of this groundwater investigation are as follows:

Summary of Collection and Use of Available Data

Considerable data and information were gathered from various sources. Much of the data is tabulated and included in this report to assist other investigators.

Preliminary Ranking of Potential Water Basins or Valleys

Based on analysis, the ranking of the major seven valleys in White Pine County as a water supply source for WPPP is as follows:

- Spring Valley (most likely water source)
- Steptoe Valley
- White River Valley
- Jakes Valley
- Butte Valley (southern portion)
- Newark Valley
- Long Valley (least likely source)

Preliminary Percentage of Water From Various Sources

a. Surface water resources are not available in sufficient quantities to constitute the entire supply for WPPP. Such resources have long been appropriated but could provide a partial water supply for the WPPP through purchase from either mining or ranching interests.

b. A long term pumping rate of about 5000 afy or 20 percent of the annual requirement might be obtained from Kennecott's Deep Ruth mine and associated mine shafts.

c. Analyses of groundwater level measurements from existing wells indicate that water levels are not declining and the perennial yields are not now being exceeded in any of the valleys. Thus 100 percent of the WPPP water supply would appear to be available from judiciously placed well fields in White Pine County.

d. Preliminary drawdown analyses indicate considerable impact on a particular valley if all the supply is obtained from a single well field. Thus consideration should be given to several smaller well fields, possibly in different valleys.

e. Preliminary drawdown studies indicate that for a well field located in valley alluvium, 40 percent of the water supply over a 25 year period could come from storage. For a well field in carbonates about 30 percent could come from storage.

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1.0 INTRODUCTION

1.1 GENERAL

1.1.1 Background

The White Pine Power Project (WPPP) is a proposed 1500-megawatt coal-fueled, steam-electric generating facility to be located in White Pine County, Nevada. The project consists of two 750-megawatt units. Unit 1 is scheduled for commercial operation in mid-1989.

A water supply of about 25,000 afy was assumed in this study to be required by the WPPP for cooling purposes. Applications have been filed with the Nevada State Engineer to appropriate a water supply from each of seven groundwater basins in White Pine County.

It is necessary to determine a specific source of water for the WPPP at the earliest practicable date. Accordingly, the WPPP through the Los Angeles Department of Water and Power, has entered into an agreement with Leeds, Hill and Jewett, Inc. (LEEDS-HILL) to undertake certain groundwater related tasks.

1.1.2 Authority

The "Agreement for Groundwater Resource Consulting Services", of White Pine Power Project Development work provides the authority for this work. Under this Agreement, LADWP serves as agent of the Owners and is designed Development Manager for the Project.

Under this Agreement, LEEDSHILL, together with its subcontractors, Environmental Dynamics and Harding/Lawson, are to undertake certain groundwater related studies.

Attachment I of this Agreement is the Scope of Services which generally describes the services LEEDSHILL is to perform. Attachment I divides LEEDSHILL's work into three successive phases, the first of which has been completed.

1.1.3 Scope

The purpose of Phase 1 is to "locate, document, analyze and summarize existing literature and data on the hydrology, related geology, water rights, and water rights appropriations of White Pine County". It is recognized by both LADWP and LEEDSHILL that Phase 1 is not, nor is intended to be, exhaustive or conclusive. It is essentially a reconnaissance-level, broad survey that will serve to focus the more expensive and time-consuming work of the next Phase specifically on those areas and locations that show highest promise of providing adequate groundwater supplies.

Phase 1 is divided into the steps and categories that are listed below. The body of this Report is, in fact, step d of this list.

a. Document existing water resource data and field inspect project area.

b. Collect additional data:

   1. General: Research state and national files on graduate theses and other publications to locate studies done on White Pine County.

   2. Hydrologic Data: Collect and review data on precipitation, streamflow, water budgets, location and amounts of basin in-flows and discharges, water quality, water use, groundwater levels, thermal springs, phreatophyte demand and location, pump tests, and present and projected land use. Provide site specific hydrologic data for flood control studies.

   3. Geologic Data: Collect and review data on soil surveys, well logs, geology maps, alluvial aquifer, regional carbonate aquifers and mine dewatering.

   4. Ecologic Data: Provide base groundwater and any environmental data found for use in the study of environmentally sensitive areas.

c. Analyze data:

   1. Prepare preliminary water budgets for individual basins or valleys including:

a. Identification of surface water streams, rivers, and wetlands including flow rates.

b. Identification of groundwater basin locations, sources, and probable outflows.

2. Prepare preliminary analysis of subsurface interflows among basins identifying specific aquifers as practicable.

3. Identify water rights conflicts that may affect project.

4. Conceptualize development of water supply including required facilities for Siting Study Candidate Areas including preliminary estimate of:

(a) Available sources

(1) Surface water

(2) Groundwater

(i) Existing wells

(ii) New wells

(iii) Mine dewatering

(iv) Other

(b) Quantities available from each source

(1) Rates of pumpage

(2) Perennial yield vs. groundwater storage

d. Prepare a report documenting the Phase 1 work and recommending the following:

1. Preliminary ranking of potential water basins or valleys.

2. Areas requiring additional data.

3. Preliminary percentage of total water requirements from each source, e.g., surface water, alluvial aquifers, carbonate aquifers, mine dewatering, and streams.

4. Re-evaluate tasks and scope for Phase 2 and Phase 3 considering results of Phase 1.

1.2 DESCRIPTION OF STUDY AREA

1.2.1 Geographic Setting

The study area shown on Plate I includes essentially all of White Pine County in east-central Nevada. The county seat, Ely, is near the center of the county. The total area of the county is 8904 square miles, making it larger than five U.S. states.

White Pine County is in the heart of the Great Basin region of the Basin and Range physiographic province, a region characterized by nearly flat-bottomed, alluviated valleys separated by north-trending mountain ranges. The valleys range in elevation from 5500 to 6100 feet, while the mountains are generally above 9000 feet elevation. The highest point is Wheeler Peak, elevation 13,063 feet, in the Snake Range in the southeastern part of the county.

Of particular interest are seven of the largest alluviated valleys, all of which are potential sources of groundwater. These valleys include Butte (southern portion), Jakes, Long, Newark, Spring, Steptoe, and White River (within White Pine County). These valleys are delineated on Plate I.

The native vegetation in the lowest parts of the valleys are salt-tolerant shrubs such as shadscale, winterfat, kochia, and greasewood. [F.A. Branson in (107)] In nonsaline soil areas of the valleys are found big sagebrush, black sagebrush and several species of grasses. In the foothills and on the lower slopes grow pinon and juniper trees, while at higher elevations are white fir, ponderosa pine and bristlecone pine.

1.2.2 Geologic Setting

1.2.2.1 General Geology

The geology of White Pine County is very complex, due to the considerable tectonic activity that has profoundly altered the structural relationship of the rock units. The principal physiographic features, the north-trending mountain ranges and intervening valleys, have resulted from block faulting in which the mountains have been uplifted relative to the bedrock underlying the valleys. The uplifted mountain blocks are termed "horsts", while the down-dropped valley blocks are termed "grabens". The geology is further complicated by thrust faulting, folding, igneous intrusion and volcanic activity. Rock units range in age from very old Precambrian rocks to Quaternary sediments. (See geologic map on Plate V.)

1.2.2.2 Geologic Structure

The mountain ranges are believed to have been formed either as horsts flanked on both sides by faults, as tilted blocks flanked on only one side by a fault, or as folded horsts.(50) The Roberts Mountains trust fault, the major structural feature of central Nevada, lies just west of the study area in Eureka County. The rocks east of the thrust, in White Pine County, have been deformed and cut by smaller thrusts, bringing into juxtaposition lithologically different faces of contemporaneous rocks.(87) The thrusting occurred prior to the basin and range block faulting that resulted in the major physiographic features of the present day. It can be observed that many of the blocks of strata forming the mountains dip at about 30 to 50 degrees, some blocks dipping to the east and some to the west; however, no generalizations regarding the attitude of bedding can be made due to complexities of faulting and deformation. The complexities of faulting deformation and igneous intrusion make any delineation of the bedrock underlying the valleys very difficult, but a number of attempts have been made in selected areas.(6,18,60,87,88).

1.2.2.3 Geologic History

From late Precambrian times through the Paleozoic, eastern Nevada was part of the Cordilleran miogeosyncline in which more than 30,000 feet of strata accumulated.(50) The older strata are mainly quartzite, while Paleozoic rocks of Silurian age or younger are mostly limestone or dolomite. During this time the sea floor was never deeply submerged, but it subsided almost continuously. During the Mesozoic era the rock in the area was warped into widely scattered broad domes, and thrust faulting occurred along multiple fault planes that lay subparellel to bedding.[18] During middle Cenozoic time volcanic activity was widespread and voluminous ash-flow tuffs were erupted.

About 17 million years ago a major change occurred in the tectonic setting with the onset of extensional block faulting.[110] +During the past 17 million years the basins and ranges which characterize the area were formed, with continental sediments being deposited in the fault-related basins. During early Quaternary time, pediment and fan gravels were deposited in the valleys along the flanks of the mountains.

Climatic changes during the late Pleistocene resulted in the formation of lakes in most of the valleys, including Newark, Long, Butte, Steptoe, Jakes, and Spring valleys.[110] Snyder and Langbein [108] estimated that the lake in Spring Valley was about 250 feet deep.

1.2.2.4 Bedrock Units

Precambrian and Paleozoic rocks form a marine sequence about five miles thick. The lowest 10,000 feet of this sequence consists mainly of quartzite; the remainder is principally limestone and dolomite with lesser amounts of sandstone, siltstone and shale.[50] Rocks of middle Tertiary through Quaternary time are represented by a sequence of continental conglomerate, lava flows, intrusive bodies and tuffs having a combined thickness of more than a mile.[18] Detailed descriptions of the bedrock units are presented by Stewart,[110] Nolan, et al[87,88] Hose and Blake,[50] and Drewes.[18]

1.2.2.5 Valley Fill

The unconsolidated alluvium in the valleys includes gravel, sand, silt and clay deposited under subaerial or lacustrine conditions. Most of the valleys are underlain by deposits of older, very coarse gravel and boulders which were deposited by streams on alluvial fans and narrow pediments along the fronts of the mountains. The older gravels are largely of early or middle Pleistocene age and were deposited at a time when coarse debris was being moved over steep gradients.[18] Younger alluvial and fan gravel overlaps and partly buries the older gravel and is generally finer grained than the older material. Some of the valleys contain fine grained lacustrine (lake) deposits of late Pleistocene age. The lacustrine material is found in the topographically lower parts of the valleys.

1.2.3 Historical Development of Water Resources

The USGS[10] reports that the first attempt at agriculture in the eastern part of Nevada was in 1861 in Ruby Valley which is located just north of Long Valley. In 1867 gold, lead, and silver ores were discovered in Robinson Canyon near Ely and in 1872 high grade silver ores were discovered at Cherry Creek. By 1900 the population of White Pine County had reached 1961, consisting primarily of ranchers and miners. These early residents relied on the springs and streams for a water supply. The major communities of Ely and McGill were located near Murry Springs and McGill Springs.

In 1907 production of copper from low grade ores began at McGill and by 1910 the population of White Pine County had reached 7441. During this period, the waters of Duck Creek in Steptoe Valley were diverted to the newly constructed mill and smelter at McGill.

In 1917-1918 the USGS drilled three test wells in Steptoe Valley just north of the Duck Creek alluvial fan (about the middle of the valley). It is noteworthy that Steptoe Valley was selected after a reconnaissance field inspection of other valleys in western Utah and eastern Nevada.

Based on the inspection, the USGS reported that three valleys in White Pine County, Spring, Ruby, and Steptoe contain considerable groundwater. One irrigation well had already been drilled in Ruby Valley and the USGS chose Steptoe in preference to other valleys because of its railroad facilities and the presence of Ely as a market for irrigated farm produce.

Since the introduction of wells in 1917 there have been numerous wells drilled in Spring, Steptoe, and White River Valleys to obtain water for irrigation use. Additionally the communities of Lund and Preston obtain water from individual wells.

In Butte, Jakes, Long, and Newark valleys groundwater pumpage from wells is generally limited to stock watering and domestic uses.

1.2.4 Population

Historical populations of the County as reported in the "General Plan for White Pine County and the City of Ely, Nevada"[13] are as noted on the following tabulation.

Year	Population	
	White Pine County	City of Ely
1900	1961	
1910	7441	
1920	8935	
1930	11,771	
1940	12,377	
1950	9,424	4369
1960	9,808	5814
1970	10,150	6168
1976 (est.)	11,928	-
1978 (est.)	-	6246

Review of the past population trends indicate a build-up from 1900 to 1920 which was based on development of nearly all of the surface waters available from springs and streams in White Pine County. These waters were generally appropriated for use by ranches and by the mining operations.

After 1920 population have generally varied between 9000 and 12,000 although the population of the County has increased steadily since 1950. Much of this increase has taken place in the City of Ely.

Overall there appears to be little evidence from the population data for significant increases in water resources development in recent years.

2.0 COLLECTION OF EXISTING DATA

2.1 INTRODUCTION

The search for published literature and existing data on the hydrology and geology of White Pine County began with a review of references collected by LADWP. This material generally consisted of various Water Resource Bulletins (WRB) and Reports prepared by the U.S. Geological Survey (USGS) in cooperation with the Nevada Department of Conservation and Natural Resources (NDCNR). Other literature included publications of the Nevada Bureau of Mines and Geology (NBMG) and the Desert Research Institute (DRI).

Utilizing this core group of references, requests for additional publications were made to various federal, state, and private agencies. A complete listing of references obtained and reviewed for this project can be located in Chapter 8 of this report.

2.2 PRECIPITATION

Currently there are 14 active precipitation gaging stations located throughout White Pine County. Of these gages eight stations have previous measurements, and the remaining six have been recently installed. Two stations which have long records are the McGill and Ely WSO Airport stations. The McGill station has a 62 year record, from 1909 to 1918 and 1927 to the present. The Ely WSO Airport station has a 55 year record, from 1889 to 1902, 1908 to 1910, and 1941 to the present. In addition to the 14 stations, eight active stations are situated in areas bordering the perimeter of the County. A summary of mean annual precipitation from all of the stations and other pertinent data is presented on Table 2-1. Stations located within White Pine County are shown on Plate III. This data was tabulated from a review of Climatological Data, Annual Summaries for Nevada.(132)

2.3 SURFACE FLOWS

Continuous surface water discharge records are being collected by the USGS at three stations located within White Pine County. These stations are a Newark Valley Tributary in Newark Valley, Cleve Creek in Spring Valley, and Steptoe Creek in Steptoe Valley. This information is published annually by the USGS in their Water Resources Data for Nevada Publications.(127) Table 2-2 summarizes the available data, and the station locations are shown on Plate III.

In addition over the years, the USGS, the NDCNR and other private agencies have measured various flows at approximately 31 creeks located throughout the County. These creeks and their measured discharges are tabulated by valley on Table 2-3.(10,22,23,25,42,68,97)

Discharge measurements from the larger springs in the County are presented on Table 2-4, and located on Plate III. These discharge measurements have been made by the USGS, NDCNR, the Bureau of Land Management (BLM) and other private agencies.[10,23,25,68,97,107] Also, the Ely District Office of the BLM has conducted an extensive survey of springs in the northern portion of Newark Valley, measuring flows and performing chemical analyses.[16] Although flow from the majority of these springs is very small, the progress of this BLM project should be monitored as it moves eastward across White Pine County.

2.4 CONSUMPTIVE USE

2.4.1 Native Vegetation and Irrigation

Essentially all of the water located within 20 feet of the land surface, in addition to the water discharged from springs, is available for use by vegetation. Previous studies by the USGS and NDCNR have estimated basin discharges by determining the areal extent of particular phreatophytes such as salt grass, rabbitbrush, and greasewood and then applying an estimated consumptive use factor determined from prior research.[10,22,23,25,42,68,97] Table 2-5 lists the estimated areas of vegetation for each of the valley areas. The majority of the research undertaken to determine consumptive use factors used by the USGS and NDCNR in their cooperative publications has been conducted by the Agricultural Experiment Station.[19,52,111] Table 2-6 illustrates the range in consumptive use factors applied to native vegetation and irrigated lands in the various USGS and NDCNR cooperative WRB. A report by the NDCNR, Division of Water Planning evaluating and estimating consumptive use at selected Nevada sites was also helpful.[91]

In 1966, the Agricultural Experiment Station located at the University of Reno, Nevada, published a map illustrating the irrigated lands of Nevada. A tabulation of irrigated lands located in White Pine County as determined from this map is shown by valley area on Table 2-7 [5].

The U.S. Soil Conservation Service (SCS) is another organization which has been working to determine locations and types of irrigated acreage. In 1975, they produced a general soil map of White Pine County[129] and in 1977, they published a study illustrating vegetative cover in White Pine County.[130] Table 2-8 lists vegetative area by valley as determined from this 1977 map.

During 1980, the Ely District Office of the SCS conducted a study to determine irrigated acreage within the County. The study produced working drawing base maps delineating areas of irrigation.[131] Currently this office of the SCS is updating and refining this study to determine some breakdown between prime farmland and pasture land.

A tabulation of the SCS estimated 1980 irrigated acreage occurring in White Pine County is given in Table 2-9.

In 1978, an extensive investigation was conducted by the State which determined the various cropped acreages on individual properties. This information is available in the County Assessors Office located in Ely.

2.5 GROUNDWATER LEVELS

Throughout the years, hundreds of well level measurements have been made by the USGS and NDCNR. These measurements are published in various Water Supply Papers (WSP) and in reports and bulletins covering the individual valley areas.[10,22,23,25,42,68,97] Most of these wells have been measured only once or twice, and have not necessarily been monitored continuously. Records of water levels in wells were also obtained from the National Water Data Exchange files, (NAWDEX), through the USGS. Of the 112 wells contained in this data file, only ten are continuing to be monitored and measured. Measurements are also being made by the City of Ely on two of their municipal supply wells located within the City limits.

2.6 SUBSURFACE FLOWS

At this time, no direct measurements of interbasin subsurface flow are available. However various investigators have prepared estimates of such flow using the basin water budget method, which assumes that equilibrium conditions exist in the basin (further discussion can be found in Section 4.3). Other approaches for estimating subsurface flow are by investigations of surface manifestations of drained or undrained valleys, along with the development of groundwater elevation maps. These approaches are discussed in Section 3.6.1.1.

Records of pumpage from the Deep Ruth Mine were obtained at the University of Nevada.[32]

2.7 AQUIFER CHARACTERISTICS

Of the various federal, state, and private agency publications collected and reviewed, the most helpful in determining aquifer characteristics were by the USGS, NBMG and DRI.[24,25,69,70] USGS WSP 467, published in 1920, deals with a hydrologic investigation of Steptoe Valley, along with the construction of three exploratory groundwater wells.[10]

A total of approximately 75 water well logs from wells located throughout White Pine County are contained in the cooperative

USGS, NDCNR Bulletins and Reconnaissance studies.[22,23,25,42,68,97] Many additional well logs, some containing information regarding discharges, drawdowns, and specific capacities are on file by Township/Range in the Carson City office of the NDCNR. Well logs, pump tests, and other data from Steptoe Valley and other areas are currently becoming available through Fugro National, Inc., who is working on the M-X deployment area selection for the Department of the Air Force. What information is available can also be found in the office of NDCNR.

Pump tests from 27 wells located primarily in the Steptoe and White River Valleys were obtained from the Ely Office of Mt. Wheeler Power, Inc. Other pump tests are available from the Cooperative Agricultural Extension Service in Ely.

2.8 WATER QUALITY

Water quality analyses are available for 15 creeks and streams, 36 springs, 40 wells and two mine shafts located in White Pine County. These analyses report chemical constituents and are published in USGS WSP, DRI references, and the cooperative USGS and NDCNR WRB.[3,10,22,23,25,42,44,68,97] Table 2-10 presents a summary of this water quality information. Geothermal water quality tests are tabulated in reference 99. The Ely District Office of the BLM has conducted an extensive water quality sampling and analyses of two areas within White Pine County. These BLM areas are the Schell and Egan environmental study areas located in the vicinity of Spring and Newark Valleys respectively.(1,16) It is anticipated that this program will expand to incorporate more valley areas within White Pine County. Miscellaneous water quality analyses are also available from the County Health Services.

2.9 GEOLOGY

Regional geology, including geologic history, geologic structure and stratigraphy are presented in reports obtained from the USGS and NBMG.(73,110) Bedrock geology of White Pine County is well described by Hose, et al.(50) Greater detail on the geology of specific areas is given in several quadrangle reports by the USGS.(6,18,87,88,139) The occurrence of groundwater in carbonate rocks has been investigated by DRI and others.(48,69,70,102) Geology and groundwater conditions in the alluviated valleys in the study area are discussed in a series of reconnaissance reports by NDCNR and USGS.(22,23,24,25,42,97,139) Geothermal studies, including the occurrences of geothermal springs, are set forth in a number of publications.(33,38,72,74,138) Several theses and doctoral studies were obtained from NBMG concerning geological areas and interpretations, cross sections and regional aquifer systems.(31,60,72,103,112,135)

3.0 ANALYSIS OF EXISTING DATA

3.1 INTRODUCTION

In this chapter data described in Chapter 2 are analyzed. The primary purposes of the analyses are to assess the validity of estimates made by others of the recharge and discharge characteristics of each major valley in White Pine County. These recharge and discharge estimates are directly related to estimates, by the State, of perennial yield.

3.2 PRECIPITATION

3.2.1 Analysis of Precipitation by Others

In 1936, George Hardman, working for the Nevada Agricultural Experiment Station, prepared a precipitation map of Nevada showing areas of assumed equal rainfall.(43) This map was prepared utilizing then existing precipitation gaging stations, and the correlation that precipitation increases with elevation. The precipitation zones illustrated on this map are presented in terms of average annual precipitation in inches, and are classified into the following ranges: 0-5, 5-8, 8-12, 12-15, 15-20, and greater than 20.

In 1962, George Hardman revised his initial work to produce an isohyetal rainfall map of Nevada.[57] These two maps have provided the basis for estimates of rainfall and recharge as calculated in the cooperative USGS, NDCNR WRB and Reconnaissance Reports investigating valleys located in White Pine County.

3.2.2 Elevation vs. Precipitation

Of the 14 active precipitation gaging stations located in White Pine County, only five were found to have periods of record which both overlap and are of sufficient length to be used to determine mean annual precipitation values. The period of record selected for analysis was a 19 year period from 1960 to 1979.

The eight active precipitation stations located in areas adjacent to the perimeter of White Pine County were also analyzed during this same period to determine mean annual precipitation.

This data is plotted in Figure 3-1. The relationship used by the USGS and the NDCNR in the Reconnaissance Reports is also shown for comparison. It is evident that the USGS/NDCNR may underestimate precipitation in White Pine County, although specific gage locations may account for the apparent difference.

3.2.3 Area vs. Elevation

Utilizing the same basin designations as the NDCNR, each of the basin boundaries was delineated, and are shown on Plate I. Areas were then planimetered between specific elevation zones to determine specific elevation verses area characteristics of the valleys located in White Pine County. This information is presented in Table 3-1. These selected elevation zones were chosen to correspond to the elevation zones used in the Maxey-Eakin method for determining recharge.

3.3 SURFACE FLOWS

3.3.1 Analysis of Surface Flows by Others

As discussed in Section 2.3 and shown on Table 2-3, many surface water flow measurements have been made. In particular, during 1918, measurements to determine the quantities of water infiltrating in three creeks located in Steptoe Valley were estimated. These infiltration estimates were determined by measuring stream discharge at an upstream and downstream location, and calculating the water loss within the given creek reach. This information is shown on Table 3-2.

3.3.2 Estimated Precipitation Verses Runoff

Characteristics of stream discharges in Cleve, Newark, and Steptoe Creeks are shown on Figures 3-2, 3-3, and 3-4. Estimated precipitation was compared with gaged runoff from Cleve and Steptoe Creeks in order to check the estimates of recharge prepared by the NDCNR and the USGS.

The annual precipitation in the Cleve and Steptoe Creek watersheds was estimated from the measured rainfall at Ely WSO Airpot using the relationship shown on Figure 3-1.

These annual precipitation estimates were then plotted against the measured flows at each of these gaging sites as shown on Figures 3-5 and 3-6. The USGS and NDCNR bases for estimating recharge to a basin is also shown for comparative purposes. Recharge to the alluvial basins takes three forms - direct precipitation, runoff from the mountainous areas and infiltration in the mountains which later enters the valleys as subsurface flow. Thus, the runoff component should be somewhat less than the total estimated recharge. As demonstrated on Figure 3-5, runoff at Cleve Creek approximates the estimates of recharge but as shown on Figure 3-6, runoff at Steptoe Creek substantially exceeds the recharge estimates. It is possible that flows in Steptoe Creek are augmented by subsurface flow from outside the topographic basin.

