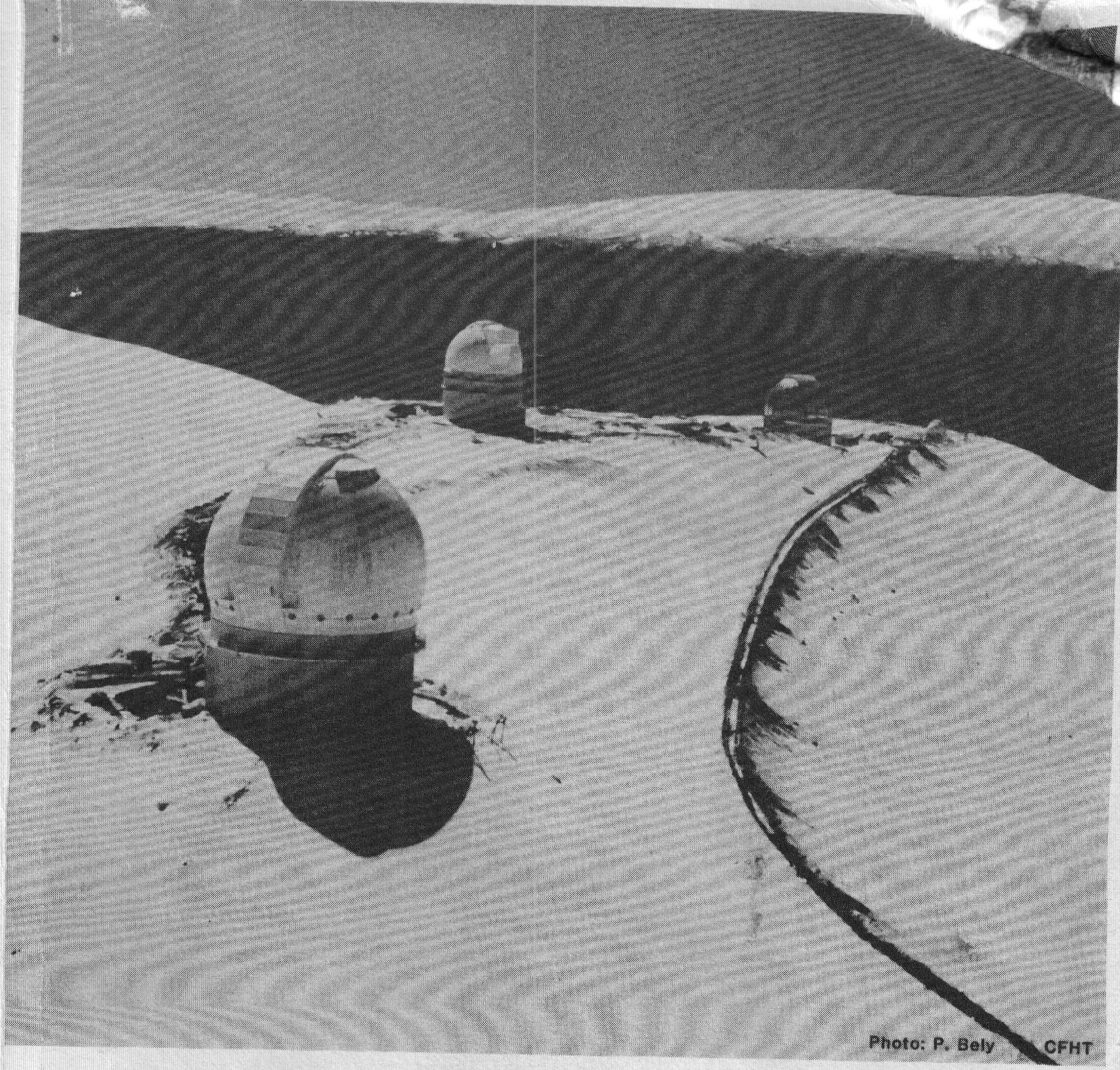


EX- F30

Mauna Kea Science Reserve
Complex Development Plan

AMENDMENT (March 1989)

to the

MAUNA KEA SCIENCE RESERVE COMPLEX DEVELOPMENT PLAN

Mauna Kea, Hamakua, Hawaii

February 1983
(as amended May 1987)

Make the following changes to the Mauna Kea Science Reserve Complex Development Plan, dated February 1983 (as amended May 1987):

1. On all pages (i.e., 7, 11, 13, 41) where there are references to "thirteen [13] telescopes [by the year 2000]" add new wording "...thirteen [13] telescopes and an additional VLBA antenna".

2. Page 13:

   a. paragraph 2, line 1: change "...four..." to "...five..."

   b. paragraph 2, line 2: change "...(A, B, C and D, Figure 3)." to "...(A, B, C, D and E, Figure 3)."

3. Page 14 (Figure 3): replace existing map with new map adding "Area E" location.

4. Page 15:

   a. after Area D description: add new heading and descriptive paragraph, as follows:

   "Area E

   Area E is a two acre area, below the summit, whose boundary (elevation between 12,200- and 12,400-feet) is approximately 2,600-feet northeast of the Mauna Kea Observatory Access Road, and which includes a 40-foot Right-of-Way to the premises from the road. It is the best location on Mauna Kea to provide the highest-quality radio images of astronomical objects, and for the Very Long Baseline Array (VLBA) to be erected and operated. The VLBA will be the tenth and westernmost antenna of the array in the United States."

b. <u>last paragraph</u>: delete the following sections:

"o An additional microwave dish in order to enable data to be transmitted from the Mauna Kea summit to Hilo and beyond at data rates in excess of 20 kilobits per second."

"o A possible satellite communication dish, not visible from areas outside of the Science Reserve, that may be constructed in the 1990s."

5. Page 58 (Figure 13): the 5 additional archeological sites in the new Area E are herewith incorporated into the **Mauna Kea Science Reserve Complex Development Plan** and the Master Plan, and will be placed on the master map which is housed at the Institute for Astronomy.

6. Page 68:

<u>paragraph 1, line 2</u>: change "...domed telescope facilities," to read "...domed telescope facilities and an additional VLBA antenna,"

7. Page 82: after the last paragraph, add a new heading and descriptive paragraph, as follows:

"<u>Area E</u>

Area E is a two acre area, below the summit, whose boundary (elevation between 12,200- and 12,400-feet) is approximately 2,600-feet northeast of the Mauna Kea Observatory Access Road, and which includes a 40-foot Right-of-Way to the premises from the road. It is the best location on Mauna Kea to provide the highest-quality radio images of astronomical objects, and for the Very Long Baseline Array (VLBA) to be erected and operated. The VLBA will be the tenth and westernmost antenna of the array in the United States."

8. Page 83:

a. <u>paragraph 1, line 2</u>: change "...(A, B, C and D)." to "...(A, B, C, D and E).".

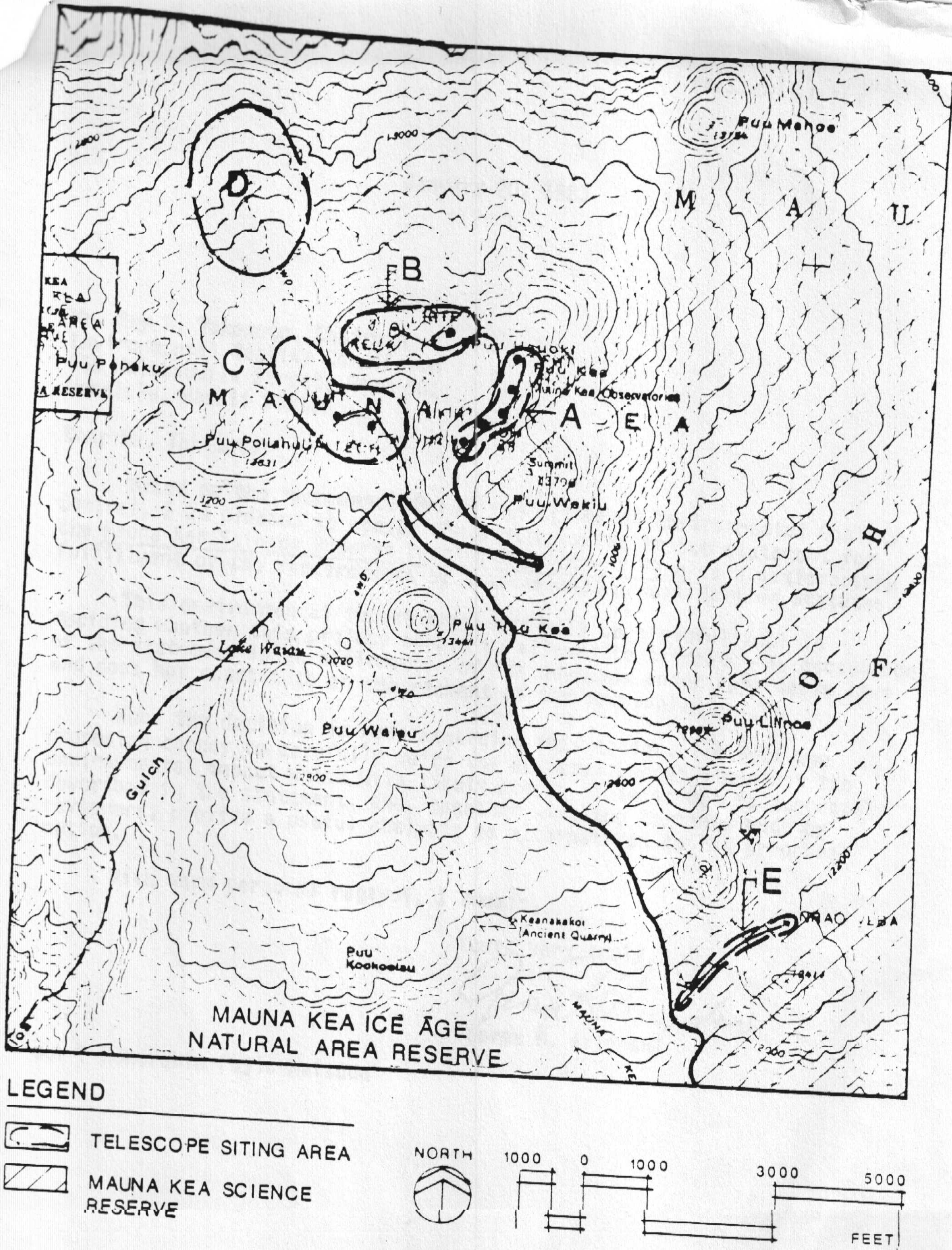
b. <u>paragraph 2, lines 7-8</u>: after "...thirteen (11 major and two smaller facilities)..." add new wording "and an additional VLBA antenna,"

AMENDMENT TO MAUNA KEA SCIENCE RESERVE COMPLEX DEVELOPMENT PLAN

9. Pages 86-87: under "Communications Facilities:" delete the sections "Microwave Link" and "Satellite Communications Dish", and add the following new section after "Fiber Optics":

   "Transmitters

   No transmitters of any kind will be allowed within the Science Reserve in the future). Those operating there now will be removed as soon as suitable alternative locations are found." (For reference, see last sentence of the "Transmitters/Receivers" section on page 40.)



TELESCOPE SITING AREAS

MAUNA KEA SCIENCE RESERVE CDP

FIG. 3 (REVISED)

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UNIVERSITY OF HAWAII
PRESIDENT'S OFFICE

January 20, 1983

Mr. Roy R. Takemoto, Chairman
Environmental Quality Commission
550 Halekauwila Street, Room 301
Honolulu, Hawaii 96813

Dear Mr. Takemoto:

Based on the recommendation of the Office of Environmental Quality Control, I am pleased to accept the environmental impact statement for the Mauna Kea Science Reserve Complex Development Plan as a satisfactory fulfillment of the requirements of Chapter 343, Hawaii Revised Statutes.

This environmental impact statement will be a useful tool in deciding whether this project should be allowed to proceed. My acceptance of the statement is an affirmation of its adequacy under applicable laws and does not constitute an endorsement of the proposal.

When the decision is made regarding this action, I expect the proposing agency to carefully weigh the societal benefits against the environmental impact which will likely occur. This impact is adequately described in the statement, and, together with the comments made by reviewers, provide a useful analysis of alternatives to the proposed action.

With warm personal regards, I remain,

Yours very truly,

George R. Ariyoshi

George R. Ariyoshi

cc: Honorable Fujio Matsuda

Sierra Club

Nelson Ho Photography
P.O. Box 590
Mt. View, Hawaii 96771

968-6278

Mauna Kea Science Reserve

Complex Development Plan

Mauna Kea, Hamakua, Hawaii **February 1983**

Amended May 1987

what was amended
what is new 87
material?

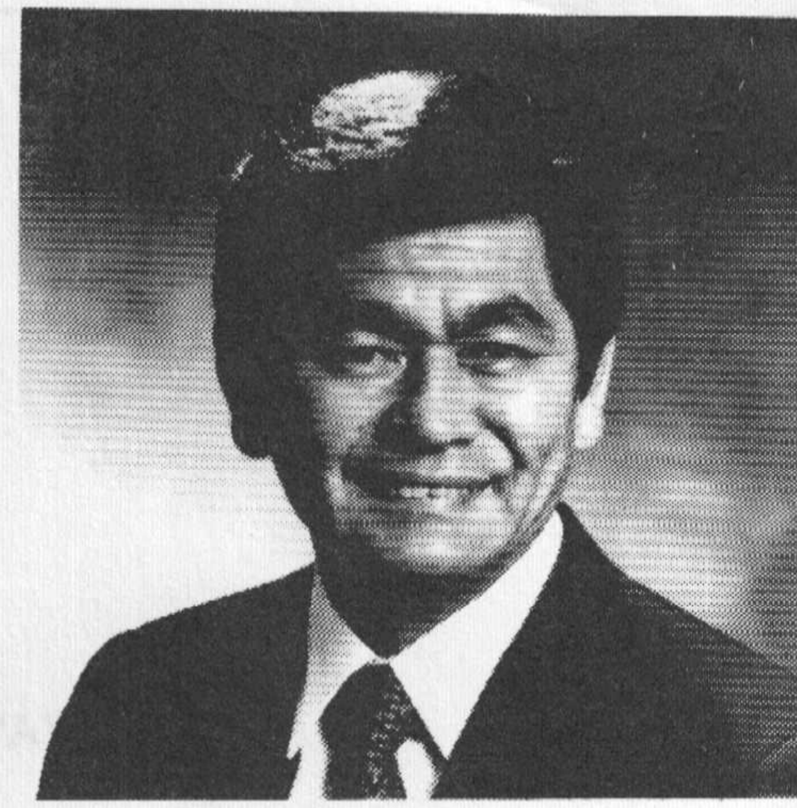
Prepared for:

Research Corporation of the University of Hawaii

Prepared by:

Group 70

Amended to include the final Management Plan, prepared by the University of Hawaii Institute for Astronomy in cooperation with the Department of Land and Natural Resources, and accepted by the Board of Land and Natural Resources, February 1985.



EXECUTIVE CHAMBERS

HONOLULU

GEORGE R. ARIYOSHI
GOVERNOR

MESSAGE FROM GOVERNOR GEORGE R. ARIYOSHI

I am happy to celebrate with all who played such vital roles in the Mauna Kea Master Plan.

It is from Mauna Kea that we will search the universe for its mysteries and answers. Mauna Kea represents, at one time, mankind's future and past, and both will be well served by this venture.

Mauna Kea's great importance to international science places a responsibility on Hawaii to see that this asset is carefully preserved, while continuing to ensure that its historic role in the lives of our people remains secure. The Mauna Kea Master Plan provides an excellent basis for charting our course to the year 2000, and I welcome its publication. I look forward to the continuing responsible use of Mauna Kea for studies in astronomy, and take pride in the University of Hawaii's leadership in this area and the fact that our state government has and will continue to play a fundamental part in supporting the growth of this exciting science in our islands.

George R. Ariyoshi

HERBERT T. MATAYOSHI
MAYOR

Office of the Mayor

MESSAGE FROM MAYOR HERBERT T. MATAYOSHI

1983

I have long advocated that future developments on Mauna Kea be based on a comprehensive master plan and am pleased that the Mauna Kea Science Reserve Complex Development Plan is consistent with this approach. A plan of this type will significantly enhance the development of a major scientific research and technology effort within our community with benefits throughout the entire County. I believe the Plan will provide a sound, acceptable basis for continuing the development of astronomy activities on Mauna Kea; at the same time, it allows for responsible development, sensitive to impacts on the environment and desires of the people.

HERBERT T. MATAYOSHI
MAYOR
COUNTY OF HAWAII

ACKNOWLEDGEMENTS

While it is difficult to give full recognition to all who contributed to this plan, we would like to express special appreciation to Dr. John Jefferies, Director, Institute for Astronomy; Mr. Harold Masumoto, UH Vice-President for Administration; and Ms. Ginger Plasch of the UH Institute for Astronomy for their efforts throughout the planning process. In addition, we would like to express our appreciation to: Mr. Louis Lopez, Research Corporation of the University of Hawaii; Ms. Mae Nishioka and Mr. George Naito of the UH Facilities Planning Office; Mr. Tom Krieger of the Mauna Kea Support Services; Dr. Terry Lee of the United Kingdom Infrared Telescope Unit; and, Mr. Joseph Calmes and Ms. Theresa Yuen of the University of California for their continued assistance and support. We would also like to recognize the important contributions of many Island of Hawaii community groups and individuals, too numerous to mention here. These people are listed in Appendix A.

Sub-consultants who assisted with this plan and its accompanying EIS are Dames & Moore, geological and soils; Sam O. Hirota, Inc. civil engineering and computer analysis; Daly & Associates, economic factors; David Rae, social impact; and the Bishop Museum who surveyed the archaeological, botanical, and biological resources of the Science Reserve. The analysis of the proposed power line was accomplished with the assistance of the Department of Accounting and General Services and its consultant, Nakamura, Kawabata & Associates, Inc.

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PART I:

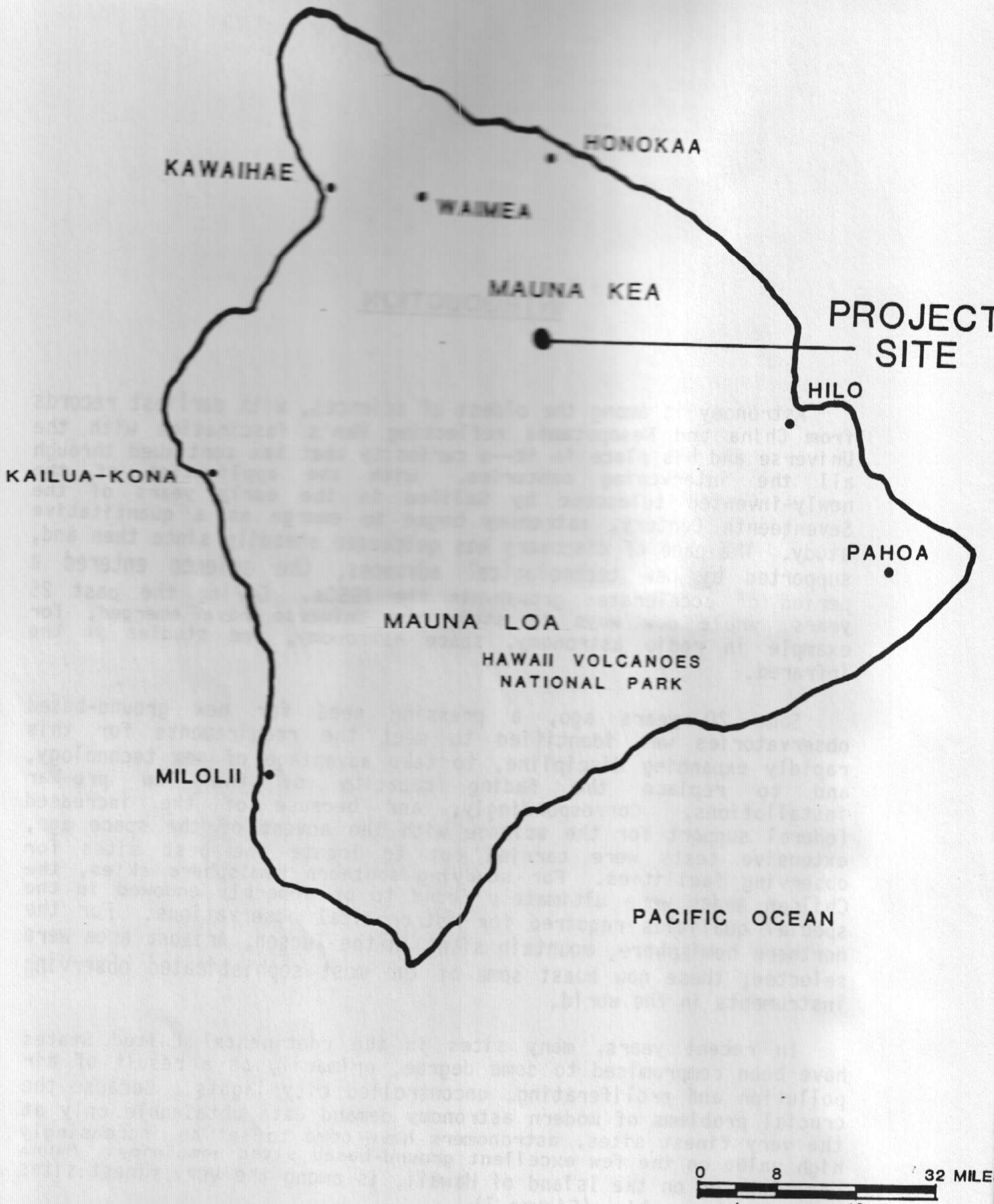
INTRODUCTION AND SUMMARY

INTRODUCTION

Astronomy is among the oldest of sciences, with earliest records from China and Mesopotamia reflecting Man's fascination with the Universe and his place in it--a curiosity that has continued through all the intervening centuries. With the application of the newly-invented telescope by Galileo in the early years of the Seventeenth Century, astronomy began to emerge as a quantitative study. The pace of discovery has quickened steadily since then and, supported by new technological advances, the science entered a period of accelerated growth in the 1950s. During the past 25 years, whole new ways to study the Universe have emerged, for example in radio astronomy, space astronomy, and studies in the infrared.

Some 20 years ago, a pressing need for new ground-based observatories was identified to meet the requirements for this rapidly expanding discipline, to take advantage of new technology, and to replace the fading capacity of the few pre-War installations. Correspondingly, and because of the increased federal support for the science with the advent of the space age, extensive tests were carried out to locate the best sites for observing facilities. For studying southern hemisphere skies, the Chilean Andes were ultimately found to be superbly endowed in the special qualities required for astronomical observations. For the northern hemisphere, mountain sites in the Tucson, Arizona area were selected; these now boast some of the most sophisticated observing instruments in the world.

In recent years, many sites in the continental United States have been compromised to some degree, primarily as a result of air pollution and proliferating, uncontrolled city lights. Because the crucial problems of modern astronomy demand data obtainable only at the very finest sites, astronomers have come to set an increasingly high value on the few excellent ground-based sites remaining. Mauna Kea, located on the Island of Hawaii, is among the very finest sites known in the world. (Figure 1).



LOCATION MAP

MAUNA KEA SCIENCE RESERVE CDP — FIG. 1

Mauna Kea's excellent qualities for astronomical observation derive from its high altitude (13,796 feet), atmospheric dryness, and minimal seasonal variation. In addition, its isolated location on an island in the Pacific; its tropical latitude which insures minimum cloud cover; the high altitude (45°) at which the galactic center transits; and the large fraction of total sky-availability make it one of the best sites in the world for ground-based astronomy. The local availability of support technicians and related personnel and the relatively flat terrain which facilitates construction of the telescope facilities also contribute to Mauna Kea's attractiveness as a major international astronomical site.

In recognition of the unique qualities of the Mauna Kea summit area for astronomical research, the Board of Land and Natural Resources (BLNR) approved a 65-year lease (beginning January 1, 1968) with the University of Hawaii (UH) for all lands above the 12,000 foot elevation on Mauna Kea. The lease refers to these lands as the Mauna Kea Science Reserve. The Reserve was established as "a scientific complex, including without limitation thereof an observatory, and as a scientific reserve being more specifically a buffer zone to prevent the intrusion of activities inimical to said scientific complex." (General Lease No.S-4191)

Since 1968, the University of Hawaii has been actively advancing mankind's understanding of the physical universe through the operation of an astronomical training and research facility on Mauna Kea. To date, the national and international scientific community has established four major and two smaller telescopes within the mountain's summit area.

Because of the excellence of the site, it is expected that the State will continue to receive requests for permission to locate additional telescopes on Mauna Kea. The importance of the site is recognized in the University's proposed State Higher Education Plan:

> "The University of Hawaii, in cooperation with other institutions and organizations, will develop the Institute for Astronomy and the Mauna Kea Observatory into a pre-eminent international center for observational astronomy."[1]

Public attention was drawn to astronomy development on Mauna Kea when the University of Hawaii began construction of its first telescope in 1967. A conceptual plan for the area was prepared by the University of Hawaii in 1975, however, the public was concerned that astronomy interests might completely take over the mountain. Hunters were concerned that further development might restrict their hunting range; naturalists pointed to the unique eco-systems on the

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slopes and at the summit; and snow play participants, skiers and hikers wanted assurance that their interests would be protected. In response, the Department of Land and Natural Resources (of the State of Hawaii) initiated a comprehensive planning process for Mauna Kea to allay their fears. Since that time, four plans specifically related to guiding and controlling development on Mauna Kea have been prepared:

- the DLNR Mauna Kea Plan, the policy guide for the mountain, which was adopted by the BLNR;
- the 1980 DLNR Hale Pohaku Complex Development Plan;
- the University of Hawaii Research Development Plan for The Mauna Kea Science Reserve and Related Facilities (UH RDP), a programmatic master plan for astronomy development to the year 2000, which was adopted by the UH Board of Regents in January, 1982; and,
- the Complex Development Plan for the Mauna Kea Science Reserve and Related Facilities (SRCDP), the subject of this report.

The general purpose of this fourth plan, the SRCDP, was to develop a physical plan to guide the implementation of all proposed astronomy development within the Mauna Kea Science Reserve and related facilities (as set forth in the UH RDP) to the year 2000, and to present a management plan and implementation strategy for managing and monitoring the various uses of the mountain from Hale Pohaku to the summit.

RELATIONSHIP OF POLICIES AND PLANS FOR MAUNA KEA

1977 DLNR Mauna Kea Plan

In addition to being a superior site for ground-based astronomy, Mauna Kea is also a unique locale for other activities. The seasonally snow-covered slopes above the 10,000-foot elevation are used for skiing and snow play. Hawaiian ecosystems, including rare plants and birds, are found between the 6,000-foot elevation and the summit.

Hunting of pigs and game birds is a traditional use within and on the perimeter of the mamane/naio forest. General recreation, photography, and sightseeing are also becoming popular uses of the mountain. The mountain's unique volcanic and glacial history and its remarkable ecosystems makes it an ideal site for scientific field research.

In the early 1970s it was generally recognized that an overall Manua Kea plan was necessary in order to control development on the mountain and to resolve the conflicting demands of various users who wanted to use the mountain for their activities. Extensive citizen participation in the planning process followed. The main objective of the process was to "determine the compatibility of Mauna Kea's resources to accommodate various uses without unacceptable damage to biotic and other natural values and historic values and the visual appearance of the mountain."[2] The Mauna Kea Plan, a policy framework for the management of Mauna Kea, was adopted by the BLNR on February 11, 1977.

