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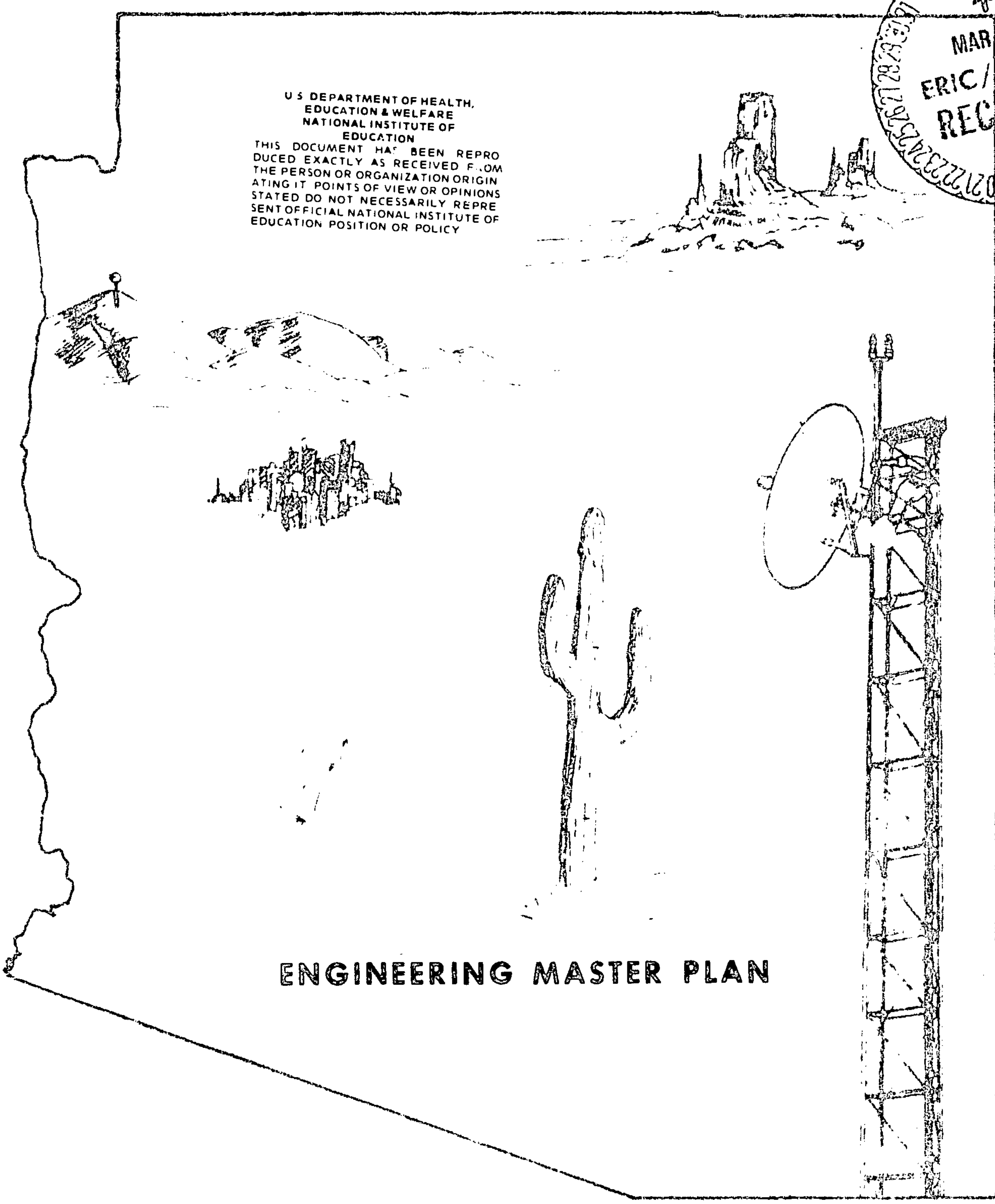
ABSTRACT

As the planning document for establishing a statewide health communications system initially servicing the Papago, San Carlos and White Mountain Apache, Navajo, and Hopi reservations, this document prescribes the communications services to be provided by the Arizona TeleMedicine Network. Specifications include: (1) communications services for each site (2-way color/monochrome television channels; 2-way voice channels between field stations and referral centers and referral centers and medical centers; 2-way slow scan television channels; 2-way physiological telemetry channels; teleprinter channels connectiing with the Tucson Health Information System computer; camera control tones); (2) recording devices for network evaluation and patient recordkeeping; (3) a wideband transmission; (4) frequency modulated microwave radio transmission; (5) radio equipment licensing in view of expansion; (6) interface capabilities; (7) switching control and network management to parallel present patient referral patterns; (8) mobile unit to include communications and clinical facilities; (9) technical maintenance at Fort Defiance, Phoenix, and Tucson; (10) color television for clinical purposes; (11) computer aided diagnosis; (12) network costs (for 27 stations) of about $8,186,936; (13) operating costs of about $298,600 annually; (14) Phase I budgetary and operating costs of about $2,040,408 and $161,400 respectively. (JC)

Arizona TeleMedicine Network



ENGINEERING MASTER PLAN

UNIVERSITY OF ARIZONA, COLLEGE OF MEDICINE

THE ARIZONA TELEMEDICINE NETWORK

ENGINEERING MASTER PLAN

Prepared for:

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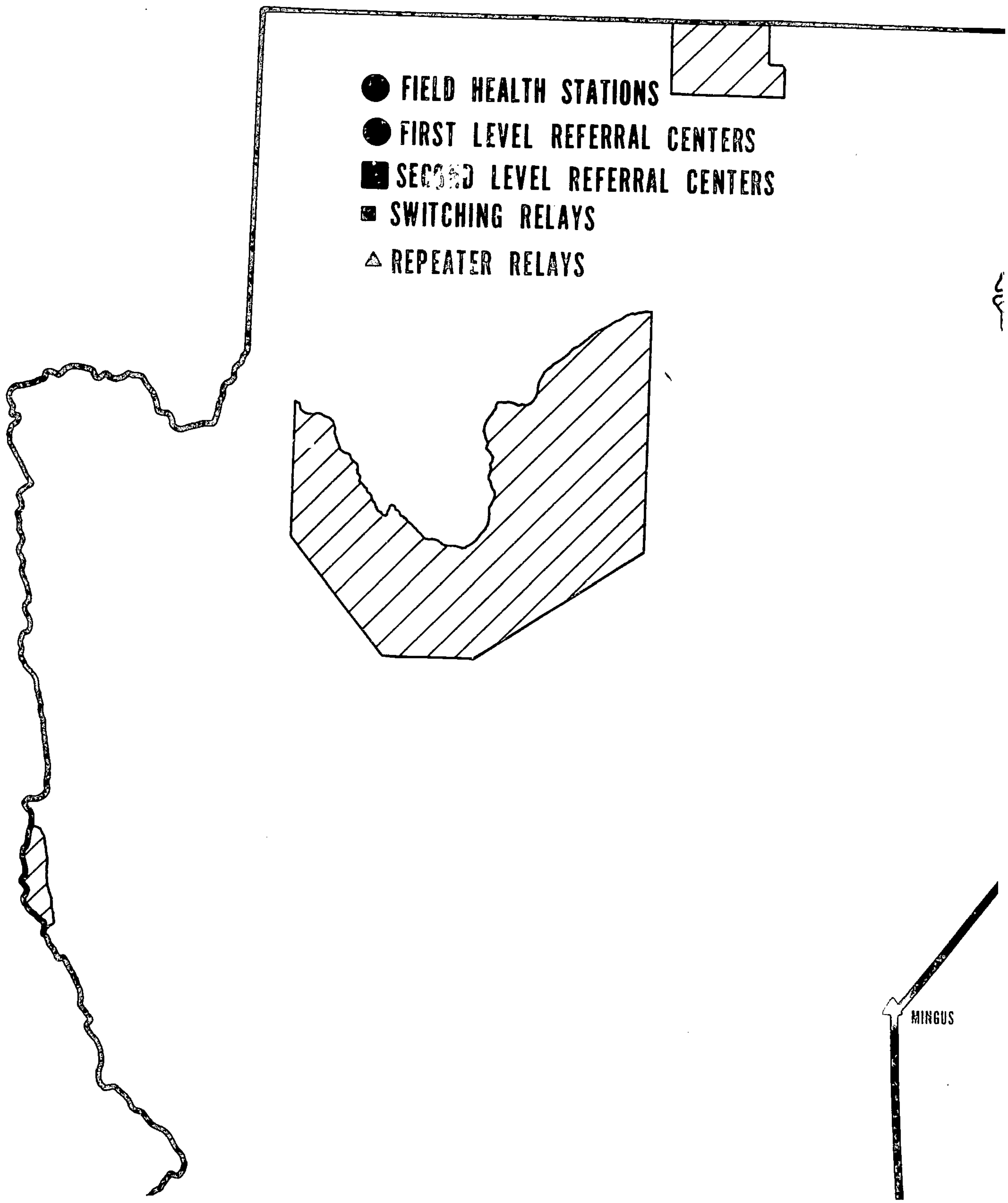
December 31, 1972



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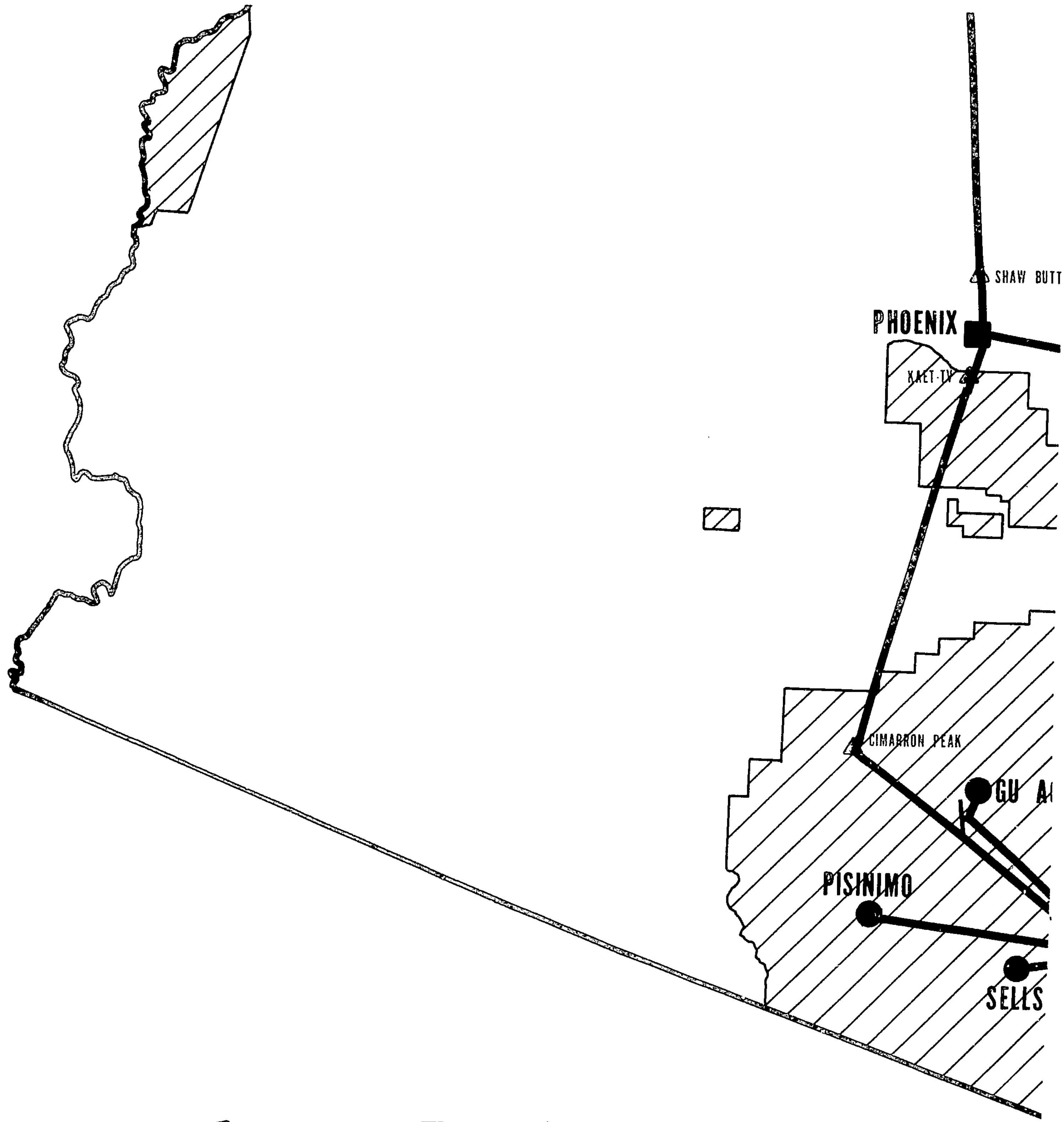

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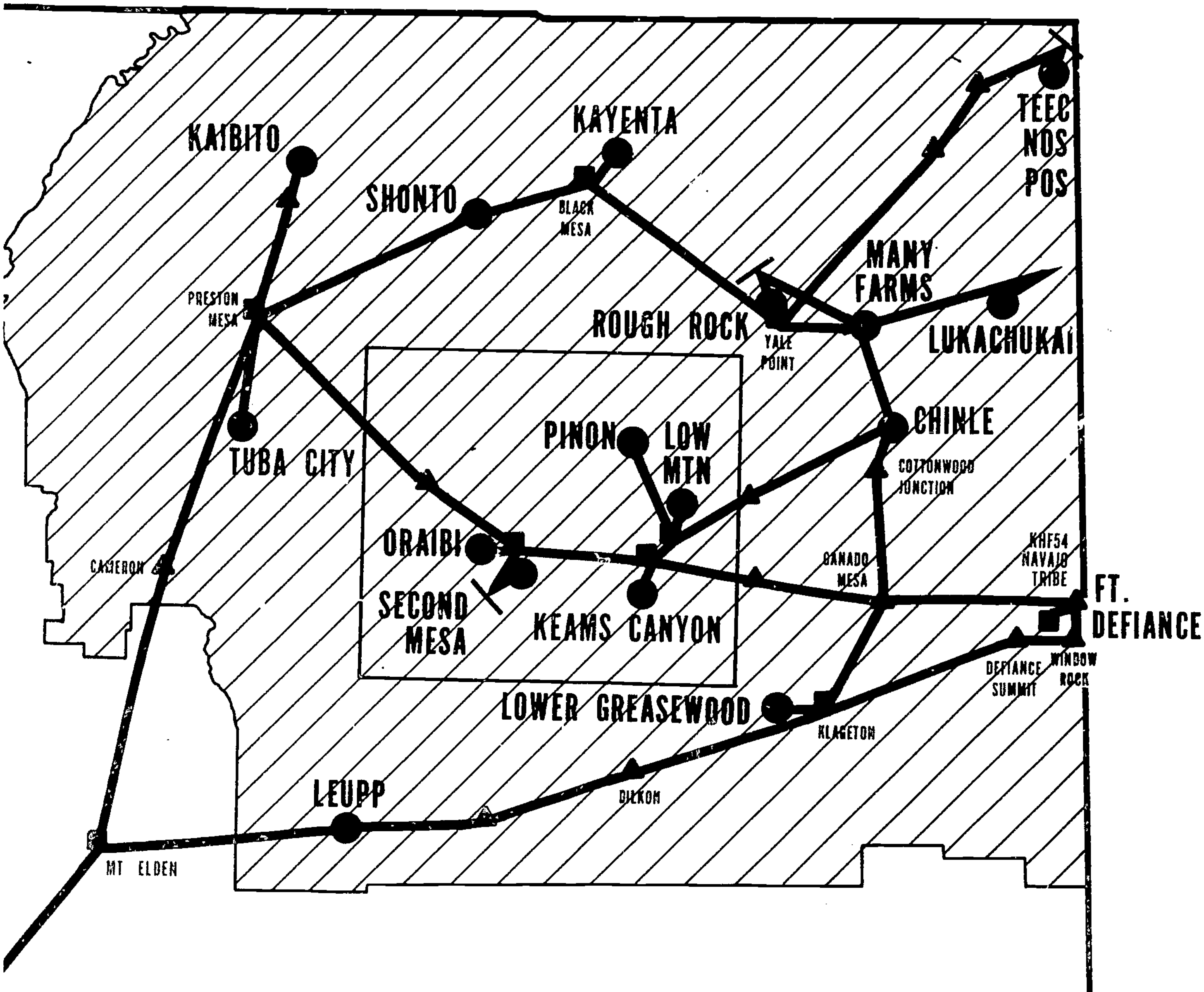
The Arizona TeleMedicine Network



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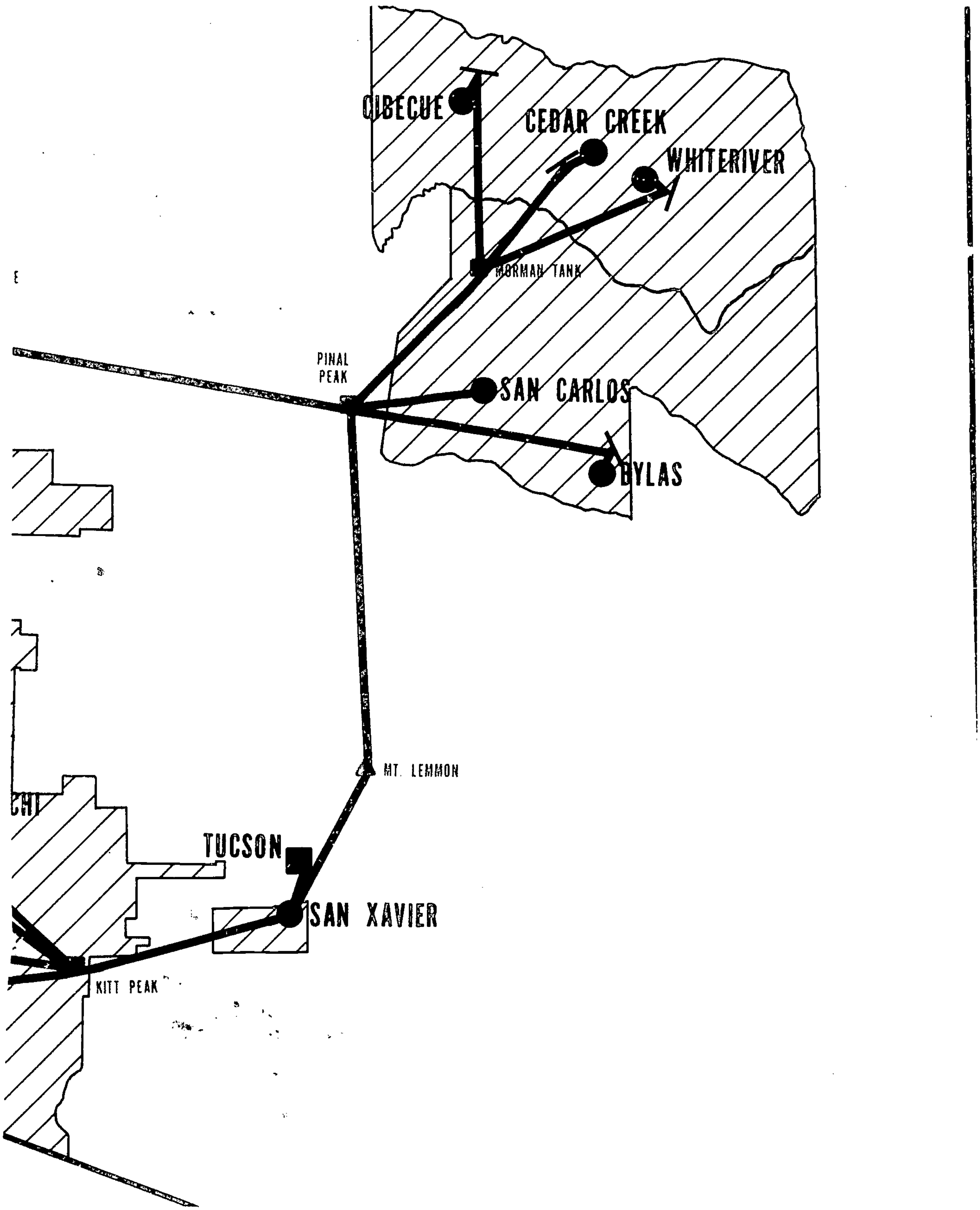

The Arizona Tele Medicine Network

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1.0 ARIZONA TELEMEDICINE NETWORK OBJECTIVES

1.1 Introduction

This study is the planning document for the long-term objective of the establishment of a statewide health communications system. Specifically the health communication system initially will link five Indian Reservations in Arizona. These reservations are:

1. Papago
2. San Carlos Apache
3. White Mountain Apache
4. Navajo
5. Hopi

In collaboration with the Indian Health Service and tribal representatives the field health stations, area and peripheral hospitals will be linked by a communications network. In addition to facilities in remote areas, urban medical centers representing the most advanced medical techniques will be part of the network. These centers are the Phoenix Indian Medical Center, (PIMC) the University of Arizona Medical Center (UAMC) and, at a later date, will include St. Joseph's and Good Samaritan Hospitals. When fully established, the network will integrate the above mentioned health service facilities and be capable of providing the Indian population with comprehensive, high quality care without the constraints of time and distance. Ultimately an expansion of this network will provide improvements in health services to other rural or isolated regions characterized by chronic shortages of health personnel.

1.2 Health Service Needs

The need to improve the delivery of health service to remote Indian reservations is great. Medical service to the Indian population is provided currently by the Indian Health Service through a system of field health stations and area and peripheral hospitals. Chronic shortages of health service personnel in remote areas combined with geographic and logistic problems associated with serving a large, low density population has hampered the achievement of optimal health service.

The physician personnel shortage, which is expected to become more critical with the end of the physician draft, has been alleviated somewhat by the increasing availability of Community Health Medics (CHMs). CHMs are Indian men and women with backgrounds in the health field who, under medical direction, are qualified to deliver primary health services in independent or semi-independent situations on the reservations. This communication network will support and maintain the CHM at a high professional level and will further expand and integrate the efforts of the Indian Health Service.

1.3 Project Goals

The objective of the Arizona TeleMedicine Project is to develop and implement an efficient and responsive communication system integrated with a comprehensive health service system.

Health is defined as the attainment and maintenance of bodily, mental and social well-being. From the individual standpoint, comprehensive health service may consist of any or all of the following:

a. Health maintenance and illness prevention

b. Acute (including emergency) care

c. Chronic illness care

d. Rehabilitation

e. Health education.

From an organizational perspective, these objectives require the integration of community health and social agencies while maintaining a focus on continuing patient care.

The basic design objectives of the communications network are:

- to link and be available to 100 percent of the designated population and to enhance care in the home locale of the patient and family insofar as practical (and consistent with quality treatment)

- to expedite primary health care delivery and where practical to deliver specialized care for those individuals requiring secondary and tertiary care beyond the present scope of primary service system

- to be patient acceptable and in harmony with his personal customs and concern for privacy

- to be user acceptable and in harmony with skills of the professional health care providers

- to be responsive in terms of cost and task effectiveness and to the associated or anticipated activities of the sponsor

- to be accessible both in term of 24 hours a day time access and geographic flexibility

- to be reliable and fail safe

- to be easily operable by health service personnel.

Within the health care delivery system, the communication network will expand, enhance, and provide for the following three functions:

1. Direct clinical health service processes

2. Management and control of health services processes

3. Educational programs.

In the area of direct clinical health service, the communications network will be responsive in the following ways:

a. By selectively directing, expanding and modifying the diagnostic and therapeutic skills and services of the on-site provider by use of remote consultants and the resources of metropolitan medical centers

b. By transmitting clinical and laboratory data to a remote source for specialized analysis

c. By establishing direct interaction between the patient and the remote health service providers.

In the area of management and control of health service, the communications network will be responsive by facilitating the control and managerial functions of the clinical encounter specifically through the Health Information System (HIS) of the Indian Health Service.

The existing HIS provides the unified multidisciplinary vehicle for rapid communication between health care team providers and offers access to a computer-based source of health information related to each patient. In addition to the problem oriented health records containing current information on all active and inactive problems, the system provides for programmed preventive interaction for early detection of disease and identification of high risk health factors. Additional programs to monitor treatment and follow-up of patients, to audit quality of health care delivery and to support planning and management of health programs are currently in progress and have potential for improvement in the health status and the entire life of the Indians.

The HIS is operationally simple and can be incorporated into a busy health service system without disruption of existing procedures. It requires only a narrowband communications link to make it available for use at almost any location, fixed or mobile.

In the educational programs area, the communication system will be responsive by utilizing voice and image communication equipment for direct training programs for health service providers, group seminars and lectures, and patient education activities.

1.4 The Value of Communications in Medicine

The value of two-way television and associated medical telemetry has been repeatedly demonstrated. The medium has been successfully used, for example, between Mary Hitchcock Hospital, Hanover, New Hampshire, and Claremont General Hospital, Claremont, New Hampshire, for psychiatric treatment, medical education and consultation. Similarly, the duplex microwave system operating between Logan Airport Dispensary and Massachusetts General Hospital in Boston has been effectively used in telediagnosis wherein registered nurses, under physician supervision, have provided primary medical care.

The purpose of the medical communication network is to alleviate the barriers and expand the availability of effective delivery of health services. These barriers are the ancient ones of time, geography and weather which tend to disrupt communication between health services providers involved in training, clinical support and delivery of health services and the recipient of health services. These professional contacts and support relationships are the actual core of the health care system. The proposed communication network permits these barriers to be circumvented and provides a system of professional support between physicians, community hospitals, metropolitan medical centers and the Community Health Medics.

1.5 Project Design Tasks

A feasibility study for the entire state was conducted. This study noted the desired locations and sites to be linked by the communication system. An existing communication facilities inventory was conducted. The inventory included (insofar as practical) all existing buildings, towers and communications related structures that could be of significant value, through joint use agreements, to the proposed networks.

Subsequent to the statewide design work, system procurement specifications were prepared for implementation of a "test bed" or pilot system.

1.5 Network Hubs

The communications hubs (network hubs) for the most part will be defined as the medical sites providing the highest level of service for a particular area. The hubs will be the peripheral hospitals; in each case, that institution responsible for health services in a specific area.

For example, for the Papago Reservation, the hub is designated as Sells Hospital. For the Hopi, the hub is designated as Keams Canyon. These hospitals currently serve as patient referral sites for particular primary field health stations. If these hospitals require professional and technical consultation, major medical centers located in the area will be utilized for additional referral. The network design attempts to maintain this referral pattern. The University of Arizona Medical Center will be responsible for evaluating the effectiveness and usage of the network system.

The general concept is to provide communications from primary sites to secondary sites and then onto the major medical centers if necessary.

2.0 COMMUNICATION NEEDS

2.1 Types of Service Indicated

Very few people would dispute the general premise that communications technology can supplant many of the person-to-person contact activities. Using modern electronic techniques, one can provide, via radio and wire, two-way high quality sound and lifelike color television. Augmenting these important basic modalities with digital data, hard copy and physiological telemetry is certainly within the state of the art. In order to maximize this “realism,” optimize the utility of the basic communications link, and provide sufficient flexibility for experimentation, a wide range of services will be supplied via the proposed network. These communication services will address the needs listed below.

Types of Data Needed	Communications Mode
Input/output terminals for computer systems	Narrowband – telephone grade digital data circuits
Voice (hot line to referral centers)	Narrowband – telephone grade circuits
Physiological signals such as respiratory rates and volumes, electrocardiographic signals	Narrowband – telemetry
Heart sounds, or other high quality “aduio” data	Narrowband telemetry with excellent low frequency response.
Photographs, charts, X-rays, non-real-time examination of subjects, prescription orders, hand or typewritten material, diagnostic/therapeutic sketches, strip chart tracings (ECG, PCG, etc.).	Narrowband-facsimile and/or slow-scan TV
Live (real-time) visual examinations of subjects in color, interactive, video educational material	Wideband – video grade duplex TV transmission circuits
Live (real-time) visual examination of subjects in black and white, interactive, video educational material. High resolution pictures	Wideband – video grade duplex TV transmission circuits

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In implementing a wideband video system, a narrowband subsystem is automatically available. Subcarriers for narrowband transmission can be added to the main wideband carrier system and thereby, tests of the effectiveness of narrowband services may be conducted independently of the wideband television services.

2.2 Traffic Level Discussion

There is very little hard data with which to predict the level of message traffic. However, it is obvious that there is a chronic shortage of health personnel for the Indian population. The pilot implementation project for the communication system in Arizona will provide some of the factors for predicting message traffic level for other parts of the health service system.

For example, consider a portion of the network (see frontispiece). There are two secondary referral sites, Whiteriver and San Carlos Hospitals, which will be referring cases to the Phoenix Indian Medical Center. However, in the present configuration either San Carlos will be communicating with Phoenix (by two-way TV) or Whiteriver will be communicating with Phoenix. The system will not allow both at the same time. This configuration or one like it in the test bed system will test the need for additional links in the network near major medical centers such as the Phoenix Indian Medical Center, Ft. Defiance or the University of Arizona Medical Center. The number of primary Indian Health Service field stations in the northern area is considerably greater than that in the pilot area. The amount of congestion found in the pilot area will be projected to the final northern configuration and adjustments made accordingly. Ft. Defiance, a major medical center serving 4 secondary centers and about 12 primary sites, would represent the "worst case" situation.

The basic microwave system is limited to a single, duplex video channel. Although it is possible to overlay a second video channel it tends to be costly and difficult from a frequency allocation viewpoint. However, additional voice or telemetry channels can be added quite readily. For example, the 12 proposed voice grade channels could be expanded easily to 24 channels. These voice grade channels are suitable for slow-scan TV, voice, and telemetry. Thus in specifying only a single duplex microwave link throughout the plan, the flexibility to expand narrowband services is maintained.

Parallel with the need to experimentally determine total communications link requirements, there is a need to determine what types of communication services transmission media are best suited to Telemedicine in general and specifically to Telemedicine in the southwest part of the country. Again, these determinations can be made with certainty only following an experimental period wherein clinical results can be analyzed. The value of various communications modalities and terminal or console designs would be reflected in statistics gathered over an experimental period. Perhaps of even greater value to the system planner will be the subjective results of the program. Here, opinions and suggestions of those who actually use the system can be carefully weighed in selecting alternatives, redesigning consoles and modifying the network's technical operations. The experience gained in having medical people working with the equipment providing various communication services will allow adjustments to be made in the "human factors" engineering area as well. A communications system that is easy to operate and helpful to the clinician will maximize network usage and efficiency in health care delivery.

3.0 EXISTING COMMUNICATION FACILITIES INVENTORY

3.1 General

Various sources of information were used to obtain an inventory of existing communication facilities. Known microwave owners were contacted, requesting route and frequency information. Applications and licenses on file with the Federal Communications Commission were searched and cataloged. Frequencies above 900 MHz were searched and displayed on a state map. Also some sites operating mobile to base with light duty towers were noted as possibilities for site sharing.

It was felt that an overall view of existing facilities within the State would aid greatly in planning for expanded use of the TeleMedicine System. Therefore two maps were prepared noting various microwave systems and other communications installations in the state. These maps are reproduced as Figures 3.1 and 3.2. Figure 3.1 displays those systems most readily usable. It shows five systems: Arizona Public Service Company, State of Arizona, Navajo Communication Company, Navajo Tribe and El Paso Natural Gas System. Figure 3.2 shows other microwave systems within the State of Arizona. Those sites near the desired routing of the TeleMedicine Network were reviewed in detail. A complete list of users and their sites is presented in Appendix C.

3.2 Sharing of Facilities

For the master plan, it was generally assumed that sites falling within the network could be shared. More directly it was assumed that for each site, at least the access road and existing electric power could be shared. This is discussed in detail in Section 4.0, "Land and Joint Use Considerations."

3.3 Channel Availability (Other Systems)

3.3.1 Private Systems

Since this system is a wideband two-way interactive TV system, with flexible switching and routing requirements, existing systems could not satisfy these requirements.

3.3.2 Common Carrier

The Mountain Bell Telephone office indicated that only the Tucson to Phoenix link of the company's network could possibly accommodate signals of the Arizona TeleMedicine Network. The telephone company did not desire to construct any additional circuits for this single purpose since their construction program for standard telephone service requires concentration of their resources in that area.

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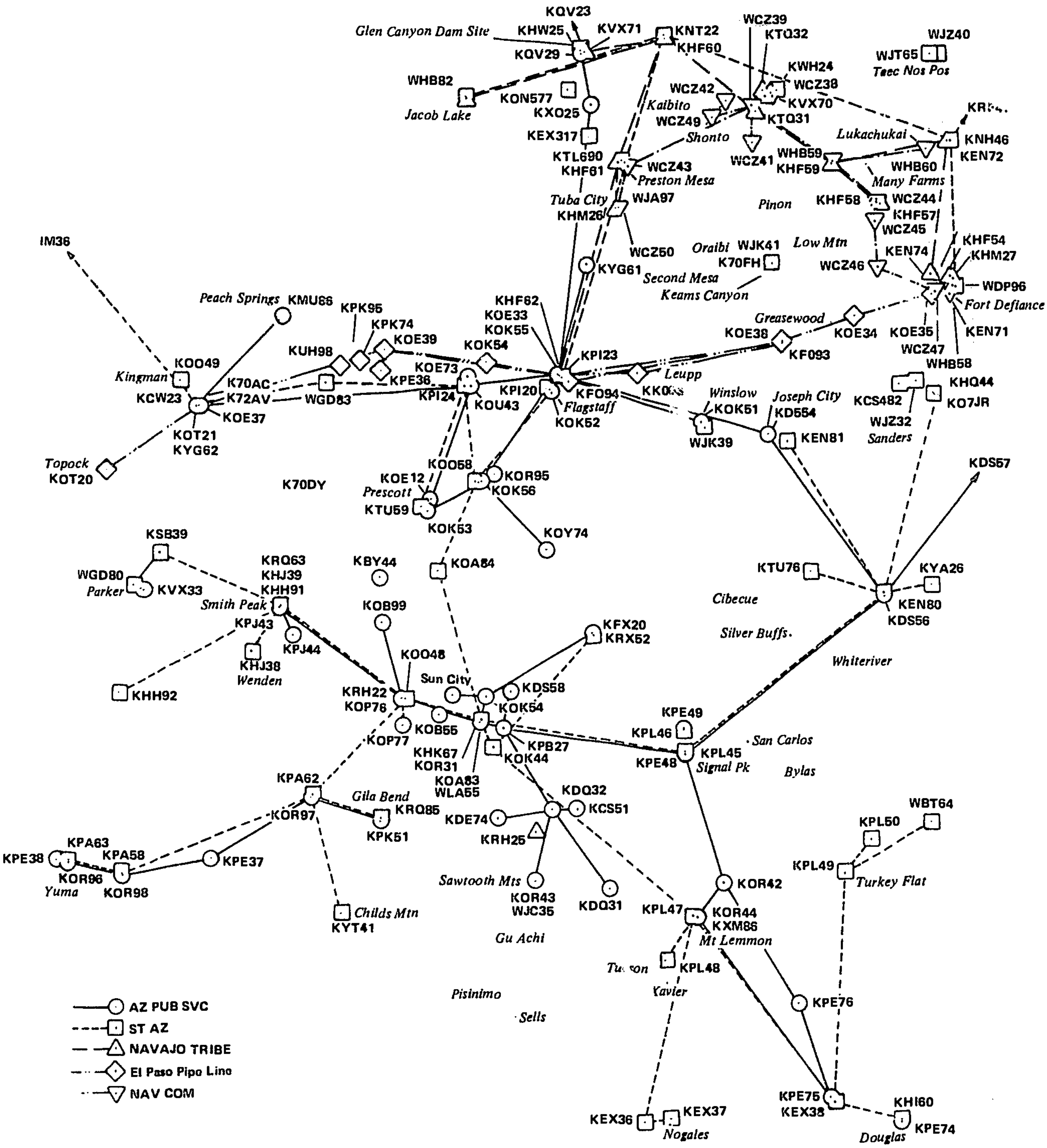

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Figure 3.1. Existing Microwave Facilities I.

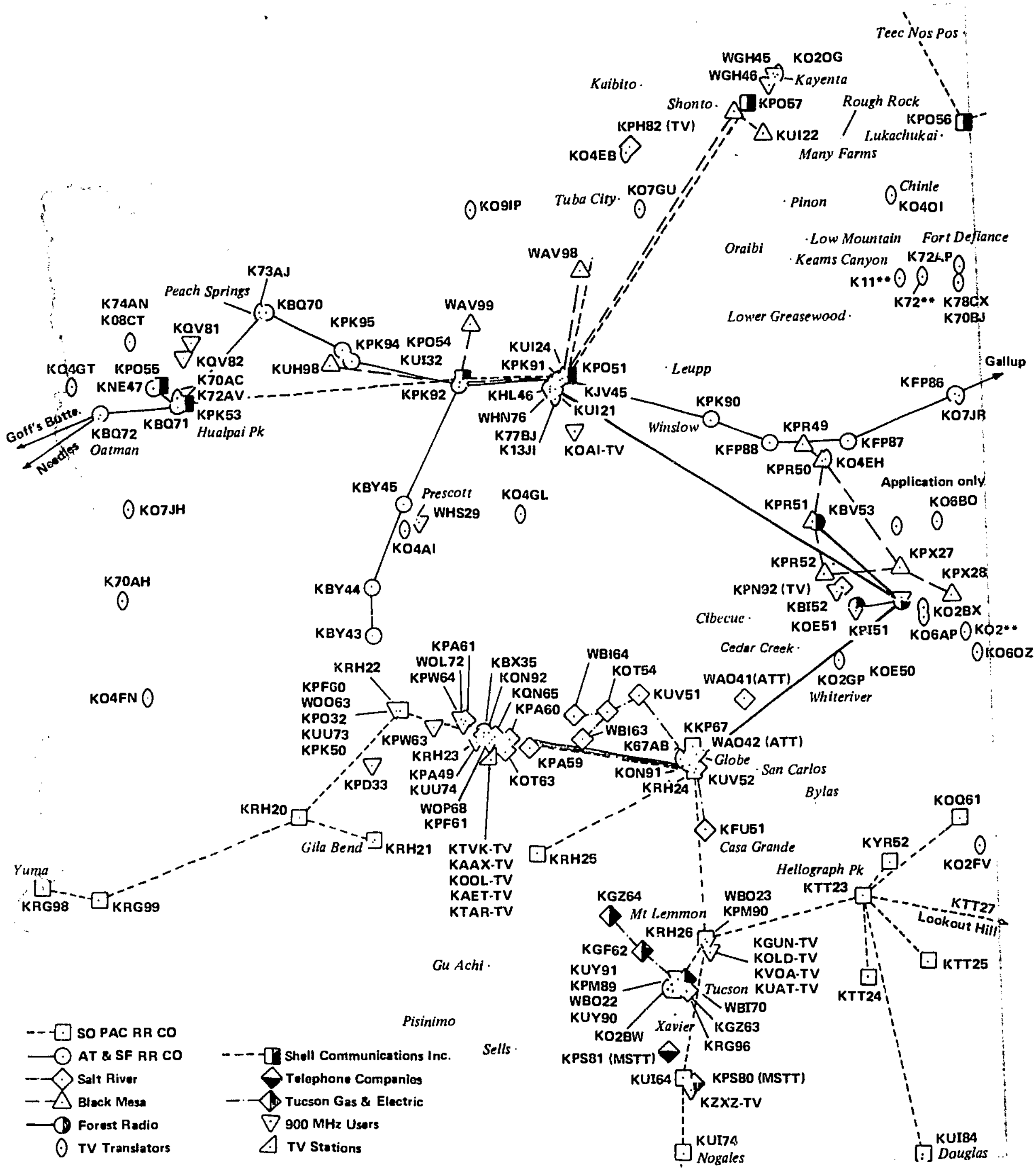

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Figure 3.2. Existing Microwave Facilities II.

It may be assumed that the rates for educational television covered in FCC Tariff 260 would apply in the Tucson/Phoenix link even though it does not involve crossing a state line.

3.3.3 Application of Tariff 260

The problem of interpretation and application of the tariff is a difficult one for complex systems of this type, since it does not specifically provide for many of the services required are not specifically provided for. There are, however, a number of similar or related services which permit an estimate of common carrier charges. These services and their applications are discussed below.

a. Video

The Long Lines tariff provides an inexpensive interexchange video service (Type 7004) intended originally for educational television networks, but now available for any purpose. It differs primarily from more expensive commercial network service in that outages of up to 2 hours for any one failure are permitted without any refund of service charges. Similar outages on the network service are limited to 30 seconds. The number of separate outages of 2 hours or less that can occur without penalty is not limited. However, most users of such systems have been satisfied with telephone company performance. The Type 7004 service is therefore considered to be the most comparable with a privately owned system without diversity or hot standby.

b. Program Channels

Type 7004 video service includes one program channel for television audio. Additional program channels can be supplied at additional cost. For purposes of cost estimates, an additional 15-kHz program channel (Type 6009) for medical telemetry, slow-scan TV, camera control signals and teleprinter services has been assumed adequate.

c. Voice Bandwidth Channels

Signals for controlling and monitoring video and program channel switching will be transmitted over 3-kHz remote control lines (Type 3001) especially arranged for multitone control signals.

3.3.4 Common Carrier Charges

Common carrier rates which may be applicable to the Arizona TeleMedicine Network are given below. These are extracted from FCC Tariff No. 260, filed at AT&T Long Lines.

By agreement with Long Lines, local rates may apply, but it is assumed that any local rates exceeding the interstate rates will not be used. Distances for tariff purposes are airline distances between specified points of service.

The interexchange line cost per mile per month is obtained by summing costs for each circuit type.

1st video channel, color (with aural)	$31.50
2nd video channel, color (with aural)	15.00
15-kHz program channel, duplex	17.30
Telephone voice duplex	2.31

Total cost, per mile per month $66.11

The airline distance from Tucson to Phoenix is approximately 105 miles. Therefore, the rental charges would be about $6,941.55 per month for the link between the Phoenix Indian Medical Center and the University of Arizona Medical Center.

4.0 LAND AND JOINT USE CONSIDERATIONS

From the existing facilities maps (Figures 3.1 and 3.2), several potential radio relay sites are apparent candidates for joint use by the Arizona TeleMedicine Network. Those sites which are satisfactory for such use by the network based on the geographic and topographic requirements of the proposed system are discussed below. Also discussed are those land requirements in areas where existing communication facilities are not present but where the network must supply service.

4.1 Forest Service Lands

Several points of high altitude in Arizona that appear to be logical network relay points are in National Forest areas. The Federal Government controls the use of lands within National Forests and administers all uses through the Forest Service. Organizations wishing to rent space from the Forest Service in these areas must file a "Special Use Application" with the Ranger District having jurisdiction over the proposed site. Whether new construction is proposed or whether existing facilities are shared, all potential occupants of Forest Service lands (such as Mt. Lemmon and Pinal Peak) must apply for a permit. Such information as maps of the proposed site, cost of improvements, cost of radio equipment, purpose of installation, frequency of transmitters, etc., must be included in the request submission. All existing users must approve before the Forest Service will consider the application.

Yearly fees paid to the Forest Service are relatively small. Their actual amounts are set by the Forest Service after the application has been carefully reviewed. The fee schedule used depends on such factors as cost of improvements, whether shared site or new site. The amount is typically under $100.

4.2 Mt. Lemmon

Mt. Lemmon is within the jurisdictional boundaries of the Catalina Ranger District. Mr. Dave Baum, Assistant District Ranger, confirmed that many organizations already maintain facilities on the mountain. Several are private firms engaged in rental of tower and equipment space. Since it appears that the State of Arizona facilities are too crowded to permit joint use by the Arizona TeleMedicine Network, the rental organizations present the best alternative.

A budgetary quotation and tower feasibility check was secured from Motorola's El Segundo, California office. This office manages several sites in the southwest and was eager to provide the necessary estimate. For three microwave dishes and two racks of associated radio and switching equipment the charges would be about $125/month. This fee includes tower space, equipment space, electric power and standby electric power. Any maintenance or repair service would be contracted on a separate basis.

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Further investigation, however, revealed that the Motorola tower is not suitable for microwave antennas proposed for use by the Arizona TeleMedicine Network. Because of the terrain and poor access road to the Motorola site, it was decided not to propose a new tower at this location. Instead another rental site (also without an adequate tower) would be proposed for use. This site, unlike the Motorola site, is situated near the hard surface roadway. Equipment space, heat, power, standby power as well as ground space for a new tower will be provided. The rental fee here would be about $100.00 per month. The site is operated by General Communications of Tucson.

For comparison purposes, it should be noted that construction of a suitable shelter, and the installation of electric power, gasoline generator and roadway to a virgin site on the mountain could run in excess of $10,000. Rental of a site as opposed to new construction has the added advantage of reducing maintenance costs for this repeater station since the Arizona TeleMedicine Network would not be concerned with maintenance of the standby electric plant.

4.3 Pinal Peak

Pinal Peak, according to Mr. Lance of the Globe Ranger District, is a better choice for a repeater site than Signal Peak. The only existing microwave site on Signal Peak is the Arizona Highway Department radio repeater. The tower is rather congested already and the Forest Service does not want additional towers or dishes placed in that area since the view from the fire lookout tower would be partially blocked.

Several adequate locations exist on Pinal Peak. The Peak is heavily used for radio installations by AT&T, other private companies and the San Carlos Indian Agency. The San Carlos Indian Agency site appears to be a reasonably good choice for the Arizona TeleMedicine Network relay site. The existing Indian Agency radio building is somewhat crowded but probably could be rearranged to accommodate the addition of three racks of medical network equipment. In addition to commercial electric power, emergency power is available within the San Carlos Indian Agency's Pinal Peak radio building. Since the unit is reported to be old and unreliable (and possibly underrated for the additional load), it is proposed that it be replaced as part of the construction effort for the Arizona TeleMedicine Network. The new generator would be installed in a new shelter outside the main building. This reinstallation would have the twin effects of improving electric power reliability and, at the same time, of making more space available within the building for the installation of new equipment.

The existing Indian Agency tower is of tubular aluminum construction and is only lightly guyed. The tower is used to support dipole antennas for VHF radio equipment but is not substantial enough to support the heavier parabolic antennas needed for the Arizona TeleMedicine

Network. The existing tower would be likely to twist in the wind an amount in excess of the limits dictated by the narrow cone of the microwave energy. A new 20- to 25-foot steel tower is recommended. The VHF antennas would be relocated to the new tower.

The San Carlos Indian Agency site, in addition to having good line of sight to Phoenix, Mt. Lemmon, San Carlos Hospital, the Bylas reflector, and Mormon Tank, has line of sight to other relay sites, to the east and north, suitable for future use.

Maintenance and repair service could be contracted if desired, from an organization in nearby Globe, Arizona.

4.4 Cimarron Peak

An intermediate repeater relay will be required between Kitt Peak and the South Mountain near Phoenix. This site, Cimarron Peak, is without power and roadway. Again, a power plant will be required.

The Cimarron relay is located within the Papago Reservation and may be considered as available.

4.5 Reflector Site Near Santa Rosa

The required reflector site northwest of Santa Rosa is, again, on Papago tribal land and may be considered as available for network use. The proposed reflector is a passive unit; therefore a permanent roadway and power are not required for operation of this site. Vehicles suitable for cross-country operation will be used for construction.

Tribal approval is likely to be forthcoming when formal land use applications are made for all Indian land based sites.

4.6 South Mountain

In completing the loop from Sells (Kitt Peak) to Phoenix, a final relay station will be required at South Mountain. Currently, South Mountain serves as the transmitter site for most of the broadcasters in Phoenix and as a relay site for the State of Arizona Department of Public Safety microwave system. The Department of Public Safety facilities, tower and building, are both filled to capacity. The educational television transmitter site, KAET, appears to be an equally good choice for a repeater for the medical network.

KAET, Channel 8, the educational television station licensed to the Arizona Board of Regents has transmitting facilities collocated with three other broadcasters. The common building is owned by KTAR who rents space to KAET. Immediately adjacent to the building is the KAET 195-foot tower. This tower is owned by KAET and is used to support their transmitting antenna and microwave dishes. The tower on the building roof can be utilized by the Arizona TeleMedicine Network for the support of its required microwave antennas looking north and south. No local obstructions exist. Waveguide runs would not be excessive since the KAET equipment space is very near the wall of the building which faces their tower. Commercial electric power is provided to the site by double mains and is regarded as highly reliable by KAET. No standby power facilities are presently available It is recommended that an 8-hour reserve battery plant be installed at South Mountain. Apparently no generator equipment is needed to ensure system continuity of operation.

South Mountain is controlled by the City of Phoenix, Parks and Recreation. Indications are that proposed new towers and/or buildings would not gain the automatic approval of this city agency. This situation is not problematic for the Arizona TeleMedicine Network since the existing KAET facilities will likely be used.

According to Mr. Ellis, General Manager of KAET, there should be no problem from the policy standpoint in securing tower space for the medical network. The Board of Regents has the final word in this matter. For equipment space within the KTAR building, negotiations would have to take place with KTAR and, jointly, KAET and the University of Arizona Medical Center. Mr. Ellis felt confident that arrangements could be made.

4.7 San Carlos and Fort Apache Sites

In addition to the terminal sites proposed for Bylas, San Carlos, Whiteriver, Cedar Creek and Cibecue, there are four passive reflector sites and one slave switching relay required in this part of the network. The Mormon Tank relay and the reflectors proposed for use near Bylas, Cibecue, Cedar Creek and Whiteriver are all situated on tribal lands. No problems are anticipated in obtaining the use of these sites.

The Mormon Tank site does not have commercial electric power available; however, a jeep trail does exist. It is proposed that a self-contained redundant power generator system be installed along with the necessary stub tower and fiber glass equipment shelter.

4.8 Shaw Butte Relay Site

This site has several users including the Arizona Public Service Company, a public utility company. The Arizona Public Service Company operates a microwave radio system for company voice communications, data exchange and telemetry. Their land holdings at Shaw Butte are extensive and, by their own admission, larger than they expect to ever require. The company's stated policy does not allow for the joint use of its equipment shelters or towers by others. However, sometimes they provide sites for the construction of similar facilities by outside organizations. This is the most likely situation that will develop for the Arizona TeleMedicine Network. Commercial electric power and access roadway would, of course, be available under this sort of arrangement. Other firms have sites on Shaw Butte and should be investigated as an alternative source of rental facilities.

4.9 Mingus and Mt. Elden Relay Sites

Both of these sites are located on Forest Service property. The procedure for gaining use of such property has been discussed. It seems that none of the existing users have sites that would be suitable for joint use by the Arizona TeleMedicine Network. One known renter of space on Mt. Elden is General Communications Company of Tucson (see the section dealing with Mt. Lemmon). However, this site does not lend itself to the installation of microwave antennas having line-of-sight to Cameron or Tuba City. Other rental organizations at these sites are: "Whitey's," "Nelson's" and "Canyon State," all Phoenix based communications companies. The property used by the Arizona Public Service Company is not large enough to provide room for the construction of new facilities for the network. Also, the company's stated policy does not favor the sharing of their tower or building by the medical network.

Nevertheless, both Mingus and Mt. Elden have the necessary access roads and existing commercial power lines that make these sites logical choices for relay points in the Arizona TeleMedicine Network.

4.10 Navajo and Hopi Sites

With the exception of two proposed relay sites on the route past Lower Greasewood, and the Cameron site, all microwave relays and terminal stations will be located on land controlled by the tribes. In the case of the Navajo Nation sites, it is presumed that relay stations of the Arizona TeleMedicine Network may be collocated with those existing microwave sites operated by the Navajo Communications Company which is a common carrier (telephone utility) owned by the tribe. Likewise it is expected that the tribe's police and administrative microwave system sites can be shared. In both cases it is assumed that either towers or buildings can be shared, although a more thorough investigation may reveal that this is technically feasible.

Capital cost projections presented in this document reflect the above mentioned assumptions in that costs for access road and electric line construction are not included. In each case where the existing sites of the El Paso Natural Gas Company are projected as jointly used, the same basic assumptions prevail. Applications have been made to the Company, a gas pipeline system, requesting a greater degree of sharing. Those applications are pending but will not affect, to any great extent, the total capital or operating cost budgets already projected. The same situation is evident in projections for the Cameron station which is shown on the maps as collocated with the Arizona Public Service Company microwave terminal.

5.0 REGULATIONS AND FREQUENCY AVAILABILITY

5.1 Licensing and Regulatory Considerations

5.1.1 General

In the United States, the coordination of frequency use and licensing for communications facilities to applicants, other than Federal Government Agencies, is the responsibility of the Federal Communications Commission (FCC). This general statement applies to all types of telecommunication systems with the partial exception of cable.

Federal Government Agencies, both military and nonmilitary, are eligible to use frequencies assigned by the InterAgency Radio Advisory Committee (IRAC).[1] IRAC functions in a way similar to the FCC in coordinating the use of the available radio frequency spectrum.

Clearly, the Arizona TeleMedicine Network may be licensed to the Indian Health Service and, therefore, be eligible to apply for IRAC frequencies. If the system is licensed, instead, to the Board of Regents of the State of Arizona or the University of Arizona Medical Center, FCC jurisdiction is indicated. In this case, precisely which set of FCC rules that will apply depends again on how the application is prepared and submitted. The following will illustrate the complexity.[2]

a. State governments and their agencies can be licensed under Part 89, "Public Safety Radio Services," Subpart E, "Local Government Radio Service."

b. Hospitals can be licensed under either Part 89, Subpart P, "Special Emergency Radio Service," or under Part 91, "Industrial Radio Services," Subpart L, "Business Radio Service."

c. Educational and Philanthropic institutions can also be licensed under Part 91, Subpart L.

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[1]See Table 5.1 for a partial listing of IRAC frequencies.

[2]See Table 5.2 for a listing of microwave frequencies available in these services.

Table 5.1. Partial List of IRAC Microwave Frequencies Allocated to Fixed and/or Mobile Operation.

Frequency (MHz)	Service
1427 — 1429	Fixed/Mobile (narrowband)
1429 — 1435	Fixed/Mobile (narrowband)
1710 — 1850	Fixed/Mobile
3500 — 3700	Fixed/Mobile
4700 — 4990	Fixed/Mobile
7750 — 7900	Fixed/Mobile
7125 — 7250	Fixed/Mobile
14,400 — 15,250	Fixed/Mobile

Table 5.2. Partial List of FCC Frequencies Allocated to Fixed and/or Mobile Operation for Wideband Transmission or Narrowband Transmission.

Frequency (MHz)	Service
150.8 — 156.25	Land Mobile (narrowband)
157.45 — 159.48	Land Mobile (narrowband)
173.2 — 173.4	Fixed/Land Mobile (narrowband)
451 — 455	Land Mobile (narrowband)
456 — 462.5	Land Mobile (narrowband)
462.7 — 467.7	Land Mobile (narrowband)
952 — 960	Fixed
6525 — 6575	Mobile
6575 — 6875	Fixed
12,200 — 12,700	Fixed

Independent of which "service" is selected, the institutions authorized to apply for FCC licensing (non-Federal Government institutions) would be entitled to apply for "wideband" channels in the 6,575- to 6,875-MHz and the 12,200- to 12,700-MHz band for intercity closed circuit television.

5.1.2 Business Radio Service, Microwave

In the Business Radio Service the lower of these two bands has two significant restrictions placed upon it. Section 91.554 of the FCC Rules states, with respect to 6,575 to 6,875 MHz, that the band is:

> "Available only for intercity closed circuit educational television systems. Such authorizations will be granted on a case-by-case basis, and applicants must furnish complete and specific factual data showing wherein, apart from economic considerations, it is not feasible to utilize frequencies above 10,550 Mc/s for such operations."

It can be adequately demonstrated that the widespread use of the higher frequency band in critical application such as a large medical network would not be as satisfactory as would the lower band. One prime consideration is system reliability as influenced by weather conditions. Another consideration is that two or three times as many microwave relay stations would be required to provide the same coverage and quality if the 12 GHz band was used instead of the 6 GHz band. The predicted equipment failure rate would also increase proportionally. Outages in this critical service area of health care delivery must be minimized. Precedence does exist for the granting of the use of 6 GHz in preference to 12 GHz band in medical networks.

The second restriction is the limitation of bandwidth to 10 MHz. This is not adequate for the transmission of standard television signals without a substantial reduction in quality. Nonetheless, the FCC Rules do provide that:

> "Consideration will be given, on a case-by-case basis, to requests for additional adjacent channels based upon a complete and specific factual showing of unique or unusual circumstances, apart from economic considerations, requiring such additional channels."

Precedence does exist for the granting of wider bandwidths, typically two channels side by side for a total of 20 MHz for interconnection of closed circuit television systems.

5.1.3 Local Government Radio Service, Microwave

In the Local Government Radio Service, the first of these restrictions does not apply and in addition the frequencies between 6,525 and 6,575 MHz are available for base/mobile operations with a specified maximum bandwidth of 25 MHz. The second restriction is stated identically for both services in the case of fixed point-to-point operation.

A 20-MHz bandwidth is permitted in the 12,200- to 12,700-MHz band. Further, there is no restriction placed on the type of material (i.e., video, audio, digital data, etc.) which may be transmitted. The usual objections to the use of this band are:

a. Slightly higher cost of equipment

b. Degradation due to heavy rainfall

c. The shorter distances possible in a single hop cause intermediate sites to be selected over those required for lower frequency transmission.

The use of frequencies below 952 MHz for point-to-point communications is drastically limited by the FCC Rules. Additionally, each particular frequency is limited to a 20-kHz bandwidth with a maximum of 5-kHz deviation. In both the Business Radio Service and the Local Government Radio Service the duration and type of any nonvoice transmissions are severely restricted.

Under the Business Radio Service (Part 91) frequencies in the 952- to 960-MHz band are restricted to repeater control and radio alarm applications.

Under the Local Government Radio Service (Part 89), the 952- to 960-MHz band may be used for point-to-point communications without restriction. However, the use of this band to transmit to and from a mobile or itinerant station would require a waiver of the rules.

The 952- to 960-MHz band does allow a 100-kHz bandwidth which is adequate for six narrowband multiplexed channels with some additional tones and a service channel. Omnidirectional use of this band in the Local Government Radio Service is restricted to developmental operations and traffic signal control on certain specified frequencies.

5.1.4 Limitation on Carriage

Although it is expected that the network will be used solely for medically related traffic on a point-to-point basis, the Arizona TeleMedicine Project may wish to make its facilities available to another group, perhaps not directly related to medicine. In addition to patient privacy considerations, there are regulatory considerations to be made as well. As an example, consider the limitations on broadcast usage. Excerpts from Parts 89 and 91 of the rules regarding this potential "sharing" of channel space are presented below:

Business Radio Service

In the Rules and Regulations of the Federal Communications Commission, Part 91, Subpart A, Paragraph 91.2(b), it is stated that:

> "The facilities of closed circuit educational television systems that have been licensed to educational institutions in the Business Radio Service may be utilized for the transmission of program material to noncommercial educational television broadcast stations, provided that the use of the facilities exclusively for carrying such program material shall be less than 50 percent of their total use during any one year of the license period. No charge either direct or indirect shall be made for such use. Licensees shall submit reports with their applications for renewals showing the breakdown of usage in terms of primary and alternate uses, during each year of the license term."

Local Government Radio Service

In Part 89, Subpart A, Paragraph 89.7 of the FCC Rules, it is stated:

> "The radio facilities authorized under this part shall not be used to carry program material of any kind for use in connection with radio broadcasting and shall not be used to render a communications common carrier service except for stations in the Special Emergency Radio Service while being used to bridge gaps in common carrier wire facilities."

5.1.5 Discussion and Recommendations

Since there is no major economic advantage[1] to limiting the Telemedicine service to a narrowband format, it is strongly recommended that only wideband microwave be considered for use in implementing the system.

[1]See Section 10.12.

It would appear that telemedicine network licensing in the Business Radio Service would have fewer limitations than in the Local Government Radio Service. However, in the Local Government Radio Service, a group of lower frequencies is available for mobile licensing in Part 89 (6525 to 6575 MHz). Though lower frequencies, especially for this purpose, are to be favored, the advantage is slight for distances under 21 miles. On the whole, should the University of Arizona Medical Center choose to be the licensee, it is recommended that applications be made in the Business Radio Service (Part 91 of the FCC Rules and Regulations). The possible exception would be in the case of mobile licenses.

The major disadvantage of using IRAC frequencies, even in this phase of the project which is concerned only with Indian Health Service Facilities, stems from the policy of IRAC not to share channel space with non-Government users. Since the Arizona TeleMedicine Network does intend to expand to cover the "civilian sector," this matter of sharing must be considered initially.

The overall consideration is, of course, the availability of spectrum space. For this reason, employing the existing communication facilities users as a data base, a frequency plan analysis was performed to determine 6 GHz "business band" frequency availabilities. The philosophy was to develop the frequency plan through the use of FCC frequencies wherever possible and especially in areas that may one day carry civilian traffic.

5.2 Frequency Availability

5.2.1 General

The lower frequency microwave band (6-GHz region) is becoming increasingly congested in many parts of the United States. In certain locations, further use of the band cannot be made without creating interference problems. In the case of the Arizona TeleMedicine Network, the need for frequencies involves obtaining two side-by-side 10-MHz channels so as to permit video transmission concurrently with the gamut of other narrowband channel services.

To ascertain the availability of frequencies in the State of Arizona, a computer based[1] search was undertaken. Using an in-house developed program, the potential interference was analyzed for each proposed microwave site in the Arizona TeleMedicine Network.

[1] Refer to Appendix C for data base used.

5.2.2 Network Frequency Plan

The results of the frequency search demonstrate that sufficient frequencies can be obtained for the construction of the Arizona TeleMedicine Network. The channel plan proposed is shown on Table 5.3.

Table 5.3. Network Frequency Plan.

Tucson	12510 MHz Hor.	→	←	12210 MHz Hor.	San Xavier
San Xavier	6675 MHz Hor. 6685 MHz Hor.	→	←	6825 MHz Hor. 6835 MHz Hor.	Kitt Peak
Kitt Peak	6855 MHz Ver. 6865 MHz Ver.	→	←	6705 MHz Ver. 6715 MHz Ver.	Santa Rosa
Kitt Peak	6795 MHz Hor. 6805 MHz Hor.	→	←	6645 MHz Hor. 6655 MHz Hor.	Pisinimo
Kitt Peak	6735 MHz Hor. 6745 MHz Hor.	→	←	6585 MHz Hor. 6595 MHz Hor.	Sells
Kitt Peak	6765 MHz Ver. 6775 MHz Ver.	→	←	6615 MHz Ver. 6625 MHz Ver.	Cimarron
Cimarron	6665 MHz Ver. 6675 MHz Ver.	→	←	6815 MHz Ver. 6825 MHz Ver.	South Mountain
South Mountain	12510 MHz Hor.	→	←	12210 MHz Hor.	Phoenix
Phoenix	6775 MHz Ver. 6785 MHz Ver.	→	←	6585 MHz Ver. 6595 MHz Ver.	Pinal Peak
Pinal Peak	12290 MHz Hor.	→	←	12590 MHz Hor.	San Carlos
Pinal Peak	6705 MHz Ver. 6715 MHz Ver.	→	←	6825 MHz Ver. 6835 MHz Ver.	Bylas
Pinal Peak	6655 MHz Hor. 6665 MHz Hor.	→	←	6855 MHz Hor. 6865 MHz Hor.	Morman Tank
Pinal Peak	6665 MHz Ver. 6675 MHz Ver.	→	←	6785 MHz Ver. 6795 MHz Ver.	Mount Lemmon
Mount Lemmon	6585 MHz Ver. 6595 MHz Ver.	→	←	6705 MHz Ver. 6715 MHz Ver.	San Xavier
Morman Tank	6815 MHz Ver. 6825 MHz Ver.	→	←	6615 MHz Ver. 6625 MHz Ver.	Whiteriver
Morman Tank	6835 MHz Hor. 6845 MHz Hor.	→	←	6585 MHz Hor. 6595 MHz Hor.	Cibecue

Table 5.3. (continued).

Morman Tank	12210 MHz Hor.	⟶ ⟵	12510 MHz Hor.	Cedar Creek
Phoenix	12250 MHz Hor.	⟶ ⟵	12550 MHz Hor.	Shaw Butte
Shaw Butte	6765 MHz Ver. 6775 MHz Ver.	⟶ ⟵	6675 MHz Ver. 6685 MHz Ver.	Mingus
Mingus	6595 MHz Hor. 6605 MHz Hor.	⟶ ⟵	6835 MHz Hor. 6845 MHz Hor.	Mount Elden
Mount Elden	6855 MHz Ver. 6865 MHz Ver.	⟶ ⟵	6625 MHz Ver. 6635 MHz Ver.	Moenkopi
Mount Elden	6815 MHz Hor. 6825 MHz Hor.	⟶ ⟵	6715 MHz Hor. 6725 MHz Hor.	Leupp
Leupp	12290 MHz Hor.	⟶ ⟵	12590 MHz Hor.	Ives Mesa
Ives Mesa	6615 MHz Ver. 6625 MHz Ver.	⟶ ⟵	6795 MHz Ver. 6805 MHz Ver.	Dilkon
Dilkon	6715 MHz Ver. 6725 MHz Ver.	⟶ ⟵	6585 MHz Ver. 6595 MHz Ver.	Klagetoh
Klagetoh	12370 MHz Hor.	⟶ ⟵	12670 MHz Hor.	Lower Greasewood
Klagetoh	12290 MHz Hor.	⟶ ⟵	12590 MHz Hor.	Ganado Mesa
Klagetoh	6645 MHz Hor. 6655 MHz Hor.	⟶ ⟵	6855 MHz Hor. 6865 MHz Hor.	Defiance Summit
Defiance Summit	12250 MHz Hor.	⟶ ⟵	12550 MHz Hor.	Window Rock
Window Rock	12590 MHz Hor.	⟶ ⟵	12290 MHz Hor.	Ft. Defiance Hill
Ft. Defiance Hill	12210 MHz Hor.	⟶ ⟵	12510 MHz Hor.	Ft. Defiance
Ft. Defiance Hill	12330 MHz Hor.	⟶ ⟵	12630 MHz Hor.	Piney Hill
Piney Hill	6635 MHz Ver. 6645 MHz Ver.	⟶ ⟵	6815 MHz Ver. 6820 MHz Ver.	Ganado Mesa

Table 5.3. (Continued).

Ganado Mesa	12530 MHz Hor.	→ ←	12230 MHz Hor.	Steamboat Canyon
Ganado Mesa	12570 MHz Hor.	→ ←	12270 MHz Hor.	Cottonwood Junction
Cottonwood Junction	12250 MHz Hor.	→ ←	12250 MHz Hor.	Chinle
Chinle	12610 MHz Hor.	→ ←	12310 MHz Hor.	Many Farms
Chinle	6585 MHz Hor. 6595 MHz Hor.	→ ←	6855 MHz Hor. 6865 MHz Hor.	Balakai Mesa
Balakai Mesa	12590 MHz Hor.	→ ←	12290 MHz Hor.	Low Mountain Repeater
Low Mountain Repeater	12210 MHz Hor.	→ ←	12510 MHz Hor.	Low Mountain
Low Mountain Repeater	12250 MHz Hor.	→ ←	12550 MHz Hor.	Pinon
Low Mountain Repeater	12330 MHz Hor.	→ ←	12630 MHz Hor.	Keams Repeater
Keams Repeater	12550 MHz HOr.	→ ←	12250 MHz Hor.	Steamboat Canyon
Keams Repeater	12590 MHz Hor.	→ ←	12290 MHz Hor.	Keams Canyon
Keams Repeater	12510 MHz Hor.	→ ←	12210 MHz Hor.	Oraibi Repeater
Oraibi Repeater	12330 MHz Hor.	→ ←	12630 MHz Hor.	Second Mesa
Oraibi Repeater	12370 MHz Hor.	→ ←	12670 MHz Hor.	Oraibi
Oraibi Repeater	12290 MHz Hor.	→ ←	12590 MHz Hor.	Rocky Ridge
Rocky Ridge	6635 MHz Hor. 6645 MHz Hor.	→ ←	6765 MHz Hor. 6775 MHz Hor.	Preston Mesa
Preston Mesa	6815 MHz Ver. 6825 MHz Ver.	→ ←	6675 MHz Ver. 6685 MHz Ver.	Moenkopi
Preston Mesa	12590 MHz Hor.	→ ←	12290 MHz Hor.	Kaibito Plateau
Kaibito Plateau	12630 MHz Hor.	→ ←	12330 MHz Hor.	Kaibito
Preston Mesa	12550 MHz Hor.	→ ←	12250 MHz Hor.	Tuba City
Preston Mesa	6855 MHz Hor. 6865 MHz Hor.	→ ←	6595 MHz Hor. 6605 MHz Hor.	Shonto

Table 5.3. (Continued).

Shonto	12510 MHz Hor.	——▷ ◁——	12210 MHz Hor.	Black Mesa
Black Mesa	12290 MHz Hor.	——▷ ◁——	12590 MHz Hor.	Kayenta
Black Mesa	6815 MHz Hor. 6825 MHz Hor.	——▷ ◁——	6685 MHz Hor. 6695 MHz Hor.	Yale Point
Yale Point	6595 MHz Ver. 6605 MHz Ver.	——▷ ◁——	6855 MHz Ver. 6865 MHz Ver.	Rock Point
Rock Point	12370 MHz Hor.	——▷ ◁——	12670 MHz Hor.	Totacon
Totacon	12590 MHz Hor.	——▷ ◁——	12290 MHz Hor.	Teec Nos Pas
Yale Point	12630 MHz Hor.	——▷ ◁——	12330 MHz Hor.	Many Farms
Many Farms	12230 MHz Hor.	——▷ ◁——	12530 MHz Hor.	Rough Rock
Many Farms	6835 MHz Hor. 6845 MHz Hor.	——▷ ◁——	6665 MHz Hor. 6675 MHz Hor.	Lukachukai

6.0 BASIC TECHNICAL REQUIREMENTS

6.1 General

Based on the list of communication needs documented in Section 2.1, the following channel requirement itemization was compiled. Discussion of each requirement is presented in the sections that follow.

Channel Description	Requirement
Administrative (coordination) voice channel	1 – duplex
Video channel (525 line/30 frames)	1 – duplex
Program voice channel (associated with video)	1 – duplex
Facsimile (slow-scan) channel	1 – duplex
Teleprinter channel	1 – duplex
Telemetry channel	1 – duplex
Camera control tones	6 – duplex
Signaling tones	duplex single frequency tones.

6.2 Administrative Voice Channel

The Administrative Voice Channel is, in all respects, a telephone "hot line" by which a remote field health station staff member, such as a community health medic or nurse, can achieve immediate voice contact with a physician at a peripheral hospital.

In seeking voice level consultation, a station may not find the appropriate specialist to be in the immediate vicinity of the telemedicine room. For this reason, and others to be discussed later, the referral centers' console operators should be provided with means whereby incoming and outgoing Administrative Voice Channel service (AdVC) can be extended via the dial up commercial telephone system. The extension of the AdVC service should not be limited to the confines dictated by the local (in-house) telephone system. In this way, voice consultation requests could be met more often than if the AdVC was limited to a console-to-console function.

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By permitting extension of the AdVC, other health services could also be provided via the Arizona TeleMedicine Network. For example, the various computer-aided diagnosis systems (ECG and spriometry) being implemented by the University of Arizona Medical Center (UAMC) could be accessed by the other network stations using the Administrative Voice Channel. Appropriate terminal/interface devices with acoustic couplers would, of course, have to be provided at those originating points. By providing the telephone system cross connect capability at the UAMC console, these signals would be relayed to the Medical Center's computer over the existing telephone network within the building.

In a like manner, means should be provided for the extension of AdVC service over existing VHF radio systems. For this extension, a simple four-wire patch cord arrangement should suffice. Since a console operator would be present during those times when the VHF extension service is needed, the push-to-talk operation of the VHF radio could be retained. A voice-operated switch (VOX) could be installed whenever and wherever such manual operation may prove cumbersome.

6.3 Video Channel and High Quality Voice Channel

The video channel and its associated high quality voice channel are provided to investigate the added impact of color television in aiding remote consultation or "telediagnosis" as it has become known. Monochrome television can also be carried in order to present a reference point for the judgment regarding the need for color. Monochrome will be provided as an alternate video service for cases where resolution is deemed more important than color.

6.4 Facsimile/Slow-Scan TV Channel

Primarily, the object of providing either or both of these narrowband services is to present an image transfer alternative to the wideband television service. Comparisons can be made as to the importance of motion (and color) in the visual level of communications.

6.5 Teleprinter Channel

This channel requirement refers to an extension to each network site of the existing computer-based "Health Information System." As was pointed out, HIS uses a data base consisting of many of the Indian Health Service's patient records. Access to the records is currently accomplished over the dial up telephone network using acoustically coupled portable terminals.

6.6 Telemetry Channel

Telemetry exchanges in the network will require at least a single channel having a response from dc to 500 Hz. Local switching or patching can determine which type of physiological data is to be transmitted. Selection would involve three possibilities: Electrocardiogram (ECG); lung function signals (spirogram); or electronic stethoscope (heart sounds, etc.). Obviously, special sensors and display apparatus are integral parts of this communication service.

6.7 Camera Control and Signaling Tones

The camera control tones listed on the chart can be termed "convenience circuits." These circuits would be provided to allow a remote operator to adjust the camera position (tilt and pan) and to zoom in or out; focus; or change the iris setting. In addition to these five control functions, the remote operator or the local operator should be able to select between color and monochrome camera signals.

The signaling tones indicated on the chart in Section 6.1 relate to the use of the "hot line" or Administrative Voice Channel already mentioned. These tones may be carried "in band" or in the supervisory control slot provided by the multiplex equipment.

6.8 Recording Devices

In order to evaluate the usefulness of the network and to aid the experiment in the production of sufficient data, some means other than written notes should be used to keep records. For this reason as well as for related clinical reasons, a means of automatically recording the transactions of the system should be provided. Various magnetic tape recorder units are available and will be used to satisfy this need.

6.9 Switching and Control of Transmissions

There is a need to maintain the existing medical referral pattern of the area or areas covered by network service. This requirement is important in assuring orderly use of the entire health service system by its members when the new avenue of electronic communications is opened to them. There is a real need to conserve the radio spectrum which is a limited natural resource like any other. Likewise, extreme demands for channel space, especially wideband channel space, will result in extreme requirements for construction funds.

6.10 Mobile Facilities

As an adjunct to the basic communication services requirement discussed in previous sections, a mobile facility would seem to have great potential. Since the Indian population is scattered into small villages, it would appear that a mobile health facility is a likely solution to the health care delivery problems in certain areas. The mobile unit envisioned should be a self-contained field health station having available many of the communication services and health care services provided at a usual, fixed health station. Staffing of such a facility would probably involve a single Community Health Medic (CHM).

7.0 EQUIPMENT CONSIDERATIONS

7.1 Transmission Equipment

7.1.1 General

Since the statewide plan must encompass many different terminal sites consisting of hospitals, field health stations and major medical centers, it was quickly determined that a wideband carrier system of some sort was required. Taking into account this knowledge, the distances involved and assuming that even greater expansion may be eventually required, the choice of microwave radio was clear. This would hold true, at least for the trunk of the system, even if no more than two voice slot channels provided sufficient communication service at each site. Because of the isolation of many sites and because telephone service in some areas was not judged sufficiently reliable, the approach of leasing telephone voice circuits was not projected to be used to any great extent in the design.

Several alternative wideband techniques were investigated before the choice of standard frequency modulated microwave radio was made.

Laser communications (see Section 7.1.2) was one of the alternative communication types investigated as part of this study and design program. Obviously, laser communications could not be expected to replace microwave radio in bridging the great distances required for most of the links in the Arizona TeleMedicine Network. However, the system may eventually be expanded to encompass several institutions within one city or town. Phoenix presents some possibilities here. For this type of use, the laser may be considered.

Cable was eliminated from consideration for all but the shortest of the links required. Long haul cables quickly become astronomical in cost and involve serious right-of-way problems as they extend beyond a very few miles. The less expensive cable television or CATV technology is generally unacceptable from the performance standpoint when the cascade gets much beyond thirty amplifiers in line, about ten miles of "run."

Instructional Television Fixed Service (ITFS), a relatively new microwave service created by the FCC, is capable of transmitting up to four television (audio and video) channels on a single carrier. This capacity would appear attractive for adaptation to the Arizona TeleMedicine Network. Unfortunately this service is capable only of limited or narrowband return. Furthermore, the service is low cost only when a single transmitter, using wide beam antennas, feeds several receivers. If it were to be used in a full duplex point-to-point mode, its cost advantage over standard microwave would be lost. In addition to these considerations, ITFS uses a form of amplitude modulation and is permitted, under existing rules, to transmit only television. The Arizona TeleMedicine Network, as planned, requires other modes of operation in addition to television.

There are other forms of modulation, all using microwave radio, that were considered for use on this network. Amplitude modulation was deemed to be unacceptable because of its extreme sensitivity to fades. Pulse code modulation was determined to be too expensive and wasteful of bandwidth. FM was selected for use on the network because of its long history of reliability in association with microwave. Equally important was the practical need to select a technique that is in heavy current use. In this way it is assured that production "bugs" have been reduced to a reasonable level. Likewise, the equipment is "off-the-shelf" with delivery times that can be held to four or five months. Pricing is kept competitive when off-the-shelf equipment is selected and regulatory problems are lessened since the equipment is usually type accepted.

7.1.2 Optical Communication Techniques

As a possible short range alternative to microwave radio, the recently developed communication systems involving lasers and light-emitting diodes (LEDS) were investigated.

The systems involving light-emitting diodes may be grouped together as "noncoherent light beam communication systems." The laser systems, by definition, are "coherent light beam communication systems." Neither system type involves FCC licensing.

Noncoherent Systems

The noncoherent light beam systems are generally inferior to the laser systems since the LED transmitters produce a multitude of frequencies and light "rays" that cannot be frequency modulated or directed in as tight a beam as laser light. The major net effect is that because the light from noncoherent systems diverges much more than laser light over the same distance, received signal levels will be less for those systems as compared to lasers having similar transmitter output powers. The result is, of course, a poor signal-to-noise ratio in the received signal at low received power.

Because of the characteristics of LEDs, analog or amplitude modulation of the transmitters is required for video transmission. The equipment availability of LED/digital systems (pulse code modulation or "PCM") is such that standard scan video cannot be accommodated at this time. Pulse code modulated systems are less subject to outages due to fades than are AM, or even FM systems. Clearly, any system using light energy as its carrier medium will be greatly affected by weather conditions such as snow, rain and fog.

Manufacturers of noncoherent light beam communications equipment include those on the following list.

Manufacturer and Type	Modulation	Baseband Capacity	Recommended Distance (coverage)
Microwave Associates Model MAQ-101	AM, Infrared	6 MHz (video plus one subcarrier)	640 feet, 99% reliability
University Instruments, KDI; Model OCL-330	AM, Infrared (digital rates to 1.6 megabit)	7.5 MHz	3,000 feet
Optical Communications, Inc. Model PL	Digital, Infrared (256 kilobits)	12 voice channels	1 mile

The cost per simplex link is typically in the $5,000 to $9,000 range.

Laser Systems

Recognizing the difficulties associated with amplitude modulation, the organizations working in this area have chosen either a frequency modulation or pulse code modulation technique. Three companies involved in laser communications hardware development were contacted. Brief descriptions of their technologies are presented below.

Georgetown Instruments "Lightline 5-7-1"

A frequency modulated laser communication system has been developed by Dr. William Thaler, president of Georgetown Instruments, Inc., and professor of physics at Georgetown University in Washington, D.C.

In this system, the modulating wave itself (video and aural information or multiplexed channel) is modulated on a 40-MHz carrier, and creates a pseudo-standing wave pattern in a transparent solid medium (crystal). The laser beam passing through the crystal acts as though it has been beamed through a diffraction grating. The result is a frequency modulated laser beam.

The beam is detected by an optical heterodying process, using a silicon epitaxial diode as a photo detector.

Specifications for the system are as follows:

Lightline 5-7-1 Specifications

Laser	Helium Neon – 5 mW
Modulator	F.M., Georgetown Instruments design, center frequency 40 MHz
Bandwidth	7 MHz – Flat to 3 db point
Range	1 mile
Input Signal	Composite Video – peak-to-peak voltage to 1.5 volts into a 75-ohm termination
Receiver Output	Video Signal Response - 1.5 volts maximum with 75 ohm termination
Power Requirements	117 volts and 60 Hz ac Transmitter 450 watts – Receiver 50 watts
Connection Cables	BNC
Signal Quality	Designed to NTSC requirements
Optical Beam	Divergence approximately 0.7 by 10^{-3} milliradians, approximately 6-inch diameter at 1 mile
Size	Transmitter – 18 by 8 by 50 inches Receiver – 8 by 8 by 60 inches
Weight	Transmitter – approximately 50 pounds Receiver – approximately 25 pounds

Sealed for outdoor operation

Mounting pads and alignment adjustments (can be mounted on any solid base)

Approximate material cost for a duplex system is $30,000.

Observed quality of the Light Line system carrying monochrome television was quite acceptable over a 1-1/2 mile path with light rain falling. Long term testing has not been done.

It should be pointed out that this system, like all laser systems, must be mounted on a very solid base (concrete pads are recommended). This is necessary so that the beam, which is very narrow, will not be momentarily thrown out of alignment due to vibrations caused by mild earth tremors, nearby machinery, or passing vehicle noise. In fact, all tremors, nearby machinery, or passing vehicle noise. As a matter of fact all laser communications systems must take into account in their design the constantly changing refracting characteristics of the air through which they pass. While laser beams of a very narrow type are helpful in maintaining good receiver levels, this same characteristic causes them to "miss the target" because of hot and cold air layers forming at points between the transmitter and receiver. This problem is corrected, at least partially, by expanding the light beam diameter, within the receiver optics, to a significantly larger size than the detector device.

Quancomm LTC

A system similar to that of Georgetown Instruments' is produced by Quancomm, Inc., of Cleveland, Ohio. Excerpts of the published specifications for this sytem are reproduced below.

Quancomm LTC-203 Specifications[1]

Signals carried	1 video channel 1 audio channel
System Weight	<50 pounds
Power Consumption	
Transmitter	<100 watts
Receiver	<10 watts
Beam Divergence	<50 Microradians
Fade Margin (recommended)	>40 dB
Baseband	8 MHz

[1]Path length and reliability data was not available.

Frequency	HeNe (visible red)
Power of Laser	3 milliwatts
Subcarrier	30 MHz
Modulation	Subcarrier, amplitude modulated on the light beam. Signal, FM on subcarrier.

AUDIO

Frequency Response (5 kHz reference)	
at 50 Hz	+0, -1.5 dB
at 100 to 7500 Hz	+0, -0.5 dB
at 15 kHz	+0, -2.5 dB
Total Harmonic Distortion (maximum)	<1 percent
Input and Output Impedance	600 ohms, balanced
Input Level	10 dBm ±10 dB
Output Level (adjustable)	10 dBm ±10 dB

ENVIRONMENTAL SPECIFICATIONS

Temperature Range	-10°C to +50°C

VIDEO

60 Hz Square Wave Tilt	<1 percent
Frequency Response	
10 kHz to 4.5 MHz	±0.5 dB
at 6.0 MHz (no audio)	-1.0 dB

Maximum Differential Gain at 3.58 MHz

10 percent APL	0.5 dB
50 percent APL	0.3 dB
90 percent APL	0.5 dB
Signal to Noise (EIA weighted)	60 dB [p-p/rms]
Signal to Hum (EIA weighted)	46 dB [p-p/p-p]
Input and Output Impedance	75 ohms, ±5 percent
Input and Output Levels	1.0 volt (p-p)

A demonstration of the Quancomm link was observed wherein test patterns and taped programming were transmitted. The link was operated over a distance of about 5,600 feet. Observed quality as good except for one failure during an unusually heavy period of rain.

Budgetary figures for a duplex system are in the $20,000 range.

Nippon Electric Company Laser System

This system is the only system found that uses pulse code modulation techniques at a rate high enough to accommodate video and two audio program subcarriers.

The following text and specifications data are abstracted from NEC's "Technical Proposal of NEC Laser Communication System for Color TV" published in October of 1972.

> One color TV signal and two audio signals are converted to coded pulse signals and these pulse signals are multiplexed by a time division multiplex system.
>
> The laser light is modulated by the multiplexed pulse signal and transmitted to the receiving side by atmospheric propagation.
>
> At the receiving side, the modulated laser light sent from the laser transmitter is focused to the photo detector and after conversion into an electrical signal, the multiplexed pulsed signal is regenerated and demultiplexed into one coded TV signal and two coded audio signals.

These coded signals are provided to the D-A converters and decoded respectively.

The transmitted one color TV signal and two audio signals are reproduced and provided as the final output of the system.

In this system, as an A-D, D-A converter of the input signal, Delta modulation is employed.

The Delta modulation system is simple in composition, capable of coding signals at a high efficiency, and economical in its hardware requirement.

As for the photo detector, a small-sized and wideband avalanche photo diode that makes electron multiplication is used to convert the light beam to the electrical signal.

Even though this signal is feeble due to transmission attenuation, it is then sufficiently amplified and subjected to pulse presence detection. A pulse signal which is free from noise and waveform jitter is therefore regenerated.

Technical Characteristics

Transmitting capacity	Color TV signal: 1 channel (NTSC) Audio signal: 2 channels
Multiplex system	Time-division multiplex system
Light wavelength	0.6328μ
Laser	Cold-cathode He-Ne gas laser
Oscillator output	More than 2 mW
Modulation system	PCM-AM modulation

Bit rate	123.492 Mb/s
Light modulator	$LiTaO_3$ crystal of temperature compensation type
Photo detector	Silicon avalanche photo diode
Input and output pulses	0 to 0.7 volts, unipolar
Power supply	110 volts ac

A duplex system is estimated to cost on the order of $42,000. Path distances, according to NEC, should not exceed 2.5 miles for reliable operation.

It would appear that a laser system using the techniques of modulation outlined by NEC is favored. An optical link if used at all should be confined to short-haul applications (under 3 miles). From the standpoint of costs, microwave may have an advantage over the prices of prototype laser systems. However, the laser systems will probably drop in price if a sufficient market for them develops and quantity of production is increased.

Laser systems should be considered for future short range expansion of the Arizona TeleMedicine Network.

7.1.3 Microwave Radio Standards

Although it is planned that SECAM color will be used primarily on the Arizona TeleMedicine Network (see Section 7.2.6), all performance characteristics of transmission equipment and common console equipment used in the network should meet or exceed all EIA and FCC broadcast standards and recommendations for NTSC television, which has more stringent requirements.

Wherever possible, heterodyne repeaters should be used to maintain the highest possible standards of transmission quality. This can be done at relay sites where no switching is necessary.

The basic requirements listed below should be used as firm guidelines in the selection of the radio system and associated equipment.

- All equipment should be FCC type accepted

- Frequency modulation (FM) is to be used with RF bandwidths of at least 20 MHz at each station

- All circuitry, with the exception of waveguide and other microwave components, shall be in the form of subassemblies or modules that may be easily disconnected and removed

- All solid state construction is to be favored.

Engineering specifications for the microwave radio system should be based on a design which takes into account the following guidelines of good practice.

- Microwave frequencies above 10 GHz should not be specified for hops of greater than 21 miles

- All paths should provide 3/10 first fresnel zone clearance using an effective earth curvature of 2/3

- Calculated 6-GHz receive levels should be in excess of -34 dBm except in cases where a tunnel diode amplifier is to be employed. In these cases, a -38 dBm lower limit for calculated receive level should be used. For 12 GHz, the recommended lower limit, without TDA, is -35 dBm

- Fade margins of at least 40 dB should be provided.

7.1.4 Automatic Failure Alarms

The network equipment should include a form of automatic "supervision" so that problem links in the system can be identified without the need for multiple site visits. The radio equipment should be provided with sensors to monitor certain parameters of operation at each station. These alarm monitors should be installed in such a way that, when a problem develops, a light and audible signal will be produced at a central maintenance plant. Because of the size of the proposed system, three maintenance centers will be required. Ft. Defiance Hospital, Phoenix Indian Medical Center and the University of Arizona Medical Center in Tucson will be established as such centers (see Section 9.0). The remote alarm panels will be installed at these points. Tucson will monitor Mt. Lemmon, San Xavier and Kitt Peak. Phoenix will monitor Cimarron, South Mountain, Phoenix (local), Mormon Tank, Pinal Peak, Shaw Butte, Mingus and Mt. Elden. All other relays will be monitored by Ft. Defiance.

Each alarm center will present the following information regarding the status of stations under its coverage area.

- Significant drop in the power of any relay system microwave transmitter
- Any relay system transmitter off frequency a pre-determined amount
- Loss of received signal on any system microwave receiver as indicated by the AGC
- Complete failure of a multiplex group
- Failure of primary ac power (operation on batteries or standby power generator)
- Failure of top tower light (if required).

7.1.5 Maintenance Intercom

A single channel voice intercom or "local order wire" should be provided for each of the master alarm centers. Each order wire will interconnect with the other centers and each center with each microwave station for which it has responsibility. This signal will be carried simultaneously with all the other communications services in the microwave baseband. Its purpose is to aid technicians in maintaining and repairing the network equipment.

7.1.6 Channelizing Equipment

The microwave system must be equipped with additional devices to permit the simultaneous carriage of the several narrowband channels required along with the main color television channel.

Standard frequency division multiplex equipment providing a maximum of twelve channels with 4-kHz spacing will have to be supplied for this purpose. The channels will be used as four wire circuits. Modulation shall be single-sideband, suppressed carrier and the entire group will be carried on the same subcarrier used for the order wire discussed above.

7.2 Terminal Equipment

Terminal equipment includes all equipment, except the microwave transmitting and receiving equipment, required at the various field health stations and hospital sites. These equipments are the studio equipment, telemetry equipment, sensors, display equipment and interface equipment.

The following types of data will be accommodated.

a. Duplex video with program audio

b. Voice (direct to next referral site)

c. Digital data (to computer center near San Xavier)

d. Slow-scan TV (facsimile)

e. Physiological signals.

Subject to switching and priority each site may communicate with any other site in the network. However, message traffic routing control will be set up to correspond to normal referral patterns.

It should be noted that the terminal equipment including studio facilities, telemedicine equipment, teleprinters and all other "operator" equipment will be basically the same for all stations in the network. Minor exceptions will, of course, exist in the switching and control consoles at the various sites. These exceptions reflect the local requirements for switching that are dictated by the number and types of stations under the control of those referral centers.

In addition to the duplex television links which include a program audio channel with a bandwidth of 50 to 15,000 Hz,[1] several other modes of communication are also required. Equipment requirements for televison, intercom, voice, physiological signals, digital data and still image transmission are discussed in the sections that follow.

[1]Should it be determined that stereophonic sound is important in maintaining realism in the doctor-patient interchange, the program aural channel could carry this service using a technique similar to that employed by commercial FM radio. The left and right channels could be matrixed and the "difference signal" carried on an audio sub carrier.

7.2.1 Audio Facilities, Administrative Voice Channel Intercom

Each site will be equipped with a telephone type handset of commercial telephone quality to allow for two-way "intercom" voice communication. An optional configuration of a miniature headset and microphone to allow free use of hands can be specified. To prevent unwanted mixing of any control tones using this channel, the circuit provided should be of the "four wire" type. Obviously the associated amplifiers, jacks and control panel will have to be provided. Means will be provided at each class "b" and class "c" station to interconnect the AdVC with the local in-house telephone systems. Likewise patching facilities will be available to extend the AdVC to any existing VHF radio unit. Both the telephone interconnect and the VHF radio patch will permit better service and improved flexibility.

Program Aural Channel

For the program audio associated with wideband television, a microphone (or group of microphones) should be provided for input from any terminal site. Reception at each site can be accomplished using a loudspeaker or earphones. Particularly attractive as an option is the use of "wireless" headsets that would permit the CHM doing an examination to hear the voice of the physician located at a remote point. The wireless headset would provide privacy and yet would not involve a cord that could prove bothersome to the CHM.

In connection with the outgoing program audio there must be provided the associated amplifier, mixer and connectors. An audio limiter should also be provided to maintain loudness at the desired level and to prevent undue distortion due to overloads that could be generated by loud speech.

Important characteristics of performance that should be met by the program aural equipment are listed below.

- Frequency response should be flat ±2 dB from 50 Hz to 15,000 Hz
- Harmonic distortion should not exceed 1.0 percent
- Signal to noise should be greater than 50 dB
- All solid state equipment should be provided.

