– A Proposal For –

A VERY LARGE ARRAY RADIO TELESCOPE

Volume IV

DECEMBER 1971

National Radio Astronomy Observatory*

Green Bank, West Virginia

* OPERATED BY ASSOCIATED UNIVERSITIES, INC., UNDER CONTRACT WITH THE NATIONAL SCIENCE FOUNDATION.

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VOLUME IV. THE SITE

Chapters 1 - 6

SUMMARY

The present report comprises the fourth volume of a Proposal for a Very Large Array (VLA) for Radio Astronomy. It describes the history, procedures, and results of the work done to locate a suitable site for the instrument. Of the 34 sites which were considered, the following 7 were found to meet the general requirements of the array.

Code	Name	State
Y15	Plains of San Augustin	New Mexico
Y16	Black Rock Desert	Utah
Y17	Monitor Valley	Nevada
Y22	Separ	New Mexico
Y23	Aguirre Valley	Arizona
Y27	Lobo Valley	Texas
Y33	Steptoe Valley	Nevada

One of the sites, Y15, the Plains of San Augustin in New Mexico, is scientifically and technically superior to all other sites considered.

Chapter 1

INTRODUCTION

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A. Introduction

A proposal for a Very Large Array Radio Telescope (VLA) was issued by the National Radio Astronomy Observatory (NRAO) in January 1967. It comprised two parts: Volume I, The VLA Concept; and Volume II, The System Design. Two years later, in January 1969, the proposal was further developed and refined in Volume III. The present volume is the fourth of the series. It is concerned with the site for the instrument--the considerations which guided the search for a suitable location, a description of all of the sites which were considered at any time, and a detailed discussion of the seven sites which proved to be suitable for the needs of the array. The basic philosophy of the site search was considered briefly in Chapter 8 of Volume I, and some specific site problems were discussed in Chapter 4 of Volume III, but detailed discussions were deferred to the present volume.

The large physical dimensions of the proposed instrument, the shape and orientation of its configuration on the ground, the antenna element mobility needed to make the array adaptable to a wide variety of astronomical tasks, and the environmental requirements place severe demands on the nature of the array site. The geometrical aspects of the array design alone impose drastic conditions on the topography of an acceptable site. Furthermore, the attainable performance of the instrument is subject to limitations which ultimately are set by its environment. Atmospheric instabilities, analogous to those which cause the stars to twinkle when viewed by eye, have a blurring effect on the radio picture synthesized by the array. The atmosphere is more favorable in some parts of the country than elsewhere. Electrical interference can mask or distort the very faint signals which the array is meant to study. For this reason, the facility must be built in an area where interference levels are low. Insofar as they govern the precise placement of the antenna elements, the features of the terrain at the site influence the capabilities of the system. Indeed, the characteristics of the site are so intimately tied to the performance of the VLA that it is reasonable to regard the site as being, in a sense, a part of the instrument.

B. The Organization of the Present Volume

Chapter 2 sets forth the primary criteria which guided the site search. These are largely topographic and geographic in nature, and comprise the basic requirements of the array location.

The secondary selection criteria are discussed in Chapter 3. These are the considerations which guided the assessment of the relative merits of the sites which satisfied the primary criteria. They are generally not so absolute as the primary criteria, tending to be more qualitative in nature.

Chapter 4 contains a description of the procedures used in finding and evaluating the potential array sites. It also lists all of the sites which were considered, together with certain basic geographic data for each.

Of the 34 potential array sites, 7 satisfied the site criteria well enough to merit detailed evaluation. These seven sites are considered in depth in Chapter 5. All are acceptable candidates for the VLA site.

Finally, in Chapter 6, the remaining 27 sites are discussed individually, with particular attention to the reasons for their exclusion from the final list of acceptable sites.

C. A Brief History of the Search for a VLA Site

The serious effort to find a site began in the fall of 1965 when the basic scientific goals of the array were clearly taking form. It was evident at this time that the very high angular resolving power envisioned for the array, with a synthesized half-power beamwidth of 1 second of arc at a wavelength of 11 cm, would demand a site with overall dimensions of approximately 30 miles. The planned versatility of the array, with the option of rearranging the elements in ways appropriate to the needs of observing programs of different kinds, also meant that the terrain along the array branches had to be smooth and level. It had been established that the most efficient configuration for the array would be an equiangular Wye, with three arms of equal length at intervals of 120° in azimuth. Finally, the site would have to be in an area where land is cheap, and where there are few human activities which could adversely affect the operation of the array or the quality of its environment. This is one of the reasons why it was decided quite early that the search should be confined to the southwestern quarter of the continental United States. This decision was also influenced by the aridity and generally high ground elevations of the Southwest, which were attractive from the standpoint of atmospheric stability.

At this stage, it was by no means certain that a suitable site could in fact be found in the United States. Accordingly, a quick examination of the available topographic maps of the Southwest was made (September 1965), and 15 possible sites were noted. In November 1965, members of the NRAO staff visited three of the possible sites in New Mexico. Only one of these looked like a viable site upon actual inspection; the other two had serious deficiencies which were not evident on the existing maps. This ratio proved to be representative of the results of subsequent trips to other localities.

By December 1965, computer studies of the performance of the Wye configuration had shown that the orientation of the array on the ground was critical for its performance at low declinations. This point had not been appreciated earlier; as a result, several of the sites in the original list of 15 were dropped from further consideration because the terrain surrounding them prevented a suitable orientation of the array branches.

The basic topographic demand now took a form which was to remain unaltered until 1969: The site must permit placement of an equiangular

Wye on level ground with each of the three arms 24 km (15 miles) in length, and with one arm on an azimuth differing from a true north-south line by between 4 and 10 degrees. The very narrow tolerance in the permissible orientation of the arms placed yet another highly restrictive condition on the terrain at a site.

With a firm set of topographic criteria established, a careful, systematic search of the topographic maps of the Southwest was made in early January 1966. Fourteen new possibilities were added to the list, giving a total of 29 sites in 6 states (California, Nevada, New Mexico, Arizona, Texas, and Utah). (As mentioned above, some of the original 15 were no longer active candidates because they failed to satisfy the basic criteria as finally specified.) Two additional sites were added to the list in 1967.

At this time it was believed that it was desirable to build the array as far south as possible in order to maximize the sky coverage. Later this consideration was given less weight. The field work in 1966, however, concentrated on the sites south of latitude 36° N, with the idea of going farther north only if it proved to be impossible to find a good site in the south. During the first three months of 1966, the 16 sites south of 36° N were assessed as well as possible from published topographic information and the 7 which seemed most promising were visited by members of the VLA design group. Four of these were judged to be feasible for array construction; and 3 of these 4 were particularly attractive for various reasons. One was in southern Arizona, about 40 miles west of Tucson; another was in western New Mexico, about 90 miles southwest of Albuquerque; and one was in western Texas, about 155 air miles southeast of El Paso. These sites were designated Y23, Y15, and Y27, respectively.

In May 1966, Limbaugh Engineers, Inc., an Albuquerque firm, was given a contract to study these 3 sites in depth. In addition to providing highly detailed information on the actual characteristics of the 3 areas, the study gave a solid assessment of the practical problems and cost factors of site development. The study included preliminary engineering work on laying out the roadways along the array branches, the work needed to provide the necessary electric power and access roads, the preliminary design of the central building complex with its supporting facilities, and the status of land ownership and the means and probable cost of site acquisition. An Interim Report was submitted to NRAO in August 1966, and the more detailed Final Report was received in November 1966. These documents provided the VLA design staff with a wealth of valuable practical information on site development problems and costs.

By 1969 the continuing studies of the array configuration had shown that it was possible to achieve a 1" [1] synthetic beam at 11 cm wavelength with array arms only 21 km (13 miles) long instead of 24 km (15 miles). This meant that on several of the sites the array layout could be re-aligned onto rather better terrain. At the same time it was decided to examine sites north of 36° N, and the northern latitude limit was extended to 42° N. The higher latitudes were less attractive because of the more limited sky coverage, but if otherwise excellent sites could be found, a compromise might be considered.

The extension of the search to 42° N permitted the addition of 3 more sites to the list, for a total of 34. The 9 most promising sites north of 36° N were inspected during May and October 1969. Three of these were worthy of further consideration. One is in Utah and 2 are in Nevada.

Thus, out of a total of 34 candidates, 7 sites seemed acceptable. In order to obtain a broader background of relevant information regarding them, Limbaugh Engineers was given a new study contract in October 1969. Three of the sites had been studied by them in 1966, and the information for these was revised and updated where appropriate. Much of their final report, dated 1 January 1970, is incorporated bodily in Chapter 5 of the present volume.

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[1] In this volume, the notation " means seconds of arc.

Chapter 2

THE PRIMARY SITE SELECTION CRITERIA

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A. Absolute and Relative Requirements

Many factors must be considered in the selection of a suitable place to build the array. Some of these are absolute ("primary criteria"), since they have a direct influence on the astronomical capabilities of the instrument; an example is the physical extent demanded by the angular resolution requirement. Others are relative ("secondary criteria"), although important, and they leave some room for compromise. In the present chapter, we deal with the "primary criteria" which must be satisfied absolutely by an acceptable site. They reflect the scientific characteristics of the VLA concept.

B. The Site Topography

Much of the power of the VLA concept lies in three of its features which together effectively define the kind of topography the site must have. These are the following:

(1) High Angular Resolving Power with Low Sidelobe Levels. One of the chief aims of the VLA is to provide a synthesized half-power beamwidth of 1" at a wavelength of 11 cm. This demands that the overall physical extent of the array be approximately 330,000 wavelengths (about 36.5 km, or 22.7 statute miles) if the sidelobes of the synthesized reception pattern are to be at an acceptably low level. Each arm of the proposed array configuration, an equiangular Wye, will be 21 km (13 statute miles). Thus the site as a whole must be at least 42 km (26 statute miles) in diameter, although the antenna elements actually occupy only three narrow radial strips, about 200 yards wide.

(2) Good Synthesized Radiation Pattern at Low Declinations. An inherent feature of the VLA concept is that it makes use of the rotation of the earth in order to sample a large number of Fourier components of a source brightness distribution with a relatively small number of

antennas. Because of the geometrical projection relationships involved in this process, the efficiency with which the array exploits the rotation of the earth varies sharply as a function of source declination, regardless of the actual configuration of the array elements. Almost any reasonable configuration gives good sampling at high declinations, near the elevated celestial pole. The performance attainable with any configuration deteriorates with decreasing declination, reaching its lowest efficiency at the celestial equator. Careful attention to the actual placement of the array elements, however, permits adequate sampling to be maintained over the entire declination range accessible to the instrument. This involves both the locations of the individual antennas on the branches of the array and the orientations of the branches on the ground. Computer studies of the low-declination performance have shown that good synthesis can be achieved with the equiangular Wye only if one branch lies between 4° and 10° off of a true north-south line. Therefore, there is a very narrow tolerance in the range of admissible array orientations on the ground.

(3) Ability to Alter the Geometry of the Array. An important feature of the proposed array is the flexibility afforded by the capability of altering the antenna configuration along the branches of the Wye. This permits optimization of the instrumental parameters to suit a wide range of astronomical problems. The required roadways will be prohibitively expensive, however, unless the terrain along the array branches is smooth enough that only minor cutting and filling is needed. It is also desirable that the finished grades along the branches be limited to about 2 percent[1].

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[1] It certainly is feasible to lay railroad tracks for the transportation of the antenna elements along the arms of the Wye in quite rough terrain; it will, however, be very expensive. Therefore, a reasonably flat area which requires a minimum of earth moving and permits a maximum finished grade of the track of less than 2 percent is highly desirable. Although this requirement does not affect the scientific performance of the array, it is judged important enough to be included as a "primary criterion".

These three aspects of the proposed array place very severe restrictions on the site topography. They lead directly to the first and most fundamental of the primary site selection criteria:

> The topography of the array site must permit three lines, radiating from a common point at intervals of 120° in azimuth, to be laid out such that one of them lies between 4° and 10° off a true north-south line. The maximum finished grade of any of these lines must not exceed 2 percent at any point within 21 km (13 miles) of the point of intersection. The original ground surface along each branch must be smooth enough to permit construction of the antenna roadway with only minimal earth moving.

C. Sky Coverage

The farther the instrument is from the equator, the smaller the declination range within which it can work effectively. Foreshortening effects and the limited accessible hour angle range seriously restrict the quality of the mapping that can be done for sources which transit at zenith distances greater than 60°. Synthesis mapping is of little value when the zenith distance at transit is over 70°. It is desirable that the VLA be useful as far south as the galactic center, which is at a declination of approximately -30°. For this reason, the latitude of the site preferably should not be higher than 40° N. A latitude higher than 42° N is not acceptable. Thus there is a second primary criterion:

> The site must be south of latitude 42° N and it preferably should be south of 40° N.

D. Elevation and Atmospheric Water Vapor Content

The presence of the earth's atmosphere, particularly its water vapor, will have a disturbing effect on the operation of the array. Its effect is to blur the synthesized maps. It is in many respects analogous to the "seeing" conditions in optical astronomy. The conditions improve with higher elevation[1], and relative elevation was a factor in comparing sites of otherwise similar quality.

> Preference should be given to sites at high elevations above sea level.

E. <u>The Availability of the Site</u>

It is not enough that a site be topographically adequate. It must also be obtainable without undue cost, and there must be no activity on it, or close to it, which might conflict with the operation of the array or which might affect its environment adversely. This is possible only in areas of very low population density. Human habitation and economic activity in the modern world inevitably imply electrical interference, and even low-density activity of certain types would have a deleterious effect on the environment of the instrument. Intensive cultivation, mining, oil or gas drilling, and defense activities in the immediate vicinity would all be inimical to the kind of environment that is needed. It is important that the human activity near the site be low-key in nature; grazing, for example. Thus the third primary criterion can be stated as:

> The site, and the country surrounding it for some miles, must not be used to any important extent for cultivation, manufacturing industries, mineral exploitation, or defense purposes. The population density in the area should be low.

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[1] Measurements of the water-vapor content were made for a period of about two years at three of the acceptable sites. The measurements, which are described in Chapter 4, Volume III of the VLA proposal, show that the sites are acceptable also from this point of view.

F. The Search Area

The second and third criteria above restrict the search for a site to the southwestern part of the United States, since the high population density and intensive human use of the eastern half of the nation are incompatible with the requirements of the VLA. In practice, the search was confined to United States territory west of the 100^{th} meridian and south of the 42^{nd} parallel. This takes in roughly one quarter of the conterminous United States. It includes all of Arizona, California, Colorado, Nevada, New Mexico, and Utah, as well as parts of Kansas, Nebraska, Oklahoma, Texas and Wyoming.

The Southwest is also the best part of the country from the standpoint of the topographic criterion. Much of this area is characterized by broad, flat valleys surrounded by mountains. These valleys are often large enough for the array, and the mountains provide a valuable shield against distant sources of interference.

The aridity and generally high elevation of the Southwestern valleys are also attractive. Both of these factors are conducive to the atmospheric stability needed to minimize the adverse effects which variations in the distribution of water vapor over the instrument can have on the synthesized maps of cosmic radio sources.

Chapter 3

THE SECONDARY SITE SELECTION CRITERIA

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A. General Remarks

In the preceding chapter, the primary criteria for the array site were developed. Those criteria can be thought of as necessary, but not sufficient, conditions. Sites satisfying them still must be evaluated in terms of other factors--some for the purpose of eliminating unsuitable candidates, and some with the aim of establishing a rational order of preference among those where array construction would be feasible. The latter aspect is the more important, since most sites meeting the primary criteria would be usable for the array. Some are much more desirable than others, however, and the secondary criteria provide the rules for sorting them out.

The secondary criteria are rather numerous, but they can be grouped naturally into a few categories. They will be discussed by category in the following sections of this chapter. Many will also be discussed at greater length in Chapter 5, which deals in detail with the most promising potential sites.

B. Natural Hazards to the Instrument

This section is concerned with those characteristics of an area which hold a potential danger to the physical safety of the installation. Factors of this kind have a bearing on the cost of the instrument, since protective measures must be taken against them whenever possible. Some natural hazards are so serious that they are in fact strong reasons for rejecting certain otherwise acceptable sites.

Some natural hazards are related to unusual weather phenomena. They include damage from flooding, high winds, and severe hail, all of which could seriously injure the array. Fortunately, the likelihood of these events can be judged accurately from existing records, since they are manifestations of stable, long-term climatic characteristics.

The Southwest is generally arid. A large fraction of the rain which falls comes in summer storms which can dump an enormous amount of water into a restricted area in a short time. Most of the potential sites are in broad, flat areas adjacent to mountains where high runoff volumes can develop, and a number of them are in closed drainage basins. Thus heavy rainfall over a considerable area can be funneled into the site. The soil is very permeable around a few of the possible sites, with the result that the influx of water is quickly absorbed. However, if the existing natural drainage pattern is poor, or if its capacity is low, local flooding will occur from time to time. The standing water can persist for some time in areas where the soil is relatively impermeable. Apart from actual flooding, there is also the danger of erosional damage to the installation from moving water. It is clear that adequate drainage control is an important part of site engineering. Particular care must be taken to ensure that any disruption which the facility makes to the natural drainage pattern is properly compensated.

Wind damage is unlikely to occur except in tornadoes, since the antennas are designed to withstand winds up to 110 miles per hour. All of the potential sites are in areas where the tornado frequency is relatively low, less than 2 per 1000 square miles being reported during the period from 1916 to 1963. The actual frequency varies considerably, however, over the area covered by the site search. It can be assessed reliably from local records in each individual case.

Heavy hail can cause serious damage to the precisely figured reflecting surfaces of the antennas. The frequency and severity of hailstorms vary considerably from one site to another. Fortunately, they can be assessed confidently from local records since the hail statistics for any given area are quite stable. Some parts of the Southwest are essentially free of damaging hail, while it is a fairly serious problem in certain areas.

Earthquake damage is also a possible hazard. There are a number of active fault zones in the Southwest where the likelihood of severe earthquakes is particularly high. For this reason, the vicinity of each site was examined for evidence of geologically recent fault movements. Damaging earthquakes can also result from deep subsurface movements without associated surface faulting. The likelihood of these can be assessed only with seismic data and historical records of earth tremors.

Of the natural hazards discussed above, hail is probably the most serious because of the fairly high frequency with which it occurs in some places and the fact that there is no economical way to protect the antenna surfaces from it. The only effective countermeasure is to avoid sites where heavy hail would be at all likely.

A tornado would almost certainly wreck any part of the installation lying directly in its path. However, the destructively high winds of a tornado are normally confined to a narrow band no more than several hundred feet wide. The vulnerable parts of the array, the antennas and the central building complex, will be widely dispersed, and serious damage would be improbable even if a tornado swept through the site. Nevertheless, the hazard must be recognized, and it would be well to build the array in a place where tornadoes are almost unknown.

In principle, the danger of flooding and running water damage can be eliminated completely by adequate drainage control. Extensive measures of this kind would be very costly, however, and the array should be built in a place which would minimize the need for them.

Earthquakes could cause serious damage, particularly to the cables connecting the antennas to the control center. Some structural damage to the antennas could occur, but it would probably not be serious unless the quake was very severe. The electronic installations on the antennas would be relatively safe since they are designed to withstand high accelerations during normal use. On the other hand, the electronic equipment at the control center, including the computer, would be susceptible to damage. This hazard can be minimized by good design.

C. Conflicting Activities

There are a number of kinds of human activity which could have a bad effect on the environment of the array, even though the number of people involved is small and the presence of the activity is not particularly obvious to the casual onlooker. It is clear that any kind of radio transmitting facility near the site could lead to a conflict if the electromagnetic radiation is powerful enough and contains frequencies which could affect the VLA system. This includes navigational aids, radar stations, communication relay stations, and almost any kind of military electronic activity. A high density of air traffic in the vicinity is undesirable because of the signals emitted from aircraft, for example, those using distance measuring equipment (DME). Aircraft can also scatter distant radio and radar signals into the reception pattern of the array. Thus it would be well to avoid placing the instrument in a region where intensive military or civil aeronautical activity takes place frequently.

There are activities at ground level which could have an unwelcome influence on the environment. For example, mining and oil or gas drilling in the immediate vicinity could hardly fail to be somewhat disruptive. Thus consideration must be given to the mineral and fuel resources in the neighborhood of each site, and the likelihood of their future exploitation must be assessed. Exploitable natural resources could also be a complicating factor in site acquisition.

Underground nuclear testing may cause seismic effects. This problem had to be considered for some of the locations in Nevada which are relatively near the Nevada Test Site of the Atomic Energy Commission.

Railroads and major highways offer a considerable, although not insurmountable, obstacle to the free movement of the array elements. The array is so large that it is not practical to try to avoid such crossings altogether, and in fact very few of the potential sites are unaffected by this problem. It is worse for some sites than others, however, and it must be treated as one of the factors which influence their relative desirability for the VLA. Highways introduce a certain amount of electrical interference into the site, owing to radiation from vehicular ignition systems. The array tends to reject most low-level interference of this type, but the rejection is not complete.

D. Human Factors

Under this heading, the aspects of a site locality which bear on the problem of hiring and keeping an adequate resident staff are considered. It also covers the less urgent, but still significant, problem of ease of access for scientists visiting the facility.

It is expected that approximately 60 persons will be needed to operate and maintain the instrument. About half of these would be people without highly specialized skills, and they presumably could be drawn from the general area of the site. The scientific and technical staff, however, would be brought in from elsewhere. Staffing will be difficult unless sufficiently attractive communities are within a reasonably convenient distance from the array site. Therefore the nearer communities must be considered from the standpoint of their schools, shopping facilities, medical services, and available housing. These communities should be close enough to the site that daily commuting by automobile would not be unreasonable. Finally, the kinds of recreation available in the area should be considered.

Nearly all of the potential sites are in fairly remote areas where the population density is low. Communities are usually small, and it might be difficult for them to absorb a large influx of new families. The ability of these places to accommodate a jump in population must be evaluated.

It is desirable that travel to the facility should not be difficult for visiting scientists. There should be no problem if a city with scheduled air service is within two or three hours driving time from the site.

E. Miscellaneous Factors Which Influence the Cost of Site Development

The cost of some items involved in site development is largely independent of the choice of site. There are others, however, which have costs that depend very strongly on site characteristics. An example is the establishment of adequate drainage control. Another factor which has a strong bearing on the cost of the site development is the smoothness of the ground along the array branches, since about 40 miles of level antenna roadway must be prepared. Also to be considered from the standpoint of cost are the availability of such raw materials as sand and gravel near the site, the kind and amount of vegetation that must be removed, highway and railroad crossings for the array branches, and so on.

The ease of obtaining ample water of quality suitable for domestic use is another important variable factor. In some areas the mineral content of the ground water is so high that wells would not be a usable source. In others, aquifers of adequate capacity can be reached only by very deep drilling.

The availability of electric power at the site is important. It is expected that the facility will have a continuous demand of 800 kW and a peak demand of 1600 kW. Power lines will have to be built to connect the facility to the existing distribution system. At some sites, this would mean going many miles. Since the demand load is so great, the capacity of the existing distribution system would often have to be increased. The utility companies will require NRAO to meet a major fraction of the construction cost. This can be considerable, since power lines of the required kind cost up to $10,000 per mile.

Every site will require a certain amount of access road construction. The actual length depends on the existing road net in the vicinity of the site, and it varies drastically from one to another. The cost of access road construction ranges from less than $40,000 to over $100,000 per mile, depending on terrain, drainage, and the cost of acquiring the right of way.

Another highly variable item is the ease and cost of acquiring the site for NRAO. This problem is discussed at length in Chapter 5.

Acquisition should be easy and inexpensive when the land is in the public domain, as it largely is for many of the possible sites. When Indian land is involved, access can be obtained only through a lease arrangement acceptable to the tribe. In some areas, it also appears that leasing of privately owned land would be more practical than outright purchase. It is desirable, however, to obtain title to the site if possible.

Finally, the prevailing wage scales for the skilled and unskilled labor needed during array construction must be considered. Much of the unskilled force probably could be drawn from the vicinity of the site, but skilled labor would usually have to be brought in from a considerable distance. This raises certain problems of compensation, and it also involves the provision of housing and food during construction. There is also a noticeable variation in the prevailing wage scales from one area to another.

F. Climate

In the present context, "climate" refers to persistent atmospheric characteristics of a site area which can influence the performance of the instrument. Weather phenomena which could result in damage to the instrument have already been discussed above with the other natural hazards.

At elevations below 1 km (3000 feet) above sea level in the Southwest, the mean daily maximum temperature in the summer is generally over 38° C (100° F). Extreme temperatures lead to a number of technical problems with the antennas and receivers, and it would be desirable to avoid them if possible. High temperatures also lead to strong convective motions in the lower atmosphere. The refractive anomalies associated with convection cells distort the plane radio waves passing through, thereby altering the relative phases of signals received at different points. With an array, this ultimately has the effect of blurring the synthesized maps of radio sources. This problem cannot be avoided entirely but it can be eased somewhat by choosing a site with regard to it.

It is therefore desirable to choose a site with as little, and as dry and stable, atmosphere above it as possible.

Chapter 4

THE BASIC SITE LIST. SITE EVALUATION PROCEDURES.

Chapter 4

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A. Locating Possible Sites

The first step in finding potential array sites was to locate all of the places which seemed, on the basis of intermediate-scale topographic maps, to satisfy the primary criteria described in Chapter 2. As explained previously, the search was confined to United States territory south of latitude 42° N and west of longitude 100° W.

Maps of the 1:250,000 series published by the U.S. Geological Survey were used. This scale was satisfactory for the purpose. For most of the area considered, these maps have a contour interval of 200 feet, which is small enough to show the general character of the topography quite well, although it is much too coarse to permit an assessment of the smoothness of the ground. Drainage patterns and channels are shown in good detail. Watershed areas can be estimated accurately. Railroads, highways, pipelines, mines, and oil fields are shown, as are all towns and cities. In the more remote areas, where the possible sites are to be found, these maps show all dirt roads and homesteads, and even many windmills and corrals. Furthermore, the boundaries of military reservations, national forests and parks, Indian reservations, etc., are given. On the whole, these maps were nearly ideal for the initial site search.

The map study provided a basic list of 34 possible array sites. These are enumerated in Table 4-1, in the order in which they were found. They are designated individually by the letter Y followed by the number given in the first column. The second column gives the state in which the site is located; the third, fourth, and fifth columns give the latitude, longitude, and elevation above sea level at the array center (the point where the branches intersect). The sixth column contains the true azimuths of the individual array branches, as seen from the center. The last column gives the name of the flat area containing the site, or of a

Table 4-1

POTENTIAL VLA SITES

Desig-nation	State	Center Coordinates North Latitude	West Longitude	Elevation at center, feet	Arm Azimuths from center	Name
Y 1	N.M.	32°11'.2	103°36'.8	3500	005°-125°-245°	San Simon
2	N.M.	33 34.8	106 40.5	4720	055 -175 -295	Jornada del Muerto
3	N.M.	33 13.5	106 23.0	4050	005 -125 -245	White Sands
4	N.M.	34 40.6	108 14.5	7300	053 -173 -293	North Plains
5	Ariz.	35 48.9	110 58.4	5740	056 -176 -296	Moenkopi
Y 6	Ariz.	31°55'.3	112°15'.0	1850	069°-189°-309°	Kupk
7	Utah	39 48.6	112 44.2	4650	090 -210 -330	Crater Springs (Alternate)
8	Ariz.	32 43.0	113 14.9	670	056 -176 -296	Sentinel Plain
9	Utah	38 40.4	113 20.0	4680	068 -188 -308	Wah Wah Valley
10	Utah	39 54.1	113 30.0	4290	065 -185 -305	Great Salt Lake Desert
Y 11	Utah	39°33'.5	113°31'.7	4900	057°-177°-297°	Tule Valley
12	Ariz.	32 27.3	113 40.6	740	047 -167 -287	Mohawk Valley
13	Nev.	36 45.1	114 23.7	2000	055 -175 -295	Mormon Mesa
14	Nev.	39 33.2	115 38.5	5890	099 -219 -339	Newark Valley
15	N.M.	34 04.7	107 37.1	6960	115 -235 -355	Plains of San Augustin
Y 16	Utah	39°02'.4	112°40'.8	4630	066°-186°-306°	Black Rock Desert
17	Nev.	39 35.4	116 27.4	6180	114 -234 -354	Monitor Valley
18	Utah	39 35.9	112 40.6	4590	115 -235 -355	Crater Springs
19	Nev.	38 08.1	117 27.9	4800	005 -125 -245	Tonopah
20	Nev.	38 26.5	117 21.7	5250	056 -176 -296	Tonopah (Alternate)
Y 21	Nev.,Cal.	36°37'.8	116°29'.8	2520	068°-188°-308°	Amargosa Desert
22	N.M.	32 15.6	108 24.2	4700	067 -187 -307	Separ
23	Ariz.	32 05.0	111 35.3	2820	115 -235 -355	Aguirre Valley
24	Tex.	31 13.1	103 16.9	2700	054 -174 -294	Pecos
25	Nev.	37 53.4	116 40.8	5550	008 -128 -248	Cactus Flat
Y 26	Tex.	31°41'.0	105°21'.0	4100	056°-176°-296°	Salt Flat
27	Tex.	30 26.4	104 23.4	4540	116 -236 -356	Lobo Valley
28	Tex.	29 04.6	100 22.5	950	004 -124 -244	Spofford
29	Cal.	34 51.9	117 23.4	2650	066 -186 -306	Mojave Desert
30	N.M.	36 17.3	108 21.5	5750	064 -184 -304	Hunters Wash
Y 31	N.M.	35°52'.2	108°33'.4	5900	116°-236°-356°	Mexican Wash
32	Nev.	40 28.3	117 15.2	4620	113 -233 -353	Buffalo Valley
33	Nev.	40 28.3	114 28.8	5600	007 -127 -247	Steptoe Valley
34	Nev.	40 29.8	115 10.9	6000	114 -234 -354	Ruby Valley

nearby town or geographical feature. For various reasons, a number of the entries in Table 4-1 do not actually satisfy the primary criteria described in Chapter 2. Nevertheless, they have been included for the sake of completeness. The table contains every site that has been considered, however briefly, for the VLA.

The locations of these 34 sites are shown in Fig. 4-1. Each is marked by a Y-shaped symbol which correctly shows the array size and orientation. Three forms of this symbol are used:

Category I	:	Prime sites which would be feasible for array development.
Category II	:	Sites which were eliminated after field examination.
Category III	:	Sites which were eliminated after serious deficiencies from the standpoint of the VLA were revealed by maps and reports.

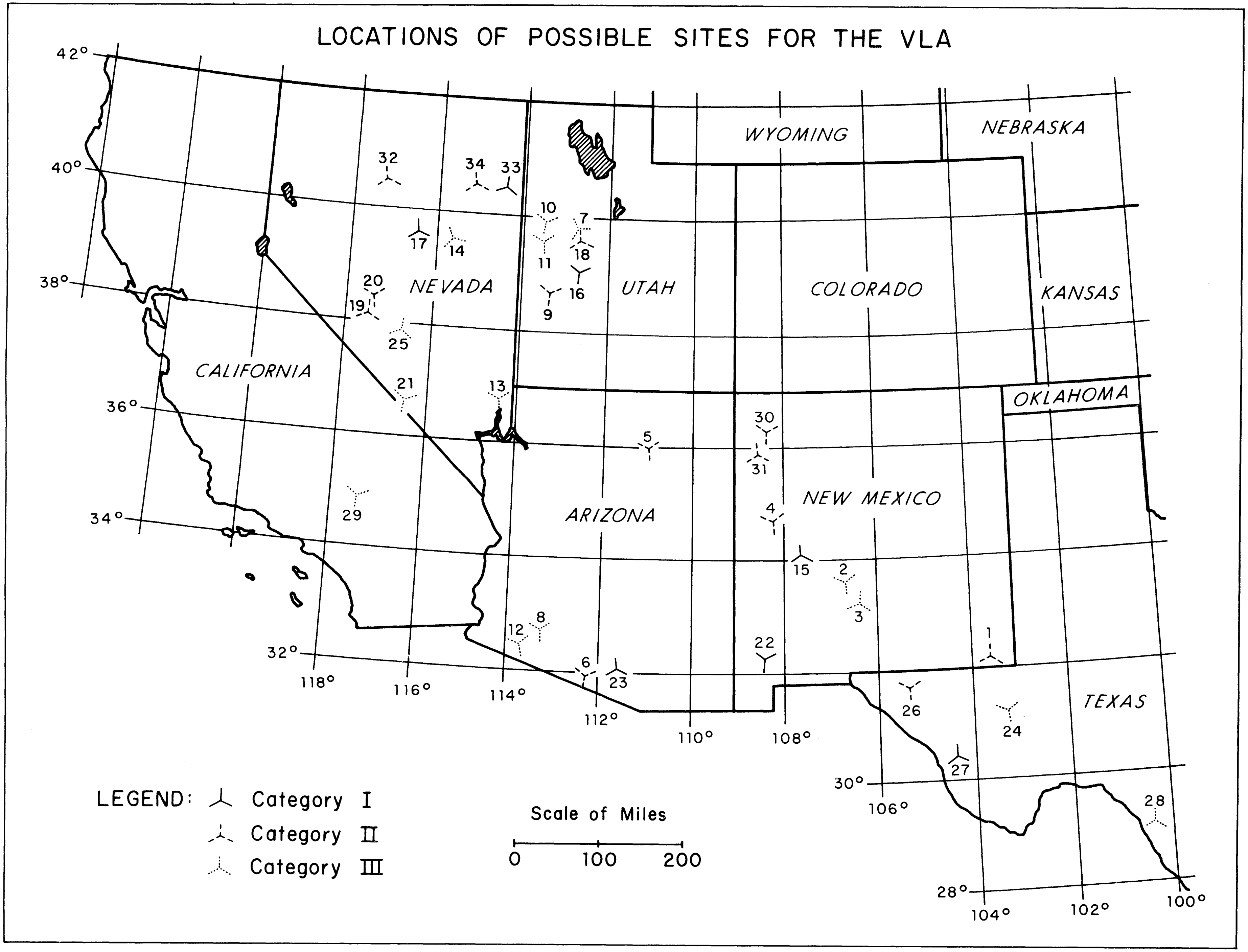
The 34 locations are distributed over six states: Arizona, California, Nevada, New Mexico, Texas, and Utah.

B. Clearly Unsuitable Sites

After the basic site list was complete, the next step was to filter out the most obviously unsuitable candidates. It was pointed out in earlier chapters that several sites were listed which did not actually satisfy the primary selection criteria. In fact, after careful examination of large-scale maps and available records, 14 of the possible sites were dropped from active consideration because of poor orientation, conflicting activities, or poor topographic characteristics. These are the sites assigned to "Category III" in Fig. 4-1. They were not visited by members of the VLA group. They are discussed individually in Section B of Chapter 6.

C. Field Inspection

The 20 remaining sites were visited and inspected by members of the VLA design group. Table 4-2 includes a log of visits to each of these



LOCATIONS OF POSSIBLE SITES FOR THE VLA
WYOMING
NEBRASKA
NEVADA
UTAH
COLORADO
KANSAS
CALIFORNIA
OKLAHOMA
ARIZONA
NEW MEXICO
TEXAS
42°
40°
38°
36°
34°
32°
30°
28°
118°
116°
114°
112°
110°
108°
106°
104°
102°
100°
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
LEGEND:
Category I
Category II
Category III
Scale of Miles
0
100
200

Fig. 4-1

Table 4-2

MAIN INSPECTION TRIPS TO POSSIBLE VLA SITES
BY MEMBERS OF THE VLA DESIGN GROUP

Site	Aerial Examination	Ground Examination
Y1	18 Nov 65	
Y4	17 Nov 65	
Y5	12 Feb 66	
Y6	17 Jan 66	
Y9	29 Oct 69	
Y15	17 Nov 65 19 Jan 66 12 Feb 66	16 Nov 65 19 Nov 65 13 Feb 66
Y16	29 Oct 69	30 Oct 69
Y17	27 May 69	28 May 69
Y18	29 Oct 69	
Y19	27 May 69	28 May 69
Y20	27 May 69	
Y22	19 Jan 66 20 Jan 66	18 Jan 66
Y23	11 Feb 66 4 Jun 66 6 Jun 66	15 Feb 66 4 Jun 66
Y26	11 Mar 66	12 Mar 66
Y27	11 Mar 66 21 Jun 66	12 Mar 66
Y30	16 Jan 67	
Y31	16 Jan 69	
Y32	27 May 69	
Y33	27 May 69	
Y34	27 May 69	

sites. The procedure usually followed was first to inspect a site carefully from the air, flying slowly along the array branches at an altitude of 100 to 200 feet above the ground. In some cases, this showed that slight adjustments to the center location and arm orientations would permit alignment onto better terrain. The aerial inspection made possible a good assessment of the suitability of the terrain, and it gave a good idea of the quality and nature of the drainage. The initial aerial inspection of a site normally took about one hour. More time was spent on the sites which appeared to be exceptionally attractive.

The aerial inspection revealed adequate cause for rejecting 11 sites without further study. In such cases, the reason was usually excessively rough or rocky terrain, or serious drainage deficiencies.

Eight of the nine sites which remained after the aerial inspection were examined on the ground by members of the VLA group. The exception was Y33, which was rather difficult of access. In the ground inspection, no attempt was made to cover the entire length of each branch. The examination was confined to the neighborhood of places where the branches cross existing roads or trails, except when there were particular places which the aerial inspection had suggested should be looked at closely. The ground examination clarified various points noted from the air, and two more sites were rejected after being visited. The 13 sites which were dropped after being inspected are discussed in Section C of Chapter 6.

D. Engineering Studies

The 7 remaining sites were studied in detail. Since numerous factors must be considered in the light of expert knowledge of many kinds, the services of a reputable civil engineering firm were enlisted. Two such studies were made. In 1966, Limbaugh Engineers, Inc. of Albuquerque was given a contract to make a preliminary engineering study of sites Y15, Y23, and Y27. In 1969, the same firm was given a second contract to make a similar but somewhat broader evaluation of all 7 of the viable sites (Y16, Y17, Y22, and Y33, in addition to the 3 named above). These studies will be discussed in detail in Chapter 5.

E. Meteorological Studies at Certain Sites

The fluctuations in the water-vapor content of the earth's atmosphere are the principal limitation to the phase stability of an array such as the VLA. It is, therefore, a useful criterion in the evaluation of a site. The water-vapor conditions at three of the sites, Y15, Y23, and Y27, have been studied over a period of 2-1/2 years. The results, which are described in detail in Chapter 4 of Volume III of the VLA proposal, show that all three sites have acceptable water-vapor conditions, with Y15 being the best by a factor of two. Generally the tests confirm that high elevation sites in the dry southwestern area of the United States are desirable.

Chapter 5

ACCEPTABLE SITES

Chapter 5

ACCEPTABLE SITES

A. Introduction

The seven sites which were considered to be most suitable for the VLA (Y15, Y16, Y17, Y22, Y23, Y27, Y33) were examined in detail. The study of these sites had two primary aims. The first, of course, was to turn up serious difficulties which might have been overlooked during the earlier work. Second, information necessary for the eventual ranking of the sites in a rational order of preference had to be assembled. Since so many diverse factors must be considered, it was clearly to our advantage to use the research capabilities and judgment of an experienced engineering firm. This work was done by Limbaugh Engineers, Inc. and their report of 1 January 1970 is the basis for most of the information presented in this chapter.

The scope of work laid out for the engineering study was based largely on the secondary site selection criteria discussed in Chapter 3. Certain other relevant items were considered, such as the cost of the building complex. The major points which Limbaugh Engineers were asked to study were the following:

(1) Climatic characteristics, including temperature and precipitation statistics, wind data, and information regarding potentially damaging weather phenomena such as thunderstorms, hail, dust storms, and tornadoes.

(2) Drainage, with particular regard to the possibility of flooding and the measures needed to protect the array from water damage.

(3) Land ownership, and the cost and procedures for site acquisition.

(4) Geological stability, particularly the frequency and severity of earthquakes.

(5) Developable natural resources in the area of each site, especially those whose exploitation might affect the environment adversely.

(6) Activities near each site which could have a bad effect on the environment. This includes radio transmitters of any kind, high-density aeronautical activity, and major highways and rail lines.

(7) Miscellaneous human factors, including site accessibility to communities of reasonable size; the quality and availability of schools and medical services in the nearer towns; the availability of adequate housing within a reasonable distance; the availability of potable water at the site; the nearest sources of skilled labor for construction; and the prevailing wage scales.

B. Organization of the Discussion of the Individual Sites

The discussion of each of the seven sites considered in this chapter is divided into ten sections dealing with different aspects of the problem. These are the following:

1. General site features

The general site features include the exact location and access to the site, a general description of the land and vegetation, and the availability of commercial transportation. Information about the nearer towns and cities is included to indicate their adequacy for the needs of the resident scientific and technical staff.

For two of the sites, Y16 and Y33, the only maps available were USGS quadrangle sheets with a scale of 1:250,000 and a contour interval of 200 feet. In critical areas where more accurate terrain data were needed, profiles were prepared using a Wild B-8 plotter with positive prints of aerial photographs obtained from the U.S. Geological Survey.

2. Climatology

Climatic data for the various sites were obtained from state climatologists, atmospheric physics laboratories, local weather bureaus, the Soil Conservation Service, the Bureau of Land Management, the Federal Aviation Agency, airports, and local private weather stations. Additional information came from the Environmental Science Services

Administration, the New York Academy of Sciences, and the Crop Hail Insurance Actuarial Association. Six major categories were considered: temperature, precipitation, winds, air pollution, relative humidity, and sky cover.

The United States Department of Commerce has published comprehensive climatological summaries for the principal cities of the country; however, the data for the smaller cities and towns are much less complete. The paucity of data is particularly apparent in the more remote areas of the West, especially in the parts of Nevada where two of the sites are located. Temperature and precipitation data exist for most areas, but systematic information on thunderstorms, fog, wind, and sky cover is usually unavailable. Data on the frequency and predominant types of cloud cover were not found for any of the site areas.

It was necessary to estimate the maximum rainfall intensities because precipitation records have been kept only in terms of total rainfall in 24-hour periods. The U.S. Weather Bureau has developed isopluvials of two-year, six-hour precipitation in some of the areas. The data were interpreted on the basis of a 50-year storm[1]. Design criteria formulations, charts, drafts and technical data available in Design of Small Dams, Bureau of Reclamation; Rainfall Intensity, Duration, Frequency, U.S. Weather Bureau; Transactions, American Society of Civil Engineers; Civil Engineers Handbook, and other sources were applied where needed.

3. Geology and foundation investigation

Surface geological field investigations were made at each of the sites. The purpose of these studies was to evaluate the stability of the soil, the magnitude and effect of surface drainage, and the availability of sand, clay, gravel and aggregate to be used in concrete and for construction. Subsurface soil investigations were carried out at three of

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[1] A 50-year storm is a storm of a severity which is attained only once in fifty years, on the average.

the sites (Y15, Y23, and Y27) during the summer of 1966. At the remaining sites, only surface soil investigations were made.

Information on the developable natural resources was obtained from published information, from state and federal agencies, and from field investigation.

4. Topography and drainage

The suitability of the terrain for construction of the array at the various sites ranges from satisfactory to good. Grades in excess of 2 percent occur for short intervals on four of the sites. In general, the sites are open and flat to gently rolling with gradients of less than 1.5 percent. The drainage design shown on the profile exhibits is planned to accommodate runoff in the existing channels. The array branches should not act as dikes to retard, divert, or hold runoff water, although this will sometimes happen during peak runoff from heavy precipitation.

In developing the drainage requirements for the sites, many factors which influence the runoff volumes and likelihood of flooding were considered; these include topography, geology, climate, watershed size and shape, percolation and infiltration of the soil, altitude, vegetation, antecedent storms, and base flow and precipitation. Geological Survey quadrangle sheets, aerial photographs, and state geological maps covering the site areas were used in the drainage studies. Precipitation and flood records were obtained from the U.S. Weather Bureau. The U.S. Geological Survey Surface Water Division and the Water Resources Division of the Department of Commerce were consulted, as well as Weather Bureau climatologists, State Highway drainage engineers, and hydrologists from various universities. Site visits were made to observe existing surface conditions and to record the effects of recent floods, if any.

Many formulas have been evolved for estimating runoff volumes. Some are appropriate for small areas; some for large watersheds; some for particular conditions; some for only certain parts of the country. These formulas include a coefficient whose value depends on the nature of the country in the drainage area. Its numerical value depends on such earth surface characteristics as the degree of saturation, compaction, surface irregularity, slope, subsoil character, and the presence of frost, snow, or ice. It is an interpretive value which normally is determined by observation, but it sometimes can be deceptive since proper evaluation requires an extensive and detailed hydrological study for each application.

5. Railway

The railway section permits the mobile antennas to be transported to different locations on the Wye. The tracks will also carry personnel and maintenance equipment to the observing stations; this makes access roads along the branches unnecessary.

The observing stations are on spurs with the centers of the stations approximately 100 feet from the center line of the main tracks. All spurs are at right angles to the main tracks. By placing the antenna stations on spurs, the main tracks are left clear for other vehicular movement. Antennas can be transferred from one branch to another at the Wye apex, where the tracks meet to form a railway junction.

The major railway-highway crossings will be accomplished with a bituminous base course over railway ballast and covered with 2-1/2 inches of asphaltic concrete surface. Minor railway-road crossings will be made by normal timber crossing methods. Railway crossings will follow AREA [1] practice and methods.

Railroad-type cattle guards will be used where existing fences cross the Wye branches.

The design of the railway was based on the following requirements:

(1) Use of standard gauge railroad track, consisting of 90 pound relayer rails on untreated hardwood, random cut, industry grade ties. Ties will be at 28-inch spacing, supported by 6 inches of gravel ballast. Tie plates and joint bars will be used material, with other accessories being new.

(2) Distance between center lines of double tracks to be 15 feet.

(3) Observation stations to be placed on spur tracks perpendicular to the main tracks.

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[1] American Railway Engineering Association

(4) Trackage to support antennas weighing 225 tons.

(5) Maximum allowable track grade of 2 percent.

(6) Provision for switching of antennas from one branch to another at the point of intersection.

(7) Antenna movement to be permissible in winds up to 35 mph.

The tracks and ballast sections will be constructed by approved methods and procedures to meet AREA specifications. The subgrade shall have a rating CBR-10 or better. Borrow material is expected to be available within the right-of-way and within free haul distance in most cases. Gravel will be obtained from the closest sources in order to reduce haul distance.

The observing stations on the spurs have three foundations--one for each leg of the radio telescope. One is centered between the tracks, and the other two are outside of the tracks and straddling them. The foundations are meant to prevent overturning of the antennas as well as to support them in a fixed position.

Each station will be enclosed with a 4-foot high open mesh stock fence. Two 15-foot long gates across the railway tracks will lock together at the center line when closed.

The foundations for the observing stations will be constructed of poured-in-place concrete, and will be of the under-reamed bell type. In most cases, bell bottom concrete footings at a depth of 15 feet will be used. The shaft will be 4 feet in diameter and the bell bottom will have a diameter of 8 feet. Three foundations will be constructed at each spur intersection for use during antenna transfer from the main track.

The staging area provides a location for the field erection of the antennas, on rails extending from a spur track near the apex, thus permitting access to the Wye. After the array becomes operational, the staging area will be used for maintenance. The design includes trackage, a hard stand for crane operation, and assembly and storage areas.

The staging area will cover 24,000 $feet^2$. It will be paved as follows: hardstand area to have 2-1/2 inches of asphaltic concrete over

6 inches of gravel base on prepared subgrade; remaining area to have bituminous double surface treatment over 4 inches of gravel base on prepared subgrade. Material and construction are to meet Asphalt Institute specifications. The access to the staging area will be by gravel road. Drainage will be minimal, and existing channels will generally be crossed by constructing dips.

6. <u>Access roads</u>

The roads serving the VLA site are the entrance road, the access road to airstrip, and the access road to the Wye apex. The design is based on the following requirements:

(1) All weather surface.

(2) Forty-five mph speed.

(3) Adequate drainage.

(4) Three hundred feet sight distance.

(5) Seven percent maximum grade.

The entrance road from the main highway to the building complex will have a wearing course of asphaltic concrete on a 6-inch gravel base. The roadway will be 24 feet wide with shoulders 2 feet wide. It is designed for the traffic classification designated "light", on the basis of the expected average daily number of equivalent 18,000-pound single axle load applications. Mix design criteria, specifications, and construction methods are MS-2 and SS-1 from the Asphalt Institute. The other access roads differ from the entrance road only in width.

7. <u>Airstrip</u>

The airstrip is to be classified as a Basic Utility Airport, meeting the FAA design criteria, Stage 11B. This is suitable for about 95 percent of the general aviation fleet.

Each end of the airstrip has a 1000-foot clear zone to provide for a 20:1 glide approach. A 30-foot wide paved taxiway and a 150-foot by 200-foot paved apron are to be located at one end of the airstrip. The runway, taxiway, and apron will be surfaced with bituminous triple surface treatment on a granular base. The paved areas can accommodate a 15,000 pound wheel loading, equivalent to a DC-3 class aircraft. The airstrip will be equipped with a wind cone. It will be reached by a paved access road.

8. Water supply

The water supply will be a "High Pressure Storage" system composed of a well, elevated storage tank, chlorinator, and softener. Water supply requirements for the VLA sites are based on 5000 gallons per day potable water and 50,000 gallons reserve for fire. Investigation of existing wells on each of the sites indicates that this quantity probably is obtainable in each area. The sites generally are situated in alluvium-filled valleys where the alluvial material serves as the aquifer. The quality of the water at the seven sites varies from satisfactory to marginal. Limits for fluoride, chloride, sulfate and total dissolved solids may exceed the U.S. Public Health Service standards at a few of the sites. There is insufficient information to give a firm indication of the water quantity and quality in some of the areas.

9. Utilities

The utility companies that would supply power to the sites were contacted to determine the availability and reliability of electric power.

This study was based on a normal load of 800 kW with a 90 percent load factor utilization. Demand load is considered as 1600 kW. The buildings will be heated electrically. This will eliminate the need for a natural or bottled gas supply source.

A completely automatic 500 kW diesel or turbine driven emergency generator set is to be installed as stand-by equipment. This unit will be complete with the necessary cleaners, filters, indicators, instrument panel, fuel tanks, lines and pumps, coolant system, shut-off safety devices, governor, 32-V automatic starting system and batteries, control panel for the generator and 800 A automatic transfer switch.

Electrical service to the observing stations will be supplied by overhead lines from an outdoor transformer supplied by the utility company. The outdoor transformer will have the following secondary characteristics: 2300 V, 3-phase, 3-wire, 60 Hz. The secondary side of the transformer will serve the 2300 V switch gear which in turn will distribute power to the overhead lines. At each observing station, there will be a 3-phase primary fused switch transformer and panel board which will drop the voltage to 277/480 V.

10. Real estate

A number of basic assumptions are made concerning the land acquisition necessary for the VLA. A strip 200 yards wide is needed for the full length of each of the three branches, or a total distance of 39 miles. This averages 72.7 acres per mile, so a total of 2835 acres is required for the Wye branches. The building complex area, access road to the site, staging area, sewage treatment areas and landing strip will require an additional 55 to 225 acres, depending on the site. Consideration of the total area required is included in the land acquisition costs.

Of the seven sites discussed in the present chapter, five are mostly on publicly owned land (state or federal), with some privately owned tracts. Public land can be acquired by administrative transfer upon payment of compensation to the present leaseholders. Other procedures are required in the case of land owned by Indian tribes or private individuals.

Land acquisition from private owners for such a facility is normally accomplished by one or more of the following methods:

(1) Perpetual easement. A lump sum, one time payment. It gives right to use but not to title. Usually 75 to 90 percent of the purchase price. Amount is based on the value of land taken, plus damages to the surrounding land.

(2) Term year leases. These are from 5 to 50 years with annual payments, renewable at the option of the lessee.

(3) Open end lease. Normally costs more than the term lease.

(4) Purchase outright. This is the fee approach whereby the land is valued, with damages to surrounding land taken into account, and then purchased.

(5) Co-use agreement. This has been used when the surface of the land is not permanently changed, as for missile ranges, drop areas, etc., and when the Government only needs to use the land on specific days. It would not apply in the case of the VLA.

It is assumed that the land will not be fenced except for small areas at the observing stations, and perhaps the building complex. It is also assumed that where fences are crossed by the array branches, gates or livestock guards will be installed.

The current land utilization is predominantly livestock grazing at all of the sites. Sales of grazing land are usually in large blocks of land at a price per acre which includes all improvements and all leased lands or grazing rights within the unit and are usually between a willing seller and a willing buyer with no severance or other damages being involved in the transaction. The taking of small parcels from a larger tract for a special use, such as the VLA will require, generally disrupts the normal operation of the parent tract, interrupts and complicates the continuity of its title, usually creates a nuisance, and in some cases causes a severance damage. In some instances a change in operation of the parent unit is made necessary as a result of the acquisition of the smaller parcel. For these reasons, the acquisition of such small or irregularly shaped and erratically located parcels generally costs more per acre than larger plots of land. As a general rule, acquisition of the right-of-way for highways and utility lines costs from two to four times the unit price for normal ranch sales or leases.

There are many advantages to purchasing the land outright instead of leasing. By purchasing, all recurring costs associated with leasing are avoided. However, the Papago Indian Reservation lands of Site Y23 would have to be leased, as that is the only method of obtaining use of Indian lands. The lands on Site Y27 apparently would also have to be leased.

The National Science Foundation has the right of eminent domain. However, it is believed that the required land can be obtained without litigation, except in the case of Y27.

C. Site Y15 (New Mexico)

This site is in Socorro and Catron Counties, in the eastern end of the Plains of San Augustin[1]. Its center is approximately 22 miles west of the town of Magdalena, a little over a mile south of U.S. Highway 60. The geographical coordinates of the center are 34° 04!7 N, 107° 37!1 W; the elevation at the center is 6960 feet above mean sea level. The branches extend from the center on true azimuths of 355°, 115°, and 235°. A map of the site area is given in Fig. 5-1, and profiles along the three branches are shown in Figs. 5-2, 5-3, and 5-4.

1. General site features

The terrain at Y15 is gently rolling, in a broad southwesterly trending valley. The elevation of the valley floor averages about 7000 feet. Many of the mountain peaks surrounding the basin attain elevations over 9500 feet. These mountains are all in national forests (Cibola, Gila, and Apache).

A low altitude federal airway (V264-1905) passes near the site, approximately 2 miles north of the end of the northern branch of the Wye.

There are no railroads in the site area, but the northern branch of the Wye would cross U.S. Highway 60 approximately 2 miles from the apex. The older and now abandoned route of U.S. Highway 60 would be crossed by both the southeastern and southwestern branches of the Wye.

The Nevada Test Site of the Atomic Energy Commission is about 500 miles northwest, and there are no military or defense activities closer than the White Sands Missile Range, which lies about 60 miles southeast of the site.

