White Pine Power Project

GROUNDWATER INVESTIGATION
PHASE 2

TECHNICAL REPORT

EXHIBIT #8
FOR:
☐ STATE OF NEVADA
☐ PROTESTANT
☑ APPLICANT
☐ ____________ OTHER
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GROUNDWATER INVESTIGATION

PHASE 2

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 commerical operation in mid-1989.

A water supply of 25,000 acre-feet per year is required by the WPPP for cooling purposes. The purpose of this report is to describe Phase 2 studies of surface and groundwater resources in White Pine County. These studies were conducted to identify potential well fields which can provide such a supply.

The Phase 1 investigation relied on data and information developed by others. The Phase 2 investigation verified and refined Phase 1 findings through geophysical investigations and field testing of existing wells. These verified findings were then used to develop specific water supply plans for each of the eight power plant sites selected in the WPPP Site Recommendation Report dated May 1, 1981.

Summary of Data Collection

Considerable information has been collected from numerous sources. Thess data consist of additional water well records, oil well records, vegetative soil and irrigation data, material from Kennecott Copper Corporation and additional masters and doctoral geology theses. Geophysical investigations were conducted in Steptoe, southern Jakes, and northern White River Valleys and pumping tests were also conducted on eight wells located in Spring, Steptoe, and White River Valleys.

Geophysical Investigation

Electrical resistivity investigations performed in southern Jakes and northern White River Valleys established a possible mechanism of subsurface flow from southern Jakes into northern White River Valley. The data seem to indicate that highly fractured zones in the Ely Limestone and Tertiary Volcanics provide the best aquifers.

Electrical self-potential measurements at Preston Big Spring indicate that the spring results from upwelling of ground-water from basement rock under artesian head. The approximate depth to this upwelling zone is 820 feet.

Similar measurements at Monte Neva Hot Spring indicate that it is formed by the upward percolation of thermal water along a fault plane or fracture zone. It is believed that this fault or fracture zone is situated at a depth of approximately 320 feet.

Perennial Yield

Review of estimates of recharge, discharge, and perennial yield in Diamond Valley indicate that withdrawals probably exceed recharge by a considerable margin. Diamond Valley has been closed to appropriation since 1964.

In Railroad Valley, estimated discharge exceeds recharge by a considerable margin but the valley may be able to provide a partial supply for a plant located in western White Pine County.

Well Fields

Twenty-three potential well fields were located in White Pine County. These well fields were then analyzed to determine long term pumping effects on existing groundwater levels. The magnitude and areal extent of well field drawdowns were calculated for each valley.

Based on an analysis of aquifer tests, wells located in Steptoe and White River Valleys appear to yield larger quantities of water with smaller drawdowns, than comparable wells located in Spring Valley. Favorable well locations appear to be in the alluvial fan materials located along the valley periphery, and away from the finer sediments located in the playa areas. Where a playa does not exist in the center of the valley, wells can be located lower on the fan to intercept more of the valley groundwater flow.

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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 acre-feet per year (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 data. Accordingly, the WPPP, through the Los Angeles Department of Water and Power (LADWP), has entered into an agreement with Leeds, Hill and Jewett, Inc. (LEEDSHILL) to undertake certain groundwater related studies to assist in determining a specific water source.

1.1.2 Authority

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

Under this Agreement, LEEDSHILL and its subcontractors, Environmental Dynamics Inc. and Harding-Lawson Associates, are to undertake specific 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 phase of the work was completed in April 1981 and this report completes the second phase.

1.1.3 Scope

The general purpose of Phase 2 is to verify and refine Phase 1 findings through geophysical investigations and testing of existing wells. Specific tasks required for Phase 2 are listed as follows:

a. Identify well fields, capacities, spacings and drawdowns to supply water to each of the eight sites identified in the Site Recommendation Report dated May 1, 1981.

b. Conduct electrical resistivity surveys in Jakes and White River Valleys (Harding-Lawson Associates).

c. Conduct self-potential surveys at two thermal springs located in Steptoe and White River Valleys (Harding-Lawson Associates).

d. Analyze well logs and geology reports.

e. Conduct pump tests.

f. Refine estimates of perennial yield for Spring, Steptoe, Butte, Newark, Jakes and White River Valleys -- check yields of Railroad and Diamond Valleys.

g. Investigate alternative measures of mitigation and provide exclusion area data.

h. Provide assistance to Siting Study (completed April 10, 1981).

i. Prepare progress reports and Phase 2 report.

j. Meet with Department Representatives.

1.2 DESCRIPTION OF STUDY AREA

During the Phase 1 work the study area consisted of seven valleys in White Pine County and is described in Section 1.2 of the Phase 1 Report. As a result of the Phase 1 work it was determined that two additional valleys, Diamond and Railroad should also be considered as possible water supplies for a plant located in Newark Valley. The locations of these valleys are shown on Plate I.

Diamond Valley has an area of approximately 700 square miles, of which 94 percent is located in Eureka County and six percent is in Elko County. The major community in Diamond Valley is Eureka which is located in the southern part of the valley.

Railroad Valley can be subdivided into a northern and southern portion. The northern portion is 2149 square miles in size, of which 18 percent is in White Pine County and 82 percent is in Nye County. The southern portion of the valley is 603 square miles in size, all of which is located in Nye County. The Duckwater Indian Reservation and the town of Currant are the larger settlements in northern Railroad Valley.

The geographic and geologic settings of these valleys are similar to those in White Pine County, which were described in the Phase 1 report.[88]

2.0 COLLECTION OF DATA

2.1 GENERAL

Since completion of the Phase 1 work in April, considerable additional data and information has been collected. This information consists of: additional water well records; oil well records; vegetative soil and irrigation data for Diamond and Railroad Valleys; material from Kennecott Copper Corporation files; and additional masters and doctoral geology theses.

2.2 WATER WELL AND PUMP TEST RECORDS

Additional well logs were obtained from Nevada Department of Conservation and Natural Resources Office (NDCNR, State Engineers Office) in Carson City and from various federal and local agency offices in Ely.[88] At the NDCNR, approximately 250 logs of wells drilled in the townships and ranges near or adjacent to the proposed well field sites were obtained. These well logs were then reviewed for water level and pumping discharge information, as well as an indication of the nature of the geologic material encountered during drilling.[122]

Some well log data and other hydrological information was obtained through publications by Ertec Western, Inc. (FUGRO), who is working on the MX deployment area selection for the Department of the Air Force.(49)

Well records available at the Ely District Office of the Bureau of Land Management were also researched to determine well depths, construction details, depth to water measurements, and pumping test data. Approximately 100 such well records were obtained from this source and reviewed.

Results from approximately 50 pump tests of wells generally located in Spring, Steptoe, and White River Valleys were obtained from the Cooperative Agricultural Service in Ely. Although these pump tests were not time-drawdown or time-recovery tests, pumping drawdowns and discharges were measured, providing data to estimate aquifer specific capacity values. Estimates of specific capacity values were also developed from data on pumping tests conducted by Mt. Wheeler Power, Inc. These estimates were reported in LEEDSHILL's Phase 1 Report.(88) All specific capacity estimates were then used to estimate and verify transmissivity values developed by LEEDSHILL from field pump test investigations (see CHAPTER 4.0 - EVALUATION OF AQUIFER CHARACTERISTICS).

Valuable information concerning depth to water, geologic formations and well yields were also gathered through interviews with local water well drillers. In a similar manner, discussions with the City and County Clerks also provided additional insight into existing groundwater conditions.

2.3 OIL WELL RECORDS

Over the years approximately 54 oil or gas wells have been drilled in White Pine County. The majority of these wells are located in either Jakes or White River Valleys. Available information concerning these wells was obtained through the files of the Nevada Bureau of Mines and Geology (NBMG) located at the University of Reno. Typical data available in the NBMG files are lithologic and other geophysical well logs, plugging data, drill cuttings and other miscellaneous hydrologic and geologic information such as water quality analyses or water level indications.[62,63,110,111,141]

Oil and gas well information was also obtained from the USGS field office located in Ely. This office oversees drilling operations and supervises plug placement on all oil and gas wells drilled on federal land in Nevada.

2.4 NATIVE VEGETATION, SOIL AND IRRIGATION DATA

To supplement data previously collected by LEEDSHILL, additional data regarding native vegetation and irrigated acreages were obtained from the NDCNR, for Diamond and Railroad Valleys, located in Eureka and Nye Counties, respectively. Also, soil maps were obtained from U.S. Soil Conservation Service (SCS) for Railroad Valley (1971) and for Diamond Valley (1980).[2,115,189]

2.5 DATA FROM KENNECOTT COPPER CORPORATION

Reports concerning the water distribution and water supply systems of the Kennecott Cooper Corporation, Nevada Mines Division in McGill, were obtained through LADWP representatives. Among other things, these reports and memos contained: average flows in Duck Creek for a nine year period between 1957 and 1965; daily flows recorded intermittently between 1961 and 1976; three driller's well logs from wells constructed in the Duck Creek drainage area; and other miscellaneous water distribution data.[81]

2.6 GEOLOGIC DATA

In addition to the numerous geologic references obtained during LEEDSHILL's Phase 1 study, more than twenty additional theses, doctoral studies, and other references describing the geologic structure and stratigraphy of the study area were obtained. Several of the theses and doctoral investigations concerned geological interpretations and cross sections.

3.0 GEOLOGIC ANALYSIS

3.1 METHODOLOGY

Phase 2 geologic studies consisted of analyses of water well and oil well logs, and review of reports received subsequent to the Phase 1 studies. The results of the analyses of well logs are discussed below. The review of recently received geologic literature revealed a number of geologic studies concerned with localized features, but few studies in areas of specific interest to the White Pine Power Project.

All available logs of water wells in the county were collected from NDCNR, including logs of borings drilled for the MX siting investigation by Ertec Western, Inc. (Fugro).[122] Several of these logs were selected for analysis based on well location, depth, and the quality of logging. In most areas, few water wells have been drilled deeper than 200 feet, thus the useful data are limited to that upper interval. Most of the logs were prepared by well drillers and are usually very brief, simple descriptions, therefore it was not possible to correlate alluvial strata from one well to the next. A comparison was made of the relative amounts of coarse and fine grained sediments in each 100 foot interval of the wells. A map showing contours of constant percent, by volume of coarse sediments (sands and gravels) in Spring and Steptoe Valleys is presented on Plate 2. The wells were further categorized as to their location in either the alluvial fan areas or in the center of the valleys, so as to compare the relative coarseness of sediments in the two depositional environments.

3.2 ANALYSIS OF WATER WELL LOGS

3.2.1 Butte Valley

Although several other stock watering wells exist in Butte Valley, logs of only three wells were available for analysis. Two of these wells are located on the periphery of the valley, and the third is located on the valley floor. The two wells at the edge of the valley penetrated predominately coarse grained sediments, while the one on the valley floor was drilled through sediments that were mainly fine grained. In the latter well, a 69 foot thick stratum of clay was penetrated below a depth of 16 feet, before a 20 foot thick water bearing gravel formation was encountered. It is difficult to say whether the 69 foot thick clay layer represents ancient lake deposits, however it does appear that some relict shorelines are present in portions of southern Butte Valley.

3.2.2 Jakes Valley

Except for a few stock and domestic wells located at the mouth of Illipah Canyon on the west side of the valley, no other wells have been drilled in Jakes Valley. At the mouth of Illipah Canyon, alluvium is predominantly coarse grained and most of the wells are perforated at a depth of about 200 feet. One shallow well produces water from porphyry, a rock of volcanic origin. It is possible that Illipah Creek has produced a sizeable alluvial fan extending from the mouth of the canyon far out into the valley, although this is not readily evident from the present-day topography. There are no records of any other wells on the valley floor of Jakes Valley, although field investigation indicates that no fine grained playa sediments occur on the surface of the valley floor.

3.2.3 Long Valley

There are sufficient logs of wells in Long Valley to illustrate that the sediments underlying the central valley floor are generally finer grained than those penetrated by wells around the periphery of the valley floor. Most of the wells are perforated in sands and gravels below a depth of 200 feet. One well located near the western edge of the valley produces from a fractured limestone aquifer below 480 feet. A 12 foot void and 50 foot fracture zone were indicated on the log of this well, suggesting extensive solution action in the limestone. Such extensive solution cavities and fracture zones may be indications of either a regional distribution system, or a very localized drainageway. However, more geologic information is necessary before a conclusion can be made.

3.2.4 Newark Valley

Considering its large size, Newark Valley has few wells, and most of these are located in the southwestern arm of the valley that extends from Fish Creek Valley. Although some of the wells produce from zones as shallow as 50 feet, most of the larger capacity irrigation wells are perforated between about 100 and 250 feet. The well logs indicate that most of the sediments are coarse sands and gravels, at least in the southwestern arm of the valley. No wells are located in the large playa area located in the north central portion of the valley.

3.2.5 Spring Valley

Wells in Spring Valley are concentrated around the periphery of the valley, particularly along the east side of the valley south of Highway 6 and along the west side of the valley north of Highway 6. The wells range in depth up to a maximum of 800 feet but are generally less than 400 feet in depth.

It is reported in the literature that there are Pleistocene age lake deposits extending along almost the entire length of the valley to depths as great as 300 feet. It is also reported that good aquifers underlie the lake deposits. An analysis of well logs indicates that the sediments are generally coarsest near the the mountain front, becoming very fine toward the valley center (see Plate 2). This tends to confirm the presence of lake deposits, even though the deposits cannot be identified positively as lacustrine sediments on the basis of the well logs. There are very few wells along the center of the valley and these wells are not deep enough to verify the presence of an aquifer underlying the lake deposits.

There is no apparent pattern in perforated intervals in the wells, probably reflecting the laterally discontinuous nature of multiple pervious zones in the sediments. The well logs indicate both confined and unconfined aquifers, with wells in the former exhibiting artesian conditions. There are several flowing wells east of Baking Powder Flat in the southern part of the valley and at least one flowing well in the northern part of the valley near McCoy Ranch.

3.2.6 Steptoe Valley

Wells in Steptoe Valley are concentrated in three areas, namely, south of Ely to Comins Lake, between McGill and Monte Neva

Hot Springs, and in the northern most part of the valley near the Elko-White Pine County line. The distribution of the coarser grained sediments is illustrated on Plate 2.

In the area south of Ely to Comins Lake the valley is narrow, with numerous streams forming small alluvial fans on the floor of the valley. The coarseness of sediments encountered by wells appears to reflect the coalescing of these small fans. There is no evidence of either playa or ancient lake deposits in the southern part of Steptoe Valley.

The area located between McGill and Monte Neva is dominated by the extensive deposits of the Duck Creek alluvial fan which extends out into the valley from Gallagher Gap. As might be expected, the alluvium is coarsest near the apex of the fan, becoming progressively finer toward the axis of valley drainage. Analysis of well logs indicates that the upper 200 feet of sediments in the fan area consist of about 80 percent sand and gravel, as opposed to about 20 per cent of these coarser materials in wells located in the valley lowlands. There appears to be a slight decrease in the coarseness of sediments with depth in the Duck Creek fan. Moving north, the valley begins to narrow, and the alluvial fans from both the west and east sides of the valley coalesce. This fact is reflected by the existence of wells further down the alluvial fans, closer to the valley axis.

In the northern part of Steptoe Valley near the Elko-White Pine County line there are numerous wells within a 5 mile square area near the east side of the valley. Most of the wells are 200 to 400 feet deep, although a few are as deep as 900 feet. The logs indicate that the alluvium contains a high percentage of clay, but there are apparently sufficient strata of coarse sand and gravel to yield good quantities of water. The logs of two wells in this area indicate the presence of a peat layer at a depth of 450 feet, which would imply that the area was once a swamp, possibly along the shore of a lake. In this same general area, on the west side of the valley, one well penetrated more than 300 feet of what was described as pyroclastic sediments with streaks of sand and gravel. Pyroclastic sediments are derived from volcanic explosions or from a volcanic vent. It therefore appears that the fine grained lake bed deposits may be confined to the eastern side of the valley.

3.2.7 White River Valley

There is a high concentration of wells in a 6 mile square area just north of Lund. Most wells are 100 to 200 feet deep, but a few wells are 400 feet or more in depth. An analysis of the relative coarseness of the sediments penetrated by wells indicates wide variations within a small geographic area. Unlike most other valleys of White Pine County, there is no discernable trend in the

White River Valley of progressively finer grained sediments occurring toward the center of the valley floor. The probable reason for this is that the sediments have been reworked by the ancestral White River system. There was apparently no lake in White River Valley during the Pleistocene Age, but it is reported in the literature that older, Tertiary Age, lake deposits occur at depth.[99] Some of the deeper wells in the valley indicate that there is a thick sequence of clay deposits with occasional lenses of sand and gravel.

At least one well produces from bedrock limestone and three wells near the mountain front east of Lund penetrated what was described as a volcanic porphyry. Volcanic rocks are exposed at the surface in this area as well as along the western side of the valley.

3.3 ANALYSIS OF OIL AND GAS WELLS

Logs of oil and gas wells are useful in determining the depth of alluvium in the valleys and the sequence of bedrock underlying the valleys. The logs are of little use in furnishing information on the valley sediments or their water bearing characeristics, since the upper few hundred feet of the wells are seldom logged.

Only in the White River Valley were a sufficient number of oil well data available to give an indication of bedrock conditions. Logs of wells in this area indicate a thick sequence of 2000 feet or more of volcanic rock underlying the valley sediments in the area south of Lund, but no volcanics were encountered in wells north of there. The bedrock underlying the volcanics in the southern part of White River Valley and beneath the alluvium in the north consists of various Paleozoic age formations, suggesting a geologic structure as complex as that of the adjacent mountain ranges.

4.0 EVALUATION OF AQUIFER CHARACTERISTICS

4.1 GENERAL

During July of 1981, numerous pump tests of wells in Spring, Steptoe, and White River Valleys, were made in an effort to determine the transmissivity and specific yield characteristics of unconfined aquifers in White Pine County. The characteristic that is equivalent to specific yield for a confined aquifer is the storage coefficient and this term will be used when discussing data, analyses, etc., of confined aquifers.

In total, pump tests from nine wells were analyzed, and the location of these wells are shown on Plate III. Four wells were located in Steptoe Valley, three wells in Spring Valley and two wells in the White River Valley. Suitable test wells are not available in Butte, Jakes or Long Valleys, however a review of available well logs and other geologic information indicate that wells in these valleys would be similar to those that were tested. In Newark Valley, specific capacity data collected by Mt. Wheeler Power, Inc. were used in lieu of actual field testing to estimate aquifer characteristics. A summary of the aquifer characteristics estimated from the pump tests are presented in Table 4-1.

4.2 TESTING PROCEDURES

Several procedures and methods can be used in the evaluation of aquifer characteristics. Properly planned and carefully conducted aquifer tests will reveal important characteristics about the groundwater reservoir which cannot be determined by other means. The information determined from the pump tests provided data on transmissive and storage characteristics of the aquifer. This information, along with well log data and other geologic data, provides a general understanding of the hydrologic groundwater regime of White Pine County.

4.2.1 Constant Rate Aquifer Drawdown Test

One of the most common testing methods used in the determination of aquifer characteristics is the constant rate aquifer drawdown test. This test consists of pumping one well over a period of time, with water level data observed in the pumping well, and other nearby observation wells, if available. During this test, it is critical that a constant pumping (or discharge) rate be maintained. Depth-to-water (DTW) measurements for the pumping well and the observation wells must be measured many times during the test. Measurements are taken at close intervals during the first part of the test when drawdowns are rapid, with time intervals gradually increasing as the test continues and rate of drawdown decrease.

4.2.2 Recovery Test

Upon completion of a constant rate aquifer drawdown test, an aquifer recovery test can be used to determine independent transmissive and storage characteristics. The recovery test begins immediately following the constant rate drawdown test and involves measurement of increasing water levels in the pumping and observation wells for a period of time after the pump is turned off. Data from the recovery test is especially important in the pumping well because well loss characteristics are not present during recovery, and a better indication of transmissivity and specific yield, or storage coefficient, can be obtained.

4.3 METHOD OF TEST DATA EVALUATION

4.3.1 General

The evaluation of pump test data commences in the field by plotting the data on semi-log graph paper while the test is being conducted. In this way knowledge is gained of the potential boundary conditions within the area and if some mechanical or other failure has occurred while drawdown or recovery is occurring, the test can be stopped and re-run if necessary.

Various methods can be used in evaluating the test data. Two methods that are commonly used are the Theis Method and the Cooper-Jacob Method. Each of these aquifer test-analysis methods will be briefly described in the following sections.

4.3.2 Theis Method - Type Curve

The Theis formula developed in 1935, was the first to consider the effect of pumping time on well yields. This development was a major advance in the field of groundwater hydraulics, and allows the prediction of drawdowns at any time after pumping begins.

Use of the Theis equation to determine the coefficients of transmissivity and specific yield, T and S, respectively, from a pumping test requires water level measurements in the pumping well and, if possible, at least one observation well. These measurements of water level data should be made as described earlier in this chapter. The values of T and S cannot be determined by direct calculation from the Theis equation but are determined by graphical curve matching methods (for a rigorous development of the theory and mathematics, see references 79 and 156). This method is reliable but somewhat difficult to use because of problems associated with identically matching the curves.

4.3.3 Cooper-Jacob Method (Modified Theis Equation)

It was noted by Cooper and Jacob that, for particular conditions, the Theis formula can be modified into a straight line equation. In this method, the drawdown or recovery, in feet, is plotted versus the logarithum of time, in minutes, after the pump is started, or stopped. A straight line is then drawn through the plotted data. The transmissive and storage characteristics of the aquifer can then be determined from the slope and location of this straight line.

In determining transmissive and storage characteristics of an aquifer from drawdown tests using the Cooper-Jacob method, care should be exercised in use of the data if boundary effects are indicated. Boundary effects, such as a fault or some other impervious boundary or a recharge condition such as a stream, will change the relationship between drawdown and time, as these effects are reflected back to the drawdown or recovery measurements in the well.

The time-drawdown and time-recovery measurements collected during the pumping and recovery periods, respectively, provide two distinct sets of data, and aquifer characteristics estimated from the recovery phase of the test can serve to check the estimates based on the drawdown data.

4.4 ANALYSIS OF AQUIFER PUMP TESTS

4.4.1 General

As previously mentioned, the most accurate and recommended method for determining aquifer coefficients involves the use of an observation well located near the pumping well. Ideally, the observation well should penetrate identical zones of the aquifer as the pumping well and be within 1000 feet of the pumping well.

When observation wells are not available, the aquifer transmissivity can be determined using drawdown and recovery measurements collected from only the pumping well. Values calculated in this manner are not as accurate as those determined using an observation well, however reasonable values can be obtained, especially in a recovery test.

It should be noted that the calculated aquifer characteristics determined from pump tests are localized values, which can vary considerably with location and proximity to either playa or recharge zones.

The aquifer pump test data collected during LEEDSHILL's field work were analyzed using the Cooper-Jacob Method. Either the constant drawdown or recovery forms of the method were used to determine values for transmissivity and storage coefficient. Of the eight wells tested, only one had a suitably located observation well. To estimate specific yields or storage coefficients it is necessary to have an observation well located near the test well to measure drawdown and recovery of the aquifer during operation of the test. Thus, estimates of aquifer storage characteristics were possible for only one of the test wells. For three of the test wells, both time-drawdown and time-recovery tests were run to confirm, by independent sets of data, the calculated values of transmissivity.

Comparative calculations were also conducted on three of the tested wells. These wells were analyzed using both the Theis and the Cooper-Jacob Methods. The results using these two methods are essentially the same and are presented on Table 4-2.

4.4.2 Spring Valley

Younger alluvial deposits of fine sand, silt, and clay appear to be the predominant formations encountered by wells drilled in the south Spring Valley area. The majority of irrigation wells are located along the eastern edge of the valley and typically range between 300 feet and 500 feet in depth, although a few wells exceeding 900 feet in depth also exist. Some well yields appear to vary with time, however the majority of irrigation wells appear to yield between 450 to 500 gpm.

To determine aquifer characteristics in the area, tests were conducted on three existing wells penetrating the valley fill deposits. These wells vary in depth from approximately 400 feet to 700 feet, and are located in both the playa and fan areas. The location of these test wells are shown on Plate III.

A constant rate aquifer test was run on a 700 foot well, roughly located along the axis of the valley in T15N/R67E-19. During this test, average discharges from this well were 525 gpm, and the calculated transmissivity was approximately 5550 gpd/ft. A graphical display of this time-drawdown curve is presented on Figure 4-1. Such a low transmissivity value is not unexpected in view of the location of this well, however it is surprising when compared to the driller's well log. On the well log, relatively thick layers of gravel were encountered between the interbedded layers of clay, leading one to expect fairly high yields. One possible explanation is the size of the well casing perforations. Apparently these perforations were large enough to allow sand, silt, and other fine grained materials to pass through, clogging both the well intake structure and the permeable gravel materials.

The second well test was performed on a well located along the eastern edge of the valley in T13N/R67E-15. This irrigation well was drilled to a depth of 387 feet, and a 487 foot abandoned irrigation well located approximately 22 feet away was used as the observation well. Drawdown measurements were made in the observation well as the pumping well discharged roughly 400 gpm. This data is presented on the time-drawdown curve illustrated in Figure 4-2. Measurements of the water level recovery in the observation well were also monitored. This time-recovery curve is presented on Figure 4-3. Calculated transmissivities varied between 11,100 gpd/ft and 16,900 gpd/ft, and the storage coefficient values ranged from 0.0036 to 0.0003 in the drawdown and recovery cases, respectively.

The relatively small storage coefficient values are typical of semi-confined or confined aquifers (79). A review of the well driller's log for this well also indicates the presence of silt and clay zones throughout the well, confirming the low storage coefficient. Observations made during the field investigations also indicate the presence of artesian wells in the area. Again indicating the presence of fine-grained confining layers. For short pumping periods, the flow system of a small confined aquifer will respond to pumping with the characteristics of an artesian system. However, over the long term, aquifer materials will slowly drain in response to pumping, and the storage coefficient will be nearly equal to the specific yield.(69)

Aquifer characteristics in a 370 foot deep well located along the eastern edge of the playa deposits in T12N/R67E-24, were evaluated using data collected during an aquifer recovery test. This time-recovery curve is shown on Figure 4-4, and the calculated transmissivity is approximately 6800 gpd/ft. This relatively low transmissivity value is probably caused by the well's proximity to the finer grained deposits of the playa area. Several fine sand and clay layers are called out in the driller's log for this well. A storage coefficient could not be calculated from this test because no suitable observation wells are located in the vicinity.

As part of the geologic and hydrologic data gathered for the MX Project, Ertec Western, Inc. has conducted an aquifer recovery test on a well located in T12N/R67E-13. The calculated transmissivity for this well was 3400 gpd/ft.[49]

Based upon data gathered during these aquifer field tests, and a review of other geologic logs in the area, well sites located on the fan deposits along either side of south Spring Valley appear to be preferable to sites located in the playa areas along the axis of the valley. Unfortunately, no well tests were possible in this area. However, it is anticipated that wells drilled into these fan deposits will be several hundred feet deep, and capable of producing 400 to 500 gpm. Transmissivity values in the fan areas of the proposed well field sites are estimated to be greater than 20,000 gpd/ft, and probably closer to 30,000 gpd/ft. Storage coefficient values in the unconfined fan areas will be much larger than the values calculated from the confined or semi-confined aquifer test well. It is anticipated that in the unconfined sand and gravel aquifers, typical specific yield values will be approximately ten percent. Table 4-3 summarizes these findings.

4.4.3 Steptoe Valley

A large part of Steptoe Valley is occupied by alluvial fans, which form conspicuous topographic features on both sides of the valley. The largest fans, formed by Duck Creek, extends across the middle of the valley, and, generally speaking, the smaller creek fans tend to merge or coalesce near the axis of the valley. Playa areas do occur in northern Steptoe Valley near the county line, as well as in other areas. However, field observations indicate that existing irrigation wells tend to be farther down the fans, and closer to the valley axis. This indicates a significant difference from the situation encountered in south Spring Valley, where very tight sediments are located over a fairly wide area in the center of the valley.

Many high producing irrigation wells are located in the area north of Ely and west of McGill. These wells are typically 125 to 250 feet deep and are capable of producing over 2000 gpm with little drawdown. As one moves in a northerly direction from McGill, well yields tend to decrease, and total well depths and drawdowns increase. Well depths generally become 400 to 500 feet or deeper, and yields drop to 600 to 750 gpm. Also as previously mentioned, wells appear to be located closer to the axis of the valley than in Spring Valley. This implies that at least in these localized areas, extensive playa zones do not exist.

To determine transmissivity values for the valley-fill deposits, tests were conducted on these existing high capacity wells in the valley. These test wells varied in depth from 120 feet to almost 400 feet, and their locations are shown on Plate III.

Constant rate aquifer drawdown and recovery tests were conducted on a well located in T26N/R65E-27. This is a 400 foot deep well located near the White Pine - Elko County line. During the test, discharges averaged 1500 gpm. The time-drawdown and time-recovery curves from this test are presented in Figures 4-5 and 4-6, respectively. It is interesting to note that during both tests, apparent groundwater barriers were encountered. In the time-drawdown curve presented in Figure 4-5, the initial transmissivity value was 51,100 gpd/ft, but this value abruptly decreased to 9200 gpd/ft. It appears that the larger transmissivity value correlates to a relatively thin layer of coarse sand and gravel material which overlays the finer-grained playa deposits. This hypothesis is supported by data obtained during the time-recovery curve, shown on Figure 4-6. From this curve, the coarser alluvial material was calculated to have a transmissivity of 56,600 gpd/ft, with the transmissivity value of the the finer sediments being approximately 29,300 gpd/ft. Storage coefficients could not be calculated since a suitable observation well could not be located.

A test was performed on a second well located in the high production area north of Ely and southeast of McGill. This irrigation well is located in T18N/R63E-36, is only 102 feet deep, and is capable of producing 900 gpm with less than ten feet of drawdown. A constant rate aquifer discharge test was conducted on this well, and the data is presented in Figure 4-7. The calculated transmissivity was approximately 160,000 gpd/ft.

The third well that was tested is a 300 foot deep municipal supply well for the City of Ely located in T16N/R63E-16. This test was also a constant rate discharge test with a discharge of 1030 gpm. Recovery data was also measured from this well. These time-drawdown and time-recovery curves are illustrated on Figures 4-8 and 4-9, respectively. In both the drawdown and the recovery curves, similar groundwater recharge boundary conditions were encountered. In the time-drawdown case, the transmissivity increased from 6300 gpd/ft to 181,300 gpd/ft, and the increase was from 61,800 gpd/ft to 170,000 gpd/ft in the time-recovery case.

These large transmissivity values appear to correlate well with the 160,000 gpd/ft value calculated from the second well that was tested and located in T18N/R63E-36. A review of well logs in the area indicate the presence of large water bearing gravel layers. Therefore it is probable that some of these gravel layers are interconnected with the source of recharge, possibly Steptoe Creek or one of its tributaries.

An aquifer pump test was conducted by Ertec Western, Inc. on a well located in south Steptoe Valley, drilled entirely in the Ely Limestone. This well could only be cased to a depth of 950 feet, but it was actually drilled to a total depth of 2557 feet.[122] The well is located in T12N/R63E-12ba, and the time-drawdown curve for this test is presented on Figure 4-10. From this Figure, it can be seen that a recharge boundary was encountered in this well, as the transmissivity changed from 440 gpd/ft to 1250 gpd/ft. These very low transmissivity values are typical of unfractured, non-water bearing consolidated deposits.

Based upon information obtained during these aquifer pump tests, field investigations, and a review of other geologic data in the area, preferable well sites appear to be located low on the fan deposits. In locations where no playa exists, wells can be situated close to the valley axis. It is anticipated that wells drilled into these deposits will be several hundred feet deep, and capable of producing 750 gpm or more. Transmissivity values for these fan deposits in the proposed well field sites are estimated to be 50,000 gpd/ft, with storage coefficient values anticipated to be ten percent in the unconfined sand and gravel deposits. Table 4-3 summarizes these findings.

4.4.4 White River Valley

Younger alluvial deposits of sand and gravel, interbedded with some silt and clay layers appear to be the primary groundwater aquifers in the White River Valley. The majority of high production irrigation wells appear in the vicinity of the towns of Preston and Lund. Wells in these areas typically penetrate depths between 150 and 400 feet, and commonly yield over 1000 gpm with little drawdown.(122) During our field investigations, it was observed that existing irrigation wells in Preston and Lund are located near the axis of the valley, indicating that no extensive playa areas are located in these regions.

Time-recovery aquifer tests were performed on two wells located in T13N/R60E-26 and T12N/R62E-19, which are 212 feet and 196 feet deep, respectively. The driller's logs for both of these wells indicate thick sequences of water bearing sand and gravel layers. This would suggest high transmissivity values, which was confirmed by the aquifer recovery tests. The well in T13N/R60E-26 has a calculated transmissivity of 95,000 gpd/ft, and the well in T12N/R62E-19 had a transmissivity value of 460,000 gpd/ft. The plotted time-recovery curves are presented on Figures 4-11 and 4-12. Storage coefficients could not be calculated from these tests because no observation wells could be located in the vicinity of the pumping wells.

Aquifer pump tests conducted by Ertec Western, Inc. in the valley-fill deposits of the White River Valley in Nye County, produced transmissivity values that ranged from 10,000 gpd/ft along the axis of the valley, to 72,000 gpd/ft in the coarser fan deposits.[49]

Based upon all the data gathered during these aquifer tests, field investigations, and other geologic data, preferable well sites located in the White Pine County portion of the White River Valley appear to be located near the axis of the valley, west of Preston and Lund. It appears that no playa zones exist in these areas, so that wells drilled into these unconsolidated sand and gravel layers can be expected to be several hundred feet deep and produce 1000 gpm. Transmissivity values in the proposed site locations are estimated to be 95,000 gpd/ft, with a storage coefficient of ten percent. Table 4-3 summarizes these findings.

5.0 GEOPHYSICAL INVESTIGATIONS

5.1 GENERAL

During July and August 1981, geophysical investigations were performed by Harding-Lawson Associates (HLA) in Steptoe, southern Jakes, and northern White River Valleys of White Pine County, Nevada.[66] The purpose of these geophysical investigations was to assist in defining feasible water supply systems for the WPPP. The scope of this geophysical work included 19 vertical electric soundings (VES) in an area extending from the northern end of the White River Valley northward, into the southern portion of Jakes Valley. In addition, self-potential surveys were conducted at two spring sites: the Preston Big Spring in the White River Valley, and the Monte Neva Hot Spring located in Steptoe Valley. A discussion of the findings, conclusions, and recommendations follows. The HLA report is included as Appendix B of this report.

5.2 ELECTRICAL RESISTIVITY SURVEY

A total of 19 vertical electrical soundings (VES) were performed for the purpose of determining the depth to groundwater and the locations of formations and aquifers through which interflow, between the southern portion of Jakes Valley and the northern end of White River Valley, is suspected. The VES locations are shown on Plate 1 of Appendix B.

The VES data exhibited a wide range of resistivities, with values ranging from less than 10 ohm-meters to over 1100 ohm-meters. In the interpretation of the VES data, resistivities less than 80 ohm-meters were assumed to represent saturated soil and rock, and values greater than this amount were interpreted to correspond to strata that is partially saturated to dry. The degree of saturation is indirectly proportional to the resistivity of the material.

A resistivity contour map of the study area, shown on Plate 1 of Appendix B, illustrates the areal distribution of resistivities at a depth of 650 feet (200 meters). Note the elongated, north-south trending, resistivity low which extends northward into the northeastern portion of the study area. This feature coincides with the location of a system of north-south trending folds and high angle faults.(90) This correlation suggests that the low may represent a zone of highly fractured rock which is saturated and may serve as a conduit for groundwater migrating southward from Jakes Valley into the White River Valley.

Resistivity data obtained in the southern end of Jakes Valley (VES 14) could be interpreted as indicative of a north-south trending high angle fault. This fault may form a near vertical zone of highly fractured rock, extending deep beneath the valley floor. This zone may act as a buried drainage system which transports groundwater out of Jakes Valley, possibly connecting with the zone of saturation indicated by the resistivity low which extends northward from White River Valley.

The electrical resistivity data seem to indicate that saturation depends more on fracturing than lithology. The data also suggest that the best aquifers are probably the Ely Limestone where it is fractured and the Tertiary Volcanics. Of all the formations encountered, only the Chainman Shale appears to be impermeable.

5.3 POSSIBLE GROUNDWATER AQUIFERS

Analysis of the electrical resistivity data obtained from the 19 VES and their correlation with the local geology as described by Lloyd indicates that the following formations show evidence of saturation:[90]

a. Ely Limestone (Cpe)
b. Dacite Flow Rocks (Tv)
c. Currant Tuff (Tct)
d. Windous (Twb)
e. Ellison Creek (Tec)

Of these rock types the most likely routes for groundwater movement is through fractured Ely Limestone and brecciated volcanics. These units exhibit the lowest resistivities and the greatest thicknesses within the saturated sequences.

5.3.1 Direction of Groundwater Movement

To determine the direction of groundwater flow, attempts were made to construct groundwater elevation contours as determined from each sounding. The results are somewhat inconclusive because the groundwater contours generally parallel the topographic contours. One possible explanation is that for many of the soundings, the groundwater depth indicated by the shallowest conductive layers may be a perched water layer, with a second saturated layer at depth. In some soundings, this shallow water table may not be hydraulically connected to this deeper aquifer due to impermeable intervening clay layers.

The north-south resistivity anomaly shown on Plate 1 of Appendix B suggests that a mechanism for the southerly movement of water from Jakes Valley into the northern portion of the White River Valley may exist. It is recommended that further work be done to confirm and define these conditions more explicitly.

5.4 SELF-POTENTIAL SURVEY

5.4.1 Preston Big Spring

Self-potential (SP) measurements obtained at Preston Big Spring covered an area of approximately one square mile (three square kilometers) with five survey lines and a total of 160 measurement stations.

The dominant feature of the self-potential (SP) field measured at Preston Big Spring (Plate 2 of Appendix B) is a roughly symmetric -50mV low centered approximately 300 feet (100 meters) west and 900 feet (275 meters) north of the spring.

This anomaly could be a manifestation of streaming potential caused by groundwater flow or of thermoelectric potential caused by heat flow. However, given the high rate of flow from the spring (8 cfs) and only a slightly elevated water temperature (about 6°F above ambient) it seems reasonable to assume that streaming potential is the source mechanism of the SP field. This streaming potential appears to be centered to the northwest of the spring and caused by upwelling of groundwater from basement rock under artesian head. The approximate depth to the zone of upwelling was estimated to be 820 feet (250 meters). Quantitative analysis and theoretical curve fitting to the observed data was then performed using the estimated 820 foot source depth. It was determined that the estimated source depth was consistent with the observed values.

5.4.2 Monte Neva Hot Spring

The SP survey performed at Monte Neva Hot Spring covered an area of approximately 0.6 square miles (1.5 square kilometers) with five survey lines and 255 measurement stations. The most significant feature of the observed SP field is an asymmetric dipolar anomaly with an amplitude of 70 mV peak to peak. This is illustrated on Plate 3 of Appendix B. The zero contour of the dipole runs roughly north to south, with the positive and negative lobes of the anomaly offset in a north-south direction by about 650 feet (200 meters). The negative lobe of the anomaly is narrow and elongated in a north-south direction. The positive lobe, which is to the east of the zero contour, is much larger in east-west dimension than the negative lobe. The Monte Neva Hot Spring orifice is located within a local minimum contained in the positive lobe of the anomaly. The asymmetry and elongation of the dipole suggests a planar source region striking slightly east of north and dipping toward the east. The relatively steep potential gradient (approximately 230 mV/km) between the positive and negative peaks of the anomaly indicates a fairly shallow depth to the top of the source region.

Experience indicates that such anomalies are frequently associated with basin and range faults and fault-controlled hydrothermal systems. The elevated water temperature of the spring (170°F) indicates that the source of the SP field may be thermoelectric in nature or that a combination of thermoelectric and streaming potential sources exists. The source or sources could be generated by the upward percolation of thermal water along a fault plane or fracture zone. The planar source region may coincide with a fault plane or fracture zone. Although we know of no direct geological evidence for the existence of such a fault or fracture zone, the strike of the hypothetical source plane is roughly parallel to the north-south strike of the major structural features in the region.

From a theoretical fit to the observed SP data, it is believed that the source of the anomaly is a fault, or fracture-controlled zone of upward percolating hot water, situated at a depth of approximately 330 feet (100 meters).

5.5 CONCLUSIONS AND RECOMMENDATIONS

5.5.1 Electrical Resistivity Survey

a. A total of 19 vertical electric soundings indicates a wide range of resistivity values from less than 10 ohm-meters to greater than 1100 ohm-meters.

b. Low resistivity values, in the range of 10 to 80 ohm-meters, seem to indicate permeable zones of saturation.

c. Values of resistivity greater than 80 ohm-meters seem to indicate zones of nonsaturated alluvium and/or rock.

d. Very high resistivity values indicate dry, impermeable rock.

e. The differences in resistivities seem to be caused primarily by variations in the degree of fracturing. Highly fractured rock has greater porosity and therefore is more permeable, more saturated and consequently more conductive.

f. A contour map of resistivity values at a depth of 656 feet (200 meters) suggest that much of the southern portion of the area is saturated. The vertical electrical sounding data indicate that this zone of saturation may extend to depths of over 300 to 400 meters.

g. Much of the northern half of the study area is resistive and probably not saturated. Exceptions to this are the southern portion of Jakes Valley and a narrow north-south trending zone of low resistivity which appears to connect the two valleys. These resistivity lows may indicate a principal route for groundwater movement between the two valleys.

h. The resistivity data obtained in Jakes Valley could be interpreted to indicate a fault in the center of the valley which acts as a subsurface drainage system carrying groundwater out of the valley.

i. An attempt to determine the direction of groundwater flow by contouring groundwater elevations determined from the vertical electrical sounding is inconclusive. This is because some of the groundwater elevations may represent an aquifer zone which is not hydraulically connected to the aquifers through which most of the groundwater transport occurs.

j. The vertical electrical sounding data, when correlated with existing geological information, suggests that groundwater movement could be occurring in the Ely Limestone, the Ellison Creek formation, the Windous formation, the Currant Tuff or in Dacite Flow Rocks, but not in the Chainman Shale. Most groundwater movement probably takes place in the Ely Limestone, where it is folded and fractured and in the Tertiary Volcanics.

k. It is recommended that further geophysical work be performed in the area to help confirm or deny the hypothesis presented in this rpeort. Principal among these is that the narrow north-south trending zone of low resistivity connecting the two valleys represents a route for groundwater movement. The proposed geophysical work would consist of the following: (a) additional VES near existing wells to refine the correlation between resistivity and lithology; (b) additional VES in the northern portion of the area to further define the limits of the resistivity trough; and (c) additional SP data in the northern portion of the area to determine the direction of groundwater flow.

5.5.2 Self-Potential Survey

5.5.2.1 Preston Big Spring

A symmetrical, monopolar SP anomaly with an amplitude of -50 mV centered approximately 100 meters west and 275 meters north of the spring was observed.

The anomaly may be interpreted as being caused by streaming potential generated by the upwelling of groundwater from basement rock under artesian head at a depth of 820 feet (250 meters).