7.2.2 Physiological Signals (Telemetry)

The requirement is to provide the capability to transfer at least one channel of physiological type data to a desired referral site. The physiological signals of interest are: heart sounds with a clinical bandwidth of 25 to 500 Hz, lung function signals (spirogram) with a clinical bandwidth of dc to 30 Hz, and the electrocardiogram with a clinical bandwidth of 0.05 to 45 Hz. Therefore, for the purpose of classification it can be seen that one wideband channel, dc to 500 Hz, will satisfy all of the above requirements for individual transmission. A discussion of the sensor and display equipment is provided elsewhere in this section.

This telemetry circuit will satisfy many other physiological signal requirements as well. The network may wish to expand its telemetry service to cover some of these at a future date. For example, clinical electroencephalograms can be transmitted via a dc to 100 Hz bandwidth circuit. Signals such as arterial pulse, plethsmographic pulse, or skin response can also be transmitted via this type of channel. One exception is the myographic signal which requires a very wideband channel (up to 5,000 Hz). Although this is not one of the signals of immediate interest it could be transmitted by the program aural channel. Likew' the three channel electrocardiographic signals could be multiplexed on the program aural channel or on the administrative voice channel. Analog voltages from the outputs of specific analyzers such as blood or gas analyzers can be transmitted via the telemetry channels or in digital form via manual imput to the teleprinter channel.

Electronic Stethoscope

The heart produces sounds as it pumps blood through the body. With a stethoscope or other amplifier these sounds can be categorized and used to aid in the diagnosis of cardiac abnormalities. Normal blood flow in the cardiovascular system creates minute vibrations which radiate to the body surface where they can be detected by auscultation, i.e., the art of listening to body sounds. The sounds and murmurs emitted from the cardiovascular system are extremely small in amplitude. These sounds and murmurs are commonly separated into two recording categories:

1. Phonocardiography (high frequency sounds and murmurs within the frequency range of 25 to 2,000 Hz)

2. Pulse wave cardiography (low frequency sounds and murmurs with typical frequencies between 0.1 and 40 Hz).

To provide adequate heart sound recordings, very sensitive amplifiers are used. The inputs to these amplifiers are provided by very sensitive microphones which will pick up not only the sounds and murmurs at the body surface, but also extraneous noises in the immediate vicinity of the patient. This fact emphasizes the importance of having a relatively quiet area for the phonocardiography facility. Common utilities like fans, air conditioners and voices from radios and television sets create vibrations within the same frequency range of the heart sounds and murmurs and will result in artifacts during the recording. The choice of microphones and bells is discussed in later paragraphs. Generally, it is considered good practice to secure the microphone to the patient's chest with a strap or stabilizing vacuum ring or both. When the microphone is hand held, it is important to remember that the microphone is a pressure sensitive device; therefore, its output will vary in accordance with the pressure applied. To reproduce reasonable repeatability, the physician or community health medic must develop a feel or "knack" for applying constant pressure to the microphone and patien (subject).

There are certain basic characteristics which should be considered when selecting components for a heart sound measuring system. These are: (1) microphones, (2) filtering, (3) gain compensation and (4) frequency response.

The selection of the microphone can be the most important single piece of the heart sound system. There are two main types: the contact and the air coupled microphones. The air coupled crystal microphones are generally used for apical pulse pickup or other low frequency surface displacement detections. These movements are not of interest in this application. The crystal contact microphone has very suitable performance characteristics for this application. They have good sensitivity and are generally smaller and less susceptible to environmental noise than the dynamic type.

The basic mechanical filtering of heart sounds is done by selection of the microphone bell or diaphragm size. Murmurs are selectively recorded by acoustically coupling the microphone to the chest of the patient in such a way as to intensify the frequency of the murmur. Conversely, sounds which are of little interest are attenuated to permit more careful examination of the specific murmur. Modern heart sound equipment utilizes electronic filtering to permit selective listening and recording of heart sounds. The microphone may then be chosen for its maximum frequency response, sensitivity, physical size, etc., and utilized during all auscultatory investigations. Isolation of specific sound frequencies is accomplished by the heart sound amplifier. Filtering should permit restriction of the low frequency sounds to prevent these sounds from interfering with the higher frequency murmurs. Restriction of the higher frequency sounds is generally not required for clinical heart sounds.

The frequency response of the microphone, heart sound amplifier should be from (3 dB down) 25 to 1,000 Hz. It should have several low filter selections which limit the low end of the band at 25, 50 and 100 Hz. A means should be provided for adjusting the gain up to at least 45 dB. The output voltage should be ± 2.5 volts for full scale. The voltage should either be clamped at the level or an indicator provided so that the operator may adjust the volume to keep the voltage within range. A set of interchangeable heads for the microphone (bell, diaphragm, etc.) should be provided.

Spirometer

The volumetric spirometer is one of the most commonly used instruments for pulmonary function testing. There are several types of instruments used to measure flow rates and volumes:

a. Pneumotoch tend to have a very limited range – that is, a variety of flow heads are necessary to perform pulmonary function testing which requires the measurement of a wide variety of dynamic flow rates.

b. Water spirometers have historically been the most popular instrument for measurements of lung volumes. These spirometers must be operated vertically, because of the liquid seal, meaning that a counterbalance must be used to offset the weight of the piston.

c. Bellows type has problems due to producing a good bellows; i.e., one that is not so "stiff" as to offer high resistance to breathing and inaccuracies at maximum breathing excursions.

d. Dry-rolling seal is usable over a large dynamic range and is a sealed unit in which the piston is usually suspended on nylon rollers with sealed bearings.

The spirometer proposed for use throughout the Arizona TeleMedicine Network should be capable for future use with the computer-based interpretation program of the University of Arizona Medical Center. They presently use a water-type spirometer. The particular unit used should have a range capable of testing small children to very healthy athletes. The output shall be a voltage that is proportional to volume (also indicative of flow rate).

Electrocardiograph

The electrocardiogram (ECG) is a measurement of the electrical potential generated by the heart during the depolarization and repolarization of the heart muscle as measured from the surface of the body. There are twelve sensing sites (leads) customarily used in clinical practice to measure the potentials. In each measurement (lead) the P wave represents the arterial depolarization, the QRS complex represents ventricular depolarization and the T wave represents ventricular repolarization. For use at network sites, it is proposed that a single-channel twelve-lead ECG machine conforming to the latest Recommendations (1966) for Standardization of Electrocardiographic Instruments of the American Heart Association be provided. The major points covered in the AHA specifications are the frequency response of the preamplifier, output voltage and noise.

7.2.3 Digital Data

The digital data requirement is the capability to retrieve information from the computer center near San Xavier. This computer center runs the Health Information System of the Indian Health Service. The present terminals, with hard copy output and keyboard input, operate over voice grade lines receiving and transmitting data asynchronously at 300 bits per second (30 characters/second).

7.2.4 Data Transmission Alternative Approaches

There are several approaches to transmission of digital data to the central computer facility. Such techniques as multidrop, frequency shifting, multiplexing, time division multiplexing, party line circuits, and concentrating techniques must be considered for optimization of the digital data circuits.

However, certain restrictions are present regardless of which method is used. At each site there must be a telephone channel "drop" for the digital data (this circuit will not be shared with other types of data). This line may be a common line to the computer and shared with similar types of data or a dedicated line.

Dedicated Line

Thus, if each site had a dedicated line (assume they are available) to the computer center, there must be a terminating telephone channel "drop" for each originating (site) point. For illustrative purposes, assume a cost[1] of $500 for a drop. Network cost for originating and terminating drops is $27,000. Fifty-four modems would be required at a cost of $16,200. Total cost is therefore $43,200.

Frequency Shift Keying Method of Sharing

At the required data rate of 300 bits/second, the number of telephone channel drops at San Xavier can be reduced from 27 (one for each originating site) to 5. This is derived from standard techniques of sharing 6 channels of FSK data at 300 baud over a telephone channel. This is a reduction of (22 X $500) $11,000. The additional cost of FSK equipment must be added. This is an increase of approximately $6,000 more than the straightforward 300 baud modems as costed above. The net reduction is about 12 percent ($5,000).

Thus, this method provides a dedicated service but at a savings of approximately 12 percent. Expansion is easily accomplished to new sites by adding "drops" at those sites and the proportionate number of drops at San Xavier (1 for 6 new sites).

Note there is no switching involved in this sharing method. This tends to increase reliability since fewer components are used.

Conference Sharing a Party Line Method

Another method to increase the number of users on a line is to service more users than the line can handle but to require a user to wait for the line to clear. Since the terminals are not heavily used and messages are short, this approach is worth considering.

For example, taking the 17 sites in the northern part and having them share one line instead of three would reduce the terminating drops from 5 to 2 or a reduction of (3 X $500) $1,500. In this manner 17 users would be waiting for one out of the six frequency slots available on the one telephone drop. In addition, the reduction of $1,500 would more than likely be eroded

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[1] Relative major equipment costs are used throughout this section for comparison purposes. Not included is labor, cost of relay facilities, terminal facilities and auxiliary equipment necessary for a functioning system.

completely away by the switching and polling equipment which would be required. Thus, for the added complexity and reduced capability, the saving, if any, would not merit this approach.

Time Division Multiplexing

Time division multiplexing (TDM) is a system of transmitting several simultaneous messages on the same circuit by time interleaving of data from many sources. Thus, at each transmission time a bit slot is occupied by a bit or character from one of the slower data sources being multiplexed. Therefore, only one signal occupies the channel at any one instant. This may be contrasted with frequency division multiplexing (FDM) in which each signal occupies a different frequency band and all signals are being transmitted simultaneously. The major advantage of the TDM technique over FDM is its efficiency. Some other advantages may be in reliability and reduction of error rates through the reprocessing inherent in most TDM equipment.

This method of implementation would approach that of the frequency shift keying (FSK). That is, the number of telephone "drops" at the terminating end (San Xavier) could be reduced from 27 to 5. However, the cost of TDM equipment is approximately three times the cost of FSK. Although it does have greater channel capacity, this network does not lend itself geographically in making use of efficient time division multiplexing concentration.

Proposed Approach

Of the alternate approaches discussed, frequency division multiplex/frequency shift keying method is straightforward, relatively simple and economically superior. Using this technique, a dedicated teleprinter channel is to be supplied at each terminal site linking it with the microwave relay station at San Xavier. From that point, the teleprinter circuits will be linked by land line (telephone company circuits) to the Bell Aerospace computer about 1-1/2 miles distant.

Each network site will be equipped for two-way digital data use. Modems using the frequency shift keying (FSK) method of modulation should be used. These modems should have a standard interface input (RS-232) and be compatible with standard terminals such as the one that is presently in use (TYMESHARE 1030, GE TERMINET 300). Provision in the network should be made for expansion using additional channels for high-speed synchronous data transmission for computer-to-computer link, computer to high-speed terminals such as printers and input devices.

This terminal, to be used in conjunction with this service, should be of the teleprinter type with a page (approximately 8-1/2- by 11-inch) output. It should have a standard alphanumeric typewriter keyboard with at least a 64 coded character set. It must be capable of sending and receiving USASCII coded information at a rate of 10 and 30 characters per second (300 baud). Provision should be made for alternate acoustic coupling to a standard voice grade telephone circuit. The acoustic coupler can be either separate or built in the terminal.

Using CCIR standards, up to six 300-baud teleprinter channels may be carried on a single 4-kHz channel. Obviously a distinct FSK center carrier frequency will have to be provided for each of the six data channels in each "voice band" slot.

7.2.5 Still Images

The image requirement is to transmit and receive various images such as X-ray films, photographs or "real time" visual examination of patients with at least a resolution of 200 lines per inch and a gray scale of at least 8 to 10 levels.

The techniques for transmission of wideband data over narrowband circuits (data compression) is extremely attractive for economic utilization of transmission facilities. However, the advantages of transmitting essentially wideband data over narrowband communication links must be weighed against such factors as loss of detail, delay in response time cost of terminal equipment and operator manipulation required.

The two major methods of narrowband transmission of wideband data are: facsimile and video scan converters.

Facsimile

The resolution of the image is expressed in lines per inch (LPI). The transmission speed is expressed in either inches per minute or minutes per 8-1/2- by 11-inch page. Speed is dependent upon resolution and the quality of the communication link (usually telephone line). The cost factor of time of use of transmission is not the predominant factor in this application. Ordinary business facsimile will transmit or receive a standard 8-1/2- by 11-inch page in 4 to 6 minutes. Some recent techniques have reduced this time to 3 minutes while still holding to the typical 3 kHz bandwidth of the telephone circuit. However, since resolution has been increased for photofax and bandwidth of the transmission circuit remains unchanged, the length of time to transmit must be increased. Typically a 200 LPI resolution facsimile will require 18 minutes for transmission. In a medical application of direct consultation, this is an inordinate amount of time. However, several 3-kHz channels can be combined to increase the bandwidth of the transmission link and consequently reduce the time required for transmission. For example, using 3 channels would reduce the transmission time by a factor of three or the time from 18 minutes to 6 minutes.

Facsimile recording techniques fall into four major categories: electrostatic, electrolytic, electrosensitive and photographic. There is a wide disparity between these techniques in resolution, ease of use and cost of supplies. Equipment is available in deck-top or console units either as a separate transmitter and receiver or as a combined transceiver unit.

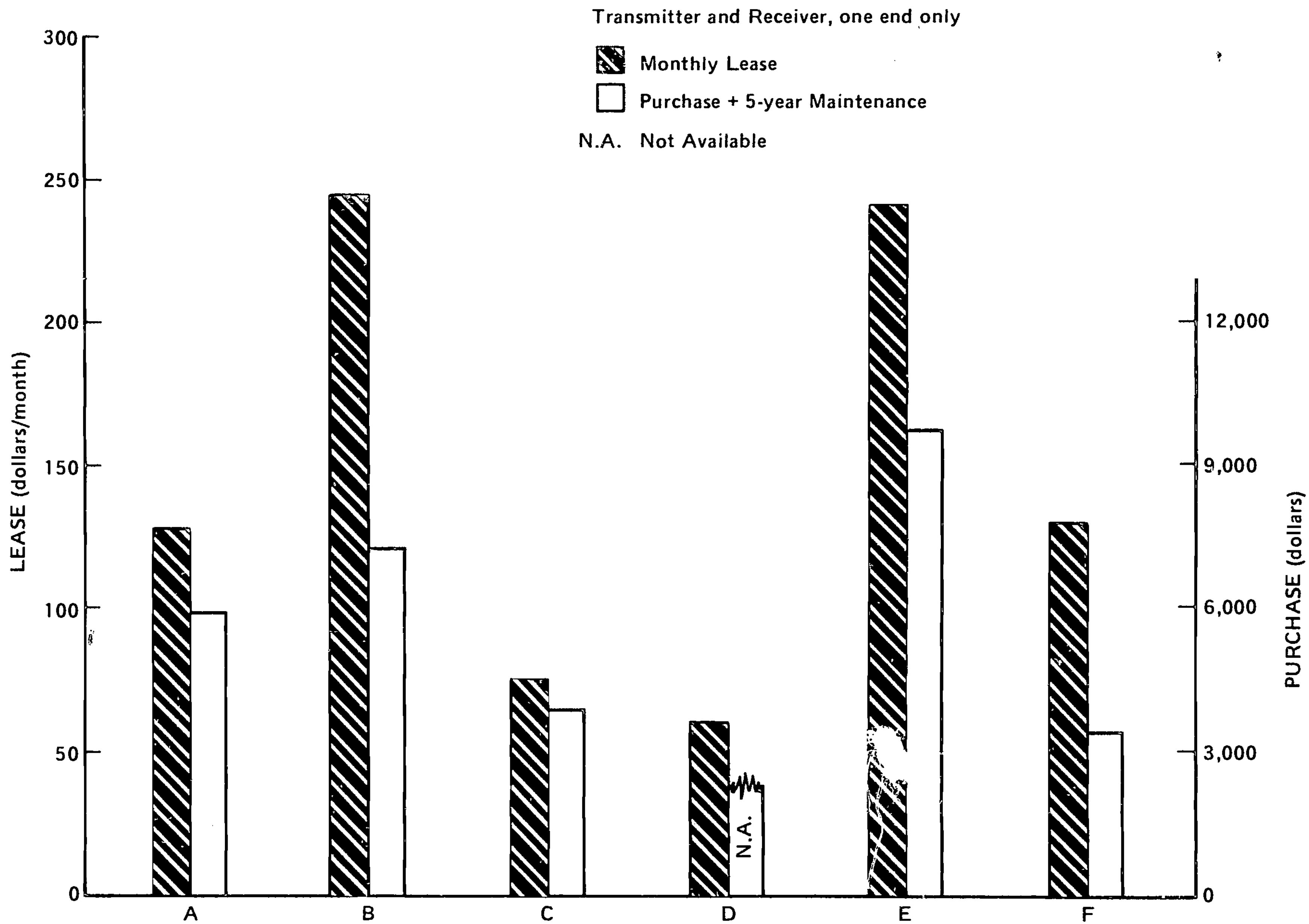
The evaluation of facsimile equipment is predicated upon its proposed use and the quality and characteristics of the available communication link. Of the approximately 25 manufacturers (U.S.) of facsimile equipment, about 80 percent emphasize the business market. "Business" type facsimile units with a resolution capability of 90 to 96 lines per inch and gray level of 1 to 4 or 5 are quite readily available. These are available for lease from about $55/month to $240/month (see Table 7.1). In the course of evaluation, some very good business type facsimiles were observed. These machines are more than adequate for most medical data such as charts, ECG tracing, prescription orders, etc. The exclusions are photographs and X-ray negatives or positives. If X-ray is one of the major image data requirements, the next level of facsimile would be required. This is the photo or weather facsimile. This type of facsimile typically has a resolution of 200 lines/inch and 8 to 10 levels of gray. The method of creating the image at the receiving end is usually photographic.

For best results, the X-ray negative should be converted to a positive photograph. This can be accomplished by a camera and "quick" self-developing film. For flexibility and utility, a camera stand with several enlargement positions is necessary. This extra process involves the cost of a camera, accessories and cost of film ($2.60 per image).

Muirhead photofax, employing a photographic technique, offers a resolution of 200 LPI and requires about 16 minutes to transmit an 8-1/2- by 11-inch page. This time can be proportionally reduced as stated above. This equipment is separate transmitter and receiver. The transmitter leases for $230/month while the receiver leases for $340/month or a purchase of $5,000 and $8,500, respectively.

The result is an acceptable image transmission method utilizing 3 3-kHz channels (for acceptable time) at a cost of $13,000 for facsimile equipment, and $2,000 to $5,000 for camera and accessories. For a total cost of $15,000 to $18,000, a facsimile system can be set up for transmission of X-ray images to a referral site.

Table 7.1. Representative Business Fax (90-96LPI) Costs.



Video Data Compression (Slow-Scan TV)

Bandwidth for television is proportional to the number of picture elements, the number of gray or color levels and the frame rate. The number of picture elements and gray scales may be reduced for some medical applications. However, many times it is desirable to preserve the resolution and gray scale. Therefore, the frame rate is reduced and the transmission time is increased but the other characteristics such as the resolution for use with a narrowband transmission link are retained.

Several techniques can be employed to reduce the transmission bandwidth by reducing the frame rate. Techniques for reduced frame rates are listed below. The discussion is directed toward monochrome transmission only.

At the transmitting end

- Slow scan cameras
- Storage tube converters with standard cameras
- Magnetic disc storage
- Sample scan converters with standard cameras.

At the receiving end

- Storage monitor CRT's (Cathode Ray Tubes)
- Storage tube scan converters
- Magnetic disc scan converters.

Most vidicon cameras with modifications to deflection systems can be used for slow-scan transmission. This technique with specially designed camera tubes can give very high resolution – up to 1,600 lines. However, cost and the main disadvantage that any motion in the picture will cause distortion has reduced availability of this type of equipment. Colorado Video Model 501 Data Camera is a compact solid-state television camera using a standard 1-inch vidicon and incorporates internal quantizing and sampling. It produces a "slow-scan" TV signal which can be transmitted over circuits capable of 10-kHz response or better. This unit is priced at $3,500.

General Electrodynamics ED 7000 camera assembly is designed to expose and read out upon command a quality TV picture. The output video of the ED 7000 is read out in 20 seconds and requires less than 1 kHz of transmission bandwidth – resolution in vertical is 200 TV lines, in horizontal is 250 TV lines.

Storage tubes which accept a frame of video from a standard camera and store it for a readout at a slow rate are available. Several of these types of converters were reviewed. One device, Princeton Electronics Products, employs a 1-inch double gun storage tube which is used for storing a single frame of video image in video format and at video rates and for readout on a monitor at video rates. The performance was quite good. There was a noticeable difference between the straight through video and the refreshed video, but it was slight. Several X-rays were displayed on the monitor. Limited enhancement is available through contrast, brightness and successive (integration) storage of the same image (noise tends to be averaged out). An additional feature is an electronic zoom which allows a small area of the image to be displayed on the entire viewing area of the monitor. This unit appears to be acceptable as a frame grabber and for narrow bandwidth imaging of X-rays. The major disadvantage of this device is that the interface required for clocking the signal out at telephone rates is not available from the manufacturer. Cost of terminals is $3,800 for normal resolution unit (525) and up to $7,000 for high resolution units.

Another unit (Hughes Industrial Products) employs a single gun tube for storage and readout of the video image. In a demonstration, a TV test pattern, X-rays and other material were displayed on a 12-inch monitor. This unit also has the buildup of successive frames and an electronic zoom feature. The quality of the image was good. It seems to be acceptable for X-rays. As with the previous unit, it does not have the necessary interface for transmission of the video image at reduced bandwidths over the telephone lines. Cost of these units is from $2,500 to $4,200 depending upon resolution desired.

Magnetic disc storage converters are similar to the storage tube converters. One complete system reviewed was a prototype produced by the Westinghouse R&D Center. This system utilizes a standard TV camera with a magnetic disc storage and an MOS input/output buffer. The disc storage system can store up to 300 images (video frames). The image to be transmitted needs to remain motionless for one frame (1/30th of a second). The transmission bandwidth is typically 1 kHz for a one-frame transmission in about 2 minutes. Acoustic couplers and a dial-up telephone circuit were used in the demonstration as the transmission link. With higher quality transmission circuits the transmission time can be reduced accordingly. It seems that this system is acceptable and could be upgraded to color with modifications primarily involving the replacement of the camera and monitor.

The physical size of the Westinghouse prototype units was about 3- by 2- by 2-feet including camera, mount and monitor. The send and receive terminals are identical – function is reversed for sending/receiving. The prototype construction price is estimated at $46,000 for two terminals.

Sample scan converters sample the picture at a rate at which the data can be transmitted over voice grade circuits (narrow bandwidth). The Colorado Video Converter VC 201A produces an output signal in the 8 to 0.5 kHz range. The disadvantage here again is that motion in the image will cause distortion of the transmitted range.

At the receiving end, storage CRT's are not widely used due to the expense of the storage tube as compared to the cost of a standard TV video monitor.

Storage tube scan converters (with standard monitors) can be used as a receiving end device as well as at the transmit end. The unit used in this way converts slow-scan data to standard video format and rates.

Magnetic disc scan converters can be used to convert from slow scan to standard video (as was pointed out in connection with the Westinghouse device). In overall purpose, these units are similar to storage tube converters. Colorado Video Magnetic Disc 220A high resolution model also uses a magnetic disc memory to convert slow scan video to standard 525 TV rates.

Based on a careful investigation of the problems associated with still frame transmission, the relative costs and benefits, the availability of systems and the projected needs of the Arizona TeleMedicine Network, the following conclusions are presented.

- Slow-scan TV techniques are more applicable than facsimile techniques to filling the needs of the Arizona TeleMedicine Network

- Facsimile is only to be favored for its characteristic of "hard copy output" in connection with the transmission of printed material (such as review documents for the CHM's).

- Slow-scan TV systems of types such as the Westinghouse unit should be provided at all network terminals in the first phase (test bed) of construction. Subsequent operating experience will determined whether this service is of sufficient clinical value to warrant its further installation throughout the full network

- Again, since operating experience will determine whether facsimile for printed text reproduction is useful, it is proposed that two or three sites in the test bed phase of the Arizona TeleMedicine Project be equipped with business facsimile. This sample should provide sufficient data to make the determination as to whether or not to expand this service throughout the network at a later date.

7.2.6 Color Television Standard for the Arizona TeleMedicine Network

Several methods of transmitting color television are currently available using "off-the-shelf" equipment. The simplest method involves transmitting three distinct video channels simultaneously (red, blue and green). This method is wasteful of channel space and cannot be considered as a rational choice in view of the alternatives. The most widely used alternatives are, of course, systems using electronic encoding processes whereby the relatively narrowband color information is transmitted along with the wideband monochrome television signal.

In all electronic encoding processes, the optical full color image is filtered so as to present three monochromatic images to the pickup device(s) within the camera. Each image carries only the representation of a single color; either red, blue or green. From these three images, three video signals are generated by the associated scanning tubes within the camera. Following this process it is normal to "matrix" the three signals such that the following signals are derived:

Luminance (Y)	R + B + G
Red Chrominance	R - Y
Blue Chrominance	B - Y

Only the luminance signal need be treated as a wideband television signal. The color difference signals are used to modulate a subcarrier which is placed in the high frequency end of the video channel where it causes fewer interference problems with respect to the final picture quality.

The various ways in which the color difference signals may be carried is the basic point of comparison between the three color television standards in use today. One such standard in use throughout the USA and several other countries is that which was proposed by the National Television Standards Committee and is, therefore, known as NTSC color. The other color systems are PAL and SECAM. PAL (Phase Alternation by Line) is the German system developed in 1962 by the Telefunken Company. SECAM (Sequential and Memory) is the French system of color. Each system is briefly described below.

NTSC Color

The NTSC color picture is transmitted using the traditional scanning pattern (525 line, 30 frame, 60 fields) that has been in use throughout the United States since the late 1940's. In color, the scanning frequencies are controlled with somewhat greater precision. The color signal corresponds to a luminance component (providing black-and-white set compatibility) transmitted as amplitude modulation of the picture carrier and a simultaneous pair of chrominance components transmitted as the amplitude modulation sidebands of a suppressed subcarrier in quadrature. The red, green and blue signals are derived at the television receiver from the transmitted chrominance information.

PAL Color

The PAL color system is very close in principle to the NTSC system but includes a way of reducing the susceptibility of the color rendition to inequalities and phase changes in the transmission of the two-color signals. As in NTSC the two color signals are transmitted simultaneously by amplitude modulation of a suppressed subcarrier, bu the polarity of one of the signals is reversed between alternate scanning lines. By this means the rrors in color are averaged out between one line and the next.

SECAM Color

In the SECAM system the red, green and blue components are generated in the same way as for the other systems: the luminance and the two-color signals are also derived in the same way. But instead of sending these two color-difference signals simultaneously; they are transmitted consecutively during alternate line periods. At the receiver a delay line is introduced to hold the information received from the first chroma transmission until the other begins to arrive. Both signals are then applied simultaneously to the matrixing and receiver display circuits over a period of two lines.

At any given moment, in SECAM systems, there are only two instead of three signals being transmitted. This means that the subcarrier, instead of having to carry two simultaneous signals by means of quadrature modulation, has only to carry a single signal. This signal is frequency modulated onto the subcarrier instead of using a suppressed carrier system. In the receiver this signal can be decoded by a frequency discriminator circuit without the need for an accurate receiver local reference oscillator. This scheme also affords some simplification in video tape recording.

Interconnection Considerations

The Arizona TeleMedicine Network may desire to interconnect with other networks of similar types. The interconnection medium may be microwave using ground-based stations or satellite relay. No matter what medium is used, the television and other signals must be compatible such that interconnection does not involve complex and costly conversion processes. Only the video scanning standards (and to a lesser extent, the color standards) must be given a great deal of consideration since narrowband signals, such as audio, present no difficulty in this regard.

If the scanning standards adopted by two networks wishing to interconnect are different, the pictures must be scan-converted using fairly sophisticated devices employing either optical-to-optical transfer or storage tubes. Color must be bypassed and re-encoded. The complexity is not so great if the scanning standards are identical. For this reason and because 525 line television appears to contain sufficient resolution for medical uses, the Arizona TeleMedicine Network will adopt a 525 line, 30 frame, 60 field standard as its own.

Proposed Color Standard

The choice for a color television system for the Arizona TeleMedicine Network is predicated on several known requirements of the network operators. First, the network will be heavily relied upon as a clinical tool. Second, the network stations are located in remote areas where maintenance technicians may not be readily available. Third, the network will very likely be interconnected with other medical networks beyond its borders. Fourth, the network stations will make heavy use of video tape in maintaining both a legal record of transactions and for internal evaluation purposes.

With all these factors taken into account, the most logical choice from the various color television systems available is a system using SECAM that has been modified to be compatible with USA monochrome television. This system is known as SECAM-60.

Using SECAM-60 will allow any standard black and white monitor to view the signals present without conversion. Color quality will be less subject to operator error and should be more stable since no operator controls are provided for hue and saturation. Transcoding to NTSC color for interconnection with other medical networks will not be difficult nor costly. A block diagram of this process is shown as Figure 7.1.

The SECAM-60 option using a 4.43-MHz subcarrier will be employed so as to prevent cross talk difficulties from arising in the transcoding process. Further, horizontal resolution will be aided by more completely utilizing the available base band to 5.5 MHz (see Figure 7.2).

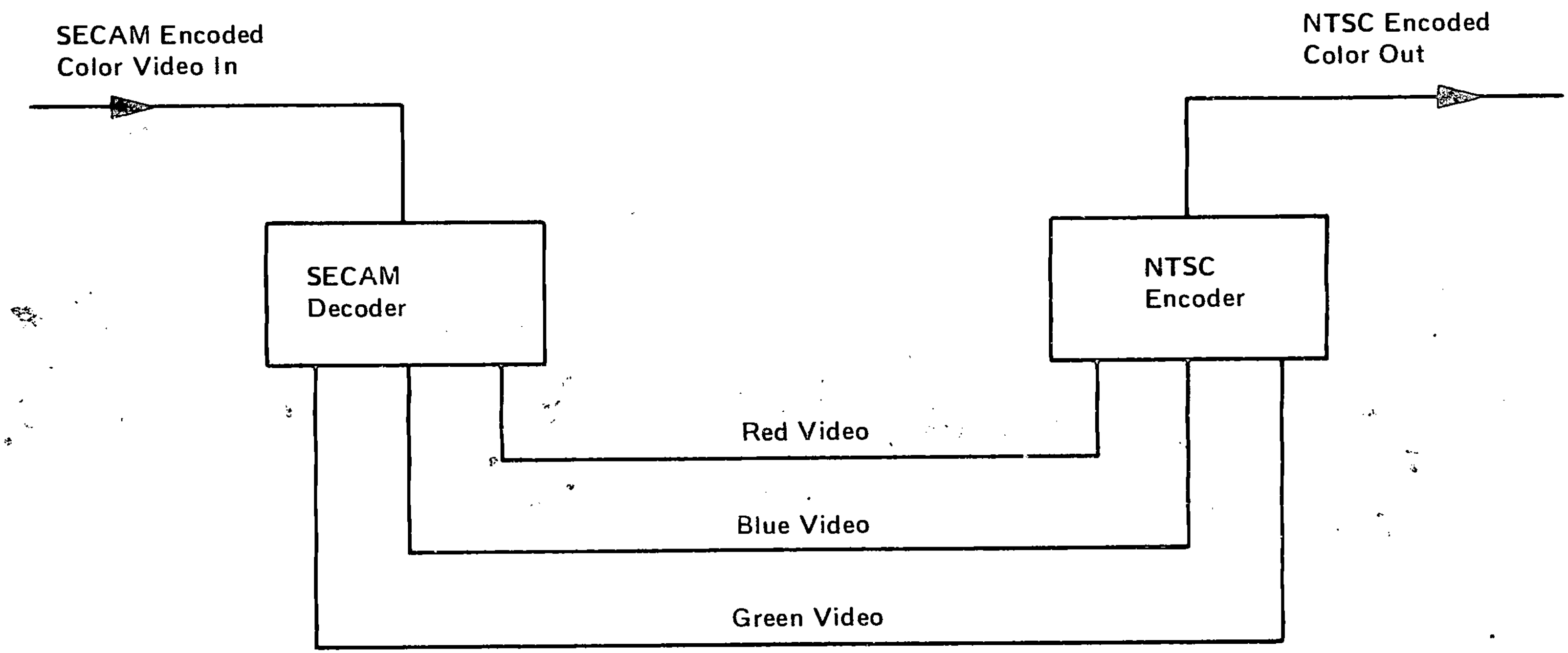


Figure 7.1. Block Diagram — SECAM to NTSC Transcoding.

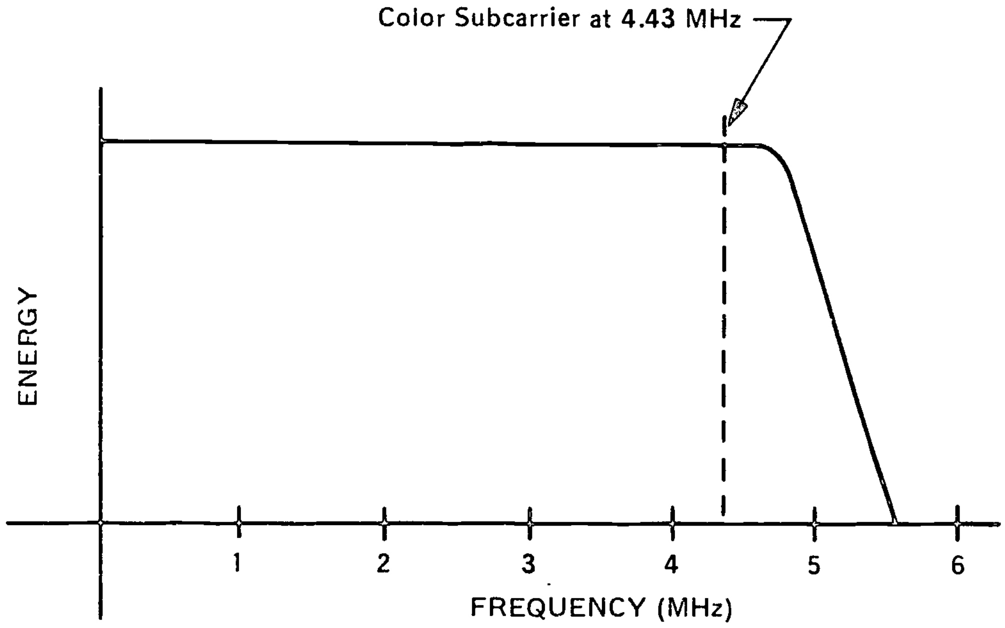


Figure 7.2. SECAM "Standard L" Video Spectrum.

7.2.7 Television Pickup and Display Equipment

Camera Equipment

Each terminal site in the network will be provided with a lightweight color television camera suitable for use under relatively poor lighting conditions. A lighting system other than normal room lights will be provided to be used when ambient illumination does not produce good results. The camera chain will be of the three tube design and will produce SECAM color as its output encoded signal. A switch, remotely controlled will be provided such that the monochrome video coming from only the green tube can be selected when improved resolution is of more clinical value than color. This would likely be the case for radiology work.

In addition to the camera itself, which will normally be wall mounted, a tripod/dolly will be provided as an optional camera support. An electrically operated "zoom" lens and remote control will be supplied. Similarly, a remote control tilt/pan head will be provided as will additional extension camera cables to permit the unit to be used at least 50 feet away from its control console.

Basic performance specifications for the camera equipment are listed below:

- The camera chain should provide broadcast quality color television images and must be completely solid state except for the image tubes
- The view finder should be easily removed
- The camera should utilize three lead oxide pickup tubes
- Individual channel aperture compensation should be provided
- Geometric distortion (not including lens effects) should be not greater than ±1 percent
- Signal-to-noise ratio should be 40 dB or better at 25 foot-lamberts scene illumination
- Resolution of not less than 400 lines, center with aperture correction when camera is in the color mode of operation. When the monochrome bypass is actuated, resolution should not be less than 600 lines center.

Video Monitor Equipment

On the input video line to each terminal's console there will be provided a "image enhancer" which is a device that improves, at least subjectively, the sharpness of the video passing through it.

Monochrome Monitors

The black and white monitors used in the Arizona TeleMedicine Network should be of professional quality in order to present high resolution monochrome images without significant degradation. Basic performance characteristics to be satisfied are as follows:

- Monochrome video monitors should be capable of presenting an image of 600 line center and corner resolution without geometric distortion greater than 3 percent of picture height
- With the exception of the high voltage rectifier and kinescope, the monitor should employ all solid-state construction
- Video response should be flat to 10 MHz ±1 dB
- DC restoration (sync tip clamp) should be provided and switchable in or out.

Color Monitors

The color monitors should also be of professional quality. Because of its stability and high brightness characteristics, the monitors should use the "trinitron" type of picture tube (kinescope). The monitors should, of course, accept SECAM color having a 4.43-MHz subcarrier.

Listed below are several important specifications which should be met by these monitors.

- The monitor should be all solid state with the exception of the kinescope
- Video band pass flat to 4.43, ±1 dB
- Linearity should be within ±2 percent of picture height
- DC restoration should be provided as a switchable option.

7.2.8 Recording Equipment

To aid in the burdensome task of keeping records of the transactions of the network; to preserve more complete patient records; and to permit adequate evaluations to be made of the network's usefulness, recording devices will be required at certain sites. Because the communications traffic on the network will be of several different types, more than one type of recorder/playback unit will be needed.

For the main television (video and audio) channel, clearly, a video tape machine is required. However, because SECAM is to be used as the system of color encoding, the video tape units need not be as sophisticated as would be the case if NTSC (American standard) color encoding was used. In addition to the basic requirements that the video tape recorder/playback devices be reliable, simple to operate (a cassette recorder), and small, the following characteristics should be included:

- o Video signal to noise should be greater than 40 dB
- o Resolution should be at least 250 TV lines
- o Reel size should permit at least 60 minutes of playing time without reloading.

The possibilities of locating a source of supply for a true video logging recorder are not good. Only one potential source was found for such a device that would record one frame every minute. This unit, a modification by Ampex Corporation of their 1-inch helical scan recorder, was to be used by broadcasters to replace or supplement their daily program logs. A representative of the company explained that the machine was demonstrated a few years ago but no market developed. Furthermore, tests revealed that the helical recorders operated at this slow tape transport speed on a 24-hour, 7-day basis soon broke down. The unit was never sold and is not in the Ampex product line at the present time.

For all other communication services carried on the network (telemetry, slow-scan TV, and intercom voice transmissions), an audio logging recorder is indicated. These machines are in wide spread use by both broadcasters and the Federal Aviation Agency as record-keeping devices. The tape speed is quite slow and, as such, the audio quality is limited. Neverless, because the unit is needed by the Arizona TeleMedicine Network for narrowband recording and because multiple track loggers are available, it is proposed that a similar type of machine be used. The following specifications are those which are the most critical.

- Four simultaneous audio tracks are to be provided
- The format should involve either cartridge or cassette packaging
- Each audio track (channel) shall reproduce a band of frequencies from 100 Hz to 4 kHz with a flat response (±2 dB)
- Signal-to-noise ratio shall not be less than 36 dB.

7.2.9 Clinical Equipment

Two sites within the proposed network must be completely provided with various items of medical equipment and clinical supplies. Bylas, the proposed mobile unit and other under-equipped sites should be provided with the items listed below. Consumable items such as tissues, swabs, bandages, etc., are needed but not individually listed.

Major Equipment

Audiometer
Blood Pressure Unit
Cauterizer
Centrifuge
Electrocardiograph
Electronic Stethoscope
Eye Chart
Incubator, Bacterial
Microscope
Microscope Camera
Opthalmoscope-Otoscope
Oxygen
Refrigerator
Scales; adult, baby
Skin Fold Caliper
Refractometer
Spirometer
Tonometer (Scheoctz)

Personal Equipment

Reflex Hammer
Stethoscope
Tape Measure
Head Lamp

Laryngeal Mirror

Tuning Fork 128 cps

Basic Furnishings

Examination Table

Incandescent Floor Lamp

Desk, Chairs, etc.

Laboratory

Unopette System

Bilelabstix

7.3 Relay Site Equipment

7.3.1 General

In addition to the microwave radio equipment, multiplex equipment and other channel equipment which have all been discussed earlier, the relay sites in the Arizona TeleMedicine Network will involve some other hardware categories, as well. These items, the switcher matrices, equipment shelters and standby power systems are discussed in this section.

7.3.2 Switcher Matrices

These units, known as "video switchers" and "audio switchers," will be located at those points throughout the Arizona TeleMedicine Network where more than two duplex links come together and require to be routed. Three independent communication switching "levels" will have to be provided. The video switchers will switch both the wideband color video and its associated sound. The audio switchers refer to those matrices associated with telemetry routing and slow-scan TV routing.

The following characteristics listed for each type of matrix should be required in implementing the Arizona TeleMedicine Network.

Video Switchers

- Solid state, self-contained modular construction should be the rule

- Frequency response should be flat within 0.5 dB to 10 MHz
- Cross talk should be 60 dB or more below desired signal
- Hum and noise should be 55 dB or more below the desired signal level (rms)
- Differential gain: ±1 percent
- Differential phase: ±0.2 degrees.

Audio Switchers

These units should also be all solid state and self-contained utilizing modular construction.

- Frequency response should be flat within 1 dB, 50 Hz to 5 kHz
- Cross talk should not exceed a level of 50 dB below the desired signal.

7.3.3 Equipment Shelters

Wherever possible, existing equipment buildings will be used throughout the network. Obviously new shelters will have to be provided at undeveloped sites. This is also true wherever the existing buildings are either too crowded, unsuitable, or cannot be secured for use. At these places, it is recommended that prefabricated metal or Fiberglas equipment shelters be used. These self-contained units can be secured from a number of sources and can be supplied with numerous options such as lights, benches, outlets, air conditioners, heaters, etc. It is recommended that these buildings be bolted down to adequate, poured concrete footings.

7.3.4 Electric Power Systems

In the planning of the Arizona TeleMedicine Network Microwave System, significant emphasis was placed on locating the sites close to existing commercial power lines. The problem of supplying electricity to the site then becomes the relatively simple matter of installing a "drop" from the power line to the station's equipment building.

Some means, however, must be provided for maintaining a constant supply of power to the station should the commercial line experience a temporary failure. In addition, an alternate source of primary power must be utilized when the station is isolated from commercial systems, as the cost of installing long sections of new overhead lines soon becomes prohibitive.

It is for these reasons that some form of auxiliary and/or commercial line replacement power source should be included on the station equipment list.

For sites far from commercial power lines, two propane gas engine generator sets are recommended.[1] For sites with commercial power already available, one standby engine generator set will be sufficient. At sites where both primary and standby power exist, no additional equipment will be required. At certain sites where outages do appear to be a problem but where such outages do not normally last longer than 8 hours, storage batteries will provide a sufficient auxiliary power source and will be used. Automatic changeover to the standby power system (or between the two primary generators at those isolated sites) must be provided for.

7.4 Towers and Support Structures

Listed below are the network sites (and reflector sites) where more than a simple tripod or roof-mounted stub tower will be required.

Site	Projected Tower/Reflector Size
San Xavier	40 ft. self-supporting three-legged tower
Kitt Peak	40 ft. self-supporting four-legged tower
Sells	20 ft. self-supporting three-legged tower
Santa Rosa	20 ft. self-supporting three-legged tower
	24 ft. x 30 ft. reflector, 15 ft. ground clearance
Pisinimo	60 ft. self-supporting three-legged tower
Cimarron	25 ft. self-supporting three-legged tower
Mount Lemmon	30 ft. self-supporting three-legged tower
Pinal Peak	40 ft. self-supporting four-legged tower
San Carlos	20 ft. self-supporting three-legged tower
Bylas	20 ft. self-supporting three-legged tower
	30 ft. x 32 ft. reflector, 15 ft. ground clearance

[1]Throughout this document wherever engine generating systems are discussed, the use of thermoelectric generating systems is to be implied as an acceptable alternate. Cost and reliability determinations will dictate the appropriate choice.

Site	Projected Tower/Reflector Size
Phoenix	10 ft. self-supporting three-legged tower
Shaw Butte	25 ft. self-supporting three-legged tower
Mingus	25 ft. self-supporting three-legged tower
Mount Elden	50 ft. self-supporting three-legged tower
Lenpp	20 ft. self-supporting three-legged tower
Ives Mesa	20 ft. self-supporting three-legged tower
Dilkon	100 ft. guyed tower
Klagetoh	100 ft. guyed tower
Lower Greasewood	100 ft. guyed tower
Defiance Summit	80 ft. guyed tower
Window Rock	20 ft. self-supporting three-legged tower
Fort Defiance Hill	20 ft. self-supporting four-legged tower
Fort Defiance	20 ft. self-supporting three-legged tower
Piney Hill	80 ft. guyed tower
Ganado Mesa	50 ft. self-supporting four-legged tower
Cottonwood Junction	20 ft. self-supporting three-legged tower
Chinle	85 ft. guyed tower
Balakai Mesa	100 ft. guyed tower
Low Mountain Repeater	80 ft. guyed tower
Low Mountain	20 ft. self-supporting three-legged tower
Pinon	150 ft. guyed tower
Keams Canyon Repeater	90 ft. guyed tower
Keams Canyon	40 ft. self-supporting three-legged tower
Steamboat Canyon	20 ft. self-supporting three-legged tower
Oraibi Repeater	110 ft. guyed tower
Second Mesa	20 ft. self-supporting three-legged tower 10 ft. x 16 ft. reflector, 8 ft. ground clearance
Oraibi	20 ft. self-supporting three-legged tower
Rocky Ridge	110 ft. guyed tower
Preston Mesa	40 ft. self-supporting four-legged tower
Tuba City	20 ft. self-supporting three-legged tower
Monenkopa Substation	20 ft. self-supporting three-legged tower
Kaibito Plateau	140 ft. guyed tower
Kaibito	130 ft. guyed tower
Shonto	180 ft. guyed tower
Black Mesa	60 ft. self-supporting three-legged tower

Site	Projected Tower/Reflector Size
Kayenta	20 ft. self-supporting three-legged tower
Yale Point	40 ft. self-supporting three-legged tower
Rock Point	20 ft. self-supporting three-legged tower
Totacon	20 ft. self-supporting three-legged tower
Teec Nos Pos	20 ft. self-supporting three-legged tower
	20 ft. x 24 ft. reflector, 8 ft. ground clearance
Many Farms	120 ft. guyed tower
Lukachukai	20 ft. self-supporting three-legged tower
	20 ft. x 32 ft. reflector, 8 ft. ground clearance
Rough Rock	20 ft. self-supporting three-legged tower
	12 ft. x 16 ft. reflector, 15 ft. ground clearance

7.5 New Equipment Shelters

Listed below are the network sites where new equipment shelters are to be required.

Site	Shelter Description
San Xavier	The shelters are prefabricated units of 8 ft. x 8 ft. x 8½ ft. dimensions. The units are insulated and wired. Heater and exhaust fan are included.
Kitt Peak	
Pisinimo	
Cimarron	
Phoenix	
Shaw Butte	
Mingus	
Mount Elden	
Ives Mesa	
Dilkon	
Klagetoh	
Defiance Summit	
Window Rock	
Fort Defiance Hill	
Piney Hill	
Ganado Mesa	
Cottonwood Junction	
Steamboat Canyon	

Site	Shelter Description
Balakai Mesa Low Mountain Repeater Keams Canyon Repeater Oraibi Repeater Rocky Ridge Kaibito Plateau Black Mesa Yale Point Rock Point Totacon	The shelters are prefabricated units of 8 ft. x 8 ft. x 8½ ft. dimensions. The units are insulated and wired. Heater and exhaust fan are included.

8.0 NETWORK PROPOSED DESIGN

8.1 General

8.1.1 Network Coverage

The terminal sites proposed for interconnect by the Arizona TeleMedicine Network are listed along with the intermediate relay and reflector sites required, on Table 8.1. These sites are also shown on the network route map presented as Figure 8.1.

8.1.2 Network Route Selection

With the exception of the short cable link connecting the Health Program Systems Center (HPSC) monitor to the San Xavier relay station, all sites will be interconnected using microwave radio. Full duplex microwave links are to be provided in all cases.

Leased telephone company wire line circuits will be used to interconnect the San Xavier relay with the Bell Aerospace Computer currently used by the Indian Health Service's Health Information System (HIS) as its data base.

The selection of relay points and microwave routes to be used throughout the Arizona TeleMedicine Network was based upon the need to provide the most efficient point-to-point paths. Route selection was also influenced by the desire to share existing facilities wherever possible. A survey[1] was undertaken to determine the location of major communication system users in the State of Arizona. Where it was found that presently developed sites could be effectively utilized, arrangements were sought for joint use.

8.1.3 Communication Services Needs

As described in Section 6.0, discussions with the physician members of the team and other interested and knowledgeable medical people, a list of communication services were developed. The intent is to provide a wide range of information transfer capability so that the clinical users will not feel constrained or inhibited in their use of the network. It is intended that a "test bed" portion of the Arizona TeleMedicine Network be implemented prior to construction of the entire system. This pilot project will produce the cost/benefit data required to judge effectiveness of the devices and channels indicated below.

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[1] Described in Section 3.0.

Table 8.1. Network Site Data.

Site Name	Elevation (ft)	Coordinates (deg)	(min)	(sec)		Antenna Azimuths (approximately) (deg)		Distance (mi)
Pisinimo[a]	1900	32	02	20	N	96	(Kitt Peak)	42.4
		112	19	00	W			
Sells[a]	2355	31	55	05	N	80	(Kitt Peak)	17.1
		111	53	26	W			
Kitt Peak	6860	31	57	34	N	73	(San Xavier)	38.1
		111	35	53	W	260	(Sells)	17.1
						276	(Pisinimo)	42.4
						305	(Cimarron)	57.4
						312	(Santa Rosa Reflector)	37.5
Santa Rosa Reflector	1880	32	19	05	N	132	(Kitt Peak)	37.5
		112	04	28	W	77	(Santa Rosa)	2.1
Santa Rosa[a]	1804	32	19	30	N	257	(Santa Rosa Reflector)	2.1
		112	02	23	W			
San Xavier	2530	32	06	43	N	26	(Mt. Lemmon)	25.6
		110	58	53	W	13	(Tucson)	9.2
						253	(Kitt Peak)	38.1
Tucson[a]	2447	32	14	22	N	193	(San Xavier)	9.2
		110	56	38	W			
Mt. Lemmon	9157	32	26	25	N	206	(San Xavier)	25.6
		110	47	13	W	358	(Pinal Peak)	57.7
Pinal Peak	7800	33	16	52	N	103	(Bylas Reflector)	42.3
		110	49	15	W	37	(Morman Tank)	35.2
						76	(San Carlos)	21.8
						178	(Mt. Lemmon)	57.7
						282	(Phoenix	73.2
Bylas Clinic[a]	2640	33	07	40	N	32	(To Bylas Reflector)	1.5
		110	06	55	W			
Bylas Reflector	2800	33	08	45	N	212	(To Bylas)	1.5
		110	06	09	W	283	(To Pinal Peak)	42.3
San Carlos[a]	2540	33	21	14	N	256	(Pinal Peak)	21.8
		110	29	27	W			
Mormon Tank	6280	33	41	11	N	355	(Cibecue Reflector)	26.5
		110	27	15	W	70	(Whiteriver Reflector)	31.6
						46	(Silver Butte Reflector)	20.4
						217	(Pinal Peak)	35.2

[a]Indicates terminal site.

Table 8.1. (continued).

Site Name	Elevation (ft)	Coordinates (deg)	(min)	(sec)		Antenna Azimuths (approximately) (deg)		Distance (mi)
Cibecue Reflector	5401	34	04	08	N	182	(Cibecue)	1.4
		110	28	56	W	177	(Mormon Tank)	26.5
Cibecue[a]	4960	34	02	58	N	2	(Cibecue Reflector)	1.4
		110	29	00	W			
Whiteriver Reflector	6243	33	50	43	N	250	(To Whiteriver)	1.9
		109	56	17	W	250	(Mormon Tank)	31.6
Whiteriver[a]	5260	33	50	10	N	70	(Whiteriver Reflector)	1.9
		109	58	09	W			
Silver Butte Reflector	6132	33	53	24	N	72	(Cedar Creek)	1.3
		110	11	41	W	226	(Mormon Tank)	20.4
Cedar Creek[a]	4940	33	53	44	N	252	(Silver Butte Reflector)	1.3
		110	10	22	W			
Cimarron Peak	4124	32	26	37	N	17	(S. Mountain)	64.7
		112	23	33	W	125	(Kitt Peak)	57.4
South Mountain	2660	33	19	59	N	197	(Cimarron)	64.2
		112	03	49	W	5	(Phoenix)	11.3
Phoenix[a]	1133	33	29	42	N	341	(Shaw Butte)	7.0
		112	02	51	W	185	(S. Mountain)	11.3
						102	(Pinal Peak)	73.2
Shaw Butte	2149	33	35	38	N	161	(Phoenix)	7.0
		112	05	10	W	4	(Mingus)	64.0
Mingus	7800	34	42	23	N	184	(Shaw Butte)	64.0
		112	07	00	W	39	(Mt. Elden)	46.5
Mt. Elden	9430	35	14	34	N	219	(Mingus)	46.5
		111	36	03	W	85	(Leupp)	36.0
						12	(Moenkopi Sub.)	42.0
Leupp[a]	4700	35	17	00	N	265	(Mt. Elden)	36.0
		110	57	49	W	82	(Ives Mesa)	20.6
Ives Mesa	5400	35	19	22	N	262	(Leupp)	20.6
		110	36	11	W	73	(Dilkon)	25.0
Dilkon	6425	35	25	36	N	253	(Ives Mesa)	25.0
		110	10	48	W	69	(Klagetoh)	27.5

[a]Indicates terminal site.

Table 8.1. (continued).

Site Name	Elevation (ft)	Coordinates (deg)	(min)	(sec)		Antenna Azimuths (approximately) (deg)		Distance (mi)
Klagetoh	6530	35	33	08	N	249	(Dilkon)	27.5
		109	43	33	W	255	(Greasewood)	8.3
						26	(Ganado Mesa)	18.0
						74	(Defiance Summit)	29.5
Greasewood[a]	5900	35	31	21	N	75	(Klagetoh)	8.3
		109	51	18	W			
Defiance Summit	7840	35	40	10	N	254	(Klagetoh)	29.5
		109	12	44	W	87	(Window Rock)	9.0
Window Peak	6940	35	40	14	N	267	(Defiance Summit)	9.0
		109	03	13	W	346	(Ft. Defiance Hill)	7.5
Ft. Defiance Hill	7400	35	46	32	N	168	(Ft. Defiance)	2.1
		109	05	03	W	166	(Window Peak)	7.5
						261	(Piney Hill)	4.7
Ft. Defiance[a]	6840	35	44	43	N	348	(Ft. Defiance Hill)	2.1
		109	04	39	W			
Ganado Mesa	6840	35	47	05	N	207	(Klagetoh)	18.0
		109	34	20	W	274	(Steamboat)	19.9
						356	(Cottonwood Junction)	18.0
						93	(Piney Hill)	22.5
Piney Hill	8120	35	45	33	N	273	(Ganado Mesa)	22.5
		109	09	53	W	81	(Ft. Defiance Hill)	4.7
Cottonwood Junction	6120	36	02	30	N	176	(Ganado Mesa)	18.0
		109	35	28	W	16	(Chinle)	8.0
Chinle[a]	5600	36	09	13	N	241	(Balakai Mesa)	24.4
		109	33	09	W	346	(Many Farms)	14.2
						196	(Cottonwood)	8.0
Many Farms[a]	5300	36	21	10	N	270	(Yale Point)	12.0
		109	37	08	W	287	(Rough Rock Reflector)	15.8
						75	(Lukachukai Reflector)	24.2
						166	(Chinle)	14.2
Lukachukai Reflector	7700	36	26	42	N	255	(Many Farms)	24.2
		109	11	30	W	234	(Lukachukai)	2.8
Lukachukai[a]	6525	36	25	03	N	54	(Lukachukai PR)	2.8
		109	13	44	W			

[a]Indicates terminal site.

Table 8.1. (continued).

Site Name	Elevation (ft)	Coordinates (deg)	(min)	(sec)		Antenna Azimuths (approximately) (deg)		Distance (mi)
Rough Rock Reflector	6300	36	25	05	N	129	(Rough Rock)	1.4
		109	53	22	W	104	(Many Farms)	15.8
Rough Rock[a]	6350	36	24	20	N	284	(Rough Rock Reflector)	1.4
		109	52	21	W			
Yale Point	8075	36	21	08	N	306	(Black Mesa)	35.0
		109	49	54	W	36	(Rock Point)	34.8
						90	(Many Farms)	12.0
Rock Point	6200	36	43	07	N	216	(Yale Point)	34.8
		109	25	05	W	33	(Totacon)	12.2
Totacon	6000	36	53	30	N	213	(Rock Point)	12.2
		109	19	05	W	73	(Teec Nos Pos)	12.8
Teec Nos Pos Reflector	5540	36	56	08	N	253	(Totacon)	12.8
		109	05	26	W	206	(Teec Nos Pos)	2.6
Teec Nos Pos[a]	5380	36	54	04	N	26	(Teec Nos Pos Reflector)	2.6
		109	06	33	W			
Black Mesa	8170	36	39	50	N	254	(Shonto)	17.8
		110	21	01	W	45	(Kayenta)	6.1
						126	(Yale Point)	35.0
Kayenta[a]	5700	36	43	40	N	225	(Black Mesa)	6.1
		110	15	21	W			
Shonto[a]	6500	36	35	38	N	74	(Black Mesa)	17.8
		110	38	28	W	243	(Preston Mesa)	35.2
Preston Mesa	6640	36	21	35	N	24	(Kaibito Plateau)	12.4
		111	12	12	W	63	(Shonto)	35.2
						131	(Rocky Ridge)	34.3
						187	(Tuba City)	15.5
						200	(Moenkopi Sub)	39.0
Kaibito Plateau	6300	36	31	25	N	204	(Preston Mesa)	12.4
		111	06	48	W	23	(Kaibito)	5.6
Kaibito[a]	5800	36	35	46	N	202	(Kaibito Plateau)	5.6
		111	04	29	W			
Tuba City[a]	4950	36	08	10	N	7	(Preston Mesa)	15.5
		111	14	21	W			

[a]Indicates terminal site.

Table 8.1. (continued).

Site Name	Elevation (ft)	Coordinates (deg)	(min)	(sec)		Antenna Azimuths (approximately) (deg)		Distance (mi)
Moenkopi Substation	4550	35	50	00	N	192	(Mt. Elden)	42.0
		111	26	36	W	20	(Preston Mesa)	39.0
Rocky Ridge	6220	36	02	04	N	311	(Preston Mesa)	34.3
		110	43	51	W	134	(Oraibi Relay)	17.0
Oraibi Relay	6260	35	52	00	N	314	(Rocky Ridge)	17.0
		110	31	06	W	277	(Oraibi)	5.6
						185	(Second Mesa Reflector)	4.1
						100	(Keams Canyon Relay)	18.4
Oraibi[a]	5680	35	52	35	N	97	(Oraibi R.)	5.6
		110	37	04	W			
Second Mesa Reflector	6320	35	48	26	N	5	(Oraibi Relay)	4.1
		110	31	28	W	133	(Second Mesa)	1.6
Second Mesa[a]	5680	35	47	30	N	313	(Second Mesa Reflector)	1.6
		110	30	14	W			
Keams Canyon Relay	6420	35	49	02	N	280	(Oraibi Relay)	18.4
		110	11	44	W	35	(Low Mountain Relay)	7.5
						95	(Steamboat Canyon)	15.0
						143	(Keams Canyon)	0.4
Keams Canyon[a]	6200	35	48	46	N	323	(Keams Canyon Relay)	0.4
		110	11	29	W			
Low Mountain Relay	6760	35	54	26	N	337	(Pinon)	14.6
		110	07	10	W	10	(Low Mountain)	2.3
						64	(Balakai Mesa)	11.8
						215	(Keams Canyon Relay)	7.5
Low Mountain[a]	6160	35	56	28	N	190	(Low Mountain Relay)	2.3
		110	06	45	W			
Pinon[a]	6350	36	06	05	N	157	(Low Mountain Relay)	14.6
		110	13	27	W			
Balakai Mesa	7360	35	58	53	N	244	(Low Mountain Relay)	11.8
		109	56	11	W	61	(Chinle)	24.4
Steamboat Canyon	7050	35	48	10	N	275	(Keams Canyon Relay)	15.0
		109	52	21	W	94	(Ganado Mesa)	19.9

[a]Indicates terminal site.

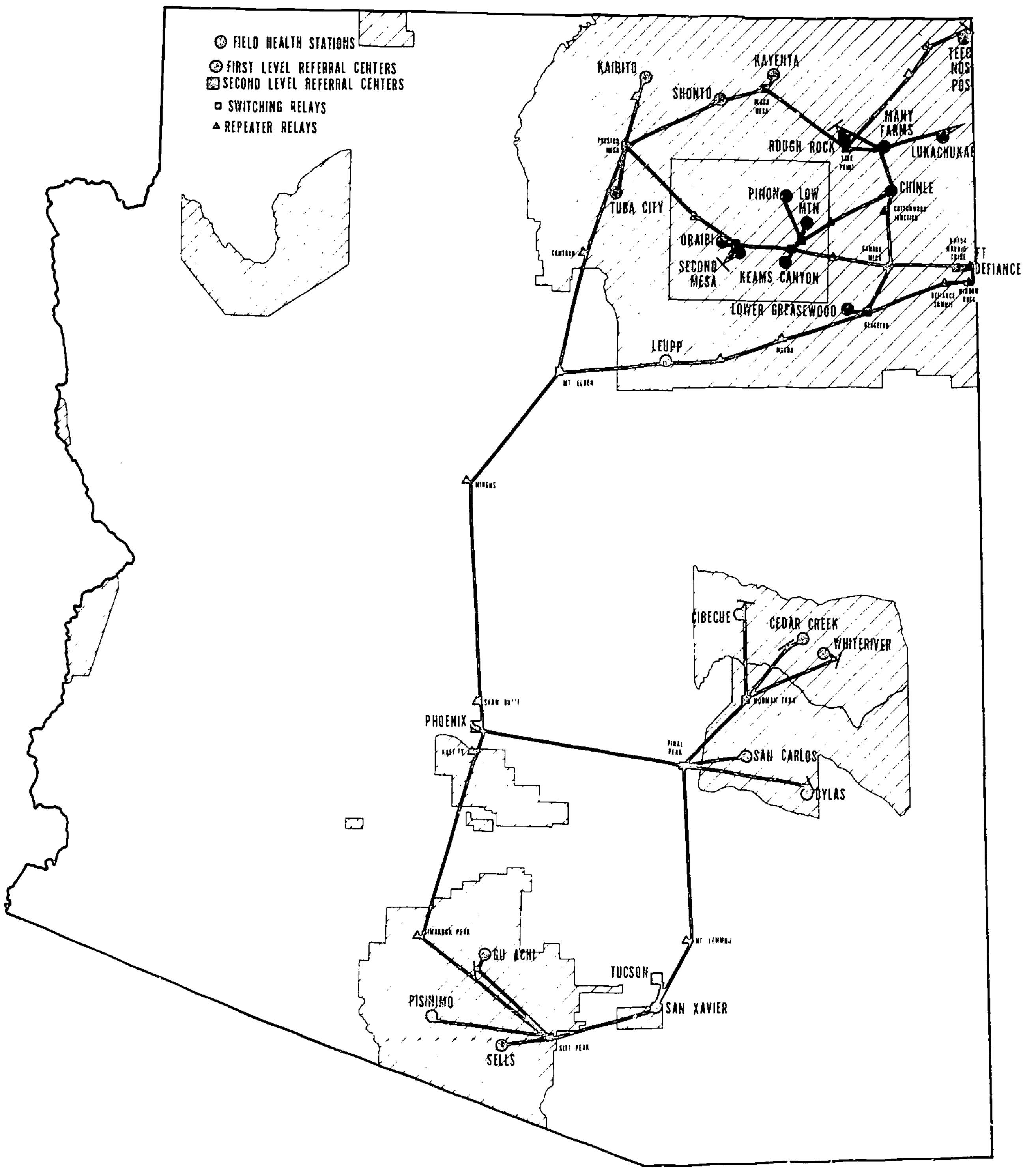

Figure 8.1. Proposed Network Route.

Communication Modes

- Administrative voice (intercom)
- Video (color and monochrome)
- Program voice (associated with video)
- Slow-scan TV/facsimile
- Teleprinter (HIS data)
- Telemetry (telediagnosis, physiological information)
- Camera control from remote sites

SECAM 60 having a bandwidth of 5.5 MHz and a color subcarrier at 4.43 MHz has been chosen as the color television standard for use in the network. Basically, the reasons for this choice of color system rests with SECAM'S stability and minimal requirement for operator adjustment of hue and saturation.[1] Transconversion to NTSC color encoding can be added at any time in the future when exchange with other television systems becomes necessary or desirable.

Facsimile and slow-scan television[2] were carefully investigated for use in the test bed system. The conclusion was that facsimile was technically and economically practical for printed material only. Halftone material, photographs, and most importantly, X-rays could not be handled efficiently by facsimile. Nevertheless, it was determined that there might be an occasion when an immediate delivery of reference material, charts or graphs is important. For this reason, it is recommended that a few of the test bed sites be equipped with "business fax" machines of the compact, desk-top variety to determine the real need.

All sites will be provided with slow-scan monochrome television systems using magnetic disc storage and voice-bandwidth modems. It appears that these units will have a great degree of acceptability for X-ray transmission and the viewing of such "real time" material as skin lesions.

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[1]See Section 7.2.6 for a discussion of this choice.

[2]See Section 7.2.5.

The teleprinter channel will provide, to each network site, a direct connection into the existing computer-based "Health Information System." A dedicated data channel for this service is to be provided for each clinic and hospital involved in the Arizona TeleMedicine Network.

As pointed out earlier, physiological signals transmissions in the network can use a single channel with a frequency response from dc to 500 Hz. This channel will carry, at local option, one of the following: Electrocardiogram (ECG); lung function signals (spirogram); or electronic stethoscope (heart sounds, etc.). Push button or patch cord selection will be used.

The network will accommodate various computer-based interpretation programs as they become available and applicable. The automated Spirometry Program of the University of Arizona Medical Center, Section of Pulmonary Diseases, has the most immediate application. One feature of the service offered is the performance of the routine calculations of spirometry. The input required is certain patient identifying data such as name, weight, height, sex and the analog spirometric signal. The system is set up to receive both types of input (digital and analog) via a single telephone line. The procedure calls for the data modem at the computer site (UAMC) to be called. The modem automatically answers the call and is ready to receive data from the teleprinter. After sufficient digital data is entered, the computer switches the modem to receive the analog signal. When the community health medic or remote site investigator has finished sending the signal, the computer system is notified (by an end of test signal) that the user is ready to receive the results via the teleprinter.

To implement this service within the Arizona TeleMedicine Network the following equipment and services must be provided.

1. Spirometer with output compatible to the computer interface. This device is to be provided as part of the terminal site equipment for the Arizona TeleMedicine Network health stations.

2. Voice grade telephone connection to the "data set" telephone interface at the computer site. This is already provided within the basic system by the telephone patch arrangement at the University of Arizona Medical Center which allows the Administrative voice channel to be connected to a telephone extension in the Medical Center.

3. Teleprinter which is used to call the program, enter data and receive results. The teleprinter supplied for the Health Information System can be switched to the automated spirometry system at the referral site console. A second

teleprinter could be provided as an alternative. The requirement is to insure compatible baud rates with the computer interface. The present automated spirometer interpretation system requires teleprinters which operate at the 110-baud rate. Future plans call for baud rates of 300 and up to 1200 for CRT type display terminals. The teleprinter for the Health Information System is of the multiple baud rate which includes 110 and 300 baud.

4. Teleprinter/Spirometry Interface contains the digital modem and the voltage controlled oscillator for applying the teleprinter data and the spirometric output to the telephone handset via an acoustic coupler. This device is not supplied as part of the basic Arizona TeleMedicine Network. It however, can be obtained from the University of Arizona Medical Center, Section of Pulmonary Diseases, for a nominal cost of $300 to $400. Or alternatively it could be constructed from specifications which are also available.

The Arizona TeleMedicine Network offers the flexibility of expansion to computer based diagnostic aids. For example, in addition to the automated spirometry program, a computer-based electrocardiographic interpretation system could be added. This program would be implemented similar to the spirometric program allowing for both digital and analog data to be transmitted to a central computer site. This would be accomplished via the Administrative voice channel or if this circuit is busy via the facsimile/slow scan channel which can be equipped with a telephone handset (if necessary) for less than $100. Also it is noted that additional voice channels can be added within the network including telephone handset at a cost of less than $600 per terminal site. Specialized switching equipment may also be required depending on what type of service is needed.

The camera control tones will allow a remote operator to adjust the camera position (tilt and pan), zoom, focus or iris. The remote operator (or the local operator) can also select between color and monochrome camera signals.[1] There will be provided at each site both color and black and white monitors. Clinically this has great appeal, especially to radiologists who generally complain that the lack of resolution presented by color camera and monitor systems which cannot transmit the black and white X-ray image with sufficient detail. In addition to its value in X-ray viewing, the monochrome/color option will experimentally determine the value of color in telediagnosis. Should monochrome prove acceptable in all respects, significant savings can be realized in further extensions of the network since the color requirement would be dropped from the basic equipment list, a savings of approximately $30,000 per site.

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[1]See Section 7.1.4.

8.1.4 Compatibility with other Systems

The proposed Arizona TeleMedicine Network communication facilities are readily adaptable to interface with Satellite communication circuits. The narrowband services to be carried on the proposed network are channelized in accord with international standards. The wideband (television) service utilizes the United States television broadcast scanning plan and, as such, may be carried over satellite communication circuits that can accommodate such broadcast signals. The color encoding system adopted for the proposed network is not the same one normally used in the United States. However, conversion between the color systems is neither difficult nor costly. Devices for color conversion can be provided wherever the facilities of the Arizona TeleMedicine Network may interface with Satellite ground station equipment. Because of this ready compatibility, the terminal, console and studio equipment at each site in the network could be used alternatively on the land-based system or on the satellite system.

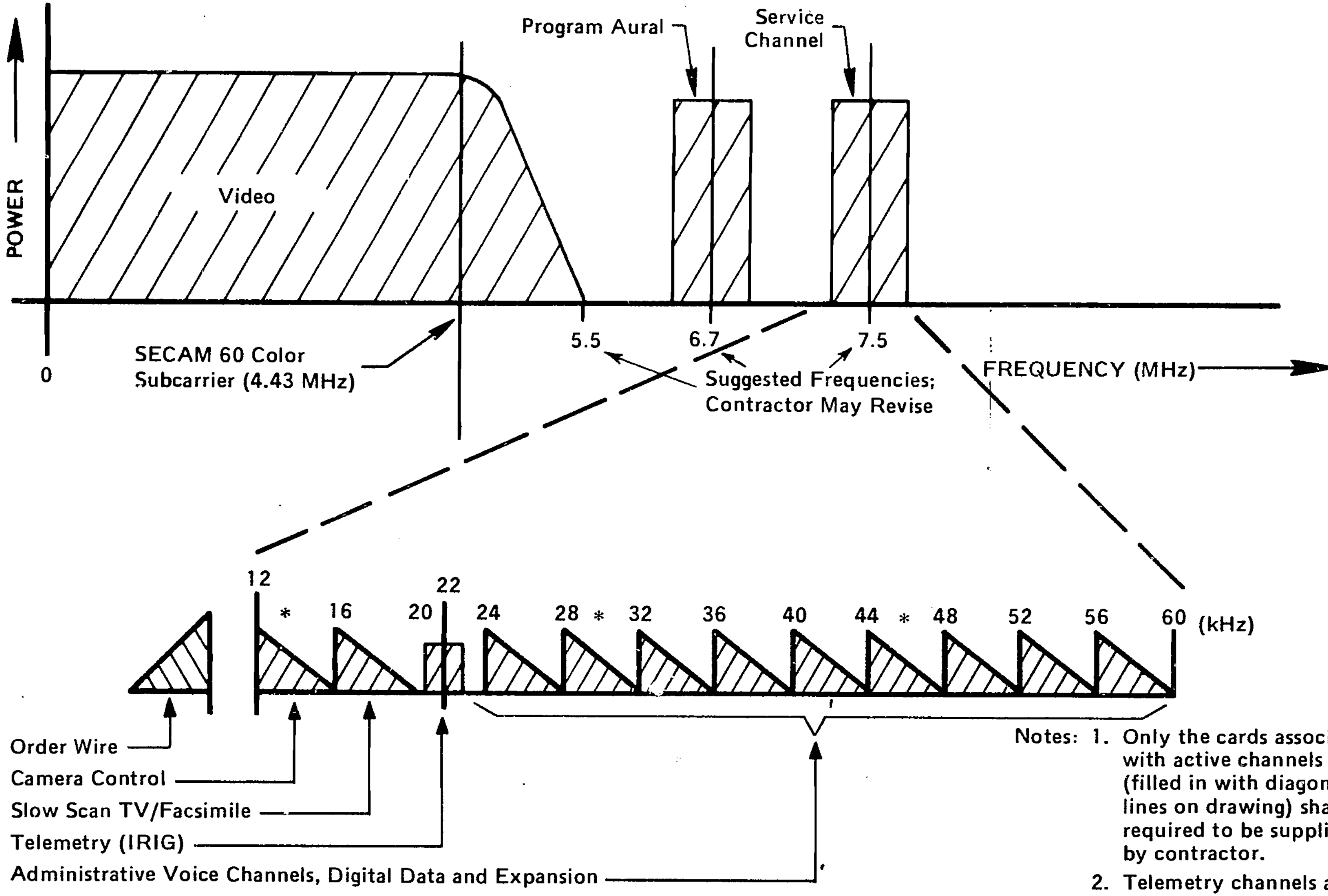
In an identical way, the Arizona TeleMedicine Network can interface with other land-based systems (such as other medical communication networks).

8.2 Utilization of the Microwave Baseband

The recommended plan for channelizing the microwave baseband is shown on Figure 8.2. This plan will not normally be filled at each site but, in a few cases, allows for upgrading of capacity to accommodate the load at some natural "hub" points in the system. Basically the channelization consists of a 5.5-MHz video channel, a 15-kHz program audio channel (subcarrier) and a voice order wire or service channel upon which a standard group of twelve 4-kHz "voice slots" has been multiplexed. A second group can be added as the need arises. In addition, the baseband will carry alarm signals[1] to indicate malfunctions on a central display panel.

Listed below are the channel requirements of a typical network terminal station. The baseband utilization plan (Figure 8.2) and this list will clarify the capability and flexibility of the system's resources. Each network site will be provided with additional modems, FSK transmitter/receivers, FM telemetry devices and the interface equipment to facilitate this plan.

[1]See Section 7.1.4.



Notes: 1. Only the cards associated with active channels (filled in with diagonal lines on drawing) shall be required to be supplied by contractor.

2. Telemetry channels are FM. Filter is to replace the multiplex card for the 20 to 24 kHz slot.

*Indicates channels with expected high noise level.

Figure 8.2. Spectrum Utilization Plan, Arizona TeleMedicine Network.

Description	Requirement	Approximate Bandpass
Administrative (coordination Voice channel	1 duplex	300 to 3,000 Hz (one voice slot)
Video channel – SECAM color (525 line/30 frames)	1 duplex	0 to 5.5 MHz
Program voice channel (associated with video	1 duplex	30 to 15,000 Hz (program subcarrier)
Teleprinter/keyboard (300 baud)	1 duplex (shares voice slot with	300 baud (FSK) (shares voice slot with others; up to total of six)
Telemetry (IRIG standard)	1 duplex	DC to 500 Hz (22 kHz center frequency FM)
Slow-scan television[1] (approximately one frame per two minute interval)	1 duplex	300 to 3,000 Hz (one voice slot)
Camera control tones	6 duplex	50 Hz each control function (share one voice slot)
Switching tones	Duplex touch-tones	Share administrative voice channel
Signaling tones	Duplex single frequency tones	Share administrative voice channel (or uses associated signal channel)

[1] Facsimile and or voice return may share the use of this channel. Local option.

8.3 Switching, Routing and Control

8.3.1 General Network Management Concepts

In selecting a switching plan for signal routing, control and network management, several factors must be taken into account. The switching plan should be compatible with the existing referral pattern; it should be reasonably simple from the operator's standpoint; and it should reflect in its technical design, the need and desire for local control. In specifying "local control," the intent is to avoid a network where all communication is solely under the control of a single centralized station or hub. The switching plan must, without compromising effectiveness, seek to minimize the total channel requirement of the system so as to minimize both the dollar expenditure and the use of the available radio spectrum.

8.3.2 Classification of Network Station Types

It is proposed that the relay and terminal sites of the Arizona TeleMedicine Network be classified into the following groups:

Class "a"	Field health stations
Class "b"	First level referral centers (peripheral hospitals)
Class "c"	Second level referral centers (major medical centers)
Class "R1"	Slave switching relays
Class "R2"	Repeater relays

By definition, class "a" stations would be the "front line" units with the least concentration of specialized skills. Examples of this classification would be the facility located in the Navajo Nation at Shonto and the facility on the Papago Reservation at Santa Rosa.

First level referral centers (class "b" stations) are those medical facilities that normally would be expected to provide backup support directly to the field health stations. As is currently the case with physical referrals, the first level referral centers would accept, via the telemedicine network, cases deemed beyond the scope of the field health stations to handle. Examples of these class "b" stations would be Kayenta and Sells.

Class "c" stations, as a group, would consist of all other terminal sites in the network. These sites are the major medical centers in the health service system to which are referred cases that cannot be effectively handled at either the field health stations or the first level referral centers. Examples here would be the medical centers at Phoenix and Tucson.

The slave switching relays, class "R1" stations, are radio relay stations that serve as intermediate stations for the transfer of signals between three or more stations of any type. Control of the route switching equipment at the slave switching relays will rest with the nearest associated class "b" or class "c" station.

Class "R2" stations, repeater relays are defined as those stations that provide full duplex interconnect facilities between two other stations of any type. No switching equipment is needed at class "R2" stations.

8.3.3 Terminal Sites

The terminal sites of the proposed Arizona TeleMedicine Network grouped according to station type classification are listed below. Refer to Figure 8.1 for their locations.

Class "a" Stations

Pisinimo	Rough Rock
Santa Rosa	Pinon
Bylas	Many Farms
Cibecue	Lukachukai
Leupp	Teec Nos Pos
Lower Greasewood	Low Mountain
Kaibito	Oraibi
Shonto	Second Mesa

Class "b" Stations

Sells	Keams Canyon
San Carlos	Kayenta
Whiteriver	Chinle
Tuba City (expanded)	

Class "c" Stations

Tucson[1]	Ft. Defiance
Phoenix	

8.3.4 Proposed Network Referral Pattern

Wherever possible and within the state lines of Arizona, the proposed network referral pattern closely parallels the existing clinical referral pattern. Listed below, arranged according to relative positions in the referral order are the terminal sites of the Arizona TeleMedicine Network. The normal case is such that class "a" stations (field health stations) first consult with class "b" stations and may be referred electronically to class "c" stations. Class "b" stations may consult directly with their respective class "c" stations. Class "c" stations (major medical centers) may also communicate directly with each other for the purpose of referral, coordination and consultation.

The proposed pattern of electronic referral is summarized below. Exceptions to the normal "a" to "b" to "c" pattern are noted with dashed lines.

Class "a" Stations Field Health Stations	Class "b" Stations Peripheral Hospitals	Class "c" Stations Major Medical Centers
Leupp Lower Greasewood	- - - - (See Note 1) - - - -	Ft. Defiance
Pinon Lucachukai Rough Rock Teec Nos Pos (See Note 4) Many Farms	Chinle	Ft. Defiance
Oraibi Second Mesa Low Mountain	Keams Canyon	Phoenix/Ft. Defiance (See Note 2)

[1] Provides monitor service to the IHS Health Program Systems Center (HPSC) located near San Xavier switching center.

Class "a" Stations Field Health Stations	Class "b" Stations Peripheral Hospitals	Class "c" Stations Major Medical Centers
Shonto	Kayenta	Tuba City
Kaibito — — — — — — — — — — — — — —	(See Note 1)	(See Note 5)
Bylas Cibecue Cedar Creek	San Carlos Whiteriver	Phoenix
Pisinimo Santa Rosa	Sells	Phoenix/Tucson (See Note 3)

Note 1: There are no intermediate (class "b") stations between Leupp, Lower Greasewood and Ft. Defiance; nor is there an intermediate (class "b") station between Kaibito and Tuba City. Referrals in these three cases are direct.

Note 2: Keams Canyon Hospital has as its normal referral class "c" station, the Phoenix Indian Health Service Hospital. Because of the changing patient referral pattern, it is possible for Keams Canyon to provide electronic referral to Ft. Defiance as well. Ft. Defiance may be regarded as the Keams Canyon optional class "c" referral station.

Note 3: Sells is a class "b" station normally associated with Phoenix, which is a class "c" station. The University of Arizona Medical Center is the optional class "c" station for Sells' referrals.

Note 4: Teec Nos Pos has electronic referral service capability to Chinle. Patient referrals may continue with Shiprock which is not proposed for network interconnect at this stage of the program.

Note 5: Tuba City is classified as an expanded class "b" station. Tuba City is third in the chain of electronic referral in its area but does not rank with Ft. Defiance in the scope of its network activity and control.

8.3.5 Levels of Communication

As has been pointed out, the terminal stations of the Arizona TeleMedicine Network will be provided with the following types of duplex communication services.

- Administrative voice channel (intercom)
- Color television
- Teleprinter (data) service
- Telemetry channel (physiological data)
- Slow-scan TV channel (facsimile)

8.3.6 Switched Channel Requirements

With the exceptions of the Administrative Voice Channel and the teleprinter (data) channel, which are both always available, all network traffic is switched. This switching process serves to route the various channels between network stations. To demonstrate the channel requirement involved, the video will be treated as an example.

Consideration of the total video channel requirement for tne network may start with the class "a" stations. These stations, representing the smallest institutional segment of the health care system, will each require one channel outgoing and one channel incoming in order to be interconnected with the associated class "b" station. Similarly, the class "b" stations will require transmission facilities for interconnection with their associated class "c" station. Clearly, interconnection with the class "a" stations must also be provided for.

If the desired referral pattern of "a" to "b" to "c" was the only consideration, then a "hub" configuration would be the natural arrangement for the Arizona TeleMedicine Network. An example of a network using the hub configuration is given as Figure 8.3. Unfortunately, other factors complicate the adoption of this configuration without modification. The prime factor affecting the network channelization plan stems from the desire to utilize existing facilities (towers, buildings, land, road, etc.) wherever possible in order to minimize the total dollar expenditure for the network.

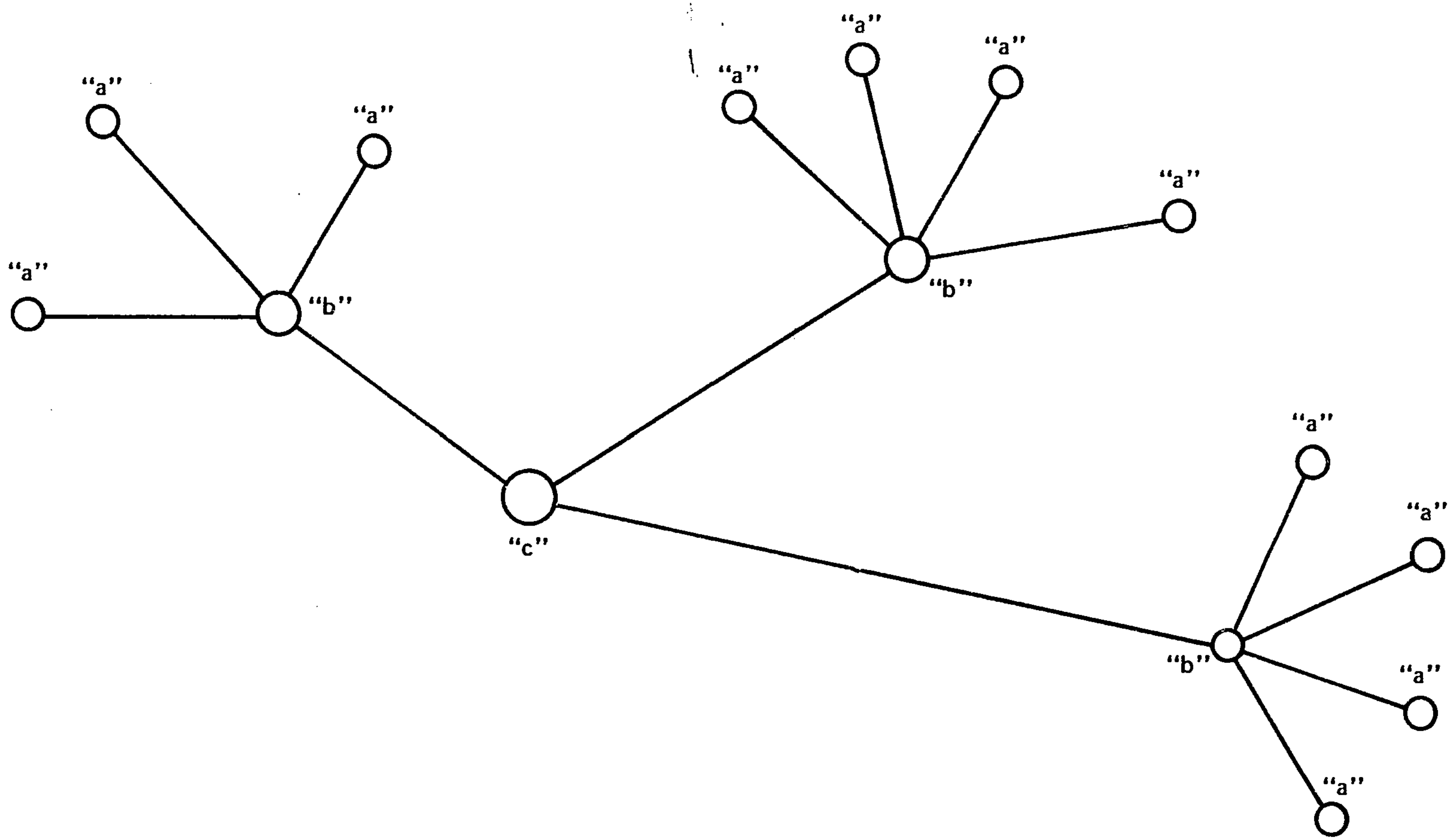


Figure 8.3. Idealized Network Using the Hub Configuration.

A second factor, the current crowding of the radio spectrum, indicates a need to minimize the total number of channels planned for the network. These factors argue for retreat from the traditional hub configuration. The relative positions of the medical facilities on each reservation, in some cases, suggest a channel sharing plan of attack. Although this approach would seem to compromise the effectiveness of the medical network, the projected traffic level from the class "a" stations would not appear to justify dedicated video channels for each site.

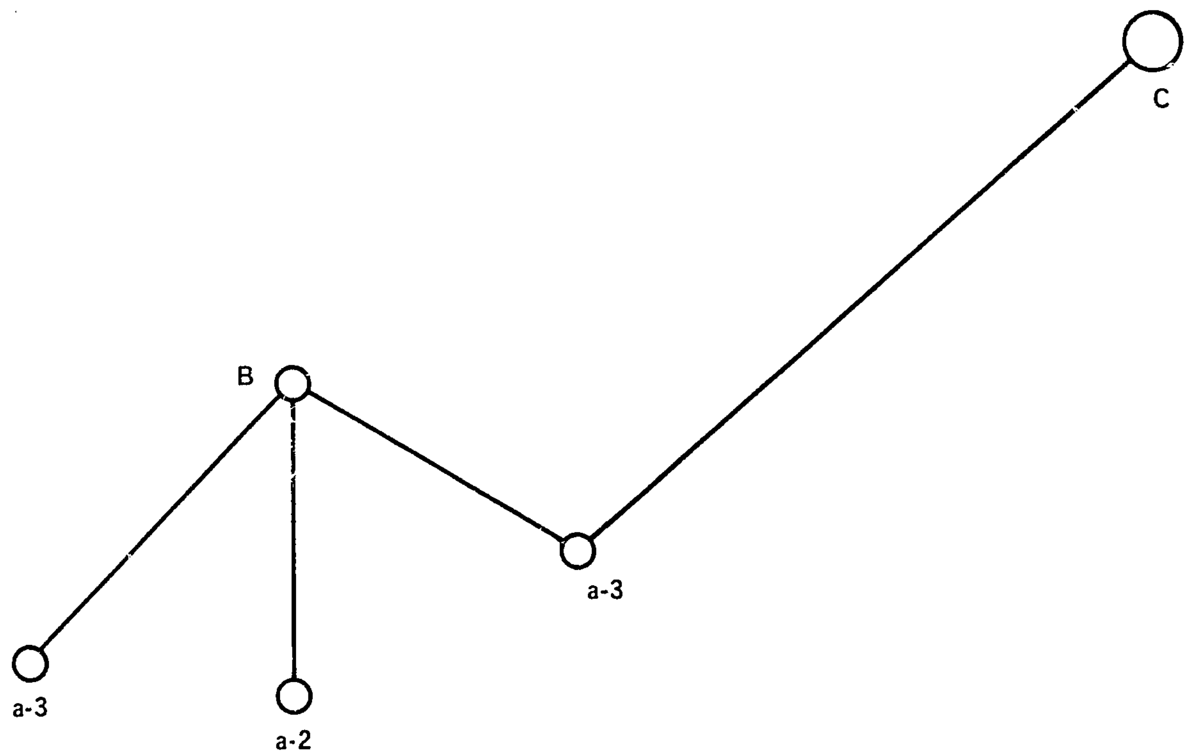
An illustration of the channel sharing plan proposed for the Arizona TeleMedicine Network is given as Figure 8.4.

8.3.7 Switching Control Centers

As already mentioned, control of the switching and routing of signals will rest with the class "b" and class "c" stations. Class "a" stations (field health stations) will have no direct control over the switching of any signals. Each class "a" station will have a voice circuit, which is always available, to its associated class "b" station. The class "a" station operator will be able to signal ("ring") its associated class "b" station. Likewise, the class "b" station can signal the class "a" stations under its command and its associated class "c" station.

The various switching points for the network are located at remote slave relay sites (class "R1" stations), at field health stations (class "a" stations) that happen to be on the route, and at the class "b" and class "c" stations themselves. Listed below are the network class "b" and class "c" stations along with the switching points under their control.

Station	Class	Switch Point	Class
Sells	"b"	Kitt Peak (partial)	"R1"
San Carlos	"b"	None, controlled by Phoenix	—
Whiteriver	"b"	Mormon Tank (partial)	"R1"
Keams Canyon	"b"	Relay near Second Mesa	"R1"
		Relay near Keams	"R1"
Kayenta	"b"	Relay near Kayenta	"R1"
		Shonto (by-pass)	"a"
Chinle	"b"	Relay near Rough Rock	"R1"
		Many Farms	"a"
		Chinle (local)	"c"



NOTE: Television communications between "B" and "C" will necessarily have to pass through "a-3". Voice communication, however, is always available and is not affected by this routing.

Figure 8.4. Typical Channel Sharing Hub Arrangement.

Station	Class	Switch Point	Class
Phoenix	"c"	Phoenix (local)	"c"
		Pinal Peak	"R1"
		Kitt Peak (partial)	"R1"
		Mormom Tank (partial)	"R1"
Tucson	"c"	Kitt Peak (partial)	"R1"
		San Xavier	"R1"
Ft. Defiance	"c"	Relay near Low Mountain	"R1"
		Relay near Ganado	"R1"
Phoenix/Ft. Defiance	"c"	Mt. Elden	"R1"
		Preston Mesa (partial)	"R1"
		Relay near Lower Greasewood	"R1"
		Leupp By-Pass	"a"
Tuba City	"b" (expanded)	Preston Mesa (partial)	"R1"

The designation "local" at some switch points indicates that the equipment for route switching is located at the same point as the control mechanism.

Certain switch points are marked "partial" to indicate that two or more stations have control of sections of the switcher located at that site. For example, Whiteriver controls the Mormom Tank switch only in regard to the routing of signals between Whiteriver and Cibecue or Cedar Creek. Phoenix controls the rest of the matrix.

Other switching relay stations that operate in a similar way are Preston Mesa and Kitt Peak.