Electrical transmission lines cross all three branches of the Wye, at a total of six locations. The line voltages for these transmission lines vary from 14.4 kV to 24.9 kV.

The old alignment of U.S. Highway 60 is just south of the apex and can be used for an access road, as can State Highway 78 which runs generally north-south about 2 miles east of the apex. U.S. Highway 60 is a two-lane road that runs generally east-west across the Plains of

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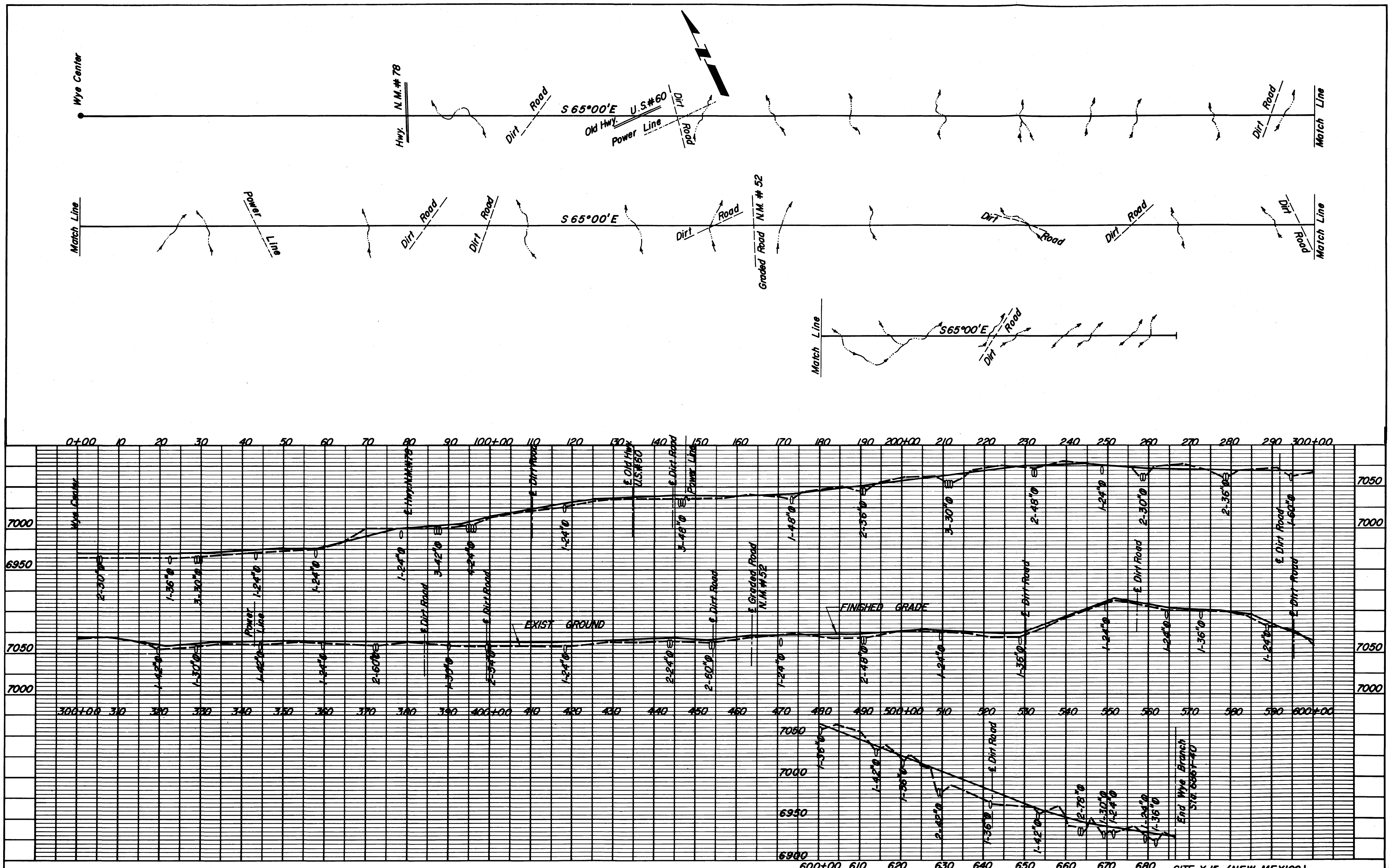
[1] Also known as the San Augustine Plains. Several spelling conventions are encountered in various publications.



Wye Center
Hwy. N.M. # 78
Dirt Road
S 65°00'E
Old Hwy.
U.S.#60
Power Line
Match Line
Graded Road N.M. # 52
S65°00'E
EXIST GROUND
FINISHED GRADE
End Wye Branch
SITE Y-15 (NEW MEXICO)
LIMBAUGH ENGINEERS, INC.

Fig. 5-2

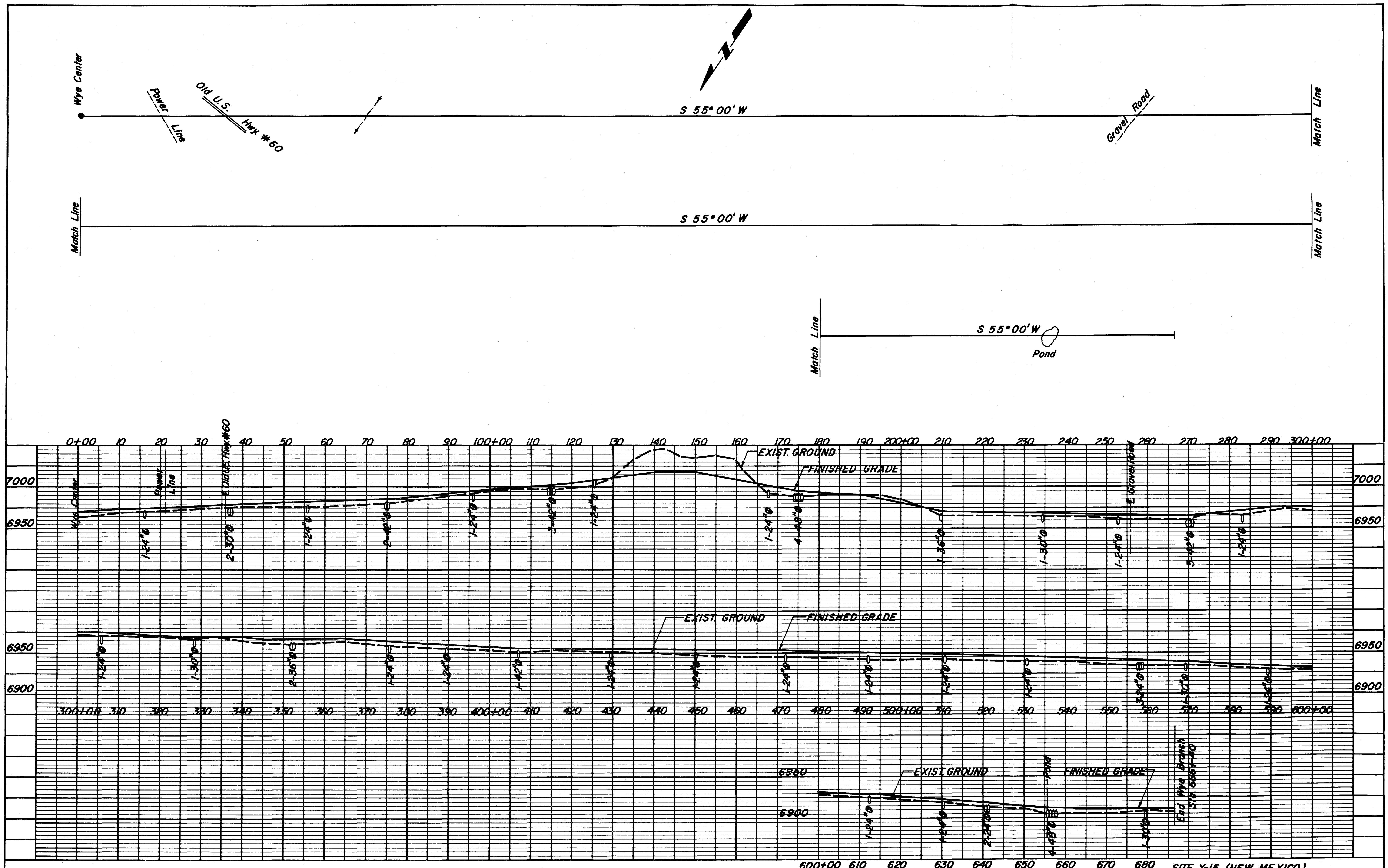
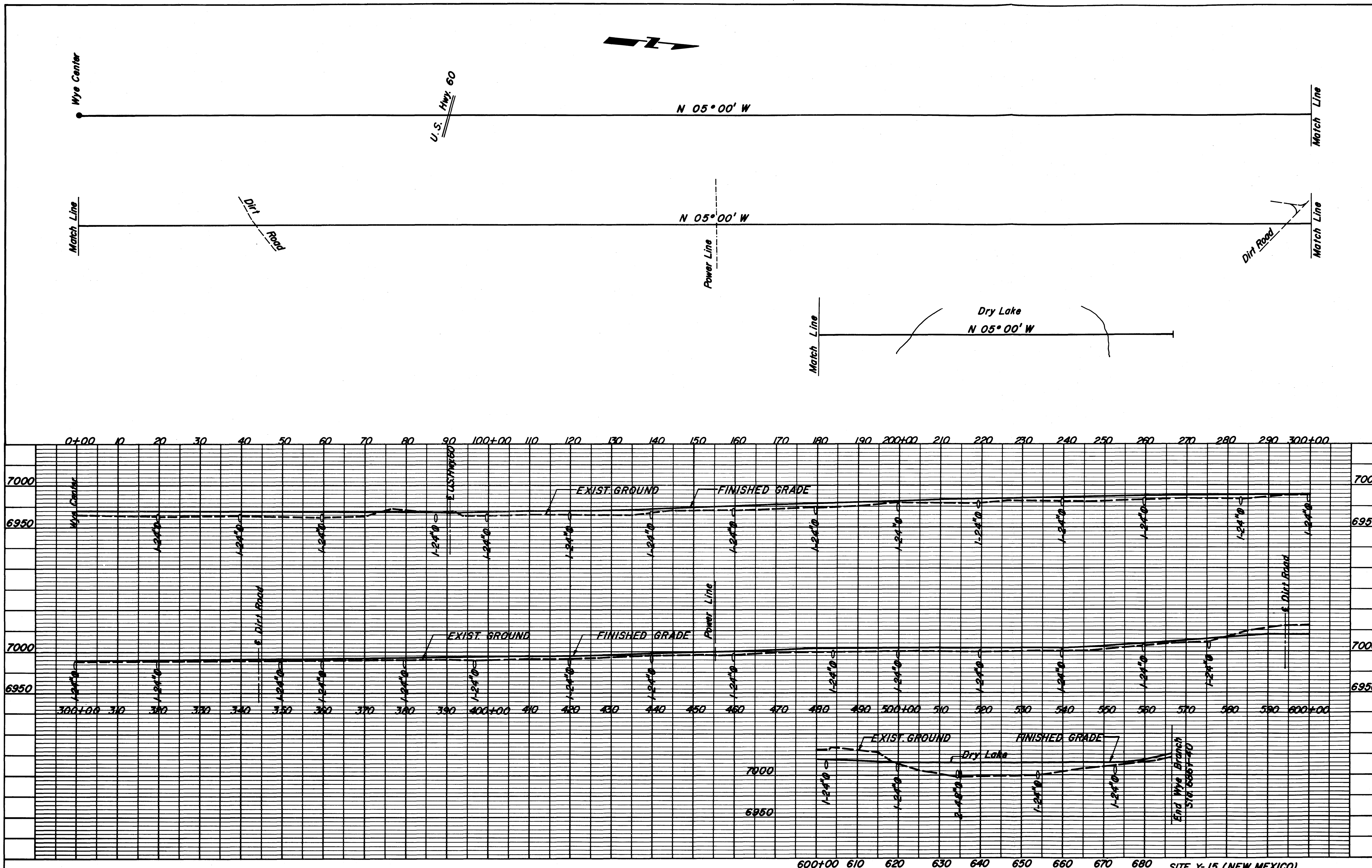

N
Wye Center
Power Line
Old U.S. Hwy #60
S 55° 00' W
Gravel Road
Match Line
Pond
EXIST. GROUND
FINISHED GRADE
7000
6950
6900
End Wye Branch
SITE Y-15 (NEW MEXICO)

Fig. 5-3



SITE Y-15 (NEW MEXICO)

Fig. 5-4

San Augustin from Datil, on the western edge of the Plains, to Magdalena and thence to Socorro in the Rio Grande Valley.

Datil, roughly 12 miles west of the site center, has a population of less than 100 and, as might be expected, has minimum facilities.

Magdalena, 22 miles to the east, has a population of 1500. There is an Indian school there, and a district office of the U.S. Forest Service. There are two reasonably modern motels and restaurants in Magdalena. A public school system serves Magdalena and the surrounding area. There are no resident physicians or medical facilities.

Socorro, the nearest town of any size, is located about 50 miles east of the site at the junction of U.S. Highway 60 and Interstate Highway 25. It has a population of 6000 and an economic background of cattle raising and mining.

The Atchison, Topeka and Santa Fe Railway provides freight service to Socorro on the line connecting Albuquerque and El Paso. Socorro is also the switchpoint for a branch line which runs to Magdalena, thus providing rail service 22 miles from the center of the site.

Socorro is on the Chicago-El Paso route of the Continental Trailways Bus Line. There is a municipal airport with lights for night operation. The nearest commercial airline service is 75 miles to the north at Albuquerque, which is served by TWA, Continental, Frontier, and Texas International Airlines.

Socorro is also the home of the New Mexico Institute of Mining and Technology, which offers bachelors' degrees in all of the basic sciences as well as masters' and Ph.D. programs in several fields. The Institute is basically a research center for metallurgy, geology, atmospheric physics, ground water hydrology, and for many other phases of the broad field of earth sciences.

Socorro has three public grade schools, one parochial grade school, one junior high school and one high school. There are over 2000 students enrolled in the public school system. The high school is accredited by the North Central Association.

Since Socorro is a junction point of major highways, there is a good selection of motels and restaurants for a town of its size. It has a mayor-council type of government, with the mayor elected every two years and the councilmen serving staggered four-year terms.

There are four medical doctors, three osteopaths, one dentist, and one optometrist as well as a modern county hospital with 46 beds. The county office of the State Health Department is located in Socorro. The town has a normal complement of churches, service clubs, banking facilities, and businesses. Recreation in the area is generally of the outdoor type and includes golfing, hunting, and fishing.

A surplus of unskilled labor exists in the Socorro area, but probably a large part of the skilled labor required for construction and operation of the array would be drawn from other communities up and down the Rio Grande Valley. As a wage scale indication, base wage rates for skilled construction workers in the Socorro area are $6.35 per hour.

2. Climatology

The average daily maximum temperature is 72° F and the average daily minimum temperature is 31° F. The highest recorded temperature is 104° F, and the lowest is -22° F. The annual mean temperature is 52.5° F.

The average annual precipitation is 12 inches; the daily and monthly maxima recorded in a four-year period are 2.25 inches and 4.66 inches, respectively. The relative humidity averages 53 percent. The sun shines approximately 70 percent of the time possible. One tornado has been recorded since 1860; this occurred in 1929 somewhat south of the site. Dust storms are infrequent and not severe, and no hail has been recorded in the last 16 years. The prevailing wind is from the west, with an average velocity of 9.6 miles per hour. Maximum 50-year wind expectancy is 77 mph.

There is a fairly high incidence of thunderstorms in the area, with an average of 45 in the summer and 35 in the winter. Because of the high rate of activity, the Langmuir Laboratory for Atmospheric Physics has been located in the mountains east of the Y15 site for thunderstorm and lightning research.

3. Geology and foundation investigation

Geologically, the region is a southwesterly trending valley probably formed by erosion cutting deeply into volcanic rocks of the Datil formation. The valley floor lies at an average elevation of about 7000 feet. Bordering the valley on the northwest and northeast are the Datil and Gallinas Mountains, which have peaks reaching elevations of 9500 feet. To the south and southwest the boundary is formed by the Luera and San Mateo Mountains, which reach as high as 10,000 feet. The southeastern branch of the Wye extends out of the San Augustine Plains and into an area of moderately dissected terrace deposits within the Mulligan Gulch drainage system.

No significant faulting is known to occur in the San Augustine Plain, but the thick alluvial cover may mask some faulting. Two small intrusive rock units occur about six miles west of Augustine. The scarcity of such intrusive bodies, in view of their abundance in other sections of southern and central New Mexico, suggests that the area is a reasonably stable one.

Nearly all of the strong earthquakes in New Mexico and a majority of the weaker ones have occurred along the Rio Grande Valley between Albuquerque and Socorro (Northrup 1961). The most active area lies just west of Socorro where two or three micro-earthquakes are recorded each day (Sanford 1963). The Magdalena area is more stable.

Four damaging earthquakes with an intensity of seven or greater (on an increasing scale from 1 to 12) have occurred in Socorro, although the last was in 1906. Since instrumentation of the central New Mexico area was completed in 1962, the strongest tremor in the area was a 2.9 on the Richter intensity scale (recorded in 1963). It is believed that the maximum ground acceleration experienced in the Magdalena area has been only about 3 cm/s^2 or 0.003 g (Sanford, written communication).

Unconsolidated Quaternary terrace and alluvial material underlie the entire site. The surrounding mountains are made up of crudely stratified beds of rhyolite and latite tuffs, flows and breccia, which are overlain in scattered localities by Quaternary basalt and basaltic andesite flows. The Tertiary volcanic units appear to have been the source of most of the Quaternary and Recent sand and gravel deposits.

Because of lack of drainage, a lake developed in Quaternary time, filling most of the present plains area. The lower sand and gravel benches probably formed while the lake surface was high and were later partly dissected as the lake level dropped to the stage where it covered only the lower portions of the valley. The floor of the lower lake, which includes the site center, is underlain by high plasticity, impervious clays.

As the region became more arid and the lake shrank, the sands on the shorelines around the lake were formed into dunes. These sands have been widely distributed and now cover most of the lower elevations of the basin to a depth ranging from a few inches to over 10 feet.

The surface sand deposits at the site generally occur in the form of dunes composed of very fine to silty sand that is poorly graded. This type of sand would not be satisfactory for use in concrete mixtures.

A highway borrow pit about one-half mile north of U.S. Highway 60 and just west of the Catron-Socorro County line contains a large stockpile of well graded sand of up to medium grain size. This material was screened from the surficial deposits in an old stream channel, suggesting that sand could be obtained also in other areas where the sands have been concentrated and washed by the action of ancient streams.

Fine grained, silty gravel deposits cover most of the San Augustine Plains. This gravel would be satisfactory for embankment material, but it ranges from fairly satisfactory to unsatisfactory for use as base course or aggregate. Generally this material contains up to 15 percent silty fines and a maximum of 20 percent fine gravel. The gravel size usually is less than 1 inch.

Two borrow pits have been developed in the area adjacent to the Catron-Socorro County line and north of U.S. Highway 60. Deposits in these areas contain less than 10 percent fines and up to 50 percent gravel; however, the average gravel size is less than 2 inches and the pebbles are fairly well rounded. As mentioned above, these deposits probably have been more actively washed and sorted by ancient stream action than the average surficial material.

Surface evidence indicates fairly good concentrations of gravel similar to those mentioned above at selected locations in the low hills just west of the midpoint of the southwestern branch of Y15.

The best gravel sources would be from outcrops of the Gila Conglomerate. These occur along U.S. Highway 60, a short distance east of the site, and also at a shallow depth beneath the surficial deposits near the end of the southeastern branch. In most of the exposures, the gravel fraction is over 60 percent. The gravel is well graded up to about 3 inches and the maximum size is about 14 inches. These pebbles and cobbles are subrounded to subangular and should be satisfactory to crush for use as aggregate. The matrix is composed of fairly clean, angular sand which is rather tightly cemented with calcium carbonate.

The nearest commercial source of aggregate is at Socorro, a distance of approximately 50 miles. Local sources of rock will have to be chosen with care, as flow banded rhyolite or tuff composes a large percentage of the hard rock outcrops in the region. Both of these rock types probably would be unsuitable for crushing to obtain aggregate.

Rock suitable for crushing is available at three locations. The best and most centrally located deposit is a dark gray, andesitic volcanic rock which is dense and very hard. It occurs just north of U.S. Highway 60 at the eastern edge of the plains. The rock is rather massively bedded, but it is quite well fractured so that material suitable for crushing should be readily available, even though blasting will be required. The over-burden is negligible, and the surface outcrops suggest that the deposit could be expected to yield more than 200,000 cubic yards of rock.

A source of high-plasticity clay was found about 1.5 miles southwest of the apex. The obvious extent of the deposit is an area about 150 feet by 400 feet and 2 feet or more in thickness. It is believed that similar deposits probably underlie much of the low ground near the apex.

In summary, all of the needed mineral construction materials can be obtained within a 15-mile radius of the Y15 apex. Test drilling and laboratory testing will be necessary in order to ascertain the extent of the usable deposits and the quality of the material for various applications.

Ten test borings were performed along the three branches of the Wye at places where it was felt that a representative sampling could be obtained. A visual inspection was also made of each branch.

Along the northern branch the soil is composed of silty sand and sandy silt with intercalated high plasticity clayey lenses. Near the apex, the surface material consists of clay covered by windblown silt and sand. Hummocky sand dune terrain prevails from just south of U.S. Highway 60 for about three miles to the north. In places, these sands are moderately loose and may be as much as 10 feet in thickness. Except near the apex, the sediments underlying the northern branch contain from 5 to 20 percent fine gravel. The sieve analyses from the test borings indicate a maximum gravel content of 9 percent in the samples tested; however, those results do not appear to be typical of the majority of the surface material. Using a 100 pound hammer with a 30 inch drop, the penetration resistance tests showed a blow count per foot of from 4 to 39 at a depth of 2 feet, 6 to 41 at 5 feet, and 17 to 62 at 10 feet with refusal in one hole. The rather wide variation was a result of the varied types of material and changes in density. In all four holes, a blow count of 20 or more was attained consistently below 12 feet.

Soils along the first 9 miles of the southeastern branch are composed of sandy silt and silty sand with varying amounts of gravel up to 25 percent. The remainder of the branch crosses an area where detritus has been washed down from the adjacent mountain slopes, causing the soil to contain more clay as well as an abundance of small, angular rock fragments. The penetration resistance tests showed a blow count per foot of from 20 to 39 at a depth of 2 feet, from 7 to 14 at 5 feet, and from 35 to 50 at 10 feet. A consistent blow count of 20 or more was attained in the three holes at depths ranging from 7 to 10 feet.

Along the southwestern branch, fine-grained sand and silty sand are the most prevalent soil constituents, but locally the branch crosses low ridges that are underlain by gravel. Windblown sand masks the soil along much of the distance; however, the sand has not been formed into well developed dunes and probably the deposits are not thick. The penetration resistance tests showed a blow count per foot of from 9 to 14 at a depth of 2 feet, 1 to 33 at 5 feet, and 70 at 10 feet, with refusal in two holes.

No difficulty should be encountered in the excavation of the alluvium, and this material should be satisfactory for embankments when properly compacted. The high degree of compressibility of some of the samples tested indicates the need for special attention to compaction, particularly in low areas subject to ponding.

The bearing capacity determinations indicate that the placement of footings could be a problem at shallow depths because of the critical deflection requirement. This problem can be circumvented if the footings are placed deeper. A careful soil test drilling program must be undertaken in order to avoid locating footings in zones of low bearing capacity, for the penetration resistance tests indicate a wide range of values, including some that are quite low. The compressibility factor of the soils under saturated conditions should also be given careful consideration.

One deep oil well was drilled a short distance from the end of the southwestern branch of the Wye. The test proved to be dry and was abandoned. The future petroleum potential of the San Augustine Plains is poor. There are several areas of possible uranium activity in the surrounding mountains, but none is directly adjacent to the site. At present, there are no active mining operations in the area.

4. Topography and drainage

The vegetation on the Y15 site consists primarily of sparse stands of low grama grass. The density of the grass is somewhat greater in the bottom lands where the water is retained more effectively. In most places the grass cover is sufficiently dense to prevent the sand and dust from blowing except during the strongest winds. In the areas of windblown sand, there are scattered growths of small sagebrush intermixed with very sparse grass.

The northern branch has almost a flat grade, rising only 50 feet in the first 62,000 feet. North Lake begins at station 620+00 and runs to station 680+00. Here the branch will be on a 15 foot fill to accommodate any ponding which may occur in the normally dry lake bed. The area from station 680+00 to 686+40 is the only place requiring protection from run-off (from the Gallinas Mountains, the flow running southward along the western side of the branch). The drainage requirements on this branch are: thirty-three 24-inch diameter and two 48-inch diameter pipe culverts.

The southeastern branch is crossed by the drainage flow from Mount Withington on the south. The gradient from the apex of the Wye to station 530+00 is consistent and relatively flat with no major drainage structures needed. From station 530+00 to station 552+00, the branch rises 40 feet crossing a saddle between two hills; it then drops 90 feet to station 686+40. This section has numerous washes and gullies which enter from the mountains on both sides of the branch. The drainage flow from station 600+00 to station 686+40 is in the same general direction as the branch, eventually emptying into Mulligan Gulch. Some realignment of this part of the branch will improve the gradient and reduce the drainage demand.

The drainage requirements on this branch are: twenty 24-inch diameter, thirteen 30-inch diameter, eleven 36-inch diameter, nine 42-inch diameter, eight 48-inch diameter, two 54-inch diameter, four 60-inch diameter, and two 78-inch diameter pipe culverts.

The southwestern branch crosses the normal drainage lines from Mount Withington and has a low gradient for practically its entire length.

The drainage demands are light except where sheet flooding enters from the hills on the northern side, in the stretch from station 650+00 to 686+40. No major drainage structures are necessary. The drainage requirements on the branch are: twenty-four 24-inch diameter, six 30-inch diameter, three 36-inch diameter, nine 42-inch diameter, and eight 48-inch diameter pipe culverts.

Riprap will be used at a wash area on the southeastern branch where erosion protection will be required.

5. Railway

The top 6 inches will have to be stripped from the ground surface in order to remove existing vegetation prior to emplacing the embankment material.

6. Access road

The total length of all access roads for Y15 is 3700 feet. The entrance road from the highway is 500 feet long. The access road from the building complex to the staging area will be 500 feet long.

7. Airstrip

The airstrip will run approximately east and west to face the prevailing wind. It will be 150 feet wide with a paved runway 75 feet wide and 5200 feet long. The length of the runway is determined by the altitude (6900 feet above sea level) and the mean maximum temperature (85°F). Drainage is provided by six 36-inch diameter and three 48-inch diameter pipe culverts.

8. Water supply

The source of the water supply is an underground aquifer which will be tapped by a 10-inch diameter well, cased to 8 inches. Delivery of the water will be by an electric, submersible, centrifugal pump in the well. The pumped water is conveyed by pipe to an elevated 65,000-gallon storage tank. This tank will contain a three-day domestic supply, and 50,000 gallons of water for fire delivered at 400 gallons per minute for a two-hour duration. Distribution from the storage tank is by gravity through a chlorinator and zeolite filter prior to consumption at the building complex.

The aquifer underlying the San Augustin Plains is not too well defined, but it appears that water will be encountered at depths of 50 to 100 feet. Wells from 75 feet to 250 feet deep should provide an adequate supply of water to meet the site demand. The well water should be potable with hardness ($CaCO_3$) in the neighborhood of 90 ppm.

9. Utilities

Electric power in the general vicinity of the site is supplied by the Socorro Electric Cooperative, Inc.

The Cooperative has a 69 kV circuit with overhead static protection from Socorro into Magdalena, New Mexico. This line has a very high grade of continuity. From the transformer station in Magdalena, a 25 kV circuit runs westerly and passes adjacent to the proposed building complex. This circuit serves about 600 miles of distribution lines from its source in Magdalena all the way to the Arizona state line. The main circuit has static protection but the feeders are connected through oil circuit reclosers. This provides a reliable service that has proven quite satisfactory for the existing users but may lack the absolute continuity required for the VLA. Socorro Electric Cooperative will also have a 69 kV line running past the site by 1974.

The existing 25 kV circuit is capable of supplying the normal operating requirements of 800 kW and possible surge to 1600 kW without excessive voltage drop. The budget estimate included as a portion of this study assumes the existing 25 kV circuit will be adequate and that no financial contribution will be required.

Telephone service in the general vicinity of the site is supplied by the Mountain States Telephone & Telegraph Company, which is a part of the Bell System. They will provide service for the VLA facility with no financial participation by AUI.

10. Real estate

The land is utilized for cattle grazing and is estimated to carry from 10 to 12 head per section. Waterings are by windmills and steel tanks, with occasional surface tanks.

The northern branch of the Wye is within the boundary of a ranch belonging to Jay Taylor. Most of the land affected is owned by the State of New Mexico and controlled by the Land Commissioner in the New Mexico State Land Office, Santa Fe, New Mexico. Two of the sections crossed by this branch are privately owned by Jay Taylor.

The southeastern branch crosses a portion of the Michael Harriet ranch, the Magdalena Stock Driveway (which is controlled by the Bureau of Land Management), a portion of the Thomas R. James Ranch, the northeasterly corner of the B. E. Walker Ranch, and the westerly portion of the Malcolm S. Major Ranch.

The southwestern branch crosses the eastern end of the W. W. Benton Ranch, the Magdalena Stock Driveway, the northwest corner of the Michael Harriet White Lake Allotment Ranch and across the northwesterly corner of the Marvin Ake C. N. Ranch. All of the land crossed by this branch is owned by the State of New Mexico, except for one small, privately owned tract of the Marvin Ake Ranch near the outer end.

It is understood that land controlled by the Bureau of Land Management, when desired by another governmental agency, can be acquired by an administrative transfer without cost.

New Mexico state land controlled by the Land Commissioner is leased for grazing purposes at various rates depending on the carrying capacity of the land. It is estimated that state lands for grazing purposes in this area would lease for approximately 10 cents per acre per year.

Leases of land between individuals for grazing purposes cost about 50 cents per acre per year in the area of Y15. Taking into consideration the type of proposed facility and the consequent interruption of normal cattle operations, it is estimated that a strip 600 feet wide through these ranches could be leased for approximately 75 cents

(75¢) per acre per year, or $51.65 per mile per year, which would pay for the land actually leased and for damage to the adjacent lands by reason of the construction.

Value conclusions

Private land	
827 acres @ $50 =	$41,350.00
State land	
687 acres @ $12.50 (compensation to lessee) =	$ 8,587.50
State land	
543 acres @ $8.35 (compensation to lessee) =	$ 4,534.05
BLM[1] land	
517 acres @ $12.50 =	$ 6,462.50
BLM land	
355 acres @ $8.35 =	$ 2,964.25
State land	
1230 acres @ $10 (compensation to state) =	$13,904.00
TOTAL	$76,198.30
CALLED	$77,000.00

[1] Bureau of Land Management

D. Site Y16 (Utah)

This site is in Millard County, in an area known as the Black Rock Desert. The center is approximately 22 miles south of the town of Delta; its geographical coordinates are 39°02′.4 N, 112°40′.8 W and its elevation is 4630 feet above mean sea level. The branches extend from this point on true azimuths of 66°, 186°, and 306°. A map of the site area is given in Fig. 5-5, and branch profiles are shown in Figs. 5-6, 5-7, and 5-8.

1. General site features

The site is in a broad, northerly trending, alluvium-filled valley bounded by the House Range on the west and the Pavant Range on the east. Local geologic features such as the Cricket Mountains and the lava flows adjacent to Pavant Butte form more localized boundaries of the area known as Black Rock Desert. The terrain varies from quite flat to gently rolling except along the northeastern branch, where slopes along the lava ridge are moderately steep.

This site lies directly under low altitude airways V21 and V257. The Union Pacific Railroad (single track) intersects the northwestern branch of the Wye at a point approximately 5 miles from the apex. A total of 16 trains daily operate along this section of track. State Highway 257, which is directly adjacent to the railroad, intersects the northwestern branch of the Wye at approximately the same point.

Two utility lines cross the northwestern branch. A telephone line of the Mountain States Telephone and Telegraph Company intersects the branch at a point approximately one mile from the apex and a 46 kV electric line crosses about 4 miles from the apex.

The site is approximately 35 miles from Delta, Utah by State Highway 257. This is a paved two-lane road that follows the alignment of the Union Pacific Railroad southward from Deseret, Utah.

Delta is predominantly an agriculture community with a population of 2000. The town has two physicians, one dentist, and a 34-bed hospital (built in 1963 and valued at $500,000). The hospital is being enlarged to accommodate administrative and record facilities. There are five

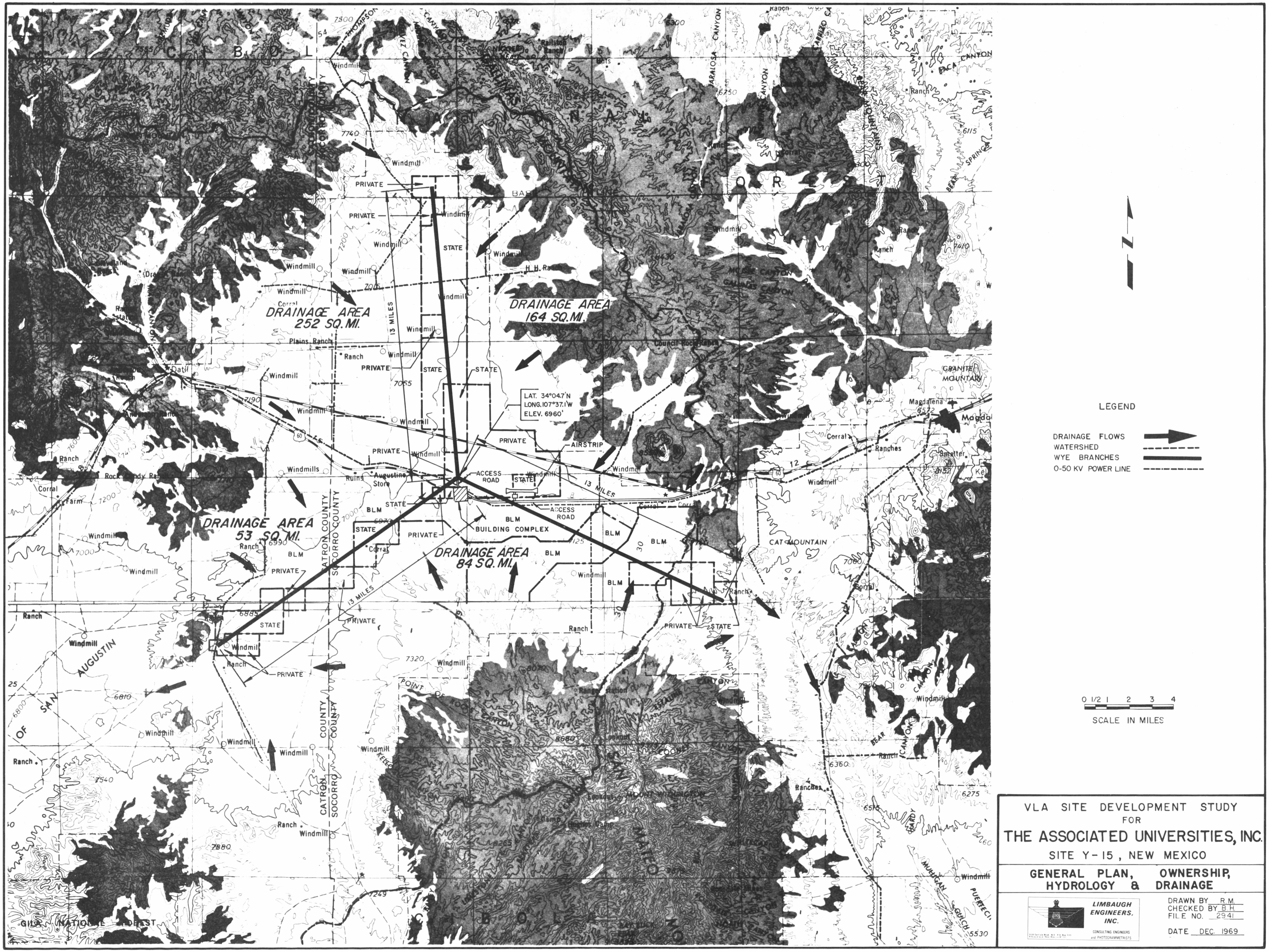

DRAINAGE AREA
252 SQ. MI.
DRAINAGE AREA
164 SQ. MI.
DRAINAGE AREA
53 SQ. MI.
DRAINAGE AREA
84 SQ. MI.
LAT. 34°04.7'N
LONG. 107°37.1'W
ELEV. 6960'
13 MILES
13 MILES
13 MILES
ACCESS ROAD
ACCESS ROAD
BUILDING COMPLEX
AIRSTRIP
PRIVATE
STATE
BLM
CATRON COUNTY
SOCORRO COUNTY
Datil
Augustine Store
Magdalena
GRANITE MOUNTAIN
CAT MOUNTAIN
LEGEND
DRAINAGE FLOWS
WATERSHED
WYE BRANCHES
0-50 KV POWER LINE
0 1/2 1 2 3 4
SCALE IN MILES
VLA SITE DEVELOPMENT STUDY
FOR
THE ASSOCIATED UNIVERSITIES, INC.
SITE Y-15, NEW MEXICO
GENERAL PLAN, OWNERSHIP, HYDROLOGY & DRAINAGE
LIMBAUGH ENGINEERS, INC.
CONSULTING ENGINEERS and PHOTOGRAMMETRISTS
DRAWN BY R.M.
CHECKED BY B.H.
FILE NO. 2941
DATE DEC. 1969

Fig. 5-1

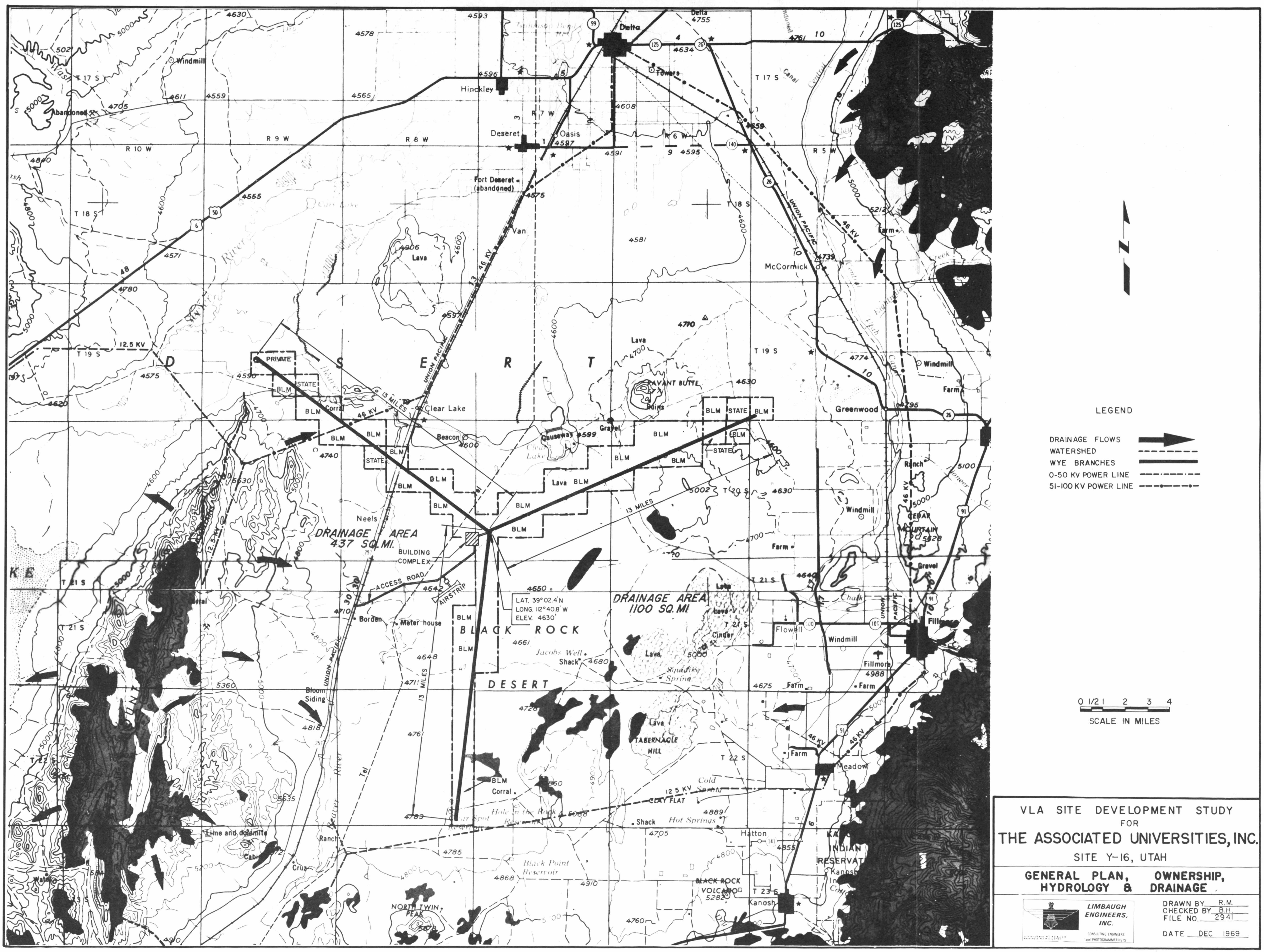

LEGEND
DRAINAGE FLOWS
WATERSHED
WYE BRANCHES
0-50 KV POWER LINE
51-100 KV POWER LINE
0 1/2 1 2 3 4
SCALE IN MILES
DRAINAGE AREA 437 SQ. MI.
DRAINAGE AREA 1100 SQ. MI.
BUILDING COMPLEX
ACCESS ROAD
AIRSTRIP
LAT. 39°02.4'N
LONG. 112°40.8'W
ELEV. 4630'
BLACK ROCK DESERT
Delta
Hinckley
Deseret
Oasis
Fort Deseret (abandoned)
Clear Lake
Pavant Butte
Greenwood
Flowell
Fillmore
Meadow
Hatton
Kanosh
Borden
Meter house
Neels
McCormick
VLA SITE DEVELOPMENT STUDY
FOR
THE ASSOCIATED UNIVERSITIES, INC.
SITE Y-16, UTAH
GENERAL PLAN, OWNERSHIP, HYDROLOGY & DRAINAGE
LIMBAUGH ENGINEERS, INC.
DRAWN BY R.M.
CHECKED BY B.H.
FILE NO. 2941
DATE DEC 1969

Fig. 5-5

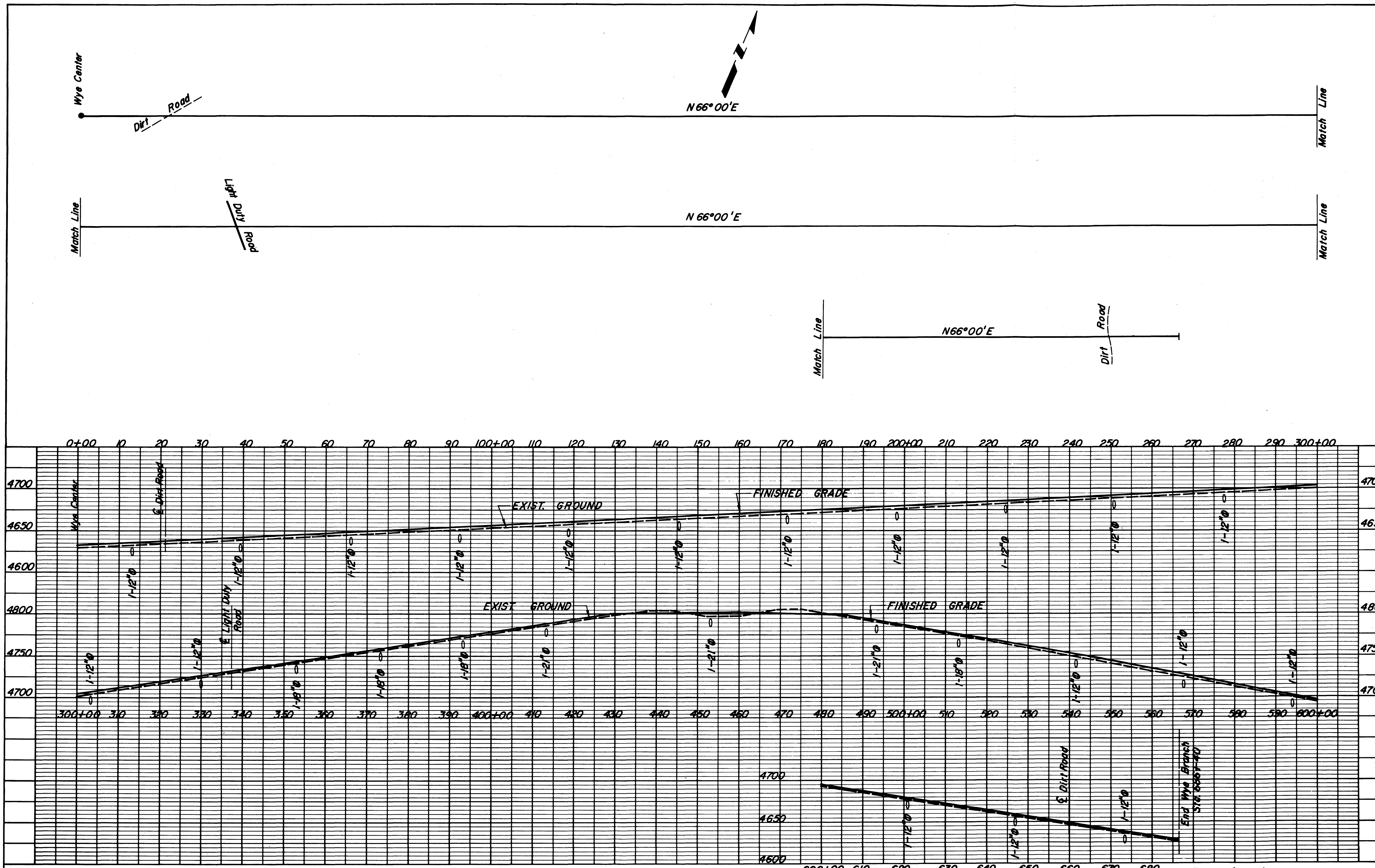
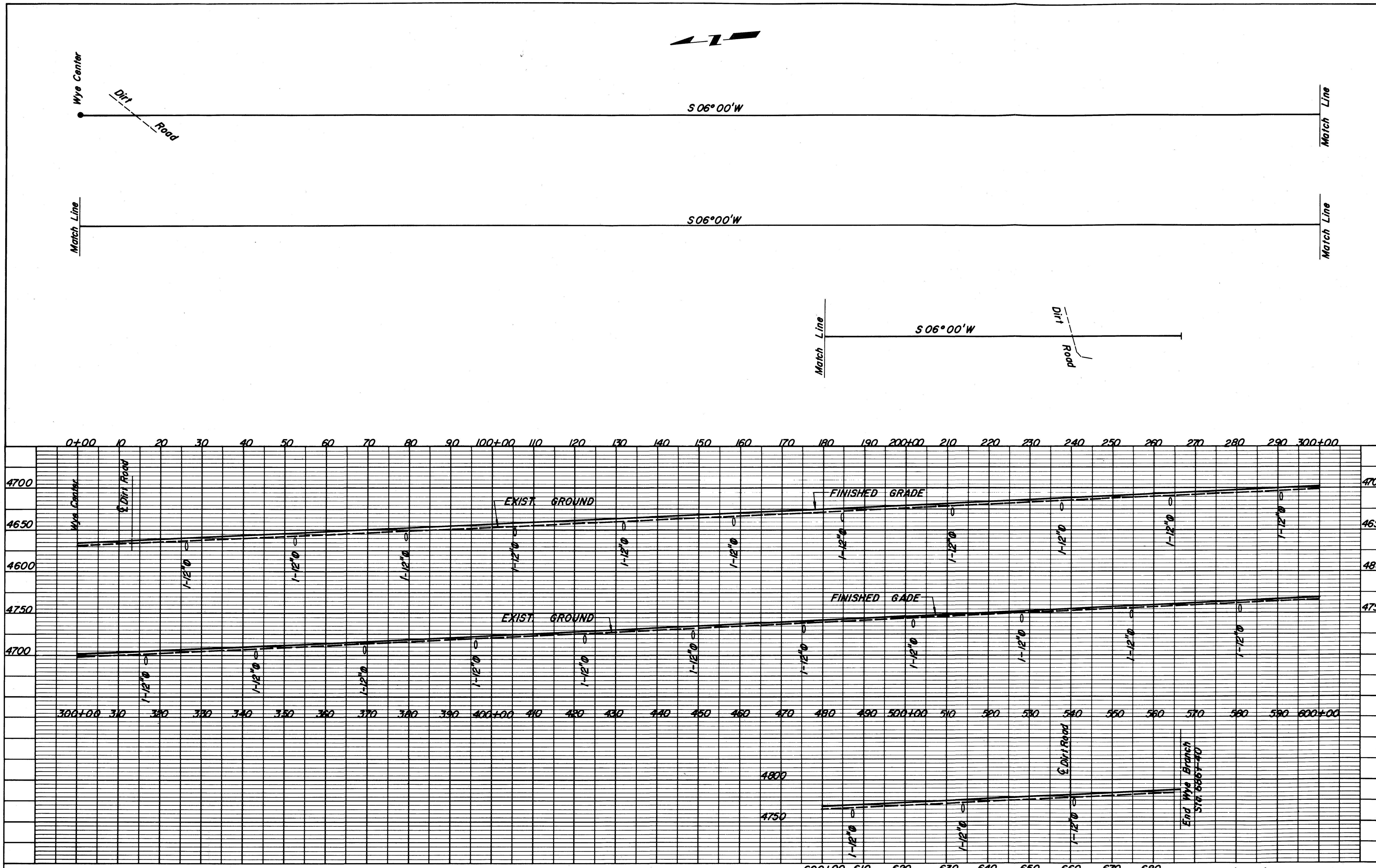
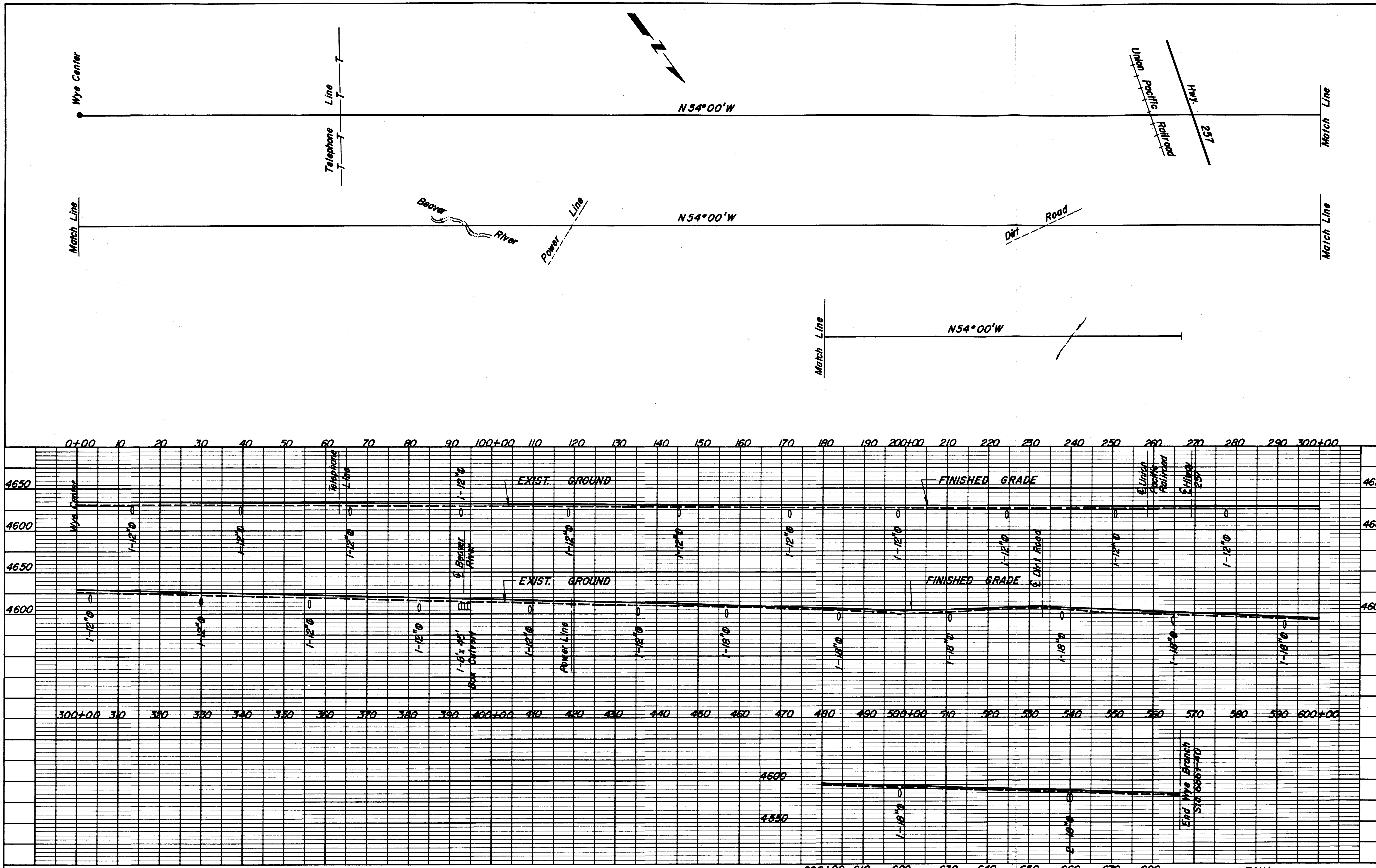

N
Wye Center
Dirt Road
N 66° 00'E
Match Line
Light Duty Road
N 66°00'E
Match Line
Match Line
N66°00'E
Dirt Road
0+00 10 20 30 40 50 60 70 80 90 100+00 110 120 130 140 150 160 170 180 190 200+00 210 220 230 240 250 260 270 280 290 300+00
4700
4650
4600
Wye Center
℄ Dirt Road
EXIST. GROUND
FINISHED GRADE
1-12"⌀
4800
4750
4700
EXIST GROUND
FINISHED GRADE
℄ Light Duty Road
1-18"⌀
1-21"⌀
300+00 310 320 330 340 350 360 370 380 390 400+00 410 420 430 440 450 460 470 480 490 500+00 510 520 530 540 550 560 570 580 590 600+00
4700
4650
4600
℄ Dirt Road
End Wye Branch Sta. 686+40
600+00 610 620 630 640 650 660 670 680
SITE Y-16 (UTAH)
LIMBAUGH ENGINEERS, INC.