5.5.2.2 Monte Neva Hot Spring

A asymmetrical, dipolar SP anomaly with an amplitude of 70 mV peak-to-peak was observed. The zero contour of the anomaly trends roughly north-south with the positive and negative lobes offset approximately 650 feet (200 meters) in a north-south direction. The orifice of the spring is located within a local minimum contained in the positive lobe of the anomaly.

The anomaly may be caused by thermoelectric potential, generated by the upward percolation of thermal water along a fault plane or fracture zone. Such a planar source region could be 650 feet (200 meters) long, 500 feet (150 meters) high, and situated at a depth of 325 feet (100 meters).

Additional electrical resistivity soundings in the vicinity of Monte Neva Hot Spring would help determine the depth to the source of the hot water, the depth to basement rock, and whether or not a fault exists in this area.

6.0 PERENNIAL YIELDS

6.1 GENERAL

In Nevada, the perennial yield of a groundwater basin is the largest quantity of water that can be withdrawn for an indefinite period of time without causing a continuing depletion of storage or a deterioration of the water quality, beyond the limits of economic recovery. The NDCNR State Engineer's Office and the USGS have noted that the perennial yield is ultimately limited by the average annual recharge to or discharge from the system. They also correctly note that ". . . specific determination of perennial yield of a valley requires a very extensive investigation, based in part on data that can be obtained economically only after there has been substantial development of groundwater for several years".(39) Accordingly, estimates of average annual discharge or recharge are used in Nevada as preliminary estimates of perennial yield. General methodologies used by the State and USGS to estimate average annual discharge and recharge are discussed in Chapter 4 of the Phase 1 report dated April 1981, and will not be repeated here. This chapter deals only with estimates of perennial yields for Diamond and Railroad Valleys.

6.2 ESTIMATION OF RECHARGE

6.2.1 Estimates by the State Engineer's Office

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 is described in Chapter 4 of LEEDS-HILL's Phase 1 report.[88]

In Diamond Valley annual recharge was estimated by the State to be about 16,000 acre feet and 21,000 acre feet for 1962 and 1968, respectively. In Railroad Valley, annual recharge was estimated to be 51,500 acre feet in 1974.

6.2.2 Comparison with Measured Runoff

Recharge estimates prepared using the Maxey-Eakin method, are described and were compared with measured runoff from Cleve Creek in Spring Valley and from Steptoe Creek in Steptoe Valley in the Phase 1 report.[88] Since then, runoff data has been obtained for Duck Creek in Steptoe Valley and for Little Currant Creek in Railroad Valley. Drainage areas and periods of record for these streams are shown below:

Cleve Creek (31.8 sq. mi.)	1959-67; 1976-79
Duck Creek (78.6 sq. mi.)	1957-76

Little Currant Creek (12.9 sq. mi.)	1965-78
Steptoe Creek (11.1 sq. mi.)	1967-78

Annual discharges are measured by recording USGS gages at Steptoe, Cleve, and Little Currant Creeks; while daily measurements by Kennecott Copper Corporation were obtained for flows at Duck Creek.

In order to compare runoff records with the Maxey-Eakin method, it was necessary to consider precipitation on the drainage area.

Precipitations for each year in the Cleve, Duck, and Steptoe Creek watersheds were estimated from rainfall measurements collected at the Ely WSO Airport, and adjusted using the rainfall versus elevation relationship shown on Figure 3-1 of the Phase 1 report. Estimates of precipitation on the Little Currant Creek basin were prepared using measured records at the Currant Highway and Duckwater precipitation stations.

These estimates of annual precipitation were plotted against the measured flows at each of these gaging sites as shown on Figure 6-1. The USGS and NDCNR basis for estimating average annual recharge to a basin are also shown for comparative purposes.

Recharge to the alluvial groundwater basins takes three forms - direct precipitation on the basin that infiltrates, surface runoff from the mountainous areas that infiltrates into the basin, and infiltration of precipitation in the mountain areas which later enters the valley groundwater basins as subsurface flow. Thus, the runoff component is only part of the total estimated recharge. The relationship between the measured runoff and estimated recharge in each watershed are discussed in the following sections.

6.2.2.1 Steptoe Creek

The Steptoe Creek drainage area is a relatively small, but very steep catchment area. Discharge measurements were made near the upper edge of the alluvial fan, where most of the runoff is still surface flow. At this location, the surface flow is subject to some evaporation and infiltration losses, however these losses are minimal upstream of the gage.

Figure 6-1 shows that the calculated Maxey-Eakin rainfall-recharge point is somewhat below the computed rainfall-runoff curve based on measured data. There are several explanations for this which include:

a. Flows in Steptoe Creek may be augmented by sources outside the drainage area.

b. The Maxey-Eakin method of recharge estimation may be somewhat low.

c. There may be some evaporative losses of the stream flow before it enters the groundwater basin as recharge.

d. Estimated precipitation at Steptoe Creek may be too high.

6.2.2.2 Cleve Creek

As shown on Figure 6-1, measured runoff in Cleve Creek is quite consistent with the Maxey-Eakin recharge estimate. The gaging station is located at a point where the stream has already crossed part of the alluvial fan. This could suggest that some recharge has already occurred. Thus the Maxey-Eakin method may result in recharge estimates which are somewhat low.

6.2.2.3 Little Currant Creek

Measured discharges at Little Currant Creek, as shown on Figure 6-1, lie generally above the point estimated with the Maxey-Eakin method. The Little Currant Creek drainage area in Railroad Valley is a small, steep catchment with the gaging station located above the alluvial fan. Thus, little recharge has occurred upstream of the gage, as was the case with Steptoe Creek, and the same possible explanations for the high rainfall-runoff curve exist for this catchment as are listed for Steptoe Creek.

6.2.2.4 Duck Creek

At Duck Creek daily discharge readings of flows into two storage reservoirs are available. This measurement point excludes higher flood flows which are discharged into a spillway channel upstream of the gage. Thus, in relatively dry years, the measurements are close approximations of the total annual runoff, but in wet years considerable discharge is not included in the recorded flows. This situation is reflected in the data presented on Figure 6-1 in which the Maxey-Eakin point is located above the measured annual flows.

6.2.2.5 Discussion of Recharge Estimates

The foregoing comparisons lead to the conclusion that estimates of recharge using the Maxey-Eakin method are reasonable as initial estimates of valley recharge. However, it should also be noted that in areas where measurements are available to test the validity of these estimates, the method generally underestimates the quantity available for recharge.

6.3 ESTIMATION OF DISCHARGE QUANTITIES

Estimates of discharge in Diamond and Railroad Valleys have been prepared by the State of Nevada and are shown, along with their bases, on Table 6-1.

It may be noted that consumptive use factors used for the two valleys are generally consistent for native vegetation. However, higher factors are used in Railroad Valley for meadow and pasture grasses than in Diamond Valley. A portion of this difference may be attributable to the lower elevations in Railroad Valley.

Comparison of consumptive use rates used in these valleys with those used in other valleys in White Pine County indicates reasonable consistency.

6.3.1 Independent Estimates of Consumptive Use

In the Phase 1 report independent estimates of consumptive use were prepared using maps of irrigated lands and native vegetation prepared by the SCS.

The SCS has not conducted similar studies in Railroad and Diamond Valleys, however soil maps have been prepared for each of the valleys by the SCS and particular soil types can be associated with certain types of vegetation. Based on such correlations, estimates of vegetative cover in each valley were developed and these estimates of consumptive use are presented on Table 6-2.

It may be noted that the estimated discharge using the aforementioned procedure agrees reasonably well with the State's estimate in Railroad Valley but is significantly higher than the State's estimate which was made in 1966 for conditions of natural equilibrium in Diamond Valley. The main source of this difference is the irrigated acreage estimated to be 35,000 acres in 1980 by the SCS. Water for the irrigated land is pumped from the south part of the valley where well yields are best, while most of the natural discharge continues to occur in the northern part of the valley around the periphery of the playa.

6.4 PERENNIAL YIELDS

Estimates of recharge, discharge, and perennial yield, for Diamond and Railroad Valleys are indicated in the following tabulation:

	Diamond Valley		Railroad Valley
	1962	1968	
Recharge	16,000	21,000	51,500
Discharge	22,850	31,000	80,200
Perennial Yield	23,000	30,000	75,000

In Railroad Valley the State estimates that recharge is augmented by subsurface inflow from Little Smoky Valley (2400 afy) and from Hot Creek Valley (700 afy), although these levels of inflow do not account for the substantial difference between the estimates of recharge and those of discharge. Three possibilities are suggested by the State for this difference.

a. The estimate of recharge (50,000 afy) may be low.

b. Estimates of subsurface inflow (3000 afy) from Hot Creek and Little Smoky Valleys may be low.

c. Water from Newark, Jakes, or White River Valleys could be entering Railroad Valley.

As previously mentioned, checks of the estimates of recharge indicate they are generally low.

The third possibility suggested by the State was checked by reviewing the water budgets in Newark, Jakes, and White River Valleys (see Section 4-4 to Phase 1 report). This review indicates that estimates of recharge and discharge in Newark and White River Valleys agree quite closely, but that recharge in Jakes Valley is about 20,000 afy compared to the estimated discharge of 3000 afy. There is apparently considerable subsurface outflow from Jakes Valley. Such outflow could be more than 20,000 afy if there is subsurface inflow into Jakes from Long Valley, as is postulated by the State estimates. Thus, there is some support for the theory that subsurface flows from Jakes Valley enters into Railroad Valley.

In Diamond Valley, the State estimated a perennial yield of 30,000 afy. Of the 30,000 afy, 21,000 afy is considered to be derived from recharge within the basin and 9000 afy from subsurface inflow from the neighboring Garden Valley. Most of the natural recharge and discharge occurs in the northern part of the valley, while in the southern portion of the valey, groundwater being is pumped for the irrigation of 35,000 acres of crop lands. As might be expected groundwater levels in the southern portion of the valley have lowered significantly since the 1960's when considerable groundwater development occurred. The valley has been closed to groundwater right appropriations since 1964. Detailed analyses of Diamond Valley groundwater conditions have not been conducted since the 1968 study by the State, but it is thought that the lowered water levels in the south part of the valley will eventually effect discharge from springs in the northern part of the valley.

7.0 PRELIMINARY WATER SUPPLY PLANS

7.1 WELL LOCATION CRITERIA

Twenty-three potential well field sites, located in seven valleys of White Pine County, were analyzed. The number of wells in each of these fields, their pumping rates, and the well locations within the valleys were determined based on criteria and data that was developed during the course of the Phase 1 and 2 work. As work continues during the Phase 3 studies, additional criteria and data for well locations may be developed that will modify the well field configurations presented in this report. However, the well field analyses presented herein are considered sufficient for preliminary screening purposes, and to define the scope of the Phase 3 work.

In this report, a well field is defined as a configuration of three or more wells that have uniform spacing between the wells. The criteria and data used to develop the well field locations as presented in this report are as follows:

a. The maximum yield of all well fields in a particular valley is the lesser of: 50 percent of the perennial yield; or the perennial yield minus existing water rights; or the plant requirement plus a 15 percent contingency (25,300 af/yr).

b. A well field will consist of a minimum of three wells.

c. No wells will be placed within one mile of existing wells or private land.

d. The pumping rate of each well is assumed to be 1.0 cfs (450 gpm), except in Steptoe and White River Valleys where respective pumping rates of 1.67 cfs (750 gpm) and 2.23 cfs (1000 gpm) were assumed based on known pumping rates of existing wells and aquifer materials (CHAPTER 4.0 - EVALUATION OF AQUIFER CHARACTERISTICS) in these areas.

e. Well fields will have a single-row configuration with either a one or two mile spacing between wells, depending upon available site locations, valley perennial yields and other criteria.

f. Well fields will, in general, be located in the alluvial fan areas along the valley edges where thicker layers of coarse alluvial material are more likely, and at least one mile from the finer grained playa deposits.

g. Well fields will be located to intercept recharge from as large a catchment area of high elevation mountain ranges as possible.

7.2 WELL FIELD LOCATIONS

Well field locations in each of the seven valleys are presented on Plate IV. Each well field is designated by a capital letter that references the valley in which it is located and an arabic number which references its particular location within the valley. A summary of the characteristics of each well field is presented in Table 7-1.

7.3 ESTIMATED WELL FIELD DRAWDOWNS

7.3.1 Aquifer Simulation Model

Well field drawdown calculations for the Phase 2 studies were made using the USGS aquifer simulation model, "Finite-Difference Model for Aquifer Simulation in Two Dimensions", by P.C. Trescott, G.F. Pinder, and S.P. Larson.(158) This model has been extensively and successfully used by the USGS and is considered to be a state-of-the-art engineering tool for groundwater studies.

In this model, a study area is divided into a number of square areas by superimposing a grid system where the distance between grid nodes is a variable that is selected by the modeler. Other variables that must be independently estimated for use in the model are: the boundary conditions of the groundwater aquifer; the specific yield, transmissivity and thickness of the aquifer; the aquifer type, i.e., confined or unconfined aquifer; the time frame over which changes in the groundwater aquifer are to be studied; and the locations, pumping rates, and bore diameters of wells operating in the aquifer.

Each of the seven valleys (Butte, Jakes, Long, Newark, Spring, Steptoe, and White River) was modelled individually, using a one mile grid system to describe the valley areas. This one mile grid is considered sufficiently accurate to model the boundaries between the different aquifer zones in the seven valleys.

The model allows three boundary condition assumptions: a constant head boundary (unlimited recharge); an impervious boundary (no recharge); and a constant flux boundary (fixed recharge). This model was operated assuming a constant head recharge boundary. However, limits were placed on the quantity of water available for recharge, by designing and sizing the well fields so that the lesser quantity of 50 percent of the perennial yield, or the perennial yield minus existing water rights would not be exceeded.

In the drawdown calculations presented in this report, the carbonate aquifers surfacing in the mountain ranges surrounding the valleys were assumed to be constant-head areas. This assumption implies that the carbonate aquifers will act as the sources of recharge to the alluvial fill valleys and water withdrawn from storage is that quantity necessary to establish equilibrium ground-water flow conditions for the pumping regime. This quantity has been termed the transitional storage reserve by the State and USGS. An analysis was made and described in a subsequent subsection to determine the sensitivity of calculated drawdowns for other assumed boundary conditions.

In addition to the assumption of constant head recharge boundaries, it was also assumed that the recharge will be constant over the year and the recharge is equally distributed along the edges of the valleys. Constant recharge during the year is a reasonable assumption because available water level data show only minor seasonal variations. Although recharge areas of the valleys are concentrated in permeable zones associated with faults, fractured zones, fan areas, and canyons, the assumption of equal distribution of recharge along the valley edges is reasonable considering the large extent of the groundwater aquifers, the well fields that were simulated, and the present state of knowledge regarding recharge areas.

The aquifer characteristics used in the simulation model are values of the hydraulic conductivity, specific yield and aquifer thickness. The hydraulic conductivity is expressed in feet per second and is defined as the transmissivity divided by the aquifer thickness. Specific yield is a dimensionless quantity, and is expressed in percent. The aquifer coefficients of transmissivity and specific yield for each of the well field locations were determined from pump tests, and other geologic data. (See CHAPTER 4.0 - EVALUATION OF AQUIFER CHARACTERISTICS). Table 7-2 gives the transmissivities, specific yields, and aquifer thicknesses used in the simulation studies. As shown in this table, the coarser grained alluvial fan areas were simulated using one set of aquifer coefficients, and in the finer grained playa areas, another set of coefficients was used.

The saturated thickness of the aquifers in the study areas is probably on the order of 1000 feet. The proposed wells, however, will not fully penetrate the aquifer and will probably be drilled to depths averaging about 500 feet (depending on the particular valley, and localized conditions). Consequently, the effective thickness of the aquifer was assumed to be 500 feet. (See Figure 7-1 for an illustration of this condition).

For all well fields that were studied, the valley aquifers were assumed to be unconfined; consisting mainly of coarse grained, water bearing sand and gravel layers with good hydraulic characteristics interbedded with layers of fine silt or clay which are comprised of relatively fine grained, impervious material. The fine grained layers are thicker and more frequent in the playa zone because of ancient lake bed deposits, therefore well fields were located so as to avoid these playa areas by at least one mile. There may also be confined or perched aquifers in some areas, especially in the playas. From the available geological information, it appears that the clay layers are quite irregular, and it would be unreasonable to assume any continuous impervious clay horizons. Thus, the aquifers were modelled as homogeneous and unconfined, and the values of transmissivity and specific yield were adjusted to represent a mixture of materials in the aquifer. The values obtained from pump tests conducted in Spring, Steptoe, and White River Valleys confirmed these assumptions.

Groundwater drawdowns were calculated in five time steps, of increasing length, adding up to 25 years. Drawdowns after 25 years were calculated using more time steps and found to give essentially the same results as the five step calculations. The drawdowns at a random selection of wells were plotted against time (Figure 7-2) and show that steady state conditions are approached after 25 years. This plot indicates that after 50 years of pumping drawdowns would probably not be more than two to three percent greater than after 25 years of pumping.

The proposed individual well sites were located in the center of the grid squares using a one or two mile center to center spacing pattern, depending on the data available for the area and quantity of water needed from the valley. Pumping rates of 450 gpm (one cfs) per well were used in all the valley areas, except for Steptoe and White River Valleys, where pumping rates of 750 gpm and 1000 gpm, respectively, were used. These variations in discharge quantities reflect LEEDSHILL's field investigations, pump tests, and geologic interpretations of the individual valley areas. A well diameter of 18 inches was assumed in the calculations. However, this well diameter will not significantly affect the maximum drawdowns at the wells, if the production well diameter is between 12- and 24-inches.

7.3.2 Results

The results of any simulation model are only as good as the data and assumptions used in the simulation. The drawdown predictions calculated for each of the seven valleys and presented in this report represent the best estimates with the information currently available. Actual drawdowns may vary from these estimates due to the uncertainties in the estimates of aquifer characteristics, proximity to recharge and playa areas, and other localized conditions. Also, except for the limiting criteria described in Section 7.1, losses due to evaporation and consumptive use in the valleys were not considered, nor were the effects of existing wells. These effects will be considered during basin valley modeling to be conducted during Phase 3.

The computer program was used with the aquifer characteristics described above to calculate and plot average drawdowns in each of the one mile square grid areas. The program also calculated maximum drawdowns at the wells. Plates V to XI show the estimated average drawdown contours around the well field and the maximum drawdowns at the individual wells after 25 years of continuous pumping.

It should be emphasized that groundwater drawdowns are presented on Plates V to XI and not depth to the groundwater table. Thus, the estimated drawdowns have to be added to existing water level conditions to obtain an estimate of the average pumping lifts. An allowance should also be added to the average pumping lifts to account for seasonal fluctuations in recharge and local deviations from the assumed average aquifer characteristics used in the calculations. For illustrative purposes, pumping lifts that include an additional 20 feet for seasonal and local variations, were calculated for the center well in each of the well field configurations and are presented on Table 7-3.

The program also calculates, using a cummulative mass-balance, the amount of water extracted from storage and the amount obtained from recharge. The percent of water from each of these sources after 25 years of pumping are presented in Table 7-4 for each of the valleys investigated.

7.3.3 Sensitivity Analyses

Several analyses were made to determine the sensitivity of the calculated drawdowns to variations in the boundary conditions and coefficients used in the simulation model.

One of the more critical assumptions used in the simulation model is that the carbonate aquifers located in the mountain ranges surrounding the valley alluvial fill acts as constant head recharge sources. To the extent that seasonal fluctuations may occur in these mountain areas, this assumption produces underestimates of well field drawdowns.

Groundwater drawdown calculations for well fields in Spring and Steptoe Valleys show that well drawdowns double if the entire boundary surrounding the valley aquifers are assumed to be impervious. This situation is highly unrealistic since it assumes that no recharge takes place and that all pumped water comes from storage.

To determine the order-of-magnitude of possible underestimates of drawdown due to the boundary condition assumption, two additional computer analyses were made for well field E5 in southern Spring Valley (Plate IV). In the first analysis it was assumed that the carbonate formation on the west side of the valley is impermeable and the carbonate formation on the east side of the valley is a constant head recharge area. In the second analysis the assumed boundary conditions were reversed, i.e., it was assumed the west side of the valley is a constant head recharge source and the east side is impermeable to the flow of groundwater.

Profiles of groundwater drawdown that were calculated using the two assumed boundary conditions are shown on Figure 7-3, for the cross-section that passes through the Shoshone Spring area at the southeast end and the southern-most well in field E5 (cross-section A-A' shown on Plate IX). Also shown on Figure 7-3 is the profile of groundwater drawdown that was calculated assuming the carbonate formations on both sides of the valley are constant head recharge sources.

As shown on Figure 7-3, the calculated drawdowns in the area of Shoshone Spring are about the same for all three assumed boundary conditions. This is because Shoshone Spring is on the valley edge furthest from the well field and because of the dampening effects on drawdowns of the playa zone between the wells and spring. Differences in calculated drawdown at the well for the three assumed boundary conditions are about four feet or about six percent of the total drawdown. The largest difference in calculated drawdown is at the west boundary of the valley. When this boundary is assumed to be impermeable to the flow of groundwater, the drawdown at the boundary is about 12 feet.

It is believed that the carbonate formations surrounding the valleys act more like a constant head recharge source than as an impermeable barrier to the flow of groundwater. The data shown on Figure 7-3 indicate that calculated drawdowns are not highly sensitive to the assumed boundary conditions.

Five different drawdown simulation analyses were made for Butte Valley to test the sensitivity of the assumed aquifer coefficients of transmissivity and specific yield. In these analyses transmissivity values were first held constant as specific yield values were varied, and then the specific yield values were fixed as transmissivity values were varied. These sensitivity analyses are summarized on Figure 7-4.

Figure 7-4 shows the relationship between calculated drawdown and the transmissivity and specific yield aquifer coefficients for two characteristic points in the valley: (1) at a typical pumping well located entirely in the alluvial material; and (2) at a random point one mile from a pumping well. A location entirely in the playa material was also examined, however it was found to be similar to a random point one mile from a pumping well (curve "b" on Figure 7-4).

As shown on Figure 7-4 the influence of transmissivity and specific yield on drawdown are similar except at the pumping well (curve "a" on Figure 7-4). Calculated drawdown at the well is much more sensitive to variations in transmissivity than to variations in specific yield.

The sensitivity of calculated drawdown to variations in the assumed aquifer thickness was also analyzed. These analyses indicated that the calculated drawdowns were quite insensitive to changes in aquifer thickness, as long as the aquifer thickness is about three times the expected maximum drawdown. Doubling the aquifer thickness from 300 feet to 600 feet, while holding other variables constant, reduced calculated drawdowns at the wells in Spring Valley by about 10 percent.

8.0 WATER RIGHTS

The water rights process and 1980 status of water rights applications for Butte, Jakes, Long, Newark, Spring, Steptoe, and White River Valleys is discussed in Section 5 of the "Phase 1 Groundwater Investigation - Technical Report for the White Pine Power Project".[88] The status of water rights applications for the seven valleys in White Pine County has been updated to 1981 conditions and is presented in Table 8-1. Table 8-1 also provides a more detailed breakdown of pending water rights applications than was presented in the Phase 1 report.

During the Phase 2 studies, the availability of water in Railroad Valley, Nye and White Pine Counties and Diamond Valley, Elko and Eureka Counties was investigated. As parts of these investigations, the status of water rights applications in the two valleys was determined by representatives of LADWP and is summarized in Table 8-2. WPPP has not applied for water rights in either Railroad or Diamond Valleys and, therefore, project needs are not included in the pending rights presented in Table 8-2.

As shown in Table 8-2, permitted water rights in Diamond Valley are about five times the estimated yield of the valley. Thus, it is not likely that WPPP can obtain a firm water supply from this valley.

In Railroad Valley pending water rights when combined with permitted rights far exceed the estimated yield. Thus, industrial water usage would have to be designated as a preferred use by the State Engineer's Office for the WPPP to obtain rights for groundwater.

Present State procedures in processing appropriations for geothermal fluids should also be noted. Permits to appropriate geothermal fluids are treated in the same manner as water rights applications, i.e., applications for these fluids are published, protest periods are required, etc. However, these applications are rarely turned down, even in designated valleys. The rational for this is the geothermal fluids are believed to come from such great depths that there is no connection with the near surface aquifers.

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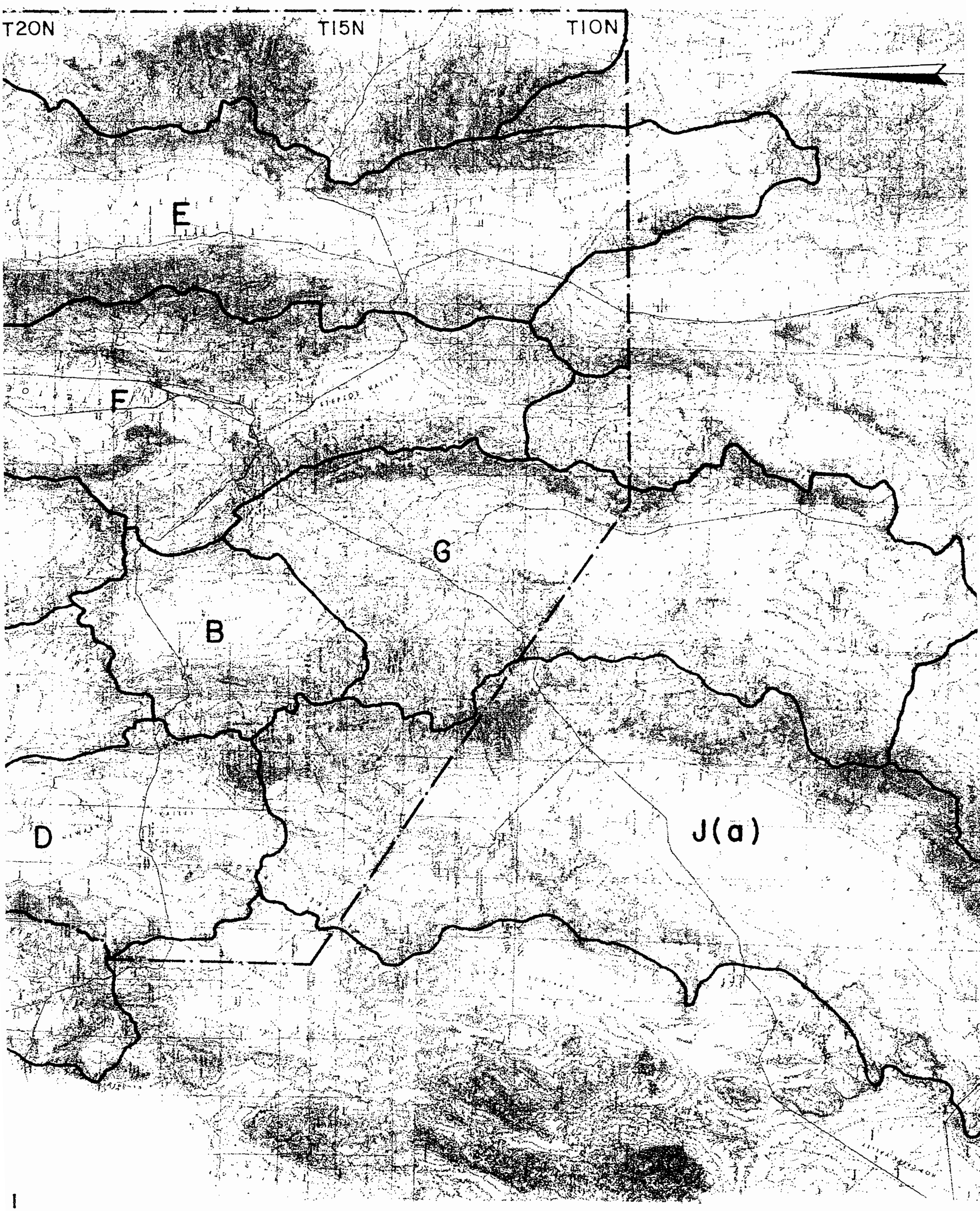
PLATES



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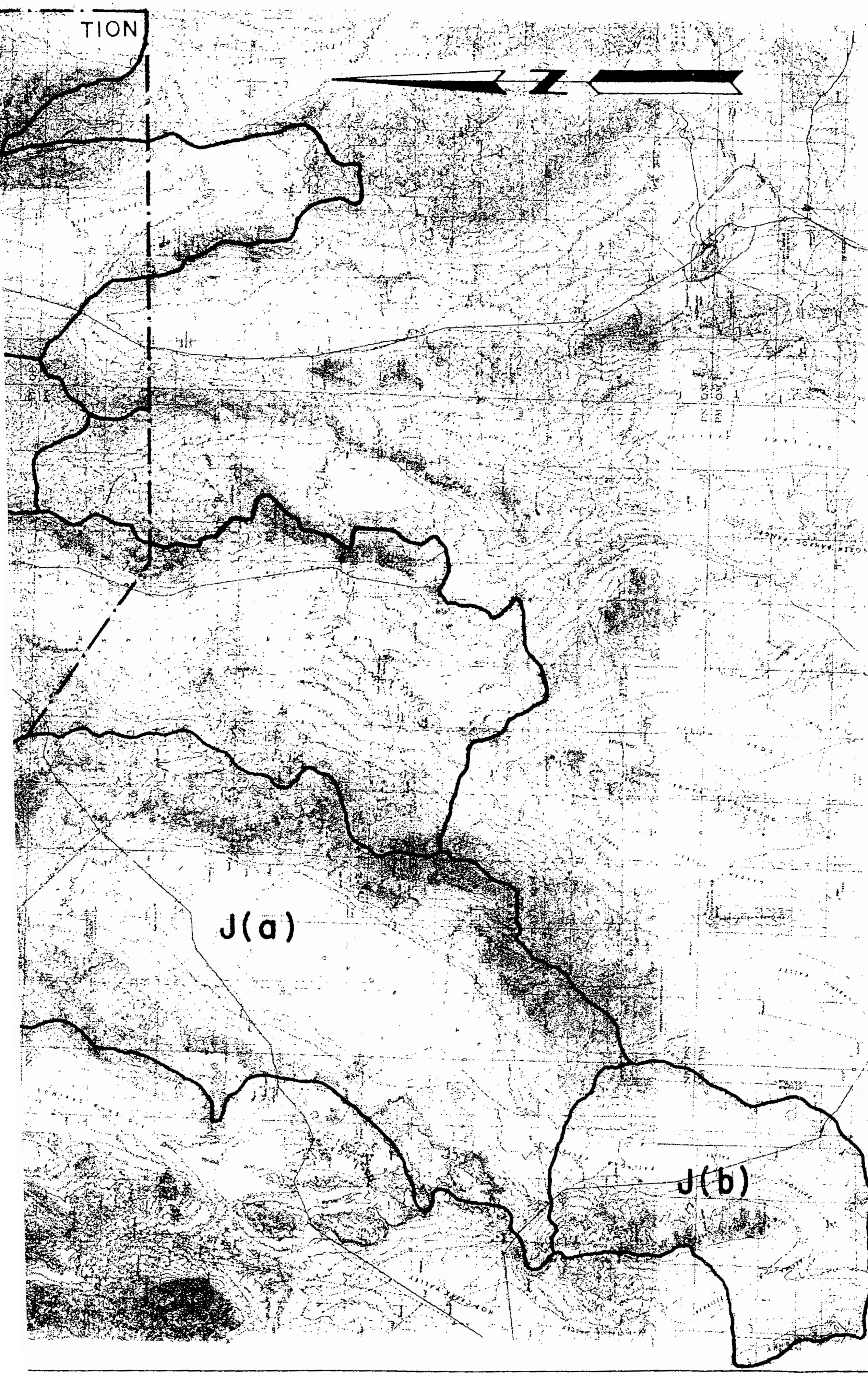

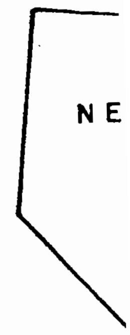

LOCATION

LEG

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BA

VALLEY LO

A BUTTE VA

B JAKES VA

C LONG VAL

D NEWARK

E SPRING

F STEPTOE

G WHITE RI

H DIAMOND

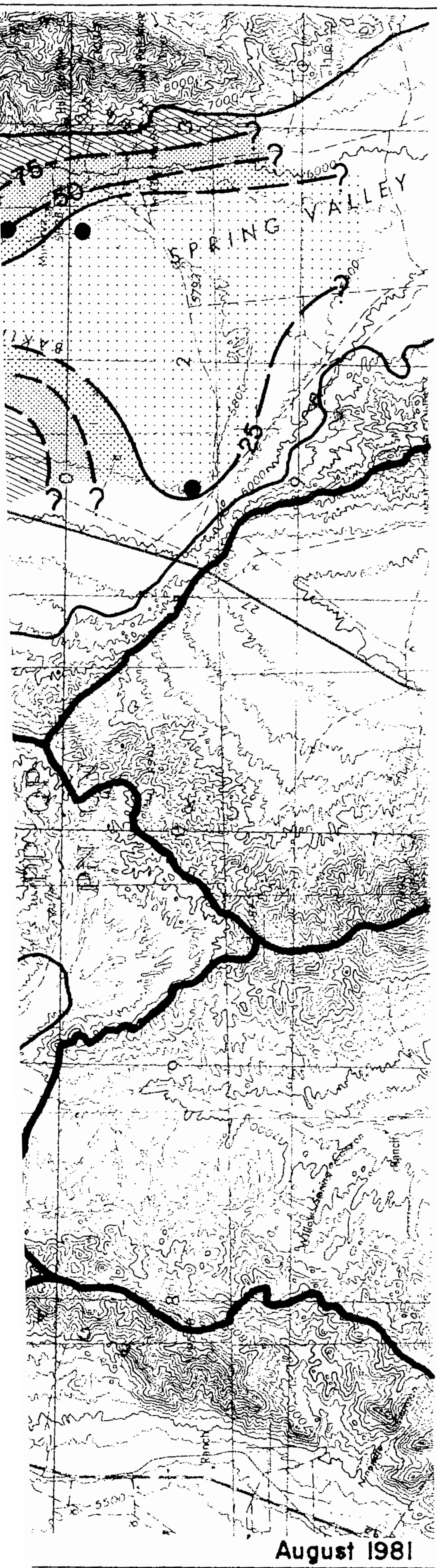
J(a) NORTHER

J(b) SOUTHER

WHITE PINE P

GENERAL L

PLA



LEGEND

COUNTY BOUNDARY

BASIN BOUNDARY

DATA POINT

SAND AND GRAVEL PERCENTAGE IN THE UPPER 200 FEET OF VALLEY FILL; DASHED LINE WHERE CONTOUR IS APPROXIMATED:

0-25% SAND AND GRAVEL

25-50% SAND AND GRAVEL

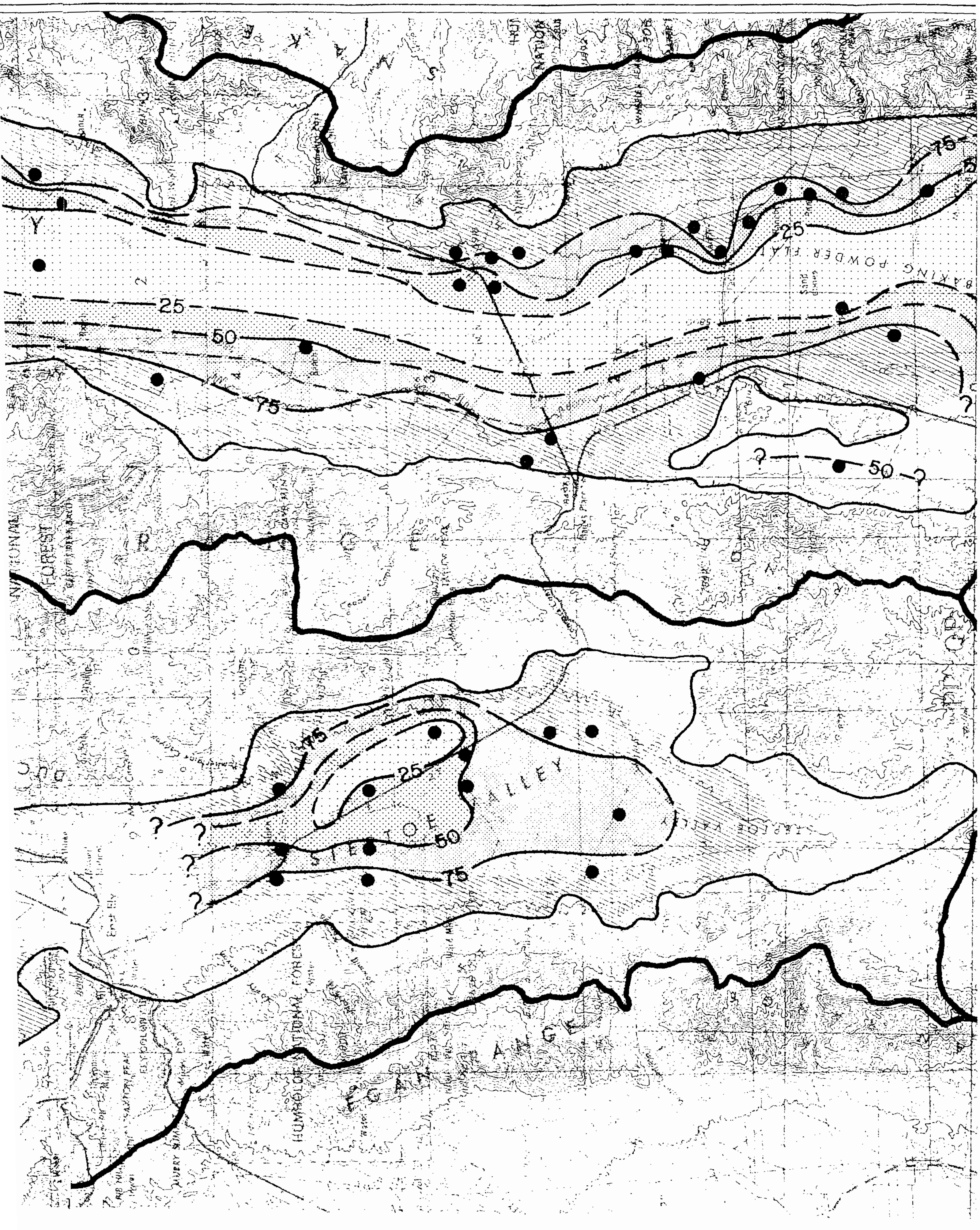
50-75% SAND AND GRAVEL

GREATER THAN 75% OR TO BEDROCK CONTACT

WHITE PINE POWER PROJECT

DISTRIBUTION OF SAND AND GRAVEL IN SPRING AND STEPTOE VALLEYS

PLATE II



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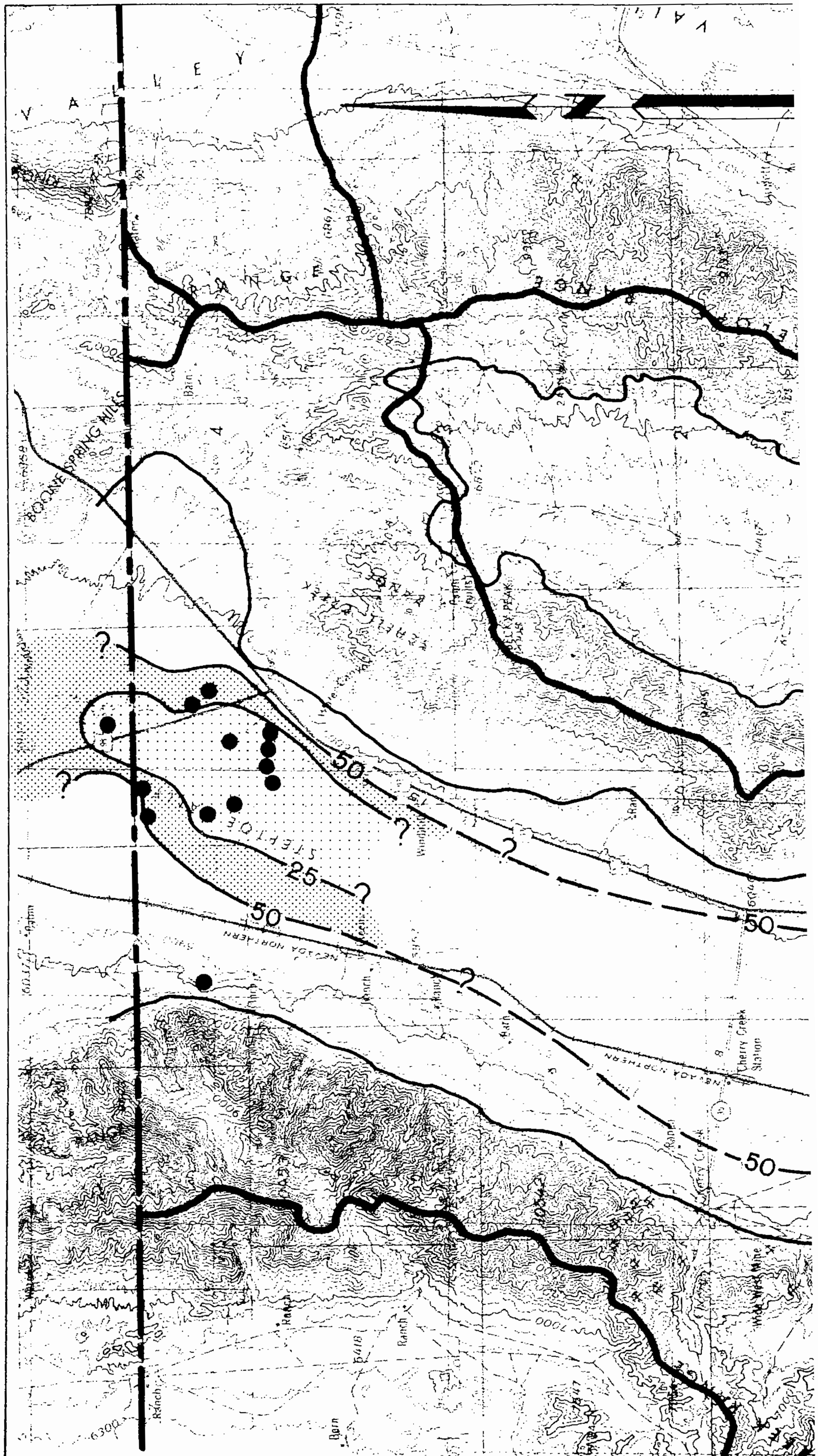
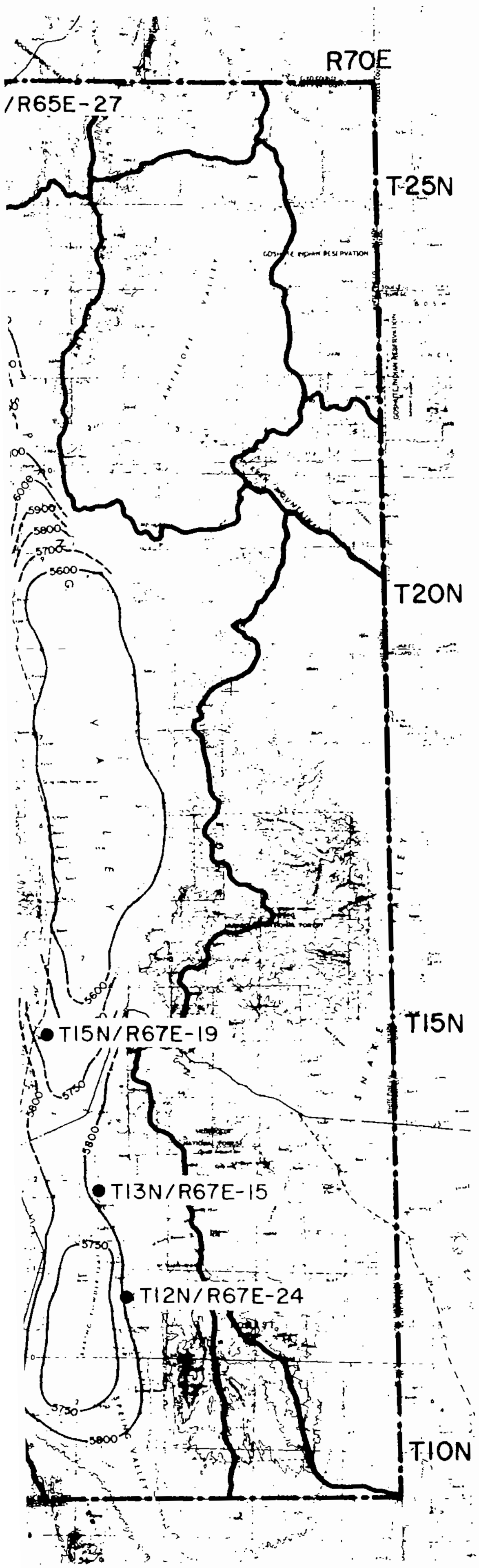
STEPTOE VALLEY
EGAN RANGE
BAKING POWDER FLAT
?