The importance of Mauna Kea for scientific applications and the necessity to justify additional expansion is stated in the 1977 DLNR Plan:

> "Recognize the world-wide significance of Mauna Kea's summit for astronomical research and set a limitation for facilities based on need and environmental concerns."[3]

An observatory needs a broad range of logistical support if it is to operate effectively. Specifically needed are access roads, reliable utilities and communications, base support facilities (or headquarters) and, in the case of Mauna Kea, a mid-level accommodation facility for acclimatization purposes. The 1977 DLNR Mauna Kea Plan contains the following polices on roads and utilities:

"The summit access road from Hale Pohaku shall not be paved but shall have road safety devices...."[4]

"On-site generators shall be used to supply electrical power for the observatories and support facilities on Mauna Kea. Alternatively, underground power lines may be installed. No overhead power lines shall be permitted."[5]

A mid-level accommodation facility at Hale Pohaku was specifically provided for in the 1977 Plan. Design of the mid-level facilities was to be controlled to minimize disturbances to the mamane/naio forest ecosystem. The DLNR Plan sets forth the following policies concerning Hale Pohaku:

"The Hale Pohaku facility will consist of mid-level facilities for necessary research personnel for the summit, a central point for management of the mountain, and a day-use destination point for visitors and primitive overnight camping facilities."[6]

The 1977 DLNR Mauna Kea Plan also recognized that conditions change over time and that a policy plan must remain flexible. Accordingly, it provided for amending the plan when new information becomes available. The Plan states that:

"The foregoing plan is conceptual and based on information now available. As data on biotic resources, impact of use, changes in research programs, and new proposals for other uses and management become available, it will become necessary to review the concepts of land use stated in this plan. Therefore the following are set forth:

1. The Mauna Kea Plan is a policy guide on land use and management adopted by the Board of Land and Natural Resources;
2. The Mauna Kea Plan shall be reviewed by the Board annually. Any proposed amendments shall be in accordance with procedures as adopted by the Board. Such procedures shall be adopted by the Board within thirty days after adoption of the Master Plan at a public hearing on the Island of Hawaii;
3. Land use and management proposals not included in but consistent with the Mauna Kea Plan may be reviewed by the Board at a regular meeting to be held on the Island of Hawaii; and,
4. Public hearings on the Island of Hawaii shall be held in the review of proposed amendments of the Mauna Kea Plan when deemed in the public interest by the Board."[7]

Hale Pohaku Complex Development Plan

In accordance with the requirements of the 1977 DLNR Mauna Kea Plan, the Hale Pohaku Complex Development Plan (CDP) was prepared in 1980. Although not officially adopted by the BLNR, the Plan served as the guide in the design and construction of the astronomy mid-level facilities and the Information Station.

The UH Institute for Astronomy mid-level facilities were planned to serve the needs of the six telescopes which were operating at the summit in 1980. As part of the recreation and management facilities called for in the 1977 DLNR Mauna Kea Plan, a 1200-square foot information/interpretive station was also constructed by the UH. Visitor parking is provided near the Information Station.

The Hale Pohaku CDP also allocated space for development of picnic areas, an arboretum, and primitive overnight campsites. To date, no construction plans have been developed for the picnic are for the camp sites; however, the DLNR Forestry Division is in the process of developing an arboretum in the area designated in the plan.

Future expansion of the mid-level facility was addressed in the 1980 CDP. The CDP states that. . . "space designated for future expansion is located within the existing disturbed site where adverse effects to the environment will be minimal. Because the designated location is very general, it will be necessary to conduct a site survey when development becomes necessary. All requirements and controls which are stated in this Plan for the programmed facilities should also be followed in any expansion program."8

UH Research Development Plan for Mauna Kea Science Reserve and Related Facilities

The Research Development Plan (UH RDP), which was approved by the UH Board of Regents in January 1982, serves as the programmatic master plan for the continued development of the Mauna Kea Science Reserve. Actions proposed in the plan include: (1) A total of 13 telescopes on the mountain by the year 2000 (including the existing four major and two minor facilities); (2) provision of commercial power from the public utility (HELCO); (3) improvements to and paving of the access road from Hale Pohaku to the summit; (4) expansion of the mid-level facilities at Hale Pohaku; and, (5) possible expansion of the visitor Information Station. The RDP also addresses the procedures by which the University will review and assess applications for new facilities on Mauna Kea and the types of agreements which will be required of all new users of the summit area.

natat the expense of the envir & cultural resources!

The basic goal of the UH RDP is to develop the Mauna Kea Science Reserve as a pre-eminent State, national and international resource for astronomical observations in cooperation with other State agencies and constituencies.

To achieve this goal, the basic planning parameters of the RDP are to: preserve and protect the multi-use objectives for Mauna Kea; and, to maximize the benefits to the University, within the context of providing a suitable and attractive environment for prospective users, and formulating a rational process by which selection of the best and most appropriate requests for use of the site will be assured.

The UH RDP was prepared to define planning parameters for the Science Reserve such that detailed CIP plans, environmental impact statements, complex development plans, and administrative and/or Board policies could be developed. These policies include those related to the management of, and contracts relating to, the telescopes and the infrastructure and, evaluation and selection of applications for telescope sites.

Mauna Kea Science Reserve Complex Development Plan

This Mauna Kea Science Reserve Complex Development Plan (SRCDP) was prepared to provide the physical planning framework necessary to implement the UH RDP. The primary objective of the SRCDP is to guide and control planned development in order to preserve the scientific, physical and environmental integrity of the mountain. A proposal for managing the mountain's resources and monitoring and controlling visitors to the area is incorporated in the SRCDP as a means to mitigate any potential adverse impacts to the surrounding environment that could result from implementation of the Plan, particularly as regards to improvement of access to the summit area.

This plan is guided by the policies set forth in the 1977 DLNR Mauna Kea Plan (although it does propose amendments to the plan) and the Hale Pohaku CDP. The goals, objectives and needs of each of the user groups and the goals, objectives and priority directions of the Hawaii State Plan, the County of Hawaii General Plan, and the State Higher Education Interim Guidelines were considered in the planning process.

The overall objectives of the SRCDP are to:

o Study Mauna Kea's summit for expanded astronomical research based on a planning goal for facilities to the year 2000 established in the UH RDP; and, determine appropriate areas at the summit, Hale Pohaku, and other areas of Mauna Kea that can accommodate the planned development without unacceptable damage to biotic values, scientific attributes, archaeological resources, and the visual appearance of the mountain;

- Evaluate infrastructure requirements and identify environmentally suitable locations and alignments for Hale Pohaku expansion, roads and powerlines;

- Establish a physical plan, within the constraints established in the first two objectives for use of the Mauna Kea Science Reserve and related facilities based on the activities outlined in the 1977 DLNR Mauna Kea Plan, UH RDP, and the Hale Pohaku CDP; and,

- Prepare a plan for managing and monitoring increased usage of the upper slopes of Mauna Kea that may occur as a result of the actions proposed in the SRCDP.

The SRCDP consists of two documents: "The Complex Development Plan" (CDP) and the "Environmental Impact Statement" (EIS). The CDP describes the considerations which led to the siting, organization, and general physical characteristics of future facilities; presents programmatic information pertinent to actual development of the area; specifies the design and environmental criteria which should be followed when implementing the development program; and presents a strategy for managing and monitoring the various uses of the mountain. The EIS describes the elements of the CDP; evaluates alternatives to each action; assesses the possible environmental impacts of implementing the actions proposed in the SRCDP; and describes mitigating actions for potential adverse impacts. Criteria and constraints that evolved from the planning and EIS process were incorporated into the CDP.

STUDY PROCEDURES

Development of the SRCDP involved extensive interaction with the client and users. In addition, representatives of the DLNR divisions were contacted for their input on matters which directly affected their particular areas of concern. Among the DLNR divisions contacted and kept informed of the progress of this planning process were:

Chairman, Board of Land and Natural Resources;
Division of Forestry and Wildlife;
Division of Water and Land Development;
Land Management;
Division of State Parks, Outdoor Recreation, and Historic Sites;
Division of Conservation and Resources Enforcement; and,
The Natural Area Reserves Commission.

In addition to meetings with DLNR and the client groups, the planning process involved coordination with the UH Facilities Planning Office, the Department of Accounting and General Services (D.A.G.S.), and D.A.G.S. consultant for design of the powerline, Nakamura, Kawabata, & Associates, Inc. Officials of the County of Hawaii, members of environmental groups, and potential recreation users of the area were also consulted during preparation of this plan. A meeting to inform the public of the SRCDP planning process and to obtain their input into the plan and EIS was held on September 22, 1982 at the Campus Center of the UH campus in Hilo. Thirty-four persons attended this meeting; twenty-five other persons were invited but did not attend. (Appendix A lists the persons contacted during the planning process.)

An EIS for the SRCDP was prepared; this EIS was accepted by the Governor on January 20, 1983. Concerns expressed in the EIS public review process were incorporated, where appropriate, into the SRCDP.

Each element of the plan required a different planning approach to achieve the desired results. These methodologies are described within the plan.

SUMMARY OF FINDINGS

The proposed physical plan for the Mauna Kea Science Reserve and Related Facilities (SRCDP) to the year 2000 is depicted in Figure 1. A brief description of the findings of the plan follows:

Future Astronomy Facilities Within the Science Reserve (Part III)

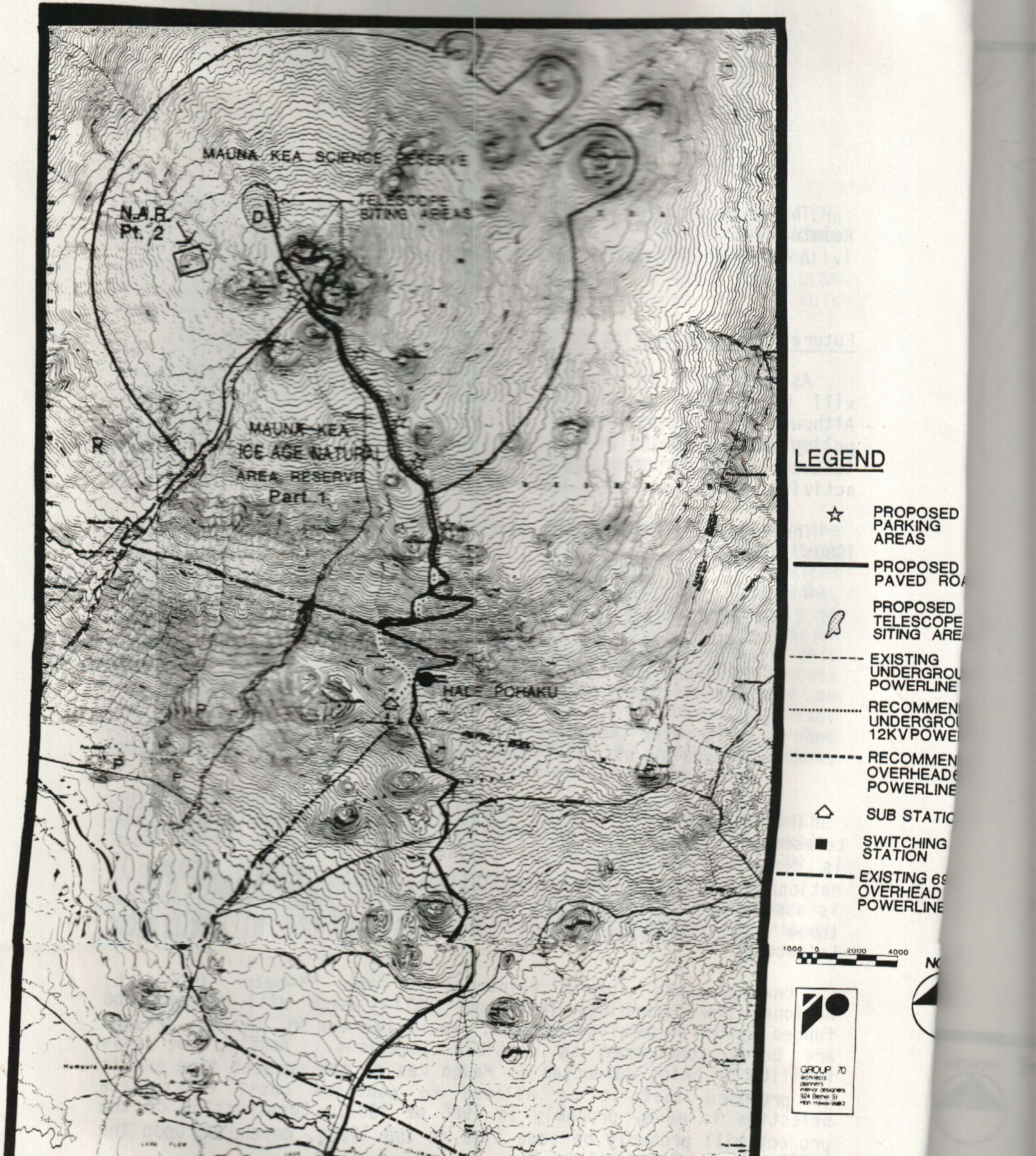
As set forth in the UH RDP, a maximum of thirteen telescopes will be located within the Science Reserve by the year 2000. Although the actual number of telescopes will depend on public policy makers, the University of Hawaii has determined that thirteen telescopes is a reasonable forecast of possible astronomical activity on the mountain between now and the end of the century.

Three new telescopes are proposed for construction during the 1980s. They are:

- The California Institute of Technology (Caltech) 10-meter submillimeter telescope;
- A 15-meter millimeter-wave telescope which is proposed for construction by the Science and Engineering Research Council (SERC) of the United Kingdom (UK/NL MT); and, ? did
- A 10-meter optical/infrared telescope sponsored by the University of California (UC TMT), and proposed to begin construction by mid-1984.

The probable number and characteristics of the additional four telescopes projected in this plan for development beyond the 1980s is derived from analysis of possible telescope demand by both national and international institutions. Based on this demand, it is assumed that requests will be received from four institutions for three major optical/infrared telescopes and one millimeter-wave telescope.

One possible future telescope is the 15-meter (600-inch) National New Technology Telescope (NNTT) which will probably be funded by the federal government. Mauna Kea and Mt. Graham, Arizona are being considered as possible locations. Testing for this facility is being conducted on Mauna Kea at the present time and it is proposed that it be allowed to continue until final site selection is made, probably in 1986 or 1987. Construction of the project will probably be some time in the 1990s, depending upon the availability of federal funding.



MAUNA KEA SCIENCE RESERVE CDP—FIG. 9

Although the SRCDP is based on the assumed mix of telescopes presented in the UH RDP, the plan allows for flexibility in that any combination of optical/infrared and millimeter-wave telescopes is acceptable as long as the total number of telescopes on the mountain does not exceed a total of thirteen telescopes (eleven major and two smaller facilities), by the year 2000.

Future telescopes are to be sited only in the four areas recommended in this plan (A, B, C and D, Figure 3). Testing activities will precede selection of sites within the areas. A description of each area follows:

Area A - Western Rim of Puu Wekiu

Area A is the location of three major telescope facilities (UH 88-inch, UKIRT, and CFHT) and the two 24-inch telescopes. Although essentially developed, the area is a prime site for a future major optical/infrared telescope. When the State receives a request for such a telescope, consideration should be given to moving one of the two smaller telescopes to another location.

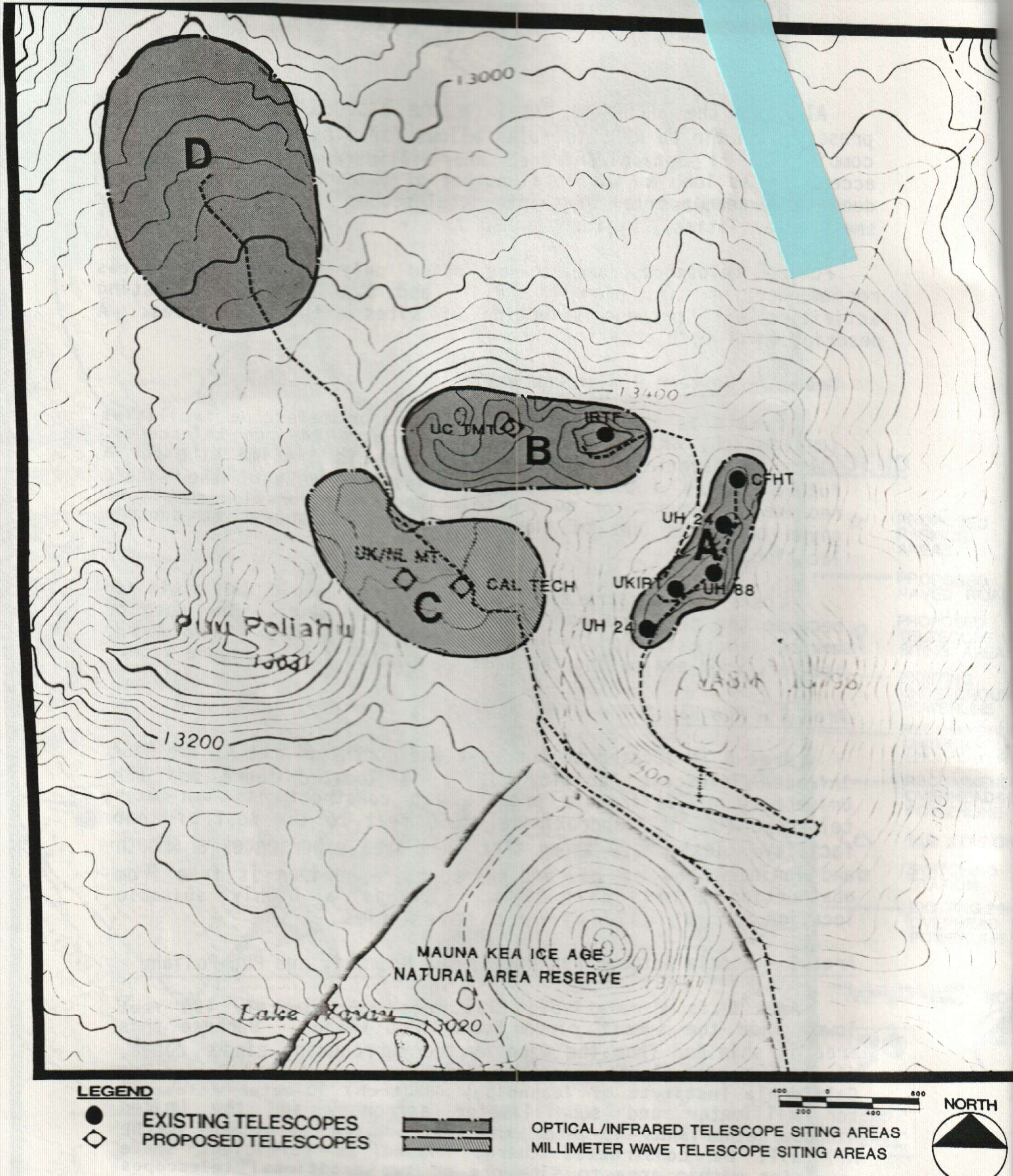
Costs of construction in this area would be minimized because the road and power are already in place. The cost of moving an existing 24-inch telescope must be considered, however, when evaluating the area as a potential telescope site.

Area B - Puu Hau Oki

Area B is located to the west and north of Area A; the NASA Infrared Telescope Facility (IRTF) is located there and the University of California proposes to construct its ten-meter telescope (UC TMT) approximately 850 feet to the west of that facility. Tests have shown that this area experiences a smooth and laminar flow of air and the southern horizon is free from obstruction to less than 12°. It is a highly suitable location for optical/infrared telescopes.

Area C - Saddle Between Puu Wekiu, Puu Hau Oki, and Puu Poliahu

Area C is a relatively flat area approximately 450 feet lower than the summit cinder cone (Puu Wekiu). Because this area is shielded from the wind by the surrounding cinder cones, it is an good location for millimeter-wave telescopes. The California Institute of Technology (Caltech) 10-meter telescope for millimeter and submillimeter astronomy and the United Kingdom/Netherlands 15-meter millimeter wave telescope (UK/NL MT) will be constructed there. There is sufficient space remaining within area to site one or two additional telescopes of this type.



FUTURE TELESCOPE SITING
AREAS TO THE YEAR 2000

Area D - North Shield Area

Area D is an oval-shaped area whose south/southeast boundary (elevation 13,285) is approximately 2000 feet north/northwest of the proposed UK/NL MT site in Area C. Although no telescopes are proposed for construction in the area during the 1980s, it is very suitable for future optical/infrared telescopes. Three to four telescopes can be accommodated on the flatter portions within the area, with some flexibility in choice of sites based on technical site selection criteria such as laminar wind flow and obscuration.

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Multi-Purpose Research Laboratory

In addition to the telescopes described in this plan, a simple multi-purpose research laboratory of approximately 200-to 300-square feet is proposed to be constructed within the Science Reserve. It will be an addition to the existing utility building located between the UKIRT and the UH 88-inch telescopes within Area A. It is planned to be used by local, national and international organizations to conduct research (which does not require the use of a telescope) at the summit on an intermittent basis. The building will be low and single-story; it does not require a dome. It would not be visible from areas outside of the immediate summit area.

Other Astronomy Requirements

The CDP also proposes that the "skiers parking lot" at the 12,700 foot elevation be used for temporary concrete batching activities during the construction phases of the various telescopes proposed in the plan. Because construction activities will take place in months without snow, use of the area for concrete batching will not conflict with use of the area for parking during the winter.

Communications facilities are also included in the plan, these include:

- o An additional microwave dish in order to enable data to be transmitted from the Mauna Kea summit to Hilo and beyond at data rates in excess of 20 kilobits per second;
- o A hardline connection of phone cable or fiber optics to be installed in the same trenches as the utility conduits; and
- o A possible satellite communication dish, not visible from areas outside of the Science Reserve, that may be constructed in the 1990s.

Visitor Facilities within the Science Reserve (Part III)

Because of the severe climatic conditions, the Science Reserve is not planned to be a major recreation area. therefore, visitor facilities at the summit will be limited to parking areas and toilets. Many of the major telescopes, however, will have visitors galleries and will arrange tours to their respective facilities.

A total of five visitor parking areas will be provided along the summit access road and within the summit area. The parking areas will be either paved or have gravel surfaces. Screened areas, containing covered containers for disposal of trash, will be located adjacent to the parking areas. Although an area of approximately 1200 square feet is reserved for possible future construction of a visitor comfort station, no permanent toilet facilities are specifically programmed for development within the 1980s. It is proposed that a concessionnaire be contracted to provide portable chemical toilets during the ski and snowplay season; these toilets should be installed adjacent to the parking areas and they should be removed during the summer months.

Buffer Zone

The unplanned areas of the Science Reserve are designated as a buffer zone to protect installations in the summit area. Recreational uses not requiring facilities are permitted within this buffer zone; hiking and hunting are two such activities.

Hale Pohaku Expansion (Part IV)

The projected increase in the number of telescopes at the summit by the year 2000 will generate the need for approximately 61 to 77 additional sleeping spaces. The area chosen for this expansion is an already disturbed area to the east of the existing UH temporary facilities, at approximately the 9250 foot elevation. Phasing of the expansion will be coordinated with the construction of specific telescope projects. All of the ground area allocated for future dormitories may not be needed; actual needs will be determined by each proposing agency when it applies for permission to locate its telescope on Mauna Kea. New buildings will be designed to be consistent with the permanent mid-level facility. Dining, recreation and maintenance facilities will be shared with the existing users.

Because Hale Pohaku is located within the critical habitat of the Palila, an endangered species, conservation measures recommended by the U.S. Fish & Wildlife Service will be undertaken in conjunction with new construction.

Usage of the Information Station and adjacent parking area will be monitored. Expansion of astronomy facilities at the summit and paving of the access road may create demands for additional facilities within the Information Station or for additional parking spaces. The plan identifies areas for expansion of the Information Station and for future parking.

The SRCDP also recommends that a gate be installed across the summit access road above the Information Station. This gate should be open during daylight hours. It should be closed at night and when weather conditions make travel upslope hazardous. (The Management Plan discusses control functions of the gate).

Power to the Summit and Hale Pohaku (Part V)

The recommended power transmission and electrical distribution system consists of an overhead 69 KV line from a switching station, located adjacent to the existing HELCO 69 KV line near the Saddle Road, to a distribution substation in the vicinity of Hale Pohaku. From there a 12.47 KV distribution system will be constructed underground to the 13,040-foot elevation at the summit.

The overhead segment of the system is proposed to run northwest of and parallel to the border of the Hamakua/North Hilo district boundary on State land within the Forest Reserve. Existing jeep trails will be used for construction and maintenance wherever possible to avoid new road construction. The approximate length of this corridor is 3.8 miles. An amendment to the Mauna Kea Plan will be required to construct powerlines overhead.

The distribution substation is planned to be located in the saddle between Puu Kalepeamoa and the hill just north of it. The substation will be sited so that it is not visible from the Mauna Kea Observatory Access Road. Access to the substation will be via an existing jeep trail.

The underground 12.47 KV electrical distribution system will run from the distribution substation to the summit along the existing road and the old Humuula Trail. Conduits for future hard-line communications will be installed with the utility cables. Extensions of the proposed system to planned and future telescopes will be constructed by the individual telescope sponsoring agencies.

Summit Access Road Improvements (Part VI)

The SRCDP recommends that the road to the summit be improved, widened to fifteen or twenty-feet, and paved for safety, maintenance, and environmental reasons; necessitating an amendment to the Mauna Kea Plan. The existing road is dusty, rough and dangerous, and safety features are lacking. There are no shoulders or gutters and there are no drainage culverts on the upper sections. The road is steep in places with grades in excess of 15 percent. Dust from the road not only interferes with astronomical observations but also is detrimental to resident flora and fauna.

Roadway improvements could include construction of a new road-bed, gutters and culverts for drainage, guard rails and signs for safety, and retaining walls for embankment stabilization. It appears that an improved road could basically follow the present alignment, except for short sections where a new alignment may have to be adopted to reduce grades to less than 15 percent.

Road improvements are only in the planning phase; a design consultant is to be retained by the State's Department of Transportation. Precise alignments, grading requirements, and details of the actual construction will be specified in greater detail when the road is actually designed. The design consultant will also be asked to assess the feasibility of constructing a new road to the summit ridge, along the slopes of Puu Hau Oki, and obliterating the existing switchback along the summit cinder cone.

<u>Conceptual Management Plan</u> (Part VII)

Because the University of Hawaii is lessee of the Mauna Kea Science Reserve, and thus has been responsible for developing and maintaining the area, the Board of Land and Natural Resources (BLNR), through discussions with staff and contingencies placed on recent CDUA's, has asked that the University also be responsible for managing and monitoring all activities that may affect the Reserve. The University is prepared to accept this responsibility, including the seeking of funds required to support the positions necessary to effectively implement the plan.

The recently completed Information Station at Hale Pohaku will serve as the central point to monitor to the upper regions of Mauna Kea. The Information Station will be manned; it will contain exhibits of the natural and man-made resources of the mountain and provide information about the hazards which could be encountered at higher elevations. A sign located near the entrance to the Station will instruct all visitors to stop and register before proceeding up the mountain.

Until the road is paved, access will be restricted to four-wheel-drive vehicles only. One position will be funded to man the Information Station and the following control measures will be instituted:

- Visitors will be required to register at the Information Station where they will be informed of precautions which must be taken and the rules to be followed when driving upslope; they will be denied access if they are not in a four-wheel-drive vehicle; and,

- Visitors who are elderly, or who appear to be in ill health, or who are not dressed for the climate at higher elevations will be encouraged to terminate their visit at the Information Station.

A gate, which would be installed on the summit access road above the Information Station, will be closed at night and opened in the morning. Hours will be posted outside the Information Station. A sign, setting out the hours that the road above Hale Pohaku is open may also be installed near the intersection of the Saddle Road and the Mauna Kea Observatory Access Road. It would indicate to visitors when the summit road is closed at other than posted times.

After the road is paved, the University is willing to assume responsiblity for monitoring uses of the summit and enforcing regulations. This will initially involve creating one more position for a security person who would patrol the summit area and, assist visitors. As usage increases, additional personnel will be hired.

additional rationale dropped from orig 83 plan

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Page 1
19

The Management Plan is only in the conceptual stage. The final plan will be subject to appropriate agreements among affected State agencies and approval by the UH Board of Regents and the BLNR. Upon approval of the final plan, new regulations will be promulgated in accordance with the State Administrative Procedures Act. Transfer of jurisdiction for management and enforcement functions from the BLNR to the UH may require an amendment to the 1977 DLNR Mauna Kea Plan.

changed from orig 83 plan

Base Support Facilities (Part VIII)

Major new telescopes on the mountain will require base support facilities for activities that do not require summit or mid-level locations. Hilo, Waimea, and Kailua-Kona are all possible locations for these facilities. The UKIRT is presently in the process of constructing an office building on land leased by the University of Hawaii adjacent to the University's Hilo campus. The UK/NL MT and Caltech are also planning to locate their sea-level offices there. CFHT has recently completed construction of their facilities in Waimea. Other new telescopes will locate their base support facilities in the area which best satisfies their needs. The MKSS offices are also located in Hilo.

Required Amendments to the Mauna Kea Plan:

- o Overhead Construction of the Powerline from the Saddle Road to Hale Pohaku - The SRCDP recommends that the powerline go overhead from the Saddle Road to Hale Pohaku. This action will require an amendment to the Mauna Kea Plan. Construction in this corridor, as well as the others that were evaluated, will require consultation with the US Department of Interior, Fish and Wildlife Service, if federal funds are involved.

- o Paving of the Road - Paving of the road will require an amendment to the Mauna Kea Plan.

- o Management Plan - Jurisdiction for management, monitoring and enforcement functions within the areas designated in the Management Plan must be transferred from BLNR to UH through appropriate agreements and new regulations must be developed. This may require an amendment to the Mauna Kea Plan.