3.4 CONSUMPTIVE USE

3.4.1 Estimates of Consumptive Use by Others

Consumptive use or basin evapotranspiration has been estimated in previous studies by the USGS and NDCNR for all basins in White Pine County except Jakes. These estimates were prepared by identifying the areas in each basin occupied by the various types of vegetation shown on Table 2-5 and then applying a consumptive use factor.

Consumptive use factors that were used by others for native vegetation are shown on Table 2-6. It should be noted that these estimates were generally developed in the 1960's except for the White River Valley estimates, which was published in 1949.

Separate estimates were made of consumptive use of irrigates land in Butte, Newark, and White River Valleys. A consumptive use factor of two feet of water per year was used for irrigated alfalfa areas in Butte Valley and one foot of water per year for irrigated pasture and wheat in Butte Valley and Newark Valley. A factor of 1.25 feet of water per year was used for all irrigated areas in White River Valley.[42,68] In the studies of other valleys, irrigated land, which is generally pasture, was considered to be in the native vegetation category and consumptive use factors of 1.0 to 1.5 feet of water per year were used.

Estimated consumptive use based on the previous studies are shown on Table 3-4.

3.4.2 Consumptive Use Factors

Consumptive use factors in Nevada have been studied by several investigators. The most recent investigation is described in a NDCNR publication entitled "Evaluation of Empirical Methods for Estimating Crop Water Consumptive Use for Selected Sites in Nevada".[91] Of the various sites that were examined in this study, Diamond Valley has conditions most similar to those in White Pine County.

In the NDCNR report estimates of annual consumptive use were presented for a reference crop, in this case alfalfa. These estimates were prepared using several standard methods as modified by the Food and Agriculture Organization (FAO) to fit values of evapotranspiration measured at specific locations. Estimates of evapotranspiration computed for Diamond Valley are shown below:

FAO Modified Method	Computed Annual Evapotranspiration inches
Blaney Criddle	41.9
Radiation	43.0
Penmon	41.9
Corrected Penmon	41.8
Pan Evaporation	30.1
SCS Technical Release -21 Blaney Criddle Method	27.4

It should be noted that the tabulated values represent the water which would be lost if the plants have an adequate supply of moisture throughout the year.

The NDCNR report recommends that the SCS Technical Release -21 method not be used in Nevada to estimate consumptive use requirements.

Measurements of evapotranspiration of native grasses were made at the Winnemucca, Nevada experiment station (elevation 4630 feet) in 1962-1963 and in 1967, 1968, and 1969.[19,20] Average consumptive use measurements were conducted over the period May 1 to October 15 of each year. These studies found that when the native grasses were maintained under wet meadow conditions the average consumptive use was as follows:

Year	Average Consumptive Use (inches)
1962	19.6
1963	22.6
1967	25.0
1968	26.0
1969	23.7

Consumptive use in White Pine County is somewhat less than at Winnemucca because of the higher elevations and the shorter growing season.

Consumptive use requirements for various crops grown in Steptoe Valley and the amount of irrigation needed to meet this requirement are listed in the publication "Consumptive Use of Irrigation Water by Crops in Nevada".[52] These are shown below for selected crops over a growing season of 119 days.

Crop	Supplied by Rainfall inches	Supplied by Irrigation inches	Total inches
Alfalfa	3	18	21
Pasture	3	16	19
Small grains	2	13	15

A consumptive use factor of 1.5 feet for irrigated lands is considered to be appropriate for this preliminary analysis.

3.4.3 Consumptive Use Estimates

The most accurate estimates of irrigated land acreage in the valleys are those prepared by the Agricultural Experiment Station in 1966[5] and by the SCS in 1980. Estimates of consumptive use, using the SCS 1980 acreage and a consumptive use factor of 1.5 feet of water per year, are shown on Table 3-5.

In addition to consumptive use by irrigated crops, there are native plants which rely on shallow groundwater and consume water from the groundwater basin. The generalized map showing vegetative cover in White Pine County[129] was used to prepare estimates of the magnitude of water use by native plants. Areas shown on the vegetative cover map as being meadow and flood plain association which exceeded the irrigated acreage reported by the SCS were computed and estimates of consumptive use of these areas were calculated using a factor of one foot of water per year.

In addition to the areas shown on the vegetative cover map as meadow and flood plain association, a transitional zone delineated as Salt Desert and Transitional Desert Shrubs, also contains some phreatophytes, such as shadscale, black greasewood, and winterfat. A consumptive use factor of 0.1 foot per year was used in this analysis for the transitional zone.

Consumptive uses in all the valleys of White Pine County were computed using the foregoing methodology and are shown on Table 3-5.

The values presented in Table 3-4 do not include an allowance for water that surfaces in the playa areas and is evaporated. Playas have sparse vegetation due to high salt concentration and losses from such areas are difficult to estimate because the frequency of standing water in such areas is not known. In undrained valleys, such as Spring Valley, which have large playa areas and are adjacent to high mountain ranges, the quantity of water lost from the playas may be large. Thus, the consumptive use estimates should be considered as miniumum values.

Consumptive use estimates developed during these studies are compared on Table 3-5 with those developed by the USGS and NDCNR. In general the estimates are of the same order-of-magnitude. However, in Butte, Long, and Newark Valleys the current estimates exceed those developed by the USGS/NDCNR because these previous estimates did not include water consumed in the large transition zone area. The use of a 0.1 feet per year consumptive use factor for this area, does not seem inappropriate. The proportion of vegetation in the transition zone which relies on groundwater may vary from one valley to the next and probably varies within a valley. Thus, a more precise land use survey would be required to refine this estimate.

3.5 GROUNDWATER LEVELS

3.5.1 Analysis of Groundwater Levels by Others

In 1974, the NDCNR in cooperation with the USGS published a static depth to groundwater contour map. This map illustrates the general depth to groundwater and areas of shallow groundwater, where groundwater discharge is likely to occur.

3.5.2 Well Level Analysis

The principal water-bearing beds tapped by most wells are in the unconsolidated sediments of sand and gravel, underlying the alluvial apron and valley floor areas.

Approximately 30 wells located throughout White Pine County have had water levels monitored in them for a period of years. A representative sampling of these wells illustrating the annual fluctuation in water levels is presented on Figures 3-7 through 3-11 by valley. Although fluctuations and short term trends can be seen on these Figures, water levels appear to be relatively stable. Groundwater levels in Steptoe Valley (Figure 3-10) even appear to be rising slightly. And in all valleys where long term well level measurements are available, no appreciable declines in groundwater levels are apparent. The location of these selected wells is shown on Plate III, and other pertinent data from these wells is given on Table 3-3.

3.5.3 Groundwater Elevation Map

Several hundred water level measurements from wells in White Pine County were used to develop the Groundwater Elevation Map shown on Plate IV. This map illustrates general intrabasin groundwater movement and provides some insight to interbasin subsurface flow (further discussion in Section 3.6.2).

The actual water level measurements were performed during the past 20 years, however, as discussed in Section 3.5.2, water levels appear to be relatively stable. Therefore in the preparation of this map, it was assumed that the year in which the measurement was taken, would not be a significant factor in water level determination.

3.5.4 Change in Groundwater Storage

By determining the specific yield of the aquifer material, and calculating the volume of saturated aquifer material in the groundwater basin, estimates of groundwater storage can be made. From measurements of groundwater levels, changes in groundwater storage can be determined. Typical specific yields used to calculate groundwater storage for an unconsolidated, alluvial material are range between 10 and 15 percent.

Water level measurements in wells are a direct measure of groundwater storage changes. As water levels either rise or decline, the product of the change in water levels times the storage coefficient times the area of the aquifer produces the net change in groundwater storage.

As discussed in Section 3.5.3, water level measurements from wells located in White Pine County appear to be quite stable.

Slight changes in water levels do occur annually, however if over a sufficiently long period of time water levels are found to remain constant, by definition no change in groundwater storage is taking place. This appears to be the case in the White Pine County groundwater basins.

3.6 SUBSURFACE FLOWS

3.6.1 Analysis of Subsurface Flows by Others

3.6.1.1 Drained vs. Undrained Valleys

The estimated depth to the groundwater table is not well defined in some areas because of a lack of water level measurement data.

In such instances it is useful to adopt the classification system for topographically closed valleys presented by the USGS in its WSP 1475-L.[107] Under this classification system, valleys in White Pine County were categorized as drained or undrained. A drained valley is hydrologically connected to another valley and loses groundwater to it. Such a valley is characterized by a deep water table, few phreatophytes, and playas which are wet only after rains and during the spring snowmelt.

Undrained valleys are characterized by shallow groundwater tables, considerable phreatophytic growth and playa areas from which groundwater discharges year round. White Pine County basins are categorized as drained and undrained as follows:

Butte	- Drained
Jakes	- Drained
Long	- Drained
Newark	- Undrained
Steptoe	- Undrained
Spring	- Undrained
White River	- Undrained

3.6.1.2 Interbasin Flow

Although the majority of basins within the study area are interior draining topographically closed basins, it is believed that interbasin flow can occur given the appropriate circumstances. The units responsible for this interbasin flow are the older carbonate rock formations, which can be highly permeable due to interstitial openings in fractures or in solution cavities. The distribution and nature of these openings are generally related to the physical and chemical characteristics of the particular formations. Previous studies and publications of the USGS, DRI, and the NDCNR have concluded that interbasin flow occurs from Long Valley into either Newark or Jakes Valley, and from Jakes Valley into the White River Valley.[31,48,69,70,96] The basis for determining these interbasin flows is the hydrologic inflow-outflow imbalances which occur when an individual basin is examined. If estimated recharge quantities are much larger than the estimated quantity of water lost through spring discharges and evaporation, and deep water levels preclude a comparable evapotranspiration loss, then this basin imbalance is corrected by assuming a basin outflow quantity sufficient to correct this imbalance.[22,68] The converse is true when determining subsurface inflows into a basin (further discussion in Section 4.3).

Preliminary appraisals of the distribution and quantities of estimated groundwater recharge and discharge within the region, and the general compatibilty of the potential hydraulic gradients led T.E. Eakin to the conclusion that subsurface flow occurs southward from Long Valley to Jakes Valley and into the White River Valley.[24]

3.6.2 Analysis of Subsurface Flow

The groundwater elevation map shown on Plate IV illustrates intrabasin groundwater flow, and also inferes interbasin groundwater movement. Subsurface flow appears to move from Long into Newark Valley, as well as from Long into Jakes. However the lack of accurate and reliable water level measurements in the southern portion of Long Valley, Jakes Valley and the northern sections of the White River Valley hamper clearer definition and delineation of flow paths.

3.7 AQUIFER CHARACTERISTICS

3.7.1 Analysis of Aquifer Characteristics by Others

Based on the preliminary appraisals of the distribution and quantities of estimated groundwater recharge and discharge, the compatibility of potential hydraulic gradients, and the hydrologic properties of the major rock groups in the region, T.E. Eakin concluded that a regional subsurface groundwater flow system was occurring in east-central Nevada.[24]

During his studies, Eakin calculated transmissivities in the fractured carbonate rocks across three locations; (1) at a section near the north end of White River Valley, (2) a section through the south end of the White River Valley, and (3) a section in central Coyote Spring Valley. The average of these three calculated transmissivities is 200,000 gpd/ft.[24] He does however note that ". . . as the actual transmission of groundwater in the carbonate rocks is localized largely in fracture or solution zones, local transmissibility values undoubtedly are much higher, perhaps 10 times or more, then the indicated average regional value."[10]

3.7.2 Analysis of Aquifer Characteristics

Valuable geologic information can be obtained by a review of well drilling logs. These logs frequently describe the formations encountered, water bearing zones, static depth to water and an occasional pump test.

A review of well logs located in Steptoe Valley near the edge of the Duck Creek fan indicate that no appreciable water bearing materials were encountered below a depth of approximately 125 feet below the ground surface. From a depth of 125 feet to 915 feet, only fine grained materials were encountered. Indicating that these fine materials were not stream deposited, but probably associated with old lake bed deposits.[10] However, this condition may be localized. Logs from wells located at Ely and in southern Steptoe Valley show sand and gravel zones to depths of several hundred feet (whether they are water bearing or not is unknown).

Spring Valley also contained a large lake at one time and clay and other fine-grained sediments can be found at considerable depth in the valley. Depths and thicknesses of these sediments will vary considerably.

Since few deep wells have been constructed in either Long, Butte, or Jakes Valleys, information is rather sketchy, and characteristics will vary with proximity to either playa or bedrock zones.

Thick sand and gravel zones appear to exist in the White River Valley in the vicinity of Preston and Lund. However, depths appear to vary, and clay layers seem to interfinger between these zones.

3.7.3 Pump and Specific Capacity Tests

Specific capacity is a measure of the productivity of the well and aquifer, and is calculated as the discharge of the well divided by the drawdown in the pumping well. The units of specific capacity are gpm/foot of drawdown, therefore the larger the specific capacity, the better the well production. Table 3-6 shows calculated specific capacities from wells located in Newark, Steptoe, and White River Valleys. Values range from several hundred gpm/foot of drawdown to less than 20 gpm/foot of drawdown. This large range in values can be attributed to the construction and condition of the well and pump, as well as the formations encountered and possibly testing procedures.

Although specific capacity values of several hundred gpm/foot are not uncommon, typical values from deeper wells drawing water from a thick section of alluvial material may range from 50 to 100 gpm/ft.

3.8 WATER QUALITY ANALYSES

The major anions and cations of the water sample analyses listed in Table 2-9 were plotted on geochemical classification charts to give a visual comparison of the various water qualities. These charts are presented as Figures 3-13 through 3-17. The predominance of bicarbonate in almost all samples illustrates the strong influence on water quality of the carbonate rocks in White Pine County.

With the exception of a few water samples taken in Steptoe Valley, which are described below, all of the water quality data are consistent. In samples of spring water, the bicarbonate constitutes 70 percent, or more, of all anion reactive values in most samples, with most of the remaining anions being sulfate. Approximately 50 percent of the cations in the spring water are calcium with most of the remaining cations being magnesium. In general, well and surface water quality are the same as the spring water, although the data for these water sources show a bit more scatter. It should be noted that the quality of water from geothermally heated springs is not different from the quality of water from other sources.

Some of the water quality samples from Steptoe Valley that are plotted on Figure 3-15 show unusually high percentages of sulfate The reasons for high sulfate concentrations in these samples are not known but it was noted that four of the high sulfate samples, data points 16, 17, 18, and 19, are from springs that are located in two adjacent sections in the same township and range just north of Ely. Possible explainations for these apparently anomalous data are drainage through mineralized deposits containing sulfides or drainage through mine waste material. Another high sulfate water sample analysis shown on Figure 3-15, data point 33, is from a pond located about 20 north of Ely. This sample contained 4 to 5 times the TDS of other samples and over 95 percent of the anions were sulfate. It is believed that this pond water is contaminated by local conditions and is not representative of water quality in White Pine County.

3.9 GEOLOGICAL ANALYSES

3.9.1 Water Bearing Characteristics of the Alluvium

The principal water bearing materials are the unconsolidated younger alluvium, older unconsolidated or poorly consolidated alluvium, and carbonate bedrock. Most existing wells produce from the younger alluvium and most springs issue from the alluvium, although the source of the springs in many instances is the underlying carbonate bedrock.

Bedrock is believed to underlie most of the valleys at depths of 1000 feet or more. The block faulting which produced the linear mountain ranges and intervening valleys occurred over several millions of years, so that the sediments which were deposited in the valleys reflect the widely varying depositional environments that existed over those years. Thus, the older valley fill may include tuffaceous deposits, freshwater limestone, sandstone or moderately consolidated sand, and conglomerate or gravel of Tertiary age.[25] The coarser materials, the gravel or conglomerate, may be expected to be localized along drainageways or in the marginal parts of the basin. The older sediments characteristically yield water to wells at low to moderate rates.

All of the major valleys contained lakes during Pleistocene time. The sediments deposited in these lakes tends to be fine-grained and they have a low permeability. In Spring Valley the fine lacustrine deposits are as much as 300 feet thick and are poorly pervious, but a good aquifer underlies these sediments.[95] Steptoe Valley may have a thick stratum of clayey beds[25], and the alluvial fans in White River Valley are apparently underlain, in part, by lacustrine sediments.[68] Newark Valley has a large playa which is a remnant of a Pleistocene lake and the valley lowland is underlain by an unknown thickness of fine-grained sediments.[23]

Figure 3-18 is an idealized cross section showing the relationship between the bedrock, the relatively coarse-grained alluvial fan material and the relatively fine grained lake bed or playa deposits in the lower areas of the valley. The figure is taken from USGS WSP 1475-L.[107] It demonstrates that wells designed to tap groundwater from the valley fill should be located on the sides of the valleys where coarser grained alluvium is most likely to occur.

It is not possible to delineate with any precision the total depth of alluvium in the major valleys, but oil well records and geophysical data give some indications of relative depths in certain areas.[8,48] The following depths in the major valleys are indicated, based on the thickest penetration of alluvium by oil wells.

Valley	Depth of Alluvium (feet)
Butte	1000
Jakes	900
Long	1300
Newark	2800
Spring	No data
Steptoe	6900
White River	5400

The data indicate a considerable alluvium thickness in some of the valleys, far greater than practical pumping depths. Other indication of depth to bedrock can be obtained from geophysical data. One study, for instance, suggests that an alluvial "trough" connects Jakes Valley with White River Valley and would be a possible conduit for groundwater flow.[8]

3.9.2 Water Bearing Characteristics of the Bedrock

The bedrock in the mountains and underlying the valley fill has a low permeability except for certain of the Paleozoic carbonate rocks. These latter rocks, consisting of limestone and dolomite, have developed substantial permeability along joints which have been enlarged by solution. Although there is little doubt that the carbonate aquifers transmit considerable water in the study area, the complicated structural relationships displayed in the mountains, and presumed to persist in the bedrock underlying the valleys, make interpretation and delineation of the aquifer very difficult. Studies by DRI suggest a regional continuity of ground-water systems through zones in the carbonate strata.[48,70] Some of the springs in the county are known to originate in carbonate rock and it is likely that carbonate aquifers transmit a substantial amount of recharge into the valley fill.

3.9.3 Geological Basis for Springs

Because springs constitute an important existing source of water, their origin should be understood so as to minimize impact on them due to groundwater withdrawal from the basins. There are several mechanisms which have been proposed to explain the occurrence of the springs, and it may be that any or all of them are applicable to springs in the study area.

There are only a few truly hot springs in the study area, most notably Monte Neva (Melvin) in Steptoe Valley, but many springs exhibit some thermal characteristics. Also a number of wells produce warm or hot water. The geothermal nature of the springs can only be explained by the circulation of groundwater to considerable depths, causing the water to be heated by geologically young, hot igneous intrusive or volcanic type rocks. The groundwater need not come into actual contact with the igneous rocks as long as the thermal gradient is sufficiently high.

In Figure 3-18, a mechanism is illustrated by which geothermally heated groundwater could rise to the surface or into the overlying alluvium along a fault which separates the alluvium from the bedrock at the side of the valley. It is known that many springs in Nevada are associated with faults, and the linear alignment of many of the springs in White Pine County suggests this type of mechanism there.

Some of the springs, such as Murry and McGill springs in Steptoe Valley and Lund and Hot Creek springs in White River Valley, are known to issue from solution cavities in carbonate bedrock. It is probable that some of the springs which emanate from the valley alluvium originate from the underlying carbonate rock.

Maxey and Eakin noted that the groundwater levels in the immediate vicinity of springs in White River Valley are at least 60 feet below the ground surface.(68) They postulate that the spring water issues from deep bedrock. As lacustrine sediments were being deposited over the bedrock, there was sufficient head to keep the orifices of the springs open. Later, when the lake dried up, windblown silt and clay became fixed to the moist, vegetated areas around the springs. Over the years a cone of fine-grained sediments built up, thus isolating the spring from the coarser alluvial fan material that was being deposited in the area around the spring.

3.10 MINE PUMPAGE

Records of pumpage from the Deep Ruth mine, the Star Pointer Shaft, and the Kellinske Shaft are tabulated in a report on "Underground Mining Operations at Ruth, Nevada 1951-1958".(32) During about seven years of more or less continuous pumping the rate declined from as much as 5723 gpm to about 3000 gpm. This latter rate is equivalent to about 4800 afy.

4.0 GROUNDWATER BALANCES OF THE VALLEYS

4.1 INTRODUCTION

Development of a water balance for the basins in White Pine County is important for at least two reasons. First, it can serve as an independent check of the general accuracy of estimates of recharge and discharge in undrained, closed basins. This is especially important in the state of Nevada where the State Engineer restricts pumping to the perennial yield where practicable. Second, in basins which are drained, i.e. where there is subsurface flow into or out from the basin, the groundwater balance can give an approximation of the quantity of water entering or leaving the basin.

4.2 METHODOLOGY

The groundwater balance analysis begins with an identification of the study area and of the various hydrologic elements which affect a basin water balance. In these studies, the basin is defined as the alluvial valley areas. The hydrologic elements which affect a water balance for any area are defined in the following equation of hydrologic equilibrium.

$$S_1 + P + Si + Im + Ssi - ETL - So - Ex - SS_o = S_2$$

where:

S_1 - Storage at the beginning of the time period

P - Precipitation

Si - Surface water inflow to the area

Im - Imported supplies into the area

SSi - Subsurface inflow into the area

ETL - Evapotranspiration losses

So - Surface water outflow from the area

Ex - Exported supplies from the area

SS_o - Subsurface outflow from the area

S_2 - Storage at the end of any period.

There are no known transfers of water among the valleys in White Pine County, and, therefore, export and import terms may be neglected. Except for the White River Valley, the valleys are completely enclosed and there is no surface outflow. Thus, with the exception of White River Valley, the above equation may be rearranged and expressed as follows:

$$SSi - SSo = (S_2 - S_1) + ETL - P - Si$$

Analyses of water well levels presented in the preceding chapter has indicated little evidence for long term changes in storage, thus, the term $(S_2 - S_1)$ in the above equation may also be neglected.

From the viewpoint of groundwater interests, it is fortunate that groundwater levels have yet to be affected by groundwater development. However, from an analytical viewpoint it is unfortunate because changes in storage, if observed and correlated with pumpage parameters, constitute one of the most straight forward approaches to the determination of safe yield or perennial yield.

The water budget is best applied over a year-by-year basis but the data is not available to conduct such an analysis for valleys in White Pine County.

4.3 USGS/NDCNR WATER BALANCE METHODOLOGY

4.3.1 Recharge Estimation

Between 1947 and 1951, T.E. Eakin, G.B. Maxey and others developed a method for estimating groundwater recharge in the State of Nevada. This method, hereafter referred to as the Maxey-Eakin method, was utilized by the USGS during its cooperative program with the NDCNR in preparation of their WRB and Reconnaissance Series Reports.[22,23,25,42,68,97] These reports were developed to produce preliminary water-budget estimates and determine the quantity of available water supplies in valleys throughout the state. The major assumption of the Maxey-Eakin study is that the groundwater discharge within a basin can be equated to the groundwater recharge (i.e., hydrologic equilibrium exists).

In this method, groundwater basin recharge is calculated by applying specific infiltration percentages to the precipitation which is estimated to fall upon several elevation zones surrounding the groundwater basin. This general relationship assumes that the potential recharge increases with increased precipitation, and that precipitation generally increases with elevation. A precipitation map illustrating the assumed zones of equal rainfall was developed by George Hardman in 1936.(43) Hardman's map shows average annual precipitation zones of less than 5 inches, 5-8 inches, 8-12 inches, 12-15 inches, 15-20 inches, and areas more than 20 inches. Maxey and Eakin combined the first two precipitation zones into a single one of less than 8 inches. The product of the area of each particular zone and the mean precipitation in that given range produces the total volume of precipitation in that zone. Maxey and Eakin then state: ". . . the amount of water from the successive zones that reach as the groundwater reservoir is estimated as 0, 3, 7, 15, and 25 percent of the precipitation in the respective zones".(68) These percentages were developed from a review of 21 valleys through Nevada,(136) assuming that the valleys were in a state of hydrologic equilibrium: ". . . recharge percentages were then balanced by trial and error with the estimated discharge".(68)

Hardman Precipitation Zones (inches)	Maxey-Eakin Recharge Percentage (percent)
Greater than 20	25
15-20	15
12-15	7
8-12	3
0-8	0

In 1976, P. Watson, P. Sinclair, and R. Waggoner published a paper investigating the Maxey-Eakin method for estimating groundwater basin recharge, to see whether or not a statistically rational basis exists for its use.[136] In this study, simple and multiple-linear regressions were used to try to approximate the techniques and final coefficients used by Maxey and Eakin. The study concludes that because of the high variability in calculated coefficients, including those developed by Maxey and Eakin, ". . . none of them can be used to reliably predict recharge. However, they can be used as first approximations of recharge."[136]

4.3.2 Discharge Estimation

The mechanism of groundwater discharge occurs through transpiration from phreatophytes and cultivated plants, evaporation from soils and free water surfaces, and discharges as surface or subsurface outflow.