Leeds, Hill and Jewett, Inc.



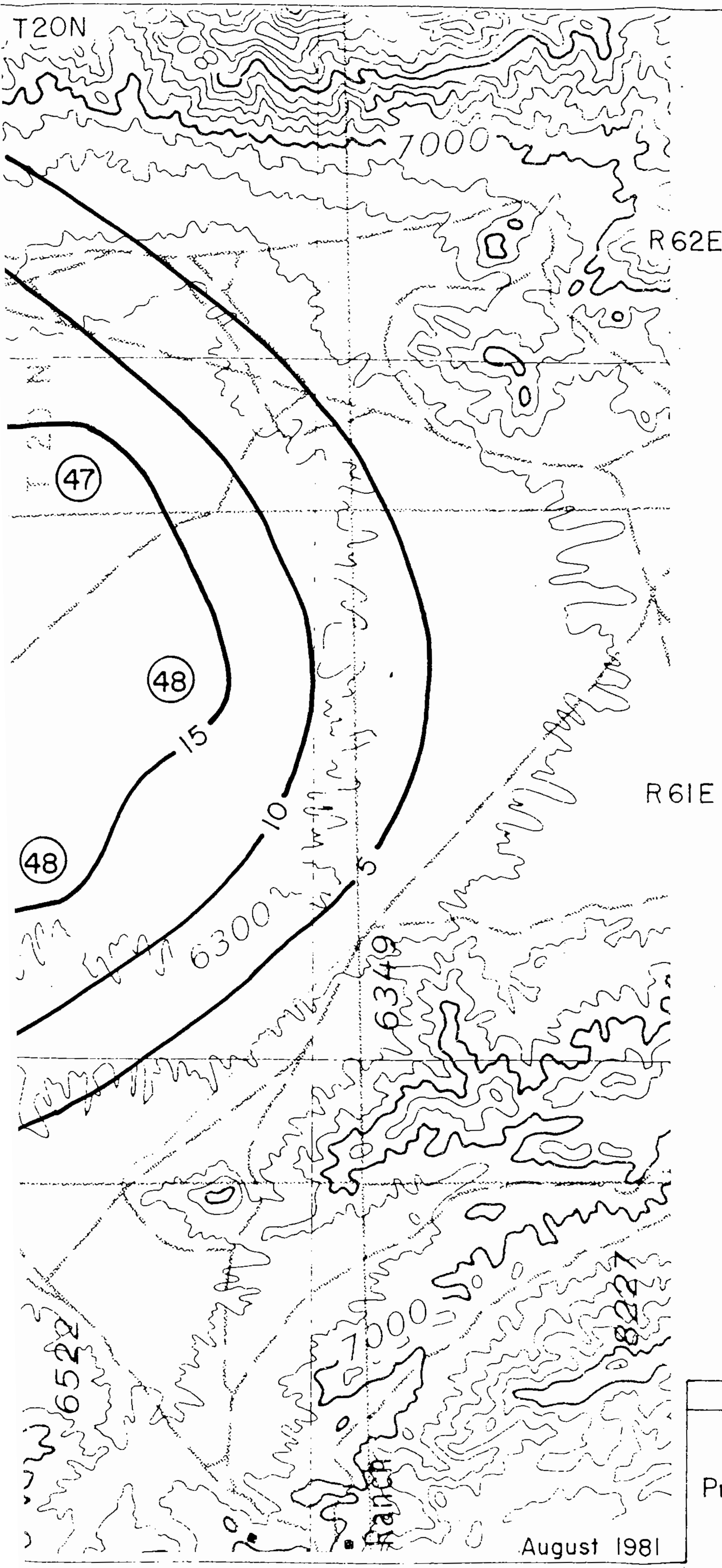
LEGEND

——6000——	WATER SURFACE ELEVATION
---6000---	INFERRED WATER SURFACE ELEVATION
●	AQUIFER PUMP TEST LOCATION

WHITE PINE POWER PROJECT

GROUNDWATER ELEVATIONS AND AQUIFER PUMP TEST LOCATIONS

PLATE III



LEGEND

(40) DRAWDOWN AT PROPOSED WELL LOCATION

10 ESTIMATED DRAWDOWN

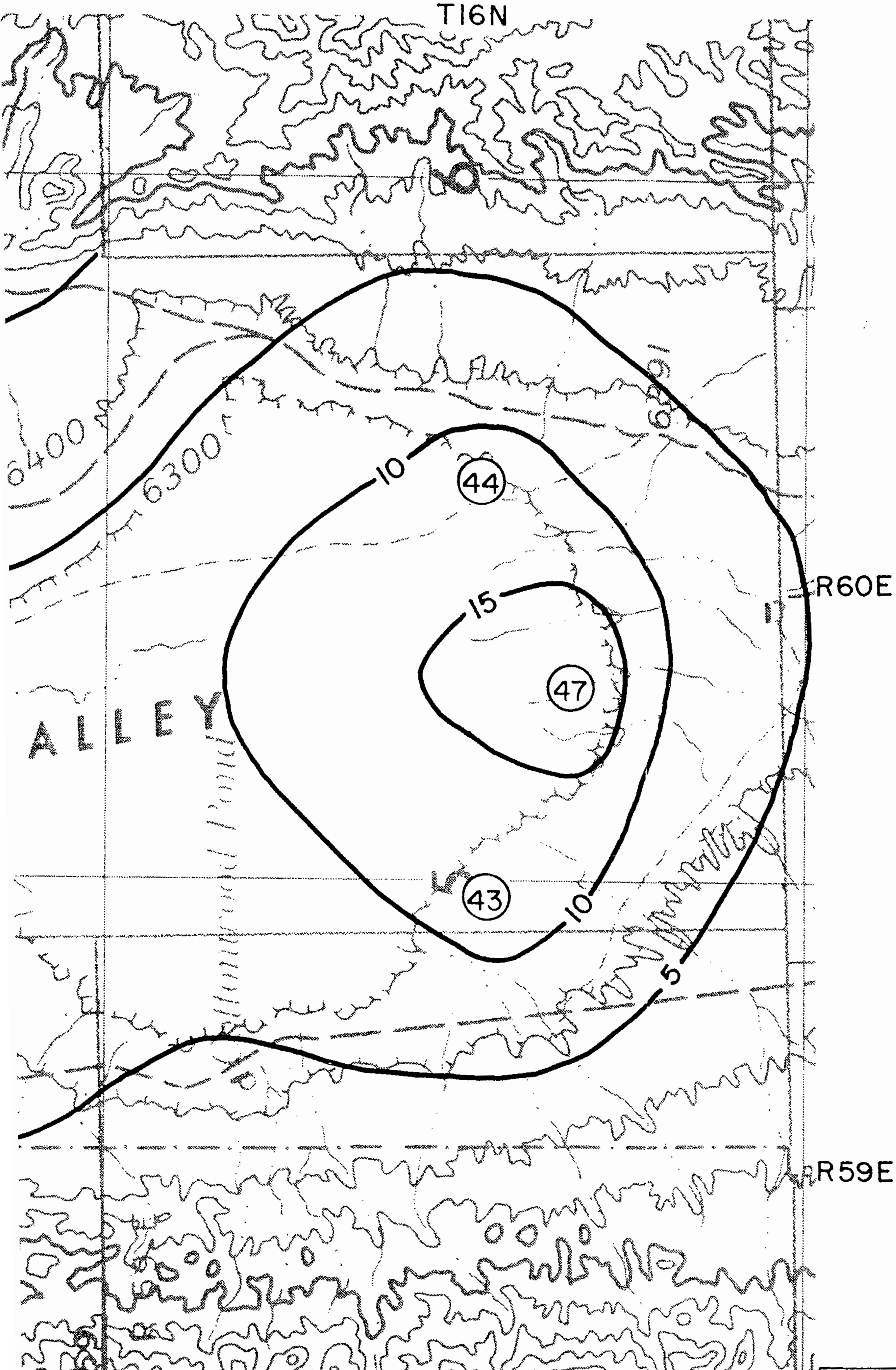
August 1981

WHITE PINE POWER PROJECT

BUTTE VALLEY

Preliminary Well Field Drawdown Estimate

PLATE V



LEGEND

(40) DRAWDOWN WELL LOCA

10 ESTIMATED

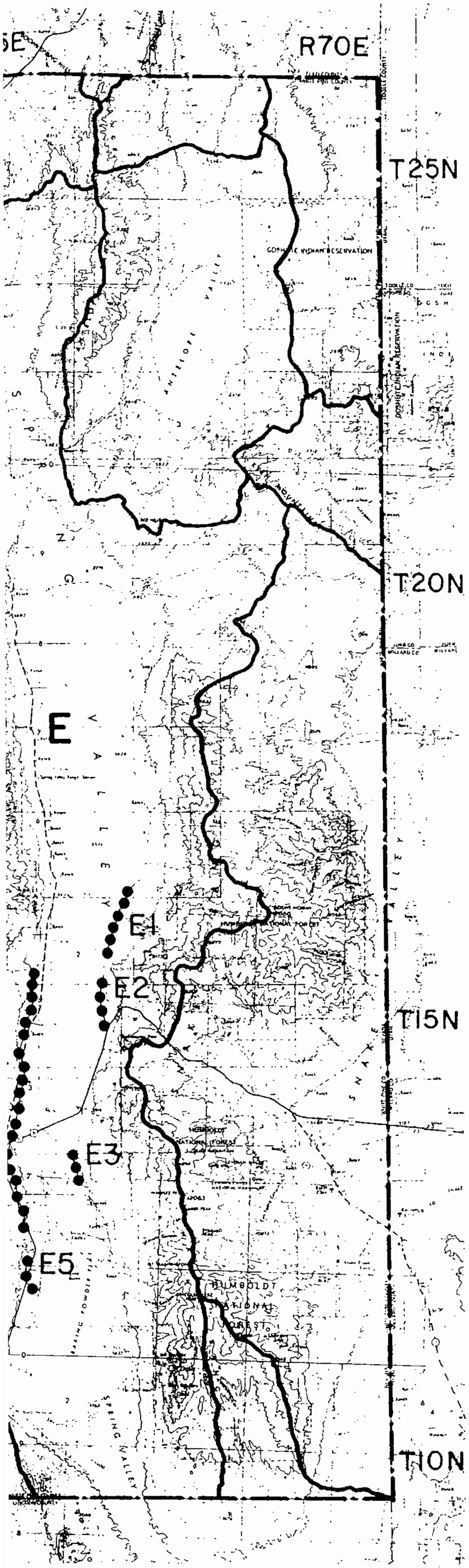
WHITE PINE POWER P

JAKES VALLE

Preliminary Well Field Draw

August 1981

PLATE VI



LEGEND

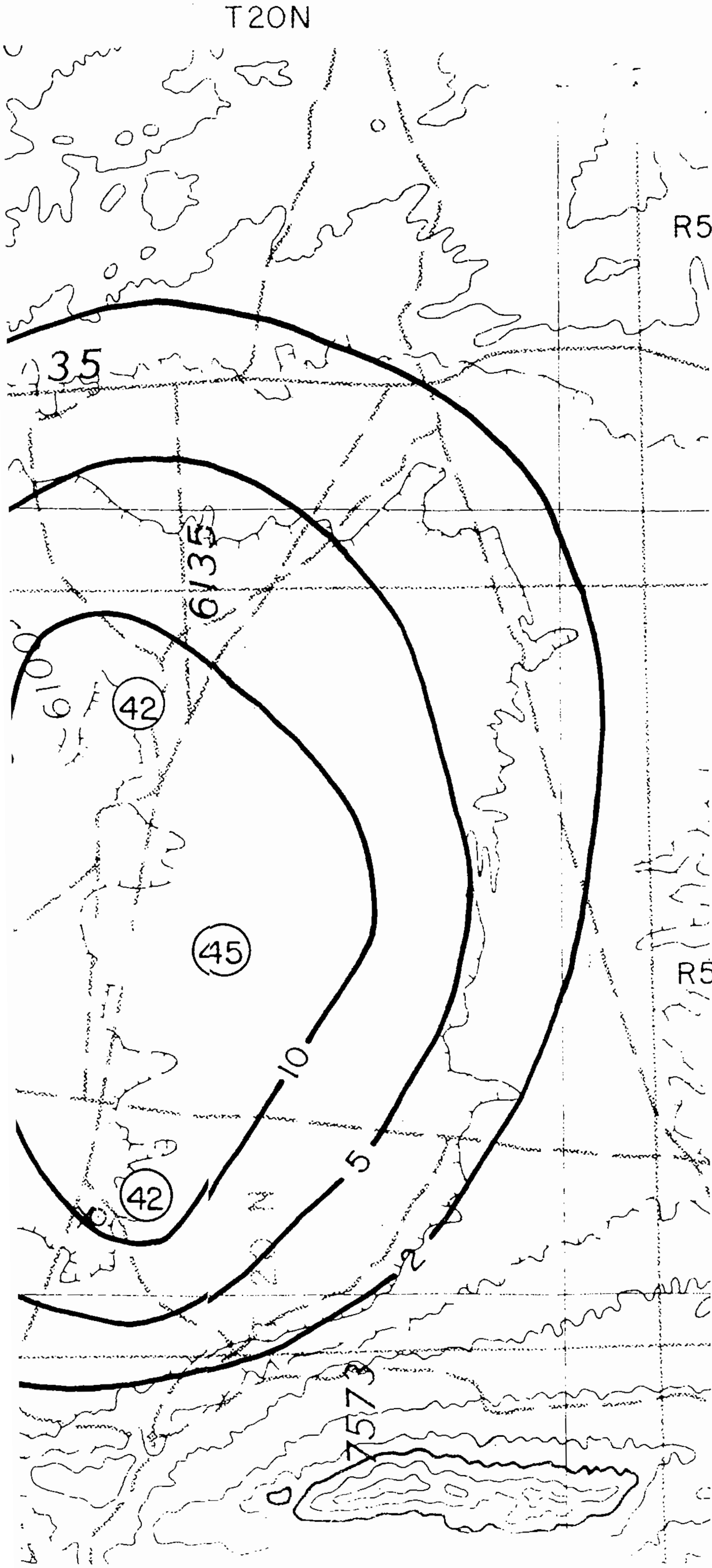
- COUNTY BOUNDARY
- BASIN BOUNDARY
- PRELIMINARY WELL FIELD LOCATION

WELL FIELD LOCATION CODE FOR EACH VALLEY

A BUTTE VALLEY WELLS
B JAKES VALLEY WELLS
C LONG VALLEY WELLS
D NEWARK VALLEY WELLS
E SPRING VALLEY WELLS
F STEPTOE VALLEY WELLS
G WHITE RIVER VALLEY WELLS

WHITE PINE POWER PROJECT

PRELIMINARY WELL FIELD LOCATIONS



LEGEND

(40) DRAWDOWN AT PROPOSED WELL LOCATION

10 ESTIMATED DRAWDOWN

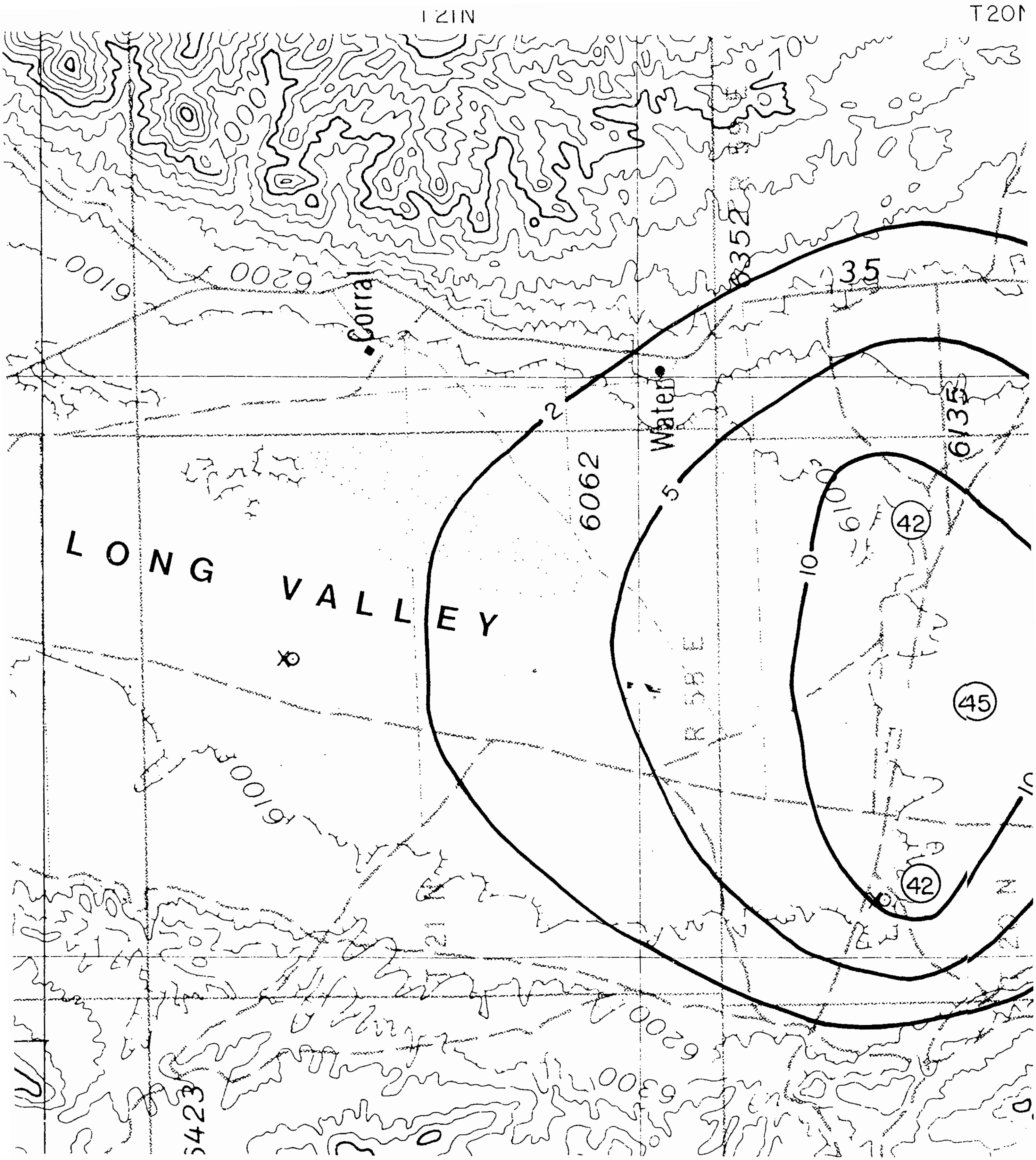
August 1981

WHITE PINE POWER PROJECT

LONG VALLEY

Preliminary Well Field Drawdown Estimates

PLATE VII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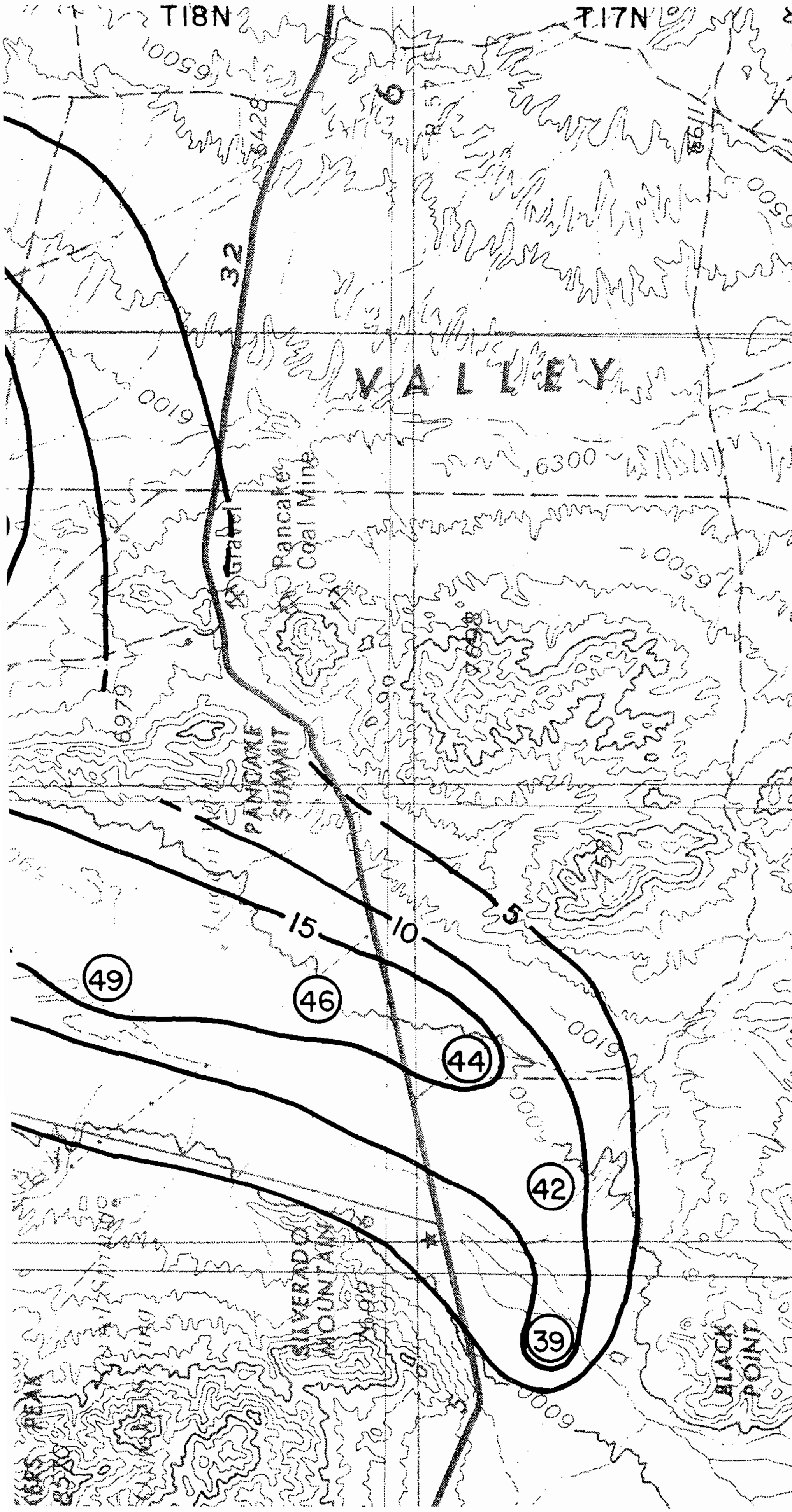


LEGEND

(40) DRAWDOWN AT WELL LOCATIC

10 ESTIMATED DF

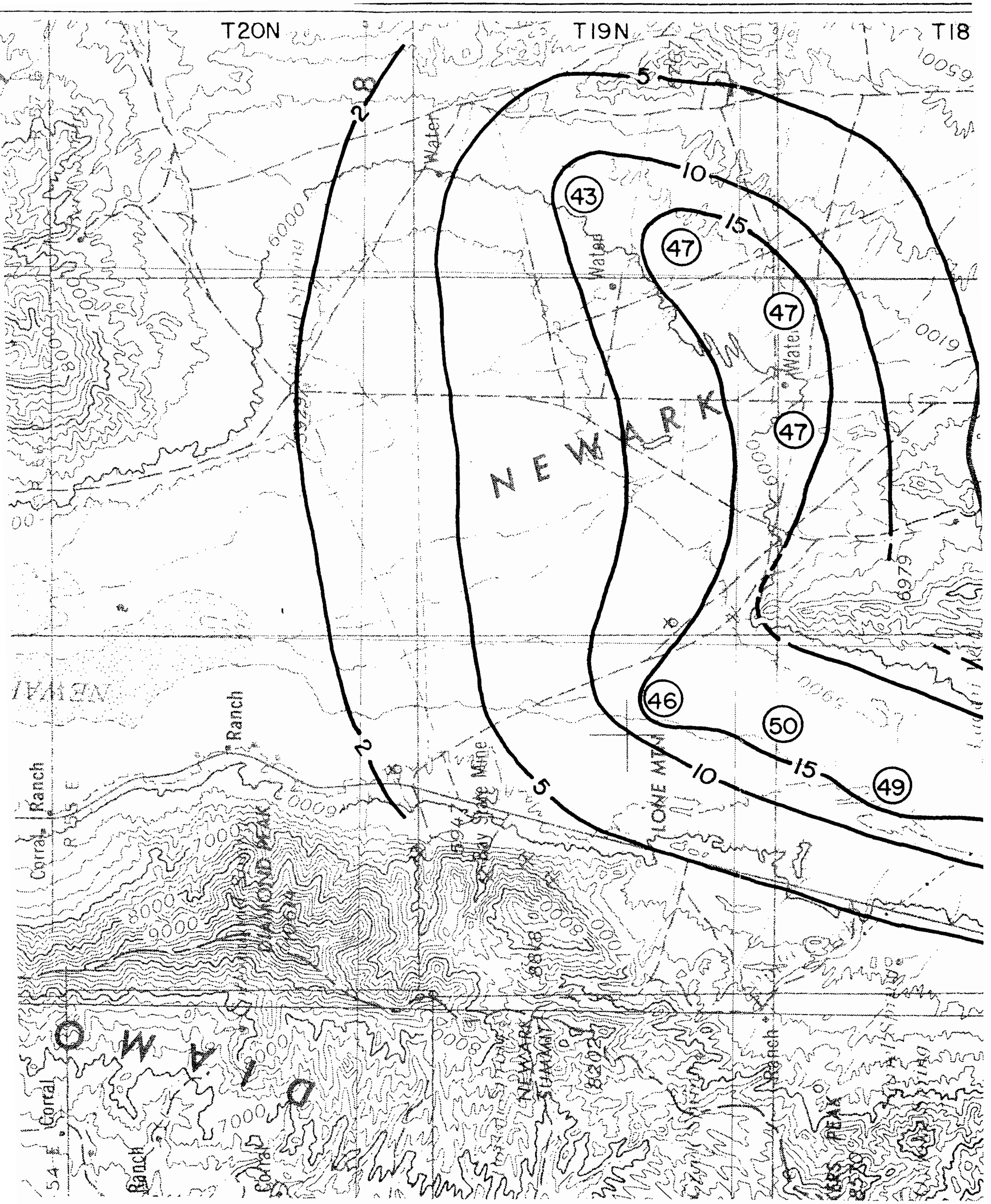
August 1981

WHITE PINE POWER PR

NEWARK VALLE

Preliminary Well Field Drawdc

PLATE VIII



T20N
T19N
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NEWARK
LONE MTN
DIAMOND PEAK
NEWARK SUMMIT
Water
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Corral
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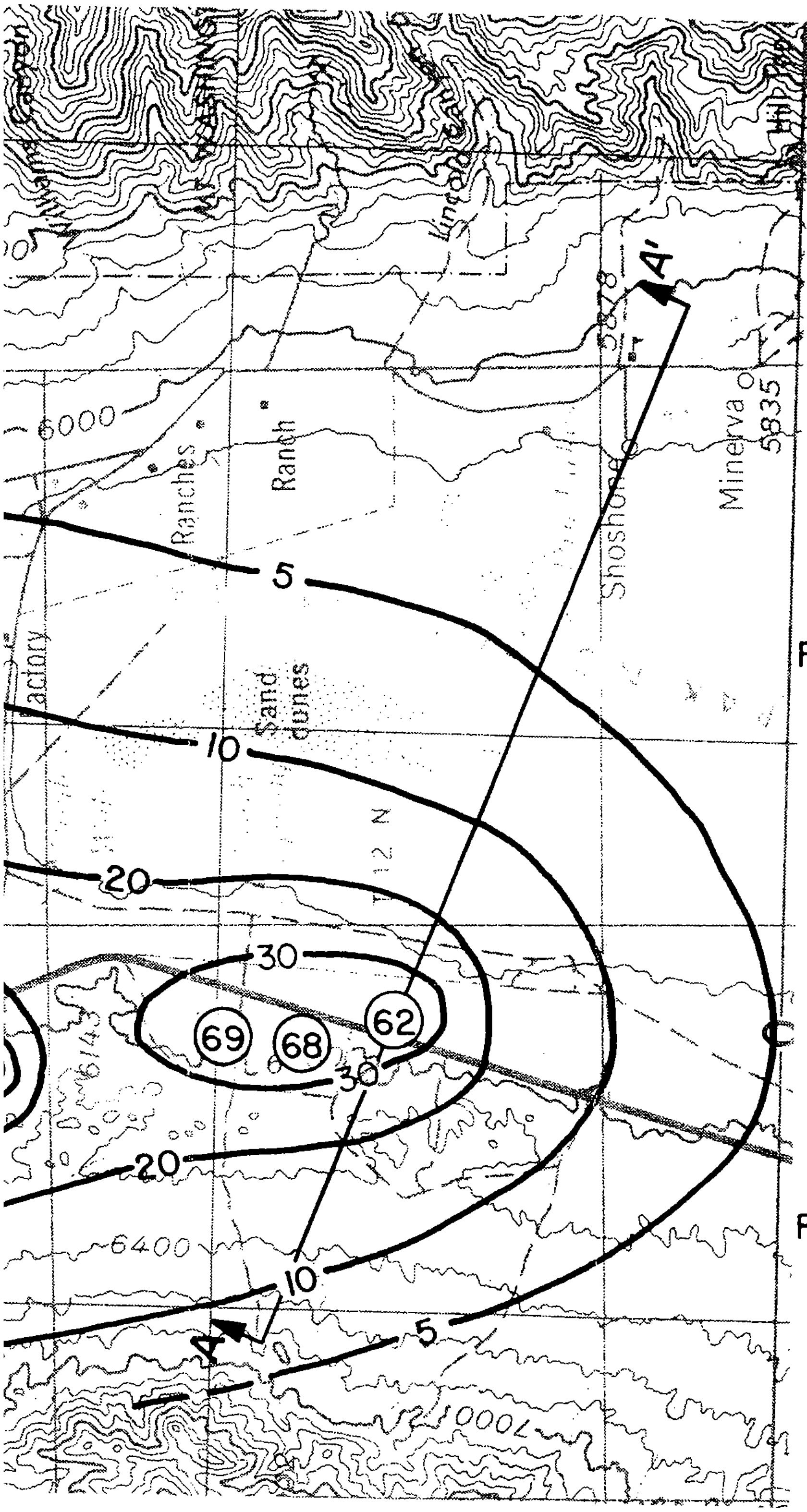
T12N



LEGEND

(40) DRAWDOWN AT PROPOSED WELL LOCATION

10 ESTIMATED DRAWDOWN

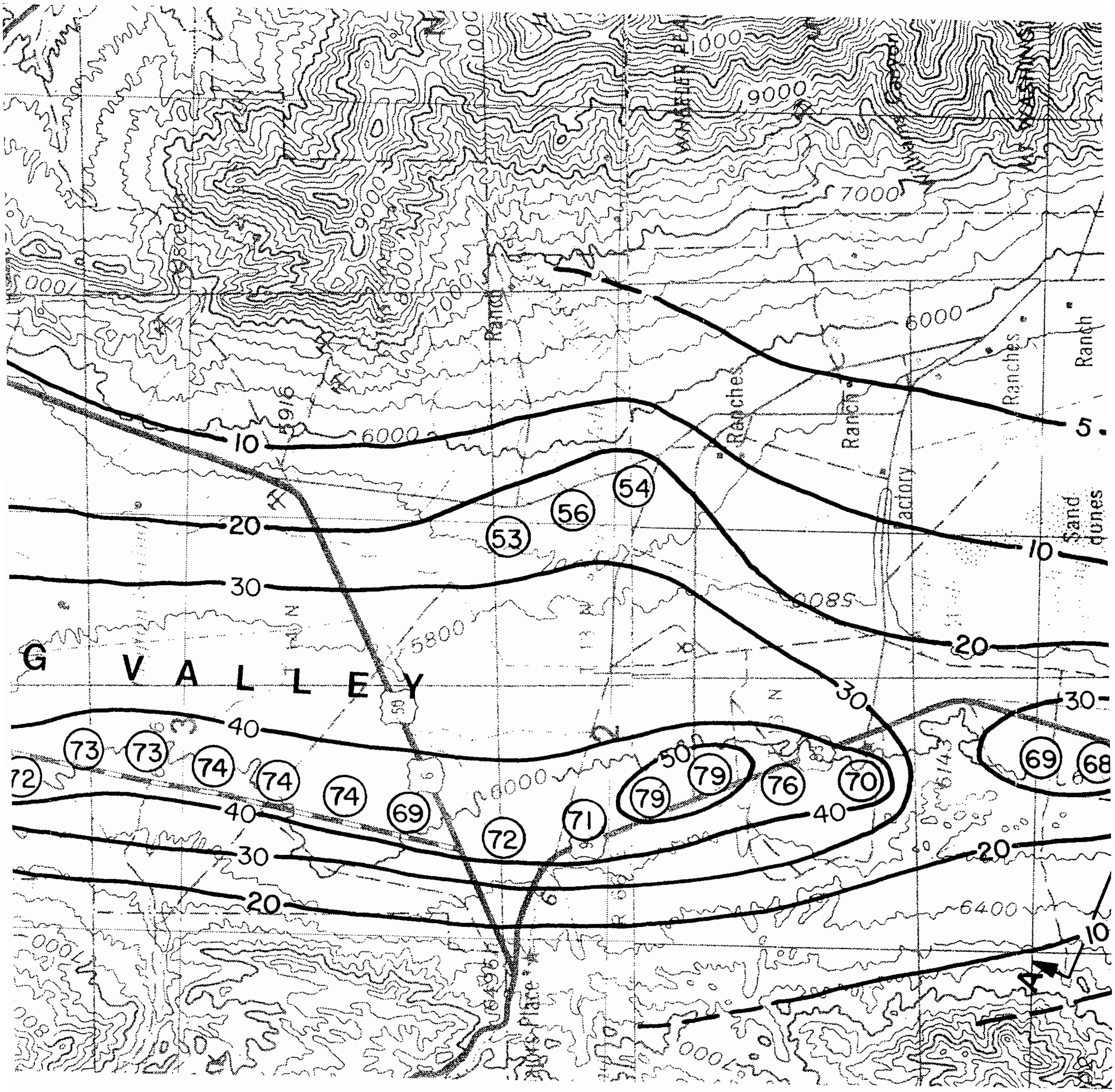
August 1981

WHITE PINE POWER PROJECT

SPRING VALLEY

Preliminary Well Field Drawdown Estimates

PLATE IX



9000
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Ranches
Ranch
Ranches
Ranch
5
10
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54
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Sand dunes
30
5800
20
G VALLEY
30
40
73
73
74
74
74
69
72
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76
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68
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30
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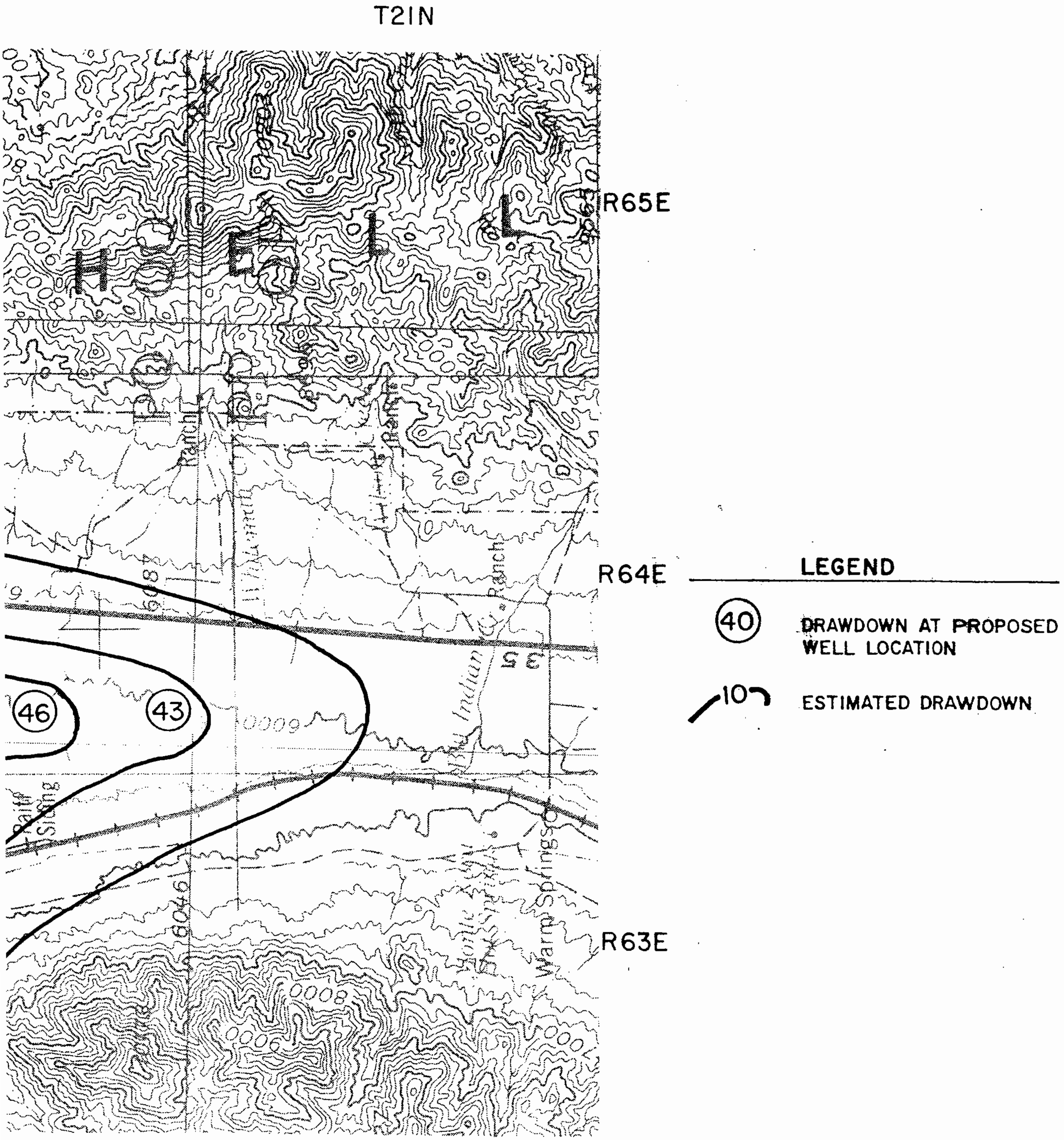
6400
20
10



August 1981

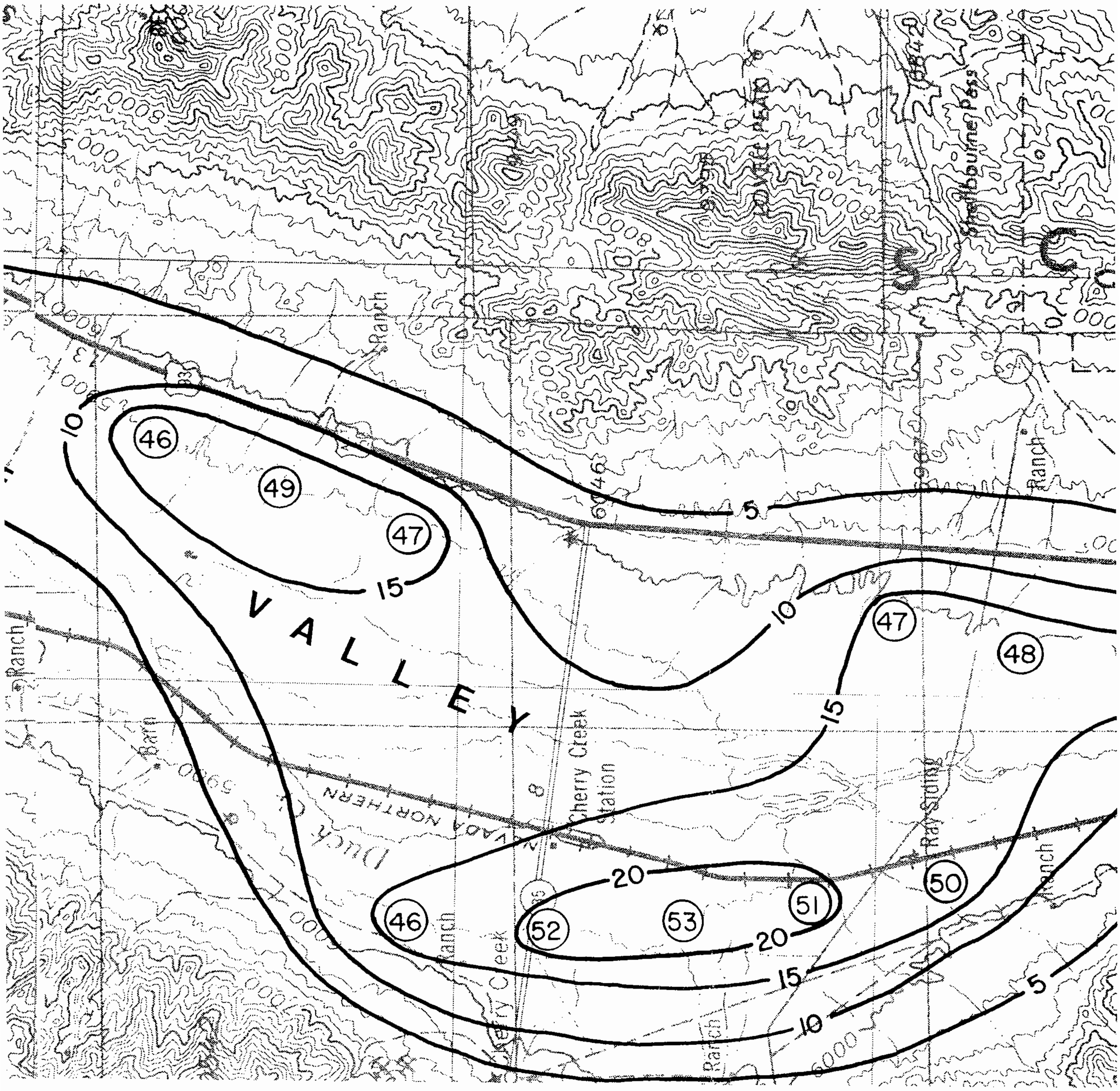
WHITE PINE POWER PROJECT

STEPTOE VALLEY

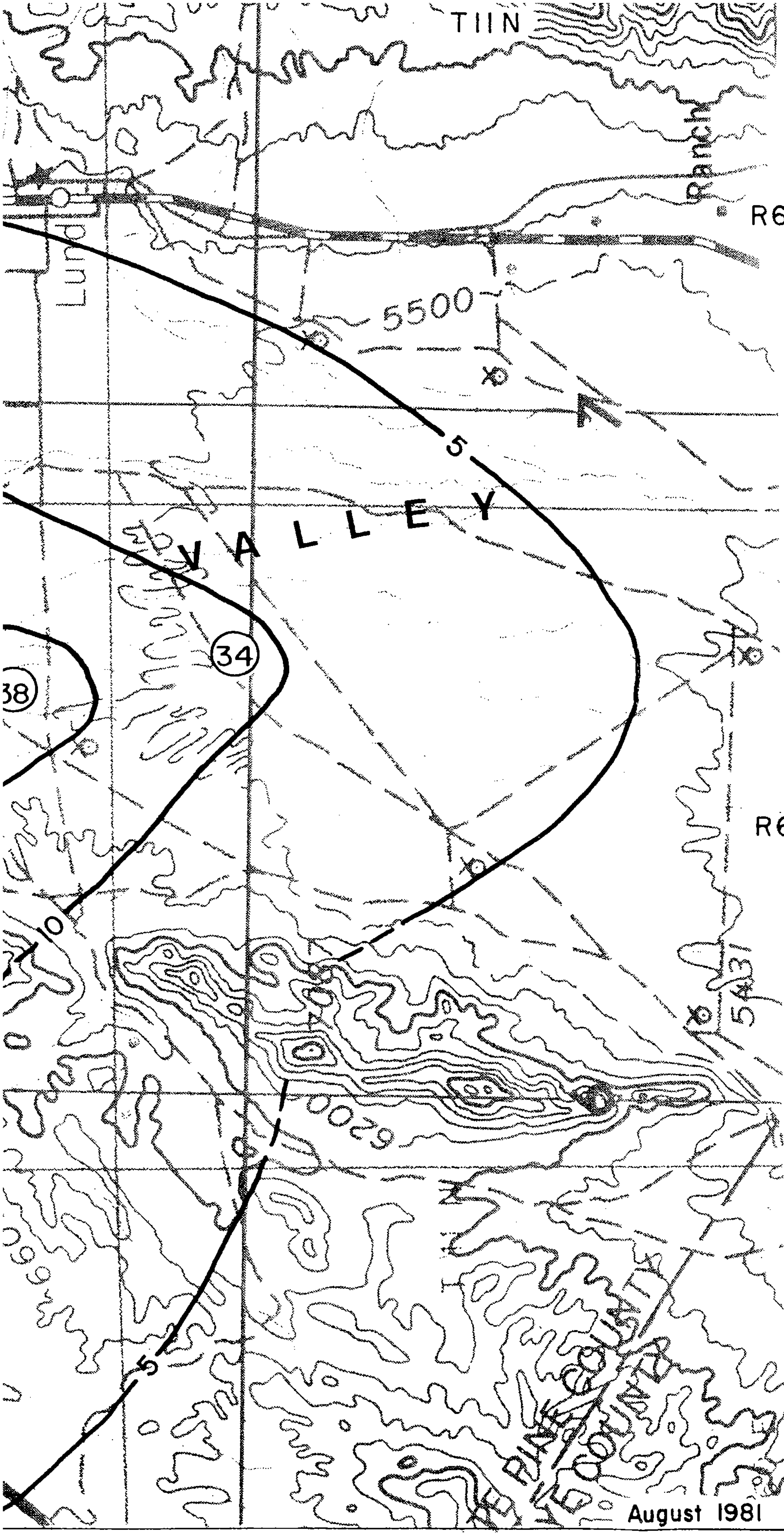
Preliminary Well Field Drawdown Estimates

PLATE X

T23N



VALLEY
5
10
15
20
46
49
47
47
48
46
52
53
51
50
Cherry Creek
Station
Cherry Creek
Raystring
Ranch
Duck
NEVADA NORTHERN
Barn
Shellbourne Pass



R62E

R61E

LEGEND

(40) DRAWDOWN A
WELL LOCAT

10 ESTIMATED I

1 0 1 2

WHITE PINE POWER P

WHITE RIVER VAL

Preliminary Well Field Drawd

PLATE XI

TABLES

Table 4-1

Calculated Aquifer Characteristics by Valley

Valley	Well Location	Discharge gpm	Transmissivity gpd/ft	Storage Coefficient (ft^3/ft^3)	Type of Test 1/
Spring	T15N/R67E-19	525	5550	-	D
	T13N/R67E-15*	400	11,100	0.0036	D
	T13N/R67E-15*	400	16,900	0.0003	R
	T12N/R67E-24	500	6800	-	R
Steptoe	T26N/R65E-27	1500	51,100/9200**	-	D
	T26N/R65E-27	1500	56,600/29,300**	-	R
	T18N/R63E-36	900	160,000	-	D
	T16N/R63E-16	1030	6300/181,300**	-	D
	T16N/R63E-16	1030	61,800/170,000**	-	R
	T12N/R63E-12	118	440/1250**	-	D 2/
White River	T13N/R60E-26	900	95,000	-	R
	T12N/R62E-19	1700	460,000	-	R

1/ D - constant rate discharge test
R - recovery test
2/ Carbonate aquifer (nonfractured Ely Limestone)
* Measurements taken in an observation well.
** Groundwater boundary condition encountered.