PART II:

HISTORICAL DEVELOPMENT AND EXISTING CONDITIONS

HISTORICAL DEVELOPMENT OF THE MAUNA KEA OBSERVATORY

The Early Years to 1970

As early as the turn of the century, astronomer Frank Lowell recognized the superiority of Mauna Kea (Figure 2). He was looking for a site for astronomical observations in the United States, but because of its distance from the mainland, Lowell chose a site in Arizona. Later, in the 1950s, Walter Steiger from the Department of Physics at the University of Hawaii (UH), tested the quality of the sky at Haleakala, on the Island of Maui, and found it to be greatly superior to any other U.S. site tested. Steiger and his colleagues at UH made a proposal to the National Science Foundation (NSF) to establish the Hawaii Institute of Geophysics (HIG) at the University, and NSF responded by awarding funds for buildings and equipment for a broad-based program in solar astronomy, oceanography and geophysics.

In 1963, the late Dr. G.P. Kuiper of the University of Arizona initiated a study of "seeing" conditions on Haleakala for the National Aeronautics & Space Administration (NASA). Haleakala was the first site tested because, at that time, there was essentially no access to the Mauna Kea summit. Because he felt it desirable to also test Mauna Kea, Kuiper persuaded the late Governor John Burns to provide funds to put through a jeep trail to the summit area. Immediately after the completion of this trail, in 1964, Kuiper and his colleagues conducted a limited series of "seeing" tests from Puu Poliahu, a summit area cinder cone. Kuiper concluded, on the basis of his observations, that "The mountaintop is probably the best site in the world - I repeat - in the world, from which to study the moon, the planets, and stars."[11]

In 1964, four scientists (Frank Orrall, Jack Zirker, John T. Jefferies and Marie McCabe) took leaves of absence from other universities to start the UH program of solar physics on Hauakaea. Subsequently, John T. Jefferies and a group from the UH conducted extensive tests of the skies above Mauna Kea on a nightly basis during 1965 and 1966. These tests were part of a program under which the UH had earlier (in mid-1965) contracted with NASA to undertake the design, fabrication, and construction of a 2.24-meter (88-inch) telescope intended for planetary and stellar observations.

Anticipated development of the 88-inch telescope attracted scientific staff and engineering talent to the UH. As a consequence, the Institute for Astronomy was established as a research unit, separate from the H.I.G., in 1969; John Jefferies was appointed its first Director. In 1968 and 1969 two 24-inch telescopes were provided to the UH by the U.S. Air Force and by NASA, to be used by faculty and students in a variety of programs where light-gathering power of a larger telescope is not necessary.

In 1972, after a 6-year worldwide search for the best site, the French National Agency responsible for research in astronomy chose Mauna Kea as the site for their nation's major telescope. In early 1973, agreement was reached between the UH and government agencies in Canada and France to cooperate in a joint venture to construct a 3.6-meter (144-inch) telescope; the Canada-France-Hawaii-Telescope (CFHT). The telescope, which became operational in 1979, serves as the principal instrument for ground-based astronomers in Canada and France; it also plays an important role in the UH research and graduate training program through the University's membership in the CFHT Corporation.

In 1973, in two separate actions, the Federal government (through NASA) and the United Kingdom (UK) applied to the State to construct infrared telescopes. The two infrared telescopes, the NASA-funded Infrared Telescope Facility (IRTF) and the United Kingdom Infrared Telescope (UKIRT), were designed for studies of cooler celestial objects such as planets, and stars in the process of formation. The cost of the IRTF construction and operation was funded entirely by NASA. The University's Institute for Astronomy managed the telescope construction under contract to NASA, and now operates the 3-meter telescope as a nationally-available facility with 25 percent of the observing time being granted to UH astronomers. The UKIRT 3.8-meter telescope is funded entirely by the British government; under the terms of an agreement UH scientists receive 15 percent of the UKIRT observing time. Both facilities began operation in late 1979.

During the 1970s it was recognized that extensive improvements to the primitive infrastructure, including access roads, electrical power, and mid-level accommodations for acclimatization of astronomy personnel who worked on the mountain, were required in order to support the planned astronomy development on Mauna Kea. The original jeep trail to the summit, funded by the late Governor John A. Burns, was realigned in 1975 following 6 years of planning. This realignment reduced some grades and removed bad curves, lengthening the original 6.5 mile road to approximately 8.5 miles. Although an improvement over the original, the road remained dusty, unsafe, and inadequate; the lack of paving contributed to erosion of the mountain slopes near the road.

Power to supply the needs of the UH 88-inch telescope and the two 24-inch telescopes was initially provided by a 150-KW generator located at the site. In 1974, in anticipation of the development of the CFHT, UKIRT, and IRTF facilities, the U.H. requested D.A.G.S. to do preliminary design studies for a high-voltage powerline to connect the summit with the public utility (HELCO) transmission system near the Saddle Road. An alignment and specifications for the line were recommended by D.A.G.S., however, the project was postponed indefinitely because of inability to obtain appropriate funding.

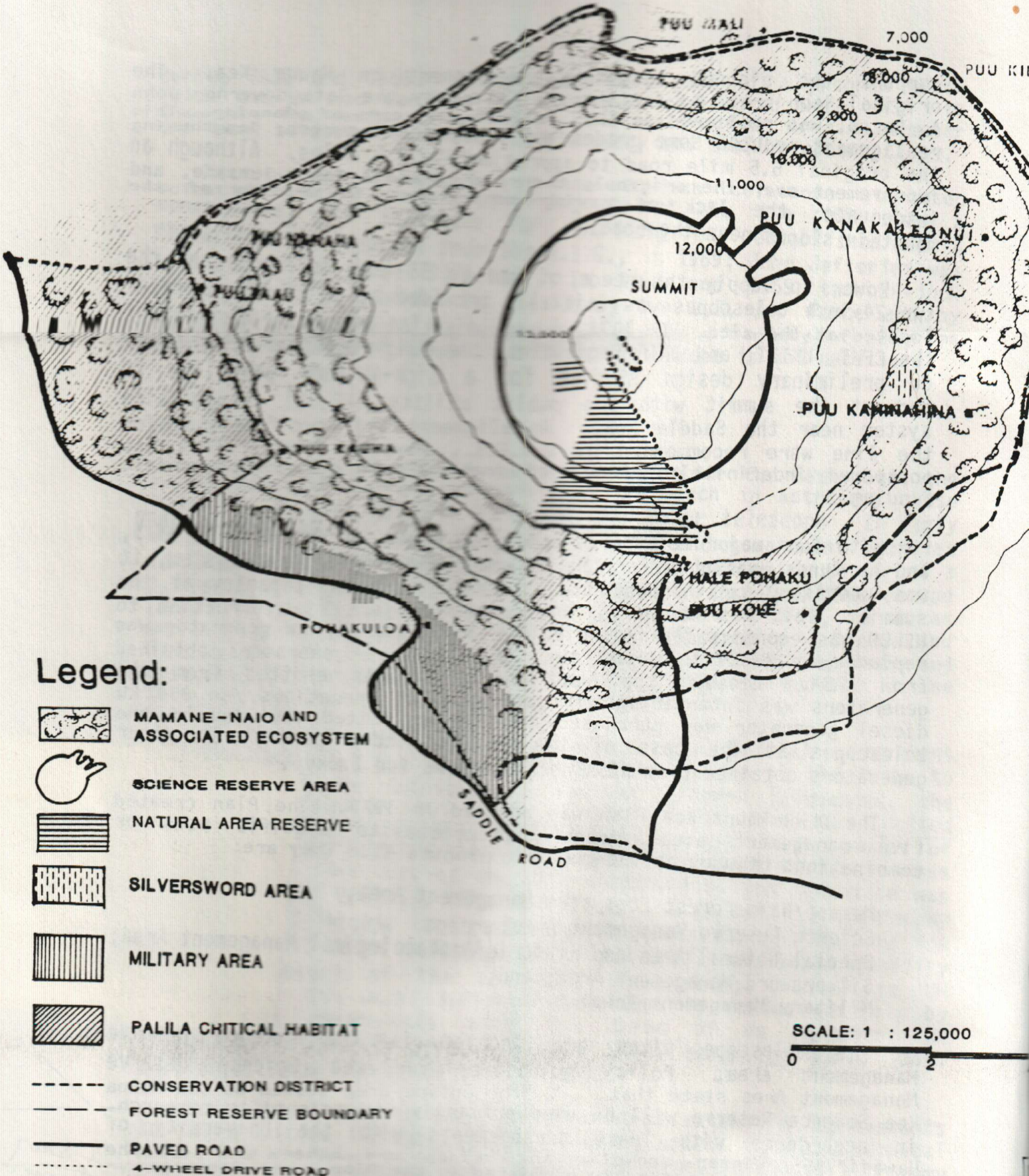
With four major telescopes scheduled to be in operation by 1979, and no funds available for the proposed commercial power system, it was necessary to increase the on-site generating capacity at the summit. This was to be an interim measure until a connection to HELCO was economically feasible. In 1978, the 150-KW generator was replaced by two 250-KW and two 150-KW diesel generators obtained from NASA. Because the heat and pollutants emitted from the generators was interfering with astronomical operations, an 850 KW diesel generator was purchased in 1979 and sited downwind of the telescopes at the base of the summit cinder cones. The four generators obtained from NASA were retained for backup.

The DLNR Mauna Kea Plan was adopted in 1977. The Plan created five management areas, each appropriate to specific uses or combinations of uses on the mountain (Figure 4). They are:

Mamane/Naio Forest Ecosystem Management Area;
Science Reserve Management Area;
Special Natural Area and Historic/Archaeological Management Area;
Silversword Management Area; and,
Military Management Area.

The telescope sites are located in the Science Reserve Management area. Policy guidelines for the Science Reserve Management Area state that. . . "the entire area leased as the Mauna Kea Science Reserve will be used primarily for scientific research, in accordance with lease arrangements with the University of Hawaii".[12] Winter snowplay and skiing are other uses of the Science Reserve specifically permitted in the Plan.

Why not say just astronomical research?



MAUNA KEA PLAN MANAGEMENT AREAS

MAUNA KEA SCIENCE RESERVE CDP — FIG. 4

The 1977 DLNR Plan stated that each new facility proposed for the summit of Mauna Kea should be evaluated and justified based on the following criteria:

"Public benefit to the people of Hawaii, in terms of employment sources, educational pursuit, overall exonomic development, etc.;

Public necessity in terms of cooperative use of facilities and overall advancement of science and research;

Evidence that Mauna Kea is the best site for such facility; and,

Compatibility with other uses of Mauna Kea and within the terms of the lease between the University of Hawaii and the Board of Land and Natural Resources."[13]

The 1977 DLNR Mauna Kea Plan also incorporated restrictions on access road improvements and specified that power lines must either be underground or power must be generated on site. Limitations on the development of mid-level support facilities at Hale Pohaku were also included in the Plan.

Because a mid-level facility is required in order for personnel who work at the summit to remain acclimatized to the high altitude, the UH sought a site to construct such a facility. A temporary construction camp had been erected at Hale Pohaku to house the workers who were constructing the telescopes at the summit. Because of delays in developing a permanent facility, the temporary buildings were remodeled and used as accommodations for astronomers and operating personnel of the telescopes. In 1978, DLNR began the preparation of a master plan for astronomy and recreation facilities at Hale Pohaku. This plan was completed in 1980, allowing design of the permanent facility to begin. The facility is scheduled for occupancy in May 1983.

The 1980s to Date

Since the construction of the six existing telescopes on the mountain, and since the adoption of the 1977 DLNR Mauna Kea Plan, applications have been received from three organizations requesting approval to construct their telescopes on the mountain. The first, California Institute of Technology (Caltech), has prepared and filed an EIS which was accepted by the Governor in August, 1982. They propose to construct a 10.4-meter telescope for millimeter and submillimeter astronomy within the Science Reserve. A Conservation District Use Application (CDUA) for the project was approved by the

BLNR, December 1982. Construction is scheduled to begin in early 1983.

A consortium from the United Kingdom and the Netherlands has begun the process of obtaining approvals to locate a 15-meter millimeter wave telescope (UK/NL MT) on Mauna Kea in the general vicinity of the Caltech site. Their CDUA was approved by the BLNR in February 1983; they propose to begin construction in April 1983.

A third facility, a 10-meter optical/infrared telescope, has been proposed by the University of California (UC TMT). UC is currently completing preliminary negotiations with the UH to begin their approval process. Construction of the UC TMT is proposed to begin in 1984.

DESCRIPTION OF THE REGION

The Island of Hawaii

The Island of Hawaii is the youngest and the largest of the Hawaiian Islands. Commonly referred to as the Big Island, it is composed of five volcanoes. The Big Island has a diverse climate and topography, with environments ranging from dense tropical forests to the snow-covered peaks of Mauna Kea and Mauna Loa. The Island of Hawaii is located approximately 200 miles southeast of Oahu (Figure 5). The State capitol of Hawaii is located on Oahu; the island contains approximately 80 per cent of the State's population.

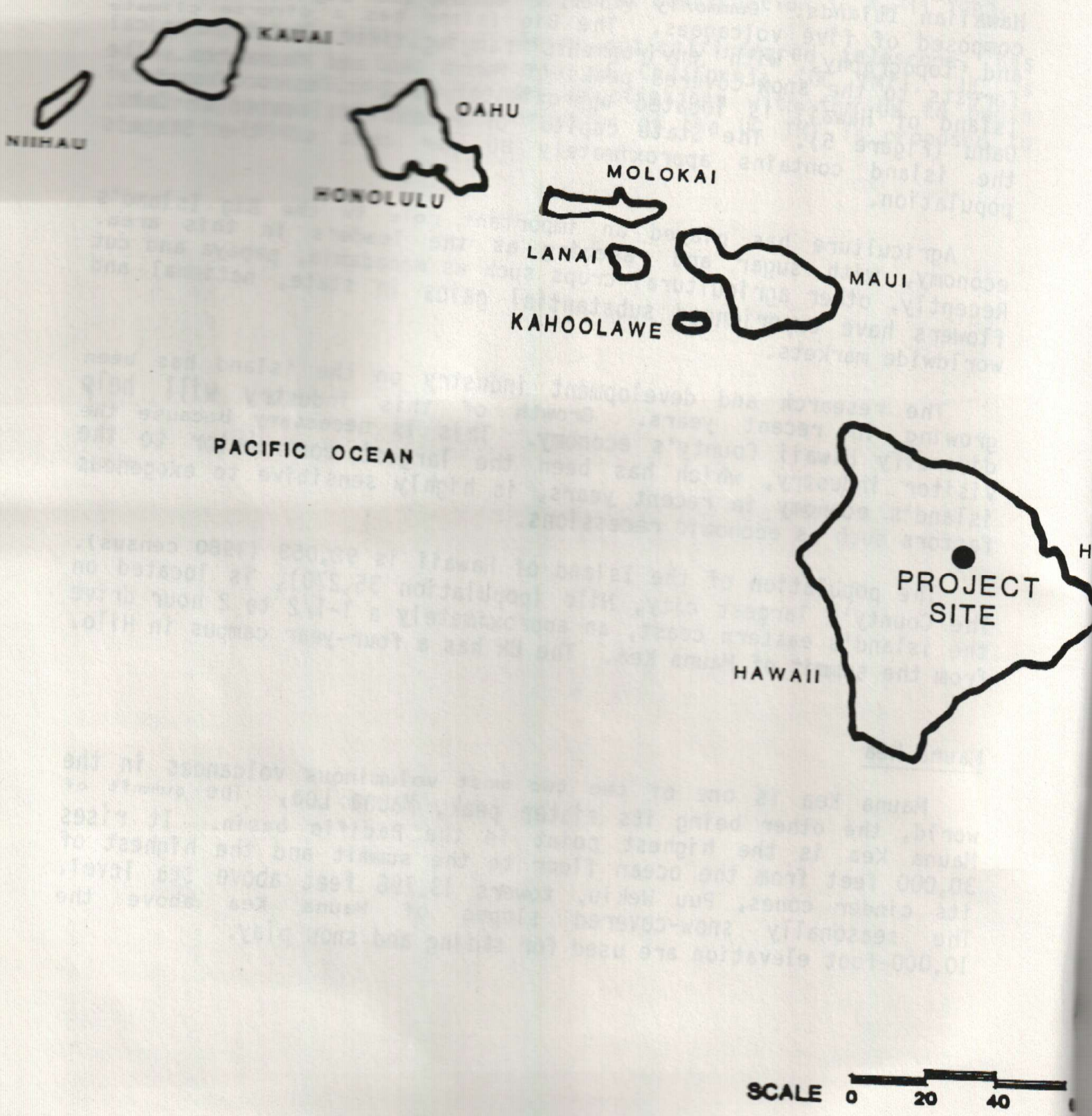
Agriculture has played an important role in the Big Island's economy, with sugar and ranching as the leaders in this area. Recently, other agricultural crops such as macadamia, papaya and cut flowers have experienced substantial gains in state, national and worldwide markets.

The research and development industry on the island has been growing in recent years. Growth of this industry will help diversify Hawaii County's economy. This is necessary because the visitor industry, which has been the largest contributor to the island's economy in recent years, is highly sensitive to exogenous factors such as economic recessions.

The population of the Island of Hawaii is 92,053 (1980 census). The County's largest city, Hilo (population 35,270), is located on the island's eastern coast, an approximately a 1-1/2 to 2 hour drive from the summit of Mauna Kea. The UH has a four-year campus in Hilo.

Mauna Kea

Mauna Kea is one of the two most voluminous volcanoes in the world, the other being its sister peak, Mauna Loa. The summit of Mauna Kea is the highest point in the Pacific basin. It rises 30,000 feet from the ocean floor to the summit and the highest of its cinder cones, Puu Wekiu, towers 13,796 feet above sea level. The seasonally snow-covered slopes of Mauna Kea above the 10,000-foot elevation are used for skiing and snow play.



STATE MAP

MAUNA KEA SCIENCE RESERVE CDP FIG. 5

Since January 1, 1968, the BLNR has leased all lands above the 12,000-foot elevation of Mauna Kea to the UH for 65 years. The lease refers to these lands as the "Mauna Kea Science Reserve". The Reserve was established as. . . "a scientific complex, including without limitation thereof an observatory, and as a scientific reserve being more specifically a buffer zone to prevent the intrusion of activities inimical to said scientific complex." (General Lease No. S-4191). The leased area is basically circular in shape, having a radius of 2.5 miles, and encompasses over 13,000 acres. Not all of the reserve is suitable or appropriate for astronomical use; much of it was intended to serve as a "buffer zone" to protect installations in the summit area.

The mountain's unique natural and historical features make it an ideal site for scientific field research. Endemic, and in some cases, indigenous plants and birds are found on the slopes between the 6,000-foot elevation and the summit. Over 30,000 acres of the mamane/naio forest area of the mountain have been designated as the critical habitat of the rare and endangered Palila, Psittirostra bailleui, (Federal Register, August, 1977). (Figure 4). Hunting of large game mammals and game birds is a traditional use within and on the perimeter of the mamane/naio forest. Hiking, sightseeing and photography are also popular uses of the mountain.

The Pohakuloa Training Area encompasses a small portion of the lower slopes of the mountain below the mamane/naio forest; it is used primarily for military operations in accordance with lease arrangements between the Army and the BLNR.

DESCRIPTION OF THE PHYSICAL CHARACTERISTICS

Geology

Mauna Kea Science Reserve

The rocks of Mauna Kea have evolved to a relatively mature stage. The most recently erupted rocks possess higher alkali and silica contents than the basalts which comprise the main mass of the volcano. Mauna Kea has been dormant for at least 3,500 years, although occasional weak seismicity and the general evolutionary characteristics do not preclude future eruptions. The subaerial portion of Mauna Kea has been dated as at least 315,000 years old (± 50,000 years).

"The lava flows on top of Mauna Kea consist of massive andesite, generally of the variety called Hawaiite. Basically these flows are of the aa type, but the lavas were more viscous than similar flows composed of the basaltic materials that are common throughout the Hawaiian Islands. The flows tend to be on much flatter gradients than the cinder cones and the surface of the flows is typically very uneven. Aa flows are characterized by a core of dense rock overlain and underlain by volcanic clinker. Clinker fragments typically are on the order of 3 inches and are very rough textured. The core is also greatly variable in thickness so that lateral contacts between rock and clinker are frequent."

"The cinder cones are composed of volcanic ash and cinder which have locally been weakly cemented to varying degrees and may be interbedded with other volcanic materials such as splatter, volcanic bombs and other ejecta. Competent rock may exist at depths shallow enough to provide support for deep foundations. The ash and cinder frequently are loosely packed and have low densities. They exhibit low crushing strength and high permeability. Natural angles of repose tend to vary between about 34 and 45 degrees, depending upon the grain size distribution and apparent cementation. The slopes of the cinder cones tend to be somewhat flatter that these inclinations. Permafrost layers may exist within the cinder cones, but if present, are not expected to be encountered by any construction." (Dames & Moore)[14]

Hale Pohaku and Lower Slopes

"Cinder cones and associated tephra layers along the south rift zone of Mauna Kea accumulated during the explosive eruptions of alkalic rocks during the late Quaternary Period . .

"The tephra succession on Mauna Kea includes many distinct layers that were erupted over a considerable span of time from a large number of vents . . . Exposed deposits are thickest and most widely distributed along the road to the Summit between the Humu'ula Sheep Station and Hale Pohaku, through a broad belt east and west of Hale Pohaku, and in a large Kipuka downslope from Puu Oo . . . Puu Hawaihine is one of the most massive cinder cones on the south flank of Mauna Kea and produced a thick and extensive blanket of tehra that is distributed mainly east of the cone (towards Hale Pohaku). It underlies much of the ground surface between Puu Hawaihine and the Hale Pohaku flow and is exposed in most roadcuts and natural outcrops within a 2-KM radius of Hale Pohaku (Porter, 1973)."[15]

Rubbly hawaiite aa flows which crop out mainly along the south and southwest sides of the volcano can be seen between the summit and Hale Pohaku. Below Hale Pohaku, between the mid-level facility and the Saddle Road, the aa flows are locally overlain by tephra; there are also postglacial stream sediments, largely gravelly sand or sandy gravel, with a variable composition that reflects local bedrock.

Hazards

Mauna Kea has progressed to a later stage in its volcanic life cycle, a stage characterized by short and stubby flows, larger and more numerous cinder cones and less frequent eruptions. Based on the infrequency of its eruptions in the recent past, the probability of Mauna Kea erupting in the next several decades is very low. If Mauna Kea does erupt again some time in the future, its eruptions will likely be of the explosive type that produces abundant blocks and ash that covers areas near the eruptive site with large and small fragments.[16]

Mauna Kea, and the entire Island of Hawaii, is located in Earthquake Zone 3 (on a scale of 0 - 3, this is in the zone of highest seismic occurrence and danger). All construction work is subject to provisions of the "Uniform Building Code" which requires that all structures be designed and constructed to meet Zone 3 requirements.

In 1966, Dames & Moore performed a geological/soils investigation of the summit in order to determine whether observatory operations would be feasible there. They concluded that an observatory could operate successfully with a foundation system designed to minimize the magnitude of ground vibrations transmitted to the telescope.[17]

Topography

Mauna Kea Science Reserve

The Mauna Kea Science Reserve includes a number of cinder cones of varying sizes and shapes along the rift zones that descend from the summit. Slopes in the area vary from flat plateaus to close to vertical slopes on the cinder cones. Puu Wekiu, the summit cinder cone, rises several hundred feet above the surrounding lava plateau. Both the inner and outer slopes of this cone average about 28 degrees.

Hale Pohaku and Lower Slopes

Hale Pohaku is located between the 9,200- to 9,300-foot elevation. Slopes west of the development vary from 10 to 15 per cent, while slopes to the east are as steep as 50 per cent. The average slope of the presently developed area is twelve percent.

Climate

Precipitation

Precipitation at the summit averages approximately 15 inches annually, most of which is in the form of freezing fog or snow. Snowfalls are more common during the cooler half-year (October to April); between April and December weather causes only minor interruptions in working schedules. From December through March, snow in the summit area can block the road and cause schedule disruptions. Major snowfalls which have caused blockage of the summit road have occurred in at least seven of the past ten years.

Records of rainfall show that Hale Pohaku averages approximately 25 inches annually, the wettest months falling between November through March. Measurements of rainfall at Pohakuloa, near the Saddle Road, show the mean monthly rainfall for the area ranges from one to five inches.

Temperature

The temperature at the summit of Mauna Kea is relatively mild for its elevation. During most of the year, the mean temperature is a few degrees above freezing. The extremes in monthly average temperature range from 11°C maximum to -4°C minimum.

Existing data indicate that temperatures at Hale Pohaku range from the 30s (Fahrenheit) to the mid-70s (Fahrenheit).

Wind

Winds at the summit follow a diurnal pattern of prevailing west/northwest daytime and east/southeast nighttime wind direction. Wind velocity usually ranges from 10 to 30 miles per hour. During severe winter storms, winds occasionally exceed 100 miles per hour on exposed summit areas, such as the top of cinder cones.

The following table shows the average daily temperature and nighttime wind velocities at the Mauna Kea summit:

TABLE 1

Average Daily Temperature and Nighttime Wind Velocities

Month	T_{max}(°C) (1965-69)	T_{min}(°C) (1965-69)	Nighttime Wind Speed (mph) (1965-69)
Jan	3	-4	11
Feb	3	-4	20
Mar	5	-1	17
Apr	5	-3	24
May	5	-1	17
Jun	10	0	15
Jul	10	0	15
Aug	11	-1	13
Sep	11	+1	13
Oct	10	0	15
Nov	6	-3	13
Dec	3	-4	19

Source: D. Morrison, R.E. Murphy, D.P. Cruikshank, W.M. Sinton, and T.Z. Martin, "Evaluation of Mauna Kea, Hawaii, as an Observatory Site", Publications of the Astronomical Society of the Pacific, Vol. 85, No. 505, (June 1973): 255 - 67.

Prevailing winds at Hale Pohaku and at the Saddle Road are from the northeast and are characterized by occasional strong to heavy gusts.

Air Quality

The summit area is well above the 7,000-foot temperature inversion layer which limits the vertical convection transport of aerosols (particulates, including dust, salt particles, water droplets and man-made pollutants); the aerosols do not cause any particular problem as long as they are generated below the inversion level. Atmospheric pollutants at the summit are locally generated by combustible engines such as in automobiles, trucks and the existing diesel generator, and by travel over unpaved roads.

Hydrology and Permafrost

Surface Water

The only perennial surface water present on the summit, except that trapped within the crater of Puu Pohaku, is Lake Waiau, a small body of water in the crater of Waiau cone, located at approximately the 13,020-foot elevation. The lake is approximately 240 feet in diameter and 8 feet deep at overflow stage.[18]

Groundwater

Because of the very limited precipitation and high permeability of the soils at the summit. . . "the only groundwater known to exist consists of perched water in the center of some of the cones, including the area immediately east of Lake Waiau "(Woodcock, 1974, 1980). Borings for existing telescopes did not encouter groundwater.[19] No water table is known to exist anywhere in the vicinity of Hale Pohaku, nor are any groundwater supplies developed in the vicinity.[20]

Permafrost

Permafrost is known to have been identified in only two locations at the summit, Puu Wekiu and Puu Goodrich, both sheltered portions of cinder cone craters. . ."Woodcock and Friedman (1979) speculate that permafrost might exist 60 meters below the top of the summit cone, and Woodcock (1981) speculates that permafrost may underlie the groundwater body east of Lake Waiau, (but not under Lake Waiau). In general, the climate on Mauna Kea is considered to be slightly too warm for permafrost. . . No borings for existing facilities are known to have encountered permafrost." (Dames & Moore)[21]

DESCRIPTION OF THE EXISTING BIOLOGICAL CHARACTERISTICS

Vegetation

Summit

Lichens and bryophytes are the principal components of the flora at the summit of Mauna Kea. The climatic conditions at that altitude tend to be so severe as to exclude most higher plants. The Bishop Museum, Department of Botany, has conducted a botanical survey of the summit area of Mauna Kea, (Volume 2, draft EIS, Appendix E). Two areas of interest were identified: the slope of Puu Wekiu below the switchback; and, an area north of Puu Poliahu to the 13,000-foot elevation. The first area contains numerous large rocks which support a substantial colony of lichens. The second area is characterized by a rich variety of lichens including the Pseudephebe pubescens, a lichen which was first discovered during the course of this survey. The latter species is primarily found in high altitude alpine regions and has never been collected before in Hawaii or anywhere in the tropics.