Evapotranspiration estimates used by the NDCNR in their WRB, are described in Section 3.4.1.

4.3.3 Perennial Yields

The perennial yield of a groundwater basin system as defined in NDCNR WRB, is the largest quantity of water that can be withdrawn for an indefinite period of time from a groundwater system, without causing a continuing depletion of storage or a deterioration of the water quality, beyond the limits of economic recovery.

The perennial yield is ultimately limited by the average annual recharge entering the system, through both surface and subsurface sources. It is also equal to existing discharge from a basin that can be salvaged for beneficial use.

In a groundwater basin which is topographically and hydrologically closed, the average recharge and discharge from precipitation and evaporation respectively are measures of the natural circulation within the system. However, in some basins subsurface interbasin flows also occur, and a portion of this water may also be salvageable in perennial yield calculations.

If the perennial yield is continually exceeded, water levels will decline, and continue to do so until the groundwater reservoir is depleted of usable quality water, or until pumpage is reduced.

The estimates developed using these methods are shown on Table 4-1. The basis for perennial yield estimates of each valley are discussed in the following sections, together with comments on the magnitude of the yield estimates based on the analysis conducted in Chapter 3.

In general, the analysis of precipitation in Section 3.2 indicated that the estimates of precipitation could be under-estimated at elevations 6000 to 8000 by perhaps eight percent. In Section 3.3 the analysis of surface runoff indicated that the recharge estimates could be somewhat low judging by the observed runoff from Cleve Creek and Steptoe Creek.

Additionally, the estimates of evapotranspiration when conducted on a consistent basis for all basins in the County is, in general, higher than that estimated previously, however no measurements have been made and small changes in a consumptive use factor used can produce large changes in the estimate of consumptive use because of the large areas involved.

4.4 ANALYSIS

4.4.1 Butte Valley

As shown on Table 4-1 recharge in Butte Valley is estimates as 15,000 afy and discharge is estimated to be 12,200 afy.

The estimate of perennial yield is an approximate average of the estimated recharge of 15,000 afy and discharge of 12,000 afy.

The estimated consumptive use of 16,360 afy in Section 3.4 plus the probable underestimate of recharge indicates the perennial yield of the southern Butte Valley to be about 16,000 afy.

4.4.2 Jakes Valley

Perennial yield of Jakes Valley is estimated by the State Engineer to be 12,000 afy[(62)] but no report describing estimates of recharge and discharge has been prepared by the USGS or the NDCNR.

The State Engineer's office in its map entitled "Water Resources and Interbasin Flows", have estimated a subsurface inflow of 8000 afy from Long Valley and an estimated subsurface outflow of 25,000 afy into White River Valley. The difference between the inflow and outflow is 17,000 afy. If the 17,000 afy difference is added to the consumptive use estimate of 3000 afy, then recharge is apparently 20,000 afy. If all the subsurface outflow could be intercepted, which is unlikely, perennial yield could be 20,000 afy. A conservative approach is to average the 3000 afy evapotranspiration with the 20,000 afy maximum rate to obtain the 12,000 afy perennial yield previously developed by the State.

4.4.3 Long Valley

In Long Valley the NDCNR has estimated recharge and discharge to be 10,000 afy and 2200 afy respectively, as shown on Table 4-1.

Estimates of subsurface outflow from Long Valley were based on subtracting the estimated evapotranspiration of 2200 afy (Section 3.4.1) from estimated recharge of 10,000 afy. Then perennial yield was estimated as the average of the two. It assumes half of the estimated outflow can be salvaged together with existing evapotranspiration losses.

The estimated 10,500 afy of evapotranspiration loss developed in Table 3-5 correspond well with the estimated 10,000 afy recharge in Long Valley and casts doubt on the estimated 8000 afy outflow.

4.4.4 Newark Valley

As shown on Table 4-1 recharge in Newark Valley was estimated as 18,500 afy which includes subsurface inflow of about 1000 afy per year from Fish Creek. Discharge from Newark Valley was estimated to be 16,000 afy. The report noted that water depths generally less than 10 feet were present in playa areas but the rate of evaporation was unknown and not included in the estimate of discharge. The estimated perennial yield approximates the estimated annual recharge.

The estimated consumptive use of 30,000 afy in Section 3.4 is somewhat high in view of the USGS/NDCRN estimate of recharge. Apparently the transition vegetative zone includes fewer phreatophytes in the transition zone in Newark Valley than into other valleys.

4.4.5 Spring Valley

Table 4-1 shows USGS/NDCNR estimates of recharge and discharge to both total 75,000 afy. The estimate of discharge includes an estimated 4000 afy outflow from Spring Valley to Hamlin Valley(97). The estimated 100,000 afy perennial yield on based on the runoff estimate of 90,000 afy from the mountain plus an estimated 10,000 afy of precipitation directly on the alluvial fans and which subsequently enters the groundwater basin. Although the estimated discharge value of 75,000 afy includes the 4000 afy outflow and 70,000 of evapotranspiration, it does not include rejected recharge that flows onto the playas and evaporates. This rejected recharge is the estimated by the USGS/NDCNR to approximate about 25,000 afy.

The estimate of consumptive use of 69,400 afy presented on Table 3-5, compares favorably with the estimates previously prepared by the USGS and NDCNR. Additionally, the recharge estimates may be somewhat low, thus perennial yield is believed to be at least 100,000 afy.

4.4.6 Steptoe Valley

In Steptoe Valley recharge is estimated by the USGS to total 85,000 afy and discharge was estimated to total 70,000 as shown on Table 4-1. The estimate of discharge of 70,000 afy was taken as the measure of perennial yield because the estimate was believed to be better controlled(25).

It is noted that the estimated consumptive use of 84,550 afy in Table 3-5 compares favorably with estimates of recharge in Steptoe Valley prepared by the USGS and NDCNR(25). This observation combined with the comparison of recharge and measured surface runoff noted in Section 3.3 indicates that the perennial yield of Steptoe Valley may be as much as 85,000 afy.

4.4.7 White River Valley

Recharge and discharge are both estimated by the USGS/NDCNR to be 53,000 afy as shown in Table 4-1.

The estimated 53,000 afy for recharge includes the Jakes Valley estimated recharge. In the White Pine Valley WRB[68] the discharge estimate included surface outflow of the valley of 1500 afy and estimated subsurface outflow of 17,500 afy. The 17,500 afy quantity was developed by subtracting the estimated evapotranspiration of 34,000 afy (see Section 3.4.1) plus surface outflow from the estimated recharge of 53,000 afy.

The White River Valley report[68] presented an estimate that 11,000 afy might be salvaged from Hot Creek and 19,000 afy of groundwater (12,000 in White Pine County and 7000 in Nye County) or that a total of 30,000 afy might be recoverable from the 53,000 afy recharge. The estimated perennial yield of 37,000 afy[62] apparently includes an allowance for estimated subsurface inflow of 8000 afy from Long Valley into Jakes Valley and associated increases in subsurface inflow to White River Valley.

Estimates of consumptive use of 28,300 afy in White River Valley presented in Table 3-5 are for the area within White Pine County and not as defined in the USGS/NDCNR reports. This accounts for part of the difference between the 28,300 afy estimated in Table 3-5 and the 33,800 afy estimated by the USGS/NDCRN report[68]. It is worth noting that if a perennial yield of 12,000 afy is developed in Jakes Valley then 37,000 perennial yield in White River Valley could not be developed without significantly depleting subsurface outflow from White River Valley to the south.

5.0 WATER RIGHTS

5.1 WATER APPROPRIATION PROCEDURES AND POLICIES

In 1913 the Nevada Legislature provided for the conservation of underground waters and declared all sources of water within the boundaries of the State, whether above or beneath the surface of the ground, to belong to the public.

The State agency charged with the responsibility of administrating Nevada's water rights procedures and policies is the Division of Water Resources (DWR). The term Division of Water Resources is used synonymously with the Office of the State Engineer since the State Engineer is the executive head of the Division.

In order to appropriate water, an application must be made to the State Engineer. If there is no unreasonable infringement with existing water rights, a permit may be issued to develop the waters for a beneficial use. A permit to appropriate water grants the right to appropriate a certain amount of water from a particular source to be used at a definite location for a particular purpose. The permitted right becomes a legal and complete appropriation, a certificated right, upon meeting all of the following conditions:

a. Completion of works of diversion.

b. Placing of the water to beneficial use.

c. Filing the proofs required.

The general policy of the State Engineer is to limit groundwater withdrawals from a basin or valley to the average annual recharge to the groundwater basin.

Interbasin transfers are not prohibited by State law and there are several instances where such transfers have been approved by the State Engineer.

The State Engineer exercises very broad discretionary powers over all aspects of water administration under the water code provisions. An example of these powers is the "designation" of groundwater basins or valleys. Under Chapter 534 NRS (Nevada Revised Statutes), the State Engineer may upon petition of appropriators or, at his discretion "designate" a groundwater basin in order to establish better control of the groundwater resources in the area. Once a basin has been designated, the State Engineer in his administrative capacity is empowered to make any necessary rules, regulations, and orders as he may deem necessary for the welfare of the area involved. Application to appropriate water for purposes consistent with a designation are given priority over other applications.

5.2 PROJECT WATER SUPPLY

WPPP, through White Pine County, has filed to appropriate groundwater from several basins within the County. Due to the uncertainty of the final plant site at the time of filing each application was for an amount sufficient to supply the project. As site selection progresses applications will be amended or relinquished as required to provide a water supply for the final site.

Table 5-1 summarizes the project's filings to date. In general filings were made for 26,063 afy; however in Steptoe Valley filings were made for a quantity sufficient to supply a larger power plant.

The estimated status as of April 1, 1981 of certified and permitted rights as well as pending applications in Butte, Jakes, Long, Newark, Spring, Steptoe and the White River valleys are tabulated in Table 5-2.

It is noteworthy that the WPPP filings in Table 5-1 are included in the pending applications listed in Table 5-2. Comparing the two tables, it may be noted that the WPPP has priority filings in Jakes and Long Valleys. In the other valleys a portion of the pending applications preceed the filings made by the WPPP.

However, it is believed that a significant number of these applications are for Carey Act lands and may not become established rights.

On September 21, 1979 Steptoe Valley was declared a designated groundwater basin to establish better control of the groundwater resources in the area.

Litigation was recently initiated against the Nevada State Engineer by approximately 40 parties whose applications to appropriate groundwater for irrigation and domestic purposes in and around the Ely area were denied by the State Engineer. While the project's pending applications are not presently affected by the litigation, the authority of the State Engineer, among other things, to designate Steptoe Valley has been challenged in the lawsuit. Should the petitioners prevail, the project may not be able to secure a reliable water supply through the appropriation process in Steptoe Valley.

6.0 COMPARISON OF GROUNDWATER BASINS

6.1 GENERAL

Various criteria are available for use in comparing the groundwater basins or valleys with respect to their capabilities to provide all or a portion of the 25,000 acre-feet annually required by the WPPP. As a minimum these criteria should address the following:

a. Water availability
b. Availability of water rights
c. Effect on environmentally sensitive areas
d. Effect on existing water users
e. Cost of water supply facilities and operation

6.2 RANKING OF CRITERIA

In the following analysis, the estimates described in Chapter 4 are used to represent water availability as shown on Table 6-1. Additionally, the area in each drainage basin over 8000 feet in elevation gives a relative order of magnitude of the total supply available.

The availability of water rights are assessed as the perennial yield, less existing water rights as of 1980, as shown in Table 5-2.

A second criterion which should be checked is the perennial yield less existing water rights less a portion of those pending applications which preceed those of WPPP. However, the required information to develop these estimates is not now available.

It should be noted that the State Engineer has declared Steptoe Valley to be a designated basin and has established irrigation as a non-preferred use in a portion of the valley. As discussed in Chapter 5 that designation is being challenged in court. If the State Engineer's designation is upheld, the WPPP filings for water rights would have priority over most of the other pending applications in Steptoe Valley.

Two criteria are used to reflect the presence of and potential effect on environmentally sensitive areas such as thermal springs or marshlands. The number of thermal springs in each valley is known. The marshland area is considered to be the total area of land classified by the SCS as "meadow and flood plain associations" from the 1977 vegetative map prepared by the SCS.(129)

The standard used to indicate the potential effect of well field development on existing users is the number of irrigated acres in the basin.

The comparative or relative cost of water supply facilities is related to the distance between the water supply and the power plant site as well as the depth from which water is pumped. The power plant site has not yet been selected; however it is known that White Pine County interests recognize that the nearer the site is to Ely, the more it would benefit the existing economy. Thus the distance between the centroid of the groundwater basin and Ely is used as a cost criterion. Estimated depth to the groundwater table is used to reflect the pumping cost.

Estimated depths to the groundwater table are not well defined in some areas due to the absence of wells in those areas. Additionally, the well field location has not been defined, thus the depth is an approximation of general depths to groundwater in the valley at a location where a well field might be sited.

The foregoing criteria are applied to individual valleys as shown on Table 6-1. In Table 6-2 the basins are ranked one through seven with the higher number being more desirable.

6.3 COMPARISON OF BASINS

Review of the information presented in Table 6-1 and Table 6-2 indicates the following general ranking of basins in White Pine County.

- Spring Valley (has less potential environmental impact than Steptoe Valley).
- Steptoe Valley
- White River Valley
- Jakes Valley
- Butte Valley (southern portion)
- Newark Valley
- Long Valley

7.0 CONCEPTUAL WATER SUPPLY PLANS

7.1 INTRODUCTION

A water source that is generally available throughout the County is groundwater. Therefore the conceptual water supply plans investigated in this chapter assume development of groundwater from hypothetical aquifers which generally represent conditions found in Valleys located in White Pine County.

The characteristics of a well field that would be required to provide a firm water supply for the project depends on several site-specific factors, some of which are listed below:

a. The hydraulic characteristics of the groundwater aquifer at a specific location.
b. The shape and depth of the aquifer being tapped.
c. The location of the aquifer being tapped relative to other aquifers or aquacludes.
d. The source and rate of recharge, if any, to the aquifer.
e. The number of wells and the configuration of the well field used to develop the water supply.

Obviously, all the above factors will change from location to location within White Pine County. Also, accurate estimates of groundwater aquifer characteristics are not available for any one location in the County, much less for potential sites of the project. Thus, the conceptual groundwater supply plans presented in the following paragraphs can only be considered as illustrative of the impacts that the assumed well fields would have on the assumed groundwater aquifers.

7.2 GROUNDWATER AQUIFERS

Review of the existing data indicates that there are two general types of groundwater aquifers in White Pine County from which it might be possible to develop a water supply for the project. The first is the alluvial materials that have been deposited in the valleys and the second aquifer type is the fractures and solution cavities in the predominately carbonate bedrock formations.

Generally, the valleys in White Pine County are relatively long and only four to ten miles in width. During geologic time material has eroded from the surrounding mountains and deposited in the valleys with the coarser material forming alluvial fans along the edges of the valleys and the fine material being deposited on lowlands or in Pleistocene lakes that once existed in the low central portions of the valleys. The fine material in the central portion of the valleys, called the playa, is relatively impermeable to the flow of groundwater. The alluvial fans between the playa and the valley edges constitute one general type of aquifer that could be a water supply source.

For purposes of these illustrative examples, the alluvial fan groundwater aquifers were assumed to be three miles in width between the bedrock formations in the mountainous areas and the impermeable playa, a minimum of 125 feet in thickness,[10] and, for purposes of groundwater drawdown calculations, infinitely long. This type and shape of groundwater aquifer is generally representative of Spring, Steptoe, Butte, Long, and Newark Valleys in White Pine County and calculations presented below are illustrative of water supply plans in any of these valleys.

Data on the hydraulic characteristics of the alluvial fan groundwater aquifers in White Pine County are very limited. A report by the NDCNR[25] indicates that reasonable values for the storage coefficient and transmissivity of the alluvial fan aquifers in White Pine County would be between 10 and 20 percent and between 10,000 and 100,000 gpd/ft., respectively. For purposes of the illustrative examples of a water supply plan that utilizes these aquifers, a storage coefficient of 15 percent and a transmissivity of 50,000 gpd/ft. were assumed.

Some pump tests were made by Mount Wheeler Power, Inc. for purposes of determining pump efficiencies. The durations of these tests are not known but, if the durations were sufficiently long, the test data would suggest that the transmissivity of the valley fill alluvial aquifers could be higher than the value assumed for the illustrative plans. To the extent that the overall transmissivity of these aquifers is higher than 50,000 gpd/ft, the depth and extent of groundwater drawdown presented below would be less. Pump tests conducted during Phase 2 studies will provide an improved basis for estimating aquifer characteristics.

An illustrative water supply plan was also developed for the portion of White River Valley that is in White Pine County. This plan utilizes a well field that taps the fractures and solution cavities of the carbonate formation underlying the surface alluvial materials. The success of developing such a water supply plan would depend on a careful hydrogeologic investigation conducted during subsequent phases of the WPPP studies.

The hydraulic characteristics of the carbonate formation aquifer are obviously highly variable and closely related to the number and openness of formation fractures or solution channels at any particular location in the aquifer. For these illustrative plans, an aquifer transmissivity of 200,000 gpd/ft. was used. This value of transmissivity was selected based on three estimates presented in a report by the NDCNR.[24] A storage coefficient of 1.5 percent was assumed for the carbonate formation aquifer.

7.3 ILLUSTRATIVE WELL FIELD PLANS

Three groundwater well field configurations to develop 25,000 acre-feet per year were analyzed to illustrate the impacts of utilizing this source of water supply on the assumed existing groundwater regimes. The well field configurations presented below were selected after a preliminary analysis of alternative configurations, but the illustrative well fields are not necesarily the most economical or efficient design.

Two well field configurations were assumed for the valley fill alluvial aquifers. One configuration consists of 3 rows of 7 wells each on 3000-foot centers and the other configuration consists of 3 rows of 21 wells each on 3000-foot centers. The long axis of these well fields would be parallel to the long axis of the valleys and would be centered between the playa and mountains in a three mile wide section of alluvial valley fill. In the calculations, it was assumed that the playa and underlying strata are impervious and that the interface between the alluvial material and the bedrock formation is vertical.

The well field configuration for the carbonate formation is a single row of 15 wells on 1000-foot centers. This well field and its radius of influence on the groundwater basin is probably much greater than any continuous unit of the carbonate formation. However, the geologic structure and the number, location, size, and hydraulic characteristics of other formations that would be interbedded with the carbonate are not known and cannot be estimated at this time. Thus, for purposes of this illustrative water supply plan, a continuous carbonate formation was assumed.

Groundwater drawdown calculations for the three well field configurations in the two types of aquifers were made using the hydraulic characteristics and assumptions presented above. In calculating drawdown in the alluvial aquifers, the influence of the relatively impermeable playa material and the relatively higher transmissivity of the carbonate formations that were assumed to be adjacent to the aquifer were considered.

Drawdowns of the groundwater aquifers that would occur after 25 years of pumping from the well fields were calculated. It was assumed that during the 25 year period each well in the well field would pump, on the average, its proportionate share of the 25,000 acre-feet per year water supply that is needed.

Results of the drawdown calculations are presented in Figures 7-1, -2, and -3 and in Table 7-1. The three figures present a plan view and drawdown cross-sections of the groundwater table for each of the three well fields that were analyzed. Table 7-1 summarizes pertinent data from the figures.

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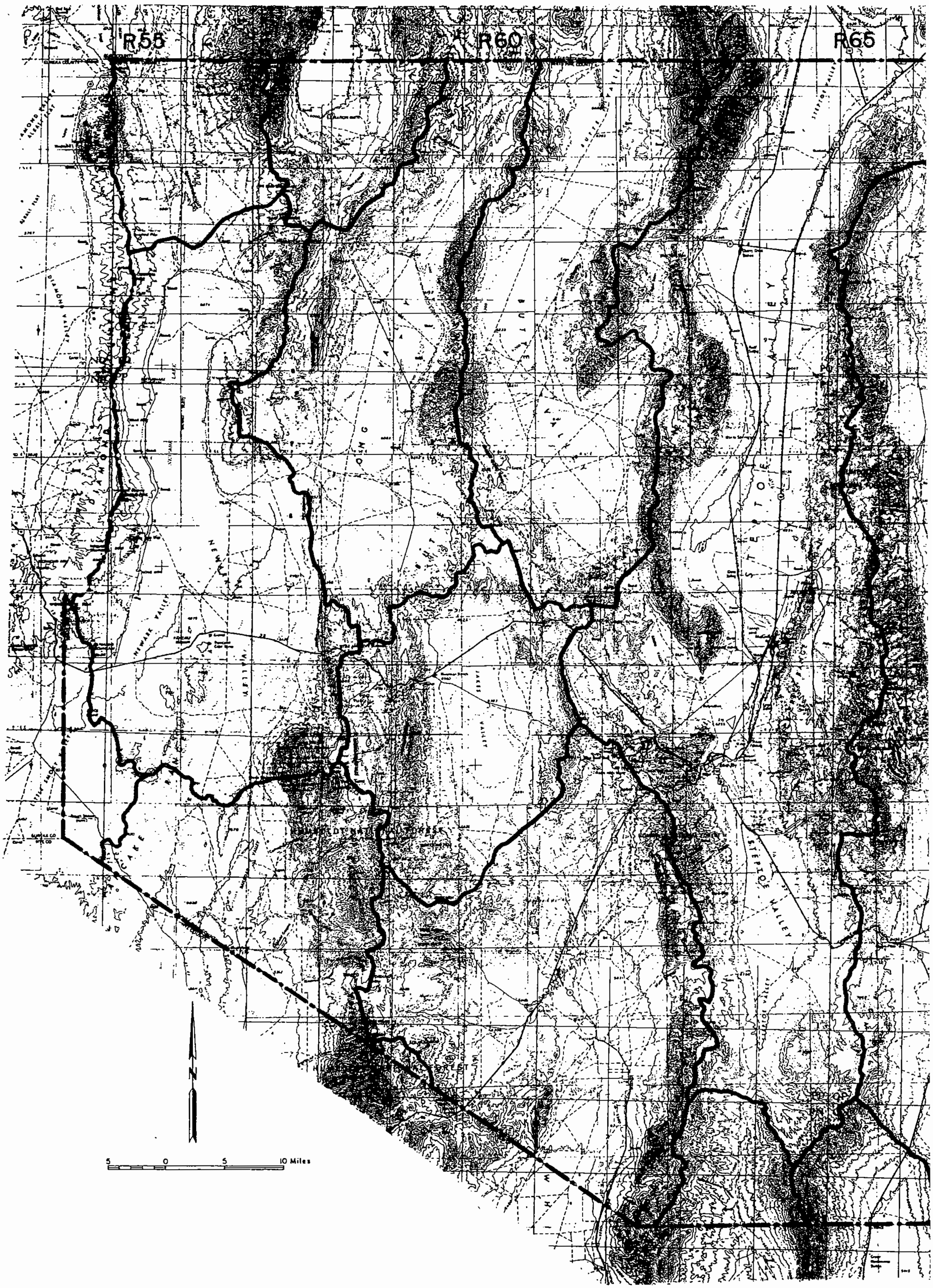
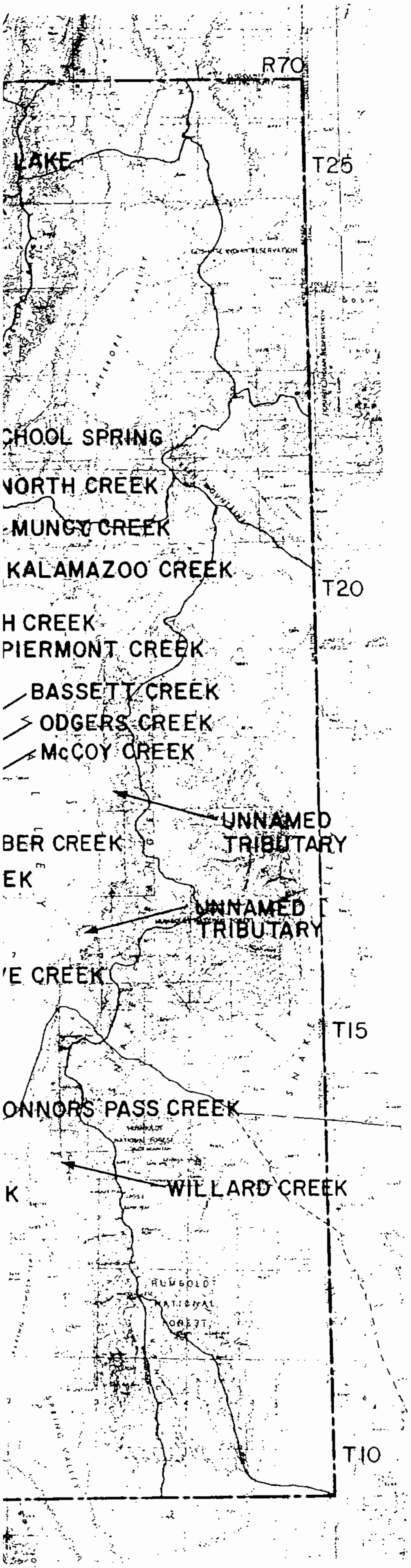
PLATES