Table 4-2

Comparison of Aquifer Characteristic Evaluation Methods

Well Location	Theis Method		Cooper-Jacob Method	
	Transmissivity gpd/ft	Storage Coefficient ft^3/ft^3	Transmissivity gpd/ft	Storage Coefficient ft^3/ft^3
Spring Valley				
T13N/R67E-15(D)	9800	0.0047	11,000	0.0036
T13N/R67E-15(R)	15,400	0.0003	16,900	0.0002
Steptoe Valley				
T26N/R65E-27(R)	26,400	-	29,300	-

(D) Constant rate drawdown test.
(R) Recovery test.

Table 4-3

Anticipated Aquifer Characteristics at Preliminary Well Field Sites

Valley	Well Depth (feet)	Well Yield (gpm)	Transmissivity (gpd/ft)	Storage Coefficient (ft^3/ft^3)
Spring	500-600	450	30,000	0.10
Steptoe	500-600	750	50,000	0.10
White River	300-500	1000	95,000	0.10

Table 6-1

State of Nevada Estimates of Discharge

	Diamond Valley (incl. So.)			Railroad Valley (incl. So.)		
	Area acres	Consumptive Use afy/ac	Total Discharge afy	Area acres	Consumptive Use afy/ac	Total Discharge afy
Native Vegetation						
a. Greasewood, etc.				69,500	0.2	14,200
b. Saltgrass, etc.				110,000	0.4	44,000
c. Total	50,000	0.3	15,000			58,200
Meadow and Pasture Grasses						
a. Flooded	1500	3.0	4500	400	4.0	1600
b. Not flooded	4650	1.2	5600	1200	1.5	18,000
c. Total						
Playa	50,000	0.1	5000	38,000	0.1	3800
TOTAL	106,150		30,100	233,900		80,200

References (69,189)

Table 6-2

Independent Calculation of Discharge

	Diamond Valley (incl. So.)			Railroad Valley (incl. So.)		
	Area acres	Consumptive Use afy/ac	Total Discharge afy	Area acres	Consumptive Use afy/ac	Total Discharge afy
Native Vegetation						
Greaswood, rabbit-bush, saltbush, saltgrass	19,000 1/	0.1	1900	650,000 1/	0.1	65,000
Meadow and Pasture Grasses	18,000	1.0	18,000	2/	1.0	-
Playa	36,000	0.1	3600	48,000	0.1	4800
Irrigated Land	35,000	1.5	52,500	12,000	1.5	18,000
TOTAL	108,000		76,000	710,000		87,800

1/ Adjusted to reflect irrigated lands.
2/ Included in irrigated land.

Table 7-1

Well Field Characteristics

Valley	Well Field Designation 1/	Number of Wells	Pumping Rate Per Well (gpm)	Well Field Yield (af/yr)	Limiting Criterion 2/
Butte	A1	3	450	2100	1 or 2
	A2	3	450	2100	1 or 2
	A3	4	450	2900	1 or 2
Jakes	B1	3	450	2100	1
	B2	3	450	2100	1
	B3	3	450	2100	1
Long	C1	3	450	2100	1 or 2
	C2	3	450	2100	1 or 2
Newark	D1	3	450	2100	1 or 2
	D2	4	450	2900	1 or 2
	D3	3	450	2100	1 or 2
	D4	4	450	2900	1 or 2
Spring	E1	6	450	4300	3
	E2	4	450	2900	3
	E3	3	450	2100	3
	E4	19	450	13,800	3
	E5	3	450	2100	3
Steptoe	F1	4	750	4800	3
	F2	6	750	7200	3
	F3	3	750	3600	3
	F4	5	750	6000	3
	F5	4	750	4800	3
White River	G1	12	1000	19,300	1 or 2

1/ See Plate IV for well field locations within each valley.
2/ 1 = 50% perennial yield; 2 = perennial yield - existing water rights, 3 = power plant requirements.

Table 7-2

Estimated Aquifer Characteristics

	Well Yield (gpm)	Aquifer Thickness (ft)	Transmissivity Fan Area (gpd/ft)	Transmissivity Playa Area (gpd/ft)	Storage Coefficient Fan Area (percent)	Storage Coefficient Playa Area (percent)
Butte	450	500	30,000	6000	0.10	0.01
Jakes	450	500	30,000	6000	0.10	0.01
Long	450	500	30,000	6000	0.10	0.01
Newark	450	500	30,000	6000	0.10	0.01
Spring	450	500	30,000	6000	0.10	0.01
Steptoe	750	500	50,000	10,000	0.10	0.01
White River	1000	500	95,000	20,000	0.10	0.01

Table 7-3

Estimated Pump Lifts for Well Field Centers

Well-Field Code 1/	Well (if not center well)	Static Depth to Water (feet) 2/	Draw-down (feet) 3/	Allowance (feet) 4/	Total Pump Lift (rounded feet)
A1		130	48	20	200
A2		110	47	20	180
A3		100	48	20	170
B1		400*	44	20	460
B2		400*	46	20	470
B3		400*	47	20	470
C1		150*	41	20	210
C2		100	45	20	170
D1		80	43	20	140
D2		60	47	20	130
D3		60	50	20	130
D4		60	44	20	130
E1		80	63	20	160
E2		100	58	20	180
E3		100	56	20	180
E4	North	125	74	20	215
E4	Middle	150	74	20	240
E4	South	150	71	20	240
E5		150	68	20	240
F1		50	50	20	120
F2		50*	60	20	130
F3		30	49	20	100
F4		30	53	20	100
F5		60	48	20	130
G1	West	30	38	20	90
G1	Middle	150	44	20	210
G1	South	75	42	20	140

1/ See Plate IV for well field code.
2/ Static depth to water determined from water table contours shown on Plate III.
3/ Drawdown calculations after 25 years.
4/ 20 feet allowance for aquifer inhomogeneities and reduced recharge in dry years.
* Estimate

Table 7-4

Source of Pumped Water

(Cumulative Mass-Balance Over 25 Years)

Valley	Recharge (Percent)	Storage (Percent)
Spring	48.4	51.6
Steptoe	67.8	32.2
White River	59.9	40.1
Jakes	51.2	48.8
Butte	42.2	57.8
Long	52.2	47.8
Newark	47.0	53.0

Note: Recharge = from constant head boundary
Storage = from aquifer depletion

Table 8-1

Summary of Groundwater Rights as of June, 1981
Acre Feet Per Year (Rounded)

Category	Steptoe	White River	Newark	Jakes	Butte	Long	Spring
Certified Rights	39,000	13,200	8200	-	1600	300	7200
Permitted Rights	1000	5100	700	-	-	2200	14,600
Total Existing Rights	40,000	18,300	8900	-	1600	2500	21,800
Pending Application:							
1. Ahead of Project							
a. Desert Land Entry	97,700	14,000	-	-	-	-	85,000
b. Non-Desert Land Entry		2500	20,500	-	3000	-	1000
2. Project Application	52,000	26,100	26,100	26,100	26,100	26,100	26,100
3. Behind Project							
a. Desert Land Entry	26,000	-	-	-	31,000	-	-
b. Non-Desert Land Entry	22,000	93,400	-	-	-	-	-
4. Total Pending	197,700	136,000	46,600	26,100	60,100	26,100	112,100
Perennial Yield (State Engineer)	70,000	37,000	18,000	12,000	14,000	6,000	100,000

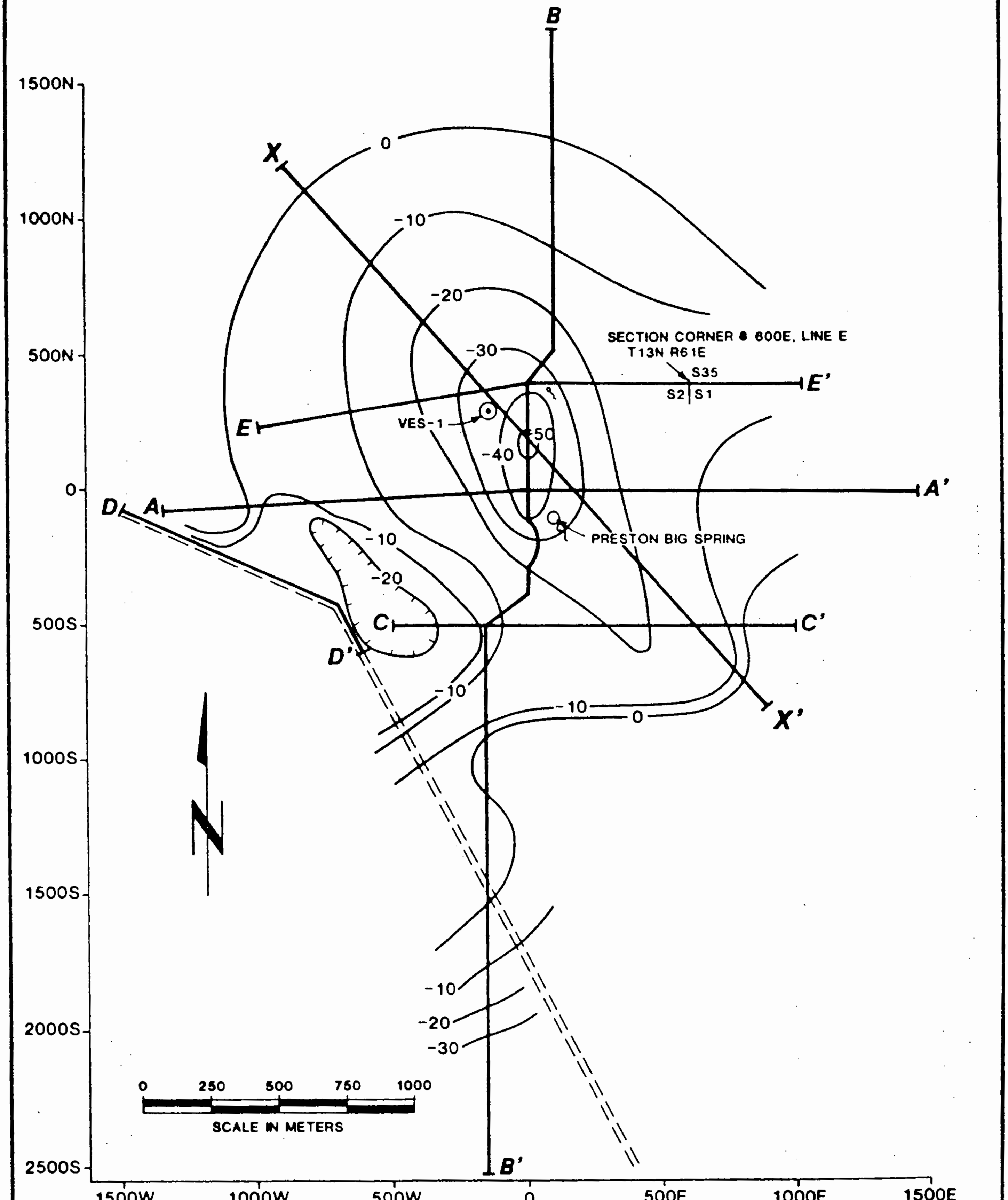
Table 8-2

Groundwater Rights as of August, 1981 for Railroad and Diamond Valleys

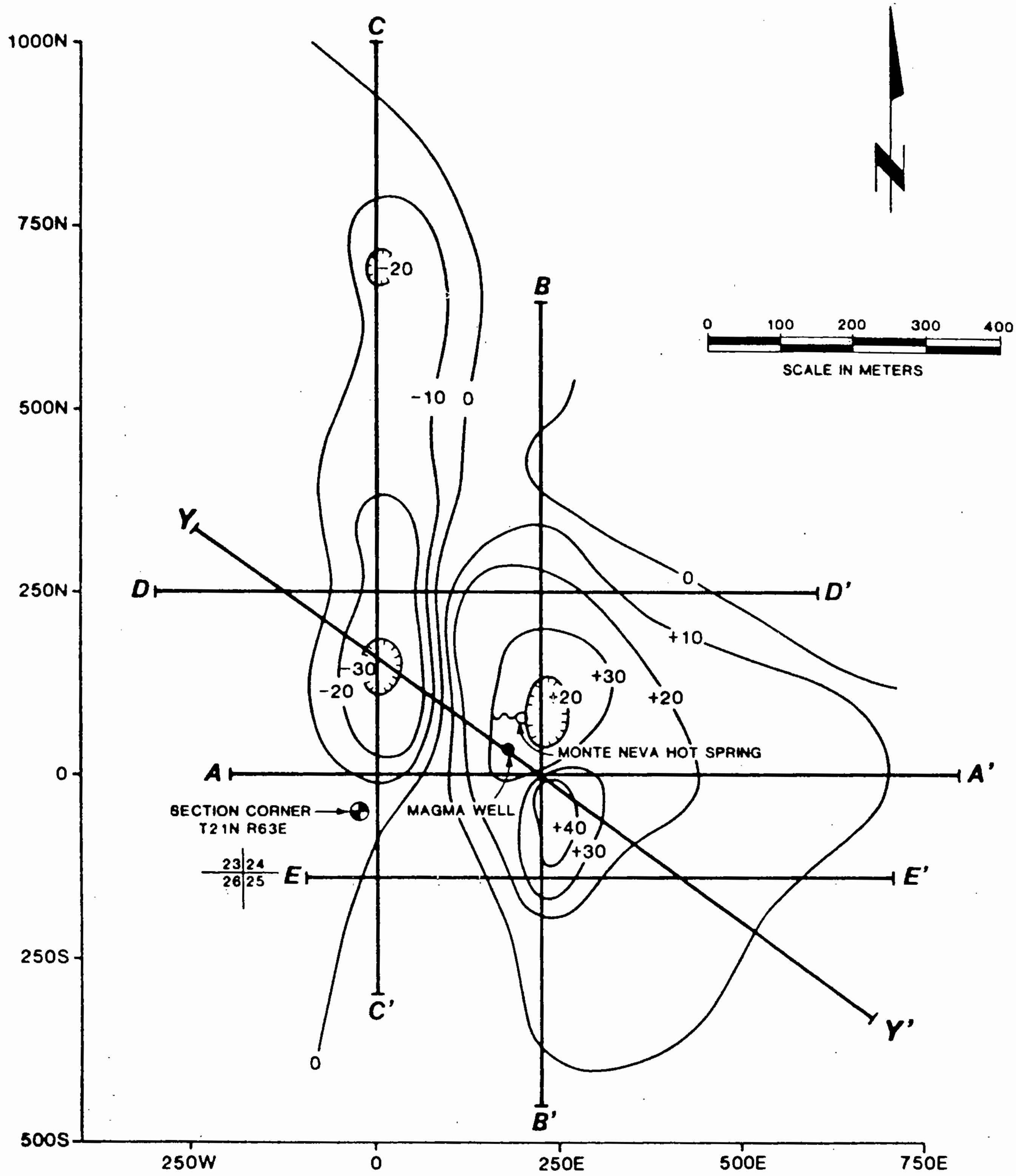
Acre Feet Per Year (Rounded)

Category	Railroad Valley	Diamond Valley
Certified Rights	3500	15,300
Permitted Rights	23,200	139,000
Total Existing Rights	26,700	154,300
Pending Applications:		
1. Desert Land Entry	±22,000	±15,000
2. Total Pending	>100,000	>53,000
Perennial Yield (State Engineer)	68,000	29,900

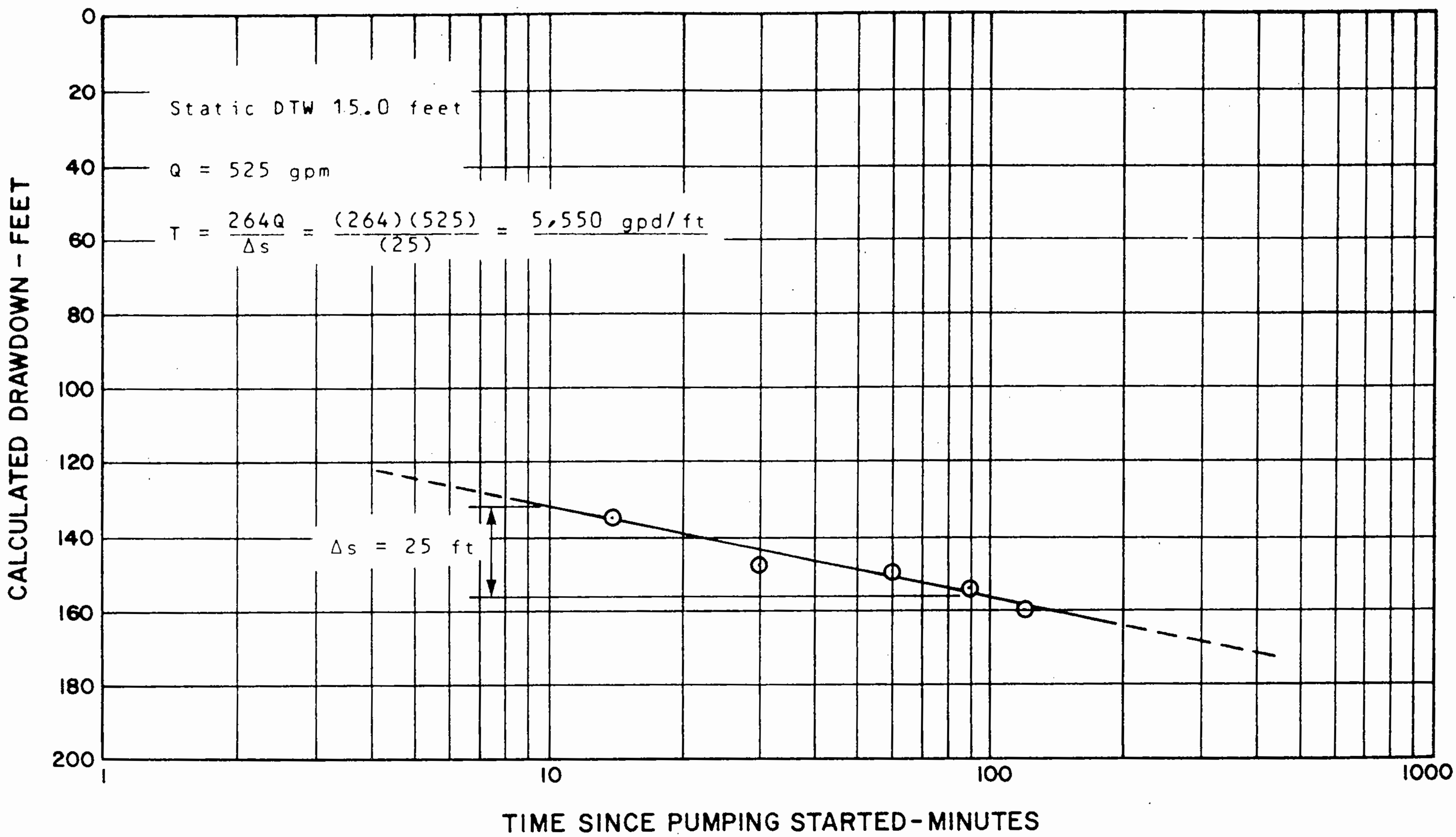
FIGURES



HARDING-LAWSON ASSOCIATES *Engineers, Geologists and Geophysicists*			SP CONTOUR MAP PRESTON BIG SPRING Geophysical Investigation White Pine County, Nevada	PLATE **2**
12,090,001.01	WEB	8/21/81		
Job No.	Approved	Date		



HARDING-LAWSON ASSOCIATES *Engineers, Geologists and Geophysicists*			SP CONTOUR MAP MONTE NEVA HOT SPRING Geophysical Investigation White Pine County, Nevada	PLATE 3
12,090,001.01	WEB	8/21/81		
Job No.	Approved	Date		



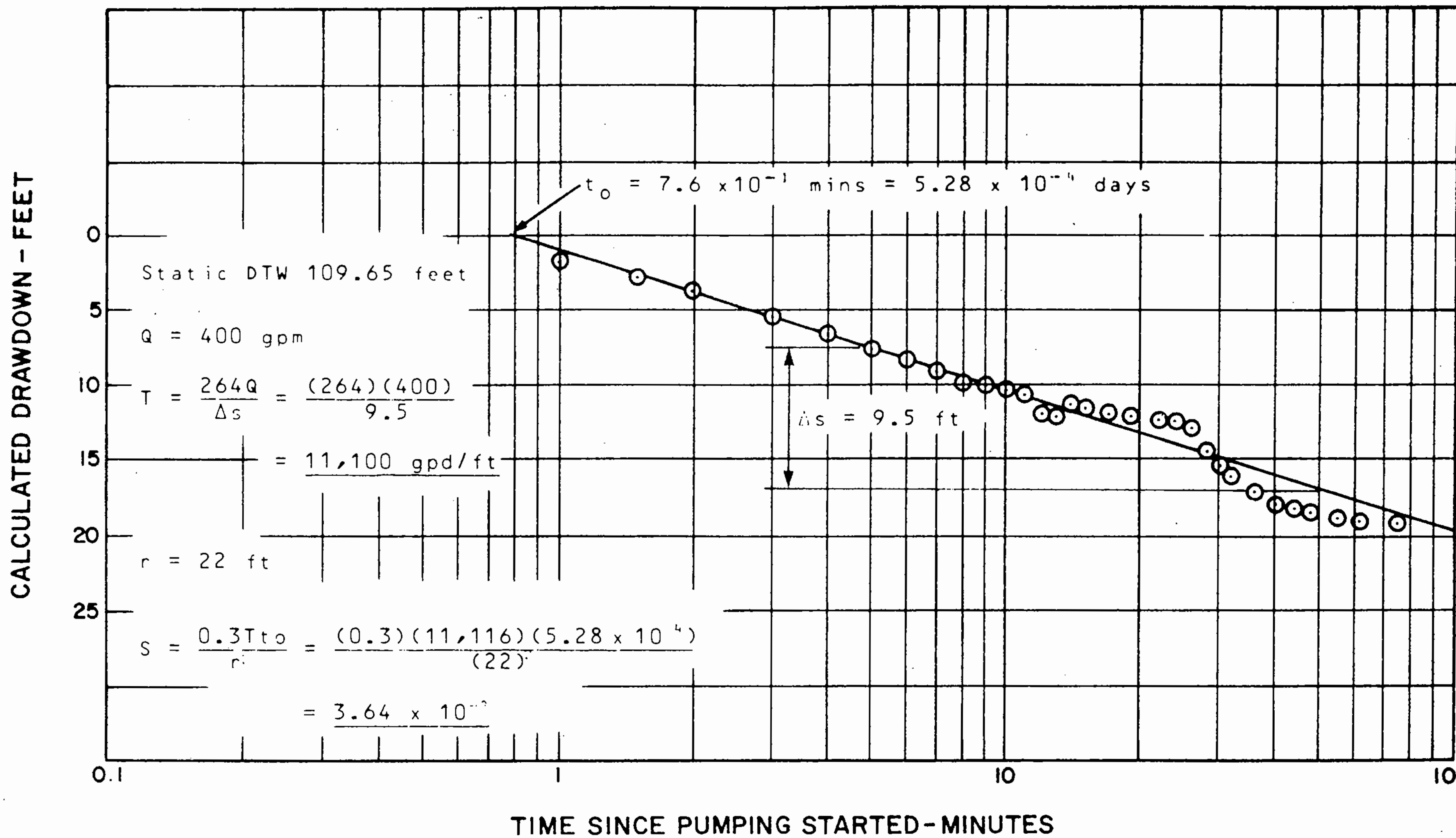
WHITE PINE POWER PROJECT

SPRING VALLEY
Time-Drawdown Curve from Pumping Well
T15N/R67E-19

FIGURE 4-1

Leeds, Hill and Jewett, Inc.

August 1981



WHITE PINE POWER PROJECT

SPRING VALLEY

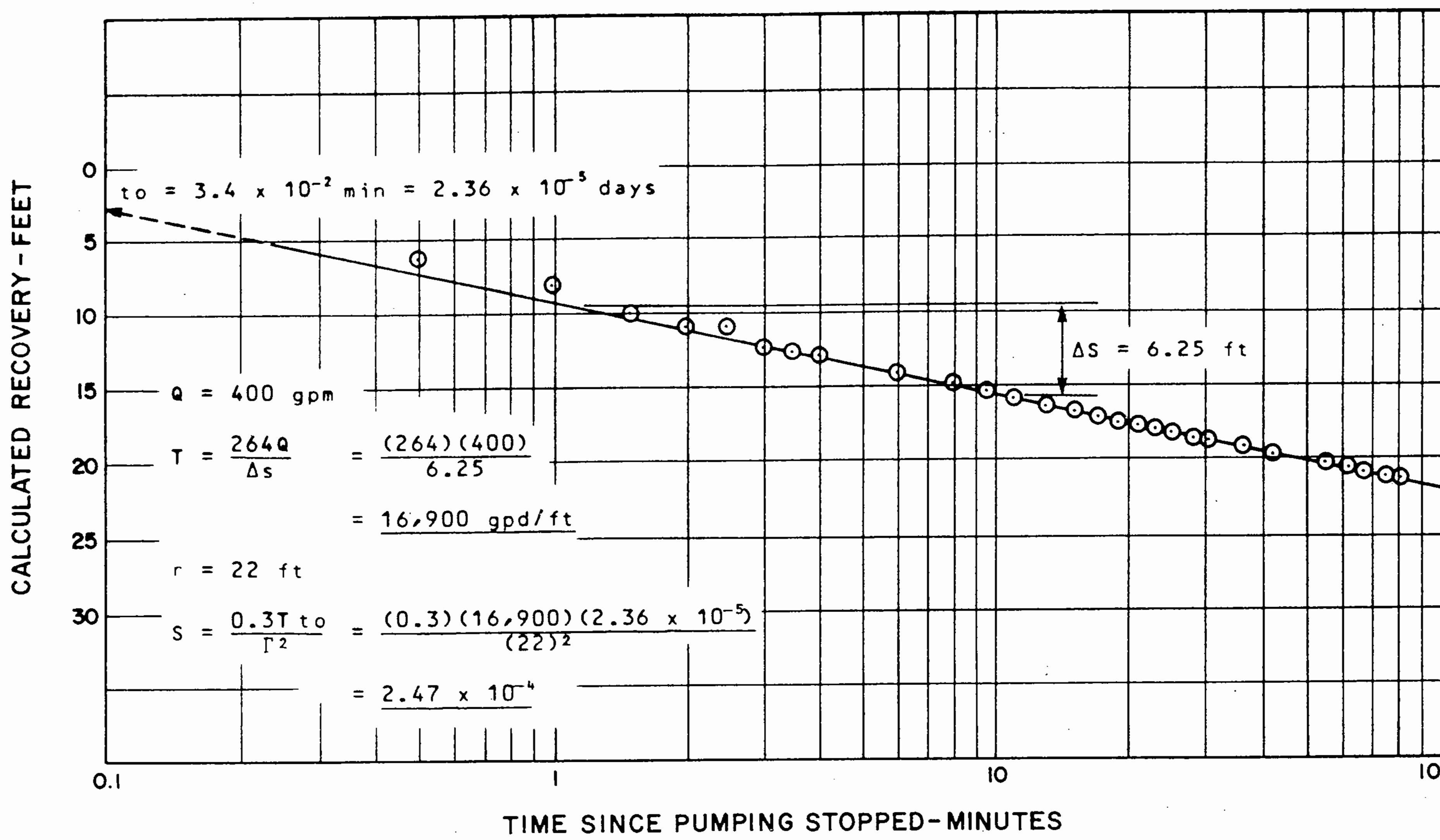
Time-Drawdown Curve from Observation Well

T13N/R67E-15

Leeds, Hill and Jewett, Inc.

August 1981

FIGURE 4-2



WHITE PINE POWER PROJECT

SPRING VALLEY

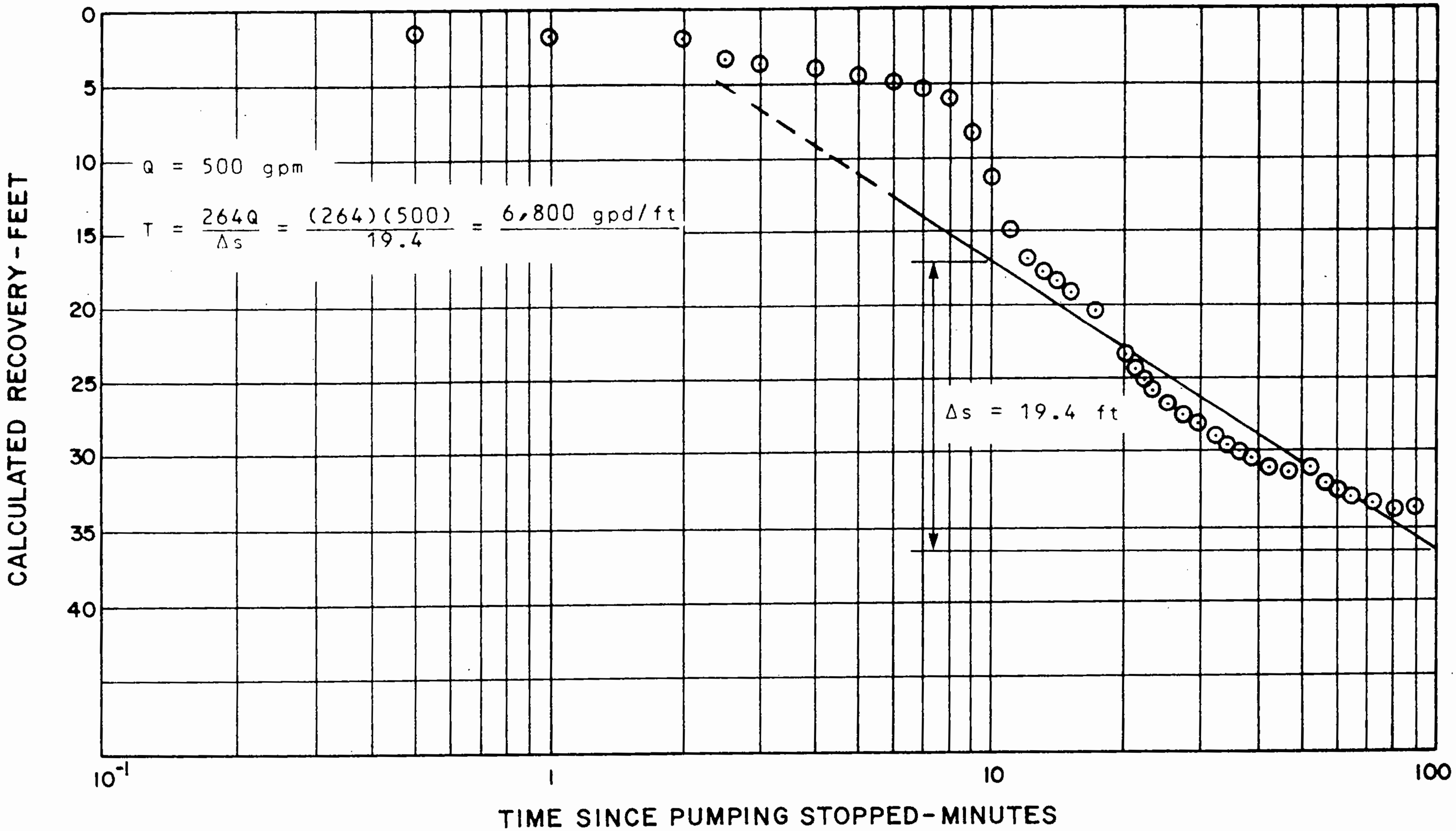
Time-Recovery Curve from Observation Well

T13N/R67E-15

Leeds, Hill and Jewett, Inc.

August 1981

FIGURE 4-3



WHITE PINE POWER PROJECT

SPRING VALLEY

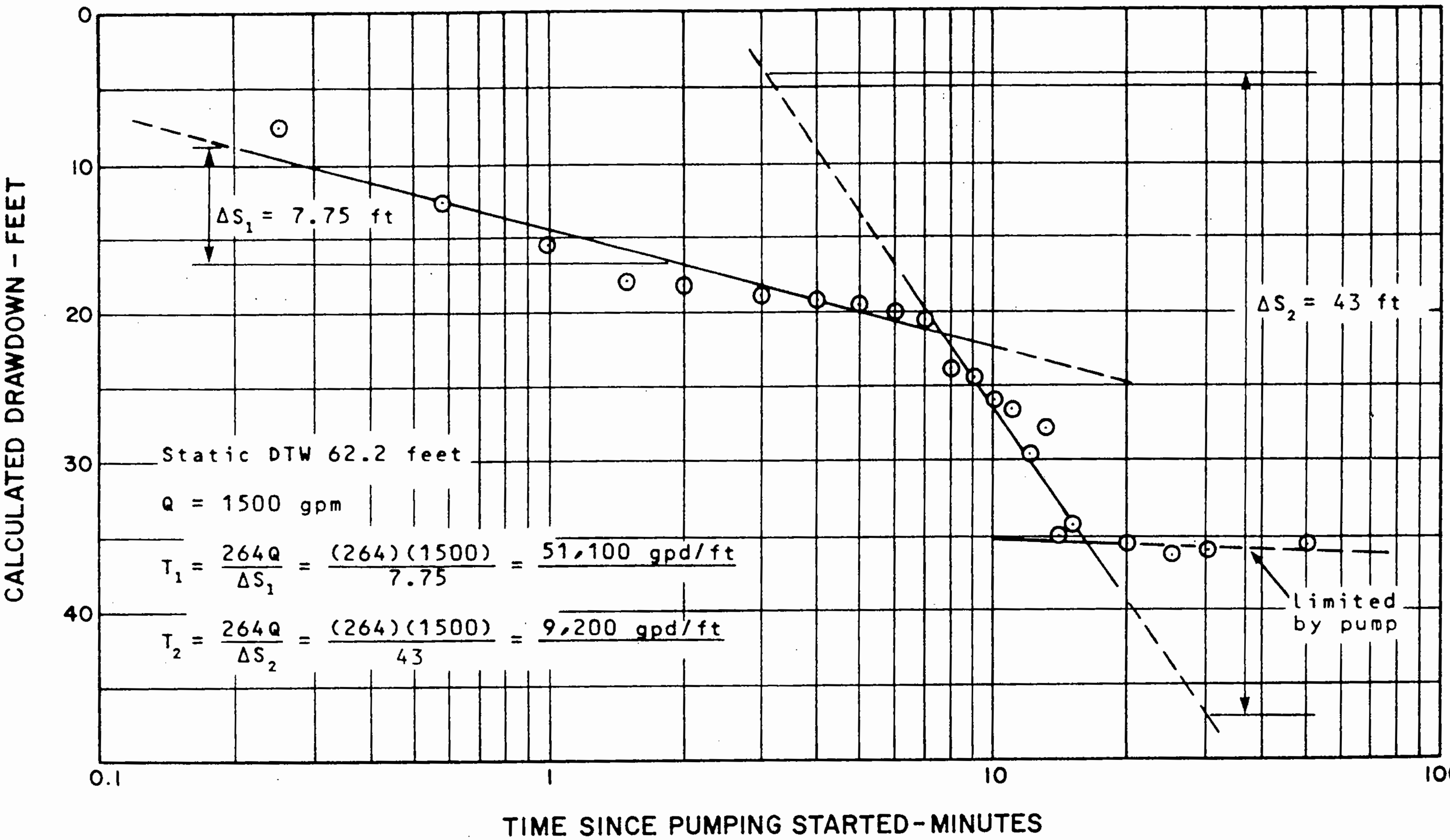
Time-Recovery Curve from Pumping Well

T12N/R67E-24

Leeds, Hill and Jewett, Inc.

August 1981

FIGURE 4-4



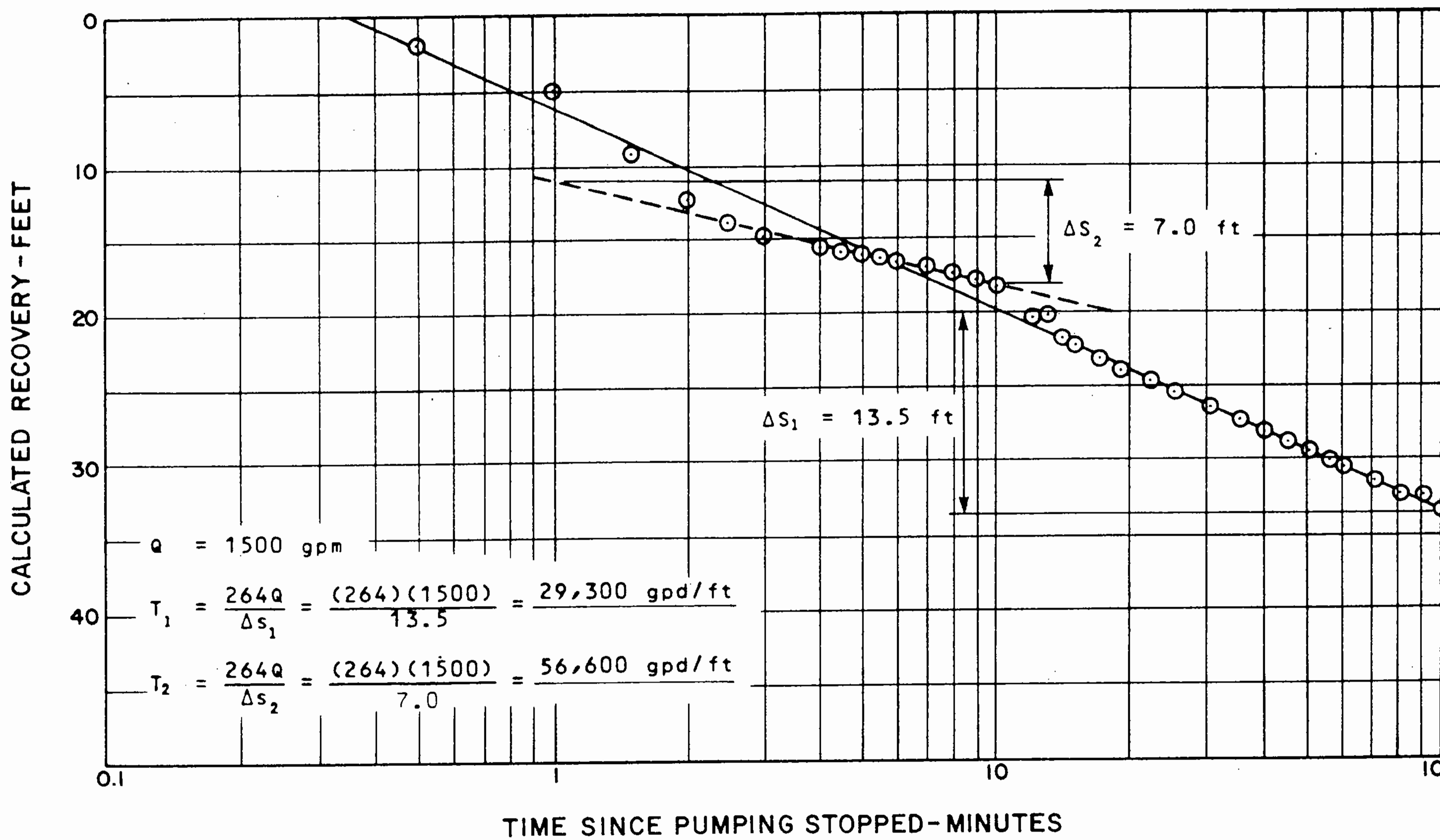
WHITE PINE POWER PROJECT

STEPTOE VALLEY
Time-Drawdown Curve from Pumping Well
T26N/R65E-27

FIGURE 4-5

Leeds, Hill and Jewett, Inc.