8.3.8 Switching Levels, Class "a" Stations

From the standpoint of the field health stations the following services, abstracted from the previous list, will be available. Switching for appropriate routing, where required, is indicated.

- Administrative Voice Channel – Each class "a" station (field health station) will have a dedicated private line voice circuit to its associated class "b" station (peripheral hospital). Signaling (ringing) will be possible from either end by the use of pushbutton control of tones. This channel will be used by the field health stations to contact the peripheral hospitals for such purposes as to solicit information (voice consultation) and to set up other levels of communication links. Patch cords and connectors will be provided so that communications via the Administrative Voice Channel can be extended to existing VHF radio facilities.

- Video Channel – Should a class "a" station desire to consult with its associated class "b" station, this need would be communicated to the class "b" station by the class "a" station using the Administrative Voice Channel. Should the signal path be available at that time, the class "b" station will actuate the appropriate remote switches to set up a duplex link.

- Program Voice Channel – This channel of high quality sound is associated with the video channel. This high quality voice channel is switched concurrently with the video channel to automatically parallel the route of the video.

- Camera Control Tones – These control tones are to position the cameras from distant locations. For example, the camera at Santa Rosa field health station could be controlled by an operator (or a physician) located at Sells. Camera functions controlled would include tilt, pan, focus, zoom and iris. In all, six functions will be possible for simultaneous remote control. The sixth may be designated as monitor on/off or camera switching. These tones will be switched en masse (and concurrently with the video) to parallel that route.

- Slow-scan TV Channel – Should a class "a" station desire to exchange diagrams, charts, printed matter or any still frame picture, with its associated class "b" peripheral hospital, the Administrative Voice Channel will be used to arrange for it. Again, the class "b" station will remotely actuate the required switches. This service is switched independently of any other communication level.

- Teleprinter Channel (HIS Network) – This channel does not require switching since all stations will be provided with a dedicated communication channel to the computer. Other possibilities were investigated in arranging for the installation of this service (see Section 7.2.4).

- Telemetry Channel – Requests for routing of this channel will be made by the class "a" stations over the Administrative Voice Channels. Control of the actual switching will rest with the appropriate class "b" station and will be independent of other services.

8.3.9 Switching Levels, Class "b" Stations, Wideband System

Class "b" stations, the peripheral hospitals, will control all remote switching matrices as they apply to that station's class "a" clinics.

The relationship of the class "b" stations to their individual class "c" stations will be nearly identical to the relationship already outlined for class "a" stations to class "b" stations. Functionally, the major difference will be that class "b" stations have some switching control whereas class "a" stations do not.

Summarized below are the communications services and switching arrangements as viewed from the standpoint of a typical class "b" station.

- Administrative Voice Channels – This channel is in the case of each class "a" station, a dedicated line back to its associated class "b" station. Clearly each line terminal will be available for access at the class "b" station. Likewise, at the class "b" station, signaling tones can be applied to each line, individually, for the purpose of "ringing" each class "a" station. These same circuits will be used by the class "b" station to transmit the necessary touch-tone signals used for control of remote switches.

  An additional Administrative Voice Channel (or two in the cases where optional class "c" stations exist) will be used for direct communication with the associated class "c" station. Again, this dedicated circuit will be used for voice consultation and switching coordination in the routing of signals to the "c" level. Provision will be made for cross connecting the Administrative Voice Channel with the local telephone system in each building. A patch cord will also be provided for interconnection with existing VHF radio units as needed.

- Video Channel – The appropriate switching to route a desired class "a" station video signal to the associated class "b" station is done remotely. The class "b" station controls this switching through the use of touch-tone codes sent over an Administrative Voice Channel. Requests are received via the Administrative Voice Channel for the class "a" stations. Likewise the class "b" stations may request interaction with the class "c" (major medical center serving the area or arrange for class "a"/class "c" interaction over the Administrative Voice Channel).

- Program Voice Channel
- Camera Control Tones – Both of these services are switched concurrently with and parallel to the video, discussed above.
- Slow-scan TV Channel – Routing of these channels is independent of any other service, however, coordination and switching control is analogous to the video plan described above.
- Teleprinter Channel – Each class of network station will have a teleprinter unit and channel provided as part of its terminal equipment compliment.

  As has been pointed out earlier, all teleprinter circuits will have as their final destination, the IHS computer service at Tucson. A leased telephone line (or lines) will interconnect the microwave terminal at San Xavier with the computer facility.
- Telemetry Channel – Control and coordination of the telemetry channel is similar to that provided for video route switching. Switching of telemetry is, again, independent of all other services.

8.3.10 Switching Levels, Class "c" Stations

The class "c" stations are the sites having the greatest concentration of specialized skills in the Arizona TeleMedicine Network. Class "c" stations may communicate directly with other class "c" and their associated class "b" stations. Class "c" stations may communicate indirectly with all other class "b" and class "a" stations by requesting the appropriate route switching that may be needed but is not controlled by the class "c" station in question.

From the standpoint of a typical class "c" station (major medical center), the levels of service and switching availabilities are as follows:

- Administrative Voice Channel – Class "c" stations will have the capability of selecting one channel from the several dedicated voice circuits available at each site. These circuits provide for direct communication to each of the other class "c" stations in the network, to the class "b" stations associated with the class "c" in question, and those class "a" stations that report directly to the class "c" station. Telephone interconnect and VHF radio patching as discussed in Section 8.3.9 will be required at class "c" sites.

  The Administrative Voice Channels will carry the necessary switching tones generated by the class "c" station in conjunction with the control of those remote switching points under the station's jurisdiction.

- Video Channel

- Program Voice Channel

- Camera Control Tones – These three related services are, as in the arrangement for class "a" and class "b" stations, switched in tandem.

- Slow-scan TV Channel – This service is switched independently of all other services.

- Teleprinter Channel – This service is not switched and is always available to all classes of stations.

- Telemetry Channel – This channel is switched and controlled, but independently of any of the other services.

8.3.11 System Switching Concept

The key to the switching control plan is this: class "a" stations can control no route switching. Class "b" stations control switching for the class "a" stations in their referral pattern. Class "b" stations can request via the "hot line" that the next level (class "c" stations) take control for routing signals from the class "a" or class "b" station up to that next referral step.

"Hot line" or Administrative Voice Channels are only provided between the appropriate stations in the pattern. In the example, Santa Rosa can only call Sells. Sells can call Tucson, Phoenix, Santa Rosa or Pisinimo. Selection is by push button and the circuits may be conferenced. By limiting the "network" of the hot lines provided at each station, the chain of command for the referrals can be maintained.

Three independent levels of route switching are proposed. Television may be routed one way throughout the network at any given moment while, at the same time, telemetry may have a different routing and the slow-scan television or facsimile service may have a third and distinct routing.

8.4 Control Console Equipment

8.4.1 General

The control console for each terminal station in the Arizona TeleMedicine Network is indicated in each floor plan layout. This unit will serve as the operator's desk and will provide additional rack space for the modulating, demodulating and signaling equipment. Figure 8.5 is an artist's sketch of a typical control console as would be encountered at a class "b" station.

While each station will involve some "customizing" of this design, the basic features and panel configurations will not change. The following sections of this document will define the aspects of the console that are common to all sites and note the differences in panels and arrangements existing between each individual site.

8.4.2 Console Utilization

Listed below are the functions and panel space allocations associated with the control consoles. Those items which involve custom changes from site to site are indicated and noted where appropriate. For additional clarification of panel locations, refer to Figure 8.5.

- Twin 9-Inch Monochrome Monitors – Located top, center.
- Monitor Feed Select Push Buttons – Located top, center near monitors. These buttons select the feed for the twin 9-inch monitors and the associated room size monitors which parallel them.

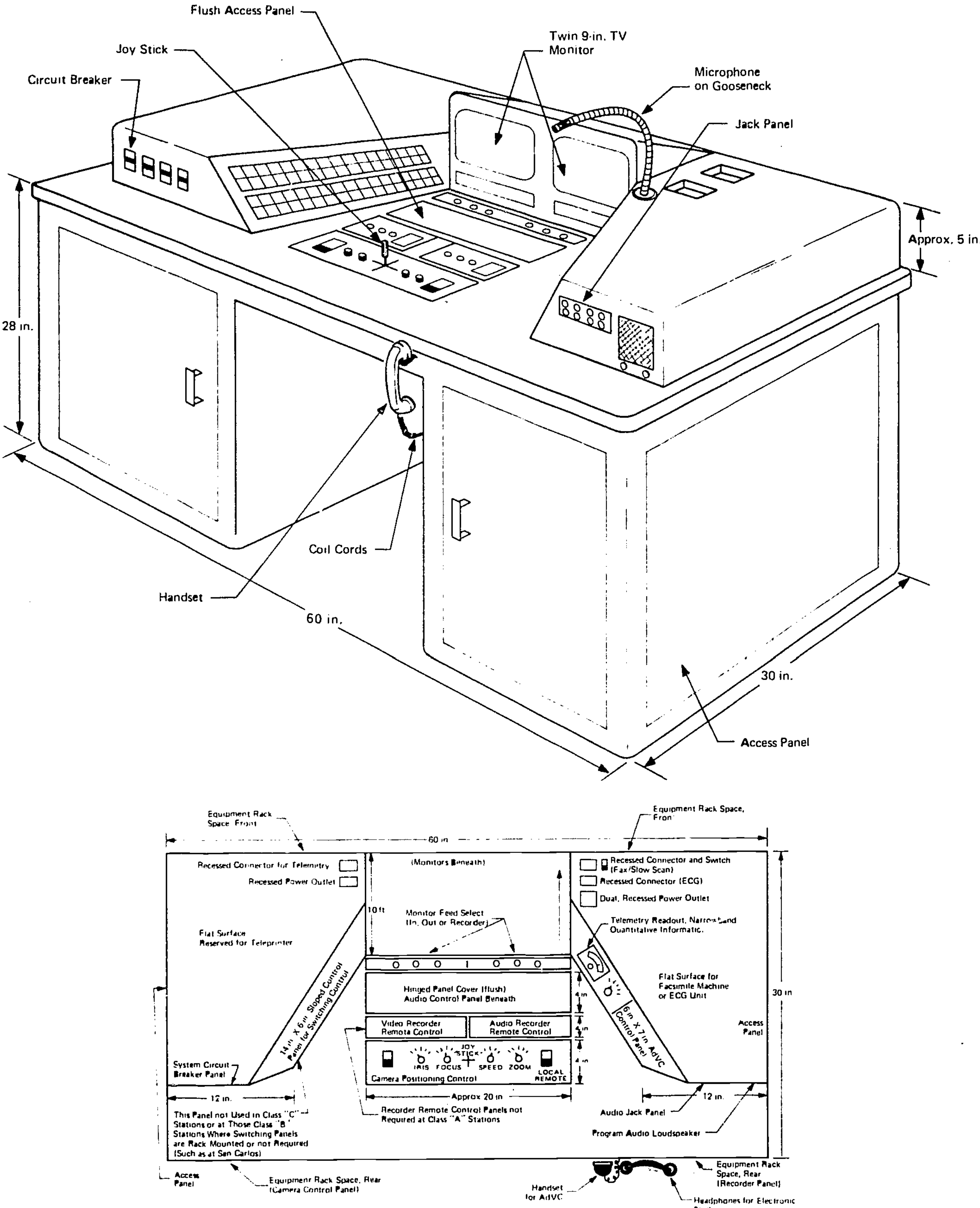


Figure 8.5. Typical Control Console.

- Audio Monitor Level Control and Speaker – Located on upper, right panel. This unit reproduces the program audio as it arrives with the desired incoming picture. Additionally, a switch will permit selection of outgoing programs or video tape sound. Placing the monitor output switch to "headset" will automatically defeat the loud speaker and allow the incoming program audio to feed the wireless headset transmitter. A jack will also be provided so that the electronic stethoscope head phone can be used in place o. the wireless headset for program audio private monitoring.

- Handset (Administrative Voice Channel) – Located on right side of desk top, connector in knee hole of desk. Extra long coil cord (15 feet) required.

- Audio Channel Select and Signaling Buttons, AdVC – Located on right side of the sloping control board, upper right panel. The precise configuration of the push buttons on this panel will vary depending on the site involved. In all cases the audio channel select and signaling positions will consist of a pair of 1- by 1-inch illuminated buttons. The top button in each position will flash (and a common audible will sound)[1] when a "ringing" signal is received via the associated Administrative Voice Channel (AdVC). The flashing light and tone will continue until this button is depressed and the handset is connected. The middle button will be used to signal the station associated with that particular AdVC. Signal tones are generated only as long as the button is depressed. At stations where more than one position appears on the AdVC panel (class "b" or "c" stations), the upper button may be depressed twice to achieve a "conference configuration" with all stations appearing on the panel. Disconnect is effected by depressing the button still a third time. The lowest button or row of buttons will be used to effect a cross connection to the local (in house) telephone system. A dial will be provided to place these calls beyond the console. An example of an AdVC control panel is presented as Figure 8.6.

- Recorder Remote Control Panels – Located top, center. These panels are not required for those consoles installed at class "a" stations. In each case, controls consist of "record," "play," "fast forward," "rewind," and "stop." Status lights for each panel should be provided to indicate "record on" and "record off."

[1]This alarm, an intermittant electronic tone and flashing light, will be paralleled for remote indications as needed at Phoenix, San Carlos, Sells and other sites where personnel may not be in the immediate vicinity of the control console.

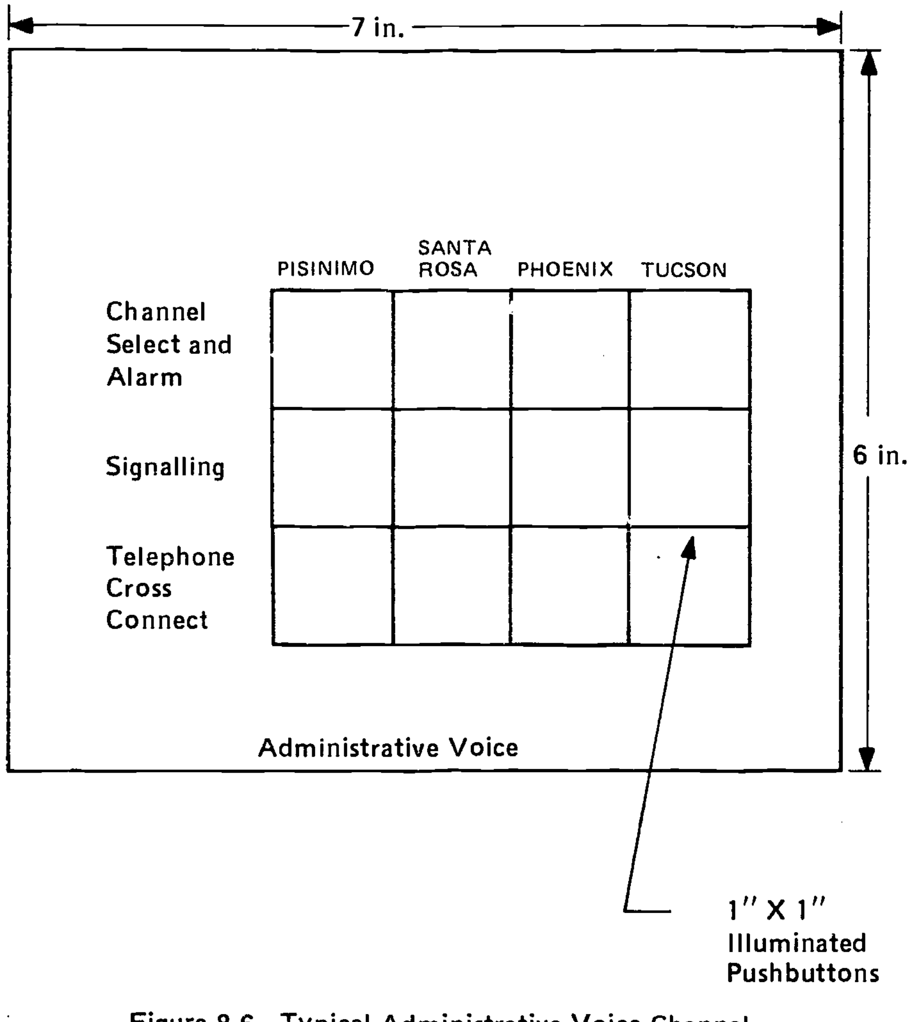


Figure 8.6. Typical Administrative Voice Channel Control Panel.

- Audio Mixer Panel – Located top, center of the console, beneath a hinged panel. This mixer shall provide a minimum of three simultaneous low level (microphone) inputs and one high level (video tape audio) input plus switched input capacity (high level) of an additional four channels (audio logger).

- Recorders (one 4-track audio and one single-track television recorder) – Located in lower, right rack at the rear of the console. Recorders are only to be installed at class "c" and class "b" stations.

- Telemetry Display – Located on the sloped panel, right, upper portion of the console. Only class "b" and class "c" stations will incorporate this unit which provides a real-time meter face readout for lung function tests or other telemetry information being received.

- Camera Joy Stick and Local/Remote Switch – Located top, center. In addition to the joy stick which controls tile and pan, switches are to be provided for zoom, focus, iris and mono/color. The mono/color switch will control bypass circuitry in the color camera (local or remote) such that a direct monochrome video feed may be shunted to the camera output. This bypass circuitry should involve only the "green gun" of the camera, prior to bandpass shaping, electronic filtering or matrixing. Resolution shall exceed 600 television lines when the bypass is activated.

  When the local/remote switch on the control panel is in the remote position, the panel controls will be disengaged from the local servo motors. These motors will then respond to control tones arriving via the microwave system. Simultaneously, the panel controls will be so connected as to produce tones on the outgoing microwave channel for control of a remote camera.

- Electronic Stethoscope Headset – This headset may be either used for its prime purpose or connected, via the patch panel, to the program channel for private listening. (See earlier discussion on audio monitor level control and speaker.)

- Microphone Connectors – located at the upper rear of the console knee hole in a recessed panel. In addition to the fixed console microphone there will be provided two lavalier microphones available for use at each site.

- Switching Panel – Located for most class "b" stations on the left-hand, sloping panel on top of the console. This panel, whether located on the console or adjacent to it, controls the local and remote switching for television, slow-scan TV, and telemetry. This panel is blank for class "a" stations. See Section 4.5.3 for additional discussion of this panel.

- Circuit Breakers – Located on the upper, left panel. These breakers, each of an appropriate value, will act as power switches to control various sections of the console apparatus. Individual breakers will be associated with the following: studio lights, monitors, camera, teleprinter, facsimile/slow-scan, and all other units in aggregate. A master breaker will also be supplied.

- Camera Control – Located at lower left of console. This unit is used for "technical set up of the camera."

- Rack Mounted Equipment – At class "b" and class "c" stations the front lower sections of the console are allocated to rack equipment. Class "a" stations utilize the rear, lower right area for rack equipment since recorders are not planned for these stations.

- Audio Jack Panel – Located on the upper right panel, adjacent to the program channel loud speaker. Input/output high level positions will be provided for: telemetry channels No. 1 and No. 2, program audio, electronic stethoscope and one spare or "aux." connector.

8.4.3 Console Cable Connections

The console should not be permanently positioned within each room. This requirement is to permit maintenance to be accomplished without the need to dismount many units for access to sections located interior to the console. For this reason, telemetry, slow-scan TV, power cables, coaxial cable cables and other signal wires are to connect to the console by way of flexible sections and multiple pin connectors.

8.4.4 Control Panel Arrangements

Each class "b" or class "c" station will have installed, as an integral part of its control panel, a group of illuminated push buttons which control the origin of the station's switching control tones. These tones will be generated by oscillator modules that produce the dual frequency notes commonly called "touch tones." Depending on which set of tones is generated over which Administrative Voice Channel, a particular cross point on a matrix located at a remote switching relay station will be energized. In some cases, such as the arrangement associated with Phoenix, the switching takes place locally and may not involve tone control. The push buttons in this case could control the matrix switch points through a direct connection.

Schematically, the control and switching process for Phoenix is presented as an example in Figure 8.7.

Further detail regarding the switching and control subsystem may be found in the document entitled "Arizona TeleMedicine Network – System Procurement Specifications, Phase I."

8.4.5 Station Identifiers Option

To facilitate later record searches of video taped material and to facilitate the real time identification of network stations, an abbreviated station name could be transmitted in each picture. This identity code (such as "FTDEF" for Ft. Defiance) could be electronically generated at each origination point using a device called an "alphanumeric character generator." It could be inserted in the lower left hand corner of the outgoing picture. Immediately adjacent to the ID code there could also be inserted a series of numerals indicating the day of the month, month of the year, last two digits of the year and the time of the day on a 24-hour basis. The full code would, perhaps, take the form shown in the example given below:

FTDEF 27 8 73 1330

The code is easily interpreted as identifying a picture originated by Ft. Defiance on the 27th day of August, 1973 at 1:30 p.m.

While the technical feasibility of providing this identifier is not to be questioned, its cost (about $3,000) is certainly to be regarded as too high for the value in improved efficiency received. A more practical approach is to make the proper labeling of tape cartons a standard procedure. This material could be kept, if required, in the patient's history file. The identification could be done on a verbal basis at the beginning of each tape segment.

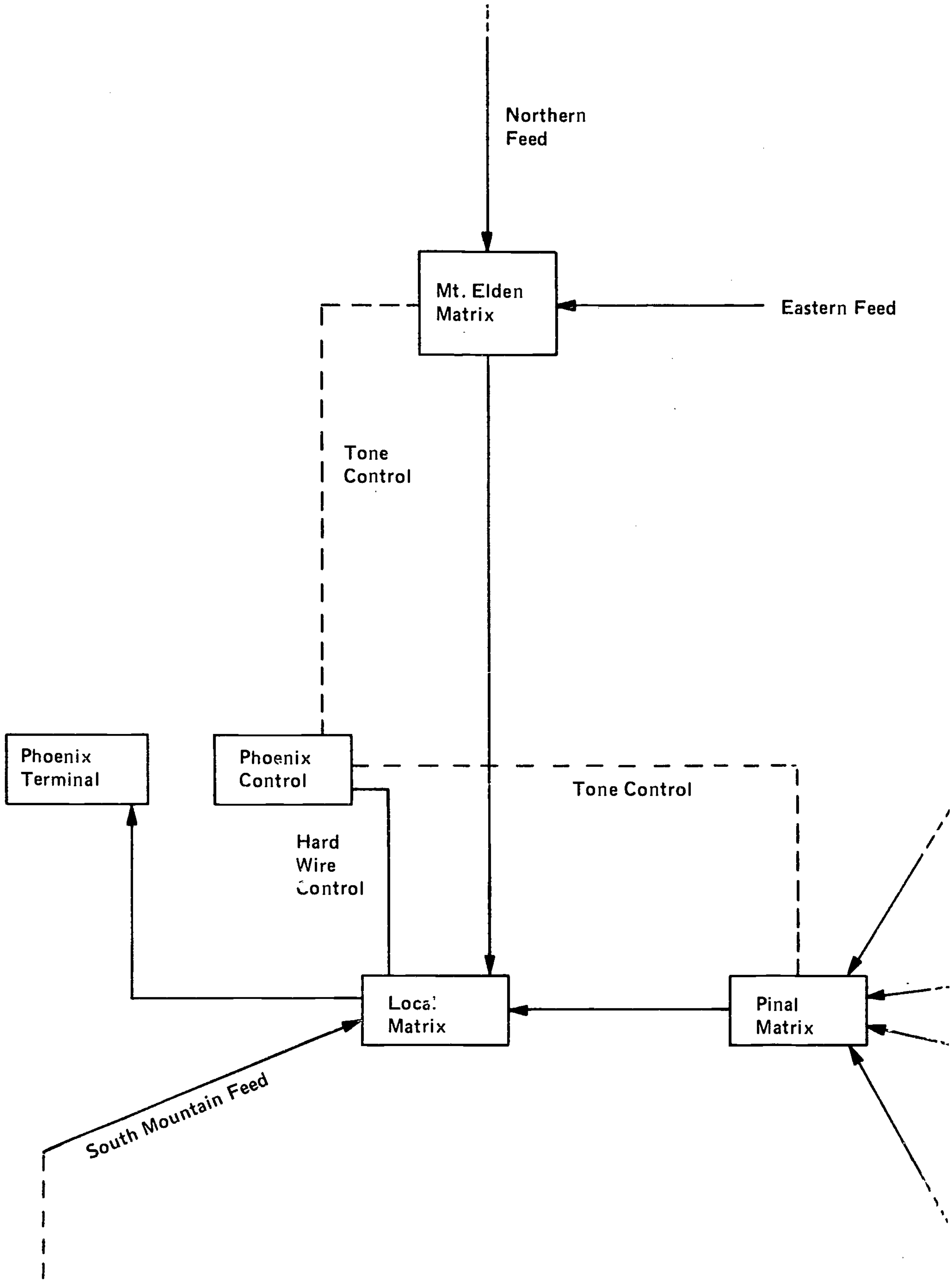


Figure 8.7. Partial Control and Switching Schematic, Phoenix.

8.5 Equipment Summary

8.5.1 Terminal Site Equipment

The following equipment will be provided at each network fixed terminal site. Amendments to this list are noted.

Control console

Color television camera

Color television monitor

Monochrome monitor, large screen

Teleprinter terminal

Slow-scan television device

Switching control panel (only at designated sites)

Facsimile unit (optional)

ECG machine and interface

Spirometer and interface

Electronic stethoscope and interface

Microwave radio equipment

8.5.2 Relay Site Equipment

The following equipment will be required at each relay site in the Arizona TeleMedicine Network. Quantities of these items, sizes and capacities will vary from site to site.

Microwave radio equipment

Route switching equipment[1]

Channelizing equipment[1]

8.3 Stand-by Power Systems

In addition to this basic list, some sites will have power supply or generating systems installed as part of the projected construction work. This requirement is described below.

Because commercial power is not available, the following sites require two electric generator sets and associated equipment:

Cimmaron
Mormon Tank
Ives Mesa
Piney Hill
Rock Point
Totacon
Kaibito Plateau
Rocky Ridge
Oraibi Repeater
Keams Canyon Repeater
Low Mountain Repeater
Balakai Mesa
Steamboat Canyon

The following sites require one electric generator set and associated equipment:

Pisinimo
Santa Rosa
Pinal Peak
Cactus (Shaw Butte)
Mingus
Mount Elden
Leupp
Dilkon
Fort Defiance Hill
Ganado Mesa
Cottonwood Junction
Many Farms
Yale Point
Black Mesa
Kayenta
Shonto

[1]Not required at class "R2" straight-through relays.

Klagetoh	Preston Mesa
Defiance Summit	Moenkopi Substation
Window Rock	

A single electric generator set will be used at each of the following sites:

a. Pisinimo mobile unit (carried on board, no load transfer panel required)

b. Pisinimo relay site

c. Pinal Peak (sufficient capacity to handle both the Network's equipment and the existing BIA equipment which consists of two VHF repeaters)

d. Santa Rosa (sufficient capacity to operate all Emergency Room facilities and lights as well as the Network equipment).

A storage battery supply system will be provided at San Xavier where commercial power outages do not normally exceed ten minutes in duration. The battery system provided will handle the equipment's power requirements for up to eight hours.

8.6 Mobile Unit

8.6.1 General

The concept of providing a complete mobile health care unit is certainly a valid extension of the aim of the major project. The objective of the Arizona Health Network is to alleviate the health care problems resulting from geographic separations. A mobile unit, fully equipped with primary health care clinical facilities as well as communications equipment would, in the right area, be an efficient alternative to several "fixed" health stations in meeting this objective.

In designing the mobile health care and communications unit and its supporting relay station, the basic goal was to provide as many of the health services as possible as would be found at any other field health station in the system. The mobile unit is shown on the system map as a class "a" station. However, the Pisinimo mobile unit design involves major modifications to the plans proposed for the usual fixed terminal to be incorporated as part of the Network. Nevertheless, the same basic "package" consisting of terminal equipment, control console, cameras, lights, monitors and microwave equipment will be provided. In addition, a set of microwave equipment will have to be provided at the fixed relay point in Pisinimo. Clearly a suitable tower, equipment shelter, and fence will also be required at the relay site. An on-board generator will be provided to supply electrical power to the unit whenever and wherever it stops. From any point within a 21 mile radius, it will be possible (line of sight permitting) for the mobile unit to establish contact with the relay site and to, thereby, enter the network on a full service, wideband basis.

The following diagram, Figure 8.8, shows the layout for a 25- by 8-foot self-propelled mobile unit. The various equipment and medical areas are noted on the diagram. As can be seen, many field health stations activities can be performed simultaneously with others. For example, a well baby examination could be conducted by one CHM while another is conducting a thorough physical examination in the general examination room.

8.6.2 General Examination Area

This room is equipped with a general examination table with stirrups and the telecommunication equipment console. General examination of surface features (rashes, infections) or orifices such as ears and mouth could be examined by positioning the TV camera on the overhead track in an appropriate viewing position. Direct communication with the consultant via the video and audio channel would help the CHM to make a diagnosis or give treatment. Various signals such as ECG, heart sounds and spirometric curves would be sent from this room to the consultant via the telecommunication console. X-rays can be viewed on the variable intensity light box by either the real time TV or by slow-scan TV for transmission to the consulting site.

8.6.3 Interview Area

In this area, the teleprinter rests on the control console which can access the Health Information System of the Indian Health Service. This unit can be conveniently used while the interview is conducted. The TV camera may be positioned to view the patient and/or the CHM while the interview is being conducted.

8.6.4 Laboratory Area

This area contains the necessary laboratory equipment for the analysis of urine specimens and limited blood analysis. Also cultures and tissue scrapings can be analyzed. This area can also be viewed by the TV camera.

In addition a small drop table on the outside wall allows for well baby examination and care. This may also be viewed by the TV camera.

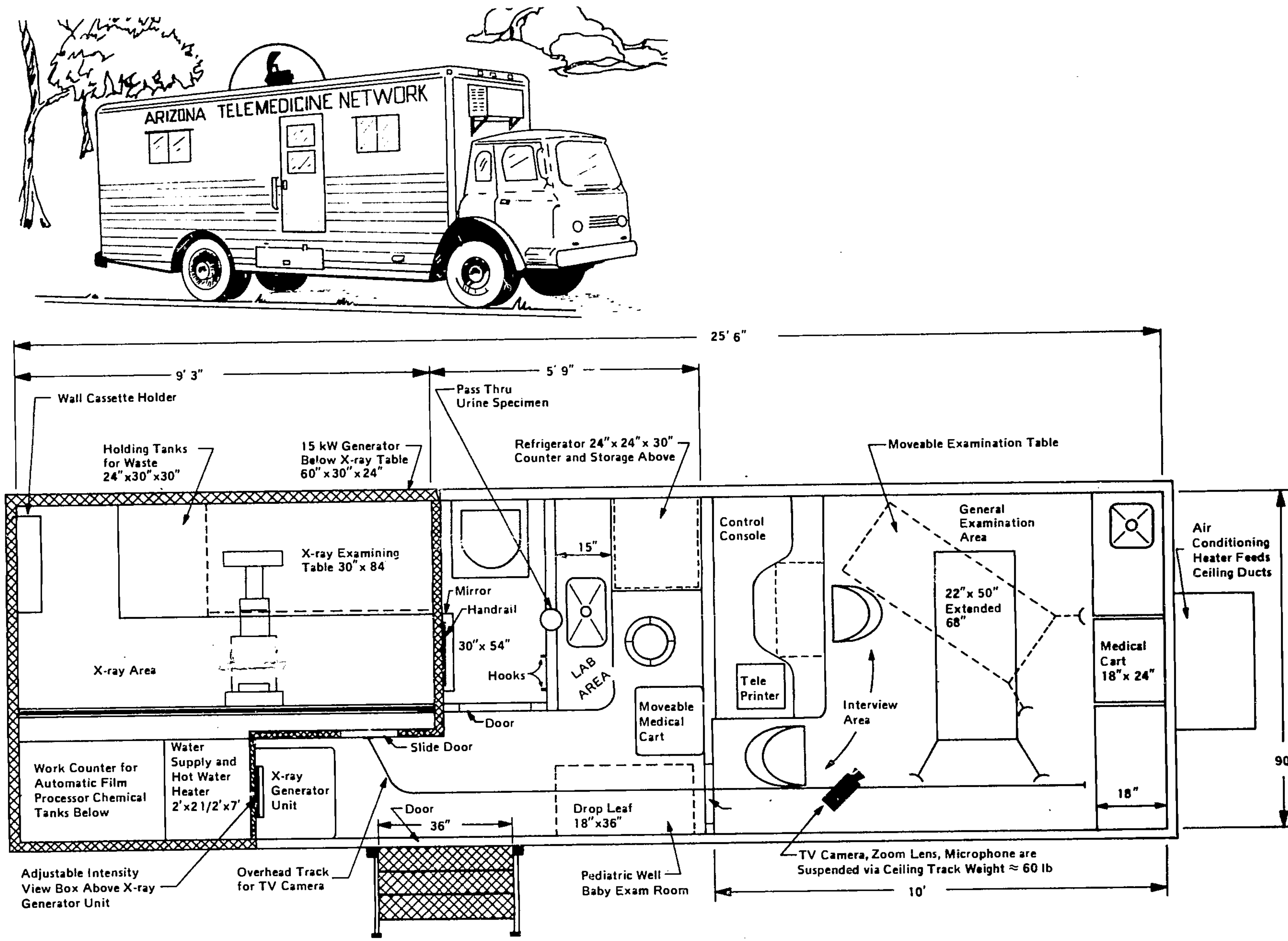


Figure 8.8. Truck and Floor Plan.

8.6.5 X-ray Area

This area contains X-ray equipment for chest and extremities X-rays. They may be developed immediately by the developing equipment and displayed on an adjustable intensity light box. This area may also be viewed by the TV camera.

8.6.6 Mobile Microwave Antenna Support

A "bubble top" radio-transparent dome will be provided as an integral part of the mobile unit. A band of optically transparent material about 10 inches wide will be provided in the construction of the dome. This band will permit a small self-contained monochrome television camera installed inside the dome to have an unobstructed view through a full 360 degrees of the horizon as seen from the position of the vehicle. This closed circuit camera will be permanently mounted to the support axis of the 2-foot microwave "dish" also contained in the dome. The dish and the camera will always point in the same direction and will be controlled, by mechanical linkage, from a handle located beneath a ceiling panel in the vehicle's main examination area. The camera will permit the vehicle's operator to position the antenna by aligning the image of the Pisinimo relay tower with the crosshairs as presented on the control console monitor.

8.6.7 Relay Antenna and Support

A parabolic (dish) antenna of a similar type and size to that contained in the vehicle's dome will be provided atop the Pisinimo relay tower. This 2-foot Pisinimo relay dish will, of course, have to be steerable in order to establish a radio path with the vehicle. Furthermore, since the Pisinimo relay station is to be unattended, this dish will require some method other than manual or local control in its positioning.

8.6.8 VHF Radio Link

It is proposed that a VHF radio transmit and receive link be provided between the mobile unit and the relay site to carry positioning control commands as issued by the vehicle operator. In addition to the carriage of positioning control tones, this link would serve as the method of initial communications for the Administrative Voice Channel. An operator in the vehicle at a remote site would automatically use the VHF (voice) link whenever the AdVC control panel was activated prior to microwave antenna alignment. After alignment had been accomplished, local and remote sensors would change the AdVC over to its usual "slot" in the microwave baseband. To summarize this point: whenever the microwave link is available, the traffic on the Administrative

Voice Channel to and from the mobile unit would automatically use that path. When the microwave link was sensed (at either end, below threshold) not to be operational, the VHF radio would be placed in operation. In either mode, the AdVC signals would be relayed by microwave from the Pisinimo relay back to Sells.

8.6.9 Relay Antenna Alignment

Whenever the microwave signal received threshold sensors indicate nonalignment of the microwave antenna(s), the received VHF demodulated signal at the relay site will be monitored by the antenna positioning device. Tones generated by the operator within the remote vehicle will be received by this device and used to change the altitude and azimuth of the relay site's steerable microwae antenna. Weather-proof electric drive motors and solenoid-operated brakes will direct and lock the antenna in any position within the operating range of the unit. The operating range will encompass 360 degrees of rotation (azimuth and between +1 and -15 degrees as referenced to the horizon (altitude). This will permit the vehicle to establish wideband contact with the relay (hence, the network) from any point within line-of-sight of the tower, but no closer than about 300 feet to the base of the tower.[1] The maximum unobstructed range of this system would be limited to between 10 and 20 miles, depending on prevailing weather conditions and accuracy of antenna alignment.

8.6.10 Mobile Unit Antenna Alignment

As pointed out, alignment of the mobile unit's own antenna will be accomplished manually with the assistance of the closed circuit television camera. Because of the generally clear weather conditions in Southern Arizona, this method should suffice and is, without doubt, much less expensive than any other positioning method except "dead reckoning." Dead reckoning would require that the mobile operator be provided with a prepared "local table of coordinates" which would tell him (or her) specific settings for altitude and azimuth for several likely sites in the service area of the vehicle. These coordinates could be displayed in quadrant form on an area map. Calibrated setting circles on the manual control for the vehicle's dome-mounted dish would allow this approach to be used. While it is recommended that the optical method be provided for in the mobile unit design, the dead reckoning method should also be available as a backup and for use in bad weather conditions. Furthermore, such data would be useful even in good weather when the

[1] For near-perfect alignment. The signal levels due to proximity will probably suffice at closer distances even though dish alignment is poor.

unit is operating at near its maximum range. In these cases, when the distant relay tower is difficult to discern, the dead reckoning method could be used for coarse adjustment (in effect to "find" the tower) and the CCTV camera image could then be used for "trim."

8.6.11 Positioning Tone Controls

The tone controls referred to previously would consist of "touch-tone" codes impressed upon the VHF voice channel (AdVC) transmitted from the mobile unit. Because of relatively wide beam of the small diameter antennas used, only a few azimuth and altitude positions need be made available for use by the mobile operator in initiating commands to the relay site's positioning apparatus. Assuming a usable beam width of 6 degrees, only 60 azimuth codes will provide sufficient alignment of the relay antenna in the horizontal plane. By restricting the altitude range to 15 degrees, seven codes will provide enough control in the vertical plane. A standard 12-digit touch-tone pad will be supplied in the mobile unit.

The mobile operator would be required to use a map similar to that described for dead reckoning of the mobile's manually positioned antenna. In this case, however, use of the map is not optional. A map such as proposed above is shown, with its appropriate overlay, as Figure 8.9. The numbers indicated in the sample sector of the overlay represent two digit codes to be keyed in upon the AdVC when it is in the VHF mode. The first two digits in each sector refer to the azimuth positioning command and the second two digits represent the altitude command. Assignments of the codes will probably be as suggested on the following tables.

Azimuth (referenced to north)

Code	Direction (degree)
1-1	0
1-2	6
1-3	12
.	.
.	.
.	.
1-0	54
2-1	60
2-2	66

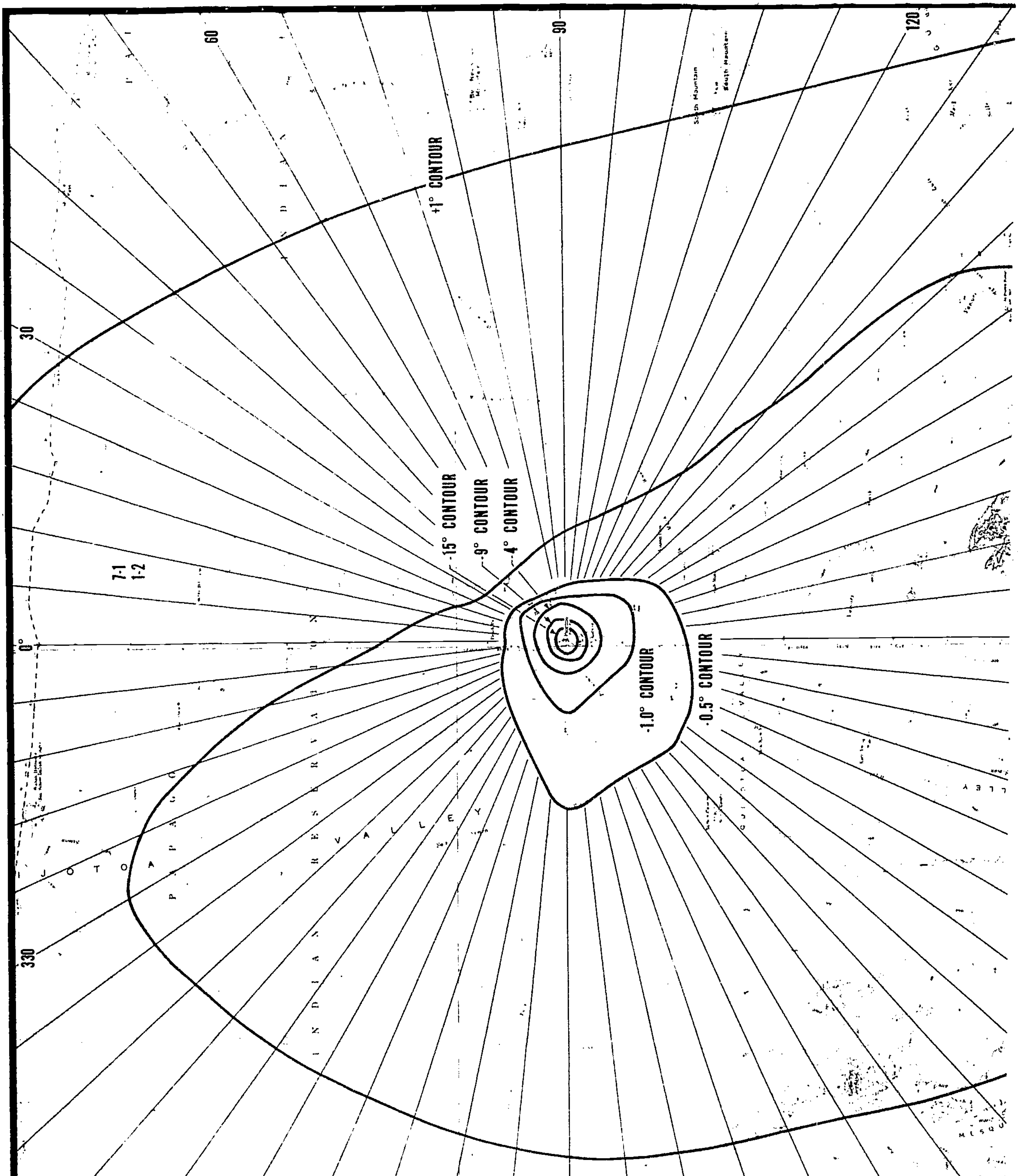


Figure 8.9. Position Guide Overlay, Pisimo Mobile Unit.

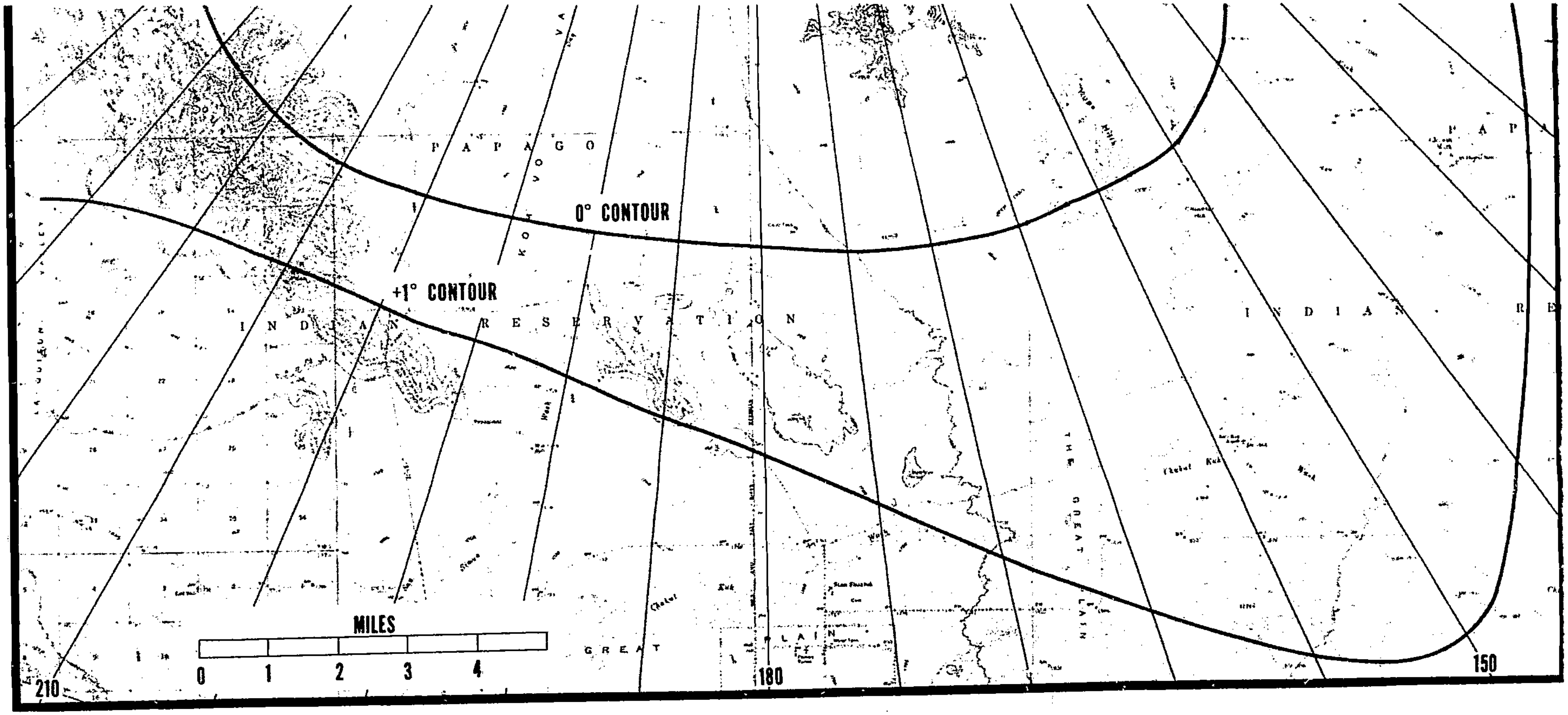


Figure 8.9. Position Guide Overlay, Pisinimo Mobile Unit.

Azimuth (reference to north) (continued)

Code	Direction (degree)
.	.
.	.
.	.
2-0	108
.	.
.	.
.	.
.	.
.	.
6-0	354

Altitude (referenced to horizon as 0 degree)

Code	Direction (degree)
7-1	-1
7-2	0
7-3	0.5
7-4	-1
7-5	-4
7-6	-9
7-7	-15

To further "peak" the alignment of the relay dish, the mobile operator, after using the proper codes (as indicated above) as selected from the map overlay, will press the # - # code(or other designated code). This code will command the relay site positioning apparatus to change over to the automatic or "maximize" mode. The apparatus will not accept this code unless its microwave receiver is being presented with a signal level of within 6 dB of a preset level which is programmed into the device based on the altitude code previously received. The altitude code is, of course, somewhat proportional to the path length and, hence, the predicted receive level.

In the automatic mode, the positioning apparatus will seek to maximize the receive signal (AGC) by "hunting." Each time the AGC voltage decreases, the antenna will reverse direction in the horizontal plane. After a reasonable period (30 seconds), the hunting will be disengaged and the control mechanism will go to rest mode to await further orders via the VHF system.

8.7 Confidentiality

The Arizona TeleMedicine Network has the responsibility to maintain the right of privileged communications.

The same general requirements that are applied to medical records or health service encounters within a hospital or a doctor's office must be applied within the Network. The usual level of privacy of communication between a physician and a patient will be maintained in the communication between the Community Health Medic and the patient and the consultants within the Network.

It can be seen, that for written material, the standard file keeping procedures for a medical office will control the written material at the network terminal sites. These sites are considered as medical offices. That is, only authorized personnel will be allowed access to the room and documents.

The video and audio tapes of encounters will be treated the same as written material and stored in the same secure manner.

The other aspect to be considered is access to the information via the microwave links. The microwave system is a point-to-point communication system and offers privacy and confidentiality similar to the public dial up telephone network. This network is considered to be private and confidential for professional consultations between physicians and other health professionals. It is very secure to the casual observer. Some effort is required to arrange for unauthorized reception of microwave signals. Costly microwave receivers must be placed within or very near the main beam of the line of sight path of the links and tuned to the precise frequency to receive signals.

The transmitters, receivers and radio equipment room must be either attended by authorized personnel or locked as per FCC regulation.

As was pointed out in the discussion on switching and control, the control of the system is limited and localized. That is, access to areas beyond the local area must go through local control points. This offers a limitation on unauthorized extended use of the system by any one station. The nature of the information is rarely of economic gain to unauthorized personnel and for this reason, the motivation to intercept these signals is not sufficient to cause concern.

Therefore, in consideration of the safeguards of secure terminal sites, the treatment of data in the same light as medical records, the high cost of unauthorized reception and the low economic appeal of the data to others, it is felt that the network offers the necessary confidentiality and privacy typical of an office examination without the need for expensive "scrambling" and other security type equipment.

8.8 Construction Schedule

8.8.1 General

While the magnitude of the project work may influence the time to complete construction, it may be assumed that this factor will not be significant. Parallel work crews can be assigned in both the engineering and construction phases of the implementation to essentially negate this influence. Therefore, whether the Arizona TeleMedicine Network is constructed as planned in total or whether only a segment (such as the Southern half) is implemented, the schedule discussed in this section will generally apply.

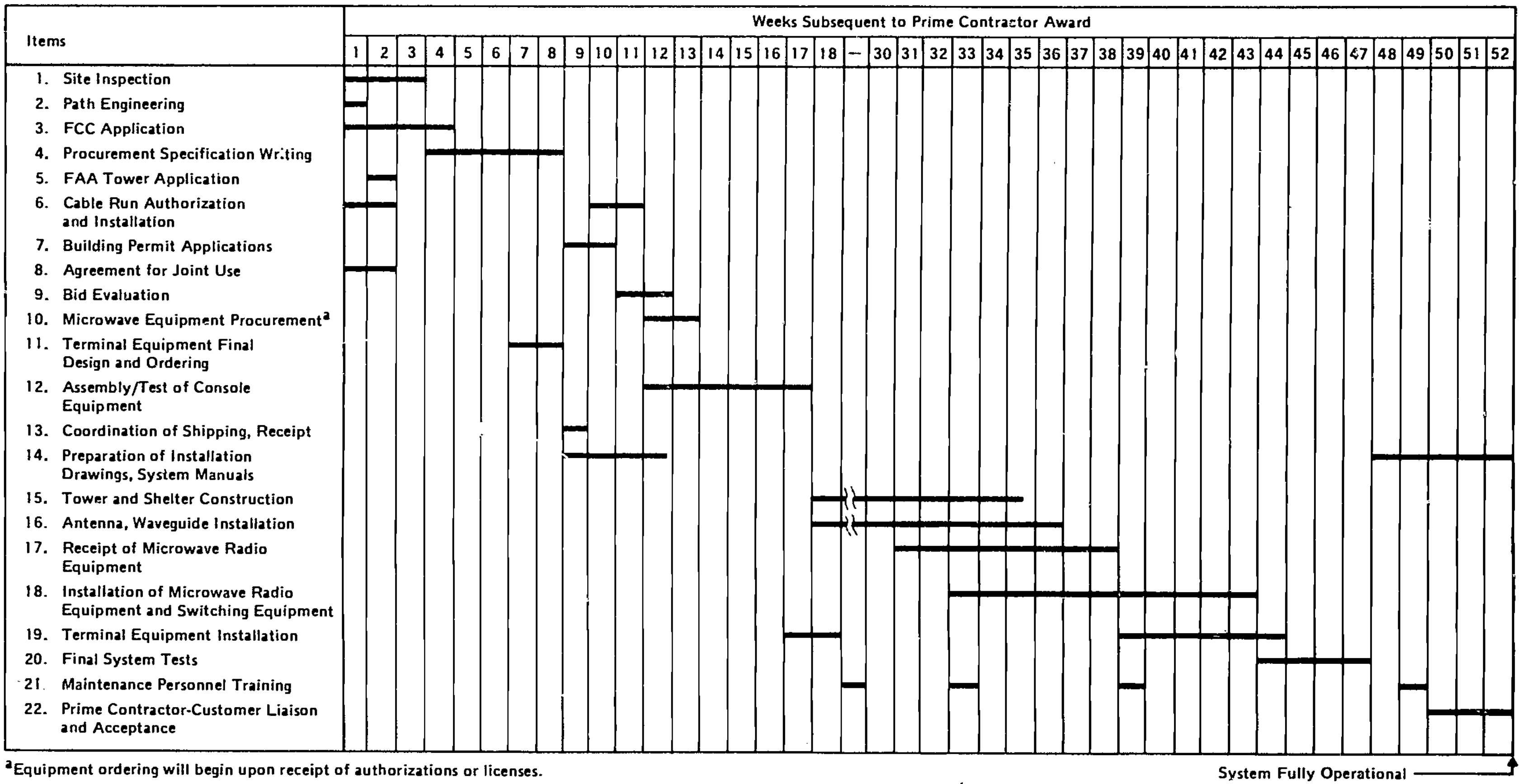
8.8.2 Project Construction Schedule

Table 8.2 shows a network construction schedule based on the following assumptions: the required funds for implementation of the project have been made available and prime contractor responsibility has been established. As can be seen, the complexity of schedule shows need for prime contractor responsibility.

It is recommended that FAA,[1] and FCC authorizations together with joint facilities use agreements be sought immediately after funding to avoid delay in equipment procurement and commencement of construction. Construction must necessarily be delayed until receipt of FAA and FCC authorization. Furthermore, it is wise to delay equipment procurement until these authorizations are received.

[1] May be required for certain antenna support structures at critical locations such as near airports and airways.

Table 8.2. Project Construction Schedule for the Arizona TeleMedicine Network.



[a]Equipment ordering will begin upon receipt of authorizations or licenses.

NOTE: Mobile unit to be constructed concurrently (schedule not shown).

Equipment specifications for procurement are vitally necessary to a project involving the interface of many types of equipment. They necessarily follow site inspection, and contain a good deal of the specific network design. It is recommended that all major items of equipment supplied by the Contractor be procured on a competitive bid basis.

Times for receipt of equipment shown in the chart are typical. The construction of the various subsystems of the network will proceed concurrently to minimize construction time. This approach is possible with good project management.

Maintenance and operating personnel training to be provided by the Contractor as part of the job scope and as reflected in the chart will be a mixture of on-the-job training during construction, and brief formal classroom training.

8.8.3 Factors Affecting the Construction Schedule

The following factors may affect the construction schedule.

Delays in reaching joint facilities use agreements may cause delay in final system planning and some of the equipment specification writing. This is not expected to present any major problem since preliminary agreements have already been established for the critical sites.

Delay in receipt of authorizations from regulatory agencies may cause delay in equipment procurement. The times allowed for receipt of the FAA and FCC authorizations are typical.

Inclement weather may delay tower construction and antenna mounting.

9.0 OPERATIONS AND MAINTENANCE

9.1 General

This section of the Arizona TeleMedicine Network planning document concerns itself with the technical operations facet of the network. The matters of clinical and administrative staff are not treated in this report.

9.2 Chief Technical Officer and Staff

The Chief Technical Officer (CTO) of the Arizona TeleMedicine Network would be directly responsible for the satisfactory operation of the network's physical plant. The CTO's other duties would include assisting the Network's Director or General Manager in developing costs to add new services or to expand the system. Also within his work scope would be the administration of contracts for performance tests, microwave servicing and new construction.

The Chief Technical Officer would supervise a staff of high level electronic technicians.

The salary of the CTO will be in the range from $18,000 to $22,000 per year.

9.3 Technical Staff and Maintenance Centers

The scattered nature of the facilities, distances between stations and expected work load indicates the need for a circulating technical crew. The members of this crew, each one competent in all the technical areas involved, would report to the Chief Technical Officer. All technicians and the CTO should have FCC First Class Commercial Licenses. Each technician should have at least five years of previous experience in similar work.

The repair technicians will be fully capable of dealing with all segments of the network, but will primarily be responsible for a particular geographic portion of the relay and terminal sites. Listed below are the maintenance centers, number of technicians assigned, and scope of responsibility for each maintenance group.

Table 9.1 lists the maintenance centers, number of technicians and geographic scope of responsibility.

page 8.50 is blank

Table 9.1. Maintenance Centers, Number of Technicians and Scope of Responsibility.

Maintenance Centers	No. of Technicians	Geographic Scope of Responsibility
University of Arizona Medical Center	2	Pisinimo
		Cimarron
		Santa Rosa
		Sells
		Kitt Peak
		San Xavier
		H.P.S.C.
		Tucson
		Mt. Lemmon
Phoenix Indian Health Service Hospital	2	Pinal Peak
		South Mountain
		Phoenix
		Shaw Butte
		Bylas
		San Carlos
		Mormon Tank
		Cibecue
		Whiteriver
		Cedar Creek
		Mingus
		Mt. Elden
Ft. Defiance	2	All other sites

Each Maintenance Center would be provided with the test equipment and spare equipment list in Tables 9.2 and 9.3 which follow. Also to be provided for the use of the technicians in their work will be a suitable maintenance vehicle. One vehicle will be supplied at each Maintenance Center.[1]

Salaries for the technicians will probably average about $12,000 per year.

Maintenance vehicles can be budgeted at $4,200 each. Upkeep will likely average about $100 per month per vehicle.

Table 9.2. Test Equipment Required at Each Maintenance Center.

2 ea. Triplett Type 630NA[2]	Multimeter
1 ea. Hewlett-Packard Type 414A	Auto-voltmeter
1 ea. Systron Donner Model 6057	Counter
1 ea. Hewlett-Packard Type 478A	Thermistor Mount
1 ea. Hewlett-Packard Type P932A	Mixer
1 ea. Hewlett-Packard Type 431B	Power Meter
1 ea. Hewlett-Packard Type 400EL AC VTVM and accessories	
1 ea. General Radio Type 1304B	Oscillator
1 ea. Telechrome 1004B	Video Receiver
1 ea. GE Type EX08A	Test Set
1 ea. Telechrome 350 B	Video Transmitter
1 ea. Hewlett-Packard Type 651	Video Oscillator
1 ea. Tektronix Type 453	TV Oscilloscope
1 ea. 12-Inch Trinitron Color Television Monitor (SECAM/NTSC)	
2 ea. 9-Inch Monochrome Television Monitors	
1 set, Test Cords, Connectors and Miscellaneous Adaptors and Tuning Tools	

[1] Because of possible seasonal difficulties in gaining access to some of the more remote sites, it is recommended that short-term lease or rental agreements be arranged for any necessary special vehicles. Weather and terrain conditions may require four-wheel drive vehicles to be used at certain times.

[2] Use of brand names is purely for descriptive purposes"or equivalent" is to be implied.

In addition to the above, four sets of hand tool kits will be provided to the Chief Technical Officer for distribution and assignment to his technical staff.

All test equipment will be treated as capital investment and represents about $20,000 per set.

Most of the investment in spare parts will be in replaceable modular units. These units, when defective, will be repaired and used again. They will, therefore, normally last for the life of the basic equipment, and will be treated as a capital investment. It is assumed that the spares inventory at each maintenance center will contain one replaceable module for each type used in the system. This is estimated to cost about $15,000 per set. Consumable spares, principally small components used in repair of modular units, should amount to about $25 per month for each terminal site and relay site in the Arizona TeleMedicine Network.

Table 9.3. Spare Equipment and Materials Required at Each Site.

1 each	Standby Monochrome Camera (self-contained)
1 each	Color Monitor (type as supplied at each site)
1 each	Monochrome Monitor, Large (type as supplied at each site)
1 each	Twin Small Monochrome Monitors (type as supplied in each console)
1 each	Audio Logging Recorder (type as supplied in each console)
1 each	Video Logging Recorder (type as supplied in each console)
2 each	Video DA Modules (type as supplied in each console)
2 each	Video DA Power Supply (type as supplied in each console)
1 each	Audio Mixer and Limiter (type as supplied in each console)
1 set	Modules for Multiplex Equipment (12 channels)
1 set	Common Equipment Modules, Panels and Circuit Boards (not channel dependent) for Microwave Radio Equipment for Both 6 GHz and 12 GHz units
4 each	Video Switcher Modules
4 each	Audio Switcher Modules
1 set	Telemetry Equipment Modules

9.4 Other Operational Considerations

Leased telephone lines will be required between the San Xavier microwave relay site and the Bell Aerospace computer about 1½ miles distant. This computer center provides service for the Health Information System and, as such, must be tied into the Arizona TeleMedicine Network.

Several different local tariff rates apply to dedicated circuits in the Tucson exchange area. The following is a list of those grades of lines which may be of use to the network for this landline link.

Service Type	Monthly Cost	Installation
5 kHz Broadcast Line	\$18.00	\$30.00
C-2 Conditioned Voice	\$21.25	\$80.00
Voice Pair	\$ 6.25	\$30.00

Because of the extremely high cost of the other options, the voice pair at \$6.25 should be selected even though 50 percent more lines will be required for a given number of FSK channels than would be the case for either of the other services.

It is projected that by using 4-wire to 2-wire hybrid couplers, the total number of lines required to serve the network can be held to eight. The total monthly cost will run about \$50 for this leased facility. Installation charges will be \$240.

10.0 BUDGETARY COST INFORMATION

10.1 General

Presented in this section are budgetary estimates for the capital and operating cost requirements of the Arizona TeleMedicine Network. Sufficient capital cost detail is included on the following data sheets so that portions of the network may be costed individually and with reasonable accuracy.

10.2 Microwave Radio System Budgetary Cost Data

Included on the following data sheets are the costs for the microwave transmission system proposed for the Arizona TeleMedicine Network. The costs are itemized for towers, radomes, equipment shelters and all other associated hardware groups.

page 9.6 is blank.

Capital Cost Data Sheet

Material and Subcontract Labor	TUCSON		To San Xavier		SAN XAVIER		To Tucson		To Kitt Peak		To Mt. Lemmon	
	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost
Microwave Radio Equipment												
Transmitters, 6 GHz									2	$7430	2	$7430
Receivers, 6 GHz									2	720ᴗ	2	7200
Transmitters, 12 GHz			2	$8400								
Receivers, 12 GHz			2	8300								
Branching				1200						1200		1200
Power supply, 115 V			1	250					1	25^	1	250
Charger/regulator, 48 V dc			1	910					1	910	1	910
Battery, 48 V			1	750							1	750
Equipment racks	1	$ 125			2	250						
Fault alarm insert transmitter					1	1000						
Local alarm display panel	1	100				100						
Master fault alarm display panel	1	3000										
Factory wiring				170						170		170
Shipping and handling		162		675		70				600		675
Installation and test		1000		2000		500				2000		2000
Antennas, Reflectors and Waveguides												
4 ft diameter antenna, 12 GHz			2	1106								
6 ft diameter antenna, 6 GHz											2	1416
8 ft diameter antenna, 6 GHz									2	2610		
Waveguide, 12 GHz			116′	452								
Waveguide, 6 GHz									118′	567	121′	581
Waveguide connector, 6 GHz									4	180	4	180
Waveguide connector, 12 GHz			4	264			See TUCSON to San Xavier					
Pressure window, 6 GHz									2	32	2	32
Pressure window, 12 GHz			2	32								
Waveguide grounding kit			4	20					4	20	4	20
Wall feed-through, 6 GHz									2	58	2	58
Wall feed-through, 12 GHz			2	66								
Waveguide hanger and adapter kit			4	158					4	158	4	158
Nitrogen tanks and fittings	1	150			1	150						
Gas distribution manifold					1	67						
Shipping and handling		8		400		11				600		600

Page #10-2 is blank.

Capital Cost Data Sheet
(continued)

Supporting Structures and Installation											
8 ft roof-mounted tripod	1	175									
Tripod footing		1000									
40 ft self supporting three-legged tower					1	2000					
Tower footing						600					
Installation of tripod/tower, antennas and waveguide		700				3200					
Soil suitability consultation						750					
Shipping and handling		9				300					
Equipment Housing, Power Line and Fence											
Shelter					1	1960					
Fence					1	300					
Power connection						30					
Installation						400					
Shipping and handling					1	515					
Miscellaneous Services											
Frequency selection and FCC application preparation				500					500		500
Specification writing and procurement				2000					2000		2000
Installation supervision and documentation				2000					2000		2000
TOTAL		6429.00		29,653.00		12,203.00			28,485.00		28,130.00
25% G&E		1607.25		7,413.25		3,050.75			7.121.25		7,032.50
		8036.25		37,066.25		15,253.75			35,606.25		35,162.50

Total, Materials and Labor	104,900.00
Contractor's G&A and Fee (25%)	26,225.00
Grand Total	131,125.00

Capital Cost Data Sheet

Material and Subcontract Labor	KITT PEAK		To Sells		To Pisinimo		To Santa Rosa		To San Xavier		To Cimmaron		SELLS		To Kitt Peak	
	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost
Microwave Radio Equipment																
Transmitters, 6 GHz			2	$7430	2	$7430	2	$7430			2	$7430				
Receivers, 6 GHz			2	7200	2	7200	2	7200			2	7200				
Branching				1200		1200		1200				1200				
Power supply, 115 V ac			2	500	2	500	2	500			2	500				
Equipment racks	3	$ 375											1	125		
Fault alarm insert transmitter	1	1000														
Local alarm display panel	1	100											1	100		
Factory wiring				170		170		170				170				
Shipping and handling		74		600		600		600				600		12		
Installation and test		500		2000		2000		2000				2000		100		
Antennas, Reflectors and Waveguides									See SAN XAVIER to Kitt Peak						See KITT PEAK to Sells	
4 ft diameter antenna, 6 GHz			1	536												
6 ft diameter antenna, 6 GHz			1	708												
8 ft diameter antenna, 6 GHz					2	2610										
10 ft diameter antenna, 6 GHz											2	3910				
12 ft diameter antenna, 6 GHz							2	7850								
24 X 30 ft reflector							1	7490								
Waveguide, 6 GHz			93′	448	141′	678	90′	433			103′	495				
Waveguide connector, 6 GHz			4	180	4	180	4	180			4	180				
Pressure window, 6 GHz			2	32	2	32	2	32			2	32				
Waveguide grounding kit			4	20	4	20	4	20			4	20				
Wall feed-through, 6 GHz			2	58	2	58	2	58			2	58				
Waveguide hanger and adapter kit			3	119	5	197	3	119			4	158				
Nitrogen tanks and fittings	1	150											1	150		
Gas distribution manifold		91														
Shipping and handling		13		600		600		4860				1000				
Supporting Structures and Installation																
40 ft self-supporting four-legged tower	1	2350														
20 ft self-supporting three-legged tower													1	625		
Tower footing		600												600		
Installation of tower, antennas and waveguides		4350												1025		
		[illegible]												[illegible]		

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Capital Cost Data Sheet
(continued)

Soil suitability consultation		750						750	
Shipping and handling		300						300	
Equipment Housing Power Line and Fence									
Shelter	1	1960							
Power connection		1000							
Installation		400							
Shipping and handling		500							
Miscellaneous Services									
Frequency selection and FCC application preparation			500	500	500		500		
Specification writing and procurement			2000	2000	2000		2000		
Installation supervision and documentation			2000	2000	2000		2000		
TOTAL		14,513.00	26,301.00	27,975.00	44,642.00		29,453.00	3,787.00	
25% G&A		3,628.25	6,575.25	6,993.75	11,160.50		7,363.25	946.75	

Total, Materials and Labor	146,671.00
Contractor's G&A and Fee (25%)	36,667.75
Grand Total	183,338.75

Capital Cost Data Sheet

Material and Subcontract Labor	SANTA ROSA		To Kitt Peak		PISINIMO		To Kitt Peak		CIMMARON		To Kitt Peak		To South Mtn.	
	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost
Microwave Radio Equipment														
Transmitters, 6 GHz													2	$7430
Receivers, 6 GHz													2	7200
Branching														1200
Power supply, 115 V ac													1	250
Equipment racks	1	$125			1	$125			1	$ 250				
Charger/regulator, 48 V dc													1	910
Battery, 48 V dc													1	750
Fault alarm insert transmitter	1	1000							1	1000				
Local alarm display panel	1	100			1	100			1	100				
Factory wiring														170
Shipping and handling		62				12				68				675
Installation and test		500				100				500				2000
Antennas and Waveguides														
10 ft diameter antennas, 6 GHz			See KITT PEAK to Santa Rosa				See KITT PEAK to.Pisinimo				See KITT PEAK to Cimmaron		2	3910
Waveguide, 6 GHz													134′	643
Waveguide connectors, 6 GHz													4	180
Pressure windows, 6 GHz													2	32
Waveguide grounding kits													4	20
Wall feed-through, 6 GHz													2	58
Waveguide hanger and adapter kit													5	197
Nitrogen tanks and fittings	1	150			1	150			1	150				
Gas distribution manifold									1	55				
Shipping and handling		8				8				11				1000
Supporting Structures and Installation														
20 ft self-supporting three-legged tower	1	640												
25 ft self-supporting three-legged tower									1	1050				
60 ft self-supporting three-legged tower					1	2900								
Reflector footing		600												
Tower footing		600				600				600				
Installation of towers, reflectors, antennas and waveguides		7045				3300				1450				

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Capital Cost Data Sheet
(continued)

Soil suitability consultation		750			750			750			
Shipping and handling		300			500			300			
Power Generators											
Motor-generator	1	1100		1	1100		2	2200			
Prime-emergency power switch	1	900		1	900		2	1800			
Installation		250			250			500			
Shipping and handling		300			300			600			
Equipment Housing, Power Line and Fence											
Shelter				1	1960		1	1960			
Fence				1	300		1	300			
Power connection					30						
Installation					400			400			
Shipping and handling					515			515			
Extraordinary Transportation Charges											
Three-day truck service with driver and two helpers					700						
Helicopter service								20,000			
Miscellaneous Services											
Frequency selection and FCC application preparation											500
Specification writing and procurement											2000
Installation supervision and documentation											2000
TOTAL		14,430.00			15,000.00			34,559.00			31,125.00
25% G&A		3,607.50			3,750.00			8,639.75			7,781.25
		18,037.50			18,750.00			43,198.75			38,906.25

Total, Materials and Labor	95,114.00
Contractor's G&A and Fee (25%)	23,778.50
Grand Total	118,892.50

Capital Cost Data Sheet

Material and Subcontract Labor	MT LEMMON		To San Xavier		To Pinal Peak		PINAL PEAK		To Mt. Lemmon		To San Carlos		To Bylas		To Phoenix	
	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost
Microwave Radio Equipment																
Transmitter, 6 GHz					2	$743'					2	$7430	2	$7430	2	$7430
Receivers, 6 GHz					2	7200					2	7200	2	7200	2	7200
Branching						1200						1200		1200		1200
Power supply, 115 V ac					2	500					2	250	2	250	2	250
Equipment racks	1	$ 125					3	$ 375								
Fault alarm insert transmitter	1	1000					1	1000								
Local fault alarm display panel	1	100					1	100								
Factory wiring						170						170		170		170
Shipping and handling		62				600		74				600		600		600
Installation and test		500				2000		500				2000		2000		2000
Antennas and Waveguides			See SAN XAVIER to Mt. Lemmon						See MT. LEMMON to Pinal Peak							
6 ft diameter antennas, 6 GHz											2	1416				
10 ft diameter antennas, 6 GHz					2	3910							2	3910	1	1955
12 ft diameter antennas, 6 GHz															1	1955
Reflector, 30 ft X 32 ft													1	11,220		
Waveguide, 6 GHz					113'	543					74'	356	93'	447	93'	447
Waveguide connectors, 6 GHz					4	180					4	180	4	180	4	180
Pressure windows, 6 GHz					2	32					2	32	2	32	2	32
Waveguide grounding kit					4	20					4	20	4	20	4	20
Wall feed-through, 6 GHz					2	58					2	58	2	58	2	58
Waveguide hanger and adapter kit					4	158					3	119	3	119	3	119
Nitrogen tanks and fittings	1	150					1	150								
Gas distribution manifold		55						91								
Shipping and handling		11				1000		13				600		5100		1400
Supporting Structures and Installation																
40 ft self-supporting four-legged tower							1	2450								
30 ft self-supporting three-legged tower	1	900														
Tower footing		600						600								
Installation of towers, antennas and waveguide		1700						4050								
Soil suitability consultation		750						750								
Shipping and handling		300						300								

Capital Cost Data Sheet
(continued)

Shipping and handling														
Power Generators														
Motor-generator						1	1100							
Prime-emergency power switch						1	900							
Installation							250							
Shipping and handling							300							
Extraordinary Transportation Charges														
Three-day truck drive with driver and two helpers							700							
Miscellaneous Services														
Frequency selection and FCC application preparation					500					500		500		500
Specification writing and procurement					2000					2000		2000		2000
Installation supervision and documentation					2000					2000		2000		2000
TOTAL		6,253.00	29,501.00		29,501.00		13,703.00			26,131.00		44,436.00		31,486.00
25% G&A		1,563.25			7,375.25		3,425.75			6,532.75		11,109.00		7,871.50
		7,816.25			36,876.25		17,128.75			32,663.75		55,545.00		39,357.50

Total, Materials and Labor	151,510.00
Contractor's G&A and Fee (25%)	37,877.50
Grand Total	189,387.50

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Capital Cost Data Sheet

Material and Subcontract Labor	SAN CARLOS		To Pinal Peak		BYLAS		To Pinal Peak		PHOENIX		To Pinal Peak		To South Mtn.	
	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost
Microwave Radio Equipment														
Transmitters, 12 GHz													2	$8400
Receivers, 12 GHz													2	8300
Branching														1200
Power supply, 115 V ac													1	250
Equipment racks	1	$ 125			1	$ 125			2	$ 250				
Charger/regulator 48 V dc														910
Battery, 48 V														750
Local alarm display panel	1	100			1	100			1	100				
Master fault alarm display panel										3000				
Factory wiring														170
Shipping and handling		12				12				168				675
Installation and test		100				100				1000				2000
Antennas and Waveguides			See PINAL PEAK to San Carlos				See PINAL PEAK to Bylas				See PINAL PEAK to Phoenix			
4 ft diameter antenna, 12 GHz													1	553
6 ft diameter antenna, 12 GHz													1	633
Waveguide, 12 GHz													133′	518
Waveguide connectors, 12 GHz													4	264
Pressure window, 12 GHz													2	32
Waveguide grounding kit													4	20
Wall feed-through, 12 GHz													2	66
Waveguide hanger and adaptor kit													5	197
Nitrogen tanks and fittings	1	510			1	150			1	150				
Gas distribution manifold										67				
Shipping and handling		8				8				11				600
Supporting Structures and Installation														
10 ft self supporting three-legged tower									1	525				
20 ft self supporting three-legged	1	650			1	650								

Capital Cost Data Sheet
(continued)

tower											
Reflector footing					600						
Tower footing		600			600			1000			
Installation of tower, antennas and waveguide		1050			9300			1325			
Soil suitability consultation		750			750						
Shipping and handling		300			300			300			
Equipment Housing, Power Line and Fence											
Shelter							1	1960			
Fence				1	300						
Installation								400			
Shipping and handling					15			500			
TOTAL		3845.00			13,010.00			10,756.00			25,538.00
25% G&A		961.25			3,252.00			2,689.00			6,384.50
		4806.25			16,262.00			13,445.00			31,922.50

Total, Materials and Labor	53,149.00
Contractor's G&A and Fee (25%)	13,287.25
Grand Total	66,436.25

Capital Cost Data Sheet

Material and Subcontract Labor	SOUTH MOUNTAIN		To Phoenix		To Cimmaron	
	No.	Cost	No.	Cost	No.	Cost
Microwave Radio Equipment			See PHOENIX to South Mountain		See CIMMARON to South Mountain	
Equipment racks	1	$125				
Antennas and Waveguides						
Nitrogen tanks and fittings	1	150				
Gas distribution manifold		55				
Supporting Structures and Installation						
Installation of antennas and waveguide		800				
Shipping and handling		32				
TOTAL		1162.00				
25% G&A		290.50				
		1452.50				

Total, Phase I	552,506.00
Contractor's G&A and Fee (25%)	138,126.00
Grand Total, Phase I	690,632.00

Capital Cost Data Sheet

Item Description	Sites No.	Sites Cost	Links No.	Links Cost	
Microwave Radio Equipment					
Transmitter, 6 GHz			36	$ 133,740	
Receivers, 6 GHz			36	129,600	
Transmitters, 12 GHz			64	268,800	
Receivers, 12 GHz			64	265,600	
Branching			100	60,000	
Power supply, 115 V ac			100	25,000	
Equipment racks	67	$ 8,375			
Fault alarm insert transmitter	26	26,000			
Local alarm display panel	46	4,600			
Master alarm display panel	1	3,000			
Factory wiring			100	8,500	
Shipping and handling		2,188		30,000	
Installation and test				100,000	
Subtotals		44,163		1,021,240	
					$ 1,065,403
Antennas, Reflectors and Waveguides					
4 ft diameter antenna, 12 GHz			36	19,908	
6 ft diameter antenna, 12 GHz			19	12,027	
8 ft diameter antenna, 12 GHz			9	9,405	
6 ft diameter antenna, 6 GHz			8	5,664	
8 ft diameter antenna, 6 GHz			20	26,100	
10 diameter antenna, 6 GHz			8	15,640	
Reflectors, 10 ft X 16 ft			1	1,950	
Reflectors, 20 ft X 32 ft			2	12,610	
Reflectors, 16 ft X 24 ft			2	8,880	
Reflectors, 24 ft X 30 ft			1	7,490	
Reflectors, 20 ft X 24 ft			1	4,990	
Reflectors, 12 ft X 16 ft			1	2,420	
Waveguide, 6 GHz			2020′	9,696	
Waveguide, 12 GHz			3930′	15,132	
Waveguide connectors, 6 GHz			72	3,240	
Waveguide connectors, 12 GHz			128	8,448	
Pressure windows, 6 GHz			36	576	
Pressure windows, 12 GHz			64	1,024	
Waveguide grounding kits			200	1,000	
Wall feed-through, 6 GHz			36	1,044	
Wall feed-through, 12 GHz			64	2,112	
Waveguide hanger and adaptor kit				8,302	
Nitrogen tanks and fittings		6,900			
Gas distribution manifolds		2,410			
Shipping and handling		512		44,800	
Subtotals		9,822		222,458	
					$ 232,280

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Supporting Structures and Installation					
20 ft towers	18	10,620			
25 ft tower	5	3,700			
40 ft tower	3	6,000			
50 ft tower	3	7,050			
60 ft tower	1	2,500			
80 ft tower	3	21,000			
85 ft tower	1	7,300			
90 ft tower	1	7,600			
100 ft tower	4	32,400			
110 ft tower	2	17,000			
120 ft tower	1	9,000			
130 ft tower	1	9,400			
140 ft tower	1	9,750			
150 ft tower	1	10,200			
180 ft tower	1	12,250			
Subtotals		165,770			
Tower footing		28,000			
Reflector footing		5,000			
Subtotal		33,000			
Installation of towers		165,770			
Installation of reflectors		38,340			
Installation of antennas		40,000			
Subtotal		244,110			
Soil suitability consultation		34,500			
Shipping and handling		13,800			
Subtotal		48,300			$ 491,180
Power Generators					
Engine generator	47	51,700			
Prime emergency power switch	47	42,300			
Installation		11,750			
Shipping and handling		14,100			
Subtotal		119,850			$ 119,850
Equipment Housing					
Shelter	26	50,960			
Installation		10,400			
Shipping and handling	26	13,000			
Subtotal		74,360			$ 74,360
Extraordinary Transportation Charges					
Helicopter		20,000			$ 20,000
Miscellaneous Services					
Frequency selection and FCC application preparation		25,000			
Specification writing and procurement		100,000			
Installation supervision and documentation		100,000			
Subtotal		225,000			$ 225,000
		Subtotal			2,228,073
		Contractor's G&A/fee (25%)			557,018
		Grand Total			2,785,091

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10.3 Switching and Channel Equipment for Relay Sites

The following budgetary costs represent the total material and labor for the installation of the routing switchers, channel equipment and tone demodulators at each relay site. Also included in the cost is the switching tone generators and associated equipment at the class "b" and class "c" sites.

1. Relay serving only two sites — N/A
2. Relay serving three sites (itemized below) — $53,844

Item	Quantity	Description	Budgetary Cost
1	3	Program mod/demods (audio)	$ 4,800
2	3	Service channel mod/demods	7,500
3	3	Multiplex card cage and common equipment	3,600
4	3 sets	Multiplex cards (average need)	6,750
5	3	22 kHz filters	900
6	1	Video switch matrix	1,500
7	2	Audio switch matrix	2,000
8		Control panel (average)	1,200
9		Tone control equipment (average)	2,800
10		Audio patching equipment	75
11		Video patching equipment	100
12		Miscellaneous material	750
		Subtotal, material	$31,975
		Labor (including engineering, installation	9,500
		Shipping and handling (5% of materials)	1,600
		Contractor's G&A/fee (25% of all items above)	10,769
		Total (3-way relay)[a]	$53,844

[a]Except for cases such as Phoenix where less demodulating equipment is required due to the co-location of a terminal site and route switching site. In these cases the reduction of Items 1 through 4 from a Quantity of 3 to a Quantity of 2 will result in a total for a 3-way relay of $41,433.

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3. Relays serving more than three sites – amount of Item 2 plus $15,051 per each site in excess of three. (marginal additions are itemized below)

Item	Quantity	Description	Budgetary Cost
1	1	Program mod/demod	$ 1,600
2	1	Service channel mod/demod	2,500
3	1	Multiplex card cage and common equipment	1,200
4	1 set	Multiplex cards (average)	2,250
5	1	22 kHz filters	300
6		Additions to video matrix	350
7		Additions to audio matrices	500
8		Additions to control equipment	425
9		Miscellaneous material	200
		Subtotal, material	$ 9,325
		Labor (assumes that installation is concurrent with Item 2 tasks)	2,250
		Shipping and handling (5% of materials)	466
		Contractor's G&A/fee (25% of all items above)	3,010
		Total marginal cost	$15,051

10.4 Terminal Equipment Costs (Class "a" Stations)

Console:

Item	Quantity	Description	Unit	Cost
1	1	Dual 9-inch monochrome monitors	$ 925	$ 925
2	1	Four-channel audio mixer	850	850
3	1	Audio limiter	695	695
4	2	Lavilier microphones	90	180
5	1	Desk microphone	110	110
6	2	Three-button passive video switches	130	260
7	1	Two-channel video D.A.	1,175	1,175
8	1	Video image enhancer	3,600	3,600
9	1	Program channel mod/demod	1,600	1,600
10	1	Service channel mod/demod	2,500	2,500
11	1	Multiplex card cage and common equipment	1,200	1,200
12	1 set	Multiplex channel cards	2,250	2,250
13	1	Wireless headset unit	300	300
14	1	Monitor headset	35	35
15	1 set	FSK demodulators/modulators	2,475	2,475
16	1	FSK rack and power supply	350	350
17	1	22 kHz telemetry transmitter	3,225	3,225
18	1	22 kHz telemetry receiver	2,525	2,525
19	1	AdVC audio select panel	150	150
20	1	Electric power breaker panel	150	150
21	1	Handset, four-wire, coil cord	20	20
22	1	Audio patch panel with accessories	75	75
23	1	Video test panel with accessories	125	125
24	1	Custom desk and frame	750	750
25	1	Desk chair	50	50
		Miscellaneous wire, cable, connectors, equipment		1,500
		Subtotal, material		$27,075

Console: (continued)

Labor (includes engineering, console fabrication and installation of all console equipment and components)	$ 7,500
Shipping and handling	1,354
Contractor's G&A/fee (25% of all items above)	8,982
Total per site (assumes at least four units are produced)	$44,911

Component Subsystems:

Item	Quantity	Description	Budgetary Cost
1	1	Color monitor with accessories	$ 1,200
2	1	Large monochrome monitor, etc.	750
3	1	Color television camera complete (with sync generator and encoder)	29,000
4	1	Tilt/pan equipment for camera	1,500
5	1	Teleprinter/keyboard unit	2,900
6	1	Business facsimile unit[a]	4,000
7	1 set	Auxiliary lights	350
8	1	EKG machine and interface	1,600
9	1	Spirometer and interface	1,050
10	1	Electronic stethoscope	525
11		Allowance for cablin and miscellaneous materials	500
		Subtotal, material	$43,375

[a]Optional – only provided at selected test sites: San Carlos, Sells, Tucson.

Components Subsystems: (continued)

Labor (including subcontracts, engineering and installation)	4,500
Shipping and handling (5% on all material except color camera)	. 719
Contractor's G&A/fee (25% on all items above except color camera)	4,898
Total per site	$53,492
Without business facsimile	$48,242
Grand total, class "a" terminal site, equipment installed (per site figure not including facsimile, clinical furniture, etc.)	$93,153

10.5 Terminal Equipment Cost (Class "b" and "c" Stations)

Console:

Item	Quantity	Description	Unit	Cost
1	1	Dual 9-inch monochrome monitors	$ 925	$ 925
2	1	Four-channel audio mixer	850	850
3	1	Audio limiter	695	695
4	2	Lavilier microphones	90	180
5	1	Desk microphone	110	110
6	2	Three-button passive video switches	130	260
7	1	Cartridge video recorder with spare tape	1,700	1,700
8	1	Remote control for video recorder	175	175
9	1	Four-channel audio tape logger	1,500	1,500
10	1	Remote control for logger	150	150
11	1	Two-channel video D.A.	1,175	1,175
12	1	Video image enchancer	3,600	3,600
13	1	Program channel mod/demod	1,600	1,600
14	1	Service channel mod/demod	2,500	2,500
15	1	Multiplex card cage and common equipment	1,200	1,200
16	1 set	Multiplex channel cards	2,250	2,250
17	1	Wireless headset unit	300	300
18	1	Monitor headset	35	35
19	1 set	FSK demodulators/modulators	2,475	2,475
20	1	FSK rack and power supply	3,225	3,225
21	1	22 kHz telemetry transmitter	3,225	3,225
22	1	22 kHz telemetry receiver	2,525	2,525
23	1	AdVC audio select panel	250	250
24	1	Conference bridge/amplifier	375	375
25	1	Electric power breaker panel	150	150
26	1	Handset, four-wire, coil cord	20	20
27	1	Audio patch panel with accessories	75	75

Console: (continued)

Item	Quantity	Description	Unit	Cost
28	1	Video test panel with accessories	$ 125	$ 125
29	1	Remote signal and alarm	75	75
30	1	Custom desk and frame	750	750
31	1	Desk chair	50	50
32		Miscellaneous wire, cable, connectors, equipment		1,500
		Subtotal, material		$34,025
		Labor (includes engineering, console fabrication and installation of all console equipment and components)		7,500
		Shipping and handling (5% of materials)		1,701
		Contractor's G&A/fee (25% of all items above)		10,807
		Total per site (assumes at least four units are produced)		$54,033

Component Subsystems:

Item	Quantity	Description	Unit	Cost
1	1	Color monitor with accessories		$ 1,200
2	1	Large monochrome monitor, etc.		750
3	1	Color television camera, complete (with sync generator and encoder)		29,000
4	1	Tilt/pan equipment for camera		1,500
5	1	Teleprinter/keyboard unit		2,900
6	1	Business facsimile unit[a]		4,000
7	1 set	Auxiliary lights		350
8	1	EKG machine and interface		1,600
9	1	Spirometer and interface		1,050

[a]Optional – not required at all sites.

Component Subsystems: (continued)

Item	Quantity	Description	Unit	Cost
10	1	Electronic stethoscope		$ 525
11		Allowance for cabling and miscellaneous materials		500
		Subtotal, materials		$43,375
		Labor (including subcontracts, engineering and installation)		4,500
		Shipping and handling (5% of all material except color camera)		719
		Contractor's G&A/fee (25% of all items except color camera)		4,898
		Total per site		$53,492
		Total (without facsimile)		$48,242
		Grand total, class "b" and "c" terminal site, equipment installed (per site figures, not including facsimile, clinical furniture, etc.)		$102,375

10.6 Budgetary Capital Cost, Mobile Unit

The mobile unit, tentatively planned for Pisinimo, will require the same basic equipment as was listed earlier for the fixed class "a" sites. In addition to these components and the basic customized vehicle, several other categories of material and equipment are needed. The budgetary costs for the various components that make up the mobile unit and its support relay are listed below.

1.	Basic vehicle with custom interior, radome, generator and standard equipment	$ 35,000
2.	Allowance for medical equipment	3,700
3.	Terminal equipment package	93,153
4.	X-ray unit, including lead walls and installation, table developing tanks, etc.	33,349
5.	VHF radio (installed)	3,200
6.	Command and control for steerable dish (development, fabrication and installation)	35,000
7.	Slow-scan television unit	23,000
8.	Antenna pointing aid (self-contained CCTV camera)	1,500
9.	Duplex microwave link[a] with two, 2-inch dishes (installed)	38,500
	Total budgetary capital cost, mobile unit	$266,402

[a]Using a dish-mounted RF unit in the mobile unit. Cost includes fabrication of mechanical subsystems for the mounts at both ends.

10.7 Capital Cost Summary

10.7.1 Items of Consideration

In arriving at a budgetary capital cost estimate for the entire network or a portion of it, the following items must be taken into account. The information set forth below is, for the most part, summarized from earlier sections in this document.

1.	Microwave radio system	See data sheets, Section 10.2
2.	Laser transmission system – (approximate installed cost for a duplex 2 mile hop)	$ 50,000
3.	Terminal equipment, per site, for class "a" stations	93,153
4.	Terminal equipment, per site, for class "b" and "c" stations	102,275
5.	Optional business facsimile unit (only to be provided at selected sites)	5,250
6.	Switching and channel equipment for relay sites:	
	• Serving two terminal sites	N/A
	• Serving three terminal sites	53,844
	• Serving three terminal sites when the relay site and one terminal site are collocated	41,433
	• Serving sites subsequent to the third site	15,051[a]
7.	Slow-scan television unit (each terminal site except Pisinimo)	23,000
8.	Mobile unit (fully equipped, including slow-scan TV and wideband support relay)	266,402
9.	Allowance for clinical furnishings and minor equipment (Bylas only)	3,700
10.	Legal services (per site proportional amount)	500

[a]Must be added to the appropriate three-site price to obtain a cost for a four-site terminal. As sites are added, $15,051 must be added to basic cost.

11.	Allowance for mobile home addition to Bylas Clinic	$ 12,000
12.	Allowance for subcontract to Medical Center Physical Resources Department for the wiring and conduit work required – (labor and conduit only)	2,500
13.	Allowance for the extension of video/camera facilities to a nearby room within the same terminal site	750
14.	Allowance for the San Xavier – HPSC monitor	4,500
15.	Test equipment (each of three maintenance centers)	20,000
16.	Maintenance vehicles (one per maintenance center)	4,200
17.	Spare equipment (per maintenance center)	15,000

10.8 Budgetary Capital Cost, Phase I Segment

As an example of the capital requirement involved in a pilot program or "test bed" project, the following summary has been developed. In this case a group of network stations, to be termed "phase I," was selected. The terminal sites to be interconnected in the example are: Pisinimo, Santa Rosa, Sells, University of Arizona Medical Center, HPSC (monitor), Bylas, San Carlos and Phoenix. The cost summary is presented below:

1.	Microwave radio equipment	$ 690,632
2.	Terminal equipment, two class "a"	186,306
3.	Terminal equipment, four class "c" and "b"	409,100
4.	Mobile unit	266,402
5.	HPSC monitor	4,500
6.	Three business "fax" units	15,750
7.	Switching and channel equipment	248,118
8.	Slow-scan TV units (all sites)	115,000
9.	Allowance for clinical furnishings	3,700
10.	Legal service	6,500
11.	Mobile home addition, Bylas	12,000
12.	Allowance for the Tucson conduit/wire subcontract	2,500
13.	Allowance for the extension of video/camera facilities (two sites)	1,500
14.	Test equipment, vehicles, spares	78,400
	Budgetary capital cost estimate, Phase I	$2,040,408

10.9 Budgetary Capital Cost, Entire Network

The following list of categories and dollar figures represents the budgetary estimate to construct the entire Arizona TeleMedicine Network.