Leeds, Hill and Jewett, Inc. April 1981



LEGEND

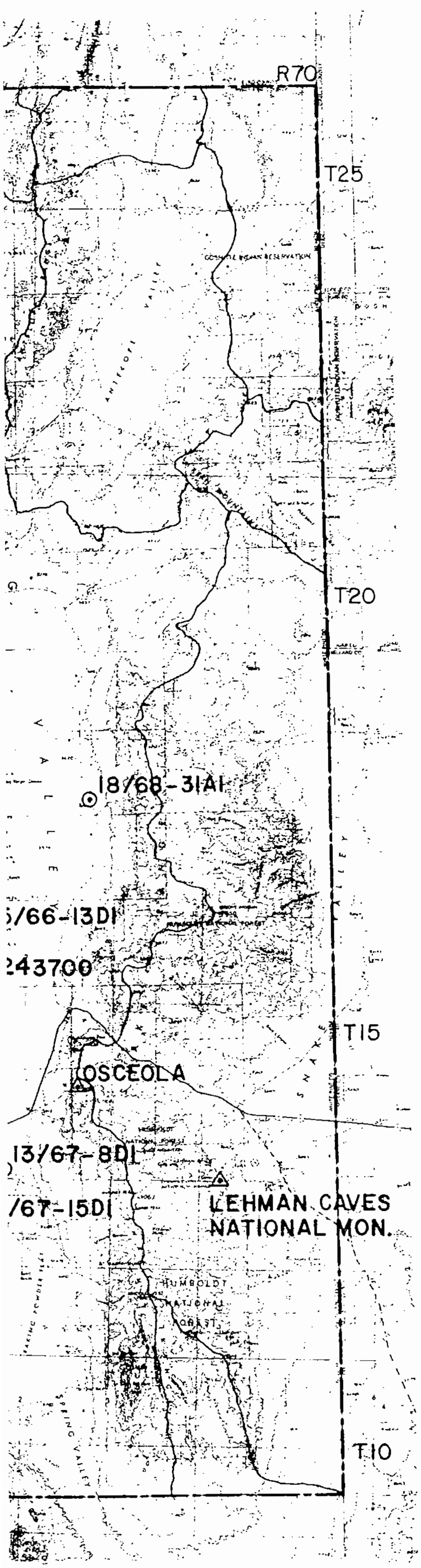
⊙ SPRINGS

← LAKES, CREEKS

WHITE PINE POWER PROJECT

SURFACE WATER RESOURCES

PLATE II



LEGEND

△ PRECIPITATION STATIONS

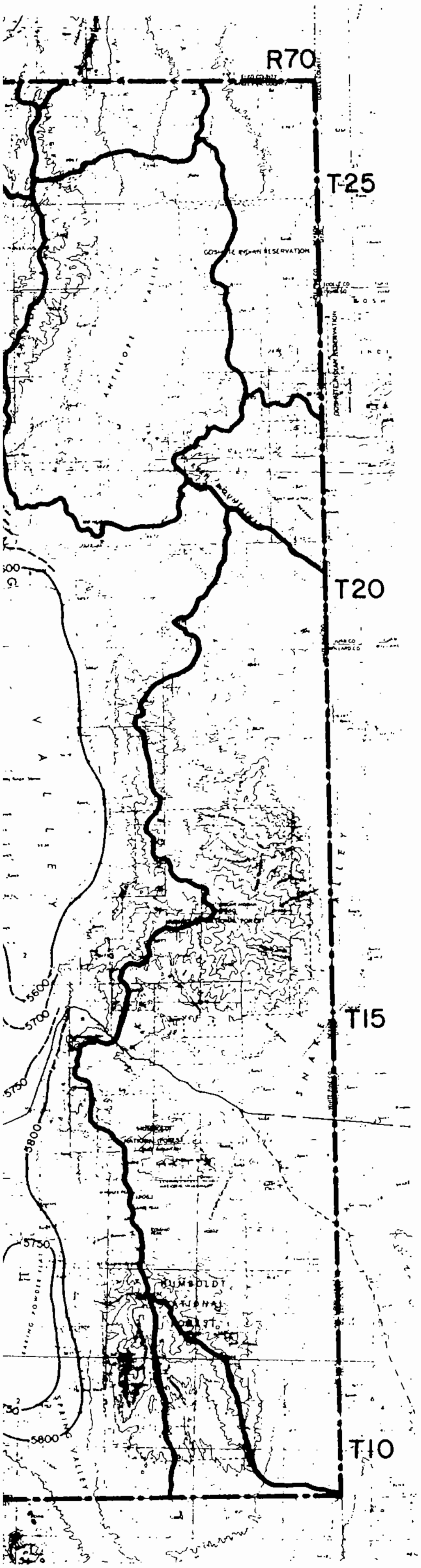
⊙ WELL LOCATIONS

⊡ STREAM GAGING STATIONS

WHITE PINE POWER PROJECT

WATER RESOURCE MONITORING STATIONS

PLATE III



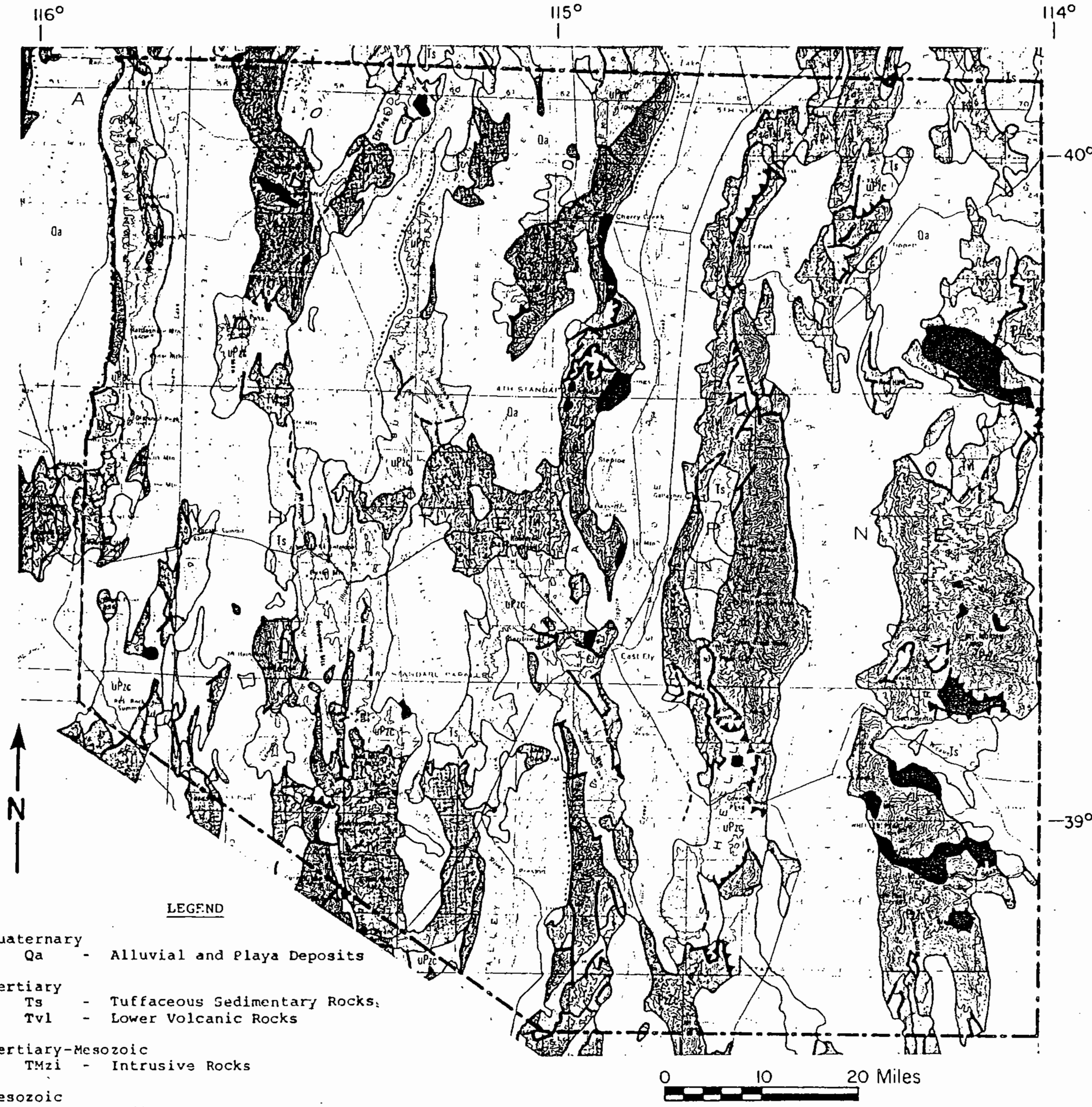
LEGEND

——6000——	WATER SURFACE ELEVATION
---6000---	INFERRED WATER SURFACE ELEVATION

WHITE PINE POWER PROJECT

GROUNDWATER ELEVATIONS

PLATE IV



LEGEND

Quaternary
- Qa - Alluvial and Playa Deposits

Tertiary
- Ts - Tuffaceous Sedimentary Rocks
- Tvl - Lower Volcanic Rocks

Tertiary-Mesozoic
- TMzi - Intrusive Rocks

Mesozoic
- Mzr - Sedimentary, Volcanic, and Intrusive Rocks

Upper Paleozoic
- uPzc - Carbonate and Siliceous Detrital Rocks

Precambrian-Lower Paleozoic
- PzZc - Carbonate and Transitional Assemblages

—— — — ...... High-Angle fault, dashed where approximately located, dotted where concealed.

▲▲▲▲▲▲...... Low-Angle fault, dashed where approximately located, dotted where concealed. Sawteeth on upper plate.

Source: Stewart, J. H. and Carlson, J. E., "Geologic Map of Nevada" Nevada Bureau of Mines and Geology, Map 57, 1977.

WHITE PINE POWER PROJECT

GEOLOGIC MAP OF WHITE PINE COUNTY

PLATE V

Leeds, Hill and Jewett, Inc. April 1981

TABLES

Table 2-1

Precipitation Stations

Station Name	Location Lat.	Location Long.	Elevation Above MSL (feet)	Period of Record	Mean Annual Precipitation (inches)
(a) White Pine County					
Cherry Creek	39°47'	114°53'	6450	1909-16	10.79
Ely WSO AP	39°17'	114°51'	6253	1889-91, 1893-1902, 1908-10, 1941-79	9.78
Hamilton	39°11'	115°29'	7977	1896-98	16.18
Lehman Caves Nat. Mon.	39°00'	114°13'	6825	1939-43, 1945-48, 1951-79	12.36
Lund	38°51'	115°00'	5565	1958-79	9.24
McGill	39°24'	114°46'	6340	1909-18, 1927-31, 1933-79	8.61
Ruth	39°17'	114°59'	6832	1962-77	12.90
Osceola	39°05'	114°26'	6500	1894-97	11.64
(b) Adjacent to White Pine County					
Callao	39°54'	113°54'	4339	1943, 1947-58, 1960-75 1977-79	4.93
Current Highway Sta.	38°48'	115°21'	6240	1964-69, 1971-74, 1976	9.81
Duckwater	38°54'	115°43'	5400	1967-74, 1976-79	7.10
Eureka	39°31'	115°58'	6540	1889, 1891, 1903-05, 1907-15, 1928, 1929, 1939-42, 1953-59, 1965-79	12.49
Garrison	38°55'	114°02'	4850	1903-10, 1912-13, 1916, 1952-55, 1957-75, 1977-79	8.24

(b) Adjacent to White Pine County (cont.)

Station Name	Location Lat.	Location Long.	Elevation Above MSL (feet)	Period of Record	Mean Annual Precipitation (inches)
Geyser Ranch	38°40'	114°38'	6020	1898, 1902, 1905-07, 1912, 1944-53, 1961-63, 1973-76, 1978	8.70
Ibapah	40°00'	114°00'	5500	1903-05, 1914-21, 1927-31, 1933-41, 1950-58, 1960-69, 1971-75, 1978-79	10.09
Partoun	39°39'	113°53'	4537	1951-75, 1977-78	7.47
Ruby Lake	40°12'	115°30'	6012	1940-43, 1945-79	12.72

Source: Reference 132

Table 2-2

Active USGS Stream Gaging Stations

USGS Station Number	Stream	Location	Drainage Area Sq. Miles	Period of Record	Discharge Average cfs	Discharge Average afy	Discharge Minimum * Consecutive 30 Day cfs	Remarks
10243700	Cleve Creek	2 miles downstream from North Fork	31.8	1959-67, 1976 to current year	8.9	6350	4.1	Spring Valley. No diversions above station.
10244950	Steptoe Creek	0.1 miles downstream from Clear Creek	11.1	1966 to current year	6.9	4900	2.7	Steptoe Valley
10245800	Newark Valley Tributary near Hamilton	Near U.S. Highway 50	157	1962 to current year	0.2	150	No data available	Newark Valley

* Ten year recurrence interval.

Source: Reference 128

Table 2-3

Measured Creek Discharges

Valley	USGS Station Number	Creek Name	Measurement Date	Discharge cfs
Butte	-	Snow	Oct. 1965	1.46
	-	Paris	Oct. 1965	1.77
Jakes	10245450	Illipah	15 measurements between 1962 and 1977	Ranges between 0 and 287
Long		NO MEASUREMENTS		
Newark	10245800	Newark Valley tributary near Hamilton	Active Gaging Station	
Spring	10243660	Connors Pass	17 measurements between 1962 and 1978	Ranges between 0 and 2
	-	McCoy	Jul. 1964 Aug. 1964	9.52 5.95
	-	Kalamazoo	Jul. 1964 Aug. 1964	6.87 4.56
	-	Muncy	Jul. 1964 Aug. 1964	4.23 1.98
	-	North	Jul. 1964	2.23
	-	Willard	Jul. 1964	0.35
	-	Unnamed Tributary (T16/R68-17)	Jul. 1964	3.03
	-	Unnamed Tributary (T18/R68-27)	Jul. 1964	0.07
	10243700	Cleve	Active Gaging Station	
	10243745	Odgers	28 measurements between 1972 and 1978	Ranges between 0.76 and 16.8

Valley	USGS Station Number	Creek Name	Measurement Date	Discharge cfs
Spring (cont.)	10243750	Bassett	Aug. 1964	3.13
			53 measurements between 1968 and 1978	Ranges between 1.68 and 26.5
	10243760	Piermont	25 measurements between 1972 and 1978	Ranges between 0.49 and 26.0
Steptoe	-	Berry	Jul. 1964	6.53
			Jul. 1965	5.68
	-	East	Jul. 1964	1.40
			Jul. 1965	1.15
	-	McDermit	Jul. 1964	4.46
			Jul. 1965	5.28
			May 1918	6.52
			Jul. 1918	5.80
	-	Goshute	May 1918	6.52
			Jul. 1918	5.80
			Aug. 1918	2.07
			Jul. 1964	2.58
	-	Egan	Jul. 1964	1.21
			Oct. 1965	0.21
	-	First	Apr. 1918	0.09
			June 1918	0.18
	-	Second	Apr. 1918	0.35
			June 1918	0.43
	-	Third	Apr. 1918	0.64
			June 1918	1.01
			Oct. 1965	0.18
	-	North	Jul. 1965	0.27
	-	Cave	Jul. 1965	1.96
	-	Corral	Jul. 1965	0.73
	-	Willow	Oct. 1965	0.64
	-	Murry	Oct. 1965	3.88
	-	Timber	Oct. 1965	2.52
	-	Duck	Oct. 1965	14.8

Valley	USGS Station Number	Creek Name	Measurement Date	Discharge cfs
Steptoe (cont.)	-	Wilson	Oct. 1965	0.59
	102450000	Big Indian	Jul. 1964	2.06
			18 measurements between 1965 and 1967	Ranges between 0.15 and 6.69
	10244950	Steptoe	Active Gaging Station	
White River	09415480	White River tributary (T12/R60-23)	16 measurements between 1962 and 1978	Ranges between 0 and 15
	09415460	White River near Red Mt. (T13/R59-33K)	69 measurements between 1965 and 1978	Ranges between 0.59 and 62.6

Source: Reference 128

Table 2-4

Selected Spring Discharge Measurements

Valley	Spring Name	Approximate Location Township/Range	Measurement Date	Discharge cfs
Butte	Stratton Spring-Paris Ranch	26/62-15C1	Aug. 1967	0.56
Newark	Indian	16/56-9C1	Jan. 1970	0.69
	Warm	22/56-1A	1960	6.38
Railroad	Big Bull	14/56-14DDC1	Nov. 1970	0.89
	Bull Creek	14/56-25BCD1	Jan. 1968	0.50
	Green	15/57-33	Apr. 1948	1.51
Spring	Siegel School	22/65-34A	1964	0.25
Steptoe	Comins	15/64-20	Prior to 1918	6.68
	Murry	16/63-10	1906, 1909-11, 1924-25, 1932-35, 1947-51, 1958-63, 1973-81	Flows range between 11.9 and 2.9 but measuring point may also be changing.
	McGill	18/64-21b	Aug. 1918	10
			Oct. 1965	10.20
	Campbell Embayment	19/63-1	Oct. 1965	10.60
	Campbell Ranch	19/63-5	Sep. 1917	2.67
	Monte Neva Hot	21/63-24	Aug. 1918	1.39
	Borchert John	22/63-16	May 1918	1.78
White River	Lund	11/62-4A1	Oct. 1910	5.36
			Mar. 1935	9.31
			Mar. 1936	6.39
	Preston Big	12/61-2A1	Oct. 1910	6.21
			Jun. 1916	8.00
			May 1935	7.10
			Mar. 1936	8.48
			May 1937	8.50
			Apr. 1939	8.34
			Mar. 1941	8.34

Valley	Spring Name	Approximate Location Township/Range	Measurement Date	Discharge cfs
White River (cont.)	Preston Big (cont.)	12/61-2A1	Apr. 1943	9.04
			May 1944	8.97
			Jul. 1945	8.58
			May 1947	8.64
	Cold	12/61-12B1	Oct. 1910	1.03
			May 1935	1.31
			Mar. 1936	1.34
			May 1947	1.74
	Nicholas	12/61-12D1	Oct 1910	2.28
			May 1935	2.63
			Mar. 1936	2.68
			May 1947	2.51
	Arnoldson	12/61-12D2	Oct. 1910	3.14
			1913	3.66
			1922	3.52
			May 1935	3.25
			Mar. 1936	3.86
			Jun. 1941	3.73
			May 1944	3.73
			May 1947	3.07

Source: References 23, 25, 68, 42, 97, 107

Table 2-5

Previously Estimated Areas of Vegetative Cover in White Pine County

(acres)

Valleys	Wet meadow & saltgrass	Some wet meadow, saltgrass, rabbitbrush	Meadow, saltgrass, greasewood	Greasewood, rabbitbrush	Playa area (sparse vegetation)
Butte*1/	0	9400	0	36,000	0
Jakes	no information available				
Long	0	0	0	11,000	
Newark	3,600	0	35,200	11,800	25,000
Spring	14,600	13,200	7,100	139,000	11,600
Steptoe	18,000	0	53,000	22,000	50,000
White River*	0	36,000	0	0	0

* Some of the area may be outside of White Pine County boundaries.

1/ Southern Butte Valley

Source: References 22, 23, 25, 42, 68, 97

Table 2-6

Consumptive Use Factors

(acre-feet per acre per year)

Valleys	Wet meadow & saltgrass	Some wet meadow, saltgrass, rabbitbrush	Meadow, saltgrass, greasewood	Rabbitbrush, greasewood	Playa Area (sparse vegetation)
Butte *1/	na	0.5	na	0.16	na
Jakes			no information available		
Long	na	na	na	0.2	na
Newark	1.0	na	0.3	0.1	(a)
Spring	1.5	1.0	0.5	0.2	0.1
Steptoe	1.5		0.3	0.1	0.5
White River*	na	0.8	na	na	na

(a) Not estimated but assumed negligible.
na - not applicable, no such areas exist within valley.
* Some of the area maybe outside of White Pine County.
1/ Southern Butte Valley

Sources: References 22, 23, 25, 42, 68, 97

Table 2-7

1966 Estimated Irrigated Acreage
In White Pine County

Valley	Irrigated Acreage (in acres)
Butte	2500
Jakes	1800
Long	0
Newark	7600
Spring	19,500
Steptoe	26,500
White River	19,000

Source: Reference 5

Table 2-8

Estimated 1977 Vegetative Cover
In White Pine County
(Acres)

Valley	Tailings Ponds	Playa	Meadow and Floodplain Associations	Transitional Desert Shrubs and Greasewood
Butte	0	0	4200	112,600
Jakes	0	0	0	16,700
Long	0	1400	0	104,800
Newark	0	14,000	8500	124,000
Spring	0	4800	40,800	154,000
Steptoe	2100	0	70,000	0
White River	0	0	5800	10,700

Source: Reference 130

Table 2-9

1980 Estimates of Irrigated Acreage In White Pine County

(in acres)

Valley	Irrigated	Marsh	Total
Butte	1470	340	1810
Jakes	920	0	920
Long	0	0	0
Newark	11,820	0	11,820
Spring	26,330	85	26,415
Steptoe	27,450	1400	28,850
White River	18,150	0	18,150

Source: Reference 131

Table 2-10

Water Quality Data from Butte Valley

Number on Diagram	Location	Source	Date of Collection	TDS (mg/l)	Temp. oF
1	21/61-6cl	Well	09/22/65	433	-
2	22/61-6cl	Well	10/05/65	258	48
3	23/61-7dl	Well	09/22/65	322	47
4	24/61-14cl	Well	09/22/65	379	56
5	25/62-17bl	Well	08/16/67	349	54
6	26/62-22al	Well	08/13/67	306	-
7	20/60-33dl	Spring	08/15/67	187	48
8	22/62-21dl	Spring	08/21/67	336	51
9	26/62-15cl	Spring	08/18/67	295	57
10	26/62-33dl	Spring	08/18/67	308	50
11	27/62-33cl	Spring	08/19/67	308	-
12	28/61-2dl	Spring	08/19/67	296	58
13	28/61-11dl	Spring	08/19/67	274	-
14	28/61-26dl	Spring	08/19/67	300	56
15	28/62-9cl	Spring	08/20/67	482	-
16	29/62-23dl	Spring	08/19/67	471	67
17	22/61-6	Water Supply	06/19/70	277	-
18	24/62-31	Mine Shaft	07/71	330	-
19	19/62-30bl	Creek	08/15/67	280	65
20	25/62-21	Creek	10/05/65	243	50
21	26/62-35	Creek	10/05/65	194	51
22	27/62-8cl	Creek	08/19/67	241	70
23	27/62-12	Creek	10/05/65	230	54