August 1981



WHITE PINE POWER PROJECT

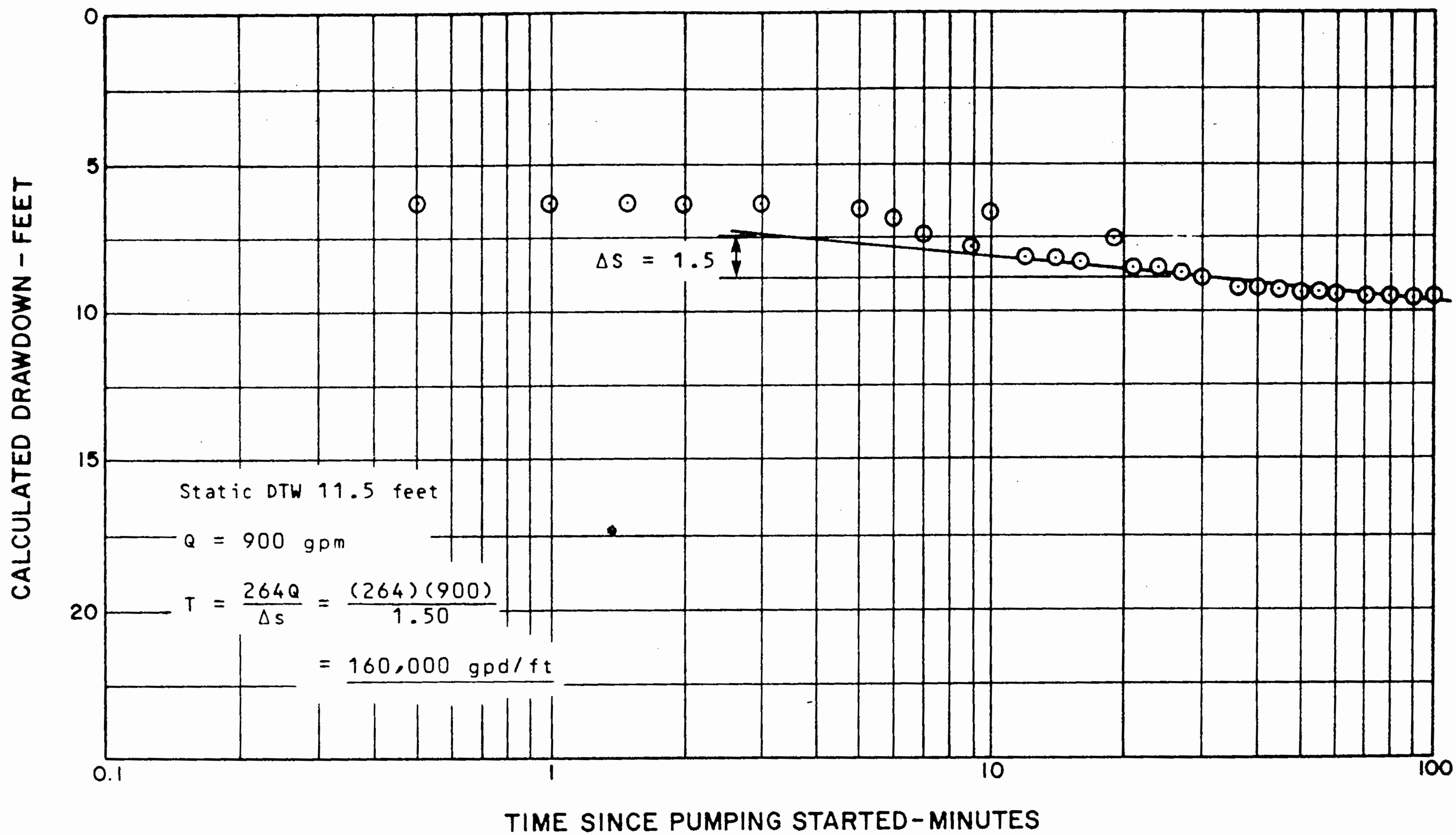
STEPTOE VALLEY

Time-Recovery Curve from Pumping Well
T26N/R65E-27

FIGURE 4-6

Leeds, Hill and Jewett, Inc.

August 1981



Leeds, Hill and Jewett, Inc.

August 1981

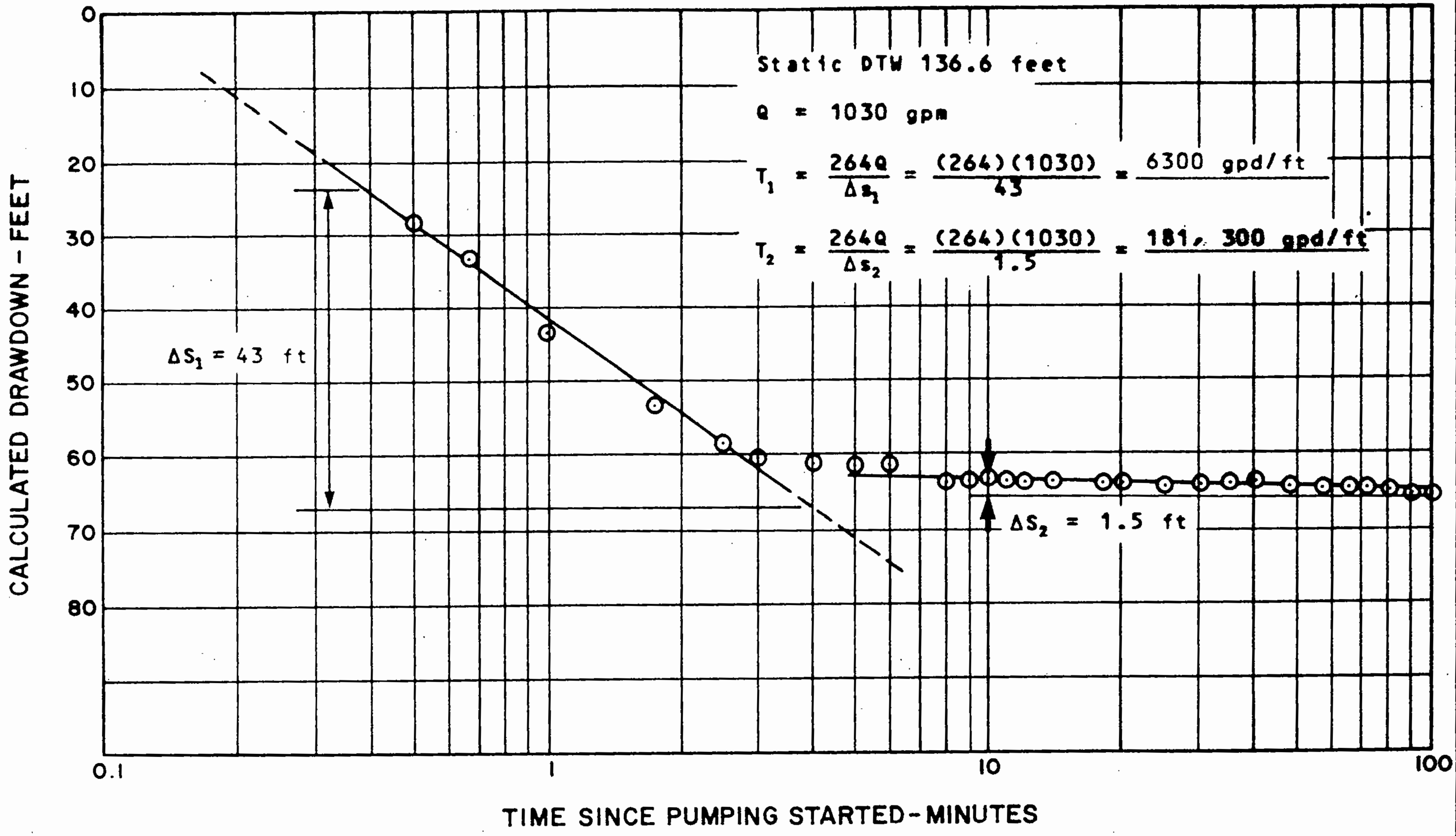
WHITE PINE POWER PROJECT

STEPTOE VALLEY

Time-Drawdown Curve from Pumping Well

T18N/R63E-36

FIGURE 4-7



WHITE PINE POWER PROJECT

STEPTOE VALLEY

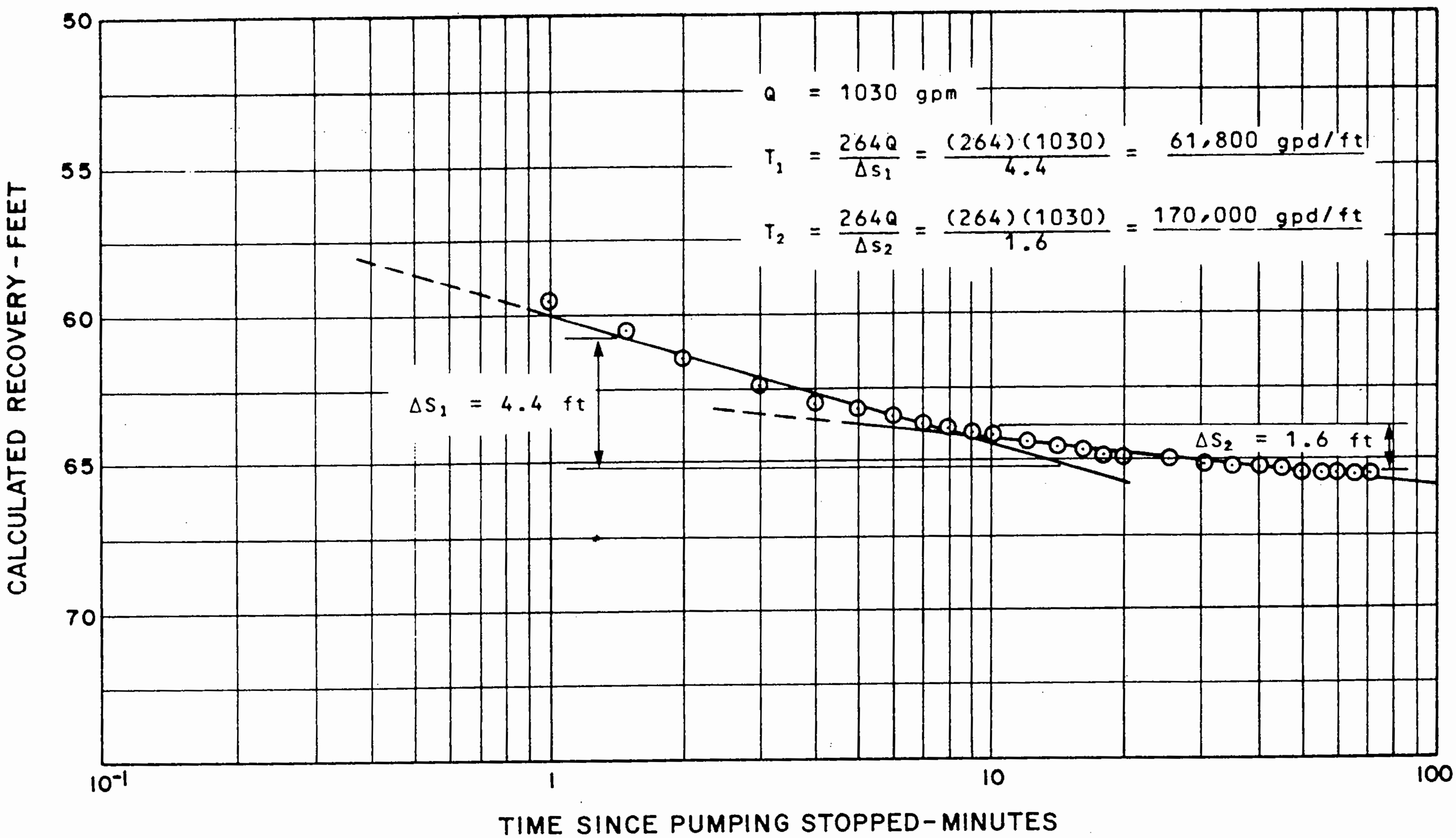
Time-Drawdown Curve from Pumping Well

T16N/R63E-16

Leeds, Hill and Jewett, Inc.

August 1981

FIGURE 4-8



WHITE PINE POWER PROJECT

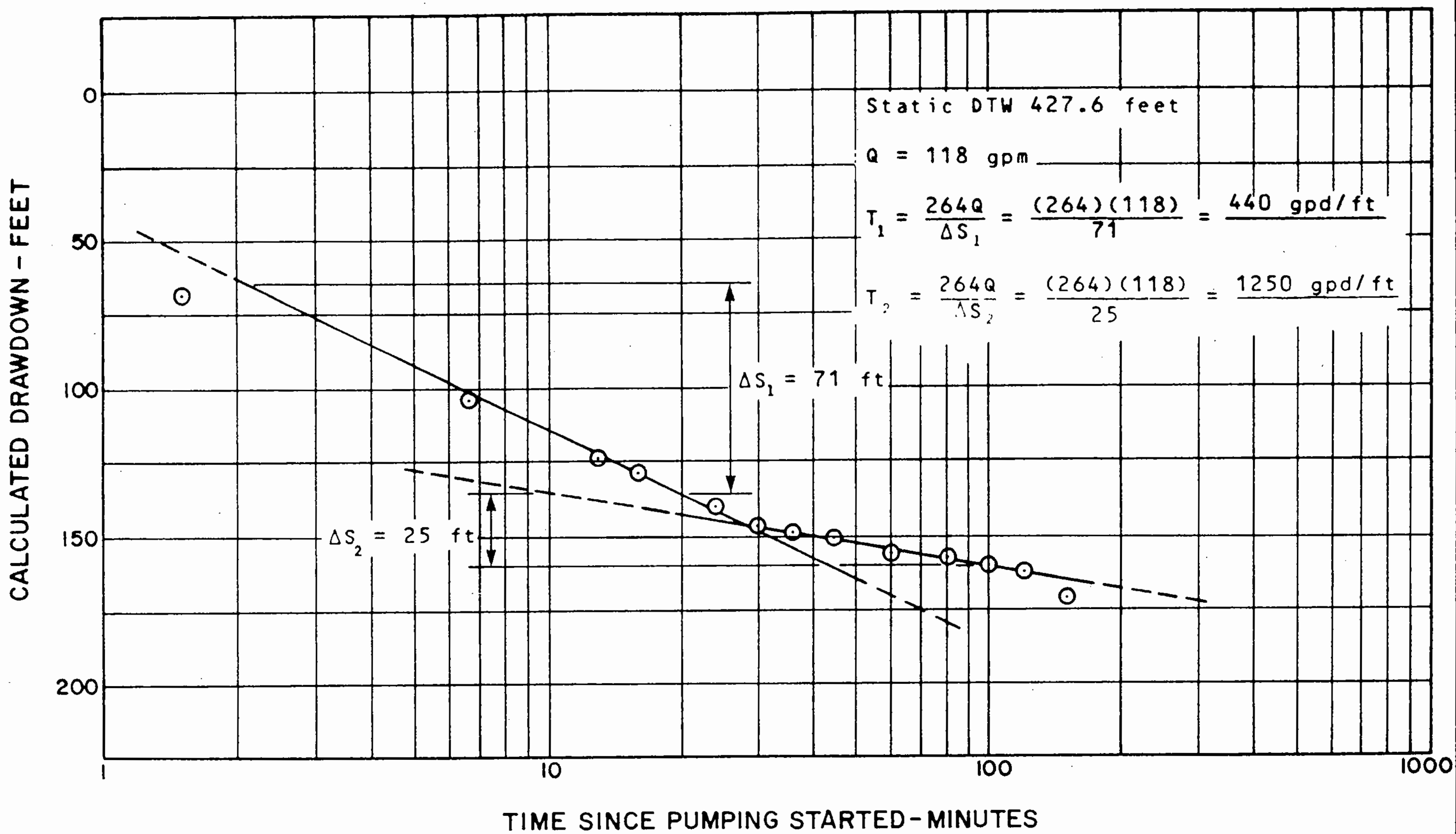
STEPTOE VALLEY

Time-Recovery Curve from Pumping Well T16N/R63E-16

Leeds, Hill and Jewett, Inc.

August 1981

FIGURE 4-9



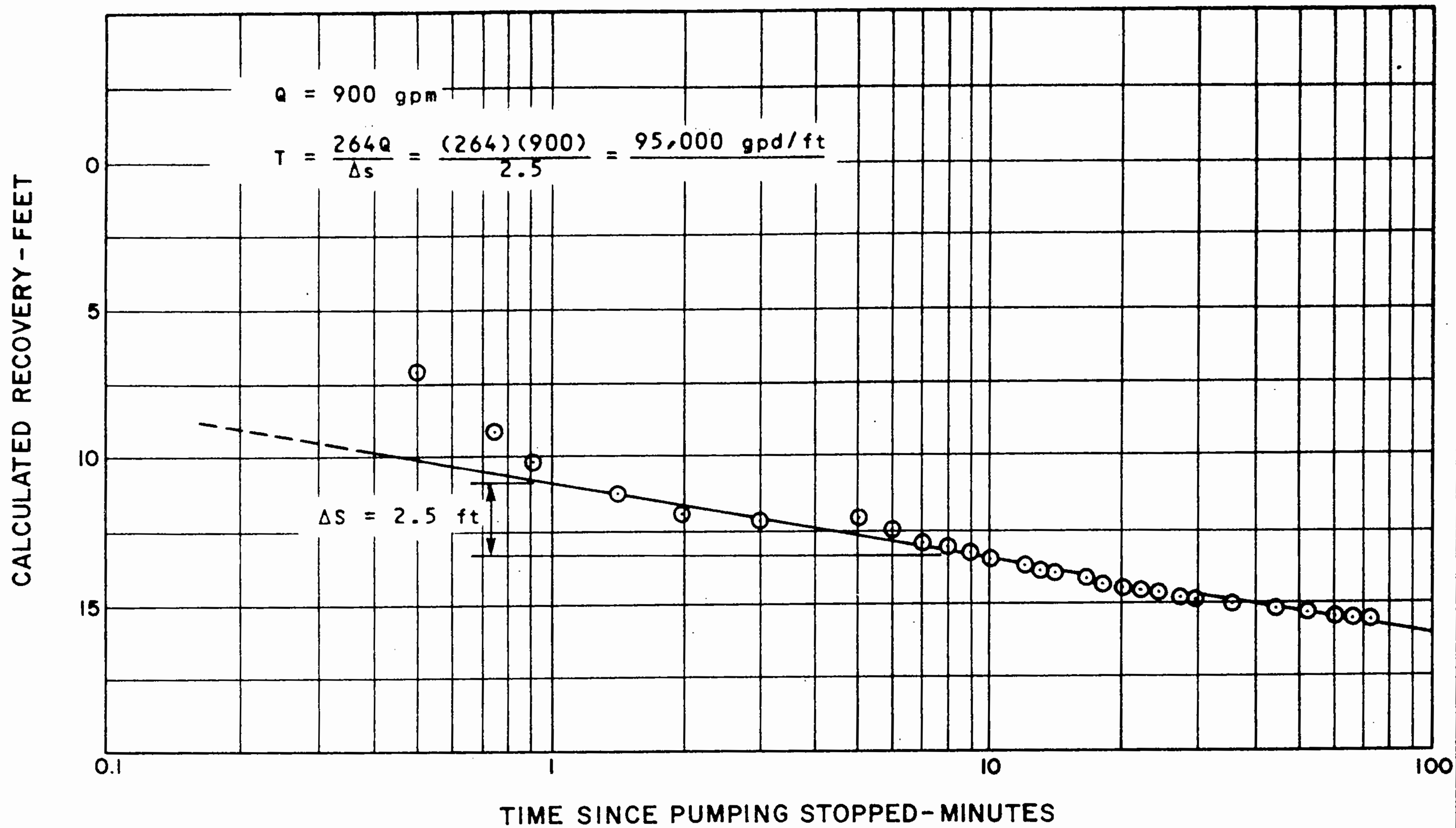
WHITE PINE POWER PROJECT

STEPTOE VALLEY
Time-Drawdown Curve from Pumping Well
(Carbonate Aquifer)
T12N/R63E-12

FIGURE 4-10

Leeds, Hill and Jewett, Inc.

August 1981



WHITE PINE POWER PROJECT

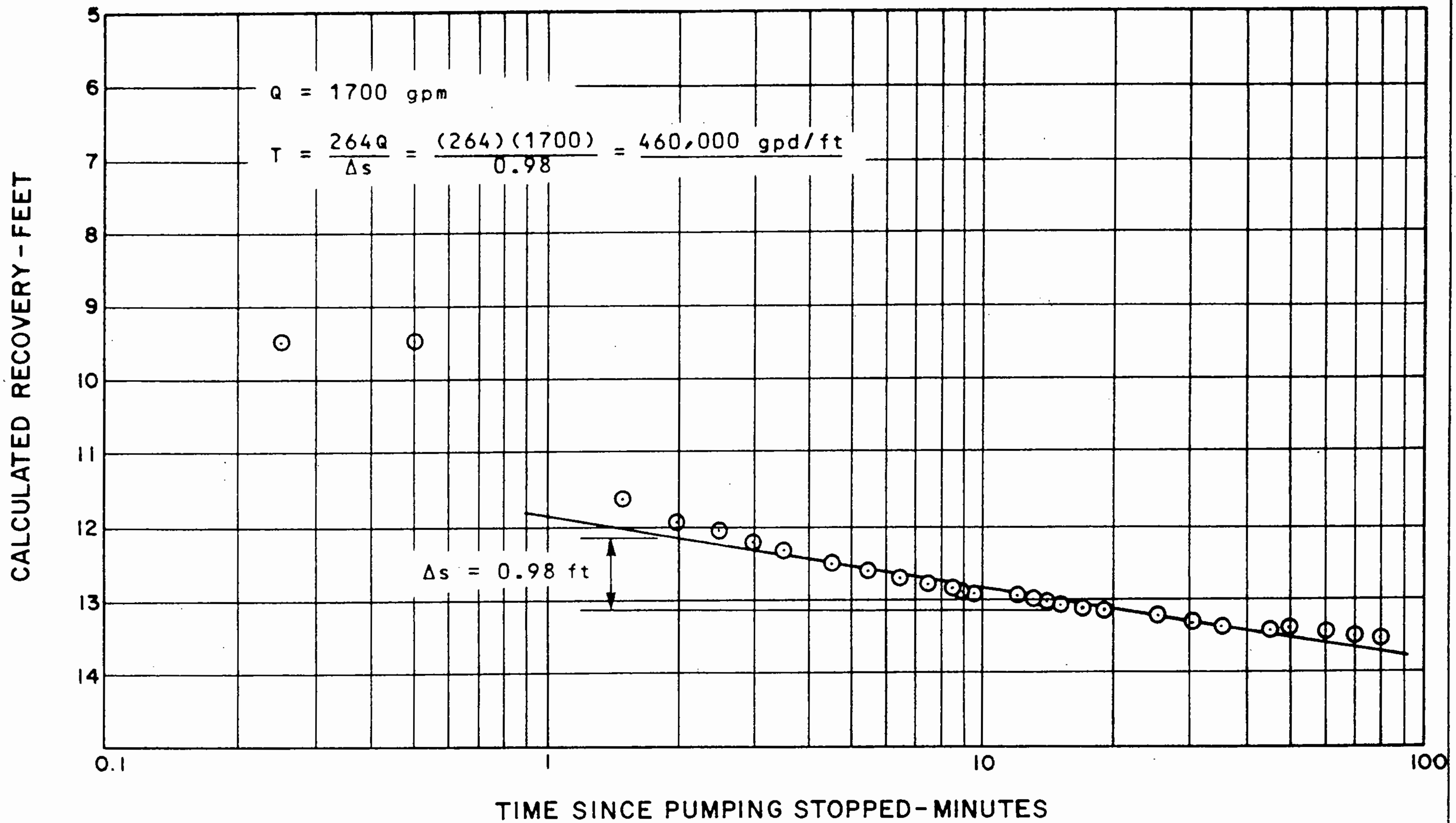
WHITE RIVER VALLEY

Time-Recovery Curve from Pumping Well
T13N/R60E-26

FIGURE 4-11

Leeds, Hill and Jewett, Inc.

August 1981



WHITE PINE POWER PROJECT

WHITE RIVER VALLEY

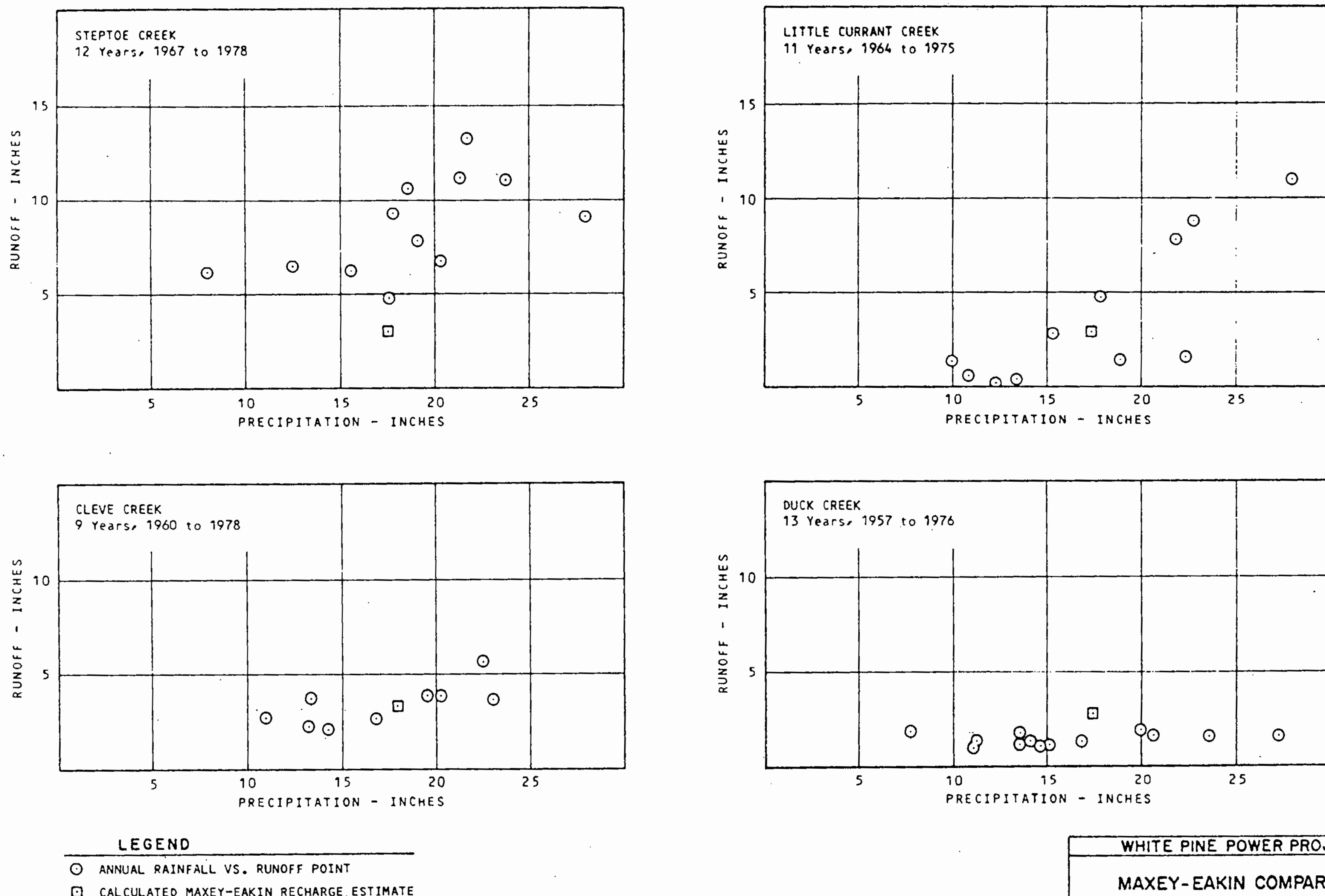
Time-Recovery Curve from Pumping Well

T12N/R62E-19

FIGURE 4-12

Leeds, Hill and Jewett, Inc.

August 1981



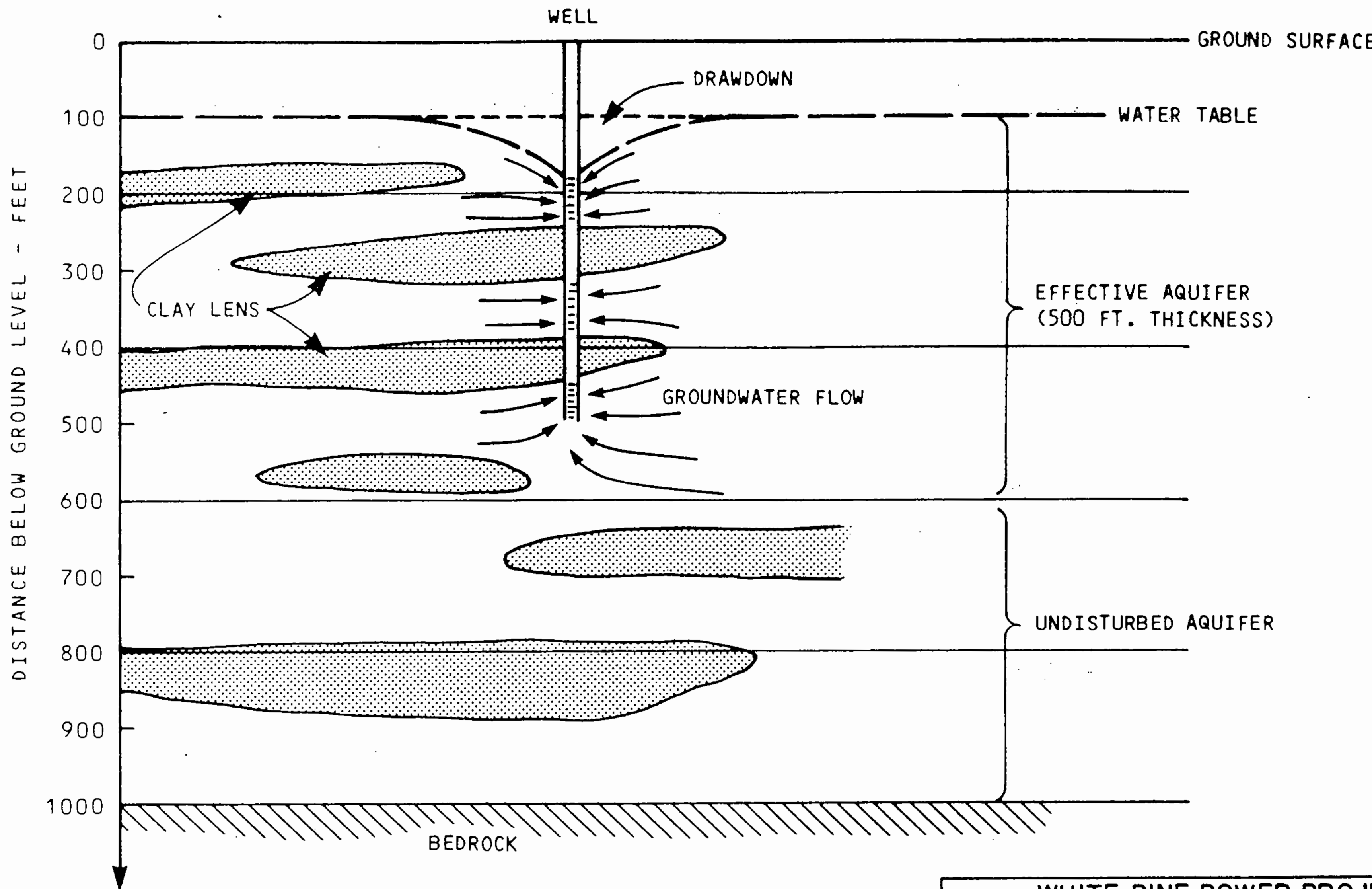
Leeds, Hill and Jewett, Inc.

August 1981

WHITE PINE POWER PROJECT

MAXEY-EAKIN COMPARISON TO MEASURED RUNOFF

FIGURE 6-1



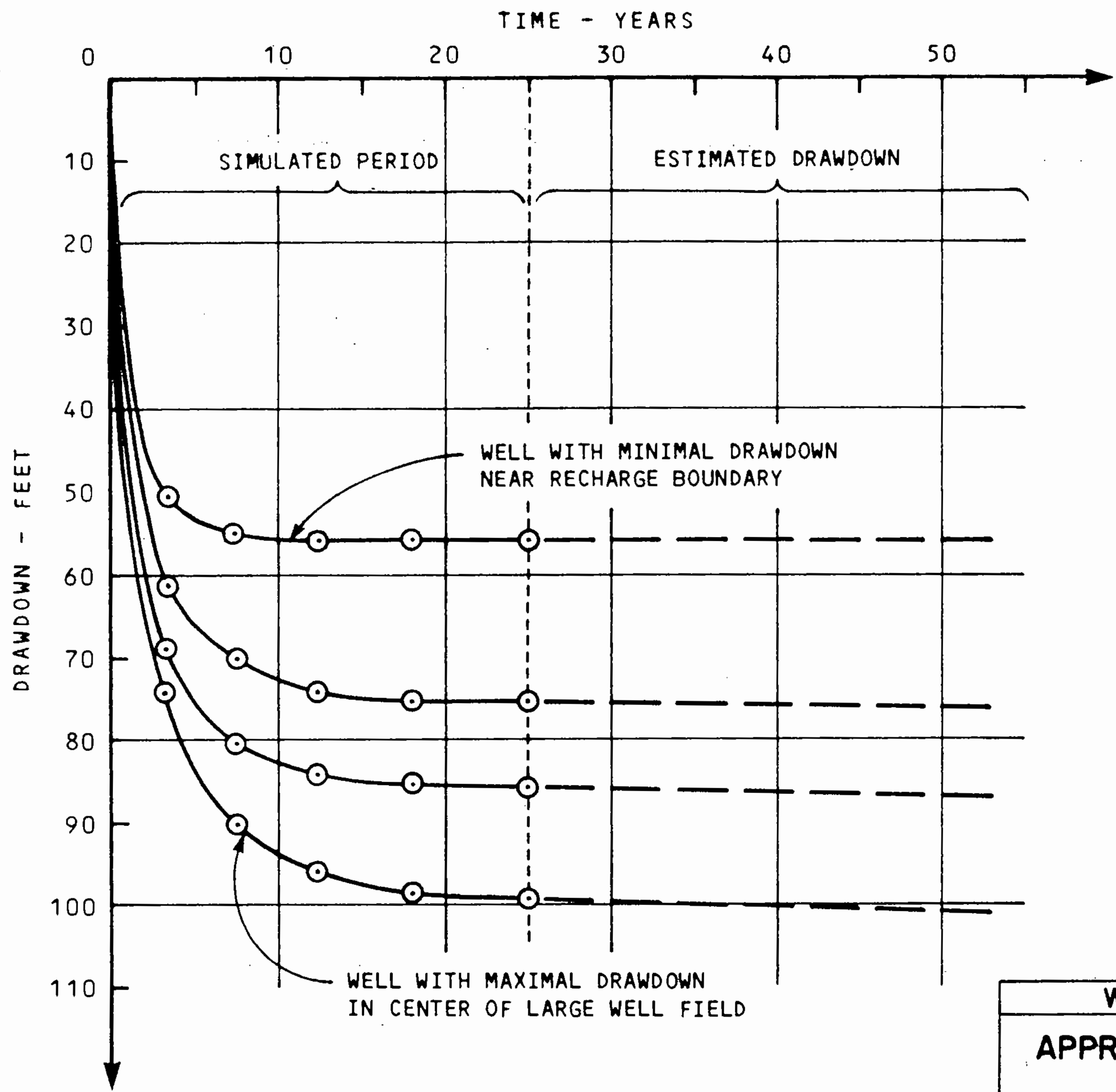
Leeds, Hill and Jewett, Inc.

August 1981

WHITE PINE POWER PROJECT

EFFECTIVE AQUIFER THICKNESS
(Schematic)

FIGURE 7-1



Leeds, Hill and Jewett, Inc.

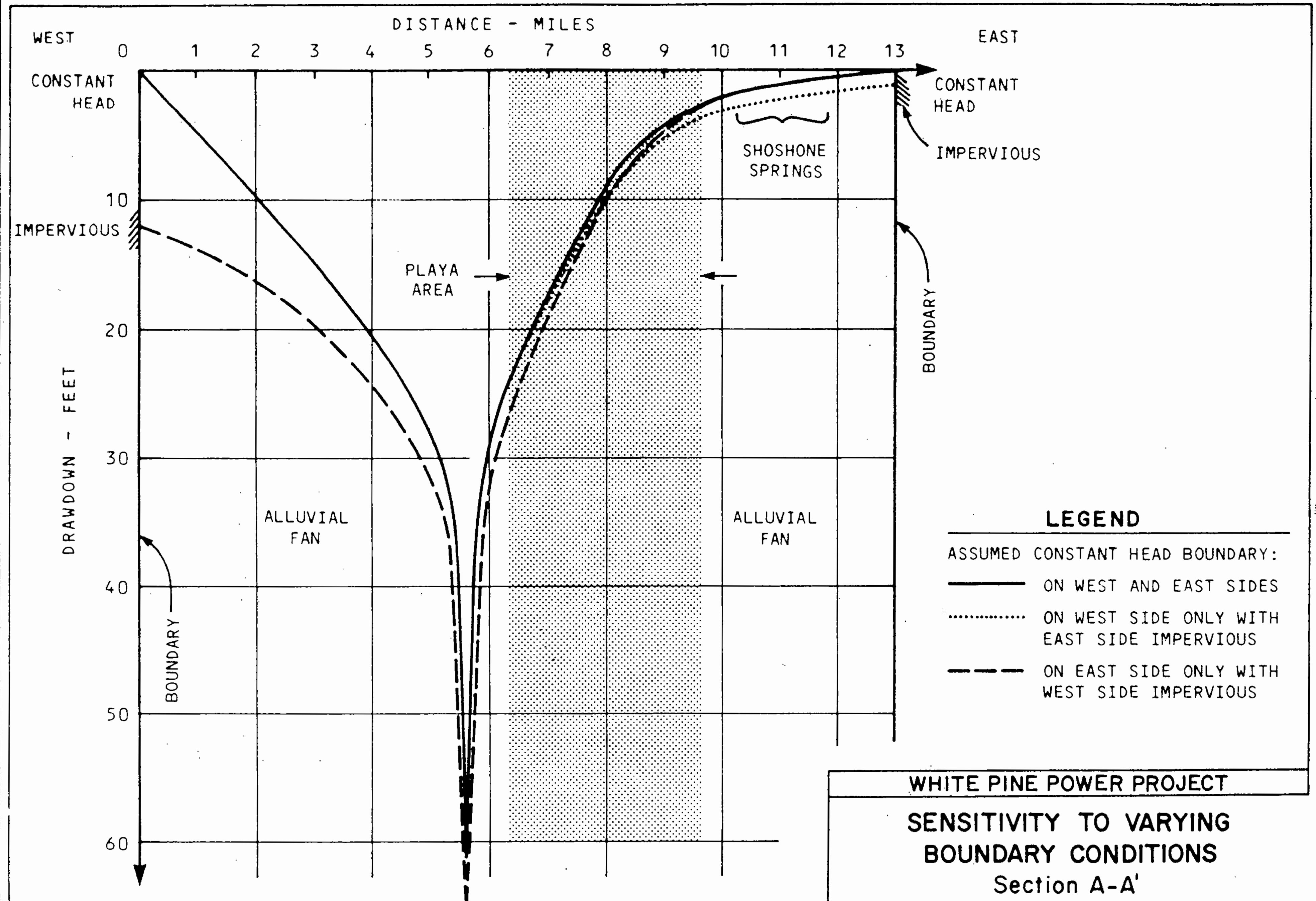
August 1981

WHITE PINE POWER PROJECT

APPROXIMATION OF STEADY STATE

Drawdown vs. Time
at Four Random Wells

FIGURE 7-2



Leeds, Hill and Jewett, Inc.