Hale Pohaku

The DLNR Division of Forestry and Wildlife, Endangered Species Program, conducted a botanical survey of Hale Pohaku in October 1981. Their general description of the vegetation at Hale Pohaku follows:

> "The vegetation of Hale Pohaku is composed of an open mamane (Sophora chrysophylla) forest with scattered native shrubs and sparse ground cover dominated by endemic and introduced grasses. Two subspecies of mamane were observed in the area: S. chrysophylla subsp. glabrata var. ovata f. maunakeaensis and S. chrysophylla subsp. and var. circularis, a candidate for endangered status. Hinahina (Geranium cuneatum var. holoeucum) and 'aheahea (Chenopodium oahuense), two endemic shrubs of occasional occurence, generally grow in the proximity of mamane trees. Four different taxa of native mint vines were frequently seen growing under mamane trees and often climbing into their canopies; these are Stenogyne microphylla, S. diffusa var. glabra, S. rugosa subsp. subulata var. nov., and S. rugosa. Grasses are an important component of the ground cover of this forest with the endemic bunchgrasses Deschampsia australis and Trisetum glomeratum and the exotic Stipa cernua most numerous." (DLNR)

Mamane is the major food source of a number of bird species, including the endangered Palila. The clumps of mamane are also important because they act as fog interceptors to provide themselves, and other species associated with them, with the small amounts of moisture they need for survival. In addition, the *Sophora* clumps help prevent the erosion of the underlying ash soil.

Fauna

Summit

The major faunal components of the summit ecosystem are arthropods such as spiders, moths, mites, springtails, centipedes, booklice, barklice, and bugs. A highly aberrant new species of the world wide genus [illegible] was recently discovered at the summit. The habitat of this new bug is most commonly found under large boulders and among cinders. There are no officially designated endangered species of arthropod fauna present at the summit.

Hale Pohaku and Lower Slopes

The Palila (*Psittirostra bailleui*) is a small bird of the Hawaiian honeycreeper family (Drepanididae); it has been listed as a endangered species since 1966. Mamane trees provide most of the food, shelter and nest sites for the Palila. Over 30,000 acres of the mamane/naio forest area of the mountain have been designated as the critical habitat of the endangered Palila, encompassing Hale Pohaku and extending above it to the 10,000-foot level. Because this endangered species is dependent on the green pods and flowers of the mamane, and because the mamane flowers sporadically on the mountain slopes, it was necessary to include, within this habitat, forest land that encompasses most of the Palila's known historic range on Mauna Kea. This designated area was established on August 11, 1977.

Another species which is currently on the federal list of endangered species is presumed to inhabit the area; the 'Ua'u. The Hawaiian Dark-Rumped Petrel or 'Ua'u (*Pterodroma phaeopygia sandwichensis*) is an endangered endemic subspecies which was recently rediscovered at Haleakala, Maui and on Lanai. The 'Ua'u is historically endemic to the major Hawaiian Islands. Earlier reported to nest between the 1,500 and 5,000-foot elevation on Mauna Kea, it now appears that the 'Ua'u only digs its burrows at higher sites where the predator population is less dense.

Hunters and State Fish and Game officials report that the Chukar partridge, Alectoris chukar, and the California quail inhabit the area. The primary habitat of the Chukar partridge is at the tree line and higher, on bare rocky slopes. The Chukar feeds primarily on gosmore, ohelo and pukiawe. The California quail feeds on seeds from sweet vernal grass, common thistle, gosmore, sheep sorrel and mamane.

The area is inhabited by feral pigs (Sus scrofa), cattle, mouflon sheep (Ovis musimon), and possibly small numbers of feral sheep (Ovis aires) and feral goats (Capra hircus). It is presumed that other small mammals such as the house mouse (Mus musculus), black rat (Rattus rattus) and mongoose (Herpeste auropunctatus) also inhabit the area.

NATURAL AND ARCHEOLOGICAL FEATURES

National Natural Landmark

Mauna Kea has been designated as a National Natural Landmark and is listed in the National Registry of Natural Landmarks. In spite of this listing, Mauna Kea, among other landmarks also designated, is not a registered landmark, since the BLNR has not officially agreed to that designation.

Mauna Kea Ice Age Natural Area Reserve

The Mauna Kea Ice Age Natural Area Reserve is located between the elevations of 10,400 and 13,200 feet. It extends into a portion of the summit area that is leased to the University of Hawaii as the Mauna Kea Science Reserve. This Natural Area Reserve (NAR) designation was approved by the BLNR on November 9, 1978. A CDUA for the area was approved by the BLNR in 1981. On November 16, 1981, the Governor signed an Executive Order establishing the Mauna Kea Ice Age Natural Area Reserve.[22]

Features within the NAR are managed by the DLNR according to their management plan for the area. Regulations for activities within NARs have also been promulgated by the the DLNR.

The main ice age features located in the NAR are Pohakuloa Gulch (formed by glacial meltwater), glacial moraine and meltwater deposits of fine sediments (present down to the 10,500-foot elevation), and the glacially sculptured features of cinder cones and lava flows. Lake Waiau, one of the highest lakes in the United States, and the Keanakakoi Adze Quarry, are other features of the Reserve.

The Keanakakoi Adze Quarry is located at the 12,400-foot elevation. The quarry site is listed on the National Register of Historic Places. There are a variety of ancient Hawaiian culture remains, dating back to about 1000 A.D., that are scattered throughout this quarry. These include religious shrines and rock shelters of different types, which were established in conjunction with a series of adze (tool) quarries and workshops.[23]

> "The Mauna Kea Adze Quarry is probably one of the nation's least known but most important National Historic Landmarks, from both a research and interpretive point of view. It is the only landmark of its kind in the United States. Moreover, it is probably one of the largest and most complex stone tool quarries in the world." (McCoy 1976)

The site was a very important and extensive center of Hawaiian adze manufacturing. Scientists at the Bishop Museum have been collecting information about the process of obtaining raw materials for, and the manufacture of, this important class of stone tools. During their excavations and analysis of the Quarry, they found the first evidence of Hawaiian rock art on the upper slopes of the volcano. They also found evidence of intermittent, short-term habitation in the numerous rockshelters, including artifacts and well-preserved food remains.[24]

Archaeology

Summit

A total of 22 archaeological sites were recorded in a recent Bishop Museum survey. All but two of the 22 sites are located on the north slope, below the summit cones. All but one site, an open air shelter, were classified as "shrines", a convenient term to designate a simple altar without a prepared court. Shrines are characterized by the presence of one or more upright stones. In a number of instances they were simply set up on the surface of an outcrop and are braced by a few stones. The platforms and cairns are distinguished by stack-stoned construction. No offerings were found at any of the 21 sites. In contrast to the structures found at the Keanakakoi Adze Quarry, the function of the 21 shrines is unknown. (EIS, Volume II, Appendix A)

Hale Pohaku and Lower Slopes

Archaeological reconnaissance surveys of Hale Pohaku, Humuulu, and a site on Hawaiian Homelands, just below the Forest Reserve boundary, were conducted by Dr. Patrick McCoy, Bishop Museum, in conjunction with the Hale Pohaku CDP. He found no archaeological or historic sites at any of these locations. He stated that the high elevations and moderately arid environment were minimally exploited by pre-contact Hawaiians. This was probably due to the lack of adze-quality basalt and the absence of other apparent resources that would have required the establishment of camps for short periods of resource exploitation.[25]

OTHER USES OF THE SUMMIT AREA

Skiing and Snow Plan

Many residents and visitors participate in snow activities during the winter season. The Ski Association of Hawaii works closely with the Institute for Astronomy in order to make certain that skiing is compatible with astronomical observation.

Hiking, Sightseeing and Photography

Hiking, sightseeing and photography are among some of the recreational activities in the summit area. Joyriding has become increasingly popular and the use of "off-road" vehicles has left scars up the cinder slopes and cones.

Other Scientific Research

Mauna Kea has a number of natural resources which are of interest to scientists from various disciplines. The Kitt Peak National Observatory (KPNO) and the UH are presently conducting a site survey of Mauna Kea. Climatological and astronomical data will be collected over a three year period. Identical surveys are being carried out simultaneously at other stations located within the United States.

Geologists are interested in Mauna Kea's unique volcanic and glacial history. The summit's altitude, climate and atmosphere are attractive for the study of meteorology. As the highest insular volcano in the world, Mauna Kea with its remnant endemic ecosystems represents a unique research environment for biologists and botanists.

Transmitters/Receivers

Presently, there are a total of four transmitters within the Science Reserve. Two National Weather Service transmitters are located at the Planetary Patrol building. The transmitters are a part of the tsunami warning system and are used primarily for transmitting weather information on a 24-hour basis from Hilo up to Mauna Kea and then to Haleakala, Maui and Ewa Beach, Oahu. Two transmitter/receivers are located at the brick power building, one is used by the DLNR Forestry Division and the other by the Volcano Observatory. The forestry transmitter is used in case of forest fires; the Volcano Observatory transmitter/receiver translator is used in monitoring the Kilauea and Mauna Loa volcanoes. Under agreements with DLNR, these transmitters are allowed until they interfere with astronomical observations and telescope functions.

PART III:

DEVELOPMENT PLAN FOR THE MAUNA KEA SCIENCE RESERVE

OVERVIEW

Background

Mauna Kea's high altitude, uniform atmospheric dryness and low latitude can be utilized to best advantage by two broad classes of telescopes: optical/infrared telescopes and millimeter-wave telescopes. Because water vapor in the earth's atmosphere absorbs radiation from space, these types of telescopes must be located in areas dry enough to ensure maximum practical usefulness. Because each different part of the sky is available for observation only at its corresponding season, for maximum efficiency the atmosphere must also be uniformly dry, without major seasonal variations. In addition, because galactic problems are major areas of study, it is advantageous to locate the telescopes at latitudes where observing at southerly declinations will not be unduly restricted and where the galactic center transits at an altitude equal to or greater than 45 degrees.

The Mauna Kea Science Reserve was established to allow the University to guard against effects such as physical obscuration of telescopes by other structures, atmospheric pollutants, heat sources, extraneous light, electrical interference and other factors detrimental to astronomical observations. All sites within the Science Reserve are not equally suitable for telescopes, the less suitable areas are intended to remain undeveloped and to function as "buffer" zones.

Six telescopes are currently in operation within the Science Reserve: four major facilities (UH 88-inch; CFHT; UKIRT; and IRTF) and two smaller 24-inch facilities which are operated by the UH. All of these telescopes, except the IRTF, are located on the west rim of Puu Wekiu, the summit cinder cone.

The UH RDP states that a maximum of thirteen telescopes will be located within the Science Reserve by the year 2000. Although the actual scope which is realized by the astronomy program at Mauna Kea will depend on the role determined for this activity by public policy makers, the UH has determined that this number is a reasonable and feasible expectation of possible astronomical activity on the mountain between now and the end of the century.

Three new telescopes are proposed for construction during the 1980s. They are:

1. The California Institute of Technology (Caltech) 10-meter submillimeter telescope;

2. A 15-meter millimeter-wave telescope which is proposed for construction by the Science and Engineering Research Council (SERC) of the United Kingdom (UK/NL MI); and,

3. A 10-meter optical/infrared telescope sponsored by the University of California (UC TMT), proposed to begin construction by mid-1984.

The probable number and characteristics of the additional four telescopes, projected in this plan for development in the latter part of the planning period (circa 1990 and later), is derived from analyses of possible telescope demand by both national and international institutions. Based on this demand, it is assumed that four institutions will request permission to located their telescopes within the Science Reserve before the year 2000. It is also assumed that these requests will be for three major (10 meters or greater aperature) optical/infrared telescopes and one millimeter-wave telescope.

The development plan is based on the mix of telescopes assumed in the UH RDP, however, various combinations of optical/infrared and millimeter wave telescopes were considered in evaluating potential telescope locations. The SRCDP, therefore, allows for flexibility, as long as the number of major telescopes at the summit does not exceed eleven (a total of thirteen when two smaller telescopes are included), any combination of optical/ infrared and millimeter-wave telescopes is acceptable. The estimates of future infrastructure, utilities, and support facilities requirements for each type of telescope are comparable.

Planning Considerations

Several planning considerations are embodied in this plan. They are:

- o Minimize disturbance to mountain ecosystems;
- o Locate facilities within the Science Reserve in as compact a configuration as is consistent with the technical requirements of the telescopes;

- Recognize biological and cultural criteria as well as physical characteristics when evaluating potential development areas;
- Within the constraints of the technical requirements of the telescopes, locate facilities to minimize visibility from developed areas of the Island;
- Minimize disturbance to undeveloped areas by locating utility lines and road alignments within currently disturbed areas, as far as is practical and feasible;
- Preserve Puu Hau Kea (Goodrich) and Puu Wekiu (the summit cinder cone); and,
- Insure that Lake Waiau and the adze quarry are not compromised by nearby development.

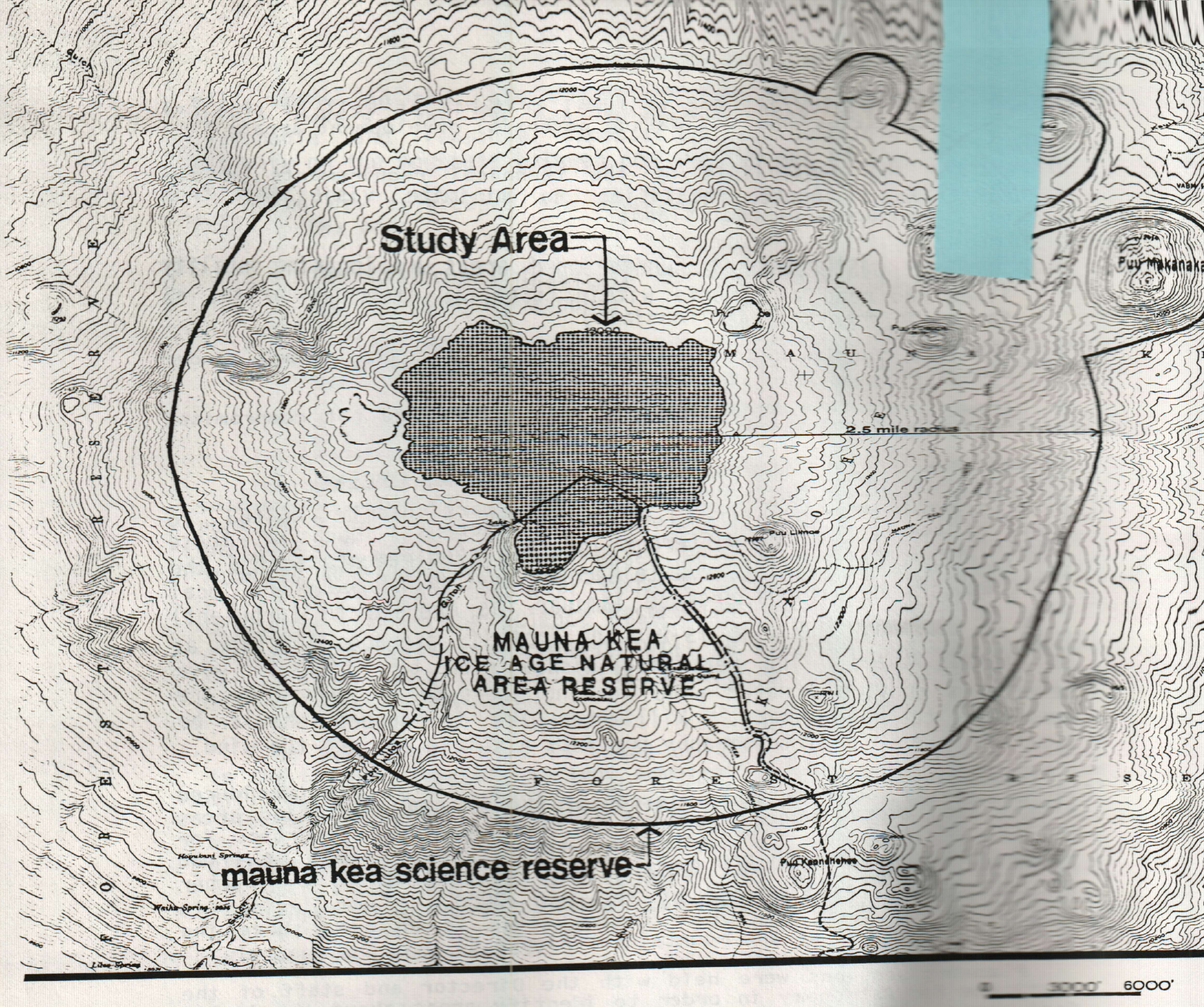
Methodology for Identifying Future Telescope Siting Areas

Mauna Kea's unique qualities are particularly suited to optical/infrared and millimeter-wave telescopes. Each of these types of telescopes has different location requirements within the summit area. Optical/infrared telescopes must be placed where local topographical conditions promote laminar (as opposed to turbulent) flow of air when the wind is blowing from its average direction at an average speed. The receiving dishes used by millimeter-wave telescopes provide greater wind loading; because of this they are sensitive to wind shake. Millimeter-wave telescopes should be located where natural topography provides a shield against the wind.

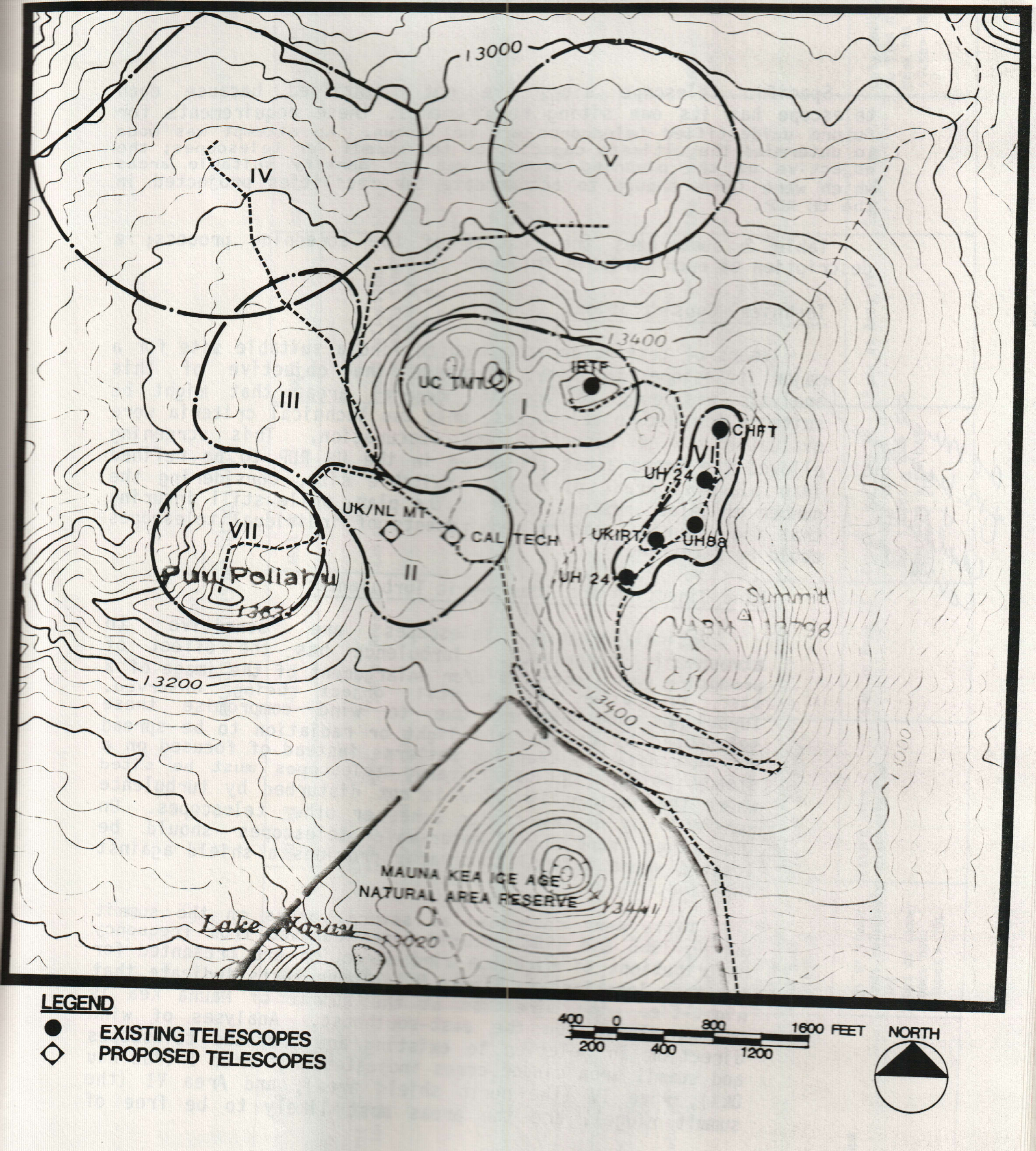
Because not all sites within the Science Reserve are considered to be equally suitable for telescopes, the UH RDP identified areas within the Reserve which appeared to have the best properties for optical/infrared and millimeter-wave telescopes. Using the broad areas defined in the UH RDP as a guide, and considering the number of telescope sites required by the year 2000, it was decided to confine the analysis of future siting areas to an area above the 13,000-foot contour of the mountain. (Figure 6)

Planning sessions were held with the Director and staff of the Institute for Astronomy in order to identify areas above the 13,000 foot contour that were potentially suitable for future development, based on scientific and technical rationale. As a result, seven areas were selected for analysis; they are identified on Figure 7.

Each of the seven areas was then assessed and evaluated based on technical and physical/environmental criteria. Following those screenings, the areas were evaluated to determine if telescopes located within them would affect their use for recreation activities. The final evaluation concerned the distance and cost to extend basic infrastructure (road and power) to each area.



Study Area
2.5 mile radius
MAUNA KEA
ICE AGE NATURAL
AREA RESERVE
mauna kea science reserve
Puu Makanaka
Puu Keonehehee
0 3000' 6000'



ANALYSIS AREAS

Specific telescope sites are not identified because each telescope has its own siting requirements; these requirements for future unidentified telescopes are not known. No attempt was made to determine the ultimate capacity of the summit for telescopes; the objective of the planning process was to identify suitable areas which were large enough to accommodate the facilities projected in the UH RDP.

Table 2 summarizes the results of the screening process; a description of each variable follows:

Technical Considerations

Years of testing are required to find a suitable site for a major telescope facility. Because the objective of this analysis was only to identify general areas that might be suitable for future telescopes, only two technical criteria were evaluated: wind direction and obscuration. This screening allowed the broad areas presented in the UH RDP to be refined into planning areas of a more suitable size, considering the number of telescopes projected in the plan, while still insuring that the technical siting requirements of individual telescopes could be satisfied.

so much for biological & cultural concerns!

Wind Direction and Atmospheric Turbulence:

Optical/infrared telescopes are sensitive to atmospheric turbulence. Turbulence has the effect of producing rapid motion and/or enlargement of the image of a star or other astronomical object being observed. Turbulence and shaking due to wind compromise these telescopes by causing the light or radiation to be spread out in constantly changing patterns instead of focused on a steady point. Optical/infrared telescopes must be sited where the laminar air flow is not disturbed by turbulence generated by nearby cinder cones or other telescopes. On the other hand, millimeter-wave telescopes should be located where natural topography provides a shield against the wind.

Tests were conducted at several areas on the summit during 1965 and 1966. Wind roses derived from frequency distributions of nighttime wind direction are presented for two test locations in Figure 3.1. These tests indicate that night-time wind direction at the summit of Mauna Kea is predominately from the south-southeast. Analyses of wind direction in relation to existing and proposed telescopes and summit area cinder cones indicates that Area I (Puu Hau Oki), Area IV (the north shield area), and Area VI (the summit ridge), are the areas most likely to be free of

Table 2

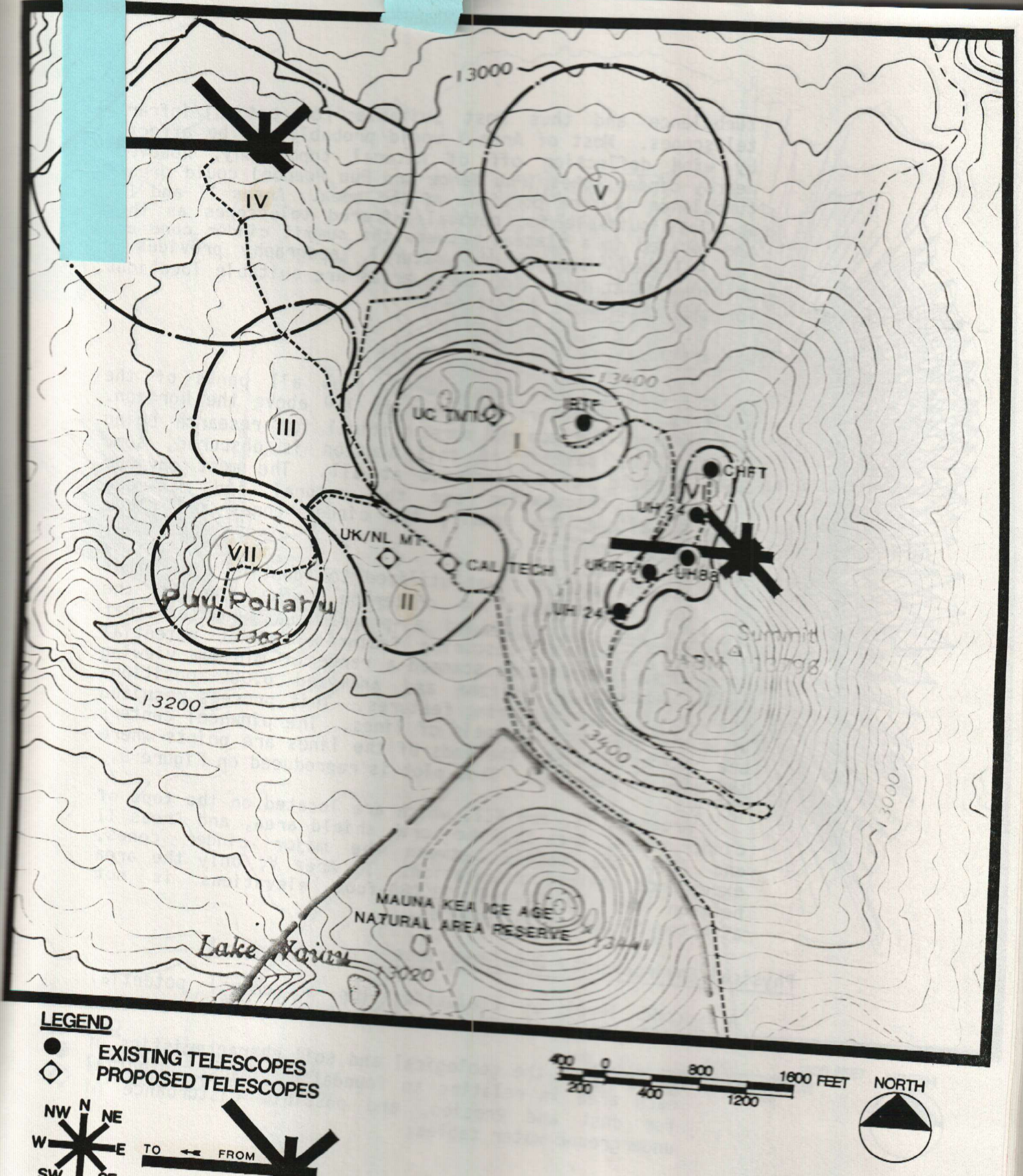
ANALYSIS OF TELESCOPE SITING AREAS

SCREEN & VARIABLES	AREA I	AREA II	AREA III	AREA IV	AREA V	AREA VI	AREA VII
Screen One - Technical							
Wind Direction, Turbulence	Laminar	Unknown - wind deflection from surrounding cinder cones expected	Same as Area II	Laminar	Wind deflection from nearby cinder cones could create turbulence in some portions	Laminar	Unknown
Obscuration	No obscuration from natural topography if telescopes are located on peaks of cinder cones	Puu Poliahu will partially obscure view of southern horizon for telescopes sited in south-southwest corner of area	Horizon from western portion of area obscured by Puu Poliahu	Puu Hau Oki obscures view of southern horizon from eastern portion of area	Southern horizon obscured by cinder cones except for area between 13,000 and 13,080 feet elevation	Horizon, as viewed from peaks, is not obscured by natural topography	None
Screen Two - Physical /Environmental							
Geological/Soils	Tephra cinders Max. foundation load 2,000 lbs. /ft. for shallow foundations High erosion potential High dust potential	Lava flows Excellent foundation support Rigid base for telescope mechanisms Low erosion potential Low dust potential	Same as Area II	Same as Area II Avoid locating within 100 feet of geologic contact	Most of the area lava flows Southwest portion is cinder deposits Flatter portions similar to II & III	Same as Area I	Same as Area I
Slope	Tops of cinder cones relatively flat Sides of cinder cones have slopes > 20%	Entire area relatively flat	Same as Area II	Eastern portion at geologic contact has slopes ≥ 20% Remaining area has slopes < 20%	Same as Area IV	Same as Area I	Only small portion ... peaks has slopes > 2...