Fig. 5-6



Wye Center
Dirt Road
S 06°00'W
Match Line
S 06°00'W
Match Line
Match Line
S 06°00'W
Dirt Road
Match Line
0+00 10 20 30 40 50 60 70 80 90 100+00 110 120 130 140 150 160 170 180 190 200+00 210 220 230 240 250 260 270 280 290 300+00
4700
4650
4600
4800
4750
Wye Center
℄ Dirt Road
EXIST. GROUND
FINISHED GRADE
1-12"⌀
EXIST. GROUND
FINISHED GADE
300+00 310 320 330 340 350 360 370 380 390 400+00 410 420 430 440 450 460 470 480 490 500+00 510 520 530 540 550 560 570 580 590 600+00
℄ Dirt Road
End Wye Branch Sta. 686+40
4800
4750
600+00 610 620 630 640 650 660 670 680
SITE Y-16 (UTAH)
LIMBAUGH ENGINEERS, INC

Fig. 5-7



Wye Center
Telephone Line
N54°00'W
Union Pacific Railroad
Hwy. 257
Match Line
Beaver River
Power Line
Dirt Road
EXIST. GROUND
FINISHED GRADE
Box Culvert
SITE Y-16 (UTAH)
LIMBAUGH ENGINEERS, INC.

Fig. 5-8

motels and three restaurants in the town. Neither bus nor railroad passenger service is available, but there is a local aircraft charter service at the Delta Airport. Dixie Airlines has commercial service to and from Salt Lake City with one flight per day.

The town of Delta has had an average growth increase of 3 percent over the past eight years, with most of this coming in the last two years, due mainly to a beryllium mine 45 miles to the northwest. It does not appear that the town could absorb even a modest increase since the number of available houses and apartments is extremely limited.

Fillmore, Utah is located approximately 20 miles east of the proposed site on U.S. Highway 91. This town is an agricultural community with a population of 1650. It has five motels and four restaurants.

The Union Pacific Railroad, which runs through Fillmore, has only freight service. Passenger transportation service is provided by two interstate bus companies with six buses each way daily. The airport has a paved runway and is equipped with fueling facilities and night landing lights.

Fillmore has a modern 42-bed hospital owned by the Church of the Latter Day Saints. There are two physicians and one dentist in residence in the town. Fillmore is without industry and has shown little growth in the last decade. The stability of the population has resulted in very little new housing construction, and consequently there are very few housing units available.

The school system for Millard County includes both Delta and Fillmore, with administrative offices in Delta. There is a high school in each town and both are accredited by the Northwest Accrediting Association. The student-teacher ratio is 27.

In the site area, construction workers' wages would be $6.05 per hour plus subsistance; electricians' wages are $7.20 per hour.

The nearest commercial air facilities, other than Dixie Airlines out of Delta, are at Salt Lake City, 160 miles north of Y16. The Salt Lake City airport is served by United, Frontier, Western and Air West Airlines.

In the immediate area of the site there is camping, fishing, hiking, and skiing. Hunting in the area includes elk, deer, antelope, mountain lion, ducks, geese, quail, and pheasants. Within a day's drive of the site are the scenic attractions of Lake Powell, Canyon Lands National Park, Zion National Park, Bryce National Park, and Cedar Breaks National Monument.

2. Climatology

Climatic information was obtained from the Clear Lake Wildlife Refuge weather station, which is just north of the site center, the U.S. Weather Bureau, the Salt Lake City Weather Bureau, and the state climatologist at Logan, Utah. The average daily maximum temperature is 73.02° F, and the average daily minimum temperature is 38.25° F. The highest recorded temperature was 101° F and the lowest was -32° F.

The average yearly precipitation is 8.41 inches, with 11.33 inches being the greatest annual amount on record. The greatest monthly precipitation on record is 2.88 inches. The mean yearly snowfall is 23.08 inches, with 14.2 inches as the record maximum single snowfall. The annual mean relative humidity is 55 percent. The sunshine throughout the year is 69 percent of the total possible. Two tornados have been recorded in Millard County over a period of 18 years. While data on dust days are lacking, it is known that the dust occurrence can be considered "heavy". Hail is infrequent, with maximum size up to a half inch. The prevailing wind direction is from the southwest, and the estimated average hourly speed for the year is 10.4 miles per hour. The maximum wind expectancy is estimated to be 90 miles per hour in a 50-year period. Thunderstorms occur an average of 35 times per year.

3. Geology and foundation investigation

The site is in the southeastern part of the Sevier Desert, in a part locally termed the Black Rock Desert because of the extensive basalt flows that form the eastern boundary of the area. Geologically, the region is a structural basin formed by the upward faulting of the Pavant Range on the east and the House Range on the west. The Cricket Mountains on the western side of the site are a local bedrock feature within the basin, probably caused by a north-south fault located a short distance west of the Union Pacific Railroad.

The fault systems that created the Sevier Desert basin probably date back to the beginning of Tertiary time. The only known earth fracture that has occurred in the region in historic times was in the Hansel Valley of northwestern Utah in 1934. At least two small earth fractures occur in the site area, one near the end of the northeastern branch in the volcanic rock and the other near the end of the southern Wye branch in the lake bed sediments. On the basis of very limited information, it would appear that these fractures, although they have occurred in relatively recent geologic time, are only minor earth adjustments probably due to a consolidation and shrinking of the lake beds following the retreat of the lake waters from the Sevier Desert.

The region as a whole is moderately active seismically. From 1850 to 1965 there have been at least 609 earthquakes in Utah, 38 of which could be termed damaging (Cook and Smith 1967). From 1950 to 1965 there have been 13 damaging earth tremors. Since the first recording equipment was installed at the University of Utah in 1909, there have been 21 earthquakes with epicenters located within Millard County. Centered chiefly along the eastern border of the county, they had an average magnitude of about 3.5 on the Richter scale, but tremors with intensities up to 6.9 have been recorded. One epicenter has been recorded within the site; it lies on the northwestern branch of the Wye about 2 miles from the apex. From the available data, it appears reasonable to assume that periodic earth tremors will be experienced in the Sevier Desert, but that the intensities should be only slight to moderate since the epicenters are located primarily along the west face of the Pavant Range.

Several Tertiary and Quaternary geologic units of local to regional extent were deposited in the basin after it was formed and prior to the inundation of the basin by the waters of Lake Bonneville, an extinct lake that covered most of northwestern Utah, parts of northern Nevada, and southern Idaho during Pleistocene time.

Pavant Butte, a volcanic cinder cone, forms the northern end of a ridge comprised of volcanic deposits which extend for approximately 24 miles, separating the Sevier Desert from the Pavant Valley to the east. In the northeastern part of the site area, the ridge consists mainly of dark gray, hard, vesicular basalt in the form of relatively level lava beds. These may be interbedded with sediments, but exposures are not sufficient to be certain. In the last stages of volcanic activity, cinder cones such as Pavant Butte were formed. At one time Pavant Butte was an island in Lake Bonneville, and consequently much of the cinder material has been eroded and washed down over the adjacent lava flows, masking their extent.

The surficial deposits throughout the site are reworked Lake Bonneville sediments. As a result, the typical soil is fine to medium grained, poorly graded, silty sand. The gravel fraction generally is under 5 percent and the average size is less than one inch in diameter. The volume of fines is estimated to vary between 5 and 25 percent with most of the samples having rapid dilatancy, low plasticity, and very slight dry strength. The Unified soil classification of the fines would be ML. There may be a few bars of fine gravel deposited in the lake, but none of any significance were noted during the field inspection. The fine, sandy sediments in the southern part of the site area have been formed into dunes elongated in a northeasterly direction. A number of these dunes are actively moving, and during heavy winds the fine sands from the dunes and the silts from the playa beds north and northwest of Clear Lake cause intense dust contamination in the air. All of the soil contains some alkali salts, the amount varying with the volume of water discharged through evaporation.

Rock for railroad ballast possibly can be obtained in the site area by crushing lava flow rock from a location along the northeastern branch. A more likely source of good quality rock for crushing is a jointed, fractured intrusive volcanic neck that occurs about 2 miles northwest of the Clear Lake siding. Another possible source would be limestone beds that could be quarried in the Cricket Mountains. Gravel for road base material probably would have to be hauled from gravel terrace deposits 5 miles northwest of the town of Fillmore. Sand could also be obtained in that area, although the deposits are quite fine grained and poorly graded.

Footing conditions should be quite similar in all of the lowland areas because of the apparent similarity of the underlying deposits of silty sand. It is also likely that beds of clay occur beneath the surface of the basin. Soil testing would have to be performed in order to be certain of the foundation conditions; however, it would appear that shallow footings would not be feasible because of the silty nature of the deposits. Such material would not be likely to have a high bearing capacity in the upper soil horizons, and it probably would be quite compressible under saturated conditions.

The northwestern and southern branches lie on soils similar to those described above. The soil will be different where the northwestern branch crosses the volcanic ridge. In some places the lava is exposed at the surface, while elsewhere the cinder material has covered the lava to a considerable depth. In general, the bearing capacity of the areas underlain by sediments should be fair to moderately good. The cinder material is quite firm and would have very low compressibility when saturated, and should have good bearing capacity. The permeability of the cinder material is high.

Footings in the lowland areas should be set at depths of at least 12 feet. Where the soil is to be used for embankment material, it should be carefully compacted and adequate drainage provided.

At present, there is no mineral exploration or exploitation activity in the immediate site area. The only possible future mineral development would center around mining of the cinder material for building block. The possibility of oil resources in the area cannot be entirely discounted, and at present there is seismograph exploration activity in the Fillmore and Delta areas. It is unlikely, however, that the prospects can be favorable with a barren section of Tertiary rocks and relatively recent volcanic activity. Two oil tests have been drilled in the region, one about 25 miles north of Clear Lake and one 22 miles southwest of Clear Lake; neither test was productive.

Other areas of possible future mineral activity are the potential potash deposits of the playa beds, particularly Sevier Lake where there are several active mining permits. Coal formerly was mined in the Pavant Mountains, but there is little or no activity at the present time. According to the U.S. Bureau of Mines, the limestone and dolomite rocks of the Cricket Mountains have been investigated for possible use as flux in steel mill operations. There is no current activity.

4. Topography and drainage

The site lies on an open, slightly undulating, basin ranging in elevation from about 4600 feet to almost 4800 feet above sea level. Except along the northeast branch, slopes are generally less than 1 percent. The entire northwest branch lies on relatively flat ground with an overall northwesterly slope of less than 0.5 percent, and at no point does the slope exceed 1 percent. Vegetation along the northwestern branch consists of scattered clumps of sagebrush generally less than 18 inches in height.

The southern branch crosses relatively level terrain that varies from quite flat near the center to slightly rolling along the southern half. About 8 miles from the apex, there is a depression a little over 3 miles wide where a number of rather large, active sand dunes are crossing in a northeasterly direction. Where the branch crosses the edges of the depression, the slopes may exceed 2 percent for short distances. The end of the southern branch is on relatively flat terrain. The vegetation, primarily sagebrush 12 to 20 inches high, is rather scattered near the center, but becomes denser toward the southern end.

The northeastern branch crosses about 2 miles of quite level terrain covered with scattered low sagebrush before encountering the lava beds that border the Sevier Desert on the east and form the divide separating it from the Pavant Valley to the east. Most of the lava beds have been largely covered by lake sediments or windblown deposits; the hard, dark gray vesicular volcanic rock crops out and would create a moderate obstacle to construction. For the next 5 miles the branch crosses an area underlain by lava beds partly covered by sand and cinders. The vegetation of this area consists of moderately dense brush up to 24 inches high with scattered small juniper trees that reach about 12 feet in height. The initial 3 miles of this section is on a rolling incline of about 1 percent grade; the last 2 miles descends from the ridge at slopes which were estimated to be as great as 4 percent. Grades in excess of 2 percent may occur over a distance of about 8000 feet. The end of the branch crosses relatively flat land with a moderately dense covering of brush up to 3 feet in height. The height and density of brush is an indication of a relatively shallow water table.

Drainage channels at the site are not well developed and the only perennial source of surface water in the region is at the Clear Lake Wildlife Refuge, where there are natural springs in the basalt outcrops. The only branch of the Wye that crosses a drainage of any significance is the northwestern one. About midway through its length, there is a low area with no clearly defined channel, and this drainage, called Beaver River, carries water northwesterly toward the Sevier River. Where slopes are slight and the soil is relatively impermeable, there is a tendency for water to pond or for sheet flow to occur during periods of heavy rain. As the average annual rainfall is only 6-8 inches, there probably are only a very few times a year when there would be any significant amount of flowing surface water. The flow of surface water is further reduced by the presence of sand dunes ranging up to 10 feet in height, particularly along the southern half of the southern branch. Even though no well-defined drainage channels exist, provision will have to be made at intervals of about 2000 to 3000 feet to allow water to pass under the Wye roadbed, which would otherwise act as a dam. This would be particularly true along the northeastern branch where it crosses the volcanic ridge.

In the central and northwesterly parts of the site, the slopes are quite uniform over long distances and borrow ditches could be graded to channel water along the sides of the roadbeds for considerable distances.

Embankment heights on the low-lying areas of the northwestern and southern branches should be 2 to 3 feet, whereas 2 feet should suffice for the remainder of the northwestern branch and 1 to 2 feet should be adequate for the remainder of the southern branch. The end of the northeastern branch where it crosses the lowlands should be about 2 feet in height, but on the slope of the volcanic ridge only about 1 foot is needed except where crossing drainages.

Vegetation in the site area consists of scattered clumps of low sagebrush and allied botanical types that are able to grow in the semi-arid, alkaline soil. Some low grass occurs, but it is quite sparse. Juniper trees up to about 12 feet in height grow on the lava range that forms the eastern boundary of the Black Rock Desert. The sparse vegetation is not adequate to hold the surface soil, and consequently there are moderately heavy dust storms in the area and abundant active sand dunes.

5. Railway

The top 3 inches will have to be stripped from the ground surface in order to remove existing vegetation prior to emplacing the embankment material.

6. Access road

The total length of all access roads for Y16 is 7.5 miles. The entrance road from the highway is 6 miles long. The access road from the building complex to the staging area will be 4750 feet long.

7. Airstrip

The airstrip will run approximately southwest-northeast to face the prevailing wind. The landing strip will be 150 feet wide with paved runway 75 feet wide and 5800 feet long. The length of the runway is determined by the altitude (4630 feet above sea level) and the mean maximum temperature (90°).

8. Water supply

If a satisfactory aquifer can be located, it will be tapped by a 10-inch diameter well cased to 8 inches. Delivery of the water will be by an electric, submersible, centrifugal pump in the well. The pumped water is conveyed by pipe to an elevated 65,000-gallon storage tank. This tank will contain a three-day domestic supply and 50,000 gallons of water for fire delivered at the rate of 400 gallons per minute for a two-hour duration. Distribution from the storage tank is by gravity through a chlorinator and zeolite filter prior to consumption at the building complex.

The water resources of the Pavant Valley to the east (Mower 1965) and the Sevier Desert to the north (Mower and Feltis 1968) have been quite well studied; however, except for the study of the Clear Lake Springs (Mower 1967), there is little published information on water resources within the site area. The basic reason is the limited use of the area and the fact that very few wells have been drilled.

According to the published information, ground water moves northward through the southeastern Sevier Desert area and westerly to northwesterly from the Pavant Valley. The springs that feed the Clear Lake area are supplied by seepage through fractures and joints in the Pavant basalt flow. It is supplied partly by precipitation falling on the volcanic rock, but mostly from ground water flowing westerly from the Pavant Valley. Most of the water in the Pavant Valley enters the aquifers on the west slope of the Pavant Range approximately 20 miles east of Clear Lake. Consequently, the quality of the ground water deteriorates as an increasing number of dissolved solids are picked up during the migration of the water westward across the valley. Total recharge to the basalt aquifer is estimated by Mower (1967) to be about 17,000 acre feet per year, whereas the discharge of the springs at Clear Lake are estimated to be approximately 14,900 acre feet per year. This would appear to indicate an untapped reservoir potential of over 2000 acre feet per year.

Extensive farming takes place in the Pavant Valley and most of the cultivated land is irrigated with well water. It has been found that the discharge of the Clear Lake Springs varies almost in direct proportion to the amount of well pumpage in the Pavant Valley, and thus this factor could place a definite limitation of the availability of water from the Pavant Valley.

The quality of water at Clear Lake Springs has deteriorated from a dissolved solids content of 1003 ppm and a specific conductance of about 1900 (micromhos per cm at 25° C) in 1900 to values of 2330 ppm and 3540, respectively, in 1964. The deterioration apparently is due to irrigation water returned to the aquifer. The water is described as slightly saline, with a moderately high sodium chloride content.

If the Clear Lake Spring were used as a source of water, a pipeline 5 miles in length would be required. The nearest place a well could be drilled to tap the basalt aquifer would be 3 to 4 miles northwest of the apex.

An alternate source of water would be aquifers in the lake bed deposits beneath the apex. The closest wells which give information on this are at the Neels and Clear Lake sidings on the Union Pacific Railroad. They are up to 1998 feet in depth, and have yielded as much as 35 gpm (gallons per minute) on pumping tests, but there are indications that the aquifer permeability is moderately low. The basic problem is the quality of the water, for water with over 500 ppm of dissolved solids is usually considered undesirable for domestic uses. The wells in the Neels and Clear Lake sidings areas contain from 4300 ppm to 9000 ppm and would be classified as moderately saline. A well near the end of the southern branch is reported to have a dissolved solids content of over 67,000 ppm and thus is classified as a brine. In the area of the apex, water probably could be expected to be moderately saline with a dissolved solids content of 5000 ppm to 10,000 ppm, and thus unsuitable for domestic purposes. Because the soil is rather impermeable and impermeable clay zones most likely occur in the subsurface, recharge from precipitation in the immediate area is unlikely.

9. Utilities

Electric power in the general vicinity of the site is supplied by the Utah Power and Light Company, Richfield, Utah.

The Utah Power and Light Company has an existing 46 kV line west of the apex from which approximately 12 miles of 46 kV line would be built at a cost of approximately $160,000. There will be no need to increase the existing system to carry the requirements for the VLA. If the expected power bill of approximately $5500 monthly were guaranteed annually for five years, there would be no cost in furnishing the electric facilities to the site.

The area is served by the Utah Telephone Company, which is part of the Continental System, with an office at Delta.

10. Real estate

Approximately 125 acres of private land are affected by this taking. This private land is located at the extreme northern end of the northwestern branch. Although it was farmed at one time, it is now similar to the surrounding country and is considered no better than grazing land.

A Bureau of Land Management Stock Driveway crosses the site in a northeasterly direction immediately southeast of the apex. The driveway is used mainly for moving flocks of sheep from one grazing range to another.

It is assumed that the Bureau of Land Management land could be obtained through an interagency transfer without cost and that the compensation to leaseholders would be $3 to $10 per acre, depending on whether the land is in the alkali flats or along Beaver Creek where there is better grazing. The purchase price for the state and private lands would be $45 per acre, including any damages.

It is estimated that the private land consists of approximately 125 acres. State land is approximately 275 acres, and land controlled by the Bureau of Land Management is approximately 2572 acres. The value of land in this area is divided between grazing land lying in the alkali flats, better quality grazing land, and land along the Beaver River which could experience some damage and could require reworking of the irrigation system.

1435 acres @ $10 =		$14,350
1137 acres @ $ 3 =		$ 3,411
400 acres @ $45 =		$18,000
	TOTAL CALLED	$36,000

E. Site Y17 (Nevada)

This site is in Eureka and Lander Counties, approximately 20 miles west of the town of Eureka. It lies in the Monitor and Kobeh Valleys. The geographical coordinates of the center are 39°35.'4 N, 116°27.'4 W; the elevation at this point is 6190 feet above mean sea level. The branches extend outward on true azimuths of 354°, 114°, and 234°. A map of the site area is given in Fig. 5-9, and the branch profiles are shown in Figs. 5-10, 5-11, and 5-12.

1. General site features

The terrain in the bottomlands of the valleys is quite flat. The surrounding low benches of an old alluvial surface are moderately dissected, and the terrain is slightly to moderately rolling. Around the perimeter of the valley, the alluvial fan deposits slope steeply upward to the bases of the adjacent mountains, which rise to elevations between 8000 and 10,000 feet above sea level.

There are no trees on the part of the site occupied by the Wye. The vegetation is mostly grass on lowlands and scattered to moderately dense sagebrush on the uplands. Most of the vegetation is less than 24 inches in height.

There are no airways or railroads in the area. U.S. Highway 50 intersects the southeastern branch of the Wye approximately 9 miles from the apex and comes close to the southwest branch at its termination point.

The nearest military or defense activities are the Wendover Bombing and Gunnery Range 150 miles to the east and the Las Vegas Bombing and Gunnery Range 125 miles south of the site.

The Central Nevada test area of the AEC is located at latitude 38°30' N and longitude 116°10' W and lies within 80 miles of the site. Nuclear tests would cause seismic effects described by the AEC as being "definitely perceptible".

This area is quite remote and the nearest towns are Austin and Eureka, Nevada, both of which are primarily mining communities. They

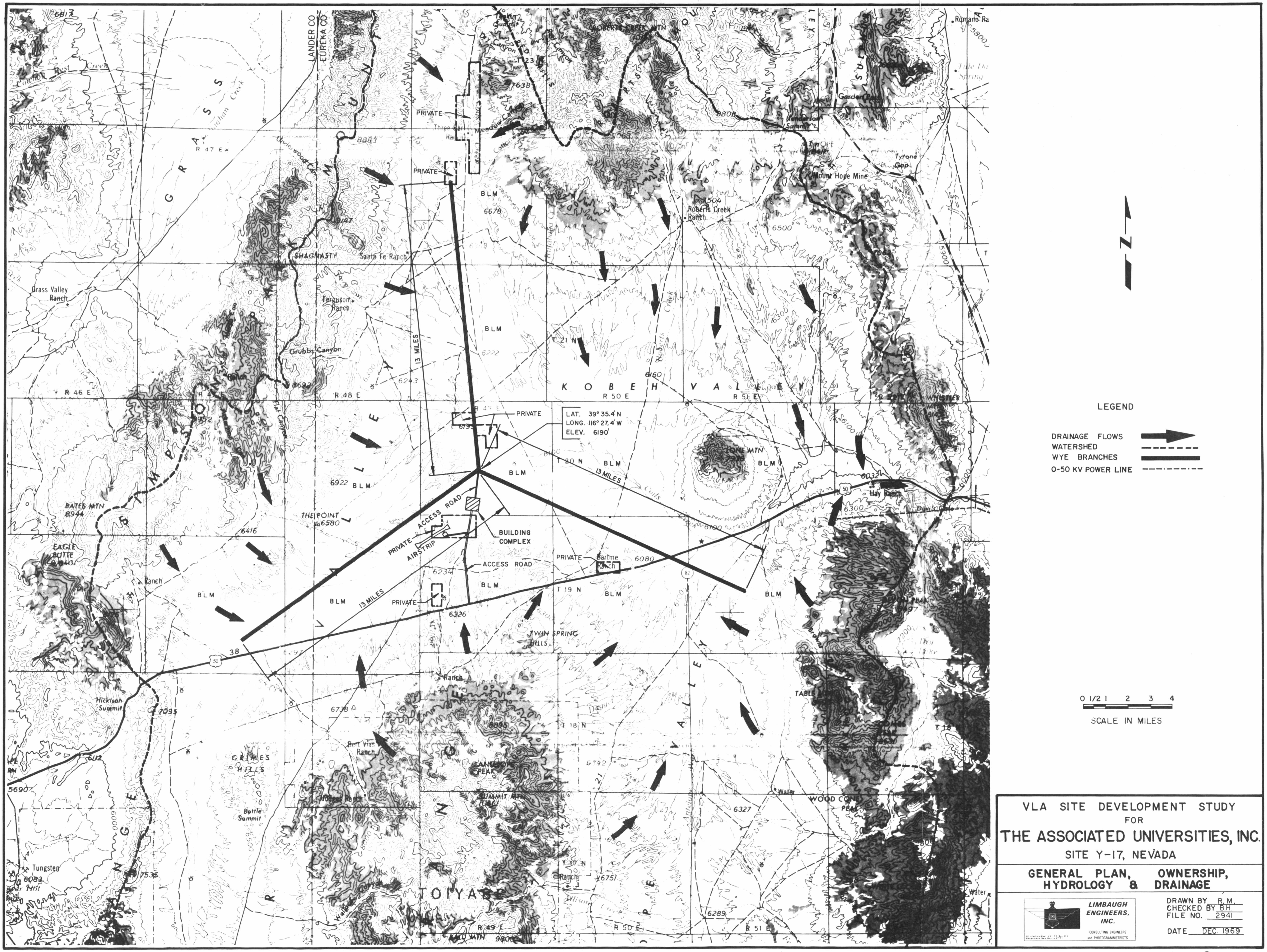
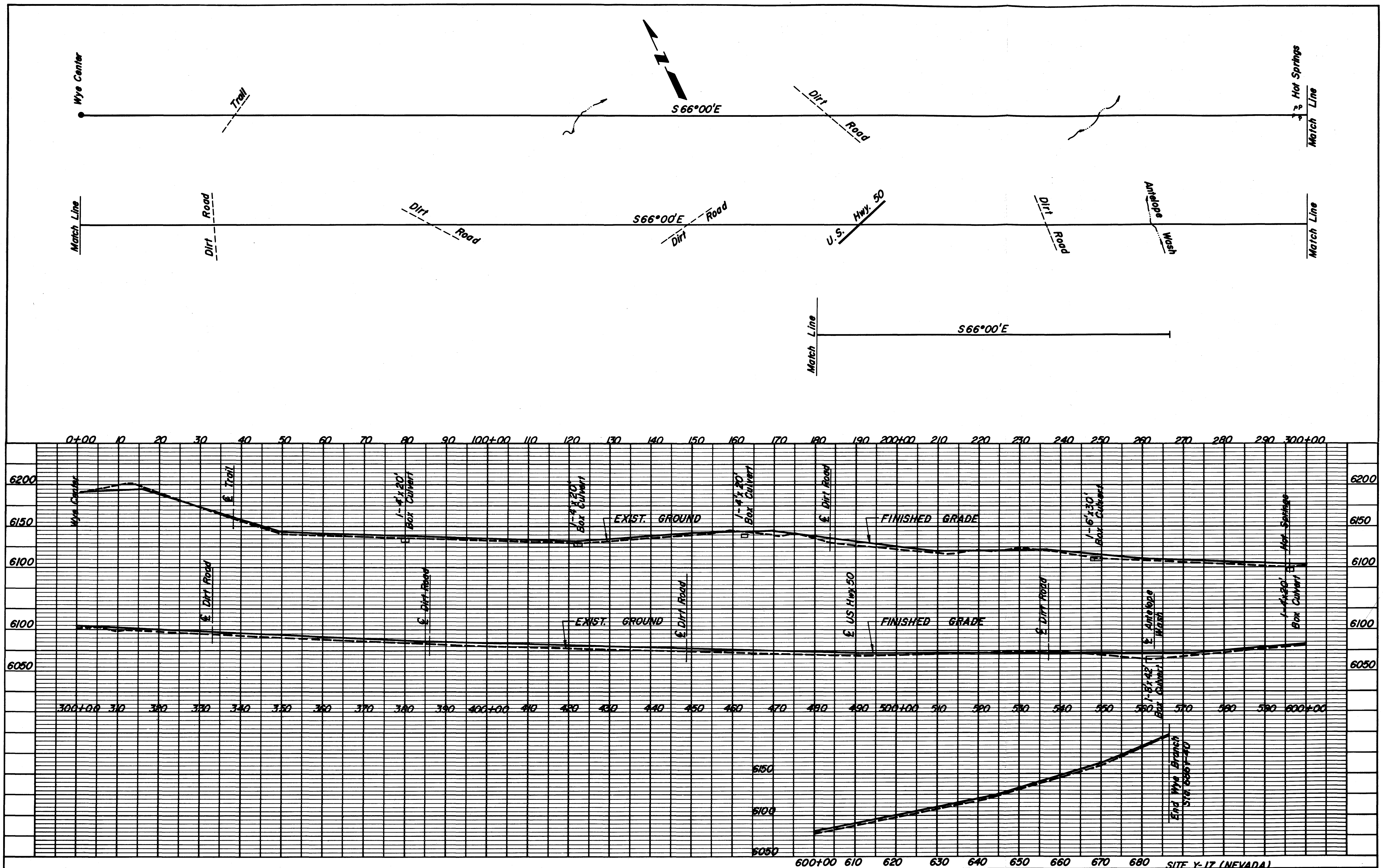

LEGEND
DRAINAGE FLOWS
WATERSHED
WYE BRANCHES
0-50 KV POWER LINE
0 1/2 1 2 3 4
SCALE IN MILES
N
LAT. 39° 35.4'N
LONG. 116° 27.4'W
ELEV. 6190'
PRIVATE
BLM
BUILDING COMPLEX
ACCESS ROAD
AIRSTRIP
13 MILES
KOBEH VALLEY
LONE MTN
R 46 E
R 47 E
R 48 E
R 50 E
R 51 E
T 21 N
T 20 N
T 19 N
T 18 N
T 17 N
LANDER CO
EUREKA CO
Grass Valley Ranch
SHAGNASTY
Santa Fe Ranch
Ferguson Ranch
Grubbs Canyon
Roberts Creek Ranch
Mount Hope Mine
Tyrone Gap
Garden Pass
Hay Ranch
BATES MTN 8944
EAGLE BUTTE
THE POINT 6580
Bartine Ranch
TWIN SPRING HILLS
Hickison Summit
GRIMES HILLS
Bottle Summit
Tungsten
WOOD CONE PEAK
ANTELOPE PEAK
SUMMIT MTN
TOIYABE
VLA SITE DEVELOPMENT STUDY
FOR
THE ASSOCIATED UNIVERSITIES, INC.
SITE Y-17, NEVADA
GENERAL PLAN, OWNERSHIP, HYDROLOGY & DRAINAGE
LIMBAUGH ENGINEERS, INC.
CONSULTING ENGINEERS and PHOTOGRAMMETRISTS
DRAWN BY R.M.
CHECKED BY B.H.
FILE NO. 2941
DATE DEC. 1969

Fig. 5-9



Wye Center
Trail
S66°00'E
Dirt Road
Hot Springs
Match Line
Dirt Road
U.S. Hwy. 50
Antelope Wash
S66°00'E
EXIST. GROUND
FINISHED GRADE
1-4'x20' Box Culvert
1-6'x30' Box Culvert
1-8'x42' Box Culvert
℄ Trail
℄ Dirt Road
℄ US Hwy 50
℄ Antelope Wash
End Wye Branch Sta 686+40
6200
6150
6100
6050
0+00
100+00
200+00
300+00
400+00
500+00
600+00
SITE Y-17 (NEVADA)

Fig. 5-10

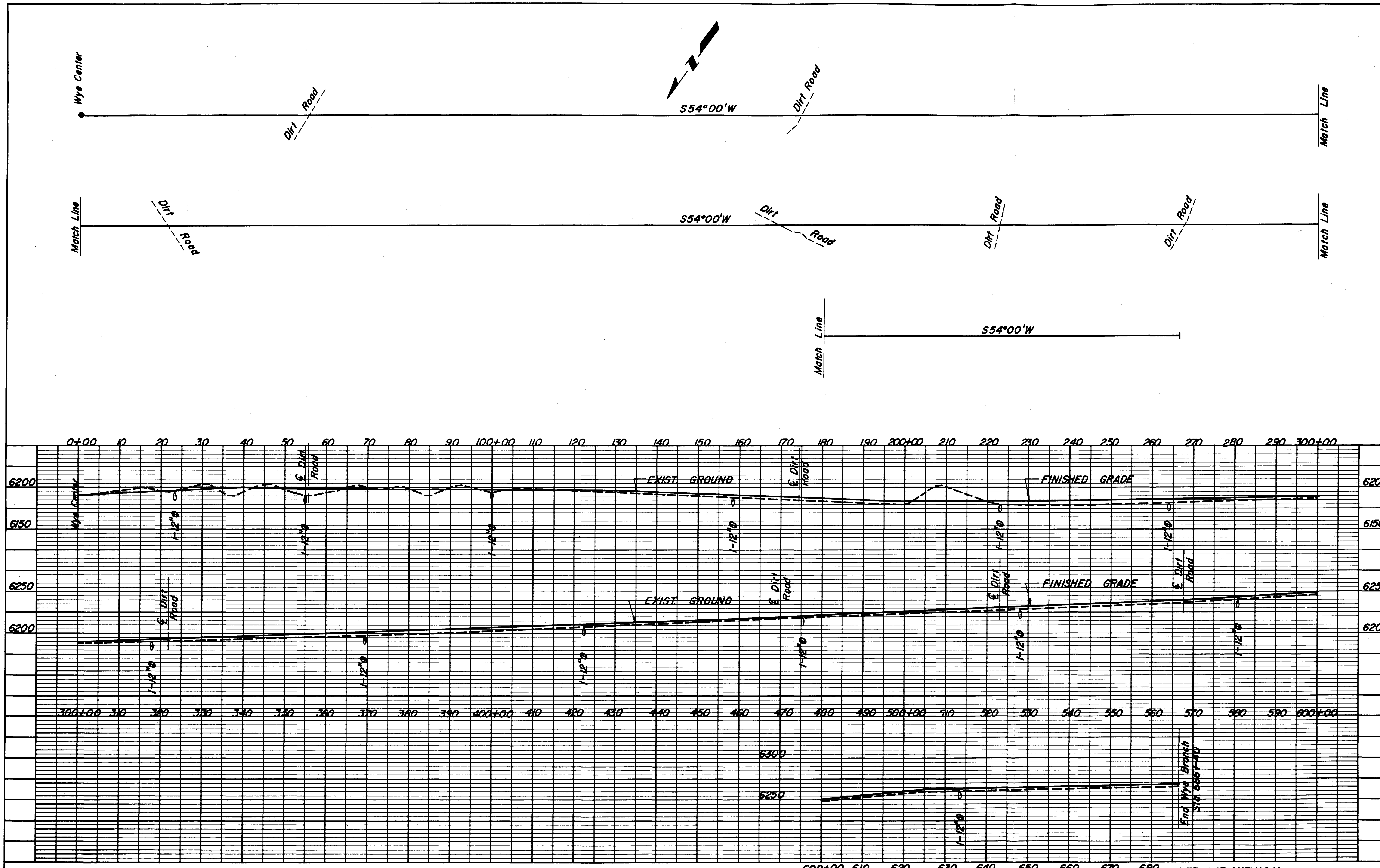

Wye Center
Dirt Road
S54°00'W
Dirt Road
Match Line
Match Line
Dirt Road
S54°00'W
Dirt Road
Dirt Road
Dirt Road
Match Line
Match Line
S54°00'W
0+00 10 20 30 40 50 60 70 80 90 100+00 110 120 130 140 150 160 170 180 190 200+00 210 220 230 240 250 260 270 280 290 300+00
EXIST. GROUND
FINISHED GRADE
℄ Dirt Road
6200
6150
1-12"⌀
300+00 310 320 330 340 350 360 370 380 390 400+00 410 420 430 440 450 460 470 480 490 500+00 510 520 530 540 550 560 570 580 590 600+00
6250
6200
6300
End Wye Branch Sta 686+40
600+00 610 620 630 640 650 660 670 680
SITE Y-17 (NEVADA)
LIMBAUGH ENGINEERS, INC.

Fig. 5-11

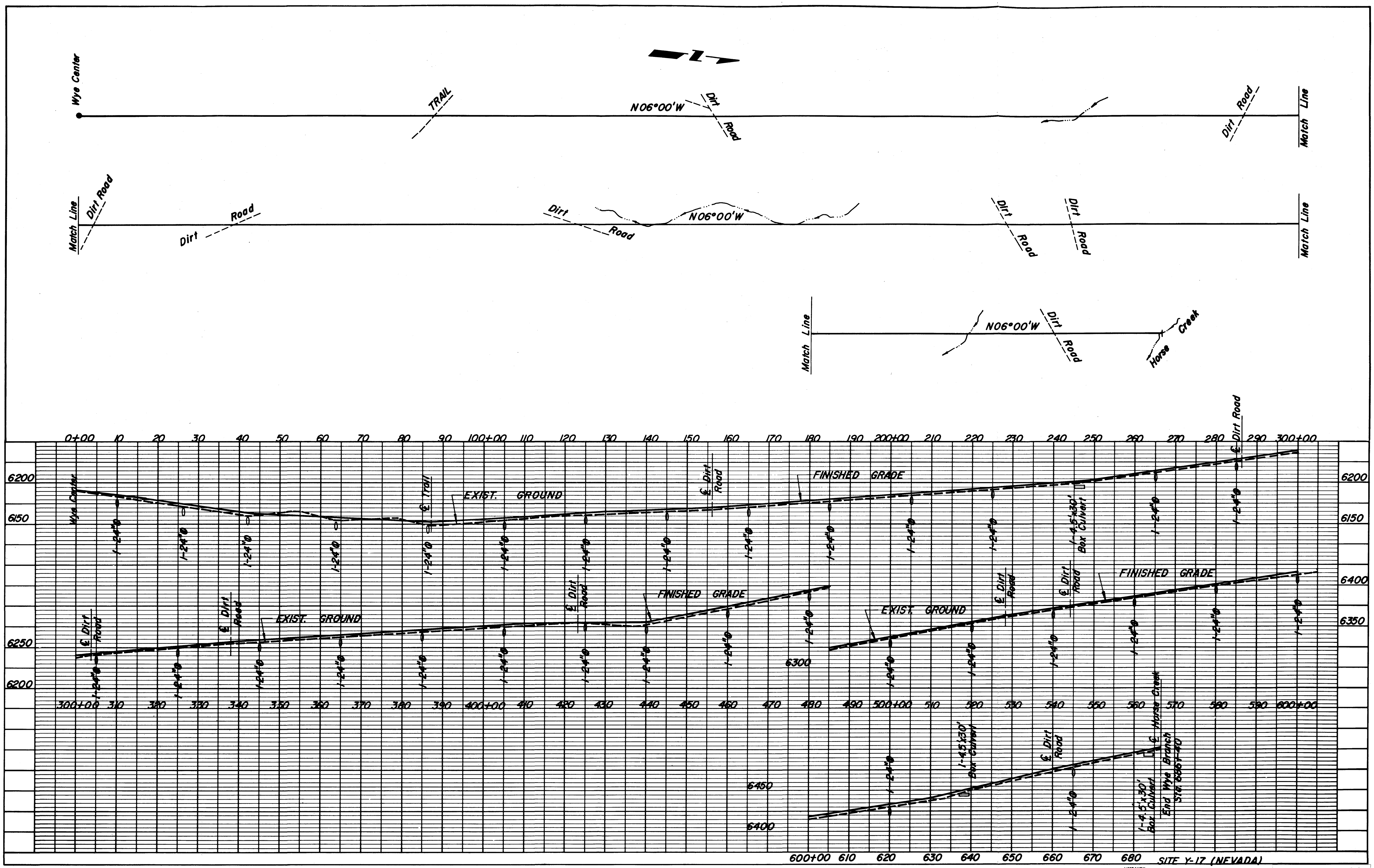

Wye Center
TRAIL
N06°00'W
Dirt Road
Match Line
Dirt Road
Match Line
N06°00'W
Dirt Road
Match Line
N06°00'W
Dirt Road
Horse Creek
EXIST. GROUND
FINISHED GRADE
℄ Trail
℄ Dirt Road
1-24"Ø
1-4.5'x30' Box Culvert
℄ Horse Creek
End Wye Branch Sta 680+40
0+00
100+00
200+00
300+00
400+00
500+00
600+00
6150
6200
6250
6300
6350
6400
6450
SITE Y-17 (NEVADA)
LIMBAUGH ENGINEERS, INC.

Fig. 5-12

are on U.S. Highway 50 but any future growth will depend mainly on an expanding mining economy.

Austin, with a population of 300, is approximately 42 miles west of the apex. Eureka is approximately 24 miles east of the apex and has a population of about 500. The nearest town with a population over 2000 is Ely, which is 105 miles east of the site and has a population of 7000. The town has two dentists and four doctors, all located in a newly constructed clinic. There is a recently built 40 bed hospital valued at 1.2 million dollars. It is adjacent to the old hospital which was a 40 bed unit and is now a nursing home. The major sources of income for Ely are the Kennecott Copper Corporation, the Nevada Northern Railroad which is a wholly owned Kennecott subsidiary, and agriculture. The city has 18 motels, 7 restaurants and 2 gambling casinos. The educational system in Ely includes three elementary schools and one high school. The student-teacher ratio is 18. There is one parochial grade school, an evening school, and an off-campus center of the University of Nevada. The community has a year-round swimming pool and a 9-hole golf course.

The growth rate for the past seven years in Ely has been less than 2.2 percent a year. Kennecott Copper Corporation has created a fairly stable employment situation in the town for many years. The local employment office lists an annual average of 600 new applicants per year, with 99 percent being employed by Kennecott. More than half the applicants are women and they would constitute the available local labor. The community has a very serious housing shortage and trailer houses have become the homes for many families. The FHA has a program of developing land for additional needed housing for the local residents. The unskilled wage rate in the area is $2.65 per hour.

The Nevada Northern Railway Company is a common carrier but has no passenger service available; however, three bus companies offer service to Reno and Wells, Nevada, and Salt Lake City, Utah. The city of Ely has an airport with both charter and commercial service available. United Airlines has two flights daily that connects with other commercial flights at Reno, San Francisco, and Salt Lake City.

The city of Ely has a council-mayor form of government. The city has its own municipal water supply, obtained from eight artesian wells in the mountains above the city. The community has recently constructed a modern sewage treatment plant.

Elko, Nevada, with a population of 10,500 is located approximately 106 miles north of the Y17 site. This city has a growth increase of over 13 percent per year. It has a city council form of government with four councilmen and an elected mayor. The sources of income for Elko are tourism, ranching, and mining.

Elko is on Interstate Highway 80, between Reno and Salt Lake City. It has several motels and restaurants and three large gambling casinos. The medical facilities appear to be adequate, with six physicians and two medical specialists, four dentists and an eighty bed hospital.

Because of the rapid growth rate of Elko, housing facilities are lacking and practically the only available accommodation is in motels. The city has recently added a water reservoir with attendant water mains and laterals, and a new sewage treatment plant. Water is obtained from wells located in and around the city. Apparently there is an adequate water supply to meet existing demands since no shortages have been experienced to date.

The school system is operated on a county-wide basis with administrative offices in Elko. There are 2200 students with a student-teacher ratio of 27 in the elementary system and 22 in the secondary system. There are four elementary schools, one junior high school, and one senior high school which is accredited by the Northwest Central Association. In addition, there is a city community college.

Because of Elko's size and diversified income, it does have an available labor force. Approximately 2100 new applications per year are received in the office of the Security Commission.

Both the Western Pacific Railroad Company and the Southern Pacific Railroad have passenger service and Greyhound and Continental Trailways bus lines connect to all major cities in the West. United Airlines has two scheduled flights per day through Elko with connections to other commercial airlines at Salt Lake City, Reno, and San Francisco. There are two private charter services available at Elko.

Labor in Nevada is highly unionized. Electricians receive $7.25 per hour plus subsistence, and construction workers $5.55 per hour plus $9 per day subsistence.

There is hunting, fishing, hiking and camping, water skiing and snow skiing in the area. Within a few hours driving time, there are several national forests and two national recreational areas, one being Hoover Dam (Lake Mead) and the other Lake Tahoe on the Nevada-California border.

2. Climatology

The average daily maximum temperature is 60.8° F and the average daily minimum is 22.0° F. The highest recorded temperature is 98.0° F and the lowest is -34.0° F.

The average yearly precipitation is 6.32 inches, with 10.57 inches being the greatest annual precipitation. The mean annual snowfall is 30 inches, with a record maximum single snowfall of 37 inches. The annual mean relative humidity is 50 percent. The sun shines 76 percent of the time possible. There is an average of one tornado every two years for the entire state. Dust storms are infrequent, and hail occurs approximately four times a year. The prevailing wind direction is from the southwest, with an estimated average velocity of 10 miles per hour.

The maximum expected wind speed in 50 years is estimated at 70 miles per hour. Thunderstorm activity is quite low, with an average of only 20 thunderstorms per year.

3. Geology and foundation investigation

The site is situated in central Nevada in the midst of the geologically complex Basin and Range Province. The northerly trending mountains have been formed primarily by a system of faulting, including low angle thrusting which has caused considerable folding and brecciation of the bedrock.

The faults bordering the mountains have long since been buried beneath the alluvial material that covers the valley lowlands. In the relatively recent geological past, the entire Kobeh Valley was covered to a depth of several hundred feet by sand and gravel deposits that formed a nearly level surface. The base level for the area has subsequently been lowered, causing extensive erosion of the old alluvial surface and the formation of a new, relatively stable level, typified by Bean Flat. Much of the northern branch, as well as parts of the other two, are underlain by remnants of the old alluvial surface.

Within a 40-mile radius of the Wye apex, 10 earthquakes have been recorded since 1852, as shown on the Nevada Bureau of Mines Map 29. The magnitude of the tremors generally has been less than 5 on the Richter scale, but at least two of the shocks have had a magnitude of between 5 and 6, and thus probably caused damage to buildings near the earthquake epicenters. There are no active fault scarps in the Kobeh Valley, but about 100 miles to the west the area in a north-south belt between Fallon and Frenchman Station is one of high earthquake activity and has experienced active faulting, including a vertical offset of 5.5 feet along a short section of U.S. Highway 50 in 1954. In addition to the natural seismological activity, tremors from some of the nuclear underground tests probably would be felt at the Y17 site, according to the Nevada Operations Office of the Atomic Energy Commission. The actual magnitude of the nuclear shocks is not known, and to date there has been only one test within a 100-mile radius of the site.

The older alluvial deposits should be entirely satisfactory for embankment material and, at least in some areas, they should prove adequate for use as road base. The gravel fraction in these deposits probably varies from 20 to 50 percent and the individual clasts usually are less than one inch in diameter. There are good exposures of this material in a pit a short distance northeast of the apex where the gravel was excavated for embankment material and surface graveling of the road that runs near the center of the site.

The Nevada Highway Department has been excavating material for road base and surfacing from pits along U.S. Highway 50 for many years. The pits are located on the lower base level near the end of the southwestern branch of the Wye. The bottomlands generally are underlain by at least 1 to 3 feet of silty or clayey sand. In the area of the pits these fine-grained sediments average about 2 feet in depth and are underlain by gravel-sands containing from 3 to 6 percent silty fines. The volume of the gravel fraction ranges from about 30 to 40 percent. It is likely that this type of gravel was deposited in an old stream bed and thus may be localized so that similar deposits could not necessarily be expected to underlie the bottomlands in other areas.

If ballast material were to be obtained locally, it would have to be crushed rock from a quarry in one of the nearby mountain ranges. Brecciation of the bedrock by faulting has occurred in the Mahogany Hills near the end of the southeastern branch and also on Lone Mountain. The brecciated limestone has been recemented, but it appears that the rock would have a tendency to shatter when crushed.

It is possible that limestone beds suitable for crushing could be found at some location near the perimeter of the valley.

Foundation conditions in the sand and gravel of the old alluvial surface should be good. The bearing capacity should be quite high and the compressibility under saturated conditions should be more moderate. In the lowland areas, particularly where the drainage is poor, the bearing capacity probably is only fair and the compressibility of the soil under saturated conditions may be moderately high. A soils drilling and testing program would be required to determine the actual bearing capacity.

There has been no petroleum activity anywhere in the vicinity of this site. The geologic section in the area may be favorable for the accumulation of petroleum, but the structural complexity has discouraged exploration activity.

The nearest mining activity is at Lone Mountain, only 8 miles east of the apex. According to statistics in Nevada Bureau of Mines Bulletin

64, more than $100,000 worth of zinc ore has been produced in the Lone Mountain District. The Mount Hope Mining District, which lies 14 miles north of Lone Mountain, has also produced more than $100,000 worth of zinc ore. About 27 miles northwest of Lone Mountain is the Roberts Mountain Mining District where substantial amounts of lead ore have been mined. The Eureka Mining District, 17 miles east of Lone Mountain, has the greatest known potential for future development. To date, well in excess of $100,000,000 of gold and silver ore has been mined. There is only a limited amount of activity in the established mines at present.

In November of 1969 a major mining company had staked a minimum of 100 mining claims covering 2000 acres near the southwestern branch of the Wye. Neither the exact location, extent, nor the type of development activity could be determined. A test drilling program was in progress at the time the site was visited in November, and there is a possibility that the mining claim could conflict with parts of the southwestern and northern branches of the Wye.

4. Topography and drainage

The site is located primarily in the Kobeh Valley, a broad and nearly equidimensional area at the heads of the Monitor and Antelope Valleys. Bean Flat and valley areas along Coils Creek have very low relief and are quite poorly drained. They are surrounded by an old, relatively flat, alluvial surface 20 to 30 feet above the present base level of the valley. Around the perimeter of the area, the old alluvial surface merges with moderately steeply rising alluvial fans. The base level is at an elevation of about 6100 feet and the base of the alluvial fans is approximately 6300 feet.

On the north, the Roberts Mountains rise to elevations of over 10,000 feet. The site is bounded on the west by the Simpson Park Mountains that attain elevations over 9000 feet. The Monitor Range on the south has areas over 10,000 feet in elevation, and along the eastern boundary of Kobeh Valley, the Whistler Mountains and the Mahogany Hills have elevations over 8000 feet. There is one isolated peak (Lone Mountain) rising out of the eastern edge of Kobeh Valley; it is about 8000 feet in elevation at the top, rising over 1800 feet from the valley floor.

Slopes along the Wye branches are generally small in the central part of the site, but approach the maximum permissible grades on the ends of the northern and southeastern branches. The northern branch has a grade of about 1 percent for a short distance just north of the apex. In the last 2 miles, the grade is between 1 and 1.5 percent. Along the remainder of the branch, the grade is from 0.5 to 0.75 percent.

The grade along most of the southeastern branch does not exceed 0.5 percent. About 2 miles southeast of the U.S. Highway 50 crossing, the grade increases to as much as 1.5 percent over a distance of about 1 mile.

The first 4-1/2 miles of the southwestern branch cross low sand and gravel benches which have moderate local relief, and there are grades of at least 2 percent over short distances. The remainder of the branch has grades of 0.5 to 0.75 percent. The localized steep grades are not a problem, because the underlying material can be readily excavated and used for embankment material in the low areas to the southwest. Also, the roadbed can be offset around areas where excavation to reduce the grade might prove burdensome.

There are no perennial streams within the site area, but there are a substantial number of channels that carry water during periods of moderate to heavy rainfall. Except near the base of the mountains surrounding the valley, the drainages are broad and rather poorly defined due to the slight gradient and the sandy character of the soils. Coils Creek, which is the primary drainage, carries water from the Simpson Park Mountains to the west, the Roberts Mountains to the north, and the Monitor Range to the south. During periods of heavy runoff, the surface flow in Coils Creek extends entirely across the site area from northwest to southeast and empties through Devils Gap at the eastern edge of Kobeh Valley. In 1964 a flow of 8 $feet^3$ per second was measured on Coils Creek in the northern part of Kobeh Valley during a period of heavy precipitation.

The northern branch of the Wye would require a minimum embankment elevation for the roadway over most of its length because the underlying area is an old alluvial bench consisting of moderately permeable sand and fine gravel. The low area just north of the apex and the relatively low areas along the last two miles of the branch would require somewhat higher embankments, probably 2 to 4 feet through the lowland areas.

In the lowland area containing most of the southwestern branch, the drainage patterns are discontinuous and during heavy rainfall the water tends to pond and then slowly drain off to the east. The underlying sediments are composed primarily of sand and gravel, but in the lowland areas there is a 2 to 3-foot zone of relatively impermeable soil. Embankments should generally be about 2 feet in height except in areas of substantial ponding, where the height should be increased to at least 3 feet.

About 60 percent of the southeastern branch crosses well drained sand and gravel bench deposits, and in these areas only a minimum embankment elevation would be required. An embankment of about 3 feet should be used on most of the remainder of the roadbed. Near the point where the Wye crosses U.S. Highway 50, there is a particularly low area adjacent to the confluence of several drainages, including the main channel of Coils Creek. Several moderate-sized culverts will be needed to carry what could be sizeable flood flows from Monitor Ridge and the Mahogany Hills.

5. Railway

The top 3 to 6 inches will have to be stripped from the ground surface in order to remove existing vegetation prior to emplacing the embankment material.

6. Access road

The total length of all access roads for Y17 is 6.7 miles. The entrance road from the highway is 4 miles long. The access road from the building complex to the staging area will be 8400 feet long.

7. Airstrip

The airstrip will run approximately southwest-northeast to face the prevailing wind. The landing strip will be 150 feet wide with paved runway 75 feet wide and 7000 feet long. The length of the runway is determined by the altitude (6180 feet above sea level) and the mean maximum temperature (80° F).

8. Water supply

The source of the water supply is an underground aquifer and can be tapped by a 10-inch diameter well cased to 8 inches. Delivery of the water will be by an electric, submersible, centrifugal pump in the well. The pumped water is conveyed by pipe to an elevated 65,000 gallon storage tank. This tank will contain a three day domestic supply and 50,000 gallongs of water for fire delivered at the rate of 400 gallons per minute for a two hour duration. Distribution from the storage tank is by gravity through a chlorinator and zeolite filter prior to consumption at the building complex.

The streams in the central part of the site area flow only intermittently. The primary source of water would be wells drilled in the valley alluvium. According to Rush and Everett (1964), the Kobeh Valley has a subsurface water storage potential of 2.7 million acre feet. The aquifer is recharged by rainfall and by runoff from the surrounding mountains; the amount of recharge is estimated to be 17,000 acre feet per year.

There is one stock well near the apex, but no information concerning it is available. The water has satisfactory color and taste. There is a slight build-up of salts around the outflow pipe indicating to some extent a hard water. The flow from the well, as drawn by a wind-powered pump, was estimated to be 2 gpm when the site was visited in November 1969. It is probable that a yield of 10 gpm could be obtained from a well in the area. The depth to the water table in the bottomland is estimated to be 50 feet to 100 feet.

9. Utilities

The area is not served with power at present; however, Mount Wheeler Power, Inc. has made application for a certificate from the Public Service Commission in Nevada. Indications are that after approval of this certificate service cannot begin in the area before April 1971.

The length of power line that would have to be built to serve the site is approximately 29 miles at a cost of $146,870. The VLA power needs would require an increase in the conductor size for about 13 miles of line from the proposed Diamond Valley substation. Capacity of the Diamond Valley substation will be adequate. The minimum monthly charge for service would be $2203. The average monthly charge is determined by the demand and energy charge. This would be estimated at approximately $10,373 per month.

The area of the site is served by the Bell Telephone Company of Nevada with local offices at Eureka and Austin, Nevada.

10. Real estate

The site lies approximately 20 miles west of Eureka, Nevada. It is in an area devoted primarily to cattle ranching; however, there are some subirrigated pastures and haying meadows in the low areas along the draws. There is also an extensive area that cuts through the western portion called Bean Flat, and this land is typically a wide alkali draw with sparse ground cover.