Source: Reference 42

Table 2-10

Water Quality Data from Spring Valley

Number on Diagram	Location	Source	Date of Collection	TDS (mg/l)	Temp. oF
1	11/67-1cl	Well	-	319	54
2	12/67-2al	Well	07/16/64	140	75
3	13/66-5	Well	07/71	354	-
4	13/67-15dl	Well	06/21/50	132	64
5	13/67-18dl	Well	07/14/64	319	54
6	13/67-33dl	Well	07/14/64	544	57
7	14/66-24al	Well	07/15/64	398	53
8	16/67-27dl	Well	07/15/64	773	60
9	18/66-25al	Well	06/21/50	975	54
10	18/67-1cl	Well	07/16/64	692	54
11	23/66-31al	Well	06/22/50	244	89
12	9/67-27al	Spring	07/15/64	195	70
13	16/66-13al	Spring	07/16/64	249	55
14	Ely-Milford Rd, Osceola	Spring	07/15/18	194	-
15	13/67-35dl	Creek	05/26/49	132	73
16	16/66-28	Creek	07/16/64	40	65

Source: References 44 and 97

Table 2-10

Water Quality Data from Steptoe Valley

Number on Diagram	Location	Source	Date of Collection	TDS (mg/l)	Temp. oF
1	13/64-9dl	Well	07/29/65	332	60
2	14/64-36al	Well	07/29/65	265	60
3	15/63-1	Well	07/21/75	246	Cold
4	15/63-12r	Well	01/14/76	273	Cold
5	19/63-12NE-1/4, 10'-12'	Well	03/12/18	289	-
6	19/63-12NE-1/4, 51'-57'	Well	03/12/18	342	-
7	20/64-6al	Well	07/31/65	516	57
8	20/64-32(1) SW-1/4	Well	02/07/18	317	-
9	20/64-32, 20'-37'	Well	06/24/18	331	-
10	20/64-32, 46'-53'	Well	06/20/18	307	-
11	22/64	Well	07/71	410	-
12	23/63-2bl	Well	07/29/65	387	-
13	27/65-29cl	Well	07/28/65	317	62
14	11/65-7dl	Spring	10/17/65	268	53
15	12/63-1dl	Spring	10/17/65	281	52
16	16/63-3al	Spring	09/21/65	317	95
17	16/63-10	Spring	04/10/18	390	85
18	16/63-10al	Spring	10/04/65	557	46
19	16/63-10dl	Spring	10/04/65	575	52
20	16/63-20al	Spring	04/16/63	314	57
21	18/63-33	Spring	10/06/18	238	-
22	19/63-5SW-1/4	Spring	10/09/18	380	76
23	19/63-5cl	Spring	05/16/66	371	-
24	19/63-5dl	Spring	10/08/65	271	-
25	19/63-32NE-1/4	Spring	05/14/18	372	-
26	20/65-20cl	Spring	10/17/65	193	42
27	29/23-35al	Spring	10/22/65	274	64
28	Warm Spring Cons. Copper Co.	Spring	10/06/18	379	84
29	Melvin Hot Springs	Spring	08/21/17	470	173-174
30	Borchert's John Spring	Spring	05/22/18	314	66
31	14/63-35al	Creek	09/23/65	209	54
32	15/65-10dl	Creek	10/18/65	269	-
33	19/63-35bl	Pond	09/21/65	1365	52
34	23/62-14al	Mine Adit	10/05/65	246	58
35	23/63-12bl	Creek	10/05/65	429	52
36	28/64-28dl	Stream	07/28/65	506	63

Source: References 25 and 44

Table 2-10

Water Quality Data from White River Valley

Number on Diagram	Location	Source	Date of Collection	TDS (mg/l)	Temp. oF
1	12/61-34D	Well	07/30/75	430	64
2	12/62-21	Well	12/15/80	179	Cold
3	12/62-33	Well	07/71	566	Cold
4	13/61-9dc	Well	07/31/75	530	65
5	14/60-4d	Well	07/30/75	525	55
6	14/62-22a	Well	07/31/75	370	62
7	6/61-18a4	Spring	05/27/49	463	-
8	7/62-28b1	Spring	05/27/49	288	-
9	11/59-1c	Spring	07/30/75	290	55
10	11/62-4a1	Spring	05/27/49	390	-
11	13/60-33a	Spring	07/31/75	200	126
12	13/61-32b	Stream	07/31/75	495	65
13	13/62-23d	Creek	07/31/75	260	60

Source: References 3 and 68

Table 3-1

Elevation Verses Area Characteristics of White Pine County Valleys

Valley	Area Located Between Given Elevation Zone (square miles)				
	Below 6000	6000-7000	7000-8000	8000-9000	Above 9000
Butte	0	502	131	16	14
Jakes	0	265	157	26	9
Long	0	496	121	7	1
Newark	234	418	104	27	2
Spring	529	504	215	151	91
Steptoe	207	669	494	218	69
White River	296	305	164	25	25

Table 3-2

Steptoe Valley Stream Recharge Estimates

Creek	Measurement Date	Upstream Location (cfs)	Downstream Location (cfs)	Calculated Loss (cfs)	Distance Between Stations (miles)	Estimated Recharge (cfs/mile)
Steptoe	May 23, 1918	10.56	9.66	0.90	3	0.30
	Jun. 18, 1918	9.07	8.35	0.72	3	0.24
Second	Jun. 12, 1918	0.43	0.21	0.22	1.75	0.13
Gosiute	May 23, 1918	6.52	2.93	3.59	1.5	2.39
	Jul. 18, 1918	5.80	2.05	3.75	1.5	2.50
	Aug. 8, 1918	2.07	0.88	1.19	1.5	0.79

Source: Reference 10

Table 3-3

Pertinent Data From Selected Wells Within White Pine County

Valley	Well Location Number	Year Drilled	Depth (feet)	Diameter (inches)	Est. Altitude of Land Surface (feet above MSL)	Well Log Available	Remarks
Butte	22/60-26A1	1925	130	6	6,190	No	
Jakes		No Information Available					
Long		No Information Available					
Newark	18/55-31C1	1900	43	36	5,930	No	
	19/57-19B1	1948	112	48	6,000	No	
	20/55-34D1	1948	22	6	6,000	No	
	21/55-9B1	1951	33	60	5,950	No	
Spring	13/67-8D1	1936	45	38	5,780	No	
	13/67-15D1	1948	290	16	5,950	Yes	
	15/66-13D1	-	82	6	5,830	No	
	18/68-31A1	1947	465	10,8,6	5,580	Yes	
Steptoe	15/64-7A1	1946	200	16	6,500	No	
	16/63-14A1	1918	130	10	6,240	Yes	
	19/63-12A1	1918	915	8	6,054	Yes	USGS well no. 2
	20/64-32C2	1918	122	10	6,070	Yes	USGS well no. 3
White River	11/61-35A1	1900	44	6	5,400	No	
	12/61-34A1	-	-	7	5,800	No	
	12/62-18D1	1947	108	6	5,600	Yes	
	12/62-31D2	-	16	48	5,517	No	

Source: References 23, 42, 97, 25, and 68

Table 3-4

USGS/NDCNR Estimates of Consumptive Use in Valleys

(afy)

Valley	Irrigated Crops	Native Vegetation	Total
Butte (Southern valley only)	1200	11,000	12,200
Jakes	-	-	-
Long	-	2200	2200
Newark	3600	12,400	16,000
Spring	-	70,000	70,000
Steptoe	-	70,000	70,000
White River	5000	28,800	33,800

Table 3-5

Estimated Consumptive Use in Valleys

Valley	Irrigated Lands - 1980		Meadow and Floodplain Lands not Irrigated		Transitional Desert Shrub-Greasewood		Total Consumptive Use	USGS/NDCNR Consumptive Use
	Acreage acres	Consumptive Use afy[1]	acres	afy[2]	acres	afy[3]	afy	afy
Butte	1800	2700	2400	2400	112,600	11,260	16,360	12,000
Jakes	900	1400	0	0	16,700	1600	3000	Not estimated
Long	0	0	0	0	104,800	10,500	10,500	2200
Newark	11,800	17,700	0	0	124,000	12,400	30,100	16,000
Spring	26,400	39,600	14,400	14,400	154,000	15,400	69,400	70,000
Steptoe	28,900	43,400	41,150	41,150	0	0	84,550	70,000
White River	18,150	27,200	0	0	10,700	1100	28,300	33,800

1 Consumptive use factor is 1.5 afy
2 Consumptive use factor is 1.0 afy
3 Consumptive use factor is 0.1 afy

Table 3-6

Specific Capacity Measurements

Location	Drawdown (feet)	Pumping Rate (gpm)	Specific Capacity (gpm/ft)
Newark Valley			
17/55-18NE-1/4 No. 1	26	1350	51.9
17/55-18NE-1/4 No. 2	56	1130	20.2
17/55-18NE-1/4 No. 3	18.5	400	21.6
Steptoe Valley			
17/63-1SW-1/2	3.9	115	29.5
17/63-1	5	1230	246
17-63-17	4	1240	310
17-64-5L No. 1	3.8	920	242.1
17-64-6L No. 2	7.4	1700	229.7
17/64-6 No. 3	10	1100	110
17/64-7L No. 4	4.4	450	102.3
18/63-36 No. 4	3	2500	833.3
18/63-36 No. 5	15	3190	212.7
20/64-32SW-1/4 No. 1	18.9	263	13.9
20/64-32 SW-1/4 No. 3	7.8	262	33.6
White River Valley			
11/62-5	44.4	600	13.5
12/62-16	22	1175	53.4
12/62-20SW-1/4	17	1585	93.2
12/62-28	11	1160	105.4
12/62-30 No. 1	17.4	1710	98.3
12/62-30 No. 3	8.4	1290	153.6
12/62-31 No. 1	11	1078	98
12/62-31 No. 2	18.8	1540	81.9
12/62-32	15.1	1440	95.4
12/62-33	15.2	620	40.8

Table 4-1

USGS and NDCNR Estimated Water Balances

Valley	Runoff afy	Recharge afy	Discharge afy	Perennial Yield afy
Butte (Southern Valley)	9400	15,000	12,200	14,000
Jakes	7000	-	-	12,000
Long	4000	10,000	2200	6,000
Newark	8000	18,500	16,000	18,000
Spring	90,000	75,000	75,000	100,000
Steptoe	78,000	85,000	70,000	70,000
White River*	26,000	53,000	53,000	37,000

* Defined as the valley north of a line eight miles south of Adams McGill Reservoir.

Table 5-1

WPPP Water Filings

Valley	Amount (afy)	Priority Date	Status	Remarks
Butte	26,063	Nov. 13, 1979	Pending	
Jakes	26,063	Nov. 13, 1979	Pending	
Long	26,063	Nov. 13, 1979	Pending	
Newark	26,063	Nov. 13, 1979	Pending	
Steptoe	51,983	June 16, 1978	Pending	Valley Designated Sept. 1979
Spring	26,063	March 30, 1981	Initial filing	
White River	26,063	Nov. 13, 1979	Pending	

Table 5-2

Groundwater Rights

Summary*

(afy)

	Steptoe	White River	Newark	Jakes	Butte	Long	Spring
Certified Rights	39,000	13,200	8,200	-	1,600	300	7,200
Permitted Rights	1,000	5,100	700	-	-	2,200	14,600
Total Existing Rights	40,000	18,300	8,900	-	1,600	2,500	21,800
Pending Applications	197,700	136,000	46,600	66,300	58,600	26,000	112,000
Perennial Yield	70,000	37,000	18,000	12,000	14,000	6,000	100,000

* Rounded quantities

Table 5-2

Groundwater Rights

Summary*

(afy)

	Steptoe	White River	Newark	Jakes	Butte	Long	Spring
Certified Rights	39,000	13,200	8,200	-	1,600	300	7,200
Permitted Rights	1,000	5,100	700	-	-	2,200	14,600
Total Existing Rights	40,000	18,300	8,900	-	1,600	2,500	21,800
Pending Applications	197,700	136,000	46,600	66,300	58,600	26,000	112,000
Perennial Yield	70,000	37,000	18,000	12,000	14,000	6,000	100,000

* Rounded quantities

Table 6-1

Comparison of Groundwater Basins

	Water Availability		Water Rights	Environmental		Existing Uses	Economic Criteria	
Ground-water Basin	Area above 8000 ft. (square miles)	Perennial Yield (thousand acre-feet) (1)	Col. (1) less 1980 rights (thousand acre-feet) (2)	Meadows and Floodplain Assn. (thousand acres) (3)	Number of Thermal Springs (4)	Irrigated Acreage (thousand acres) (5)	Distance from Ely (miles) (6)	Static Ground-water Depth (feet) (7)
Butte	30	16	14.4	4.2	1	1.5	48	75
Jakes	35	12	12	0	0	0.9	34	400
Long	8	10	7.5	0	1	0	63	75
Newark	29	18	9.1	8.5	0	11.8	70	10
Spring	242	100	78.2	40.8	1	26.3	47	10
Steptoe	287	85	45.0	70.0	13	27.5	47	25
White River	50	37	18.7	5.8	4	18.1	30	25

Source: References 62, 130, 131.

Table 6-2

Comparison of Groundwater Basins

	Water Availability		Water Rights	Environmental		Existing Uses	Economic Criteria	
Ground-water Basin	Area above 8000 ft.	Perennial Yield (1)	Col. (1) less 1980 rights (2)	Meadows and Floodplain Assn. (3)	Thermal Springs (4)	Irrigated Acreage (5)	Distance from Ely (6)	Static Ground-water Depth (7)
Butte	3	3	4	5	5	5	3	3
Jakes	4	2	3	7	7	6	5	1
Long	1	1	1	7	5	7	2	3
Newark	2	4	2	3	7	4	1	7
Spring	6	7	7	2	5	2	4	7
Steptoe	7	6	6	1	1	1	7	5
White River	5	5	5	4	3	3	6	5

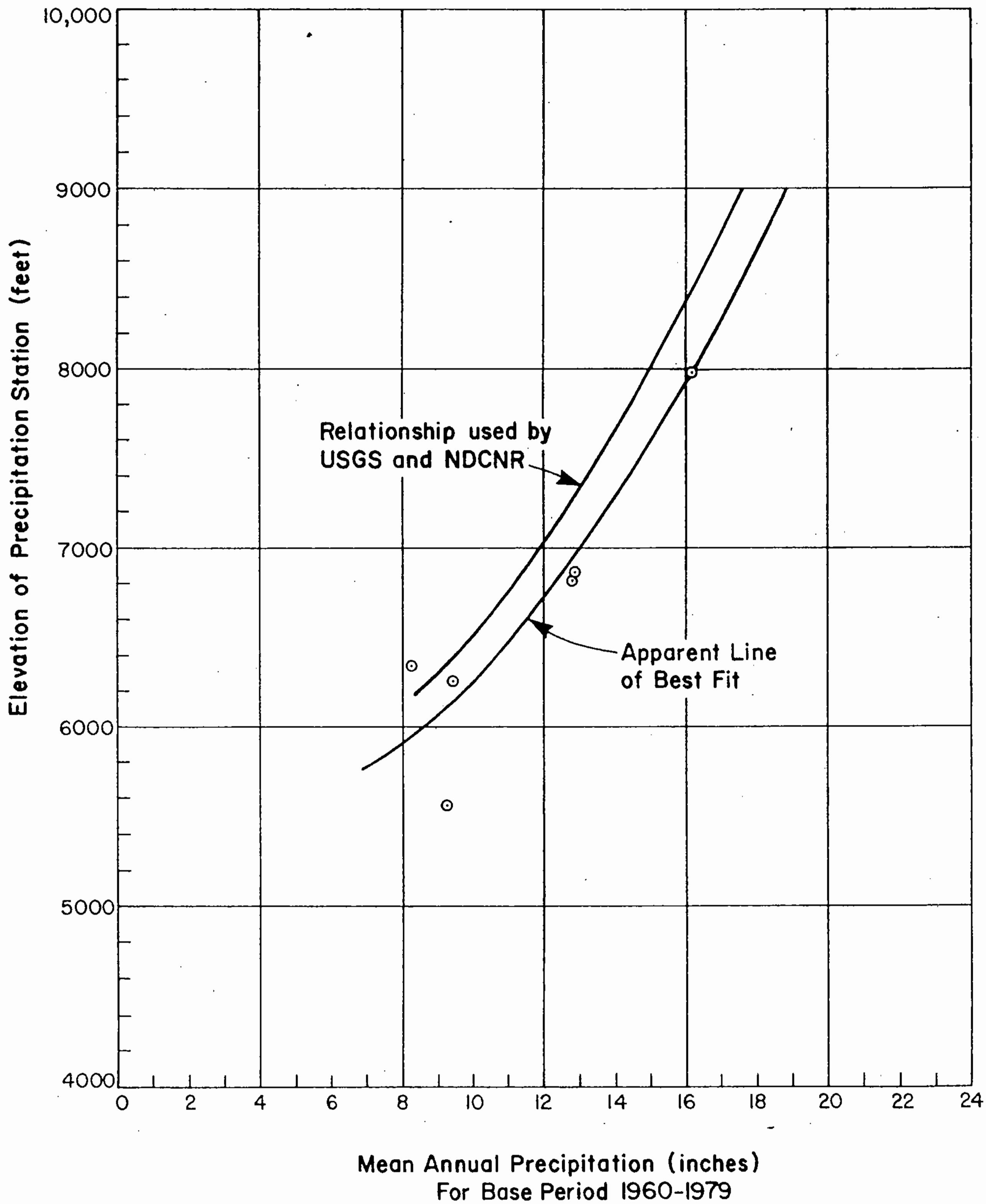
Ranking Order: 7 = best possible condition
4 = average condition
1 = worst possible condition

Table 7-1

Aquifer Drawdown Characteristics

	Valley Fill Alluvial Aquifer		Carbonate Aquifer
	3 x 7 Well Field	3 x 21 Well Field	1 x 15 Well Field
Maximum Drawdown, feet	150	90	75
Aquifer section where drawdown is greater than:			
a) 10 Feet -			
Length, miles	16	20	30
Area, sq. miles	50	60	650
b) 25 Feet -			
Length, miles	10	14	14
Area, sq. miles	30	40	60
Water Source:			
Percentage from Storage	40	40	30
Percentage from Recharge	60	60	70

FIGURES



LEGEND

⊙ Precipitation Stations

Leeds, Hill and Jewett, Inc. April 1981

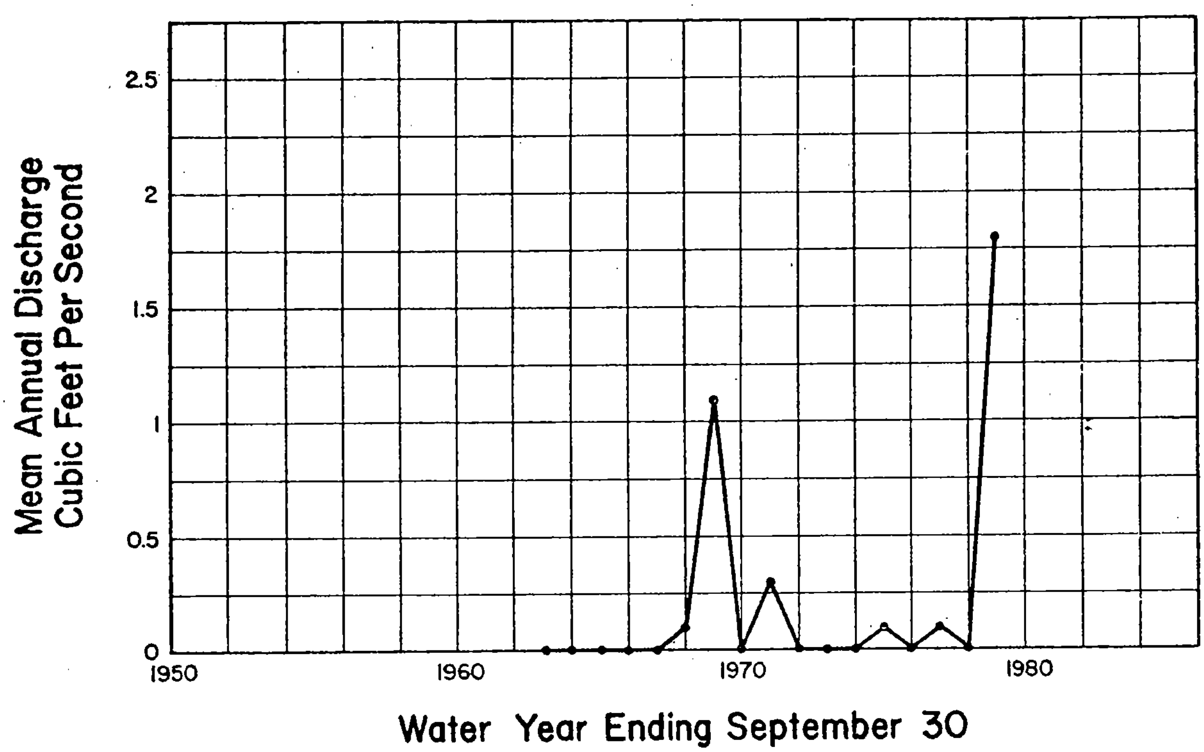
WHITE PINE POWER PROJECT

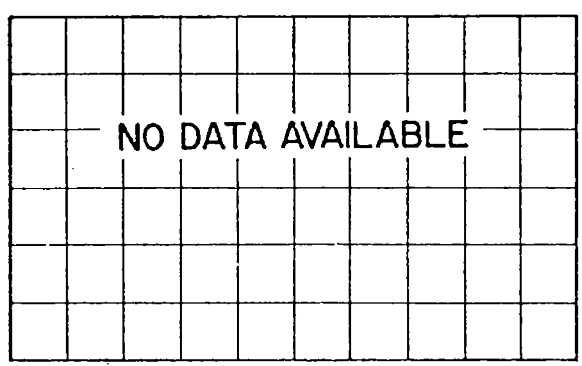
PRECIPITATION
AND
ELEVATION

FIGURE 3 - 1

VALLEY: NEWARK

USGS STATION NAME: NEWARK VALLEY TRIBUTARY NEAR HAMILTON, NV.
USGS STATION IDENTIFICATION: 10245800
DRAINAGE AREA: 157 SQUARE MILES
PERIOD OF RECORD: AUG. 1962 TO CURRENT YEAR
MEAN ANNUAL DISCHARGE: 0.2 CFS





WHITE PINE POWER PROJECT

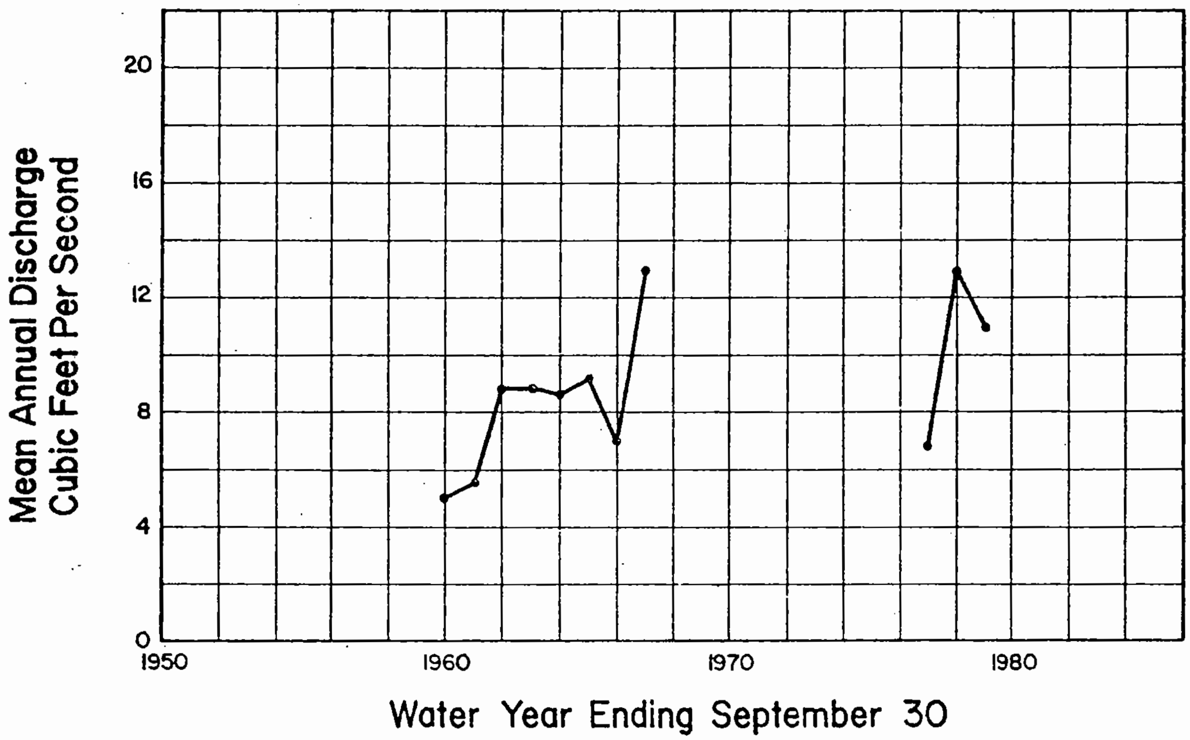
NEWARK VALLEY TRIBUTARY DISCHARGE CHARACTERISTICS

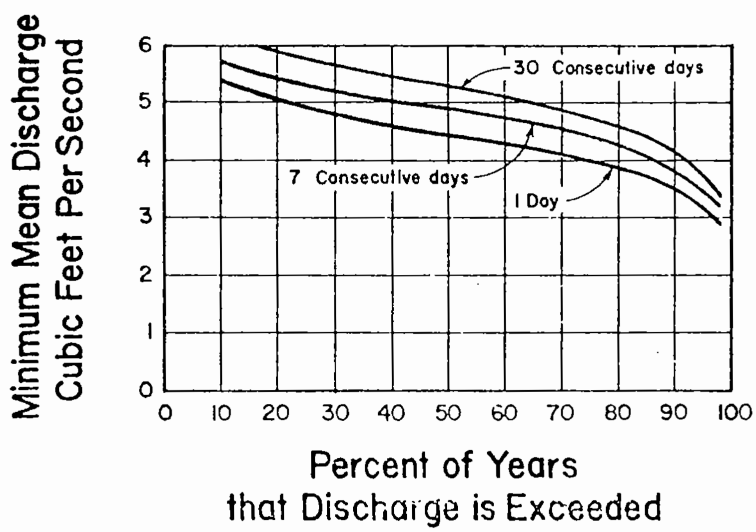
FIGURE 3-2

Leeds, Hill and Jewett, Inc. April 1981

VALLEY: SPRING

USGS STATION NAME: CLEVE CREEK NEAR ELY, NV.
USGS STATION IDENTIFICATION: 10243700
DRAINAGE AREA: 31.8 SQUARE MILES
PERIOD OF RECORD: JUNE 1914 TO DEC. 1916, OCT. 1959 TO SEPT. 1967, OCT. 1976 TO CURRENT YEAR
MEAN ANNUAL DISCHARGE: 8.9 CFS