Table 2 (Continued)

SCREEN & VARIABLES	AREA I	AREA II	AREA III	AREA IV	AREA V	AREA VI	AREA VII
Biological/ Botanical	Prime habitat of Nysius Unsuitable for flora	Lycosa common Southwest portion moderate density Nysius Low density and diversity of lichen	Lycosa common Northern portions sensitive for rare lichens	Lycosa common Most of area sensitive for rare lichens	Moderate density Nysius Not sensitive for lichens	Adjacent area (but not within area) prime habitat Nysius Unsuitable for flora	Moderate Nysius Unknown botanical
Archaeological Sites	None present	Two sites southern portion	One site north-east corner	Three sites	Four sites	None	Unknown
Visibility	Visible from Waimea, South Kohala, Hawaii Volcanoes National Park	Not visible outside of immediate area	Telescopes sited in northern portion may be visible from Waimea, South Kohala	Visible from Waimea, South Kohala some portions of North Kona	Same as Area IV	Visible from Hilo, Waimea, Hawaii Volcanoes National Park	Unknown
Screen Three Recreational Uses							
Skiing	No effect	Some effect - Menehune run	Some effect - Maidens run	No effect	Some effect - Warriors Run	No effect	Hvy ski ... e
Hiking	No effect	No effect	No effect	No effect	No effect	No effect	...effect
Hunting	No effect	No effect	No effect	No effect	No effect	No effect	...effect
Screen Four Infrastructure							
Costs	Road-IRTF to UC IMT: $106,000 UC IMT to east of area: $100,000 Power-IRTF to UC IMT: $116,000 UC IMT East: $109,000	Cost of road to UK/NL MT: $200,000 Power extension: $272,000	Road-UK/NL MT to to N. Boundary: $300,000 Power extension: $326,000	Road-UK/NL MT to 13,000 foot: $650,000 Power extension: $707,000	Road-UK/NL MT to N. Boundary: $700,000 Power extension: $762,000	Infrastructure in place	...d: ...00,000 ...er: ...05,000

not surveyed



NIGHT-TIME WIND DIRECTION
(2000 to 0400 HST)

turbulence and thus most suitable for optical/infrared telescopes. Most of Area V would probably not be affected by wind deflection off of natural topography, however, nearby cinder cones (Puu Mahoe and Puu Poepoe) could create turbulence in some portions of the area. Areas II and III are less suitable for optical/infrared telescopes as they are located in a plateau between the summit cinder cone and Puu Poliahu. Because the natural topography provides a shield against the wind, these areas are suitable locations for millimeter-wave telescopes.

12°

Obscuration:

Telescopes must be able to view all parts of the southern and northern sky down to 12° above the horizon. The southern horizon is more critical for research being conducted in Hawaii; if this horizon is obscured, some objects could not be observed at all. The most obvious sources of obscuration are the natural and man-made features within the summit, the cinder cones and other telescopes.

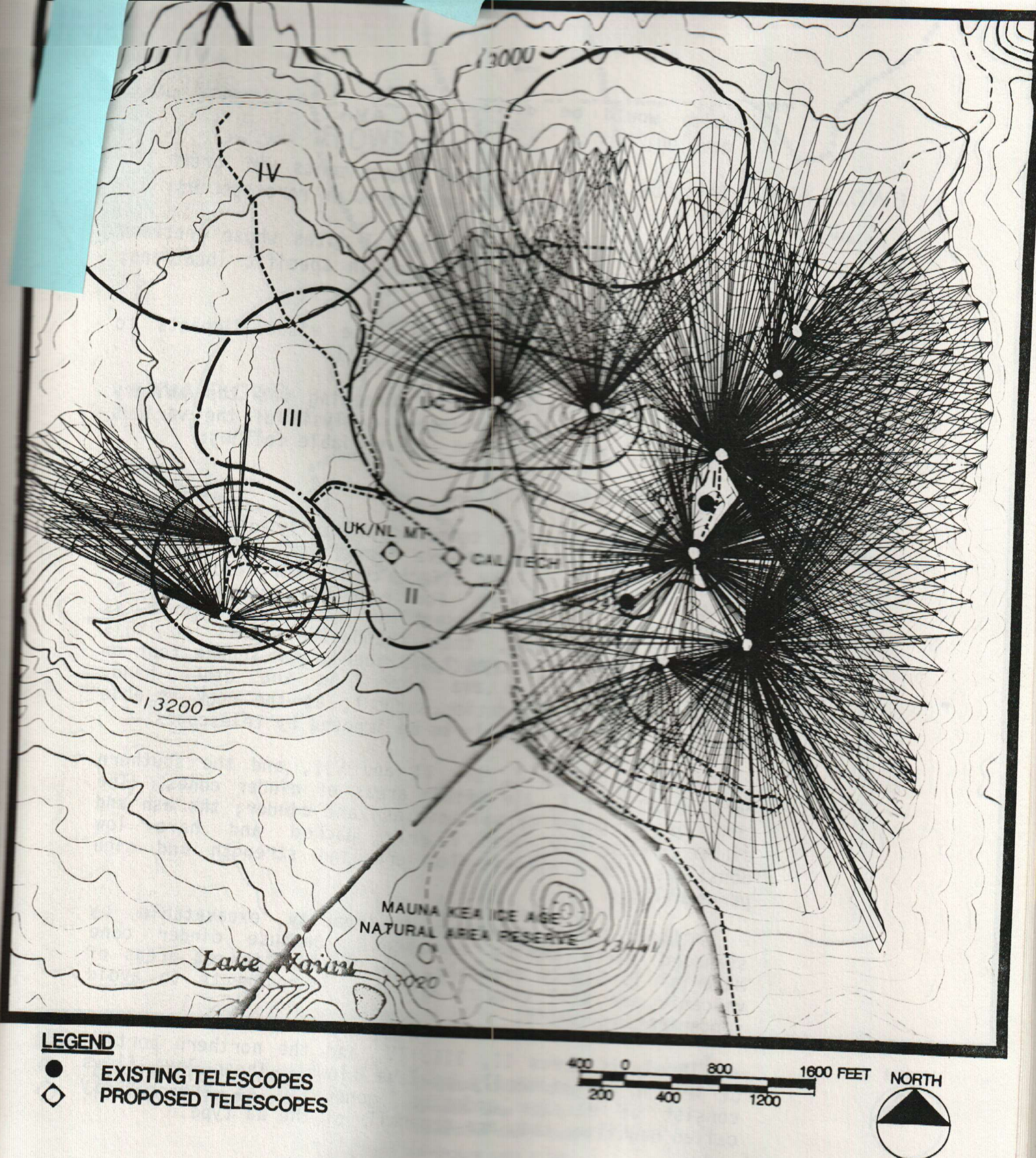
Computer analysis was utilized to identify sites that met the 12° obscuration criterion. The top of the mountain was digitized and a program was written that allowed testing of obscuring features against potential locations. The program scanned a range of minimum viewing angles above the horizon and analyzed 6,000 positions against 11 major obscuring features. This process resulted in a plot showing pinwheels of lines. The pinwheel centers are obstructions and the ends of the lines are points where the view is obscured. This plot is reproduced on Figure 9.

Areas I, VI, and VII, which are located on the tops of cinder cones, Area IV, the north shield area, and Areas II and III, the saddle between the major cinder cones, experience minimal obscuration. In Area V, only the area between the 13,000-and 13,080-foot elevations is not affected by obscuring features.

Physical/Environmental Considerations

A second level of evaluating (or screening) potential telescope siting areas involved the following:

(1) Analysis of the geological and soil characteristics of each area in relation to foundation loads, potential for dust and erosion, and possible disturbance of underground water tables;



AREAS OF OBSCURATION

(2) Slope analysis in order to eliminate the steeper areas which would be difficult, and thus expensive, to develop;

(3) Botanical and biological assessments in order to minimize disturbance to endangered or rare species;

(4) Identification of archaeological sites whose presence may preclude siting facilities in specific locations; and,

(5) Visibility analysis to determine visual impacts to other areas on the Island of Hawaii.

The physical/environmental screening was the primary basis for an environmental impact analysis of the various siting areas. An analysis of each variable follows:

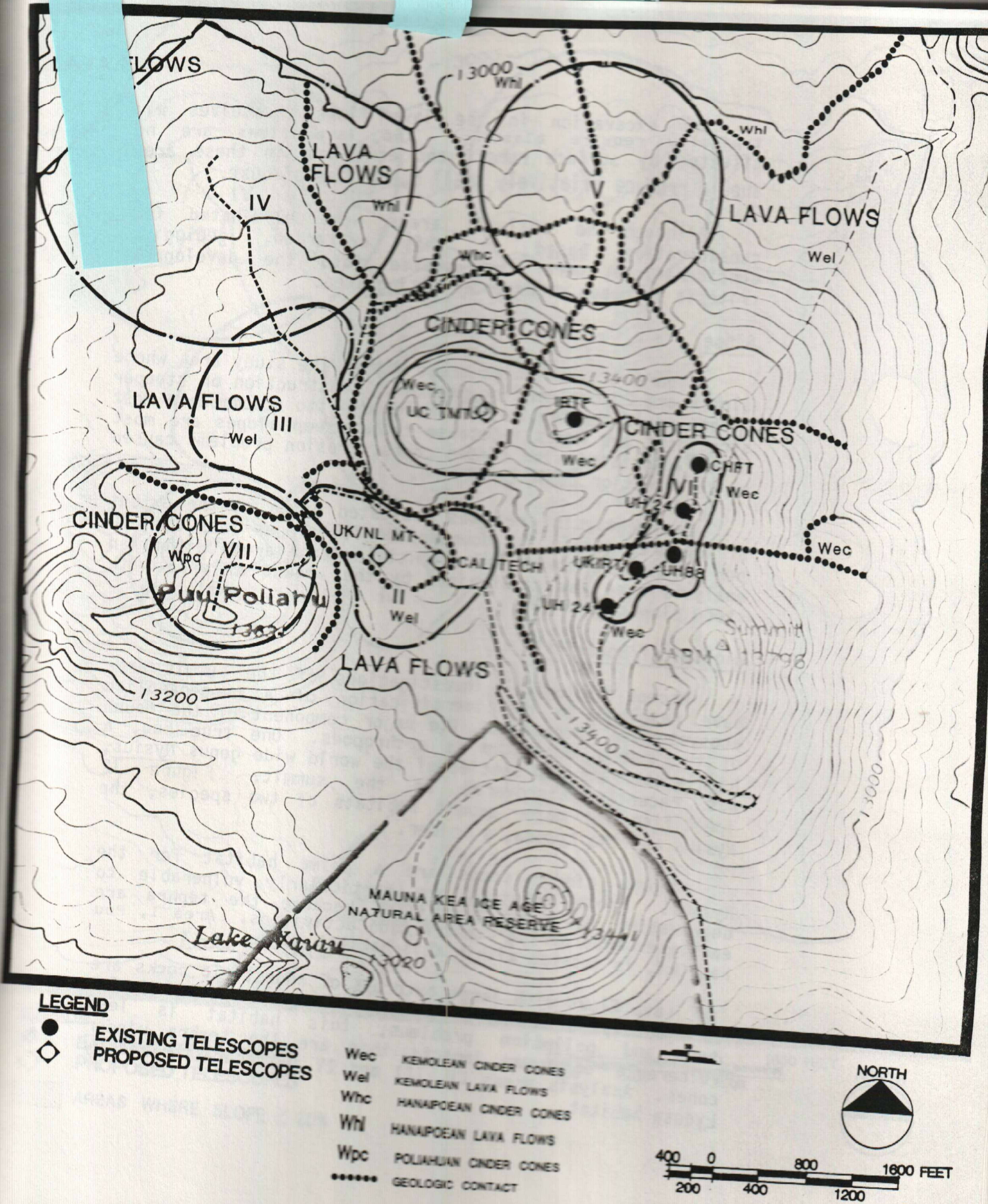
Geology/Soils (Figure 11)

The summit area is composed primarily of two ground types, tephra cinders and lava flows; each has different characteristics which may affect the construction and the operation of telescopes. For example, the density of volcanic ash material present on the cinder cones is frequently rather low, thus foundation loads on this material should not exceed 2,000 pounds per square foot on shallow foundations. Lava flows, on the other hand, provide excellent foundation support, as the rock is able to support any loads likely to be imposed by telescopes.

Analysis areas I, IX, VI and VII, and the southern portion of Area V, lie within areas of cinder cones. The cones are composed of volcanic ash and cinder; the ash and cinder frequently are loosely packed and have low densities, they exhibit low crushing strength and high permeability.

Cinder cone material is readily excavatable by standard earth moving equipment. Because cinder cone material is highly erodible, any construction in areas of volcanic ash will require drainage improvements to avoid concentrating runoff.

Analysis areas II, III, IV, and the northern portion of Area V are primarily on lava flows. These lava flows consist of massive andesite, generally of the variety called Hawaiite; they are generally of the aa type.



GEOLOGICAL\SOILS

MAUNA KEA SCIENCE RESERVE

Any excavation in the lava flows themselves will typically require blasting. The lava flows are not affected by surface runoff and earthwork in these areas should produce relatively small quantities of dust.

Although no analysis areas were eliminated from consideration based on this criterion, geological considerations were incorporated into the development criteria for each recommended siting area.

Slope

Figure 11 identifies areas within the study area where slopes are 20 per cent or greater. Construction on steeper slopes would require massive re-grading to accommodate most structures and roads. Because these steep slopes are most often associated with cinder cones, erosion problems caused by construction could be severe.

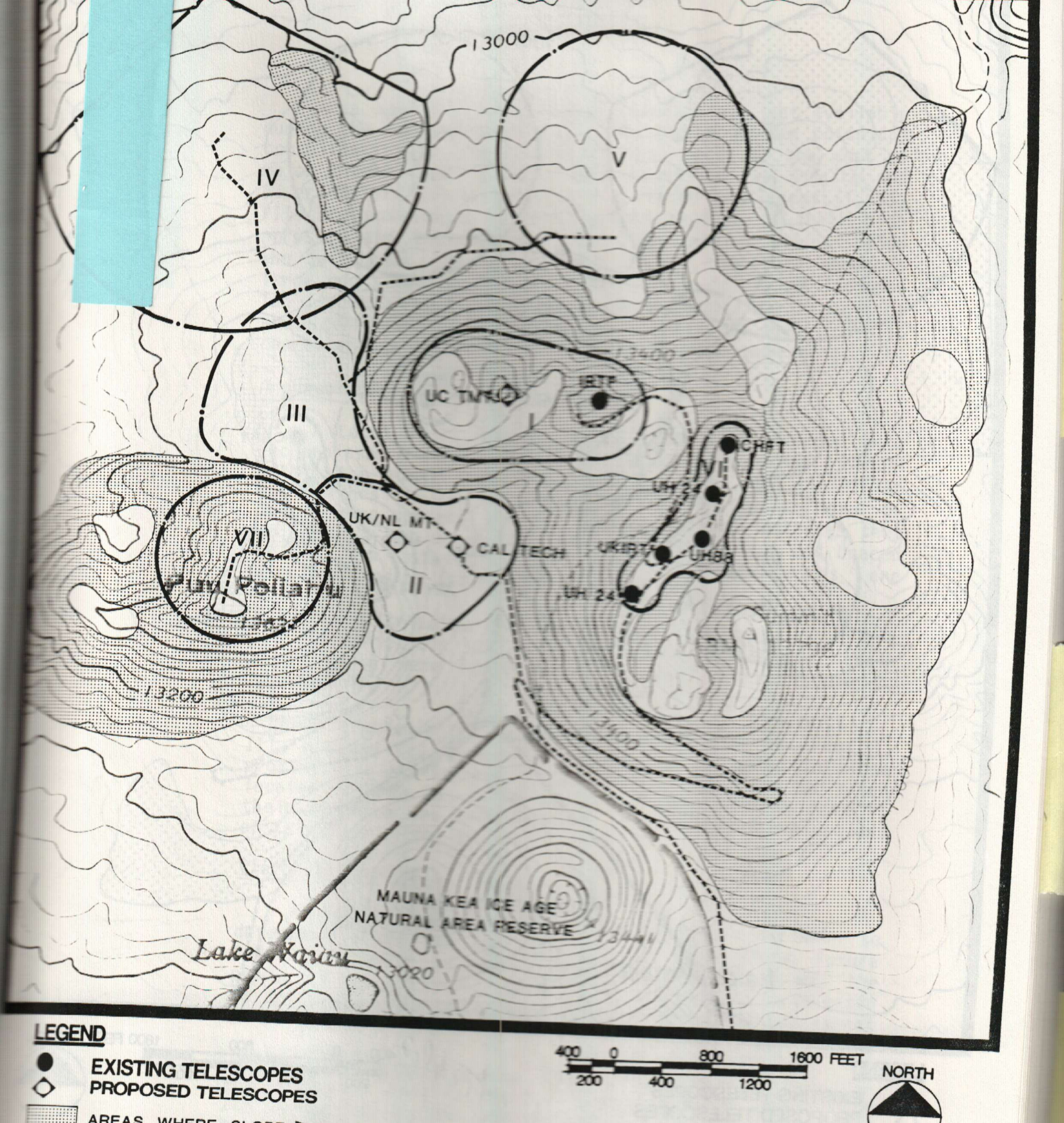
Each analysis area was evaluated based on the extent of the area within its boundaries with slopes less than 20 per cent. The number of potential siting areas within an analysis area was constrained by the amount of area with steep slopes.

Biological/Botanical

Recent biological investigations of the summit area have resulted in the identification of a neogeoaeolian ecosystem on Mauna Kea. The major component of the fauna of the summit ecosystem is arthropods. One true bug, a highly aberrant new species of the world wide genus Nysius, was recently discovered at the summit. Figure 12 identifies the major summit habitats of two species, the Nysius and the Lycosa, a spider.

Tephra cinder cones are a prime habitat for the Nysius. These habitats are particularly vulnerable to degradation by human activities because the tephra are easily crushed during construction activities. Area I, Puu Hau Oki, is located within this habitat.

Lava flows with large outcrops of andestitic rocks are the principal habitat of the spider Lycosa. Except for dust and pollution problems, this habitat is less vulnerable to human impacts than are the tephra cinder cones. Analysis areas II, III and IV are characterized by Lycosa habitat.


13000
IV
V
III
IRTF
I
CHFT
VI
UH 24
UK/NL MT
CAL TECH
UKIRT
UH88
II
VII
Puu Poliahu
UH 24
13200
13400
MAUNA KEA ICE AGE
NATURAL AREA RESERVE
Lake Waiau
13020
LEGEND
EXISTING TELESCOPES
PROPOSED TELESCOPES
AREAS WHERE SLOPE ≥ 20%
400 0 800 1600 FEET
200 400 1200
NORTH

SLOPE MAP

LEGEND

EXISTING TELESCOPES

PROPOSED TELESCOPES

1600 FEET NORTH

match w/ trails pg 48

LYCOSA COMMON

NYSIUS HIGH DENSITY

ARTHROPOD FAUNA

Area specific botanical information was not available during the screening process. The Bishop Museum botanical consultants have since reported that areas to the west of major cinder cones (II and III) support a low density and diversity of lichens and that the cinder cone areas (I, VI, VII) are unsuitable for most plants because of their high porosity and instability. The slope of Puu Wekiu, below the switchback, was of interest because there are numerous large rocks in the area which support a colony of lichens. Two lichens, Pseudephebe pubescens and Umbilicaria pacifica are confined to Mauna Kea. Analysis area IV is characterized by the presence of Pseudephebe pubescens.

Archaeological Sites

A total of 22 archaeological sites were recorded in a reconnaissance survey of approximately 1,000 acres of land within the summit area. All but one site were classified as "shrines". They are characterized by the presence of one or more upright stones. In a number of instances they were simply set up on the surface of an outcrop and braced by a few stones. The platforms and cairns are distinguished by stacked-stone construction.

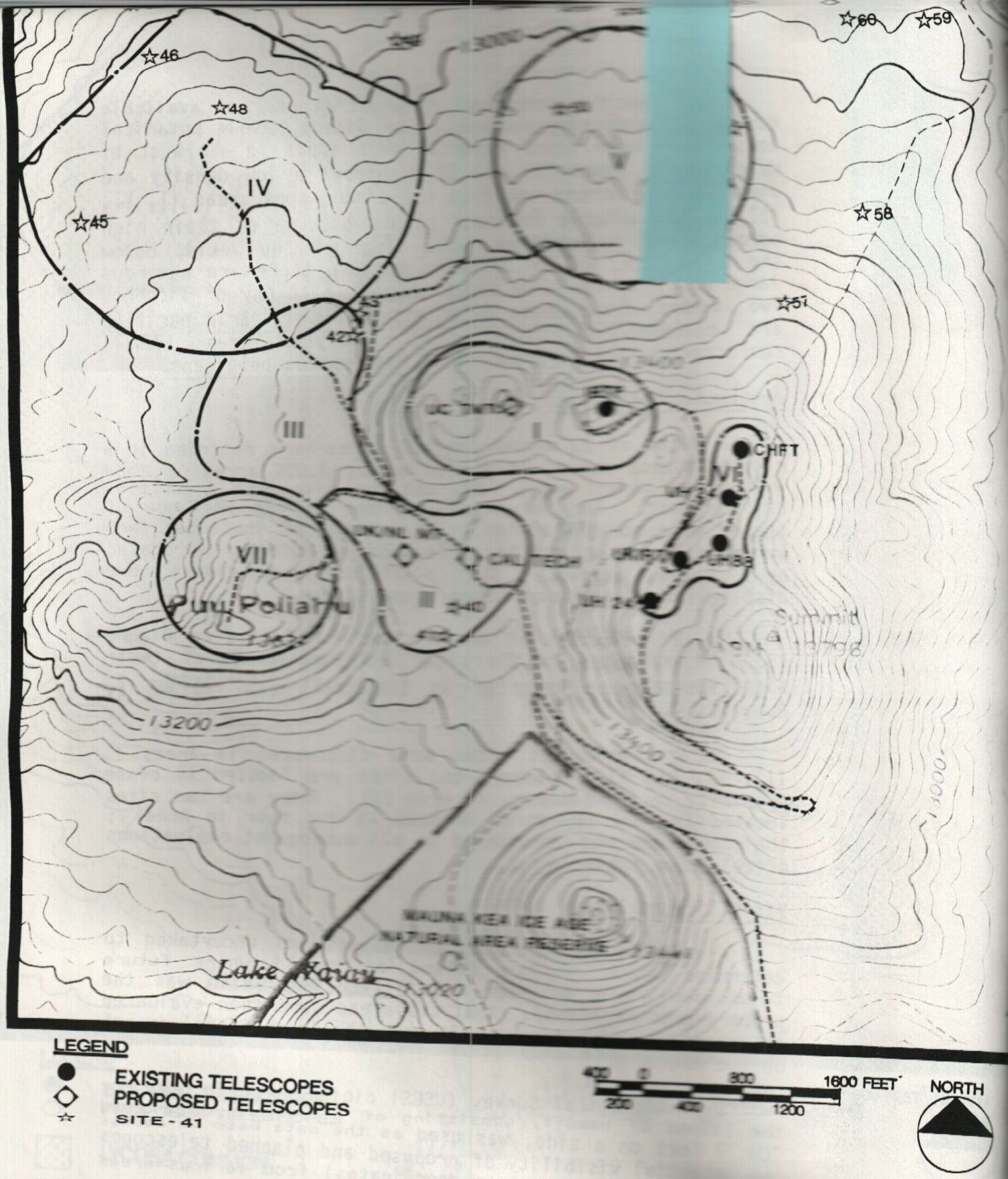
The distribution of these sites is plotted on Figure 13. (Descriptions of the sites and assessments of their significance were reported in the draft EIS, Volume 2, Appendix A).

No archaeological sites were discovered in Areas I, III, VI, and VII, however, two sites are located in close proximity to the boundary of Area III. There are two sites located in Area II, three in Area IV and four in Area V; their presence was considered in all subsequent evaluations of telescope siting areas.

Visibility Analysis

A computerized visibility analysis was undertaken to determine areas on the Island of Hawaii where future telescopes would be seen (visibility from Hilo was the primary consideration). Analysis areas were then evaluated to determine which areas would have the least visual impact on the mountain.

U.S. Geological Survey (USGS) digital terrain data for the Island of Hawaii, consisting of elevations on a grid 208.33 feet on a side, was used as the data base to assess the potential visibility of proposed and planned telescopes (identified by State plane coordinates) from various areas



ARCHAEOLOGICAL SITES

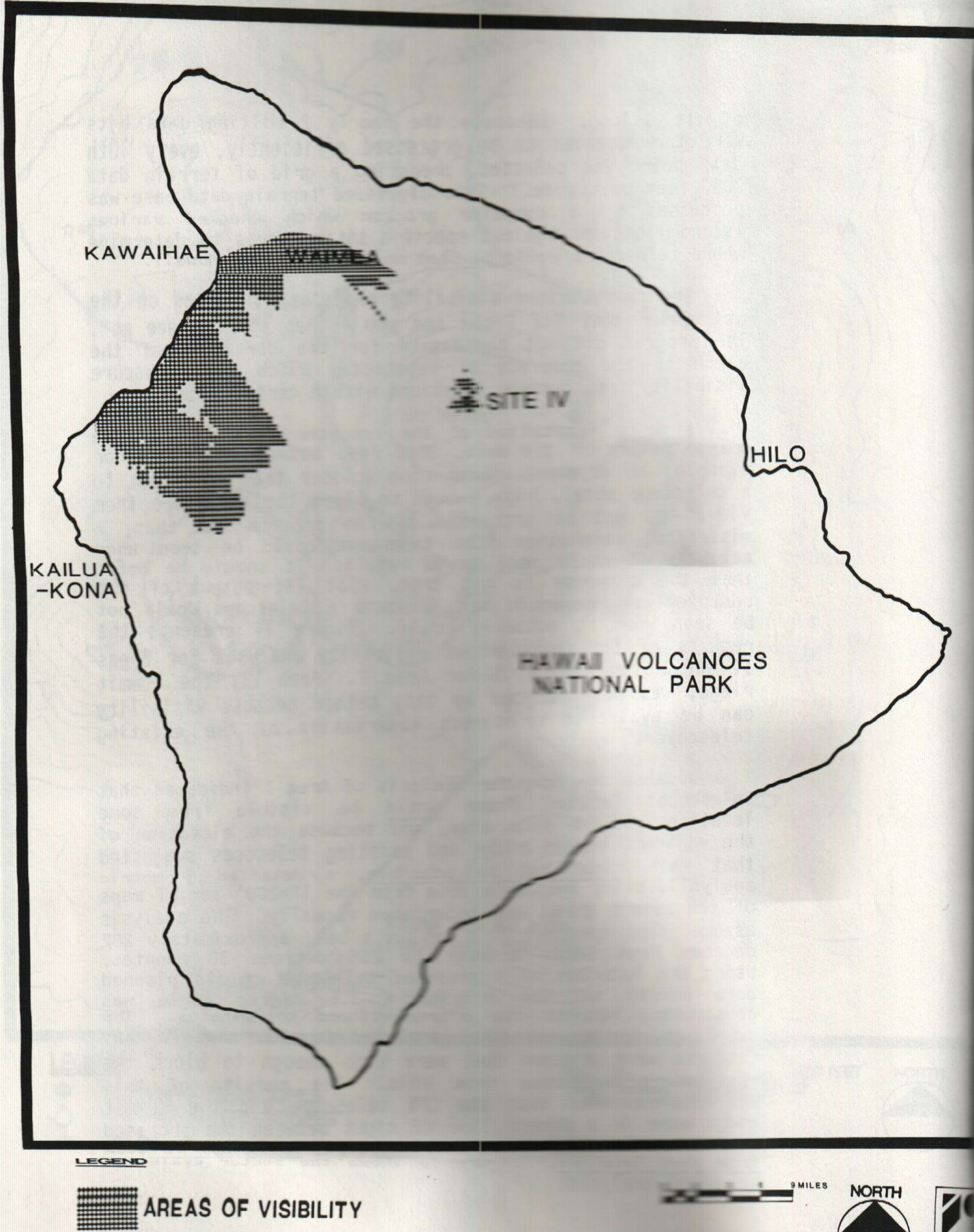
MAUNA KEA SCI

of the Island. (Because the nearly 2 million data bits were too numerous to be processed efficiently, every 10th data point was selected, producing a grid of terrain data 2080 feet on a side.) This digitized terrain data base was processed by a computer program which checked various Island locations against specific siting areas to determine where telescopes could be seen on the Island of Hawaii.