The Bureau of Land Management office in Battle Mountain, Nevada, reports that applications to acquire public land in Kobeh Valley totaling 6400 acres are presently pending under provisions of the Desert Land Act.

This property is quite complex since each of the Wye branches crosses different types of land. It is anticipated that there may be extensive damage to both public and private lands since a public highway is crossed, two watering stations are affected, several county maintained roads are materially disrupted, and irrigated haying pastures will be bisected.

It is estimated that approximately 140 acres of private land and 2820 acres of Bureau of Land Management land will be affected. There are approximately 140 acres of irrigated hay land, 500 acres of subirrigated pastures, and approximately 2320 acres of grazing land.

Haying land is estimated to be worth approximately $300 per acre. Since the fields will be damaged, we have estimated $450 per acre for the haying land that would be taken. Subirrigated land has an estimated value of from $30 to $40 per acre. We have used a $40 per acre figure since this should cover any damages to the property. Grazing land is estimated to be worth $15 per acre.

Irrigated Hay Land	
140 acres @ $450 =	$ 63,000
Subirrigated Meadows	
500 acres @ $40 =	$ 20,000
Grazing Land	
2320 acres @ $15 =	$ 34,800
TOTAL CALLED	$117,800

F. Site Y22 (New Mexico)

This site lies in Grant, Hidalgo, and Luna Counties, approximately 19 miles east of Lordsburg. The center is about 4-1/2 miles north of Separ, on Interstate Highway 10. Its geographical coordinates are 32°15!6 N, 108°24!2 W, the elevation at this point being 4670 feet above mean sea level. The branches extend outward on true azimuths 67°, 187°, and 307°. A map of the site area is given in Fig. 5-13, and the branch profiles are shown in Figs. 5-14, 5-15, and 5-16.

1. General site features

The Y22 site is located mainly on the northern slope of a broad east-west valley. The regional slope is southerly from the base of the Burro Mountains at an average gradient of slightly over 1.5 percent. The base of the mountains is at an elevation of about 5200 feet whereas the bottom of the valley lies about 4300 feet above sea level. The terrain varies from quite flat towards the center of the valley to moderately rolling near the mountains.

The San Simeon-Deming and San Simeon-Columbus controlled air spaces cross over the 13 mile radius circle encompassing the site. A low altitude federal airway (V94) crosses over the northeastern and northwestern branches of the Wye.

The southern branch of the Wye intersects the Southern Pacific Railroad (single track) and Interstate Highway 10 at a point approximately 4 miles south of the apex.

There is a "defense area" associated with the Mexico-United States border, which is about 40 miles southeast of the site. When military activity is taking place in that general area, the FAA is informed and air traffic is routed away from the area.

There does not appear to be any underground nuclear testing which would affect the area.

El Paso Natural Gas underground pipelines intersect the northwestern and northeastern branches of the Wye as well as the extremity of the southern branch. A Southern Pacific products pipeline crosses the

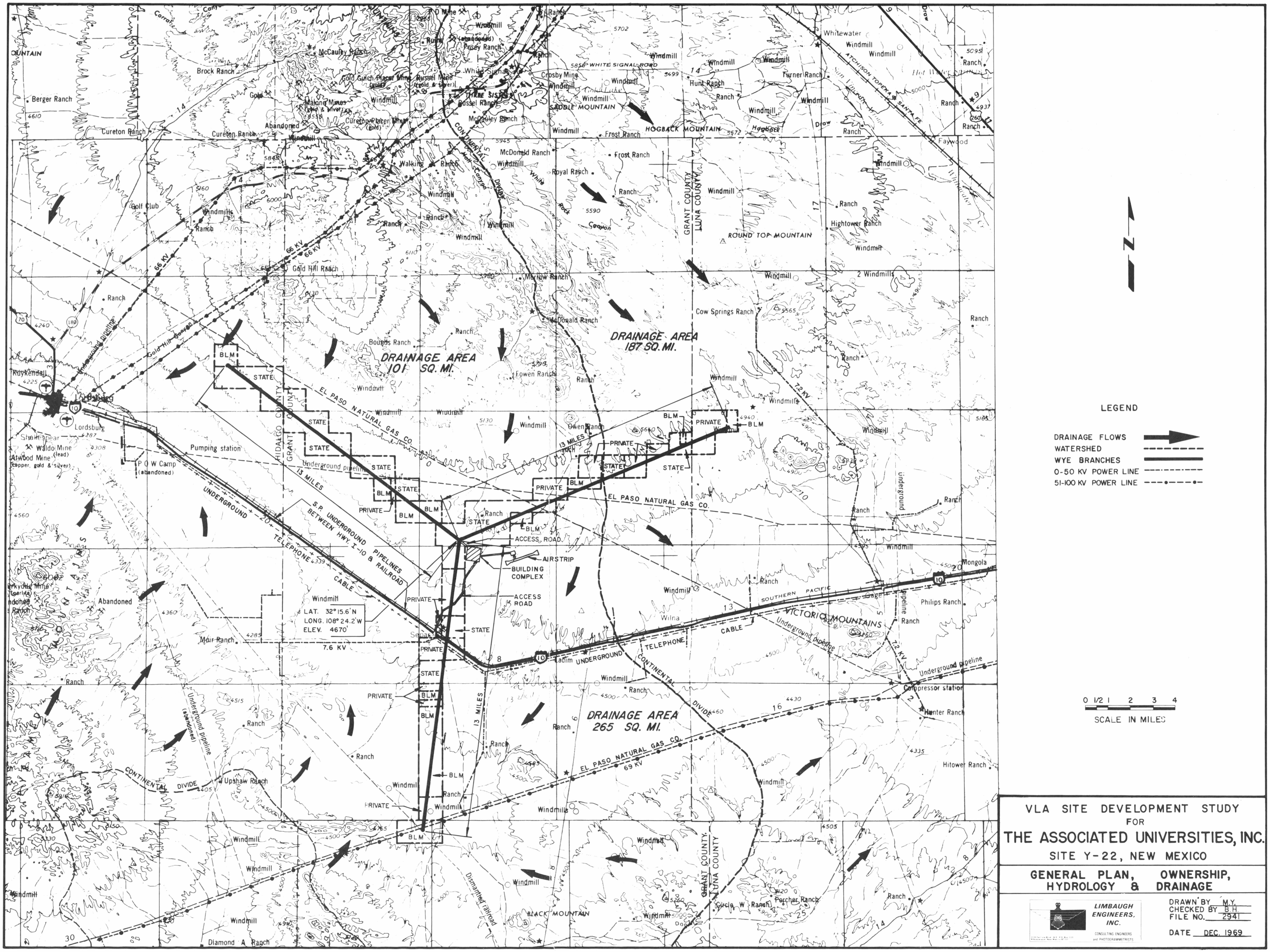
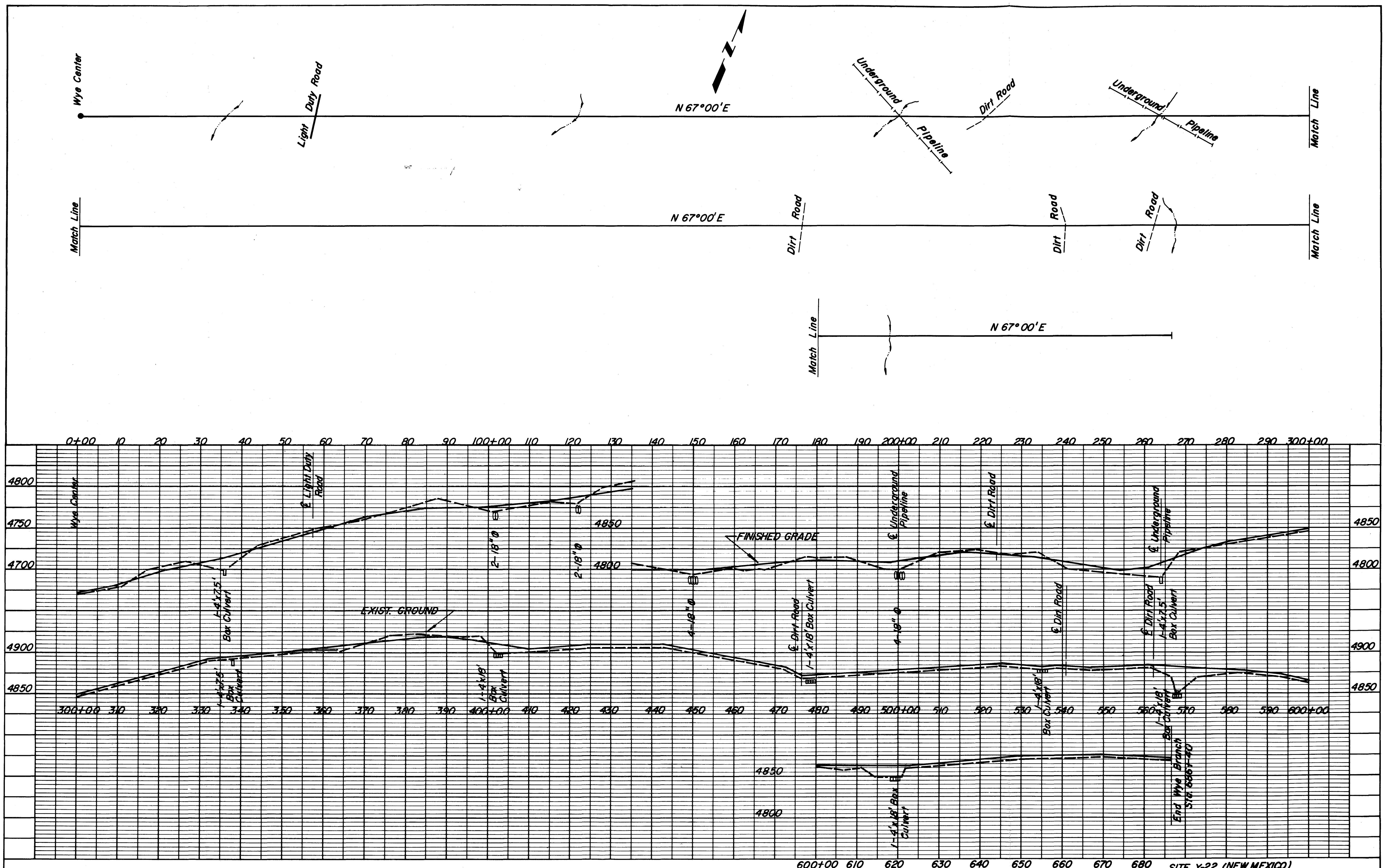
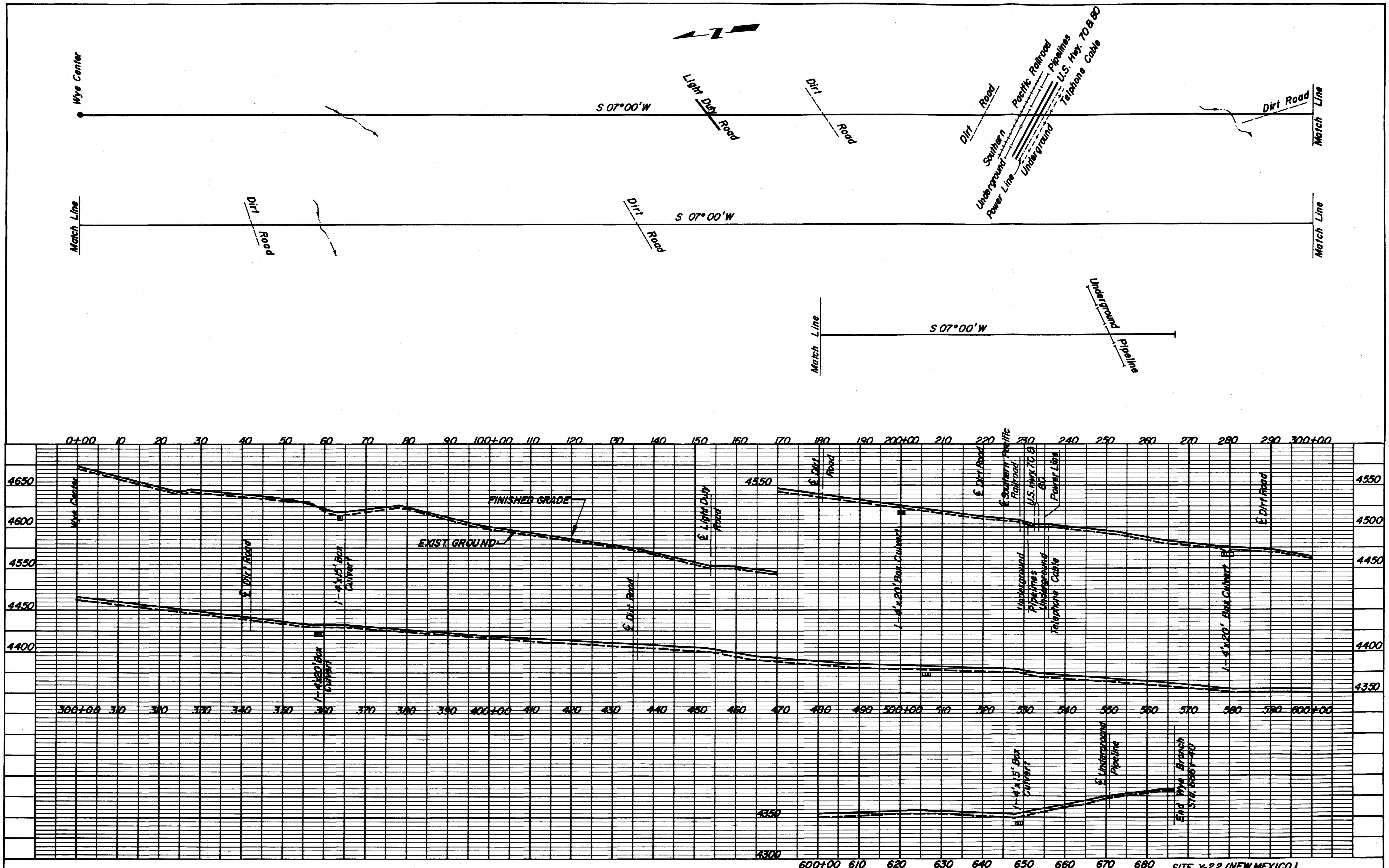

LEGEND
DRAINAGE FLOWS
WATERSHED
WYE BRANCHES
0-50 KV POWER LINE
51-100 KV POWER LINE
0 1/2 1 2 3 4
SCALE IN MILES
N
DRAINAGE AREA 101 SQ. MI.
DRAINAGE AREA 187 SQ. MI.
DRAINAGE AREA 265 SQ. MI.
S.P. UNDERGROUND PIPELINES BETWEEN HWY. I-10 & RAILROAD
LAT. 32° 15.6' N
LONG. 108° 24.2' W
ELEV. 4670'
BUILDING COMPLEX
AIRSTRIP
ACCESS ROAD
EL PASO NATURAL GAS CO.
UNDERGROUND TELEPHONE CABLE
CONTINENTAL DIVIDE
13 MILES
VICTORIO MOUNTAINS
HOGBACK MOUNTAIN
ROUND TOP MOUNTAIN
GRANT COUNTY
LUNA COUNTY
HIDALGO COUNTY
VLA SITE DEVELOPMENT STUDY
FOR
THE ASSOCIATED UNIVERSITIES, INC.
SITE Y-22, NEW MEXICO
GENERAL PLAN, OWNERSHIP, HYDROLOGY & DRAINAGE
LIMBAUGH ENGINEERS, INC.
CONSULTING ENGINEERS and PHOTOGRAMMETRISTS
DRAWN BY M.Y.
CHECKED BY B.H.
FILE NO. 2941
DATE DEC. 1969

Fig. 5-13



Wye Center
Light Duty Road
N 67°00'E
Underground Pipeline
Dirt Road
Underground Pipeline
Match Line
Match Line
N 67°00'E
Dirt Road
Dirt Road
Dirt Road
Match Line
Match Line
N 67° 00'E
0+00 10 20 30 40 50 60 70 80 90 100+00 110 120 130 140 150 160 170 180 190 200+00 210 220 230 240 250 260 270 280 290 300+00
4800
4750
4700
4900
4850
Wye Center
℄ Light Duty Road
1-4'x7.5' Box Culvert
2-18" ⌀
2-18" ⌀
4850
4800
FINISHED GRADE
4-18" ⌀
℄ Underground Pipeline
4-18" ⌀
℄ Dirt Road
℄ Underground Pipeline
℄ Dirt Road
1-4'x18' Box Culvert
℄ Dirt Road
℄ Dirt Road
1-4'x7.5' Box Culvert
EXIST. GROUND
1-4'x7.5' Box Culvert
1-4'x18' Box Culvert
1-4'x18' Box Culvert
1-4'x18' Box Culvert
300+00 310 320 330 340 350 360 370 380 390 400+00 410 420 430 440 450 460 470 480 490 500+00 510 520 530 540 550 560 570 580 590 600+00
4850
4800
4850
4800
1-4'x18' Box Culvert
End Wye Branch Sta 686+40
600+00 610 620 630 640 650 660 670 680
SITE Y-22 (NEW MEXICO)
LIMBAUGH ENGINEERS, INC.

Fig. 5-14



Wye Center
S 07°00'W
Light Duty Road
Dirt Road
Southern Pacific Railroad
Pipelines
U.S. Hwy. 70 & 80
Telphone Cable
Underground
Underground Power Line
Match Line
FINISHED GRADE
EXIST. GROUND
℄ Dirt Road
1-4'x15' Box Culvert
℄ Light Duty Road
1-4'x20' Box Culvert
℄ Southern Pacific Railroad
U.S. Hwy. 70 & 80
Power Line
Underground Pipelines
Underground Telephone Cable
℄ Underground Pipeline
End Wye Branch Sta. 686+40
SITE Y-22 (NEW MEXICO)

Fig. 5-15

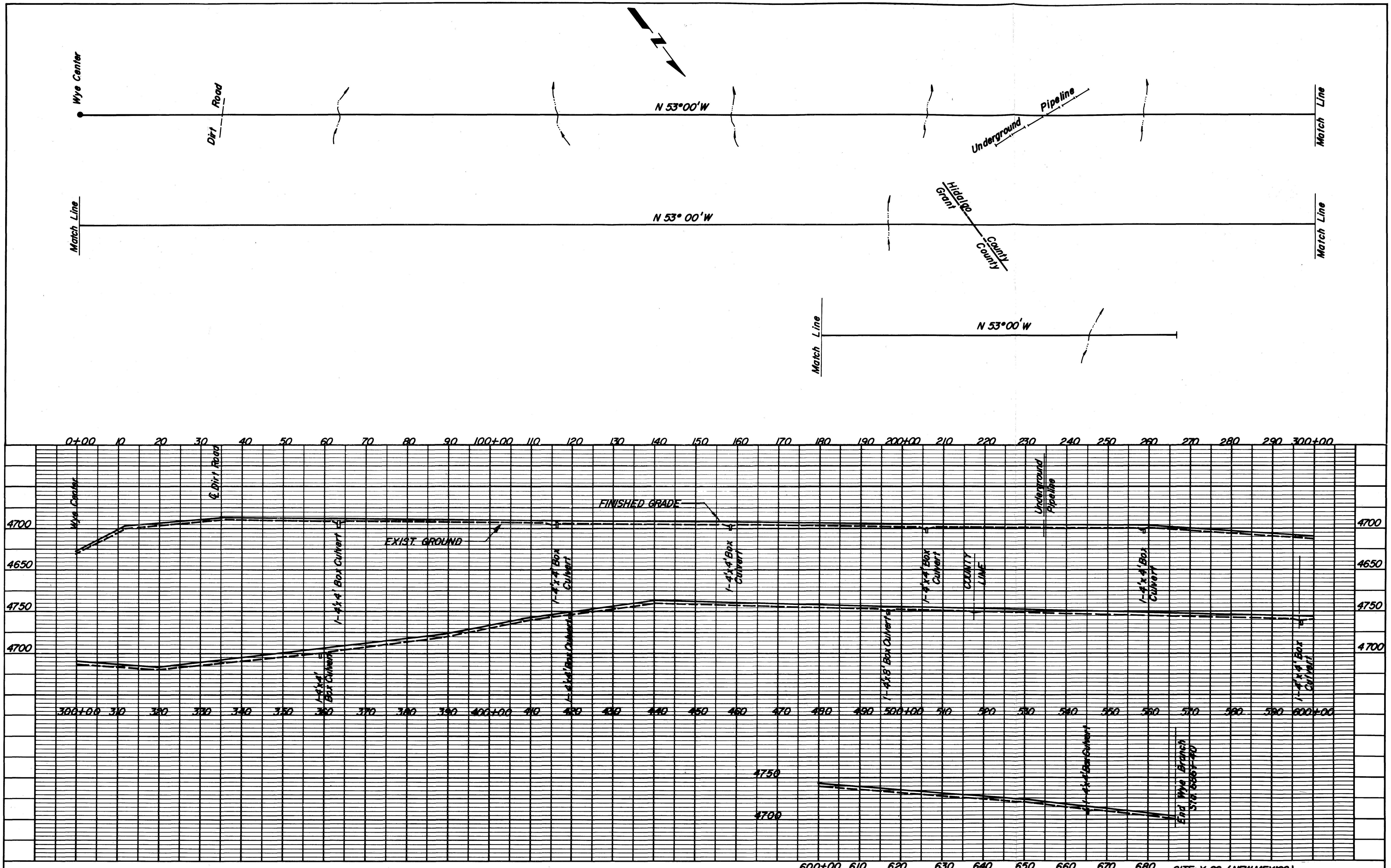

Wye Center
Dirt Road
N 53°00'W
Underground Pipeline
Match Line
Hidalgo County
Grant County
Match Line
N 53° 00'W
Match Line
Match Line
N 53°00'W
0+00
10
20
30
40
50
60
70
80
90
100+00
110
120
130
140
150
160
170
180
190
200+00
210
220
230
240
250
260
270
280
290
300+00
Wye Center
℄ Dirt Road
FINISHED GRADE
EXIST. GROUND
Underground Pipeline
1-4'x4' Box Culvert
1-4'x4' Box Culvert
1-4'x4' Box Culvert
1-4'x4' Box Culvert
COUNTY LINE
1-4'x4' Box Culvert
4700
4650
4750
4700
300+00
310
320
330
340
350
360
370
380
390
400+00
410
420
430
440
450
460
470
480
490
500+00
510
520
530
540
550
560
570
580
590
600+00
1-4'x4' Box Culvert
1-4'x4' Box Culvert
1-4'x8' Box Culvert
1-4'x4' Box Culvert
1-4'x4' Box Culvert
End Wye Branch
4750
4700
600+00
610
620
630
640
650
660
670
680
SITE Y-22 (NEW MEXICO)
LIMBAUGH ENGINEERS, INC.

Fig. 5-16

southern branches of the Wye at the intersection of the branch and the railroad.

Lordsburg, New Mexico is 24 miles west of the proposed site. It has a population of 3000, with its major income derived from tourism, farming, mining and ranching. Most of the mining takes place at the Federal Resources Mine, Inc., located 5 miles south of Lordsburg. The mine employs about 150 people in the production of copper. Lordsburg is served by the Southern Pacific Railroad, with one passenger train each way daily. Both the Continental Trailways and Greyhound bus lines serve Lordsburg, operating a total schedule of 20 bus departures daily.

There are 11 motels and 15 restaurants in the town. The community has a 25 bed hospital built in 1963, 2 physicians and 1 dentist.

The public school system serves 1200 students and is accredited by the North Central Association. The student-teacher ratio is 24. The community has a mayor-council form of town government. The growth rate has been approximately 2 percent per year for the last seven years. The town could probably absorb about 15 families by using available motels and trailer space. Local labor is scarce and mostly unskilled. Recently, a large gas line was constructed through the town and many workers on this job had to commute from Silver City, Deming, Wilcox, and Tucson. There is an adequate supply of potable water in the town. The airport consists of a small dirt runway, with no lighting facilities and practically no services.

The town of Deming, New Mexico, which has a population of about 10,000, is approximately 45 miles east of the site, and it is served by the same bus lines and railroad as Lordsburg. The Santa Fe Railway also has a line through Deming, but with freight service only. The branch line connects with the main line between Albuquerque and El Paso and the Kennecott Copper Mine in the Silver City area.

Deming has a 40 bed hospital which was built in 1957. The town has four physicians and three dentists in residence.

The public school system in Deming serves approximately 3540 students enrolled in five elementary schools, one junior high school, and one senior high, which is accredited by the North Central Association. The student-teacher ratio of this system is 23.

Deming would appear to have available housing for 60 families. A recent survey indicated that the preponderance of the work force would be women, who outnumber the men 1.6 to 1. There is evidently a supply of unskilled labor.

The city of Deming is governed by an elected city council and an elected mayor. The community has an airport with a 4300 foot paved runway and medium intensity lighting. There are no commercial air facilities, but local aircraft charter service is available. The nearest commercial air service is at the Grant County Airport, near Hurley, New Mexico. Driving time to the airport is one hour and 20 minutes from Y22. Frontier Airlines has two flights daily connecting with other airlines in Tucson and Albuquerque. The El Paso International Airport, 2-1/2 hours driving time east of Y22, is served by Frontier, Texas International, American and Continental Airlines. Tucson Airport is three hours driving time from the site, with service on American, Frontier, TWA, and Air West Airlines.

The wage rates for skilled labor in the area are $6.35 an hour for construction workers and $5.50 an hour for electricians, plus subsistence. The unskilled rate is $3.78 per hour.

2. Climatology

The average daily maximum temperature is 78.3° F, and the average daily minimum is 44.6° F. The highest temperature recorded is 110° F, and the lowest is -9° F.

The average annual precipitation is 10 inches, with a record maximum daily fall of 3.08 inches and a maximum monthly fall of 6.46 inches. The mean yearly snowfall is 4.3 inches, with a record maximum snowfall of 10.0 inches. The annual mean relative humidity is 45 percent. The sunshine for the year averages 80 percent of the possible amount. The dust days per year for the site are estimated to average a total of 20. Hail occurs about one to two times per year. The prevailing wind direction is from the southwest. The average hourly wind speed for the year is 10.0 miles per hour, with a maximum 50-year wind expectancy of 75 miles per hour. One tornado has been recorded in the area in the last 52 years. There are an average of 46 thunderstorms per year.

3. Geology and foundation investigation

The site is on the southern flank of the Burro Mountains in a broad, alluvium-filled valley that stretches from Lordsburg eastward beyond Deming. The branches of the Wye do not cross outcrops of bedrock, but there are a number of isolated volcanic hills and ridges bordering the eastern, southern, and western sides of the site. Exposures of volcanic rock and granite occur a short distance north of the northwestern branch.

Since 1885, more than 600 earthquakes have been recorded in New Mexico, although only since 1959 have reports been based on instrumentation within the state. Most of the tremors have occurred in a narrow belt along the Rio Grande trough, and the Y22 site probably has been subjected to only a few of the strongest earthquakes, with epicenters in areas remote from the site. There are no known active faults in the region.

The northwestern branch lies on an alluvial fan radiating outward from the southern margin of the Burro Mountains. The bedrock of the mountains is deeply weathered and fractured granite. The alluvial outwash deposits are a relatively fine-grained decomposed granite, with the gravel fraction varying from 10 to 40 percent. The maximum size is about 6 inches and the average is less than 1 inch. The matrix is silty sand, with the fines constituting up to 15 percent by volume. This branch lies close to the edge of the mountains, where there are a great number of small washes which discharge water during periods of heavy precipitation.

The northeastern branch is underlain by deposits of silty and clayey sand and gravel. In the exposures observed, the gravel fraction appeared to be 10 percent or less, and much of the terrain in this area appears to be an old alluvial surface rather than a fan deposit. Scattered outcrops of volcanic bedrock occur in the deeper arroyos that cross the western part of the branch. The rock is not very resistant and in many places it is covered by at least 3 feet of alluvium.

The southern branch crosses an alluvial surface which slopes quite uniformly to the south. The alluvial sediments appear to decrease somewhat in size as the distance from Burro Mountain increases. The gravel fraction is not over 10 percent and it is generally of pea size. The silty fines constitute 10 to 15 percent by volume, and the soil is slightly cemented with caliche in the zone 1 to 3 feet beneath the surface.

Embankment material can be obtained locally along all the branches of the Wye. The quality is no better than fair because of the fine texture and the content of silty fines. Good quality gravel does not appear to be readily available in the vicinity of the site. Poorly graded sand and gravel deposits occur at several localities around the base of the mountains. They are slope wash deposits which appear quite thoroughly coated with carbonate material.

Crushed stone for aggregate or ballast can be obtained from limestone outcrops in an isolated hill 1.5 miles north of the junction of Interstate Highway 10 and New Mexico Highway 81. The limestone from this site has been crushed satisfactorily for highway construction purposes.

The bearing capacity of the soils throughout the site are estimated to range from very good on the northwestern and northeastern branches to good on the southern branch. Near the end of the southern branch in the ponding areas, the surface material bearing capacity may rate only fair.

The soil underlying the Wye branches generally has fair permeability except near the southern end where an impermeable surface layer has been built up in the areas of ponding.

An oil well has recently been drilled about 6 miles south of Separ, and there may be as much as one million acres under lease in the area south of Interstate Highway 10. The well apparently was dry and has been abandoned. There are extensive exposures of granite to the north and widely scattered outcrops to the southwest and southeast, indicating that the sedimentary section is not very promising with regard to petroleum potential.

The largest mineral activity in the region is at Tyrone, where the Phelps-Dodge Corporation is developing an open pit copper mine with large long-term reserves. This operation is about 28 miles north of the Y22 site apex. There have been numerous mining operations in the Burro Mountains between Tyrone and the site, but most of these were quite small and are no longer active. The Lordsburg-Pyramid Mountains Mining District lies 20 miles west of the site and there is some activity at present. A potential for uranium development exists in the granite on the south edge of Burro Mountain a short distance north of the northwestern branch.

4. Topography and drainage

Y22 is on the northern side of a broad, east-west semi-arid valley covered with sparse grass and scattered sagebrush of several varieties On the slopes directly adjacent to the mountains, the vegetation is primarily greasewood and mesquite with lesser amounts of low sagebrush. The only trees at the site are near dwellings.

The apex of Y22 lies at an elevation of approximately 4700 feet. The base of the adjacent mountains to the north is about 5200 feet. The lowest part of the site is near the end of the southern branch, where the elevation is about 4340 feet.

From Interstate Highway 10 toward the Burro Mountains, the terrain becomes more sharply rolling and the drainages are more pronounced and deeply incised. This is particularly true along the northwestern branch because it lies directly adjacent to the edge of the mountains. In that area, the branch crosses a succession of low ridges separated by narrow stream channels. The vertical relief between adjacent high and low points would generally be 5 to 10 feet.

The first 6 miles of the northeastern branch has the most rugged terrain in the site because of the larger arroyos crossing this section. The vertical relief along the margins of Ninetysix Creek and in the Burro Cienega exceeds 40 feet and the resulting gradients in those areas, before adjustments for cut and fill, would be 3-1/2 to 5 percent. For the most part the grade along the 6 miles would not exceed 2 percent. The remainder of the northeastern branch would have slopes not exceeding 1 percent.

The first 3 miles of the southern branch would have a negative slope of 1.5 to 2 percent, tapering off to less than 1 percent about 9 miles from the apex. Near the end of the southern branch, there is a section of 3 miles where the gradient is very slight. The last mile of the branch has a positive grade of slightly less than 1 percent.

No perennial streams are found in the site, and there are only three major drainages. Black Mountain Draw is the central drainage of the large valley in which the site is situated. Except during periods of heavy rainfall, the water is confined to a narrow ditch. Adjacent to the ditch, there are local ponding areas which tend to collect local rainfall and also to prevent sheet flow from reaching the ditch until the ponding areas overflow.

Ninetysix Creek, which is the largest drainage at the site, runs through the central part of the area in a southwesterly direction. Near the apex, the stream canyon is over 1000 feet wide and about 50 feet deep. The present stream bed normally covers only a small part of the canyon bottom, although water may cover the entire canyon bottom during periods of flooding. Burro Cienega would also carry substantial flows during flood periods. It has a width of approximately 600 feet and a depth of about 40 feet.

In addition to the drainages mentioned above, there are many others, particularly along the northwestern branch. The stream canyons are typically narrow and have sandy bottoms. A visual inspection of the area gives the impression that these drainages seldom receive enough water to maintain a surface flow. Within three to four miles from the edge of the mountains, this type of drainage rapidly disappears as the slope decreases.

During periods of heavy rainfall, sheet flooding will occur in the areas of intermediate elevation. Protection against this type of flow can be provided by a combination of channelization and adequate embankment heights.

Along the northwestern branch embankment heights of 1 to 2 feet should suffice if adequately large culverts are emplaced to carry the expected flood flows beneath the roadway. Substantial fills will be required to minimize the grade of the roadway along the first 6 miles of the northeastern branch. In addition, an average embankment height of 1 to 2 feet should be maintained. A height of 1 to 2 feet should also be satisfactory along the southern branch except for a stretch of about 3 miles where the Black Mountain Draw is crossed, where a 3-foot embankment would be required.

5. Railway

The top 3 inches will have to be stripped from the ground surface in order to remove existing vegetation prior to emplacing the embankment material.

6. Access road

The total length of all access roads for Y22 is 6 miles. The entrance road from the highway is 3.7 miles long. The access road from the building complex to the staging area will be 3700 feet long.

7. Airstrip

The airstrip will run approximately southwest-northeast to face the prevailing wind. It will be 150 feet wide, with a paved runway 75 feet wide and 5800 feet long. The length of the runway is determined by the altitude (4700 feet above sea level) and the mean maximum temperature (92° F).

8. Water supply

The source of the water supply is an underground aquifer which will be tapped by a 10-inch diameter well cased to 8 inches. Delivery of the water will be by an electric, submersible centrifugal pump in the well. The pumped water is conveyed by pipe to an elevated 65,000-gallon storage tank. This tank will contain a three-day domestic supply and 50,000 gallons of water for fire delivered at the rate of 400 gallons per minute for a two-hour duration. Distribution from the storage tank is by gravity through a chlorinator and zeolite filter prior to consumption at the building complex.

A study of the water resources of the area has been made by the U.S. Geological Survey. There are several wells near the apex of the site, but most are stock wells and very little information is available concerning the production capabilities, aquifiers, and water levels.

A well drilled near the apex could be expected to yield 5 to 50 gallongs per minute and the water table probably would be at a depth of less than 100 feet. The alluvial material and possibly the Gila Conglomerate form the potential aquifer, and these units wedge out against the granite core of the Burro Mountains about 3 miles to the north. It is possible that higher yields can be obtained from wells drilled at a greater distance from the bedrock outcrops.

Quality of the ground water varies from satisfactory to marginal. The total dissolved solids probably would not exceed 600 ppm, but some wells in the region have sulphate contents at the upper limit of the acceptable scale and the fluoride content frequently exceeds the acceptable limit. At least one well in the region produces water with an abnormally high temperature.

9. Utilities

The Columbus Electric Cooperative, Inc., of Deming, New Mexico, serves the area of Y22. The existing electric service, which goes through Separ, about 4-1/2 miles south of the apex of Y22, is not adequate for the array, and a new line from the substation 8 miles south of Separ would be required. This substation is serviced by a 69 kV line. The distance from the substation to the site is approximately 13 miles, which will require an estimated power line installation cost of $118,000. In addition to the estimated construction cost, which would apparently be borne by the VLA project, there would be a monthly charge estimated at $3000. It appears that a contract could be worked out which would enable the original installation charge to be paid off on a monthly basis by a guarantee of a minimum number of use years.

The area is served by the Mountain States Telephone and Telegraph Company with offices at Lordsburg and Deming, New Mexico.

10. Real estate

The ownership pattern consists of approximately 800 acres of private land, 900 acres of Bureau of Land Management land, and 1150 acres of State land.

There are no serious problems affecting acquisition of the State land or the Bureau of Land Management land. These lands have been valued at $12 per acre (compensating for any damages to the lessee or permittees). Private lands have been valued at $50 per acre, including compensation for damages.

Value conclusion

Private land	
820 acres @ $50 =	$41,000
BLM land	
935 acres @ $12 =	$11,220
State land	
1170 acres @ $12 =	$14,040
TOTAL CALLED	$67,000

G. Site Y23 (Arizona)

This site is located in Pima County, about 40 miles west of Tucson. It lies mostly within the Papago Indian Reservation, in the Aguirre Valley, immediately north of Kitt Peak. The center is 2800 feet above mean sea level, at geographical coordinates 32°05′.0 N, 111°35′.3 W. The branches radiate outward on true azimuths of 355°, 115°, and 235°. A map of the site area is shown in Fig. 5-17, and the branch profiles are displayed by Figs. 5-18, 5-19, and 5-20.

1. General site features

The Aguirre Valley is a broad, sandy area that slopes off to the north with a gradient of slightly less than 1 percent. The apex of the Wye is about 5 miles north of the base of Kitt Peak. Many small drainages cross the area, tending to create a rolling topography.

Both the low altitude federal airway V105 and the low altitude approach pattern for the Tucson Municipal Airport cross this site. There are no railroads near Y23.

The southern border domestic air defense identification zone between the United States and Mexico lies approximately 38 miles south of Y23.

There is no underground nuclear testing which would affect this site.

Arizona Highway 86 is well-aligned, reasonably high-speed, two-lane highway connecting Tucson and Ajo, Arizona. It would be crossed by the southeastern branch of the Wye approximately 6-1/2 miles from the apex. A power line parallels the highway in the area where the southeastern branch crosses.

The southwestern branch lies approximately 2 miles north of Highway 86 and parallels it for a considerable portion of its length. The northern branch does not conflict with any existing roads or utility lines.

The vegetation on the site includes moderately dense stands of tall greasewood along the outer ends of the northern and southwestern branches and moderately dense concentrations of mesquite, paloverde, cat

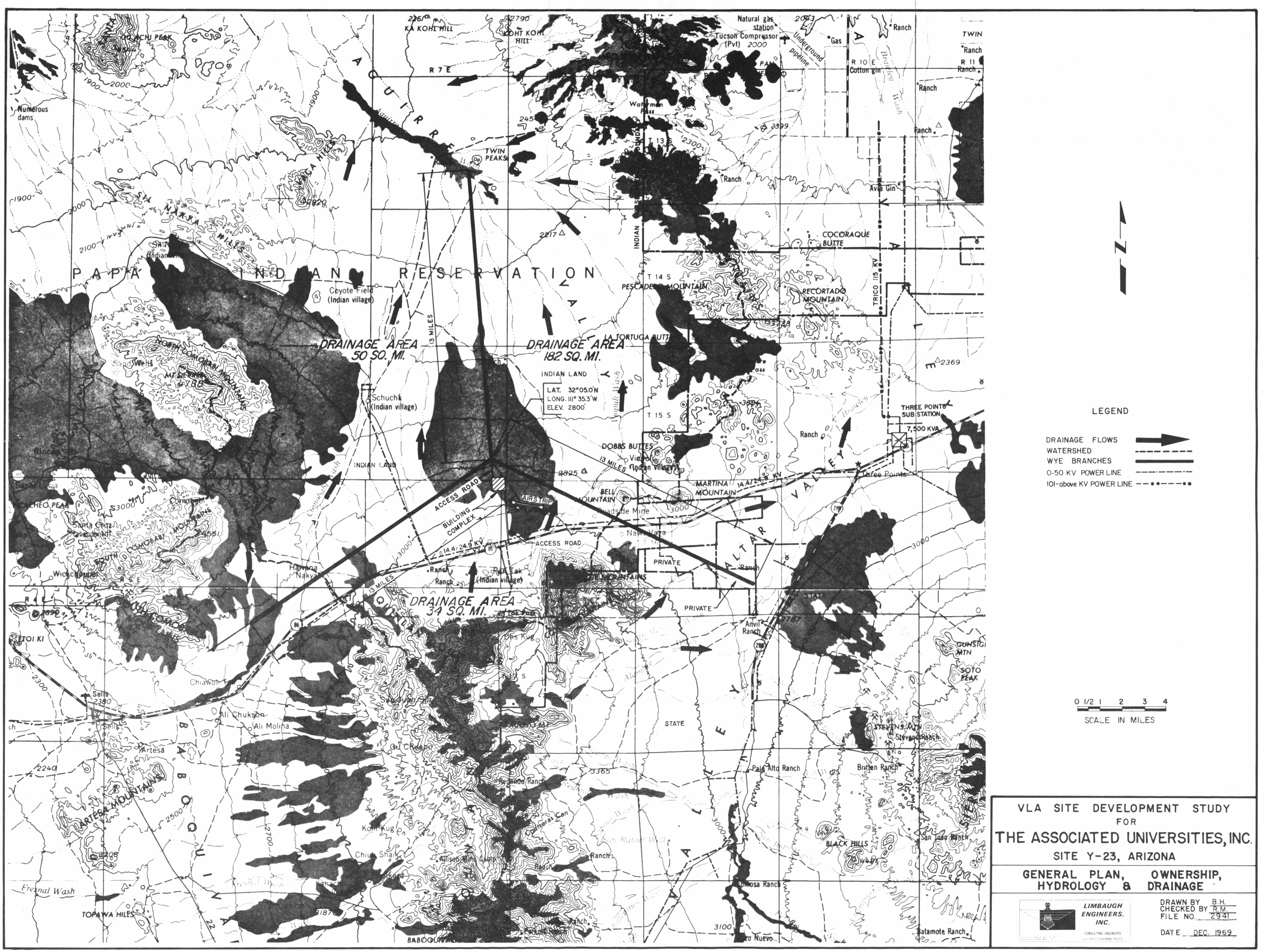
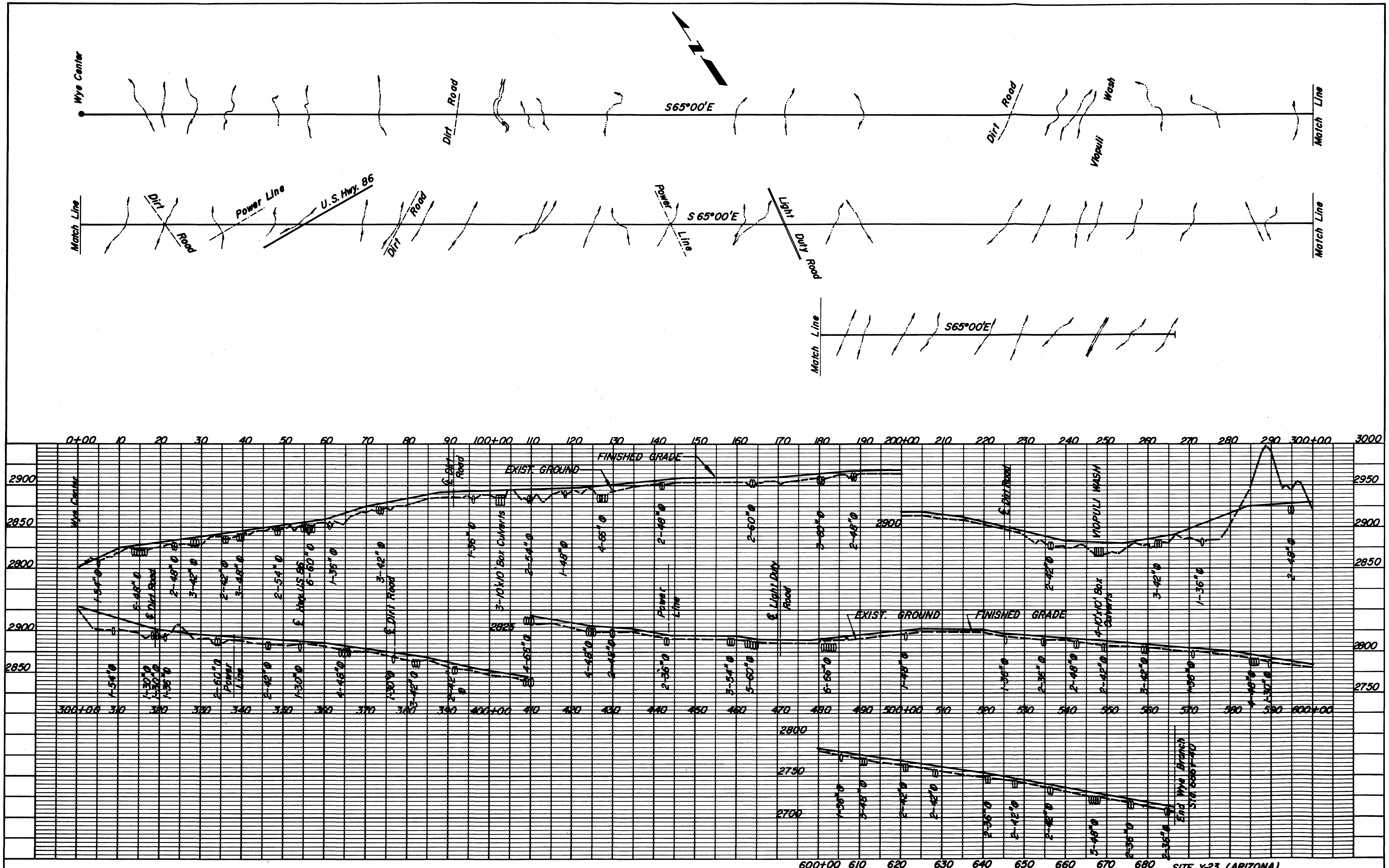

VLA SITE DEVELOPMENT STUDY
FOR
THE ASSOCIATED UNIVERSITIES, INC.
SITE Y-23, ARIZONA
GENERAL PLAN, OWNERSHIP, HYDROLOGY & DRAINAGE
LIMBAUGH ENGINEERS, INC.
DRAWN BY B.H.
CHECKED BY R.M.
FILE NO. 2941
DATE DEC. 1969
LEGEND
DRAINAGE FLOWS
WATERSHED
WYE BRANCHES
0-50 KV POWER LINE
101-above KV POWER LINE
0 1/2 1 2 3 4
SCALE IN MILES
N
PAPAGO INDIAN RESERVATION
DRAINAGE AREA 50 SQ. MI.
DRAINAGE AREA 182 SQ. MI.
DRAINAGE AREA 34 SQ. MI.
INDIAN LAND
LAT. 32°05.0'N
LONG. 111° 35.3'W
ELEV. 2800'
13 MILES
ACCESS ROAD
BUILDING COMPLEX
AIRSTRIP
AGUIRRE VALLEY
ALTAR VALLEY
THREE POINTS SUB STATION
7,500 KVA
TRICO 115 KV
14.4/24.9 KV
PRIVATE
STATE
Coyote Field (Indian village)
Schuchk (Indian village)
DOBBS BUTTES
MARTINA MOUNTAIN
BELL MOUNTAIN
COCORAQUE BUTTE
RECORTADO MOUNTAIN
PESCADERO MOUNTAIN
LA TORTUGA BUTTE
TWIN PEAKS
KA KOHL HILL
Natural gas station
Tucson Compressor (Pvt)
Underground pipeline
Waterman Pass
Avra Gin
Three Points
Anvil Ranch
Sells
Ali Chukson
Ali Molina
Artesa
ARTESA MOUNTAINS
TOPAWA HILLS
Fresnal Wash
BLACK HILLS
STEVENS MTN
Palo Alto Ranch
Britten Ranch
San Juan Ranch
Batamote Ranch
Allison Mine Camp
Redondo Ranch
Numerous dams

Fig. 5-17



Wye Center
S65°00'E
Dirt Road
Wash
Vlopuli
Match Line
Power Line
U.S. Hwy. 86
S 65°00'E
Light Duty Road
S65°00'E
EXIST. GROUND
FINISHED GRADE
3-10'x10' Box Culverts
VLOPULI WASH
4-10'x10' Box Culverts
End Wye Branch
SITE Y-23 (ARIZONA)

Fig. 5-18

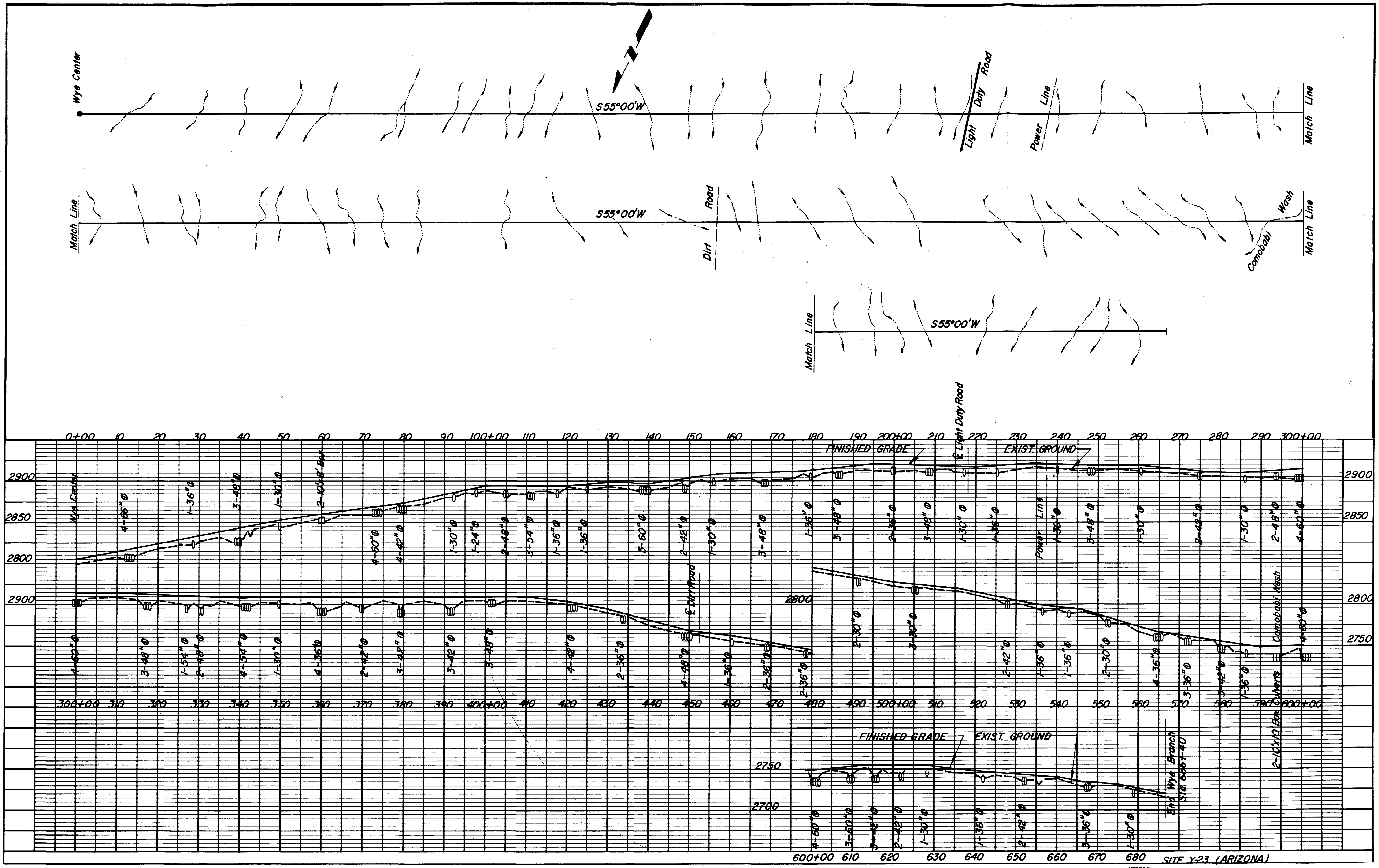

Wye Center
S55°00'W
Light Duty Road
Power Line
Match Line
Dirt Road
Comobabi Wash
FINISHED GRADE
EXIST. GROUND
End Wye Branch Sta 6667+40
SITE Y-23 (ARIZONA)
LIMBAUGH ENGINEERS, INC

Fig. 5-19

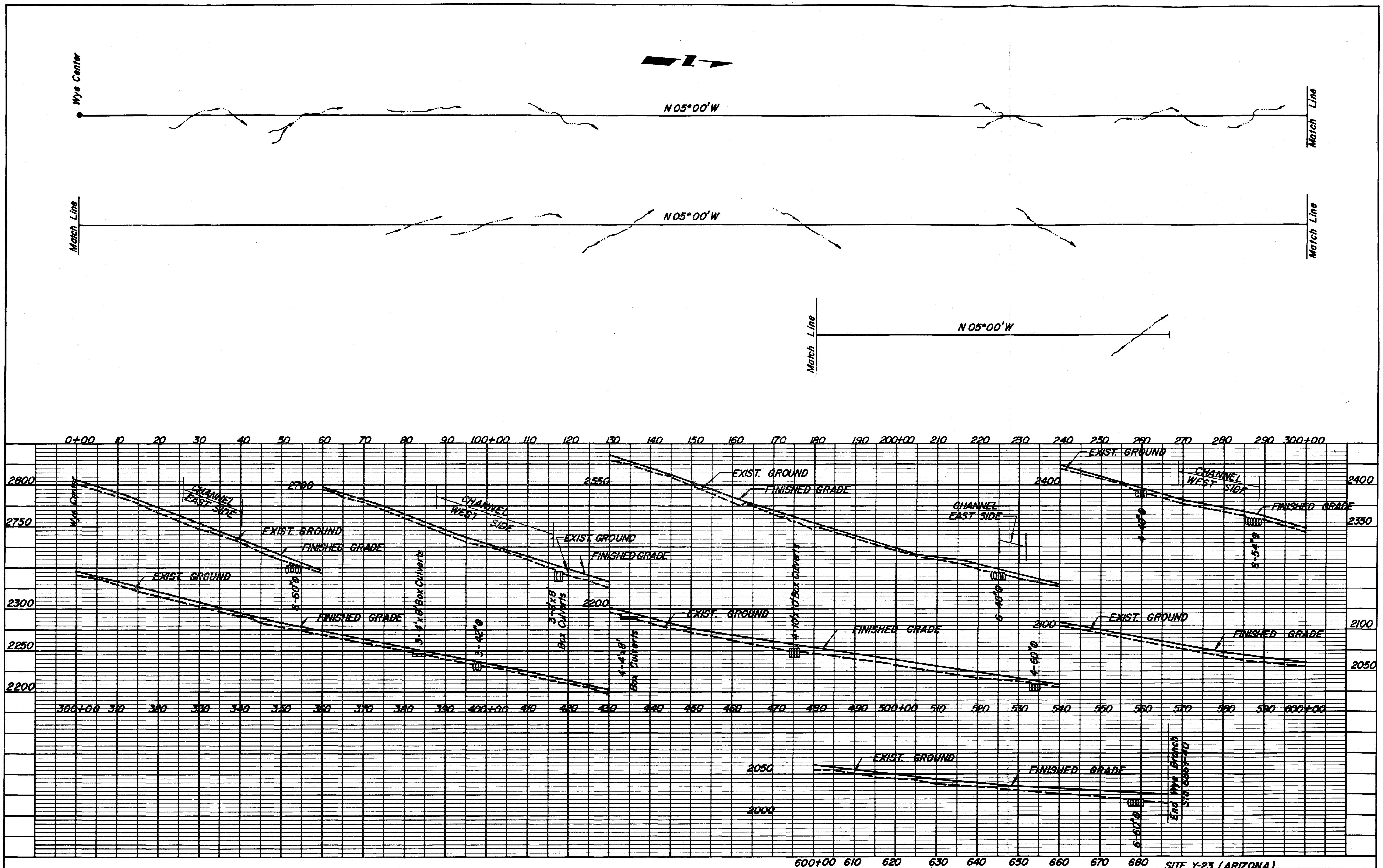

Wye Center
N 05°00'W
Match Line
EXIST. GROUND
FINISHED GRADE
CHANNEL EAST SIDE
CHANNEL WEST SIDE
6-60"Ø
3-4'x8' Box Culverts
3-42"Ø
3-8'x8' Box Culverts
4-4'x8' Box Culverts
4-10'x10' Box Culverts
6-48"Ø
4-60"Ø
4-48"Ø
6-54"Ø
End Wye Branch Sta. 683+40
SITE Y-23 (ARIZONA)

Fig. 5-20

claw bushes, and Saguaro cactus elsewhere. In many areas, including the apex, visibility is restricted to approximately 200 feet by thick stands of vegetation reaching about 20 feet in height. The only grassland of consequence occurs on the King Ranch and on the Papago Hereford Ranch where the native vegetation has been removed.