Leeds, Hill and Jewett, Inc. April 1981

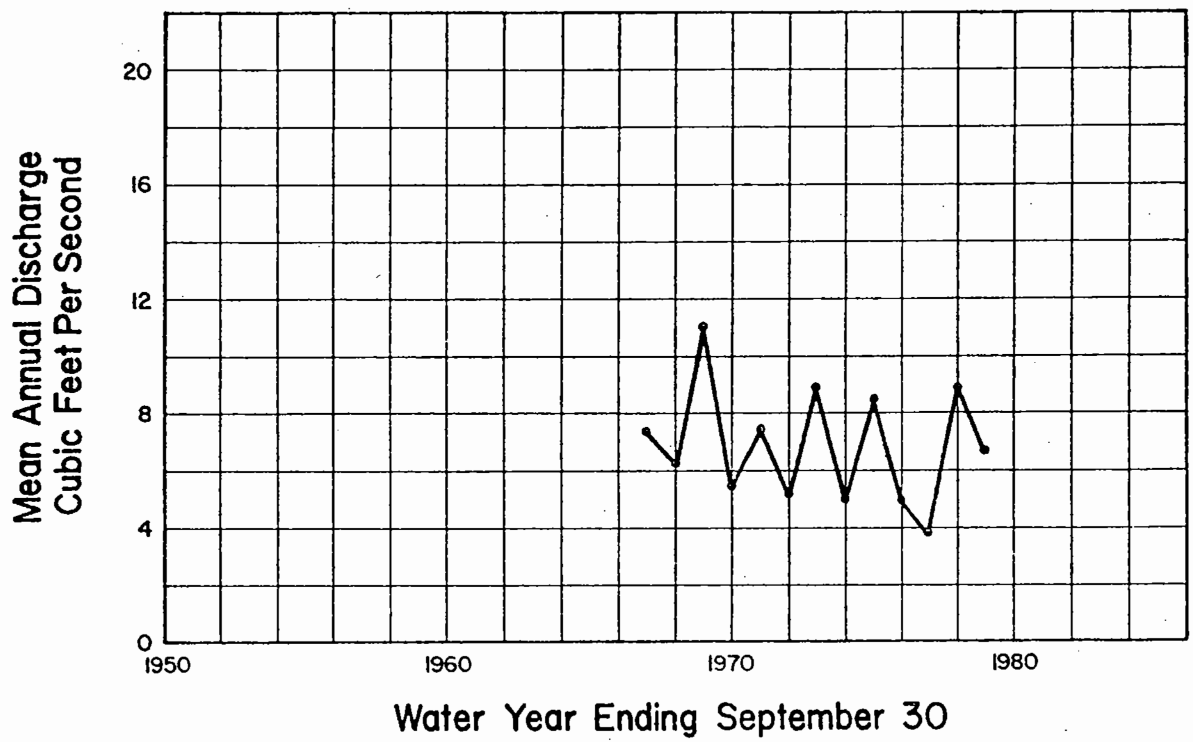
WHITE PINE POWER PROJECT

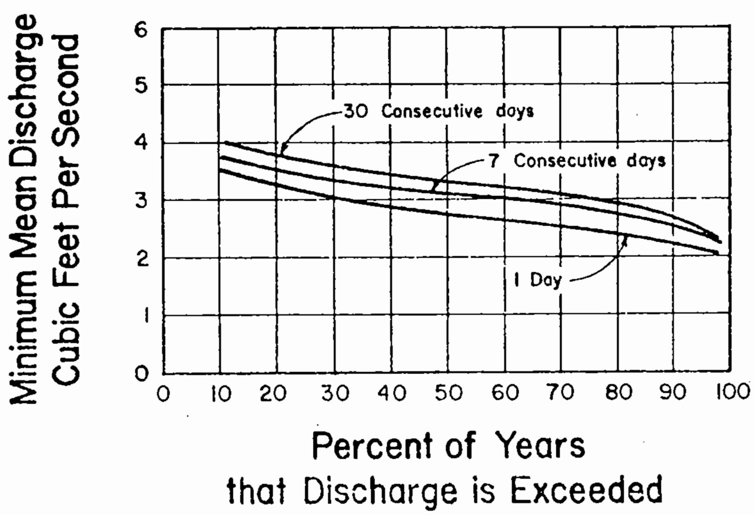
CLEVE CREEK
DISCHARGE CHARACTERISTICS

FIGURE 3-3

VALLEY: STEPTOE

STATION NAME: STEPTOE CREEK NEAR ELY, NV.
USGS STATION IDENTIFICATION: 10244950
DRAINAGE AREA: 11.1 SQUARE MILES
PERIOD OF RECORD: JUNE 1966 TO CURRENT YEAR
MEAN ANNUAL DISCHARGE: 6.9 CFS