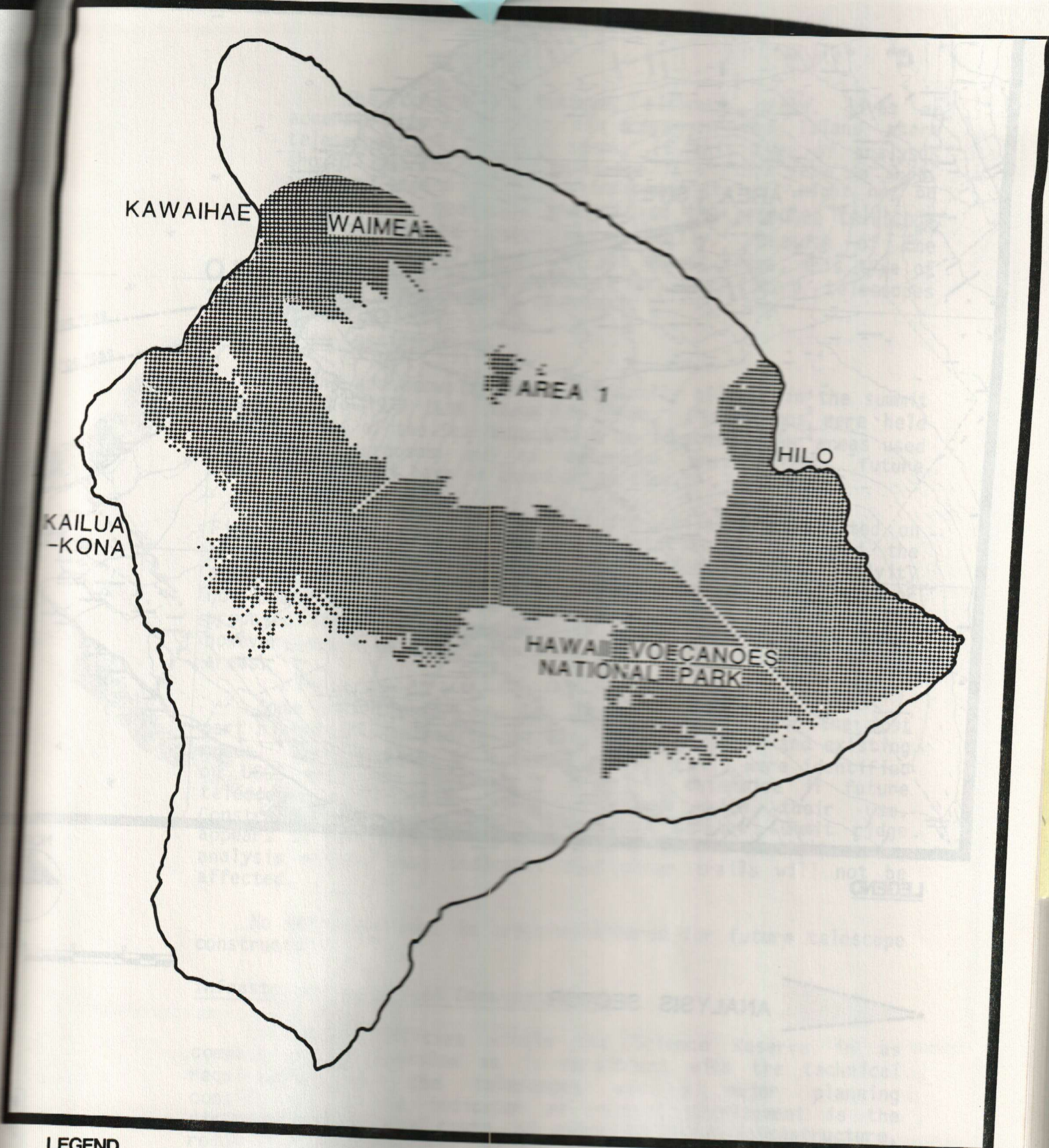
The computerized visibility analysis was based on the assumption that "if I can see you - then you can see me". The program did not compensate for the curvature of the earth or the presence of vegetation which could obscure visibility from certain locations within certain areas.

A major limitation of the computer analysis was the coarse nature of the data, 2080 feet between points. For example, an adjacent cinder cone (closer than 2080 feet to a telescope site), high enough to block the telescope from view, may not be processed by the program and thus, a misleading conclusion (the telescope could be seen when actually it could not) could result. It should be noted that the converse is not true, that is, output of the computer program would not indicate a telescope could not be seen when it actually could. Figure 14 presents the results of the computerized visibility analysis for Areas IV and V and Figure 15 for Area I. Area VI, the summit ridge, was not analyzed by this method because visibility can be evaluated by direct observation of the existing telescopes.

Because the computer analysis of Area I indicated that telescopes located there would be visible from some locations in the Hilo area, and because the elevation of the adjacent summit ridge and existing telecopes suggested that this might not be possible, a detailed geometric analysis, using available data from the 1"=200' aerial maps of the summit area, was undertaken manually. The analysis assumed that downtown Hilo was in a band approximately 282 degrees from South azimuth to 285 degrees 30 minutes. Using the location of a proposed telescope at its planned dome height as the origin, a 3.5 degree angle was constructed between the aforementioned coordinates. The resulting sector was then analyzed to determine if any features were present that were high enough to block the view of a telescope from Hilo. The results of this analysis revealed that the CFH telescope and the summit ridge were in a direct line of sight between the proposed site and Hilo, therefore, the telescope, would not be seen from that location. Figure 16 shows the sector evaluated by manual analysis.



VISIBILITY OF SITE IV



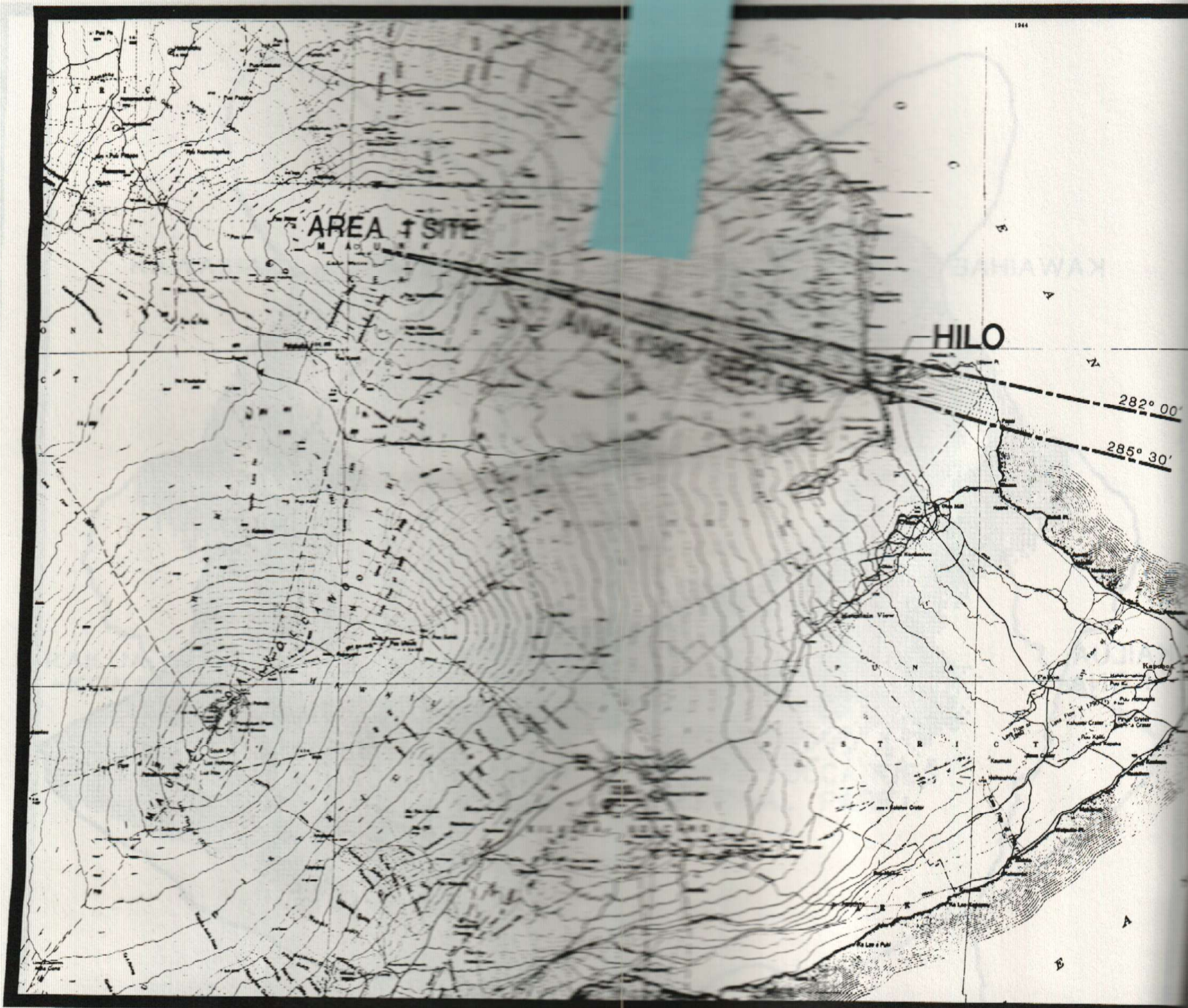
LEGEND

AREAS OF VISIBILITY

3 0 3 6 9 MILES

NORTH

VISIBILITY OF AREA 1



LEGEND

ANALYSIS SECTOR

VIEW AZIMUTHS

The computer technique, although gross, gives an accurate representation of areas on the Island where telescopes will not be seen. If this type of analysis should indicate that a telescope is visible from an area, and knowledge of the area indicates that it might not be seen, then a geometric analysis of the proposed telescope site, could be undertaken manually. Because of the proximity of Puu Hau Oki to the summit ridge, this type of analysis may be undertaken for any future telescopes proposed to be located in Area I.

Recreation Considerations

Skiing and snowplay are specifically allowed in the summit area by the 1977 DLNR Mauna Kea Plan. Discussions were held with members of the Ski Association to identify major areas used for these purposes and to determine what effects future development might have on these activities.

Areas that are commonly used for skiing are depicted on Figure 17. Members of the Ski Association evaluated the proposed telescope siting areas in relation to these activity areas. The skiers contacted felt that there would be little or no impact on skiing from proposed telescopes in any of the proposed locations. The proximity of ski and snowplay areas, however, was a major consideration in locating proposed parking areas.

Some hiking occurs in the summit area, but for the most part hiking is confined to the Natural Area Reserve and existing roads. The locations of existing hiking trails were identified on USGS maps and examined in order to determine if future telescope construction would interfere with their use. Construction of the existing telescopes on the summit ridge appears to have changed the alignment of an old trail, however, analysis of the maps indicates that other trails will not be affected.

No hunting occurs in areas considered for future telescope construction.

Infrastructure and Cost Considerations

Locating facilities within the Science Reserve in as compact a configuration as is consistent with the technical requirements of the telescopes was a major planning consideration. One indicator of compact development is the distance, and related costs, of extending basic infrastructure, roads and power conduits, to the respective siting areas. Each siting area was evaluated based on the relative costs of extending the needed infrastructure.

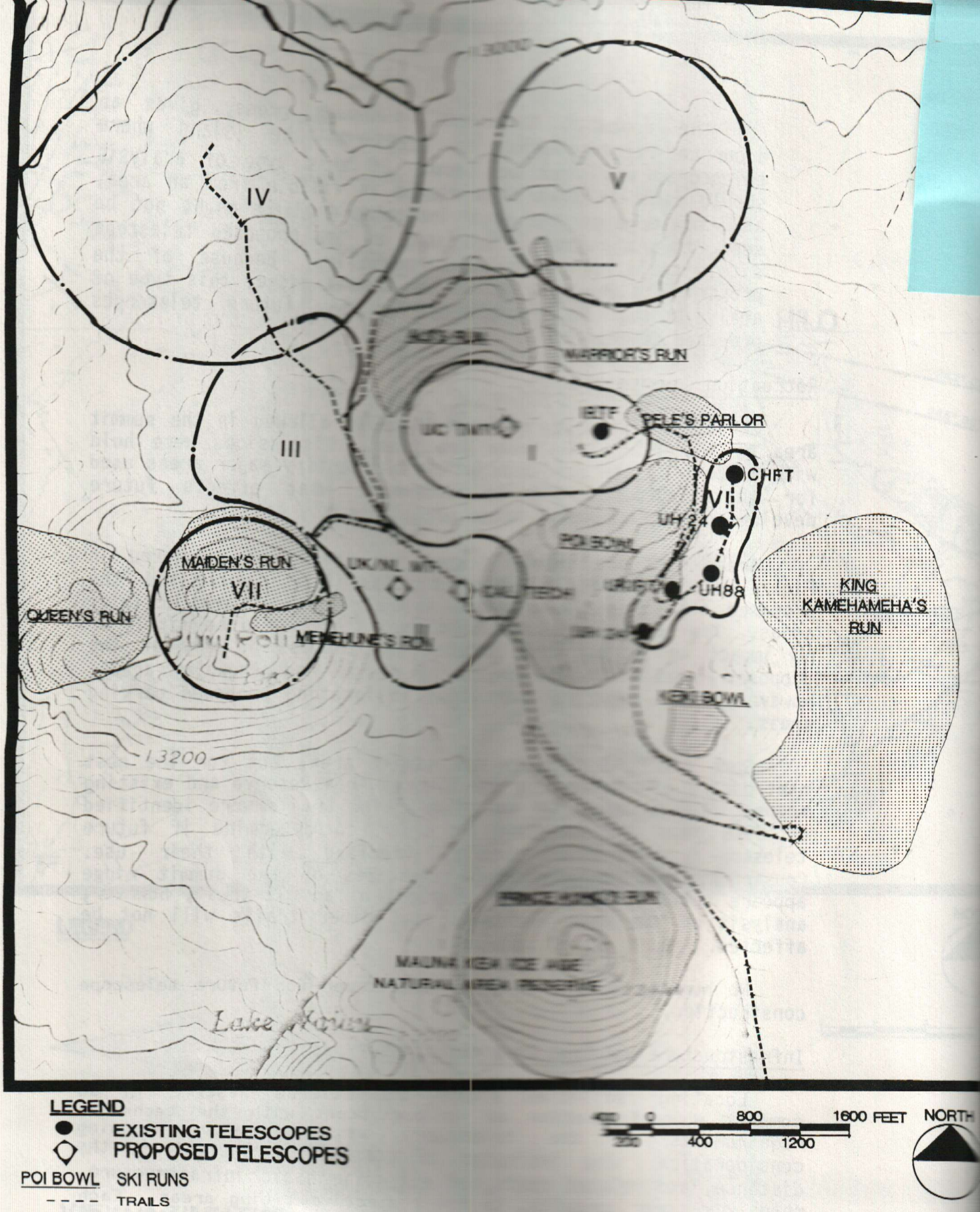


FIG.16

RECREATIONAL USES

Areas IV, V and VII would be the most costly to develop based on this criterion. For example, additional road construction costs (from UK/NL MT boundary) are estimated at $650,000, $700,000 and $700,000, respectively. This is compared to the $246,000 required to improve and pave the existing spur road from the generator to the boundary of the UK/NL MT site. Costs of infrastructure improvements to service additional telescopes in Area I would depend on whether or not a new road would be required.

Each analysis area was rated for suitability for telescope development. The results are as follows:

Area I: This is the proposed location of the UC TMT. Based on technical considerations, it is a prime site for optical/infrared telescopes. If additional telescopes are proposed for the area, it is important that appropriate mitigating measures to control erosion are incorporated into the telescope design. The area is not sensitive botanically, however, it is a prime habitat for the Nysius bug.

Area II: This area was judged to be a suitable location for millimeter-wave telescopes based on the technical and environmental screens. Because of its proximity to existing and planned infrastructure improvements, Area II was recommended as the location for future millimeter-wave telescopes. The analysis area boundary was modified and slightly enlarged in order to allow some flexibility in the choice of sites, for technical reasons.

Area III: This area was also judged to be a suitable location for millimeter-wave telescopes, based on technical and environmental screens. Its proximity to archaeological sites, however, made it necessary to redefine the boundaries of the area to insure that these features would not be disturbed. Because of the additional costs to extend the access road, Area III was rated secondary to Area II for future telescopes.

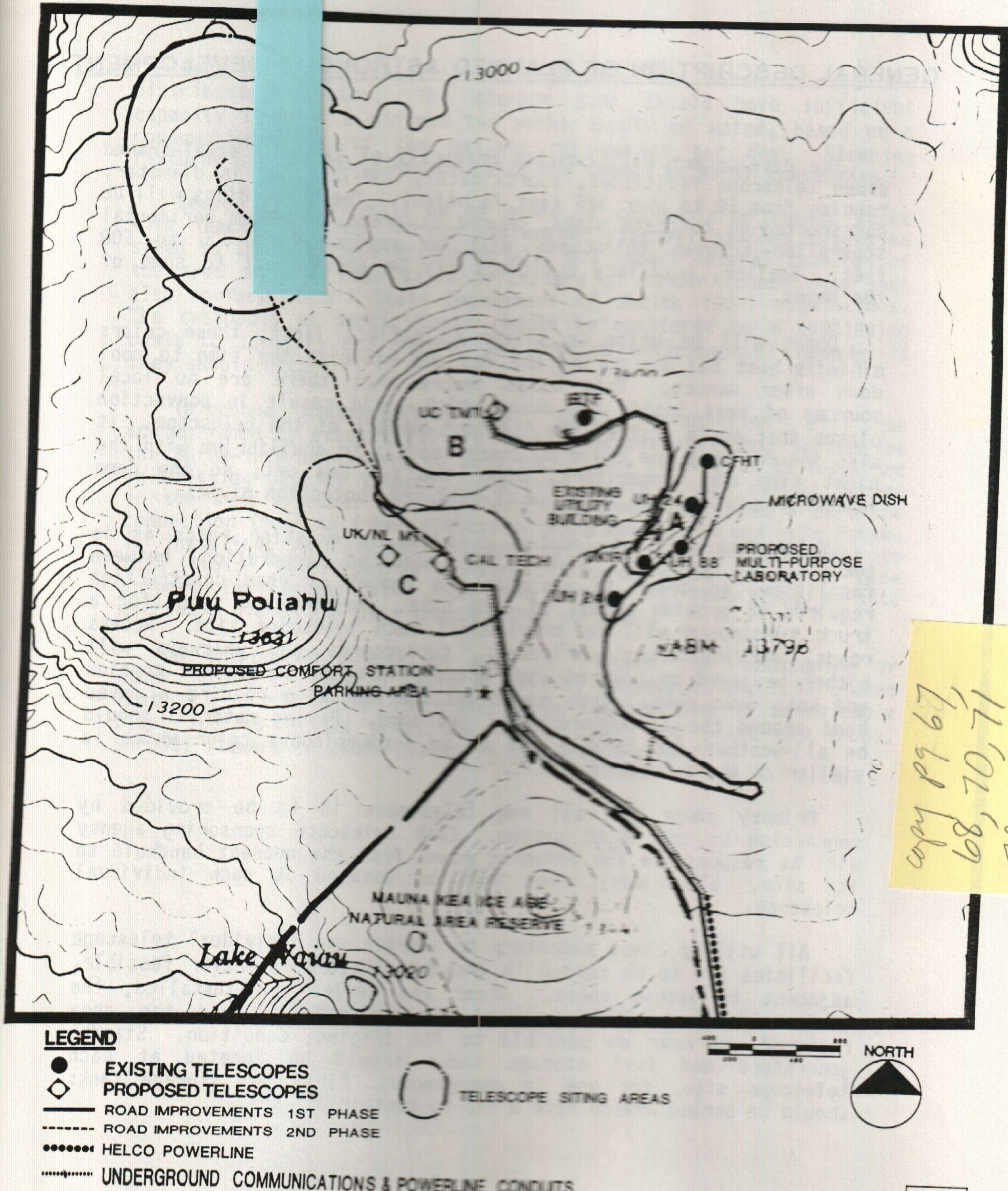
Area IV: This area is a highly suitable location for future optical/infrared telescopes. As a result of the screening process, the analysis area boundary was adjusted in order to incorporate the flatter areas and to avoid some archaeological sites. The area can accommodate 3-to-4 telescopes with some flexibility in choice of sites based on technical site selection criteria. Because the area has been identified as sensitive for lichens, care should be taken to protect the flora when future sites are selected. Construction in the area will require extension of the existing spur road and proposed utility conduits.

Area V: Analysis of the area revealed that only certain sections were technically and environmentally suitable for telescope construction and that the most suitable locations were farthest away from existing development. Area V should only be considered for future telescopes if the technical requirements of a specific facility indicate that it is the only suitable location.

Area VI: Area VI, the summit ridge, is already disturbed; additional damage to the environment from telescope development would be minimal. The area meets all technical locational requirements and the infrastructure is already in place. The major limitations of the area are lack of space for additional telescopes and the visibility of the area from developed areas on the Island of Hawaii.

Area VII: Because of lack of information on wind conditions and because it is presently used for recreation purposes, Puu Poliahu is not recommended for development within this plan.

Based on the results of the screening process, and considering the specific siting requirements of each class of telescope, four areas were selected for future telescope development. These areas are large enough to allow flexibility in the siting of individual facilities, while still encompassing the minimum area required to allow a reasonable selection of sites for the planned additional seven telescopes. These recommended siting areas are identified as A, B, C and D on Figure 18. (Formerly identified as VI, I, II and IV respectively).



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PROPOSED PHYSICAL PLAN FOR THE SUMMIT TO YEAR 2000

MAUNA KEA SCIENCE RESERVE CDP FIG 10

GROUP 70

GENERAL DESCRIPTION OF PLANNED ASTRONOMY DEVELOPMENT

The development will consist primarily of thirteen steel-framed domed telescope facilities, approximately 100-125 feet in diameter, ranging from 60 to over 125 feet in height. These buildings will be constructed on concrete slabs, poured at grade. Minimum horizontal separation between telescopes will be approximately 300 to 500 feet. Smaller, auxiliary buildings may be appurtenant to some of the domes.

Domes will be white or silver to reflect light; these colors minimize heat buildup during the day and minimize the time to cool down after sunset. This helps insure that there are no local sources of heat inside the domes which could result in convection plumes that could destroy the "seeing" quality of the telescope. It also insures that the building comes rapidly to equilibrium with the night time air temperature, after the sun has set, so the dome itself does not become a source of heat and convection plumes.

Telescopes will be located as close to existing roads as is technically feasible, given the required separation between facilities, in order to minimize the amount of road construction required to provide access to each site. Parking and space for a truck turnaround will be provided at each telescope site. Access roads, parking areas, driveways, turnarounds and walkways will either be paved or covered with gravel, in order to prevent erosion and keep down dust. Each new telescope may also require a paved band around the circumferance of its dome. Paving material should be all-weather and durable and of an inconspicuous color which is similar to the surrounding soil.

Primary power for all new telescopes is to be provided by connection to the HELCO system. Each telescope sponsoring agency will be responsible for bringing power from the nearest handhole to its site. Electricity usage will be metered at each individual telescope.

All utility lines necessary to service the individual telescope facilities are to be buried in trenches located, wherever feasible, adjacent to access roads. After the cables are installed, the trenches will be filled with selected material and the area restored, as near as possible to its original condition. Standby generators and fuel storage tanks should be located at each telescope site, for use in emergencies. The fuel storage tanks should be buried and/or have a lip to contain oil spills.

Each telescope facility must provide for water storage and distribution on-site. The storage tank should have sufficient capacity to hold a minimum two weeks supply of water, based on a consumption ratio of ten gallons per person per day. Plumbing fixtures within the telescope buildings should be water conserving.

Sewage disposal will be by means of cesspools or septic tanks with leaching fields. These wastewater disposal systems should be sited so that effluent discharge will not impact natural features of the area such as Lake Waiau or craters of cinder cones; they must also conform to all State Department of Health (DOH) regulations. The cesspools or septic tanks should be monitored on a continuing basis to identify and control any adverse environmental impacts if they should occur.

Telephone communication and data transmission will be accomplished by extending lines from a microwave system, located at the UH 88-inch telescope, to each site. The lines will be installed in existing utility trenches, wherever possible, and can be buried in the same trenches as the electrical conduits. When a hardline connection (such as fiber optics) between the summit and Hale Pohaku is installed, each telescope facility will be able to connect to this link. Telescopes with direct line-of-sight to their base support facilities, also have the option of installing on-site microwave dishes for data transmission purposes.

No introduced vegetation will be allowed for landscaping or other purposes. General Lease No. S-4191 between UH and BLNR states that . . . "in order to prevent the introduction of undesirable plant species in the area, the lessee shall not plant any trees, shrubs, flowers or other plants in the leased area."

PLANNED TELESCOPE SITING AREAS

Area A - Western Rim of Puu Wekiu

Description

Area A (elevation 13,700 feet to 13,750 feet) is located adjacent to Puu Wekiu (13,796 feet), the highest point in the Pacific. Three major telescopes (UH 88-inch, UKIRT, and CFHT) and two smaller (24-inch) telescopes are located there. Experience has proven that sites along this ridge are superior, in many respects, to other astronomical sites in the Northern Hemisphere. The area experiences an especially smooth and laminar flow of air in normal circumstances, resulting in exceptionally steady optical images, making it an exceptionally fine site for optical/infrared telescopes. Because of its location on top of cinder cones, viewing is free from obscuration by natural and man-made features of the mountain. A Hawaii County lighting ordinance (Bill No. [illegible]), which calls for shielding and filtration of outdoor light on the Big Island, has eliminated the potential problem of spurious sky light from developed areas.

Development Considerations

This area is situated on cinder cones. The cinder cones are composed of volcanic ash and cinder which have locally been weakly cemented to varying degrees and may be interbedded with other volcanic materials such as spatter, volcanic bombs and other ejecta. The ash and cinder frequently are loosely packed and have low densities. They exhibit low crushing strength and high permeability. Natural angles of repose tend to vary between about 34 and 45 degrees, depending upon grain size distribution and apparent cementation. The slopes of the cinder cones tend to be somewhat flatter than these inclinations.

Because it is already developed, the area is not sensitive botanically; there are also no known archaeological sites which could be affected by further development. The areas to the north and west of the ridge and the steep slopes of Puu Wekiu are habitat for the Nysius bug. Care must be taken during construction activities to insure minimal disturbance to this habitat.

Although essentially fully developed, this area is a prime site for a future major optical/infrared telescope. When the State receives a request for such a telescope, consideration should be given to moving one of the two UH 24-inch facilities to another location. If technically suitable, the site now occupied by the UH/NASA Planetary Patrol (between the UH 88-inch telescope and CFHT, Figure 18) would be the most environmentally suitable of the two sites as a location for a major facility. Construction on that site would be less likely to adversely impact the undisturbed areas of Puu Wekiu.

Area A is served by the summit access road which should be paved in the near future. Power to service a new facility in Area A would be via the existing electrical distribution system at the summit. Although the cables may have to be upgraded to service the increased needs of a major facility, the new conduits could be laid in the existing trenches. Communications can also be accomplished by connection to the existing system.

Multi-Purpose Research Laboratory

It is expected that the UH will continue to receive requests from local, national and international organizations to conduct research (which does not require the use of a telescope) at the summit on an intermittent basis. At the present time, there is no facility available that can be used primarily as a laboratory for these scientists. The current practice is to borrow space within the UH 88-inch telescope building; this space is not always adequate and is frequently unavailable at the times that it is requested.

A simple metal laboratory of approximately 200-to-300 square feet may be added to the existing utility building, located between the UKIRT and the UH 88-inch telescopes in Area A. The building should be oriented so that its north-south viewing axis is not obstructed by the existing telescope buildings. Parking could be shared with the UH 88-inch facility.

The building should be constructed at grade on a concrete slab. It should have a roll-back roof (not a dome) so that open-air experiments can be conducted at the site.

The interior of this laboratory should contain spaces for work and minimal storage. The building should have electricity and heat, however, plumbing is not necessary as the scientists using the laboratory can use the facilities in the UH building. A low single-story building will not be visible from areas outside the Science Reserve.

Area B - Puu Hau Oki

Description

Area B (elevation 13,500 feet to 13,650 feet) is located to the west and north of Area A. The NASA Infrared Telescope Facility (IRTF) is located there and the University of California plans to construct its ten-meter telescope (UC TMT) approximately 850 feet to the west of the NASA facility. Tests have shown that this area experiences a smooth and laminar flow of air in normal circumstances and viewing of the southern horizon is free from obscuration. One or more additional major optical/infrared telescopes can be accommodated in Area B, depending on the sites which are selected.