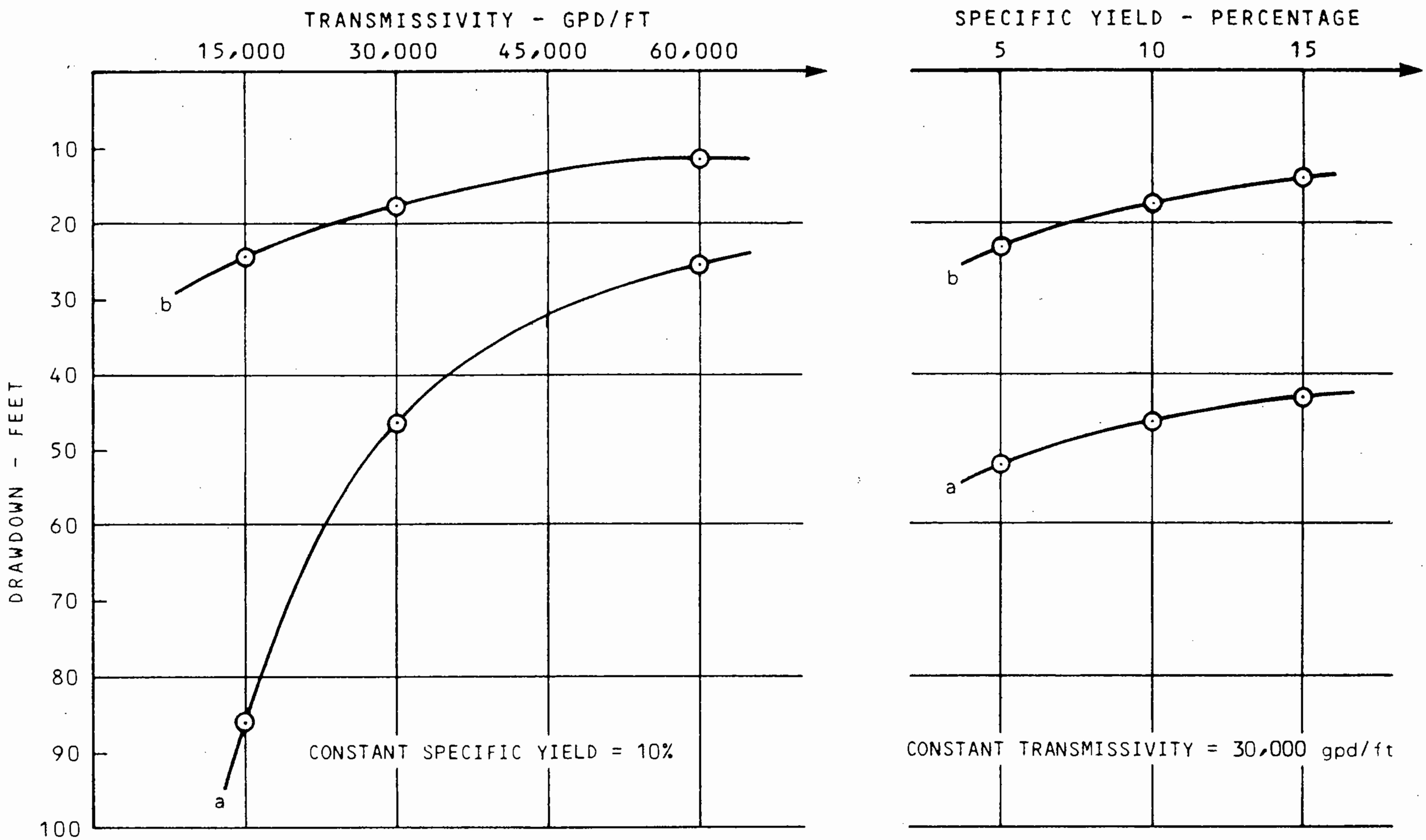
August 1981

WHITE PINE POWER PROJECT

SENSITIVITY TO VARYING BOUNDARY CONDITIONS

Section A-A'

FIGURE 7-3



LEGEND

a TYPICAL PUMPING WELL ENTIRELY IN ALLUVIAL MATERIAL

b RANDOM POINT ONE MILE FROM PUMPING WELL IN ALLUVIAL MATERIAL

Leeds, Hill and Jewett, Inc. August 1981

WHITE PINE POWER PROJECT

SENSITIVITY ANALYSIS

Influence of Varying Transmissivity and Specific Yield in Butte Valley

FIGURE 7-4

APPENDIX A

List of Abbreviations

afy	acre-feet per year
BLM	Bureau of Land Management
cfs	cubic feet per second
^oF	degrees Fahrenheit
DRI	Desert Reserach Institute
DTW	depth to water (from ground surface)
DWR	Division of Water Resources
FAO	Food and Agricutural Organization
gpd/ft	gallons per day per foot
gpm	gallons per minute
gpm/ft	gallons per minute per foot
HLA	Harding-Lawson Associates
hp	horsepower
LADWP	Department of Water and Power of the City of Los Angeles
LEEDSHILL	Leeds, Hill and Jewett
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
s	drawdown, from static water level to pumping water level, in feet
S	coefficient of storage (dimensionless, ft^3/ft^3)

SCS	U.S. Soil Conservation Service
SP	self-potential
sq. mi	square miles
t	time
T	coefficient of transmissivity (gpd/ft)
TDS	Total Dissolved Solids
USGS	U.S. Geological survey
VES	vertical electric soundings
WPPP	White Power Project
WRB	Water Resource Bulletin
WSP	Water Supply Paper

APPENDIX B

A GEOPHYSICAL INVESTIGATION OF A PORTION OF WHITE PINE COUNTY, NEVADA

HLA Job No. 12,090,001.01

A Report Prepared for

Leeds, Hill and Jewett, Inc.
1275 Market Street
San Francisco, California 94103

by

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Geophysicist - 843

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Geophysicist - 11

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Novato, California 94948
415/892-0821

August 28, 1981

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LIST OF ILLUSTRATIONS

I INTRODUCTION

This report contains the findings of a geophysical investigation performed by Harding-Lawson Associates (HLA) during the period July 18 through August 5, 1981 in a portion of White Pine County, Nevada. The report was prepared by HLA for Leeds, Hill and Jewett, Inc. (LEEDSHILL) as authorized under HLA Service Agreement dated July 13, 1981 and co-signed by Jerome S. Nelson, Principal Geophysicist, HLA, and Mr. James Jenks, Vice-President, LEEDSHILL. The results of the geophysical investigation will be used to assist in defining a feasible water supply program for the White Pine Power Project to be located near Ely, Nevada.

A. Scope

1. Electrical Resistivity Data

A total of 19 vertical electric soundings (VES) were performed in an area extending from the northern end of the White River Valley northward into the southern portion of Jakes Valley (Plate 1). The soundings were performed for the purpose of determining (a) the estimated depth to groundwater; and (b) the locations of formations and aquifers through which interflow is suspected of occurring.

2. Self-Potential (SP)

Self-potential surveys were conducted at two springs: Preston Big Spring in White River Valley and the Monte Neva Hot Spring in Steptoe Valley. The purpose of the SP survey is (a) to determine the relationship between water issuing from the spring and the local groundwater regime; and (b) the probable mechanism and source of flow of the springs.

B. Site Location and Conditions

1. Electrical Resistivity Survey

Electrical resistivity measurements were performed in a portion of White Pine County, Nevada approximately 25 miles southeast of Ely, Nevada (Plate 1). The area extends northwest from the north end of the White River Valley to the southern end of Jakes Valley. Both valleys are bounded on the east by the Egan Range and on the west by the White Pine Range. The approximate geodetic limits of the area extend from latitude 38°55' north to 39°12' north and from longitude 115°4' west to 115°17' west. Much of the area of investigation is easily accessible from U.S. Highway 6 which crosses the northern end of the White River Valley, by State Highway 318 and by numerous dirt roads. The terrain in the area varies from flat and open in the valley floors to steep and rugged with numerous small trees in the mountainous area between Jakes Valley and White River Valley. During the course of the field work the weather was generally hot and dry with occasional gusty winds.

2. Self-Potential Survey

The Preston Big Spring SP survey was conducted at the south end of the electrical resistivity area of investigation in White River Valley (Plate 1). The Monte Neva Hot Spring SP survey was performed in Steptoe Valley approximately 6 kilometers north of McGill, Nevada (not shown). In both areas, the terrain is flat and open and easily accessible by dirt roads and paved highways.

C. Geologic Setting

1. Electrical Resistivity Survey Area

The area of investigation lies within the Basin and Range geomorphic province of central Nevada. The geology of much of the area has been mapped by George Perry Lloyd II and is described in detail in his unpublished master's thesis (1959). In the central portion of the area the transition zone between the two valleys is characterized by fairly rugged topography where thick sequences of sedimentary and volcanic rocks ranging in age from late Devonian to Recent are exposed. To the north and south this gives way to flat open valley floors where the rock is covered by valley fill alluvium. According to Lloyd (1959), the major structural features in the area are north-trending longitudinal faults which parallel the topographic features. These consist of both strike-slip and normal faults and a thrust fault of late Tertiary age. In addition, folding during late Tertiary time has resulted in the formation of two large, open, north-trending folds.

2. SP Survey Areas

Both SP surveys were conducted in areas where Quaternary valley fill alluvium overlies bedrock. There is no geologic information available relating to the thickness of the alluvium or the lithology of the bedrock. The prominent feature at each locale is the spring(s) about which the surveys were centered. These are described in Part III, Section B of this report.

D. Acknowledgements

HLA personnel who took part in the field work include William E. Black, Associate Geophysicist; Robert F. Corwin, Associate Geophysicist; Richard J. Palm, Geophysical Technician; and field technicians Robert Schwartz, Kent Hanson, and Alice Bell.

Data reduction and interpretation were performed by William E. Black and Chad Harding, Geophysicist. Kenneth G. Blom, Associate Geophysicist, and Jerome S. Nelson, Principal Geophysicist, provided project management and overall project supervision.

II SUMMARY OF FINDINGS

A. Electrical Resistivity Survey

A total of 19 vertical electrical soundings (VES) with AB/2 expansions up to 610 meters, were performed in a portion of White Pine County, Nevada. The soundings were performed for the purpose of determining the depth to groundwater and the locations of formations and aquifers through which interflow is suspected of occurring between the southern portion of Jakes Valley and the northern end of White River Valley (Plate 1).

The VES data exhibit a wide range of resistivities, with values ranging from less than 10 ohm-meters to over 1100 ohm-meters. In correlating the VES data with the available geologic information and well log data we have inferred that resistivities less than 80 ohm-meters represent saturated soil and rock and that values greater than this amount correspond to strata that is partially saturated to dry. The degree of saturation is indirectly proportional to the resistivity of the material.

A resistivity contour map of the study area showing the areal distribution of resistivities at a depth of 200 meters shows that most of the southern portion of the area is conductive (low resistivity, possibly saturated) while the northern portion is resistive (high resistivity, possibly dry). Anomalous to this pattern is an elongate resistivity low which extends northward into the northeast portion of the area of investigation (Plate 1). This feature coincides with the location of a system of north-south trending folds and high angle faults (Lloyd, 1959). We suggest that the low may represent a zone of highly fractured, permeable rock which is saturated and may serve as a conduit for groundwater migrating southward from Jakes Valley into White River Valley.

Resistivity data obtained near the southern end of Jakes Valley (Profile C-C', Plate 5) could be interpreted as indicative of a fault near the center of the valley (VES-14). This fault may form a near vertical zone of highly fractured and thus permeable rocks extending deep beneath the valley floor. This could act as a buried drainage system which transports groundwater out of Jakes Valley, possibly connecting with the zone of saturation and low resistivity mentioned above. The geoelectric structure in this area could also be explained by an increase in grain size and thus permeability toward the center of the valley.

The electrical resistivity and geologic data seem to indicate that saturation depends more on fracturing than lithology. The data also suggest that the best aquifers are probably the Ely Limestone where it is fractured and the Tertiary Volcanics. Of all the formations encountered, the Chainman Shale has the highest resistivities and thus appears to be relatively impermeable.

We contoured the surface of the conductive zone defined by the resistivity data in an attempt to determine the direction of groundwater migration. The resulting contour map (not shown) seems to indicate only the direction of flow in shallow aquifers which are probably fed by surface runoff. Deeper aquifers, through which water may be migrating from Jakes Valley into White River Valley, cannot be differentiated from the shallow ones without additional correlating data.

B. Self-Potential Survey

1. Preston Big Spring

Self-potential (SP) measurements obtained at Preston Big Spring covered an area of approximately three square kilometers with five survey lines and a total of 160 occupied measurement stations. We have interpreted an SP low of -50 millivolts (mV) which is centered to the northwest of Preston Big Spring as being caused by the upwelling of groundwater from basement rock under artesian head. The approximate depth to the zone of upwelling was estimated to be 250 meters (820 feet). A quantitative analysis was performed to verify that the estimated source depth was consistent with reasonable values for the physical constants (spring flow rate and the hydraulic conductivity and electrical resistivity of the valley sediments) of the flow system.

2. Monte Neva Hot Spring

The SP survey we performed at Monte Neva Hot Spring covered an area of approximately 1.5 square kilometers with five survey lines and 255 occupied stations. We observed a dipolar

SP anomaly with an amplitude of 70 mV peak-to-peak. We believe the source of the anomaly is a fault- or fracture-controlled zone of upward percolating hot water, situated at a depth of approximately 100 meters (330 feet). The symmetry of the anomaly suggests that the source plane strikes slightly east of north and dips toward the east.

III RESULTS

A. Electrical Resistivity Survey

The results of the electrical resistivity survey are illustrated by the resistivity contours shown on Plate 1, by the combined geoelectric and geologic profiles shown on Plates 4 and 5 and by the two resistivity models illustrated on Plates 6 and 7. In addition, the apparent resistivity data obtained from each of the 19 vertical electric soundings (VES) are tabulated in Appendix C.

1. Resistivity Contour Map

A resistivity contour map was constructed using data obtained with the 19 VES (Plate 1). This map illustrates the areal distribution of earth resistivities at a depth of 200 meters below the ground surface. We also contoured the resistivity values at depths of 100 and 300 m but these are nearly identical to the 200 m map. Thus the 200 m depth resistivity contours represent a typical pattern for the area.

The contours show a wide range of resistivity values across the study area. The values range from less than 50 ohm-meters in the southern portion to over 1100 ohm-meters in the north.

One of the most notable features on the map is the broad, somewhat spherical shaped high that occupies the northwest portion of the area. Lloyd (1959) shows this area to be largely devoid of any structural features. This is in sharp contrast to another notable feature, that being the north-northeast trending elongate zone of low resistivity which flanks the high on the east. This feature, which broadens considerably to the south, coincides with an area dominated by structural features. These consist of two major north-south trending folds and a series of north-south trending high angle faults. Lloyd (1959) notes that one of the characteristic features of these faults is that rocks in their immediate vicinity are crushed. Based on these factors, we feel that it is reasonable to assume that the resistivity low (conductive zone) indicates a zone of highly fractured rock which, as a consequence, is very permeable and thus saturated. Conversely, the highly resistive areas probably indicate dry, relatively impermeable rocks. It is possible that the elongate north-south trending conductive zone represents a route for groundwater migration from Jakes Valley southward into the White River Valley. If indeed this is the case, then the contours indicate that it forms a rather narrow channel along the southeast flank of the high. Where this feature broadens out to the south may indicate an area where more permeable rocks are encountered (probably the Tertiary volcanics which occupy this area) and where the groundwater flow spreads out over a wider area. In addition, there may be some flow coming from the west which joins with the north-south flow to saturate a broad area as suggested by the widespread resistivity low. The apparent termination of the conductive zone to the north may be a result of the distribution of the VES. It is possible that additional soundings located between VES-16 and VES-17 would show that the low continues to curve westward and connects with an area of low resistivity indicated by VES-14 in the south central portion of Jakes Valley.

2. Geoelectric/Geologic Cross Sections

In addition to the resistivity contour map we have illustrated the distribution of earth resistivities laterally and with depth by means of three geoelectric/geologic cross sections, A-A', B-B' and C-C' as shown on Plates 4 and 5. On each cross section we have shown both the resistivity data obtained from the VES along the profile and geologic information after Lloyd (1959). The resistivity information is in the form of vertical logs at each sounding location showing the true resistivity and depth range of each layer. Thin, near-surface layers have been lumped together to form single layers for which the range of resistivities is shown. The numbers on the right hand side of the logs represent the depth of each resistivity interface in meters. The numbers in parentheses on the left represent the equivalent depths in feet. The geology at each VES location is presented to the right of the resistivity logs in the form of formation symbols used by Lloyd (1959). The wavy lines represent the approximate elevation of the geologic layer interfaces. These are very approximate and where possible they have been made to conform with resistivity layer interfaces. Wherever possible we have included well log data as furnished by

LEEDSHILL. We have used these data, along with the available geologic information to develop correlations between resistivity and lithology as discussed in Appendix B (Data Reduction and Interpretation). Table A, which is included in Appendix B, shows that we have assumed a resistivity range of 10 to 80 ohm-meters for saturated material. Following this assumption we have inferred groundwater elevations on the cross sections as represented by dashed lines. These lines are used to represent both the top and the bottom of the saturated zone.

a. A-A'

Section A-A', the longest of the three sections, extends from a well location near Preston Big Spring northwest to Smith Creek Road (see Plate 1). The section includes the data from nine soundings: VES-1 through VES-8 and VES-10 (which is common to B-B'). As shown on Plate 4, the resistivities throughout the section are generally quite low ($\leq$80 ohm-meters) except in the near surface and at depth beneath VES-1 and VES-2. The low resistivities probably indicate saturated alluvium and rock whereas the high values represent the unsaturated strata above the water table and dry insulating basement rock below. It can be seen that along most of the section the conductive zone is quite shallow, on the order of 5 to 15 meters, and that it extends to depths in excess of 300 to 400 meters. However, at the southeast end of the section, it is on the order of 50 to 60 meters deep. This is in good agreement with the local groundwater level as evidenced by two nearby wells

(Plate 4). Northeast of VES-2 this zone of low resistivity shallows reaching an elevation just 4 meters below the surface in the vicinity of VES-3. It is in this same area where bedrock shoals, as evidenced by what appears to be Tertiary volcanics (possibly Dacite Flow Rocks) outcropping at the surface. Another well situated between VES-3 and VES-4 also indicates that groundwater is shallow in this area. These factors give good indication that the conductor represents saturated rock and that the water table parallels the bedrock surface as it dips beneath the alluvium, until reaching the alluvial groundwater table.

One of our soundings, VES-5, showed indications of a discontinuity in the apparent resistivity field curve at an AB/2 spacing of 300 m. This type of feature indicates the presence of a lateral discontinuity. One interpretation is that the discontinuity results from a change in groundwater level across a fault. Although the location of this apparent fault is uncertain, one possibility is that it parallels the range front in a northeasterly trend, just southeast of VES-5.

Geologic information was available for only the portion of the section from VES-5 northwestward. These data indicate that the rock type along the section is all Tertiary volcanics and is comprised of Currant Tuff (Tct) overlying Dacite Flow Rocks (Tv). The Dacite Flow Rocks are characteristically more conductive than the Currant Tuff (lower resistivity) and therefore probably more saturated.

b. B-B'

Section B-B' (Plate 5) extends from VES-9 near Smith Creek, northeastward to VES-13 just east of Jakes Wash (Plate 1). In addition to these soundings, the section covers VES-10 through VES-12 and VES-19. Like section A-A' this section indicates low resistivities from the near surface (5 to 20 meters) to depths in excess of 300 to 400 meters along most of the profile. The exception is at the northeast end of the profile approaching VES-13 where the saturated zone thins considerably. Here, not only does the water table drop off from a depth of only 5 meters at VES-12 to a depth of 40 meters at VES-13, but the bottom of the saturation zone becomes more shallow. That is, the depth to insulating basement rock (ρ = 205 to 570 ohm-meters) decreases from 360 meters at VES-19 to only 80 meters at VES-13. Based on the available geologic information (Lloyd, 1959) it appears that the conductive rock, which we interpret to be saturated, consists of Ely Limestone, Tertiary Volcanics, Windous Formation and older alluvium. The resistive rock, which we interpret to be unsaturated and relatively impermeable, is possibly Chainman Shale.

At VES-13 there is evidence of a perched water table. At depths of 5 to 15 meters there is a 40 ohm-meter layer which correlates with older alluvium. Beneath this is a section of Ely Limestone which extends to a depth of 80 meters. The upper 25 meters of this unit has a resistivity of 125 ohm-meters and thus is probably unsaturated. The lower 40 meters has a resistivity of 70 ohm-meters which we interpret as saturated or partially saturated rock (see Table A, Appendix B). The difference in saturation between the upper and lower portions may be due either to textural changes within the unit and/or to variations in the amount of fracturing.

c. C-C'

Section C-C' trends west to east across the southern end of Jakes Valley (Plate 1). The section is comprised of VES-14 through VES-16. No geologic information is available for this cross section but it is reasonable to assume that the Quaternary allvuium which blankets the area is fairly thick, especially near the center of the section (VES-14). The notable feature here is a conductive layer which is fairly thin on the flanks of the valley and of indeterminate thickness in the center. Beneath VES-15 and VES-16 this layer, which has a resistivity of 65 ohm-meters all the way across the valley, varies in thickness from 100 meters to 27 meters, respectively. Its depth in these locations varies from 20 to 30 meters while in the center of the valley it is 115 meters deep. The layer probably represents saturated alluvium. The overlying material with resistivities ranging from 40 to 580 ohm-meters is probably dry alluvium, containing some thin clay layers. On the flanks of the valley the conductive zone is underlain by a layer with resistivities ranging from 90 to 185 ohm-meters. This resistive unit, which is discontinuous across the valley, varies in thickness from approximately 110 meters on the west side of the valley to 160 meters on the east side. It, in turn is underlain by another conductive layer (ρ = 15 to 55 meters) which extends to an undetermined depth. In keeping with the resistivity-lithologic relationships outlined in Table A (Appendix B) we interpret the conductive material (ρ = 15 to 65 ohm-meters) to be saturated and the resistive strata (ρ = 90 to 580 ohm-meters) to be unsaturated and relatively impermeable. Of question here, then, is the deepening water table indicated by the 65 ohm-meter layer and the discontinuous nature of the underlying resistive layer. One possible explanation is that VES-14 coincides with the location of a fault which forms a permeable zone extending deep beneath the valley floor. This would explain the absence of the 90 to 185 ohm-meter resistive layer in that location. The lithologic layer it represents may be present but in the fault zone it would be highly fractured, permeable, saturated and therefore more conductive. It is also possible that such a feature would act as a buried drainage system, carrying ground-water out of the valley. This, then would explain the depressed water table in the vicinity of VES-14. The fact that there is no indication of a fault in the VES-14 field curve can be explained if the fault zone is nearly vertical, fairly wide and strikes parallel to the electrode array in a general north-south direction.

Another possible interpretation of the geoelectric structure depicted by Section C-C' is that there is a change in grain size within the resistive layer. If the grain size increases towards the center of the valley, then the layer would probably become more permeable in that direction. This would result in the layer being saturated and more conductive. In addition, it would allow groundwater in the shallow conductive layer to drain downwards into the deep conductor which might also explain the depressed water table level at VES-14.

3. Outlying Soundings

Two of our vertical electrical soundings were not included on any of the cross sections. These are VES-17 and VES-18 (Plate 1). Both are in the northwest portion of the area and are detached from the three major profile alignments. They were located in the area between Profiles B-B' and C-C' for the purpose of defining the north-south trend of resistivities between the two profiles.

a. VES-17

This sounding is located at the extreme southern end of Jakes Valley, approximately 3.2 kilometers north of Midway Well (Plate 1). The layered resistivity model computed from the data obtained with this sounding is illustrated on Plate 6. Of all the soundings performed in the area of investigation this one exhibits the highest resistivities (ρ = 105 to 1115 ohm-meters). These values indicate that the strata underlying VES-17 is unsaturated to the depth of the sounding.

Lloyd (1959) shows this area to be covered by older alluvium (Q). However, he also shows outcrops of Ellison Creek formation (Tec), Ely Limestone (Cpc) and Chainman Shale (Cmch) to the south and east. From his geology map it looks as if the limestone and shale are blanketed by Ellison Creek formation to the southeast and by older alluvium in the vicinity of the sounding and to the north. Judging from the close proximity of the Ely and Chainman outcrops, the alluvium is probably not very thick, perhaps on the order of 5 to 10 meters at the VES location. It is difficult to determine how thick the Ely is beneath the sounding. However, the pattern of the limestone and shale outcrops suggests that it may be fairly thin and could be in either stratigraphic or thrust fault contact with the underlying Chainman Shale. Based on what we have seen of these two formations in other areas and their resistivity relationships, we have inferred that the material in the depth range of 5 to 80 meters, with resistivities ranging from 105 to 525 ohm-meters is probably Ely Limestone (Plate 6). The very resistive (ρ = 1115 ohm-meters) layer from 80 to 365 meters is possibly Chainman Shale and the lithology of the deepest layer (ρ = 995 ohm-meters) is unknown. The thin 315 ohm-meter layer which caps the sequence probably represents the older alluvium. That the Ely and Chainman are both so much more resistive in this area as opposed to other locales (see Section B-B') is probably due to the amount of fracturing. In this area, both formations probably contain less fractures, are less permeable and, therefore, less saturated.

b. VES-18

This sounding is located at the site of an abandoned wildcat oil well approximately 2.5 kilometers southwest of VES-12 (Plate 1). The results of the sounding are illustrated by the resistivity curve and resistivity model shown on Plate 7. According to Lloyd this area is mantled by Ellison Creek formation overlying Ely Limestone. Since the Ely crops out just a short distance to the south, the mantle is probably fairly thin at this locale.

As shown on Plate 7, we have resolved the data from VES-18 into a resistivity model consisting of three major layers. The top layer, actually a combination of several thin layers, is 3 meters thick with resistivities ranging from 1 to 120 ohm-meters. We believe this layer represents the compacted fill of the drill pad on which the VES is centered. Below this, to a depth of 73 meters, is a 35 ohm-meter layer which probably represents the Ellison Creek mantle. The low resistivity of this layer suggests that it is probably saturated. We have assumed that the bottom of this layer corresponds to the bottom of the mantle and that the more resistive material underneath, which extends to undetermined depth, is Ely Limestone. The resistivity value of 305 ohm-meters for this layer is within the range (105 to 525 ohm-meters) determined for the Ely beneath VES-17. This indicates that here, as at VES-17, the Ely is unsaturated. This is in sharp contrast to VES-12, just 2.5 kilometers northeast where we have indicated resistivities of only 10 to 45 ohm-meters for the Ely. We assume that the difference is due, primarily, to the degree of fracturing of the rock. Where it is highly fractured it is permeable, saturated, and thus more conductive.

4. Groundwater Aquifers

Our analysis of the electrical resistivity data obtained from the 19 VES and their correlation with the local geology as described by Lloyd (1959) indicates that the following formations show evidence of saturation:

a. Ely Limestone (Cpe)

b. Dacite Flow Rocks (Tv)

c. Currant Tuff (Tct)

d. Windous (Twb)

e. Ellison Creek (Tec)

There is evidence to indicate that in at least one of these units, the Ely Limestone, saturation occurs only where the rock is highly fractured (see Appendix B). Of these rock types the most likely routes for groundwater movement is through fractured Ely Limestone and brecciated volcanics. These units exhibit the lowest resistivities and the greatest thicknesses within the saturated sequences. The only geologic unit penetrated by a VES which does not show evidence of saturation is the Chainman Shale (Cmch).

5. Direction of Groundwater Migration

As part of our analysis of the electrical resistivity data we sought to determine the direction of groundwater migration. Our procedure was to construct a contour map (not shown) showing the variations in groundwater elevation as determined from the VES data. In constructing this contour map we assumed that the top of the conductive zone depicted on the cross sections for profiles A-A', B-B' and C-C' (Plates 4 and 5) represents the water table. Furthermore, we assumed that lines drawn perpendicular to the contours and in the direction of decreasing elevation would represent the direction of groundwater movement. The results indicate that groundwater moves from Jakes Valley southeast toward Jakes Wash and from west to east across the north end of White River Valley where it fans out moving southeast into the valley and east and northeast toward Jakes Wash. Unfortunately these results do not provide information on groundwater migration between the two valleys. This is evidenced by the following factors:

1. The groundwater contours parallel the topography
2. The water table is relatively shallow
3. The indicated direction of flow is, in some areas, opposite to what we would expect for groundwater movement from Jakes Valley to White River Valley

One interpretation of the groundwater contours is that they represent a shallow, possibly perched, water table which is fed by surface runoff. In this case the direction of flow would be dependent only on the surface topography which would be reflected in the groundwater elevation contours.

If there is a major aquifer carrying water from Jakes Valley into White River Valley we would expect it to be deeper, to be independent of surface topography and to exhibit north to south flow in the vicinity of the northward trending resistivity low which encompasses soundings 11, 12 and 19. There is no deep, continuous conductor evident on any of the cross sections shown on Plates 4 and 5 which can be differentiated from the shallow conductive layers except for the one shown on Section C-C' beneath VES-15 and VES-16. The reason for this may be that (a) the two systems are hydraulically connected or (b) any intermediate layers which isolate the two are either too thin or have too low of a resistivity contrast to be resolved.

B. Self-Potential Survey

The results of the self-potential (SP) surveys are presented on Plates 2, 3, 8 and 9 and are tabulated in Appendix D.

1. Preston Big Spring

The dominant feature of the self-potential (SP) field measured at Preston Big Spring (Plate 2) is a roughly symmetric -50 mV low centered approximately 100 meters west and 275 meters north of the spring.

This anomaly could be a manifestation of streaming potential caused by groundwater flow or of thermoelectric potential caused by heat flow. However, given the high rate of flow from the spring (8 cfs) and an only slightly elevated water temperature (about 6°F above ambient) it seems reasonable to assume that streaming potential is the source mechanism of the SP field.

The long (2.4 kilometer) wavelength of the SP low suggests that it could be caused by either a localized high intensity source at considerable depth, or by a relatively diffuse symmetric source region at shallower depth. In order to arrive at a reasonable estimate of the depth of the source flow, various flow geometries which might give rise to an SP field with the size and polarity observed were considered. An explanation of a possible origin of Preston Big Spring presented in Maxey and Eakin (1949) suggests that the relatively constant flow rate and low (60-foot depth) water table in the vicinity of the spring imply a deep flow source under artesian head. The presence of thick zones of clay and silt around the spring orifice are taken as evidence of an impermeable barrier preventing leaky discharge from the spring conduit into the alluvial fan sediments which comprise the top 40 to 50 meters of valley fill (Maxey and Eakin, 1949). Deep circulating groundwater discharging from localized fractures in the basement into the overlying valley fill sediments is a plausible streaming potential source mechanism which is consistent with this hydrological model and the observed SP data. An estimate of the depth to the localized zone of the discharge source was performed using the methods of potential field theory. The depth to source was estimated to be approximately 250 meters. A quantitative analysis and theoretical curve fitting to the observed data along section X-X' (Plate 8) was then carried out using this depth estimate (Appendix B). It was determined that the strength of the source required to match the observed data was consistent with reasonable ranges of spring flow rate and the hydraulic conductivity and electrical resistivity of the valley sediments.

As mentioned previously, a shallower, more diffuse streaming potential source might also produce a fit to the observed SP data. A reasonable shallow flow geometry which would generate such a streaming potential source could result from leaky dischage of water from the spring conduit into the valley fill sediments. However, because this flow geometry was not consistent with the hydrological model developed above, it was not considered further.

2. Monte Neva Hot Spring

The most significant feature of the observed SP field at Monte Neva Hot Spring (Plate 3) is an asymmetric dipolar anomaly with an amplitude of 70 mV peak to peak. The zero contour of the dipole runs roughly north to south, with the positive and negative lobes of the anomaly offset in a north-south direction by about 200 meters. The negative lobe of the anomaly is narrow and elongated in a north-south direction. The positive lobe, which is to the east of the zero contour, is much larger in east-west dimension than the negative lobe. The Monte Neva Hot Spring orifice is located within a local minimum contained in the positive lobe of the anomaly. The asymmetry and elongation of the dipole suggests a planar source region striking slightly east of north and dipping toward the east. The relatively steep potential gradient (approximately 230 mV/km) between the positive and negative peaks of the anomaly indicates a fairly shallow depth to the top of the source region.

It has been our experience that such anomalies are frequently associated with basin and range faults and fault-controlled hydrothermal systems. The elevated water temperature of the spring (170°F) (Waring, 1965) indicates that the source of the SP field may be thermoelectric in nature or that a combination of thermoelectric and streaming potential sources exists. The source or sources could be generated by the upward percolation of thermal water along a fault plane or fracture zone. The planar source region may coincide with a fault plane or fracture zone. Although we know of no direct geological evidence for the existence of such a fault or fracture zone, the strike of the hypothetical source plane is roughly parallel to the north-south strike of the major structural features in the region (Olmsted, 1975).

A theoretical fit to the observed SP along section Y-Y' was calculated (see Appendix B) using a vertical source plane striking perpendicular to section Y-Y'. The results of the curve fitting are presented on Plate 9. The depth to the top and bottom of the source plane were 100 meters and 250 meters, respectively, and the plane was 200 meters in length. These depths are taken below the intersection of section Y-Y' and the zero contour of the anomaly (Plate 3). The temperature of the source plane in the calculation was taken as 185°F.

The relation between the SP source plane, a hypothetical fault or fracture zone, and the hydrology of Monte Neva Hot Spring is not clear. Judging by the temperature of the spring water at the surface, the source plane depth of 100 meters is too shallow to coincide with the actual source of the hot spring. It is possible that the hot water, circulating upward from a deep basement reservoir, percolates along a dipping fracture or fault zone to a depth of between 100 and 250 meters. If the hot water then migrated vertically upward through valley fill, ultimately reaching the surface as Monte Neva Hot Spring, a planar SP source region would be developed where the water changes course.

The local minimum of the SP field in the immediate vicinity of the hot spring is probably the result of a negative potential generated by near-surface upward filtration through the travertine dome which surrounds the orifice. Normally, upward filtration of water would produce a signal with positive polarity, adding to the overall magnitude of the positive lobe. In calcareous rocks like travertine, however, streaming potential and thermoelectric potential polarities are reversed, so the effect of shallow upward filtration is to reduce the overall potential in the region surrounding the orifice.

IV CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of our geophysical investigation of the area extending south from the southern end of Jakes Valley to the northern portion of White River Valley and of Preston Big Spring and Monte Neva Spring, we make the following conclusions and recommendations.

A. Electrical Resistivity Survey

1. A total of 19 vertical electrical soundings indicates a wide range of resistivity values from less than 10 ohm-meters to greater than 1100 ohm-meters.

    a. Low resistivity values, in the range of 10 to 80 ohm-meters, seem to indicate permeable zones of saturation.

    b. Values of resistivity greater than 80 ohm-meters seem to indicate zones of nonsaturated alluvium and/or rock.

    c. Very high resistivity values indicate dry, impermeable rock.

2. The differences in resistivities seem to be caused primarily by variations in the degree of fracturing. Highly fractured rock has greater porosity and therefore is more permeable, more saturated and consequently more conductive.

3. A contour map of resistivity values at a depth of 200 meters suggests that much of the southern portion of the area is saturated. The vertical electrical sounding data indicate that this zone of saturation may extend to depths of over 300 to 400 meters.

4. Conversely, much of the northern half of the area is resistive and probably not saturated. This is with the exception of the southern portion of Jakes Valley and a narrow north-south trending zone of low resistivity which appears to connect the two valleys. This resistivity low may indicate a principal route for groundwater movement between the two valleys.

5. The resistivity data obtained in Jakes Valley could be interpreted to indicate a fault in the center of the valley which acts as a subsurface drainage system carrying groundwater out of the valley. Alternatively, the data may indicate an increase in sediment grain size and thus permeability towards the center of the valley.

6. A contour map of groundwater elevations determined from the vertical electrical sounding data does not illustrate groundwater movement from Jakes Valley towards White River Valley. This is because the near-surface groundwater parallels the topography. Deeper aquifers which may serve as a main route for groundwater transport could not be differentiated from the shallow system.

7. The vertical electrical sounding data when correlated with existing geological information suggests that groundwater movement could be occurring in the Ely Limestone, the Ellison Creek Formation, the Windous Formation, the Currant Tuff or in Dacite Flow Rocks, but probably not in the Chainman Shale. Of these, most groundwater movement would probably take place in the Ely Limestone where it is folded and fractured and in the Tertiary Volcanics.

8. It is our recommendation that additional geophysical work be performed in the area to further resolve the objectives of this study. We recommend the following items:

    a. Additional VES near existing wells to refine the correlation between resistivity, lithology and saturation.

    b. Three more VES in the area encompassed by soundings 12, 14, 15, 16, 17 and 18 to better define the extent of the resistivity low.

    c. Two VES south of sounding 13 to define the eastern extent of the resistivity low.

    d. Several SP profiles across the resistivity low to determine the direction of groundwater movement.

    e. Several SP profiles north of the Preston Big Spring to determine the direction of groundwater movement in that area.

B. Self-Potential Survey

1. Preston Big Spring

We observed a symmetrical, monopolar SP anomaly with an amplitude of -50 mV centered approximately 100 meters west and 275 meters north of the spring (Plate 2). We interpret the anomaly as being caused by streaming potential generated by the upwelling of groundwater from basement rock under artesian head at a depth of 250 meters.

2. Monte Neva Hot Spring

a. We observed an asymmetrical, dipolar SP anomaly with an amplitude of 70 mV peak-to-peak. The zero contour of the anomaly trends roughly north-south with the positive and negative lobes offset approximately 200 meters in a north-south direction. The orifice of the spring is located within a local minimum contained in the positive lobe of the anomaly. We interpret the anomaly as being caused by thermoelectric potential generated by the upward percolation of thermal water along a fault plane or fracture zone. We estimate the planar source region to be 200 meters long, 150 meters high, and situated at a depth of 100 meters.

b. We recommend that electrical resistivity soundings be performed in the vicinity of Monte Neva Hot Spring to help determine the depth to the source of the hot water, the depth to basement rock, and whether or not a fault does exist in this area.

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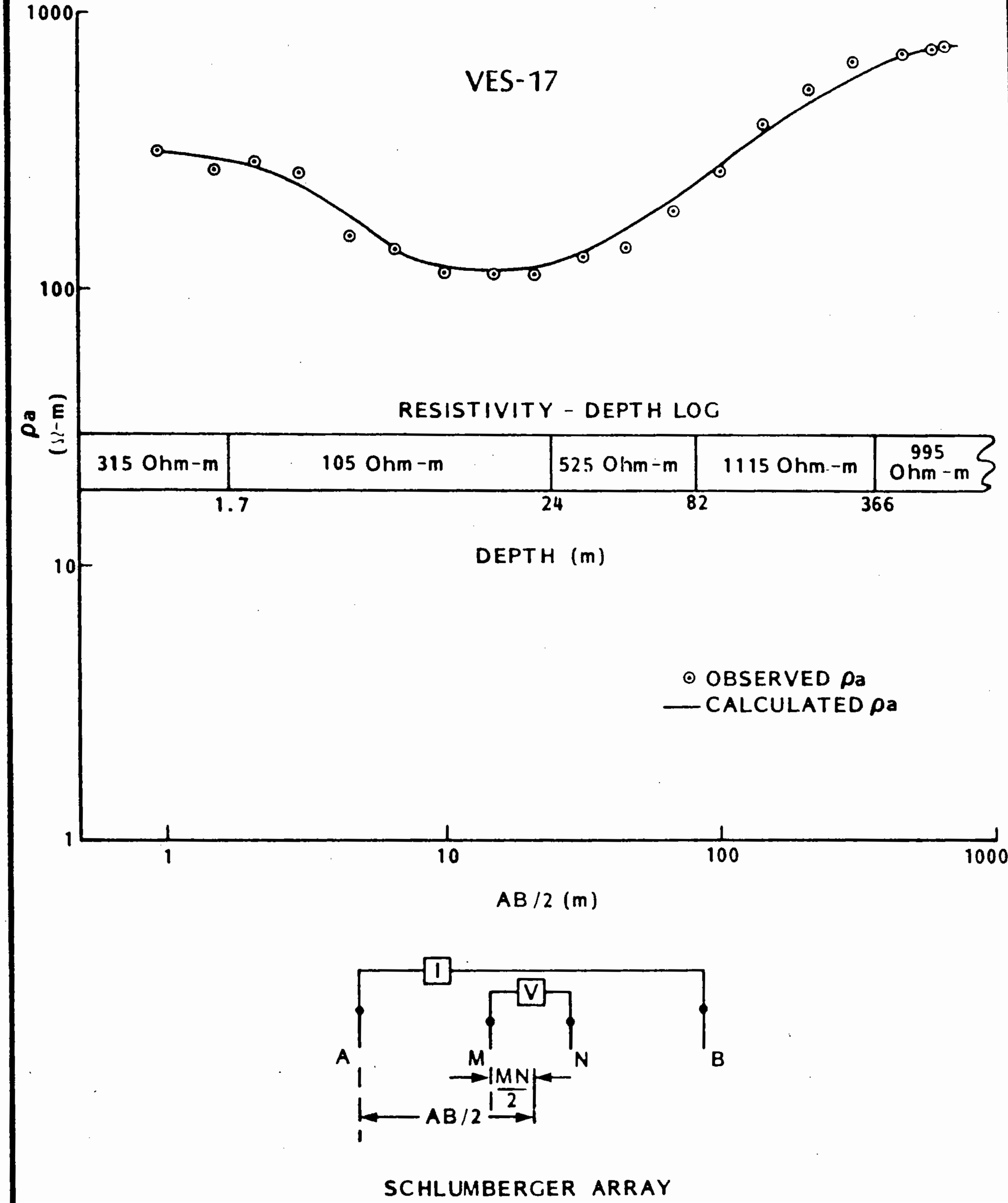
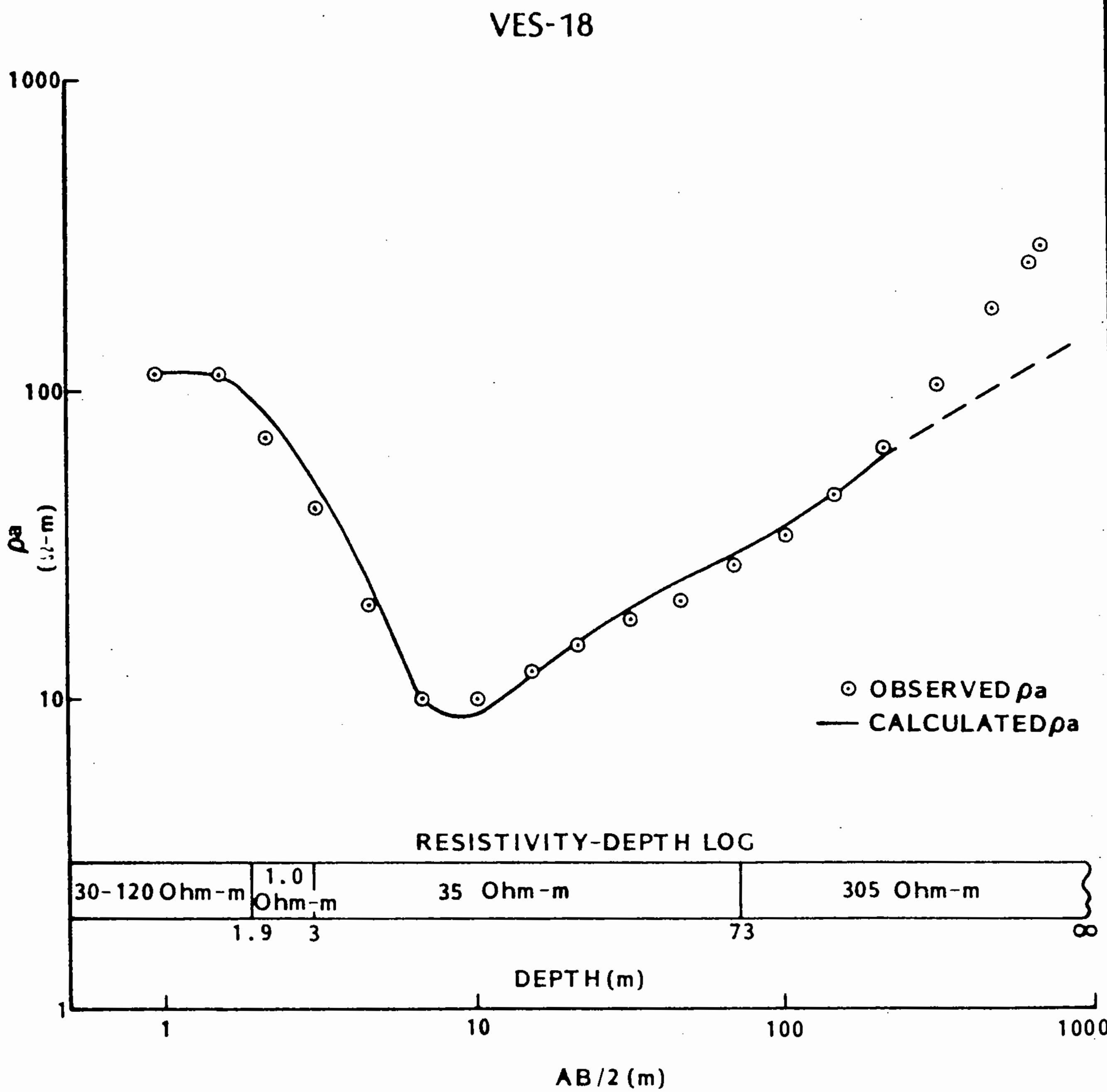