The nearest railhead is in Tucson, where the Southern Pacific Railroad provides direct or connecting service to all major rail centers.

The airport in Tucson provides the nearest airline service. Air West, American, TWA and Frontier Airlines provide frequent flights, including jet service to New York, Chicago, Houston and the West Coast. Aeronaves de Mexico offers daily flights to major cities south of the border, terminating in Mexico City.

The closest existing small airstrip is at Sells, Arizona, where there is a 2700 foot dirt runway.

The town of Sells, the nearest settlement of any size, is the headquarters of the Papago Indian Agency, Bureau of Indian Affairs, Department of the Interior. The population of Sells is approximately 750, mostly Papago Indians. The Bureau of Indian Affairs maintains a small hospital in Sells and there are a limited number of general merchandise stores, filling stations, grocery stores, etc., to support the inhabitants themselves as well as the populace of the surrounding countryside. The Sells school comprises grades one through ten.

Tucson, 40 miles east of the site, has a population in excess of 300,000. It is an old historic city, established in 1776, and still retaining the flair of its Spanish and Mexican heritage. There is a good selection of restaurants, hotels, motels, apartments, and housing developments which could more than adequately provide for the permanent and temporary personnel assigned to the VLA.

The public school system in Tucson is considered one of the finest in the country, providing curricula in both general and college preparatory courses. In the greater Tucson area, there are eight senior high schools and 88 junior high and elementary schools. There are four parochial senior high schools and twenty elementary and junior high schools. In addition, the highly accredited University of Arizona in Tucson has an enrollment of more than 21,000 students in its 16 colleges and schools.

Tucson has five large community hospitals with specialists in many fields of medicine practicing in the area. It also has a wide variety of churches, civic groups, recreation opportunities for both active and spectator sports, art museums, banking and stock brokerage firms, and shopping facilities.

As could be expected in a city the size of Tucson, there is an adequate supply of skilled labor. Construction worker wages are $5.60 per hour; however, the construction trades are highly unionized and require portal to portal pay when working outside of Tucson.

2. Climatology

The climate at the Y23 site is similar to that of Tucson. The average daily maximum temperature is 81.4° F and the average daily minimum is 58.6° F. The record high temperature is 117° F and the record low is 19° F. The average yearly precipitation is 12.8 inches, with a maximum of 6.0 inches falling in any one day or 6.30 inches falling in any one month in the last 24 years. The area is subject to local extremely heavy downpours. During one such storm, in September 1962, over six inches of rain fell on the site in a three day period.

The average relative humidity is 44 percent. The sunshine averages 86 percent of the possible maximum. The maximum wind velocity reported in the last 18 years was 58 mph, with a maximum 50-year expectancy of 67 mph. Average wind velocity is 7.8 mph. Tornadoes are almost nonexistent in the area, although there was one in the Tucson area in 1964. In the past 25 years, there has been an average of 35 thunderstorms per year. These thunderstorms produce infrequent hail, and the maximum size reported was 1/2 inch.

The area is occasionally dusty, as can be expected in a relatively arid climate.

3. Geology and foundation investigation

The site is situated primarily within the upper part of the Aguirre drainage system, although the southwestern and southeastern branches of the Wye extend into the Baboquivari and Altar Valley drainages.

The apex lies on a sloping alluvial surface at an elevation of about 2800 feet. The valley is ringed on three sides by mountains that reach elevations of up to 6875 feet. The North and South Comobabi Mountains border it on the west, the Roskruge Mountains form the eastern boundary and on the south it is bounded by the Quinlan Mountains (which include Kitt Peak). To the north, the Aguirre Valley is open and slopes off at about 50 feet per mile.

The pre-Tertiary formations in the area west of Tucson have a predominant northwesterly alignment. This is reflected in both the faulting pattern and the geological outcrop pattern. The area has been considerably affected by faulting, folding, and the intrusion of various types of igneous bodies, some of which have been emplaced as recently as Tertiary time.

The Tucson area is subject to periodic weak earth tremors. The last reported earthquake which caused extensive damage to buildings occurred in 1877; however, it is believed by experts that strong, damaging earth tremors (possibly accompanied by earth fracturing) could occur in the Tucson area at some time in the future. There are no known active faults in the area at the present time.

In recent geologic time, the region has undergone extensive erosion that has carved deep valleys and then filled them with up to a depth of several hundred feet with sand and gravel. Most of the Cretaceous and Tertiary strata have been removed from the upland areas by erosion, contributing thereby a large percentage of the alluvial deposits.

Good quality, angular, well graded, relatively clean sand can be obtained from the surficial deposits that underlie much of the area covered by Y23.

The sandy material is comprised primarily of decomposed granite derived from the Quinlan and Coyote Mountains. The best source for sand would be the alluvial deposits that radiate outward from these mountains.

Quaternary terrace deposits are the best source of gravel. Good exposures of this material occur in road cuts along State Highway 86 about 7.5 miles southwest of Kitt Peak Junction. The material is up to 20 feet thick and lies directly on a truncated bedrock surface. It is a light brown to light gray, moderately consolidated, conglomerate with 3 to 4 feet lenticular beds containing up to 70 percent well-graded gravel. The matrix is silty sand with calcium carbonate veining. The conglomerate clasts generally are sub-rounded and average 3 to 4 inches in size, but occasionally are as large as 14 inches in maximum dimension. The thin intercalated sandstone beds are composed of silty sand containing up to 15 percent fines. The conglomerate probably could be crushed satisfactorily to make concrete aggregate.

Other exposures of this material occur extensively along the east side of the Baboquivari Valley, but in many places the conglomerate constitutes such a thin veneer over the bedrock that excavation would not be feasible.

Scattered deposits of the terrace material also occur north of Kitt Peak, and although they appear to be thin and discontinuous, a test drilling program might locate a pit area of satisfactory size within 4 miles of the Y23 apex.

The best source for crushed rock is in the low hills just east of Sells. The rock is a hard, greenish-gray andesite that has been moderately well fractured. There is a minor amount of alteration in some areas. The most centrally located source for crushed rock would be near the point where the southeastern branch crosses State Highway 86. The rock is a greenish-gray andesite rather similar to that in the Sells area, but the amounts of fracturing and alteration are somewhat greater, suggesting that there would be considerably more waste in the quarrying operation.

About 6 miles northwest of the apex, there are two isolated hills underlain by hard, black basalt. The rock is very resistent and possibly would be difficult to break into fragments small enough for crushing.

Moderately good aggregate can be obtained by crushing gravel from the terrace deposits. The angularity of the aggregate would not be nearly as good as that from one of the sources of crushed rock.

No clay deposits of good quality were located in the Y23 area; however, a silty clay with medium plasticity and moderate dilatancy occurs along State Highway 86 about 3 miles east of Sells. The permeability of the silty fraction might make necessary the addition of sealing compounds in order to use the silty clay as a pond lining.

Additional test drilling and laboratory testing will be necessary in order to determine the extent of usable deposits and the quality of the material for various applications.

Visual inspections were made of the soils, vegetation, and drainage features along each of the branches of Y23. In addition, six test holes were drilled in order to study the subsurface soil characteristics.

In the vicinity of the apex, the soil is a rather cohesionless silty sand consisting primarily of granitic detritus. This type of material will require a moderate amount of compaction during roadway construction. Some caving probably will occur in the upper part of the footing excavations. About 5 miles north of the apex, the soil contains considerably more fines and is therefore more cohesive. The percentage of clayey and silty material appears to increase progressively outward along the northern branch of the Wye until the Aguirre Wash is reached. Surfician silt is widespread as a result of periodic flooding in the low areas.

Along the southeastern branch, sandy soil prevails throughout most of the section from the apex to State Highway 86. About 2 miles from the highway, it crosses bedrock exposures of fractured andesite. The andesite outcrops are continuous for almost the entire distance to the highway. Blasting will be required along at least 1000 feet of the line during the roadway construction; however, because the roadway design is quite flexible, it might be more practical in most places to construct a shallow fill section over the bedrock.

The southwestern branch of Y23 is underlain by soils grading from sandy at the apex to moderately cohesive silty and clayey sand at the southwestern extremity. Gravel is present in varying amounts along the middle of this branch as a result of reworking of the Quaternary terrace deposits exposed along the valley perimeter. About 3 miles southwest of the village of Haivana Nakya, this branch crosses a low area within the upper reaches of the Sells Wash. The soil is stable when dry, but there are indications that silt has accumulated in the area because of flooding in recent years.

During the field work in September 1966, there were heavy rains that rendered much of the rugged, gullied terrain of the northern branch impassable to 4-wheel drive vehicles. This was particularly true of the area adjacent to Aguirre Wash, where thick silt deposits have been built up. Flash flooding was common along the highway between Tucson and Sells, and unpaved roads were so muddy as to be nearly impassable.

Three test holes drilled adjacent to the southwestern branch of Y23 encountered silty sand with some intercalated beds of silty, sandy gravel and silt. The highest gravel percentage was about 40; however, the actual percentage probably is somewhat higher as the small diameter of the auger did not permit the larger clasts to be sampled. The penetration resistance tests in the three holes showed a blow count per foot of from 20 to 44 at a depth of 2 feet, from 12 to 26 at 5 feet with refusal in one hole, and 34 at 10 feet with refusal in two holes.

Three test holes were drilled along the southeastern branch of Y23 and the soils in these holes were predominantly silty sand with minor amounts of fine gravel. A hole near State Highway 86 was drilled through clayey deposits that probably are an alteration product of the andesite bedrock that crops out to the northwest. The penetration resistance tests showed a blow count per foot of 18 to 52 at a depth of 2 feet, 13 at 5 feet with refusal in two holes, and 12 at 10 feet with refusal in two holes.

No test holes were drilled along the northern branch because access was denied at the time the drilling program was performed.

Mineral activity in the Y23 site area is minimal at the present time although several copper, manganese and tungsten prospects are located on the northeastern and southwestern flanks of Kitt Peak. The tungsten deposits, which occur about 12 miles southwest of the apex, have the greatest potential for future development. A large group of active mines is about 24 miles north of the apex.

4. Topography and drainage

The ground elevation along the northern branch has a differential of 735 feet. This occurs as a gradual decline from the intersection of the Wye to station 686+40 at Aguirre Wash. The surface of the ground along the axis is broken by occasional washes although the drainage flow is in the same general direction as the branch.

Drainage protection for the northern branch will require that the railway surface be elevated above the existing ground for the entire length. The embankment will need erosion protection on the upstream side. It must be noted that this branch will be inundated for most of its length during a flood of the magnitude of the one in September 1962. Diversion channels and dikes must be constructed at several areas along this branch to assist in flood control.

The drainage requirements on this branch are: four 10 foot by 10 foot, three 8-foot by 8-foot, and seven 8-foot by 4-foot box culverts; three 42-inch diameter, ten 48-foot diameter, six 54-inch diameter, and sixteen 60-inch diameter pipe culverts.

The southeastern branch is crossed by washes and gullies which carry the runoff from the Coyote Mountains. Erosion protection will be required along the upstream side of the embankment from station 640+00 to station 686+40.

The drainage requirements for the southeastern branch are: seven 10 foot by 10 foot box culverts, five 30-inch diameter, seventeen 36-inch diameter, thirty-one 42-inch diameter, forty-five 48-inch diameter, nine 54-inch diameter, eighteen 60-inch diameter, and fourteen 66-inch diameter pipe culverts.

The southwestern branch crosses many well-defined washes and gullies carrying drainage from the Quinlan Mountains and the Comobabi Mountains. The largest is the Comobabi Wash at station 592+00, just above its junction with Sells Wash. The Comobabi Wash may be subject to flooding from heavy precipitation. It is interesting to note that the Sells Wash developed 17,200 cubic feet per second peak discharge at the village of Sells during the September 1962 flood.

The drainage demand on this branch is: two 10 feet by 8 feet, and two 10 feet by 10 feet box culverts; one 24-inch diameter, nineteen 30-inch diameter, thirty-five 36-inch diameter, thirty-two 42-inch diameter, thirty-one 48-inch diameter, eight 54-inch diameter, seventeen 60-inch diameter, and four 66-inch diameter pipe culverts.

Channels and dikes will be required to assist in drainage control for sections of the northern branch and the southeastern branch of Y23. The erosion protection will be provided by gabions, riprap and fencing.

5. Railway

The top 12 inches will have to be stripped from the ground surface in order to remove existing vegetation prior to emplacing the embankment material. It is expected that the last 12 observing stations on the northern branch will require special study, in view of the deteriorating foundation conditions in and near the Aguirre Wash.

6. Access roads

The total length of all access roads for Y23 is 21,350 feet. The entrance road from the highway is 14,800 feet long. Drainage is provided by one 30-inch diameter, four 42-inch diameter, four 48-inch diameter, and one 54-inch diameter pipe culverts.

7. Airstrip

The airstrip will run approximately west-northwest to face the prevailing wind. The landing strip will be 150 feet wide with a paved runway

75 feet wide and 4200 feet long. The length of the runway is determined by the altitude (2900 feet above sea level) and the mean maximum temperature (100° F). Airstrip drainage is provided with one 42-inch diameter, two 72-inch diameter, and three 84-inch diameter pipe culverts.

8. Water supply

The source of the water supply is an underground aquifer which will be tapped by a 10-inch diameter well cased to 8 inches. Delivery of the water will be by an electric, submersible, centrifugal pump. The pumped water is conveyed by pipe to an elevated 65,000 gallon storage tank. This tank will contain a three-day domestic supply and 50,000 gallons of water for fire delivered at the rate of 400 gallons per minute for a two-hour duration. Distribution from the storage tank is by gravity through a chlorinator and zeolite filter prior to consumption at the building complex.

The aquifer in the Aguirre Valley is estimated to occur at a depth between 400 feet and 700 feet, with a subsurface flow to the north. The drainage divide between the Aguirre Valley and the Baboquivari Valley is roughly along an east-west line just north of the village of Haivana Nakya.

Potable water in sufficient volume to fulfill the site requirements probably can be obtained in the vicinity of the apex from a well drilled to a depth of from 600 to 800 feet. Water supply prospects are less favorable to the southeast as the water-bearing strata apparently wedge out south of the Haivana Nakya area.

9. Utilities

Electric power in the vicinity of Y23 is supplied by Trico Electric Cooperative, Inc., Tucson, Arizona.

The Cooperative presently has a 25 kV, 3 phase power line along State Highway 86, approximately 2.5 miles south of the planned building complex. This 25 kV distribution circuit feeds from a 7.5 kVA substation at Three Points. The Three Points voltage is regulated by a TCUL transformer. The substation is served by a 115 kV transmission line owned and operated by Trico.

It would cost \$34,000 to extend their present system to the building complex, including the required transformers and circuit breakers. They propose that AUI pay Trico this sum as a refundable connection charge prior to the construction of the line. This cost then would be refunded at a rate of 15 percent of each monthly bill on the amount the bill exceeds the minimum charge. The monthly minimum charge will be \$0.75 per kVA of installed transformer capacity.

Trico is under the jurisdiction of the Arizona Corporation Commission and the approved large power rate is as follows:

Demand Charges

\$1.75 per month per kW of billing demand

Plus Energy Charges

\$0.02 per kWh for the first 50 kWh used per month per kW of billing demand.

\$0.015 per kWh for the next 100 kWh used per month per kW of billing.

\$0.008 per kWh for all remaining kWh used per month.

Telephone service in the general area is provided by the Mountain States Telephone and Telegraph Company, a part of the Bell System. They will construct the required facilities into the site with no financial contribution by AUI.

10. Real estate

With the exception of approximately 4.4 miles of the southeastern branch of the Wye, all of the proposed site is within the Papago Indian Reservation. About 4.2 miles of the Wye outside of the Indian Reservation is on land privately owned by the King Ranch. The other 0.2 miles is owned by the State of Arizona.

Land sales are quite active between Tucson and Three Points (junction of State Highway 86 and State Highway 286), with several sales as high as \$350 per acre in lots of approximately 1000 acres. There have been no sales west of Three Points within recent years; however, it is reasonable to assume that approximately $150 per acre would be required to purchase this land.

The customary lease of state land for grazing purposes is 50 cents per animal unit month; estimating this land to carry approximately 6 to 10 head of livestock per year per section would indicate about 10 cents per acre per year average lease for grazing purposes. However, it is expected that a facility such as the VLA would require approximately 30 cents per acre per year to effect negotiations with the State Land Commissioner or $20.66 per mile of right of way 600 feet wide. It is also estimated that this figure would be the value of the right of way needed on the Indian Reservation.

If private land is to be acquired for this facility, it is estimated that the lease on this land could not be negotiated for less than $1.00 per acre per year and might even be higher.

Portion to be Purchased		
Private Land		
301 acres @ $150 =		$45,150.00
State Land		
28 acres @ $10 =		$ 280.00
	TOTAL	$45,430.00
	CALLED	$46,000.00
Portion to be Leased		
1349 acres @ $20 =		$26,980.00
1253 acres @ $0.30 =		$ 375.90
	TOTAL	$27,355.90
	CALLED	$28,000.00
TOTAL LEASE AND PURCHASE		$74,000.00

8. Site Y27 (Texas)

This site lies in Presidio and Jeff Davis Counties, some 23 miles west of Marfa. The center is 4535 feet above mean sea level, at geographical coordinates 30°26!4 N, 104°23!4 W. The branches lie on true azimuths 356°, 116°, and 236° from the center. A map of the site area is given in Fig. 5-21, and the branch profiles are shown on Figs. 5-22, 5-23, and 5-24.

1. General site features

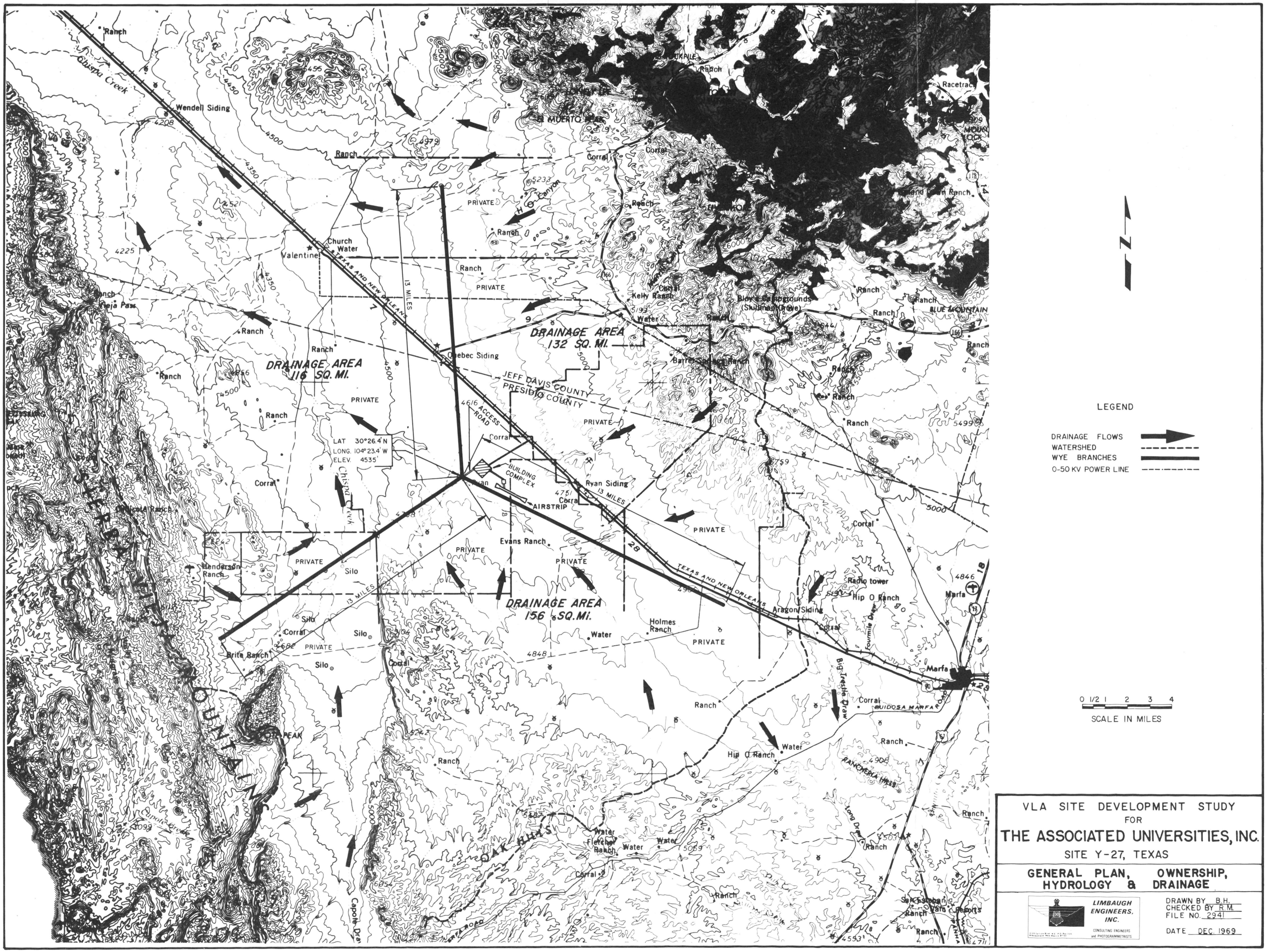
The site includes topography ranging from generally sloping plains to low foothills. In the latter areas, the vegetation types are controlled by the soil types. Where volcanic rock occurs at or near the surface, as in the central part of the northern branch and the end of the southwestern branch, the foothills are covered by sparse to moderate dense stands of greasewood growing up to four feet in height. In places where alluvial deposits occur, there is a moderately dense cover of low grass dotted with scattered yucca.

The plains areas are covered by grass varying from low and sparse in dry areas to knee deep and very thick in moist areas. Most of the southwestern and southeastern branches cross this type of grassland. The central portion of the southeastern branch crosses several low ridges underlain by gravel deposits. In these areas, there is a moderate covering of mesquite bushes with scattered yucca.

The Texas and New Orleans Railroad (single track) intersects the northern branch of the Wye at a point approximately 4-1/2 miles from the apex. This same railroad parallels the southeastern branch of the Wye at a distance of less than one-fourth mile for approximately the last 3-1/2 miles of its length.

U.S. Highway 90 intersects the northern branch at a point approximately 4-1/2 miles from the apex. State Road 166 intersects the northern branch at a point approximately 5 miles from the apex.

The site lies within 40 miles of the southern border Domestic ADIZ (Air Defense Identification Zone) between the United States and Mexico. There is no underground nuclear testing that would affect this site.



VLA SITE DEVELOPMENT STUDY
FOR
THE ASSOCIATED UNIVERSITIES, INC.
SITE Y-27, TEXAS
GENERAL PLAN, OWNERSHIP, HYDROLOGY & DRAINAGE
LIMBAUGH ENGINEERS, INC.
CONSULTING ENGINEERS and PHOTOGRAMMETRISTS
DRAWN BY B.H.
CHECKED BY R.M.
FILE NO. 2941
DATE DEC. 1969
LEGEND
DRAINAGE FLOWS
WATERSHED
WYE BRANCHES
0-50 KV POWER LINE
0 1/2 1 2 3 4
SCALE IN MILES
N
DRAINAGE AREA 116 SQ. MI.
DRAINAGE AREA 132 SQ. MI.
DRAINAGE AREA 156 SQ. MI.
LAT 30°26.4' N
LONG. 104°23.4' W
ELEV. 4535'
13 MILES
ACCESS ROAD
BUILDING COMPLEX
AIRSTRIP
JEFF DAVIS COUNTY
PRESIDIO COUNTY
TEXAS AND NEW ORLEANS
Valentine
Wendell Siding
Quebec Siding
Ryan Siding
Aragon Siding
Marfa
Evans Ranch
Holmes Ranch
Henderson Ranch
Brite Ranch
Hip O Ranch
Kelly Ranch
Fletcher Ranch
Chispa Creek
Capote Draw
Big Tessie Draw
Radio tower
PRIVATE
OAK HILLS
RANCHERIA HILLS

Fig. 6-21

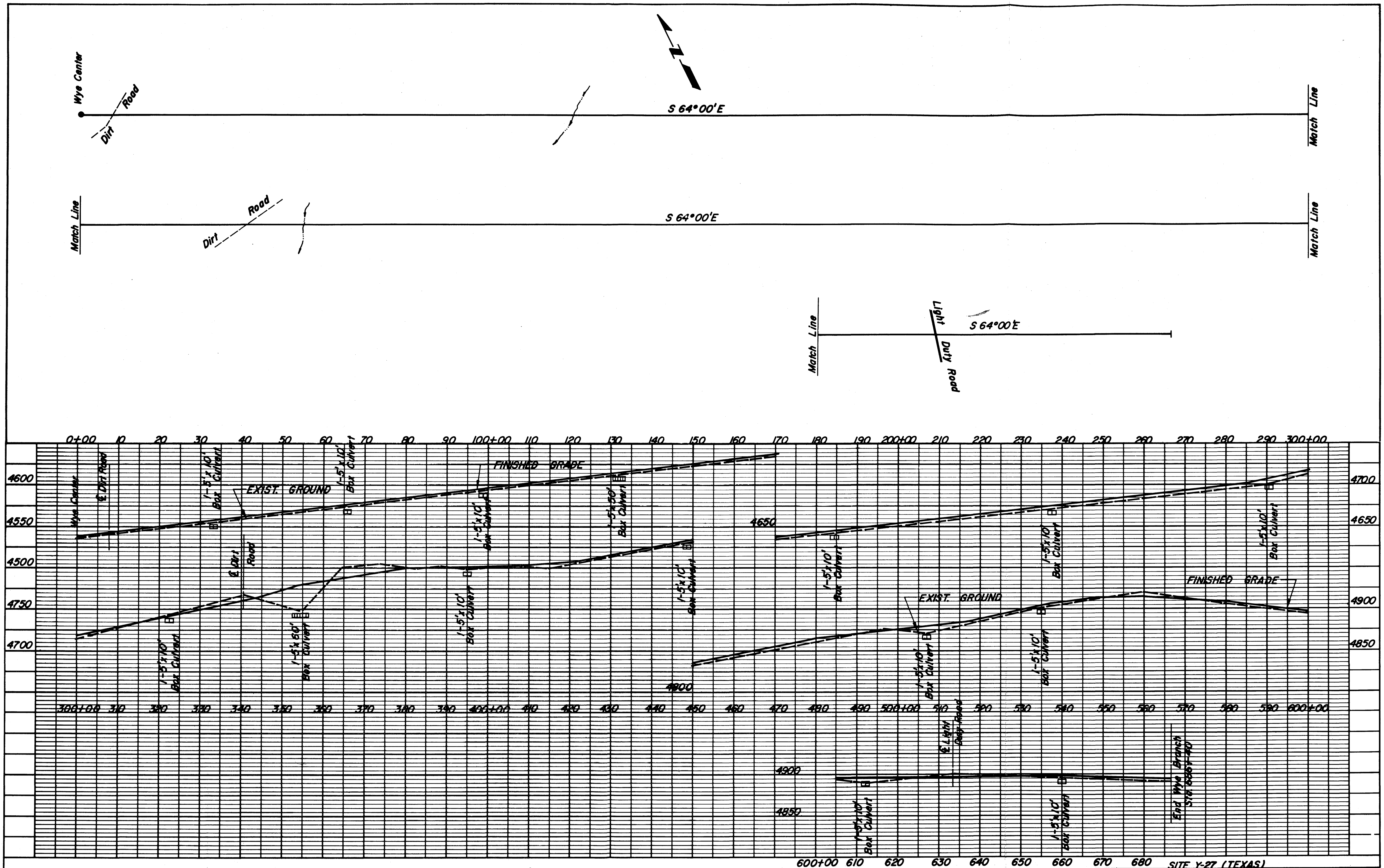
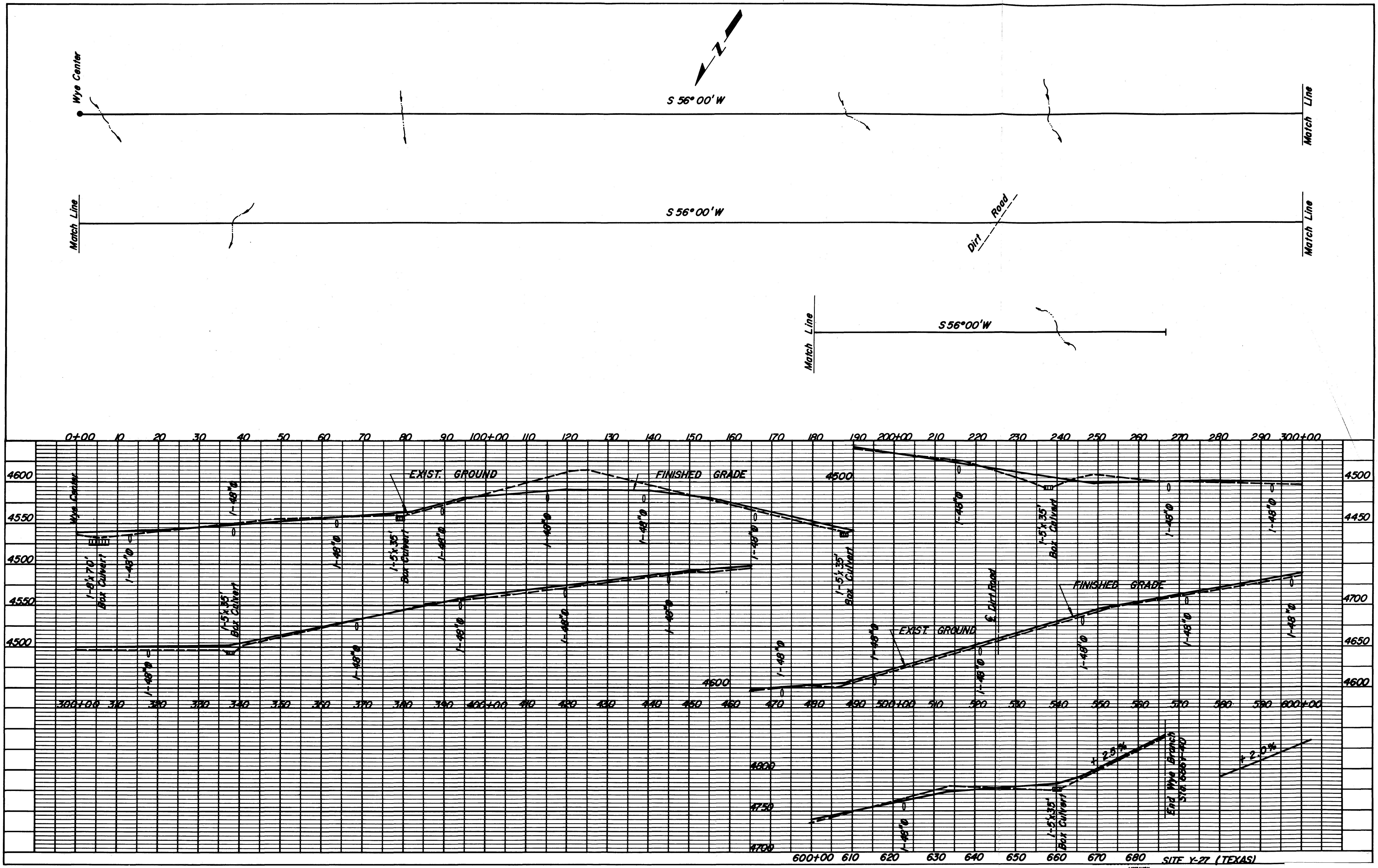
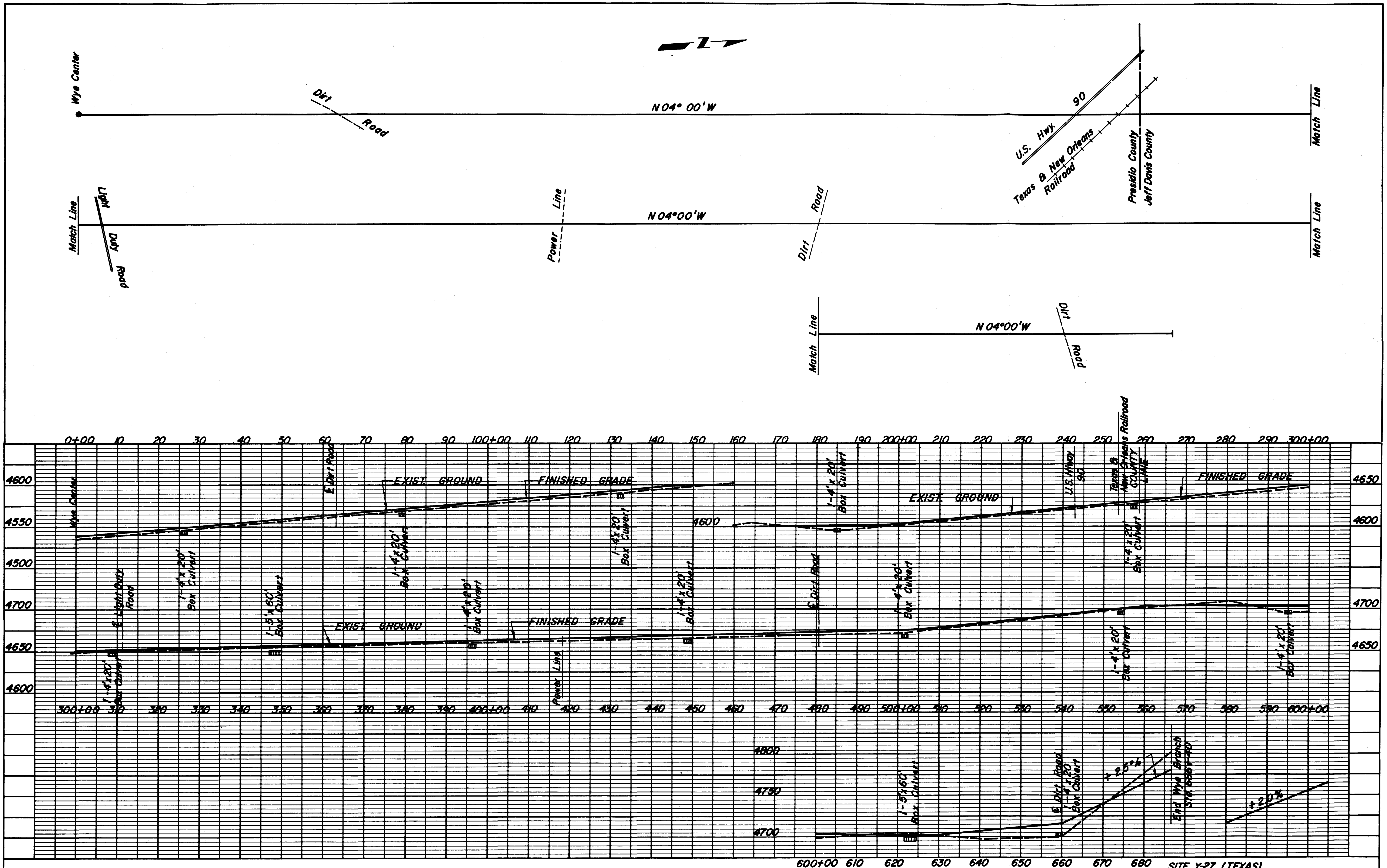

Wye Center
Dirt Road
S 64°00'E
Match Line
Light Duty Road
FINISHED GRADE
EXIST. GROUND
1-5'x10' Box Culvert
1-5'x60' Box Culvert
℄ Dirt Road
℄ Light Duty Road
End Wye Branch Sta 683+40
SITE Y-27 (TEXAS)

Fig. 5-22



Wye Center
S 56° 00' W
Match Line
Dirt Road
EXIST. GROUND
FINISHED GRADE
1-8'x70' Box Culvert
1-5'x35' Box Culvert
1-48"0
4600
4550
4500
4450
4700
4650
4800
4750
End Wye Branch Sta 686+40
+2.5%
+2.0%
SITE Y-27 (TEXAS)

Fig. 5-23



Wye Center
Dirt Road
N 04° 00' W
U.S. Hwy. 90
Texas & New Orleans Railroad
Presidio County
Jeff Davis County
Match Line
Light Duty Road
Power Line
N 04°00'W
Dirt Road
EXIST. GROUND
FINISHED GRADE
1-4' x 20' Box Culvert
1-5' x 60' Box Culvert
℄ Dirt Road
℄ Light Duty Road
U.S. Hiwy 90
Texas & New Orleans Railroad
COUNTY LINE
+2.5%
+2.0%
End Wye Branch Sta. 680+40
SITE Y-27 (TEXAS)
LIMBAUGH ENGINEERS, INC.

Fig. 5-24

U.S. Highway 90 is a good, high-speed, two-lane roadway which is being increased to four-lane in a number of sections between the site and El Paso, 165 miles to the west.

As noted above, the Texas and New Orleans Railroad passes through the array and there is a rail siding approximately five miles east of the apex.

Marfa, with a population of 3000, is the nearest town, 23 miles east of the apex. It is served by the Texas and New Orleans Railroad and Continental Trailways Bus Line, but there are no scheduled airlines operating from the small municipal airport. The nearest available commercial air service is in Midland, Texas, which is 150 miles away. However, charter air service is available in Marfa.

The Marfa school system has approximately 800 students. The one high school is accredited by the Southern Association of Colleges and Secondary Schools. The town has a city library and municipal golf course. There are seven churches and several civic clubs. There are two physicians and a private clinic in Marfa, but the nearest hospital is in Alpine, 28 miles farther east. This hospital, the Brewster County Memorial Hospital, has 52 beds. It serves all of Jeff Davis County, Presidio County, and Brewster County. Seven doctors are on the staff and the facilities are considered quite up to date.

Alpine, with a population of 5000, is the home of Sul Ross State College, which offers a four year curriculum in the arts, education and science fields. Alpine seems to be the cultural center in the area. Housing availability could probably absorb 25 families.

Fort Davis, which is 21 miles north of Marfa, has a population of slightly over 1000. It is the closest town to the McDonald Observatory on Mount Locke and also the Harvard Air Force Radio Observatory at Cook Flat.

It is expected that skilled labor would have to be drawn from a wide area for the construction and operation of the VLA facility. As an example of wage scales in the Midland, Texas area, construction workers receive $5.10 per hour base rate.

2. Climatology

The average daily maximum temperature is 82.5° F, with an average daily minimum temperature of 57.3° F. The record high and low temperatures are 111° F and -5° F, respectively. The prevailing wind direction is from the southeast with an average velocity of 10.4 mph and a maximum 50-year expectancy of 67 mph. The sun shines 67 percent of the possible time through the year. There are fairly severe dust storms several times per year. The greatest daily rainfall recorded is 4.50 inches, and the average annual rainfall is 17.83 inches.

The most interesting aspect of the climatology at site Y27 concerns the incidence and severity of hailstorms recorded within the past nine years. Hailstones from the 1966 storm were "golf-ball" size; in 1965 hail the size of "tennis balls" was recorded; and the 1962 records list hail up to "baseball" size. Hail up to 12 inches in depth was recorded in 1966 and was 4 inches deep in the 1965 storm.

Tornado activity averages one per year.

3. Geology and foundation investigation

The apex of the site is situated about 12 miles southeast of Valentine, Texas in a northwesterly-trending structural and topographic basin of interior drainage that includes parts of Presidio and Jeff Davis Counties. The floor of the basin lies at an average elevation of about 4500 feet.

On the northeast, the basin is bounded by the sawtooth peaks of the Davis Mountains, which rise to elevations in excess of 8000 feet. The Sierra Vieja Mountains are a linear, tilted fault block that forms a prominent barrier on the southwest side of the basin. Peaks in the Sierra Vieja attain elevations of up to 6400 feet. Low drainage divides on the gently sloping valley floor constitute the northwestern and southeastern boundaries of the basin.

Although there may be faulting of small to moderate scale within the basin, it is not readily apparent because of the lack of good outcrops. Some structural instability is indicated by the strong earthquake which occurred on August 16, 1931. The intensity of this tremor, as evidenced by measurements and an evaluation of surface damage, was rated as 8 on a scale of increasing intensity from 1 to 12. In Valentine there was minor cracking of the earth and rather substantial cracking of concrete, brick, and adobe structures.

The mountains surrounding the basin are composed primarily of bedded volcanic flows, tuff and agglomerate with interbedded tuffaceous sandstone and conglomerate, and thick conglomerate beds. The best section of the volcanic rocks is exposed near the Brite Ranch headquarters, where over 1800 feet of white-to-red colored, thick-bedded tuff deposits form a steep mountain face that is capped by about 100 feet of hard, gray rhyolite porphyry. In the Davis Mountains, the volcanic rocks have been intruded by a light gray, medium-grained moderately micaceous granitic rock that appears to be a syenite from its mineral composition.

Overlying the rocks of the volcanic series are old terrace gravels, which in turn are mostly obscured by recent outwash deposits from the local mountains. The alluvial material generally contains gravel in percentages ranging from less than 10 to over 50. Near the center of the basin the deposits become progressively finer grained and consist primarily of silt, clay and sand.

The only local source of sand is from decomposed tuffaceous sand beds. It is doubtful that this would be of any value for use in concrete mixtures because of the unstable glass constituents. Sand could be obtained from local gravel deposits, but the cost of screening and washing the material might be prohibitive. The closest established commercial sources are at Gifford Hill (near Van Horn) and Fort Stockton--distances of 55 and 135 miles, respectively. It is quite possible that other sources outside the Valentine area could be developed, but further investigations would have to be made in order to determine their feasibility.

Gravel suitable for use as base course in road construction can be obtained locally from several places. A U.S. Highway 90 resurfacing project in Jeff Davis County utilized caliche-cemented gravels taken from a pit excavated in a low ridge situated about 4 miles west of Valentine. Laboratory analyses made by the Texas Highway Department show that for 104 tests of stockpile material crushed for use as flexible base, the average liquid limit and plasticity index were 33.5 and 11.7, respectively. The design criteria for this material called for a liquid limit not to exceed 35 and an allowable plasticity index of 12. According to Mr. Andrew Jones of the El Paso District Highway Office, 1 percent lime was added in order to meet the specifications. This step was necessary because of the presence of high plasticity clay lenses within the gravel beds. Mr. Jones indicated that material from the pit described above is typical of caliche gravel deposits from other pit locations between Valentine and Marfa.

Gravel deposits similar to those just described occur north of the end of the southeastern branch of Y27. A visual inspection of an old pit in that area indicates that the material is quite similar to that in the pit west of Valentine. The deposit is a conglomerate that is white in color due to the abundance of caliche cement. About 60 percent of the material is composed of subangular to subrounded clasts averaging 3 to 4 inches in sizes, but varying up to 12 inches in maximum dimension. The matrix is made up of caliche and sand with thin lenses of clay. Overburden along the ridge top is negligible. Other exposures in the same general area consist of caliche-cemented conglomerate with thin, lenticular beds of fresh water limestone, thick-bedded sandstone, conglomeratic sandstone, and sandy siltstone.

Conglomerate also underlies the low hills south of the southwestern branch of the Wye at about the 7 mile point. Generally the material resembles that described above except that the conglomerate occurs in association with beds of white tuff and tuffaceous sandstone.

There is no local commercial source of aggregate in the Valentine area; however, igneous rocks exposed in the Davis Mountains should be suitable for aggregate if economic factors justify the cost of excavation and crushing. Large, resistant outcrops of granite occur in the Davis Mountains, about 25 miles from the center of Y27. Aggregate from volcanic rock outcrops probably could be developed within 12 miles of the apex. The main problem with the volcanic rocks is that the beds are not very thick and in many places the rocks have been folded and fractured, and have suffered alteration effects that would tend to reduce their usefulness. A core drilling program would have to be undertaken in order to determine the amount of usable rock available at each potential quarry site. Added to the cost of the core drilling would be the cost of drilling and "shooting" the rock in order to prepare it for the crusher.

The current road project at Valentine utilizes aggregate transported by truck from the commercial plant at Gifford Hill, a haul of about 55 miles. This material is dense, reddish-colored rhyolite that occurs as an intrusive body within older rocks that crop out in the area west of Van Horn. The rhyolite crushes to a slightly tabular form, but it has proven satisfactory for Highway Department use.

A commercial rock crusher is located at Fort Stockton, and in this plant limestone deposits are used. The rock is light gray to white, dense, and crushes into angular, rather equidimensional forms.

Because of the volume of aggregate required for the Y27 site development, it is believed that a search for a local aggregate source would be warranted. Laboratory analyses should be made of each potential quarry location before making a final decision as to the acceptability of the material.

In order to obtain as good an indication as possible concerning the engineering qualities of the native soil, visual inspections were made along each of the Wye branches and 10 locations for test borings were selected in areas believed to be underlain by soils typical of the several types present in the basin.

Test borings along the northern branch indicate that the soil consists mainly of sandy silt with percentages of fine gravel ranging from 0 to 45. The visual inspection reveals that adjacent to the present drainages the surface material is composed of sandy clays. The penetration resistance tests showed a blow count per foot of from 25 to 59 at a depth of 2 feet, 28 to 42 at 5 feet with refusal in one hole, and 45 at 10 feet with refusal in three holes.

Along the southeastern branch, the soil varies from sandy silt on both ends to silty sand and gravel in the central portions. The sieve analyses of two samples show a gravel percentage that varies from 0 at the apex to 29 at the midpoint of the branch. Surface indications are that in a few areas the gravel percentage may be even higher. The penetration resistance tests showed a blow count per foot of from 14 to 29 at a depth of 2 feet, 33 to 57 at 5 feet, and 45 to 58 at 10 feet with refusal in two holes.

Visual determinations and test borings along the southwestern branch show the soil to be sandy silt except in the valley areas adjacent to drainage features, where the deposits are clayey. Some sandy and rocky areas occur where the branch crosses outcrops of tuff or resistant volcanic beds. The penetration resistance tests showed a blow count per foot of from 35 to 37 at a depth of 2 feet with refusal in one hole, 29 at 5 feet with refusal in two holes, and 33 at 10 feet with refusal in two holes. Two of the tests were made adjacent to bedrock outcrops of rather limited extent, and the high penetration resistance obtained is not indicative of the branch as a whole.

Excavation of the alluvial material should be relatively easy along the three branches of the Wye. Some difficulty may be encountered locally where the branches cross exceptionally dense caliche zones or in the areas where bedrock outcrops occur. Some ripping and even a minor amount of blasting probably will be required. In general the native soil should be satisfactory for use as embankment material when it is satisfactorily compacted. The high degree of compressibility of the saturated soil samples should be noted, for the volumes of water generated by heavy rainfalls in the area may cause parts of the roadway fill to approach a saturated condition.

An investigation of mineral exploration activity revealed that at least three oil wells have been drilled in the southern part of the site.

All of the wells were dry and abandoned. Another well was drilled about one mile northeast of Valentine, and it also was dry and abandoned. There are no active mining claims in the immediate vicinity of the site.

4. Topography and drainage

The northern branch of Y27 rises gradually 265 feet from the Wye intersection to Station 686+40. It crosses U.S. Highway 90 at Station 240+28 and the Texas and New Orleans Railroad at Station 250+35. The country traversed by this branch and the southeastern and southwestern branches are for the most part gently sloping and grass covered.

All three branches of Y27 are subject to sheet flooding produced by heavy rainfalls on the sloping mountain areas. This is apparent along the railroad where there is a 4-foot dike along the upper side to protect the trackage for the entire length of the southeastern branch of the Wye.

Control of the marshy areas could be easily accomplished, but channelizing would be in conflict with the land usage, which is to deliberately spread the water to produce better grassland. The Wye branch drainage system is designed to continue this practice.

The preliminary drainage requirements of the northern branch include: two 5 foot by 60 foot box culverts to be located at approximately Station 348+50 and 623+00; also thirteen 4 foot by 20 foot box culverts to be spaced approximately every mile.

The southeastern branch follows the highway and railroad, having a gradual vertical rise of 355 feet from the apex to Station 560+00. The ground cover changes from grassland to mesquite and yucca along the eastern half of this branch. The preliminary drainage requirements consist of two 5-foot by 50-foot box culverts to be placed approximately at Stations 132+00 and 356+40; also thirteen 5-foot by 10-foot box culverts to be spaced approximately every mile.

The southwestern branch of Y23 crosses six major drainage channels in its 13 mile length. This branch rises from the Wye intersection 80 feet to Station 120+50, where it then descends 150 feet to a major stream crossing at Station 330+75. From Station 330+75 the branch rises 375 feet to Station 686+40, where it terminates. The preliminary drainage requirements consist of one 8-foot by 70-foot box culvert placed at Station 5+60; five 5-foot by 35-foot box culverts at Station 79+00, 188+00, 237+50, 337+50, and 660+00, respectively.

5. Railway

The top 9 inches will have to be stripped from the ground surface in order to remove existing vegetation prior to emplacing the embankment material.

6. Access road

The total length of all access roads for Y27 is 4 miles. The entrance road from the highway is 2 miles long. The access road from the building complex to the staging area will be 5280 feet long.

7. Airstrip

The airstrip will run approximately southeast-northwest to face the prevailing wind. The landing strip will be 150 feet wide with paved runway 75 feet wide and 5900 feet long. The length of the runway is determined by the altitude (4500 feet above sea level) and the mean maximum temperature (100° F).

8. Water supply

The source of the water supply is an underground aquifer which will be tapped by a 10-inch diameter well cased to 8 inches. Delivery of the water will be by an electric, submersible, centrifugal pump in the well. The pumped water is conveyed by pipe to an elevated 65,000-gallon storage tank. This tank will contain a three-day domestic supply and 50,000 gallons of water for fire delivered at the rate of 400 gallons per minute for a two-hour duration. Distribution from the storage tank is by gravity through a chlorinator and zeolite filter prior to consumption at the building complex.

Wells in the Y27 site area reach water 300 to 530 feet below the ground surface. Analysis of wells in the area indicates that a properly constructed well will produce the quantity and quality of water desired with a well depth of 700 feet.

9. Utilities

West Texas Utilities Company has an existing 12 kV line from Marfa to Valentine which would have to be converted to at least a 69 kV line, and 26.5 miles of line would have to be constructed to serve the center of the site. Also, the Rio Grande Electric Cooperative, Inc., has a 14.4 kV line which parallels U.S. Highway 90; this line could be upgraded to carry the VLA loads.

The West Texas Utilities Company indicates that the establishment of the desired facilities would require a 10-year contract with a non-refundable advance payment of $181,000 and a monthly minimum billing of $7200.

The area is served by Southwestern Bell Telephone Company, with an office in Marfa, Texas.

10. Real estate

Dr. James N. Douglas in the Department of Astronomy of the University of Texas was contacted for information regarding the University of Texas' acquisition of a similar site some miles east of Marfa, Texas. The University of Texas site is in the shape of a "T", measuring 7 miles by 7 miles. Dr. Douglas reports an agreement with the landowner was reached after nearly a year of negotiation; however, they had to lease 35,000 acres, which is roughly a block of land 7 miles by 7 miles. This land was leased on the basis of 90 cents per acre per year for the first five years and is subject to renegotiation each five years during the term of the lease. Dr. Douglas stated that they anticipated subleasing (for grazing purposes) the land not required for their facility at approximately 50 cents per acre per year, which would make the net cost to the University approximately 40 cents per acre per year for the entire block of land. He said the owners would not talk about leasing just the right of way needed for the facility but insisted on leasing all of the land affected by the installation.

Investigation reveals that from 65 cents to 75 cents per acre per year is being paid for grazing purposes in this area; however, it would appear that the price of 90 cents per acre per year as paid by the University of Texas will set the minimum limit for the cost of acquisition of the site, or $65 per mile for a right of way 600 feet wide.

All of the site is on privately owned land; therefore, the lease for the entire facility, including the Wye, building complex, airstrip, staging area, roads, etc., would be approximately $2649 per year (called $2700).

I. Site Y33 (Nevada)

This site is in Elko County in the Steptoe Valley, about 50 miles southeast of Wells. Its center is at geographical coordinates 40°28!3 N, 114°28!8 W, the elevation at this point being 5600 feet above mean sea level. The branches extend outward on true azimuths 7°, 127°, and 247°. A map of the site is shown in Fig. 5-25, and the branch profiles are given by Figs. 5-26, 5-27, and 5-28.

1. General site features

The site is situated in an elongated, northerly trending valley surrounded on three sides by mountain ranges with peaks that attain elevations over 8000 feet. Slopes in the central part of the valley are very slight, but around the margins of the valley they increase rapidly toward the bases of the adjacent mountains. The terrain at the site is flat to slightly rolling.

A low altitude federal airway (V269) crosses the southwestern branch of the Wye. The Nevada Northern Railroad (single track) also crosses the southwestern branch at a point approximately 8 miles from the apex. A telephone line parallels the railroad through Steptoe Valley. There are no highway crossings on any of the branches.

The site lies within 50 miles of the Wendover Bombing and Gunnery Range (Utah).

The Central Nevada test area of the AEC is located at approximate coordinates 38°30'N, 116°10'W. Although the test area lies more than 100 miles away, the AEC indicates that there would be perceptible seismic effects at the site.

This site is in a remote area where the communities are small, widely scattered and localized at road junctions. The nearest town of any size is Wells, Nevada, a long-established railhead for three different railroads. It is approximately 75 miles north of the site. The town has a population of 1100 people, with the nearest medical facilities approximately 60 miles away at Elko. It is served by bus lines with connections to Salt Lake City and Reno Nevada. There are a few motels and restaurants and two gambling casinos.