1.	Microwave radio equipment	$3,475,723
2.	Terminal equipment, all sites	2,513,198
3.	Three business facsimile units	15,750
4.	Switching and channel equipment, all relays	1,145,313
5.	HPSC monitor	4,500
6.	Slow-scan TV unit, all sites	598,000
7.	Mobile unit and support facilities	266,402
8.	Clinical furnishings, Bylas	3,700
9.	Legal services	28,500
10.	Bylas mobile home addition	12,000
11.	Allowance for Medical Center Department of Physical Resources subcontract	2,500
12.	Allowance for the extension of video/camera facilities at five sites	3,750
13.	Test equipment, vehicles, spares	117,600
	Budgetary capital cost estimate, Arizona TeleMedicine Network	$8,186,936

10.10 Operating Costs

10.10.1 Entire Network

For the entire Arizona TeleMedicine Network, as planned, the following minimum operating costs may be budgeted. Administrative costs are not itemized.

Staff salaries (technical operation)	$ 92,000
Overhead (75% of salaries)	69,000
Electric power[a]	30,500
Bonds, insurance, miscellaneous[b]	61,000
Consumable spare equipment/materials[c]	18,300
Vehicle costs[d]	3,600
Contract and professional service[e]	24,200
Total, Operating Costs	$298,600

[a]Based on $500 per site per year, including gas.

[b]Based on $1,000 per site per year.

[c]Based on $25 per site per month.

[d]Based on $100 per month per vehicle.

[e]Based on $200 per site per year plus $12,000 for helicopter service.

10.10.2 Phase I

For "Phase I" as defined in Section 10.8, the following budgetary operating costs may be used.

Staff salaries	$ 68,000
Overhead	51,000
Electric power	7,000
Bonds, insurance, miscellaneous	14,000
Consumable spares/material	4,200
Vehicle costs	2,400
Contract and professional services	14,800
Total Operating Costs	$161,400

10.11 Leased System Comparison

The Arizona TeleMedicine Network Project Director has two alternatives open to him in regard to financing the physical plant and communication services requirement. The plant may be owned by the Network or it may be leased. The third possibility, a Bell System lease arrangement, is not considered likely in face of the company's position on new dedicated system expansion. (see Section 3.3.2).

In an earlier study conducted by Atlantic Research for a microwave system similar in scope to the Arizona TeleMedicine Network, a cost comparison was done between an owned and a Bell System lease. This comparison for a 2 million dollar plant indicated that an owned system is the more economical approach if operations are to continue beyond 6 years. The result of this comparison, in graph form, is reproduced as Figure 10.1.

The comparison of an owned system to a privately leased system was done on the basis of annualized costs over a 10-year term. In both cases, the total capital cost is $8,186,936 as presented in Section 10.9.

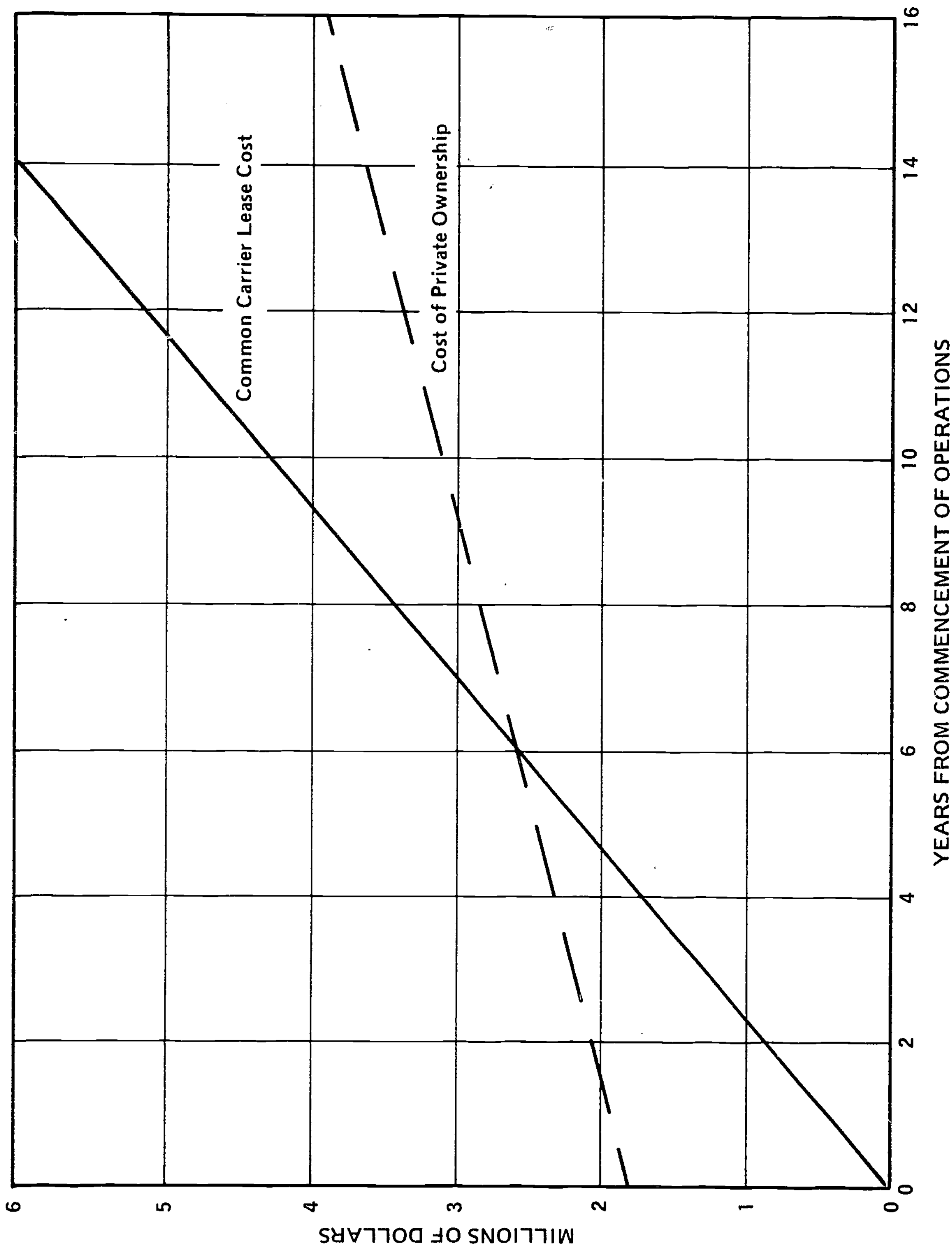

Figure 10.1. Comparison of Cumulative Costs, Transmission, Terminal and Switching Facilities.

For an owned system, the following approximations can be made:

Depreciation[a] (assumes straight line over 10 years)	$ 818,694
Annual capital charge in excess of depreciation (six percent interest assumed)	293,092
Operations and maintenance (from Section 10.10)	298,600
Owned system, total annualized cost	$1,410,386

For the owned system with an annualized cost of $1,410,386, the monthly cost would be $117,532 and the monthly cost-to-capital investment would be 1.44 percent.

For an identical system owned and maintained by a private company for the Arizona TeleMedicine Project, the following annual costs may be developed. It is assumed that the private company will require an 8½ percent after-tax return on his investment of $8,186,936.

Depreciation (same as in previous example)	$ 818,694
Required after-tax earnings at 8½ percent[b]	695,890
State and Federal Income Tax	695,890
Other taxes including gross receipt taxes (estimated at 10 percent of gross receipts)	278,786
Operations and maintenance (same as previous example)	298,600
Leased system, total annualized cost	$2,787,860

[a]There is actually no reason that modern solid-state equipment in a favorable environment (no vibration or temperature extremes) should not last indefinitely, since there is nothing except the travelling wave tubes that can "wear out." The most usual cause in the past for replacing microwave equipment has been technical obsolescence, particularly with respect to the older nonmodular all-tube equipment. It is difficult to project that another revolution in electronic equipment of the magnitude of that brought on by solid-state and semiconductor technology occur in the next 10 to 20 years. In any case, improvements will be made and eventually it will prove desirable to replace old equipment with that which gives improved performance, higher reliability, and lower operating and maintenance cost.

[b]Note that this figure is equal to the next line down, State and Federal Income Tax which is 50 percent of gross income after expenses.

If the State of Arizona takes into account the fact that the leasing company is paying annual taxes approximating 10 percent of gross receipts, the true annualized cost for a leased system drops to about $2,509,074.

10.12 Narrowband Versus Wideband Cost Comparison

10.12.1 General

Wideband microwave radio has been selected as the means of carriage for the various signals over the Arizona TeleMedicine Network. This choice is necessitated by the desire to transmit standard scan-rate television pictures. In this section of the report, a comparison is drawn between the costs of a narrowband system with several channels of audio circuits and a wideband system that includes either many voice channels alone or several voice channels and a television channel. The example considered in the following tabulations consists in each case of a hypothetical duplex network connecting two points using a single hop. The path length is 30 miles, the tower heights 20 feet. In one case, 6 GHz radio is used, in the other 960 MHz radio is used.

10.12.2 Wideband System Costs (6 GHz)

Microwave radio equipment	$14,630
Antennas, radomes, waveguide, circulators	3,784
Towers	1,200
Buildings	6,000
Generators	5,220
	30,834
5% materials handling	1,542
	32,376
Labor	6,920
Prime Contractor's G&A/fee	9,824
Total	$49,120

If two sets of class "a" stations terminal equipment packages (Section 10.4) are added to this figure, the cost for the completely functional two station system becomes $232,818.

10.12.3 Narrowband System Costs (960 MHz)

Microwave radio equipment	$ 6,300
Antennas, radomes, cable, duplexers	4,777
Towers	1,200
Buildings	6,000
Generators	5,220
	23,497
5% materials handling	1,175
Labor	6,800
	31,472
Prime Contractor's G&A/fee	7,868
Total	$39,340

If two sets of class "a" stations terminal equipment packages without standard scan television equipment are added to the radio system costs, the total for the two-station system would be approximately $133,500.

10.12.4 Comparison of System Types

By comparing the total system cost of $232,818 for the wideband system (with standard scan color television) to the total system cost of $133,500 for the narrowband system it is obvious that a vast differential exists. In fact, the wideband system with a full complement of terminal equipment is about 75 percent more than a narrowband system with a full complement of narrowband services. However, a comparison of transmission system costs alone (without terminal facilities) shows only a 25 percent increase in capital requirement to install a wideband network instead of a narrowband network when the costs of these two transmission systems are related to their respective bandwidths (channel capacities) a choice of system type is very clear. This comparison is shown in Table 10.1. This choice is essentially independent of the need for standard scan color television. The additional channel capacity of the wideband system used in a narrowband configuration would permit extensive growth of all of the network's narrowband services plus it would allow new services such as high speed digital data to also be added.

Table 10.1. Comparison of Transmission Systems.

Transmission System Type	Two Station Duplex Cost[a]	Maximum Bandwidth of Baseband	Voice Channel Capacity	Cost per Voice Channel (approximate)	Standard Scan TV Capability
6 GHz "wideband"	\$49,120	8 MHz	128	\$380	Yes
960 MHz "narrowband"	\$39,340	24 kHz	6	\$6,550	No

[a]Not including terminal or multiplex equipment.

11.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

11.1 Project Objective and Rationale

The objective of the Arizona TeleMedicine Project is to plan and implement an efficient and responsive communications system integrated with a comprehensive health care system.

The need to improve the delivery of health service to remote Indian reservations is great. Medical service to the Indian population is hampered by a chronic physician shortage and by the geographic and logistic problems associated with a large, low-density population.

The shortage of physician manpower on the reservations has been alleviated somewhat by the increase, use of Community Health Medics (CHMs). The Arizona TeleMedicine Network communication services will help to provide the CHMs with immediate consultation and the professional services available only at major health facilities. The network will support and maintain the CHM at a high professional level and will further expand and integrate the efforts of the Indian Health Service.

In the educational programs area, the proposed communications system will be responsive by utilizing voice and image communication equipment for health service providers, group seminars and patient education activities.

11.2 Coverage Area

The Arizona TeleMedicine Network will initially interconnect five Indian reservations. These reservations are:

- The Papago
- The San Carlos Apache
- The White Mountain Apache
- The Navajo
- The Hopi

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11.3 Communication Services

Based on an assessment of the communication needs for each station in the network, it was determined that the following communication service should be provided at each site:

- A two-way color/monochrome television channel with its associated high quality sound.
- A full-time, two-way voice channel between each field health station and its principal referral center and between the referral centers and major medical centers. This "hot line" telephone-type or intercom service is called the Administration Voice Channel (AdVC) throughout this document.
- A two-way slow-scan television channel which can be shared by other narrowband services such as facsimile and voice.
- A two-way physiological telemetry channel to carry ECG, spirometry and electronic stethoscope signals.
- A dedicated teleprinter (data) channel interconnecting each network site with the Health Information System Computer in Tucson.
- Camera control tones to and from each site. These tones will permit remote positioning of the television cameras used in the network.

In addition to the above channels, other control circuits for equipment failure alarms, remote switching and signaling (ringing) will be provided as needed throughout the proposed network. A maintenance intercom voice circuit or "order wire" will also be provided between various points throughout the system.

Provisions will be made to extend the Administration Voice Channel (AdVC) service beyond the confines of each station's control console. At peripheral hospitals and major medical centers, the AdVC equipment will include cross-connect facilities to each station's telephone system. At network stations where VHF (two-way) radios are already installed, patch cords will also be supplied to allow interconnection of these facilities with the network's AdVC.

11.4 Recording Devices

In order to adequately evaluate the usefulness of the network, video and audio recorders will be provided at certain stations in the network. These units will also serve both a legal and clinical purpose as a medium for the maintenance of patient records.

11.5 Sharing of Existing Facilities

An existing communications facility survey for the entire State of Arizona was undertaken prior to selecting the final route plan for the Arizona TeleMedicine Network. This survey served to inventory the existing radio relay sites in the state that could potentially be shared by the proposed network.

Existing private communications systems in Arizona were found to have insufficient channel space availability to be of potential use to the proposed network. Channel rental agreements involving existing systems are not feasible alternatives to new construction. Site rental agreements wherever possible are recommended.

According to the Tucson office of Mountain States Bell, only the Tucson-to-Phoenix part of their Arizona facilities could accommodate the wideband service needs of the proposed network. The monthly rental cost can be estimated to be approximately $6,941.

11.6 Narrowband Versus Wideband

Since there is no major economic advantage to the construction of a narrowband transmission system (several voice channels) as compared to a wideband transmission system (video plus several voice channels), it is recommended that wideband technology be utilized throughout the Arizona TeleMedicine Network.

11.7 Transmission Medium

It is recommended that frequency modulated (FM) microwave radio be used as the communications medium to link the sites encompassed by the Arizona TeleMedicine Network. For future expansion of the network within urban areas and in other short distance applications, cable carrier technology and laser communications technology should be considered, on a case-by-case basis, as alternate choices to microwave. Economic and reliability factors will dictate the choice in each case considered.

Instructional Television Fixed Service (ITFS), noncoherent light beam systems and amplitude modulated microwave are not recommended for use in this application. Signal quality and reliability considerations are the basis for this recommendation.

11.8 Licensing

Because the proposed network will eventually expand to cover medical facilities other than those of the Indian Health Service, it is recommended that licensing of the radio equipment be applied for through the Federal Communications Commission. The alternative of making application through the Interagency Radio Advisory Committee would seem to limit the use of the proposed network to government agencies.

11.9 Frequency Availabilities

A careful search for frequency availabilities was undertaken as a part of the master planning work described in this document. The results of this search indicate that sufficient microwave channel space does exist and can be obtained for construction of the Arizona TeleMedicine Network.

11.10 Compatibility

The proposed Arizona TeleMedicine Network is compatible with other wideband communication systems. Interface can easily be effected with communications satellite circuits as well as with land-based circuits.

11.11 Switching Control and Network Management

Switching, control and network management plans for the transmission system closely parallels the existing patient referral patterns of the areas involved. This design will assure orderly and efficient use of the Arizona TeleMedicine Network when this new avenue of electronic communications is opened to the staffs of the network health stations.

11.12 Mobile Facility

A proposed design for a mobile field health station was developed. This mobile unit design includes communications facilities and clinical facilities functionally equivalent to those found at fixed field health stations.

11.13 Technical Operations

Three network sites will be designated as maintenance centers. These sites, Ft. Defiance, Phoenix and Tucson will be equipped with test equipment and will be supplied with the necessary repair parts and spare components needed to maintain the system in good working order. Each maintenance center will be provided with a suitable vehicle and will be staffed with two well-qualified maintenance technicians. At each maintenance center, a status board will automatically check the basic operating parameters of the remote microwave relay stations for which the center has responsibility. This will be accomplished through the use of remote fault alarm tones generated at each relay site. To assist in trouble shooting, an order wire will be provided between the remote sites and the maintenance centers.

11.14 Telemetry

The telemetry channel to be provided on the network's microwave system will have a frequency response from dc to 500 Hz. The electronic stethoscope transducer/amplifier device should have selectable filters to limit the low frequency cutoff at 25 Hz, 50 Hz and 100 Hz. The spirometer provided as part of the network's telemetry equipment should be a water-filled type. The electrocardiogram machine to be provided at network sites should be a single channel, 12 lead unit conforming to the latest recommendations of the American Heart Association.

11.15 Teleprinter Transmission

There are several alternative approaches to providing the HIS teleprinter service over the facilities of the Arizona TeleMedicine Network. It was determined that a dedicated channel approach was the optimal method to use. Each station will be assigned a separate 300 baud FSK data channel. Six such channels will be multiplexed upon a single "voice slot" in the network. A sufficient number of voice slots will be allocated to this service so as to permit all stations to have immediate and continuous access to the HIS computer located near Tucson. Portable teleprinter/keyboard terminals similar to those already used by HIS equipped health stations will need to be provided at each network site. The software additions necessitated by this geographic expansion of HIS will also have to be implemented.

11.16 Still Image Transmission

Several still image transmission techniques were investigated in the course of developing the design for the Arizona TeleMedicine Network. These techniques can be divided into two groups: slow scan television systems and facsimile techniques to meeting the special requirements of the network. Facsimile is only to be favored for those few instances where "hard copy" is needed. Therefore, it is recommended that slow scan television systems be provided at all network sites. To verify hard copy needs under actual clinical operating conditions, facsimile units of the "business fax" type should be placed in a few test bed sites.

11.17 Color Television

SECAM-60, a color television encoding system, is recommended for use in the Arizona TeleMedicine Network. This choice is dictated by the importance of accurate color rendition in this clinical application. Equally important is the need to minimize routine maintenance or adjustments to keep color quality at a high level. Color television cameras of a high commercial grade with good color and sensitivity characteristics will be provided at each site. A color/monochrome by-pass circuit will be provided at each site to permit monochrome transmission for cases when high resolution is deemed more important than color.

11.18 Computer Aided Diagnosis

The network design incorporates sufficient flexibility to accommodate various computer based diagnostic programs as they become available and applicable.

11.19 Patient Privacy

The Arizona TeleMedicine Network will permit the confidentiality of conversations to be maintained at a level equivalent to that expected in a face-to-face doctor/patient conversation. The following reasons contribute to this privacy: little economic gain in intercepting these conversations, inherent high cost of intercepting and physical and technical difficulty in intercepting these conversations.

Furthermore, physical security measures (locked doors, etc.) can be used to prevent unauthorized use of terminal equipment and, thereby, limit access to only authorized personnel. The radio equipment itself must be kept under lock and key according to FCC regulations.

It is felt that these measures provide sufficient security and it is not recommended that scrambling or other extraordinary privacy features be included in the design of the network.

11.20 Implementation Schedule

It is projected that the Arizona TeleMedicine Network, or a portion of it, can be implemented within twelve months from the time that a prime contractor is selected. To limit the fragmentation of responsibility, it is recommended that a single turn-key contractor be selected to construct the entire system.

11.21 Budgetary Capital Costs, The Entire Network

To construct the entire 27-station Arizona TeleMedicine Network as defined in this document, the capital cost requirement will amount to approximately $8,186,936.

11.22 Technical Operating Costs, The Entire Network

Technical operating costs for the entire network as presently planned will cost approximately $298,600 per year. This cost does not include the administration and program operating or medical consulting costs associated with the functioning network.

11.23 Budgetary Capital Costs, Phase 1

For Phase 1 of the Arizona TeleMedicine Network, the budgetary capital cost requirement is $2,040,408. Phase 1 encompasses the terminal sites at Phoenix, Bylas, San Carlos, Tucson, Sells, Pisinimo and Santa Rosa. Also included is the monitor facility at the Health Program Systems Center (HPSC) and the mobile field health station based at Pisinimo.

11.24 Technical Operating Costs, Phase 1

Technical operating costs for Phase 1 of the Arizona TeleMedicine Network are budgeted at $161,400.

APPENDIX A

PATH PROFILES

Note: When towers are not specified on the Vertical Earth Profiles, only minimum tower heighths governed by antenna size, will be required.

Note: Corrections for earth curvature and Fresnel zone radius have been included on each profile:

Λ 0.3 first Fresnel zone radius

Δ earth curvature for k = 2/3

page 11-8 is blank.

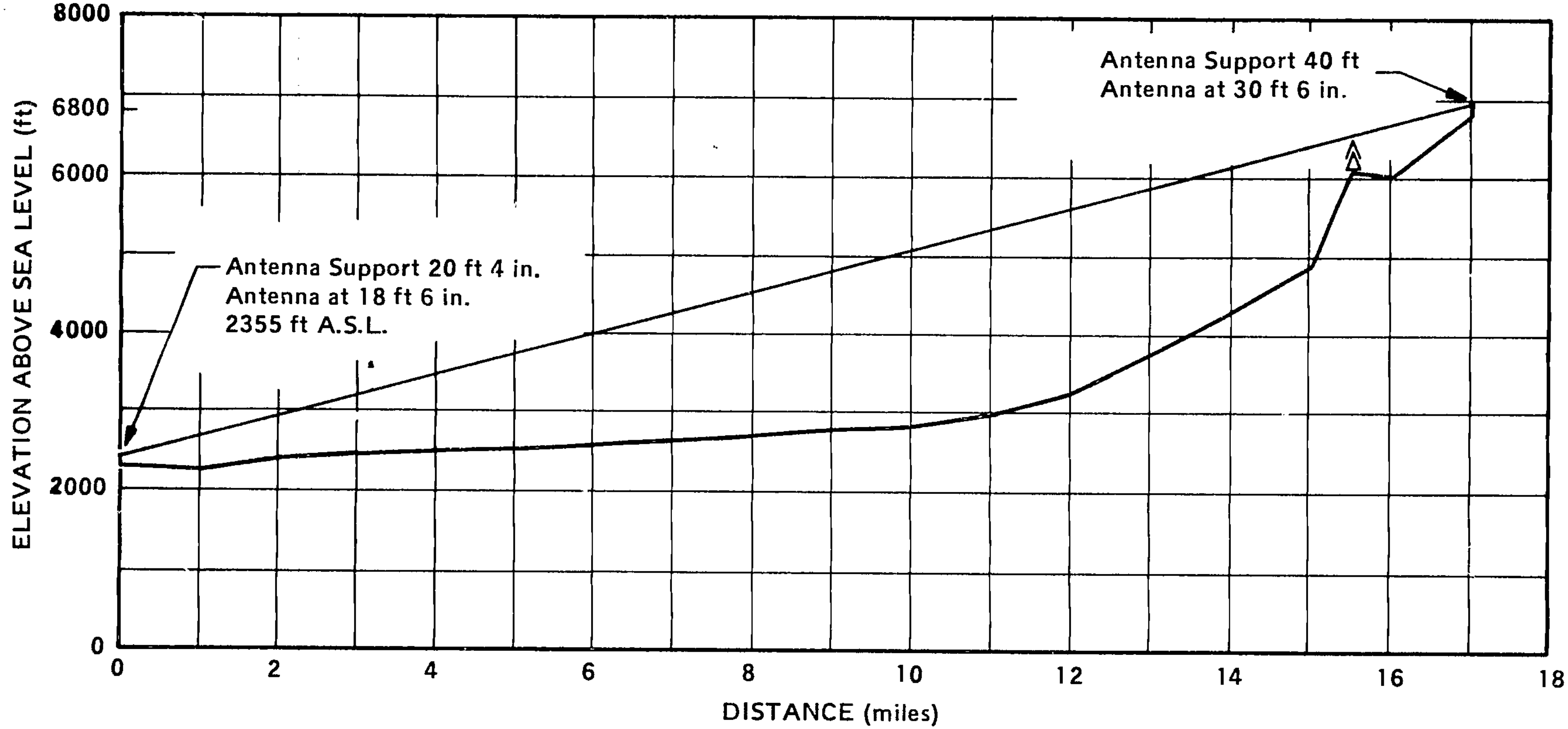

Figure A.1. Microwave Path Profile, Sells to Kitt Peak.

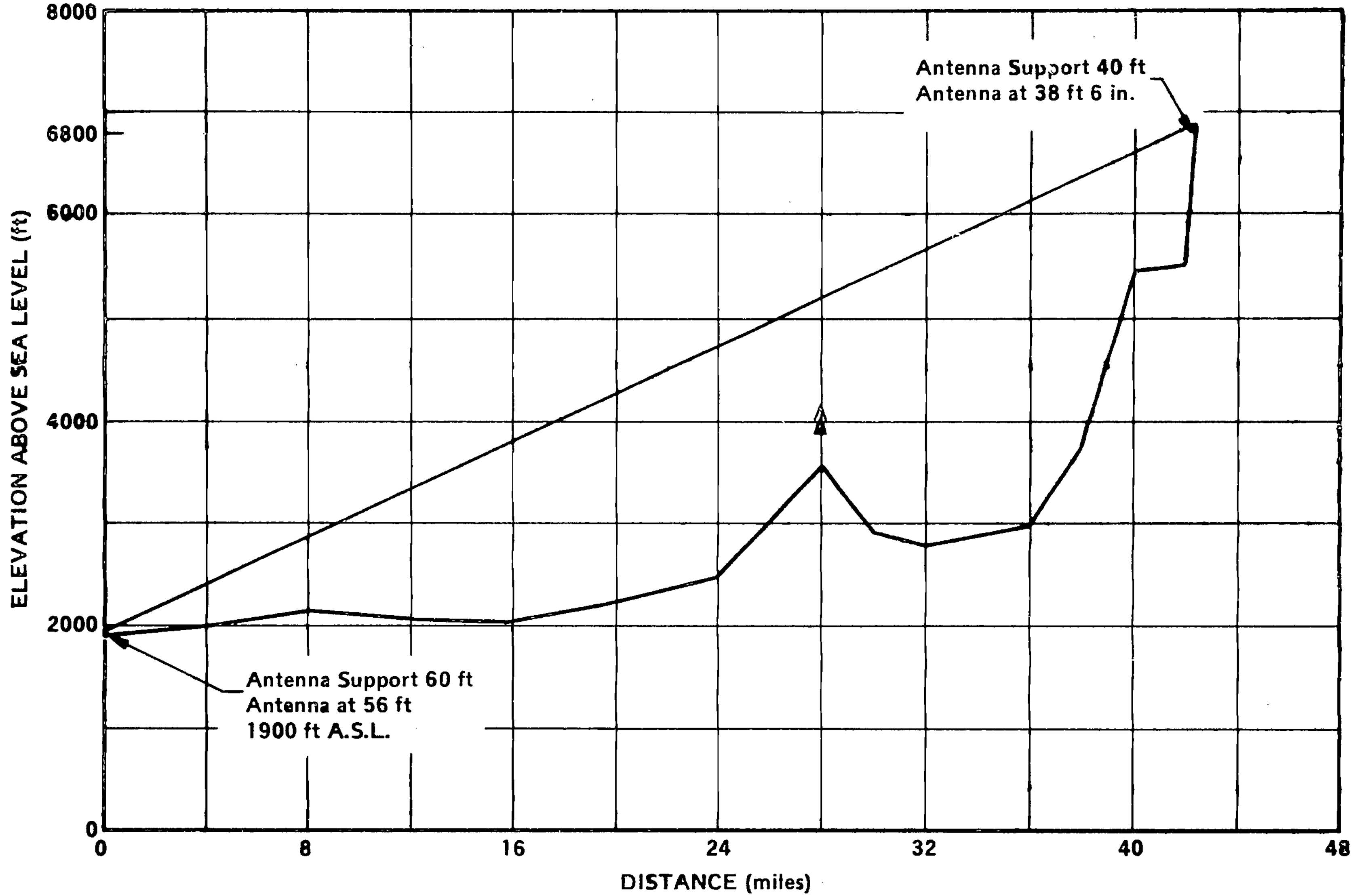

Figure A.2. Microwave Path Profile, Pisinimo to Kitt Peak.

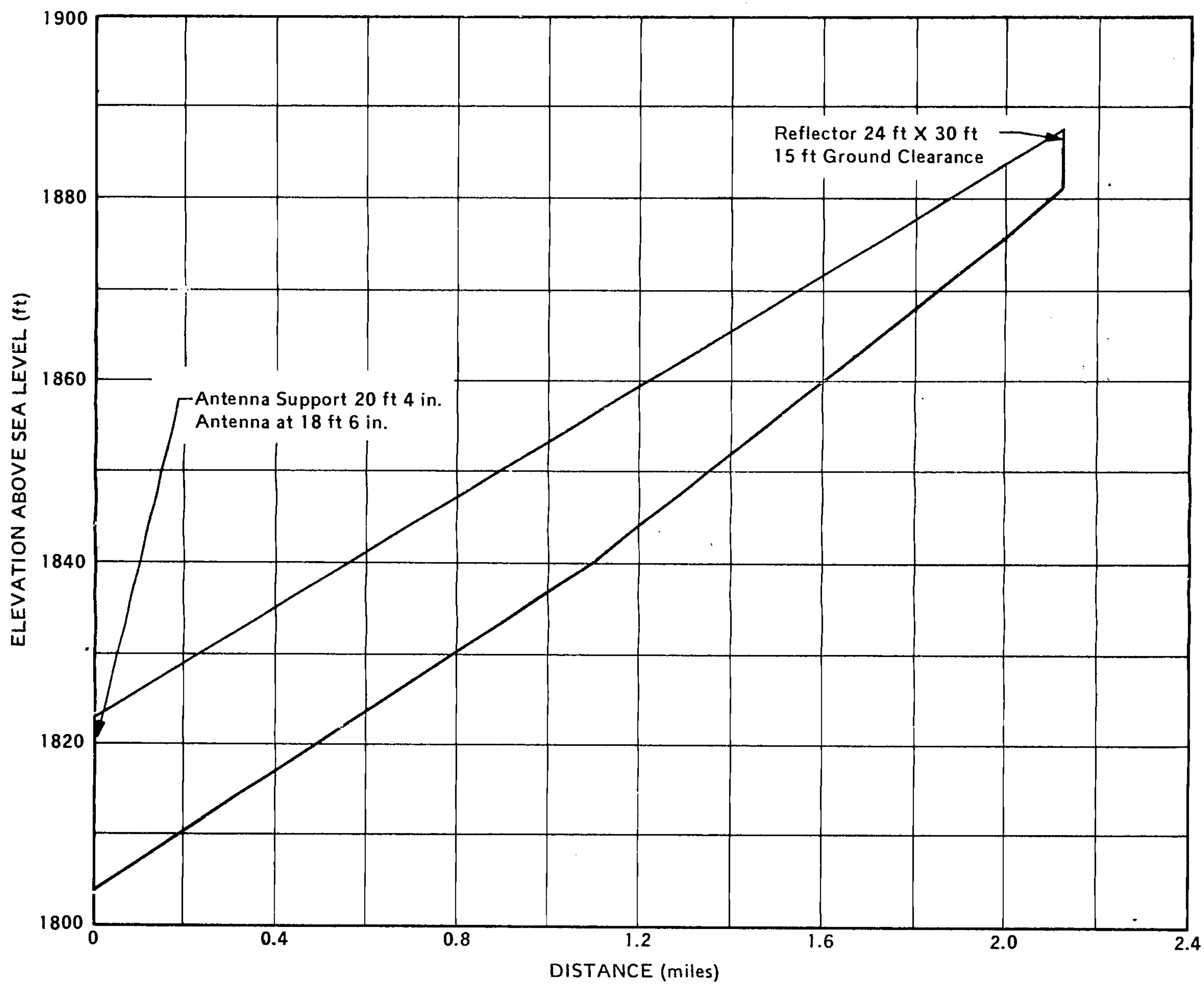

Figure A.3. Microwave Path Profile, Santa Rosa (Guachi) to Santa Rosa Reflector.

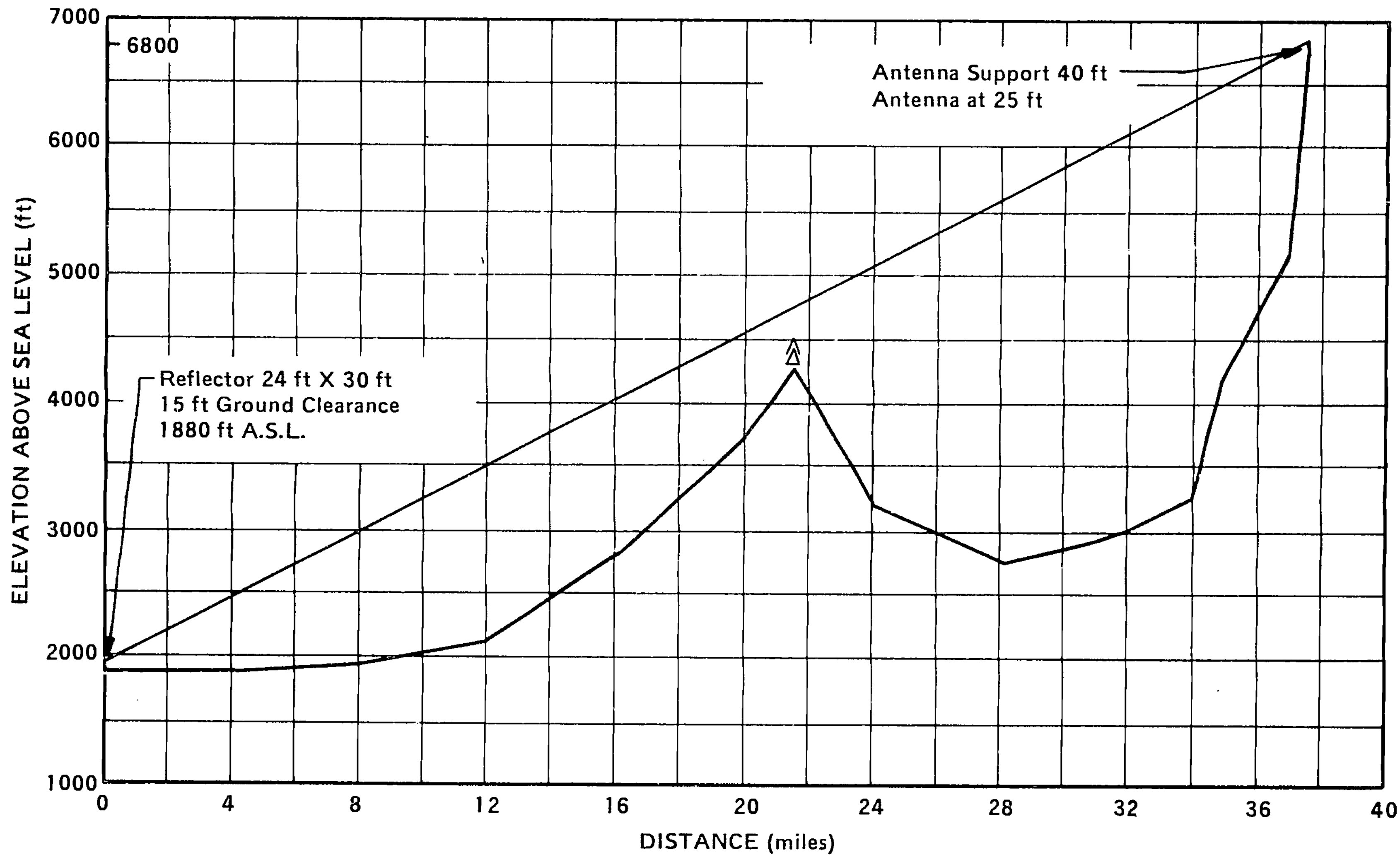

Figure A.4. Microwave Path Profile, Santa Rosa Reflector to Kitt Peak.

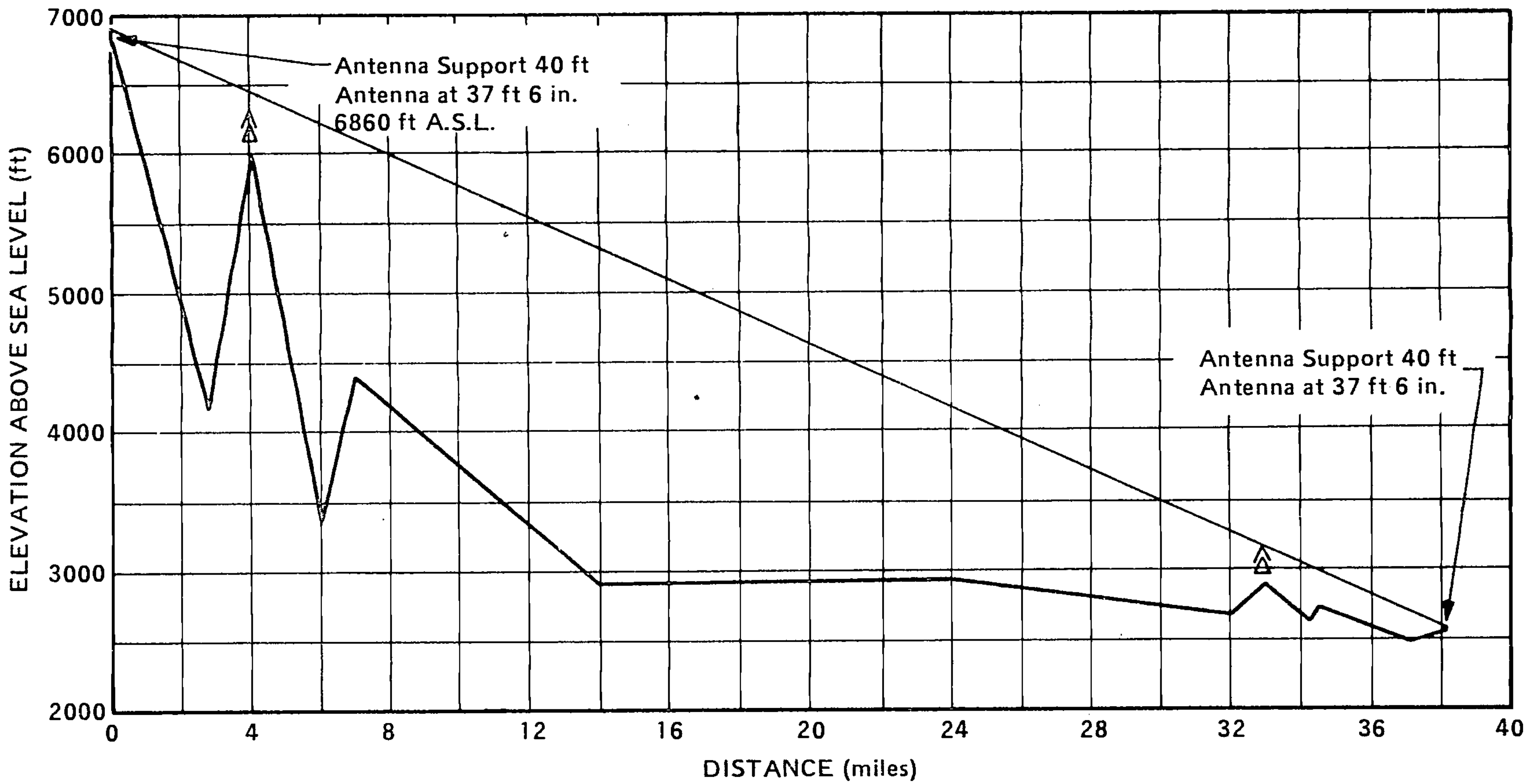

Figure A.5. Microwave Path Profile, Kitt Peak to San Xavier Antenna.

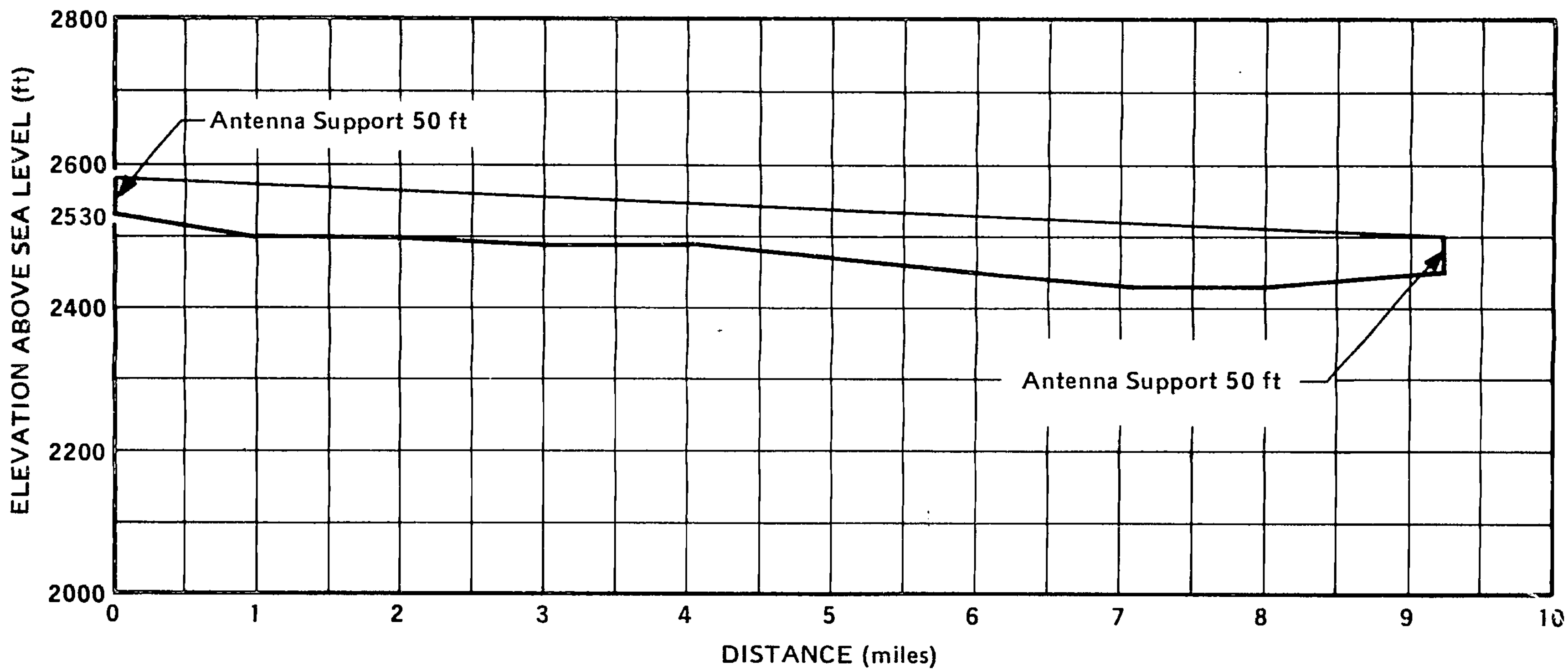

Figure A.6. Microwave Path Profile, San Xavier to Tucson.

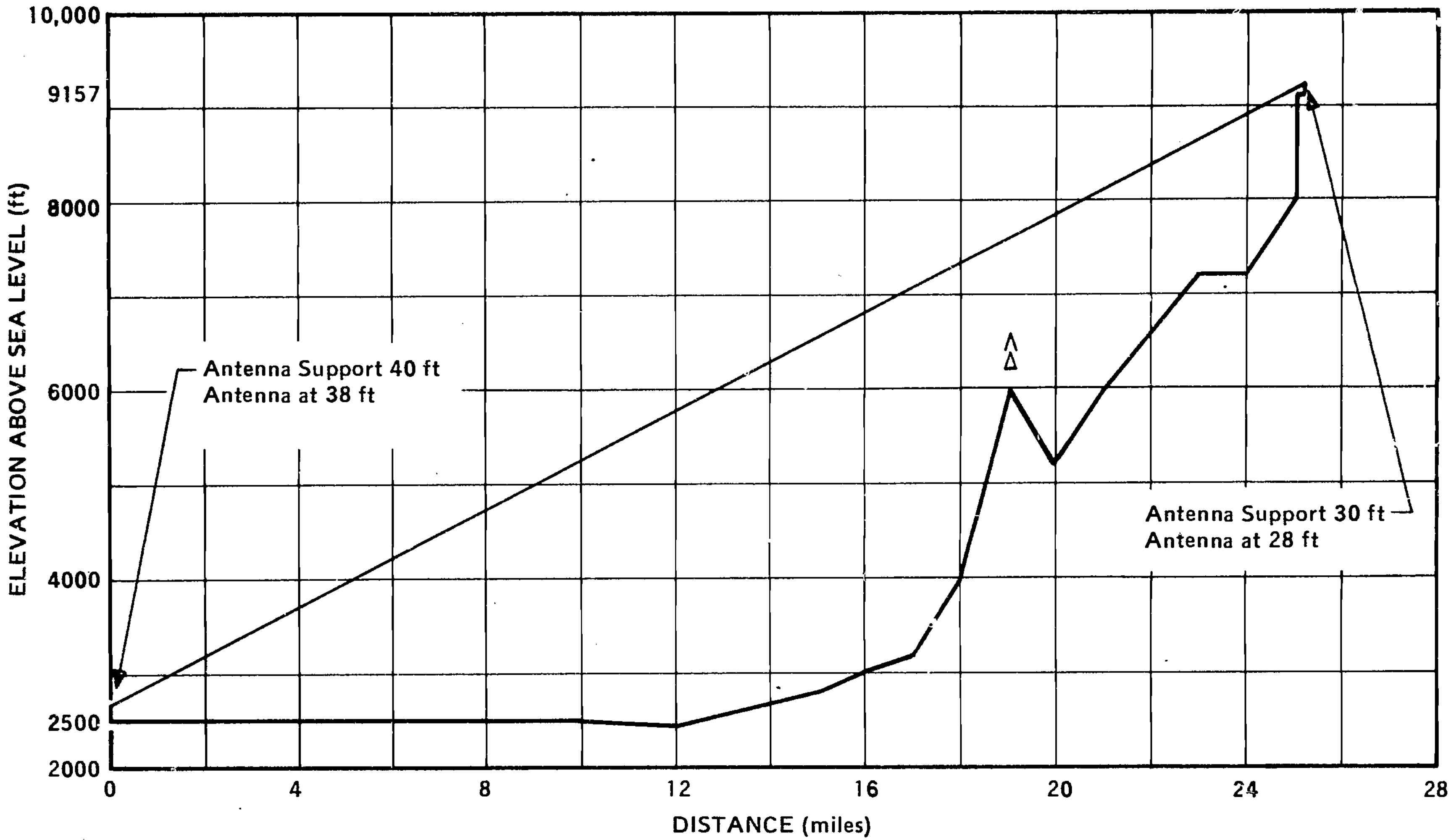

Figure A.7. Microwave Path Profile, San Xavier to Mount Lemmon.

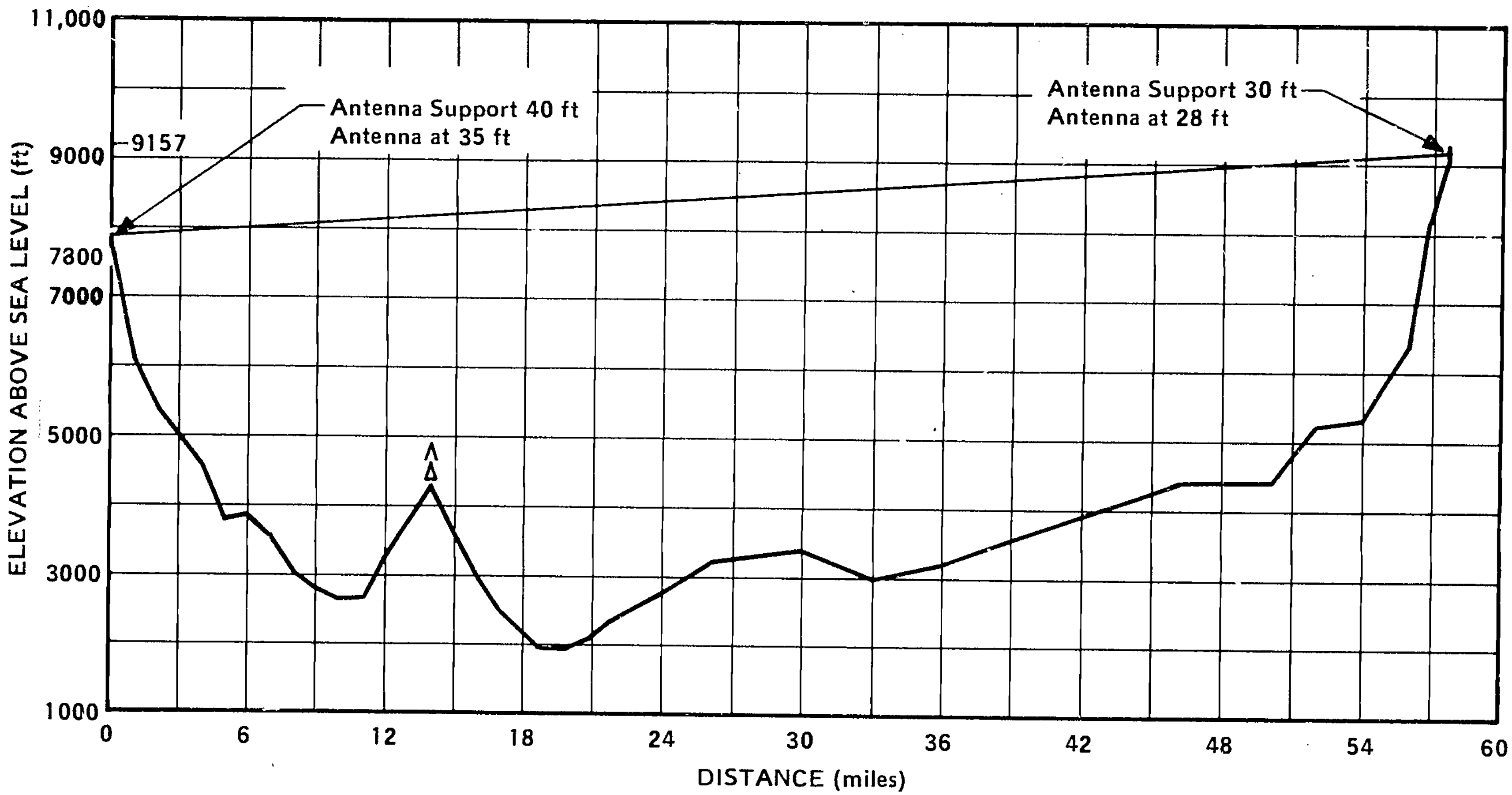

Figure A.8. Microwave Path Profile, Pinal Peak to Mount Lemmon.

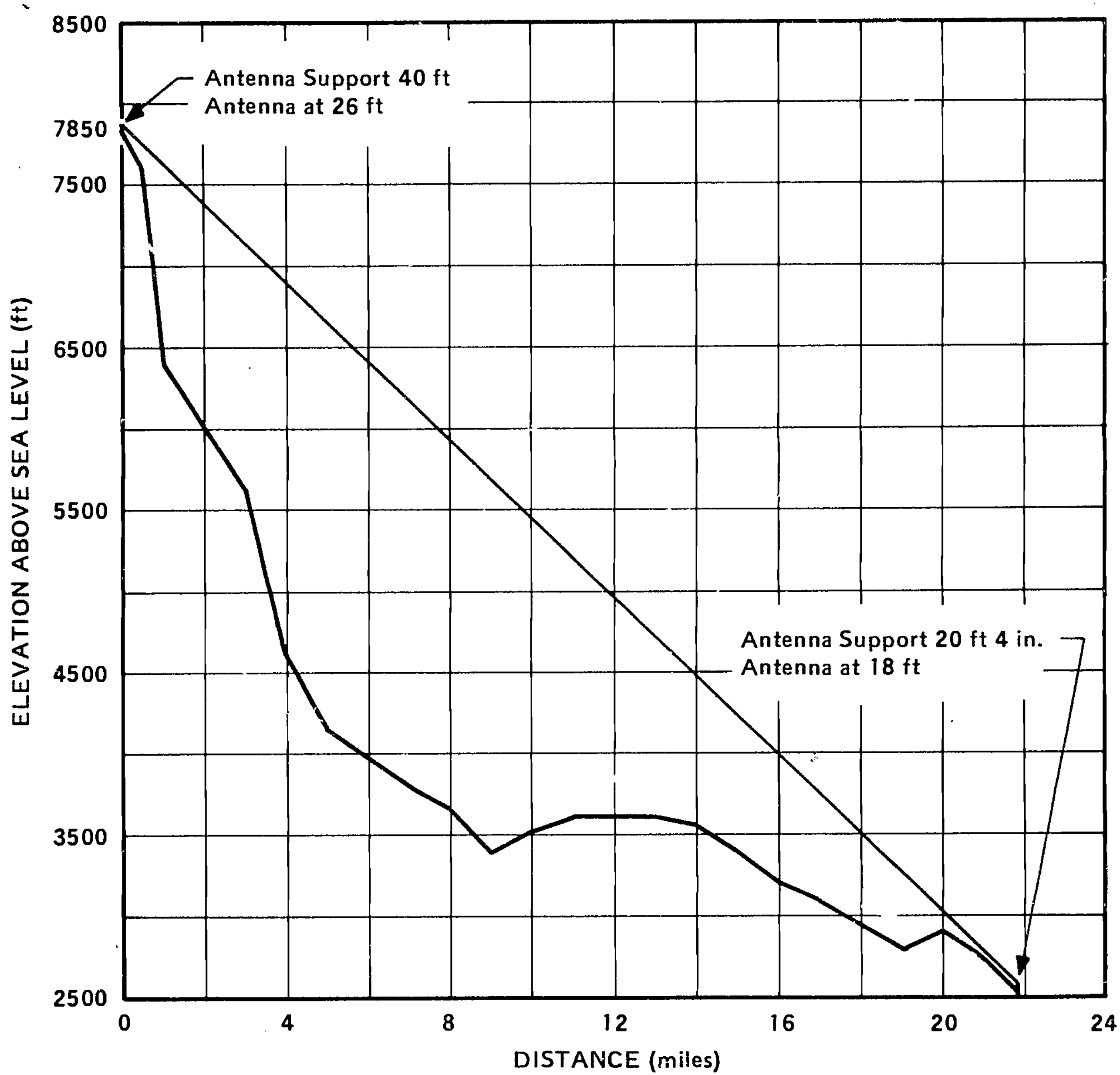

Figure A.9. Microwave Path Profile, Pinal Peak to San Carlos.

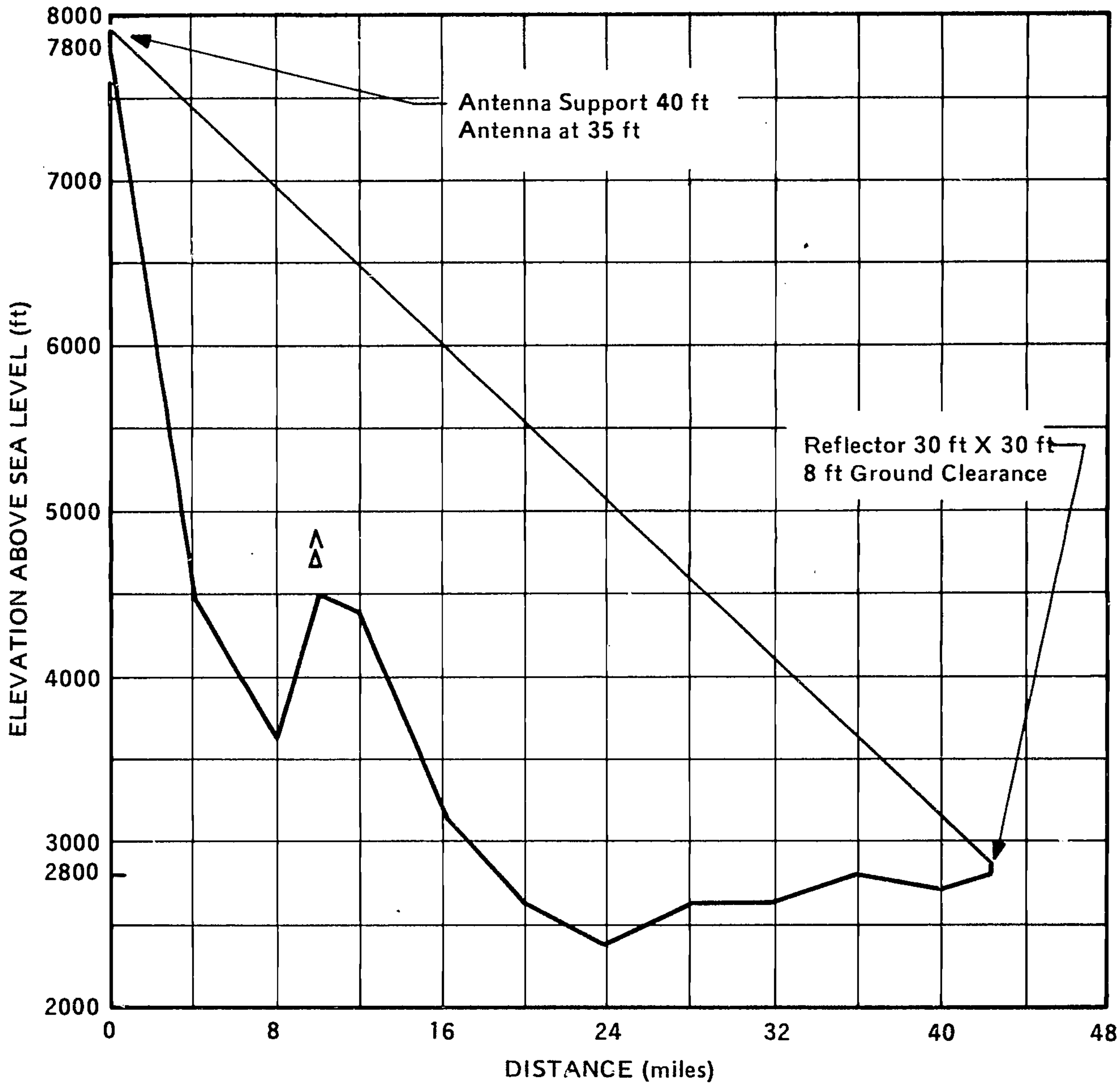

Figure A.10. Microwave Path Profile, Pinal Peak to Bylas Reflector.

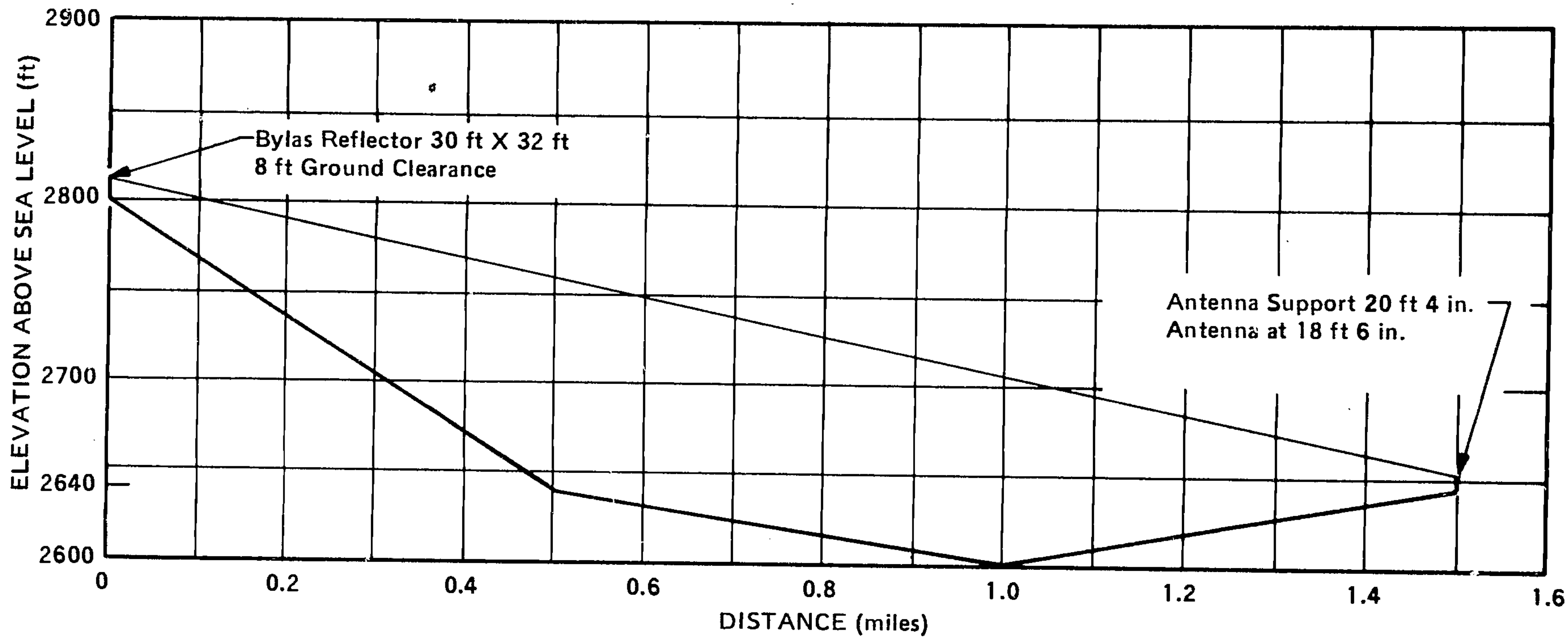

Figure A.11. Microwave Path Profile, Bylas Reflector to Bylas.

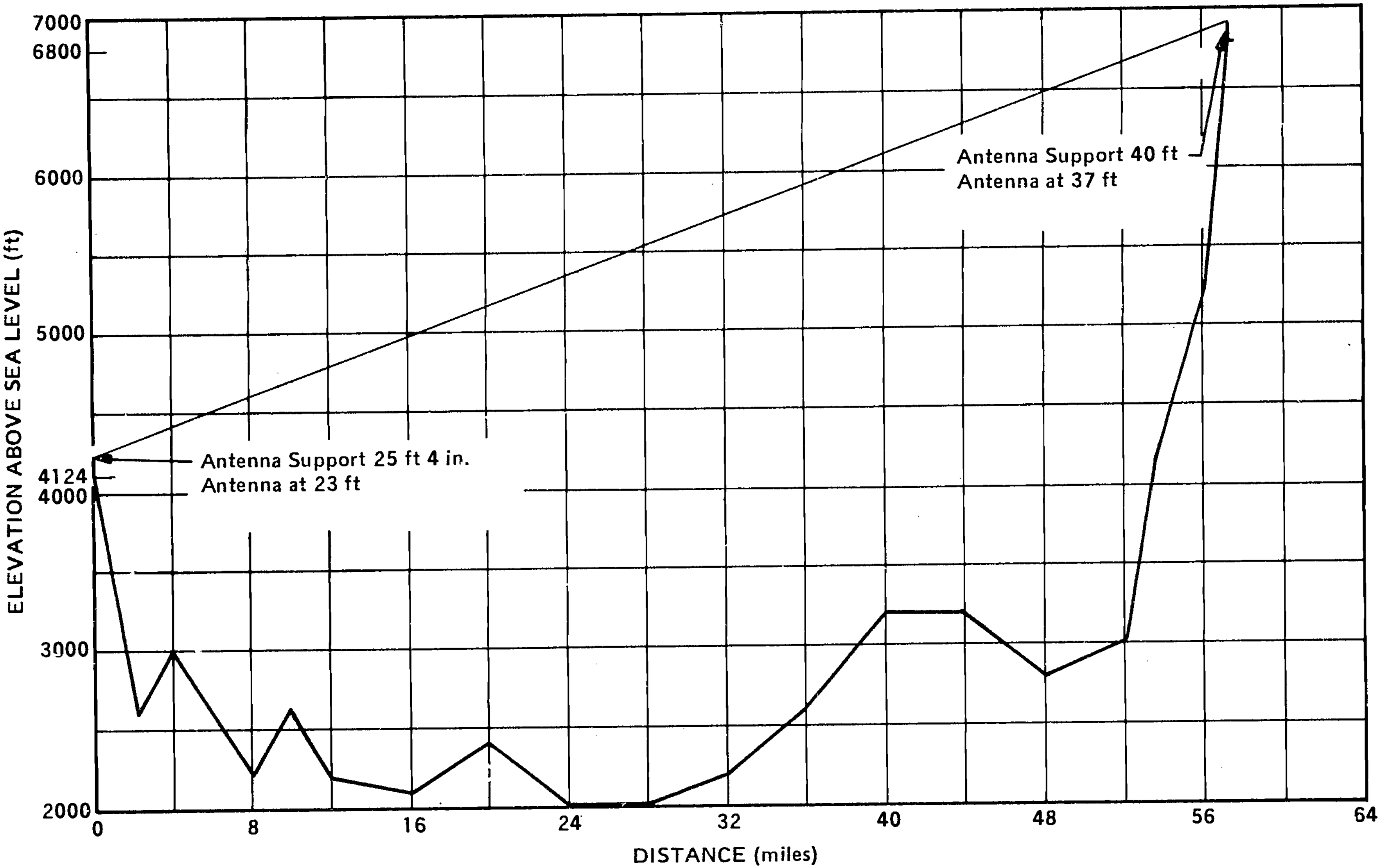

Figure A.12. Microwave Path Profile, Cimarron Peak to Kitt Peak.

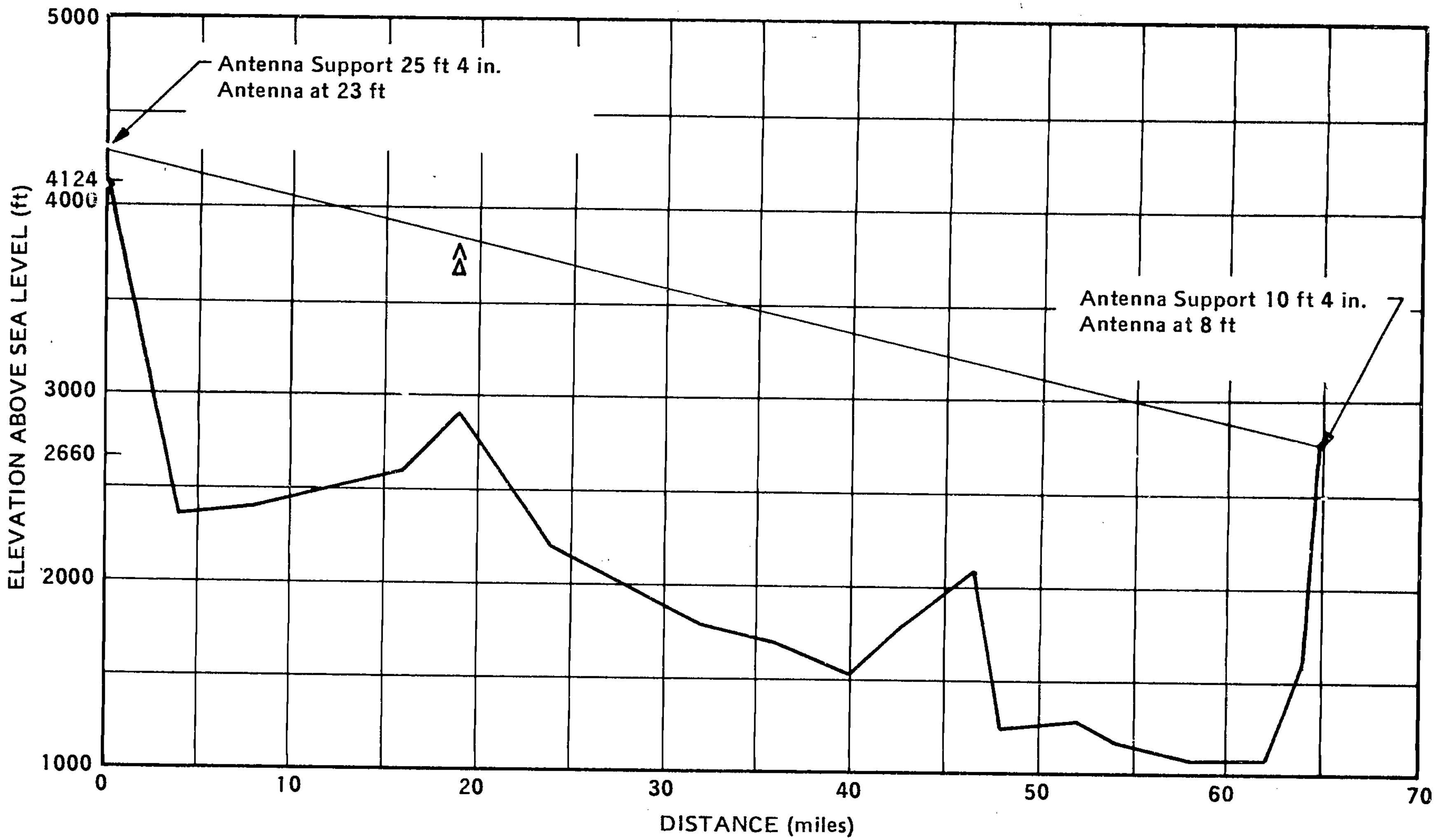

Figure A.13. Microwave Path Profile, Cimarron Peak to South Mountain.

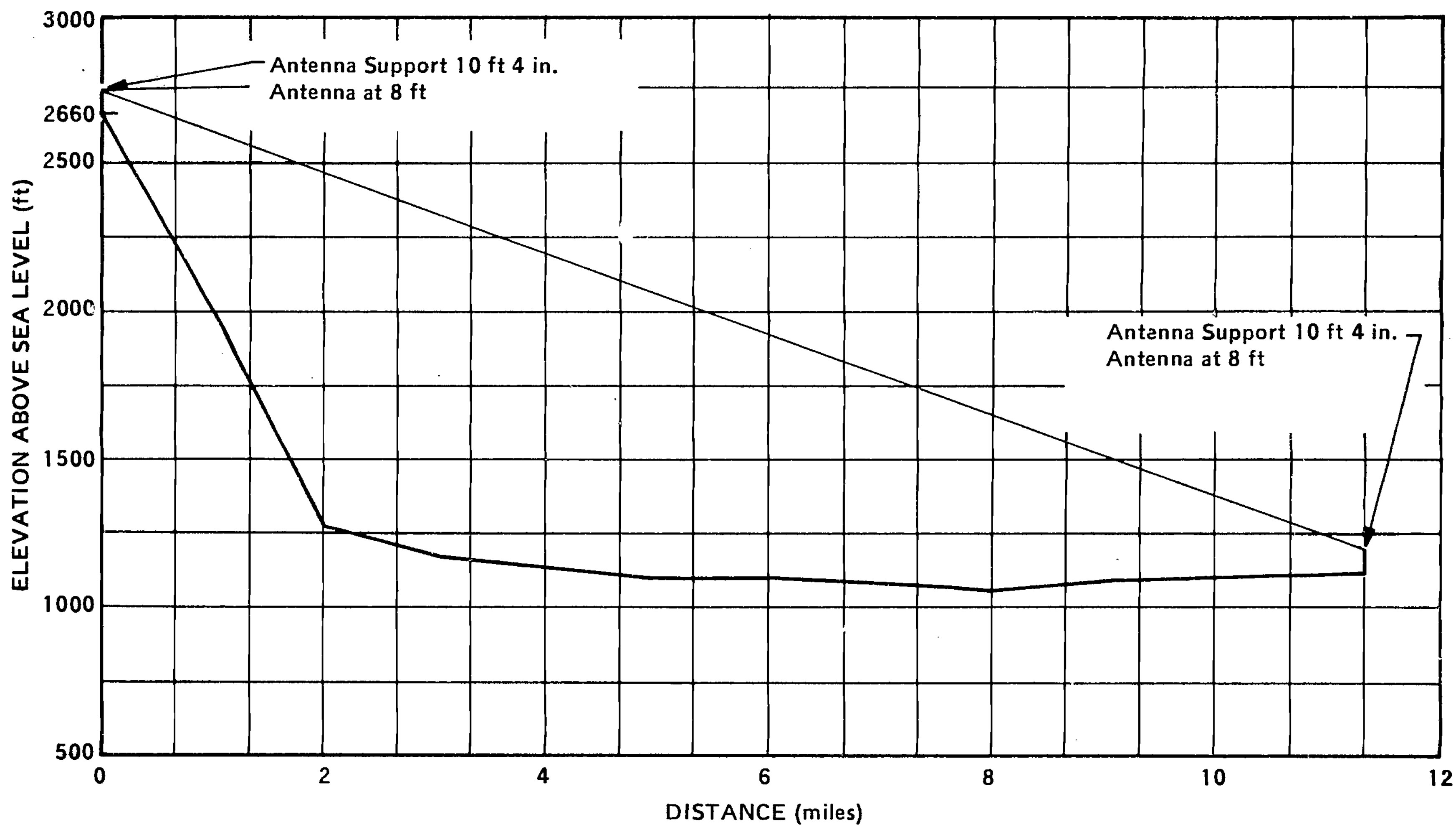

Figure A.14. Microwave Path Profile, South Mountain to Phoenix.

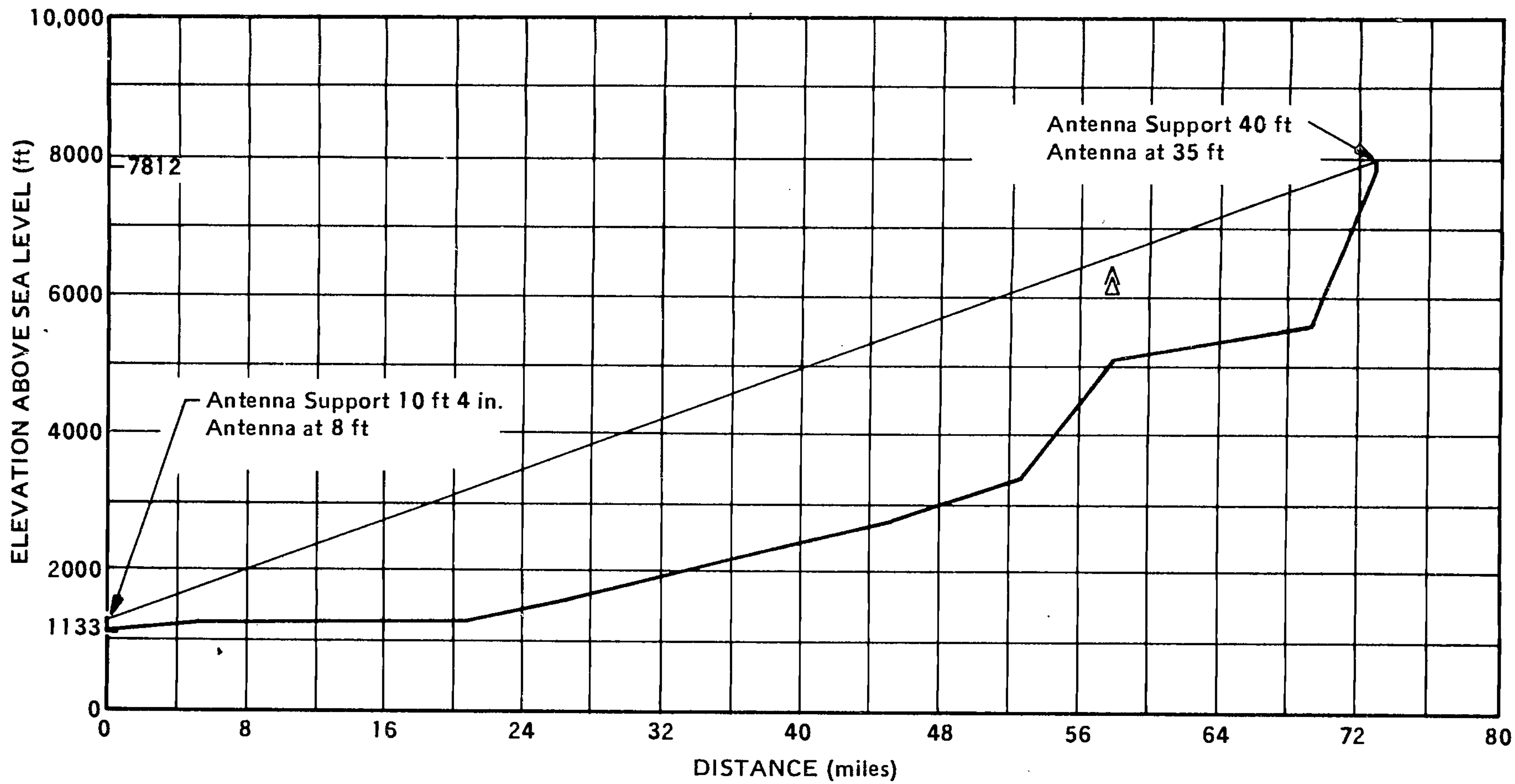

Figure A.15. Microwave Path Profile, Phoenix to Pinal Peak.

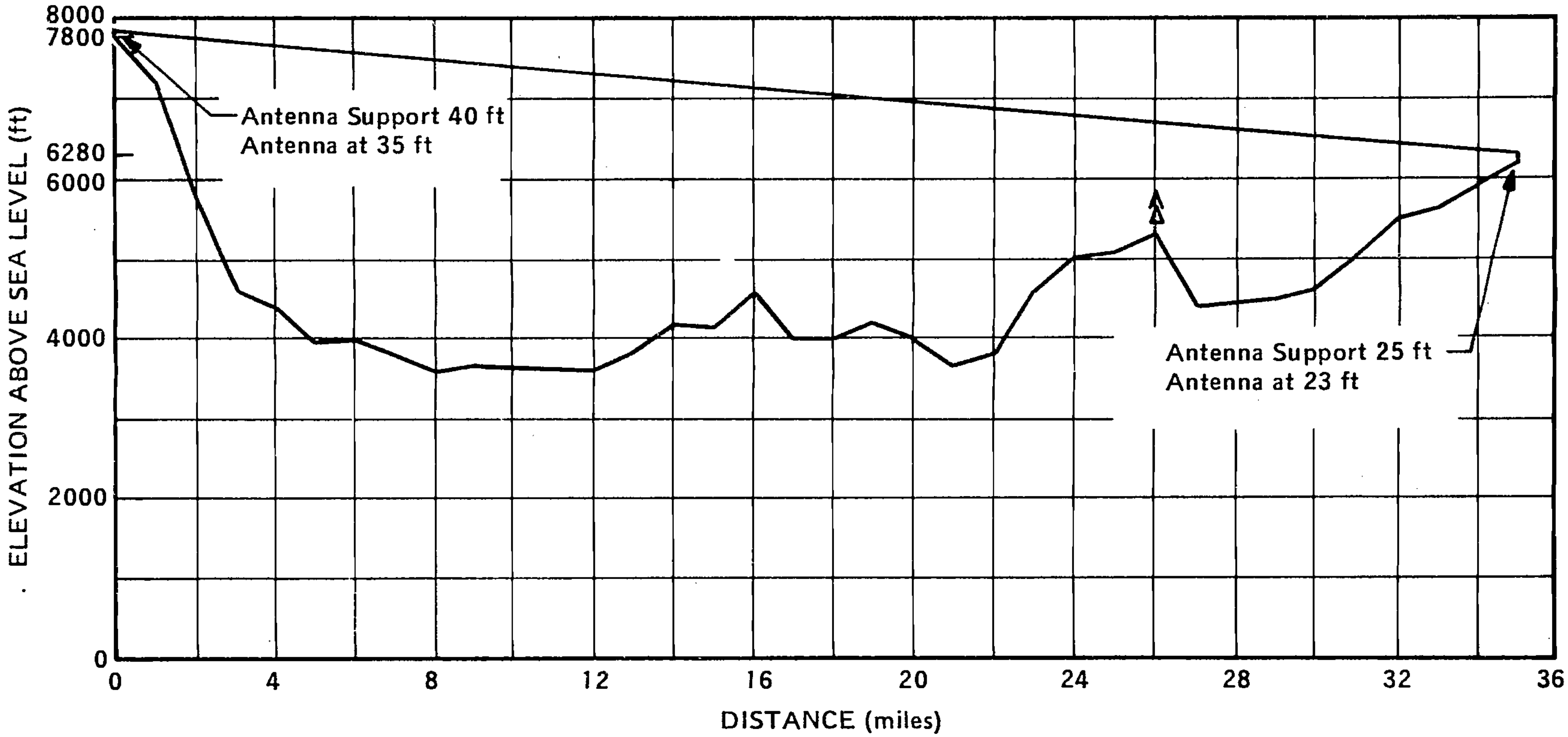

Figure A.16. Microwave Path Profile, Pinal Peak to Mormon Tank.

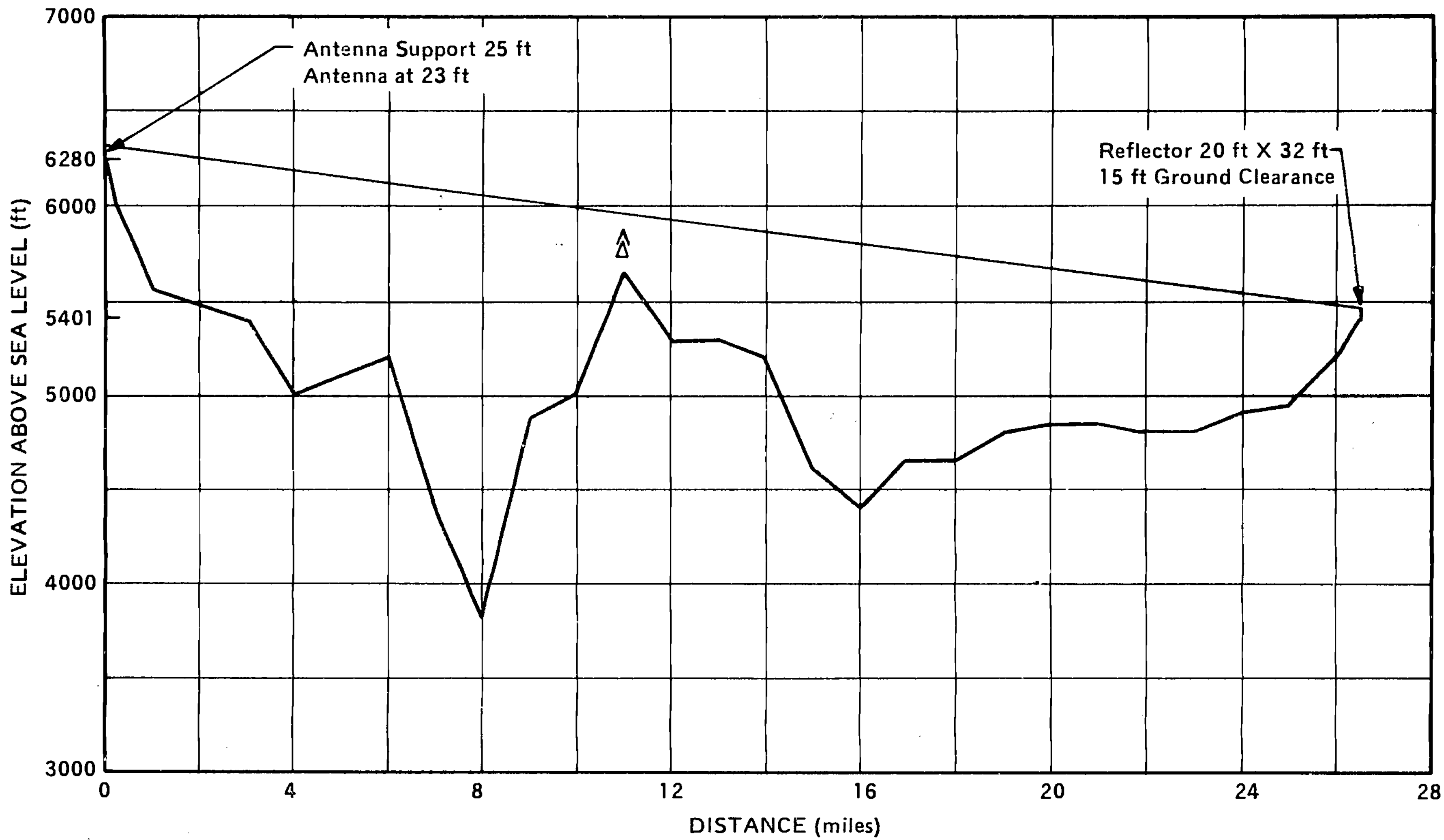

Figure A.17. Microwave Path Profile, Mormon Tank to Cibecue Reflector.

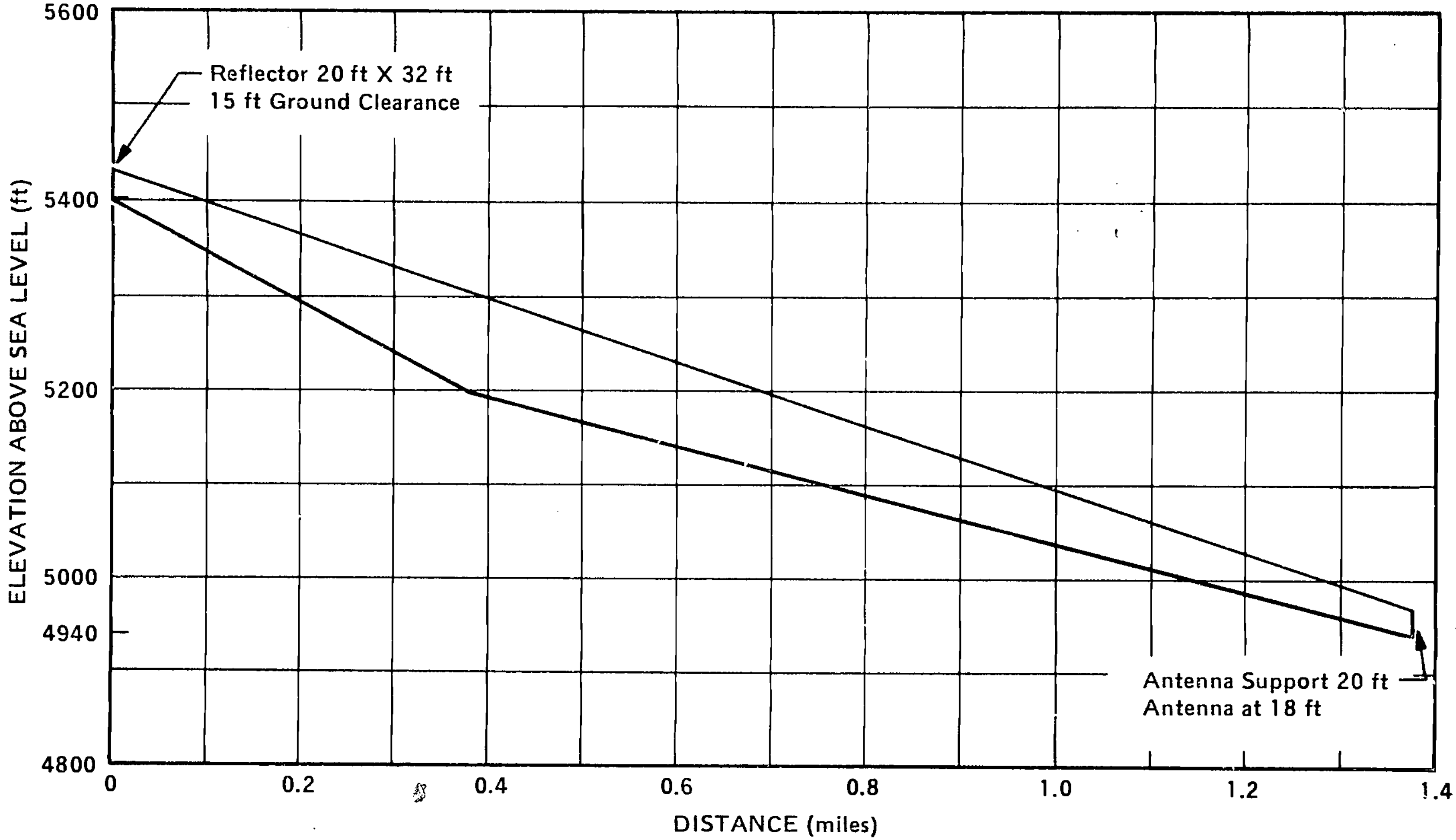

Figure A.18. Microwave Path Profile, Cibecue Reflector to Cibecue.

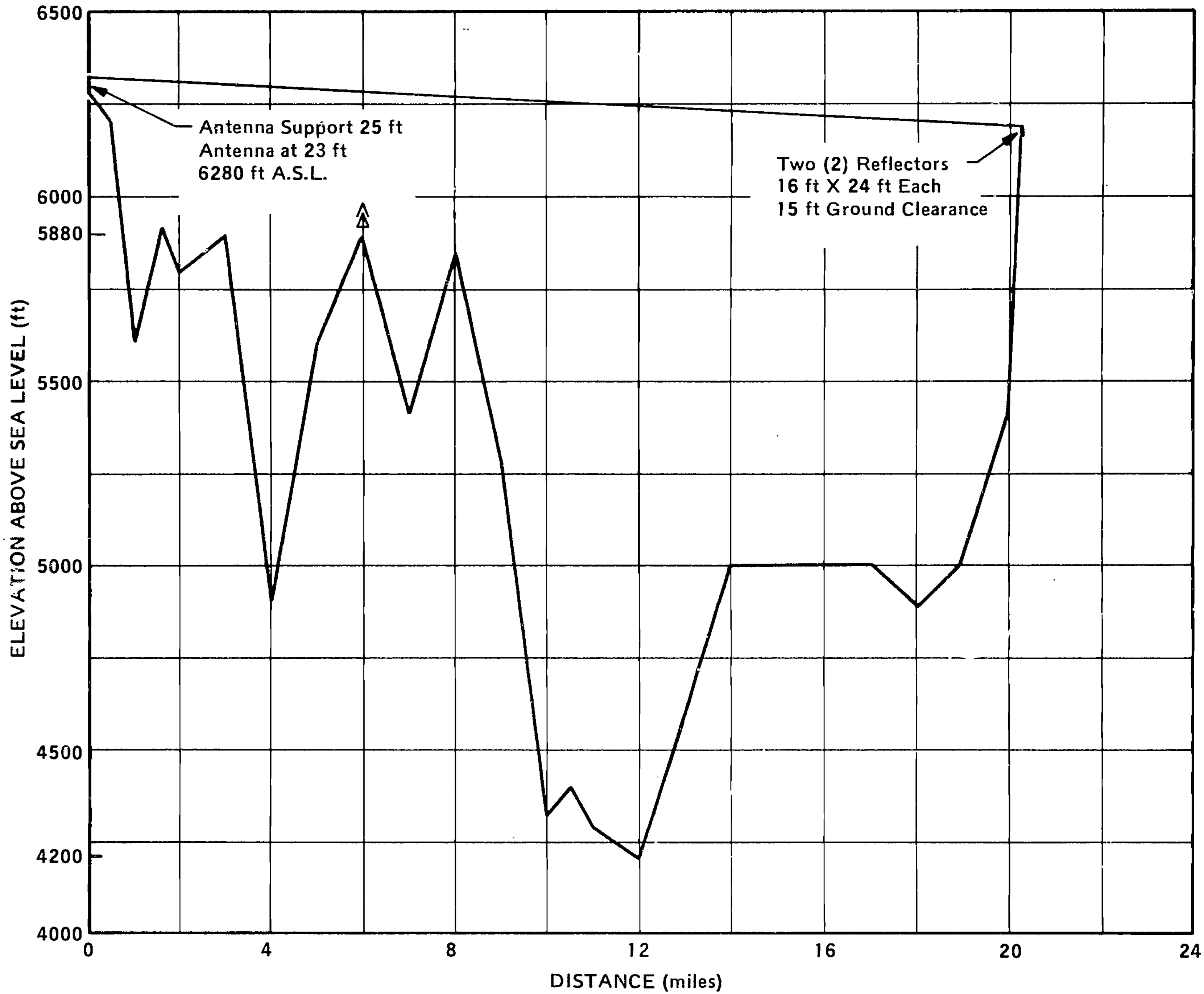

Figure A.19. Microwave Path Profile, Mormon Tank to Silver Butte Reflector.