HARDING-LAWSON ASSOCIATES *Engineers, Geologists and Geophysicists*			VES-17 FIELD CURVE AND MODEL/SCHLUMBERGER ARRAY DIAGRAM	PLATE
12,090,001.01	WEB	8/24/81	Geophysical Investigation White Pine County, Nevada	6
Job No.	Approved	Date		



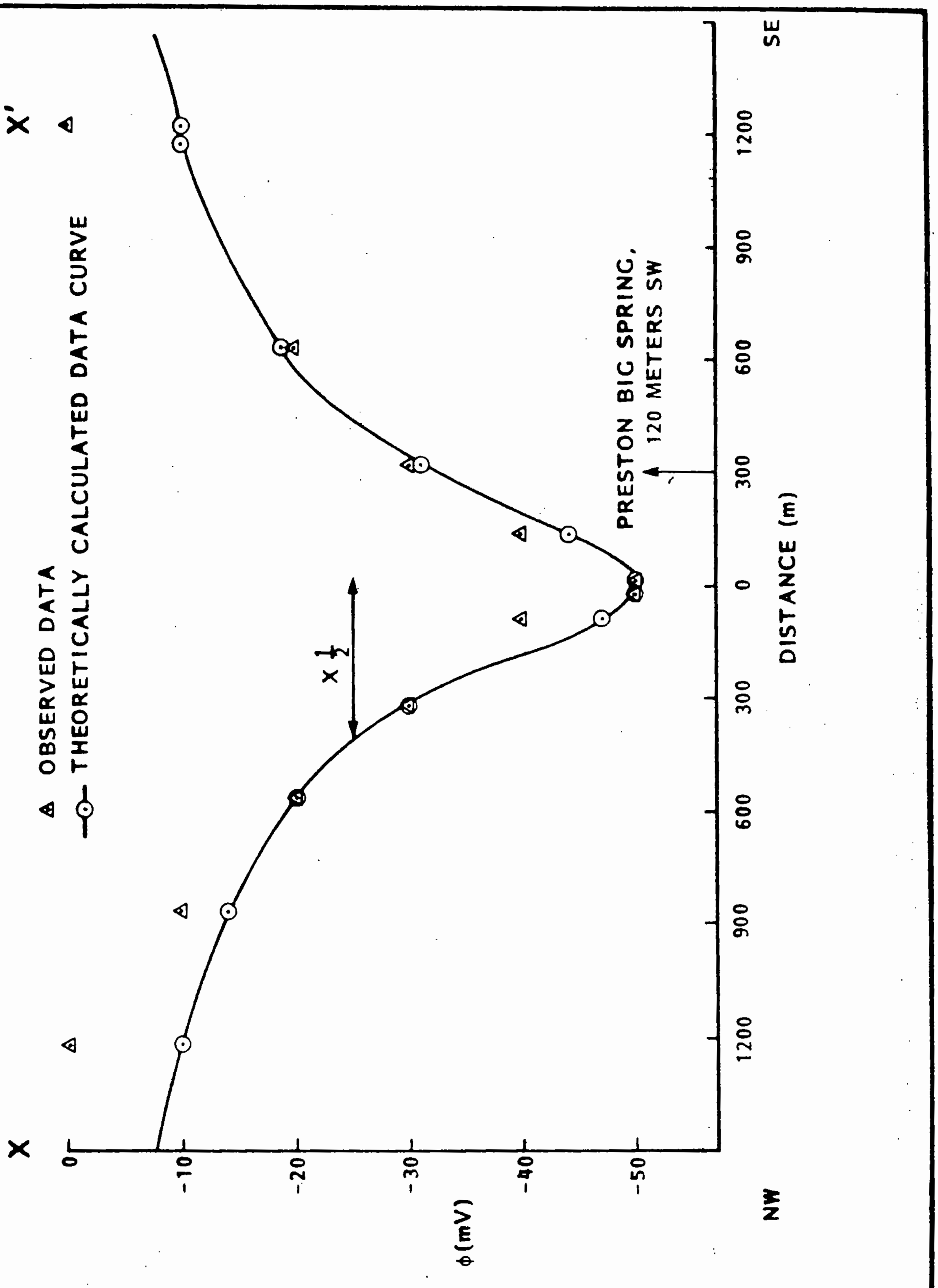
HARDING - LAWSON ASSOCIATES
Engineers, Geologists and Geophysicists

12,090,001.01	WCB	8/24/81
Job No.	Approved	Date

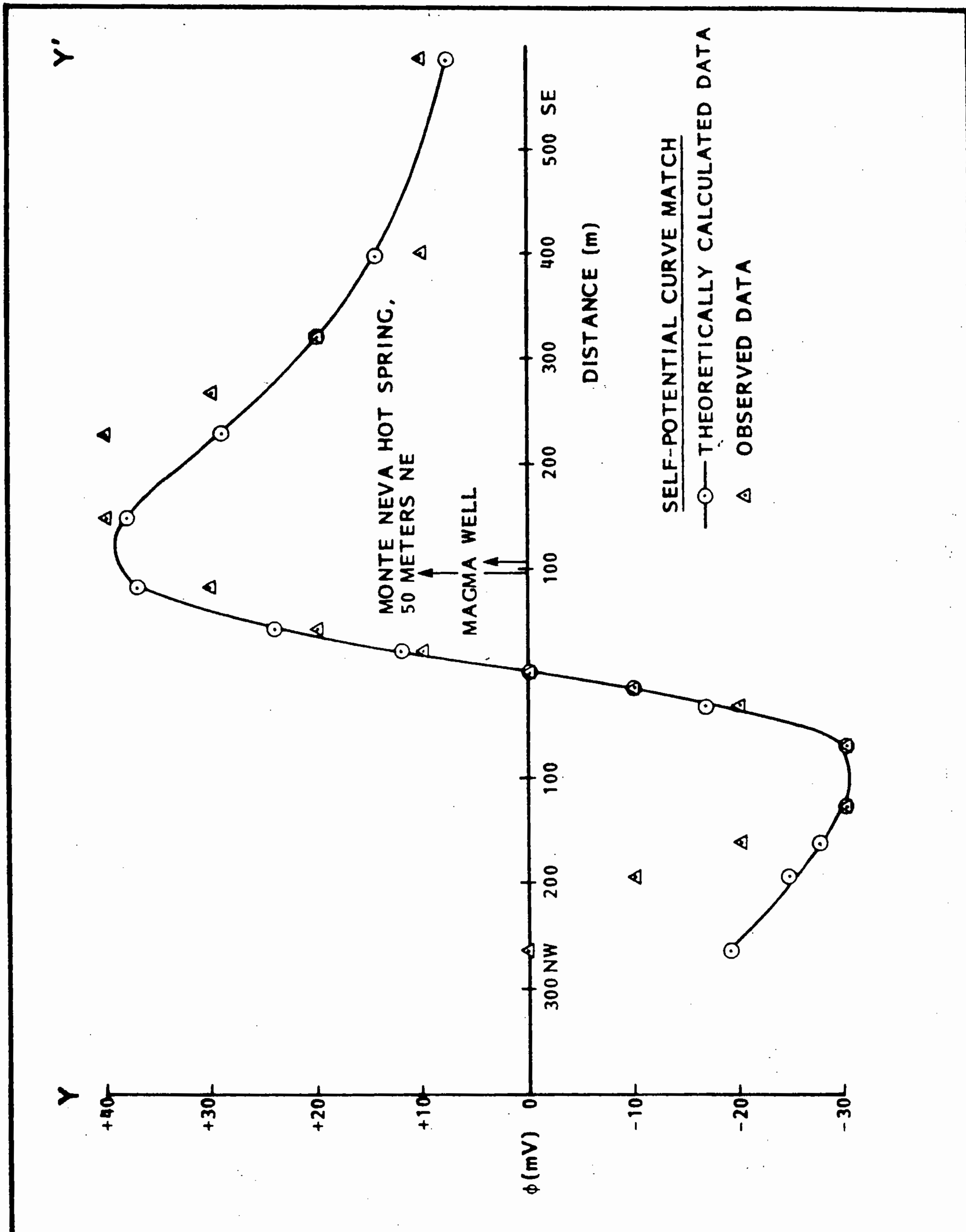
VES-18 FIELD CURVE AND MODEL

Geophysical Investigation
White Pine County, Nevada

PLATE 7



HARDING - LAWSON ASSOCIATES *Engineers, Geologists and Geophysicists*			SP PROFILE X-X' PRESTON BIG SPRING	PLATE 8
12,090,001.01	WEB	8/24/81	Geophysical Investigation White Pine County, Nevada	
Job No.	Approved	Date		



HARDING - LAWSON ASSOCIATES

Engineers, Geologists and Geophysicists

12,090,001.01	WEB	8/24/81
Job No.	Approved	Date

SP PROFILE Y-Y'
MONTE NEVA HOT SPRING

Geophysical Investigation
White Pine County, Nevada

PLATE
9

Appendix A

DATA ACQUISITION

I. ELECTRICAL RESISTIVITY SURVEY

A. Field Procedure

We obtained vertical electrical sounding (VES) data using the Schlumberger array (see Plate 6). This consists of four electrodes arranged on a colinear array. Electrical current (I) is introduced into the earth through the outer two electrodes (AB) while the resulting potential drop is measured between the inner two electrodes (MN). By separating the current electrodes by increasingly larger distances, the electrical current is forced to flow deeper into the substrate thus increasing the depth of the sounding. The potential electrodes are maintained at a fairly close spacing ($AB/MN \geq 5$) which is expanded only when the potential becomes too small to measure accurately. In many cases there is a shift in the apparent resistivity data when MN is expanded. Therefore, it was our procedure in the field to overlap the data whenever the shift was made. That is, we would usually repeat one or two readings using the expanded MN. This would provide us with a means of compensating for the MN shift if necessary.

For every vertical electrical sounding we took readings at 18 different AB/2 values ranging from approximately 1 meter to 610 meters. Our AB/2 spacings were chosen to provide distribution at even logarithmic intervals with 6 data points per cycle.

Electrical current was input in the form of a square wave using an IP transmitter (see Instrumentation section, below).

We monitored both the input current (I) and the measured voltage (V) using portable, high impedance chart recorders (see Instrumentation section).

It was our procedure to reduce and plot the data in the field (see Appendix B, Data Reduction) to insure data quality.

B. Instrumentation

We used one of two IP transmitters to input electrical current into the earth. One is an HEW-200 time domain IP transmitter. This unit is capable of transmitting up to 5 amps at 1200 volts thus giving it a power output of up to 6 kw. The power supply for this unit consisted of an array of 45 volt dry cell batteries wired in series. With this instrument we transmitted an on/off, positive to negative square wave with pulse duration of either four or two seconds. This results in a waveform frequency of 0.0625 to 0.125 Hz. The other transmitter we used is a Geotronics Corporation, FT-10 frequency domain IP transmitter. This unit is powered by an 11 KVA motor generator and is capable of transmitting up to 10 amps at 800 volts. We used this unit to transmit a positive-negative square wave with no off cycle at a frequency of 0.3 hertz. With both transmitters we monitored current output (I) using a Soltec model VP 6723S chart recorder connected to the transmitter through a precision shunt. The potential readings were obtained using a Linear Model 142 chart recorder connected to two Tinker and Rasor Cu-$CuSO_4$ half-cell electrodes.

II SELF-POTENTIAL SURVEY

The self-potential (SP) exploration method involves the measurement of the naturally occurring DC electric potential field in the earth. The SP surveys performed at Preston Big Spring and Monte Neva Hot Spring in White Pine County, Nevada, were "total field" surveys, meaning that voltage measurements were made with respect to a base electrode whose location remains fixed throughout the survey.

Voltage measurements during the surveys were made with a high input impedance (10 MΩ) Fluke 8020A multimeter and Tinker and Rasor Model 6B Cu-$CuSO_4$ nonpolarizing electrodes. When making potential readings, the measuring electrode was seated in a shallow hole, usually no more than 10 to 20 cm deep, to bring it into contact with moist soil, thereby reducing the contact resistance. In addition, at each measuring station the contact resistance was read so that variations in the quality of electrical contact, and therefore of the data, could be monitored.

Sources of unwanted DC electric signal, or "noise," in SP surveys include electrode polarization, telluric currents, near-surface geologic noise and man-made or "cultural" noise. Electrode polarization, usually caused by contamination of the electrode electrolyte with groundwater solutions, was corrected for by periodically comparing the measuring electrode with a portable reference electrode which was kept in an electrolyte bath at a relatively constant temperature. Telluric currents, caused by temporal fluctuations in the earth's magntic field, were monitored on the survey site with a 400-meter electrode dipole and a strip chart recorder. Telluric field variations observed during the survey were less than 5 millivolts/ kilometer, a value which is well under the noise level usually found in SP surveys. Near-surface geologic noise appears to be correlated with soil type and moisture content (Corwin and Hoover, 1979). Therefore, during the SP surveys, changes in soil type and moisture content were noted on the data sheets (Appendix D). The presence and location of man-made objects were also noted on data sheets, so that any effect these might have on the SP could be accounted for. A discussion of the near-surface geological noise at Preston Big Spring and Monte Neva Hot Spring is provided in Appendix B (Data Reduction and Interpretation).

A summary of the SP data acquired at each survey site is presented in Table B on the following page. The precise station locations are tabulated in Appendix D and the survey lines are shown on Plates 2 and 3. Station locations were selected in the field to be more densely spaced as potential gradients were observed to increase. At Preston Big Spring we used station spacings which varied from 25 to 200 meters. At Monte Neva we used spacings which varied from 10 to 200 meters.

Table B. Self-Potential Data Summary

Preston Big Spring Survey

Line	Length of Line (meters)	No. of Stations Occupied
A	1750	57
B	4190	51
C	2400	22
D	1000	10
E	2000	20
Totals	11.34 km	160

Average Station Spacing = 14 stations/kilometer

Monte Neva Hot Spring Survey

Line	Length of Line (meters)	No. of Stations Occupied
A	2200	47
B	1500	66
C	2010	62
D	1090	44
E	1700	36
Totals	8.5 km	255

Average Station Spacing = 30 stations/kilometer

Appendix B

DATA REDUCTION AND INTERPRETATION

I ELECTRICAL RESISTIVITY SURVEY

A. Data Reduction

The data obtained in the field: V, I, AB/2 and MN/2 are reduced to apparent resistivities (ρ_a) according to the following equation:

$$\rho_a = \pi \frac{(AB/2)^2 - (MN/2)^2}{MN} \quad \frac{V}{I}$$

The values of ρ_a are plotted on 3 x 3 cycle log-log paper as a function of AB/2. The resulting curve is examined for shifts in the data caused by the expansion of the MN spacing as revealed by differences in the repeat readings. These are compensated for by manually adjusting the curve. Once this has been accomplished, the data is input into a computer program which inverts the data and produces a layered resistivity model. As part of this procedure the program computes the theoretical values of ρ_a corresponding to the model. These are tabulated along with the observed values. These tables and the ones listing the thicknesses and true resistivities of each model are contained in Appendix C. The validity of each model can be determined by comparing the observed ρ_a with the theoretical values. This is illustrated by the sample curves shown on Plates 6 and 7.

B. Data Interpretation

The factors that affect the electrical resistivity of a material include porosity, saturation, the salinity of the saturating fluid, temperature and tortuosity. Of these the resistivity is indirectly proportional to all but the latter. Many of these parameters are interrelated. Probably the most important in most geological applications are porosity, saturation and the salinity of the saturating fluid.

C. Resistivity-Lithology Correlation

Based on the scant well log data that is available, and on geological data taken from Lloyd (1959) we have inferred the following correlation between resistivity and lithology.

Table A. Resistivity-Lithology Correlation

Resistivity (ohm-meters)	Lithology
5- 10	Saturated alluvium (Qal), probably with a high clay content and therefore not very permeable
10- 80	Saturated Qal and rock, the latter consisting of Ely Limestone (Cpe), Ellison Creek formation (Tec), Windous formation (Twb), Currant Tuff (Tct) and Dacite Flow Rock (Tv)
80-105	Partially saturated to unsaturated and possibly argillaceous Cpe; moist, unsaturated Qal
125-1115	Dry, unsaturated Qal, Cpe and Chainman Shale (Cmch)

II SELF-POTENTIAL SURVEY

A. Data Reduction

The chief objective in reducing the SP data was to smooth the short spatial wavelength distortions in the field produced by near-surface geological effects, so that longer wavelength features caused by hydrologic or thermal sources at greater depth would be more clearly visible. After the data were corrected for electrode polarization drift, smoothing was performed using a 5-point running mean. The smoothed data were then plotted and contoured using a 10-millivolt contour interval.

The short 10- to 15-meter wavelength noise observed in both the Preston and Monte Neva surveys correlated strongly with changes in surface soil type and moisture content. Noise levels ranged from ±10 mV in dry rocky soils to ±3 mV in moist uniform soils. These levels are typical for arid regions (Corwin and Hoover, 1979) and it seems unlikely that significant deep hydrologic or thermal source information was lost by smoothing the data.

B. Data Interpretation

Subsurface flows of groundwater and/or heat have long been known to generate self-potential fields at the earth's surface (Nourbehecht, 1963). The electric potential field generated by the flow of fluid through porous media is known as streaming potential. When heat flows through such a medium, the field is known as a thermoelectric potential field. Quantitative methods for calculating the electric fields associated with fluid and heat flow through the earth have been described by Nourbehecht (1963), Fitterman (1979) and Sill (in press). It has been established that when flows of fluid or heat, usually known as the primary flows, cross boundaries between earth media having different capacities to convert the primary flow energy into electrical energy, a self-potential field is produced. In addition, if a volume within the earth contains a source of the primary flow, that volume must also contain a source of electric current, as long as the earth medium within the volume has a finite capacity to convert primary flow energy into electrical energy. The ratio of electric field per unit of pressure or temperature gradient that a particular rock or soil type generates can be measured experimentally and is defined as the "coupling coefficient" of the material.

The hydrogeologic model upon which the following analyses are based are described in Section III of this report.

1. Preston Big Spring

Following the analytical methods developed by Sill (in press), the source of self-potential which is generated by the discharge of upwelling groundwater from fractured basement rocks into overburden was derived. The strength of the electric current source giving rise to the self-potential is given by

$$I = \frac{\sigma C Q_f}{K} \qquad (1)$$

where I = current strength (amperes)

σ = electrical conductivity (mhos/meter)

K = hydraulic conductivity (meters/second)

Q_f = flow rate (cubic meters/second)

C = streaming potential coupling coefficient (volts-square meters/Newton)

In equation (1) the hydraulic conductivity and coupling coefficient correspond to the overburden. It was assumed that the coupling coefficient of the basement rock is zero and the electric conductivity is constant throughout the medium.

Assuming that the depth to the source of the outflow was large compared to the diameter of the conduit, the self-potential field at the surface should resemble the field of a point current source. The depth to a point current source of 250 meters was then estimated from the half-width (X 1/2) of the anomaly along Section X-X' (see Plate 8). Using this estimate of depth to source and physically reasonable values of the parameters in equation (1), a theoretical fit to the observed data was calculated. The results of the calculation are presented in Plate 8. The parameters used in the calculation are given below.

$K = 10^{-9}$ meters/second

$C = 2.5 \times 10^{-7}$ volts-square meter/Newton

$Q_f = .314$ cubic meters/second (11 cfs)

The fact that all parameter values lie within physically reasonable ranges lends weight to the idea that the source of the anomaly is a relatively deep and localized.

2. Monte Neva Hot Spring

The Monte Neva Hot Spring SP anomaly was modeled using an approach developed by Fitterman (1979). The model consists of a vertical fault plane separating two quarter-spaces having different electrical conductivities and coupling coefficients. The source of the SP anomaly is a plane rectangular "patch," lying in the fault plane, whose intensity is proportional to the temperature of the patch and the difference between the thermoelectric coupling coefficients of the two quarter-spaces.

Profiles of surface SP perpendicular to the fault strike were calculated using the computer program SPDIP, and a theoretical profile was fit to the observed data along Section Y-Y' (Plate 9). Emphasis was placed on fitting the theoretical profiles to the observed steep potential gradient between the negative and positive peaks of the anomaly. This is because the gradient of potential near the zero crossing is the feature of the anomaly which is most sensitive to the depth to the top of the source plane. The depths to the top and bottom of the source plane thus obtained were 100 meters and 250 meters, respectively. The source temperature was 85°C (185°F) and the coupling coefficient contrast was 6.7 mV/°C.

Appendix C

ELECTRICAL RESISTIVITY DATA

VES 1

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.80000	.80000	202.82077
.42313	1.22313	402.39197
1.65746	2.88059	70.17026
.97677	3.85736	49.37338
19.48811	23.34546	82.97612
12.84899	36.19445	52.91375
22.38478	58.57923	83.68079
295.98602	354.56525	18.94830
99998416.00000	99998768.00000	186.51984

AB/2	CALC. VES	OBSERVED VES
1.00000	207.27719	204.00000
1.46780	205.60345	214.00000
2.15443	188.33859	187.00000
3.16228	151.70285	154.00000
4.64159	111.15753	108.00000
6.81292	85.62599	82.00000
9.99999	77.77232	76.00000
14.67798	78.02193	76.00000
21.54433	78.32680	80.00000
31.62276	76.00250	76.00000
46.41586	71.04840	69.00000
68.12915	63.41422	64.00000
99.99991	52.30490	49.00000
146.77979	39.32708	38.00000
215.44324	29.27212	31.00000
316.22742	25.57309	28.00000
464.15833	28.27310	28.00000
681.29114	36.14864	38.00000

VES 2

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.44134	.44134	483.16632
.20557	.64691	188.04919
.35337	1.00028	27.62506
.87127	1.87155	120.09157
5.50486	7.37641	67.60088
2.42902	9.80543	130.78329
19.42620	29.23162	116.27611
20.37967	49.61130	164.91895
43.86751	93.47881	64.27303
29.81043	123.28923	7.12028
297.82977	421.11902	33.27395
99993088.00000	99993504.00000	968.03870

AB/2	CALC. VES	OBSERVED VES
.10000	481.59222	485.36823
.14678	480.55115	484.09711
.21544	475.37091	478.59454
.31623	462.08331	465.14240
.46416	429.61890	431.44189
.68129	359.13123	356.79071
1.00000	251.24579	246.08698
1.46780	148.38843	147.06348
2.15443	92.58139	95.71178
3.16227	79.03938	79.54634
4.64158	78.91258	74.01962
6.81291	78.23390	72.52740
9.99999	79.32327	75.77144
14.67797	85.25377	82.01236
21.54432	94.08984	90.40274
31.62273	102.44862	100.46460
46.41582	108.05115	108.76462
68.12910	107.53128	109.39491
99.99985	95.79803	96.00037
146.77969	72.73065	69.00458
215.44312	48.86540	42.15939
316.22723	36.43491	30.49415
464.15800	37.83978	35.29456
681.29077	49.10129	49.49831

VES 3

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISITIVITY
2.05959	2.05959	199.16434
1.93599	3.99558	82.50999
11.29772	15.29329	21.14321
7.57925	22.87254	15.65552
99999952.00000	99999968.00000	44.49196

AB/2	CALC. VES	OBSERVED VES
.10000	199.09113	203.26807
.14678	198.91837	203.06464
.21544	198.65701	202.52856
.31623	198.46991	201.92850
.46416	198.41885	201.09445
.68129	198.09531	198.33498
1.00000	196.56476	192.85425
1.46786	192.20984	186.85577
2.15443	181.26950	178.89368
3.16227	157.96921	158.09229
4.64158	120.59985	119.81292
6.81291	78.05125	75.63527
9.99999	45.05038	45.19231
14.67797	28.44964	29.68864
21.54432	23.68742	23.08399
31.62273	24.11830	21.78518
46.41583	26.82691	24.14389
68.12910	30.79396	28.61286
99.99985	34.96526	33.73078
146.77969	39.48331	38.12101
215.44312	41.02739	41.02199
316.22723	42.65505	42.90901
464.15808	43.56901	44.47525
681.29377	44.07265	44.95708

VES 4

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.69953	.69953	116.71924
.58416	1.28369	35.12333
.81045	2.09414	9.14231
8.68094	10.7741[illegible]	37.76406
65.21461	75.98806	23.73281
239.66351	315.65234	11.73046
99999648.00000	99999968.00000	15.14132

AB/2	CALC. VES	OBSERVED VES
.10000	116.29567	117.19265
.14679	116.32771	117.22380
.21544	116.19556	117.06378
.31623	115.25006	116.09745
.46416	112.62433	113.34671
.68129	106.08046	106.47864
1.00000	91.72102	91.51387
1.46780	68.56239	67.72284
2.15443	43.90057	42.65146
3.16227	28.25537	26.83498
4.64158	24.32256	23.13503
6.81291	26.58510	26.14643
9.99999	29.46871	25.91769
14.67797	31.82919	31.77590
21.54432	30.35281	31.24642
31.62273	23.49945	29.05263
46.41589	26.22821	26.56358
68.12911	24.11321	24.472[illegible]
99.99995	21.80375	22.11473
146.77969	19.91261	18.93887
215.44317	15.98623	15.46243
316.22723	14.03885	13.35669
464.15608	13.34466	12.76263
681.29877	13.52112	12.89794

VES 5

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.93276	.93276	40.38540
3.91685	4.84961	64.95433
3.96940	8.81901	26.94126
17.67704	26.49606	9.75370
168.80927	195.30533	80.90004
99999744.00000	99999936.00000	52.94550

AB/2	CALC. VES	OBSERVED VES
.10000	40.36007	40.05969
.14678	40.37665	40.07872
.21544	40.37955	40.07706
.31623	40.39567	40.09119
46416	40.50352	40.22396
.68129	40.92527	40.71043
1.00000	42.16700	42.05220
1.46780	44.77911	44.83397
2.15443	48.56876	48.94378
3.16227	52.27625	52.91482
4.64158	53.98105	54.38426
6.81291	51.47550	51.31250
9.99999	43.43504	42.87953
14 67797	31.74958	31.03267
21.54432	21.61065	21.01461
31.62273	17.39545	17.18639
46.41582	19.32679	19.46012
68.12910	24.99951	25.32984
99.99985	32.41575	32.88764
[illegible]	40.63008	41.05214
215.44312	49.74603	48.66311
316.22223	55.30807	54.42489
464.15918	58.84745	57.72656
681.29077	59.10328	59.15136

VES 6

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.48870	.48870	32.85986
1.94563	2.43434	28.46797
1.86775	4.30208	35.57738
44.61546	48.91755	15.99685
179.47513	228.39267	50.83811
99999728.00000	99999952.00000	31.96130

AB/2	CALC VES	OBSERVED VES
.10000	32.94518	33.17117
.14678	32.84069	33.18021
.21544	32.80911	33.12051
.31623	32.70442	32.94036
.46416	32.45441	32.53941
.68129	31.94891	31.60374
1.00000	31.15839	29.92484
1.46780	30.25710	28.27427
2.15443	29.53431	27.90379
3.16227	29.11813	28.78167
4.64158	28.55588	29.47188
6.81291	26.88585	28.71523
9.99999	23.83617	26.34432
14.67797	20.51957	22.58368
21.54432	19.26144	18.06027
31.62273	17.44036	14.80317
46.41587	17.94807	14.83176
68.12910	19.93447	18.03287
99.99935	23.56385	22.86814
146.77969	28.31482	28.03756
215.44313	33.12718	32.69587
316.22723	36.77623	36.66973
464.15808	38.25681	37.71091
681.29077	37.53644	37.93202

VES 7

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISITIVITY
.50930	.50930	67.55463
.23804	.74734	26.98620
1.49660	2.24394	13.60828
2.36197	4.60591	45.19336
.21222	4.81813	16.53600
48.50282	53.32095	22.15838
251.74295	305.06390	12.89615
99999534.00000	99999840.00000	34.56858

AB/2	CALC VES	OBSERVED VES
.10000	67.34893	67.37601
.14678	67.31905	67.39738
.21544	66.95325	67.09170
.31623	65.83165	66.04341
.46416	62.99334	63.41646
.68129	56.47491	57.11040
1.00000	45.18682	45.30199
1.46780	32.15828	30.84093
2.15443	23.00950	20.67453
3.16227	20.35384	18.41571
4.64158	22.08997	21.23351
6.81291	24.66108	24.25980
9.99999	25.93523	24.46443
14.67797	25.61312	21.63256
21.54432	24.44347	18.10681
31.62277	23.22463	16.35250
46.41592	22.13799	16.68570
68.12912	20.78570	17.83925
99.99985	18.64499	18.34017
146.77969	16.73775	17.65132
215.44312	15.30356	16.44267
316.22723	15.17727	15.79680
464.15808	16.58568	16.49062
681.29877	19.30759	18.84266

VES 8

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.81113	.81113	93.89807
.97299	1.78412	35.24633
1.61302	3.39714	19.60736
11.41985	14.81699	33.04685
80.21124	95.02823	8.46643
322.25275	417.28101	27.24334
99999504.00000	99999920.00000	18.54028

AB/2	CALC VES	OBSERVED VES
.10000	93.64445	93.92882
.14678	93.62479	93.89873
.21544	93.58066	93.87665
.31623	93.21944	93.56671
.46416	92.06888	92.48126
.68129	89.05623	89.62892
1.00000	81.89651	82.86194
1.46780	68.92288	70.17378
2.15443	52.52137	53.27876
3.16227	38.32567	38.13438
4.64158	30.32475	29.76338
6.81291	28.02785	27.79842
9.99999	28.20018	28.27899
14.67797	27.74337	27.70511
21.54432	24.92737	24.60473
31.62273	19.59403	19.57159
46.41587	14.28644	14.53747
68.12910	11.12334	11.27849
99.99985	10.48481	10.32395
146.77969	11.62473	11.31040
215.44312	13.80305	13.61300
316.22723	16.41962	16.40255
464.15808	18.85568	18.73658
681.29077	20.49984	19.96441

VES 9

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.96431	.96431	90.23779
1.17770	2.14202	118.80892
1.73000	3.87201	41.90027
.77083	4.64284	2.48379
32.67295	37.31583	15.18197
29.62018	66.93600	10.07612
293.98511	360.92114	59.94350
99999535.00000	99999904.00000	36.21951

AB/2	CALC. VES	OBSERVED VES
.10000	90.27043	88.76413
.14678	90.19534	88.68750
.21544	90.03680	88.51598
.31623	89.95927	88.51039
.46416	90.16936	89.02711
.68129	90.65489	90.08022
1.00000	91.35052	91.48927
1.46780	92.13879	93.19476
2.15443	91.13110	93.18486
3.16227	83.47179	85.08548
4.64158	65.43350	64.03477
6.81291	41.64273	37.27040
9.99999	23.10874	18.79649
14.67797	15.23614	12.98622
21.54437	14.18978	13.64699
31.62273	14.66502	14.89301
46.41587	14.85274	15.18373
68.12910	15.25424	15.20363
99.99985	16.92735	16.46345
146.77969	20.52132	20.14537
215.44312	25.74279	25.98525
316.22723	31.65383	32.57352
464.15808	37.09832	38.15022
681.29077	40.81689	41.13251

VES 10

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISITIVITY
.33325	.33325	116.79247
1.59552	1.92856	95.11366
.61169	2.54055	36.40878
2.20735	4.74791	19.56343
4.15223	8.90014	36.48354
82.11594	91.01607	21.31886
99999872.00000	99999968.00000	39.39191

AB/2	CALC. VES	OBSERVED VES
.10000	116.61882	117.14437
.14678	116.34630	116.80052
.21544	115.79192	116.24675
.31623	114.66322	115.32965
.46416	112.14674	112.68927
.68129	107.65921	107.00375
1.00000	101.77177	100.53938
1.46780	95.08765	95.50638
2.15443	85.79301	86.90175
3.16227	70.84851	69.57785
4.64158	52.17654	49.55617
6.81291	37.27473	36.79678
9.99999	30.23901	32.06501
14.67797	27.94770	29.59910
21.54432	26.23266	26.69647
31.62273	24.29938	24.18575
46.41582	22.97620	22.50110
68.12910	22.63950	21.79187
99.99985	23.31432	22.45803
146.77969	25.13601	24.28041
215.44312	27.97572	26.97695
316.22725	31.19574	30.57875
464.15808	34.07583	34.39153
681.29077	36.23835	37.05495

VES 11

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
1.14606	1.14606	22.52601
15.55754	16.70359	62.96935
35.19477	51.89837	25.98904
81.98140	133.87976	49.01569
252.39835	386.27814	18.49145
99999360.00000	99999744.00000	9.98020

AB/2	CALC. VES	OBSERVED VES
.10000	22.57350	22.38977
.14678	22.60561	22.40796
.21544	22.63038	22.45236
.31623	22.66932	22.49676
.46416	22.79211	22.51172
.68129	23.12948	22.64782
1.00000	24.01685	23.29862
1.46780	26.15697	24.68977
2.15443	30.21278	27.14692
3.16227	36.01772	31.67571
4.64158	42.52023	38.78020
6.81291	48.46576	47.16050
9.99995	52.90343	54.47939
14.67797	55.05636	58.34753
21.54432	53.84119	56.34901
31.62273	48.61932	48.43331
46.41583	41.31981	39.64432
68.12910	35.94614	35.51236
99.99957	34.51312	35.60600
146.77969	34.94444	35.36951
215.44312	33.67339	32.50897
316.22723	29.31841	28.26798
464.15808	23.29874	23.55606
681.29077	17.76240	18.14332

VES 12

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
1.07617	1.07617	78.85135
5.17041	6.24658	47.78373
5.25763	11.50421	10.22208
72.51395	84.01816	25.17188
38.25162	122.26978	9.59136
33.82381	156.09360	2.39426
9999945[illegible].00000	99999616.00000	45.70695

AB/2	CALC. VES	OBSERVED VES
1.0[illegible]	75.95[illegible]	77.0[illegible]
1.46[illegible]	[illegible].11972	76.0[illegible]
2.15443	65.57689	72.00000
3.16229	57.82156	57.00000
4.64159	50.73183	47.00000
6.81292	43.76370	41.00000
9.99999	35.23396	34.00000
14.67798	26.59122	24.00000
21.54433	21.46701	19.00000
31.62276	20.62123	18.00000
46.41[illegible]	21.67488	20.00000
68.12915	2[illegible].25149	23.50000
[illegible]9.9999[illegible]	[illegible]	23.00000
14[illegible].77979	18.74[illegible]	19.60000
215.44[illegible]	15.48741	15.80000
316.22742	14.13765	13.00000
464.15[illegible]	1[illegible]	15.00000
681.29[illegible]	2[illegible].12776	19.00000

VES 13

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.47317	.47317	152.85501
.37455	.84772	38.48996
.23301	1.08073	18.71259
3.90922	4.98995	72.04926
11.13856	16.12851	39.98308
23.49039	39.61890	123.85257
41.28777	80.90666	69.09642
354.82269	435.72937	206.34521
99999200.00000	99999632.00000	489.39490

AB/2	CALC VES	OBSERVED VES
.10000	152.45979	152.72581
.14678	153.20496	153.44876
.21544	150.62845	152.02216
.31623	147.26379	148.23755
.46416	138.47205	139.93875
.68129	119.55579	118.77184
1.00000	91.35115	89.18192
1.46780	65.63156	62.58688
2.15443	53.61845	50.28374
3.16227	53.90016	51.56775
4.64158	57.78351	57.83070
6.81291	59.27500	60.84919
9.99999	57.24487	57.53253
14.67797	54.14214	52.24505
21.54472	54.25079	52.22425
31.62273	60.64609	59.86314
46.41592	69.89424	67.58093
68.12910	79.97649	75.55247
99.99985	89.27711	85.57242
146.77969	100.85246	111.20959
215.44312	117.93916	121.17952
316.22773	140.43103	141.96401
464.15808	167.23395	166.18564
681.29077	199.97885	200.24890

VES 14

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISITIVITY
.68717	.68717	109.56355
1.82520	2.51237	42.02641
7.51254	10.02491	217.59473
17.61408	27.63900	173.43503
87.24008	114.87907	270.03528
152.85690	267.73596	62.54881
89.32594	357.06189	15.91407
99999360.00000	99999712.00000	47.37504

AB/2	CALC. VES	OBSERVED VES
.10000	109.31076	109.60240
.14678	109.37718	109.72898
.21544	109.30081	109.76563
.31623	108.66418	109.21854
.46416	106.82573	107.54753
.68129	102.14503	103.21764
1.00000	92.19357	93.02031
1.46780	77.74713	76.61974
2.15443	65.53580	62.08688
3.16227	63.37675	60.15214
4.64158	73.30690	73.12988
6.81291	91.54239	94.87914
9.99999	113.24518	118.05885
14.67797	134.99545	137.92273
21.54432	154.40527	154.15732
31.62273	170.53046	170.28882
46.41582	184.74548	187.57953
68.12910	198.32822	202.57645
99.99985	207.67053	210.22495
146.77969	202.37411	203.56866
215.44312	172.68365	174.53430
316.22723	123.80455	126.06909
464.15808	77.14807	78.63635
681.29077	50.52769	50.71825

VES 15

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.62430	.62430	245.24207
.31881	.94311	99.93910
.21318	1.15629	21.81892
.07906	1.23535	1.07105
18.69014	19.92548	108.94774
101.75342	121.67891	65.30777
107.42592	229.10483	92.15883
209.99543	439.10029	44.06049
99999136.00000	99999568.00000	18.21361

AB/2	CALC. VES	OBSERVED VES
.10000	244.24298	247.29499
.14678	244.39977	247.47357
.21544	242.86426	246.82251
.31623	241.11345	243.80994
.46416	233.87759	236.14145
.68129	216.23270	217.00089
1.00000	178.49686	175.67638
1.46789	121.04460	114.87573
2.15443	66.51541	60.31636
3.16227	38.91402	34.37572
4.64159	37.84538	33.94101
6.81291	48.10407	44.44238
9.99979	59.91641	57.78209
14.67797	71.04459	71.84209
21.54432	83.33395	84.12016
31.62273	95.50107	90.43487
46.41590	85.01329	88.59239
68.12910	80.17519	81.47670
99.99985	74.54443	74.50421
146.77959	71.04105	70.68521
215.44312	69.66795	69.81517
316.22777	67.30499	65.69913
464.15903	60.19387	58.52850
681.29077	47.88129	47.48939

VES 16

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.40577	.40577	239.24951
.51952	.92529	577.79469
4.02156	4.94715	108.31015
24.46250	29.40965	117.81604
26.75505	56.16470	65.70038
161.45439	217.61909	182.70071
99999632.00000	99999254.00000	57.33456

AB/2	CALC. VES	OBSERVED VES
1.00000	313.95892	310.00000
1.46780	329.78491	351.00000
2.15443	312.32312	325.00000
3.16228	270.52203	257.00000
4.64159	225.31186	205.00000
6.81292	189.99979	176.00000
9.99999	163.26572	160.00000
14.67793	142.22922	133.00000
21.54433	127.26796	126.00000
31.62276	116.99224	115.00000
46.41586	109.58931	105.00000
68.12915	103.62099	100.00000
99.99991	106.57094	97.00000
146.77979	116.86342	112.00000
215.44324	126.99661	127.00000
316.22742	137.55259	129.00000
464.15833	114.19092	116.00000
681.29114	92.65579	93.00000

VES 17

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISITIVITY
1.73303	1.73303	315.35077
22.43749	24.17052	105.55342
57.40562	81.57614	522.00896
284.23486	365.81104	1114.89600
99999520.00000	99999888.00000	995.14661

AB/2	CALC. VES	OBSERVED VES
.10000	315.10760	315.82404
.14678	314.76367	315.52698
.21544	314.51135	315.22900
.31623	314.54077	315.15820
.46416	314.36249	315.15869
.68129	312.89307	314.45099
1.00000	308.69580	311.70947
1.46780	298.15167	303.51544
2.15443	273.17529	283.02484
3.16227	229.03424	244.15405
4.64158	177.33694	191.61258
6.81291	138.28223	143.48737
9.99999	119.87224	115.49641
14.67797	116.16399	108.28560
21.54432	121.63545	114.67223
31.62273	138.48563	130.79068
46.41582	171.27228	158.72025
68.12910	220.84857	204.31961
99.99985	286.24341	272.50165
146.77969	368.40631	363.34204
215.44312	468.26361	471.91217
316.22723	582.00781	588.23657
464.15808	699.31384	697.55261
681.29077	805.63220	785.67981

VES 18

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
1.37741	1.37741	121.89192
.52940	1.90682	30.10458
1.07635	2.98316	1.20223
69.63013	72.61330	36.45840
99999552.00000	99999632.00000	303.44409

AB/2	CALC. VES	OBSERVED VES
.10000	121.62703	121.96533
.14678	121.40556	121.75291
.21544	121.37068	121.79567
.31623	121.45485	121.95538
.46416	121.03706	121.61369
.68129	119.31020	120.21587
1.00000	114.99028	116.45494
1.46780	104.32765	105.34163
2.15443	81.86580	80.99405
3.16227	49.89465	47.96566
4.64158	22.33836	21.43565
6.81291	9.72278	10.14778
9.99999	8.89739	9.44968
14.67797	12.01859	11.85080
21.54432	15.64200	14.55595
31.62273	19.72666	17.78041
46.41582	24.47818	21.74523
68.12910	29.98889	27.29489
99.99985	37.19582	35.39579
146.77969	47.98965	47.28311
215.44312	64.00336	63.88041

VES 19

REDUCED THICKNESS	REDUCED DEPTH	REDUCED RESISTIVITY
.63803	.63803	145.54050
.31399	.95202	34.41111
1.33745	2.28947	20.03551
1.51164	3.80112	30.85400
1.02247	4.82359	16.19261
20.60694	25.43053	52.93843
53.19656	78.62709	12.92988
16.15511	94.78220	39.43415
262.96881	357.75104	22.65518
99995744.00000	99996096.00000	507.72693

AB/2	CALC. VES	OBSERVED VES
.10000	145.01855	145.52466
.14678	145.05896	145.59808
.21544	144.60129	145.15582
.31623	142.84702	143.39899
.46416	138.39294	139.05502
.68129	127.36238	128.34482
1.00000	104.72302	105.58450
1.46780	72.96259	72.75655
2.15443	44.75249	43.84262
3.16227	29.98970	29.22683
4.64158	26.79841	25.52812
6.81291	28.59062	26.22581
9.99999	31.93045	29.76989
14.67797	35.86624	35.61408
21.54432	39.14091	40.74081
31.62273	39.61789	41.22459
46.41582	35.61550	35.66528
68.12910	28.46407	27.54393
99.99985	22.44395	21.96920
146.77969	20.46162	20.13634
215.44312	21.78423	20.38168
316.22723	24.87775	22.79263
464.15808	30.27154	29.25996
681.29077	39.89925	40.99075

Appendix D

SELF-POTENTIAL DATA

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 28 July 1981
LOCATION Preston Big Spring, Nevada
LINE A
BASE ELECTRODE LOCATION
PERSONNEL Corwin, Palm