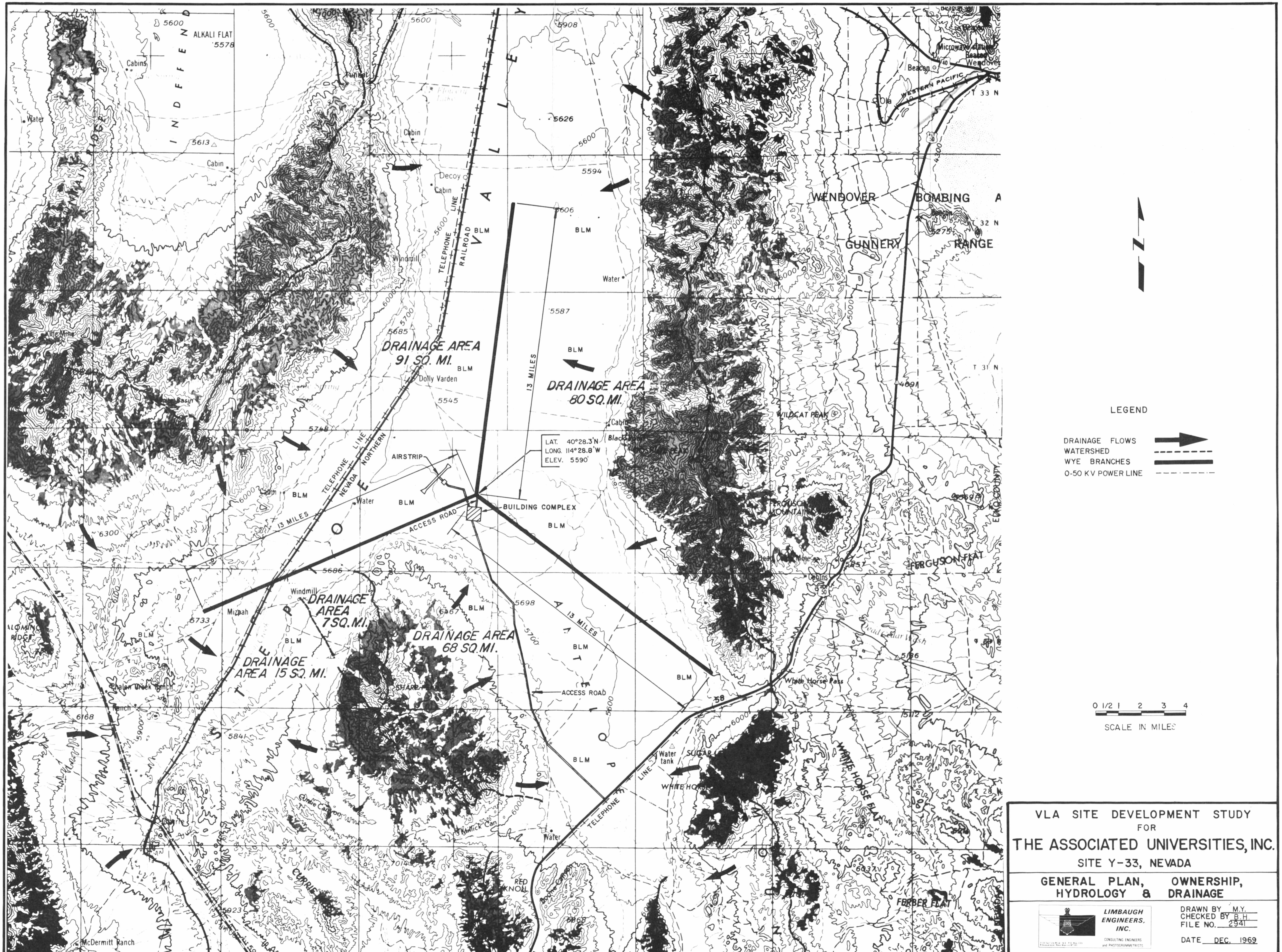
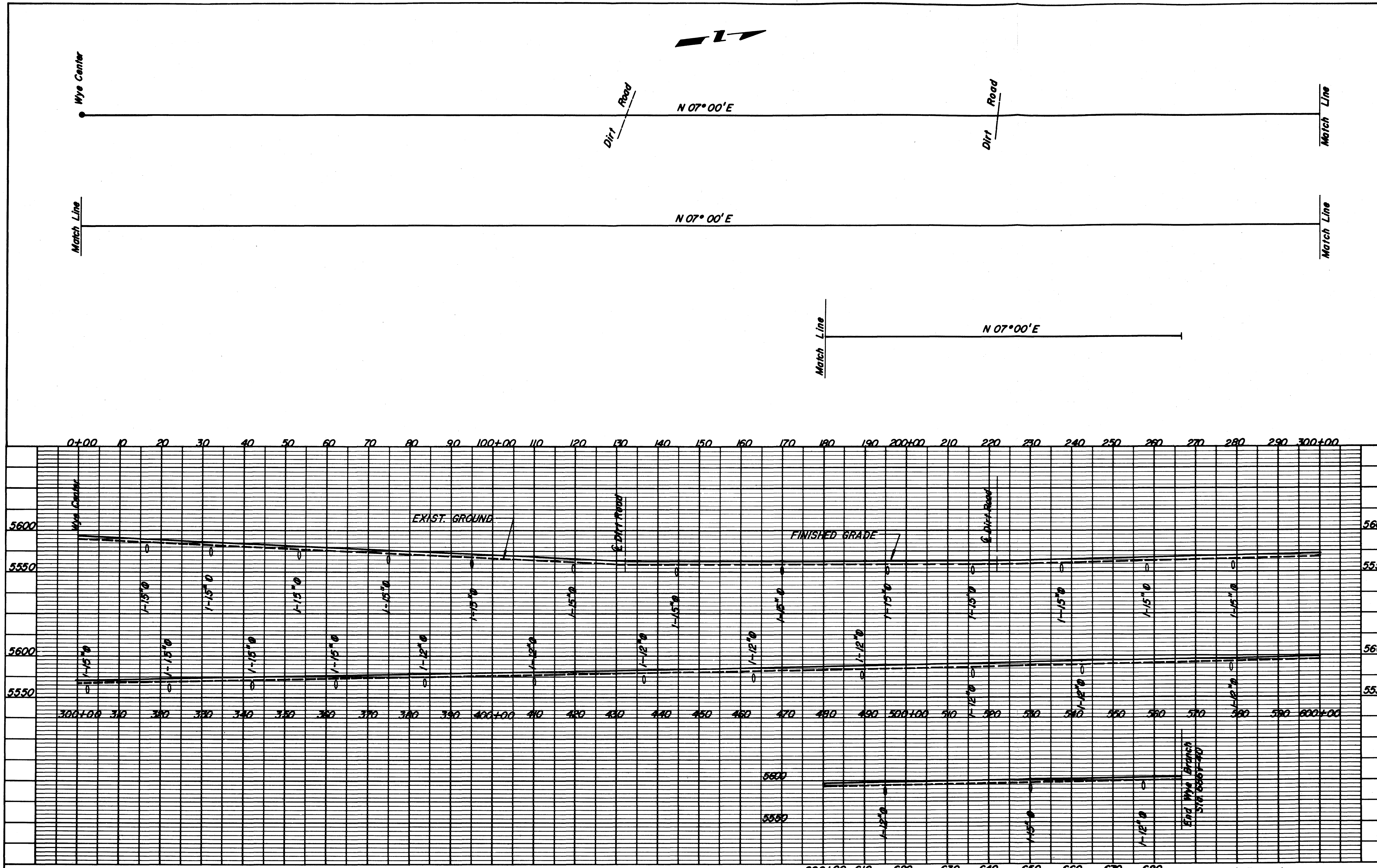
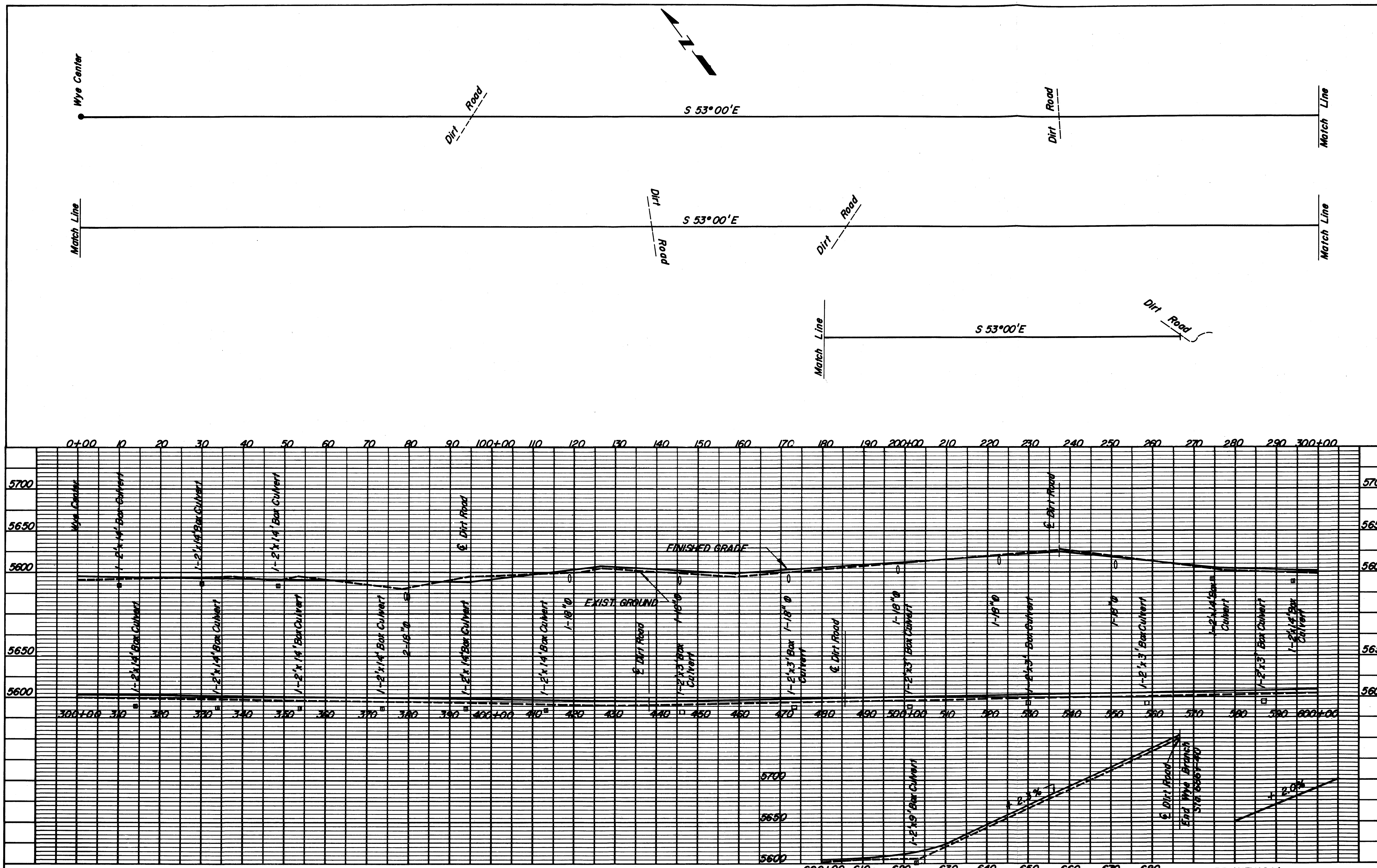

VLA SITE DEVELOPMENT STUDY
FOR
THE ASSOCIATED UNIVERSITIES, INC.
SITE Y-33, NEVADA
GENERAL PLAN, OWNERSHIP, HYDROLOGY & DRAINAGE
LIMBAUGH ENGINEERS, INC.
CONSULTING ENGINEERS and PHOTOGRAMMETRISTS
DRAWN BY M.Y.
CHECKED BY B.H.
FILE NO. 2941
DATE DEC. 1969
LEGEND
DRAINAGE FLOWS
WATERSHED
WYE BRANCHES
0-50 KV POWER LINE
0 1/2 1 2 3 4
SCALE IN MILES
N
DRAINAGE AREA 91 SQ. MI.
DRAINAGE AREA 80 SQ. MI.
DRAINAGE AREA 7 SQ. MI.
DRAINAGE AREA 68 SQ. MI.
DRAINAGE AREA 15 SQ. MI.
13 MILES
13 MILES
13 MILES
LAT. 40°28.3'N
LONG. 114°28.8'W
ELEV. 5590'
BUILDING COMPLEX
AIRSTRIP
ACCESS ROAD
ACCESS ROAD
BLM
TELEPHONE LINE
RAILROAD
NEVADA NORTHERN
WENDOVER BOMBING
GUNNERY RANGE
WHITE HORSE FLAT
FERGUSON FLAT
FERBER FLAT
WILDCAT PEAK
White Horse Pass
ALKALI FLAT
Dolly Varden
Windmill
Mizpah
Decoy
Wendover
WESTERN PACIFIC
Currie
McDermitt Ranch
RED KNOLL

Fig. 5-25



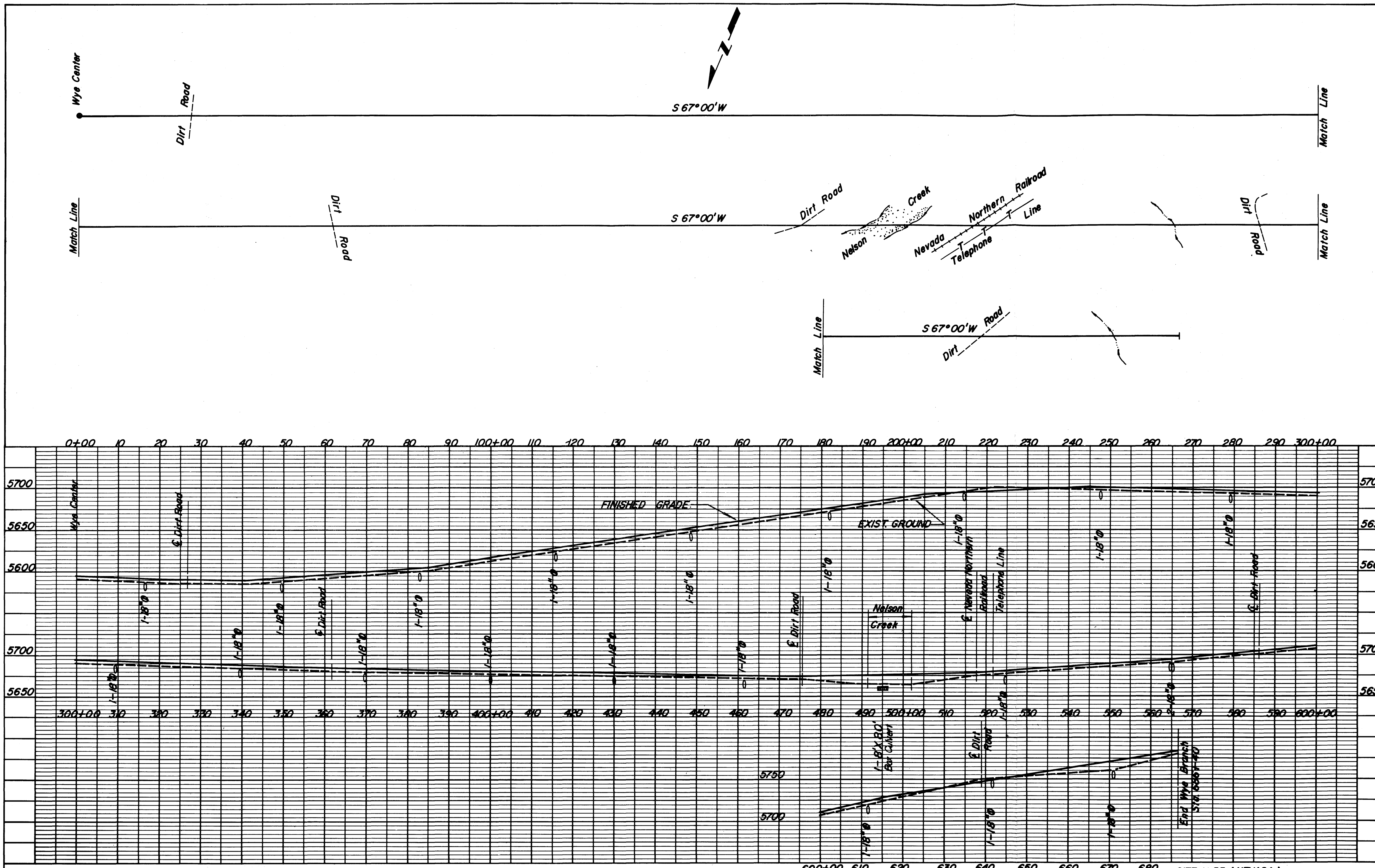
Wye Center
Dirt Road
N 07° 00' E
Match Line
EXIST. GROUND
FINISHED GRADE
℄ Dirt Road
5600
5550
1-15" Ø
1-12" Ø
End Wye Branch
SITE Y-33 (NEVADA)

Fig. 5-26



Wye Center
Dirt Road
S 53°00'E
Match Line
FINISHED GRADE
EXIST. GROUND
1-2'x14' Box Culvert
1-18"Ø
2-18"Ø
1-2'x3' Box Culvert
1-2'x9' Box Culvert
℄ Dirt Road
End Wye Branch
+2.3%
+2.0%
5700
5650
5600
0+00
100+00
200+00
300+00
400+00
500+00
600+00
SITE Y-33 (NEVADA)

Fig. 5-27



Wye Center
Dirt Road
S 67°00'W
Match Line
Dirt Road
Nelson Creek
Nevada Northern Railroad
Telephone Line
FINISHED GRADE
EXIST. GROUND
1-18"Ø
℄ Dirt Road
℄ Nevada Northern Railroad
Telephone Line
Nelson Creek
1-6'X8.0' Box Culvert
End Wye Branch
5700
5650
5600
5750
0+00
100+00
200+00
300+00
400+00
500+00
600+00
SITE Y-33 (NEVADA)
LIMBAUGH ENGINEERS, INC.

Fig. 5-28

The nearest towns with a population of 2000 or more are Ely and Elko. Ely is 104 miles south of the site by State Road 93 and Elko is 106 miles northwest by State Road 93 and Interstate Highway 80. Both Elko and Ely have been described under site Y17.

2. Climatology

The average daily maximum temperature is 60.3° F and the average daily minimum is 30.2° F. The highest recorded temperature was 100° F and the lowest was -26° F.

The average yearly precipitation is 12.89 inches, with 18.84 inches as the greatest annual precipitation on record. The greatest monthly precipitation total was 4.61 inches and the mean yearly snowfall is 51.2 inches, with a maximum single snowfall of 28.4 inches. The annual mean relative humidity is 55 percent. The sunshine throughout the year is estimated at 70 percent of the maximum possible. The number of tornadoes in the state averages one in two years. Dust storms are not severe and hail occurs about four times per year. The prevailing wind direction is from the southwest and the estimated average hourly speed for the year is 10.2 miles per hour with a maximum wind expectancy of 75 miles per hour in 50 years. Thunderstorms occur on the average of 25 times per year.

3. Geology and foundations investigation

The site is the upper part of the Steptoe Valley, which is 10 to 12 miles wide and over 40 miles long. The site area is bounded on the west by the Pequop Mountains, on the east by the Goshute Mountains, and on the south by the Dolly Varden Mountains. The surrounding mountains all have peaks over 8000 feet, with some areas along the east side attaining elevations over 9000 feet. The maximum relief from the bottom of the valley is over 4000 feet.

The mountains were formed by tilted fault blocks millions of years ago and the evidence of more recent activity is a fault line along the west side of the Dolly Varden Mountains. This faulting, although more recent, probably did not take place during historic time, for it appears that the immature alluvial fans that began to develop after the faulting have been truncated by the Pleistocene Age lake beds around the perimeter of the valley. Geologically, the area seems stable at the present time. The closest recorded earthquake epicenter is in the Elko area over 60 miles to the northwest, where in 1901 an earthquake with an intensity of 7 (on an increasing scale from 1 to 12) was felt over an area of 3500 square miles and caused building damage in Elko.

The branches of the Wye lie entirely on Quaternary deposits of sand, gravel, silt, and clay that were deposited as alluvial fans, lake sediments and beach deposits. The areas between 5700 feet elevation and the base of the mountains at about 6000 feet elevation are underlain primarily by silty sand and gravel, with many areas of well-developed shoreline deposits of sand and gravel bars formed at the edge of an ancient lake. The lowland areas are underlain by low to medium plasticity clays and silty clays that are relatively impermeable. Along the southwestern branch, there is a stretch about 3 miles in length that is mantled by low brush-covered sand dunes.

Sand and gravel deposits for use in construction are abundantly available around the perimeter of the valley wherever the old shoreline deposits are well developed. The amount of gravel varies considerably, ranging from about 15 percent in the sandier areas to over 60 percent in the gravel bar deposits. Rock for railroad ballast can be obtained by crushing the limestone that crops out in all of the mountains surrounding the valley. There are particularly good exposures of thick-bedded, gray limestone in the southern end of the Goshute Mountains adjacent to the southeastern branch of the Wye.

In areas where the Wye branches cross sandy slopes, the soil should make good embankment material. It is quite likely that considerable hauling might be required to obtain satisfactory embankment material for building up the roadbed along the northern branch in the lowland areas of silty and clayey sediments.

The only test pits in the area are old ones along Alternate U.S. Highway 50 south of the end of the southeastern branch. The material is a sandy gravel with up to 8 percent silty fines. It has been given an AASHO rating of A-3, indicating that it has quite good bearing capacity.

The bearing capacity of that part of the southwestern branch west of the railroad should generally be quite good. Special investigations will be required should observing stations be needed in the immediate vicinity of the Nelson Creek crossing. The remainder of the southwestern branch should have fair to good bearing capacity.

Almost all of the northern branch, as well as most of the southeastern branch, should be in areas where the bearing capacity will be fair or possibly poor. The silty and clayey deposits and the bottomlands may have moderate compressibility when saturated, and it is possible that expansive clays could occur below the surface. The end of the northern branch is in an area where the water table could be quite shallow, and this might cause a further complication during construction.

The end of the southeastern branch is in an area of sand and gravel deposits, and the bearing capacity should be good.

Investigation of mineral activity in the area disclosed that one test well was drilled in search of oil in the southeastern corner of Township 30 North, Range 64 East, but it was abandoned and there were no oil indications. Three oil tests have been drilled in the southern part of the Steptoe Valley, also without signs of oil. Chances of future oil activity are slight but cannot be ruled out entirely.

At present the closest large-scale mining operation is at Ruth, approximately 100 miles to the south. The largest adjacent area of potential activity would be the Dolly Varden Mountains, where the Anaconda Company has an inactive copper-bismuth mine, apparently with substantial remaining reserves. Mining claims, mostly lead-zinc, are located in the White Horse, Spruce, and Pilot Mountains. There is only very minor activity at present, and although the future potential is now known, it is unlikely that any really large mining operations will develop, on the basis of present information.

4. Topography and drainage

The apex of Y33 lies at an elevation of approximately 5600 feet and the Wye branches cover parts of the valley ranging in elevation from about 5550 feet along the northern branch to 5900 feet at the end of the south-eastern branch.

Slopes are negligible on the northern branch and on most of the other two branches. From Nelson Creek southwesterly the slope increases to about 1 percent. Along the easternmost 6000 feet of the southeastern branch, the gradient of the Wye averages slightly over 2 percent and short segments may exceed 4 percent. In this area the excessive gradient can probably be circumvented either by a shift in the array or by curving the railroad tracks to conform to the contour of the hill.

On the alluvial fans and gravel beds along the valley perimeter, there is a covering of sparse grass and scattered clumps of low sage. The low, poorly drained areas are covered with moderately dense sagebrush that reaches heights of 2 to 3 feet. In areas of shallow water table, such as near the end of the northern branch, the growth becomes fairly dense, except in localized areas of ponding, where the vegetation is sparse.

The primary drainage in the upper Steptoe Valley is Nelson Creek, an ephemeral stream flowing northeasterly, parallel to the Nevada Northern Railroad at the southwestern side of the site. Near the Dolly Varden siding, the gradient becomes so slight that the water tends to pond. Although there are undoubtedly substantial flows in canyons of the mountains bordering the site, few of these drainages extend into the valley for more than a few hundred feet from the base of the mountains, indicating that the soil around the perimeter of the valley is quite permeable. One factor that tends to reduce runoff from the adjacent mountains is that, in many areas around the valley, there are well-developed shoreline deposits of sand and gravel that are very permeable and would tend to absorb all but the largest flows from the uplands. When large flows do occur or substantial rainfall occurs on the lowland areas, there would be a tendency for sheet flooding to take place in areas of the valley of slight to moderate gradient and for ponding to occur in all of the nearly flat areas underlain by accumulations of impermeable slit and clay.

The southwestern branch is the only one that will need to have a substantial number of culverts to pass floodwaters beneath the roadway. The Nelson Creek crossing is about 500 feet in width as presently laid out, and it could be substantially wider if the Wye were shifted farther south. In order to minimize the crossing structure, some dike construction with appropriate riprap protection will be required. The section of the southwestern branch from the railroad west is on an alluvial fan with numerous small drainage channels. The number of culvert structures will vary, depending on the protecting dikes and ditches that are built. Because the quantities of water reaching the roadbed would not normally be substantial, it would be practical to do a moderate amount of drainage diversion.

Flowing waters during heavy storms will also occur at the end of the southeastern branch and possibly where it crosses the northeastern flank of the Dolly Varden Mountains.

Embankments about 2 feet in height are recommended for the southwestern branch west of the railroad; in the area to the east, embankments should be about 3 feet in the more poorly drained areas and 2 feet in the sand dune and better drained areas. Three-foot embankments probably would be advisable along most of the southeastern branch because of the possibility that substantial quantities of water may accumulate in the bottomlands during extremely heavy storms. A 2-foot embankment with adequate culvert structures should fulfill requirements for the end of the southeastern branch. The northern branch is almost entirely on the lowland areas of the valley and consequently embankments of 3 and possibly 4 feet should be considered, particularly in areas that are normal ponding locations. All of the lowland areas will require at least a minimum number of culvert structures in order to prevent the roadway from becoming a dike. The height of the roadway and the number of culverts can be minimized by constructing drainage courses to channel the lowland waters and divert them across or away from the roadway.

5. Railway

The top 9 inches will have to be stripped from the ground surface in order to remove existing vegetation prior to emplacing the embankment material.

6. Access road

The total length of all access roads for Y33 is 17 miles. The entrance road from the highway is 14 miles long. The access road from the building complex to the staging area will be 5800 feet long.

7. Airstrip

The airstrip will run approximately southwest-northeast to face the prevailing wind. The landing strip will be 150 feet wide with a paved runway 75 feet wide and 6600 feet long.

8. Water supply

The source of the water supply is an underground aquifer which will be tapped by a 10-inch diameter well cased to 8 inches. Delivery of the water will be by an electric, submersible, centrifugal pump in the well. The pumped water is conveyed by pipe to an elevated 65,000 gallon storage tank. This tank will contain a three-day domestic supply and 50,000-gallons of water for fire delivered at the rate of 400 gallons per minute for a two-hour duration. Distribution from the storage tank is by gravity through a chlorinator and zeolite filter prior to consumption at the building complex.

Information on the availability of water from wells in the site area is very sketchy. There are several stock wells scattered around the upper Steptoe Valley, but they are all quite shallow and no pumping tests have been run. The aquifers are in sandy horizons in the valley fill deposits. According to the U.S. Geological Survey, the subsurface flow is northerly on both sides of Dolly Varden Mountains at least as far as a point midway between the Dolly Varden and Decoy sidings on the Nevada Northern Railroad.

Near the apex, the water level is estimated to be at a depth of about 70 feet and the potential yield based on bailing tests of wells in the general vicinity would be 20 to 30 gallons per minute. There is no information at present about the quality of water, but the U.S. Geological Survey is currently analyzing water samples from the area. Near the end of the northern branch the water table probably is only 40 to 50 feet deep. On the basis of information from similar aquifers in the southern part of the Steptoe Valley, the water might be expected to have a medium salinity hazard. In that area some of the well water contained a sulphage content of over 250 ppm, the maximum level suggested by the U.S. Health Department. It can be expected that wells drilled along the edges of the valley will yield better quality water than those in the center of the valley.

9. Utilities

At present no electric service is available in the vicinity of the Y33 site; however, Mount Wheeler Power, Inc., would apply for certification from the Nevada Public Service Commission to serve that area. In order to provide service to the site area, it would be necessary to construct 33.2 miles of line, to upgrade about 5.6 miles of line and to increase the capacity of the proposed Steptoe Valley substation. Under regulations of the Nevada Public Service Commission, a contract could be negotiated subject to their approval, and because of their rules an advance of funds for this service would not be required. The estimated billing, however, would be approximately $10,373 per month.

The telephone company serving this area is the California-Pacific Utilities Company, which has a business office at Elko, Nevada.

10. Real estate

All portions of the land to be acquired in this instance belong to the Bureau of Land Management. The Valley is essentially devoid of improvements; however, at the extreme end of the southwestern branch, the taking comes within a quarter mile of a watering facility and crosses the tracks of the Nevada Northern Railroad Company. Damages are considered minimal.

Ranch land in this general area is currently valued at $15 per acre. Since no private lands are involved, and since damages to the ranching operation are minimal, the value of the entire 3056 acres is estimated on the basis of $15 per acre. If the property is to be acquired by another government agency from the Bureau of Land Management, the acquisition could be made without cost for the land, but with a reimbursement to the lessee for damages. The estimated cost of acquisition as reported herein is deemed to be the maximum figure that would have to be paid for this site.

3056 acres @ $15 =		$45,840
	CALLED	$46,000

J. Site Preparation Cost Estimate

The cost estimates for this study have been developed as "budget type" estimates for each site. These cost estimates cover all the physical facilities including land required, but not special laboratory and scientific equipment and apparatus, shop equipment, movable antennae, cables to observation stations, terminal boards, dormitory and office furnishings and similar items. These budget estimates are sufficiently detailed to be used as a basis for determining funds required later for design and construction of the project.

In order to determine the best possible unit cost estimates, the services of the C. L. Noe consulting firm, which specializes in cost estimating in the Southwest, were obtained for the original 1966 estimates on the Y15, Y23, and Y27 sites. Cost estimates on these sites have been updated. This firm is familiar with cost estimating for government projects, having done so in such contracts as the AMRAD Facilities, White Sands, New Mexico; the Manned Spacecraft Center, Clear Lake, Texas; the Air Force Academy Complex, Colorado Springs, Colorado; and many others.

In addition to these services, an independent determination of unit prices was made by one of the largest contractors in New Mexico. While certain of the unit prices had considerable variance between these two sources, the total costs compared favorably. Individual item differences can be discounted because of the normal contractor tendency to unbalance bids. Labor rates for the various labor categories were obtained from the Labor Commissions of the different states.

Cost estimates have been prepared on the following:

1. Air strip, including drainage.
2. Access roads, including drainage.
3. Water supply system.
4. Sewage treatment system.
5. Wye branches and spurs, including drainage.
6. Cable trenches.
7. Foundations.

8. Staging area.
9. Power supply.
10. Telephone system.
11. Real estate.
12. Buildings.

The unit prices used in this report are based on existing material and labor costs in New Mexico, Arizona, Texas, Utah, and Nevada as of 1968. It is expected that when the time schedule of request for funds, design, and tentative construction is set, these figures will require adjustment to reflect costs expected during the construction period.

The estimated costs for two of the above categories are the same for all sites. These are the cable trenches ($1,248,100) and the building complex ($921,585).

A possible building complex plot plan is shown in Fig. 5-29.

K. Summary

The comparative merits of the 7 acceptable sites which are discussed in the present chapter are in the following tables*:

Table 5-8	Conflicting activities
Table 5-9	Physical characteristics of the sites
Table 5-10	Accessibility (support)
Table 5-11	Industrial support
Table 5-12	Climatology
Table 5-13	Developable natural resources
Table 5-14	Site preparation costs

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* The data presented in Tables 5-8 through 5-13 is of January 1, 1970.

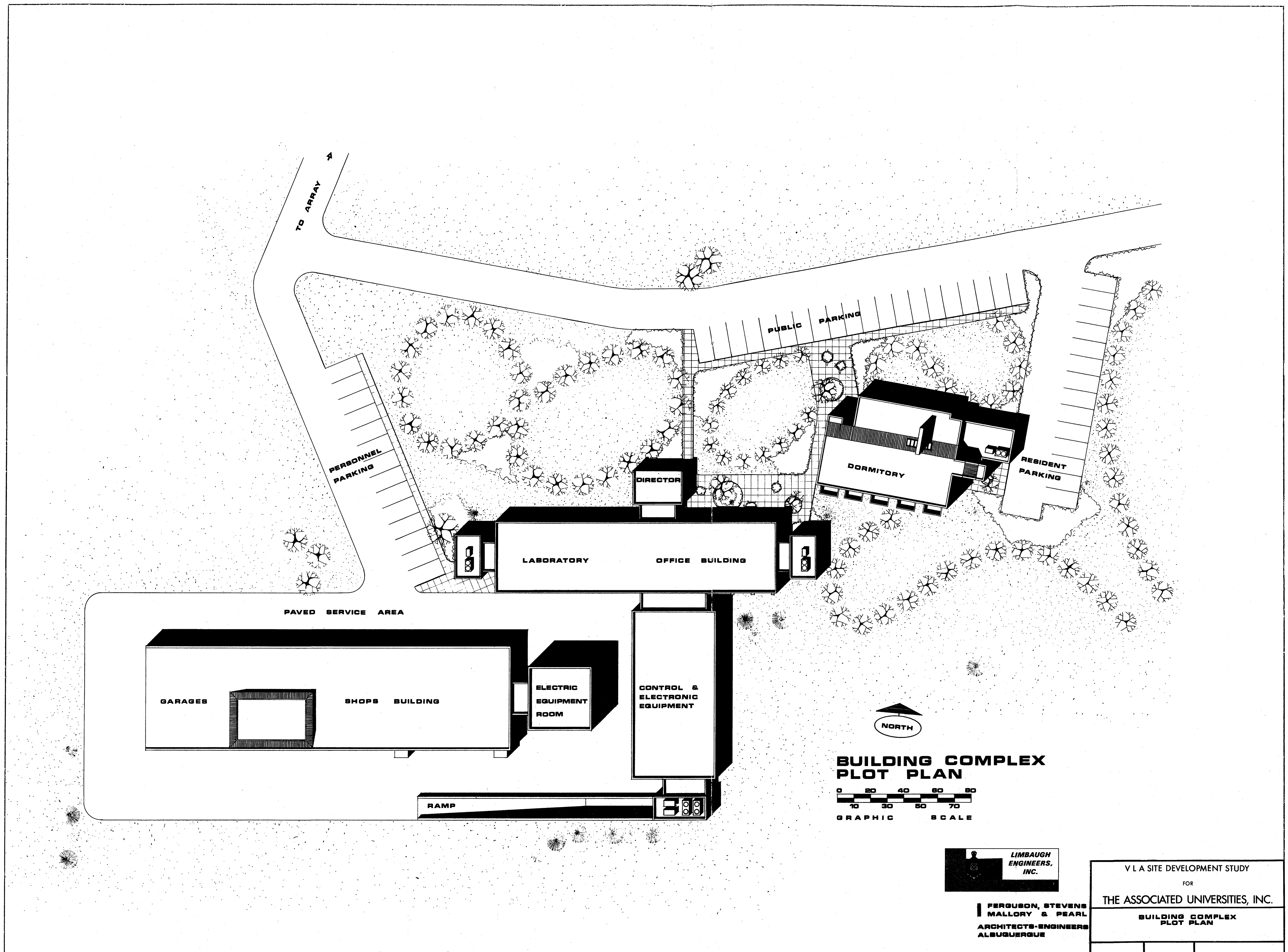
TO ARRAY
PUBLIC PARKING
PERSONNEL PARKING
DIRECTOR
DORMITORY
RESIDENT PARKING
LABORATORY
OFFICE BUILDING
PAVED SERVICE AREA
GARAGES
SHOPS BUILDING
ELECTRIC EQUIPMENT ROOM
CONTROL & ELECTRONIC EQUIPMENT
RAMP
NORTH
BUILDING COMPLEX PLOT PLAN
0 20 40 60 80
10 30 50 70
GRAPHIC SCALE
LIMBAUGH ENGINEERS, INC.
FERGUSON, STEVENS MALLORY & PEARL
ARCHITECTS-ENGINEERS ALBUQUERQUE
V L A SITE DEVELOPMENT STUDY
FOR
THE ASSOCIATED UNIVERSITIES, INC.
BUILDING COMPLEX PLOT PLAN

Fig. 5-29

Table 5-8

CONFLICTING ACTIVITIES

ITEM	Y-15 NEW MEXICO	Y-16 UTAH	Y-17 NEVADA	Y-22 NEW MEXICO	Y-23 ARIZONA	Y-27 TEXAS	Y-33 NEVADA
AIRWAYS	Federal Airways No. V264-V1905	Federal Airways No. V21-V257	None	San Simeon-Deming San Simeon-Columbus Federal Airways No. V94	Federal Airways No. V105 F.A.A. Restricted Area No. R-2303A	None	Federal Airways No. V269
RAILROADS	None	Union Pacific Railroad	None	Southern Pacific Railroad	None	Texas and New Orleans Railroad	Nevada Northern Railroad
MAJOR HIGHWAYS	U.S. Highway 60	State Road 257	U.S. Highway 50	Interstate Hwy. 10	State Road 86	U.S. Highway 90 State Road 166	None
MILITARY OR DEFENSE ACTIVITIES	White Sands Missile Range	None	Wendover Bombing and Gunnery Range	"Defense Area" Associated with Mexico - U. S. Border	Southern Border Domestic A.D.I.Z.	Southern Border Domestic A.D.I.Z.	Wendover Bombing and Gunnery Range
RELAY STATIONS - RADIO NAVIGATIONAL AIDS - RADAR	RML (Radio Microwave Link) 34° 10' 48"N 106° 57' 22"W 33° 39' 34"N 107° 04' 13"W 33° 52' 01"N 106° 44' 01"W	RCAG (Remote Air - Ground) 39° 23' 54"N 112° 30' 06"W VORTAC (Radio Tactical Air Navigation) 39° 18' 09"N 112° 30' 17"W RML (Radio Microwave Link) 39° 33' 32"N 111° 54' 02"W 39° 12' 06"N 112° 09' 59"W 38° 59' 11"N 112° 24' 30"W 38° 48' 33"N 112° 53' 30"W 38° 22' 24"N 112° 57' 06"W	RCAG (Remote Air - Ground) 48° 24' 11"N 116° 52' 02"W Radar 40° 24' 11"N 116° 52' 02"W RML (Radio Microwave Link) 40° 35' 45"N 116° 30' 24"W	RML (Radio Microwave Link) 32° 59' 20"N 108° 57' 40"W 32° 45' 07"N 108° 19' 31"W 32° 25'N 107° 53'W RCAG (Remote Air - Ground) 31° 56' 10"N 108° 41' 50"W FSS (Flight Service Station) No Coordinates	Radar 32° 09' 36"N 110° 53' 10"W VORTAC (Radio Tactical Air Navigation) 32° 53' 09"N 110° 54' 29"W 32° 07' 21"N 110° 49' 12"W TACAN (Tactical Air - Navigation) 32° 09' 36"N 110° 52' 49"W ATC (Air Traffic Control) 32° 07' 04"N 110° 56' 30"W RAPCON (Radar Approach Control) 32° 10' 12"N 110° 52' 33"W	VOR (Voice Radio) 30° 17' 53"N 103° 57' 15"W McDonald Observatory 30° 30'N 104° 01'W	RML (Radio Microwave Link) 41° 03' 08"N 115° 20' 46"W 41° 08' 49"N 114° 58' 58"W 41° 20' 02"N 114° 05' 37"W VORTAC (Radio Tactical Air Navigation) 40° 45' 35"N 115° 45' 38"W VOR (Voice Radio) 41° 08' 40"N 114° 58' 35"W
UNDERGROUND NUCLEAR TESTING WITHIN 100 MILES	None	None	Central Nevada Test Area of the A. E. C. 38° 30'N 116° 10'W	None	None	None	Central Nevada Test Area of the A. E. C.
SATELLITE COMMUNICATION FACILITIES	None	None	None	None	None	None	None

Table 5-9

PHYSICAL CHARACTERISTICS OF THE SITES

ITEM	Y-15 NEW MEXICO	Y-16 UTAH	Y-17 NEVADA	Y-22 NEW MEXICO	Y-23 ARIZONA	Y-27 TEXAS	Y-33 NEVADA
LAND OWNERSHIPS	827 Ac. Private 1230 Ac. State 872 Ac. BLM & St. Value $77,000	125 Ac. Private 275 Ac. State 2572 Ac. BLM Value $36,000	140 Ac. Private 2820 Ac. BLM Value $117,800	820 Ac. Private 935 Ac. BLM 1170 Ac. State Value $67,000	301 Ac. Private 28 Ac. State Value $46,000 Plus 2602 Ac. Indian Lease Value $28,000	2835 Ac. Private Lease Value $2,700/year	3056 Ac. BLM Value $46,000
GEOLOGICAL STABILITY	No significant faulting has been recorded in area. Earthquake activity has occurred in Rio Grande Valley. Since 1962 the strongest tremor in the Socorro area was 2.9 on Richter Scale.	Nearest active fault 50 miles from site. One earth fracture noted on each of NE Branch and South Branch. Since 1909-21 earthquakes have occurred with epicenters in Millard County.	No active faulting in area. Nuclear testing blasts probably would be felt in area. Since 1852-1940 earthquake epicenters have been recorded within a 40 mile radius of the Site to magnitude between 5-6 on Richter Scale.	No active faults are found in Site area. Probability of tremors small. Only a few of the strongest earthquakes with epicenters in remote areas would be felt.	Area is subject to periodic small intensity earth tremors.	Major earthquake occurred in area 1931. Surface damage on scale noted as 8. in Valentine. Minor cracking of earth.	Area appears stable. Closest recorded earthquake 60 miles to Northwest where intensity was registered as 7 on Richter Scale.
DRAINAGE	Only a moderate number of structures are required. No major streams cross array. A diversion lateral end North Branch will be required in drainage control.	Site has very little drainage problem and has high permeability. Most culverts are to keep water from ponding on one side of embankment. There is one large structure over Beaver River on Northwest leg.	Would require several large drainage structures due to large drainage areas involved on two Branches. One Branch has poor drainage and is affected by local ponding.	Main drainage across two Branches with several larger sized structures required. Third Branch has ponding in 2 mile low area.	Considerable drainage required on all branches. North Branch requires diversion channels, dikes and erosion protection. Box culverts are required to assist pipe culverts on all Branches. Major flooding has occurred in Site area.	All Branches subject to sheet flooding. All Branches require a substantial number of drainage structures. The Southwest Branch is crossed by 6 major stream channels.	Main drainage flow is in Nelson Creek which would require a bridge over channel. Much ponding is present in low area of Site comprising half of the array.

Table 5-10

ACCESSIBILITY (SUPPORT)

ITEM	Y-15 NEW MEXICO	Y-16 UTAH	Y-17 NEVADA	Y22 NEW MEXICO	Y23 ARIZONA	Y27 TEXAS	Y33 NEVADA
TRAVEL TIME AND MILEAGE FROM TOWNS W/2,000 OR MORE IN POPULATION	Socorro, N. Mex., 50 Miles East of Site, Travel Time 1 hour.	Delta, Utah, 35 Miles from Site, Travel Time 45 minutes.	Ely, Nevada, 105 Miles East of Site, Travel Time 2 hours. Elko, Nevada, 106 Miles from Site, Travel Time 2 hours.	Lordsburg, N. Mex., 24 Miles West of Site, Travel Time 30 minutes. Deming, N. Mex., 45 Miles East of Site, Travel Time 50 minutes.	Tucson, Ariz., 40 Miles East of Site, Travel Time 45 minutes.	Marfa, Texas, 23 Miles East of Site, Travel Time 30 minutes.	Ely, Nevada, 104 Miles South of Site, Travel Time 2 hours. Elko, Nevada, 106 Miles from Site, Travel Time 2 hours.
DISTANCE FROM THE NEAREST CITY WITH AIR SERVICE	Albuquerque, N. Mex., 125 Miles, TWA, Continental, Forntier, and Texas Inter-National Airlines.	Delta, Utah, 35 Miles, Dixie Airlines. Salt Lake City, Utah, 160 Miles, United Airlines, Frontier Airlines, Western Airlines, and Air West.	Elko, Nevada, 104 Miles, United Airlines, with connec-tions in Salt Lake City, Reno, and Albuquerque.	Grant County Airport, 70 Miles, Frontier Airlines, with connections in Tucson and Albuquerque.	Tucson, Arizona, 40 Miles, American Airlines, TWA, Continental, Apache & Frontier Airlines.	Midland, Texas, 150 Miles, Continental, Texas Inter-national Airliens.	Elko, Nevada, 104 Miles, United Airlines, with connections in Salt Lake City, Reno, and San Francisco.
AVAILABILITY AND QUALITY OF SCHOOLS	Socorro, N. Mex.; 3 Elementary, 1 Parochial Grade School, 1 Junior High, 1 Senior High, New Mexico Institute of Mining and Technology.	Provo, Utah; Brigham Young University. Delta Schools under County System; 1 Elementary, 1 Junior High, 1 Senior High.	Elko, Nevada; 4 Elementary, 1 Junior High, 1 Senior High, University of Nevada in Reno. Ely, Nevada; 3 Elementary, 1 Junior High 1 Senior High.	Deming, N. Mex.; has modern School System, 5 Elementary, 1 Junior High, 1 Senior High, Silver City, N. Mexico. New Mexico Western University Las Cruces, N. M., New Mexico State University. Lordsburg, N. M., 3 Elementary, 1 Junior High, 1 Senior High.	Tucson, Arizona; 88 Elementary and Junior High, 8 Senior High, 20 Parochial, Episcopal, Hebrew, Lutheran, Seventh Day Adventist, Elementary and Junior High, 4 Parochial Senior Highs, University of Arizona.	Marfa, Texas; 1 Senior High. Alpine, Texas, Sul Ross State College.	Elko, Nevada; 4 Elementary, 1 Junior High, 1 Senior High, University of Nevada in Reno. Ely, Nevada; 3 Elementary, 1 Junior High, 1 Senior High.
AVAILABILITY OF MEDICAL SERVICE IN THE NEAREST TOWN	Socorro, N. Mex.; 4 Physicians, 3 Osteopaths, 1 Dentist, 46 bed hospital.	Delta, Utah; 2 Physicians, 1 Dentist, 34 bed hospital. Fillmore, Utah; Has new 42 bed hospital run by L.D.S. Church 2 Doctors, 1 Dentist.	Elko, Nevada; 6 Physicians, 2 Specialists, 4 Dentists, 80 bed hospital. Ely, Nevada; 4 Doctors, & 2 Dentists in new clinic.	Lordsburg, N. Mex.; 2 Physicians, 1 Dentist, 25 bed hospital. Deming, N. Mex.; 4 Physicians, 3 Dentists, 40 bed hospital.	Tucson, Arizona; 5 large community hospitals with specialists in all fields of medicine.	Marfa, Texas; 2 Physicians, Private clinic. Alpine, Texas; 28 miles from Marfa, 52 bed hospital.	Elko, Nevada; 6 Physicians, 3 Specialists, 4 Dentists, 24 Registered Nurses, 80 bed hospital. Ely, Nevada; 4 Doctors, & 2 Dentists in New clinic
POPULATION INCREMENT WHICH COULD BE ABSORBED IN THE NEAREST TOWN	Socorro, N. Mex.; 60 Families.	Fillmore, Utah; 20 Families. Delta, Utah; 15 Families.	Elko, Nevada; 30 Families. Ely, Nevada; 15 Families.	Lordsburg, N. M.; 15 Families. Deming, N. Mex.; 60 Families.	Tucson, Arisona; could provide excellent accomodations for both V.L.A. personnel and construction workers	Marfa, Texas; 25 Families. Alpine, Texas; 35 Families.	Elko, Nevada; 30 Families. Ely, Nevada; 15 Families.

Table 5-11

INDUSTRIAL SUPPORT

ITEM	Y-15 NEW MEXICO	Y-16 UTAH	Y-17 NEVADA	Y-22 NEW MEXICO	Y-23 ARIZONA	Y-27 TEXAS	Y-33 NEVADA
ELECTRICAL POWER	Socorro Electric Cooperative, Inc.- Requires 1 mile of line to tie to existing facility. Monthly minimum charge of $2,625.00 plus graduated energy charge.	Utah Power and Light Co. - Requires 12 miles new line. Power cost based on monthly usage is $5,500.00.	Mt. Wheeler Power, Inc. - Requires 29.2 miles of line. Monthly minimum $2,203.00. Based on 541,000 KWH demand charge and energy charge. Rate would be $10,373.00 per month.	Columbus Electric Cooperative, Inc.- Requires 13 miles of line. Minimum monthly charge of $3,000.00 plus demand charge.	Trico Electric Cooperative, Inc.- Requires 2.5 miles of power line. Minimum monthly billing rate is $1,125.00. Monthly billing rate is based on demand and energy charges of $1.75 per month per KW and $4,329.00 on 541,000 KW.	West Texas Utilities Co.- Requires 26.5 miles of new line. Minimum monthly billing rate is $7,200.00. Demand billing for 1600 KW is $10,250.00 per month.	Mt. Wheeler Power, Inc.- Requires 33.2 miles of new line. Minimum monthly billing rate is $2,807.00. Based on 541,000 KWH demand charge and energy charge rate would be $10,373.00 per month.
AVAILABILITY OF WATER	Existing wells range from 75' to 250' deep for potable water supply.	Clear lake spring could serve as potable water source. Requires 5 miles of pipeline. Drilling deep wells questionable due to presence of high amount of dissolved solids.	Wells for potable water appear practical for depths of 100'.	Drilling wells to 100' should produce a potable water supply.	A supply of potable water requires drilling wells 600' to 800' deep.	A potable water supply requires drilling wells up to 700' deep.	A potable water supply requires drilling wells 50' to 100' deep.
AVAILABLE CONSTRUCTION LABOR FORCE AND AVERAGE WAGE RATE	Local labor is available in Socorro area. Wage rate $6.36 for skilled laborers plus subsistence.	Very little local labor available. Wage rate is $6.05 for construction workers plus subsistence.	Very limited quantity of local labor available. Would have to come from larger cities. Skilled labor rate is $5.55 plus subsistence. State is highly unionized.	Limited quantity of local unskilled labor available. Construction workers would come from larger cities. Skilled labor rate is $6.35 plus subsistence.	Good supply of labor available in area. Construction workers rate $5.60 in Tucson area. Plus subsistence.	Would have to be drawn from a very wide area. Skilled labor rate is $5.10 plus subsistence.	Limited quantity of unskilled labor available. Skilled construction labor from larger cities. Skilled labor rate $5.55 plus subsistence. State highly unionized.

Table 5-12

CLIMATOLOGY

	ITEM	Y-15 NEW MEXICO	Y-16 UTAH	Y-17 NEVADA	Y-22 NEW MEXICO	Y-23 ARIZONA	Y-27 TEXAS	Y-33 NEVADA
TEMPERATURE-	AVERAGE DAILY MINIMUM-°F	31.0°	38.3°	22.0°	44.6°	58.6°	57.3°	30.2°
	AVERAGE DAILY MAXIMUM-°F	72.0°	73.0°	60.8°	78.3°	81.4°	82.5°	60.2°
	RECORD LOW-°F	-22.0°	-32.0°	-34.0°	-9.0°	19.0°	-5.0°	-26.0°
	RECORD HIGH-°F	104.0°	101.0°	98.0°	110.0°	117.0°	111.0°	100.0°
	ANNUAL MEAN-°F	52.5°	54.6°	44.7°	61.5°	70.0°	69.7°	45.2°
PRECIPITATION-	GREATEST ANNUAL-INCHES	N/A	11.33	10.57	19.70	N/A	N/A	18.84
	GREATEST DAILY-INCHES	2.25	2.00		3.08	6.00	4.50	N/A
	AVERAGE ANNUAL TOTAL-INCHES	12.00	8.41	6.32	10.00	12.80	17.83	12.89
	GREATEST MONTHLY-INCHES	4.66	2.88	3.50	6.46	6.30	15.79	4.61
	MEAN YEARLY SNOW-INCHES	25.0	23.1	30.0	4.3	1.5	1.5	51.2
	RECORD MAX. SNOWFALL-INCHES	N/A	14.2	37.0	10.0	6.4	4.7	28.4
	THUNDERSTORMS-AVG. PER YEAR	80	35	20	46	35	40	25
WINDS-	STATE TORNADO FREQUENCY/YR.	1 in 109 Years	2 in 18 Years	1 in 2 Years	1 in 52 Years	Almost Non-Existent	5 in 5 Years	1 in 2 Years
	50 YR. MAXIMUM WIND-M.P.H.	77	90	70	75	67	67	75
	MEAN HOURLY SPEED FOR YR.-M.P.H.	9.6	10.4	10.0	10.0	7.8	10.4	10.2
	DIRECTION PREVAILING WIND	W	SW	SW	SW	SE	SE	SW
AIR POLLUTION-	DUST DAYS PER YEAR	Infrequent	Heavy	Light	3 Severe, 4 Moderate, 13 Light	Light	Fairly Severe Several Per Year	Light
	HAIL DAYS PER YEAR	0 in 16 Years	Infrequent	4 Per Year	2 Per Year	Infrequent	Frequent-Severe	4 Per Year
	HEAVY FOG DAYS PER YEAR	2	4	Little Fog	1	1	14	Little Fog
RELATIVE HUMIDITY-	MEAN ANNUAL REL. HUMIDITY	53%	55%	50%	45%	44%	60%	55%
SKY COVER-	ANNUAL AVERAGE CLEAR DAYS	N/A	132	123	165	194	132	N/A
	ANNUAL AVE. PTLY. CLOUDY DAYS	N/A	104	76	121	91	99	N/A
	ANNUAL AVERAGE CLOUDY DAYS	N/A	129	166	79	80	134	N/A
	SUNSHINE POSSIBLE THROUGH YEAR	70%	69%	76%	80%	86%	67%	70%
	SOLAR RADIATION (LANGLEYS)	490	421	460	487	513	528	425

HEAVY FOG reduces visibility to 1/4 mile or less.
PRECIPITATION includes snow reduced to inches of water.
ALL TEMPERATURES are in degrees fahrenheit.
HIGHEST WIND recorded does not include gusts which could exceed highest wind.
N/A - Not Available.

SKY COVER is expressed in a range of 0 for no clouds or obscuring phenomena to 10 for complete sky cover. The number of clear days is based on average cloudiness 0-3; partly cloudy days 4-7 and cloudy days 8-10 tenths.