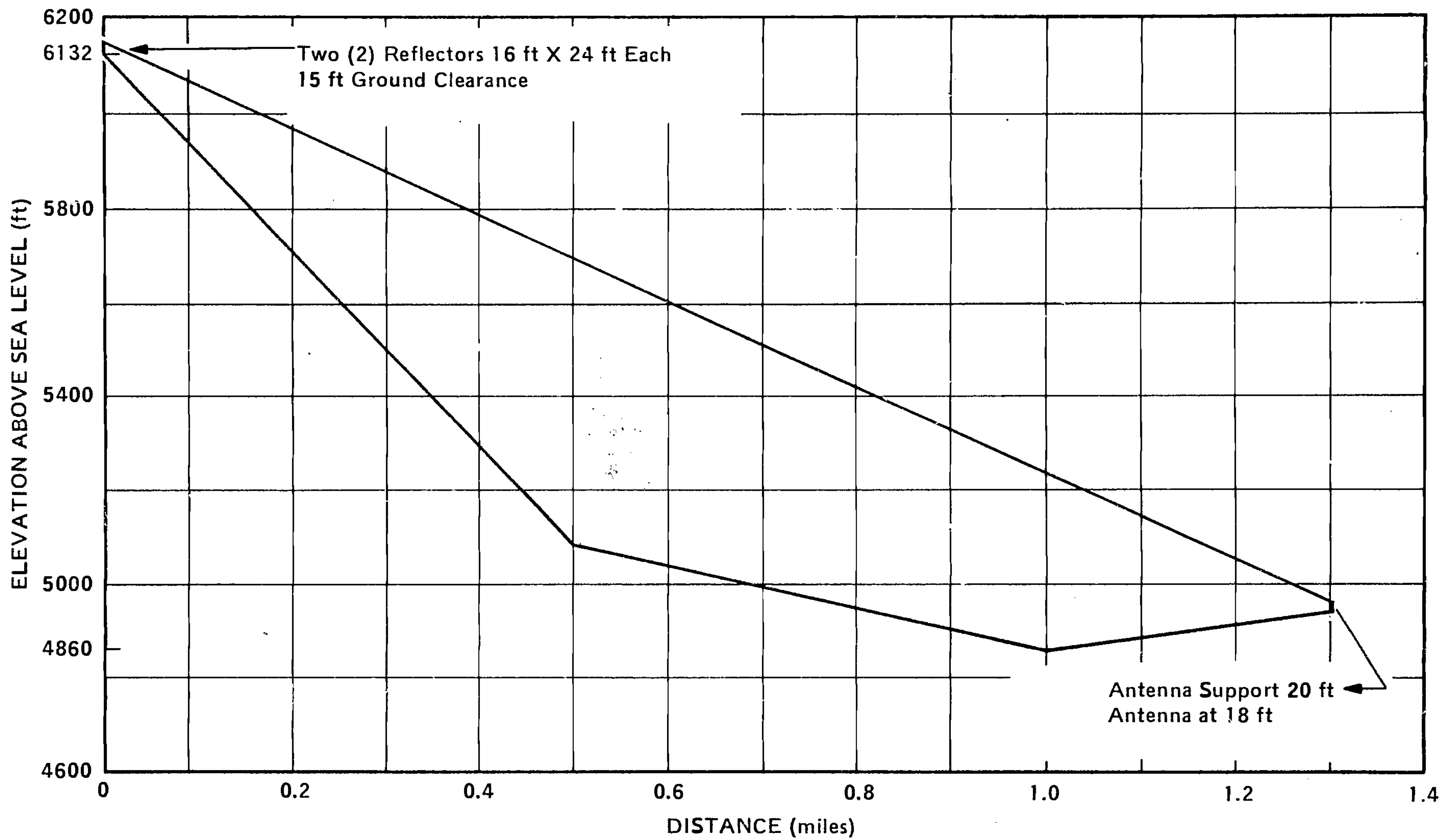

Figure A.20. Microwave Path Profile, Silver Butte Reflector to Cedar Creek.

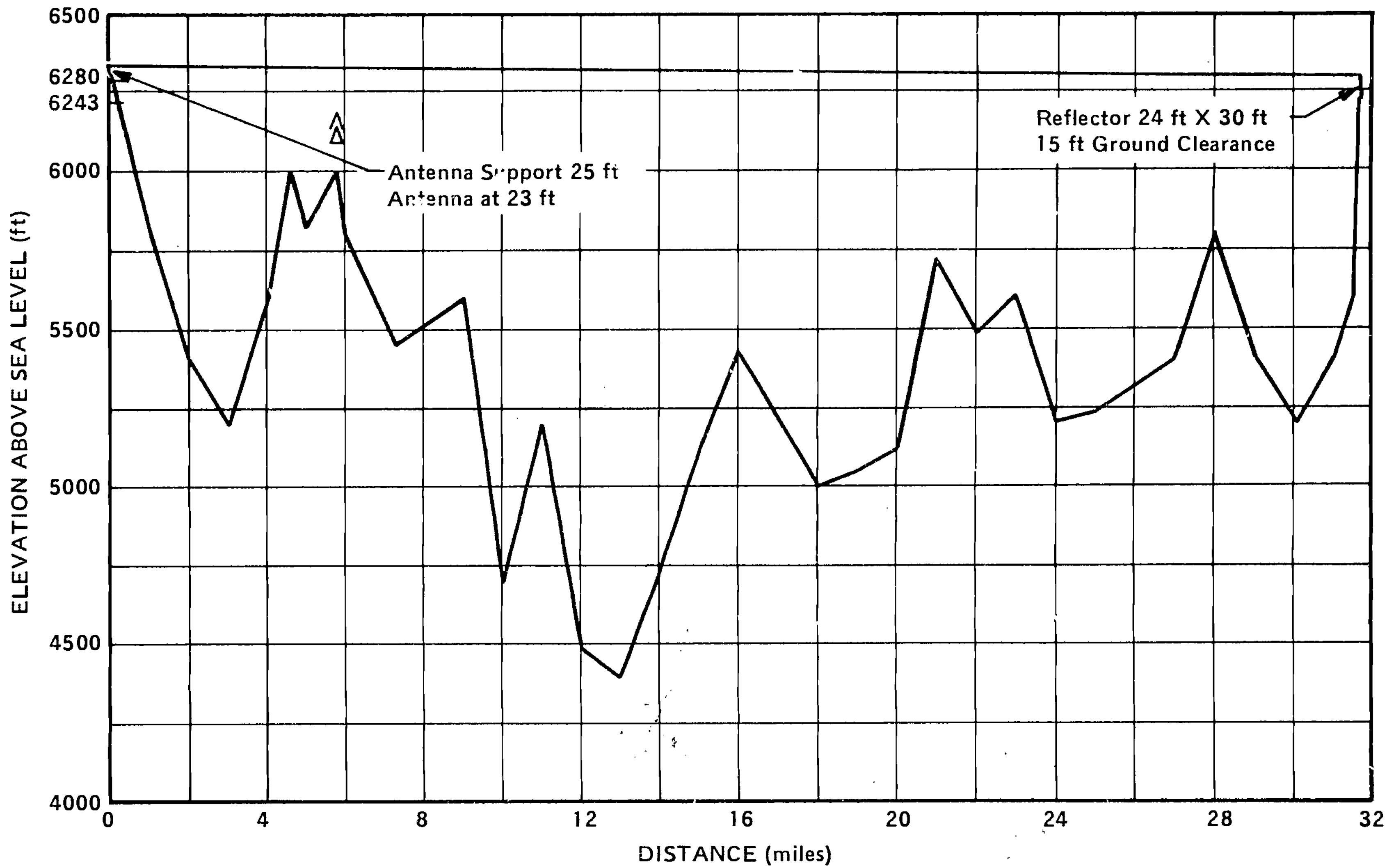

Figure A.21. Microwave Path Profile, Mormon Tank to White River Reflector.

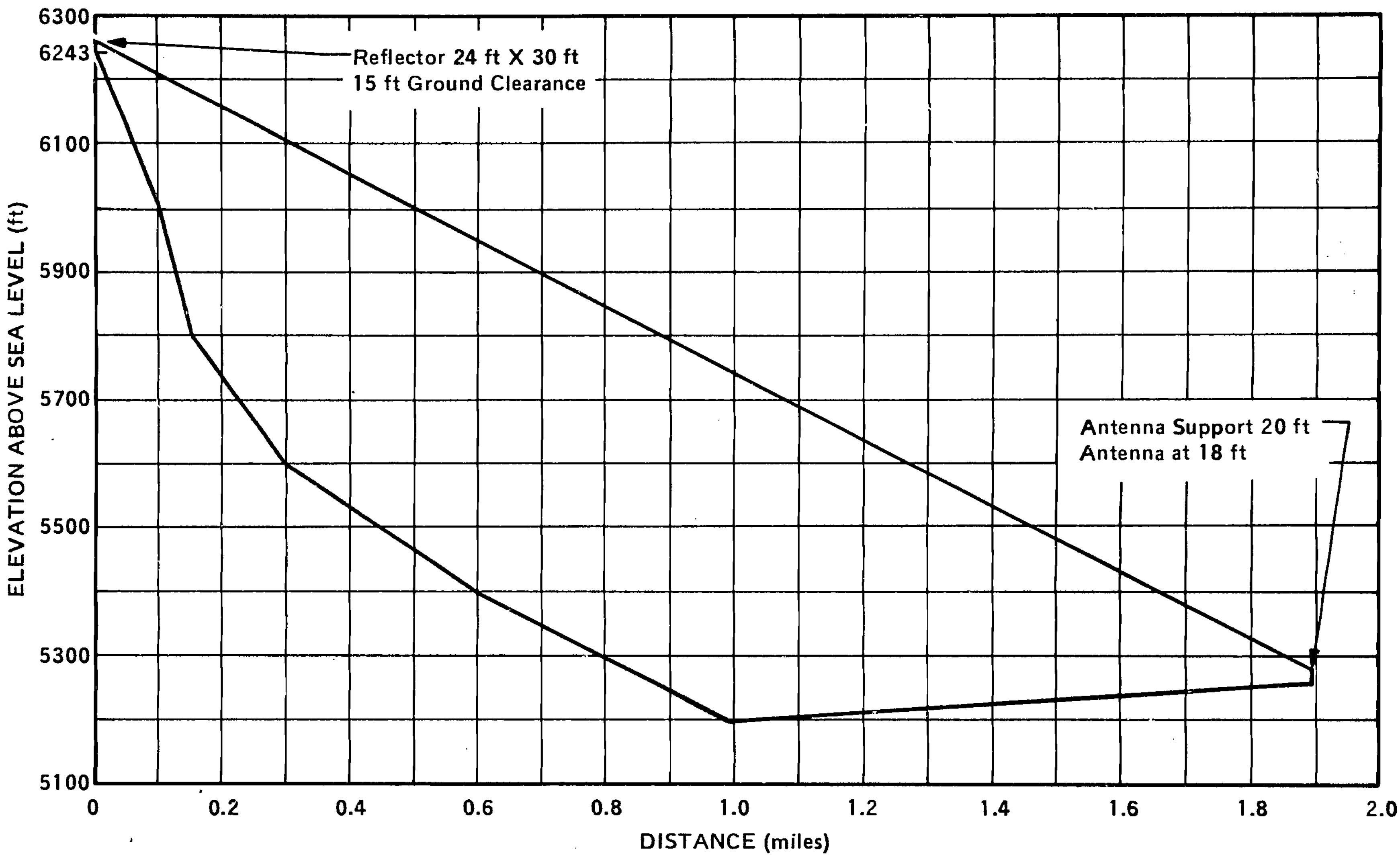

Figure A.22. Microwave Path Profile, Whiteriver Reflector to Whiteriver.

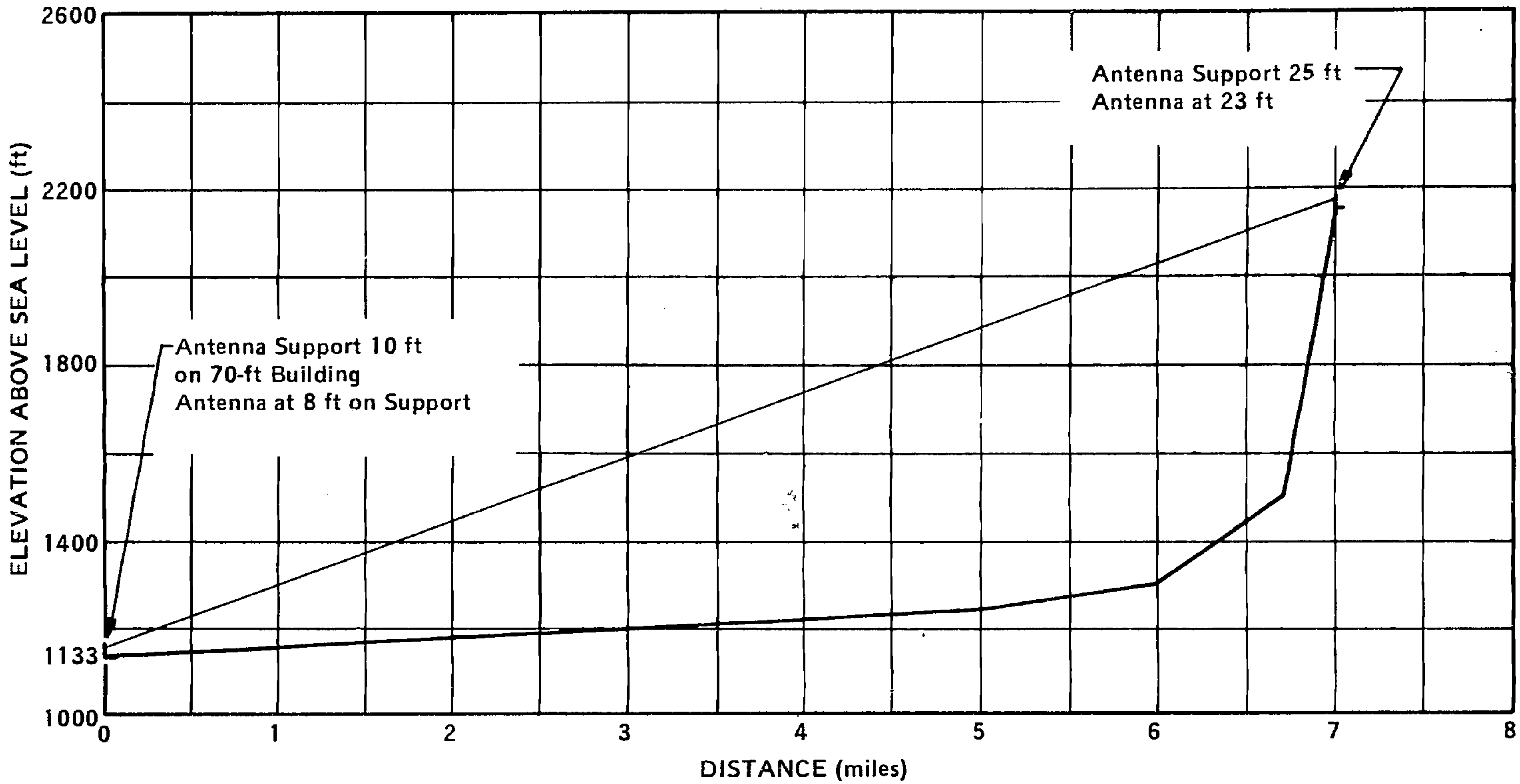

Figure A.23. Microwave Path Profile, Phoenix to Shaw Butte.

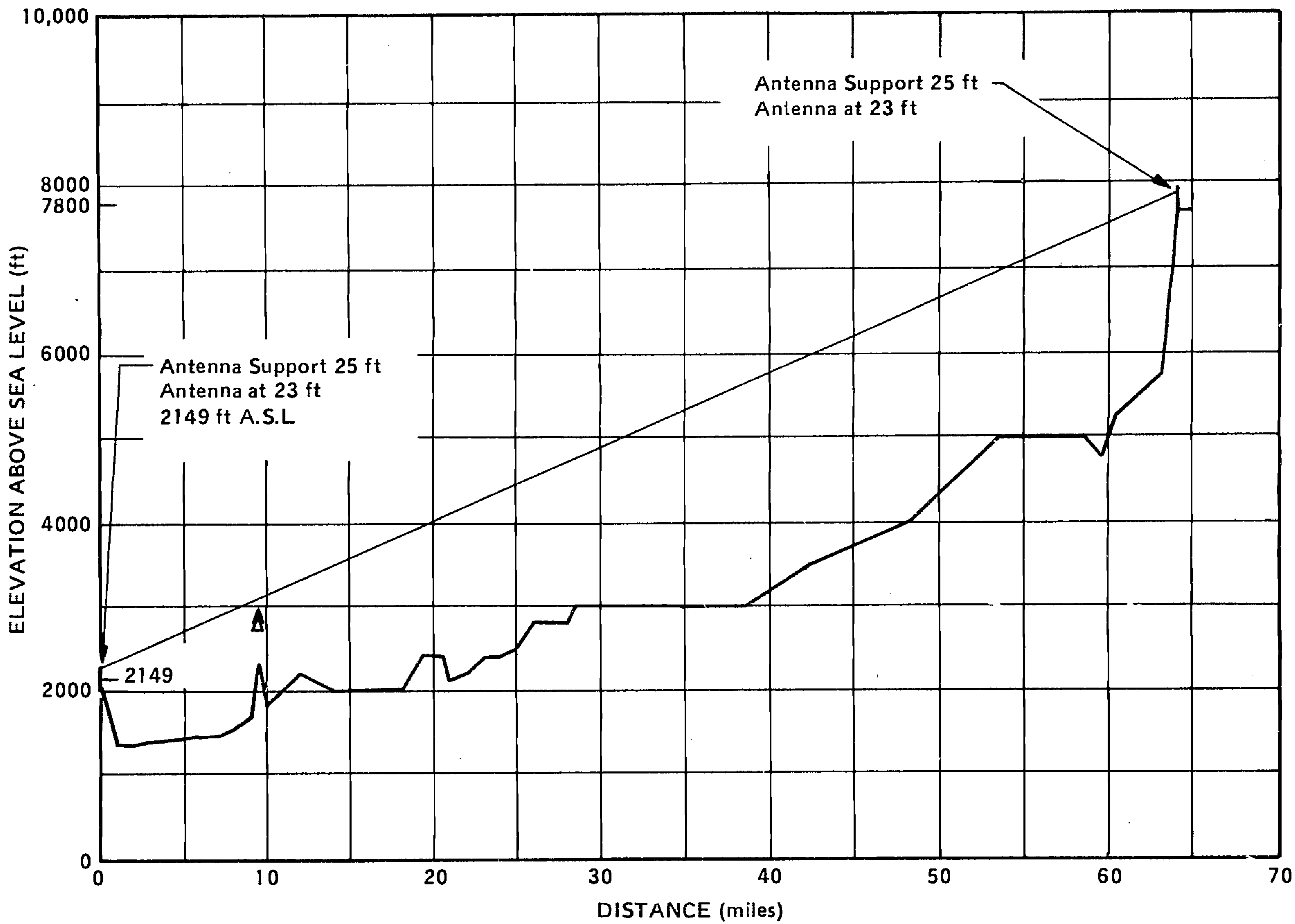

Figure A.24. Microwave Path Profile, Shaw Butte to Mingus Mountain.

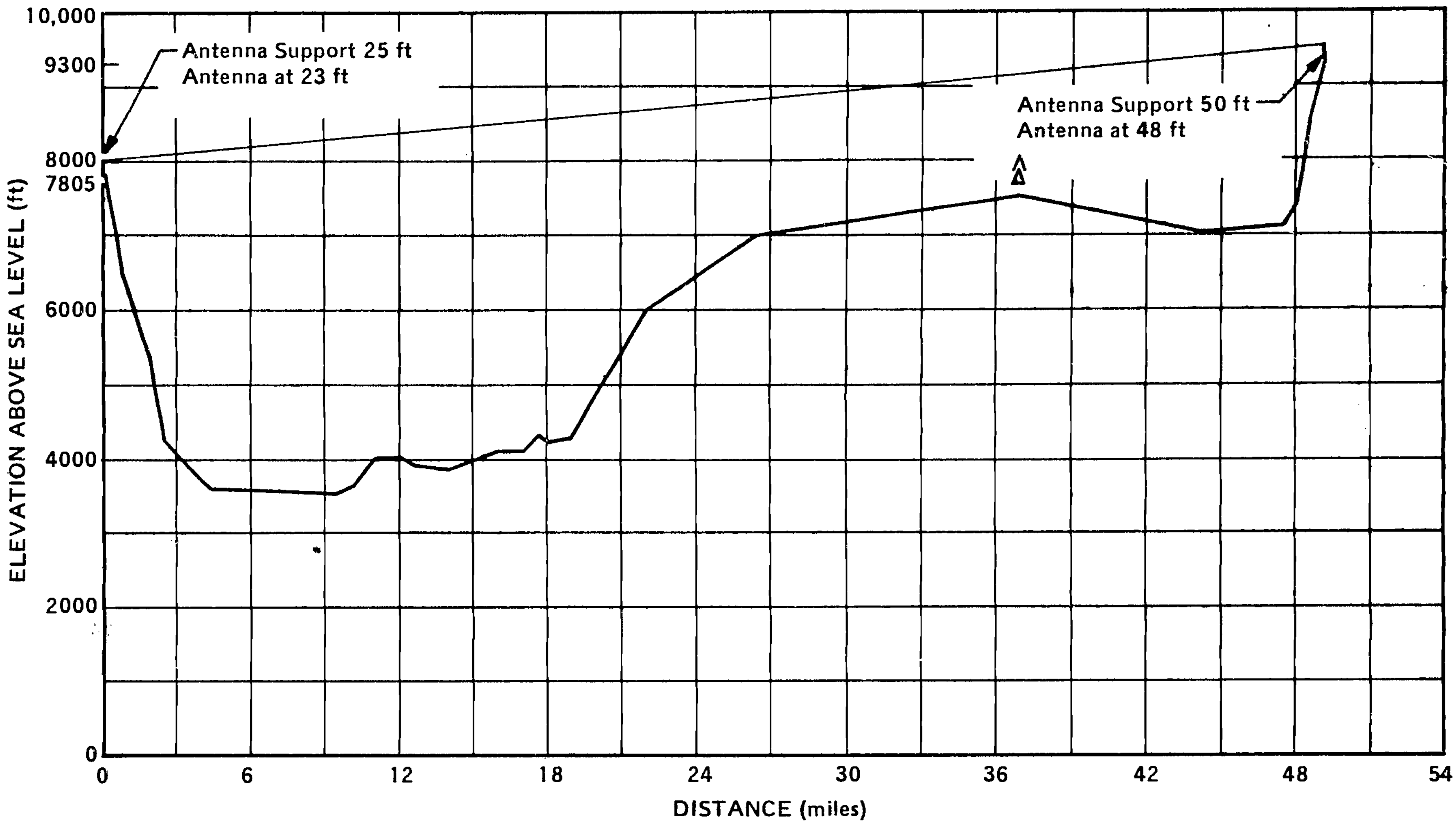

Figure A.25. Microwave Path Profile, Mingus Mountain to Elden Mountain.

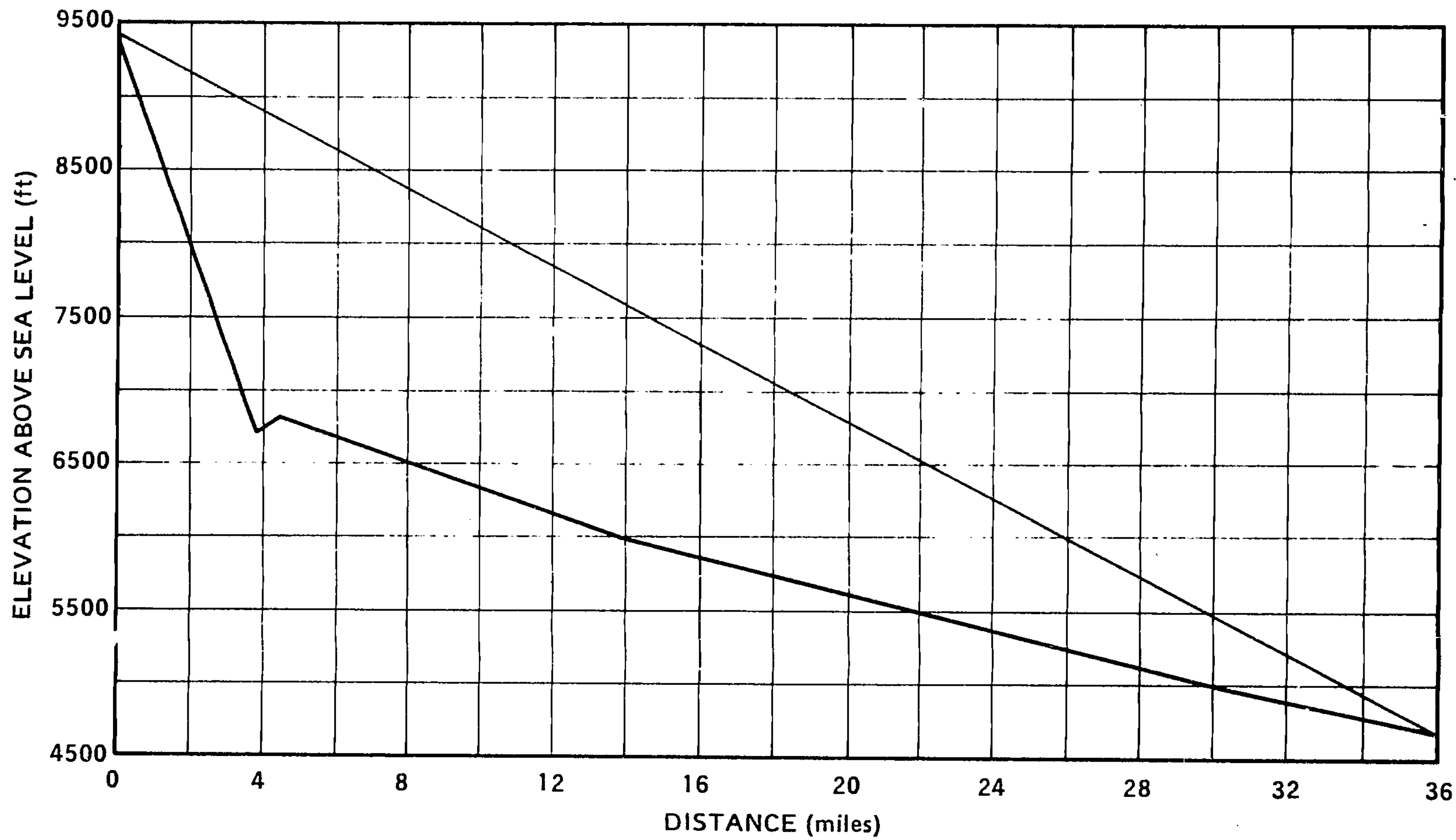

Figure A.26. Microwave Path Profile, Mount Elden to Leupp.

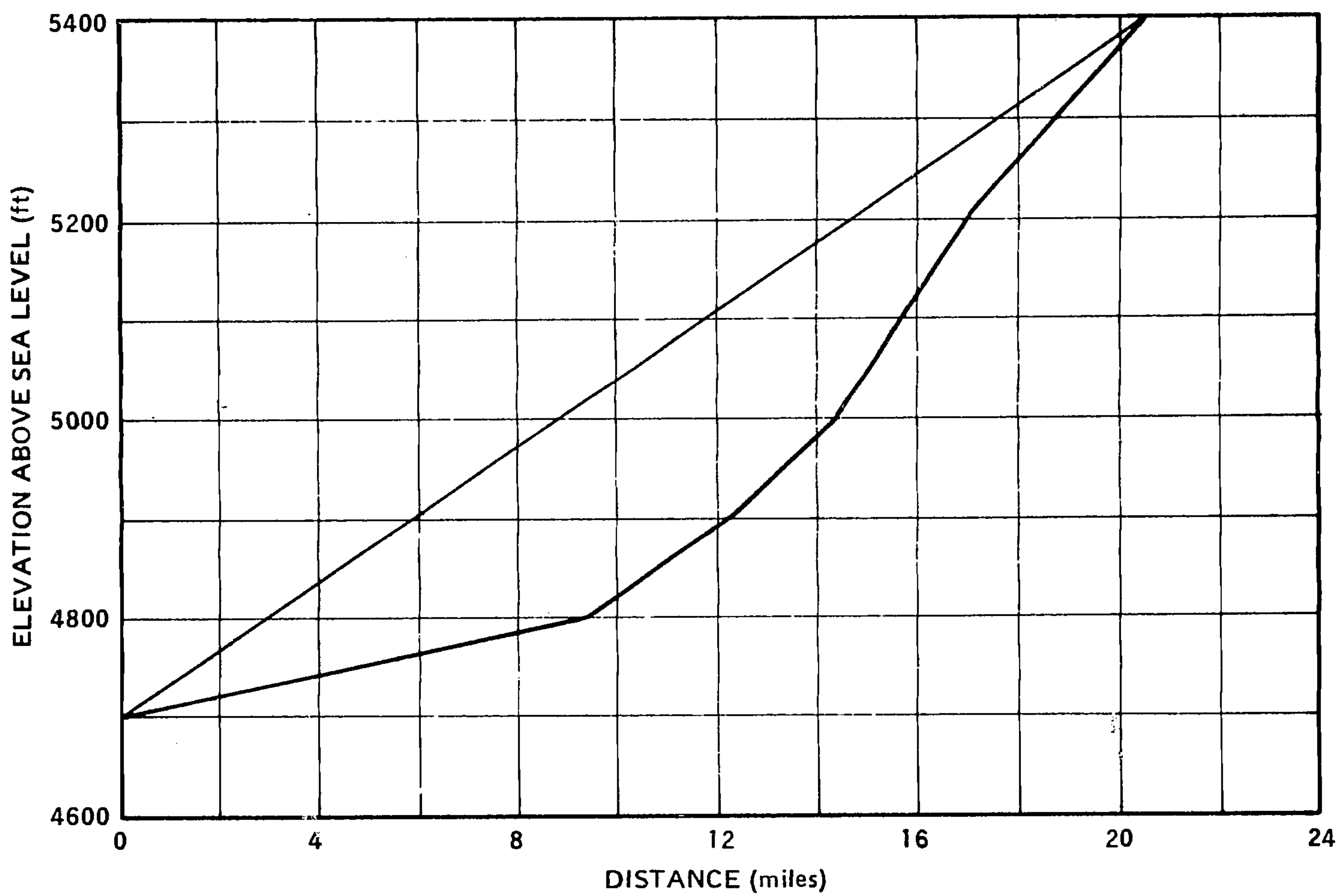

Figure A.27. Microwave Path Profile, Leupp to Ives Mesa.

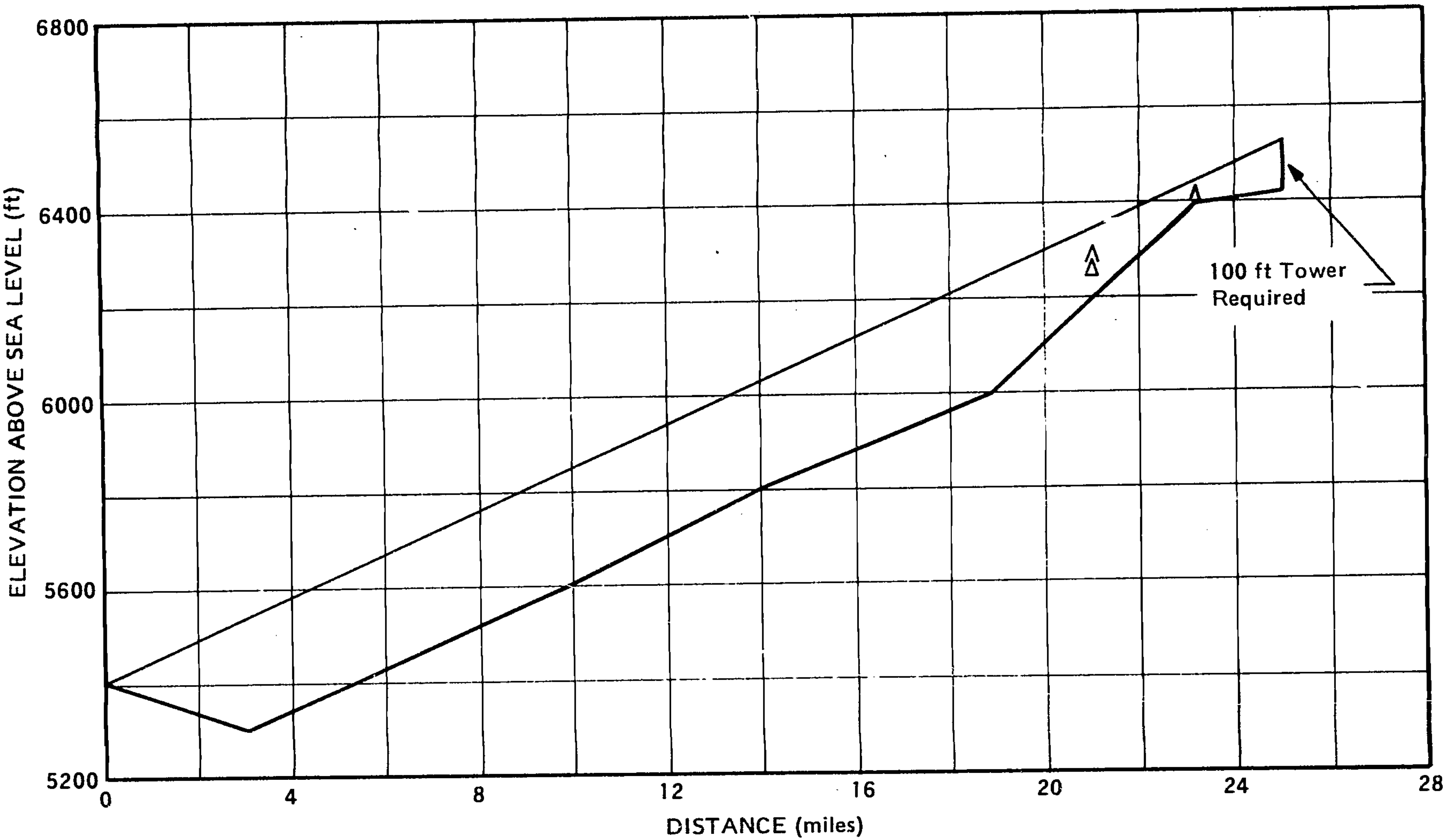

Figure A.28. Microwave Path Profile, Ives Mesa to Dilkon.

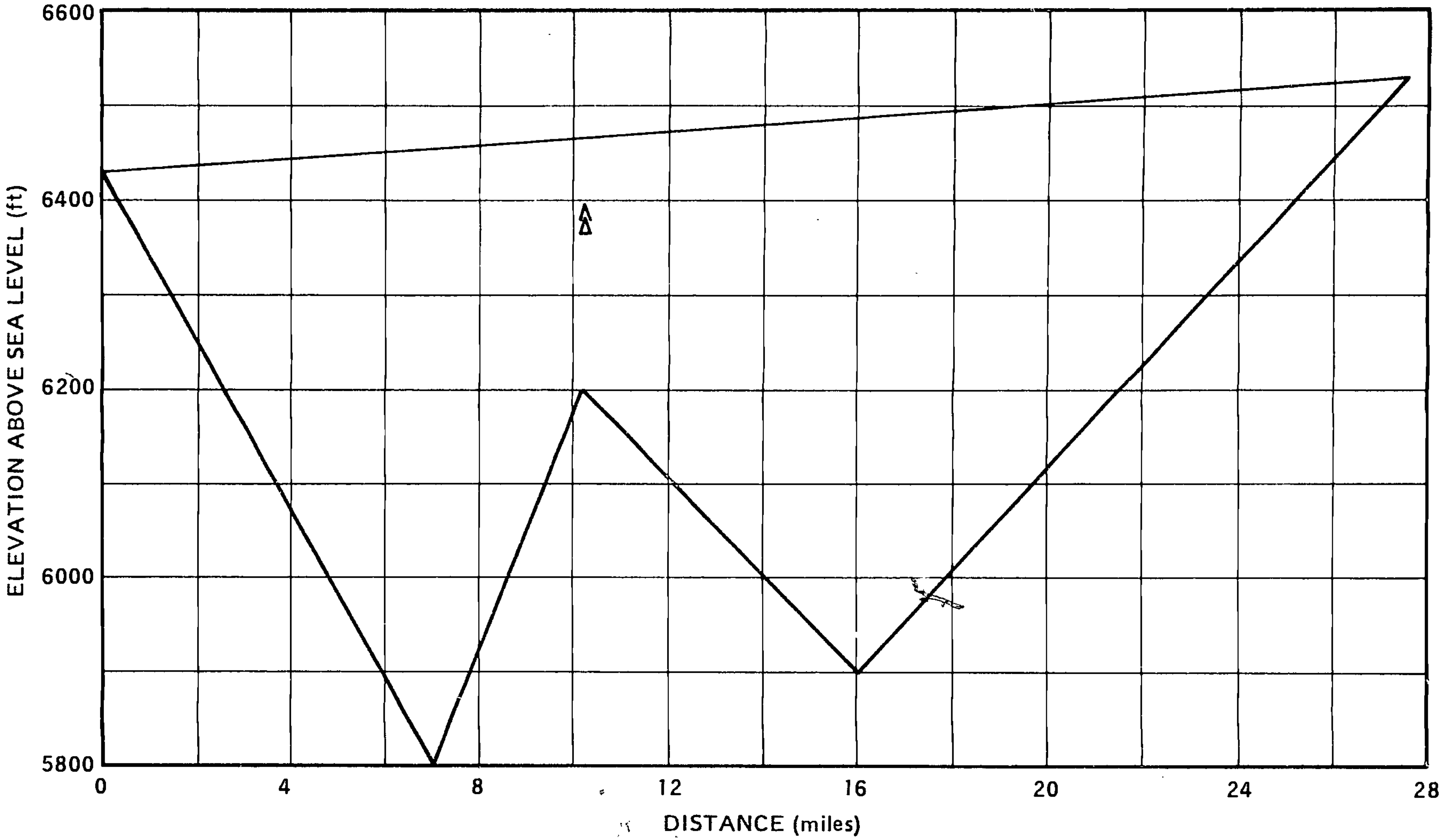

Figure A.29. Microwave Path Profile, Dilkon to Klagetoh.

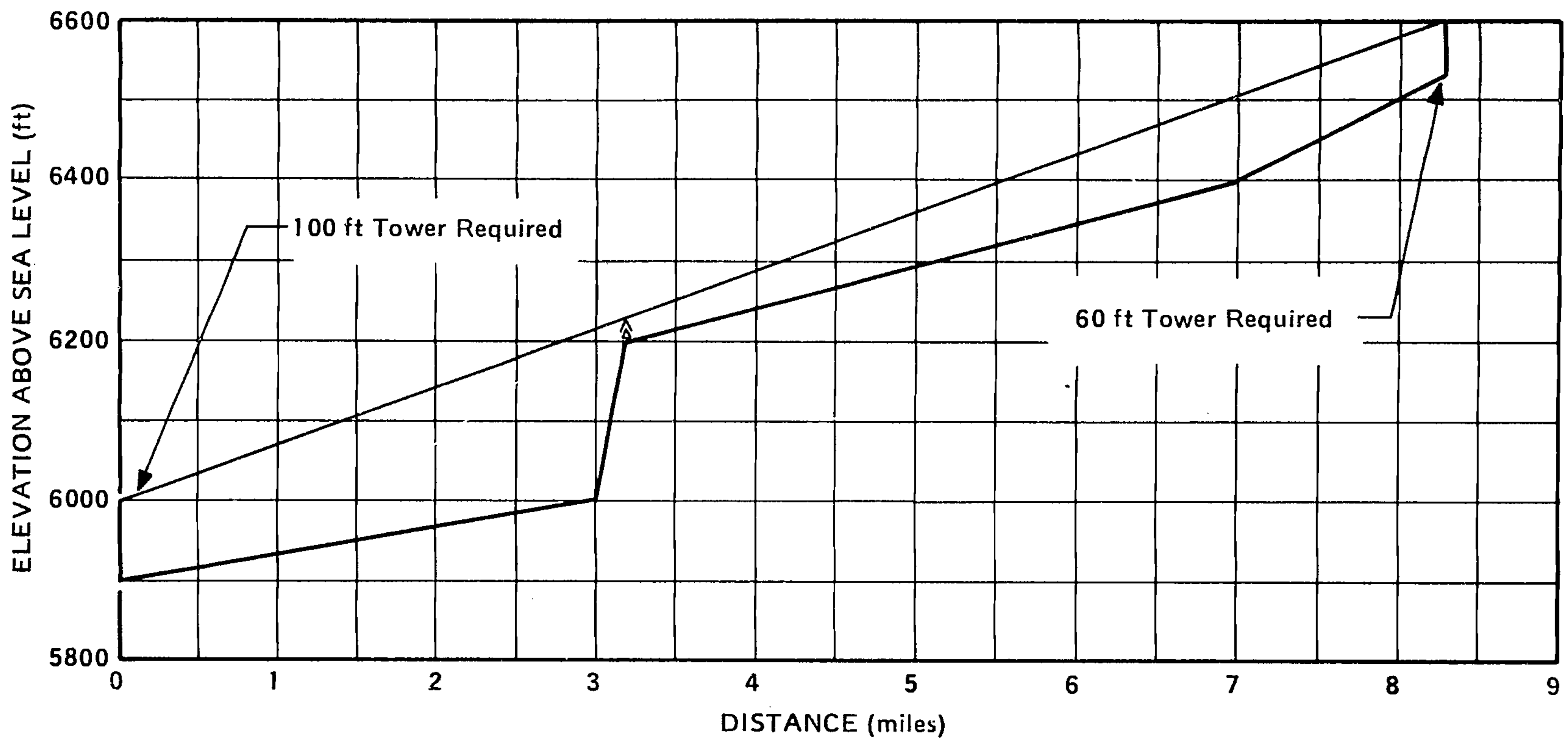

Figure A.30. Microwave Path Profile, Greasewood to Klagetoh.

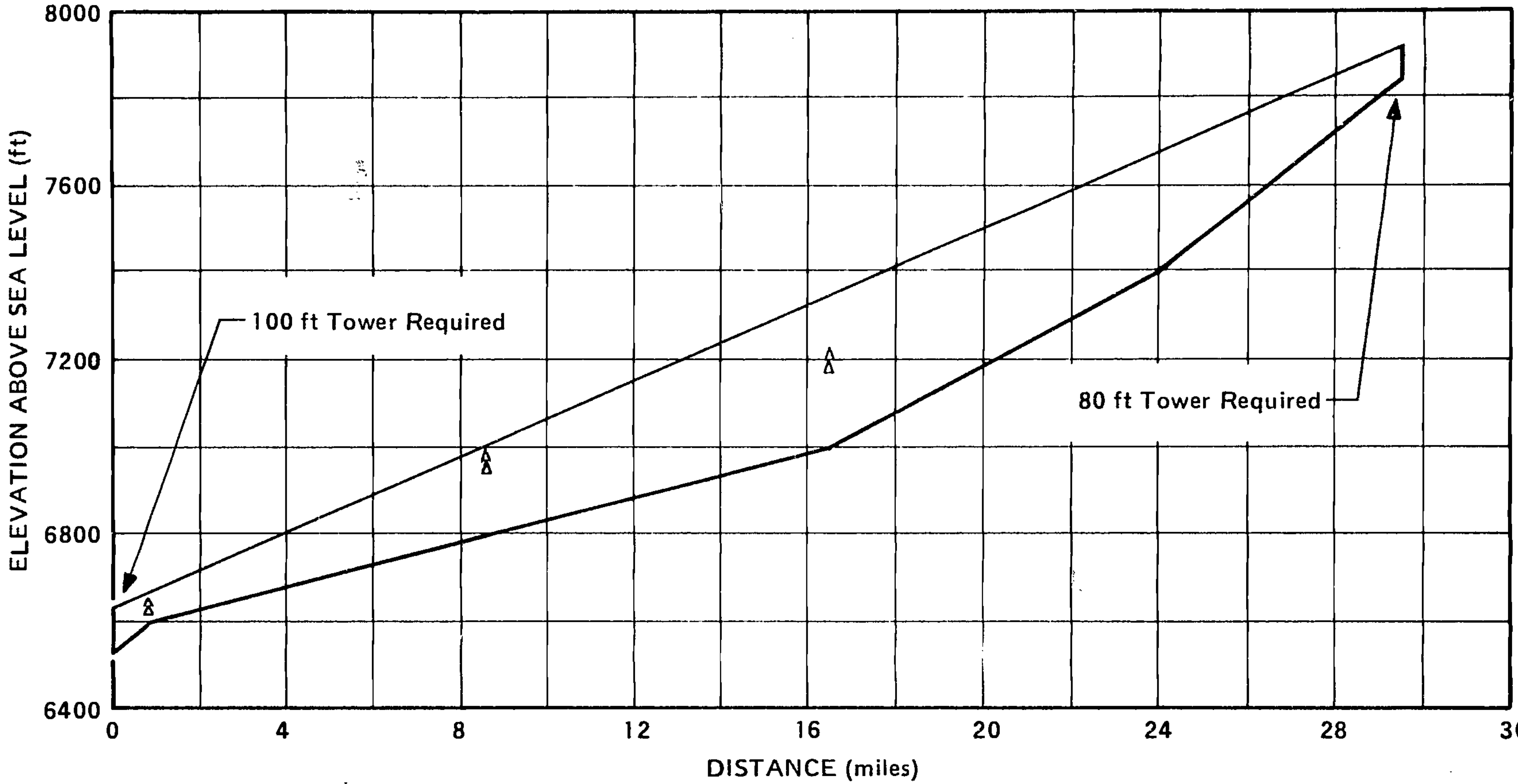

Figure A.31. Microwave Path Profile, Klagetoh to Defiance Summit.

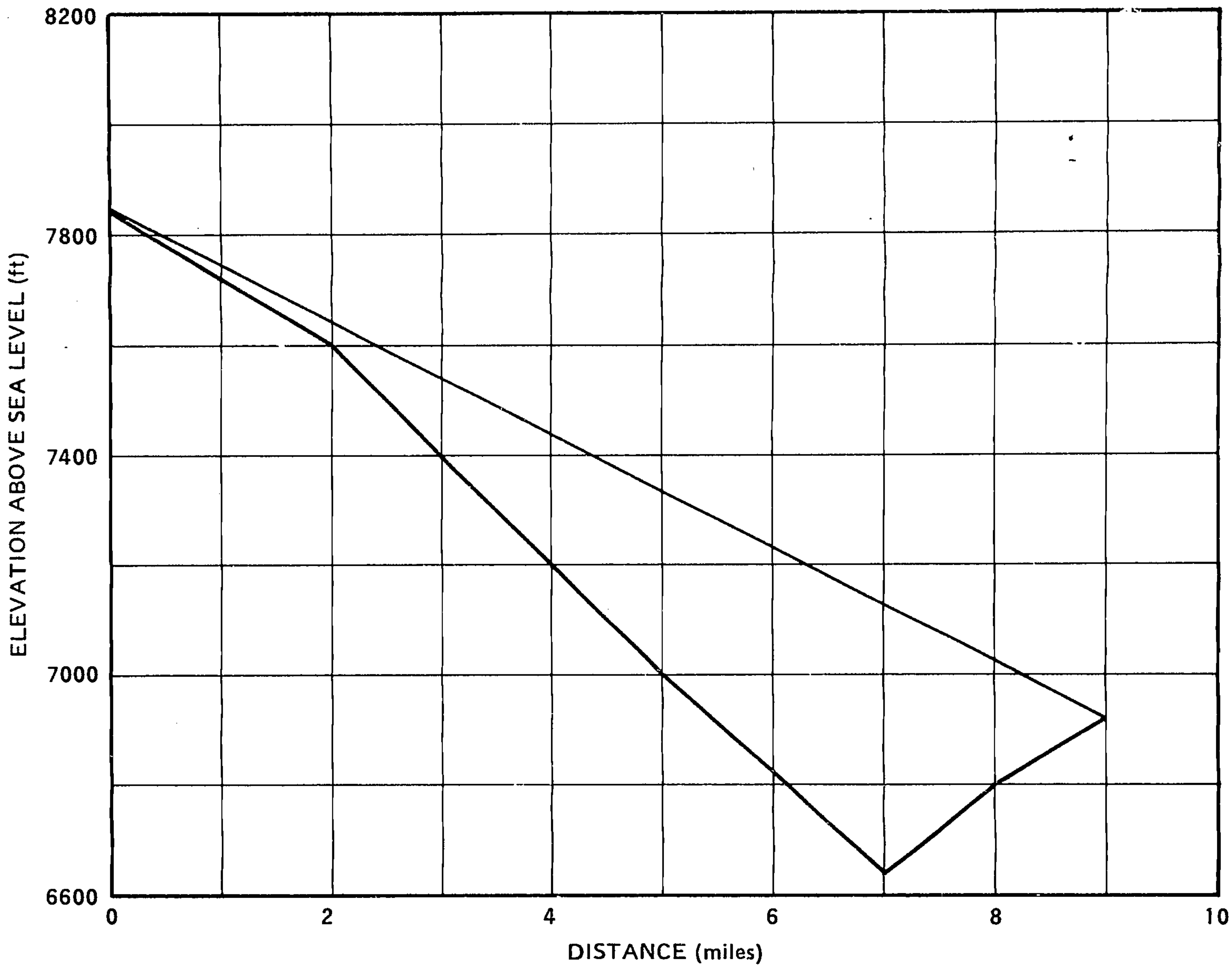

Figure A.32. Microwave Path Profile, Defiance Summit to Window Rock.

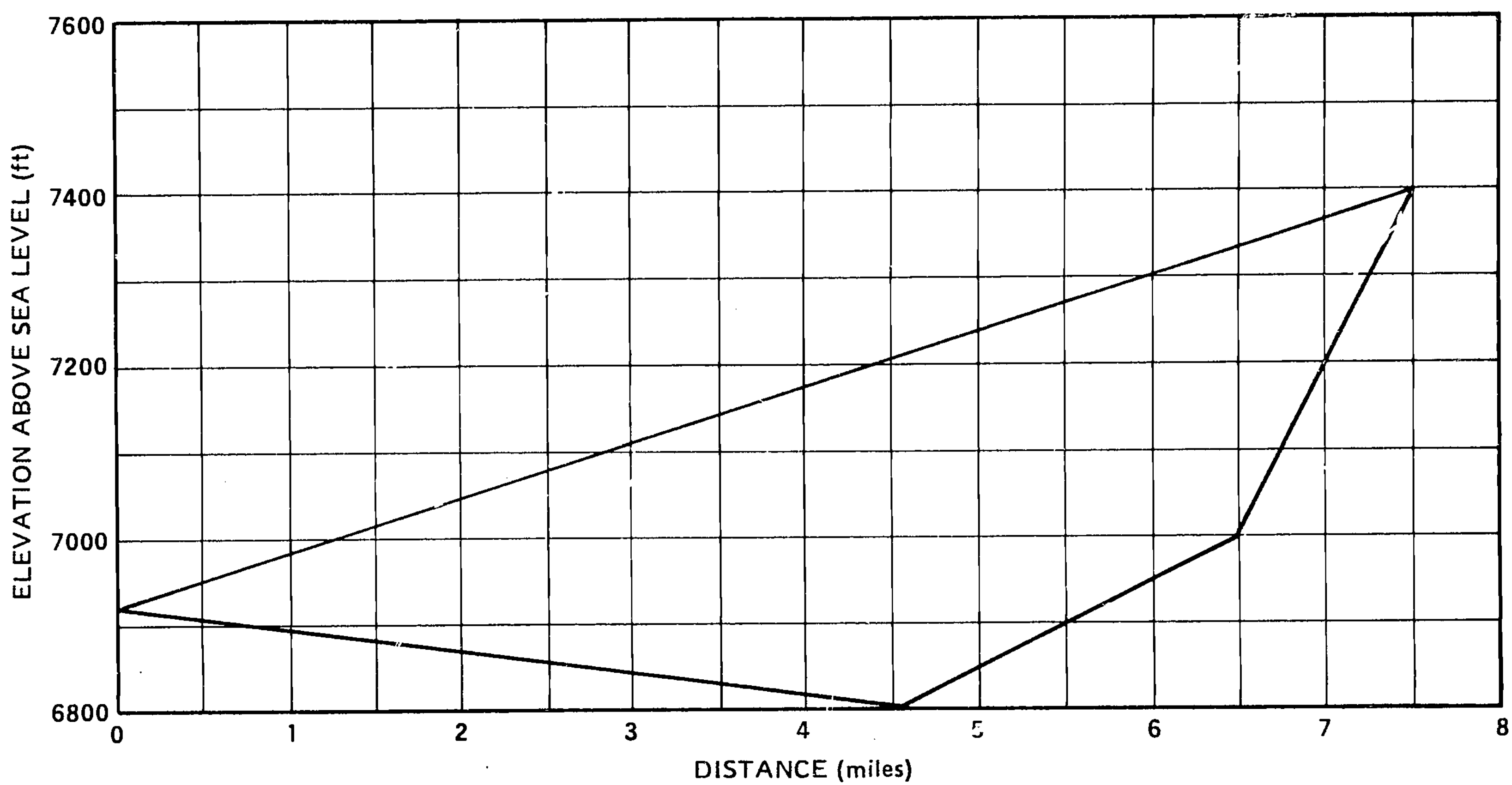

Figure A.33. Microwave Path Profile, Window Rock to Fort Defiance Hill.

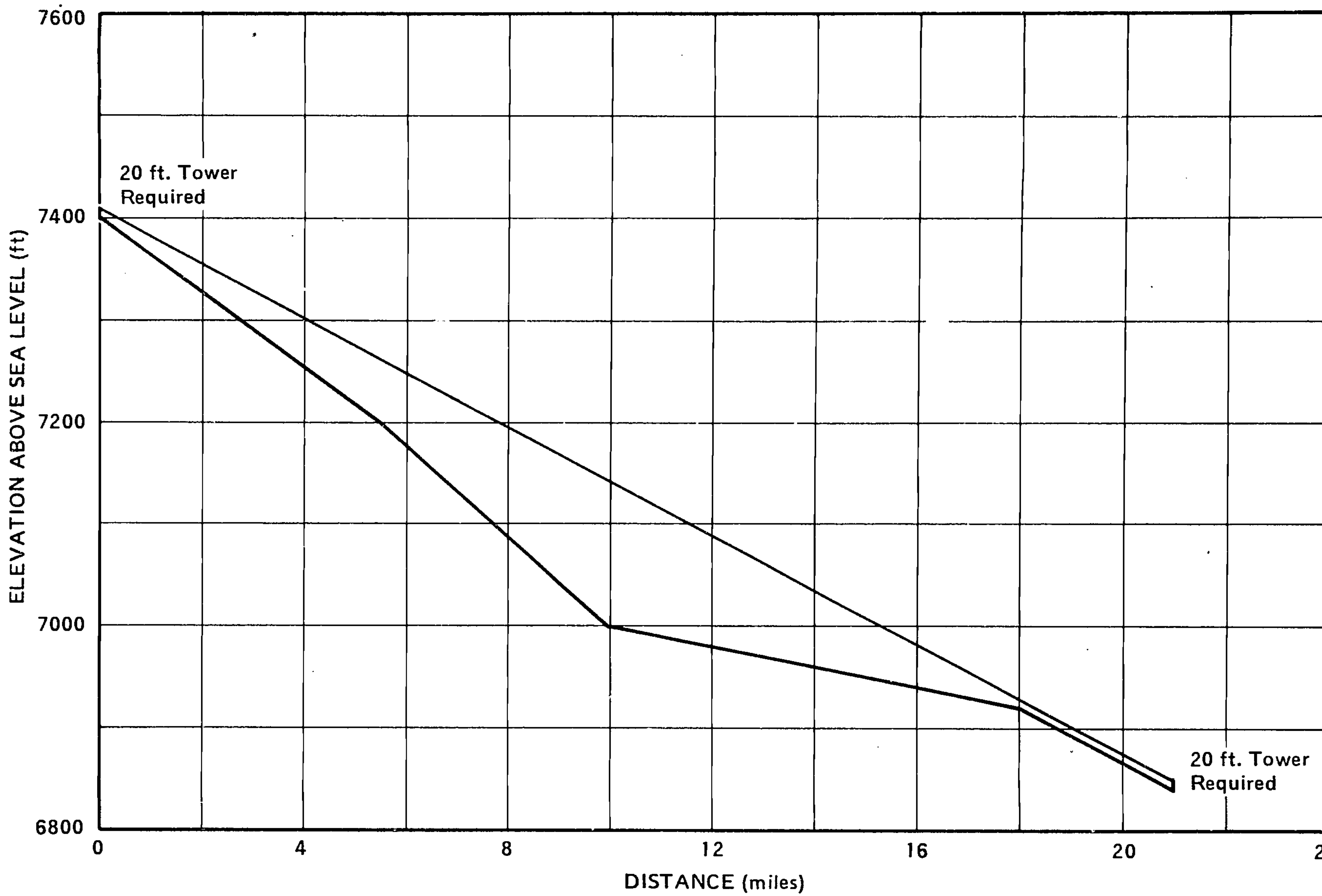

Figure A.34. Microwave Path Profile, Fort Defiance Hill to Fort Defiance.

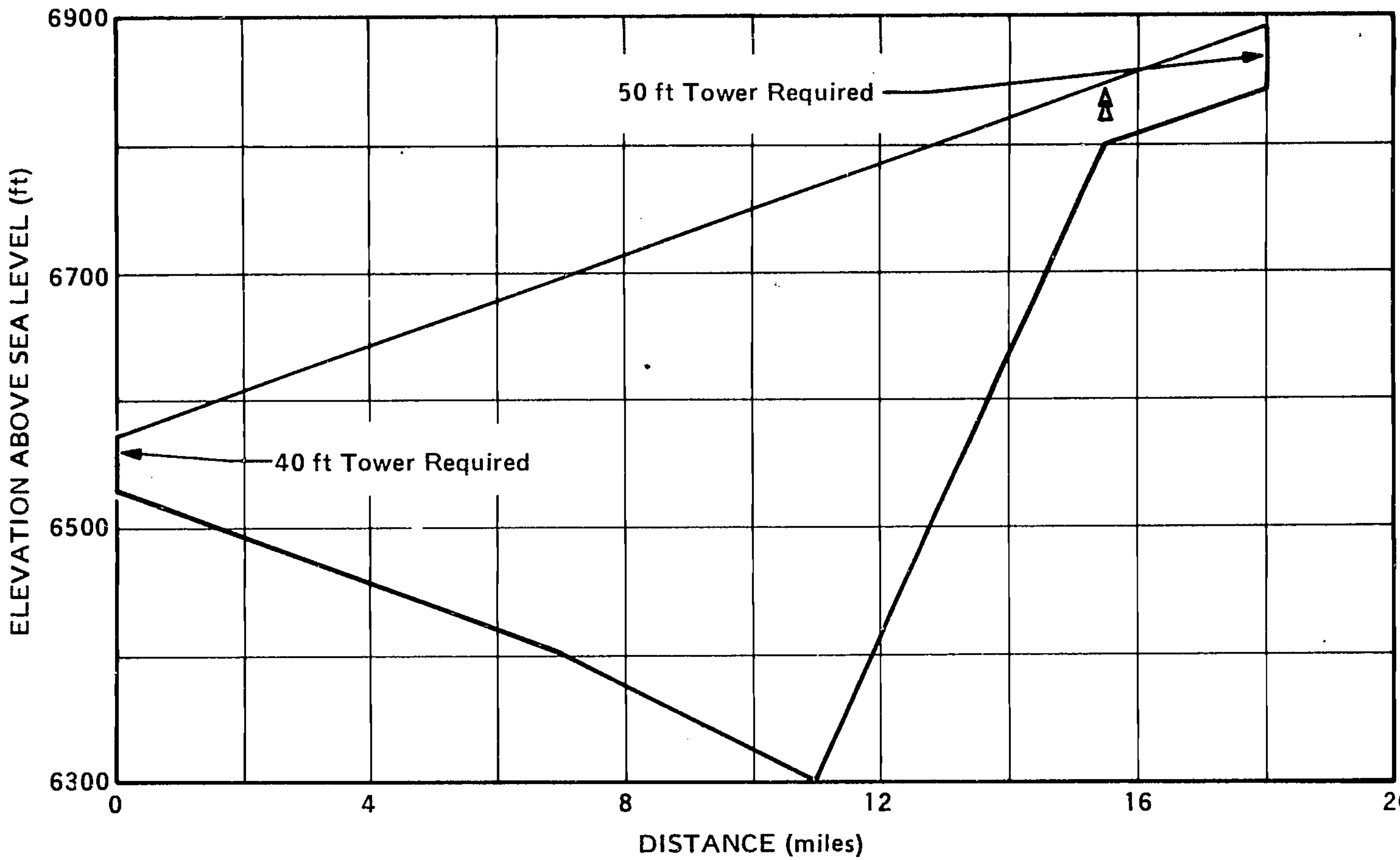

Figure A.35. Microwave Path Profile, Klagetoh to Ganado Mesa.

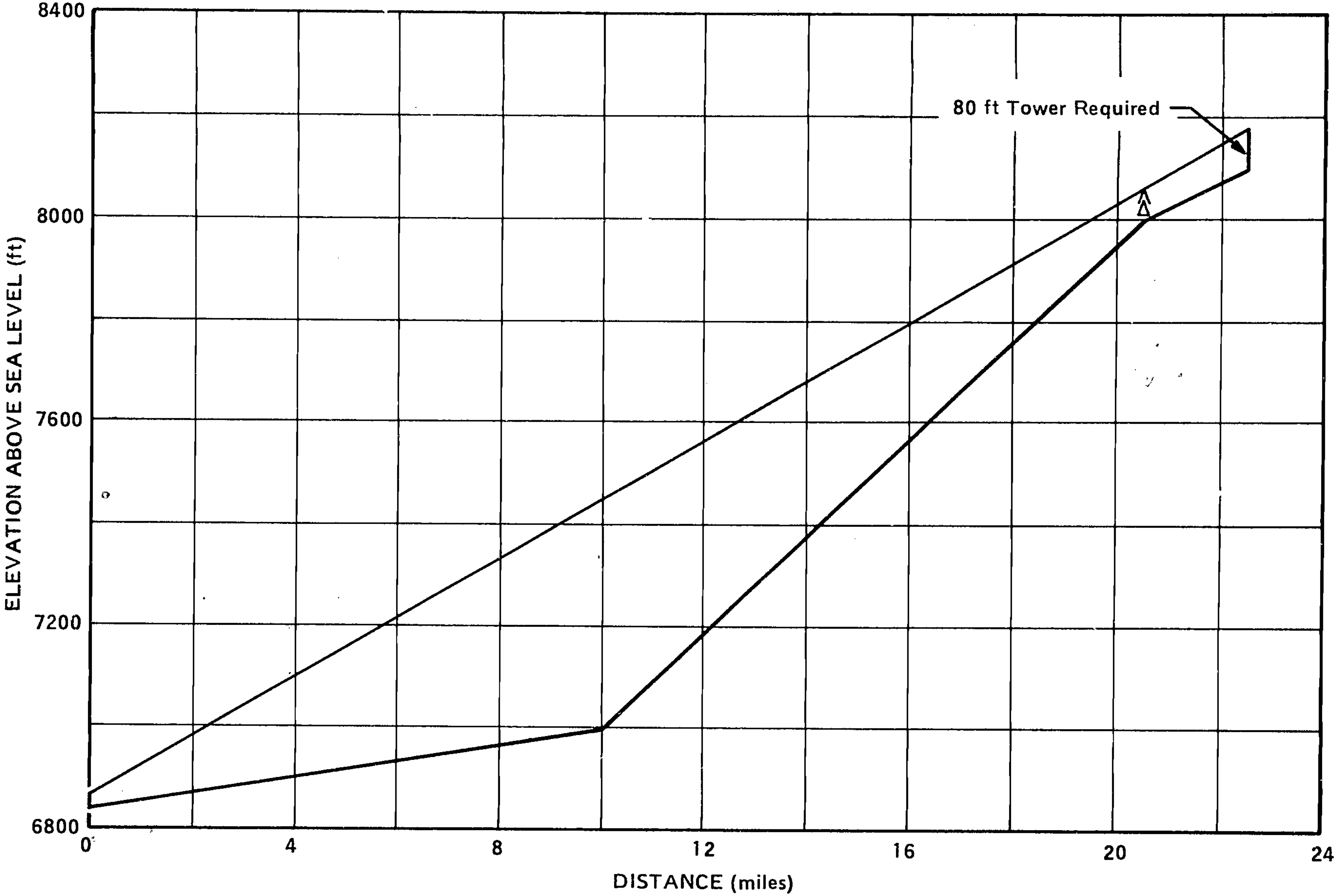

Figure A.36. Microwave Path Profile, Ganado Mesa to Piney Hill.

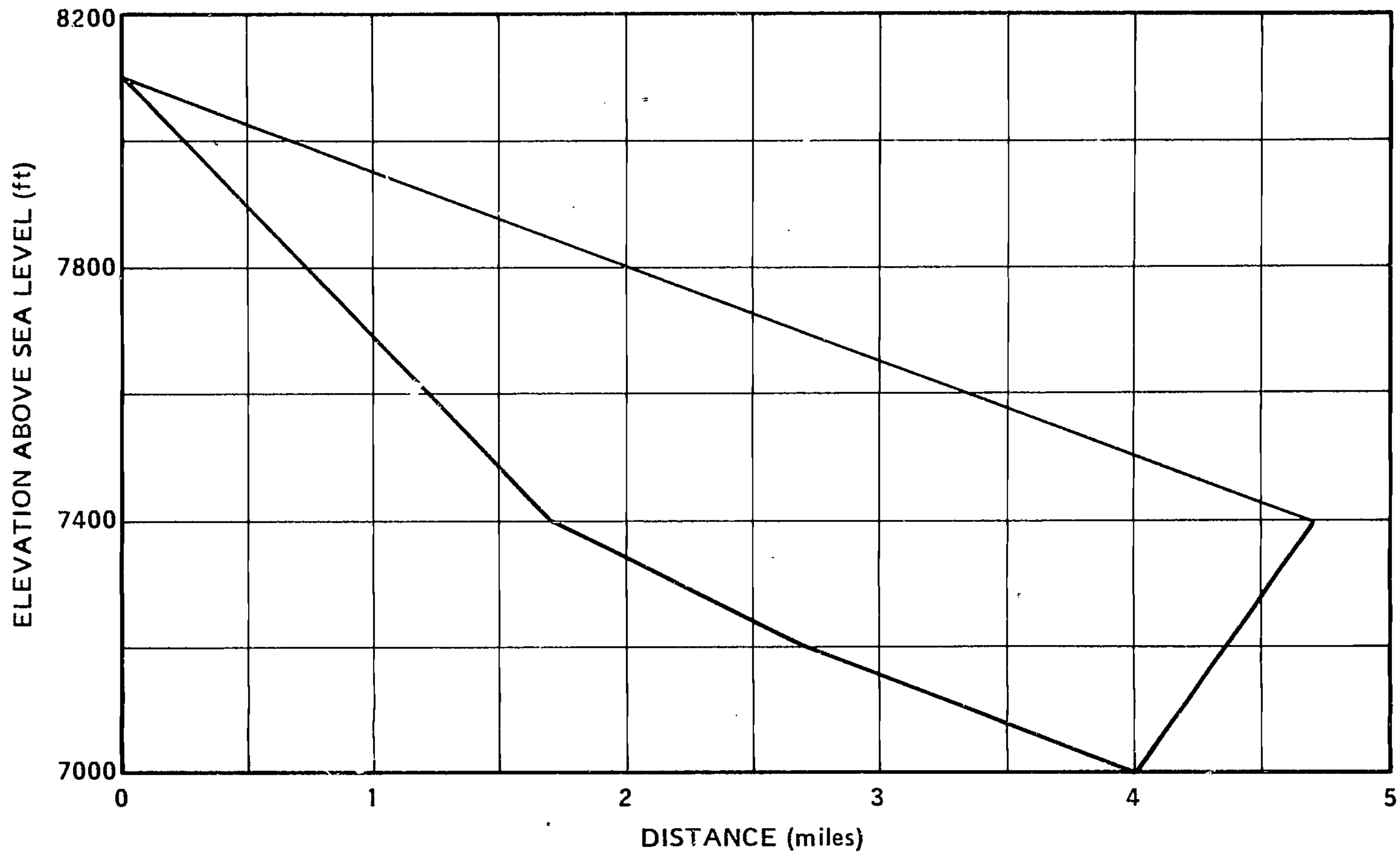

Figure A.37. Microwave Path Profile, Piney Hill to Fort Defiance Hill.

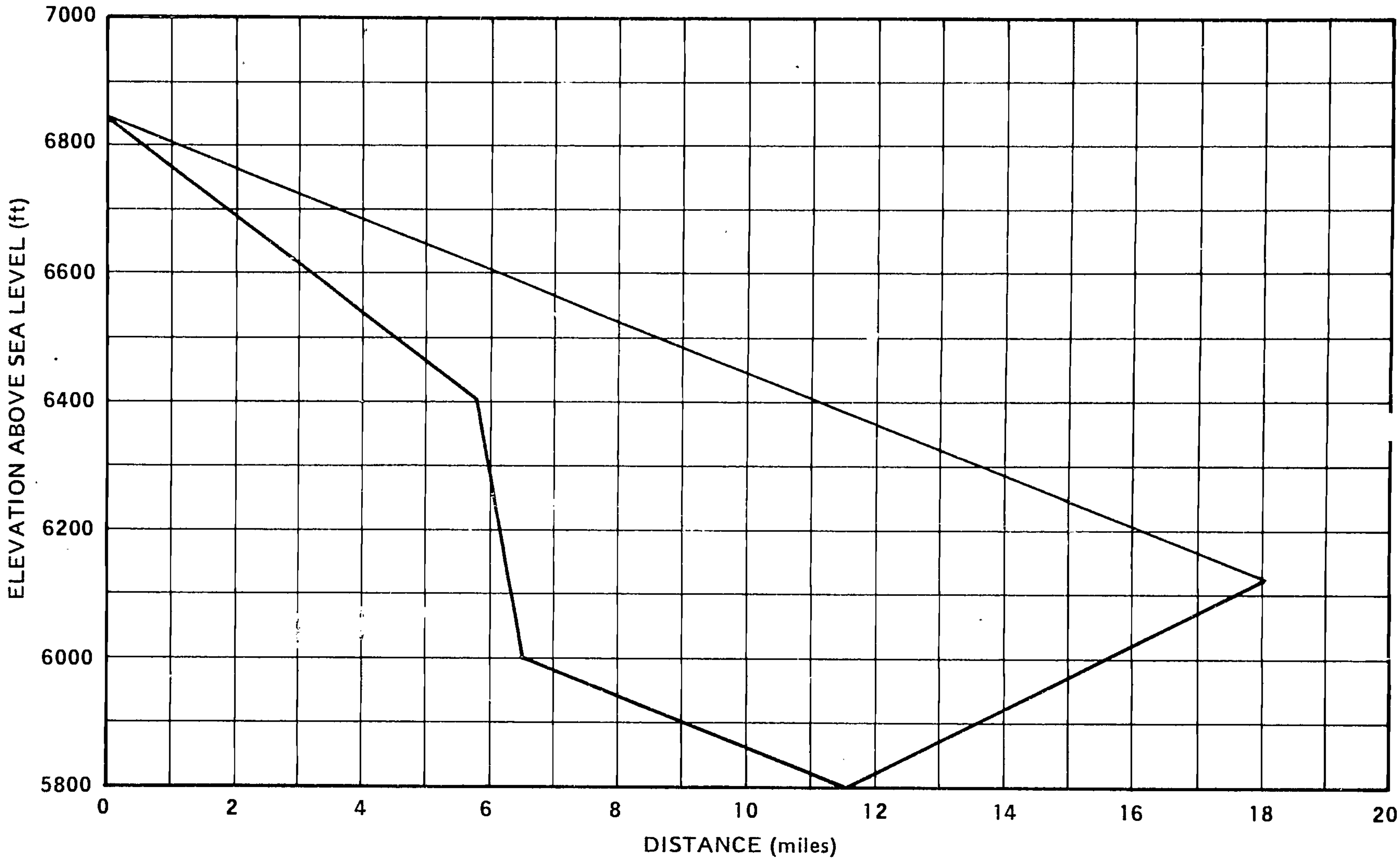

Figure A.38. Microwave Path Profile, Ganado Mesa to Cottonwood Junction.

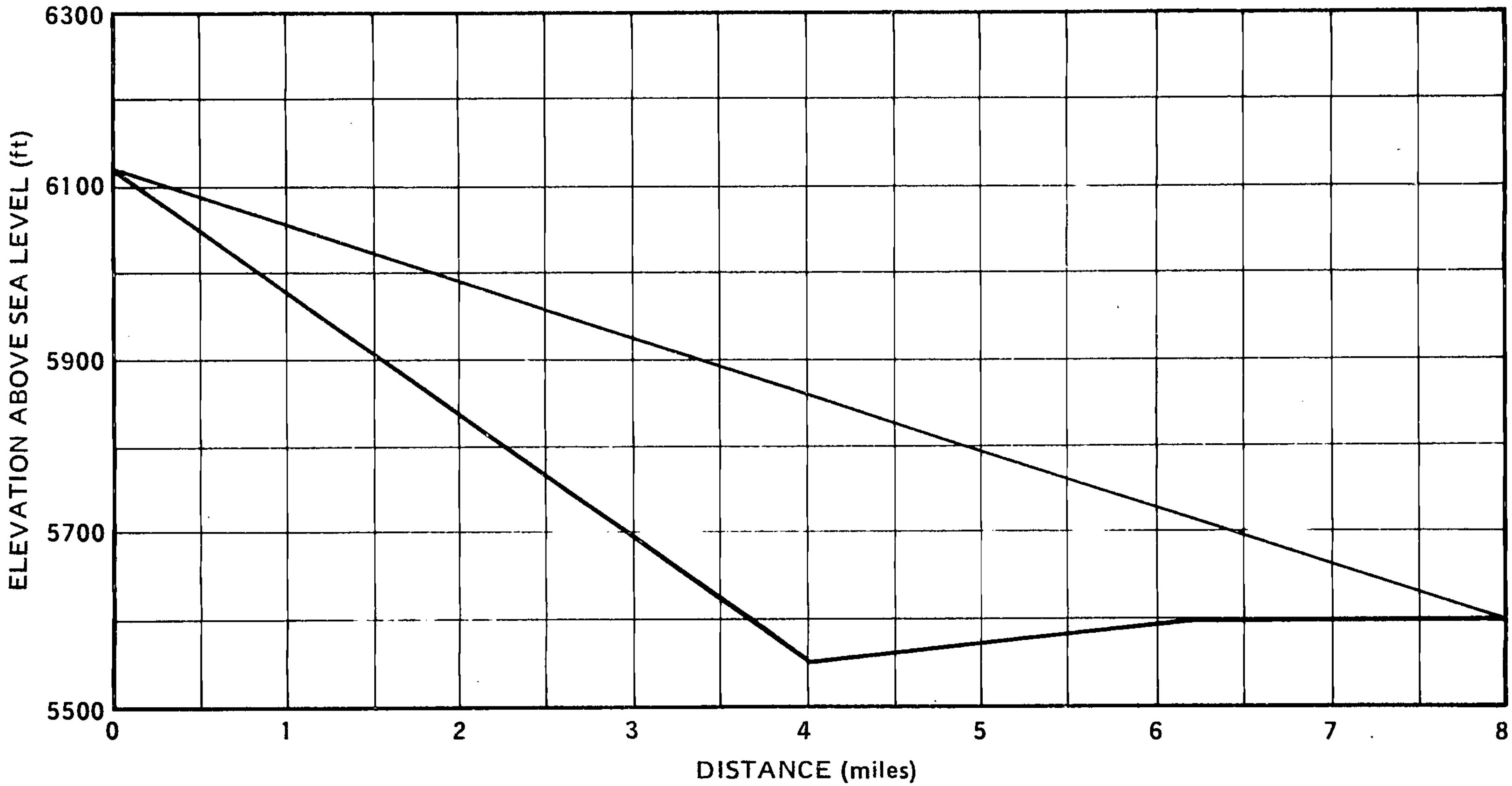

Figure A.39. Microwave Path Profile, Cottonwood Junction to Chinle.

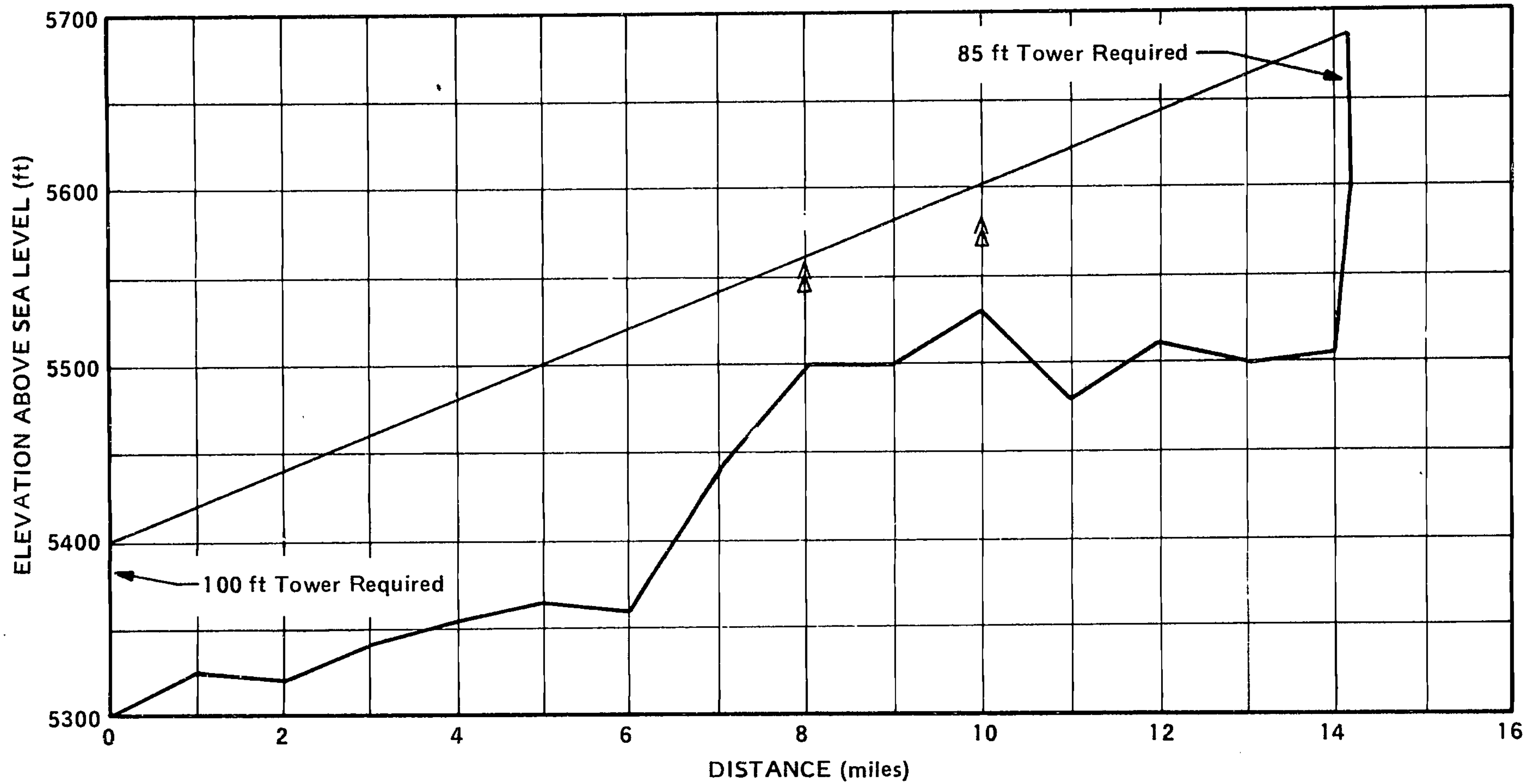

Figure A.40. Microwave Path Profile, Many Farms to Chinle.

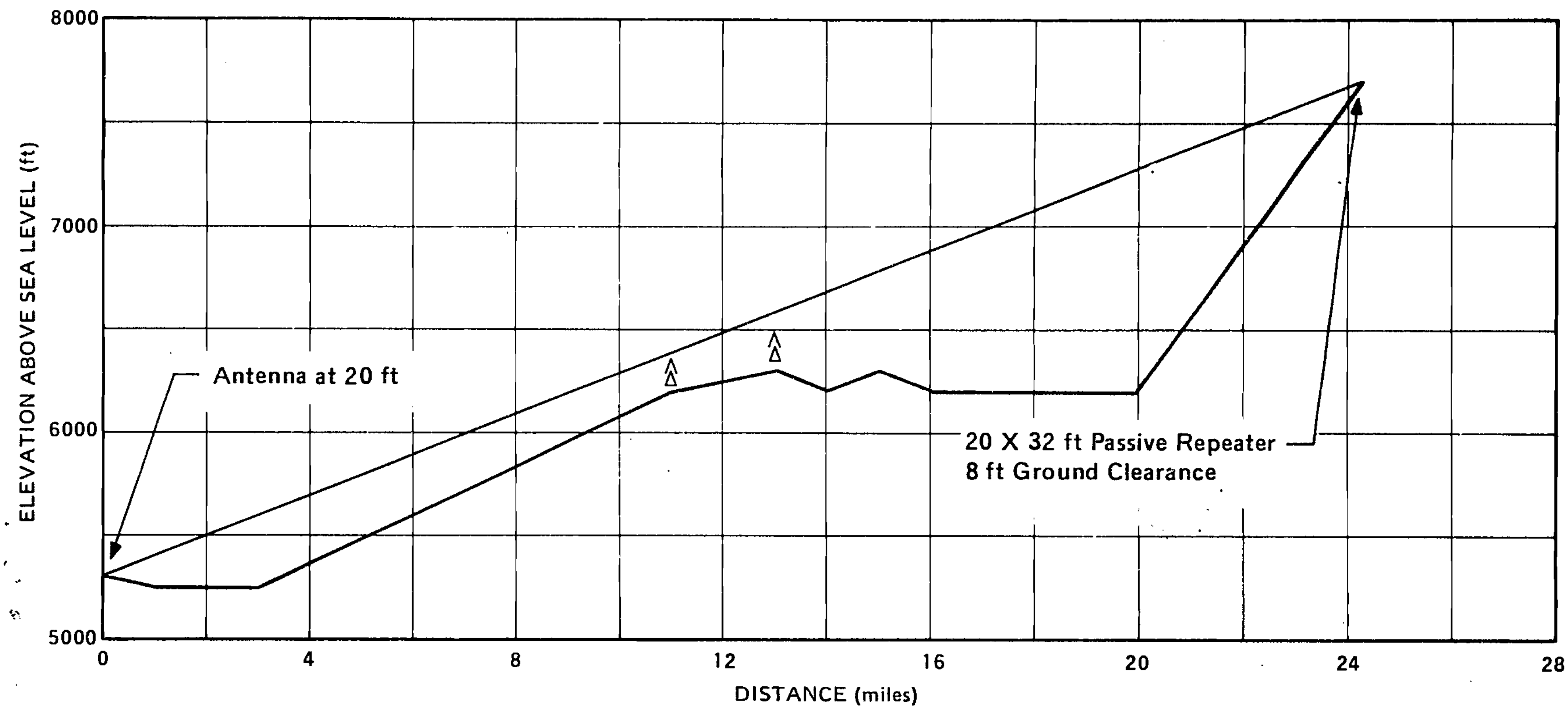

Figure A.41. Microwave Path Profile, Many Farms to Lukachukai Reflector.

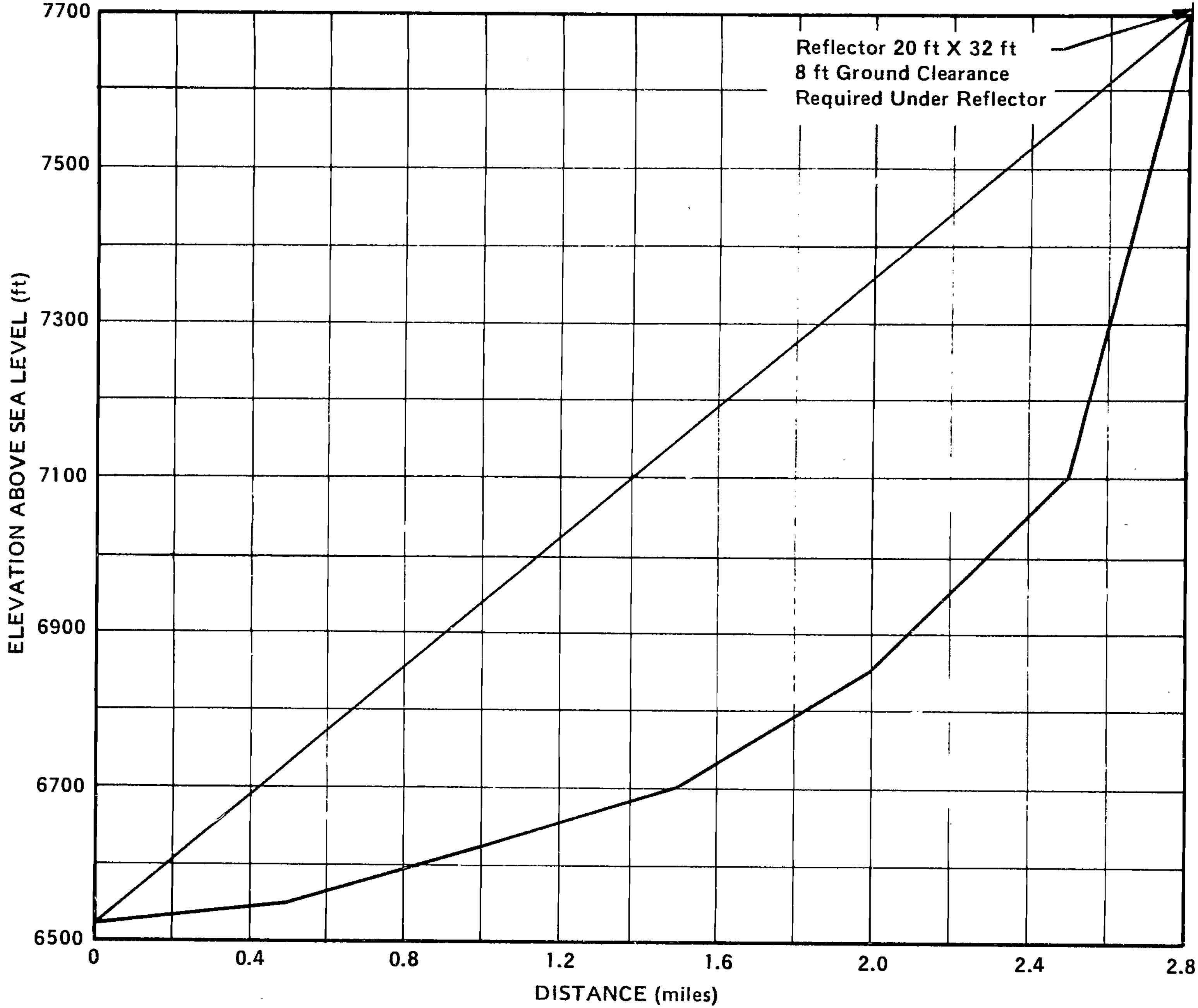

Figure A.42. Microwave Path Profile, Lukachukai to Lukachukai Reflector.

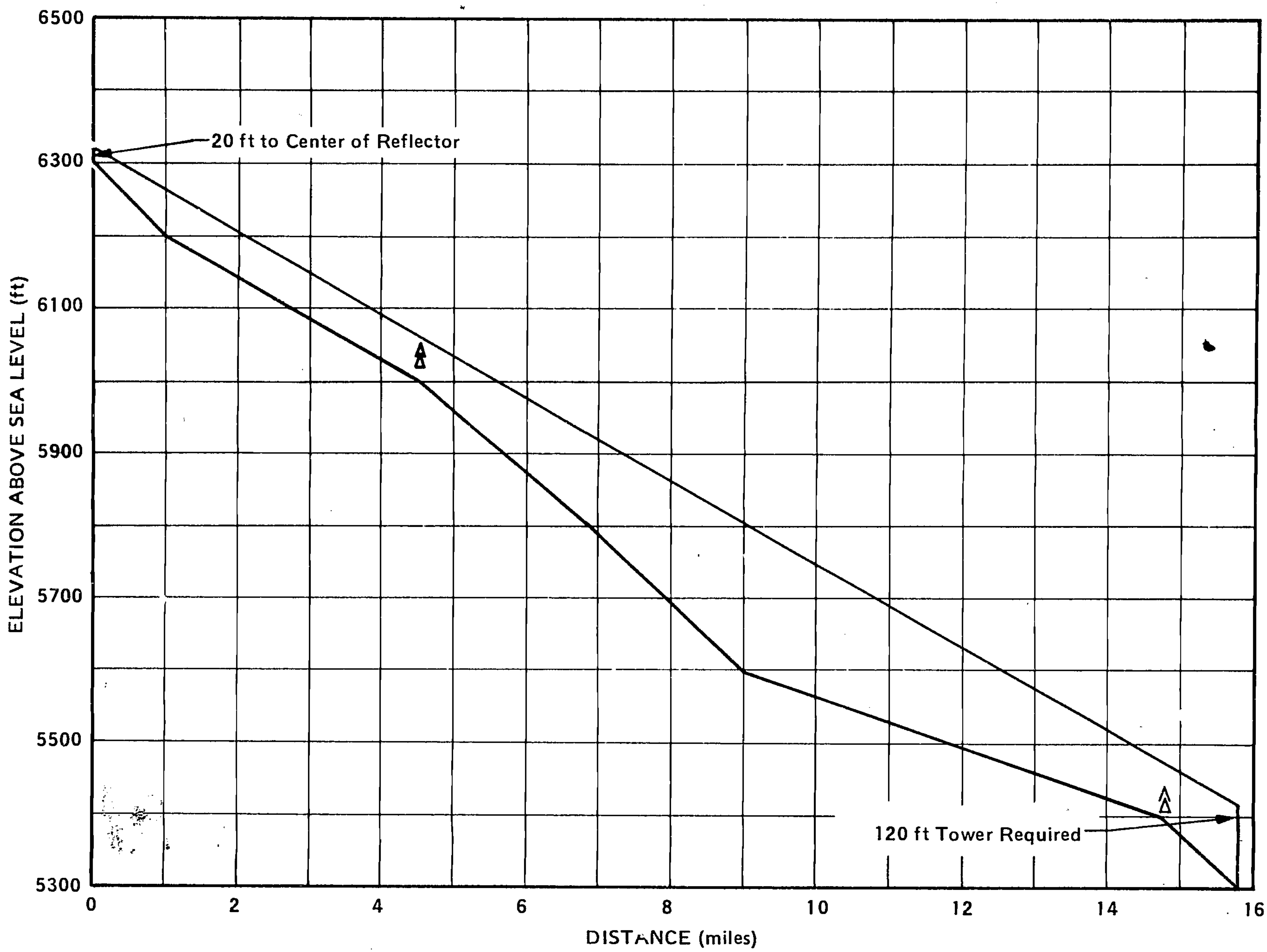

Figure A.43. Microwave Path Profile, Rough Rock Reflector to Many Farms.