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H2
MEASURING ELECTRODE H10
REEL CHECKS RESISTANCE 507 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
	Center of spring is ~75 m SE of base electrode							
1126	In container H1⁻ H10⁺ = +2.1 mV, H2⁻ H10⁺ = -1.5 mV, H1⁻ H2⁺ = +3.6							
1151	Begin Line A to west. 50 m station spacing (pace 50, marks @ 100)							
1200	0	+3	4.7	-2	0	+1	-4	1 m NW of base, red flag
1211	50W	0	4.6	-5	0	-5	-2	fine dry soil
1221	80W	-8	3.7	-9	0	-17	+1	gravelly soil, just west of wash
1231	100W	+20	10.3	-12	0	+8	+2	gravel soil
1236	150W	+33	9.0	-15	0	+18	+4	gravel soil
1239	In container H2⁻ H10⁺ = +11							
1245	200W	+19	7.7	-15	0	+4	+9	10 m E of fence
1259	250W	+26	8.6	-17	0	+9	+15	
1302	300W	+24	7.2	-18	0	+6	+16	
1306	350W	+58	11.9	-20	0	+38	+20	
1310	400W	+46	14.9	-21	0	+25	+24	
1316	450W	+44	13.5	-23	0	+21	+28	electrode leaking
1325	500W	+53	10.2	-24	0	+29	+29	
1328	In container H2⁻ H10⁺ = +20							
1335	550W	+52	10.7	-24	0	+28	+29	
1340	600W	+65	12.9	-23	0	+42	+30	
1344	650W	+45	12.0	-22	0	+23	+30	
1350	700W	+48	12.7	-20	0	+28	+30	
1354	750W	+49	11.3	-19	0	+30	+23	
1357	800W	+47	10.7	-18	0	+29	+18	
1359	In container H2⁻ H10⁺ = +14							
1408	850W	+23	8.0	-18	0	+5	+15	

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 28 July 1981
LOCATION Preston Big Spring, Nevada
LINE A
BASE ELECTRODE LOCATION
PERSONNEL Palm, Corwin

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H2 (H12)
MEASURING ELECTRODE H10 (H2)
REEL CHECKS RESISTANCE 507 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1414	900W	+17	9.4	-17	0	0	+13	
1418	950W	+26	8.6	-15	0	+11	+13	
1424	1000W	+33	8.5	-14	0	+19	+10	
1426	In container $H2^-$ $H10^+$ = +10							
1440	1100W	+42	58	-14	0	+28	+13	electrode leaking
1445	1200W	+5	5.3	-15	0	-10	+13	in topographic low
1453	1300W	+33	9.4	-16	0	+17	-	
1501	1400W	+29	13.6	-17	0	+12	-	road centerline 60 m west
1505	In container $H2^-$ $H10^+$ = +13							
1540	In container $H2^-$ $H10^+$ = +9, $H2^-$ $H12^+$ = -2.5							
New measuring electrode is H2								
1608	In container $H12^-$ $H2^+$ = +5							
1615	0	+6	5.9	-4	0	+2		
1621	25E	+7	6.5	-5	0	+2	-1	soil compacted along jeep trail ~2m S of fence line
1628	50E	+5	6.7	-5	0	0	0	50m due N of open water in spring
1631	75E	+2	5.2	-6	0	-4	+4	soft soil
1635	100E	+11	7.4	-7	0	+4	+7	soft soil
1641	150E	+24	10.8	-7	0	+17	+11	
1645	200E	+24	13.0	-8	0	+16	+20	
1646	In container $H12^-$ $H2^+$ = +9							
1654	250E	+32	10.9	-8	0	+24	+24	hard soil
1701	300E	+47	11.7	-8	0	+39	+23	hard soil
1707	350E	+32	10.0	-8	0	+24	+24	hard to medium soil
1715	400E	+22	7.6	-8	0	+14	+26	hard, moist soil ~5m SW of fence end
1719	In congainer $H12^-$ $H2^+$ = +9							
1723	450E	+27	9.0	-8	0	+19	+23	
1728	500E	+40	9.8	-8	0	+32	+25	soft, powdery soil

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE --
SHORT CIRCUITS --

DATE 28 July 1981
LOCATION Preston Big Spring, Nevada
LINE A
BASE ELECTRODE LOCATION
PERSONNEL Palm, Corwin

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1732	550E	+33	9.9	-7	0	+26	+35	
1741	600E	+42	13.9	-7	0	+35	+39	fence corner
1749	650E	+70	6.9- 21.9+	-6	0	+64	+35	rocky
1751	In container H12⁻ H2⁺ = +7							
1757	700E	+45	10.9	-6	0	+39	+36	
1801	750E	+15	9.7	-6	0	+9	+34	
1806	800E	+40	12.0	-6	0	+34	+23	
1810	850E	+29	14.8	-5	0	+24	+18	
1815	900E	+13	9.0	-5	0	+8	+23	
1816	In container H12⁻ H2⁺ = +6							
1821	950E	+22	8.5	-5	0	+17	+26	
1825	1000E	+39	4.9	-5	0	+34	+35	
1830	1100E	+74	15.0	-4	0	+70	+50	
1836	1150E	+63	14.0	-4	0	+59	+49	
1840	1200E	+43	15.2	-4	0	+39	+48	
1845	1250E	+32	9.6	-3	0	+29	+43	
1850	1300E	+46	12.9	-3	0	+43	-	
1852	In container H12⁻ H2⁺ = +4							
1858	1350E	+49	13.8	-3	0	+46	-	east of Hwy. 318 Hwy. 318 centerline @ 1340
1912	1050E	+49	11.8	-3	0	+46	+45	
1936	In container H1⁻ H2⁺ = +4.6, H2⁻ H10⁺ = -2.6, H1⁻ H10⁺ = +2.3							
1933	0	+20	21	-5	0	+15	-	

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

VOLTMETER Fluke 8020A

DATE 29 July 1981

BASE ELECTRODE H1

LOCATION Preston Big Spring, Nevada

PORTABLE REFERENCE ELECTRODE H12

LINE B

MEASURING ELECTRODE H2

BASE ELECTRODE LOCATION

REEL CHECKS RESISTANCE 99 ohms

PERSONNEL Palm, Corwin

SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
0923	In container $H1^-$ $H2^+$ = +4.0, $H1^-$ $H12^+$ = -0.9, $H12^-$ $H2^+$ = +4.8							
0936	50N	-2.9	5.7	-4	0	-7	-5	soft soil, truck survey
0943	100N	-5.6	6.9	-5	0	-11	-6	
0950	150N	-0.7	5.9	-5	0	-6	-9	fine, soft clay soil
0954	200N	-0.7	5.7	-6	0	-7	-10	red flag
0956	In container $H12^-$ $H2^+$ = +7.0							
1000	250N	-6.3	5.0	-6	0	-12	-6	harder soil
1004	300N	-8.3	4.9	-6	0	-14	-6	normal soil
1008	350N	+15	8.5	-6	0	+9	-1	drier soil
1013	400N	+1	6.1	-6	0	-5	+7	fence corner 35/2 section line
1045	500N	+25	10.2	-6	0	+19	+11	
1514	In container $H12^-$ $H2^+$ = +7.4							
1516	400N	+3	5.4	-6	0	-3	+7	
1521	500N	+22	6.8	-6	0	+16	+11	~50m short of rd junction not in previous reading ho
1530	600N	+32	8.4	-6	0	+26	+16	red flag on E side of rd.
1534	700N	+12	5.9	-6	0	+6	+23	
1540	800N	+42	8.2	-6	0	+36	+24	red flag
1544	900N	+34	8.9	-6	0	+28	+31	red flag
1548	1000N	+32	8.6	-6	0	+26	+36	
1552	1100N	+62	17.2	-5	0	+57	+38	
1557	1200N	+37	14.7	-5	0	+32	+39	rocky soil
1601	1300N	+50	11.0	-5	0	+45	+40	
1605	1400N	+38	9.5	-5	0	+33	+35	
1608	1500N	+40	17.5	-5	0	+35	+41	
1612	1600N	+37	10.4	-5	0	+32	-	
1616	1690N	+64	15.3	-5	0	+59	-	very rocky
1622	In container $H12^-$ $H2^+$ = +6.2							

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 29 July 1981
LOCATION Preston Big Spring
LINE B
BASE ELECTRODE LOCATION
PERSONNEL Palm, Corwin

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 99 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1710	In container $H12^- H2^+$ = +5.8							
1714	50S	+4	4.8	-5	0	-1	-4	adjacent to spring (west)
1717	100S	+3	4.7	-5	0	-2	0	
1730	200S	+5	5.9	-5	0	0	+14	orange flag
1734	300S	+17	9.0	-5	0	+12	+21	slightly rocky
1738	400S	+68	16.7	-5	0	+63	+23	orange flag
1743	500S	+36	9.2	-4	0	+32	+36	
1747	600S	+12	7.6	-4	0	+8	+37	
1753	700S	+77	28.2	-4	0	+73	+28	rocky soil adjacent to more water
1801	800S	+22	9.5	-4	0	+18	+32	at triple juncture
1804	In container $H12^- H2^+$ = +4.7							

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 30 July 1981
LOCATION Preston Big Spring, Nevada
LINE B
BASE ELECTRODE LOCATION
PERSONNEL Palm, Corwin

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS. RESISTANCE 492 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
0855	In container H1⁻ H2⁺ = +1.3 H12⁻ H2⁺ = +1.5, H1⁻ H12⁺ = -0.2							
0923	800S	+12	10.5	-1	0	+11	+32	station occupied on 29 July
0937	700S	+60	29.0	-2	0	+58	+28	
0947	900S	+20	11.2	-3	0	+17	+40	
0953	1000S	+61	16.5	-5	0	+56	+33	
0958	1100S	+52	16.2	-6	0	+46	+38	
1004	1200S	+40	13.9	-7	0	+33	+43	
1010	In container H12⁻ H2⁺ = +7.7							
1013	1300S	+47	18.4	-7	0	+40	+47	rocky soil
1019	1400S	+49	20.0	-7	0	+42	+44	~40m to rd. centerline
1030	1500S	+80	21.6	-7	0	+73	+42	rocky
1036	1600S	+38	17.5	-7	0	+31	+38	rocky
1041	1700S	+32	14.7	-8	0	+24	+35	rocky
1046	1800S	+26	13.5	-8	0	+18	+23	rocky, ~30 m ahead is possible buried stream
1052	1900S	+36	13.7	-8	0	+28	+15	
1058	2000S	+20	8.7	-8	0	+12	+9	playa area with soft, fine clay soil
1100	In container H12⁻ H2⁺ = +8.6							center of playa, fine clay
1108	2100S	-1	5.5	-8	0	-9	+6	
1112	2200S	+3	7.0	-8	0	-5	+1	edge of playa, ~30 m ahead is wash
1119	2300S	+13	9.5	-9	0	+4	+3	rocky
1126	2400S	+13	13.8	-9	0	+4	-	sandy soil with rocks
1130	2500S	+32	10.2	-9	0	+23	-	sandy soil with rocks
1132	In container H12⁻ H2⁺ = +9.9							

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 30 July 1981
LOCATION Preston Big Spring, Nevada
LINE C
BASE ELECTRODE LOCATION
PERSONNEL Palm, Corwin

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE --
SHORT CIRCUITS --

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
	Begin Line C, 625S to E+W, 0 at 600S (Line B) +25 ms							
1255	Container H12⁻ H2⁺ = +6.8 mV							
		+7	8.2	-6	0	+1	-	
1311	+100W	+33	11.8	-6	0	+27	+17	line is along jeep trail trending E from 600S sta.
1314	200W	+14	8.7	-6	0	+8	+22	
1318	300W	+17	10.6	-5	0	+12	+22	
1321	400W	+31	7.6	-5	0	+26	+16	soil color change - moisture present
1323		+40	10.8	-5	0	+35	+15	
1324	In container H12⁻ H2⁺ = +6.2							
Now go to NW along main gravel road to tie with Line A								
1336		+3	5.9	-5	0	-2	+20	
1341		+11	9.0	-5	0	+6	+24	hard & rocky, rd. ditch
1344	500N	+40	16.3	-5	0	+35	+22	hard & rocky, rd. ditch
1348	700N	+51	12.2	-4	0	+47	+29	hard, rd. ditch
1353	900W	+38	13.6	-4	0	+34	-	
1417		+26	14.4	-4	0	+22	-	Tie to Line A (ΔV=H2)
1420	Container H12⁻ H2⁺ = +5.3							
1459	Container H10⁻ H2⁺ = +6.7							
1502		+6	7.2	-6	0	0	+28	along trail trending W from Sta.600S (Line B)
1508	200E	+40	8.3	-6	0	+34	+26	red brick-like soil
1512	300E	+48	12.4	-6	0	+42	+18	
1516	400E	+21	8.3	-5	0	+16	+20	
1527	500E	+2	5.2	-5	0	-3	+19	
1531	600E	+16	7.3	-5	0	+11	+19	fine clay soil on edge of large wash
1538	700E	+32	11.0	-5	0	+27	+27	rocky
1544	800E	+48	13.5	-4	0	+44	+41	
1548	900E	+62	14.4	-4	0	+58	-	

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 30 July 1981
LOCATION Preston Big Spring, Nevada
LINE C, E
BASE ELECTRODE LOCATION
PERSONNEL Palm, Corwin

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE --
SHORT CIRCUITS --

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1552	1000E	+67	15.8	-4	0	+63	-	
1602	Container H12+ H2+ = +5.3 mV							
	Begin Line E (0 at 400N, Line A)							
1707	Container H12+ H2+ = +4.7 mV							
1708	100W	-6	5.3	-4	0	-10	+7	
1713	200W	+14	7.5	-4	0	+10	+8	
1716	300W	+29	8.3	-4	0	+25	+12	
1720	400W	+24	7.3	-4	0	+20	+19	
1723	500W	+20	7.0	-4	0	+16	+25	
1727	600W	+29	9.3	-4	0	+25	+26	
1730	700W	+43	11.5	-4	0	+39	+33	
1733	800W	+35	12.4	-4	0	+31	+34	
1737	900W	+58	12.5	-4	0	+54	-	
1741	1000W	+25	8.4	-4	0	+21	-	
1743	Container H12+ H2+ = +4.6 mV							
	Begin east traverse of Line E							
1808	Container H12+ H2+ = +5.7 mV							
1807		+20	6.9	-5	0	+15	+9	
1814		+17	6.4	-5	0	+12	+18	
1817		+36	8.4	-4	0	+32	+23	
1824	400E	+39	10.7	-4	0	+35	+25	T13N R61E
1834	500E	+23	9.3	-3	0	+20	+24	corner of Secs. 35,2,1
	Note 600E at Section Marker							
1843	600E	+27	8.3	-3	0	+24	+21	T13N R61E
	625E marker							Section corner 35,36,1
1849	700E	+12	6.5	-2	0	+10	+27	T12N R61E
1854	800E	+17	12.3	-2	0	+15	+27	

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 30 July 1981
LOCATION Preston Big Spring, Nevada
LINE E
BASE ELECTRODE LOCATION
PERSONNEL Palm, Corwin

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE --
SHORT CIRCUITS --

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1858	900E	+68	19.6	-1	0	+67	--	
1905	1000E	+20	19.0	-1	0	+19	--	orange flag, 5 m from Hwy 318 shoulder
1915	Container $H12^{-}$ $H12^{+}$ = +2.0 mV							
1948	Final container $H1^{-}$ $H2^{+}$ = +2.0 mV, $H12^{-}$ $H2^{+}$ = +1.4 mV, H1 $H12^{+}$ = +1.3							

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

PAGE 1

DATE 31 July 1981
LOCATION Monte Neva Hot Spring, Nevada
LINE A
BASE ELECTRODE LOCATION
PERSONNEL Palm

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 50 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1155	In container $H1^-$ $H2^+$ = +7.5, $H12^-$ $H2^+$ = +10.2, $H1^-$ $H12^+$ = -1.3mV							
	$H10^-$ $H12^+$ = 12.0							
	Line A trending E-W, crossing base electrode. Base is planted in moderately packed, fine clay soil - adjacent to south post of south gate - hard packed fine clay soil - packed by animals, feces present, slightly moist							
1215	0	+8	7.8	-8	0	0	-5	
1222	50E	-9	5.2	-7	0	-16	-5	hard pack fine clay, upper layer penetrated w/p:
1233	100E	+14	6.5	-5	0	+9	+11	moderately moist organic clay soil
1236	Container $H12^-$ $H2^+$ = +7.4 mV							
1245	150E	+41	8.7	-5	0	+36	+28	very moist clay soil surface alkaline & grassy
1253	175E	+32	7.9	-4	0	+28	+33	soil as at 150E
1259	200E	+52	10.4	-2	0	+50	+38	soil as at 150E, ~50m S of magma well, ~100m S of sprin
1303	Container $H12^+$ $H2^+$ = +4.0 mV							
1312	225E	+43	9.6	-2	0	+41	+39	as above
1319	250E	+34	8.9	-1	0	+33	+39	as above
1326	275E	+40	8.7	+1	0	+41	+35	as above
1332	300E	+28	7.5	+2	0	+30	+32	as above
1336	Container $H12^+$ $H2^+$ = +0.3 mV							
1348	325E	+30	7.9	+2	0	+32	+29	as above
1356	350E	+23	7.7	+2	0	+25	+26	as above
1405	400E	+18	6.5	+1	0	+19	+23	wet organic soil w/ sulfur odor
1408	Container $H12^+$ $H2^+$ = +1.4 mV							
1415	450E	+22	6.8	+1	0	+23	+19	moist clay much surface alkalinity
1422	500E	+15	6.5	+1	0	+16	+18	as above
1432	550E	+12	9.4	+2	0	+14	+16	brown, moist, fine granular clay soil

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 31 July 1981
LOCATION Monte Neva Hot Spring, Nevada
LINE A
BASE ELECTRODE LOCATION
PERSONNEL Palm

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 50 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1439	600E	+15	7.9	+2	0	+17	+12	25m past topo high, moist clay in flat playa area
1446	Container H12⁻ H2⁺ = -0.4 mV							
1454	700E	+10	8.2	+2	0	+12	+11	slightly moist to dry fine clay soil
1505	800E	0	4.9	+1	0	+1	+7	as above but hard-packed 5 m W of fence line
1514	900E	+14	7.7	-3	0	+11	-	as at 700E
1517	Container H12⁻ H2⁺ = +5.4 mV							
1527	1100E	-5	4.0	-3	0	-8	-	fine brown clay soil
	Head west, Container H12⁻ H2⁺ = +4.5 mV							
1637	50W	+6	9.3	-3	0	+3	+5	fine tan, semi-dry, rocky clay soil
1647	110W	+7	12.5	-4	0	+3	+8	as above, 10 m N of main gravel rd. center
1655	200W	+23	15.5	-5	0	+18	+7	as 50W
1704	300W	+17	13.9	-6	0	+11	+8	as above
1708	Container +7.7 mV = H12⁻ H2⁺							
1717	400W	+12	12.8	-6	0	+6	+8	as above
1722	500W	+13	9.0	-5	0	+8	+12	same soil, 10 m W of jeep trail
1734	600W	+26	16.8	-5	0	+21	+15	as 400W - 50S
1742	700W	+19	16.7	-4	0	+15	+17	"
1752	900W	+29	15.1	-4	0	+25		"
1804	1100W	+17	14.6	-3	0	+14		"
1805	Container H12⁻ H2⁺ = +4.6							
1824	250W	-2	8.5	-3	0	-5	+8	
	Container H12⁻ H2⁺ = +5.7							
1838	150W	+13	9.7	-4	0	+9	+7	"
1842	75W	+13	13.5	-4	0	+9	+6	"
1847	25W	+10	11.8	-3	0	+7	0	", hard packed
1856	Final container H1⁻ H2⁺ = +3.4, H12⁻ H2⁺ = +4.6, H1⁻ H12⁺ = 1.5 mV							

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 2 August 1981
LOCATION Monte Neva Hot Spring, Nevada
LINE A
BASE ELECTRODE LOCATION
PERSONNEL Palm, Hansen

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 50 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
	Telluric recorder set with + electrode at base and - ~750' to the south							
	Base is ~50 m N of section corner 23, 24, 26, 25							
1120	Container $H1^- H2^+$ = +7.1, $H12^- H2^+$ = +8.5mV							
	$H1^- H12^+$ = -2.2, $H11^- H12^+$ = -6.9							
	Line A stations occupied for better resolution							
1127	0	+12	9.0	-7	0	+5	-5	
1132	25E	-15	4.5	-7	0	-22	-6	fine brown very hard pack clay soil - moist
1136	50E	-12	5.7	-6	0	-19	-5	
1142	75E	+7	7.3	-6	0	+1	-1	moist fine clay soil alkaline surface deposits
1147	85E	-2	5.5	-5	0	-7	-3	moist sandy silt w/roots
1153	110E	+7	6.3	-5	0	+2	+12	as above
1158	120E	+27	8.0	-4	0	+23	+21	"
1201	130E	+36	9.2	-3	0	+33	+22	light brown silty sand, moist
1203	Container $H12^- H2^+$ = +5.0 mV							
1208	160E	+19	7.5	-3	0	+16	+30	
1213	185E	+36	10.3	-3	0	+33	+29	light brown silty-coarse grain sand w/overlying clay
1218	210E	+48	10.5	-3	-	+45	+40	as above w/o clay cover
1223	240E	+35	22.0	-3	0	+32	+38	station on vesicular calcareous hardpan
1239	Container $H12^- H2^+$ = +4.9 mV							

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

VOLTMETER Fluke 8020A

DATE 2 August 1981

BASE ELECTRODE H1

LOCATION Monte Neva Hot Spring, Nevada

PORTABLE REFERENCE ELECTRODE H12

LINE B

MEASURING ELECTRODE H2

BASE ELECTRODE LOCATION

REEL CHECKS RESISTANCE 50 ohms

PERSONNEL Palm, Hanson

SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
	Line B runs due north, Station 0 is Line A 250E							
1244	0	+30	8.5	-3	0	+27	+21	light brown silty sand, fine-grained, moist
1248	10N	+12	15.7	-3	0	+9	+18	coarse-grained calcareous sand
1254	20N	+27	9.6	-3	0	+24	+19	fine-grained silty sand
1304	30N	+15	6.8	-3	0	+12	+16	as above
1307	40N	+25	8.0	-3	0	+22	+20	"
1309	Container H12⁻ H2⁺ = +5.0 mV							
1312	50N	+18	7.2	-3	0	+15	+16	"
1316	60N	+28	11.2	-3	0	+25	+14	"
1319	70N	+11	6.6	-3	0	+8	+15	"
1321	80N	+5	18.9	-3	0	+2	+15	dry calcareous 'flow' area weathered travertine
1325	90N	+27	8.9	-3	0	+24	+11	silty fine-grained sand, moist
1328	100N	+18	7.3	-3	0	+15	+10	medium brown sand, ~50 m due east of outflow
1333	110N	+7	7.1	-3	0	+4	+15	medium brown silty sand
1338	120N	+8	8.6	-2	0	+6	+14	weathered travertine, some moisture, warm
1342	130N	+26	8.9	-2	0	+24	+19	silty sand, moist
1345	135N	+25	8.8	-2	0	+23	+26	as above
1348	140N	+40	8.9	-2	0	+38	+30	as above
1356	150N	+40	8.9	-2	0	+38	+32	as above
1359	160N	+30	8.2	-2	0	+28	+33	as above
1401	Container H12⁻ H2⁺ = +4.0 mV							
1408	170N	+33	8.3	-2	0	+31	+32	as above
1411	180N	+31	8.6	-2	0	+29	+29	as above, soft
1414	190N	+34	8.1	-2	0	+32	+32	as above, soft
1417	200N	+27	7.5	-2	0	+25	+30	as above
1421	220N	+42	5.2	-1	0	+41	+28	as above
1426	240N	+24	7.3	-1	0	+23	+25	as above

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 2 August 1981
LOCATION Monte Neva Hot Spring, Nevada
LINE B
BASE ELECTRODE LOCATION
PERSONNEL Palm, Hanson

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 50 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1430	260N	+22	7.2	-1	0	+21	+23	silty sand, moist
1436	280N	+14	6.7	-1	0	+13	+19	"
1441	300N	+20	7.0	-1	0	+19	+17	" on edge of small thermal water outflow
1445	320N	+20	7.3	-1	0	+19	+15	dark brown silty clay w/ grass mat-N edge of mound
1452	340N	+15	6.7	-1	0	+14	+10	as above
1458	360N	+9	5.7	-1	0	+8	+6	" at N edge of E-W fenced area
1505	380N	-10	4.0	0	0	-10	+2	brown silty clay (CL) in grass meadow with streams
1509	400N	-2	4.6	0	0	-2	-1	brown clayey silt (ML)
1514	450N	0	5.4	0	0	0	-2	brown clayey silt w/sand
1516	Container $H12^-$ $H2^+$ = +1.5 mV							
1551	500N	0	8.0	0	0	0	+2	"
1558	550N	+3	7.3	-1	0	+2	+2	"
1603	650N	+11	5.8	-1	0	+10	+1	wet clayey silt, adjacent to irrigated area
1610	750N	-2	5.2	-2	0	-4	-	dry clayey silt - near second E-W fence
1618	850N	-3	5.3	-2	0	-5	-	cemented silty sand hard-pan w/desiccation cracks
1621	Container $H12^-$ $H2^+$ = +4.0 mV							
	Head south (0 m is Line A, 250E)							
1732	Container $H12^-$ $H2^+$ = +2.7 mV							
1734	0	+28	7.3	-2	0	+25	+21	
1738	10S	+20	7.4	-2	0	+19	+22	light brown silty sand, moist
1742	20S	+29	7.2	-2	0	+28	+26	dark brown silt (ML), moist, flag
1743	30S	+26	6.6	-2	0	+25	+26	brown sandy silt, wet
1745	40S	+30	7.5	-2	0	+29	+29	moist brown sandy silt
1747	50S	+28	7.8	-1	0	+27	+29	as above
1750	60S	+37	8.0	-1	0	+36	+28	light brown silty sand, dry
1753	70S	+28	7.7	-1	0	+27	+28	as above, but moist

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 2 August 1981
LOCATION Monte Neva Hot Spring, Nevada
LINE B
BASE ELECTRODE LOCATION
PERSONNEL Palm, Hanson

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 50 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1757	80S	+22	7.5	-2	0	+19	+32	moist silty sand
1759	90S	+33	12.3	-2	0	+30	+35	as above only dry
1802	100S	+48	8.9	-1	0	+47	+39	moist silty sand
1804	110S	+52	9.0	-1	0	+51	+43	as above
1807	120S	+50	10.7	-1	0	+49	+45	as above
1809	130S	+37	8.3	-1	0	+36	+44	"
1811	140S	+44	8.3	-1	0	+43	+38	"
1815	150S	+40	8.0	-1	0	+39	+35	"
1820	160S	+23	6.9	-1	0	+22	+33	" S edge of mound, but dry
1823	170S	+35	14.8	-1	0	+34	+27	", dry
1825	180S	+27	8.4	-1	0	+26	+22	", dry
1828	190S	+16	6.5	-1	0	+15	+19	", on edge of dry wash
1830	200S	+12	6.2	-1	0	+11	+12	"
1832	Container $H12^{-}$ $H2^{+}$ = +2.5 mV							
1836	220S	+9	6.9	-1	0	+8	+9	dry silty sand in dry wash
1842	250S	+3	6.4	-1	0	+2	+6	dry silty sand
1846	300S	+12	7.8	-1	0	+11	+7	", porous surface soil
1858	350S	+1	8.4	-1	0	0	+8	"
1904	450S	+15	11.3	0	0	+15	+11	
1911	550S	+13	10.4	0	0	+13	-	as above
1916	650S	+18	10.8	0	0	+18	-	as above
1919	Container $H12^{-}$ $H2^{+}$ = +2.0 mV							
1934	Final container $H1^{-}$ $H12^{+}$ = 0.9 mV, $H12^{-}$ $H2^{+}$ = +3.0 mV,							
	$H1^{-}$ $H12^{+}$ = -3.3 mV							

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 3 August 1981
LOCATION Monte Neva Hot Spring, Nevada
LINE C, (A)
BASE ELECTRODE LOCATION
PERSONNEL Palm, Hanson

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 50 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
	Line C, due north, Station 0 is Station 25E, Line A							
0715	Container $H1^-$ $H2^+$ = -2.6, $H12^-$ $H2^+$ = -2.9 mV							
		$H1^-$ $H12^+$ = -2.2 mV						
0736	10E	-7	9.7	+3	0	-4	-	hard pack soil, dry
	Line C							
0744	0	-19	4.4	+1	0	-18	-6	hard pack soil, dry
0758	20N	-23	4.3	0	0	-23	-22	"
0802	40N	-24	3.8	-2	0	-26	-19	"
0806	60N	-15	4.9	-3	0	-18	-17	"
0809	75N	-3	8.2	-5	0	-8	-15	S edge of spring, access road, soil is same
0813	100N	-7	7.8	-6	0	-13	-20	soil as above, with gravel
0816	90N	-2	8.8	-8	0	-10	-16	"
0819	Container $H12^-$ $H2^+$ = +8.3 mV							
0822	110N	-24	5.3	-8	0	-32	-25	"
0825	120N	-28	3.3	-8	0	-36	-28	softer soil, silty sand, dry to moist
0828	130N	-24	3.6	-8	0	-32	-31	"
0831	140N	-21	3.8	-7	0	-28	-31	"
0840	150N	-19	4.1	-7	0	-26	-29	"
0845	160N	-25	3.7	-7	0	-32	-29	soft light brown silty sand, dry
0847	Container $H12^-$ $H2^+$ = +6.7 mV							
0852	170N	-21	3.7	-7	0	-28	-29	"
0856	180N	-24	3.6	-8	0	-32	-28	"
0900	200N	-19	3.8	-8	0	-27	-27	", but moist
0903	220N	-15	4.4	-8	0	-22	-27	hard, dry silty sand
0906	240N	-16	4.2	-9	0	-25	-24	"on S side of bathhouse foundation
0912	280N	-17	9.4	-10	0	-27	-23	hard, dry silty sand

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 50 ohms
SHORT CIRCUITS

DATE 3 August 1981
LOCATION Monte Neva Hot Spring, Nevada
LINE C
BASE ELECTRODE LOCATION
PERSONNEL Palm, Hanson

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
0915	300N	-11	8.6	-10	0	-21	-22	hard, dry silty sand
0917	Container H12⁻	H2⁺ =	+10.4 mV					
0925	345N	-9	5.1	-10	0	-19	-22	"at E-N fence line ~10 m E of outhouse
0930	400N	-10	6.9	-10	0	-20	-17	same soil
0936	500N	-12	14.0	-10	0	-22	-11	", next to adobe hut
0943	600N	+15	10.4	-10	0	+5	-11	", next to metal-roofed shed
0946	Container H12⁻	H2⁺ =	+10.0mV					
0950	625N	+2	7.0	-10	0	-8	-13	soil same but reworked, fuel oil odor to soil
0955	650N	-17	6.9	-10	0	-27	-17	ranch yard area ~20m from pile of irrigation pipe
9059	675N	-24	14.3	-11	0	-35	-19	"
1003	700N	-8	8.3	-11	0	-19	-21	soil same in ranch yard
1007	725N	+4	10.5	-12	0	-8	-18	"
1011	750N	-2	11.2	-12	0	-14	-14	same soil, at E-W fence ~4m E of ¼ corner 23,24
1018	775N	-2	8.1	-13	0	-15	-10	same soil
1021	800N	-3	8.5	-13	0	-16	-9	"
1023	Container H12⁻	H2⁺ =	+12.6 mV					
1026	900N	+13	11.7	-13	0	0	-2	"
1031	950N	+20	10.3	-13	0	+7	+3	"
1035	1000N	+12	8.2	-14	0	-2	+4	"
1040	1100N	+23	9.6	-14	0	+9	+5	"
1045	1200N	+19	8.8	-14	0	+5	+6	"
1051	1300N	+22	7.8	-15	0	+7	-	"
1055	1500N	+28	12.3	-15	0	+13	-	
1058	Container H12⁻	H2⁺ =	+14.9 mV					
1120	850N	+16	11.5	-15	0	+1	-5	"
1128	550N	+10	7.7	-11	0	-1	-9	
1130	Container H12⁺	H2⁺ =	+11.6 mV					

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

VOLTMETER Fluke 8020A

DATE 3 August 1981

BASE ELECTRODE H1

LOCATION Monte Neva Hot Spring

PORTABLE REFERENCE ELECTRODE H12

LINE C

MEASURING ELECTRODE H2

BASE ELECTRODE LOCATION

REEL CHECKS RESISTANCE 50 ohms

PERSONNEL Palm, Hanson

SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1306	Container H12⁻ H2⁺ = +9.2 mV							
1308	10S	-14	3.2	-9	0	-23	-15	dry silty sand, medium dense
1310	20S	-8	4.0	-9	0	-17	-11	"
1313	30S	+14	8.8	-9	0	+5	-7	"
1316	40S	+7	5.8	-9	0	-2	-5	"
1320	50S	+12	7.2	-9	0	+3	0	"
1322	60S	-4	4.2	-9	0	-13	0	"
1325	70S	+15	9.5	-9	0	+6	0	"
1328	80S	+14	9.3	-9	0	+5	+1	"
1331	100S	+8	9.3	-9	0	-1	+5	"
1334	120S	+19	10.7	-9	0	+10	+6	hard, dry, cemented silty sand
1337	140S	+15	10.5	-9	0	+6	+7	"
1340	160S	+20	8.7	-9	0	+11	+9	"
1343	Container H12⁻ H2⁺ = +8.8 mV							
1346	180S	+20	10.6	-9	0	+11	+8	"
1350	200S	+15	16.5	-9	0	+6	+9	"
1355	250S	+12	12.4	-8	0	+4	+6	"
1359	300S	+21	9.9	-8	0	+13	+4	"
1403	350S	+4	7.2	-8	0	-4	+3	"
1407	400S	+11	18.8	-8	0	+3	+4	"
1412	450S	+5	17.9	-7	0	-2	-	10 m N of E-W fence
1418	510S	+16	10.0	-7	0	+9	-	" on S side of main gravel road
1419	Container H12⁻ H2⁺ = +6.8 mV							
	Reached N edge of land owned by Clive Sprouse							

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

VOLTMETER Fluke 8020A

DATE 3 August 1981

BASE ELECTRODE H1

LOCATION Monte Neva Hot Spring, Nevada

PORTABLE REFERENCE ELECTRODE H12

LINE D

MEASURING ELECTRODE H2

BASE ELECTRODE LOCATION

REEL CHECKS RESISTANCE 50 ohms

PERSONNEL Palm, Hanson

SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
	Line D runs E-W (90°), Station 0 is Station 250N Line C							
	~25 m from N-S fence							
1528	Container H12⁻ H2⁺ = +9.1 mV							
1530	0	-12	3.1	-9	0	-21	-	
1538	10E	-11	3.6	-9	0	-20	-22	
1541	20E	-14	2.9	-8	0	-22	-22	
1543	30E	-17	2.7	-8	0	-25	-24	warm, moist silty sand
1546	40E	-15	2.8	-8	0	-23	-25	", grassy area
1548	50E	-21	2.3	-8	0	-29	-20	"
1551	60E	-17	2.6	-7	0	-24	-12	"
1558	70E	+10	4.9	-7	0	+3	-4	brown moist silt, with organics
1559	78E	+20	6.1	-7	0	+13	+6	wet sandy silt w/mineral odor W edge thermal stream
1606	100E	+24	6.5	-7	0	+17	+17	wet silty clay, east edge of thermal spring
1609	110E	+29	6.7	-6	0	+23	+21	brown clayey silt, moist
1613	120E	+37	7.4	-6	0	+31	+23	dark brown silt w/horse feces and other organics
1618	Container H12⁻ H2⁺ = +6.4 mV							
1624	130E	+28	6.5	-6	0	+22	+23	dry to moist silty sand
1629	140E	+27	6.6	-6	0	+21	+22	moist light brown sandy silt
1634	150E	+23	6.6	-6	0	+17	+21	"
1637	160E	+28	7.0	-7	0	+21	+22	"
1640	180E	+32	7.6	-7	0	+25	+24	"
1645	200E	+32	7.5	-7	0	+25	+29	"
1658	220E	+37	7.9	-7	0	+30	+30	"
1700	Container H12⁻ H2⁺ = +6.5 mV							
1707	240E	+49	8.8	-7	0	+42	+30	" crosses Line B Station 220N
1709	260E	+36	8.2	-7	0	+29	+25	"
1711	280E	+31	7.6	-7	0	+24	+20	"

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 3 August 1981
LOCATION Monte Neva Hot Spring, Nevada
LINE D
BASE ELECTRODE LOCATION
PERSONNEL Palm, Hanson

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 50 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1716	300E	+8	5.0	-7	0	+1	+13	dry to moist light brown sandy silt with roots
1720	325E	+9	4.9	-7	0	+2	+9	moist brown silty sand with roots
1723	350E	+14	4.8	-6	0	+8	+5	"
1725	375E	+16	6.4	-6	0	+10	+6	moist silty sand w/porous surface soils, ~25m NW outflow
1730	400E	+10	7.2	-6	0	+4	+4	soil as above
1733	450E	+14	6.5	-6	0	+8	0	light brown silty coarse-grained sand, moist
1738	500E	-5	5.6	-6	0	-11	-3	"
1739	Container $H12^-$ $H2^+$ = +5.9 mV							
1744	550E	-5	4.4	-6	0	-11	-6	"
1747	600E	0	5.1	-6	0	-6	-11	fine-grained light brown silty sand, moist
1751	700E	-1	4.5	-7	0	-8	-	"
1755	790E	-12	3.2	-7	0	-19	-	dry silty sand at N-S fence
1758	Container $H12^-$ $H2^+$ = +6.9 mV							
	Head west, Line D							
1816	Container $H12^-$ $H2^+$ = +7.5 mV							
1818	10W	-14	2.7	-8	0	-22	-21	brown, dry silty sand, some gravel
1822	20W	-12	9.7	-8	0	-20	-22	", at N-S fence
1826	30W	-15	3.8	-8	0	-23	-18	same soil
1829	40W	-14	5.7	-8	0	-22	-16	" but harder and drier
1831	50W	+4	10.0	-8	0	-4	-13	"
1834	60W	-1	8.6	-8	0	-9	-8	"
1839	80W	+2	7.6	-8	0	-6	-4	" plus gravel
1844	100W	+9	9.9	-8	0	+1	-2	"
1846	150W	+6	10.3	-8	0	-2	+1	" on E edge of main gravel road
1851	200W	+12	11.6	-8	0	+4	-	"
1856	300W	+16	9.8	-8	0	+8	-	"
1900	Container $H12^-$ $H2^+$ = +7.7 mV							wire broken by vehicle

1937 Final container $H1^-$ $H12^+$ = +0.6, $H12^-$ $H2^+$ = +6.3, $H1^-$ $H12^+$ = -5.8

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 4 August 1981
LOCATION Monte Neva Hot Spring, Nevada
LINE E
BASE ELECTRODE LOCATION
PERSONNEL Palm, Hanson

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 50 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
	Line E runs E-W (90°) Station 0 is Station 140S Line C							
1036	Container $H1^{-}$ $H2^{+}$ = +5.4 mV, $H12^{-}$ $H2^{+}$ = +4.8, $H1^{-}$ $H12^{+}$ = +0.6							
1050	0	+7	10.9	-5	0	+2	-	dry silty sand, with gravel
1101	25E	+9	11.9	-7	0	+2	0	"
1104	50E	+2	5.8	-9	0	-7	-2	"
1125	Container $H12^{-}$ $H2^{+}$ = +8.6 mV							
1126	75E	+15	8.1	-9	0	+6	-4	"
1130	100E	-6	5.5	-8	0	-14	-3	", slightly harder
1132	125E	+3	5.9	-8	0	-5	+2	"
1134	150E	+14	6.0	-7	0	+7	+7	"
1136	175E	+22	7.3	-6	0	+16	+18	", softer, slightly organic
1139	200E	+36	7.9	-5	0	+31	+28	"
1141	225E	+48	8.8	-5	0	+43	+31	dry to moist, slightly organic silty sand
1149	240E	+51	9.2	-4	0	+47	-	moist silty sand w/ organics
1216	Container $H12^{+}$ $H2^{+}$ = +4.1 mV							
1217	275E	+25	7.2	-4	0	+21	+28	"
1221	260E	+43	8.3	-4	0	+39	-	moist brown silty sand
1224	300E	+28	7.7	-4	0	+24	+21	"
1226	325E	+11	5.8	-4	0	+7	+16	"
1228	350E	+16	6.3	-4	0	+12	+14	"
1230	375E	+20	6.4	-4	0	+16	+13	"
1232	400E	+16	6.3	-4	0	+12	+12	"
1236	450E	+22	7.1	-5	0	+17	+11	"
1239	500E	+9	5.4	-5	0	+4	+10	dry, soft light brown silt
1242	550E	+11	6.2	-5	0	+6	+12	"
1245	600E	+16	6.5	-5	0	+11	+11	"
1247	650E	+27	8.2	-5	0	+22	+17	"

HARDING-LAWSON ASSOCIATES
SELF-POTENTIAL SURVEY DATA

DATE 4 August 1981
LOCATION Monte Neva Hot Spring, Nevada
LINE E
BASE ELECTRODE LOCATION
PERSONNEL Palm, Hanson

VOLTMETER Fluke 8020A
BASE ELECTRODE H1
PORTABLE REFERENCE ELECTRODE H12
MEASURING ELECTRODE H2
REEL CHECKS RESISTANCE 50 ohms
SHORT CIRCUITS

Time	Station (m)	ΔV measured (mV)	Resistance (kΩ)	Electrode correction (mV)	Tie-in correction (mV)	ΔV corrected (mV)	ΔV smoothed (mV)	Comments
1251	700E	+18	7.3	-5	0	+13	+23	dry, soft, light brown silty sand
1256	800E	+40	10.9	-5	0	+35	+23	just E of fence
1259	850E	+40	10.6	-5	0	+35	+18	much scrap metal in this area
1300	Container $H12^-$ $H2^+$ = +5.3 mV							
1306	900E	+15	7.6	-5	0	+10	+13	"
1309	1000E	+1	5.2	-5	0	-4	-	"
1313	1100E	-5	5.2	-5	0	-10	-	dry, brown silty sand moderately cemented
1316	Container $H12^-$ $H2^+$ = +5.0 mV							
	Head west							
1335	Container $H12^-$ $H2^+$ = +9.0 mV							
1336	25W	+5	10.2	-9	0	-4	-3	dry, brown silty sand
1341	50W	0	15.0	-9	0	-9	-4	on western edge of road
1346	75W	+3	16.1	-9	0	-6	-6	", very dry
1351	100W	+5	18.8	-9	0	-4	-6	", on W edge of main gravel road
1356	200W	+4	16.1	-9	0	-5	-4	dry, brown silty sand
1402	400W	+3	9.9	-9	0	-6	-	"
1409	600W	+12	8.9	-9	0	+3	-	coarse grain sand w/silt dry, alluvial fan
1410	Container $H12^+$ $H2^+$ = +8.7 mV							
1423	Final container $H1^-$ $H2^+$ = +4.4, $H12^-$ $H2^+$ = +6.1 mV, $H1^-$ $H12^+$ = -0.7 mV							

DISTRIBUTION

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