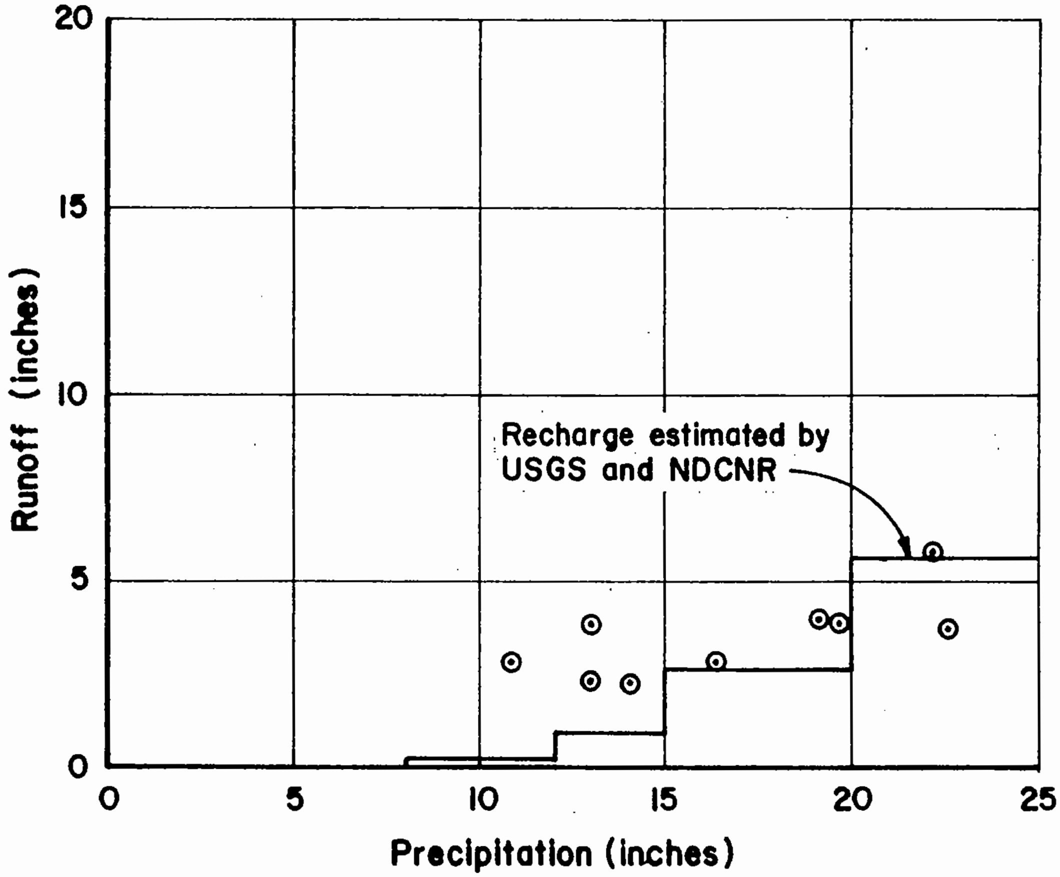


WHITE PINE POWER PROJECT

STEPTOE CREEK
DISCHARGE CHARACTERISTICS

FIGURE 3-4

Leeds, Hill and Jewett, Inc. April 1981

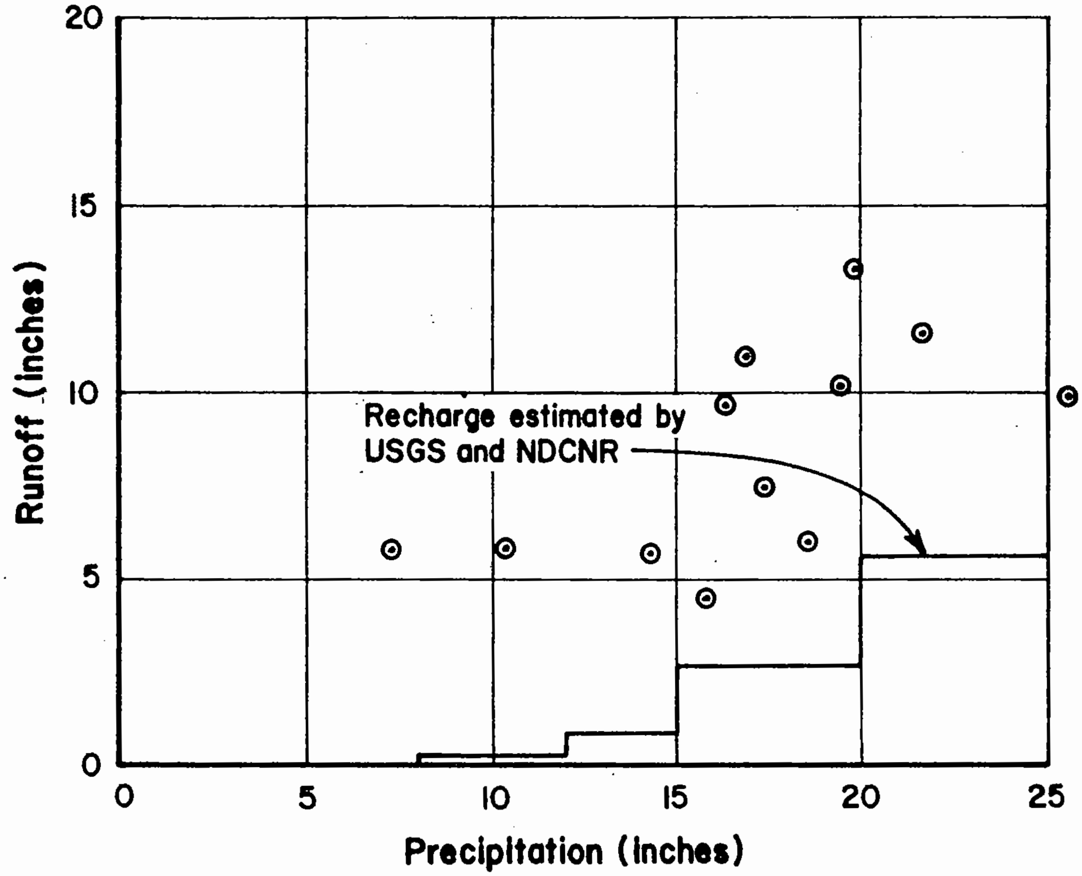


WHITE PINE POWER PROJECT

ANNUAL RUNOFF AND PRECIPITATION AT CLEVE CREEK

FIGURE 3-5

Leeds, Hill and Jewett, Inc. April 1981

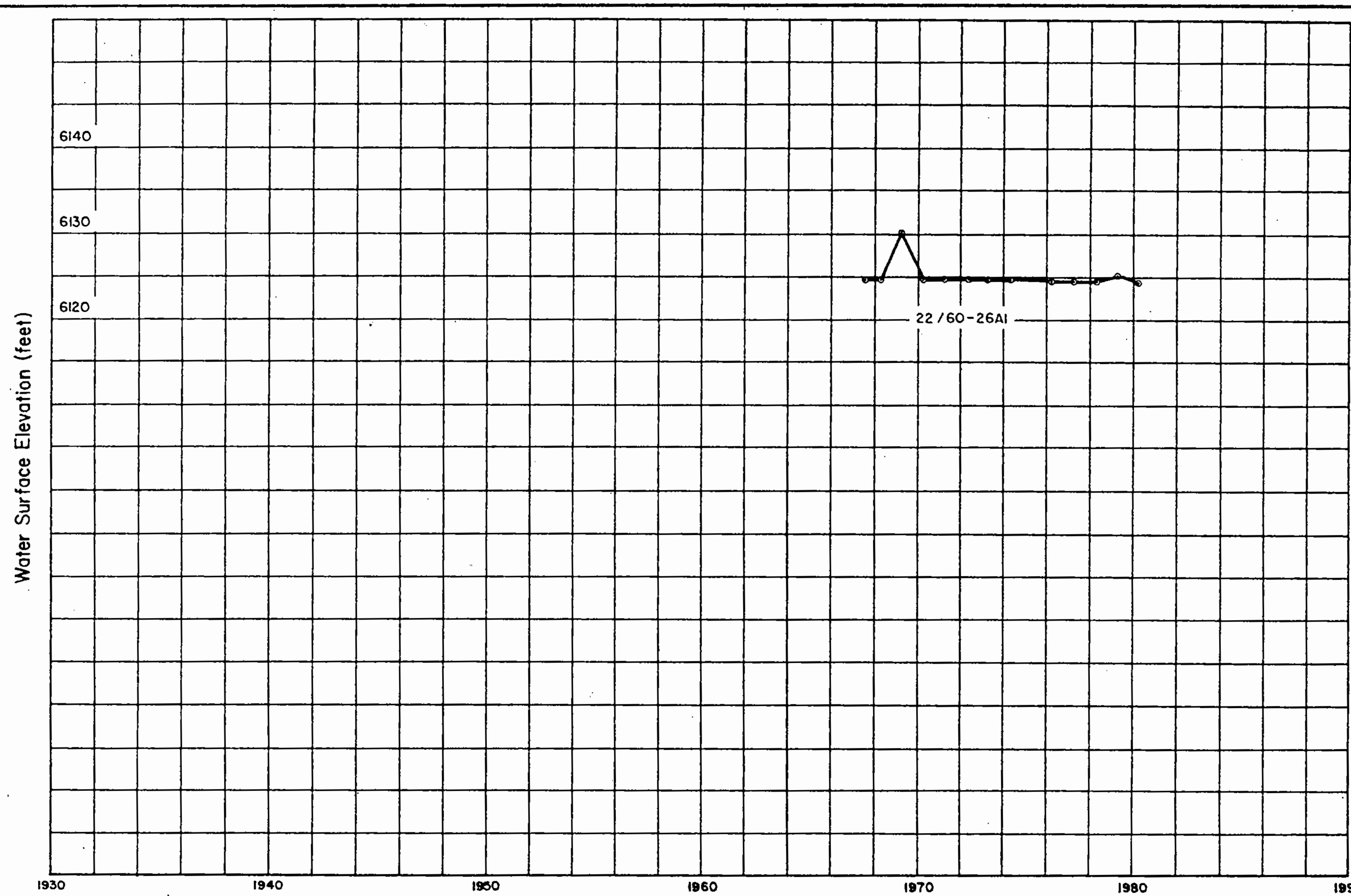


WHITE PINE POWER PROJECT

ANNUAL RUNOFF AND PRECIPITATION AT STEPTOE CREEK

FIGURE 3-6

Leeds, Hill and Jewett, Inc. April 1981

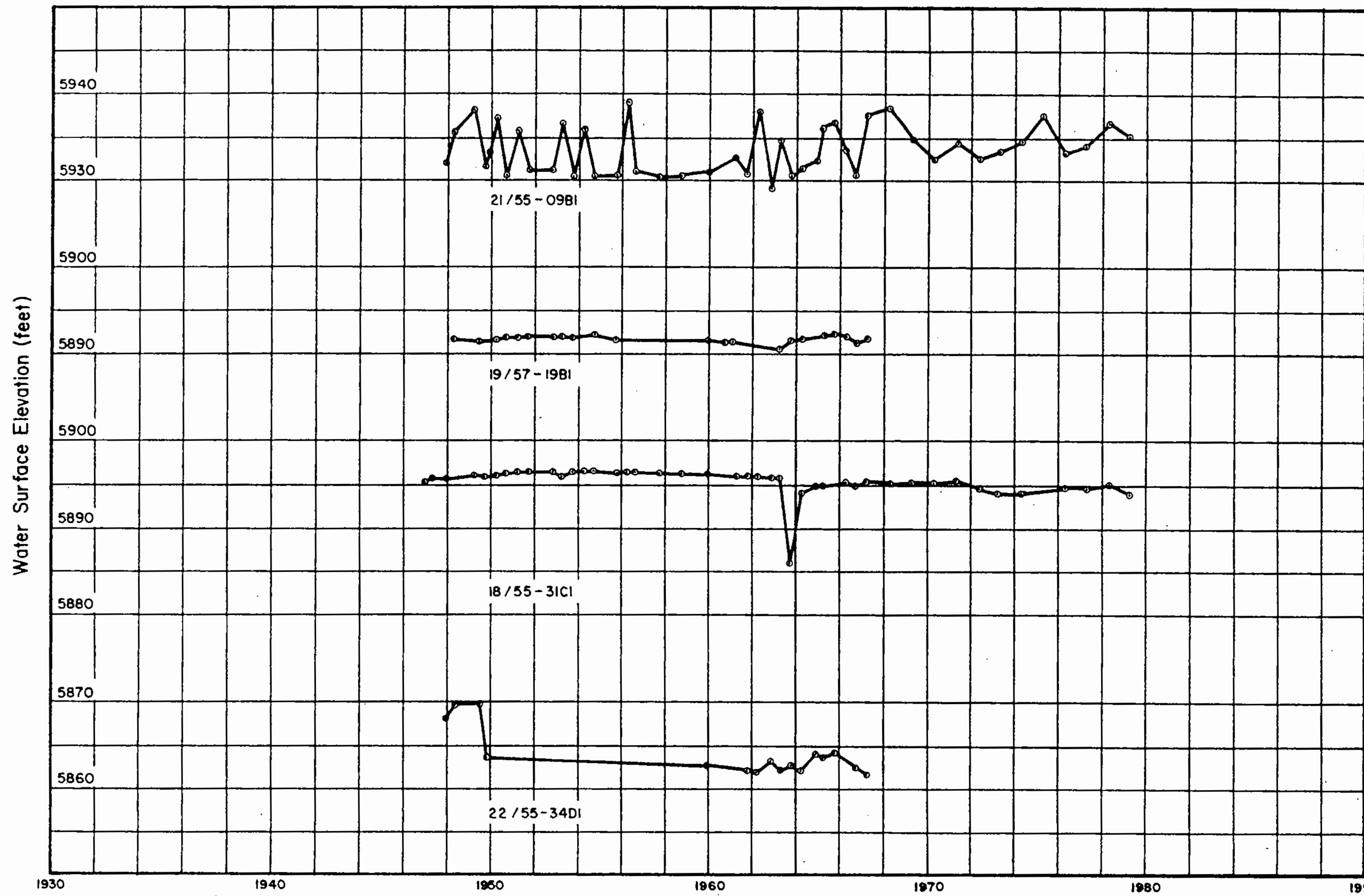


WHITE PINE POWER PROJECT

BUTTE VALLEY WELL

FIGURE 3-7

Leeds, Hill and Jewett, Inc. April 1981

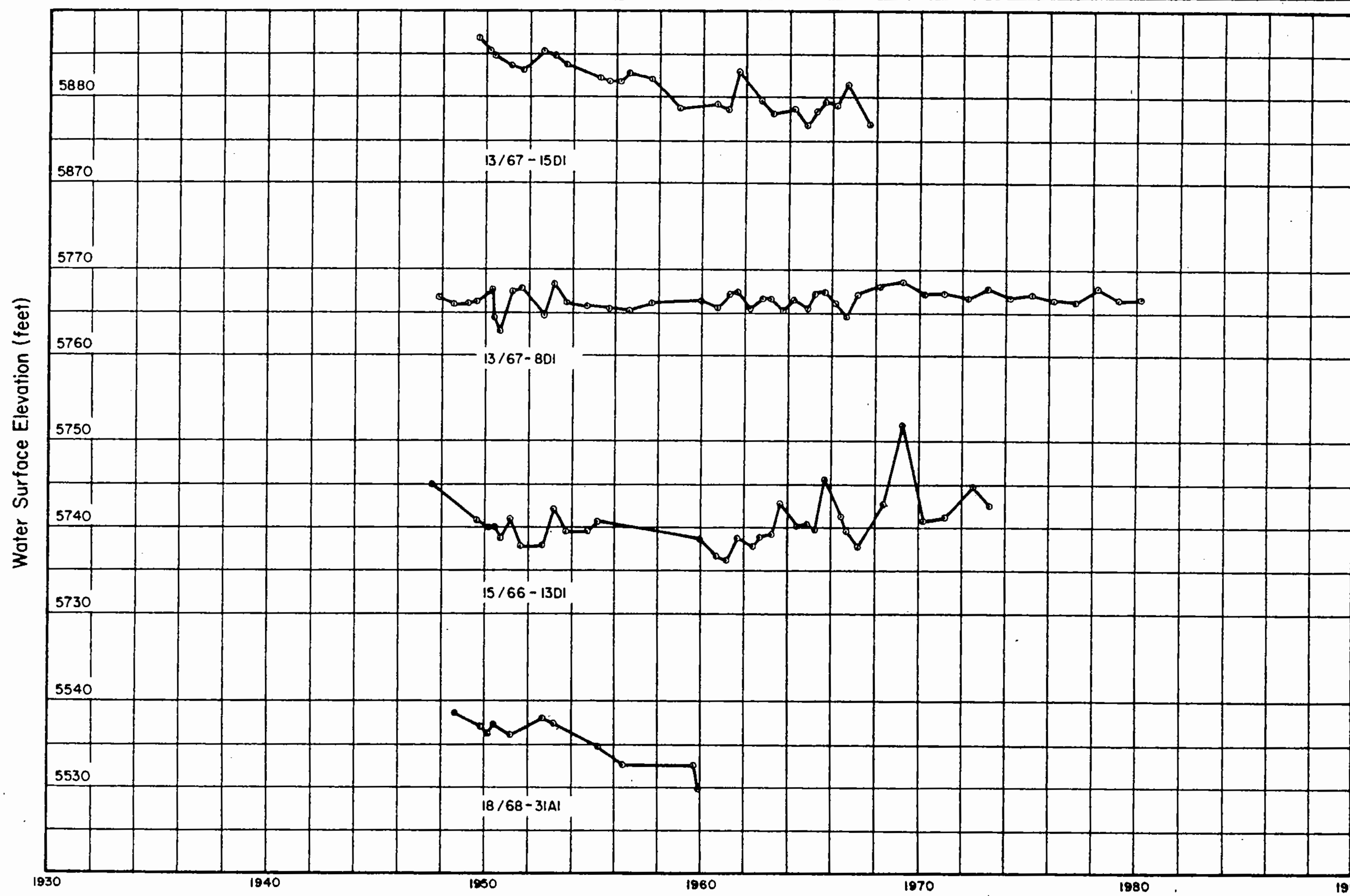


WHITE PINE POWER PROJECT

NEWARK VALLEY WELLS

FIGURE 3-8

Leeds, Hill and Jewett, Inc. April 1981

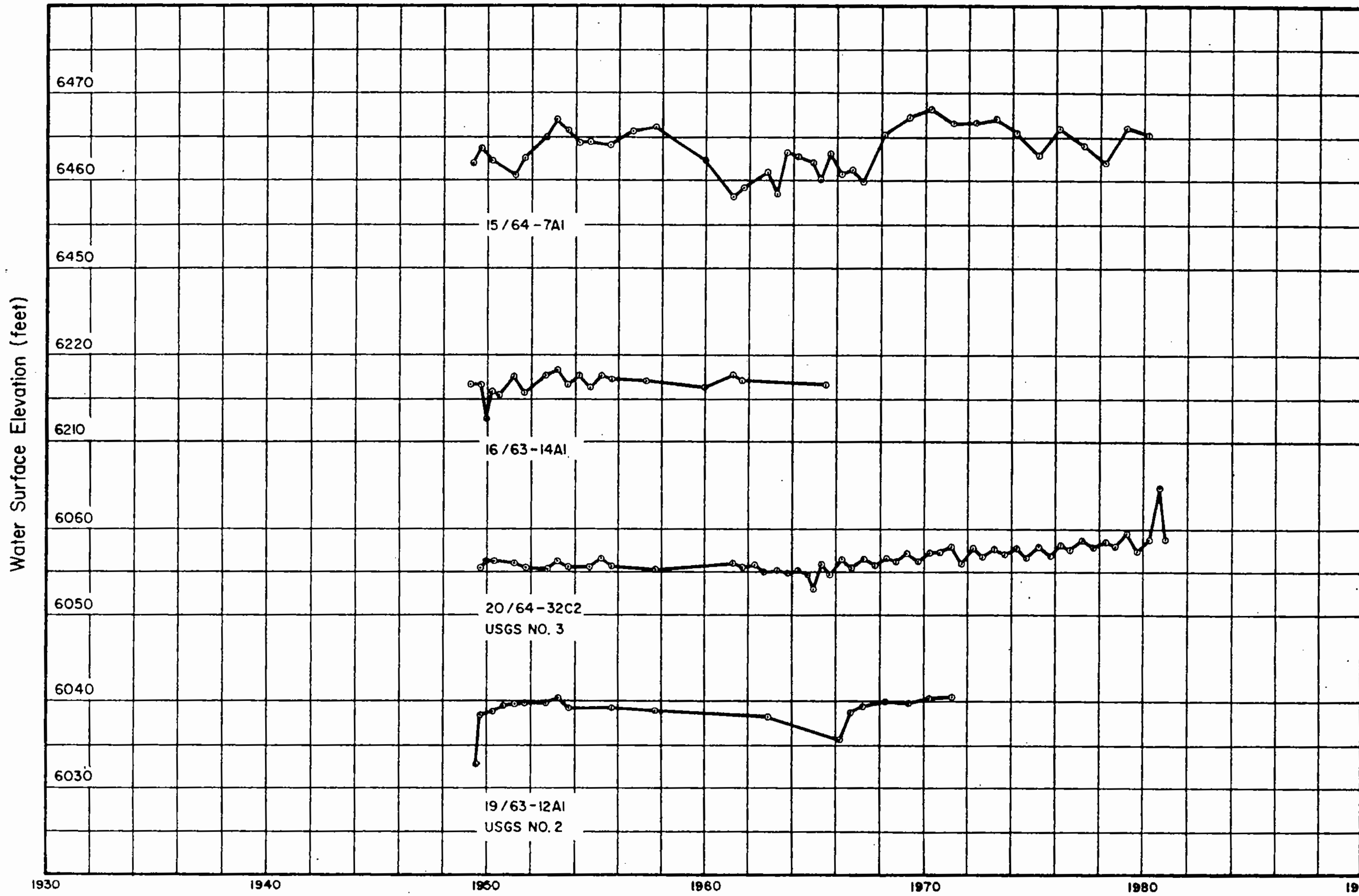


Leeds, Hill and Jewett, Inc. April 1981

WHITE PINE POWER PROJECT

SPRING VALLEY WELLS

FIGURE 3-9

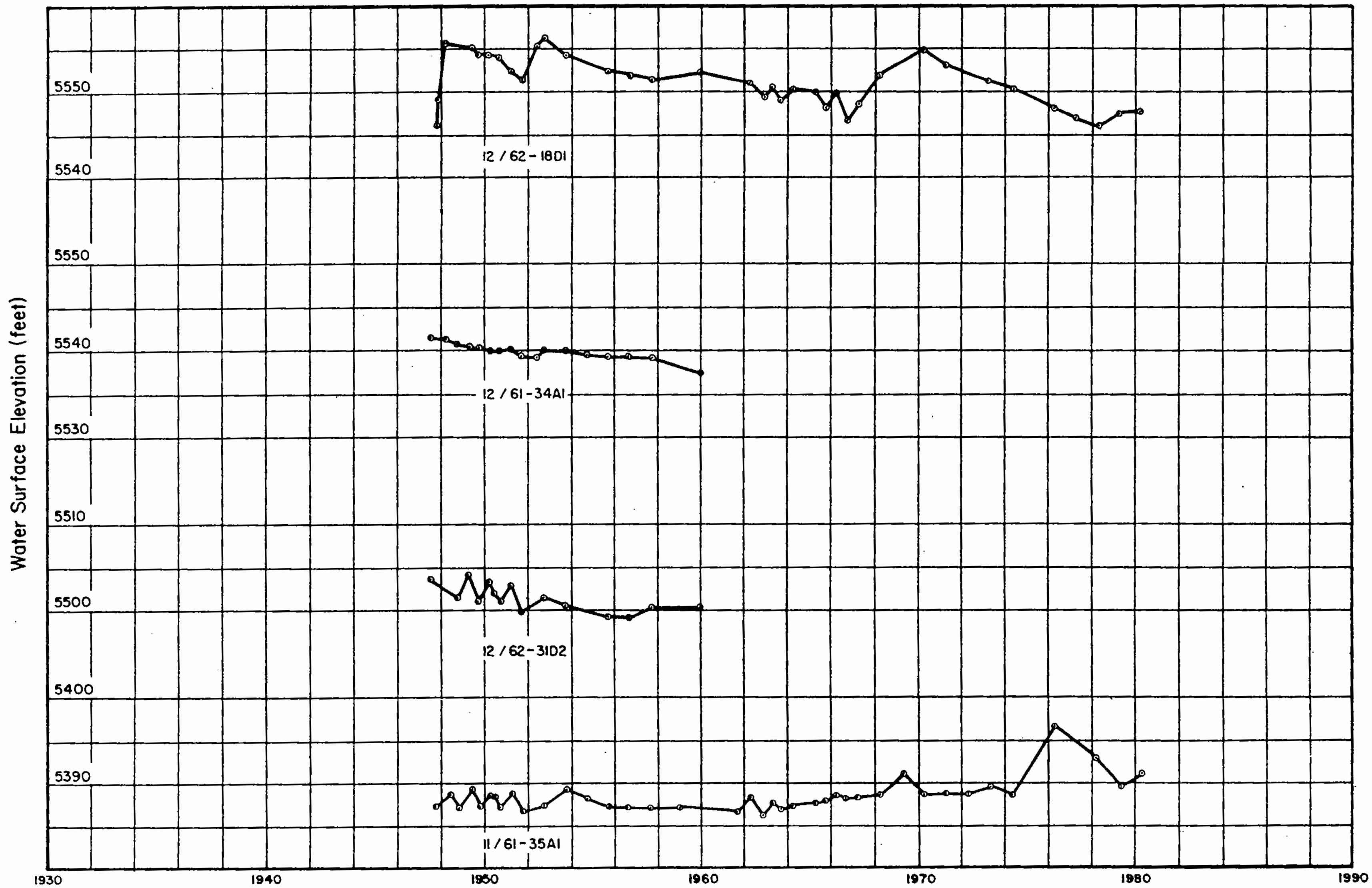


Leeds, Hill and Jewett, Inc. April 1981

WHITE PINE POWER PROJECT

STEPTOE VALLEY WELLS

FIGURE 3-10



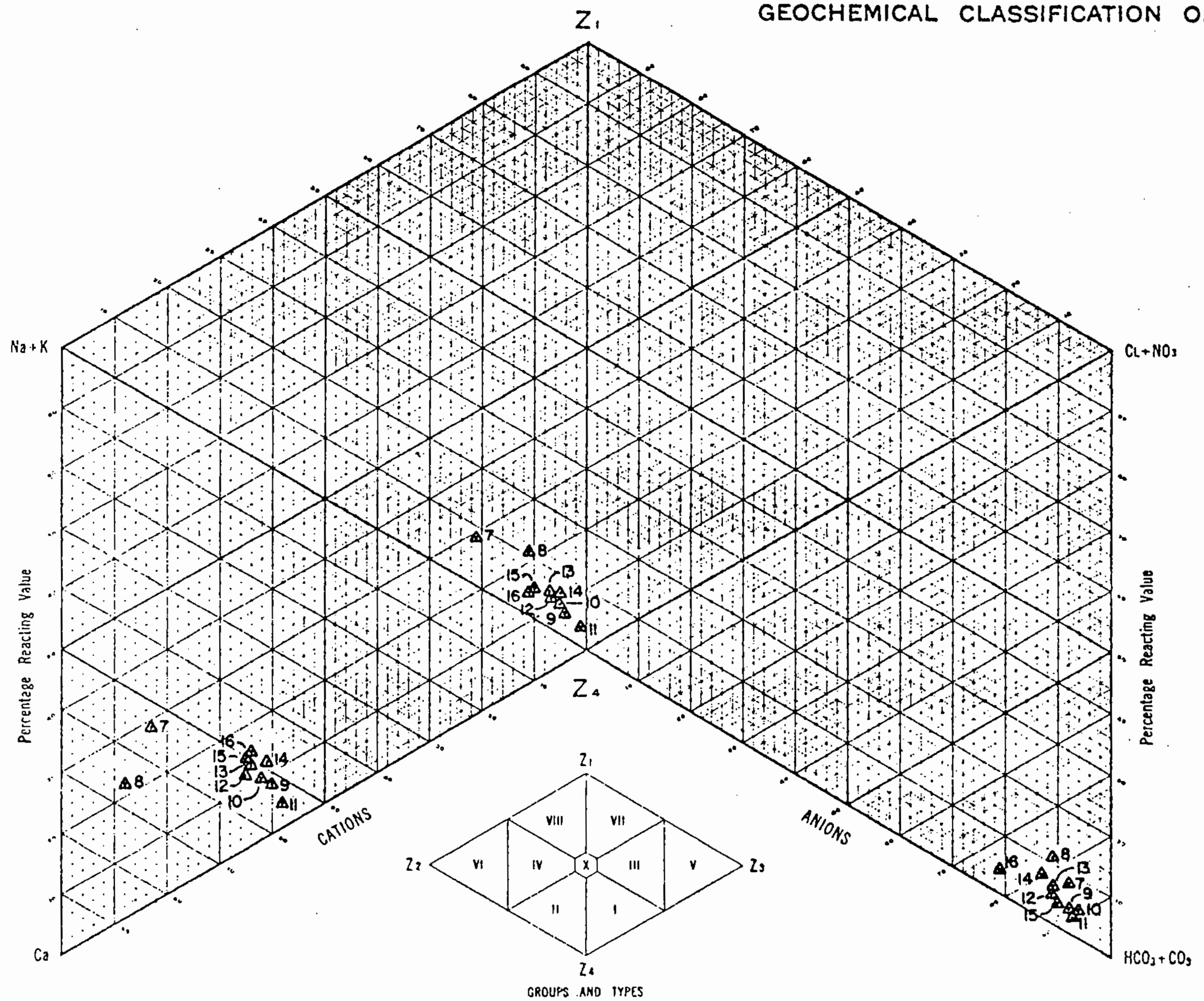
Leeds, Hill and Jewett, Inc. April 1981

WHITE PINE POWER PROJECT

WHITE RIVER VALLEY WELLS

FIGURE 3-11

GEOCHEMICAL CLASSIFICATION OF WATERS

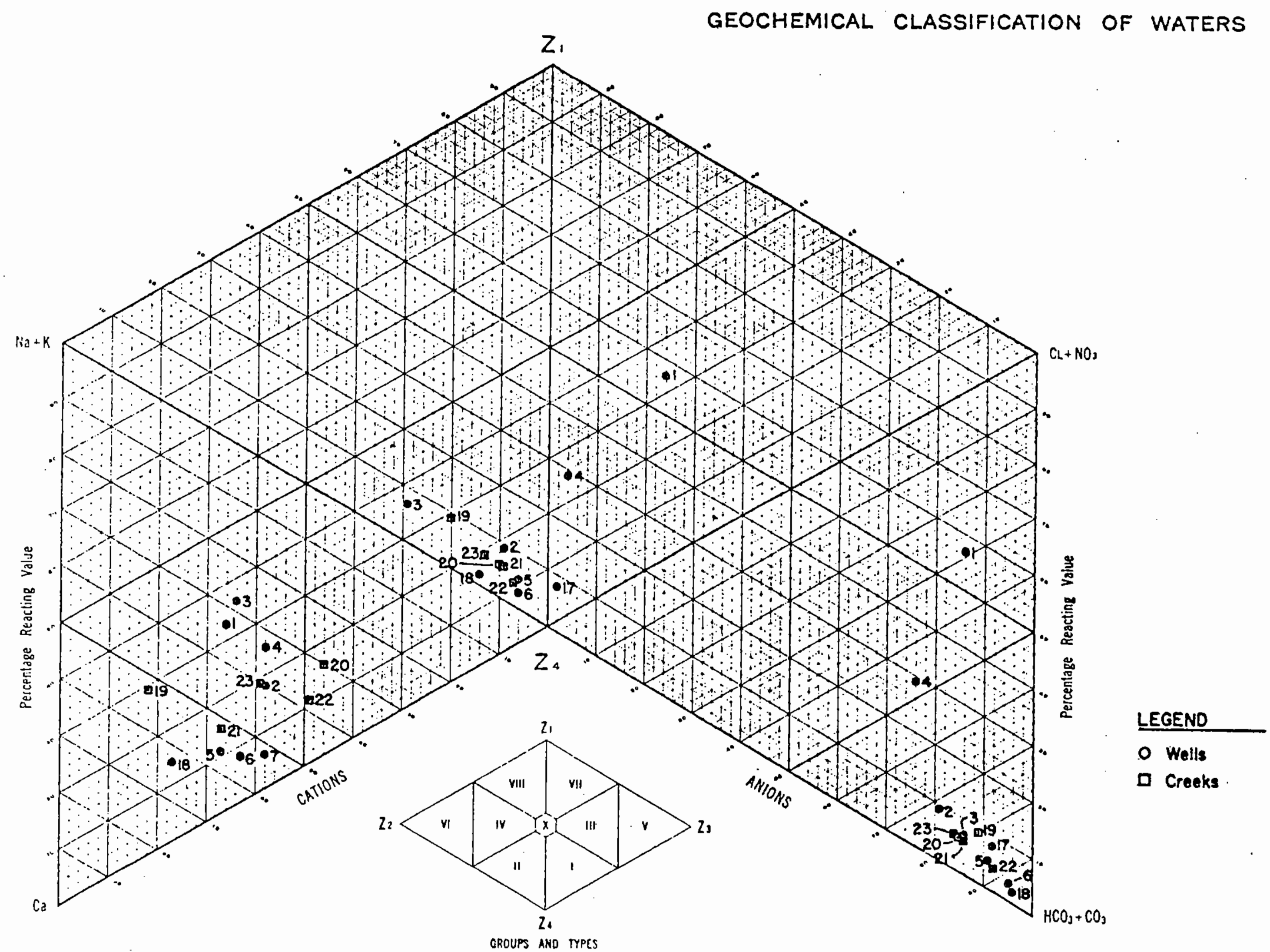


Leeds, Hill and Jewett, Inc. April 1981

WHITE PINE POWER PROJECT

BUTTE VALLEY
SPRING WATER ANALYSES

FIGURE 3-12



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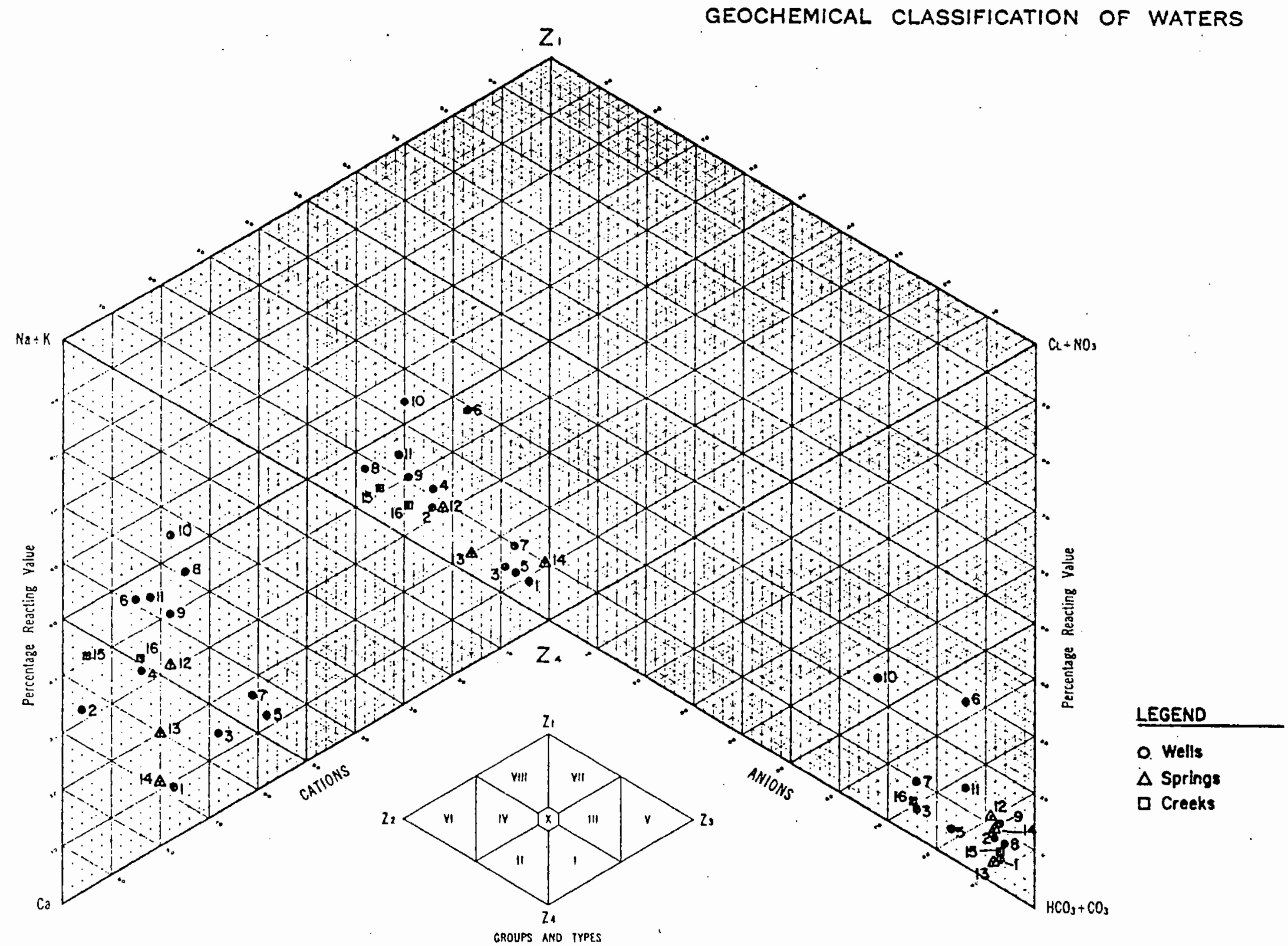
WHITE PINE POWER PROJECT