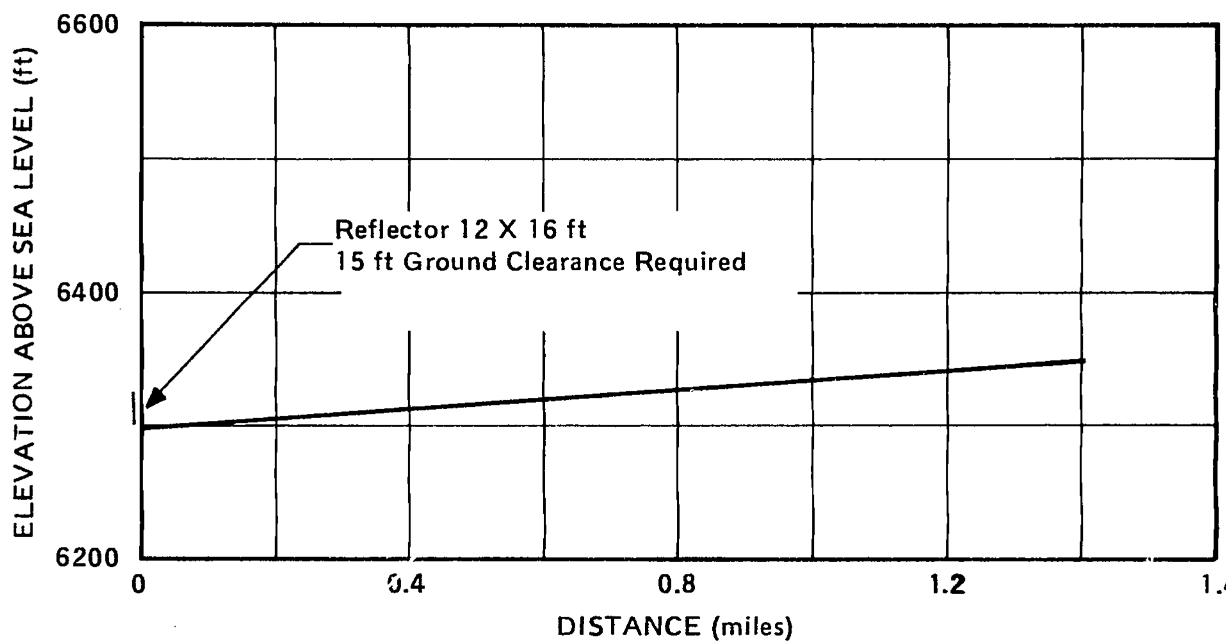

Figure A.44. Microwave Path Profile, Rought Rock Reflector to Rough Rock.

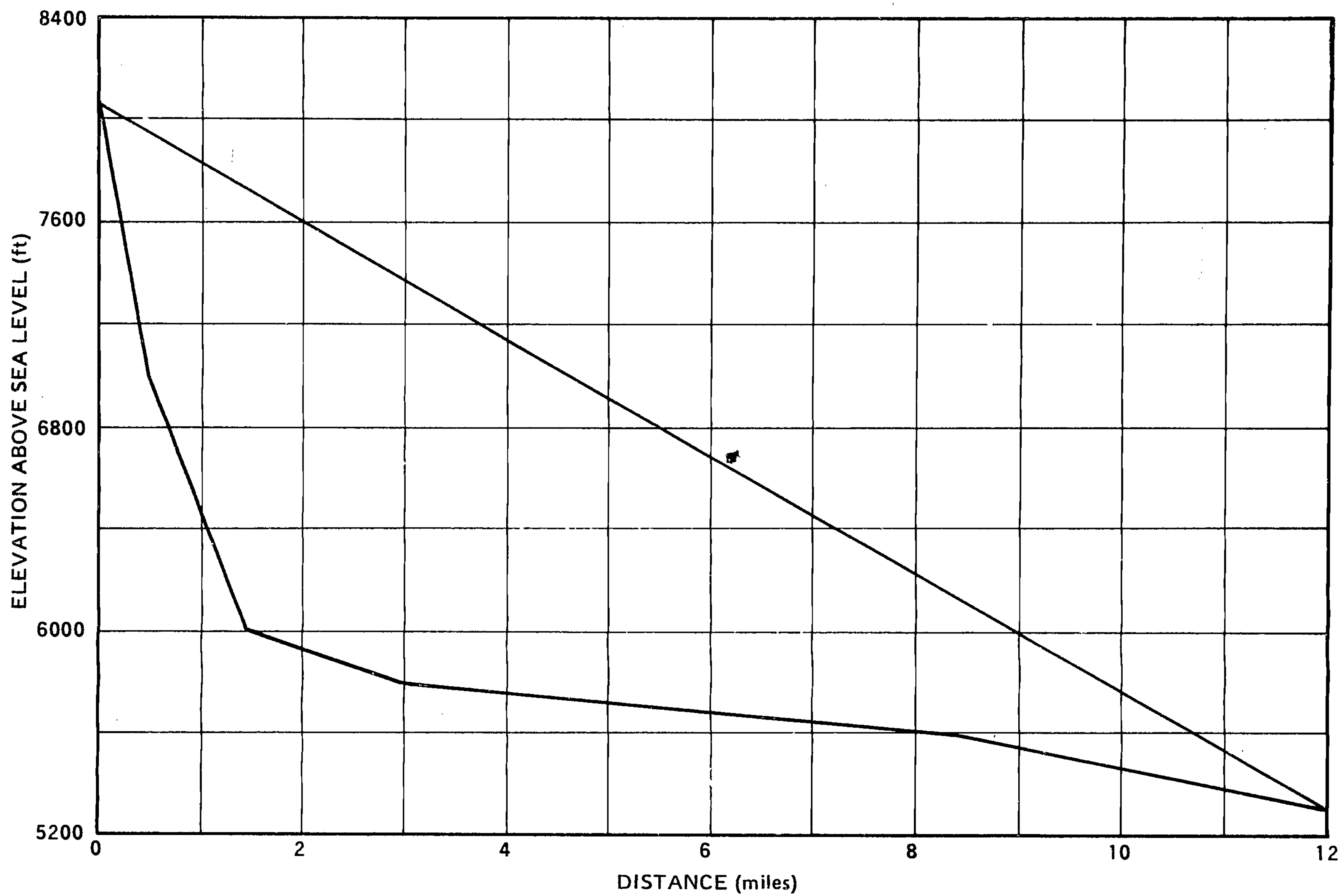

Figure A.45. Microwave Path Profile, Yale Point to Many Farms.

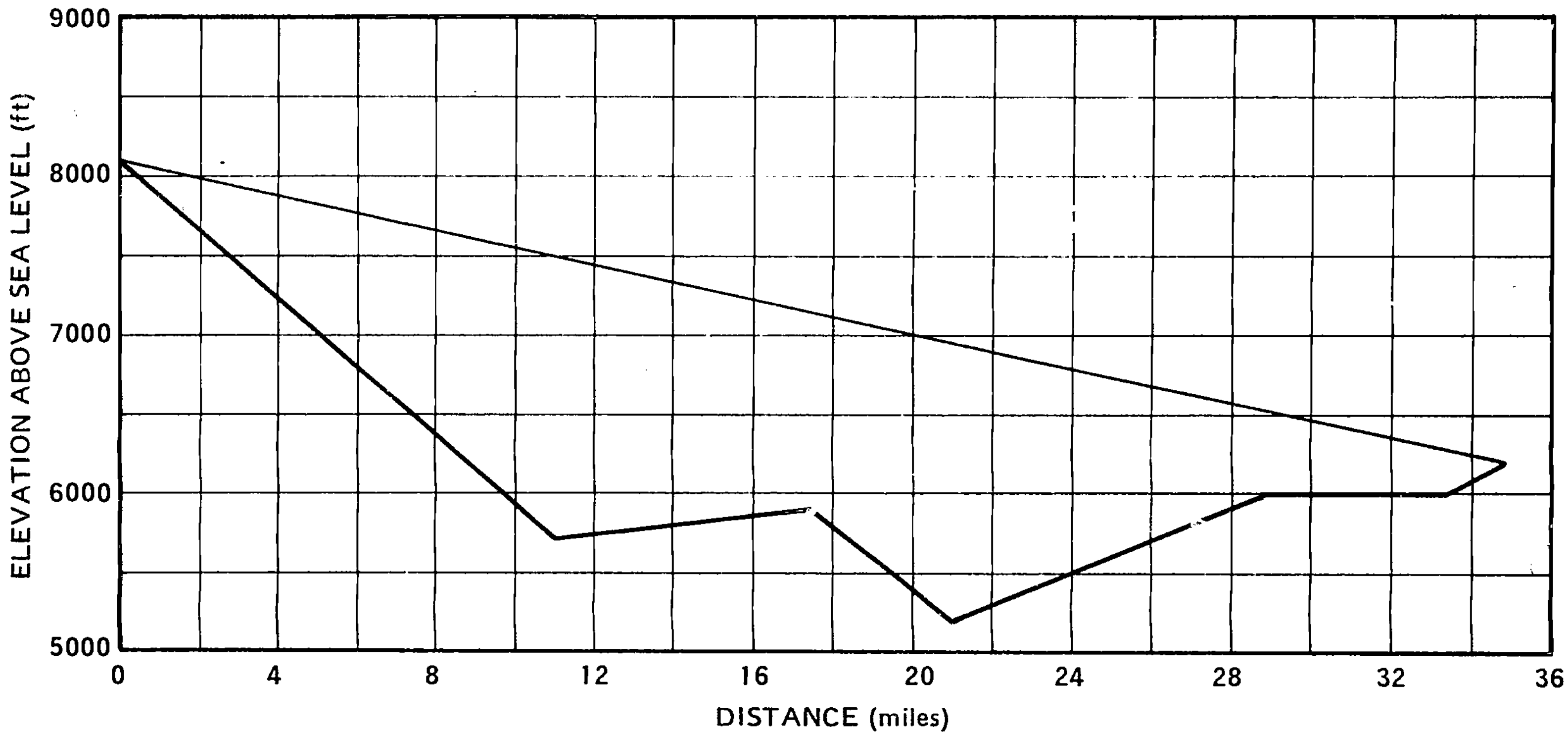

Figure A.46. Microwave Path Profile, Yale Point to Rock Point.

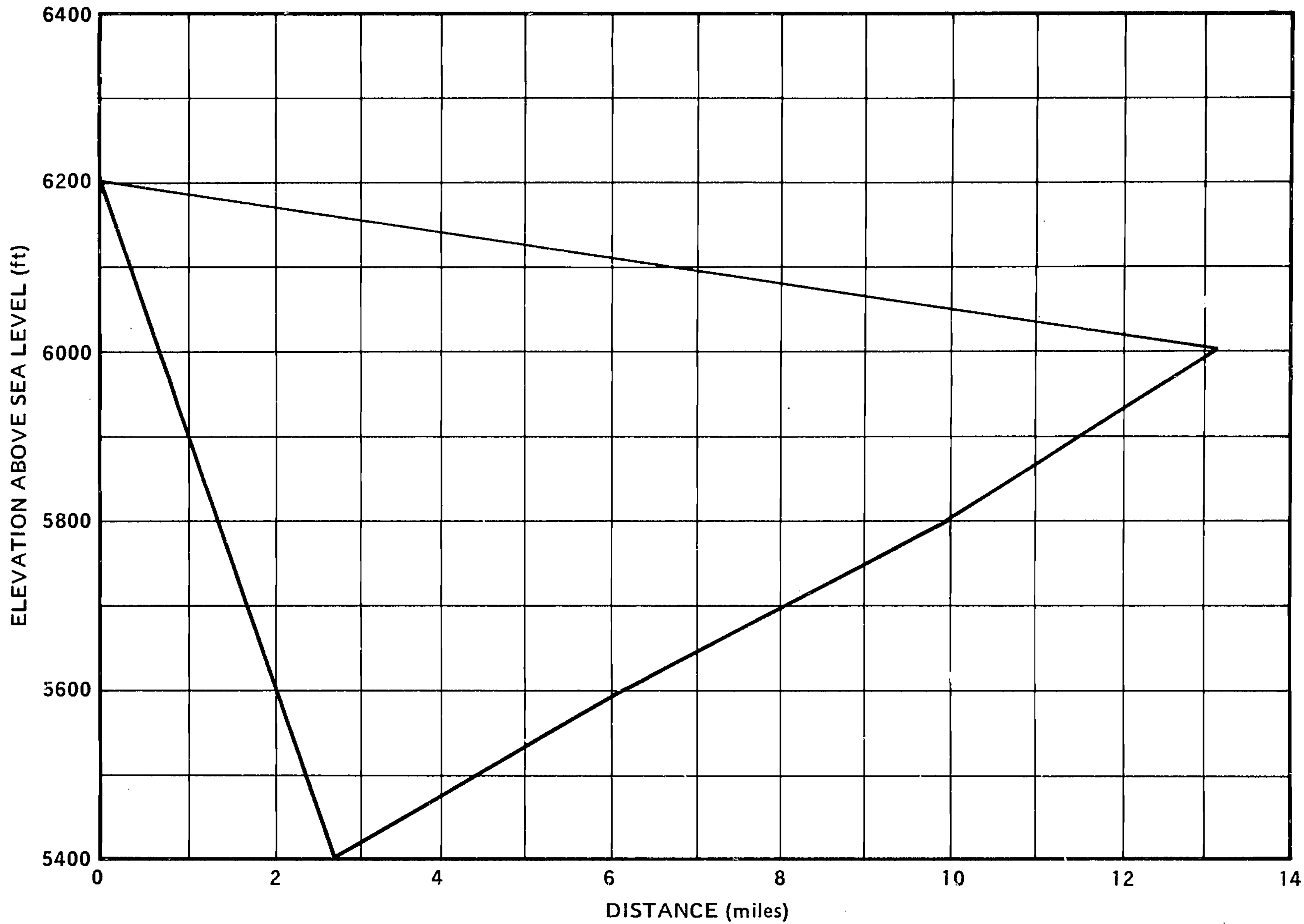

Figure A.47. Microwave Path Profile, Rock Point to Totacon.

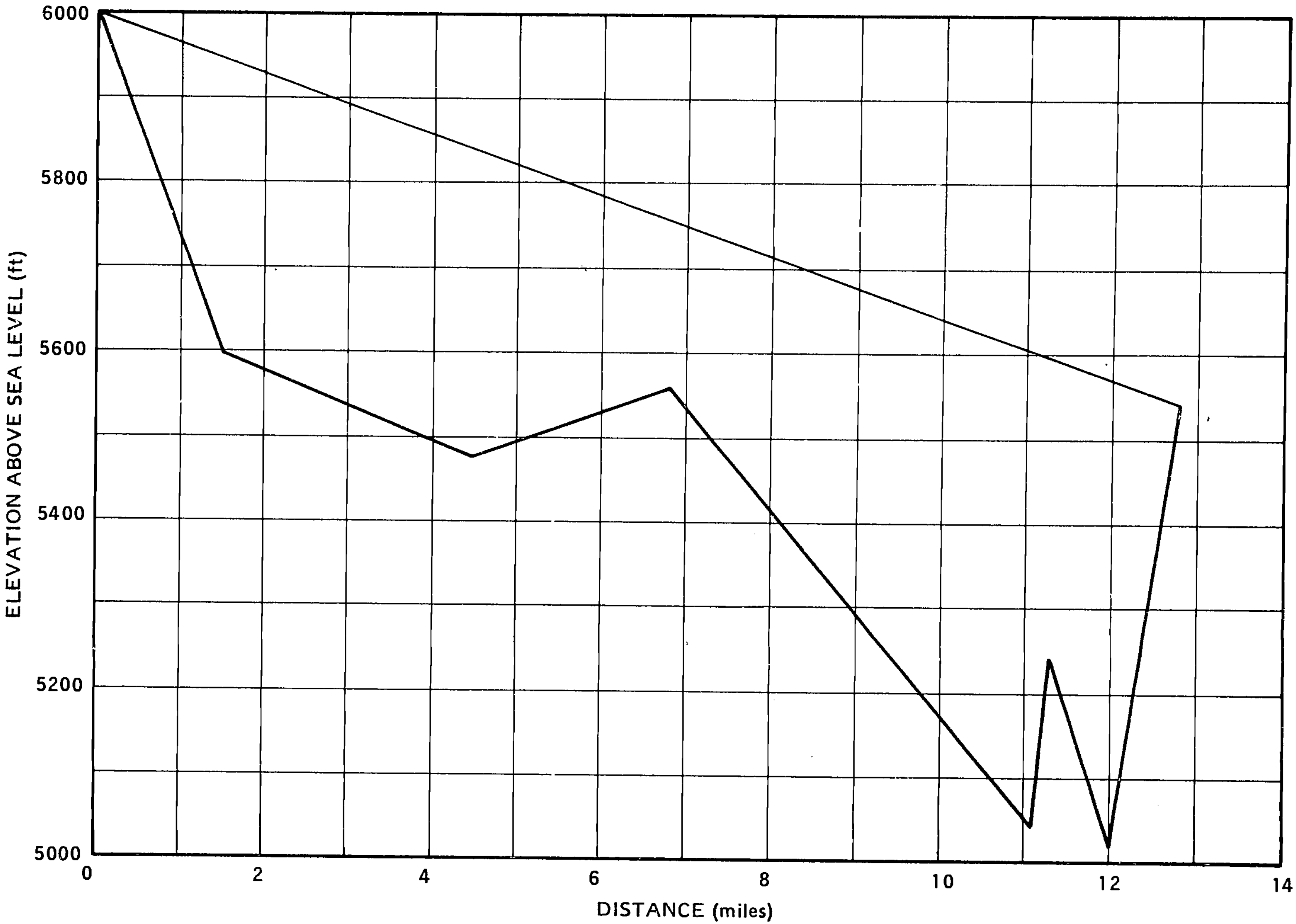

Figure A.48. Microwave Path Profile, Totacon to Teec Nos Pos Reflector.

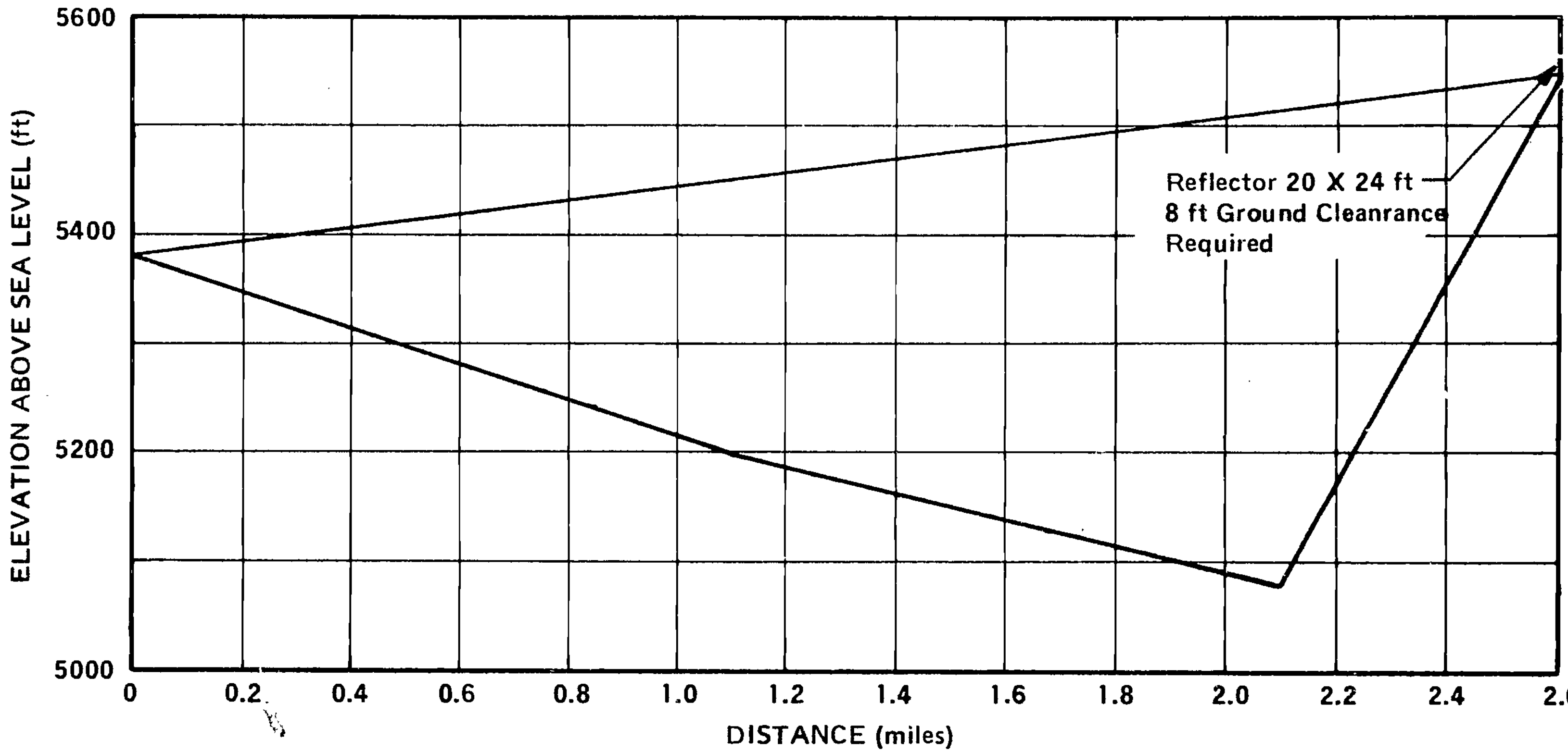

Figure A.49. Microwave Path Profile, Teec Nos Pos to Teec Nos Pos.

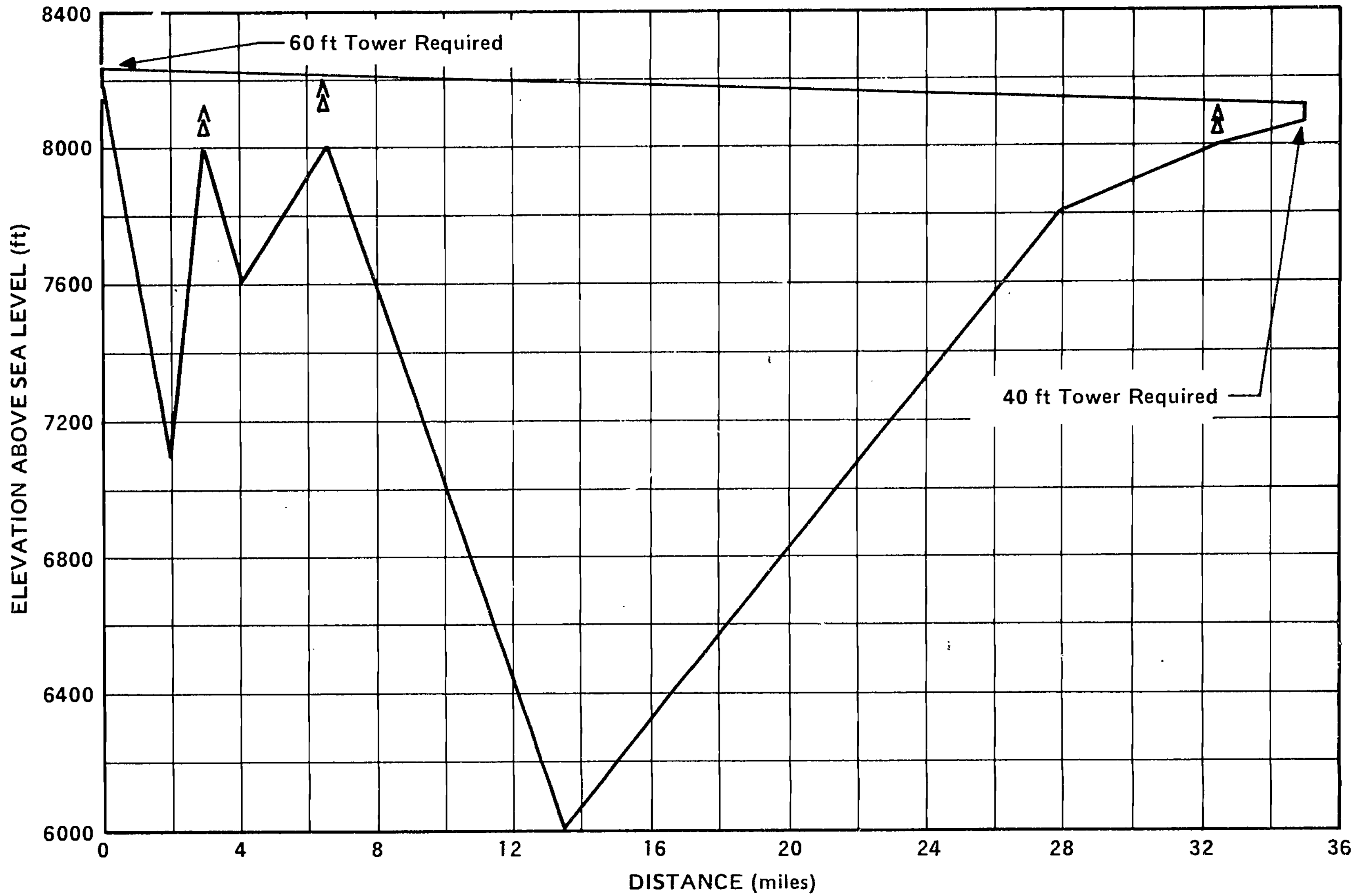

Figure A.50. Microwave Path Profile, Black Mesa to Yale Point.

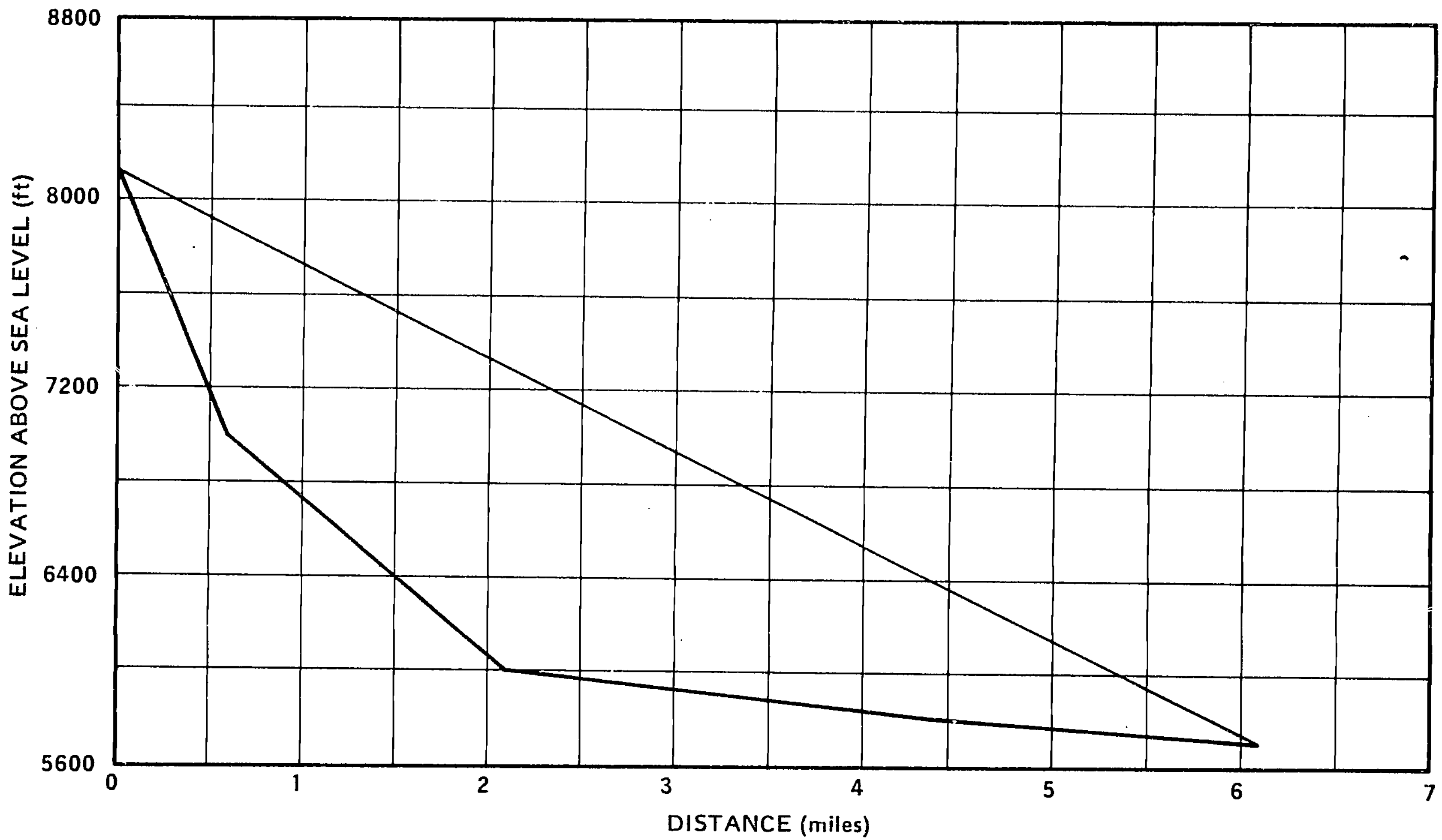

Figure A.51. Microwave Path Profile, Black Mesa to Kayenta.

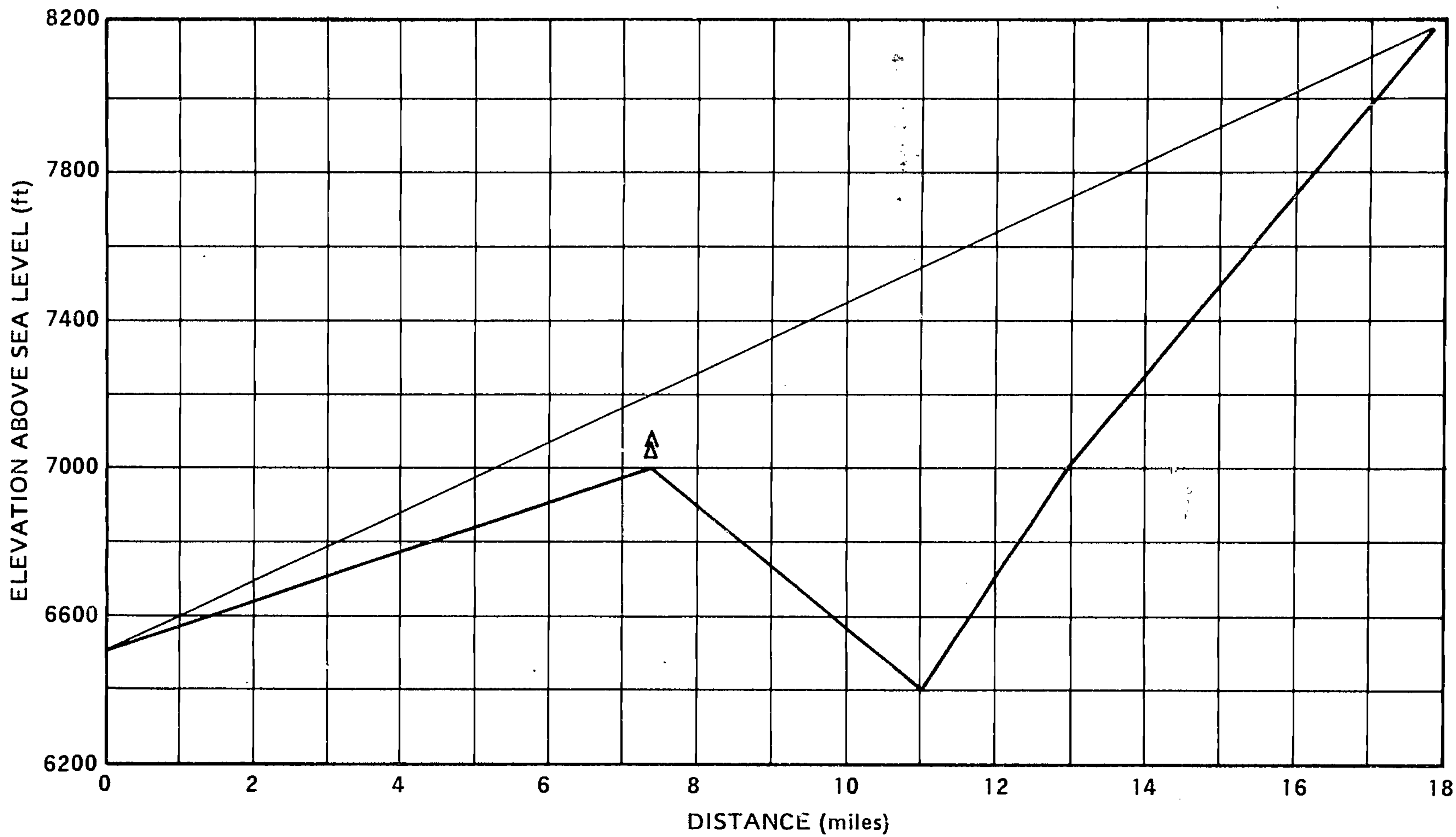

Figure A.52. Microwave Path Profile, Shonto to Black Mesa.

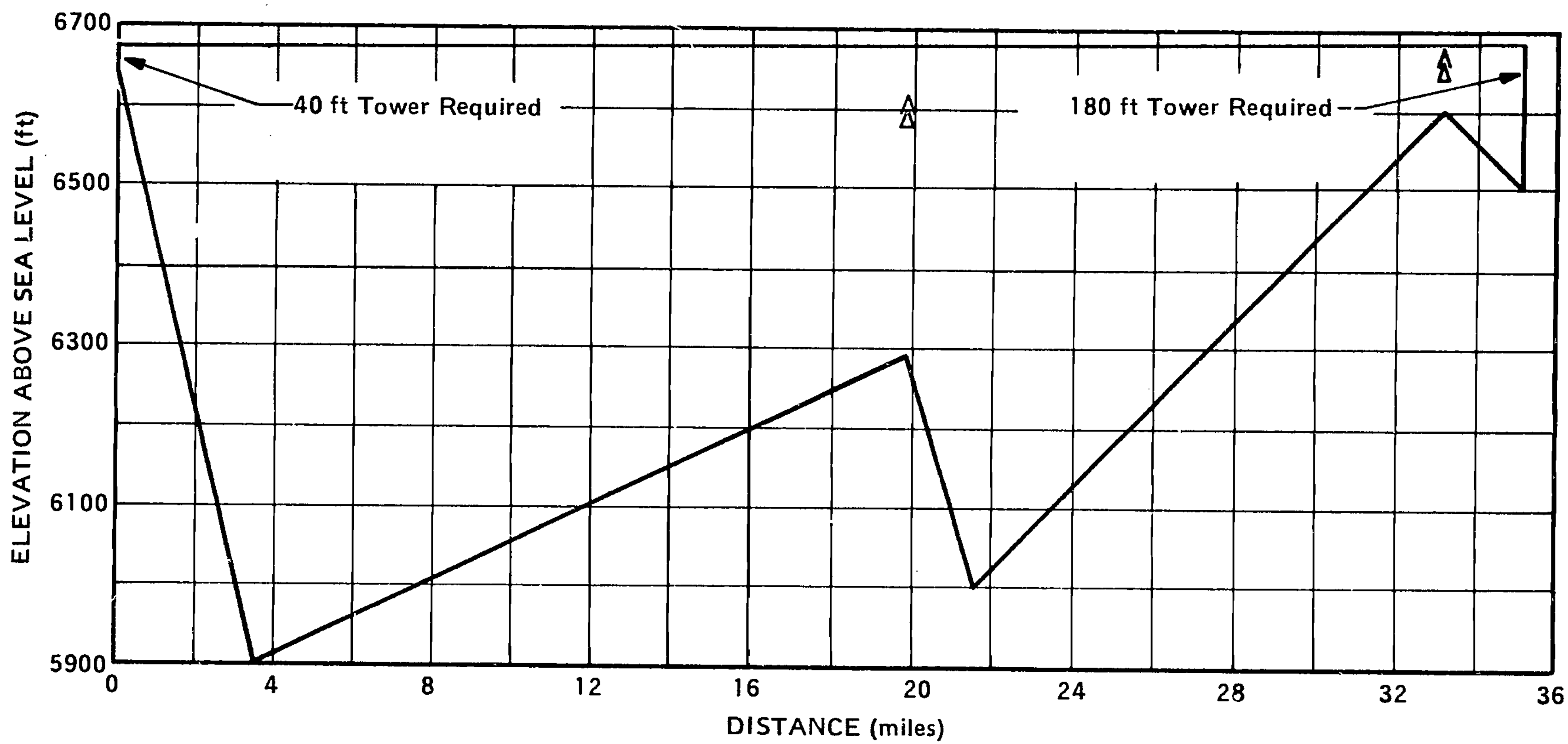

Figure A.53. Microwave Path Profile, Preston Mesa to Shonto.

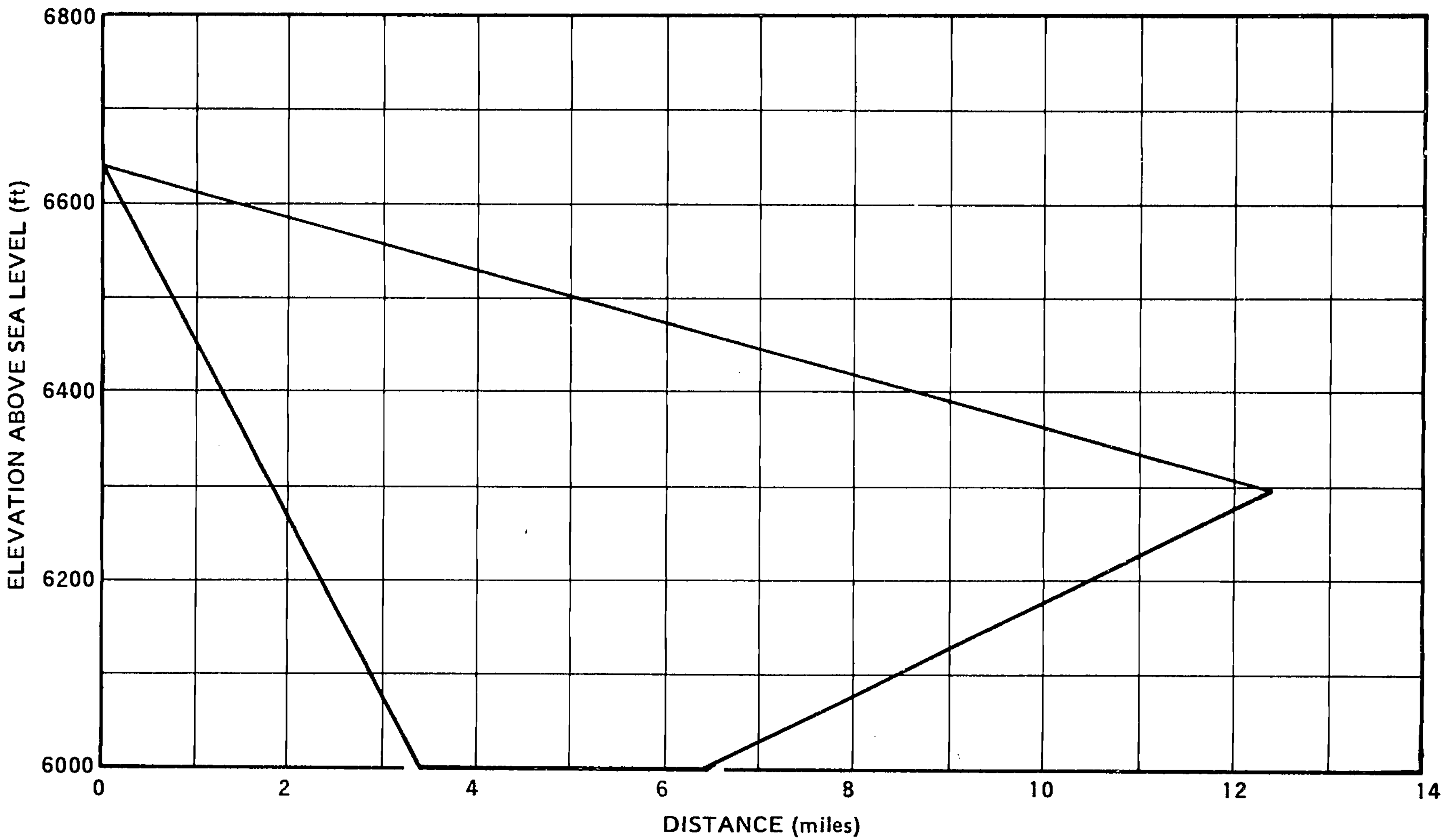

Figure A.54. Microwave Path Profile, Preston Mesa to Kaibito Plateau.

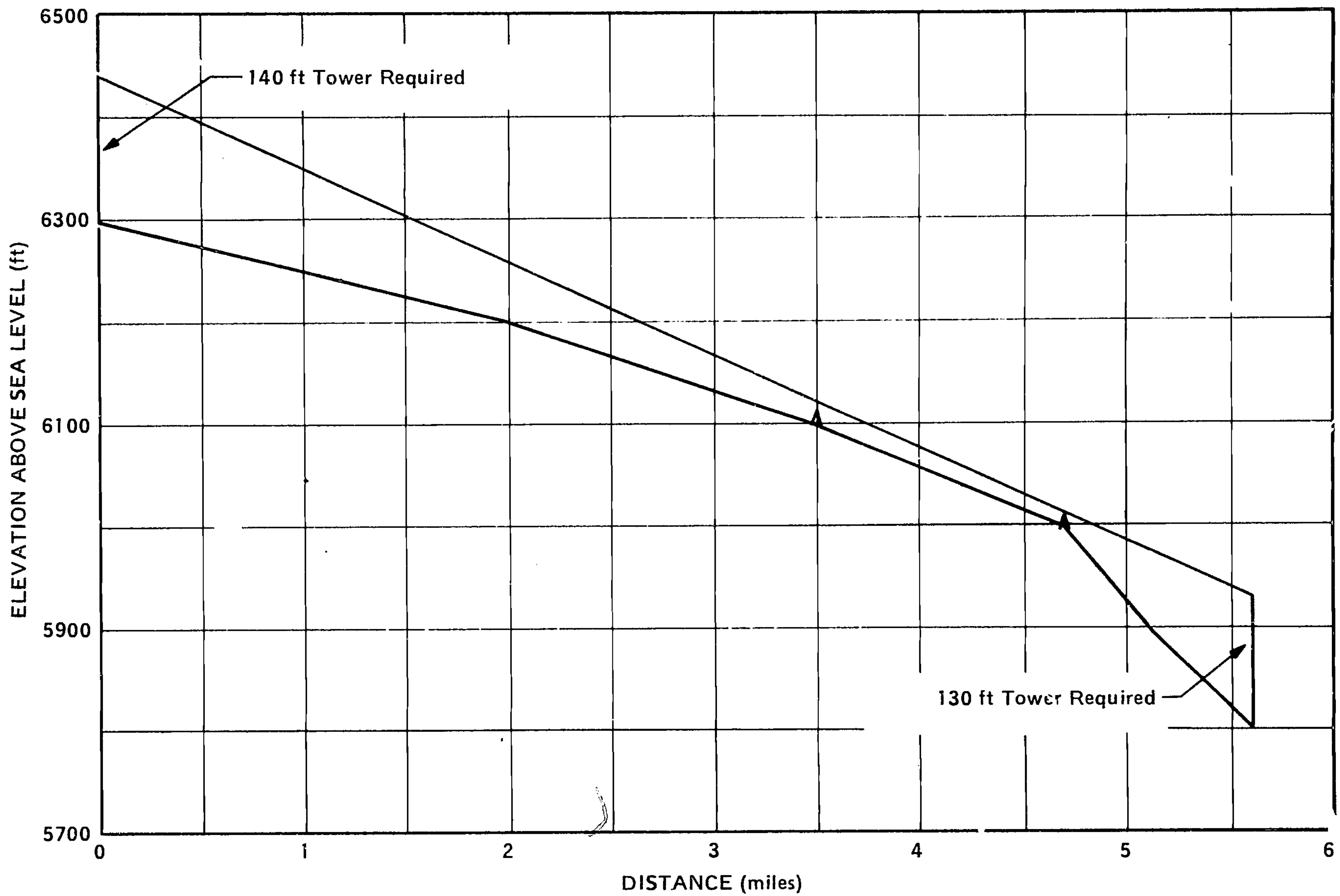

Figure A.55. Microwave Path Profile, Kaibito Plateau to Kaibito.

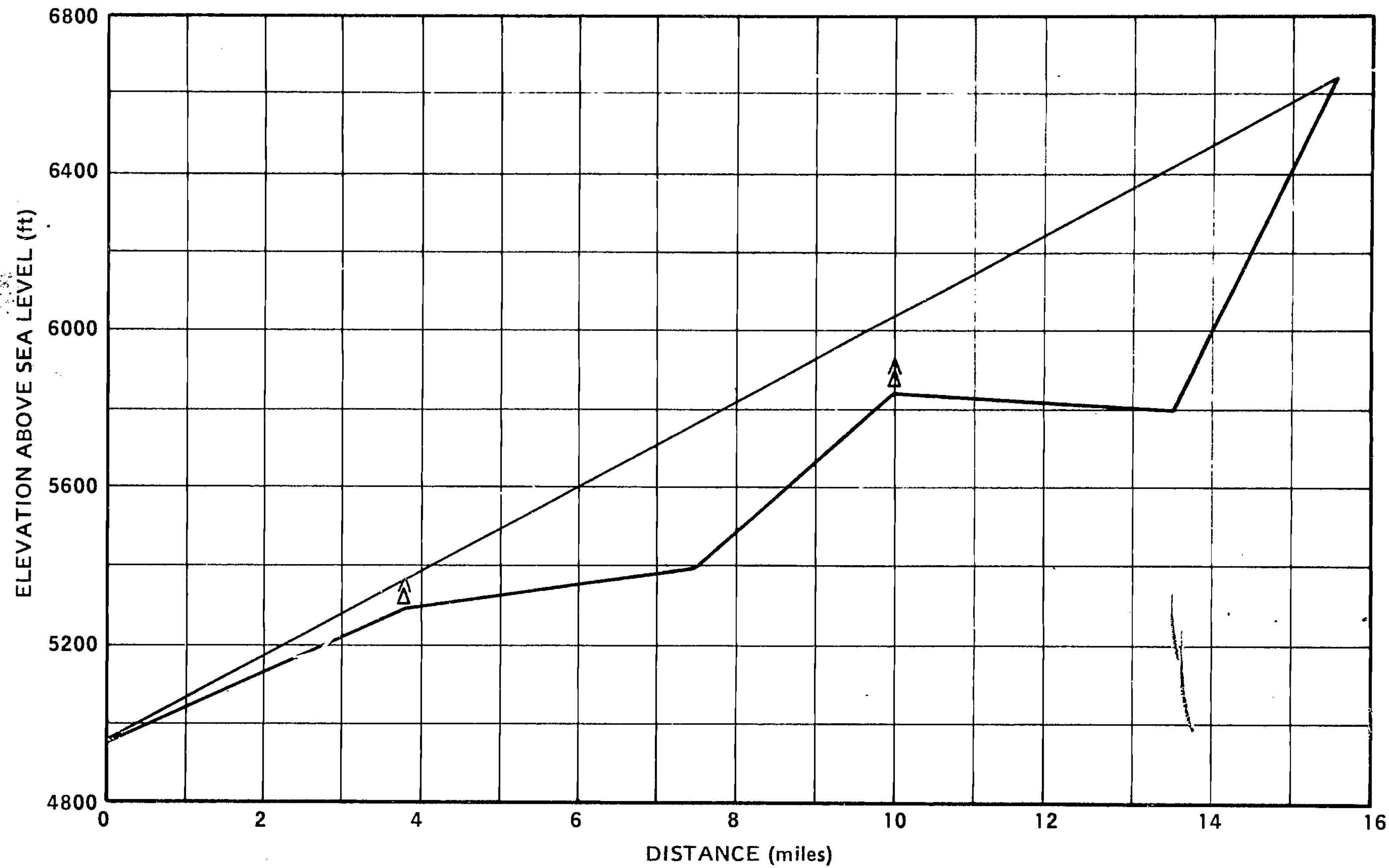

Figure A.56. Microwave Path Profile, Tuba City to Preston Mesa.

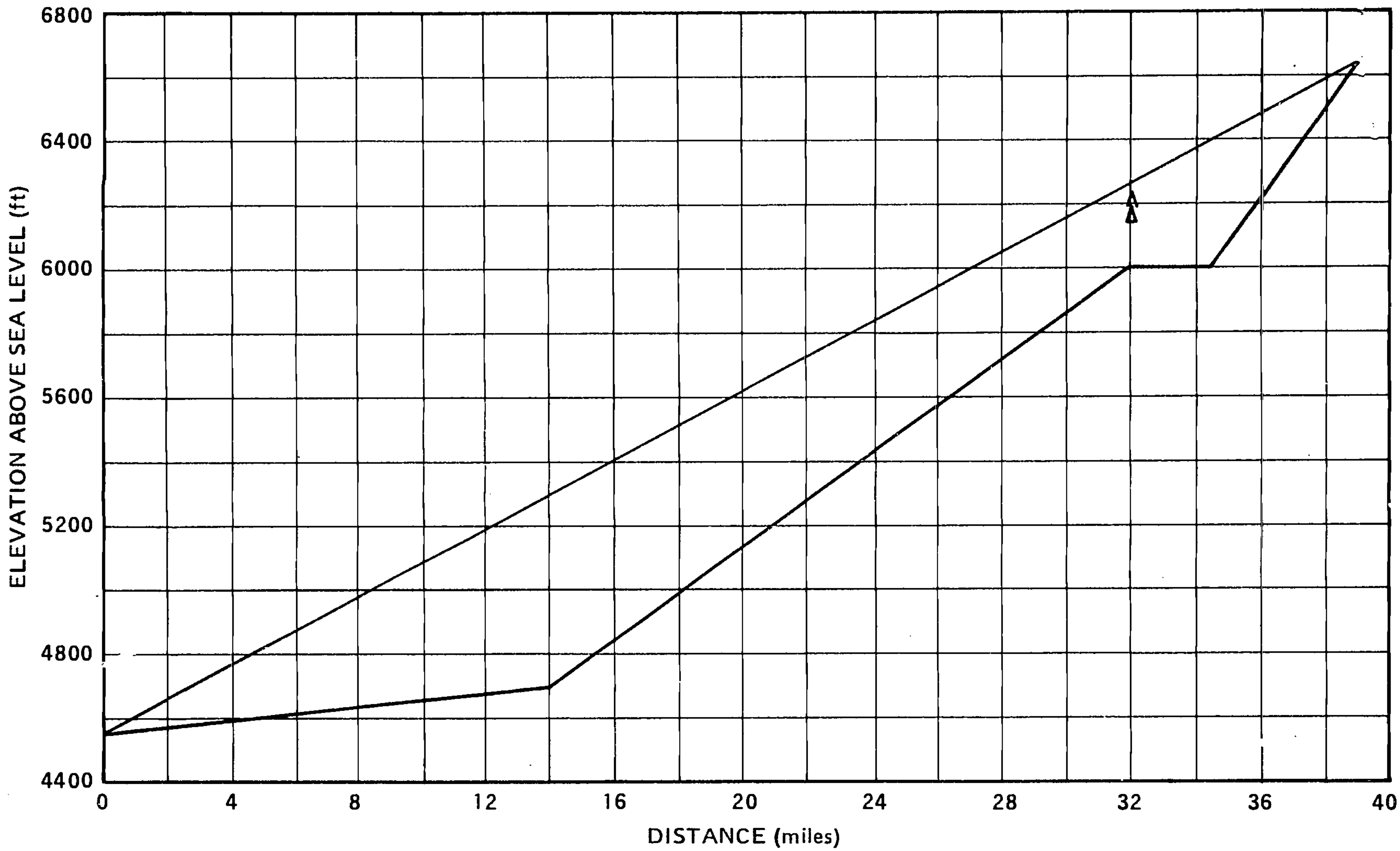

Figure A.57. Microwave Path Profile, Moenkopi Substation to Preston Mesa.

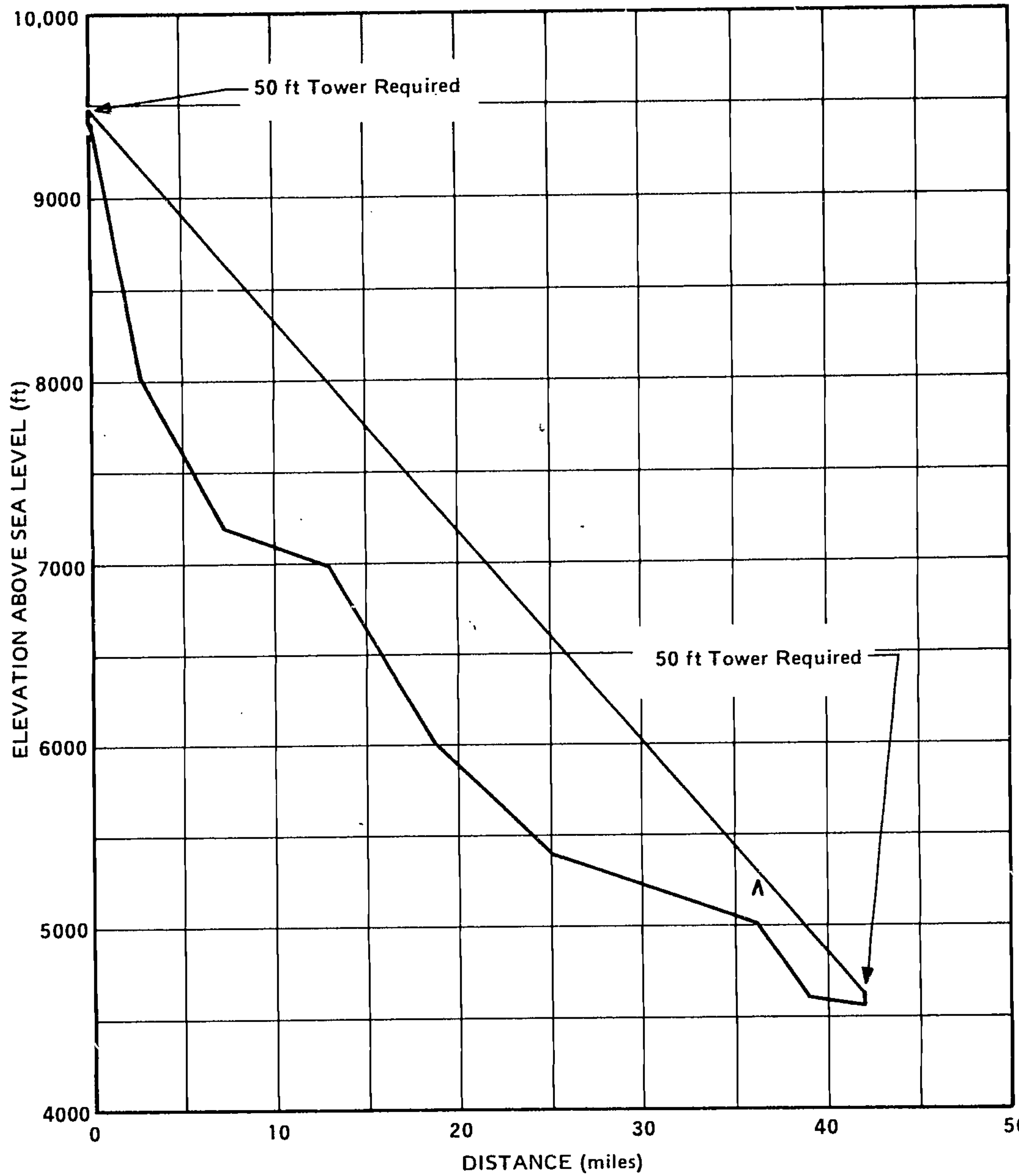

Figure A.58. Microwave Path Profile, Mount Elden to Moenkopi Subs ..on.

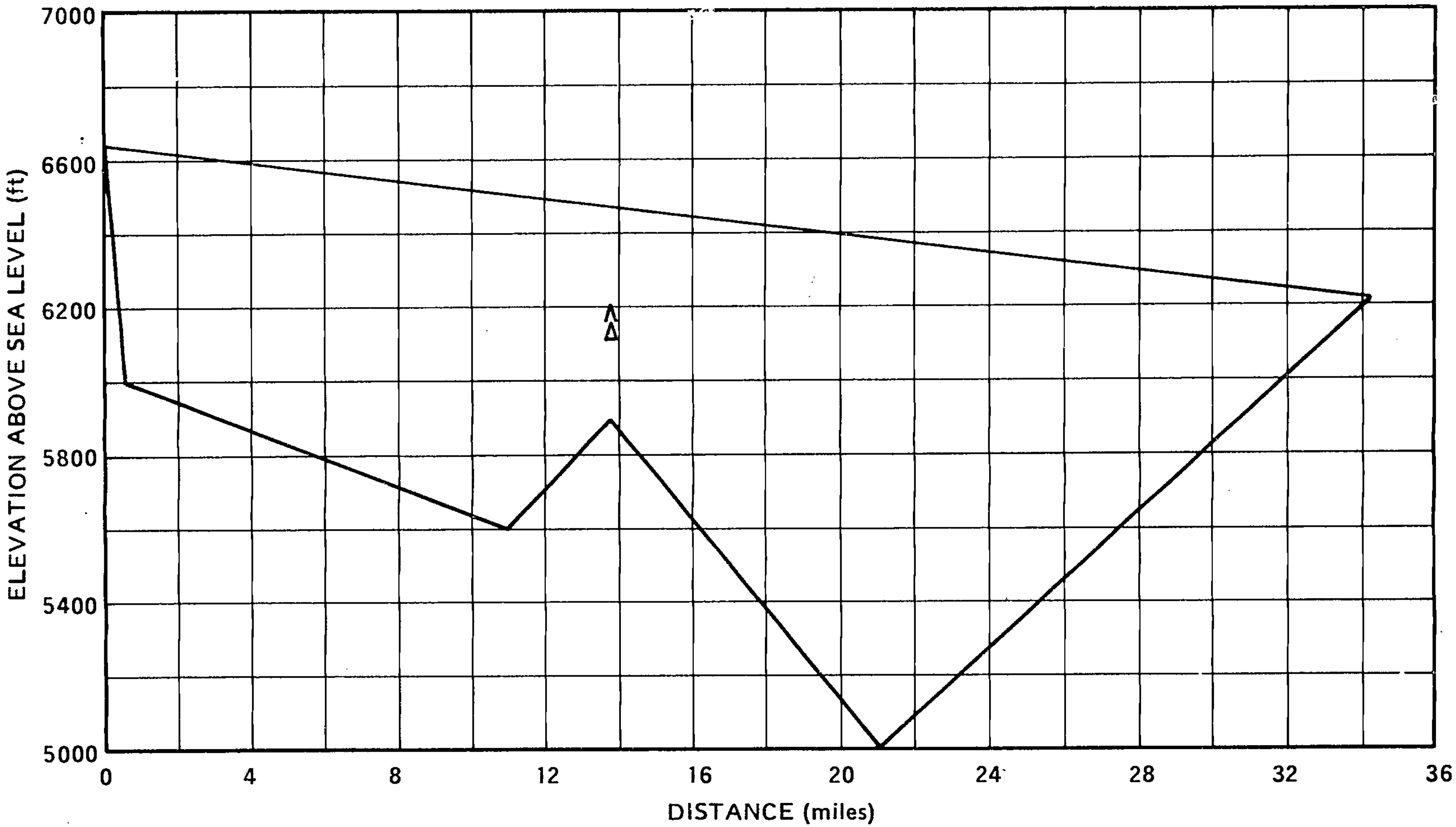

Figure A.59. Microwave Path Profile, Preston Mesa to Rocky Ridge.

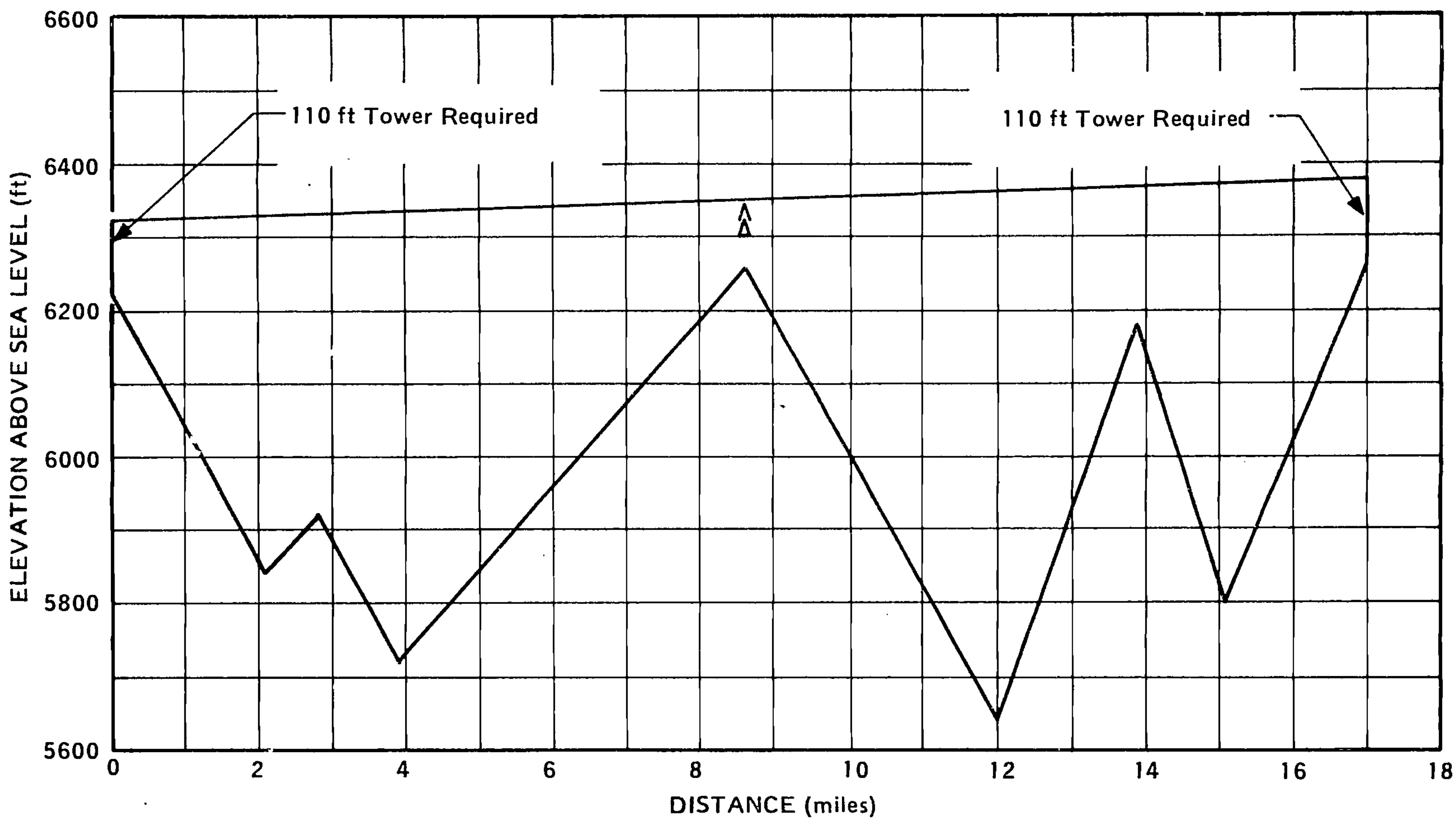

Figure A.60. Microwave Path Profile, Rocky Ridge to Oraibi Repeater.

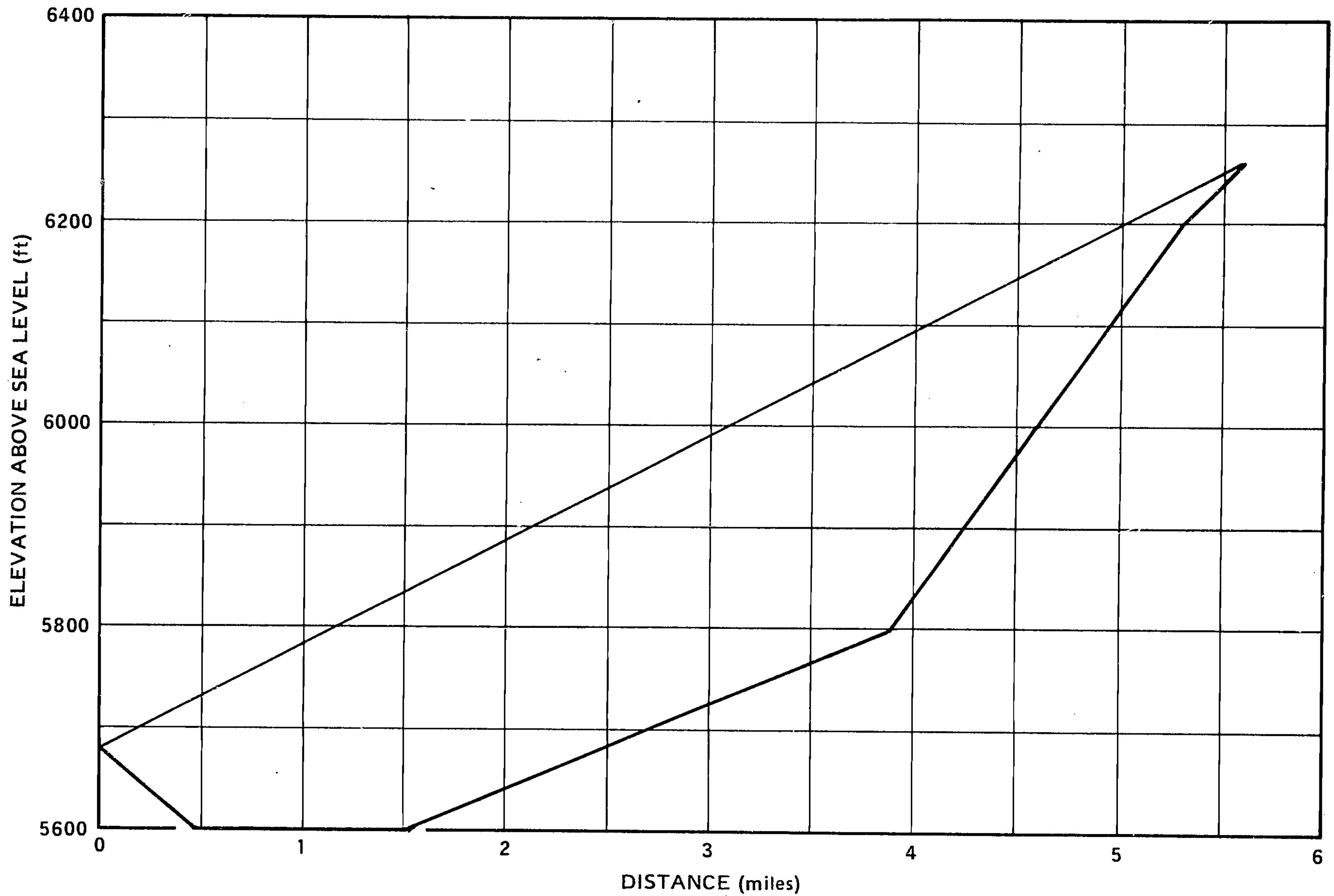

Figure A.61. Microwave Path Profile, Oraibi to Oraibi Repeater.

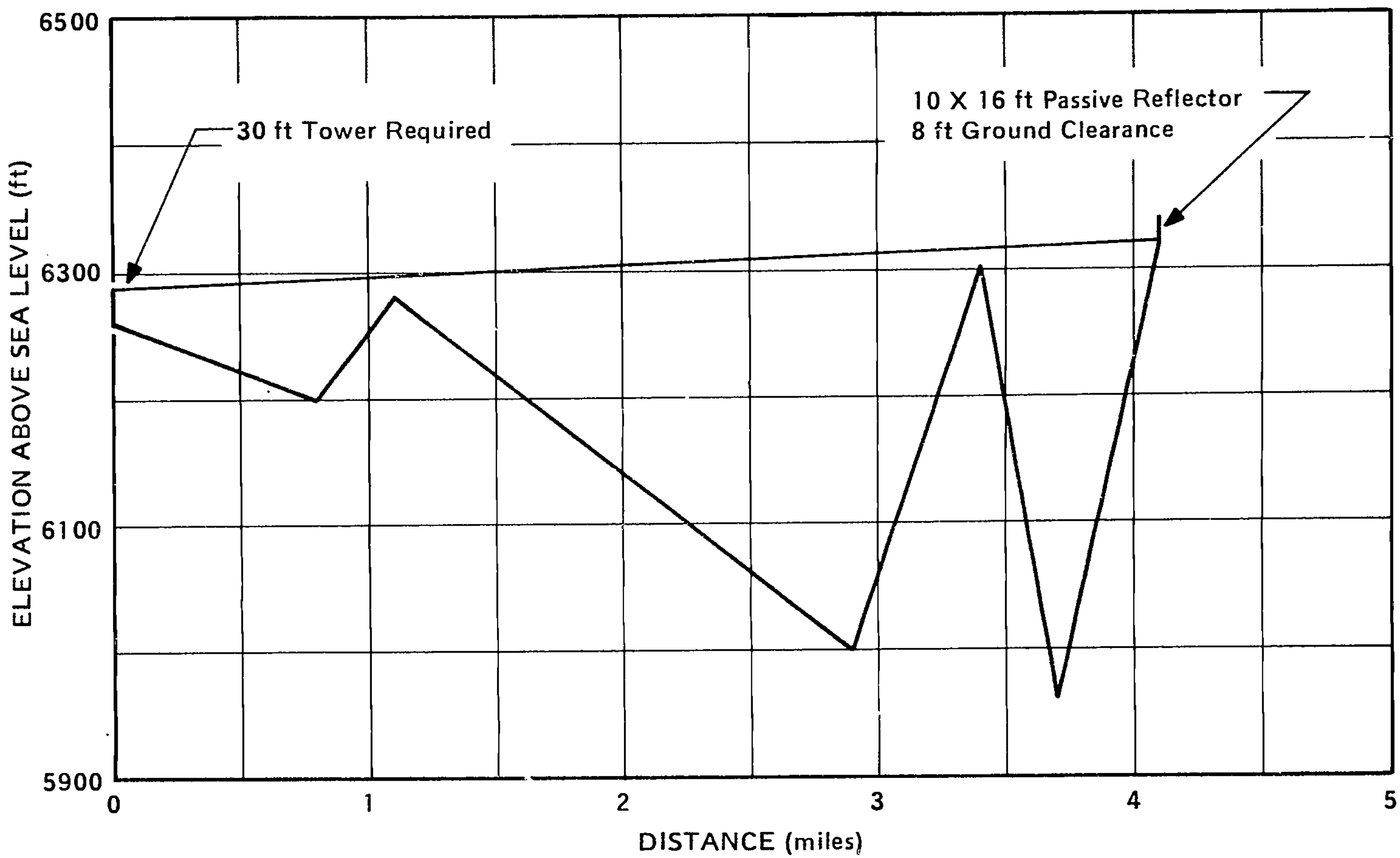

Figure A.62. Microwave Path Profile, Oraibi Repeater to Second Mesa Reflector.

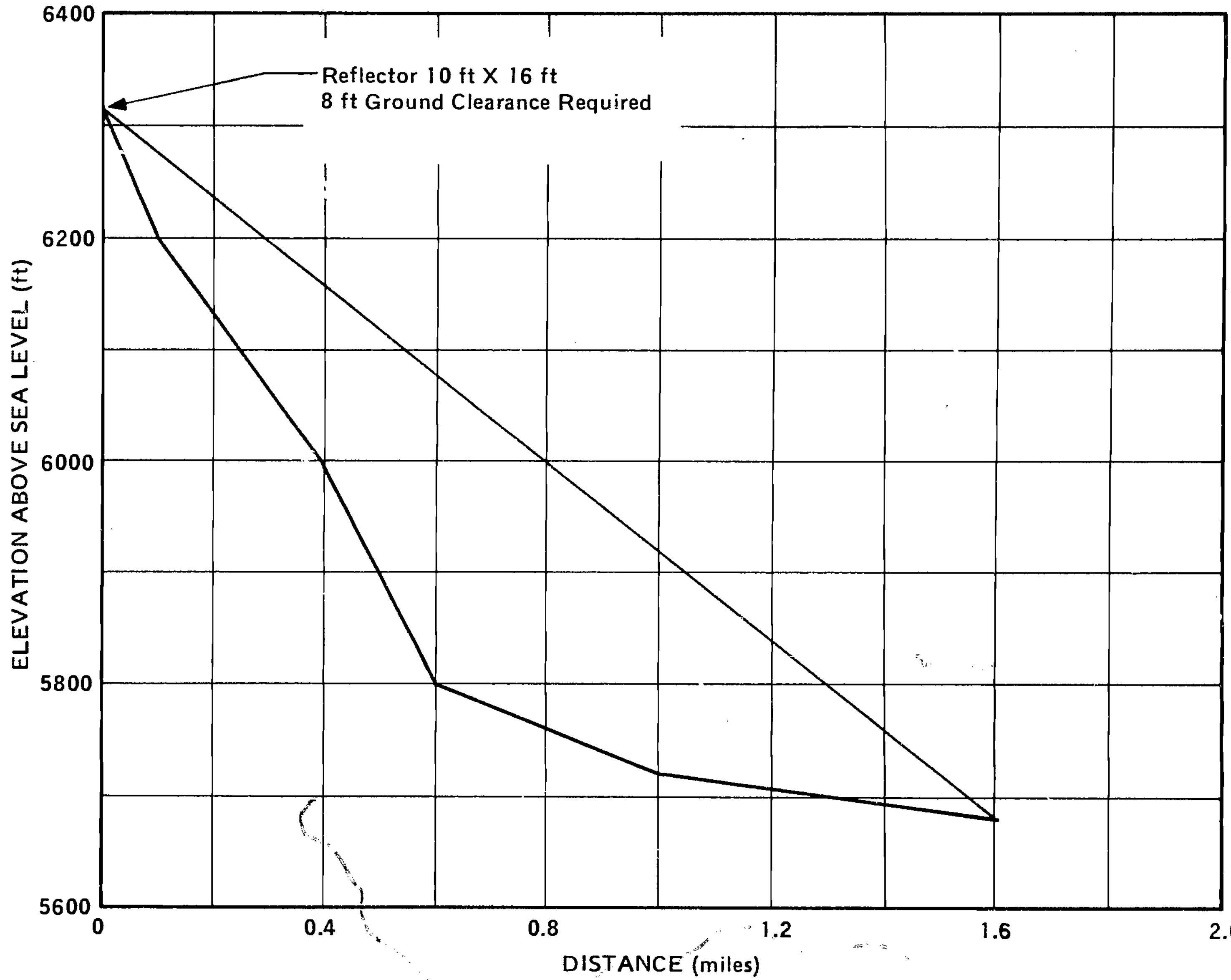

Figure A.63. Microwave Path Profile, Second Mesa Reflector to Second Mesa.

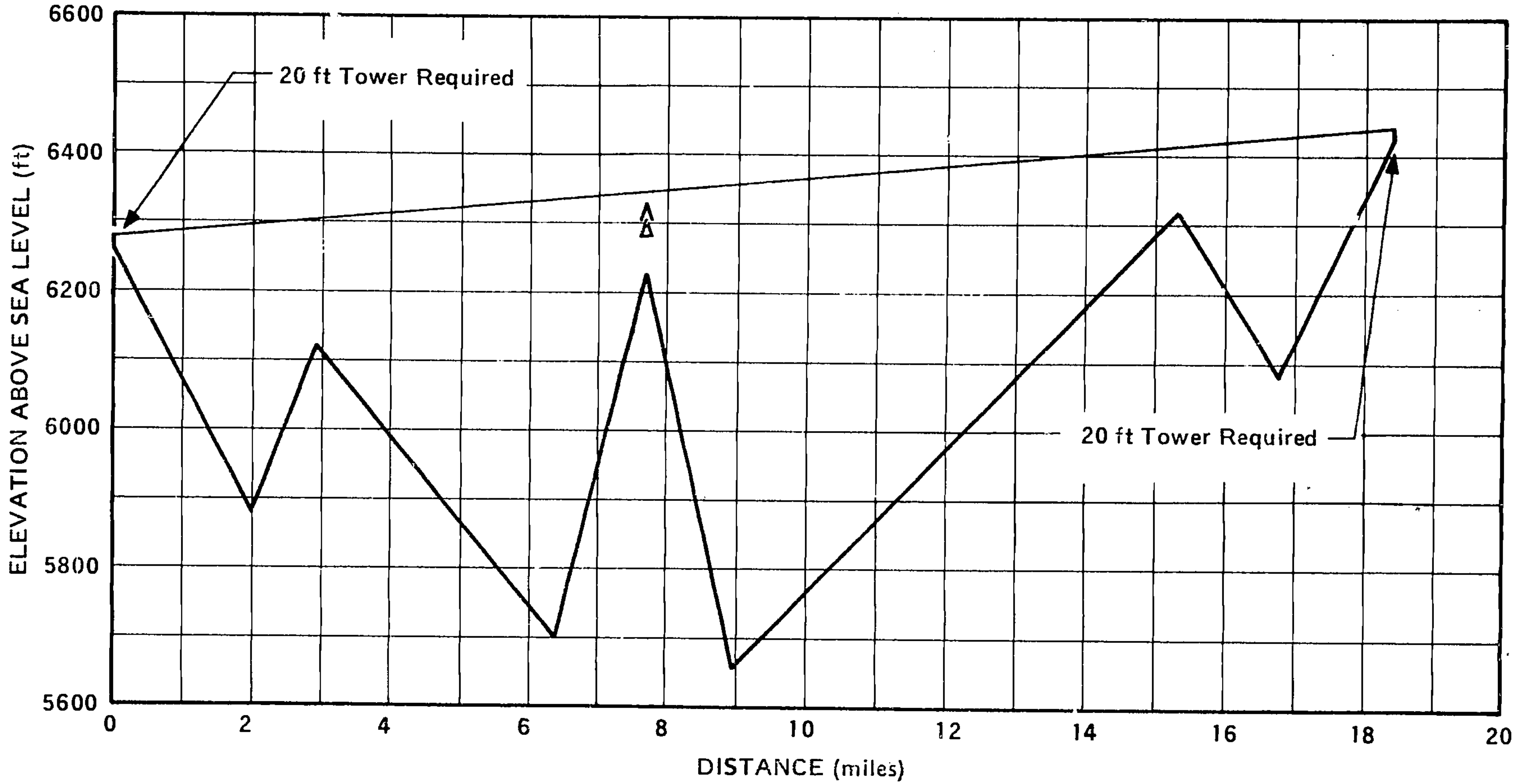

Figure A.64. Microwave Path Profile, Oraibi Repeater to Keams Canyon Repeater.

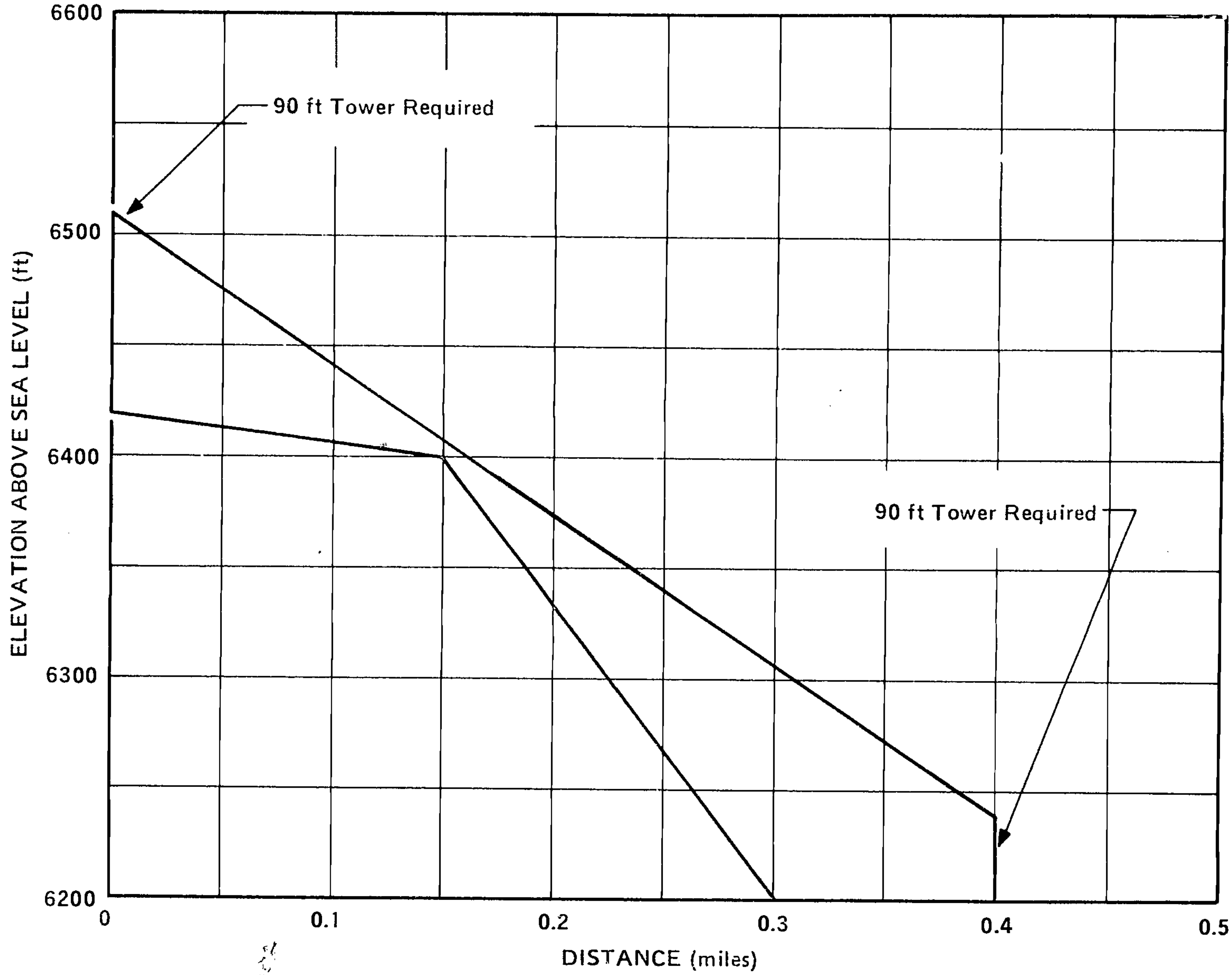

Figure A.65. Microwave Path Profile, Keams Canyon Repeater to Keams Canyon.

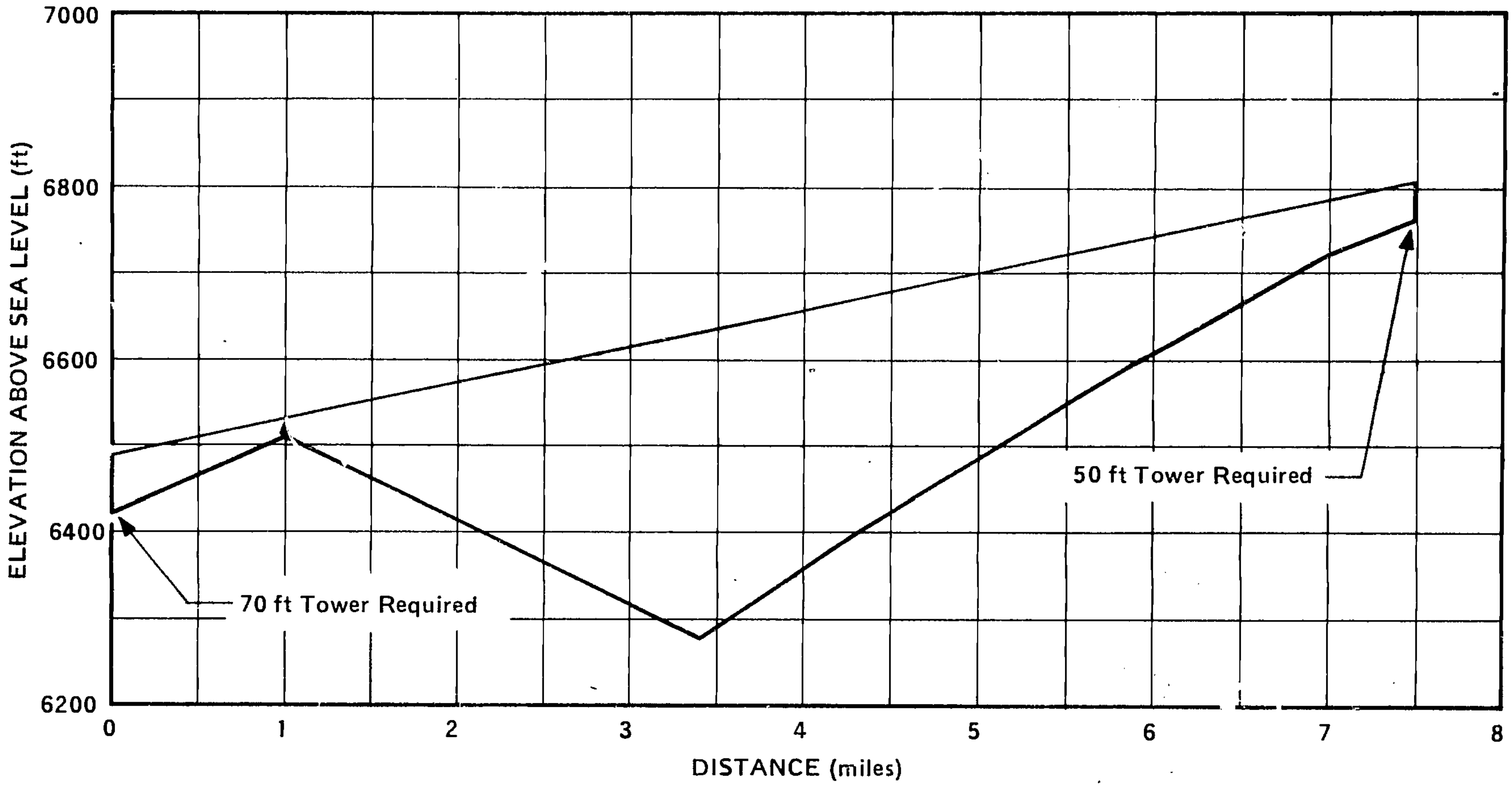

Figure A.66. Microwave Path Profile, Keams Canyon Repeater to Low Mountain Repeater.

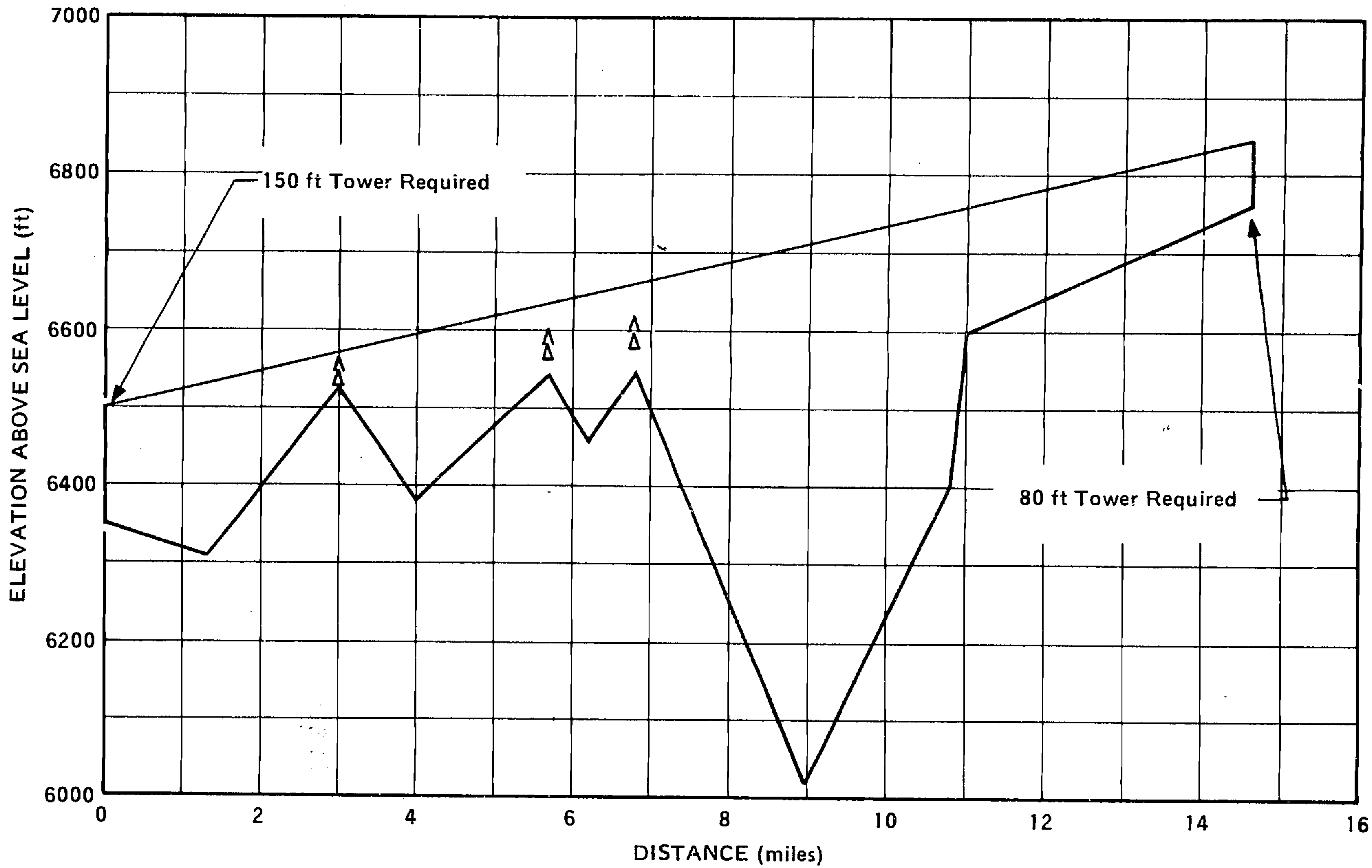

Figure A.67. Microwave Path Profile, Pinon to Low Mountain Repeater.

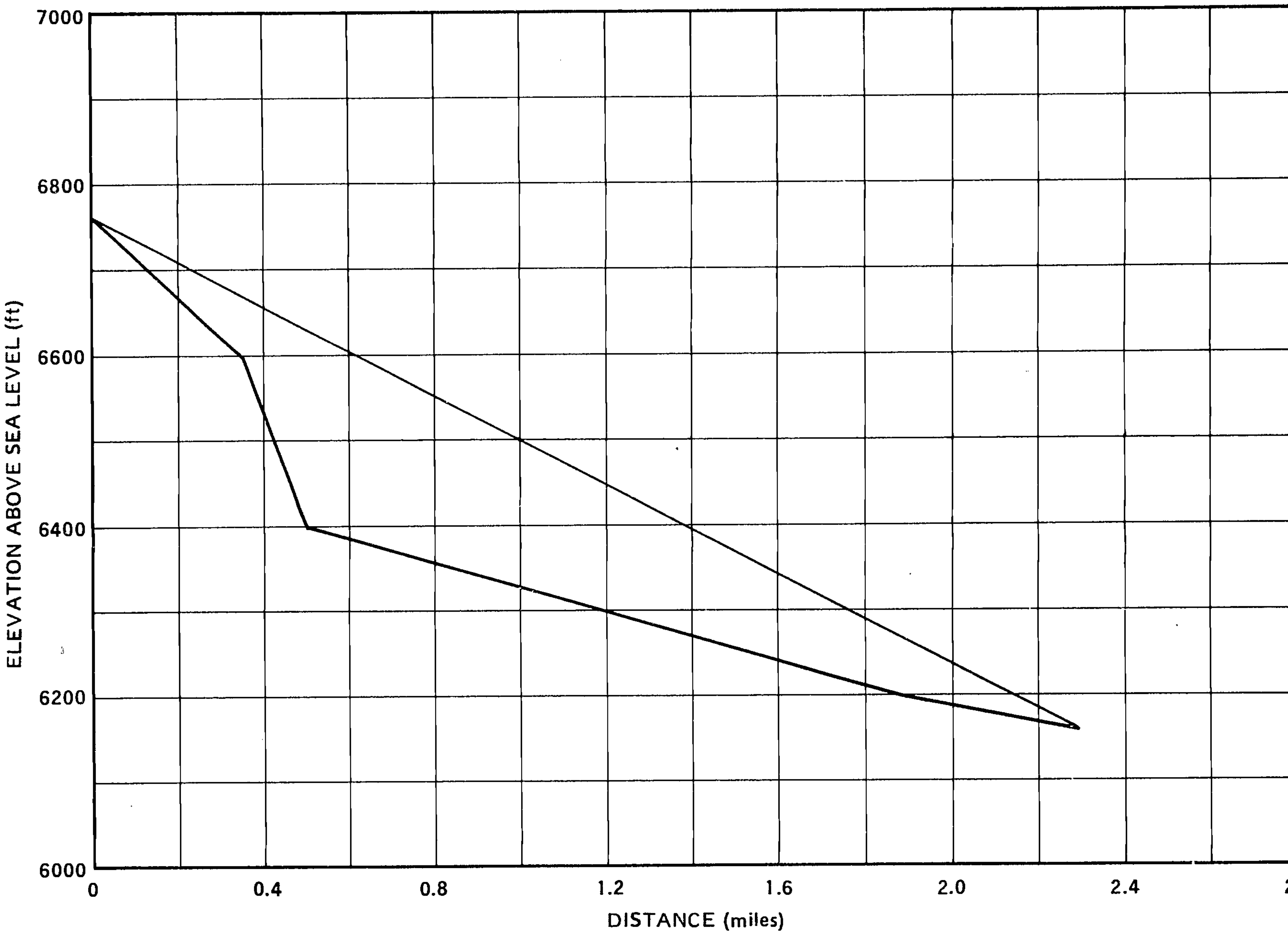

Figure A.68. Microwave Path Profile, Low Mountain Repeater to Low Mountain.