Table 5-13

DEVELOPABLE NATURAL RESOURCES

*ITEM	Y-15 NEW MEXICO	Y-16 UTAH	Y-17 NEVADA	Y-22 NEW MEXICO	Y-23 ARIZONA	Y-27 TEXAS	Y-33 NEVADA
MINERAL RESOURCES	Some Uranium Prospects in the region - no active mining.	Possible mining of cinder material near Pavant Butte. Possible potash deposits in Sevier Lake area.	Zinc mining 8 miles from apex. Little current activity in Eureka mining district for lead 25 miles from site. Mining claims have been filed near both Southwestern and Northern Branches.	Large amount of open pit copper mining 28 miles North of apex. Some copper mining 20 miles west of site.	Large mines operating 24 miles North of apex. Several inactive claims with future potential in Southern part of Site.	No active mining	Inactive copper Bismuth mine with substantial reserves located in Dolly Varden Mountains.
OIL AND GAS RESOURCES	One well on Site - dry and abandoned	There is seismograph activity in the valley at present. Two wells in region - dry and abandoned	None	There are approximately 1,000,000 acres under oil lease. One well near array proved dry and abandoned.	No activity	Several wells in area - all dry and abandoned	One well on Site - dry and abandoned.

* Within 40 Miles of Site Locations.

Table 5-14

SITE CONSTRUCTION COSTS (1968$)

NO.	ITEM	Y-15 NEW MEXICO	Y-16 UTAH	Y-17 NEVADA	Y-22 NEW MEXICO	Y-23 ARIZONA	Y-27 TEXAS	Y-33 NEVADA
1.	AIRSTRIP	134,000	109,756	133,047	104,876	175,255	138,741	149,829
2.	ACCESS ROADS	26,742	383,283	401,247	273,253	268,130	455,952	1,208,028
3.	WATER SUPPLY	63,115	70,680	70,680	70,680	70,680	70,680	70,680
4.	SEWAGE TREATMENT	33,725	35,125	35,125	35,125	35,125	35,125	35,125
5.	WYE	5,825,339	5,964,678	5,708,192	5,552,542	7,480,363	6,095,644	5,955,084
6.	CABLE TRENCHES	1,248,100	1,248,100	1,248,100	1,248,100	1,248,100	1,248,100	1,248,100
7.	FOUNDATIONS	800,000	800,000	800,000	800,000	800,000	800,000	800,000
8.	STAGING AREA	51,501	71,481	71,481	71,481	71,481	71,481	63,731
9.	POWER SUPPLY	454,000	600,000	587,000	558,000	474,000	621,000	640,000
10.	TELEPHONE	3,000	1,300	5,200	4,600	3,000	14,500	12,000
11.	REAL ESTATE	100,000	36,000	117,800	67,000	74,000**	2,700*	46,000
12.	BUILDING COMPLEX	921,585	921,585	921,585	921,585	921,585	921,585	921,585
	TOTAL CONSTRUCTION COSTS	$9,661,107	$10,241,988	$10,099,457	$9,707,242	$11,621,719	$10,475,508	$11,150,162

* Yearly Lease Required

** Of This Amount $28,000 Per Year is Lease of Indian Land

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Chapter 6

THE REJECTED SITES

Chapter 6

THE REJECTED SITES

A. General Remarks

Of the total of 34 possible VLA sites which were listed in Chapter 4, 7 were found acceptable and these have been described in Chapter 5. The 27 remaining sites, however, were judged unacceptable for the array, and in the present chapter the reasons for removing these sites from the active list are discussed. A map of each site is provided (Figs. 6-1 to 6-26) at the end of the chapter.

B. Sites Rejected on the Basis of Examination of Maps and Records

Eight of the 14 sites in this group lie wholly or partly in military reservations and would be subject to interference of one type or another. One is in an oil field. In the remainder, the VLA cannot be layed out with an acceptable orientation, or the terrain is excessively rough. The sites in this group are shown as "Category III" on Fig. 4-1. They include the following:

Site Y2 — Sierra and Otero Counties, New Mexico (Fig. 6-1). On the Jornada del Muerto, its center is approximately 26 miles south southeast of San Antonio, New Mexico, and about 4 miles northwest of the site of the first atomic bomb test. Rejected because it lies within the White Sands Proving Ground (except for the outermost 8 miles of the northwest branch); existing activities in the area are incompatible with the VLA.

Site Y3 — Socorro, Lincoln, and Sierra Counties, New Mexico (Fig. 6-2). The center is in the Tularosa Valley, about 35 miles northwest of Alamogordo. Also rejected because it lies entirely within the White Sands Proving Ground.

Site Y7 — Juab County, Utah (Fig. 6-3). The center is near the junction of Judd and Meadow Creeks, approximately 28 miles northwest of Lynndyl, and about 14 miles north of the center of site Y18. The surrounding mountains prevent placement at an acceptable orientation.

Site Y8 — Maricopa and Yuma Counties, Arizona (Fig. 6-4). The center is about 14 miles southeast of Aztec. Rejected because, except for the outermost extremities of the northeast and northwest branches, it lies entirely within the Williams Bombing and Gunnery Range.

Site Y10 — Tooele and Juab Counties, Utah (Fig. 6-5). The center is at the southern edge of the Great Salt Lake Desert, approximately 63 miles northwest of Delta. Rejected because it lies within the Wendover Bombing and Gunnery Range and the Dugway Proving Ground (Desert Test Center).

Site Y11 — Juab and Millard Counties, Utah (Fig. 6-6). The center is at the northern end of the Tule Valley, about 53 miles west northwest of Delta. Rejected because of difficult terrain. The slope of the northwest branch is excessive (over 3 percent) for the first 3-1/2 miles out from the center. There are also two places on the northeast branch where locally difficult ground would be encountered. The first of these is a high spur running from the hill north of the center, which crosses the branch about 1-1/2 miles from the center. The second is at Sand Pass, 8 miles from the center, where the northernmost spur of the House Range juts into the path of the branch.

Site Y12 — Yuma County, Arizona (Fig. 6-7). The center is in the Mohawk Valley, approximately 48 miles west of Ajo. Rejected for two reasons. First, the surrounding terrain prevents alignment of the branches on an acceptable orientation. Second, the site lies entirely within the Williams Bombing and Gunnery Range.

Site Y13 — Clark County, Nevada (Fig. 6-8). The center is on Mormon Mesa, some 56 miles northeast of Las Vegas. Rejected because Interstate Highway 15 passes right through the center, and no realignment permitted by the terrain could significantly alleviate this problem. The maps of the area also suggest that the ground may be fairly rough.

Site Y14 — White Pine County, Nevada (Fig. 6-9). The center is in the Newark Valley, about 18 miles east of Eureka. Rejected because the surrounding mountains do not permit placement on the desired orientation. Furthermore, grades greater than 3 percent occur near the middle of the east branch.

Site Y21 -- Nye County, Nevada and Inyo County, California (Fig. 6-10). This site, which straddles the California-Nevada line, has its center in the Amargosa Desert, approximately 25 miles southeast of Beatty, Nevada. Rejected because the outer half of the northeast branch extends into the Las Vegas Bombing and Gunnery Range.

Site Y24 — Reeves and Pecos Counties, Texas (Fig. 6-11). The center is approximately 19 miles southeast of Pecos. Rejected because of the numerous oil wells in the vicinity. The northeast branch passes within a few hundred yards of the test track of an automotive proving ground. The northwest branch crosses the southwestern extremity of Toyah Lake, which is shown as intermittent on modern topographic maps of the area.

Site Y25 — Nye County, Nevada (Fig. 6-12). The center is on Cactus Flat, about 32 miles east southeast of Tonopah. Rejected because the southeast and southwest branches lie entirely within the Nellis Air Force Range. The center lies close to the northern boundary of the Range, and it is only 50 miles from the Nevada Test Site of the Atomic Energy Commission, where underground nuclear tests are carried out. Seismic effects from large tests would undoubtedly be felt at this site.

Site Y28 — Maverick and Kinney Counties, Texas (Fig. 6-13). The center is 17 miles south of Brackettville, not far from the Mexican border. This is the most southerly site in the list. The Southern Pacific Railroad crosses the southwest branch about 2 miles from the center. Rejected because of unsatisfactory terrain. In particular, at least three of the drainage channels crossing the branches are wide and deep enough to require major bridging or causeways.

Site Y29 — Kern and Los Angeles Counties, California (Fig. 6-14). The center is in the Mojave Desert, about 21 miles west of Barstow. The outer half of the northwest arm lies within the Flight Test Center, Edwards Air Force Base. The south branch comes within 6 miles of George Air Force Base; the center lies in line with the main runway at a distance of 19 miles. The very high density of military air traffic in the immediate vicinity and the consequent high intereference levels led to the rejection of this site.

C. Sites Rejected After Air and/or Surface Inspection

Most of the 13 sites in this group were dropped from active consideration because inspection revealed that they are poorly drained or excessively rough. Three sites were ruled out because of nearby activities that would conflict with the array. The sites in this group are the following:

Site Y1 — Lea and Eddy Counties, New Mexico (Fig. 6-15). Inspected from the air. The center is approximately 40 miles east southeast of Carlsbad. Rejected because it lies in the midst of numerous oil wells.

Site Y4 — Valencia and Catron Counties, New Mexico (Fig. 6-16). Inspected from the air. At 7300 feet above sea level, this is the highest site in the list. The center is in the North Plains, about 40 miles southwest of Grants. Rejected because the ground is much too rough for the array. There are several clearly defined, geologically recent fault scarps in the vicinity. One comes close to the northwest arm, and would pass under it about 10-1/2 miles from the center.

Site Y5 — Coconino County, Arizona (Fig. 6-17). Inspected from the air. The site lies on the Moenkopi Plateau, and its center is approximately 25 miles southeast of the village of Moenkopi. The entire site is on Indian land. Most of the northwest branch is in the Navajo Indian Reservation, while the remainder, including all of the northeast and south branches, is in the Hopi Indian Reservation. The south and northwest branches terminate near the abrupt escarpment which overlooks the Painted Desert. The terrain is far too rough for the array. There are numerous rock outcrops which would make construction of the antenna roadways difficult and expensive.

Site Y6 — Pima County, Arizona (Fig. 6-18). Inspected from the air. This site lies entirely within the Papago Indian Reservation. Its center is approximately 21 miles west of Sells. The outer end of the south branch is about 1 mile from the Mexican border. The ground is generally very flat and largely covered by desert scrub. The entire area is covered by a fairly dense net of clearly defined, narrow, and sometimes interlaced drainage channels. There are also several major channels which cross the array branches. The northeast branch actually lies in one of these (the San Luis Wash) for most of its length. Each of the other two arms crosses two major washes. There is no room to realign the array to ease this problem, owing to the surrounding hills and mountains. It was rejected because of the very extensive work that would have to be done to protect this site from water damage.

Site Y9 — Millard and Beaver Counties, Utah (Fig. 6-19). Inspected from the air. This site is in the Wah Wah Valley, a short distance south of Sevier Lake. The center is some 26 miles northwest of Milford. The first third of the south branch lies on the Wah Wah Valley Hardpan, a medium-sized playa (about 6 miles long by 2 miles wide) which is normally dry. Owing to a recent period of heavy rainfall, it was nearly half full of water when the site was examined. This was sufficient reason to exclude the site from further consideration. The terrain along the northwest branch is excessively steep. The outer end is 1120 feet higher than the center, so the average grade is about 1.6 percent. The rise is not uniform, however, and locally the slope is as much as 8 percent. The surface is generally quite uneven on this branch.

Site Y18 — Juab and Millard Counties, Utah (Fig. 6-20). Inspected from the air. The site lies in the Sevier Desert, and its center is approximately 17 miles west northwest of Lynndyl. It lies near the lowest part of a large closed drainage basin. When Y18 was examined, there were several miles of shallow standing water on the part of the north branch nearest to the center. This was presumably a temporary condition resulting from recent heavy rains; nonetheless, it makes the site unacceptable. It appears that the whole area enclosed by the 4600-foot contour may be subject to occasional shallow flooding.

Site Y19 — Esmeralda and Nye Counties, Nevada (Fig. 6-21). Inspected from the air and on the ground. The center is at Millers, about 14 miles west northwest of Tonopah. U.S. Highway 6 crosses the north branch 0.6 miles from the center, and the southwest branch 11 miles out. An electrical substation and small abandoned open-pit mine are within a few hundred yards of the center. Rejected because the outer half of the southeast branch is excessively steep, with grades reaching 3 percent over long stretches. There is another serious objection to this site. A radar station on one of the hills just north of Tonopah is potentially a source of serious interference. This facility is visible from nearly all of Y19. There is also a relay station on Booker Mountain, about 3-1/2 miles northeast of Tonopah, which would generate interference.

Site Y20 — Nye County, Nevada (Fig. 6-21). Inspected from the air. This site is in the Big Smoky Valley, about 22 miles north of Y19 and on the same broad flat area. The center is approximately 27 miles north of Tonopah. It is subject to the same interference as Y19 (see above) and it was rejected for this reason.

Site Y26 — Hudspeth County, Texas (Fig. 6-22). Inspected from the air and on the ground. This site is on a gently sloping plain just to the west of Salt Flat, a large dry lake bed. The center is about 70 miles east of El Paso. Rejected because the ground is too rough for the array. Furthermore, grades as steep as 4 percent occur on the northeastern and northwestern branches.

Site Y30 — San Juan County, New Mexico (Fig. 6-23). Inspected from the air. The site lies entirely within the Navajo Indian Reservation. Its center is approximately 31 miles south southwest of Farmington. Rejected because the terrain is very rough and deeply eroded.

Site Y31 — McKinley and San Juan Counties, New Mexico (Fig. 6-24). Inspected from the air. The site is entirely within the Navajo Indian Reservation; its center is approximately 26 miles north northwest of Gallup. Rejected because of rough terrain similar to that of Y30.

Site Y32 — Lander, Humboldt, and Pershing Counties, Nevada (Fig. 6-25). Inspected from the air. The site lies mainly in the Buffalo Valley; the outer part of the southeast branch reaches into the Reese River Valley. The center is about 20 miles southwest of the town of Battle Mountain. The north branch crosses the western foot of Battle Mountain, and the site was rejected because the outer half of this branch is much too rough.

Site Y34 — Elko County, Nevada (Fig. 6-26). Inspected from the air. This site is located in the Ruby Valley, and its center is approximately 38 miles southeast of Elko. Rejected because the outer half of the southwest branch lies on the marshy ground surrounding Franklin Lake, which is subject to occasional flooding during the wet season.

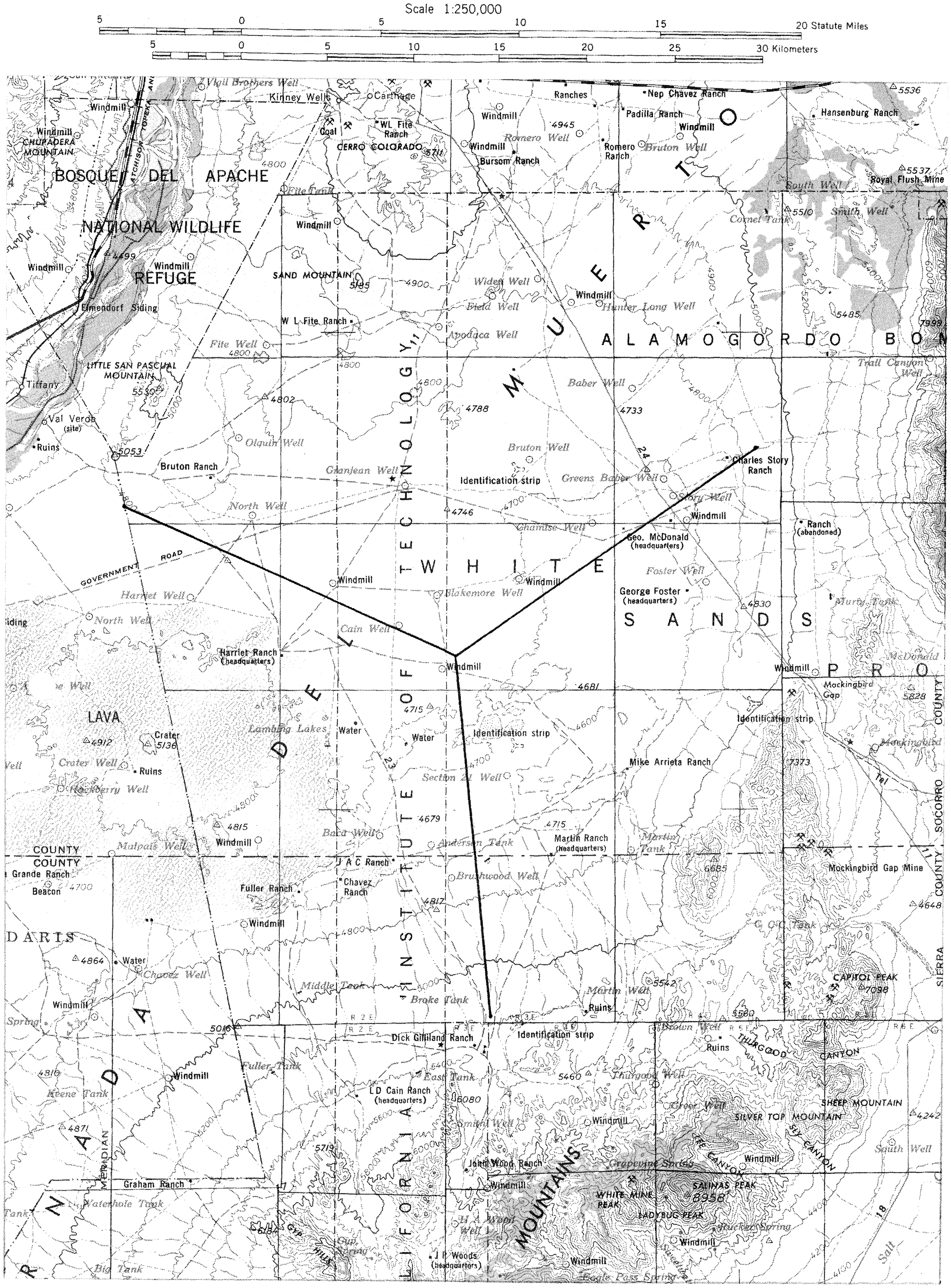

Fig. 6-1. Site Y2 (New Mexico)

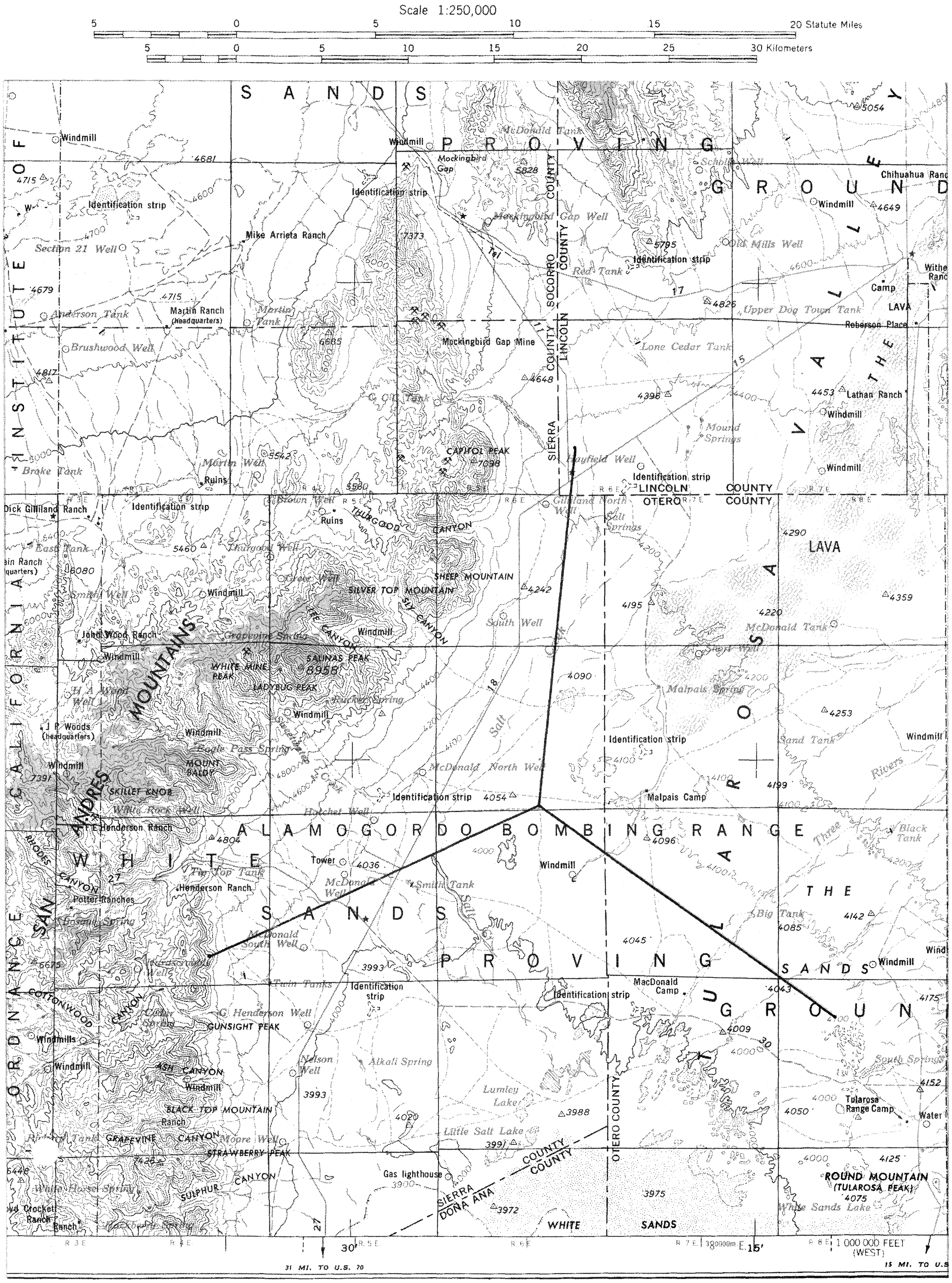

Fig. 6-2. Site Y3 (New Mexico)

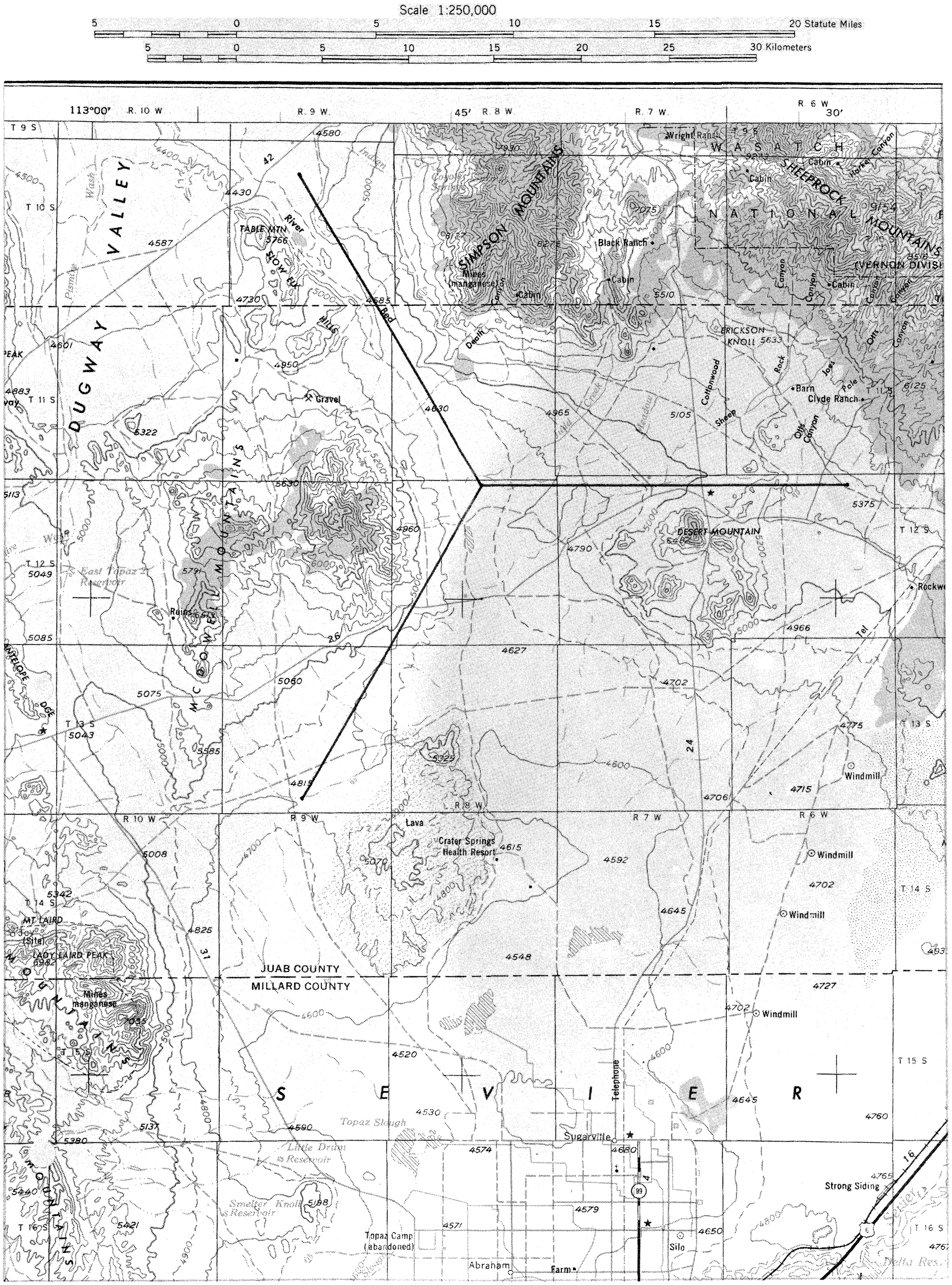

Fig. 6-3. Site Y7 (Utah)

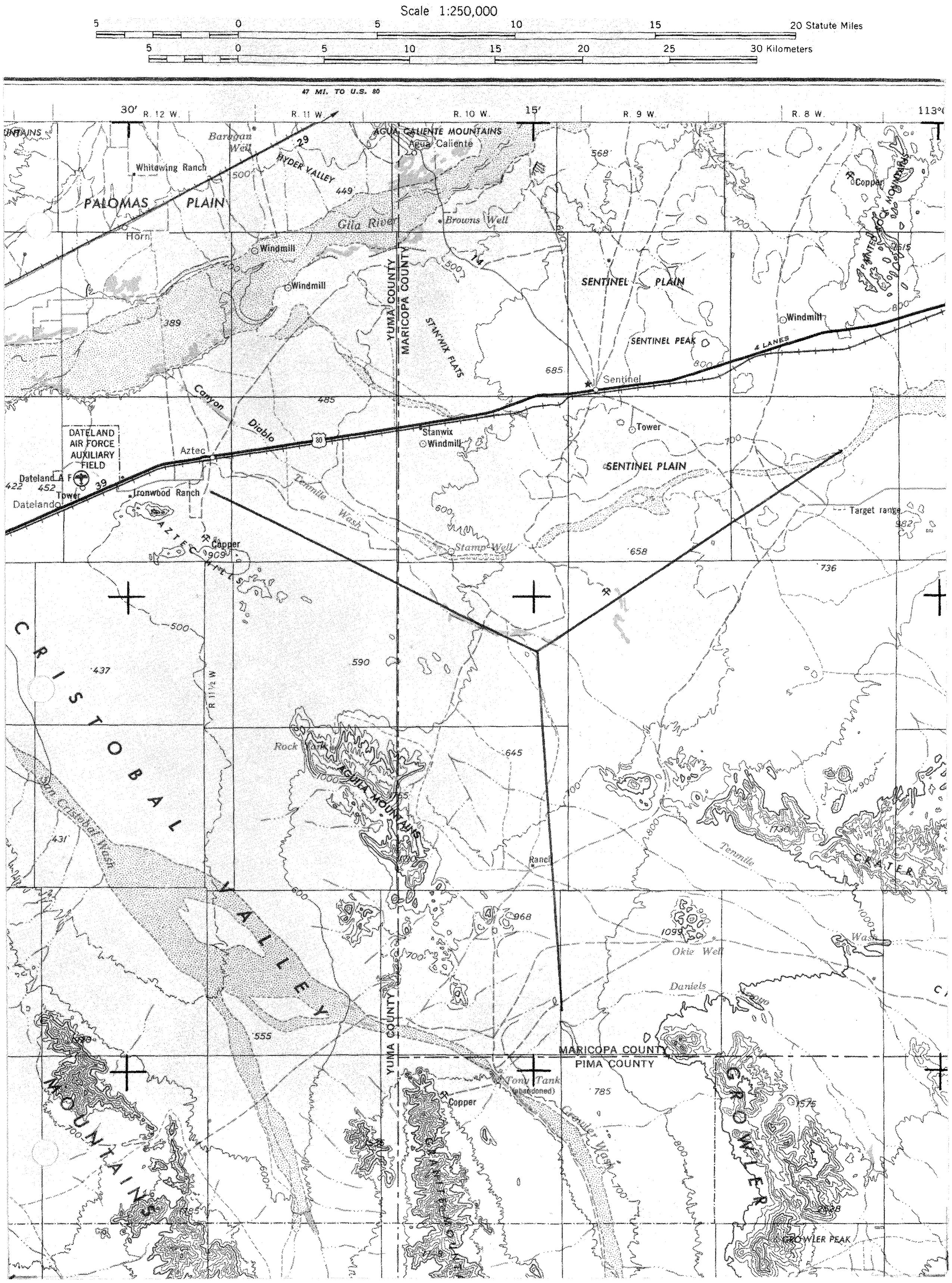

Fig. 6-4. Site Y8 (Arizona)

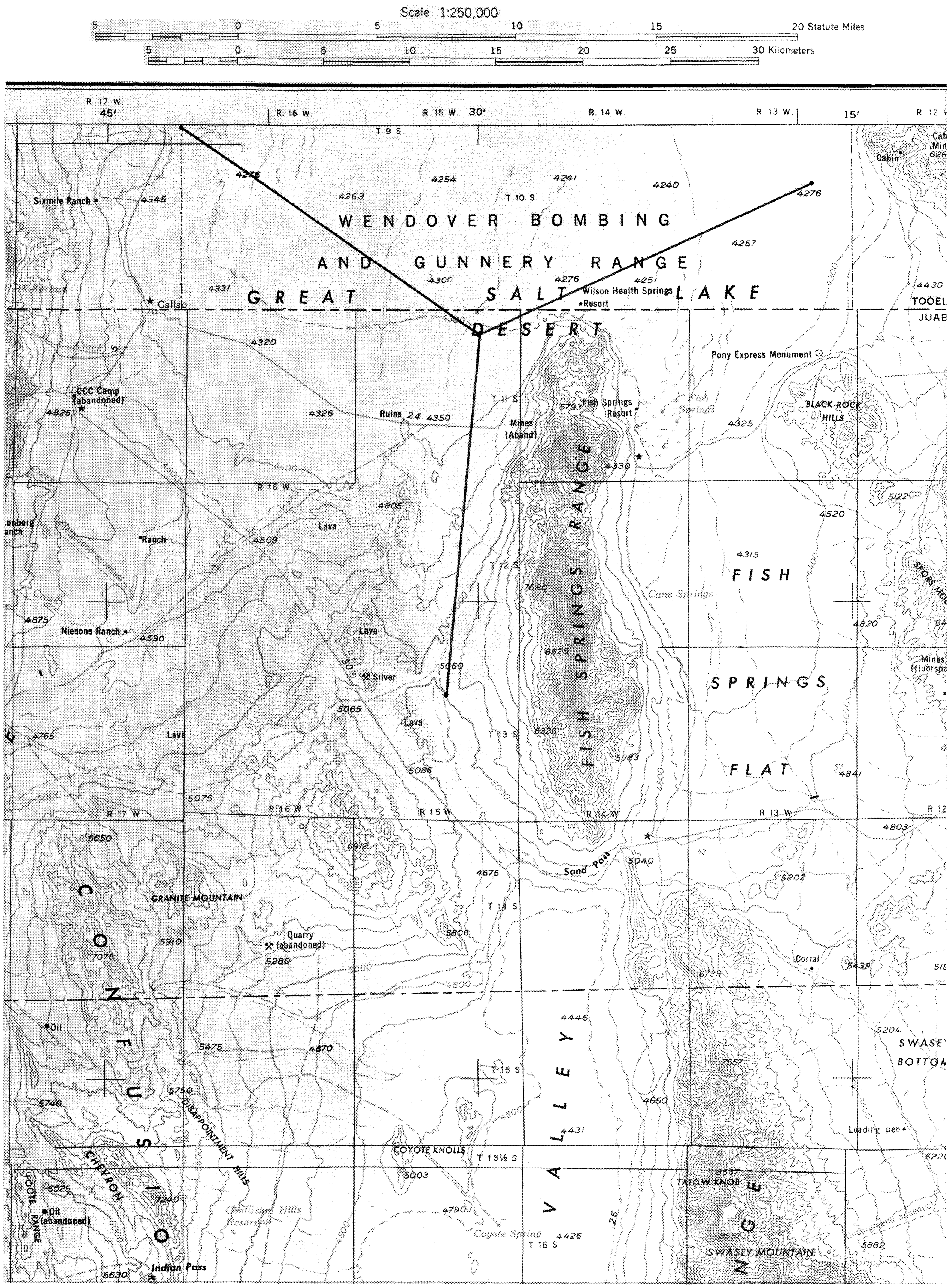

Fig. 6-5. Site Y10 (Utah)

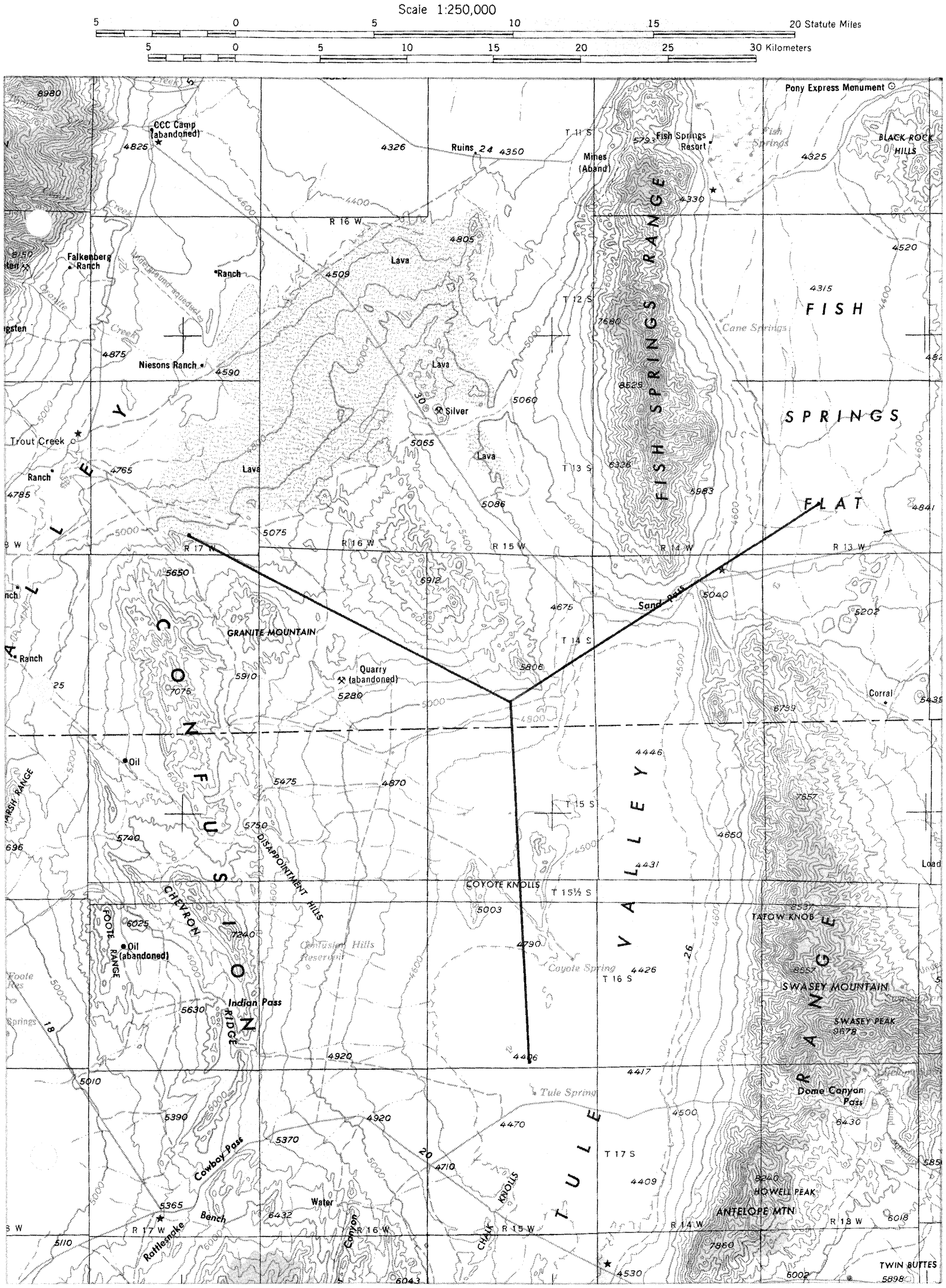

Fig. 6-6. Site Y11 (Utah)

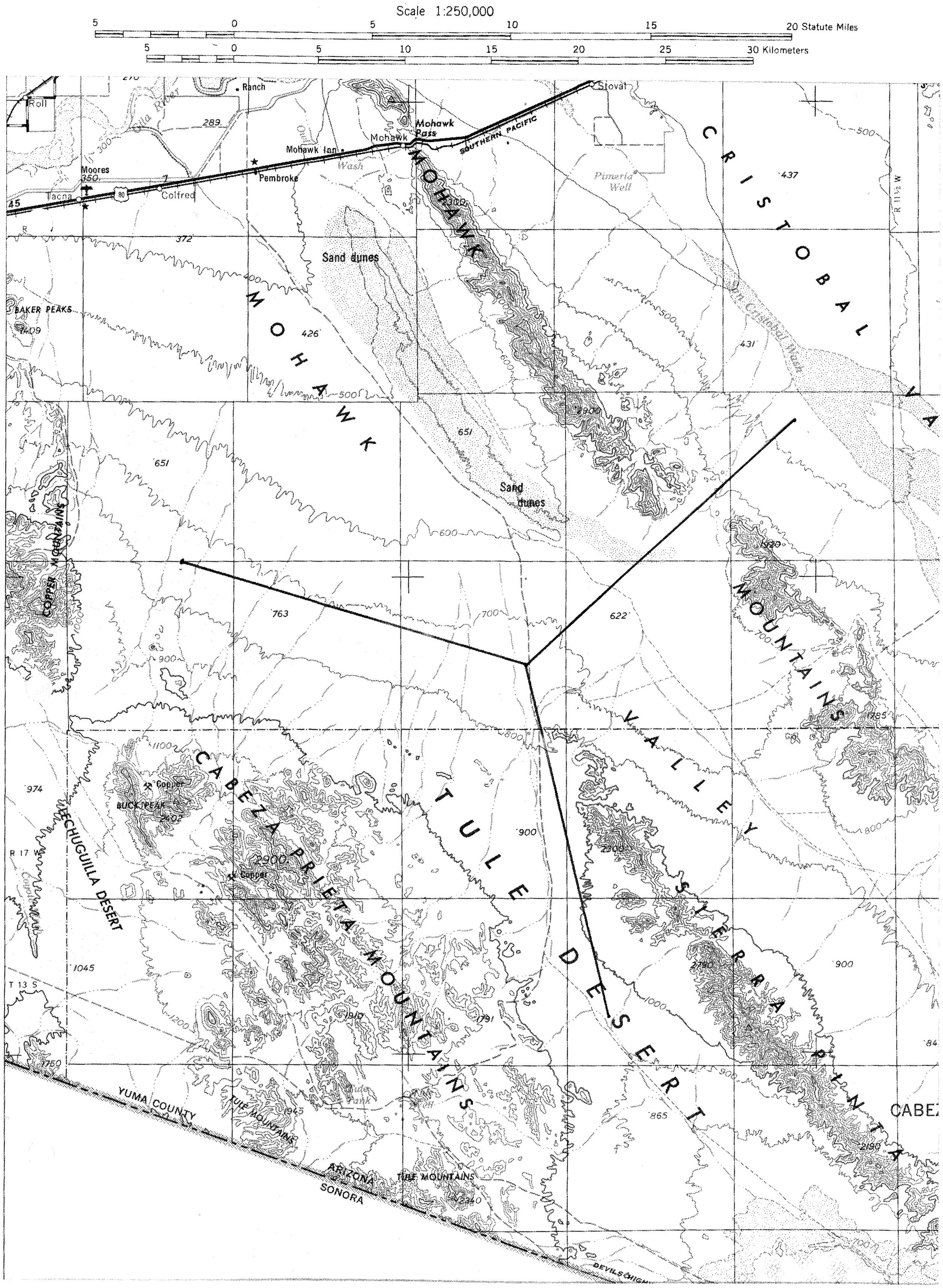

Fig. 6-7. Site Y12 (Arizona)

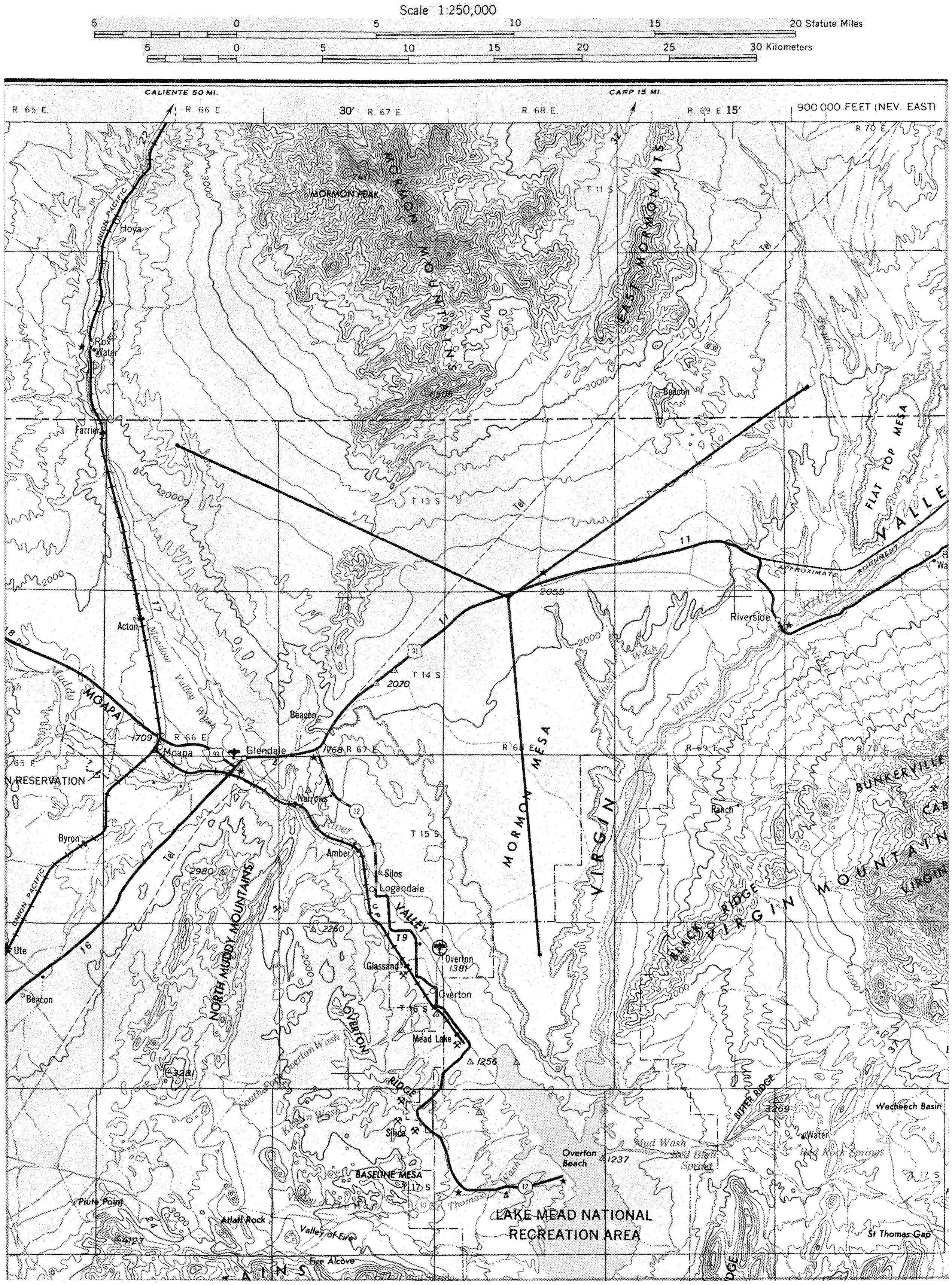

Fig. 6-8. Site Y13 (Nevada)

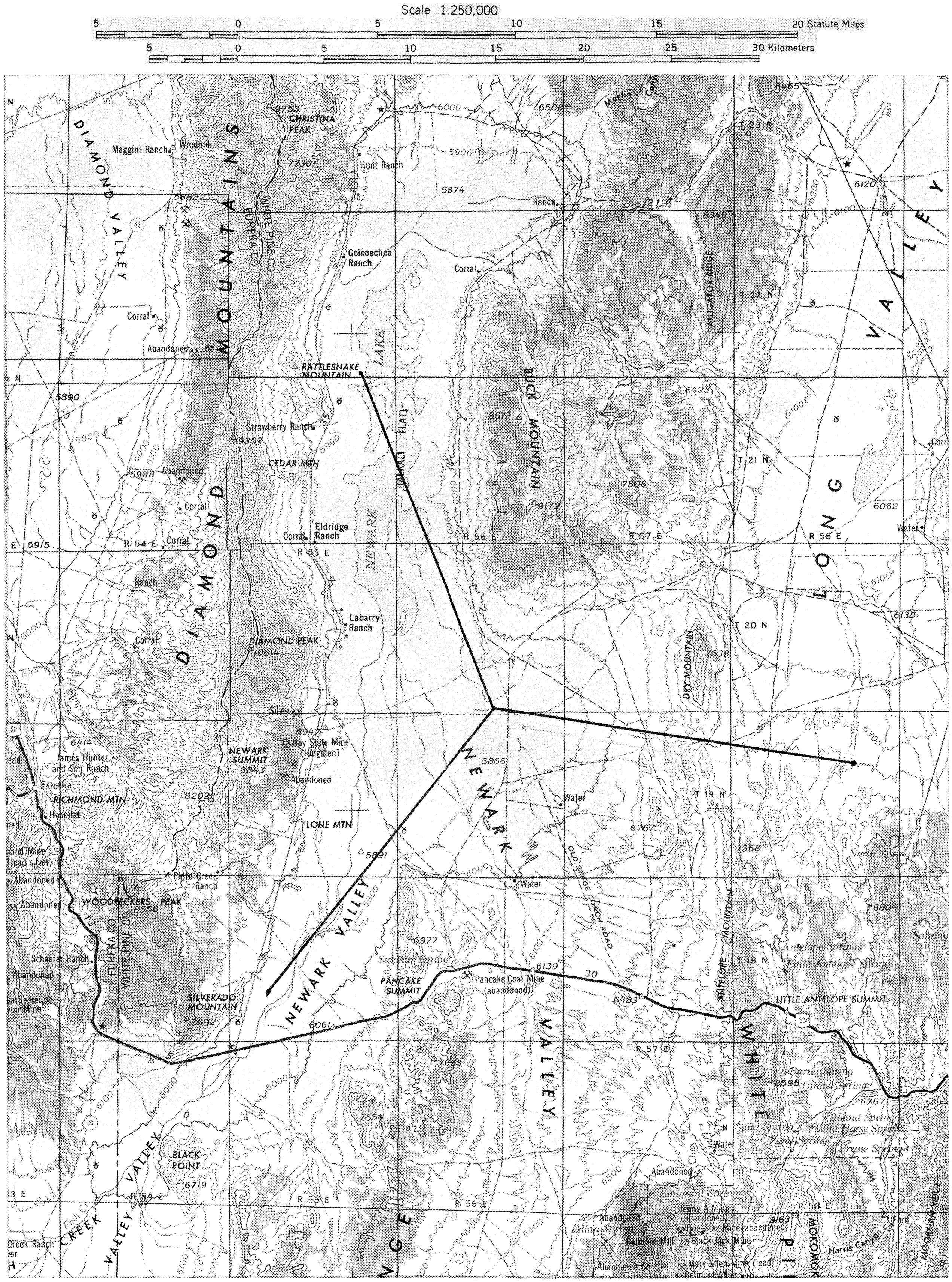

Fig. 6-9. Site Y14 (Nevada)

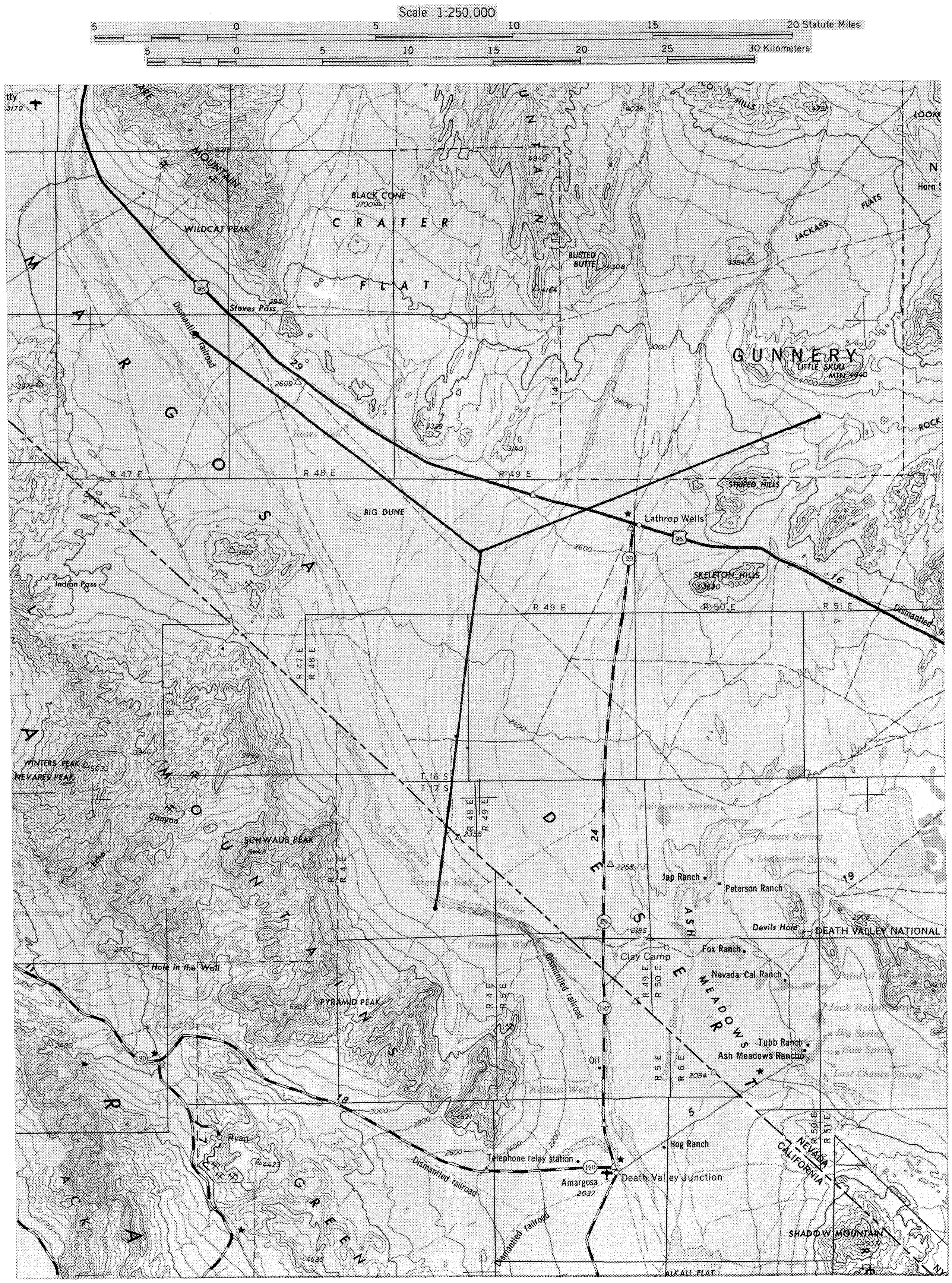

Fig. 6-10. Site Y21 (Nevada and California)

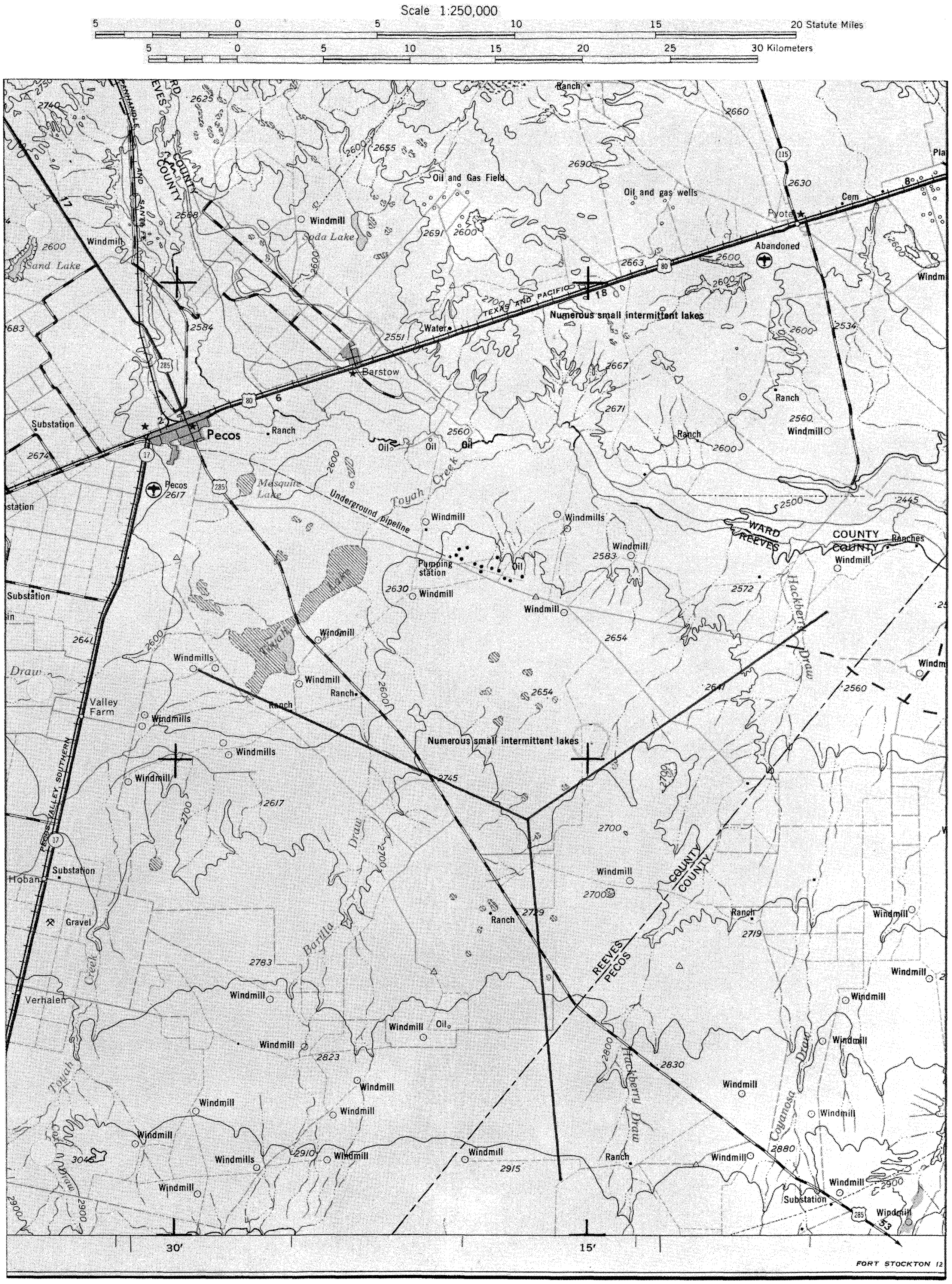

Fig. 6-11. Site Y24 (Texas)