Development Considerations

The geologic characteristics of this siting area are similar to Area A, cinder cones composed of volcanic ash and cinder. Competent rock may exist at depths shallow enough to provide support for deep foundations. Because the density of this material is frequently very low, foundation loads may also need to be low to avoid significant amounts of settlement. Borings and soils analysis will be required in order to determine specific conditions at each proposed telescope site.

Because cinder cone material is highly erodible, any construction in this area will require drainage improvements in order to insure that surface runoff is not concentrated and is allowed to percolate into the ground. In problem areas, such as steep grades, drainage improvements such as paved ditches and dry wells under catch basins may be required.

The area is not sensitive botanically; the cinder material is an unsuitable substratum for most plants due to cinder instability and high porosity.[26] The area is, however, a prime habitat for the Nysius bug; design and construction of facilities in Area B must recognize this fact and must minimize disturbance to the surrounding area. There are no known archaeological sites in Area B.

At present, the summit access road terminates at the IRTF site. The University of California proposes to extend this road to service its planned telescope. If required, extension of the UC TMT access road would be the most appropriate means to serve one additional telescope site within area B. If a third and fourth telescope should locate there, consideration must be given to construction of a new access road along the south slopes of Puu Hau Oki, from the spur road which services the Caltech and UK/NL MT sites to a point at the top of the cinder cone west of the UC TMT site. (This option is discussed in the section on road improvements). In order to minimize disturbance to the area, roadway construction must be the minimum necessary to provide access to each site.

Power to service each new facility in Area B would be via an extension of the existing electrical distribution system at the summit. Communications can also be accomplished by connection to the master system located at the UH 88-inch telescope. Trenches for both electrical and communications conduits must be constructed as close as possible to access roads.

Each individual telescope facility that locates in Area B must provide for water storage and distribution and wastewater disposal on site. Water storage tanks and cesspools or septic tanks with leaching fields should be sited so that their construction and use will not disturb the inside slopes of the Puu Hau Oki cinder craters.

University of California 10-Meter Telescope

The University of California 10-meter telescope (UC TMT) will be the largest and most powerful optical/infrared instrument in the world. When operational, it will be able to produce images of unprecedented clarity and detail. It will be able to detect faint distant objects so far away that their light has been on its way since the beginning of time. In addition to being able to look farther back toward the beginning of creation, the telescope will allow closer objects to be studied in much greater detail and precision than is possible with existing instruments. For example, the telescope will be able to observe new stars in development or see new solar systems being born. This telescope will contribute to the establishment of new theories and understanding about the Universe. It will aid in the discovery of new objects and deep-space phenomena and it will challenge some of the most strongly held theories of science.

The University of California has applied to the UH to locate this telescope in Area B, on a cinder cone approximately 850 feet directly west of the IRTF, at an elevation of 13,618 feet. Although the telescope mirror will be twice the diameter of the largest optical telescope in the US (400 inches compared to the 200-inch Hale telescope on Mt. Palomar), its design (36 computer-controlled mirror segments, rather than one very large mirror) permits housing in a relatively small, cost-efficient dome, approximately 103 feet in diameter and 124 feet high (similar in size to CFHT). The dome will not be visible from Hilo, however, it may be seen from some areas in Hawaii Volcanoes National Park, Waimea and South Kohola.

The dome will be 24-sided, spherical in shape, and composed of 15-degree segments radiating from the top. It will be mounted on a precision-ground steel rail fixed to the building ring girder. Dome rotation will be accomplished by two electric motors. The dome will include four shutters which are to be moved by a cable drive and guided by cam followers.

Aside from the telescope, the interior of the dome will also contain a control room, computer room, coude room, equipment and storage room, aluminizing room, engineering and document room, visitors' gallery, pump room, relay room, heat and ventilation room, transformer room, auxiliary power room, darkroom, data preparation room, instrument assembly room, restrooms, three small offices, small electronics and machine shops, and mirror maintenance room.

Within the summit, access to the proposed telescope will be via an extension of the road which now terminates at the IRTF. The telescope building has been sited to allow the access road to arrive on the southerly side. The road is proposed to be located along the flatter slopes of the cinder cone, in order to minimize earthwork. Its location was also affected by the general or prevailing wind direction. Because of the high erodibility of the tephra cinders, the road will be surfaced with asphaltic concrete paving over an aggregate base material. Drainage improvements will be incorporated into the road design.

A paved parking area for 8 cars will be located midway between the entry walk and the service entrance to the buildings. A paved band around the circumference of the telescope may also be required. A truck-size entry will be located directly in line with the service entrance; space will be provided for a truck turn-around area.

A 10,000-gallon water tank (4-to-6 week supply) and a 2,000-gallon diesel fuel storage tank will be located below grade at the terminating point of the truck manuvering space. The fuel storage tank will have adequate capacity to run a stand-by 300 KW - 500 KW generator for 48 hours. A tunnel, approximately 60-to-70 inches in diameter, will be constructed to convey unwanted warm air to a point approximately 130 feet north of the telescope building.

Sewage disposal will be by means of a 2,000-gallon capacity septic tank, also constructed below grade. The septic tank will be reinforced concrete or similar material to prevent leakage. Effluent will be disposed of through an on-site leaching field. This leaching field will be sited away from the adjacent cinder cone crater in order to insure that the inner slopes of the environmentally sensitive crater, habitat of the Nysius bug, are not disturbed.

The telescope will require an average 265 KW (500 KW peak) of electrical power. This will be supplied by the HELCO transmission line. Underground conduits will be extended from the transformer, located at the UH 88-inch telescope, to the site. Communications conduits will be buried in the same trench.

Because the soils in the area are highly erodible, grading for the road and site will be designed so that surface runoff is not concentrated and is allowed to percolate into the ground. Drainage improvements, such as paved ditches and drywells under catch basins, will be constructed in problem areas, such as steep grades.

Twelve to fourteen people will be present at the telescope site in two shifts. Telescope personnel will use 4,500 to 9,000 gallons per month of water for heating, cooling and domestic consumption and generate 3,000 to 6,000 gallons per month of liquid sewage. Six to seven round trips per day from Hilo and Hale Pohaku will be generated by telescope personnel and service vehicles; an unknown number of trips is expected to be generated by visitors who wish to see telescope. (A visitors' gallery will be located within the telescope building).

Construction of the dome and telescope is expected to last four years, commencing in 1984. Total project costs are currently estimated to be approximately $62 million, of which about one-third is expected to be expended on the Big Island. Funding for the project's capital expenditures will be from University of California sources.

Area C - Saddle Between Puu Wekiu, Puu Hau Oki, and Puu Poliahu

Description

Area C, elevation 13,300 feet to 13,400 feet, is a relatively flat area approximately 450 feet lower than the summit cinder cone (Puu Wekiu). Because this area is shielded from the wind by surrounding cinder cones, it is an ideal location for millimeter-wave telescopes. The California Institute of Technology 10-meter telescope for millimeter and submillimeter astronomy (Caltech) and the United Kingdom/Netherlands 15-meter millimeter-wave telescope (UK/NL MT) are programmed for development there. There is sufficient area to allow construction of one or two additonal telescopes of this type in the future.

Development Considerations

The area is situated on lava flows which consist of massive andestite, generally of the variety called Hawaiite. The flows are of the aa type and tend to be on much flatter gradients than the cinder cones. Glaciation has both removed the uppermost clinker material from the lava flows and deposited glacial debris on top of the flows, therefore, assorted rocky soil cover, up to several feet thick, exists in places. The lava flows are not affected by surface runoff. They may, however, concentrate runoff because of density and general impermeability of the rock. The lava flows will provide excellent foundation support; the rock will be able to support any loads likely to be imposed by telescopes.

Area C is not sensitive botanically. Although there is a general homogeniety of the lichen communities over most of the Science Reserve, there is a distinct paucity of species in this area, due possibly to the rainshadow effect of the surrounding cinder cones.[27]

The area is the habitat of the moth Archanarta, the spider Lycosa species and the centipede Lithobius; they are common in this location. Except for dust and pollution problems, this habitat is less vulnerable to human impacts than are the tephra cinder cones (Area B).[28] Construction in the area will not require specific biological mitigating measures other than minimizing dust.

There are two archaeological sites located approximately 450 feet south-southwest of the Caltech site. These features are classified as "shrines", as a convenient term to designate a simple altar without a prepared court.[29] Telescopes should not be located on or in close proximity to these features.

Access to sites within Area C will be via a spur road which branches off from the main summit access road at approximately the 13,000-foot elevation. This road should be improved and paved to the northern boundary of the UK/NL MT site. If a future telescope should locate north of this boundary, the road improvements and paving should be extended to service the new site.

Power will be distributed to sites in Area C via a buried conduit, extending from a connection with the HELCO system, at approximately the 13,040-foot elevation, to the entrance of UK/NL MT site. If additional telescopes locate in the area, the utility trench must be extended to the boundary of northernmost site. Construction of this system and on-site electrical distribution systems is the responsibility of the individual telescopes.

Telephone communication and data transmission should be accomplished by extending a line from the microwave system, located at the UH 88-inch telescope, to each telescope site. This line should be installed in the existing utility trench which runs approximately 1,600 feet along the slopes of Puu Wekiu to the 13,040 foot handhole. From this handhole to each telescope site, the conduit should be buried in the same trench as the power conduits. Handholes for allowing access to the communications conduits are required at intervals of 400 feet. Those along the existing utility trench can be installed adjacent to those already in place.

Each individual telescope facility that locates in Area C must provide for water storage and distribution and wastewater disposal on its respective site. Cesspools or septic tanks with leaching fields must be sited so as to insure that there is no possibility of effluent reaching Lake Waiau. If possible, these septic tanks should be located on the north side of the summit where effluent will tend to flow northward, away from Lake Waiau.

Two telescope facilities have selected sites in Area C, they are:

<u>California Institute of Technology 10.4-Meter Telescope for Millimeter and Submillimeter Astronomy</u>

The California Institute of Technology (Caltech) 10.4-meter telescope will operate in that part of the electromagnetic spectrum called the submillimeter, which lies between the radio and infrared bands. Submillimeter wavelength astronomy is a field which is emerging in the 1980s, promising to be a major contributor to both galactic and extragalactic science. It covers one of the few unexplored regions of the astronomical electromagnetic spectrum; unexplored because of the attenuating effects of the earth's atmosphere and the difficulties involved in constructing large telescopes to high accuracy and sensitive receivers at high frequencies.

Until now, submillimeter research has been carried out either with radio telescopes used somewhat above their optimum frequency or with optical telescopes, which are relatively small for submillimeter wavelengths. Recently, however, it has become feasible to construct large radio-style telescopes which will attain diffraction limited performance in the submillimeter. The development of an instrument capable of studying the submillimeter band has opened a whole new field of inquiry for astronomers. The telescope provides a new way to investigate the astronomical environment in regions inaccessible to optical methods because of extinction. When used as a continuum instrument, the telescope will effectively double the frequency range that is now available to radio astronomy.

Although astronomers know that stars are formed within dense patches of gas in the galaxy, the detailed processes by which the gas increases its density even further to form a condensation of particles which become the star and its planets, remain to be discovered. The best way to investigate these processes is by the study of the emission of radiation from the gas. Study of the submillimeter band will also be the only way to observe the characteristic emission lines of many of the most important molecules and atoms that make up gas patches. The telescope will encourage qualitatively different projects, which have heretofore been impossible because of the lack of instrumental sensitivity.

The submillimeter band is only available for study on a very high and very dry mountain, such as Mauna Kea, because the water vapor in the earth's atmosphere absorbs the radiation emitted by celestial objects in this wavelength region. The extremely dry air of Mauna Kea and its lack of sky "noise" make it especially well suited for submillimeter research.

The telescope will be constructed on a 0.75-acre site in Area C at approximately the 13,360-foot elevation. It will consist of a 10.4-meter dish-shaped reflector housed in a 60-foot diameter dome. The dome will rotate on circular rails at ground level. It will be a slotted aperture astronomical dome having the external appearance of a truncated sphere. The dome has been designed to fit around the telescope with minimum clearance and will also be able to open to clear the full aperture at all opening angles. It will have two movable shutter doors; a spherical top-cap which will roll on rails toward the rear of the dome; and, a front door shutter which will roll up and over the dome, nesting between the top-cap and the rear dome surface.

The interior of the dome will be fitted with four floors. These structural components will considerably increase the stiffness of the dome while providing adequate working space. A reinforced concrete footing will incorporate the telescope pad, the circular rail bed, and any needed subsurface facilities. The footing will be about 40 to 50 feet in diameter, with a six-foot wide circular apron-walkway joined to the outer edge.

The facility plans include a 6,000-square-foot paved parking area with truck access and turnaround. A 14-by 30-foot paved driveway will provide access to the telescope site from the existing spur road. A 10-foot wide band around one-half the circumference of the building will also be paved.

The telescope requires an average of 15 KW of electrical power with a 60 KW peak demand. These power needs will be met initially by the existing 850-KW generator, located nearby at the 13,000-foot elevation. Power will be distributed to the site via a conduit buried in a trench running approximately 1,300 linear feet alongside the spur road from the generator to the telescope. Connection to the future HELCO system will be provided through the same ducts.

An estimated five to seven people will be present on the mountain at one time, operating in two shifts at the telescope site; including visiting astronomers, engineers and technicians. These personnel are expected to use approximately 60 to 120 gallons per day of water for heating, cooling and domestic consumption. Sewage effluent discharge is estimated at 40 to 80 gallons per day into either a cesspool or septic tank with leaching field wastewater disposal system. The disposal system should be monitored regularly to insure that there is no leakage that might affect Lake Waiau.

Caltech has selected Hilo as the location of its base support facility. Construction of the Caltech telescope is expected to begin in 1983, becoming operational in 1985 or early 1986.

United Kingdom/Netherlands 15-Meter Millimeter Wave Telescope

The United Kingdom/Netherlands millimeter-wave telescope (UK/NL MT) is being developed by the Science and Engineering Research Council of the United Kingdom (SERC) in collaboration with the Netherlands Organization for the Advancement of Pure Science (ZWO). It is a very accurate radio telescope, designed to operate through the millimeter and into the submillimeter wave-band.

Detailed information about the cold material in the universe, particularly the enormous clouds of interstellar molecules and dust, will be obtained by observing at millimeter wavelengths. This material, its distribution, and the identification of molecules and their excited states, will provide clues on star formation and the recycling of enriched material produced by earlier generations of stars. An important long-term objective of the telescope is to understand the way galaxies have evolved to reach their present condition.

Millimeter-wave studies of nearby galaxies will give a global view of molecular clouds and, through spectral measurements, the dynamics of galaxies themselves. Of special interest is the galactic center which is rich in molecular species and difficult to study at other wavelengths. In addition, the study of molecules in the space between stars will result in a better understanding of their formation and destruction.

Compact radio sources emit synchrotron radiation. By monitoring these systematically, information from active galactic nuclei close to the ultimate energy sources can be obtained. Other objects, like old stars which eject shells of matter, are also strong emitters of millimeter line spectra; the millimeter-wave telescope will allow mass loss and dust formation be studied. Millimeter-wave observations will facilitate the understanding of the origin of microwave background radiation, a remnant of the earliest phases of the universe. Solar system observations will give new information about the surfaces of planets and their satellites and about the lower atmosphere of the sun itself.

The 15-meter diameter telescope, consisting of a dish-shaped reflector mounted on horizontal and vertical axes, will be situated within Area C on a 2-acre site, north-northwest of the Caltech facility, at the 13,390-foot elevation, near the base of Puu Poliahu. The telescope will have a cylindrical enclosure (carousel) with a flat roof for protection from the severe weather conditions at the summit. This carousel will be about 92 feet in diameter and 88 feet high. It will be mounted on a circular track and rotate with the telescope. The carousel and the telescope will be mounted on independent foundations.

The main front doors and the roof shutter of the carousel will open to enable the telescope to either view the sky directly or through a protective membrane, transparent to millimeter waves. When closed, the main doors and roof shutter will provide a seal against storm conditions.

Aside from the telescope, the interior of the carousel will also contain a computer/control room/office and workshop. A reinforced concrete footing will incorporate the telescope pad, the circular rail bed, toilet and washroom facility, 1,000-1,500-gallon watertank and batteries to provide standby power for the door, roof and carousel. Sewage disposal will be by means of an on-site 150-gallon capacity septic tank with leaching field or a cesspool.

The UK/NL MT facility will include a paved 66-foot by 38-foot parking area for 4-5 vehicles, with truck access and turnaround. A 224-foot gravel or paved driveway will provide access to the telescope site from an existing spur off the main summit access road. A band around the circumference of the telescope may also be paved.

The telescope requires an average of 105 KW of electrical power with a 150 KW peak demand. These immediate power needs will be met by underground connection to the existing 850-KW generator, located at the 13,000-foot elevation. Future power will be supplied by the HELCO transmission line; at that time additional instrumentation may be added which could increase peak power consumption to 225 KW.

In the period after commissioning, but prior to a transition to remote operations, two people will usually be present at the site on night shift and four on day shift. Water usage at the telescope is estimated to be 600-1,200 gallons per month; 450-900 gallons per month of liquid sewage will be generated.

The telescope will be turned over to UKIRT for operation out of Hilo. Remote monitoring and operating techniques and the joint operation with UKIRT will keep the number of people on the mountain from both facilities to no more than nine at any one time.

Construction of the carousel and telescope is expected to last three to four years. Total construction costs are estimated at $15 million; construction expenditures in Hawaii are currently estimated to be over $4 million. Eighty per cent of the funding for the telescope is being provided by the SERC of the United Kingdom with the remaining 20 per cent from the Netherlands (ZWO). Construction of the UK/NL MT is expected to begin in 1983 with operations beginning in 1985.

Area D - North Shield Area

Description

Area D is an oval-shaped area whose south/southeast boundary (elevation 13,285 feet) is approximately 2,000 feet north/northwest of the UK/NL MT site. Approximately 2,800 feet long and 1,800 feet wide at its longest and widest point respectively, it extends to the 13,000-foot contour at its north/northwest boundary.

A temporary data collection station is presently located in the central portion of the area. Area D is highly suitable for future major optical/infrared telescopes. It can accommodate three to four telescopes, on the flatter portions, with some flexibility in choice of sites based on technical site selection criteria such as laminar wind flow and obscuration.

Development Considerations

Most of Area D lies in the area of Kemolean lava flows; there are no geotechnical considerations to select one specific site over another. Because the eastern boundary of Area D is also the boundary between two lava flows, rock along this line of geological contact is likely to be more broken than elsewhere. Telescopes sites should be located at least 100 feet from this boundary.

The area is characterized by a rich variety of lichens including Pseudephebe pubescens, a newly discovered species found only on Mauna Kea. Construction in this habitat must be carefully planned to minimize disturbance to this rare species of flora.

The arthropods Lycosa, Archanarta, and Lithobius are common in this area. As with Area C, the lava flow habitat is less vulnerable to human impacts than are tephra cinder cones. Construction in the area will not require specific measures to mitigate impacts on these arthropods, other than to minimize dust.

There are two archaeological sites in the northern portion of Area D, one is located between the 13,000-and 13,150-foot elevation and the other at the 13,140-foot elevation, near the terminus of the existing spur road. Both of these features are classified as "shrines" as a convenient term to designate a simple altar without a prepared court.[30] If future telescopes are proposed to be sited on or in close proximity to either one of these features, archaeological mitigation, as specified by the State Historic Preservation Officer, will be required.

Access to sites within Area D will be via the spur road which services the telescopes located in Area C. When future telescopes are planned for this area the road must be improved and paved. A new road will have to be constructed from the terminus of the existing spur road, at the 13,140-foot elevation, if future telescopes are sited north of this point. Power and communications conduits must also be extended from the nearest handhole to each future telescope site. These conduits must be buried; this will require new trenches which should be excavated alongside the access road. Handholes for allowing access to the conduits will be required at intervals of 400 feet. Access roads, power, and communications extensions should be phased in conjunction with the construction of each new telescope. Proration of costs of infrastructure extension is subject to negotiation between the UH and the proposing institution.

Each individual telescope facility that locates in Area D must provide for water storage and distribution and wastewater disposal on its respective site. Because this area is located in the northern portion of the summit, sewage effluent will flow to the north, away from Lake Waiau. No specific siting criteria for cesspools or septic tanks is required.

There are no astronomy facilities planned for development in Area D during the 1980s.

FUTURE PLANNED ASTRONOMY DEVELOPMENT IN THE MAUNA KEA SCIENCE RESERVE

Basic Conditions

Future telescopes (to the year 2000) are to be sited only in the four areas recommended in this Plan (A, B, C and D). Although the specific sites selected within each area will be determined primarily by the technical requirements of the individual telescopes, as far as practical, development must be located so as to minimize the area to be disturbed by construction. Every effort should be made to select sites which require minimum grading and alteration of landform. If alternative sites within an area are equal in respect to technical, physical and environmental considerations, the site which would lead to a more compact configuration of facilities at the summit should be chosen.

The following discussion of future telescopes is based on the assumptions of the UH RDP, that is, the University will receive requests to locate three major optical/infrared and one millimeter-wave telescope within the reserve by the year 2000. As stated previously, because of the uncertainty of these projections, the SRCDP is flexible in that, as long as the number of major telescopes at the summit does not exceed thirteen (11 major and two smaller facilities), any combination of optical/infrared and millimeter-wave telescopes is acceptable.

Optical/Infrared Telescopes

National New Technology Telescope

Mauna Kea is being considered as the location for a proposed 15-meter (600-inch) National New Technology optical/infrared telescope (NNTT) which will probably be funded by the federal government. When operational, this telescope will be the largest in the world, exceeding the light - gathering power of the proposed UC TMT and any other telescope either in existence at the present time or proposed for construction in the near future. The location for the telescope is expected to be chosen sometime in 1986. Construction of the $100 million project will probably be some time in the 1990s, depending upon the availability of federal funding.

The actual dimensions of the dome and auxiliary buildings cannot be determined at the present time because the telescope design is only in the discussion stage. Two major designs are being tested: the first is similar to the segmented mirror concept being developed for the UC TMT, consisting of a 15-meter diameter mosaic of 90 hexagonal mirrors, each 2 meters across; the second concept is a larger version of a multi-mirror telescope (MMT) which began operation in 1980 on Mount Hopkins in southern Arizona; this design would achieve an equivalent diameter of 15 meters with an array of four or six individual mirrors, each 6 meters across. (Each of the six mirrors would be larger than the Palomar 200-inch mirror). The dome needed for either of these designs would probably be larger than the UC TMT (103 feet in diameter, 124 feet high); however, the size of the dome would not necessarily be commensurate with the 15-meter diameter equivalent total light-gathering power of the telescope because each mirror would be considerably smaller than 600 inches.

Because the telescope design has not been finalized, estimates of infrastructure requirements are also preliminary at this time. The UH Institute for Astronomy, however, has made several assumptions in order to facilitate its future planning. Based on the experience of other large facilities, and assuming a certain degree of remote operations, it can be estimated that the telescope may require a minimum three-acre site for construction of the building and dome, auxiliary buildings and parking areas. (In comparison, the land area of the CFHT site is 1.5 acres). During telescope operations, assuming a high degree of remote control, an average 12 to 14 people could be present at the telescope in two shifts. Based on this estimate, the facility would probably use 150 to 300 gallons of water per day for heating, cooling and domestic consumption and generate 100 to 200 gallons per day of liquid sewage.

Power to service the facility, estimated at 500 KW to 1,000 KW peak, would be supplied by connection to the proposed HELCO transmission line. Telephone communications would be by the system in operation at the time of construction.

<u>Other Future Optical/Infrared Telescopes</u>

The plan provides for the development of two additional optical/infrared telescopes of the 10-meter class during the 1990s. Based on the requirements of the UC TMT, each of these facilities would require a site of approximately 2 acres.

Assuming that each telescope will operate with 12 to 14 people on-site in two shifts, water usage for each facility would be 150 to 300 gallons per day. The corresponding amount of sewage effluent discharge would be 100-200 gallons per day per telescope.

Electrical needs of each telescope, estimated at 265 KW each on the average (500 KW peak), would be met by connection to the HELCO transmission line. Each facility would also require a paved access road, the length of such a road would be determined by the proximity of the selected site to the existing summit road network.

Capital costs for projects of this size would be in the range of $60 million (1982 dollars) with approximately $20 million expended in Hawaii for each telescope. Each telescope would probably expend approximately $2.5 million per year in operating expenditures on the Big Island.

Site Selection for Future Optical/Infrared Telescopes

Although further testing by proposing institutions will be required in order to select the most suitable site for each individual telescope, future optical/infrared telescopes should be sited in either Area A, Area B or Area D.

Future Millimeter-Wave Telescopes

An additional single-dish millimeter-wave or radio telescope is planned for development in the Mauna Kea Science Reserve during the 1990s. The dish of such a telescope could range in size from 10 meters (such as Caltech) to over 25 meters (as once proposed by the National Radio Astronomy Observatory [NRAO]).

Using a large telescope (in the range of 25 meters) as an example of the type of millimeter-wave telescope that may be proposed in the future, a 3-acre site would probably be required. Based on previous estimates, and depending on the degree of remote operations that are undertaken, it can be anticipated that a telescope of this type and size would average approximately 8 to 10 people on the mountain at one time, operating in two shifts. Water usage for the facility would be approximately 100-to-200 gallons per day and the corresponding amount of sewage effluent discharge would be 70-to-140 gallons per day.

Electrical needs of the telescope, estimated at 250 KW on the average (500 KW peak), would be met by connection to the HELCO transmission line. The facility would also require a paved access road, the length of such a road would be determined by the proximity of the selected site to the existing summit road network.

Capital costs for projects of this size would be in the range of $30 million (1981 dollars) with operating costs approximating $2 million per year.

Future millimeter-wave telescopes should be located in Area C, where the Caltech and UK/NL MT are programmed for construction.

Other Requirements

Temporary Concrete Batching Plant Site

A 30,000-square foot area, known as the "skier's parking lot", at the 12,700-foot contour is proposed as the site for a temporary concrete batching plant. This site will be used from time to time during the construction periods of the proposed and planned telescopes. Because construction activities will take place in months without snow, use of the area for concrete batching will not conflict with use as a parking area for winter snowplay participants and skiers.

During large pours, aggregate and sacks of cement will be hauled to the site. The concrete will be mixed there and then transferred in ready-mix trucks to the respective telescope sites. No permanent facilities will be constructed. After this phase of the construction process for each of the future telescopes is completed, the contractor will be required to remove all equipment and restore the site to its original condition. This requirement will be enforced.

The proposed batch plant site is currently located within the Natural Area Reserve, however, procedures are being undertaken to remove the site from the NARS.

Communications Facilities

Microwave Link

Additional communications equipment may be installed in order to transmit data from the Mauna Kea summit to Hilo and beyond at data rates in excess of 20 kilobits per second. This microwave link requires a dish antenna eight feet in diameter on Mauna Kea with line-of-sight to Hilo, and a similar installation in Hilo with line-of-sight to Mauna Kea. The antenna is similar to those currently in use by Hawaiian Telephone and by HELCO. The dish would be attached to the UH 88-inch telescope building; it would not be visible from Hilo with the naked eye.

Fiber Optics

Long wavelength fiber optics utilize thin glass strands bound together in a thin cable. Ten of these strands, which have the capability of carrying 3,360 two-way voice transmissions, can be bundled together in a technology is far enough advanced by the time the powerline trenches are excavated (that is, having the capability to handle the data rates required), and the cost is competitive with other communications systems, then a fiber optics cable may be installed in the trench at that time. In any event, a conduit will be placed in the trench with the power conduits so that this communications link can be installed in the future. No regenerators or repeaters are required when fiber optics is used. With a hardline connection between Hale Pohaku and the summit, it may not be necessary to have microwave dishes at both locations.

Satellite Communications Dish

By the end of the decade, it is likely that earth satellite communication relays will become the usual means of long distance high-speed communication. When this becomes a reality, a communications antenna may be installed on Mauna Kea. Because this antenna does not require line-of-sight to sea level, it would be located in Area C, near the proposed millimeter-wave telescopes. It would not be visible from areas outside of the Science Reserve.

The diameter of the communications dish would be approximately 24 feet and its appearance would be similar to antennae used for satellite broadcast reception, such as by cable companies. An example of such a dish is the one sited at COMTEC in the vicinity of the Hilo Shopping Center.

VISITOR FACILITIES

Background

Hunting and other forms of recreational activities within the Science Reserve are specifically provided for in the lease between the UH and the DLNR. The 1977 Mauna Kea Plan also states that winter snow play and skiing will be permitted in appropriate summit areas. Because of the severe climatic conditions, the Science Reserve is not planned to be a major recreation area, therefore, visitor facilities at the summit will be limited to parking areas and toilets. Many of the major telescopes, however, will provide visitors' galleries and will arrange tours to their facilities.