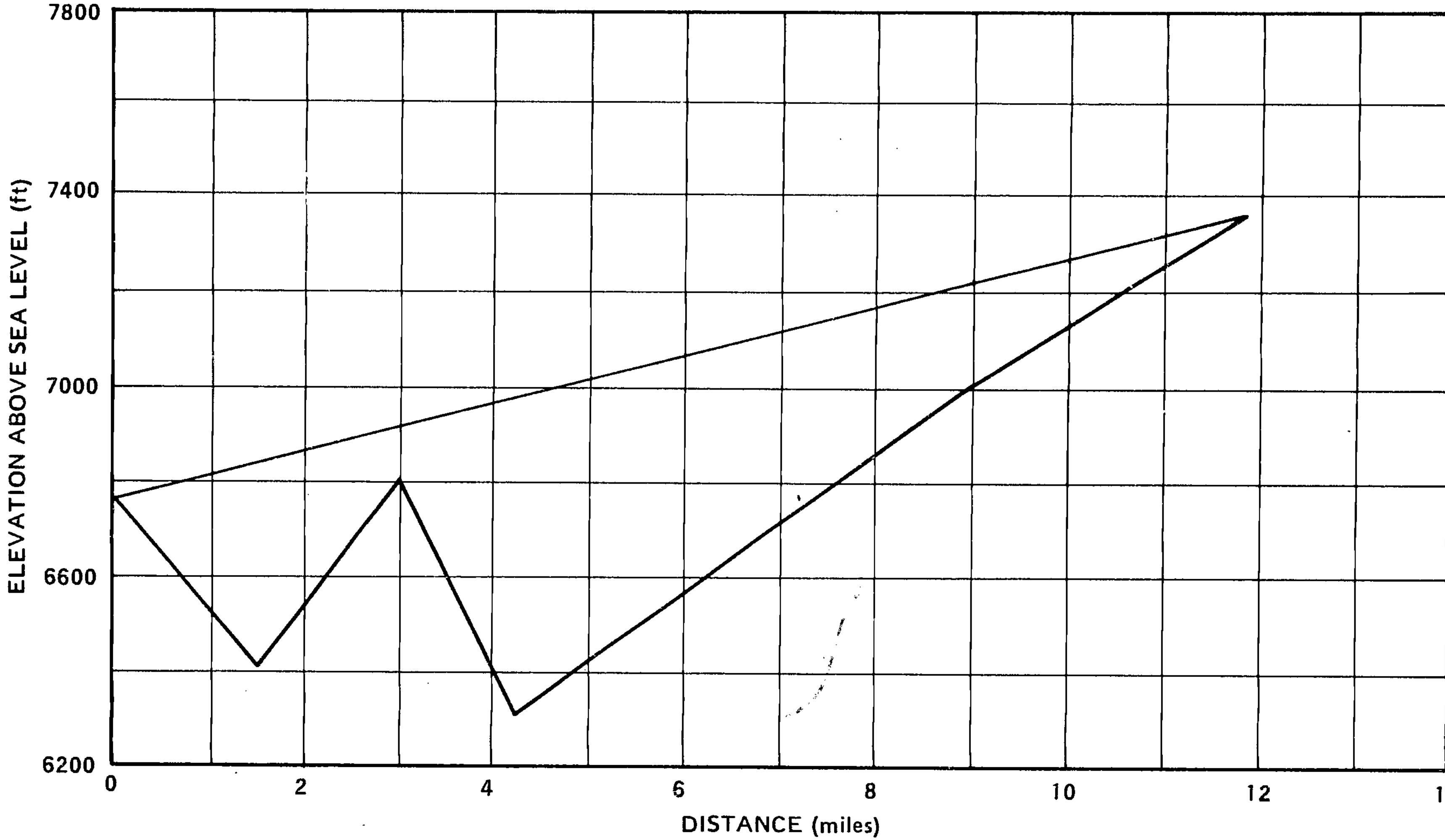

Figure A.69. Microwave Path Profile, Low Mountain Repeater to Balakai Mesa.

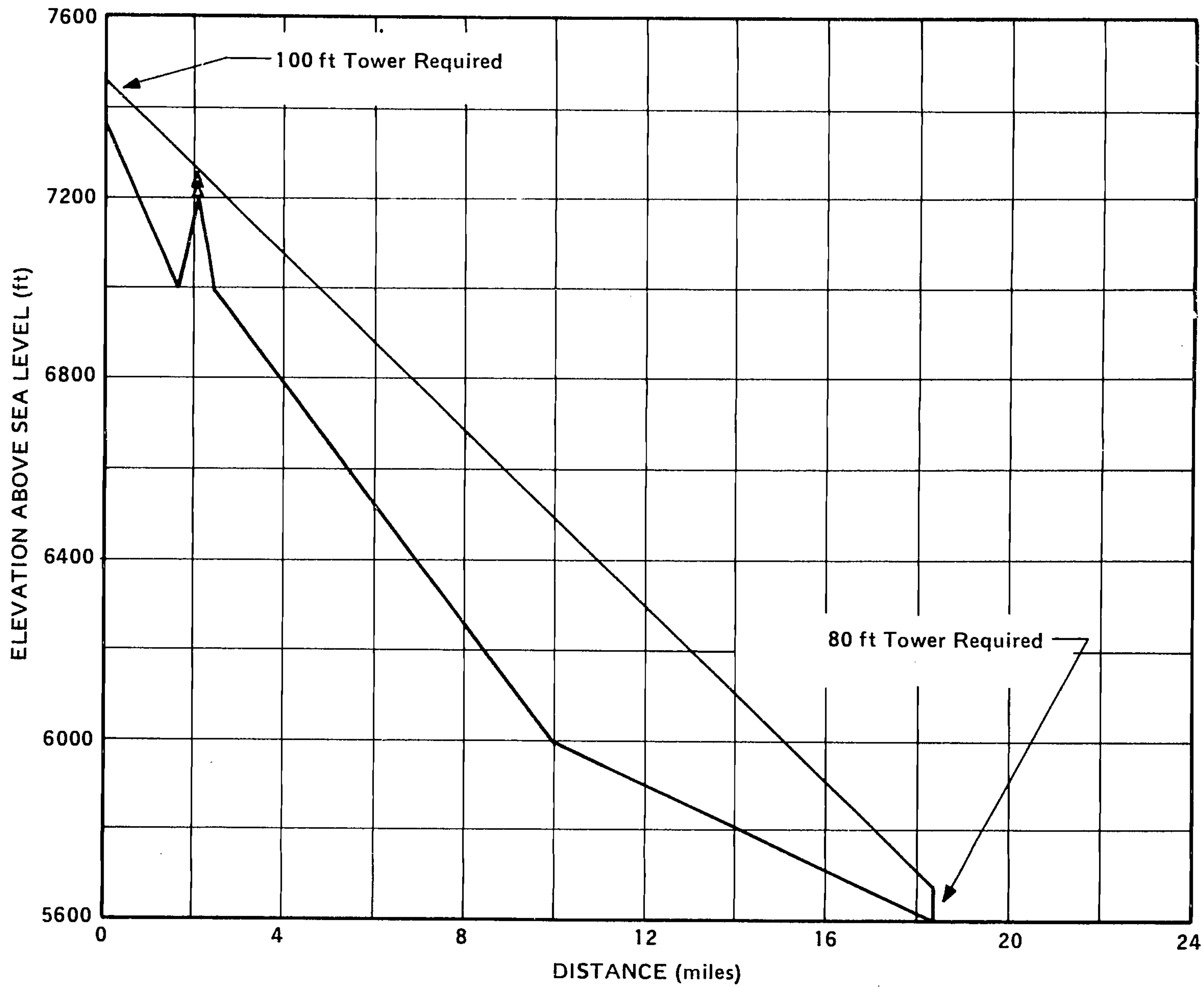

Figure A.70. Microwave Path Profile, Balakai Mesa to Chinle.

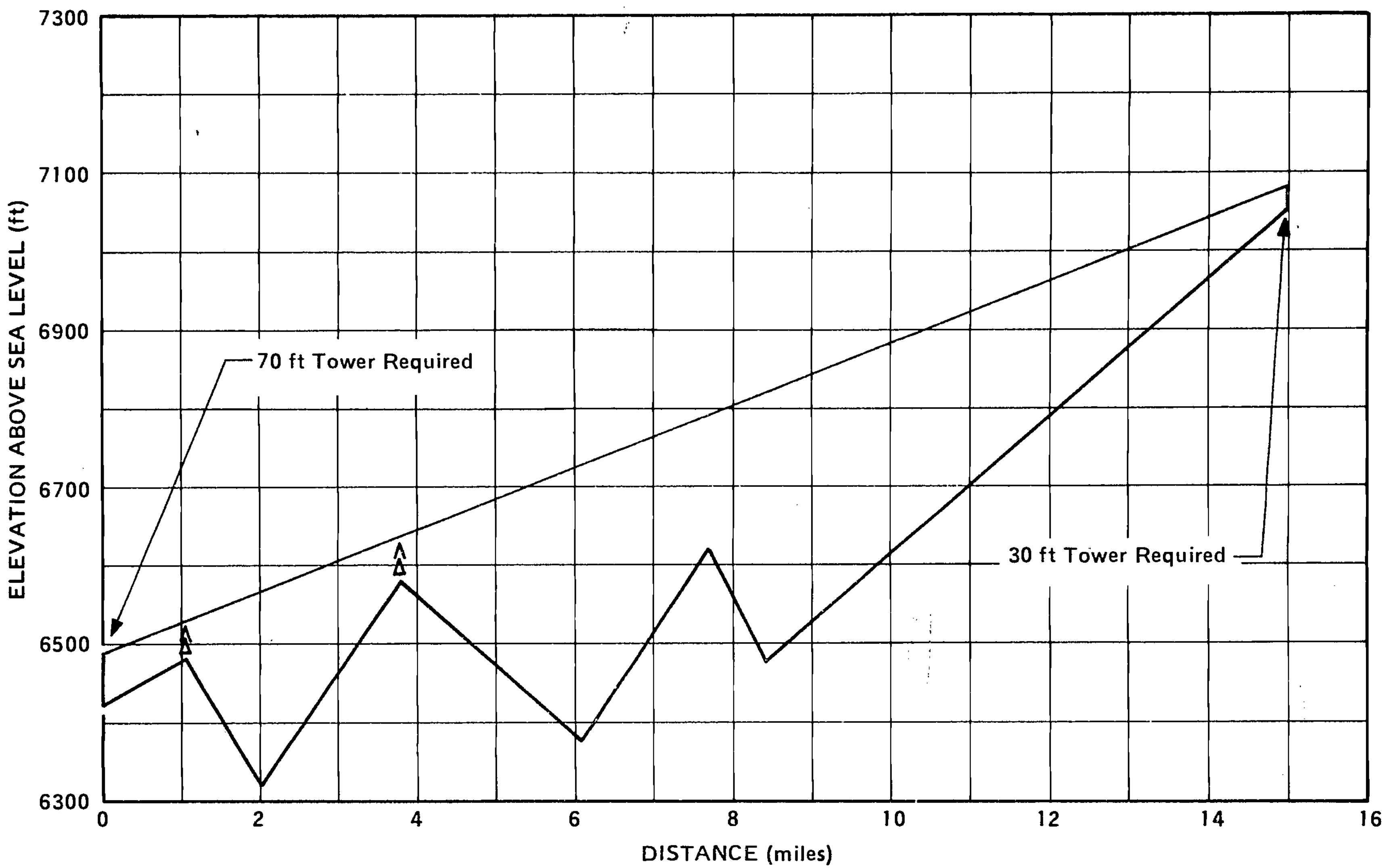

Figure A.71. Microwave Path Profile, Keams Canyon Repeater to Steamboat Canyon.

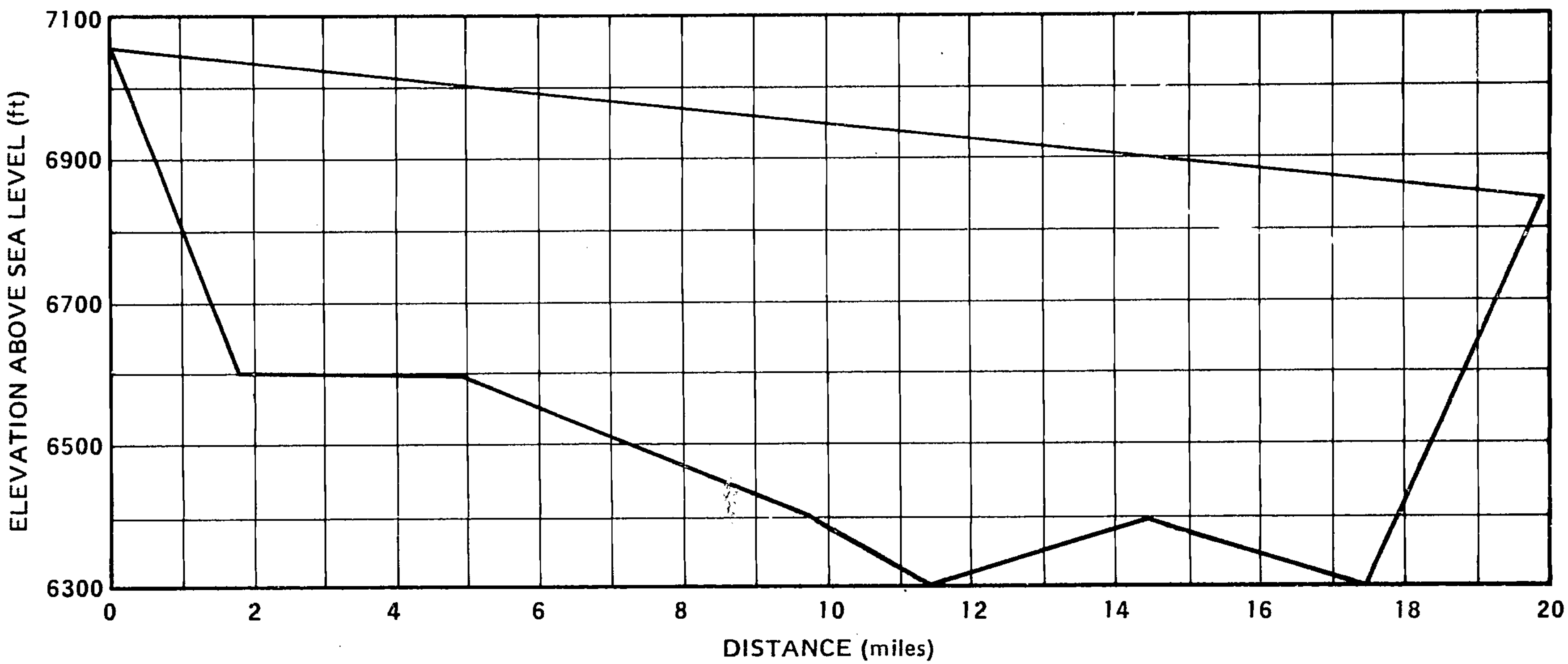

Figure A.72. Microwave Path Profile, Steamboat Canyon to Ganado Mesa.

APPENDIX B

PHOTOGRAPHIC LOG

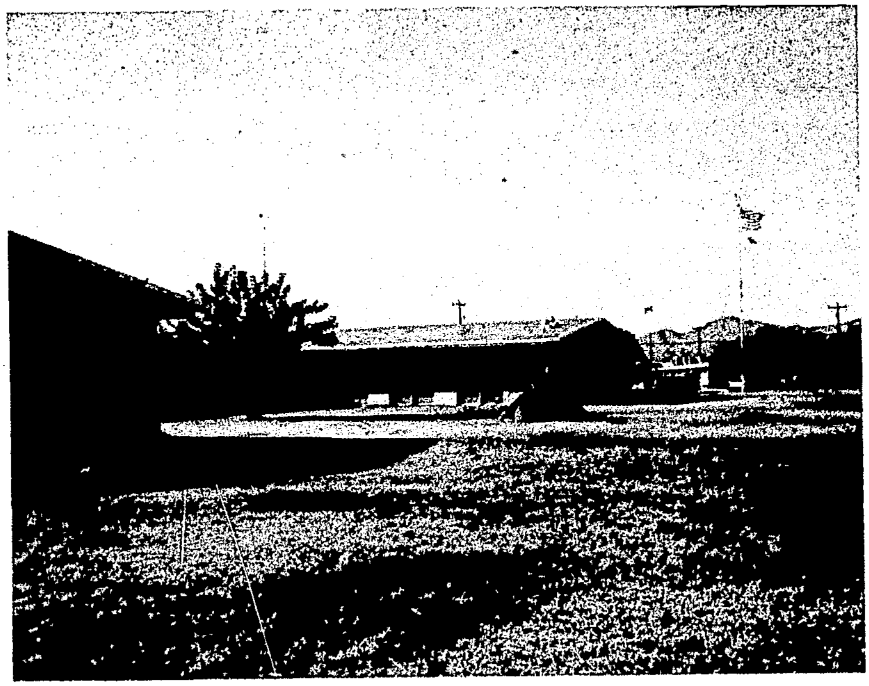

Figure B-1. Sells Hospital, Front View Looking Northwest.

Figure B-2. Kitt Peak as Seen from the South Grounds of Sells Hospital.

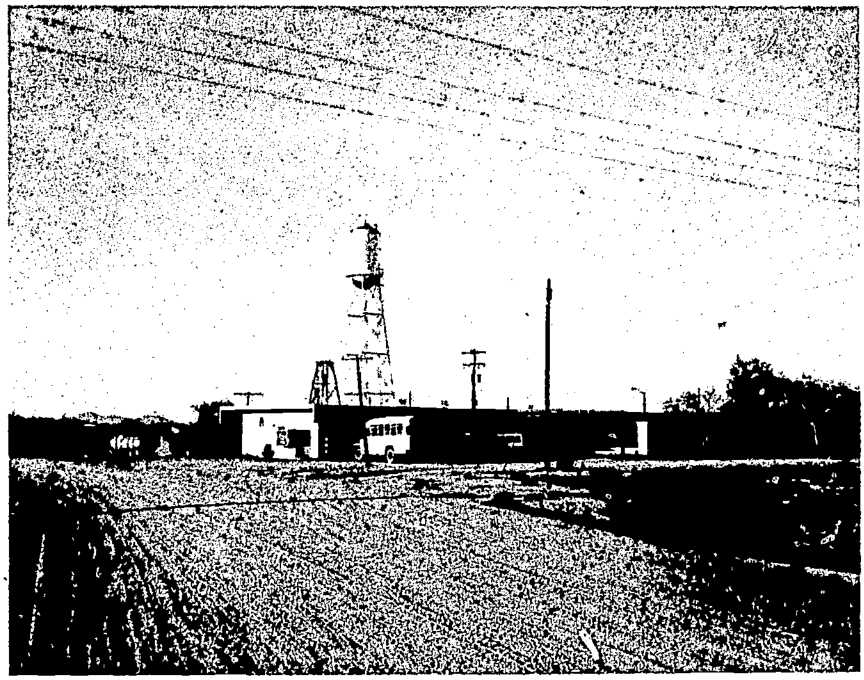

Figure B-3. Santa Rosa Health Center Looking North.

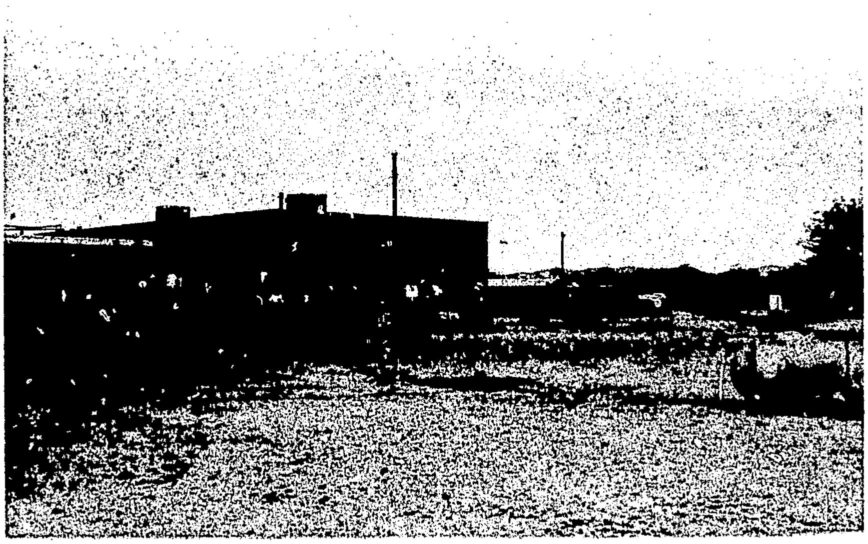

Figure B-4. Pisinimo, Showing the Existing Meeting Hall and Clinic with Proposed Relay Site in Foreground.

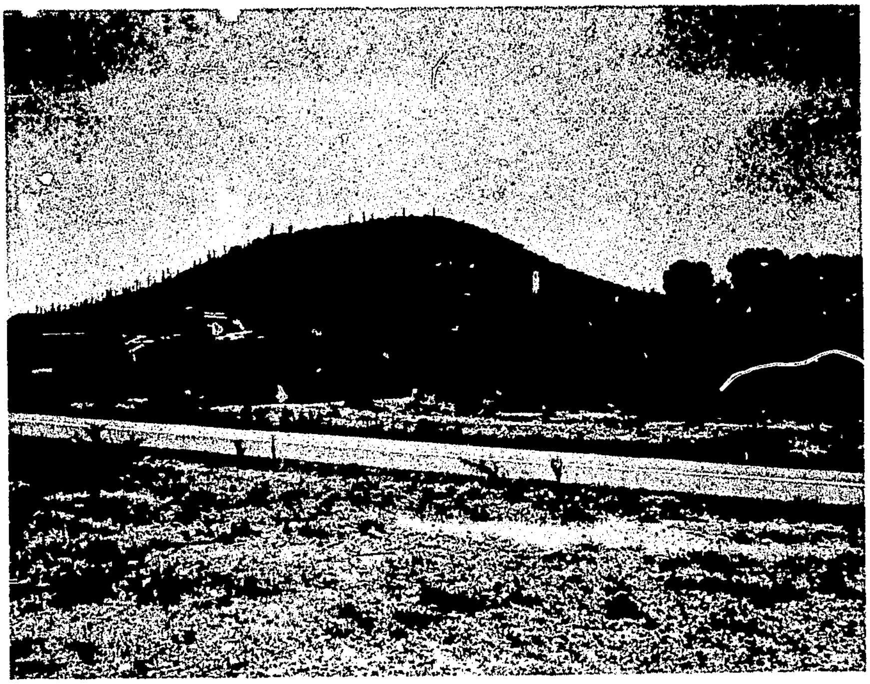

Figure B-5 Indian Health Service Health Program Systems Center Near San Xavier Mission (Tucson). View Looking West.

Figure B-6. Health Program Systems Center Near San Xavier Mission - West Side of Building.

Figure B-7. Kitt Peak as Viewed from Proposed Antenna Site Near I.H.S. Facility, San Xavier Reservation.

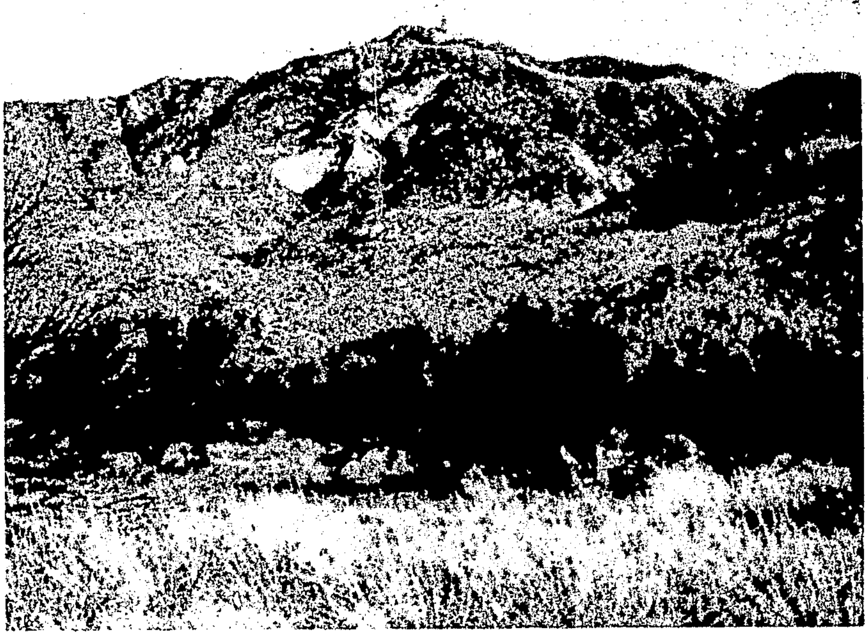

Figure B-8. Kitt Peak, View Looking Southeast.

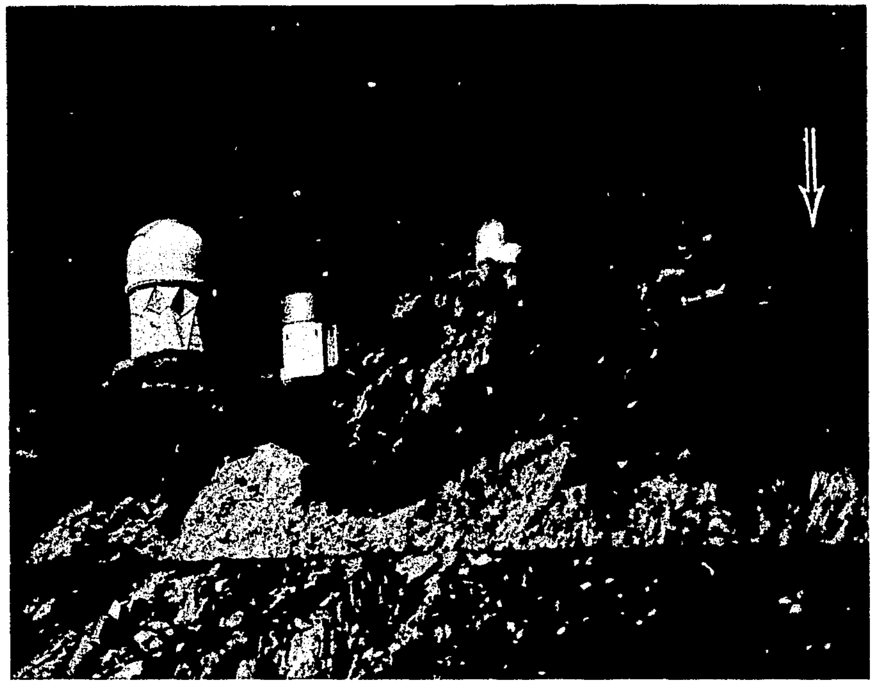

Figure B-9. Proposed Kitt Peak Relay Site, View Looking East.

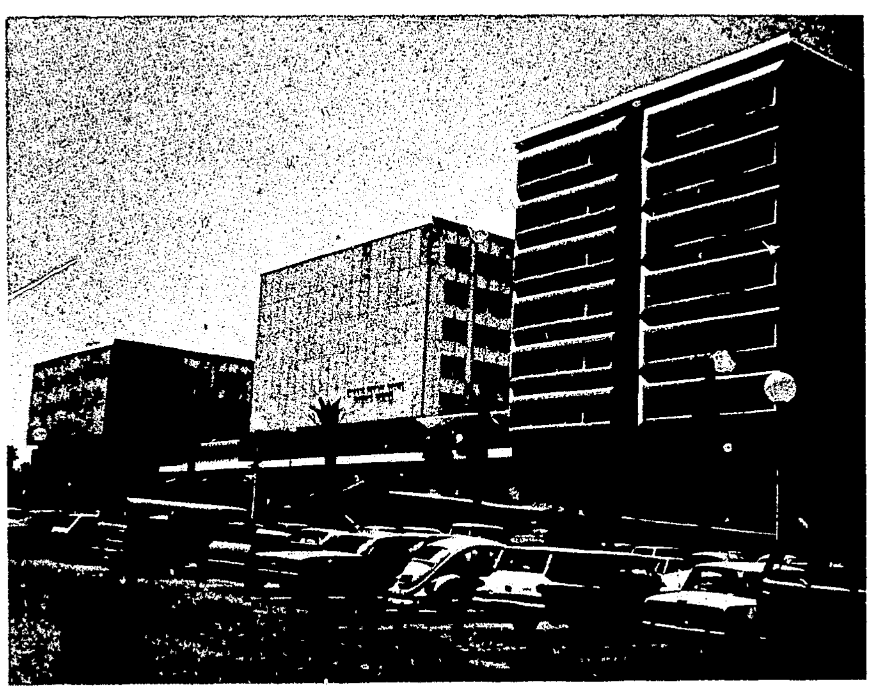

Figure B-10. University of Arizona Medical Center, Tucson.

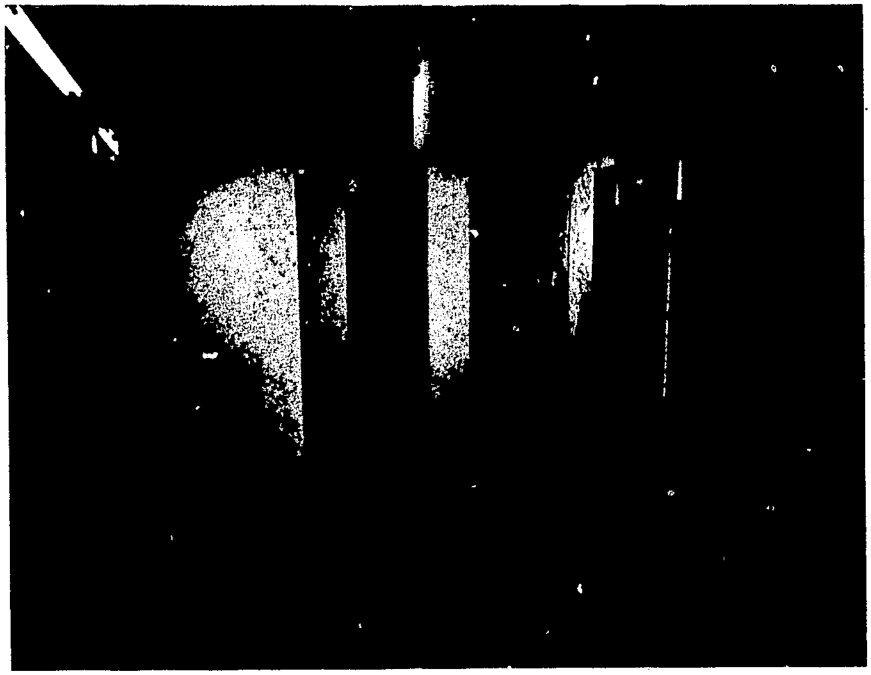

Figure B-11. Proposed Equipment Site, University of Arizona Medical Center Penthouse.

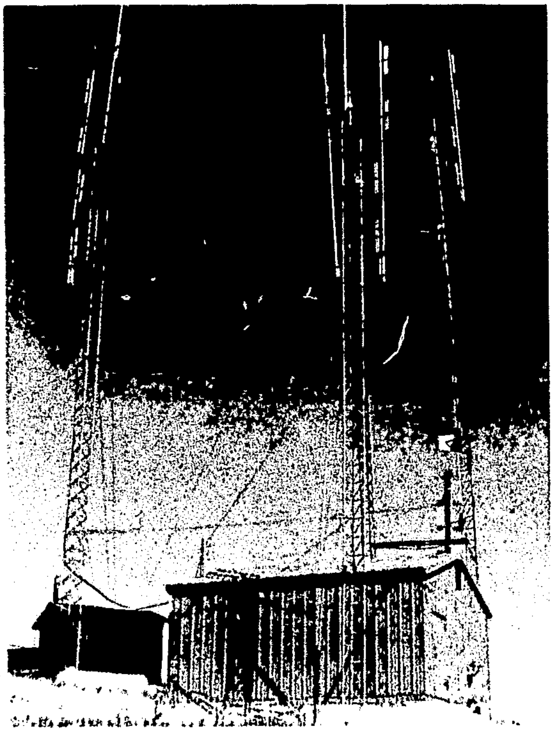

Figure B-12. Mt. Lemmon, Showing the Existing Facilities of General Communications Inc. Proposed Network Relay and Tower Site.

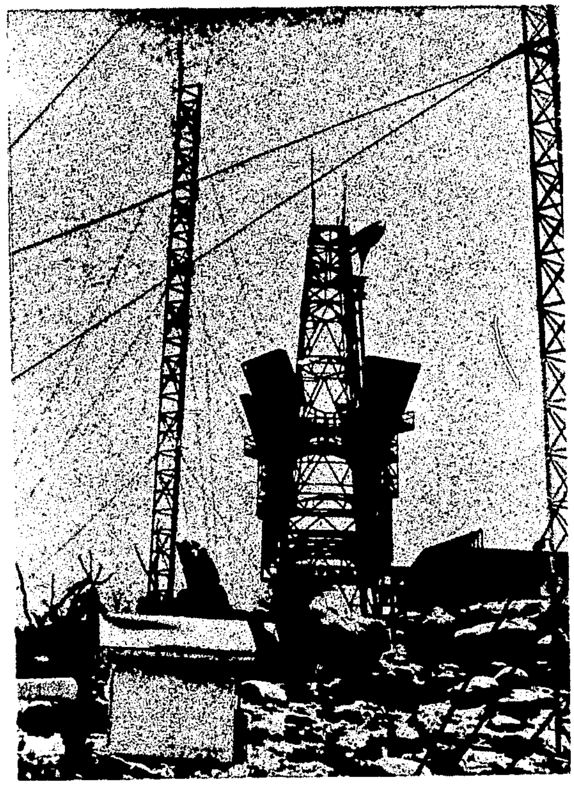

Figure B-13. Pinal Peak B.I.A. Radio Station (foreground left of center).

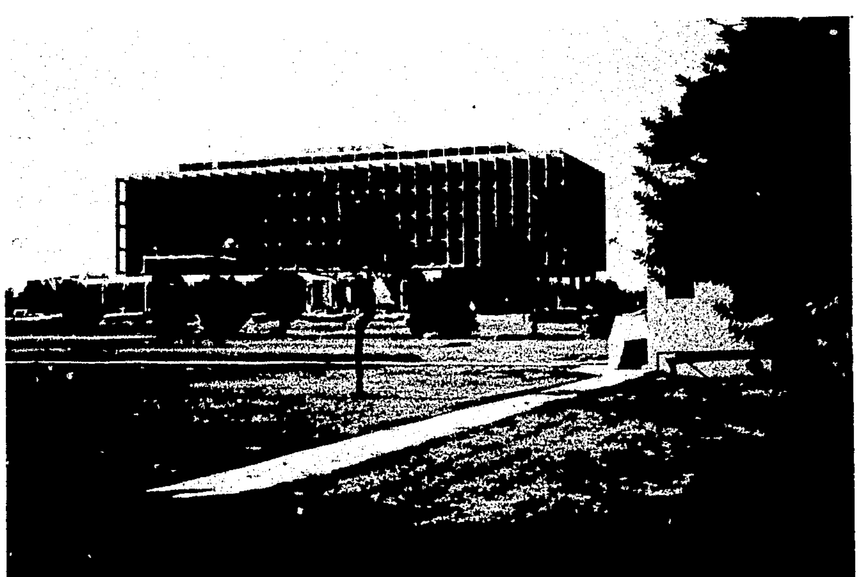

Figure B-14. Phoenix Indian Medical Center.

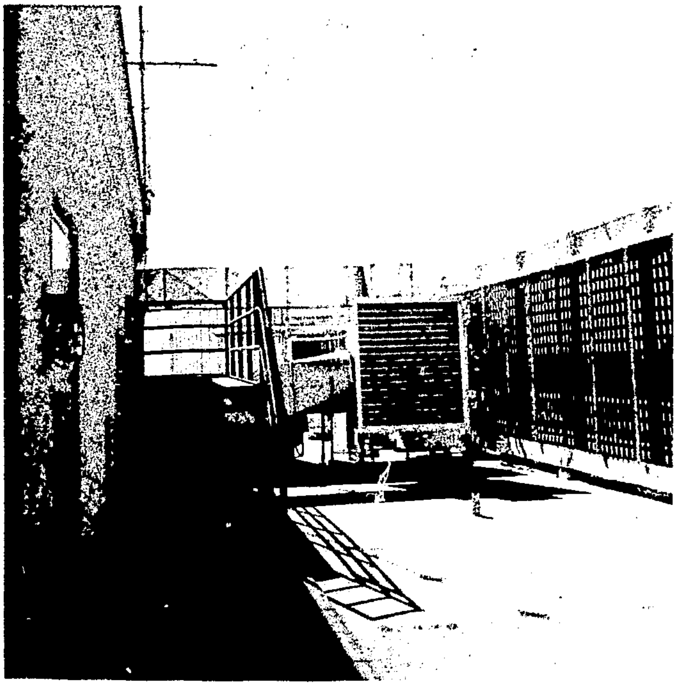

Figure B-15. View of Proposed Equipment Shelter Site, Phoenix I.H.S. Hospital Roof. View Looking North.

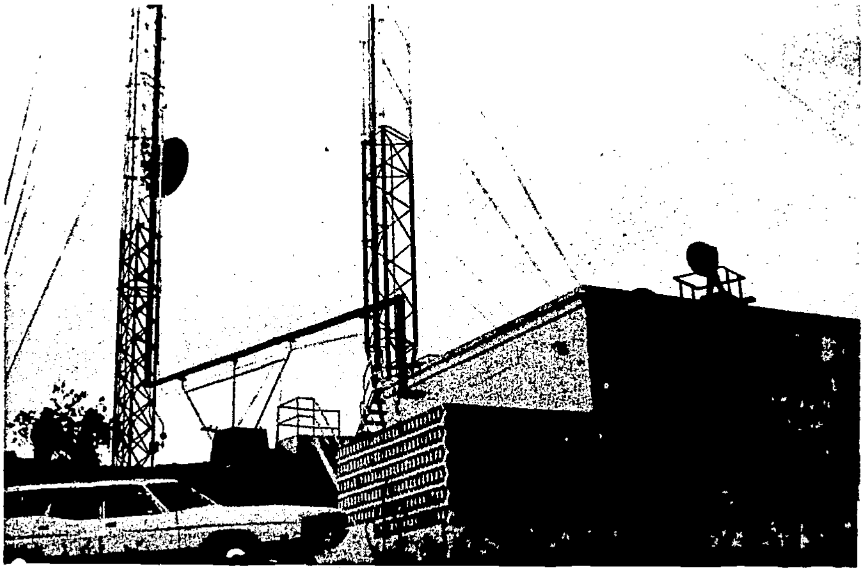

Figure B-16. South Mountain, Showing KAET Tower (left) and Equipment Building.

Figure B-17. Bylas Health Center, View to Northeast.

Figure B-18. San Carlos Hospital, View Looking North.

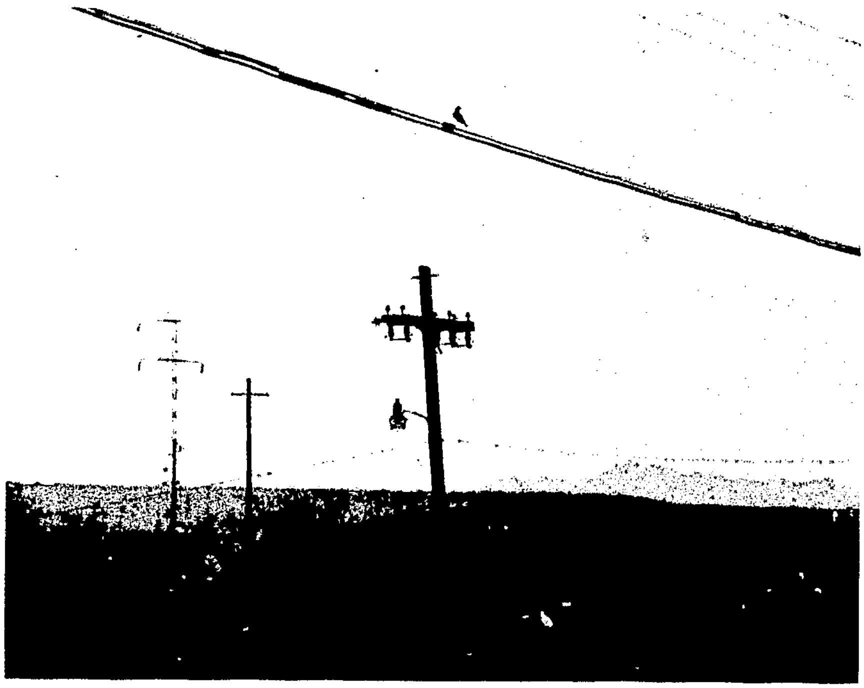

Figure B-19. Pinal Peak, as seen from San Carlos.

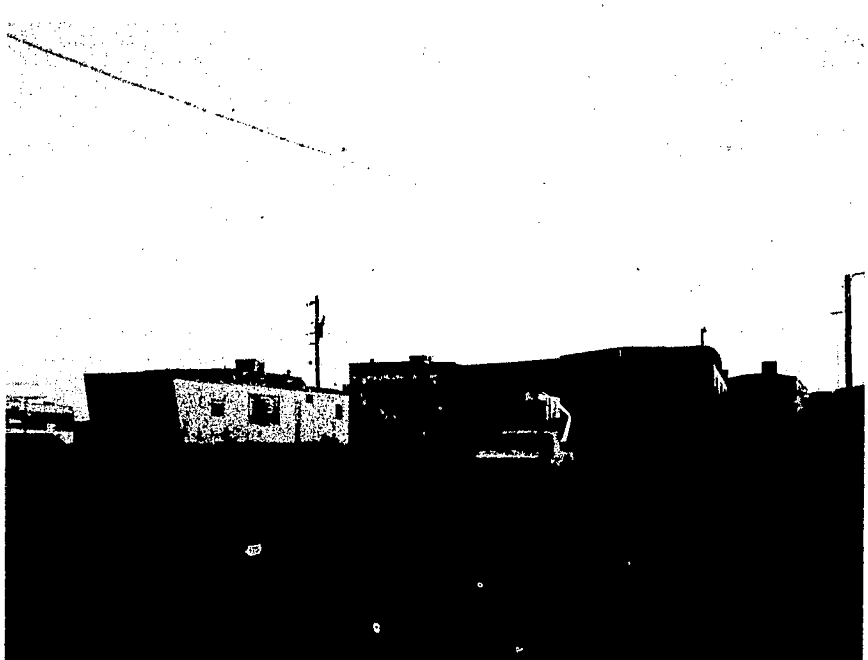

Figure B-20. Cibecue Health Center.

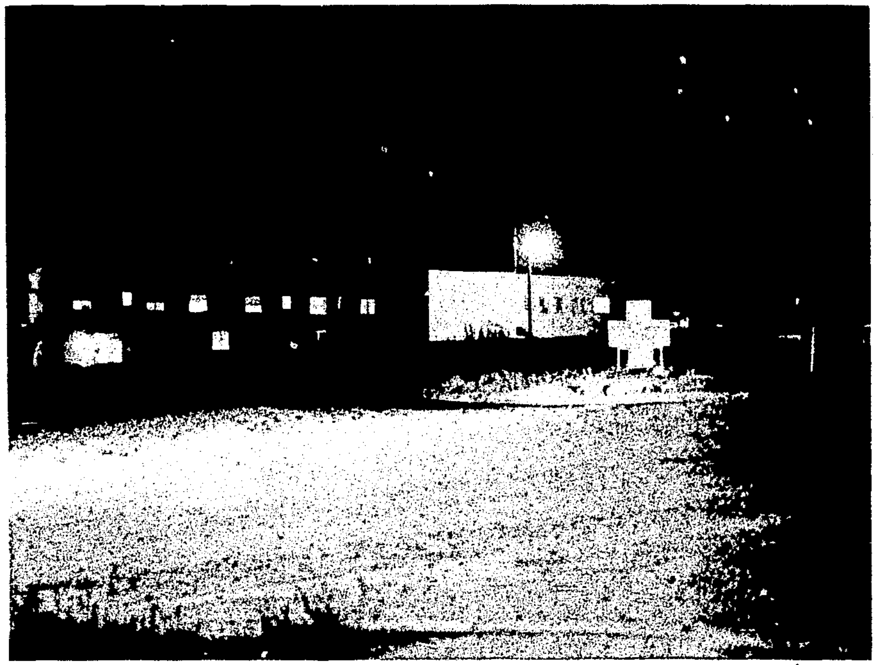

Figure B-21. White River Hospital (clinic in building to the rear).

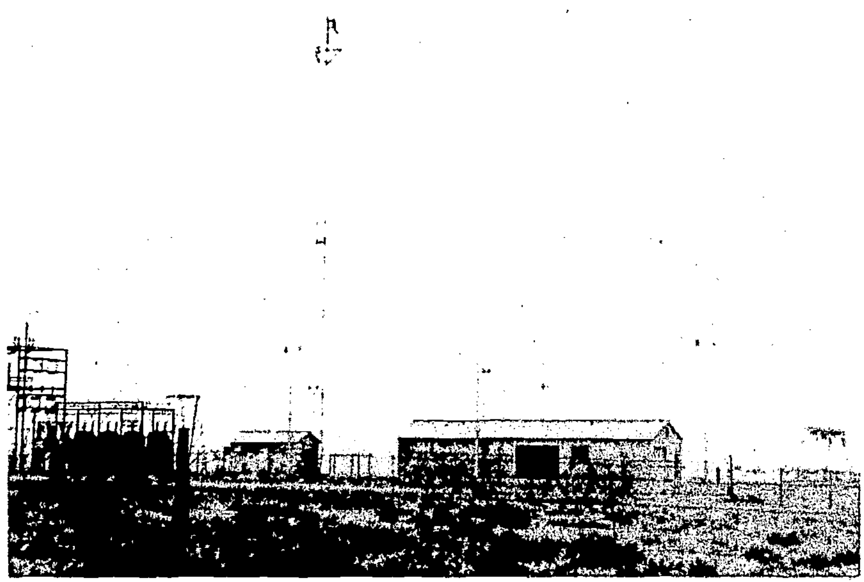

Figure B-22. Existing Microwave Site 5 Miles South of Cameron.

Figure B-23. Tuba City Hospital, View Looking East.

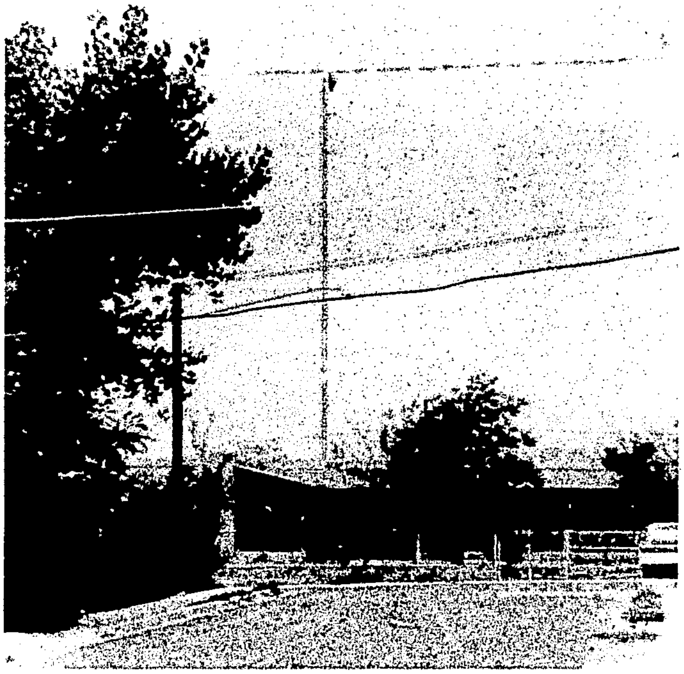

Figure B-24. Existing Microwave Tower Near Hospital in Tuba City. (Navajo Communications Co.)

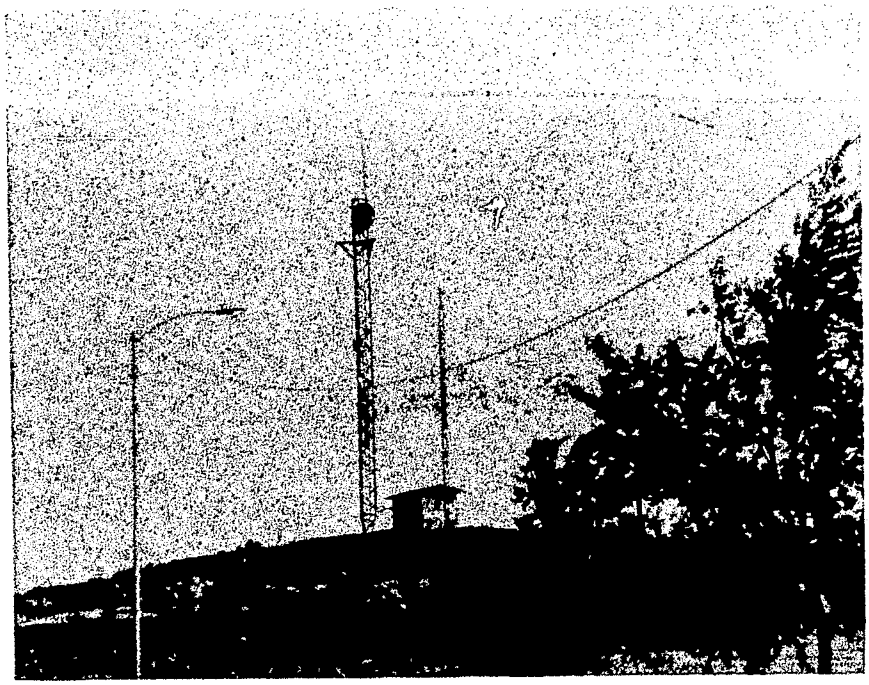

Figure B-25. Existing Microwave Facility Approx. 1 1/2 Miles North of Rt. 160, Near Tuba City. (Navajo Nation).

Figure B-26. Second Mesa, Site of Clinic.

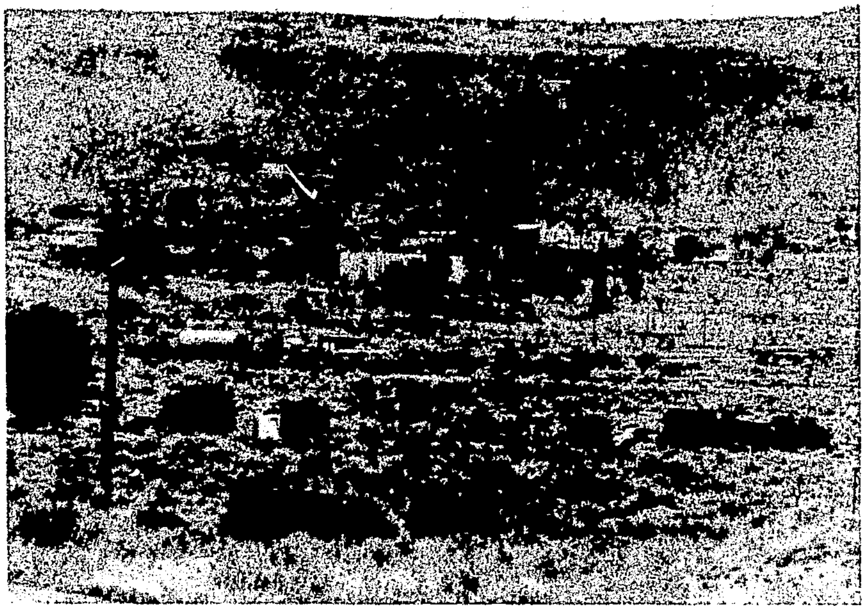

Figure B-27. Oraibi, View Looking Southwest.

Figure B-28. Indian Health Station at Oraibi School.

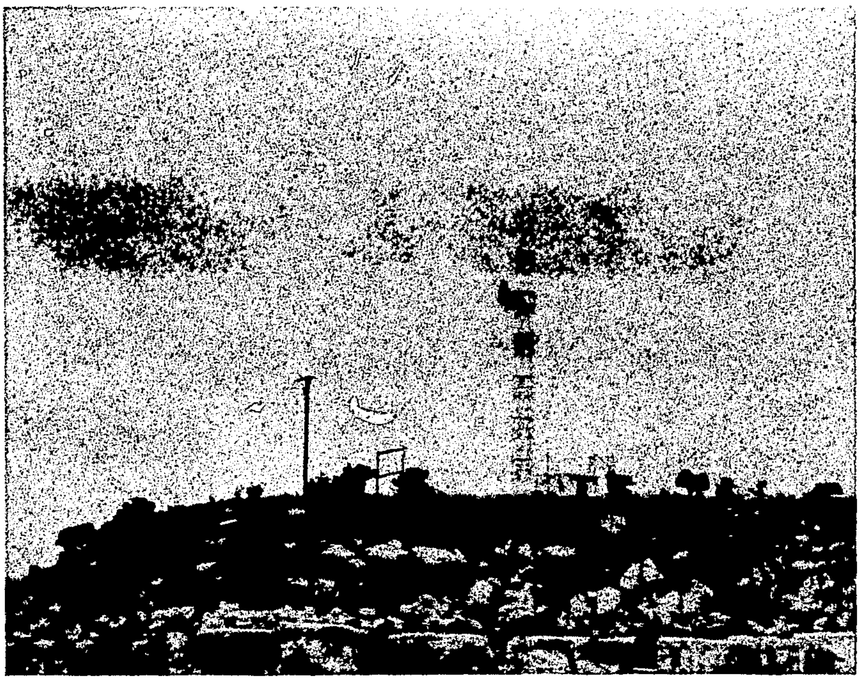

Figure B-29. Existing Microwave Terminal Approx. 3 Miles West of Keams Canyon.

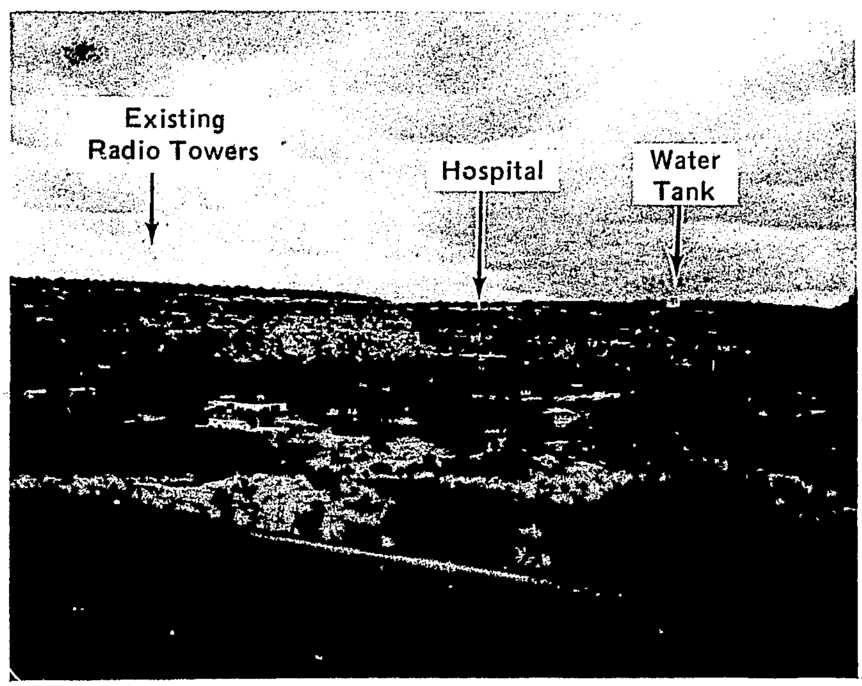

Figure B-30. View of Keams Canyon, Looking Northwest.

Figure B-31. Keams Canyon Hospital.

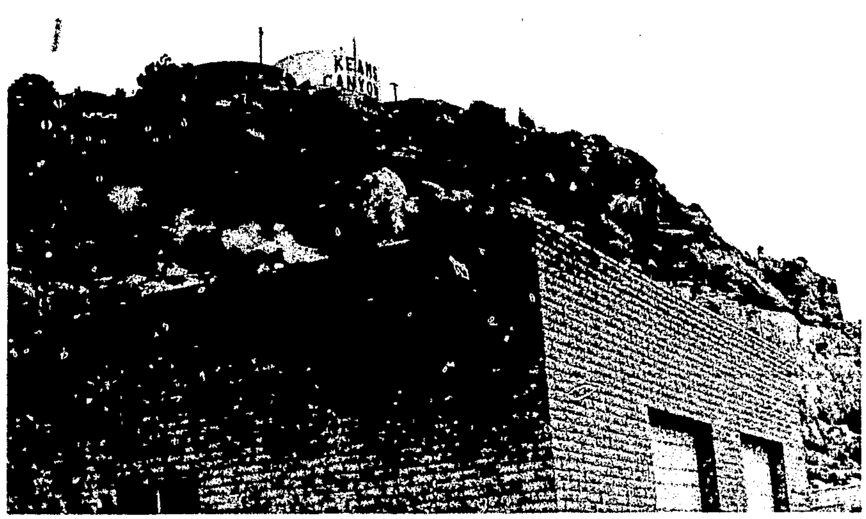

Figure B-32. View of North Bluff from Keams Canyon Hospital.

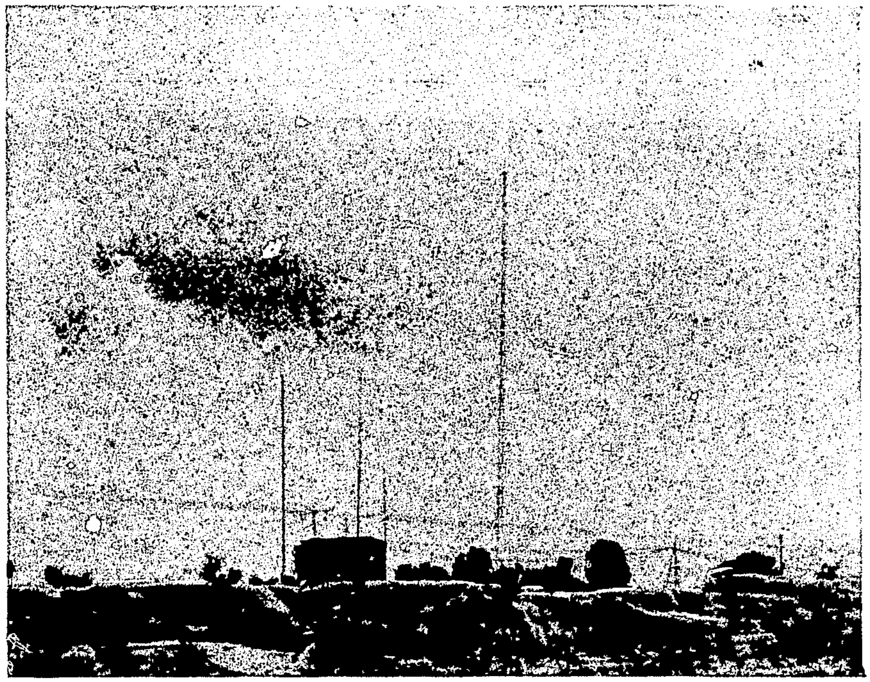

Figure B-33. Existing Radio Facilities Located on the Western Bluff Near Keams Canyon. (approx. 1 mile southwest of hospital).

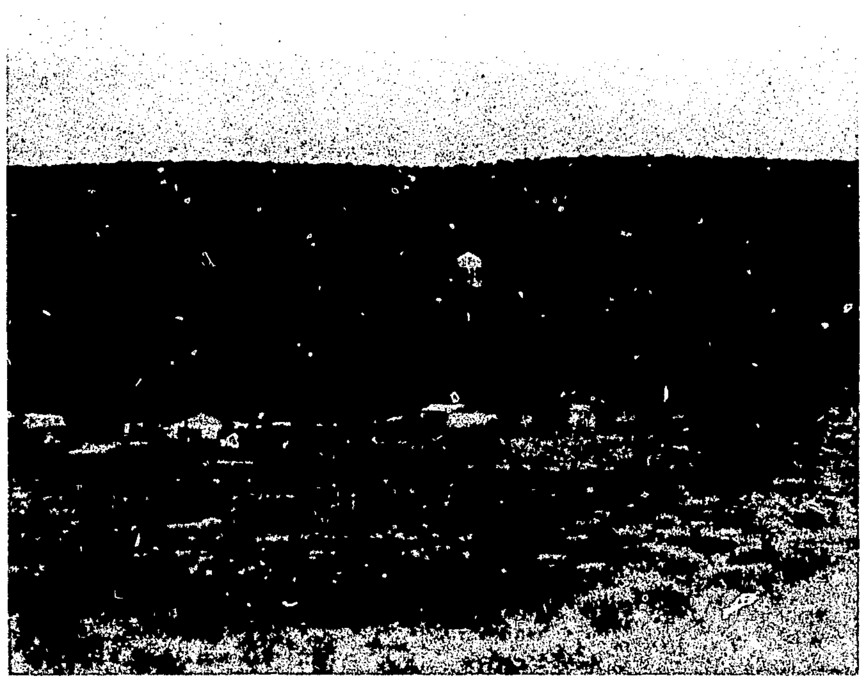

Figure B-34. Low Mountain, View Looking East.

Figure B-35. Low Mountain School, Site of Clinic Sessions.

Figure B-36. View of Kaibito, Looking Southwest.

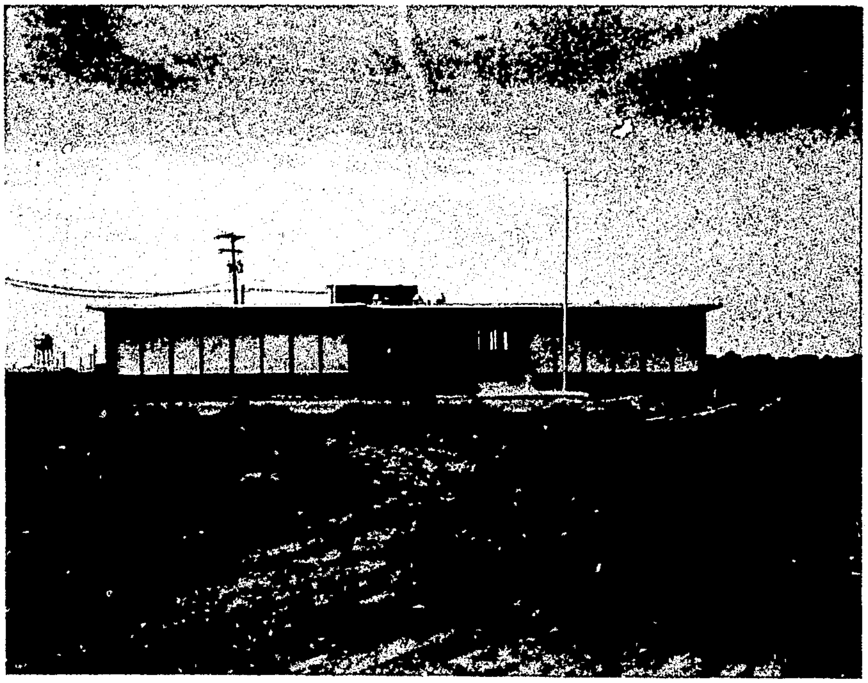

Figure B-37. Indian Health Station, Kaibito.

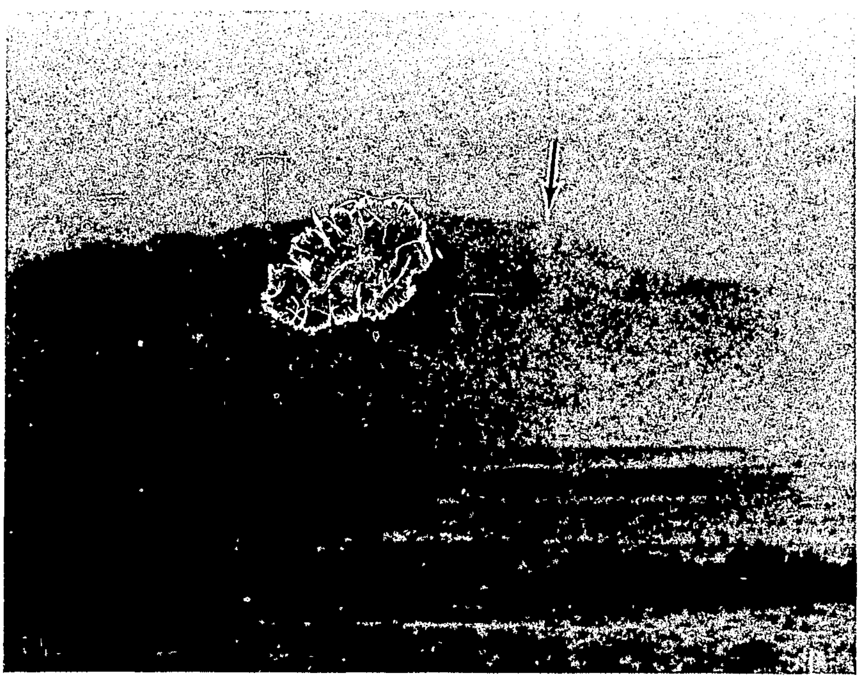

Figure B-38. Navajo Mountain (site of exisiting microwave realys for the Navajo Nation).

Figure B-39. Indian Health Center, Kayenta.

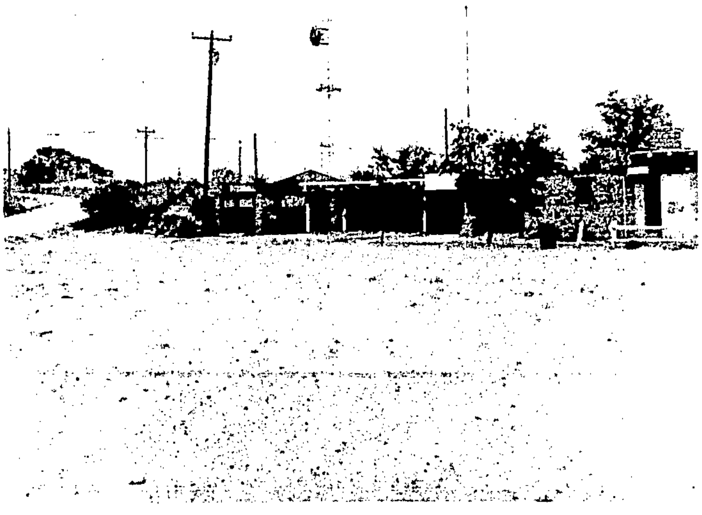

Figure B-40. Existing Microwave Terminal, Kayenta.

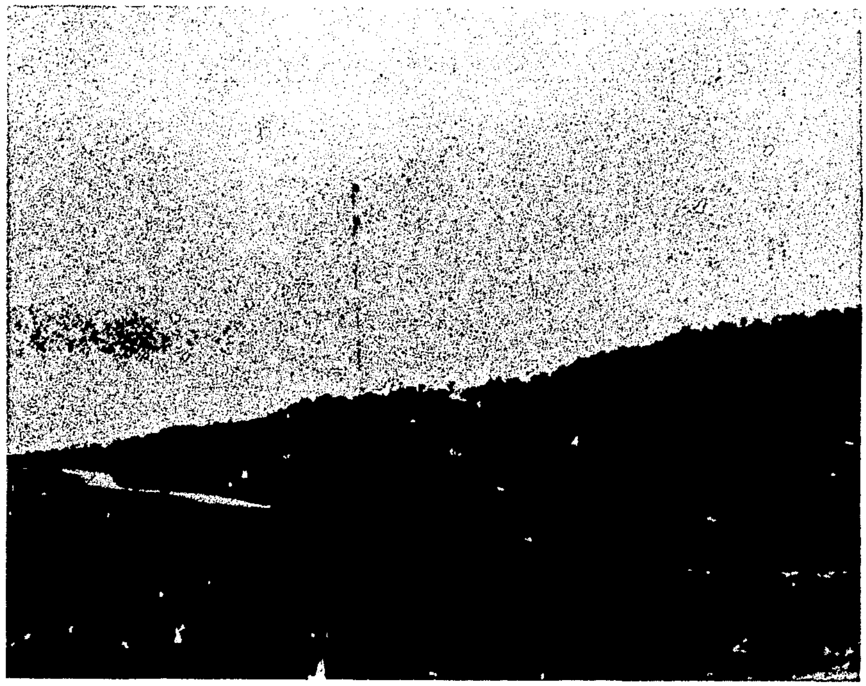

Figure B-41. Existing Microwave Relay Approx. 3 Miles South of Rt. 264, Midway Between 3honto and Kayenta. (Navajo Communications Co.)

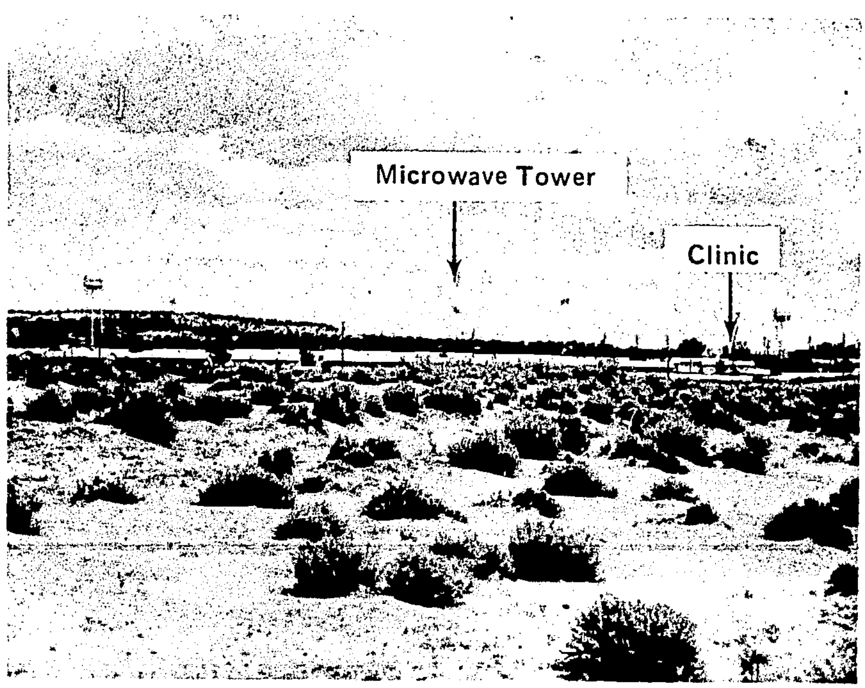

Figure B-42. Shonto, View Looking Northwest.

Figure B-43. Indian Health Center, Shonto. View Looking North.

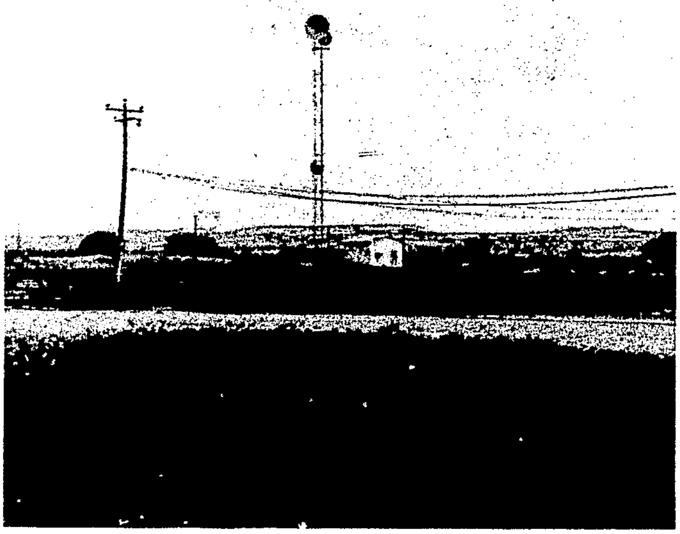

Figure B-44. Existing Microwave Facility in Shonto. (Navajo Communications Co.)

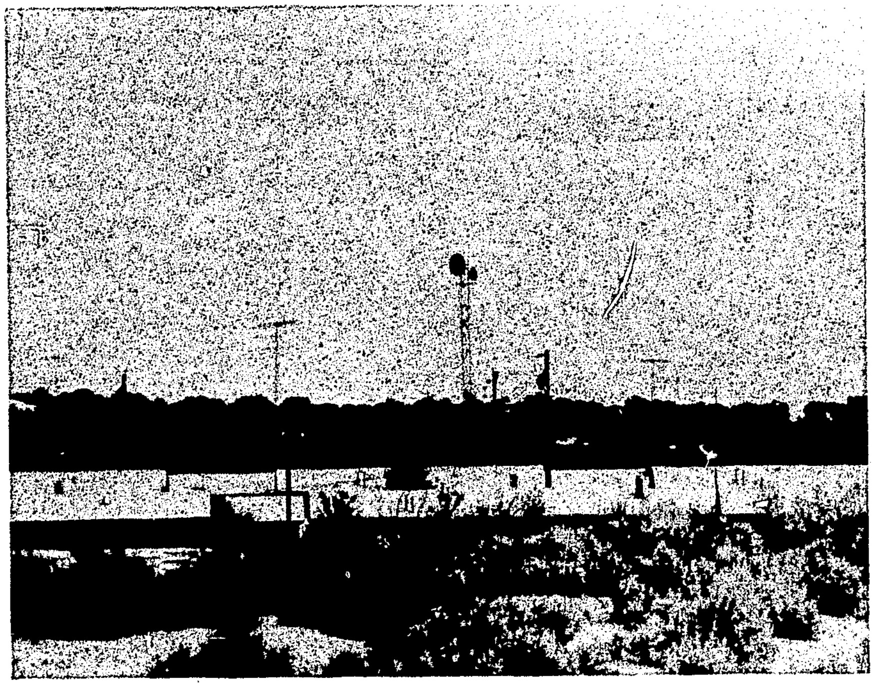

Figure B-45. Existing Microwave Tower in Shonto as Viewed from Clinic.

Figure B-46. View of Pinon. Looking West.

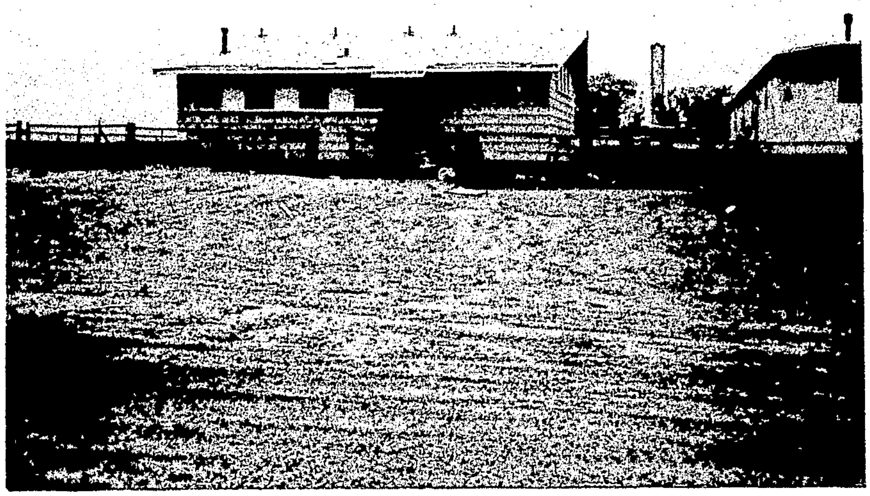

Figure B-47. Pinon Health Center.

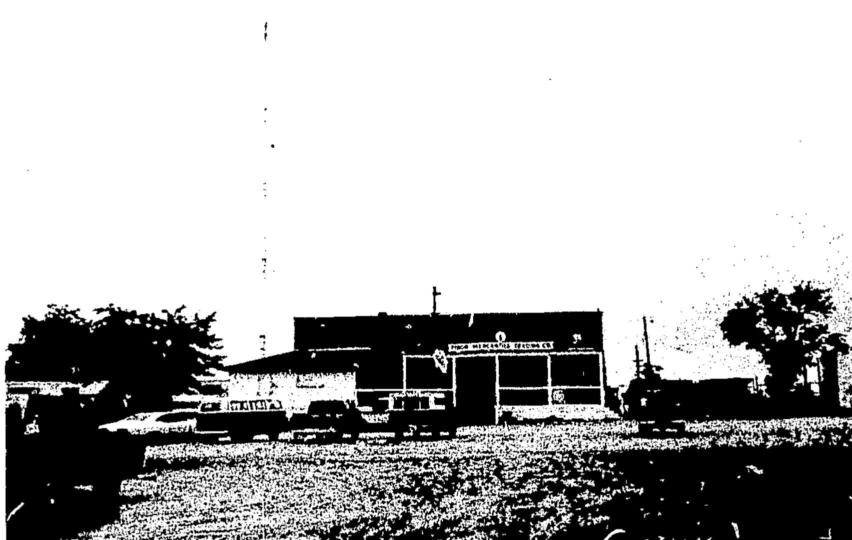

Figure B-48. Existing Radio Tower, Pinon (approx. 100 yards west of Clinic)

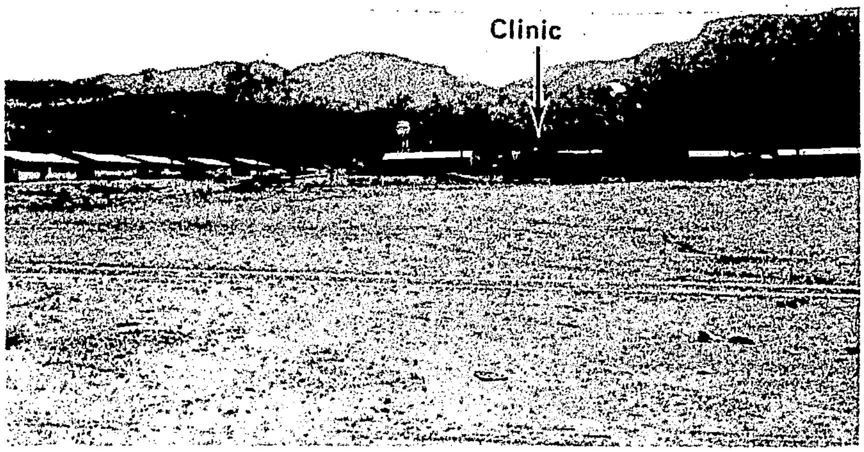

Figure B-49. Indian Health Station, Teec-Nos-Pos.

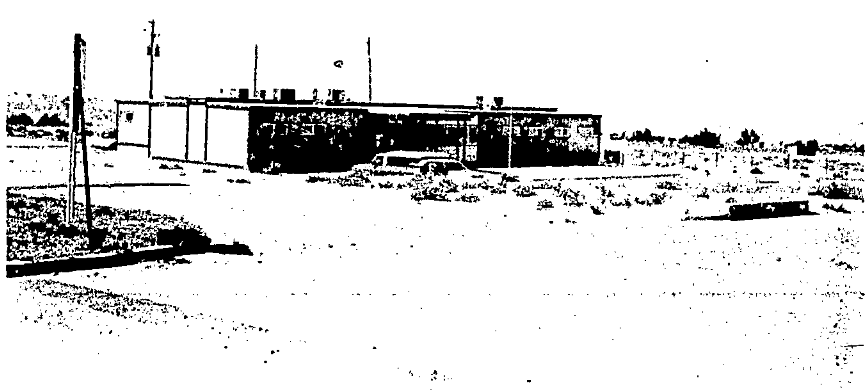

Figure B-50. Indian Health Center, Teec-Nos-Pos.

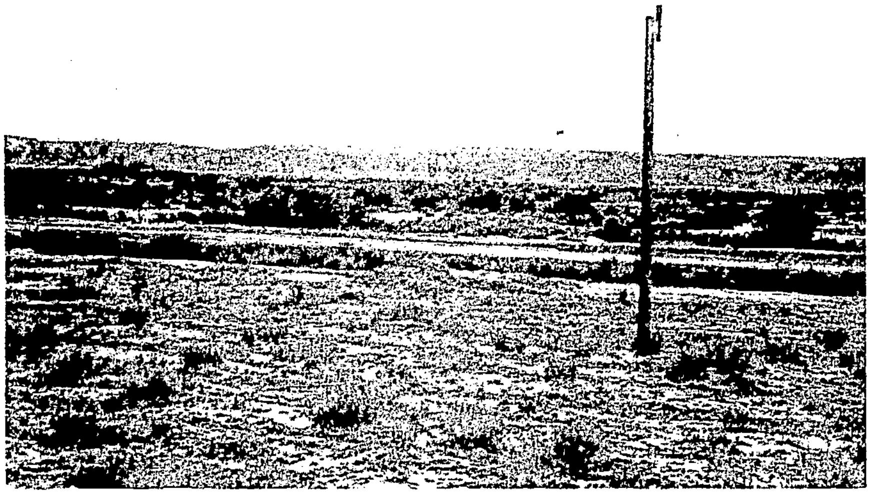

Figure B-51. View of Many Farms, Looking West.

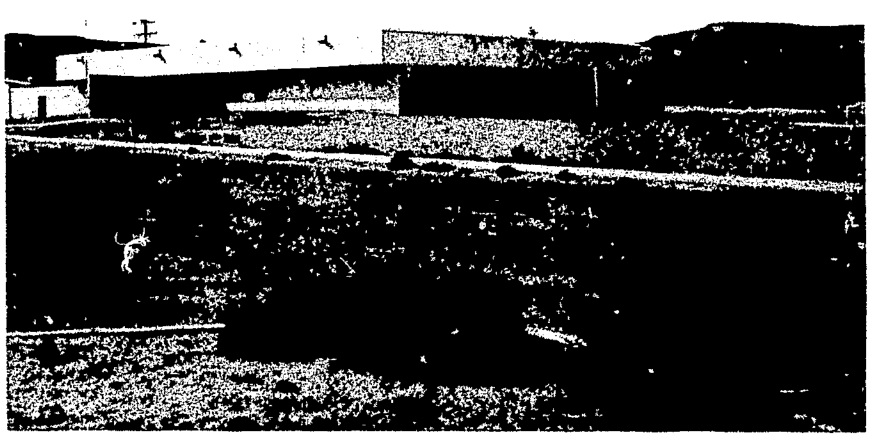

Figure B-52. Indian Health Center, Many Farms.

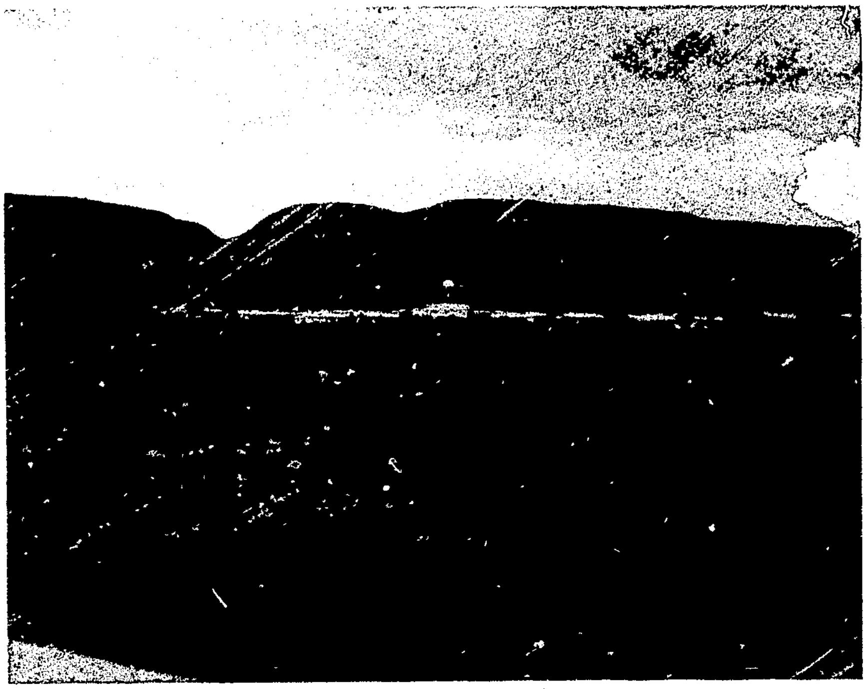

Figure B-53. Rough Rock, View Looking Southwest.

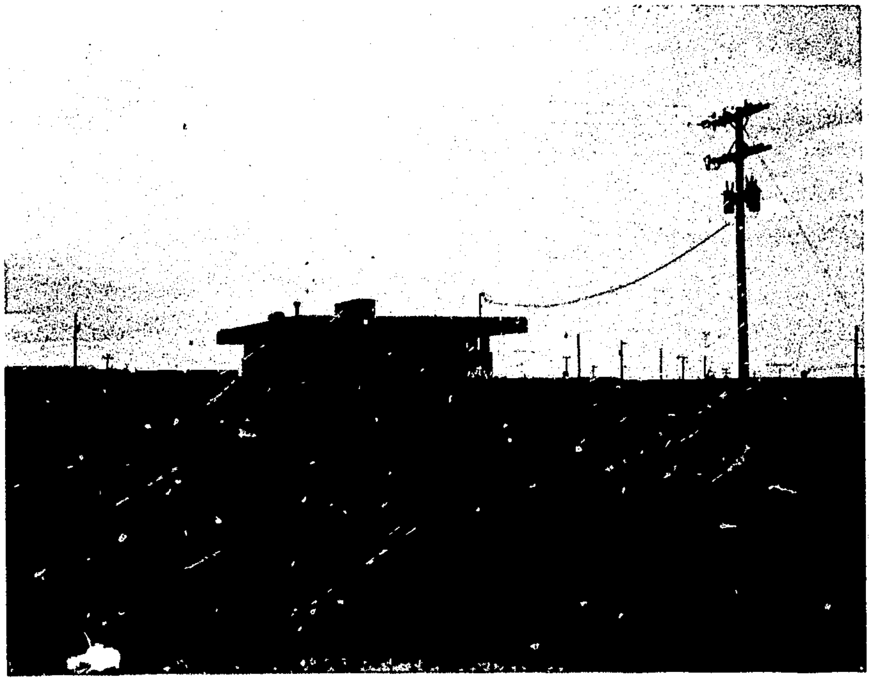

Figure B-54. Indian Health Center, Rough Rock.

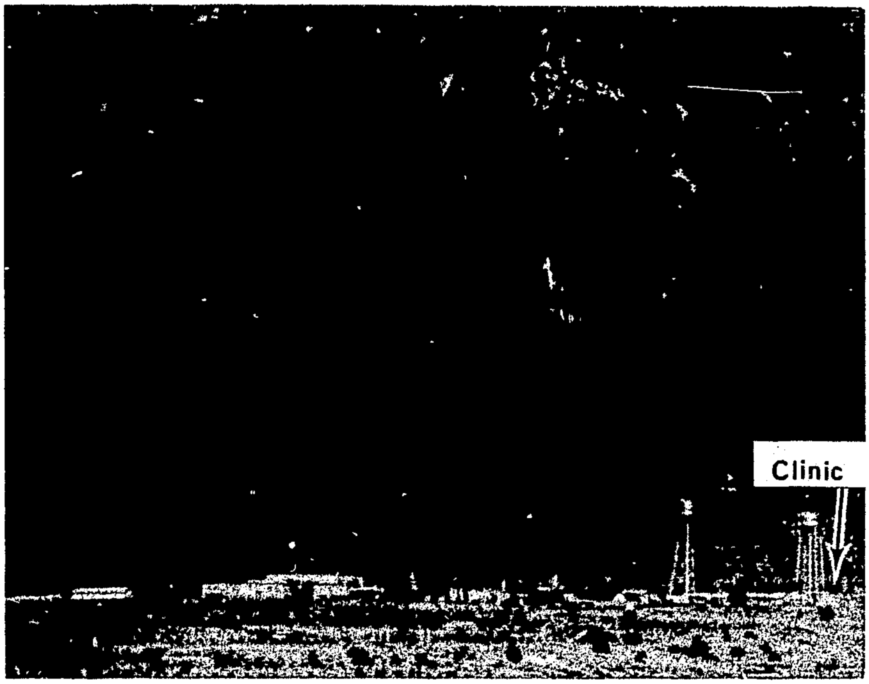

Figure B-55. Lukachukai, View Looking East.

Figure B-56. Lukachukai, View to the East.

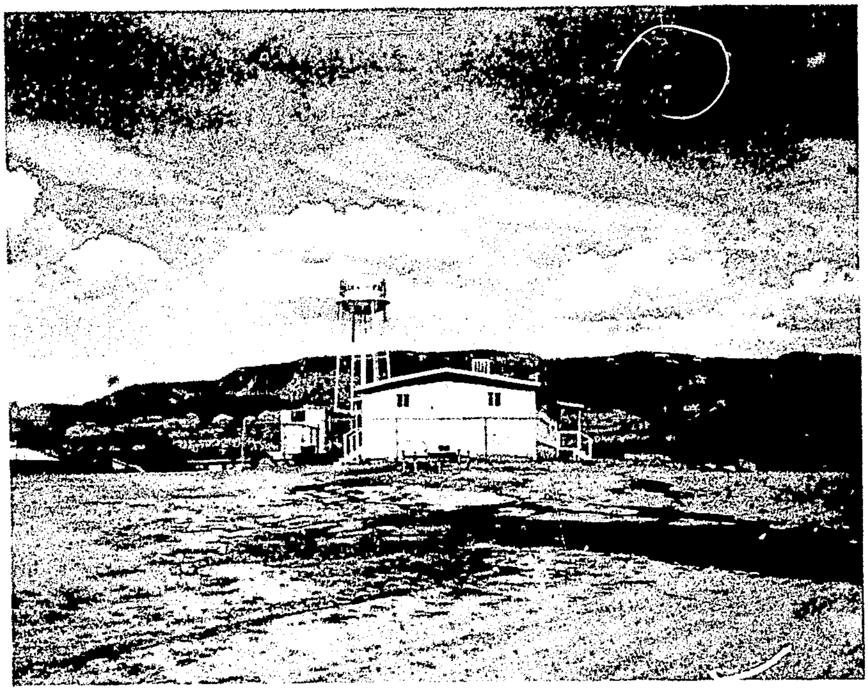

Figure B-57. Indian Health Center, Lukachukai.

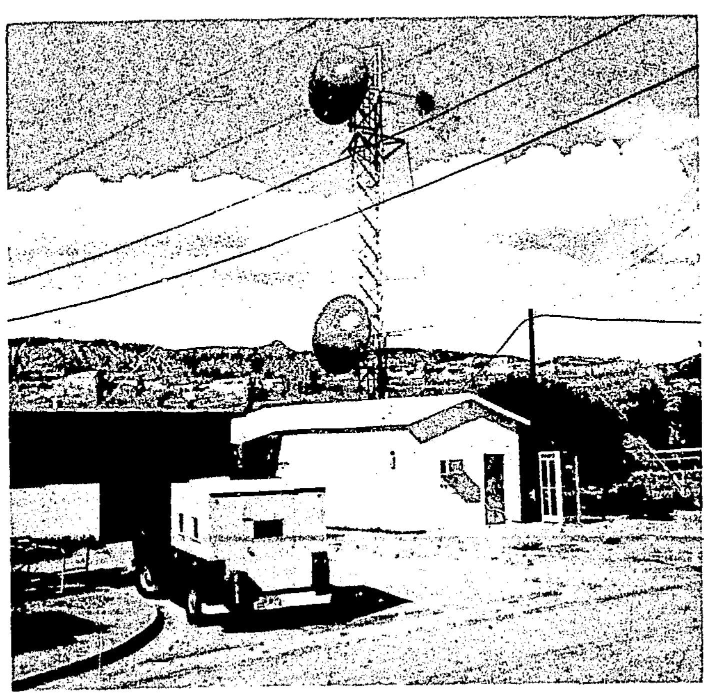

Figure B-58. Existing Microwave Terminal, Lukachukai.
(Navajo Communications Co.)