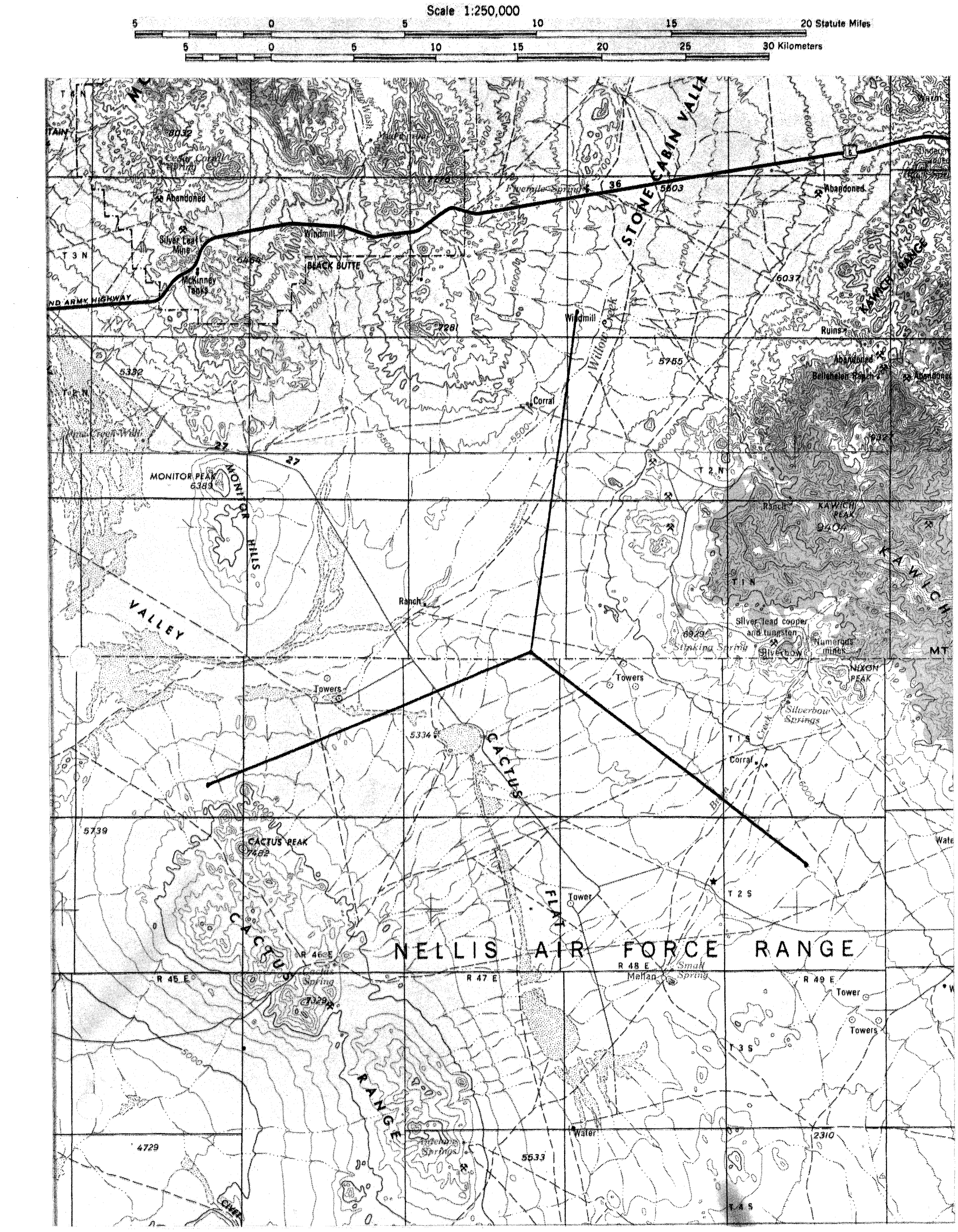

Fig. 6-12. Site Y25 (Nevada)

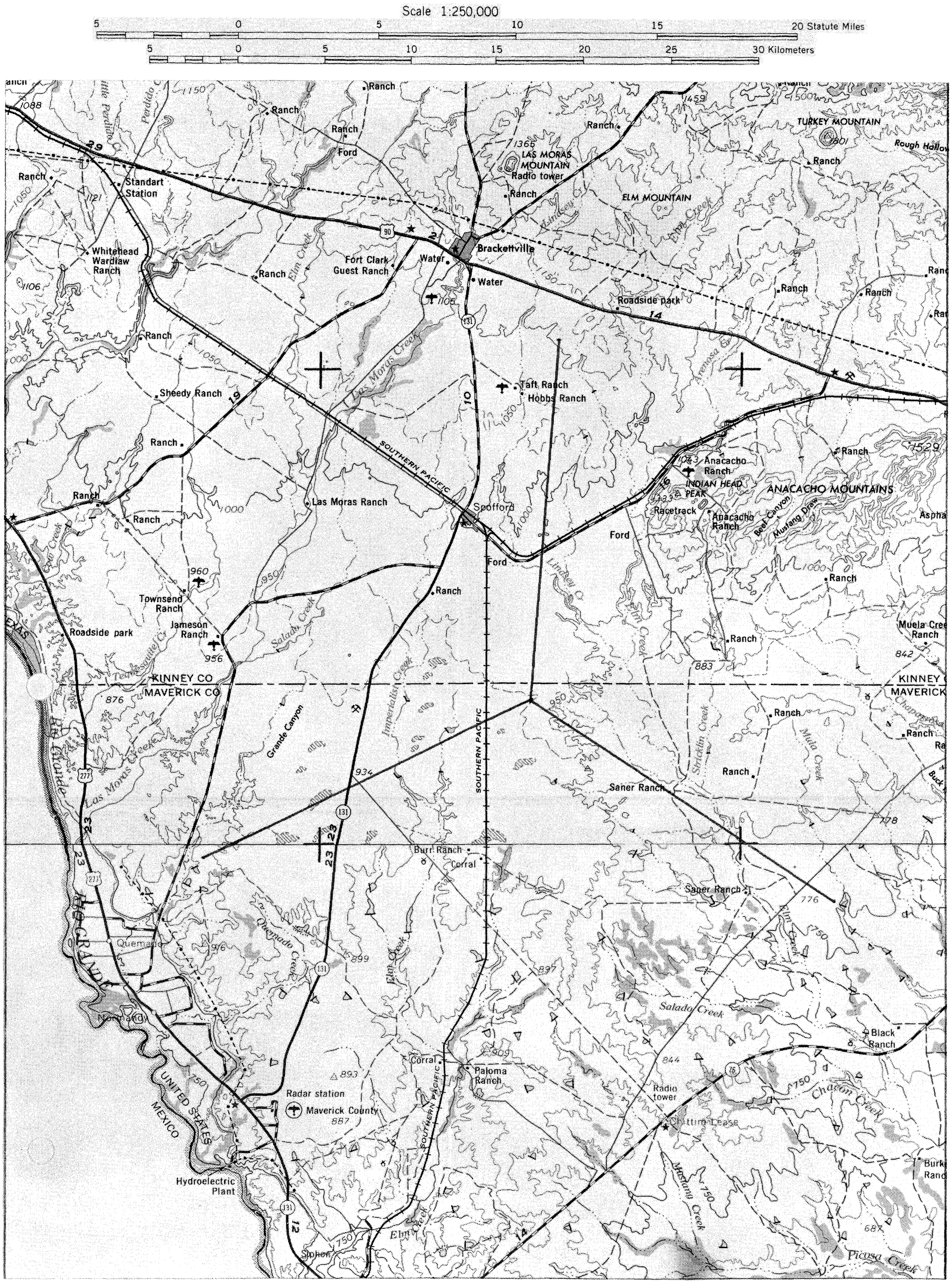

Fig. 6-13. Site Y28 (Texas)

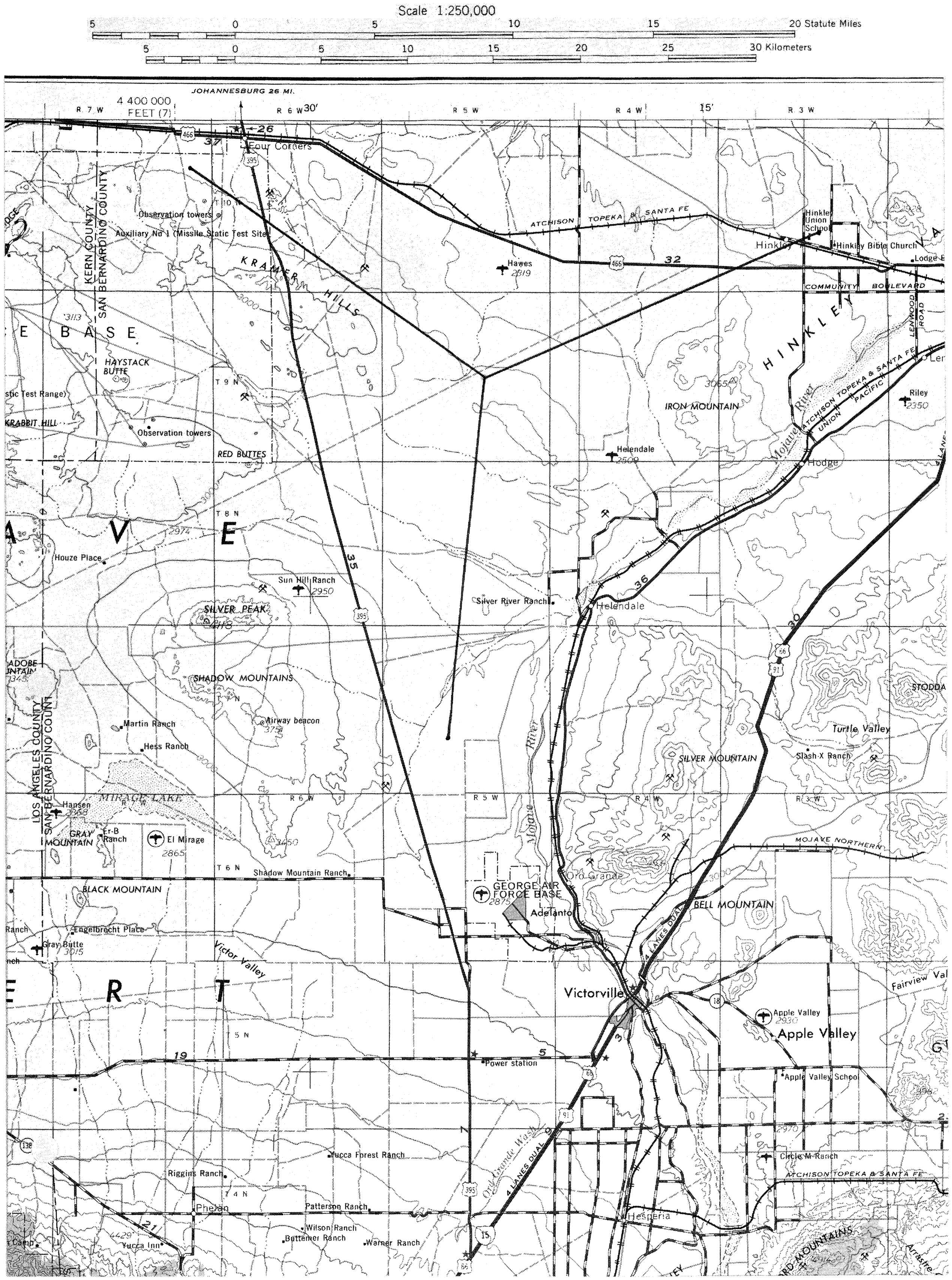

Fig. 6-14. Site Y29 (California)

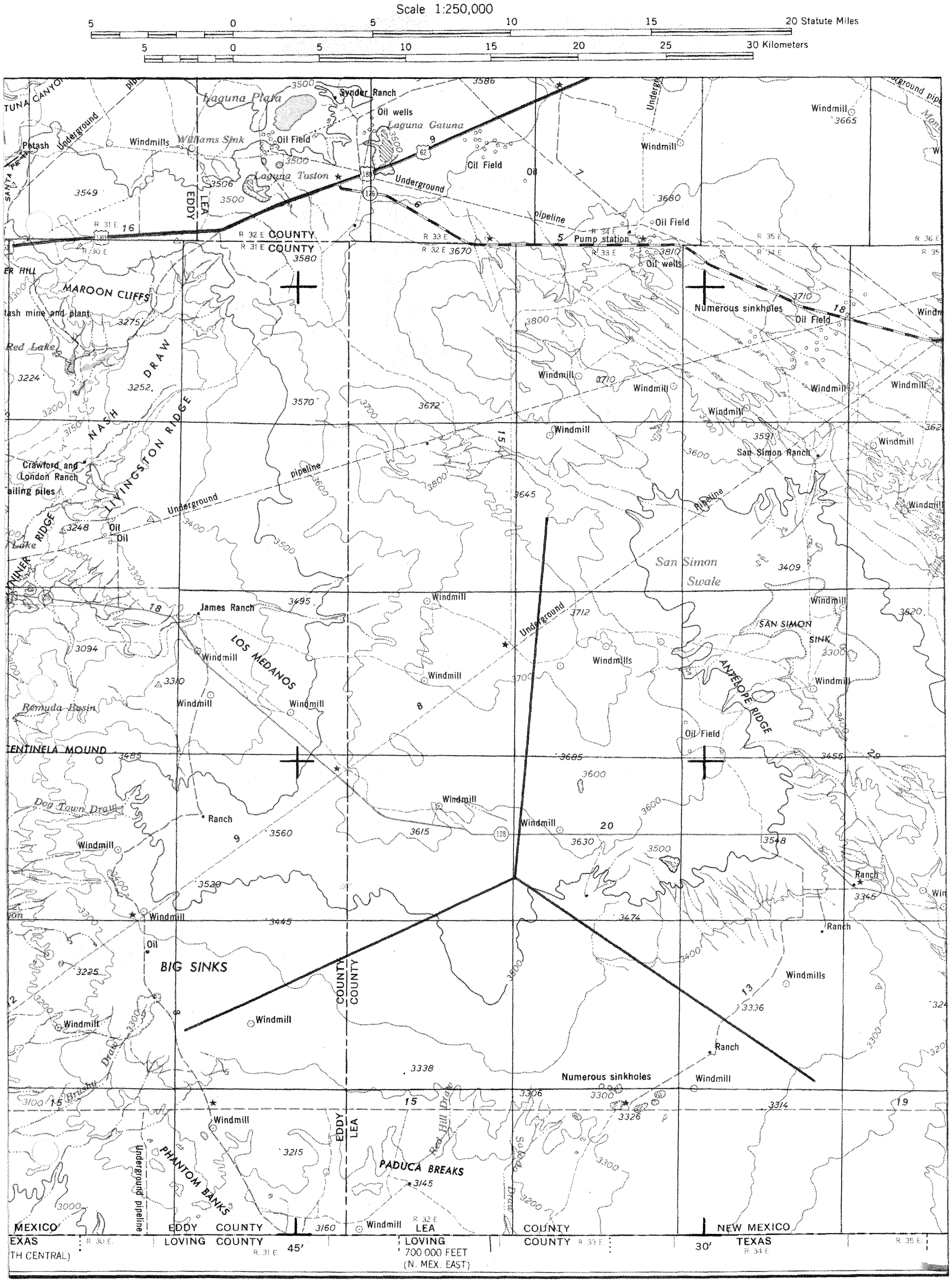

Fig. 6-15. Site Y1 (New Mexico)

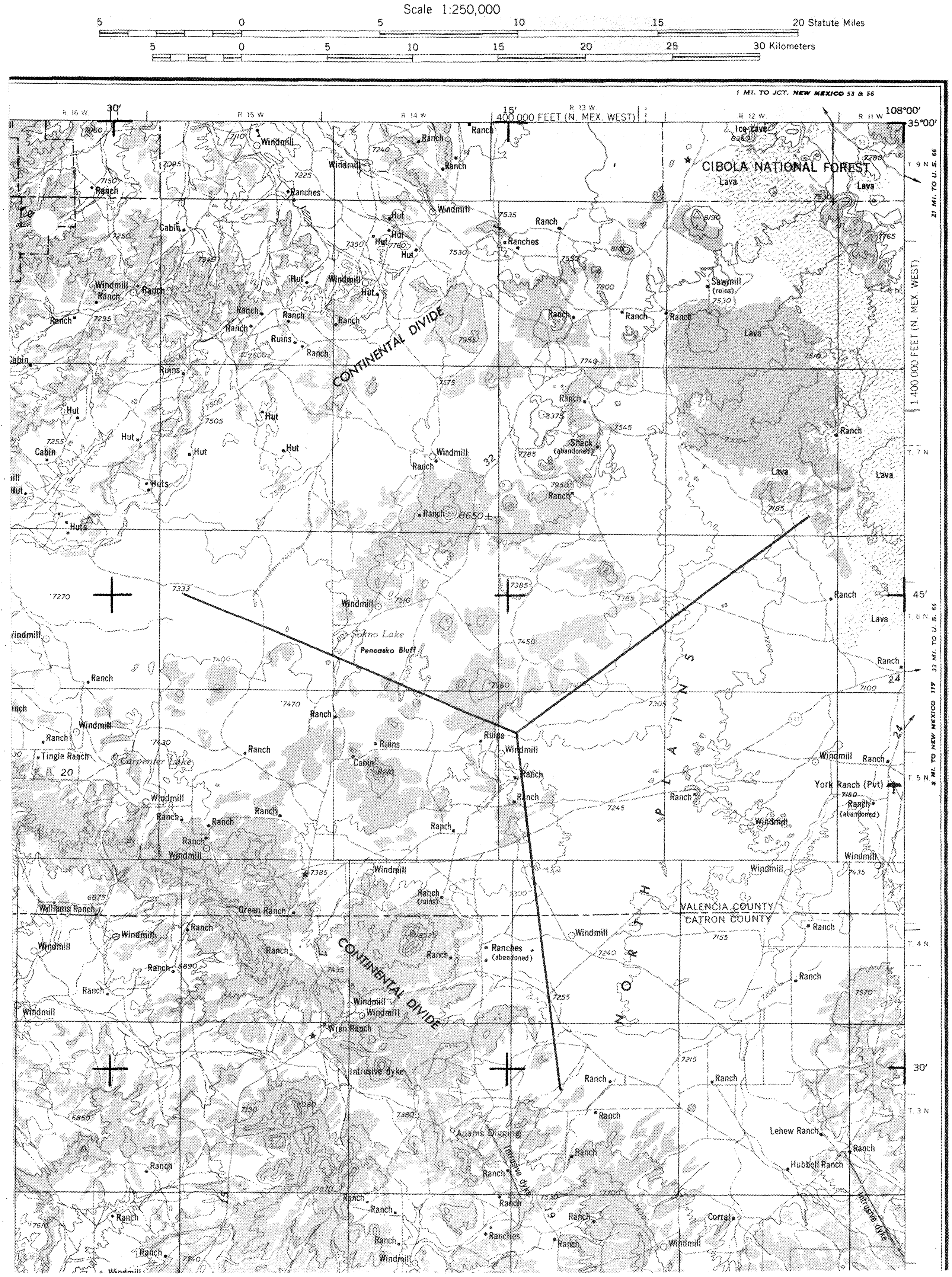

Fig. 6-16. Site Y4 (New Mexico)

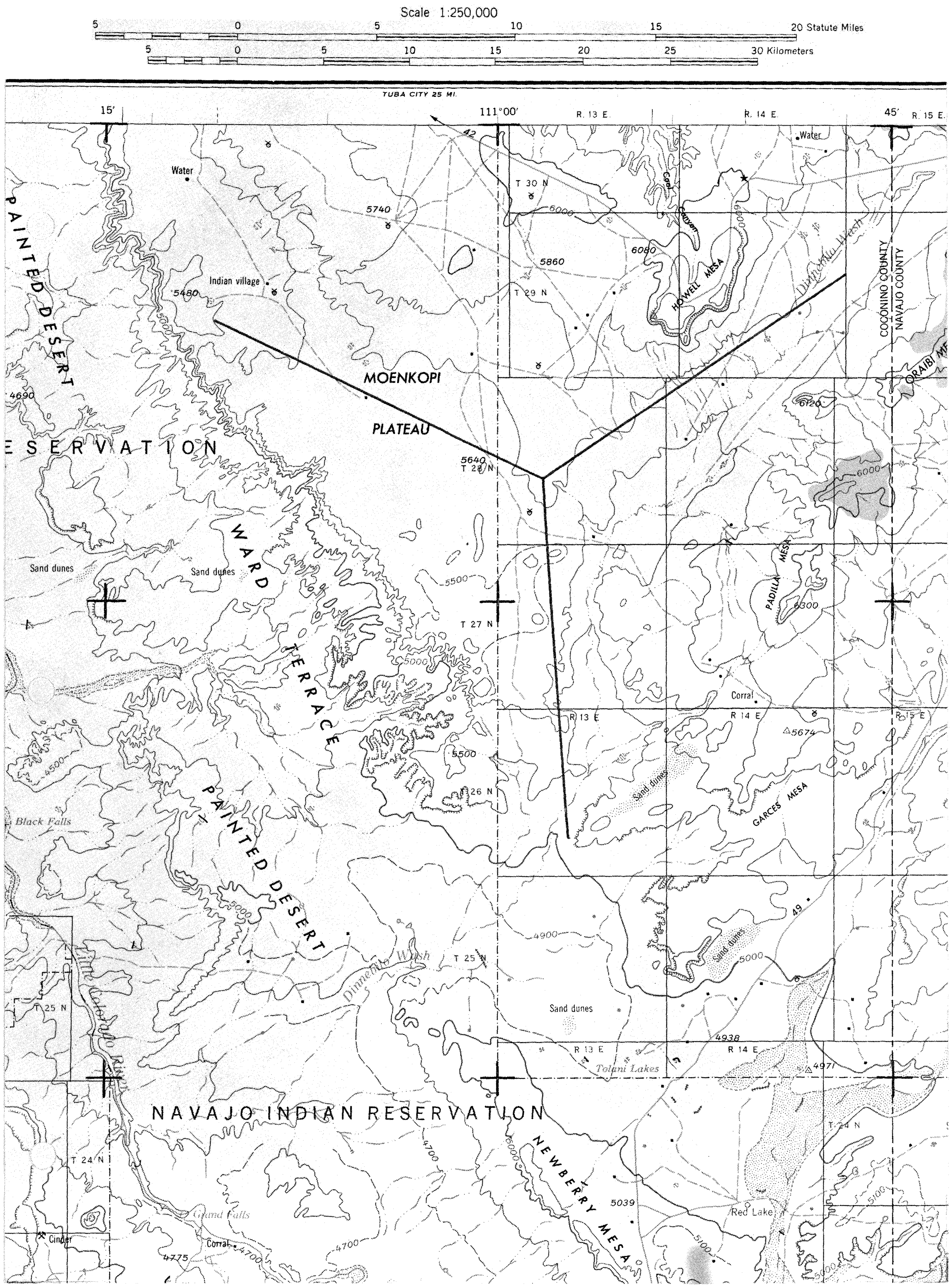

Fig. 6-17. Site Y5 (Arizona)

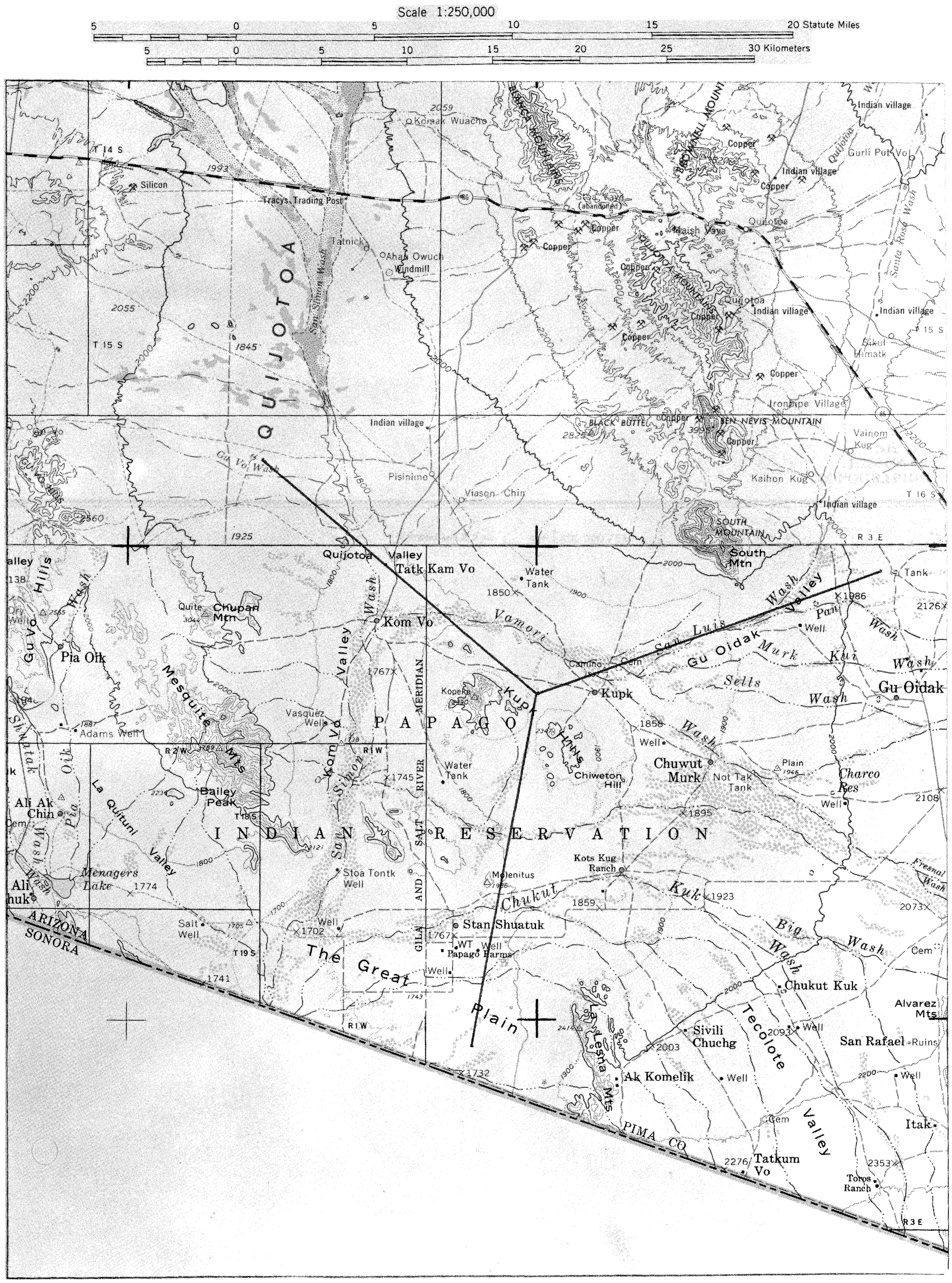

Fig. 6-18. Site Y6 (Arizona)

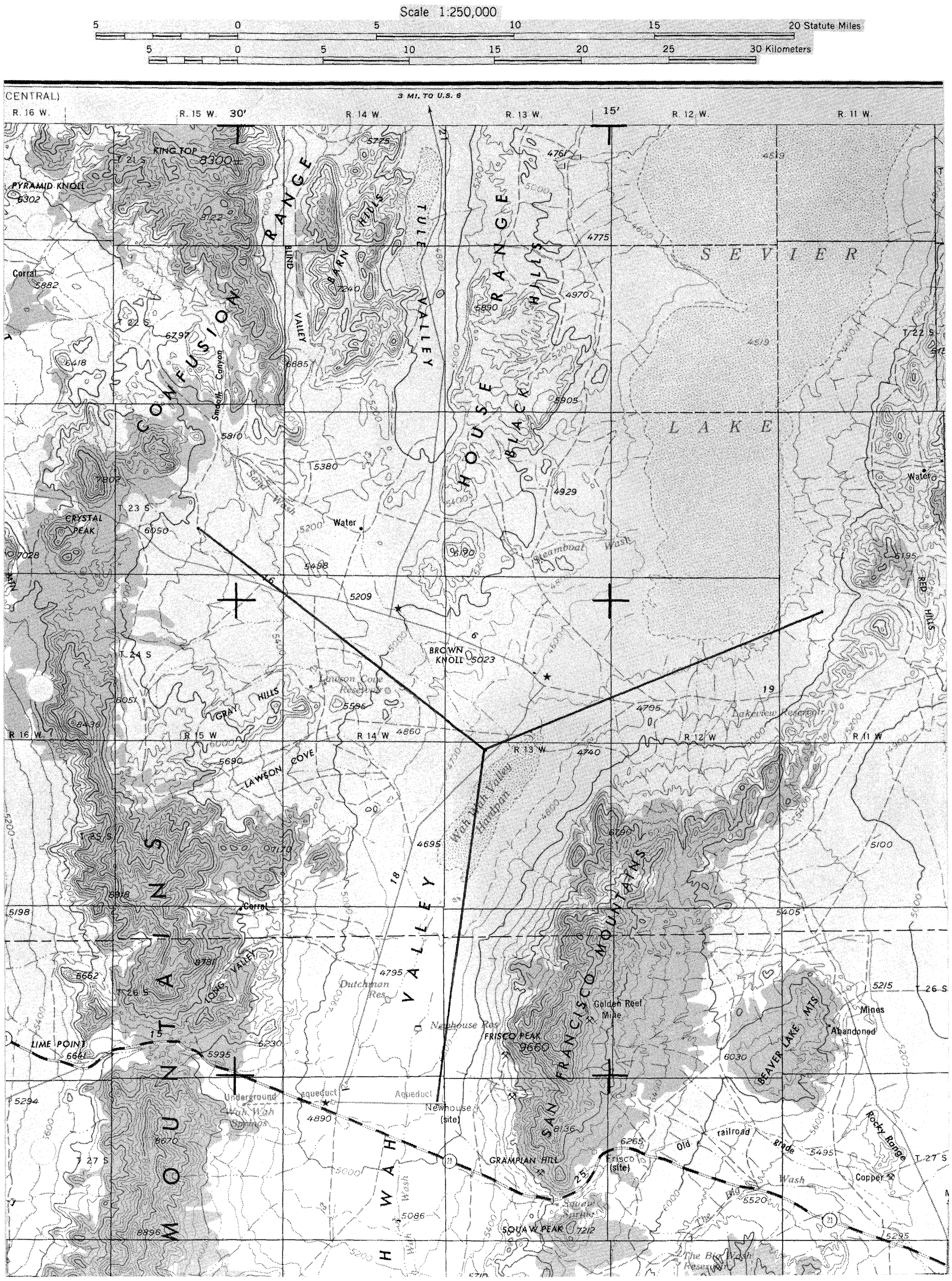

Fig. 6-19. Site Y9 (Utah)

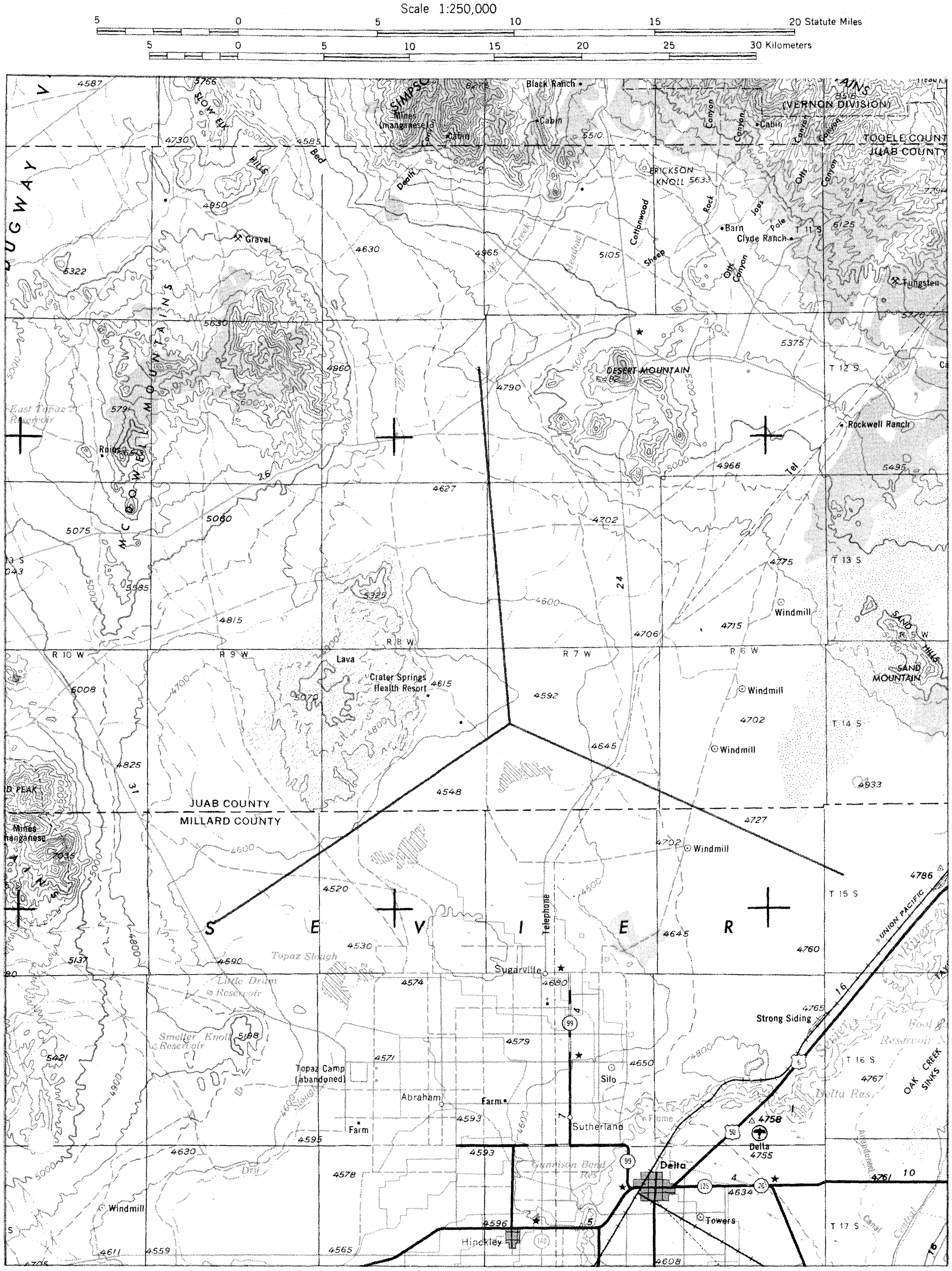

Fig. 6-20. Site Y18 (Utah)

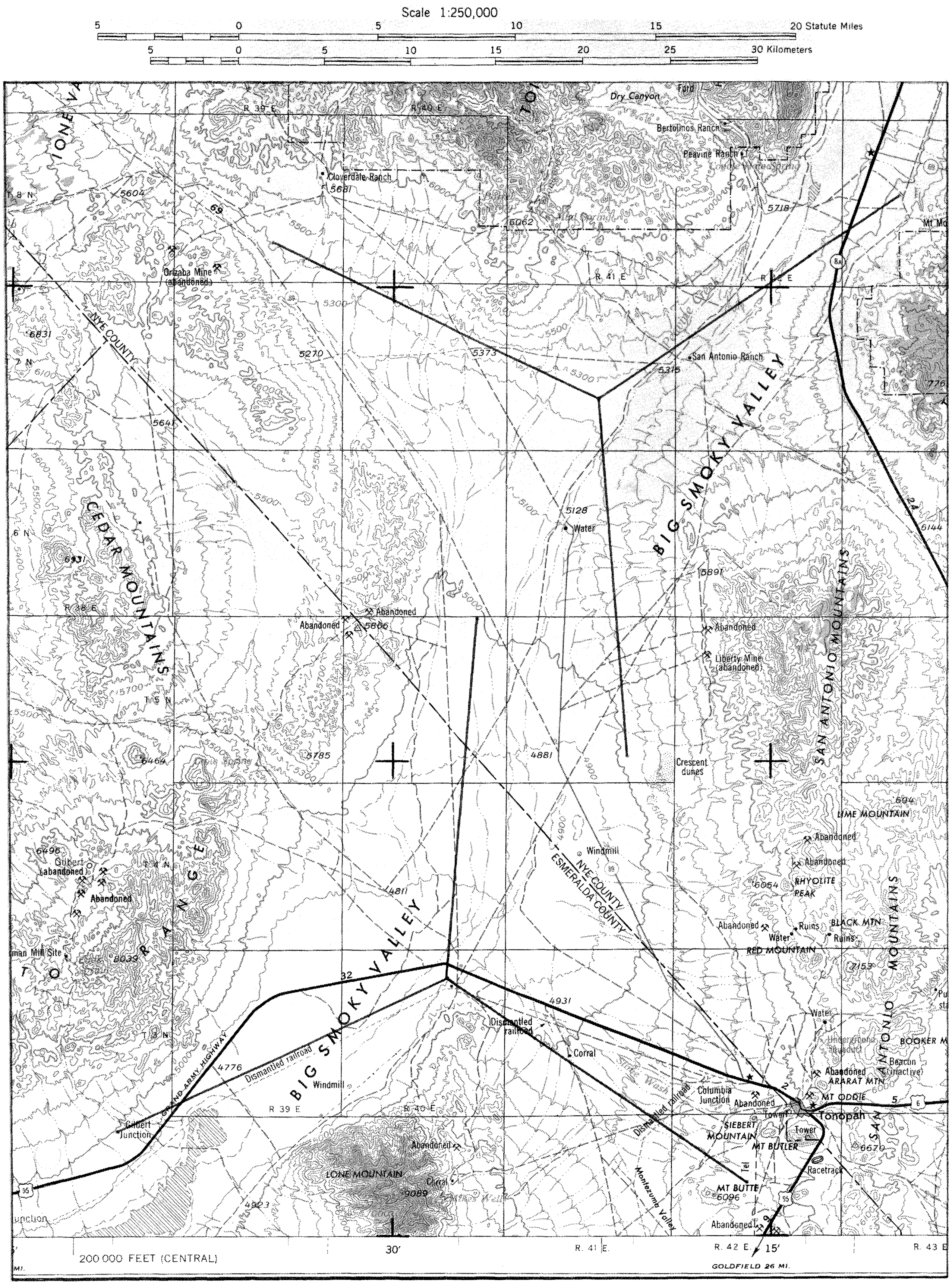

Fig. 6-21. Sites Y19 [bottom] and Y20 [top] (Nevada)

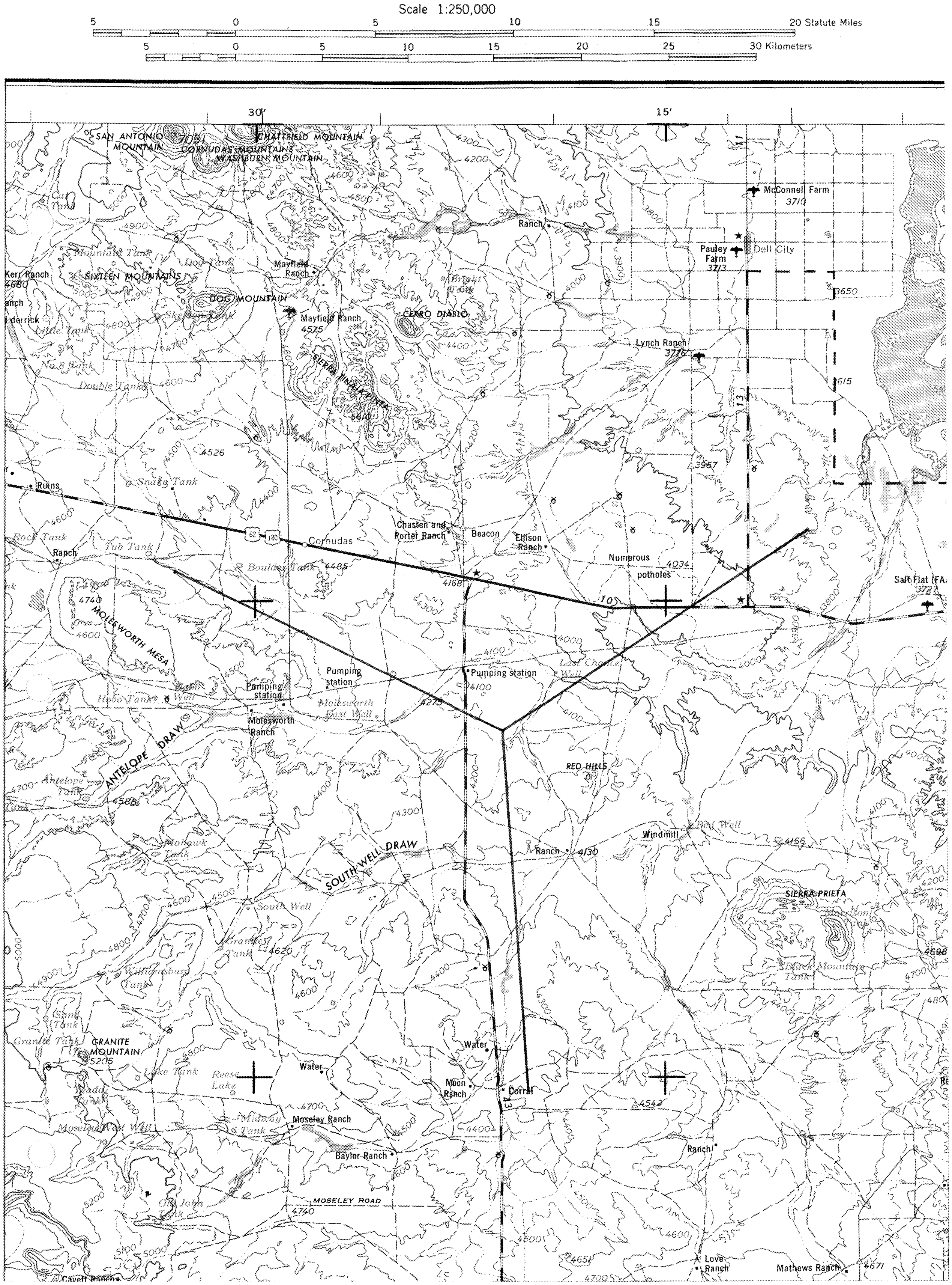

Fig. 6-22. Site Y26 (Texas)

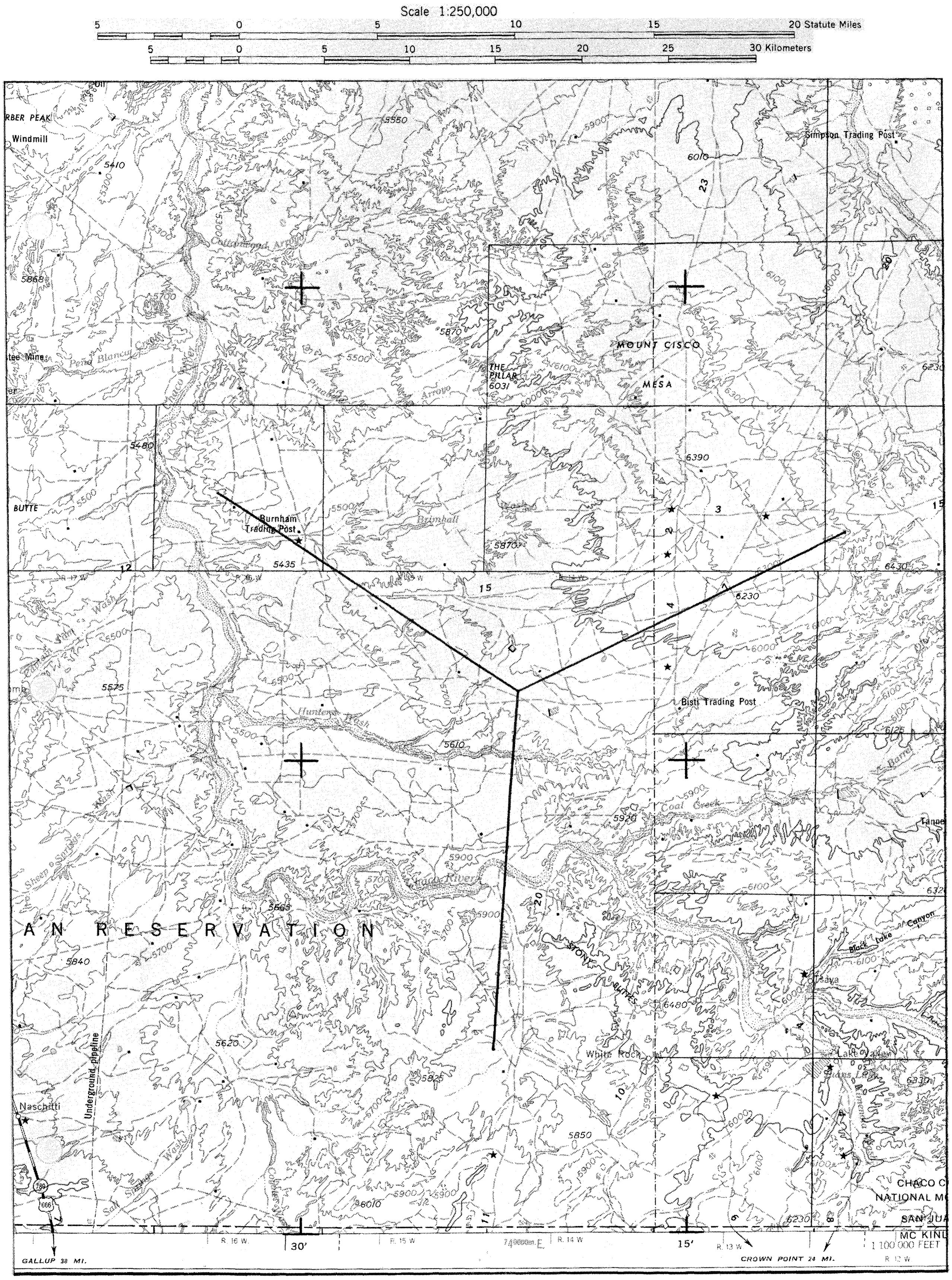

Fig. 6-23. Site Y30 (New Mexico)

Fig. 6-24. Site Y31 (New Mexico)

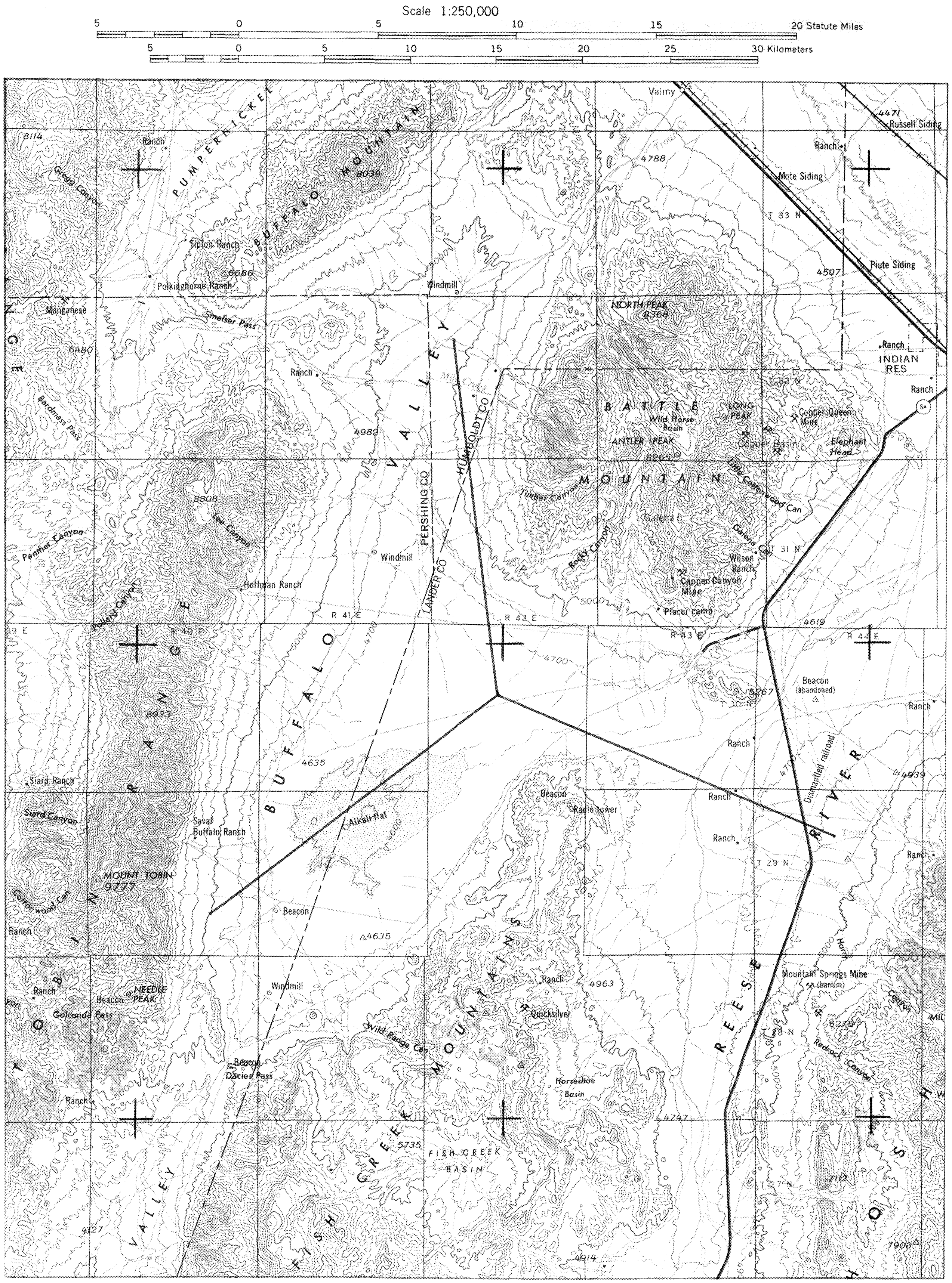

Fig. 6-25. Site Y32 (Nevada)

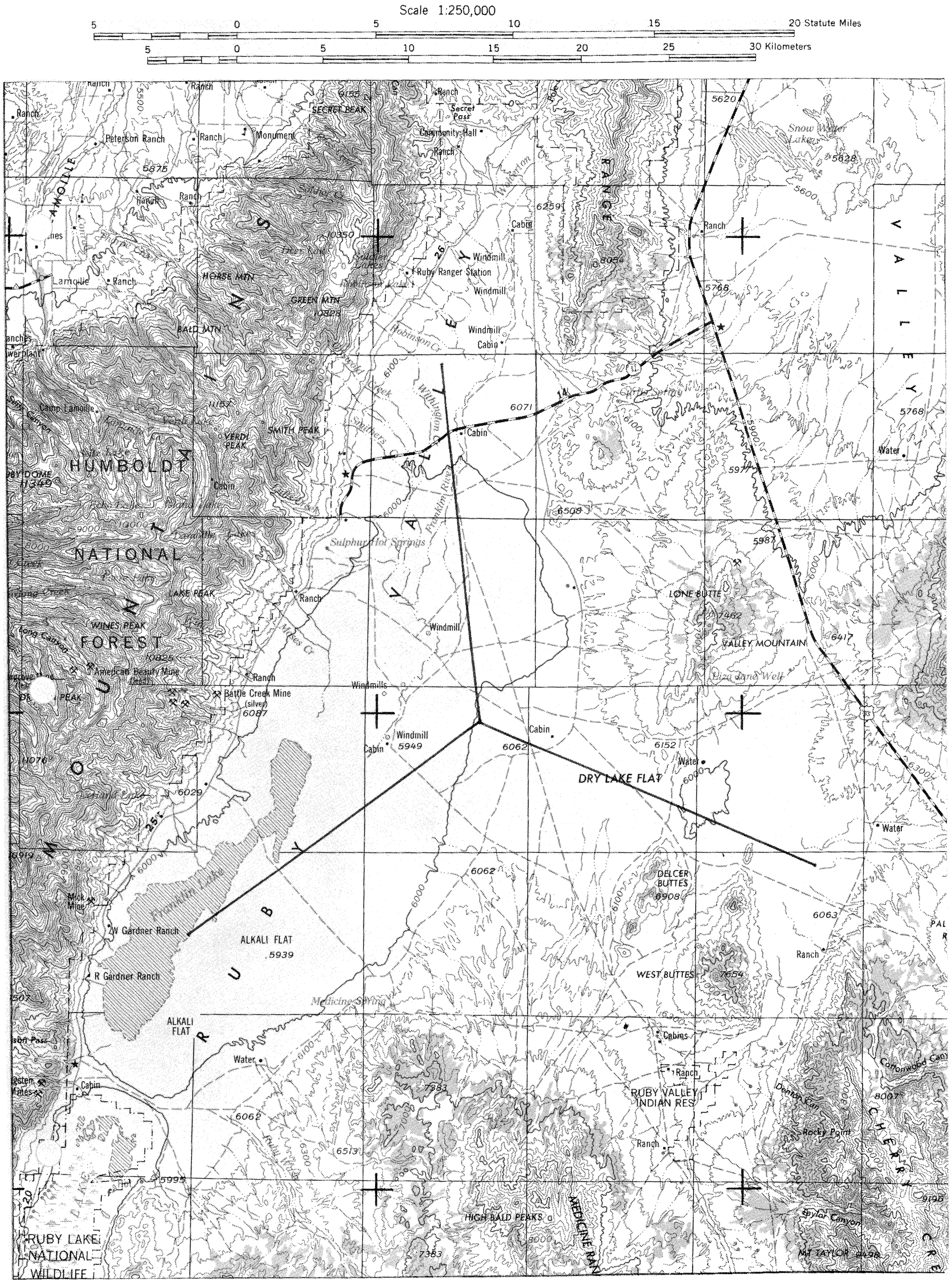

Fig. 6-26. Site Y34 (Nevada)