Discussions with representatives of DLNR, the County of Hawaii and interested groups indicated that certain visitor facilities should be considered within the Plan for future development. Parking was determined to be a key requirement, in order to insure that all visitor traffic would be confined to designated areas. The following considerations were incorporated in selecting sites for these facilities: that the area was not a prime habitat for flora and fauna; that the area did not contain any archaeological sites; that the area be located nearby to frequently used recreation areas; and, wherever possible, that the location chosen for these facilities be already disturbed.

Planned Facilities

Parking

A total of five visitor parking areas will be provided along the summit access road and within the summit area. The parking areas will be either paved or have a gravel surface; paved areas will have drainage improvements incorporated into their design.

All visitors will be required to park in the designated areas. The areas were selected because of their proximity to known recreation areas and because most of them are already being used for parking during the snow season.

The proposed parking area within the summit is shown on Figure 18. It consists of a gravel or paved parking area for approximately 50 vehicles near the existing 850-KW generator. (This area is currently being used for this purpose during snow season). This parking area is centrally located in relation to ski runs and snowplay areas. Other parking areas are described in Part VI, Road Improvements.

Trash Disposal

Screened areas, containing covered containers for disposal of trash, will be constructed in the Science Reserve. They will be located adjacent to parking areas.

Toilets

No permanent facilities are specifically programmed for development within the 1980s. It is proposed that a concessionnaire be contracted to provide portable chemical toilets during the skiing and snowplay season. These toilets should be installed adjacent to the parking areas. They should be removed during the summer months.

An area of approximately 1,200-square-feet is reserved for possible future construction of a visitor comfort station in the area now occupied by the generator trailer (Figure 18). When this building is planned it should be designed to have a rustic appearance. It should contain toilets for men and women, a small storage room for security personnel supplies and equipment, and a water tank. The building should have electricity and running water. Heat can be provided by electric space heaters. Toilets should be either waterless or watersaving. The sewage disposal system associated with the toilets should be sited so that effluent flows away from Lake Waiau.

BUFFER ZONE

The unplanned areas of the Mauna Kea Science Reserve are designated as buffer zones to protect installations in the summit area. These areas should remain undeveloped. Recreational uses not requiring facilities will be permitted within the buffer zones; hiking and hunting are two such activities. For safety, and to protect the fragile environment, all hiking should be confined to existing trails.

PART IV:

HALE POHAKU EXPANSION

OVERVIEW

Background

Because the summit of Mauna Kea is 13,796 feet high, it is physically hazardous for scientists, support staff, and construction workers to go directly from sea-level to work at the summit without acclimatizing themselves for a period of time at a lower elevation. For this reason, from the time the UH began construction of its first telescope, Hale Pohaku has been used as a construction camp/astronomy support facility because its altitude (9,200-feet) is ideal for acclimatization purposes.

The newly completed Hale Pohaku mid-level facility, which replaced the temporary structures used since 1968, was constructed to support the six telescopes which were in operation on the mountain in 1980. The three dormitories contain sleeping accommodations for fifty-nine people; offices, kitchen, dining and recreation areas are located in a commons building and shared by all of the users. A maintenance area upslope provides space for the generator, two 40,000-gallon water tanks, open and covered storage areas, and space for minor equipment repairs and other repair and maintenance functions.

A 1,200-square foot visitor reception area and Information Station has been constructed as part of the permanent mid-level facility. This station will serve as both the control point for managing and monitoring the mountain as well as an interpretive center for disseminating information about the man-made and natural features of Mauna Kea. The Information Station contains offices for personnel managing the station, exhibit areas, public bathrooms and parking for 28 cars. The DLNR Division of Forestry is developing an arboretum of flora native to Mauna Kea adjacent to the station.

Two stone cabins and five temporary buildings remain on the mid-level site, adjacent to the new construction. The temporary buildings were originally used by workers who were constructing the telescopes at the summit. Because of delays in developing the permanent mid-level facilities, these buildings were remodeled to serve the needs of astronomers and other telescope personnel working at the summit. The larger of the two stone cabins was also used for astronomy personnel; the smaller cabin has been used by the Mauna Kea Ski Patrol for storage of equipment during the summer months and for overnight accommodations during the ski season. The temporary buildings and the stone cabins are supposed to be returned to DLNR jurisdiction when they are no longer needed for astronomy purposes.

Two 40,000-gallon water tanks are located in the maintenance area of the astronomy facility. Water is trucked to Hale Pohaku from Hilo to replenish the supply. It is estimated that 8,400 gallons of water per day is required to satisfy the needs of the astronomy facility and 3,000 gallons per day for the Information Station. The approximately 30,000 gallons remaining is a reserve for fire flow.

Water requirements for the Information Station were estimated for moderately heavy usage of the toilet facility (100 people per day, 3,000 gallons per day). Currently this water is provided via a pipeline from the water tanks located in the maintenance area of the astronomy facility.

The power needs of the mid-level users are being met by connection to the 250-KW diesel generator which is located in the maintenance area of the astronomy complex. Upon construction of a permanent commercial power transmission and distribution system, the entire Hale Pohaku development will be served by that source. Power is distributed on-site through underground direct-buried cables and concealed conduits and wire systems.

Water at the mid-level facilities is heated by solar power. A field of eighty 3-foot by 8-foot solar panels is located west of the commons building and a 2,000-gallon hot water storage tank is located below the building.

Cesspools for sewage disposal are located adjacent to each astronomy building and the Information Station. The Department of Health (DOH)has approved this method of wastewater disposal.

The permanent mid-level facility and the Information Station are maintained through Mauna Kea Support Services (MKSS), a special division of the Institute for Astronomy run by the Research Corporation of the University of Hawaii. MKSS provides general daily maintenance including cleaning, trash removal and, minor repairs.

Planning Considerations

The major planning guidelines for expanding of Hale Pohaku were:

- Incorporate design criteria from the Hale Pohaku CDP into the development criteria for the expansion facilities;
- Locate structures and activities so that disturbance to the mamane/naio forest ecosystem and the critical habitat of the Palila will be minimal;
- Plan the expanded information facilities so as to minimize conflict between day-time visitors and astronomers who must sleep during the day;
- Minimize the visual impact of the development on the mountain;
- Utilize existing infrastructure wherever possible; and,
- Insure that the facilities will be both water and energy efficient.

Methodology

Estimates of future astronomy needs at Hale Pohaku were based on the UH RDP and an evaluation of future planned telescope development at the summit. A site was then selected which would be in conformance to the planning considerations embodied in the 1980 Hale Pohaku CDP. The primary consideration was to utilize a previously disturbed area so as to minimize impacts to the mamane/naio forest ecosystem and the critical habitat of the Palila. The U.S. Fish and Wildlife Service was requested to give an informal opinion of the area chosen.

Buildings were also identified which would be suitable for housing workers employed in the construction of new telescopes. Expansion of the Information Station and adjacent parking also considered in the

DESCRIPTION OF ASTRONOMY FACILITIES EXPANSION

Astronomy Space Requirements

The projected increase in the number of telescopes at the summit by the year 2000 will generate the need for expansion of the mid-level facilities. Expansion of these facilities was provided for in the Hale Pohaku Complex Development Plan (CDP) which was prepared by the DLNR in 1980. By the year 2000 it is estimated that 61 to 77 additional bedspaces will be necessary to accommodate the proposed and projected new telescopes at the summit. The number of additional rooms required, by telescope, are:

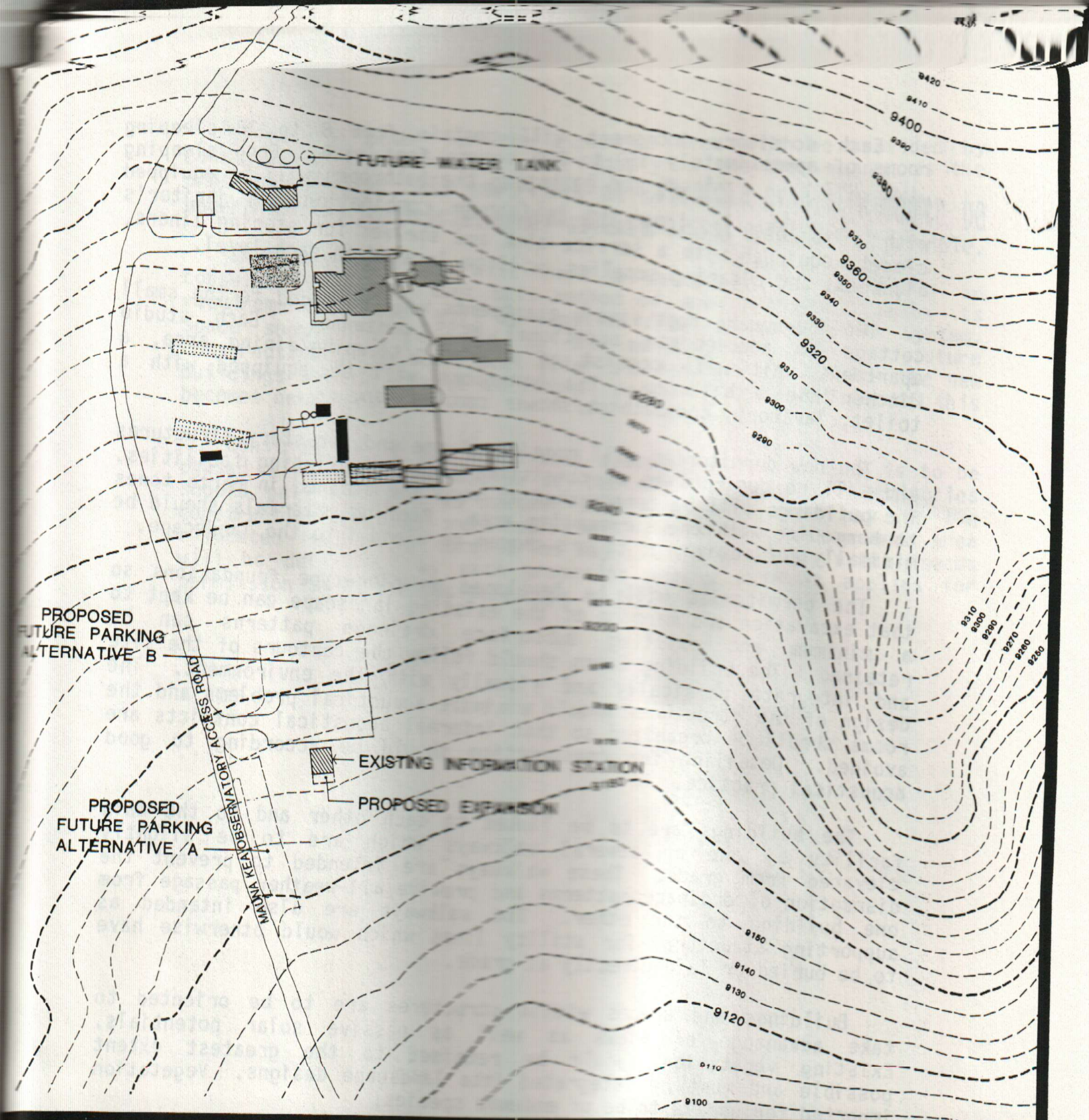
Facility	Bedrooms Required	Years
Caltech	5 - 6	mid-1980s
UC TMT	12 - 14	mid-1980s
Future Millimeter-Wave Facility	8 - 10	1990s
NNTT	12 - 14	1990s
Future Optical/Infrared	12 - 14	1990s
Future Optical/Infrared	12 - 14	1990s
Mauna Kea Support Services	5	1990s
Additional Rooms Required	61 - 77	
HP Capacity - Year 2000	120 - 136	

Expansion Area

The area selected for dormitory expansion (Figure 20) is a previously disturbed area to the east of the existing UH temporary facilities, at approximately the 9,250-foot elevation. If estimates of future dormitory needs are accurate, it is expected that one or both of the UH temporary buildings will be replaced by permanent dormitories in the 1990s. The additional five people added to the MKSS staff can be accommodated in the main area by remodeling and expanding the small cottage. The proposed expansion facilities are sited in areas which will cause minimal disturbance to the critical habitat of the Palila, an endangered bird.

Facilities

The expanded Hale Pohaku astronomy facilities will consist of dormitories to provide sleeping accommodations for telescope personnel and studio apartments to house the additional MKSS employees who will be needed to operate and maintain the facility. Telescope personnel will share dining and recreation facilities with the current users, the research support and common areas will not be expanded.



LEGEND

- NEW MID LEVEL FACILITIES
- EXISTING STONE CABINS
- PROPOSED DORMITORY EXPANSION
- EXISTING TEMPORARY BUILDINGS

100 50 0 100 200

NORTH

GROUP 70
architects
planners
interior designers
924 Bethel St
Hon. Hawaii 96813

HALE POHAKU EXPANSION

MAUNA KEA SCIENCE RESERVE CDP

Each dormitory increment will contain from 8 to 20 sleeping rooms of approximately 150-to-200 square feet each. Each sleeping room will have a closet and bathroom; the bathrooms will be equipped with a toilet, lavatory and tub/shower combination. A janitor's closet, equipped with a service sink and shelves for storing linens, blankets, and cleaning supplies, will be located on each level.

Two 450-square foot studio apartments will be added to the small cottage to accommodate additional MKSS personnel. Each studio apartment unit will consist of a living/sleeping/dining area, a kitchen and a bathroom. The bathrooms will be equipped with a toilet, lavatory, and bathtub/shower combination.

The new dormitories will consist of one and two-story structures and will be designed to be consistent with the existing facilities. The buildings will be constructed of wood and stained in earth tones to harmonize with the surrounding area. Roofing materials should be minimally reflective, in colors chosen to blend into the landscape.

The dormitories will be developed on pier-type foundations so that excavation and marring of the existing landscape can be kept to a minimum and existing subsurface drainage patterns can be retained. The building forms should follow the contours of the site and integrate physically and visually with the environment. The design of the structures should minimize acoustical problems and the rooms should be organized so that internal acoustical conflicts are avoided. Detailing for construction should be according to good acoustical practice.

The buildings are to be linked to each other and to the main facility by one or several walkways which are to be slightly elevated from grade. These walkways are intended to prevent the disruption of drainage patterns and provide all-weather passage from one building to the other. The walkways are also intended as supporting structures for utility lines which would otherwise have to be buried or laid directly at grade.

Buildings and spaces within structures are to be oriented to take advantage of views as well as passive solar potentials. Existing vegetation should be retained to the greatest extent possible and must be integrated into landscape designs. Vegetation imported for use is to be of endemic species.

Parking for the new domitories is available in the area currently serving the UH temporary facilities and the stone cabins. The parking area should be paved and appropriate drainage improvements should be constructed.

Electrical power for the expansion area will be provided by connection to the permanent power supply in the same manner as the present facility. All powerlines at Hale Pohaku should either be underground or constructed under walkways where they are not visible.

Each new building will have a cesspool; the DOH will be consulted to insure that this method of sewage disposal meets its requirements. Water will be supplied from the Hale Pohaku system. Space should be reserved in the maintenance area for future construction of an additional water storage tank to service the new buildings and to provide additional reserve for fire flow, if this becomes necessary.

Construction of the additional sleeping accommodations is to be phased with the construction of the new telescopes. Dormitories should only be built as needed; each user group will pay for the construction of its required rooms. All of the ground area allocated for future dormitories may not be required; actual needs will be determined by each proposing agency when it applies for permission to locate its telescope on Mauna Kea.

DESCRIPTION OF THE INFORMATION, MANAGEMENT AND MONITORING FACILITIES

Information Station

Expansion of astronomy facilities at the summit and paving of the access road may create demands for additional spaces within the Information Station. A small telescope may be installed there for use by the public. The telescope should be available for visitors to use in the daytime and citizen and school groups to view at night.

The Information Station can be expanded by extending the existing building approximately 550 feet in the downslope direction. The building extension should be single-story and be architecturally compatible with the main facility; it should have the appearance of a stone building. If a telescope is located there, the extension should have a roll-back roof to view the sky; no dome should be constructed as it would be incompatible with the appearance of the surrounding area.

Electrical power will be furnished by extending the existing distribution system. If the building is expanded downslope, as recommended, the existing cesspool may have to be relocated. Landscaping should be a continuation of the existing landscape plan.

Visitor Parking Expansion

Parking may have to be expanded to accommodate a greater number of visitors and/or to provide an area where visitors can leave their cars to travel up to the summit in four-wheel drive vehicles, shuttle buses, or on foot. Usage of the parking area should be carefully monitored in order to determine when and if additional spaces are necessary. Two alternative locations for expanded visitor parking are proposed in this plan (Figure 20), they are:

Alternative A - This area extends along the Mauna Kea Observatory Access Road from approximately the 9,160-foot contour to the Information Station driveway. A new entrance off of the County road would have to be constructed in order to provide downslope access to this parking area. The exit could be designed to incorporate the existing Information Station driveway. Expanding the parking area in this location will create a traffic pattern which will allow tourist limousines and shuttle buses to visit the site without having to provide extensive turnaround areas for the vehicles. Mamane trees should be planted along the western edge of this parking area to buffer the parking spaces from the road. Because mamane is a slow growing tree, planting should be commenced as soon as possible, so that the trees will be mature when the parking area is developed.

Alternative B - This area is located upslope of the existing parking lot. Because of its proximity to the proposed dormitory expansion area, it should only be developed if engineering studies indicate that Alternative A is not suitable. Drainage improvements will be required to be incorporated into the parking area design. Vegetation should be planted to buffer the parking area from the dormitories upslope. Existing vegetation to the west of the proposed area should be retained.

Gate

A gate should be installed across the summit access road above the Information Station to control access to the upper slopes of Mauna Kea. This gate should be open during daylight hours. It should be closed at night and when weather conditions make travel upslope hazardous. (The Management Plan discusses control functions of the gate).

CONSTRUCTION CAMP HOUSING

Temporary UH Facilities

One of the temporary UH buildings (adjacent to the large stone cabin) should be used for accommodating construction workers. The building has ten bedrooms and two storage areas. It is currently being used by scientists and other astronomy personnel who are working at the summit. Dining and recreation facilities for construction workers can be accommodated in the other temporary UH building which was formerly a messhall but is currently being used as a research preparation area.

Both UH buildings are electrically lighted and heated and have hot and cold running water and indoor bathrooms. Sewage generated by these facilities is disposed of in a nearby cesspool. Water storage facilities are located adjacent to the buildings.

When the area on which the temporary UH buildings are located is needed for construction of permanent dormitory space, it will no longer be available to accommodate construction workers. When, and if, this occurs, other arrangements for construction worker camp housing must be made.

Stone Cabins

The UH and DLNR are currently discussing the possibility of the University assuming responsibility for the two stone cabins which are currently under the jurisdiction of DLNR Division of State Parks, Outdoor Recreation and Historic Sites. If this transfer of jurisdiction takes place, the large stone cabin can also be used to house construction workers; the cabin can be arranged to sleep 12 people. The cabin is electrically lighted and heated, however, there is no potable water or plumbing available in the building. Water and bathroom facilities are available in the adjacent UH temporary building.

INFRASTRUCTURE AND UTILITIES

Roads and Parking

All driveways and parking areas should be paved with asphaltic concrete to prevent erosion. Drain intakes should be provided in low areas to minimize local erosion. All banks should be stabilized by planting, retaining walls, and/or soil cement.

Electrical Power

Extension of the existing power distribution system to service the new facilities should be through underground direct-buried cables and concealed conduits and wire systems. Wiring should be concealed under walkway systems connecting building and other facilities. Small transformers at individual buildings may be required to step-up or step-down power as demands dictate. Power to service the expanded Information Station can be accomplished by modifying and adding to the existing wiring.

Solar Hot Water

By the year 2000, approximately 40 additional solar panels and an additional 1,000-gallon hot water storage tank may be required by the expanded development. The solar panel field has sufficient space for adding panels; excavation below the commons building will be required to install an additional storage tank.

Water

Astronomy Facilities

An additional 8,400 to 10,780 gallons of water per day will be required to service the expanded astronomy facility. Actual water usage should be monitored closely to determine if the existing water storage capacity might be sufficient to supply these needs by increasing the number of daily water tanker trips. As future dormitories are proposed, the water requirements should be evaluated carefully. It is possible that an additional water tank may be required by the year 2000. There is space available for another 40,000-gallon water tank in the maintenance area.

Additional water requirements for expansion facilities will necessitate additional trips by the water tanker to keep the storage tanks full. Because the water being trucked from Hilo will serve over 25 people, the truck carrier will have to comply with the State of Hawaii Chapter 20, Title II, Administrative Rules, Section 11-20-31 on Use of trucks to deliver drinking water.

Construction Camp Housing

The 2,000 to 3,000 gallons of water per day necessary to fulfill the needs of approximately 12 to 22 construction workers can be provided from the existing water storage tank, located near the temporary UH buildings. This system should be retained until both UH buildings are moved from the area.

Information Station

Actual water usage should be monitored carefully. If visitors to the Information Station increase remarkably additional water may be required. These needs can be met by additional trips by the water tanker until such a time as a new water storage tank is constructed in the maintenance area of the astronomy facility.

Sewage Disposal

Astronomy Facilities

An additional 61 to 77 people at the facility will generate an estimated 3,000 to 3,800 gallons per day of liquid sewage. At present it is planned that a cesspool will be constructed at each new dormitory for sewage disposal. The additional cesspools will be subject to approval by the DOH.

Construction Camp Housing

The cesspool located near the temporary UH building has sufficient capacity to dispose of the 600-to-1,000 gallons per day of effluent generated by construction workers.

Information Station

A cesspool is located near the downslope side of the Information Station. If the Information Station is expanded in the area designated by this Plan, this cesspool may have to be relocated.

Other Requirements

Endangered Species Act of 1973

Hale Pohaku is within the critical habitat of the Palila, an endangered species. Section 7 of the Endangered Species Act of 1973 stipulates that any project funded, authorized, or carried out by a Federal agency which may affect an endangered or threatened species must be reviewed by the U.S. Fish and Wildlife Service. Consultation between NASA and the Fish and Wildlife Service was undertaken during the planning and permitting process required for the existing facilities. If federal funds are involved in the expansion of the mid-level facilities, consultation will again be required between the affected Federal agency and the U.S. Fish and Wildlife Service.

Construction Timing

Construction should not be initiated during the Palila breeding season unless birds are discouraged from nesting in the construction area prior to and continuing into the nest selection, pairing and breeding/rearing period.

Landscaping

As few mamane trees as possible should be removed or transplanted from the project site (planned future dormitories are sited so as not to require removal of any mamane trees).

Landscaping of buildings, infrastructure, and other facilities should consist of vegetation endemic to the eco-system at Hale Pohaku. Mamane trees, U'ulei (Osteomeles), and native grasses should be the primary landscaping materials.

Fire Protection

Fire hose cabinets should be placed strategically throughout the expansion area. A backup system of portable fire extinguishers should also be available for extinguishing minor fires. All new residents of the mid-level facility should be educated in the importance of fire prevention.

The UH has acquired a fire engine; it is based at Hale Pohaku. A volunteer fire brigade, made up of MKSS personnel, is being trained in fire fighting techniques. In addition to protecting buildings, the brigade is prepared to fight brush fires in the surrounding area.

Medical

An appropriately furnished emergency room is located within the astronomy complex. If needed, it can be made available for emergency treatment of visitor injuries and illnesses. An ambulance, located at the summit, can be called on in case of emergency to transport injured or ill personnel to hospital facilities in Hilo.

PART V:

POWER TO THE SUMMIT

OVERVIEW

Background

The need for economical, reliable electrical power to service the summit and Hale Pohaku has been recognized since the initiation of astronomy projects on Mauna Kea in 1966. Continued delays in developing such a system have necessitated the generation of electricity by on-site diesel generators; an interim measure which is an expensive and environmentally unacceptable solution for the long-term power needs of the development envisioned in the SRCDP.

Power to service the existing telescopes at the summit is presently being provided by an 850-KW diesel generator. When the Caltech and UK/NL MT projects are operational, this generator will be operating near its rated capacity. Implementation of the additional telescope projects described in the SRCDP is dependent upon the early development of a permanent power source. Peak power consumption at the summit and the mid-level facility is expected to approach 3 megawatts by the year 2000. Planning for the power source to service both existing and proposed development was directed towards providing a system with sufficient capacity to carry this peak load.

Electricity for the UH 88-inch Telescope and the two 24-inch telescopes was initially provided by a 150-KW generator located in a utility building adjacent to the UH facility. During the early 1970s, in anticipation of future telescope development, the UH requested the Department of Accounting and General Services (DAGS) to develop preliminary designs and assess the feasibility of a system which would allow the Hawaii Electric Light Company (HELCO) to provide power to the mid-level facilities and the summit. This study, prepared by Nakamura, Kawabata and Associates, Inc., was completed in 1974.

The electrical system recommended in the 1974 DAGS study consisted of a 69-KV overhead line from the HELCO source to a substation at Humuula; 12.47-KV overhead lines from the substation to the conduits at the 13,040-foot elevation; and installation of two miles of 12.47-KV lines through existing conduits to the summit. The University intended to ultimately replace the overhead lines, from about the 8,000-foot elevation to the summit, with an underground installation, when additional funds became available. The project was postponed indefinitely because of inability to obtain appropriate funding.

In July 1974, the Canada-France-Hawaii Telescope (CFHT) began construction; the NASA Infrared Telescope Facility (IRTF) and the United Kingdom Infrared Telescopes (UKIRT) followed shortly thereafter. With four major telescopes scheduled to be in operation by 1979, and no funds available for the commercial system proposed in 1974, it was necessary to increase the on-site generation capabilities at the summit, as an interim measure, until a permanent connection to the public utility system was possible.

The UH utility building was expanded in 1978 and the 150-KW generator was replaced by two 250-KW and two 150-KW diesel generators obtained from NASA. After these generators were installed, it became evident that pollutants and heat emitted from them were interfering with astronomical operations, necessitating their relocation to a site downwind of the telescopes. After assessing several alternative locations, a site at the 13,000-foot elevation at the base of the summit cinder cone, was selected.

Before relocating the four existing generators, a decision was made to purchase a new generator of approximately 850 KW capacity. This was accomplished in 1979, and the 850-KW generator is still (in 1983) the primary source of power for the telescopes on the summit.

On-site generation of power has always been considered a temporary solution to the problem of supplying power for astronomy observations. During the planning process that culminated in the 1977 DLNR Mauna Kea Plan, however, staff members of the DLNR and some members of the Hawaii Island community were opposed to the previous D.A.G.S plan which recommended overhead lines as the major component of a commercial power system. This opposition, focused primarily on the issues of aesthetics and control of summit development, resulted in the following policy on power being incorporated into 1977 DLNR Mauna Kea Plan:

> "On-site generators shall be used to supply electrical power for the observatories and support facilities on Mauna Kea. These generators shall incorporate emission control devices so as to reduce air pollution to the lowest practicable level. Alternatively, underground powerlines may be installed. No overhead power lines shall be permitted. The Board may require the use of underground

facilities on land not under the jurisdiction of the Board as a condition of approval. Any installation of generators or powerlines shall be subject to approval under laws relating to the conservation districts."

The 1977 DLNR Mauna Kea Plan allows for amendments when new information becomes available. It states that:

"The (foregoing) plan is conceptual and based on information now available. As data on biotic resources, impact of use, changes in research programs, and new proposals for other uses and management become available, it will become necessary to review the concepts of land use stated in this plan."

Since the adoption of the DLNR Plan in 1977, diesel fuel costs have nearly doubled. In addition, experience has shown that generators are not reliable and that they are subject to mechanical failures. Equipment failures have resulted in oil spills which have the potential of damaging the environment. Underground powerlines are very costly when the distance they would have to be installed (from the Saddle Road to the 13,040-foot elevation of the summit) is considered.

The 1982 Legislature appropriated funds for DAGS to again conduct a preliminary design and planning study for a permanent connection to the HELCO system. The UH directed DAGS to instruct its consultant to evaluate both underground and overhead systems, recognizing the fact that construction of overhead lines would require an amendment to the 1977 DLNR Mauna Kea Plan.

Alternative Energy Sources

Prior to initiation of the preliminary design study for a connection to the HELCO system, alternative renewable energy sources were assessed to determine if their use could help fulfill at least a portion of the projected power requirements. The following analysis is excerpted from a letter report prepared by Art Seki, Hawaii Natural Energy Institute. (The complete report is presented in Mauna Kea Science Reserve Complex Development Plan draft EIS, Volume 2, Appendix N).

"Alternate energy resources at the Observatory are limited to wind and solar. Development of either presents problems. . . . While the summit of Mauna Kea has an obvious wind energy potential, the costs of developing it may outweigh savings for several reasons:

o wind speed variation from zero to 120 mph;