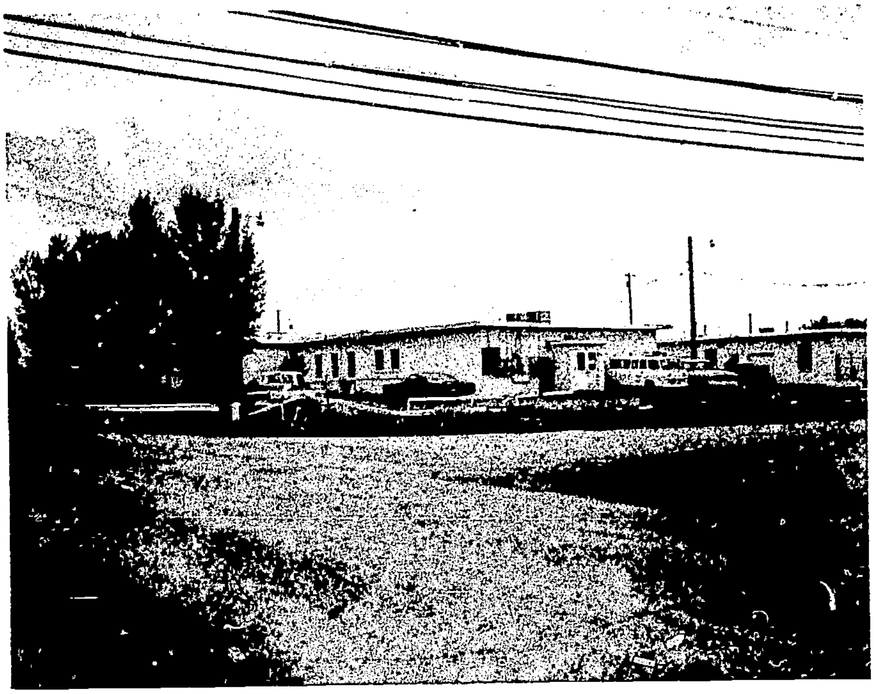

Figure B-59. Indian Health Center, Chinle.

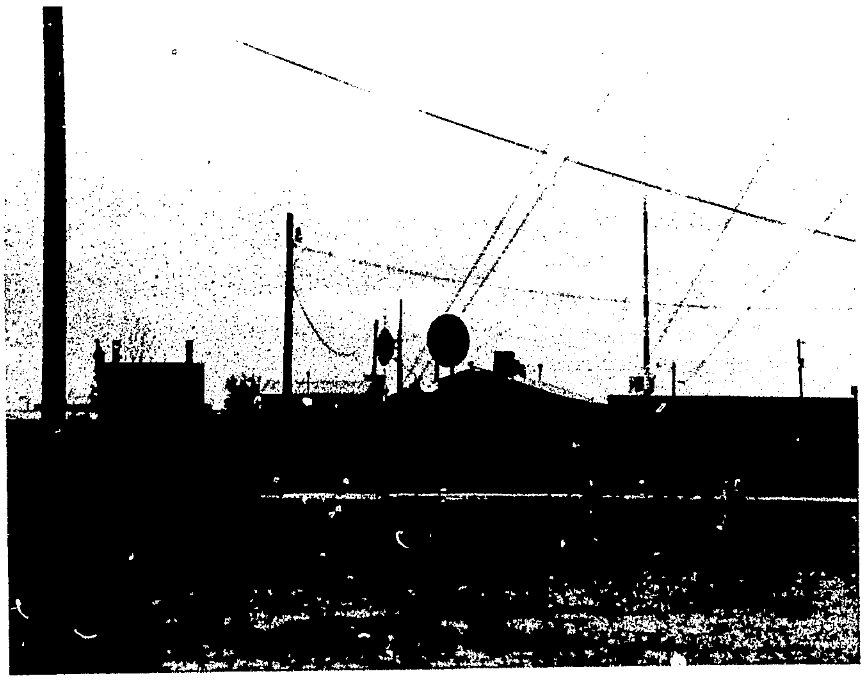

Figure B-60. Existing Microwave Facility in (Navajo Nation).

Figure B-61. Existing Microwave Facility, Chinle Near Clinic. (Navajo Communications Co.)

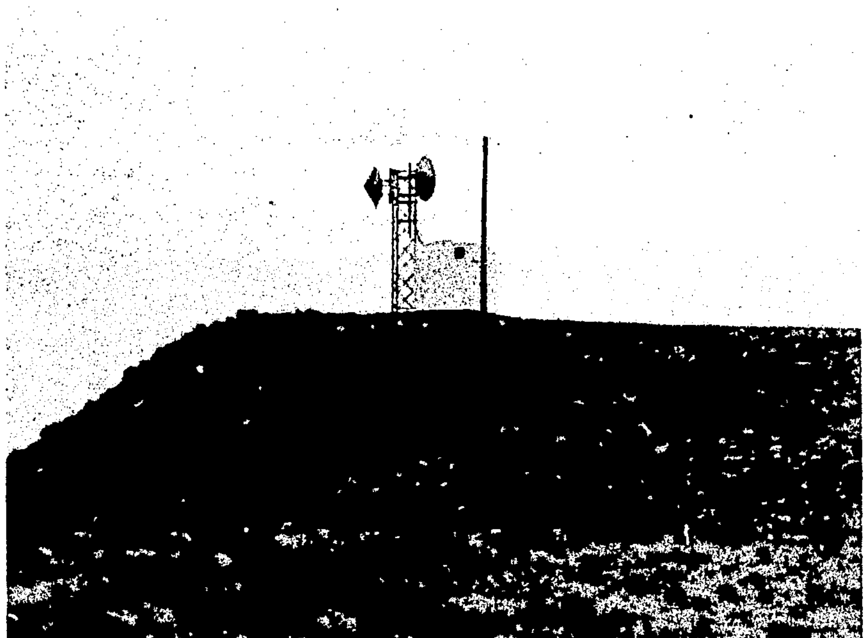

Figure B-62. Existing Microwave Relay 8 Miles South of Chinle (Navajo Communications Co.)

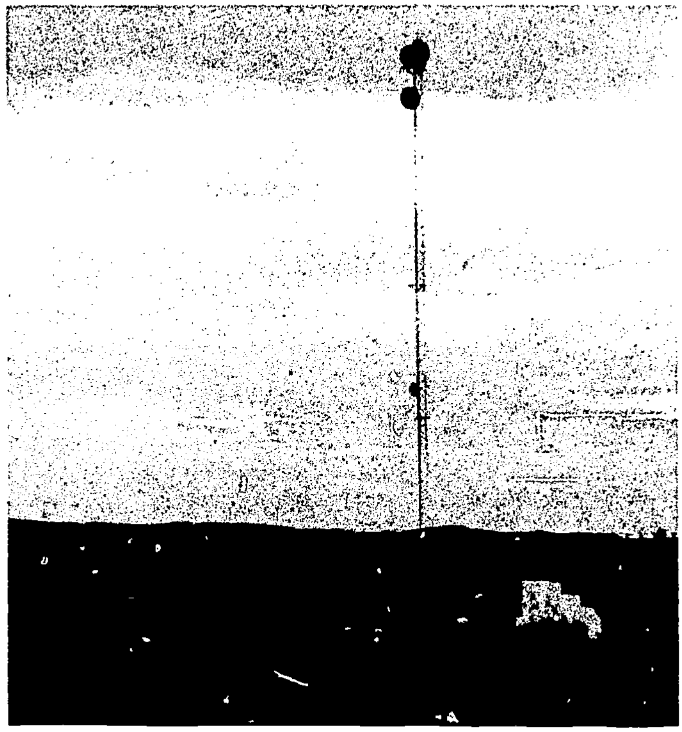

Figure B-63. Existing Microwave Facility Approx. 2 Miles North of Window Rock.

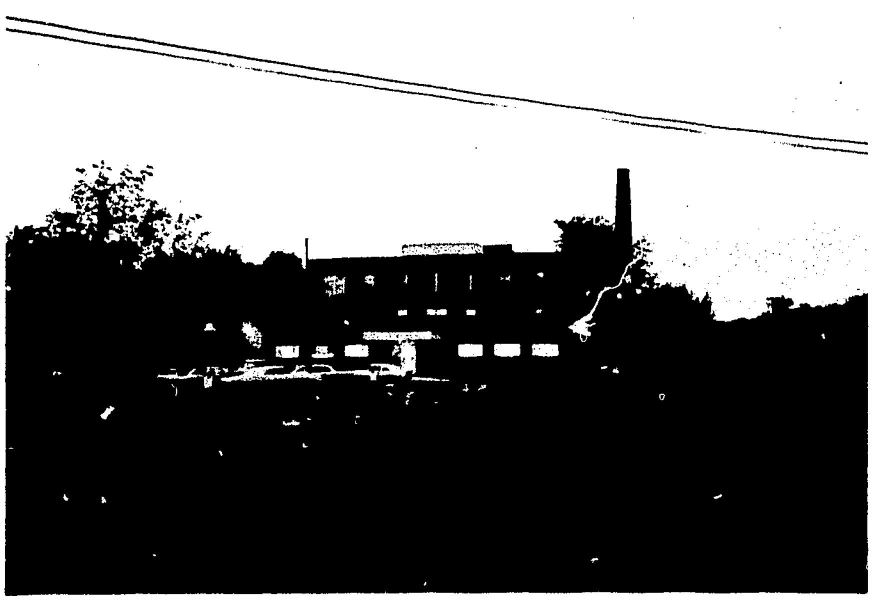

Figure B-64. Indian Health Service Hospital, Fort Defiance.

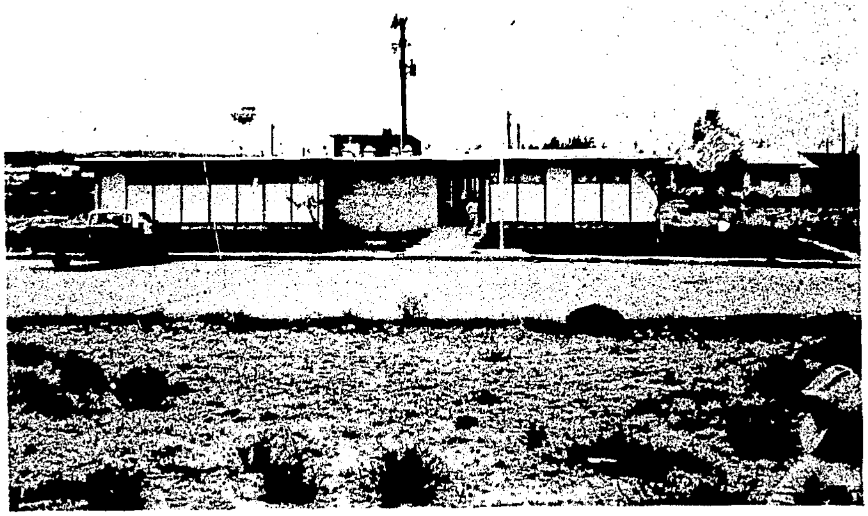

Figure B-65. Indian Health Station, Lower Greasewood.

Figure B-66. Existing Tower, Approx. 12 Miles East of Leupp.
(Transmission Pipe Line Co.)

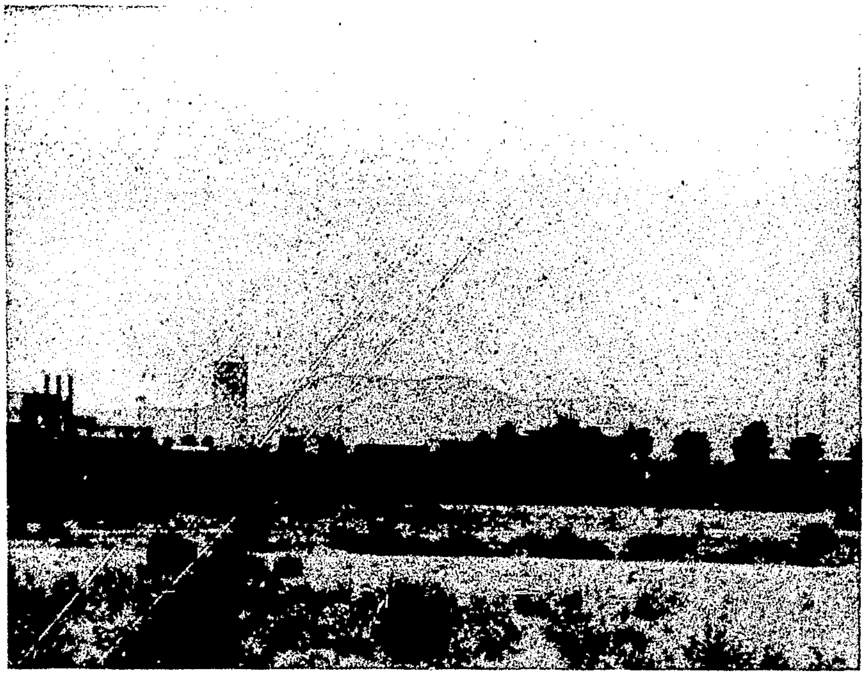

Figure B-67. Pipe Line Station, Leupp.

Figure B-68. Leupp, View Looking West.

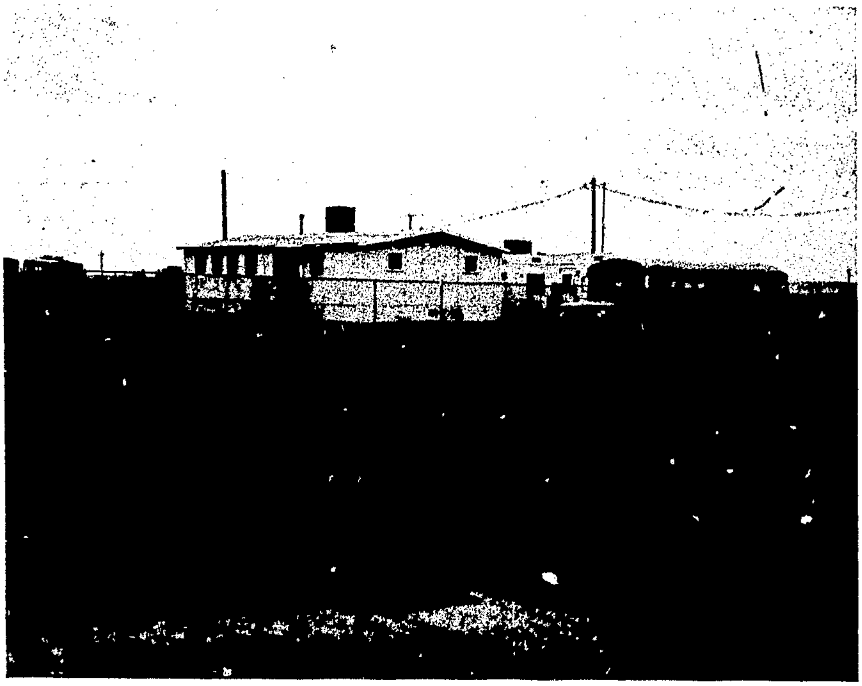

Figure B-69. Indian Health Station, Leupp.

APPENDIX C

EXISTING NON-GOVERNMENT RADIO

FACILITIES IN THE AREA

Atchison, Topeka and Santa Fe Railroad

Call Letters	Location	County[a]
KBQ 70	Peach Springs	Mohave
KBQ 71	Hualapai Mountain	Mohave
KBQ 72	Oatman	Mohave
KBY 43	Wickenburg	Maricopa
KBY 44	Yarnell	Yavapai
KBY 45	Tonto Mountain	Yavapai
KFP 82	Mount Taylor	Valencia, New Mexico
KFP 83	South Guam	McKinley, New Mexico
KFP 84	Gallup	McKinley, New Mexico
KFP 86	Manuelito	McKinley, New Mexico
KFP 87	Adamana	Navajo
KFP 88	Joseph City	Navajo
KHL 46	Flagstaff	Coconino
KNE 47	Kingman	Mohave
KPK 90	Winslow	Navajo
KPK 91	Elden Mountain	Coconino
KPK 92	Bill Williams Mountain	Coconino
KPK 94	Seligman	Yavapai
KPK 95	Red Mesa	Coconino

Union Pacific Railroad Co.

KDA 61	Las Vegas	Clark, Nevada
KDA 62	Sloan	Clark, Nevada
KDP 25	Apex	Clark, Nevada
KDP 26	Arrow Canyon	Clark, Nevada
KDP 28	Lund	Iron, Utah
KDP 29	Milford	Beaver, Utah
KDP 30	Mineral Mountain	Beaver, Utah
KDP 31q	Mormon Mesa	Lincoln, Nevada
KDP 32	Enterprise	Washington, Utah
KDP 33	Santa Clara	Washington, Utah
KDP 38	Cricket Mountain	Millard, Utah

[a]Those without state are Arizona.

Union Pacific Railroad Co. (continued)

Call Letters	Location	County[a]
KDP 40	Oak City	Millard, Utah
KDP 41	Tintic	Tooele, Utah
	Garkane Power Association, Inc.	
KQY 76	Monroe Peak	Sevier, Utah
KQY 77	Barney Tcp	Garfield, Utah
	Navajo Communications Company, Inc.	
WCZ 38	Kayenta	Navajo
WCZ 39	Black Mesa	Navajo
WCZ 41	Peabody Coal Mine	Navajo
WCZ 42	Navajo National Monument	Navajo
WCZ 43	Preston Mesa	Navajo
WCZ 44	Chinle	Navajo
WCZ 45	Cottonwood Junction	Navajo
WCZ 46	Ganado Mesa	Navajo
WCZ 47	Defiance Summit	Navajo
WCZ 49	Shonto	Navajo
WCZ 50	Tuba City	Coconino
WHB 58	Window Rock	Apache
WHB 59	Yale Point	Apache
WHB 60	Lukachukai	Apache

[a]Those without state are Arizona.

State of Arizona

Call Letters	Location	County
KCW 23	Hualapai Mountain	Mohave
KEN 80	Greens Peak	Apache
KEN 81	Holbrook	Navajo
KEX 36	Calabasas Canyon	Santa Cruz
KEX 37	Nogales	Santa Cruz
KEX 38	Mule Mountain	Cochise
KHH 91	Smith Peak	Yuma
KHH 92	Quartzsite	Yuma
KHI 60	Douglas	Cochise
KHJ 38	Wenden	Yuma
KHJ 39	Pete Smith Peak	Yuma
KHM 36	Boulder City	Clark, Nevada
KHQ 44	10 Miles Se Sanders	Apache
KNH 46	Lukachukai	Apache
KNO 27	Douglas	Cochise
KNO 28	Mule Mountain	Cochise
KNT 22	Navajo Mountain	San Juan, Utah
KOA 83	Phoenix	Maricopa
KOA 84	Crown King	Yavapai
KOK 44	Phoenix	Maricopa
KOO 48	White Tank Mountain	Maricopa
KOO 49	Kingman	Mohave
KOO 58	Mingus Mountain	Yavapai
KPA 58	Telegraph Pass	Yuma
KPA 62	Oatman Mountain	Maricopa
KPA 63	Yuma	Yuma
KPI 20	Flagstaff	Coconino
KPI 23	Mount Elden	Coconino
KPI 24	Bill Williams Mountain	Coconino
KPL 45	Signal Peak	Gila
KPL 46	Claypool	Gila
KPL 47	Mount Lemmon	Pima

State of Arizona (continued)

Call Letters	Location	County
KPL 48	Tucson	Pima
KPL 49	Heliograph Peak	Graham
KPL 50	Safford	Graham
KRQ 63	Pete Smith Peak	Yuma
KRQ 69	Hualapai Mountain	Mohave
KRQ 85	Gila Bend	Maricopa
KBX 52	Mount Ord	Gila
KSB 39	Black Metal	Yuma
KTU 59	Prescott	Yavapai
KTU 76	Show Low	Navajo
KYA 26	Springerville	Apache
KYT 41	Childs Mountain	Pima
WBT 64	Guthrie Peak	Graham
WDP 96	Window Rock	Apache
WGD 80	Parker	Yuma
WGD 83	Juniper Mountain	Yavapai
WHB 82	Jacob Lake	Coconino
WHC 73	Litchfield	Maricopa
WHF 44	Phoenix	Maricopa
WJZ 32	Sanders	Apache
WLA 55	Phoenix	Maricopa

Plains Electric Generation and Transmission Cooperative, Inc.

KHD 78	La Mosca	Valencia, New Mexico
KHD 79	Sandia Crest	San Doval, New Mexico
KDH 81	San Ysidro	San Doval, New Mexico
KNR 56	Bluewater Substation	Valencia, New Mexico
KTY 87	Cuba	San Doval, New Mexico

State of New Mexico

KUH 47	Caballo Mountain	Sierra, New Mexico
KUH 65	Mesilla Park	Dona Ana, New Mexico
WCP 30	Little Flame Mountain	Luna, New Mexico
WCP 31	Socorro	Socorro, New Mexico

Gallup Cable TV Co.

Call Letters	Location	County[a]
KEY 20	Mount Powell	McKinley, New Mexico

Duval Corp.

KQV 81	Mineral Peak	Mohave
KQV 82	16 Miles NW Kingman	Mohave

J. W. Davenport Paving, Inc.

WBO 22	Tucson	Pima
WBO 23	Mount Lemmon	Pima

Chet W. Johns and Son

KPW 63	Litchfield	Maricopa
KPW 64	Glendale	Maricopa

JWJ Contracting Co., Inc.

WDP 67	Globe	Gila
WDP 68	Phoenix	Maricopa

Flash TV Corp.

KUY 90	Tucson	Pima
KUY 91	Tucson	Pima

Howard P. Foley Co.

WHN 76	Flagstaff	Coconino
WHS 28	Preston Mesa	Coconino
WHS 29	Prescott	Coconino

Newbery Energy Corporation

KPM 89	Tucson	Pima
KPM 90	Mount Lemmon	Pima

[a]Those without state are Arizona.

Royden Construction Co.

Call Letters	Location	County[a]
KUU 73	White Tank	Maricopa
KUU 74	Phoenix	Maricopa

Peabody Coal Company

WGH 45	Kayenta	Navajo
WGH 46	Black Mesa	Navajo

Tanner Bros. Contracting Co.

KPA 49	Phoenix	Maricopa
KPK 50	White Tank	Maricopa

United Fruit Produce, Inc.

WDL 72	Glendale	Maricopa
WDP 63	White Tank	Maricopa

B. F. Walker

KVM 52	Butte Mountain	Apache

Denver and Rio Grand Western Railroad Co.

KPK 83	Beaverson	Carbon, Utah
KPK 84	Geyser, Green River	Grand, Utah
KPK 85	Pyramid, Thompsons	Grand, Utah
KAZ 40	Glade Park	Mesa, Colorado

Utah Power and Light Co.

KCU 45	Beaver Mountain	Carbon
KQV 21	Siguro Sub	Sevier, Utah
KQV 22	Antimony	Garfield, Utah
KQV 23	Barney Top	Garfield, Utah
KQV 24	Plateau	Sevier, Utah
KVG 35	Monticello	San Juan, Utah
KVP 73	Bald Mesa	Grande, Utah
KFQ 72	Castle Gate	Carbon, Utah

[a]Those without state are Arizona.

Western States Telephone Co., Inc.

Call Letters	Location	County[a]
KPR 49	Holbrook	Navajo
KPR 50	Woodruff	Navajo
KPR 51	Snowflake	Navajo
KPR 52	Show Low	Navajo
KPX 27	Cerro Montosa	Apache
KPX 28	Springerville	Apache

Tucson Gas and Electric Co.

KGZ 62	Rillito	Pima
KGZ 63	Tucson	Pima
KGZ 64	Redrock	Pinal
WBI 70	Tucson	Pima

City of Tucson

KPK 54/KPL 94	Tucson	Pima
KPK 55/KPL 95	9.5 Mile NE Tucson	Pima

City of Phoenix

KOO 56	Sunnyslope Mountain	Maricopa
KOO 57	Phoenix	Maricopa

Pima County

KZF 72	Johnson Ranch	Pima
KZF 73	Mount Lemmon	Pima
WDW 39	Tucson	Pima
WDW 40	Tucson	Pima

Maricopa County

KPF 60	White Tank	Maricopa
KPF 61	Phoenix	Maricopa

[a]Those without state are Arizona.

Mountain States Telephone and Telegraph Co.

Call Letters	Location	County[a]
KOS 52	Tucson	Pima
KPS 80	Madera Canyon	Pima
KPS 81	Twin Buttes	Pima
	Mountain Fuel Supply Co.	
KDB 58	Bruin Point	Carbon, Utah
KDB 59	Beaver Mountain	Carbon, Utah
KDB 61	Price	Carbon, Utah
KNN 29	Price	Carbon, Utah
KNN 30	Beaver Mountain	Carbon, Utah
KNN 31	Castle Dale	Emery, Utah
KZN 70	Bruin Point	Carbon, Utah
KZN 71	Roosevelt	Duchene, Utah
	Nevada Power Co.	
KOY 99	Las Vegas	Clark, Nevada
WBU 80	Boulder City	Clark, Nevada
	University of Nevada	
KMI 50	Las Vegas	Clark, Nevada
	State of Nevada	
KAI 23	Eureka	Eureka, Nevada
KAI 24	Austin	Lander, Nevada
KAJ 25	Winnemucca Mountain	Humboldt, Nevada
KAK 27	Ely	White Pine, Nevada
KAK 79	Lovelock	Pershing, Nevada
KTY 21	Goldfield	Esmeralda, Nevada
KTY 26	Tonopah	Nye, Nevada
KTY 27	Springdale	Nye, Nevada
KTY 28	Angel Peak, Las Vegas	Clark, Nevada
KTY 29	Las Vegas	Clark, Nevada

[a]Those without state are Arizona.

State of Nevada (continued)

Call Letters	Location	County[a]
WCP 40	Apex, Las Vegas	Clark, Nevada
WCP 41	Highland Peak, Pioche	Lincoln, Nevada
WCP 42	St. George	Washington, Utah
WIK 71	Red Mountain, Boulder	Clark, Nevada
	Navopache Electric Coop.	
WBI 50	Greens Peak	Apache
WBI 51	Cinder Mountain	Apache
WBI 52	Lakeside	Navajo
	American Telephone and Telegraph	
WAD 40	McNary	Apache
WAD 41	Seneca	Gila
WAD 42	Miami	Gila
WAD 43	Florence	Pinal
	American TV Relay, Inc.	
KPH 82	Wilcat Peak	Coconino
KPH 83	Jacks Peak	Coconino
KPN 92	Porter Mountain	Navajo
	Shell Communications, Inc.	
KDP 51	Mount Elden	Coconino
KDP 52	Cameron	Coconino
KDP 53	Hualapai	Mohave
KDP 54	Bill Williams Mountain	Coconino
KDP 55	Kingman	Mohave
KDP 56	Lukachukai	Apache
KDP 58	Bluff	San Juan, Utah
KLG 33	Farmington	San Juan, New Mexico

[a]Those without state are Arizona.

Forest Radio Co.

Call Letters	Location	County[a]
KBV 53	Snowflake	Navajo
KDN 91	Pinal Peak	Gila
KDN 92	Phoenix	Maricopa
KOE 50	Green Peak	Apache
KOE 51	McNary	Apache
KJV 45	Flagstaff	Navajo
	Bruce Church	
KPD 32	White Tank	Maricopa
KPD 33	Dixie	Maricopa
KPH 91	Gila Mountain	Yuma
KPH 93	Yuma	Yuma
	Salt River Project Agriculture Improvement and Power District	
KDT 63	Tempe	Maricopa
KDT 64	Horse Mesa Dam	Maricopa
KFU 51	Winkleman	Gila
KGX 35	Usbr Phoenix	Maricopa
KPA 59	Mesa Switch	Maricopa
KPA 60	Tempe	Maricopa
KPA 61	Agua Frio, Glendale	Maricopa
KQW 65	Pool Dispatch Center, Phoenix	Maricopa
KUV 51	Roosevelt	Gila
KUV 52	Pinal Peak	Gila
WBI 63	Goldfield	Maricopa
WBI 64	Mormon Flat Dam	Maricopa
	Black Mesa Pipeline, Inc.	
KUI 20	Shonto	Navajo
KUI 21	Flagstaff	Navajo
KUI 22	21 Miles SW Kayenta	Navajo

[a]Those without state are Arizona.

Black Mesa Pipeline, Inc. (continued)

Call Letters	Location	County[a]
KUI 24	Devils Head	Coconino
KUI 32	Bill Williams Mountain	Coconino
KUH 98	Seligman	Yavapai
WAV 98	Cameron	Coconino
WAV 99	19 Miles N Williams	Coconino

Texas, New Mexico Pipeline Co.

KLL 33	Bisti Station, Farmington	San Juan, New Mexico
KLL 35	Ship Rock	San Juan, New Mexico
KLL 36	Bisti Junction, Farmington	San Juan, New Mexico
KLL 37	Lybrook	San Doval, New Mexico
KLL 41	Sandia Crest	Bernalillo, New Mexico
KPG 95	Aneth Junction	San Juan, New Mexico
KPJ 48	Aneth	San Juan, New Mexico

South Pacific Co.

KDQ 61	Clifton	Greenlee
KKP 67	Claypool	Gila
KRG 96	Tucson	Pima
KRG 98	Yuma	Yuma
KRG 99	Telegraph Pass	Yuma
KRH 20	Oatman Mountain	Maricopa
KRH 21	Gila Bend	Maricopa
KRH 22	White Tank Mountains	Maricopa
KRH 23	Phoenix	Maricopa
KRH 24	Pinal Peak	Gila
KRH 25	Casa Grande	Pinal
KRH 26	Mount Lemmon	Pima
KTT 23	Heliograph Peak	Graham
KTT 24	Willcox	Cochise
KTT 25	Bowie	Cochise
KTT 28	Gage Gap	Luna, New Mexico
KTT 29	Deming	Luna, New Mexico

[a]Those without state are Arizona.

South Pacific Co. (continued)

Call Letters	Location	County[a]
KTT 30	Adens Hill	Dona Ana, New Mexico
KUI 64	Mount Hopkins	Santa Cruz
KUI 74	Nogales	Santa Cruz
KUI 84	Douglas	Cochise
KYR 52	Safford	Graham

El Paso Natural Gas

KHO 26	20 Miles East Kingman	Mohave
KFO 93	Dilkon	Navajo
KFO 94	4 Miles NE Flagstaff	Coconino
KKO 53	Leupp	Coconino
KKO 54	NE Williams	Coconino
KOE 33	Elden Mountain	Coconino
KOE 34	Klagetoh	Apache
KOE 35	Window Rock	Apache
KOE 36	Topock	Mohave
KOE 37	Kingman	Mohave
KOE 38	10 Miles E Dilkon	Navajo
KOE 39	Mount Floyd	Coconino
KOT 20	Topock	Mohave
KOT 21	10 Miles SE Kingman	Mohave
KPE 36	7 Miles SE Seligman	Yavapai
KPK 39	Guadalupe, South Phoenix	Maricopa
KPK 40	Shaw Butte	Maricopa
KXM 80	Tucson	Pima
KXM 86	16 Miles NE Tucson	Pima
WGS 28	Ehrenberg	Yuma
WGS 29	Quartzsite	Yuma

[a]Those without state are Arizona.

Arizona Public Service Co.

Call Letters	Location	County[a]
KCS 51	Coolidge	Pinal
KDS 54	Cholla, Joseph City	Navajo
KDS 55	Four Corners	San Juan, New Mexico
KDS 56	Greens Peak	Apache
KDS 57	Cousins	McKinley, New Mexico
KDS 58	Pinnacle Peak	Maricopa
KDS 96	Chuska	San Juan, New Mexico
KFX 20	Mount Ord	Gila
KHK 67	Phoenix	Maricopa
KMU 86	Peach Springs	Mohave
KOB 55	Litchfield Park, Phoenix	Maricopa
KOB 99	Wickenburg	Maricopa
KOE 72	Prescott	Yavapai
KOE 73	Williams	Coconino
KOE 74	Santa Rosa Sub	Pinal
KOK 51	Winslow	Navajo
KOK 52	Flagstaff	Coconino
KOK 53	Prescott	Yavapai
KOK 54	Shaw Butte	Maricopa
KOK 55	Mount Elden	Coconino
KOK 56	Mingus	Yavapai
KOP 76	White Tank	Maricopa
KOP 77	Apa	Maricopa
KOQ 31	Red Rock	Pinal
KOQ 32	Sacaton Peak	Pinal
KOR 31	Phoenix	Maricopa
KOR 42	San Manuel	Pinal
KOR 43	Casa Grande	Pinal
KOR 44	Mount Lemmon	Pima
KOR 95	Cottonwood	Yavapai
KOR 96	Yuma	Yuma
KOR 97	Oatman	Maricopa
KOR 98	Telegraph Pass	Yuma

[a]Those without state are Arizona.

Arizona Public Service Co. (continued)

Call Letters	Location	County[a]
KOU 43	Bill Williams Mountain	Coconino
KOY 74	Ike's Backbone	Yavapai
KPB 27	Tempe	Maricopa
KPE 37	Mowhawk	Yuma
KPE 38	Yuma	Yuma
KPE 48	Signal Peak	Yuma
KPE 49	Claypool	Gila
KPE 74	Douglas	Cochise
KPE 75	Mule Mountain	Cochise
KPE 76	Benson	Cochise
KPJ 43	Smith Peak	Yuma
KPJ 44	Eagle Eye Sub, Aguila	Yuma
KPK 51	Gila Bend	Maricopa
KQV 29	Glen Canyon	Coconino
KXO 25	White Cliffs	Coconino
KXV 33	Black Peak	Yuma
KYG 61	Moenkopi Sub	Coconino
KYG 62	Hualapai	Mohave
WJC 35	Tat Momoli	Pinal

The Navajo Tribe

Call Letters	Location	County[a]
KEN 71	Window Rock	Apache
KEN 72	Roof Butte	Apache
KEN 73	Ship Rock	San Juan, New Mexico
KEN 74	Piney Hill	Apache
KHF 54	Ft. Defiance Hill	Apache
KHF 55	Crown Point	McKinley, New Mexico
KHF 56	Tohatchi	McKinley, New Mexico
KHF 57	Chinle Police Dept.	Apache
KHF 58	Chinle Tribal Office	Apache
KHF 59	Yale Point	Apache
KHF 60	Navajo Mountain	San Juan, Utah
KHF 61	Preston Mesa	Coconino

[a]Those without state are Arizona.

The Navajo Tribe (continued)

Call Letters	Location	County[a]
KHF 62	Mount Elden	Coconino
KHM 26	Tuba City	Apache
KHM 27	Ft. Defiance	Apache
KTQ 31	Black Mesa	Navajo
KTQ 32	Kayenta Sub	Navajo
KVX 70	Kayenta	Navajo
KVX 71	Glen Canyon Dam	Coconino

[a]Those without state are Arizona.

APPENDIX D

ABBREVIATED PRINT OUT, MICROWAVE

FREQUENCY SEARCH PROGRAM

POTENTIAL FREQUENCIES	POLARITY	RX = RECEIVER TX = TRANSMITTER	SIGNAL/INTERFERENCE RATIO OBJECTIVE DEGRADATION	FOREIGN STATION USER	NAME OF FOREIGN STATION	COORDINATES OF FOREIGN STATION	AZIMUTH OF FOREIGN STATION	FOREIGN STATION FREQUENCY	SIGNAL/INTERFERENCE RATIO OBJECTIVE DEGRADATION	FOREIGN STATION USER	NAME OF FOREIGN STATION	COORDINATES OF FOREIGN STATION	AZIMUTH OF FOREIGN STATION	FOREIGN STATION FREQUENCY
			0.90DB	SALT	TEMPE	332630N 1115625W	99.4	6805.0						
		RX												
			-0.60DB	SALT	GOLDFIEL	3327 9N 1113024W	266.4	6865.0	30.40DB	SALT	GLOBE	331655N 11049 5W	280.0	6805.0
6815.0	H	TX												
			19.20DB	AZPS	SIGNAL P	331736N 11050 9W	279.1	6805.0	20.10DB	SPAR	PINAL PE	331648N 1104910W	279.2	6825.0
		RX												
			8.40DB	SALT	GLOBE	331655N 11049 5W	266.0	6805.0						
	V	TX												
			16.20DB	AZPS	SIGNAL P	331736N 11050 9W	279.1	6805.0	17.30DB	SPAR	PINAL PE	331648N 1104910W	279.2	6825.0
		RX												
			5.40DB	SALT	GLOBE	331655N 11049 5W	[illegible]	6805.0						
6825.0	H	TX												
			4.10DB	AZPS	SIGNAL P	331736N 11050 9W	279.1	6805.0	45.10DB	SPAR	PINAL PE	331648N 1104910W	279.2	6825.0
		RX												
			12.90DB	SALT	GOLDFIEL	3327 9N 1113024W	266.4	6825.0	16.00DB	STAZ	SIGNAL P	331737N 11050 9W	358.0	6825.0
	V	TX												
			1.10DB	AZPS	SIGNAL P	331736N 11050 9W	279.1	6865.0	42.20DB	SPAR	PINAL PE	331648N 1104910W	279.2	6825.0
		RX												
			[illegible]	SALT	GOLDFIEL	3327 9N 1113024W	266.4	6825.0	16.00DB	STAZ	SIGNAL P	331737N 11050 9W	358.0	6825.0
6835.0	H	TX												
			20.10DB	SPAR	PINAL PE	331648N 1104910W	279.2	6825.0						
		RX												
	V	TX												
			17.20DB	SPAR	PINAL PE	331648N 1104910W	279.2	6825.0						
		RX												
6845.0	H	TX												
			-0.30DB	AZPS	TEMPE	3326 0N 1115445W	355.7	6845.0	3.20DB	AZPS	TEMPE	3326 0N 1115445W	273.4	6845.0
			14.20DB	SALT	GLOBE	331655N 11049 5W	176.4	6845.0	5.10DB	SPAR	PINAL PE	331648N 1104910W	279.2	6825.0
			[illegible]	SPAR	PINAL PE	331648N 1104910W	243.0	6855.0						
		RX												
			3.30DB	STAZ	SIGNAL P	331737N 11050 9W	279.9	6865.0						
	V	TX												
			[illegible]	AZPS	TEMPE	3326 0N 1115445W	355.7	6845.0	-3.20DB	AZPS	TEMPE	3326 0N 1115445W	273.4	6845.0
			13.20DB	SALT	GLOBE	331655N 11049 5W	176.4	6845.0	2.20DB	SPAR	PINAL PE	331648N 1104910W	279.2	6825.0
		RX												
6855.0	H	TX												
			25.50DB	SPAR	PINAL PE	331648N 1104910W	243.0	6855.0						
		RX												
			16.30DB	STAZ	SIGNAL P	331737N 11050 9W	279.9	6865.0						
	V	TX												
			16.60DB	SPAR	PINAL PE	331648N 1104910W	243.0	6855.0						
		RX												
			[illegible]	STAZ	SIGNAL P	331737N 11050 9W	279.9	6865.0						
6865.0	H	TX												
			3.50DB	SPAR	PINAL PE	331648N 1104910W	243.0	6855.0						
		RX												
			[illegible]	STAZ	SIGNAL P	331737N 11050 9W	279.9	6865.0						
	V	TX												
		RX												
			34.90DB	STAZ	SIGNAL P	331737N 11050 9W	279.9	6865.0						
PINAL PEAK			AZIMUTH: [illegible] DEGS.			([illegible] FROM PHOENIX		)						
6585.0	H	TX												
			[illegible]	FORC	PINAL PE	331735N 1104954W	[illegible]	6585.0	-3.30DB	SPAR	PINAL PK	331657N 1104912W	356.2	6585.0
			[illegible]	STAZ	[illegible]	[illegible]	232.4	6585.0	-1.10DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6605.0
			4.90DB	STAZ	WHITE TA	3334 2N 1123328W	223.3	6585.0						
		RX												
			[illegible]	FORC	PHOENIX	332415N 112 422W	100.4	6565.0	23.50DB	SPAR	CLAYPOOL	332454N 1104950W	176.2	6585.0
			[illegible]	STAZ	SIGNAL P	331737N 11050 9W	51.7	6585.0	4.40DB	SALT	PHOENIX	332629N 112 441W	89.8	6585.0
			[illegible]	STAZ	PHOENIX	332821N 112 61 W	99.2	6605.0						
	V	TX												
			4.10DB	FORC	PINAL PE	331735N 1104954W	[illegible]	6585.0	-3.30DB	SPAR	PINAL PK	331657N 1104912W	356.2	6585.0
			[illegible]	STAZ	[illegible]	[illegible]	232.4	6585.0	4.90DB	STAZ	WHITE TA	3334 2N 1123328W	223.3	6585.0
		RX												
			[illegible]	FORC	PHOENIX	332415N 112 422W	100.4	6585.0	14.50DB	SPAR	CLAYPOOL	332454N 1104950W	176.2	6585.0
			[illegible]	STAZ	SIGNAL P	331737N 11050 9W	51.7	6585.0	5.50DB	SALT	PHOENIX	332629N 112 441W	89.8	6585.0
			[illegible]	STAZ	PHOENIX	332821N 112 61 W	[illegible]	6585.0						
6595.0	H	TX												
			[illegible]	SALT	ROOSEVEL	334022N [illegible]	142.6	6605.0	13.90DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6605.0
		RX												
			[illegible]	FORC	PHOENIX	332415N 112 422W	100.4	6585.0	-1.50DB	SPAR	CLAYPOOL	332454N 1104950W	176.2	6585.0
			[illegible]	STAZ	PHOENIX	332821N 112 61 W	99.2	6605.0						
	V	TX												
			[illegible]	SALT	ROOSEVEL	334022N [illegible]	142.6	6605.0	6.70DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6605.0
		RX												
			1.70DB	FORC	PHOENIX	332415N 112 422W	100.4	6585.0	9.40DB	STAZ	PHOENIX	332821N 112 610W	99.2	6605.0
6605.0	H	TX												
			31.50DB	SALT	ROOSEVEL	334022N [illegible]	142.6	6605.0	38.90DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6605.0
		RX												
			13.90DB	FORC	PHOENIX	332415N 112 422W	146.4	6585.0	-3.30DB	SALT	GLOBE	331655N 11049 5W	322.8	6605.0
			[illegible]	STAZ	PHOENIX	332821N 112 61 W	99.2	6605.0						
	V	TX												
			[illegible]	SALT	ROOSEVEL	334022N [illegible]	142.6	6605.0	31.70DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6605.0
		RX												
			[illegible]	SALT	GLOBE	331655N 11049 5W	322.8	6605.0	35.00DB	STAZ	PHOENIX	332821N 112 610W	99.2	6605.0
6615.0	H	TX												
			[illegible]	SALT	ROOSEVEL	334022N [illegible]	142.6	6605.0	13.90DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6605.0
		RX												
			[illegible]	STAZ	PHOENIX	332821N 112 61 W	99.2	6605.0	-1.20DB	STAZ	PHOENIX	332821N 112 610W	137.8	6615.0
	V	TX												

	-2.50H SALT ROOSEVEL 334.22N 11113.W 142.0 6605.0	
DX	11.1DH STAZ PHOENIX 332821N 112 01 W 99.2 6605.0	
6625.0 H TX	5.4DH AZPS TEMPE 3326 0N 1115445W 98.5 6645.0	3.6DH SALT GOLDFIEL 3327 9N 1113028W 48.1 6625.0
	2.4DH EPFP [illegible] 322723N 11147 W 354. 6625.0	-1.1DB STAZ WHITE TA 3334 2N 1123328W 103.9 6605.0
	-1.1DH STAZ PHOENIX [illegible] 112 33 W 47.0 6625.0	
WX	14.4DH AZPS SIGNAL P 331736N 1105 W 51.9 6625.0	-2.1DB SPAR WHITETAN 333431N 1123441W 107.3 6645.0
	1.2DH STAZ PHOENIX 332821N 112 01 W 99.2 6605.0	14.3DB SALT NORMAN P 3333 2N 1112648W 61.5 6625.0
V TX	-0.1DH AZPS TEMPE 3326 0N 1115445W 98.5 6645.0	-3.7DB SALT GOLDFIEL 3327 9N 1113028W 48.1 6625.0
	2.6DH SPAR [illegible] 322723N 11147 W 354. 6625.0	
WX	6.5DH AZPS SIGNAL P 331736N 1105 W 51.9 6625.0	1.8DB SALT NORMAN P 3333 2N 1112648W 61.5 6625.0
6635.0 H TX	20.0DH AZPS TEMPE 3326 0N 1115445W 98.5 6645.0	
DX	12.9DH SPAR WHITETAN 333431N 1123441W 107.3 6645.0	
V TX	14.5DH AZPS TEMPE 3326 0N 1115445W 98.5 6645.0	
DX	1.3DH SPAR WHITETAN 333431N 1123441W 107.3 6645.0	
6645.0 H TX	16.6DH EPEC PINAL PK 331736N 1104954W 51.6 6645.0	45.9DB AZPS TEMPE 3326 0N 1115445W 98.5 6645.0
	4.5DH SPAR PHOENIX 332640N 112 44 W 98.5 6665.0	
WX	37.5DH SPAR WHITETAN 333431N 1123441W 107.3 6645.0	
V TX	12.9DH EPEC PINAL PK 331736N 1104954W 51.6 6645.0	39.9DB AZPS TEMPE 3326 0N 1115445W 98.5 6645.0
	2.4DH SPAR PHOENIX 332640N 112 44 W 98.5 6665.0	
WX	26.4DH SPAR WHITETAN 333431N 1123441W 107.3 6645.0	
6655.0 H TX	6.1DH CPHC SUNNYSLO 3335 0N 112 41W 181.0 6655.0	4.7DB TGEL RED ROCK 3233 5N 1111759W 27.0 6655.0
	26.4DH AZPS TEMPE 3326 0N 1115445W 98.5 6645.0	23.9DB SPAR PHOENIX 332640N 112 440W 98.5 6665.0
WX	12.3DH SPAR WHITETAN 333431N 1123441W 107.3 6645.0	
V TX	-6.6DH CPHC SUNNYSLO 3335 0N 112 41W 181.0 6655.0	-4.3DB TGEL RED ROCK 3233 5N 1111759W 27.0 6655.0
	14.4DH AZPS TEMPE 3326 0N 1115445W 98.5 6645.0	17.9DB SPAR PHOENIX 332640N 112 440W 98.5 6665.0
WX	1.3DH SPAR WHITETAN 333431N 1123441W 107.3 6645.0	
6665.0 H TX	5.4DH AZPS TEMPE 3326 0N 1115445W 98.5 6645.0	48.9DB SPAR PHOENIX 332640N 112 440W 98.5 6665.0
WX	-2.1DH SPAR WHITETAN 333431N 1123441W 107.3 6645.0	9.9DB SPAR PINAL PE 331644N 1104910W 279.2 6665.0
	7.1DH SALT TEMPE 332630N 1115625W 99.2 6665.0	3.8DB SALT TEMPE 332630N 1115625W 99.4 6685.0
V TX	-0.1DH AZPS TEMPE 3326 0N 1115445W 98.5 6645.0	42.9DB SPAR PHOENIX 332640N 112 440W 98.5 6665.0
WX	5.1DH SPAR PINAL PE 331644N 110491 W 279.2 6665.0	6.1DB SALT TEMPE 332630N 1115625W 88.2 6665.0
	-2.2DH SALT TEMPE 332630N 1115625W 99.4 6685.0	
6675.0 H TX	23.4DH SPAR PHOENIX 332640N 112 44 W 98.5 6665.0	
RX	16.8DH SALT TEMPE 332630N 1115625W 99.4 6685.0	
V TX	17.9DH SPAR PHOENIX 332640N 112 44 W 98.5 6665.0	
DX	12.9DH SALT TEMPE 332630N 1115625W 99.4 6685.0	
6685.0 H TX	15.1DH AZPS PHOENIX 332629N 112 441W 93.3 6685.0	0.1DB SPAR WHITETAN 333431N 1123441W 221.7 6685.0
	8.8DH SPAR PHOENIX 332640N 112 44 W 98.5 6665.0	10.2DB SALT GLOBE 331655N 11049 5W 280.0 6685.0
RX	41.8DH SALT TEMPE 332630N 1115625W 99.4 6685.0	
V TX	9.2DH AZPS PHOENIX 332629N 112 441W 93.3 6685.0	0.1DB SPAR WHITETAN 333431N 1123441W 221.7 6685.0
	2.8DH SPAR PHOENIX 332640N 112 44 W 98.5 6665.0	10.2DB SALT GLOBE 331655N 11049 5W 280.0 6685.0
RX	57.4DH SALT TEMPE 332630N 1115625W 99.4 6685.0	
6695.0 H TX	1.0DH SPAR CASA GRA 325233N 1114519W 62.5 6705.0	
RX	14.8DH SALT TEMPE 332630N 1115625W 99.4 6685.0	
V TX	-4.2DH SALT PHOENIX 332629N 112 441W 89.8 6705.0	
RX	12.8DH SALT TEMPE 332630N 1115625W 99.4 6685.0	
6705.0 H TX	3.6DH SALT GOLDFIEL 3327 9N 1113028W 48.1 6705.0	9.3DB SPAR CLAYPOOL 332454N 1104950W 176.2 6705.0
	26.7DH SPAR CASA GRA 325233N 1114519W 62.5 6705.0	19.6DB SALT PHOENIX 332629N 112 441W 89.8 6705.0
	-3.2DH STAZ PHOENIX 332821N 112 01 W 167.7 6705.0	
RX	10.9DH SPAR PINAL PK 331657N 1104912W 356.2 6705.0	8.0DB SPAR PINAL PE 331644N 1104910W 243.0 6705.0
	8.7DH SPAR PINAL PE 331644N 110491 W 349.6 6705.0	3.9DB SALT TEMPE 332630N 1115625W 99.4 6685.0
	-0.5DH STAZ WHITE TA 3334 2N 1123328W 103.9 6725.0	14.6DB STAZ CLAYPOOL 332440N 1105027W 178.0 6705.0
	14.3DH SALT NORMAN P 3333 2N 1112648W 61.5 6705.0	
V TX	-3.7DH SALT GOLDFIEL 3327 9N 1113028W 48.1 6705.0	0.3DB SPAR CLAYPOOL 332454N 1104950W 176.2 6705.0
	17.1DH SPAR CASA GRA 325233N 1114519W 62.5 6705.0	20.7DB SALT PHOENIX 332629N 112 441W 89.8 6705.0
	-2.2DH STAZ PHOENIX 332821N 112 01 W 167.7 6705.0	
RX	10.9DH SPAR PINAL PK 331657N 1104912W 356.2 6705.0	8.0DB SPAR PINAL PE 331648N 1104910W 243.0 6705.0
	8.7DH SPAR PINAL PE 331644N 110491 W 349.6 6705.0	-2.1DB SALT TEMPE 332630N 1115625W 99.4 6685.0
	5.6DH STAZ CLAYPOOL 332440N 1105027W 178.0 6705.0	1.8DB SALT NORMAN P 3333 2N 1112648W 61.5 6705.0
6715.0 H TX		

POTENTIAL FREQUENCIES	POLARITY	R = RECEIVER T = TRANSMITTER	SIGNAL/ INTERFERENCE RATIO OBJECTIVE DEGRADATION	FOREIGN STATION USER	NAME OF FOREIGN STATION	COORDINATES OF FOREIGN STATION	AZIMUTH OF FOREIGN STATION	FOREIGN STATION FREQUENCY	SIGNAL/ INTERFERENCE RATIO OBJECTIVE DEGRADATION	FOREIGN STATION USER	NAME OF FOREIGN STATION	COORDINATES OF FOREIGN STATION	AZIMUTH OF FOREIGN STATION	FOREIGN STATION FREQUENCY
			1.0DB	SPAR	CASA GRA	325233N 1114519W	62.5	6705.0						
		RX												
			0.3DB	SALT	ROOSEVEL	334022N 1111035W	142.6	6725.0	14.5DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6725.0
✓	V	TX												
			-4.3DB	SALT	PHOENIX	332629N 112 441W	69.8	6705.0						
		RX												
			7.1DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6725.0						
6725.0	H	TX												
			38.6DB	FORC	PHOENIX	332915N 112 422W	100.4	6745.0	2.9DB	SALT	GLOBE	331655N 11049 5W	322.8	6725.0
		RX												
			25.4DB	SALT	ROOSEVEL	334022N 1111030W	142.6	6725.0	39.5DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6725.
	V	TX												
			11.4DB	FORC	PHOENIX	332915N 112 422W	100.4	6745.0	2.9DB	SALT	GLOBE	331655N 11049 5W	322.8	6725.0
		RX												
			16.4DB	SALT	ROOSEVEL	334022N 1111035W	142.6	6725.0	32.3DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6725.0
6735.0	H	TX												
			53.6DB	FORC	PHOENIX	332915N 112 422W	100.4	6745.0						
		RX												
			6.4DB	SALT	ROOSEVEL	334022N 1111035W	142.6	6725.0	14.5DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6725.0
	V	TX												
			26.4DB	FORC	PHOENIX	332915N 112 422W	100.4	6745.0						
		RX												
			7.3DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6725.0						
6745.0	H	TX												
			75.2DB	FORC	PHOENIX	332915N 112 422W	100.4	6745.0	7.8DB	STAZ	SIGNAL P	331737N 11050 9W	51.7	6745.0
			15.5DB	SALT	MORMAN P	3333 2N 1112648W	61.5	6745.0	15.5DB	SALT	MORMAN P	3333 2N 1112648W	61.5	6745.0
		RX												
			2.7DB	SALT	GOLDFIEL	3327 9N 1113028W	48.1	6745.0	-3.3DB	SPAR	MTLEMMON	322623N 11047 4W	358.0	6745.0
			-0.4DB	STAZ	WHITE TA	3334 2N 1123328W	103.9	6725.0						
	V	TX												
			51.4DB	FORC	PHOENIX	332915N 112 422W	100.4	6745.0	2.8DB	STAZ	SIGNAL P	331737N 11050 9W	51.7	6745.0
			3.9DB	SALT	MORMAN P	3333 2N 1112648W	61.5	6745.0	3.0DB	SALT	MORMAN P	3333 2N 1112648W	61.5	6745.0
		RX												
			-4.9DB	SALT	GOLDFIEL	3327 9N 1113028W	48.1	6745.0	-3.3DB	SPAR	MTLEMMON	322623N 11047 4W	358.0	6745.0
6755.0	H	TX												
			53.6DB	FORC	PHOENIX	332915N 112 422W	100.4	6745.0						
		RX												
			-3.2DB	SALT	PHOENIX	332629N 112 9 0W	89.9	6765.0						
	V	TX												
			26.4DB	FORC	PHOENIX	332915N 112 422W	100.4	6745.0						
		RX												
6765.0	H	TX												
			18.6DB	FORC	PHOENIX	332915N 112 422W	100.4	6745.0	-3.8DB	SALT	WINKLEMA	325814N 1104742W	356.5	6765.0
			8.5DB	STAZ	WHITE TA	3334 2N 1123328W	307.2	6765.0						
		RX												
			16.5DB	SALT	GLOBE	331655N 11049 5W	176.4	6765.0	21.8DB	SALT	PHOENIX	332629N 112 9 0W	89.9	6765.0
	V	TX												
			11.4DB	FORC	PHOENIX	332915N 112 422W	100.4	6745.0	-3.8DB	SALT	WINKLEMA	325814N 1104742W	356.5	6765.0
			8.5DB	STAZ	WHITE TA	3334 2N 1123328W	307.2	6765.0						
		RX												
			18.5DB	SALT	GLOBE	331655N 11049 5W	176.4	6765.0	13.5DB	SALT	PHOENIX	332629N 112 9 0W	89.9	6765.0
✓ 6775.0	H	TX												
		RX												
			-3.2DB	SALT	PHOENIX	332629N 112 9 0W	89.9	6765.0						
✓	V	TX												
		RX												
6785.0	H	TX												
			7.7DB	AZPS	SIGNAL P	331736N 11050 9W	51.9	6785.0	-0.9DB	SPAR	WHITETAN	333431N 1123441W	107.3	6805.0
			15.2DB	SALT	TEMPE	332630N 1115625W	99.4	6805.0						
		RX												
			-3.1DB	AZPS	GREENS P	34 629N 1093422W	232.6	6785.0	0.4DB	AZPS	TEMPE	3326 0N 1115445W	98.5	6805.0
	V	TX												
			6.1DB	AZPS	SIGNAL P	331736N 11050 9W	51.9	6785.0	9.2DB	SALT	TEMPE	332630N 1115625W	99.4	6805.0
		RX												
			-3.1DB	AZPS	GREENS P	34 629N 1093422W	232.6	6785.0						
6795.0	H	TX												
			14.1DB	SPAR	WHITETAN	333431N 1123441W	107.3	6805.0	30.2DB	SALT	TEMPE	332630N 1115625W	99.4	6805.0
		RX												
			15.4DB	AZPS	TEMPE	3326 0N 1115445W	98.5	6805.0						
	V	TX												
			[illegible]	SPAR	WHITETAN	333431N 1123441W	107.3	6805.0	24.2DB	SALT	TEMPE	332630N 1115625W	99.4	6805.0
		RX												
			9.4DB	AZPS	TEMPE	3326 0N 1115445W	98.5	6805.0						
6805.0	H	TX												
			[illegible]	AZPS	GREENS P	34 629N 1093422W	232.6	6805.0	39.1DB	SPAR	WHITETAN	333431N 1123441W	107.3	6805.0
			[illegible]	SALT	TEMPE	332630N 1115625W	[illegible]	6805.0	55.1DB	SALT	TEMPE	332630N 1115625W	99.4	6805.0
		RX												
			47.4DB	AZPS	TEMPE	3326 0N 1115445W	98.5	6805.0	3.6DB	SPAR	PHOENIX	332640N 112 440W	98.5	6825.0
			-1.1DB	SALT	GLOBE	331655N 11049 5W	280.0	6805.0						
	V	TX												
			[illegible]	AZPS	GREENS P	34 629N 1093422W	232.6	6805.0	27.5DB	SPAR	WHITETAN	333431N 1123441W	107.3	6805.0
			[illegible]	SALT	TEMPE	332630N 1115625W	[illegible]	6805.0	49.1DB	SALT	TEMPE	332630N 1115625W	99.4	6805.0
		RX												
			34.4DB	AZPS	TEMPE	3326 0N 1115445W	98.5	6805.0	-2.4DB	SPAR	PHOENIX	332640N 112 440W	98.5	6825.0
			[illegible]	SALT	GLOBE	331655N 11049 5W	280.0	6805.0						

6815.0 H TX	[illegible] WHITETAN 333431N 1123441W 107.3 6805.0	39.10B SALT TEMPE 332630N 1115625W 99.4 6805.0
RX	15.[illegible] AZPS TEMPE 3326 0N 1115445W 98.5 6805.0	16.60B SPAR PHOENIX 332640N 112 440W 98.5 6825.0
V TX	2.[illegible] WHITETAN 333431N 1123441W 107.3 6805.0	24.10B SALT TEMPE 332630N 1115625W 99.4 6805.0
RX	3.[illegible] AZPS TEMPE 3326 0N 1115445W 98.5 6805.0	12.60B SPAR PHOENIX 332640N 112 440W 98.5 6825.0
6825.0 H TX	-1.[illegible] WHITETAN 333431N 1123441W 107.3 6805.0 1[illegible] SALT TEMPE 332630N 1115625W [illegible] 6825.0 11.[illegible] STAZ CLAYPOOL 332440N 1105027W 178.0 6825.0	14.20B SPAR PINAL PE 331648N 1104910W 279.2 6825.0 15.10B SALT TEMPE 332630N 1115625W 99.4 6805.0
RX	[illegible] AZPS TEMPE 3326 0N 1115445W 98.5 6805.0	43.60B SPAR PHOENIX 332640N 112 440W 98.5 6825.0
V TX	1[illegible] SPAR PINAL PE 331648N 110491[illegible] 279.2 6825.0 [illegible] SALT TEMPE 332630N 1115625W 99.4 6805.0	13.00B SALT TEMPE 332630N 1115625W 88.2 6825.0 2.40B STAZ CLAYPOOL 332440N 1105027W 178.0 6825.0
RX	17.[illegible] SPAR PHOENIX 332640N 112 440W 98.5 6825.0	
6835.0 H TX		
RX	[illegible] AZPS PHOENIX 332629N 112 441W 93.3 6845.0	16.60B SPAR PHOENIX 332640N 112 440W 98.5 6825.0
V TX		
RX	12.[illegible] SPAR PHOENIX 332640N 112 440W 98.5 6825.0	
6845.0 H TX	1[illegible] SALT GLOBE 331655N 11049 5W 176.4 6845.0 7.[illegible] STAZ PHOENIX 332821N 112 61[illegible] 99.2 6865.0	14.90B SALT PHOENIX 332629N 112 9 0W 89.9 6845.0 3.10B STAZ PHOENIX 331957N 112 358W 126.8 6845.0
RX	2[illegible] AZPS PHOENIX 332629N 112 441W 93.3 6845.0 [illegible] SPAR PHOENIX 332640N 112 440W 98.5 6825.0	-1.80B SPAR WHITETAN 333431N 1123441W 221.7 6845.0 -3.00B SPAR CASA GRA 325233N 1114519W 62.5 6855.0
V TX	14.50B SALT GLOBE 331655N 11049 5W 176.4 6845.0 1.[illegible] STAZ PHOENIX 332821N 112 61[illegible] 99.2 6865.0	6.60B SALT PHOENIX 332629N 112 9 0W 89.9 6845.0
RX	14.30B AZPS PHOENIX 332629N 112 441W 93.3 6845.0 -2.40B SPAR PHOENIX 332640N 112 440W 98.5 6825.0	-1.80B SPAR WHITETAN 333431N 1123441W 221.7 6845.0
6855.0 H TX	11.90B SPAR PINAL PE 331648N 110491[illegible] 243.0 6855.0	22.50B STAZ PHOENIX 332821N 112 610W 99.2 6865.0
RX	-4.80B AZPS PHOENIX 332629N 112 441W 93.3 6845.0	22.00B SPAR CASA GRA 325233N 1114519W 62.5 6855.0
V TX	11.90B SPAR PINAL PE 331648N 110491[illegible] 243.0 6855.0	16.50B STAZ PHOENIX 332821N 112 610W 99.2 6865.0
RX	13.00B SPAR CASA GRA 325233N 1114519W 62.5 6855.0	
6665.0 H TX	47.40B STAZ PHOENIX 332821N 112 61[illegible] 99.2 6865.0	
RX	-2.40B SPAR CASA GRA 325233N 1114519W 62.5 6855.0	
V TX	[illegible] STAZ PHOENIX 332821N 112 61[illegible] 99.2 6865.0	
RX		

PINAL PEAK AZIMUTH: 178.05 DEGS. (TOWARDS/FROM MT LEMMON)

6585.0 H TX	14.90B CTUC TUCSON 321230N 1105516W 0.5 6585.0 17.80B SPAR PINAL PE 331648N 1104910W 349.6 6585.0 5.90B STAZ MT LEMMO 322725N 1104713W 144.1 6585.0	-4.00B SPAR PINAL PK 331657N 1104912W 356.2 6585.0 -0.90B STAZ SPRINGER 34 640N 1093426W 232.4 6585.0
RX	-1.40B SPAR CLAYPOOL 332454N 110495[illegible] 176.2 6585.0	
V TX	4.60B CTUC TUCSON 321230N 1105516W 0.5 6585.0 8.80B SPAR PINAL PE 331648N 1104910W 349.6 6585.0 5.90B STAZ MT LEMMO 322725N 1104713W 144.1 6585.0	-4.00B SPAR PINAL PK 331657N 1104912W 356.2 6585.0 -0.90B STAZ SPRINGER 34 640N 1093426W 232.4 6585.0
RX	-1.40B SPAR CLAYPOOL 332454N 1104955W 176.2 6585.0	
6595.0 H TX		
RX		
V TX		
RX		
6605.0 H TX	16.50B TGEL RILLITO 32 938N 1105418W 322.2 6605.0 31.40B SPAR MTLEMMON 322623N 11047 4W 358.0 6625.0	6.80B SALT ROOSEVEL 334022N 1111030W 142.6 6605.0
RX	-4.20B SALT GLOBE 331655N 11049 5W 322.8 6605.0	
V TX	9.00B TGEL RILLITO 32 938N 1105418W 322.2 6605.0 1.40B SPAR MTLEMMON 322623N 11047 4W 358.0 6625.0	6.80B SALT ROOSEVEL 334022N 1111030W 142.6 6605.0
RX	-4.20B SALT GLOBE 331655N 11049 5W 322.8 6605.0	
6615.0 H TX	46.40B SPAR MTLEMMON 322623N 11047 4W 358.0 6625.0	
RX		
V TX	16.40B SPAR MTLEMMON 322623N 11047 4W 358.0 6625.0	
RX		
6625.0 H TX	12.10B TGEL TUCSON 32 948N 1105423W 355.5 6625.0 16.00B STAZ MT LEMMO 322725N 1104713W 210.8 6625.0	71.40B SPAR MTLEMMON 322623N 11047 4W 358.0 6625.0
RX	10.30B SPAR PINAL PE 331648N 1104910W 178.0 6625.0	
V TX	13.80B TGEL TUCSON 32 948N 1105423W 355.5 6625.0 16.60B STAZ MT LEMMO 322725N 1104713W 210.8 6625.0	41.90B SPAR MTLEMMON 322623N 11047 4W 358.0 6625.0
RX	10.30B SPAR PINAL PE 331648N 1104910W 178.0 6625.0	
6635.0 H TX	46.40B SPAR MTLEMMON 322623N 11047 4W 358.0 6625.0	
RX		
V TX	16.80B SPAR MTLEMMON 322623N 11047 4W 358.0 6625.0	
RX		
6645.0 H TX	-1.80B AZPS TEMPE 3326 0N 1115445W 98.5 6645.0 12.20B STAZ MT LEMMO 322725N 1104713W 191.8 6645.0	31.40B SPAR MTLEMMON 322623N 11047 4W 358.0 6625.0
RX		
V TX		

POTENTIAL FREQUENCIES	POLARITY	Rx = RECEIVER Tx = TRANSMITTER	SIGNAL/ INTERFERENCE RATIO/ OBJECTIVE DEGRADATION	FOREIGN STATION USER	NAME OF FOREIGN STATION	COORDINATES OF FOREIGN STATION	AZIMUTH OF FOREIGN STATION	FOREIGN STATION FREQUENCY	SIGNAL/ INTERFERENCE RATIO/ OBJECTIVE DEGRADATION	FOREIGN STATION USER	NAME OF FOREIGN STATION	COORDINATES OF FOREIGN STATION	AZIMUTH OF FOREIGN STATION	FOREIGN STATION FREQUENCY
			-1.80H	AZPS	TEMPE	3326 0N 1115445W	96.5	6645.0	1.80B	SPAR	MTLEMMON	322623N 11047 4W	358.0	6625.0
			12.20H	STAZ	MT LEMMO	322725N 1104713W	191.8	6645.0						
		RX												
√ 6655.0	H	TX												
			4.00H	TGEL	RED ROCK	3233 5N 1111759W	27.0	6655.0 — [illegible]						
		RX	7.10H	SPAR	PINAL PE	331648N 1104910W	279.2	6665.0						
√	V	TX												
		RX	-1.90H	SPAR	PINAL PE	331648N 1104910W	279.2	6665.0						
√ 6665.0	H	TX	1.20H	SPAR	PHOENIX	332646N 112 44 W	96.5	6665.0						
		RX	32.10H	SPAR	PINAL PE	331648N 1104910W	279.2	6665.0						
√	V	TX	1.20H	SPAR	PHOENIX	332646N 112 44 W	96.5	6665.0						
		RX	23.10H	SPAR	PINAL PE	331648N 1104910W	279.2	6665.0						
6675.0	H	TX	6.50H	STAZ	MT LEMMO	322725N 1104713W	309.5	6685.0						
		RX	7.10H	SPAR	PINAL PE	331648N 1104910W	279.2	6665.0						
√	V	TX	-2.50H	STAZ	MT LEMMO	322725N 1104713W	309.5	6685.0						
		RX	-1.90H	SPAR	PINAL PE	331648N 1104910W	279.2	6665.0						
6685.0	H	TX	9.50H	SALT	GLOBE	331655N 11049 5W	200.0	6665.0	31.50B	STAZ	MT LEMMO	322725N 1104713W	309.5	6685.0
		RX	11.30H	SPAR	MTLEMMON	322623N 11047 4W	215.4	6685.0	-4.10B	SALT	TEMPE	332630N 1115625W	99.4	6685.0
	V	TX	9.50H	SALT	GLOBE	331655N 11049 5W	200.0	6685.0	22.50B	STAZ	MT LEMMO	322725N 1104713W	309.5	6685.0
		RX	11.30H	SPAR	MTLEMMON	322623N 11047 4W	215.4	6685.0	-4.10B	SALT	TEMPE	332630N 1115625W	99.4	6685.0
6695.0	H	TX	.30H	SPAR	CASA GRA	325233N 1114519W	62.5	6705.0	6.50B	STAZ	MT LEMMO	322725N 1104713W	309.5	6685.0
		RX	6.10H	SPAR	PINAL PE	331648N 1104910W	243.0	6705.0	6.40H	SPAR	PINAL PE	331648N 1104910W	349.6	6705.0
√	V	TX	-2.50H	STAZ	MT LEMMO	322725N 1104713W	309.5	6685.0						
		RX	-2.70H	SPAR	PINAL PE	331648N 1104910W	243.0	6705.0	-2.20B	SPAR	PINAL PE	331648N 1104910W	349.6	6705.0
6705.0	H	TX	25.30H	SPAR	CASA GRA	325233N 1114519W	62.5	6705.0						
		RX	5.60H	CTUC	TUCSON	321232N 1105516W	0.5	6705.0	16.00B	SPAR	PINAL PK	331657N 1104912W	356.2	6705.0
			31.10H	SPAR	PINAL PE	331648N 1104910W	243.0	6705.0	31.80B	SPAR	PINAL PE	331648N 1104910W	349.6	6705.0
	V	TX	16.30H	SPAR	CASA GRA	325233N 1114519W	62.5	6705.0						
		RX	15.00H	SPAR	PINAL PK	331657N 1104912W	356.2	6705.0	22.30B	SPAR	PINAL PE	331648N 1104910W	243.0	6705.0
			22.40H	SPAR	PINAL PE	331648N 1104910W	349.6	6705.0						
√ 6715.0	H	TX	2.30H	SPAR	CASA GRA	325233N 1114519W	62.5	6705.0						
		RX	6.10H	SPAR	PINAL PE	331648N 1104910W	243.0	6705.0	6.80B	SPAR	PINAL PE	331648N 1104910W	349.6	6705.0
√	V	TX												
		RX	-2.60H	SPAR	PINAL PE	331648N 1104910W	243.0	6705.0	-2.20B	SPAR	PINAL PE	331648N 1104910W	349.6	6705.0
6725.0	H	TX												
√			2.20H	SALT	GLOBE	331655N 11049 5W	322.8	6725.0						
		RX	9.50H	SALT	ROOSEVEL	334322N 1111037W	142.6	6725.0	25.30B	SPAR	MTLEMMON	322623N 11047 4W	358.0	6745.0
			16.10H	SPAR	MTLEMMON	322623N 11047 4W	74.9	6725.0	-3.40B	STAZ	MT LEMMO	322725N 1104713W	144.1	6725.0
	V	TX	2.20B	SALT	GLOBE	331655N 11049 5W	322.8	6725.0						
		RX	0.50H	SALT	ROOSEVEL	334322N 1111037W	142.6	6725.0	-4.30B	SPAR	MTLEMMON	322623N 11047 4W	358.0	6745.0
			9.20H	SPAR	MTLEMMON	322623N 11047 4W	74.9	6725.0	-3.40B	STAZ	MT LEMMO	322725N 1104713W	144.1	6725.0
√ 6735.0	H	TX												
		RX	40.30H	SPAR	MTLEMMON	322623N 11047 4W	358.0	6745.0						
√	V	TX												
		RX	19.60H	SPAR	MTLEMMON	322623N 11047 4W	358.0	6745.0						
6745.0	H	TX	9.70H	FORC	PHOENIX	332915N 112 422W	100.4	6745.0	0.50B	SALT	WINKLEMA	325814N 1104742W	356.5	6765.0
			16.40H	SPAR	PINAL PE	331648N 1104910W	178.0	6745.0	4.10B	STAZ	TUCSON	321228N 1105745W	30.7	6745.0
		RX	65.30H	SPAR	MTLEMMON	322623N 11047 4W	358.0	6745.0	-3.10B	STAZ	MT LEMMO	322725N 1104713W	210.8	6745.0
	V	TX	9.70H	FORC	PHOENIX	332915N 112 422W	100.4	6745.0	-4.50B	SALT	WINKLEMA	325814N 1104742W	356.5	6765.0
			16.40B	SPAR	PINAL PE	331648N 1104910W	178.0	6745.0	-3.90B	STAZ	TUCSON	321228N 1105745W	30.7	6745.0
		RX	35.80H	SPAR	MTLEMMON	322623N 11047 4W	358.0	6745.0	-3.10H	STAZ	MT LEMMO	322725N 1104713W	210.8	6745.0
6755.0	H	TX	15.50H	SALT	WINKLEMA	325814N 1104742W	356.5	6765.0						
		RX	40.30H	SPAR	MTLEMMON	322623N 11047 4W	358.0	6745.0						
	V	TX	10.50H	SALT	WINKLEMA	325814N 1104742W	356.5	6765.0						
		RX	10.80H	SPAR	MTLEMMON	322623N 11047 4W	358.0	6745.0						
6765.0	H	TX												

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                [illegible] SALT WINKLEMA 325814N 1104742W 356.5  6765.0
            RX
                -3.70B [illegible]         32 [illegible] 111541W 322.2  6765.0     0.60B SALT WINKLEMA 325814N 1104742W  21.0  6765.0
                15.[illegible] SALT GLOBE    331655N 11049 5W 176.4  6765.0     25.30B SPAR MTLEMMON 322623N 11047 4W 358.0  6745.0
          V TX
                35.[illegible] SALT WINKLEMA 325814N 1104742W 356.5  6765.0
            RX
                -4.[illegible] SALT WINKLEMA 325814N 1104742W  21.0  6765.0     15.60B SALT GLOBE    331655N 11049 5W 176.4  6765.0
                -4.[illegible] MTLEMMON    322623N 11047 4W 358.0  6745.0
6775.0 H TX
                15.[illegible] SALT WINKLEMA 325814N 1104742W 356.5  6765.0
            RX
          V TX
                1[illegible] SALT WINKLEMA 325814N 1104742W 356.5  6765.0
            RX
6785.0 H TX
                [illegible] SALT WINKLEMA 325814N 1104742W 356.5  6765.0
            RX
                -2.[illegible] TUCSON      32 [illegible] 110542W 355.5  6785.0     -4.00B AZPS GREENS P 34 629N 1093422W 232.6  6785.0
          V TX
                -4.[illegible] SALT WINKLEMA 325814N 1104742W 3[illegible].5  6765.0
            RX
                -[illegible] TUCSON        32 [illegible] 110542W 355.5  6785.0     -4.00B AZPS GREENS P 34 629N 1093422W 232.6  6785.0
6795.0 H TX
            RX
          V TX
            RX
6805.0 H TX
                [illegible] GREENS P 34 [illegible] 10935 W 232.5  6805.0     -2.40B SPAR PINAL PE 331648N 1104910W 279.2  6825.0
                7.[illegible] SALT TEMPE    332630N 1115625W  99.4  6805.0
            RX
                -2.[illegible] SALT GLOBE    331655N 11049 5W 280.0  6805.0
          V TX
                [illegible] FORC GREENS P 34 6 LN 10935 W 232.5  6805.0     7.40B SALT TEMPE    332630N 1115625W  99.4  6805.0
            RX
                -2.[illegible] SALT GLOBE    331655N 11049 5W 280.0  6805.0

6815.0 H TX
                12.[illegible] SPAR PINAL PE 331648N 1104910W 279.2  6825.0
            RX
          V TX
                3.50B SPAR PINAL PE 331648N 1104910W 279.2  6825.0
            RX
6825.0 H TX
                37.50B SPAR PINAL PE 331648N 1104910W 279.2  6825.0
            RX
                -1.70B SALT WINKLEMA 325814N 1104742W 356.5  6845.0     -4.30B SPAR PHOENIX  332640N 112 440W  98.5  6825.0
          V TX
                2[illegible] SPAR PINAL PE 331648N 1104910W 279.2  6825.0
            RX
                -4.30B SPAR PHOENIX  332640N 112 440W  98.5  6825.0
6835.0 H TX
                12.50B SPAR PINAL PE 331648N 1104910W 279.2  6825.0     -4.70B SPAR PINAL PE 331648N 1104910W 243.0  6855.0
            RX
                13.30B SALT WINKLEMA 325814N 1104742W 356.5  6845.0     -3.00B STAZ MT LEMMO 322725N 1104713W 309.5  6845.0
          V TX
                3.[illegible] SPAR PINAL PE 331648N 1104910W 279.2  6825.0
            RX
                8.3[illegible] SALT WINKLEMA 325814N 1104742W 356.5  6845.0
6845.0 H TX
                3.[illegible] SALT WINKLEMA 325814N 1104742W  21.0  6845.0     17.80B SALT GLOBE    331655N 11049 5W 176.4  6845.0
                9.90B SPAR MTLEMMON 322623N 11047 4W 215.4  6845.0     -2.50B SPAR PINAL PE 331648N 1104910W 279.2  6825.0
                10.30B SPAR PINAL PE 331648N 1104910W 243.0  6855.0
            RX
                38.30B SALT WINKLEMA 325814N 1104742W 356.5  6845.0     -3.90B SPAR CASA GRA 325233N 1114519W  62.5  6855.0
                22.[illegible] STAZ MT LEMMO 322725N 1104713W 309.5  6845.0
          V TX
                -2.[illegible] SALT WINKLEMA 325814N 1104742W  21.0  6845.0     17.80B SALT GLOBE    331655N 11049 5W 176.4  6845.0
                8.90B SPAR MTLEMMON 322623N 11047 4W 215.4  6845.0      1.50B SPAR PINAL PE 331648N 1104910W 243.0  6855.0
            RX
                33.30B SALT WINKLEMA 325814N 1104742W 356.5  6845.0     13.00B STAZ MT LEMMO 322725N 1104713W 309.5  6845.0
6855.0 H TX
                35.20B SPAR PINAL PE 331648N 1104910W 243.0  6855.0     -3.40B SPAR MTLEMMON 322623N 11047 4W  74.9  6865.0
            RX
                13.30B SALT WINKLEMA 325814N 1104742W 356.5  6845.0     21.10B SPAR CASA GRA 325233N 1114519W  62.5  6855.0
                -3.10B STAZ MT LEMMO 322725N 1104713W 309.5  6845.0
          V TX
                26.50B SPAR PINAL PE 331648N 1104910W 243.0  6855.0
            RX
                8.30B SALT WINKLEMA 325814N 1104742W 356.5  6845.0     12.10B SPAR CASA GRA 325233N 1114519W  62.5  6855.0
6865.0 H TX
                10.20B SPAR PINAL PE 331648N 1104910W 243.0  6855.0     21.60B SPAR MTLEMMON 322623N 11047 4W  74.9  6865.0
                -0.30B STAZ PHOENIX  332821N 112 610W  99.2  6865.0
            RX
                -1.60B SALT WINKLEMA 325814N 1104742W 356.5  6845.0     -3.80B SPAR CASA GRA 325233N 1114519W  62.5  6855.0
          V TX
                1.50B SPAR PINAL PE 331648N 1104910W 243.0  6855.0     14.70B SPAR MTLEMMON 322623N 11047 4W  74.9  6865.0
                -0.30B STAZ PHOENIX  332821N 112 610W  99.2  6865.0
            RX
MT LEMMON     AZIMUTH: 358.07 DEGS.   (TOWARDS/FROM PINAL PEAK  )
6585.0 H TX
                11.20B FORC PINAL PK 331730N 1104954W 281.0  6585.0     11.10B SPAR PINAL PK 331657N 1104912W 356.2  6585.0
                39.90B STAZ MT LEMMO 322725N 1104713W 144.1  6585.0
            RX
                41.20B SPAR CLAYPOOL 332454N 1104955W 176.2  6585.0     12.40B SPAR PINAL PK 331657N 1104912W 169.6  6585.0
          V TX
                11.20B FORC PINAL PK 331730N 1104954W 281.0  6585.0     10.30B SPAR PINAL PK 331657N 1104912W 356.2  6585.0
                55.20B STAZ MT LEMMO 322725N 1104713W 144.1  6585.0
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GLOSSARY OF TERMS AND ABBREVIATIONS

AMERICAN TELEPHONE & TELEGRAPH CORPORATION (AT&T) – A communication common carrier.

AMPLIFIER – Device through which audio, video or telemetry signals are strengthened.

ATTENTUATOR – Device through which audio, video or telemetry signals are decreased.

AUDIO – Of or concerning sound; specifically, the electrical energy representing a sound program or the sound portion of a television program.

AUTOMATIC GAIN CONTROL (AGC) – A circuit which automatically controls the gain of an amplifier so that the output signal level is virtually constant for varying input signal levels. Sometimes referred to as automatic level (ALC).

BAND – A range of radio frequencies within two definite limits and used for a definite purpose; for example, the Standard Broadcast Band extends from 550 to 1,600 kHz, VHF television from 54 to 216 MHz, UHF television from 470 to 890 MHz, international broadcasting uses several bands between 6,000 and 22,000 kHz, and Domestic FM from 88 to 108 MHz.

BANDWIDTHS (pass band) – Describes the frequency range of a communication channel or the frequency range required to convey information through a specific communication medium. For example, the bandwidth of a television channel in the U.S. is 6 MHz.

BASEBAND – In the process of modulation, the frequency band occupied by the aggregate of the information signals used to modulate a carrier.

BAUD – The measure of the rate of transmission of digital data. For a two-level code the baud rate is equivalent to bits per second. Not a good term to use for digital transmission rates, since other than two-level codes are often used.

BROADCAST – Radio or televison service on standard assigned frequencies transmitted over an area. Stations may be commercial or noncommercial. For example, one transmitter conveying information to many receivers.

CHANNEL – A range or "band" of frequencies assigned for the transmission of communications signals; in television it is the group of frequencies comprising the transmitted visual (video) and sound (audio) signals.

CHANNEL ALLOCATION – The channel or band in the radio spectrum to which a television station is assigned, or the channel space in the radio spectrum to which a communication service is assigned.

CLOSED CIRCUIT – A private wire or radio circuit used as one means of carrying or conveying from one location to another an audio or television program for specialized audience use.

COAXIAL CABLE (concentric line) – A transmission line formed by two coaxial conductors, each insulated from the other by some suitable insulating material such as air or polyethylene, polyfoam, Teflon, etc.

COMBINING NETWORK – A passive network which permits the addition of several signals into one combined output with a high degree of isolation between individual inputs. Sometimes called "mixer."

COMMON CARRIER – A company franchised to provide specialized communications interconnection services such as telephone, telegraph and other forms of telecommunication, to the public. The telephone company is a typical example.

COMMUNICATIONS CHANNELS – Cable or radio connections through which video, voice, data, telemetry or other information may be transmitted. Important parameters of a channel are bandwidth, noise figure, cross-modulation and fidelity.

COMMUNITY ANTENNA TELEVISION (CATV OR CABLE-TV) – A master antenna array (head end) and the signal distribution system, i.e., the amplifiers, antennas, coaxial cable connecting devices, etc., necessary to distribute several TV signals throughout a community.

COMPATIBLE COLOR SYSTEM – A color television system that permits normal black and white reception of its transmitted signals without altering currently used receivers.

CONDITIONED TELEPHONE LINE – A telephone channel that has been modified for special communication use, usually for more usable bandwidth.

CROSS-MODULATION – A form of distortion where modulation of an interfering station appears as a modulation of the desired station. Caused by third and higher odd order nonlinearities.

DA (DISTRIBUTION AMPLIFIER) – A device used to distribute video signals among several video receivers.

DATA CHANNELS – A communications channel for handling information other than video or voice. For example, digital signals such as teletype and analog signals such as telemetry.

DECIBEL – A unit expressing a power or voltage ratio. Decibel (or dB) $dB_{power} = 10 \log P_1/P_2$; $dB_{voltage} = 20 \log E_1/E_2$.

DEMODULATION – The process of recovering the video, audio and data signals from their respective carrier waves. Extracting the original signal form from the modulated carrier.

DETECTOR – See "DEMODULATOR."

DIRECTIONAL ANTENNA – An antenna radiating or receiving radio waves more effectively in some directions than in others. In microwave engineering: a parabolic "dish."

DUPLEX CIRCUIT – A communications circuit that can transmit and receive.

ECG or EKG (Electrocardiogram) – Measurement of electrical activity associated with the heart.

EEG (Electroencephalogram) – Measurement of electrical activity associated with the brain.

EIA (Electronic Industries Association) – EIA provides recognized standards for a wide variety of communications equipment and systems.

ELECTRONIC STETHOSCOPE – A stethoscope which uses an electronic amplifier and microphone to strengthen the sound of the heart on the exterior chest wall. See "STETHOSCOPE."

EMG (Electromyogram) – Measurement of electrical activity associated with muscles.

EQUALIZATION – A means of modifying the frequency response of an amplifier or network, thereby resulting in a more usable band of frequencies.

FEDERAL AVIATION ADMINISTRATION (FAA) – Federal agency responsible for safe aeronautical practices in the U.S.

FACSIMILE – A data compression technique used to send hard copy material over wire or radio circuits which are of smaller bandwidth than the information content of material. Transmission speed is typically 2 to 5 minutes per picture.

FEDERAL COMMUNICATIONS COMMISSION (FCC) – The U.S. Government agency governing all civilian radio and TV radiations in the air and, to some extent, those through wire or cable.

FIDELITY – The degree to which a system, or a portion of a system, accurately reproduces at its output the essential characteristics of the signal that is impressed upon its input.

FREQUENCY – Number of cycles per second or Hertz.

FREQUENCY DIVISION MULTIPLEX (FDM) – Separation of information by use of several separate frequencies within a communications channel.

GIGAHERTZ (GHz) – 1,000 MHz – Microwave frequencies.

HARD COPY – A printed, physical copy of machine output. For example, reports, listings, documents, summaries, pictures.

HEAD-END – In the Cab! -TV industry: the location of facility used in receiving and processing television and radio signals for subsequent transmission by a CATV system to many distant points.

HETERODYNE-REPEATER – In radio transmission, a relay station where the baseband information is not demodulated.

HERTZ (Hz) – 1 cycle per second.

HIS (Health Information System) – the computer-based storage system used by the Indian Health Service.

HUBBING – A commonly used communications term to indicate the routing of communications channels within a network. A network that takes on the appearance of the hub of a wheel with the communication channels configured as the spokes of the wheel.

IHS (Indian Health Service) – The organization within the Public Health Service responsible for the provision of health service to the Indian population.

INTERACTIVE – Terminals or circuits in which the input may be modified by the return of information.

INTERCONNECTION – The electronic system for connecting two or more locations for some type of communications service.

INTERFERENCE – Disturbance in radio reception caused by undesirable signals or stray currents from electrical apparatus, atmospheric static, etc. Also called noise.

INTERMODULATION – A form of distortion where two modulated or unmodulated carriers produce beats according to the frequency relationship $f = nf_1 \pm mf_2$, where n and m are whole numbers. Intermodulation is caused by second and higher order curvature.

IRAC (Interagency Radio Advisory Committee) – The Government organization charged with the responsibility of frequency coordination for authorized users of Federal frequencies.

IRIG (Inter Range Information Group) – An accepted standard regarding telemetry transmission.

KILOHERTZ (kHz) – 1,000 cycles per second.

LIVE – Studio or on-the-spot televising of events and people, in contrast to the transmission of recorded material, such as film or video tape.

LOOP-THROUGH – Term used to indicate series wiring of communication facilities.

MEGAHERTZ (MHz) – One million cycles: when used as a unit of frequency, it is equal to one million cycles per second.

MICROWAVE – Radio waves above UHF frequencies, generally 1,000 to 15,000 MHz. Because of their shortwave length, they begin to behave as visible light.

MICROWAVE RELAYS – Systems used for transmission of video and audio signals by highly directional radio beams at frequencies between 1,000 and 15,000 MHz. Distances of typically 30 miles may be covered by a single link consisting of a transmitter and receiver; longer distances may be covered by multiple links receiving and transmitting the original signal.

MODULATION – The process of impressing audio or video information on the carrier wave (one specific frequency) for transmission through the air or through cable.

MONITOR – To control the picture shading and other factors involved in the transmission of both a scene and the accompanying sound. Monitoring usually occurs in the studio control room and at the transmitter. Also denotes a special type of high-quality receiver or audio system.

MULTIPLEX – A general term for the techniques whereby two or more signals are carried on a single communications channel (wire, radio or other carrier medium).

NETWORK (as, the network) – The Arizona TeleMedicine Network.

NOISE FIGURE – A measure of the noisiness of an amplifier. Noise factor is defined as input signal-to-noise ratio to output signal-to-noise ratio. Noise figure is noise factor expressed in dB. The lowest possible value for a matched system is 3 dB.

PHS – Public Health Service, Department of Health, Education and Welfare.

PLUMBICON – A type of television camera pickup tube, also known as the lead-oxide vidicon. This type is most commonly used in more expensive, professional television cameras, especially in color units.

RF (Radio-Frequencies) – Usually used to distinguish between television channel allocation ult, frequencies and base-band video frequencies.

RECEIVER – An electronic device used to recover a transmitted signal and demodulate it.

RELAY STATION – A station used to receive picture and sound signals from a preceding station and to transmit them to another relay station or to a television broadcast transmitter.

REPEATER – A device for receiving, amplifying and retransmitting a signal.

SIGNAL – Information transposed into electrical impulses. Two basic signals are involved in television transmission – the picture or video signal and the sound or audio signal. Each signal contains electrical impulses representing the elements transmitted.

SIGNAL-TO-NOISE (S/N) RATIO – The ratio of desired to undesired electronic information usually expressed in decibels (dB).

SLOW-SCAN TELEVISION – Television systems capable of producing still pictures at a reduced frame rate. Bandwidth requirement for this still picture medium is much less than standard television.

SPECTRUM – A range of frequencies of interest, or the information content of a signal expressed in frequencies.

SECAM (Sequential with Memory) – A form of compatible color television whereby the color information is carried on an FM subcarrier near the upper limit of the television channel. The standard used in France.

SECAM-60 – The form of SECAM adapted to the usual United States television scanning pattern of 525 lines, 60 fields, 30 frames.

SPIROMETER – A device used to measure orally the inspired or expired air. The output is indicative of lung function.

TARIFF – A schedule of services and rates files by common carriers with regulatory bodies.

TELECO (TELCO) – A commonly used contraction referring to a telephone company and its facilities.

TELEMETRY – The process of conveying signals from one location to another. May use radio links, wire, cable or other transmission mediums.

TELEVISION – The radio or electrical transmission of a succession of images and their reception in such a manner as to give a substantially continuous and simultaneous reproduction of an object or scene before the eyes a distant observer.

TELEVISION CHANNEL – A band of frequencies 6 megacycles wide in which are contained all of the frequency components of a television broadcast signal (picture and sound).

TELEVISION TAPE RECORDER – An electromechanical device for storing television program material on a magnetic tape.

TERMINAL – (1) A point at which information can enter or leave a communication network, and (2) an input/output device designed to receive or send source data in an environment associated with the job to be performed and capable of transmitting entries to and obtaining output from the system of which it is a part.

TRANSMITTER – The electronic device with sufficient energy to convey a signal through a transmission medium.

STETHOSCOPE – A mechanical device used to amplify the sounds on the chest wall produced by the heart.

VCO (Voltage Controlled Oscillator) – A type of device in which the frequency of the carrier wave is changed according to the varying voltage of the input signal.

VIDEO – Of or concerning sight. Specifically, those electrical currents representing the elements of a television picture.

VIDEO SIGNAL – The frequencies generated by the scanning of a scene or image plus the synchronizing pulses involved.

VIDEO TAPE – A magentic tape for recording television signals.

VIDEO TAPE RECORDER (VTR) – Originally a proprietary name of the Ampex Corporation for a television tape recorder. Currently a common generic term for the technique.

VHF (Very High Frequency) – Normally between 30 to 300 MHz.

VOICE GRADE CHANNEL (Voice Circuit) – A channel suitable for transmission of speech, digital or analog data, or facsimile, generally with a frequency range of about 300 to 3,000 cycles per second (hertz). A "voice slot."

VSWR (Voltage Standing Wave Radio) – Reflections prese· ᵗ in a communications cable, wire or waveguide due to mismatch (faulty termination) combine with the original signal to produce voltage peaks and dips by addition and subtraction. The ratio of the peak-to-dip voltage is termed VSWR. A perfect match with zero reflections produces a VSWR of 1. For freedom from ghosting, most matches in a CATV system must have a VSWR of 1.25 or less.

WAVEGUIDE – The transmission path between microwave antennas and transmitters and/or receivers. Similar to coaxial cable, but does not require a center conductor.

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