BUTTE VALLEY
CREEK AND WELL
WATER ANALYSES

FIGURE 3-13



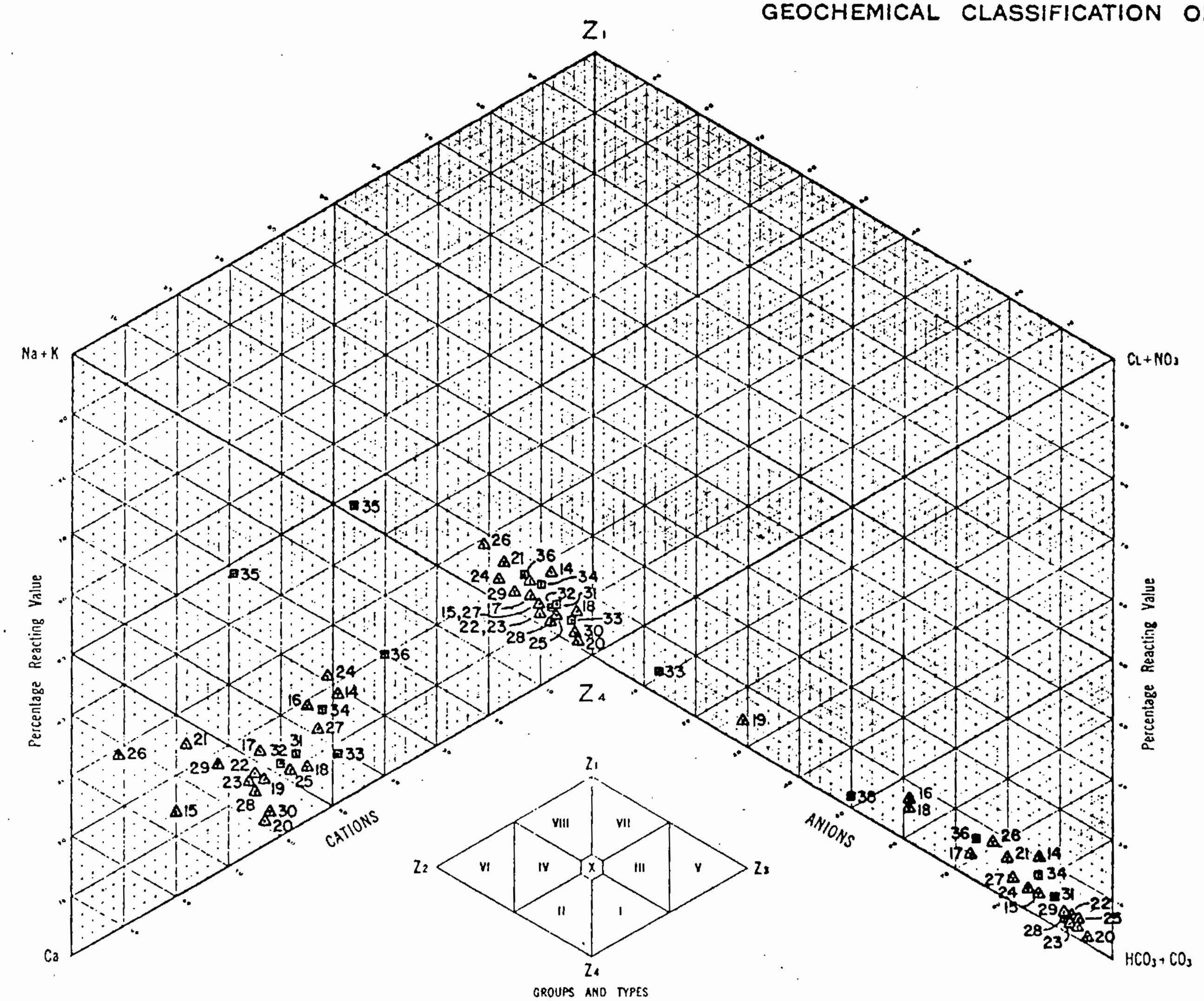
WHITE PINE POWER PROJECT

SPRING VALLEY
WATER QUALITY ANALYSES

FIGURE 3-14

Leeds, Hill and Jewett, Inc. April 1981

GEOCHEMICAL CLASSIFICATION OF WATERS



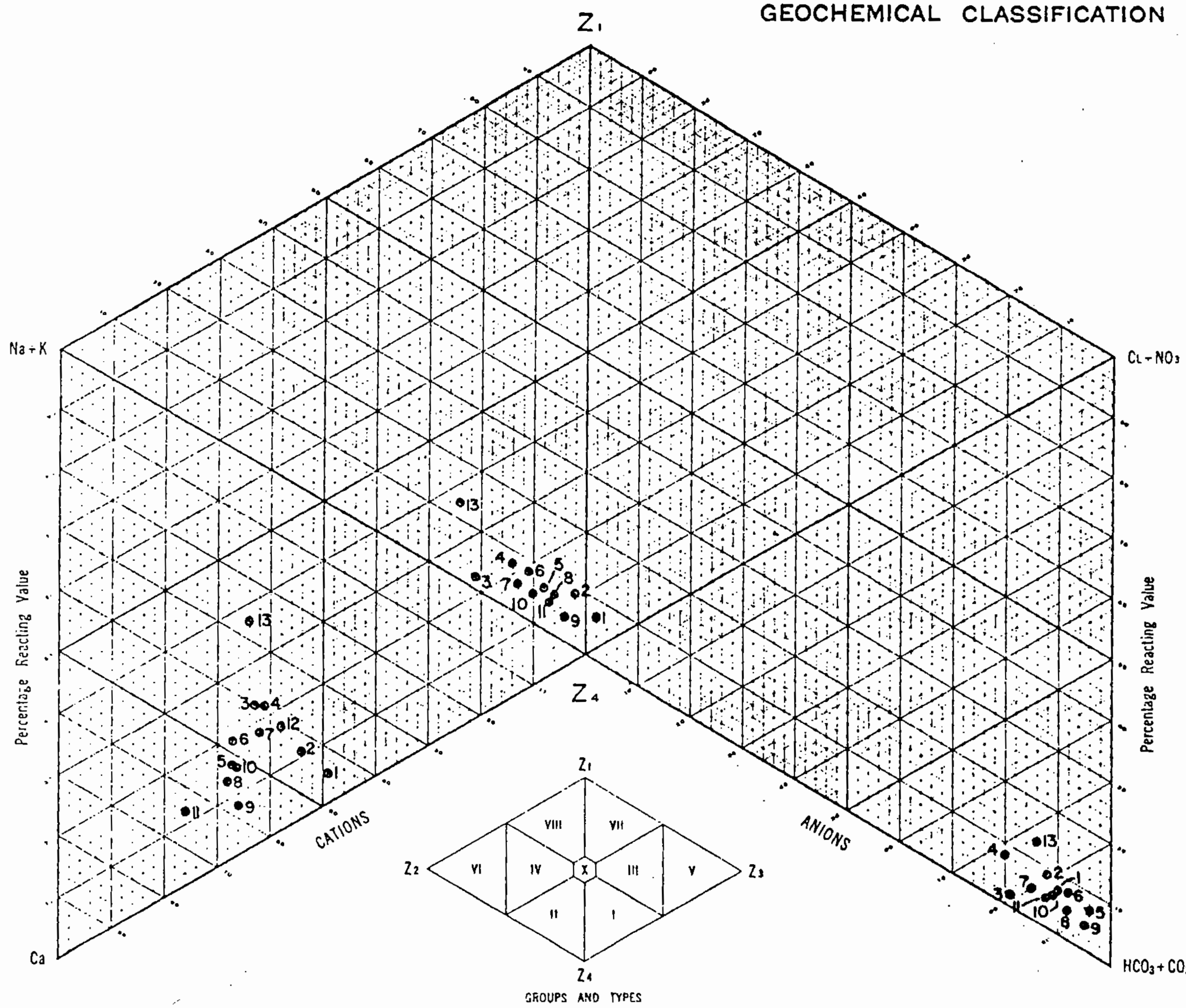
WHITE PINE POWER PROJECT

STEPTOE VALLEY
CREEK AND SPRING
WATER ANALYSES

FIGURE 3-15

Leeds, Hill and Jewett, Inc. April 1981

GEOCHEMICAL CLASSIFICATION OF WATERS



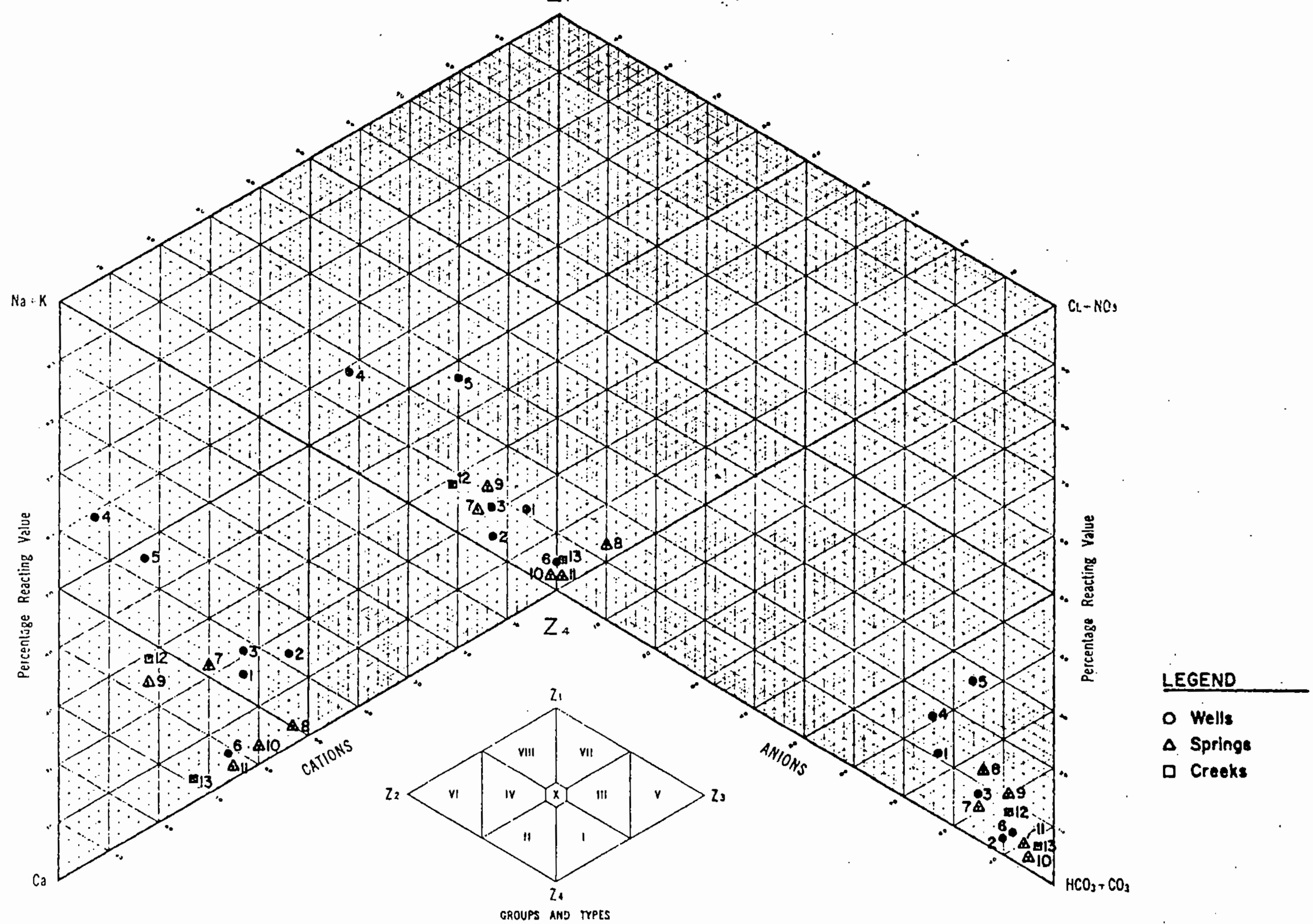
WHITE PINE POWER PROJECT

STEPTOE VALLEY
WELL WATER ANALYSES

FIGURE 3-16

Leeds, Hill and Jewett, Inc. April 1981

GEOCHEMICAL CLASSIFICATION OF WATERS

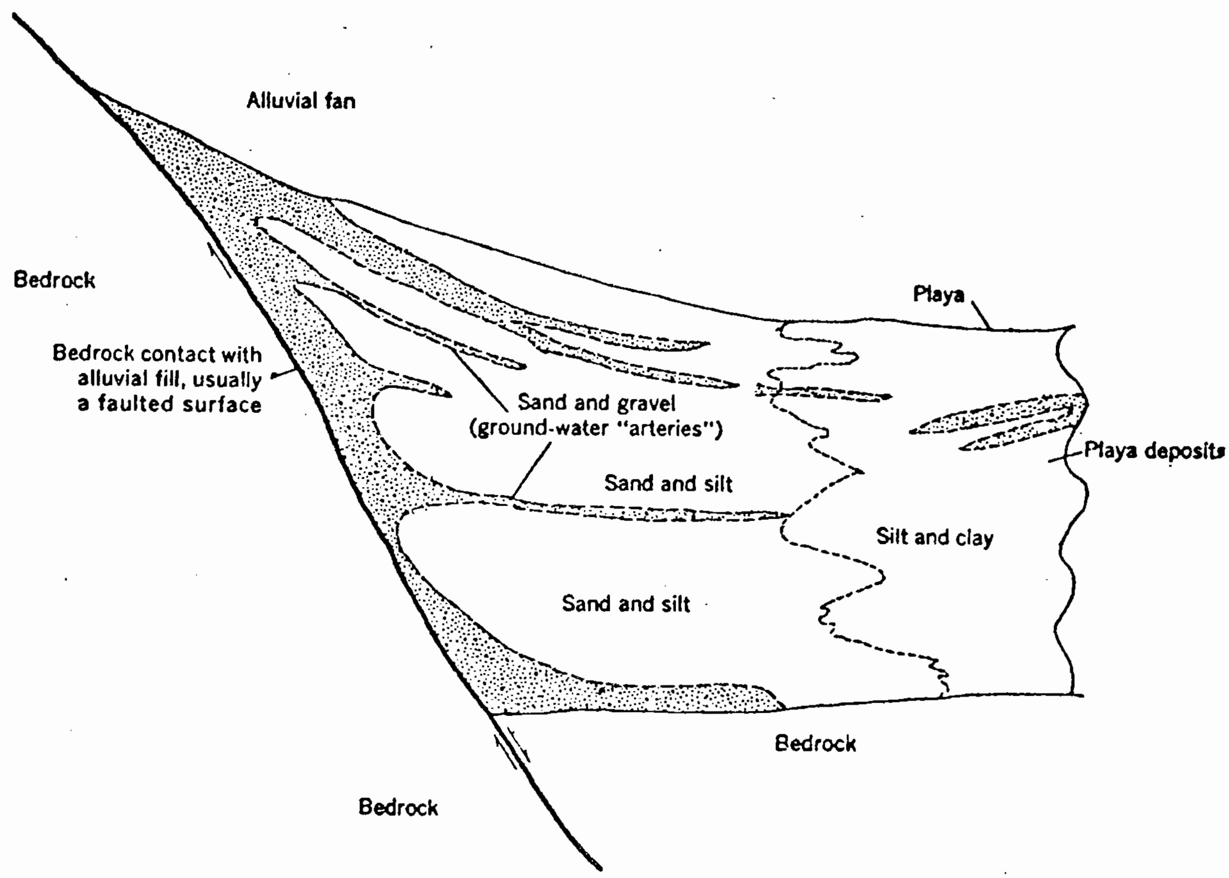


WHITE PINE POWER PROJECT

WHITE RIVER
WATER QUALITY ANALYSES

FIGURE 3-17

Leeds, Hill and Jewett, Inc. April 1981

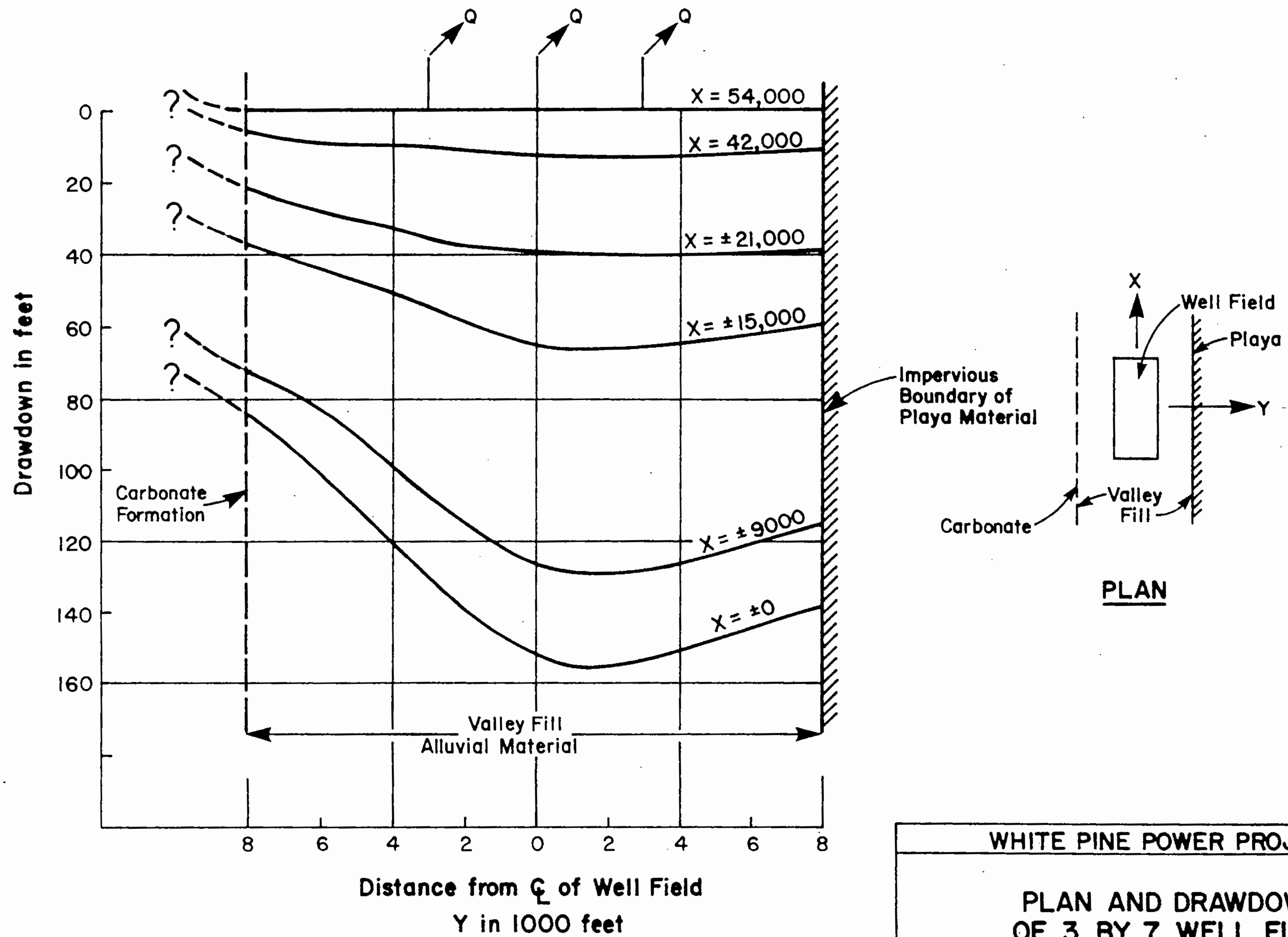


WHITE PINE POWER PROJECT

IDEALIZED ALLUVIAL VALLEY

Leeds, Hill and Jewett, Inc. April 1981

FIGURE 3-18



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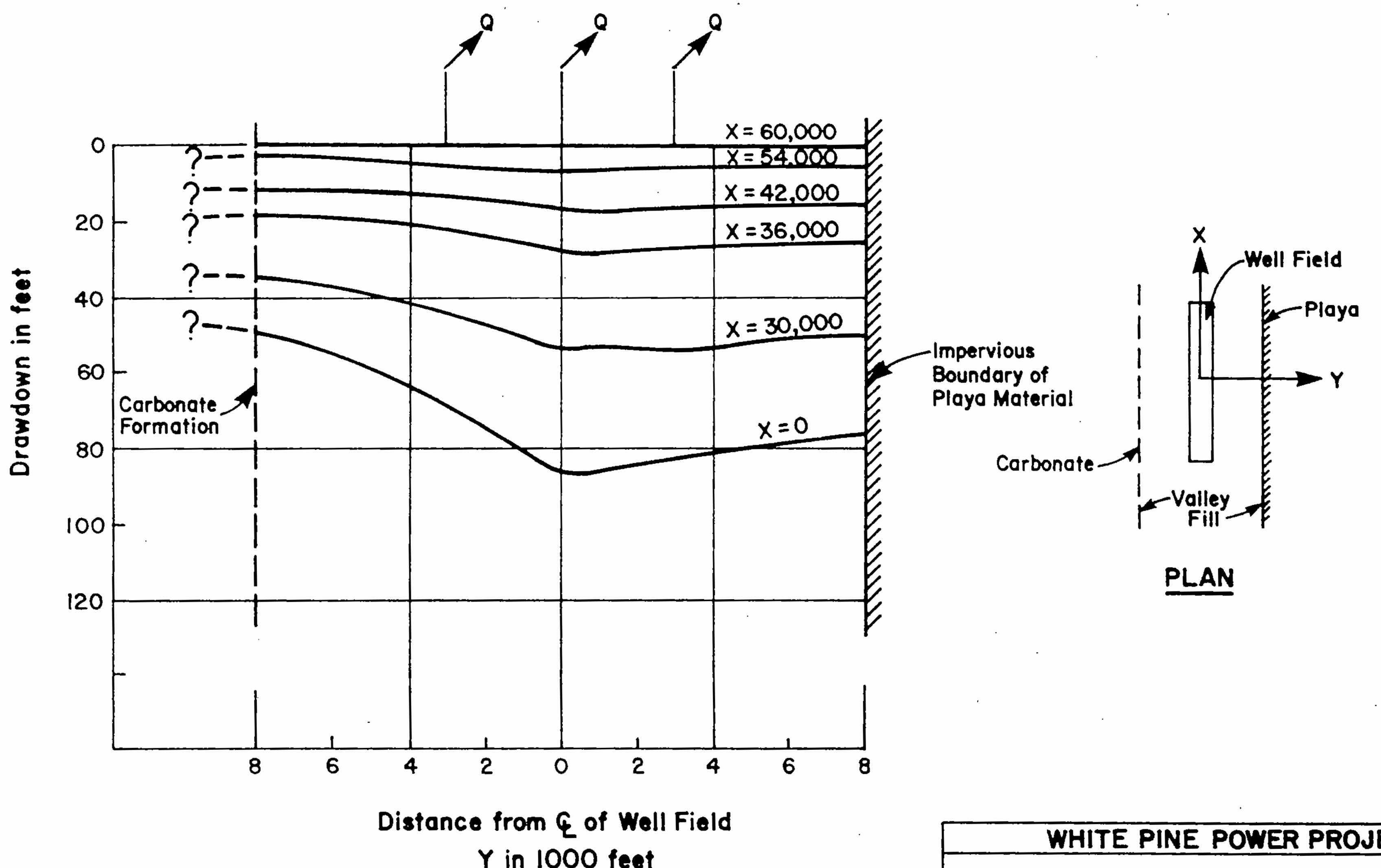
WHITE PINE POWER PROJECT

PLAN AND DRAWDOWN
OF 3 BY 7 WELL FIELD
IN VALLEY FILL ALLUVIAL MATERIAL

FIGURE 7-1



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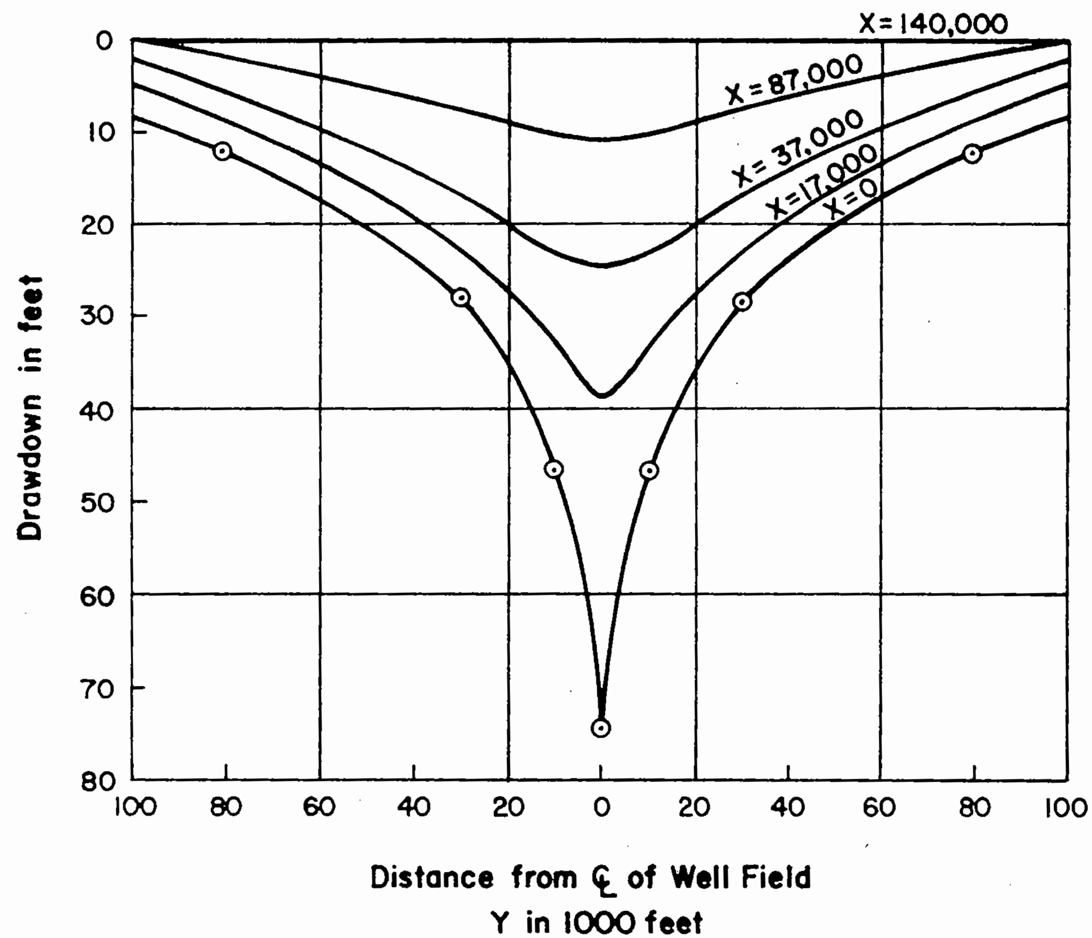
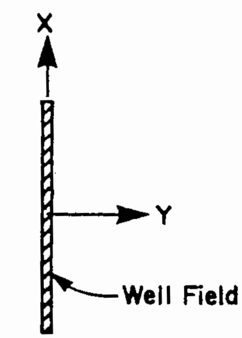
WHITE PINE POWER PROJECT

PLAN AND DRAWDOWN OF 3 BY 21 WELL FIELD IN VALLEY FILL ALLUVIAL MATERIAL

FIGURE 7-2





PLAN

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WHITE PINE POWER PROJECT

PLAN AND DRAWDOWN
OF 1 BY 15 WELL FIELD
IN CARBONATE FORMATION

FIGURE 7-3

APPENDIX A

List of Abbreviations

afy	acre-feet per year
BLM	Bureau of Land Management
cfs	cubic feet per second
^{o}F	degrees Fahrenheit
DRI	Desert Research Institute
DWR	Division of Water Resources
FAO	Food and Agricultural Organization
gpd/ft	gallons per day per foot
gpm	gallons per minute
gpm/ft	gallons per minute per foot
hp	horsepower
LADWP	Department of Water and Power of the City of Los Angeles
mg/l	milligrams per liter
msl	mean sea level
NAWDEX	National Water Data Exchange Files
NBMG	Nevada Bureau of Mines and Geology
NDCNR	Nevada Department of Conservation and Natural Resources
ppm	parts per million
SCS	U.S. Soil Conservation Service
sq. mi.	square miles
TDS	Total Dissolved Solids
USGS	U.S. Geological Survey
WPPP	White Pine Power Project
WRB	Water Resource Bulletin
WSP	Water Supply Paper