

FINAL REPORT

Archaeological Monitoring Plan In Support of Construction of the Thirty Meter Telescope in the Astronomy Precinct on Mauna Kea, Ka'ohē Ahupua'a, Hāmākua District, Island of Hawai'i, State of Hawai'i

TMK: (3) 4-4-015: 09 (por.)

Prepared for:

TMT Observatory Corporation
1200 E. California Boulevard
Pasadena, CA 91125

May 2013

PACIFIC CONSULTING SERVICES, INC.

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INTRODUCTION

At the request of the Parsons Brinkerhoff, Inc. (Parsons), Pacific Consulting Services, Inc. (PCSI) prepared this Archaeological Monitoring Plan (AMP) in support of construction of the Thirty Meter Observatory (TMT) in the Astronomy Precinct on Mauna Kea (Figure 1). The TMT project area is located within the approximate 525-acre Astronomy Precinct and within Area E on Mauna Kea (Figure 2). The tax map key (TMK) for the Astronomy precinct is: (3) 4-4-015: 09 (por.). The purpose of this AMP is to ensure that: (1) any recorded surface sites or subsurface historic properties that may be encountered during construction of the TMT are documented fully, including an evaluation of significance; (2) appropriate recommendations on what to do with any new finds that are made; (3) and that human skeletal remains, if discovered, are protected in compliance with Hawaii Revised Statutes (HRS), Chapter 6E-8 and Title 13 of the Hawaii Administrative Rules (HAR), Subtitle 13 (State Historic Preservation Division Rules), Chapter 279 (*Rules Governing Standards for Archaeological Monitoring Studies and Reports*) and Chapter 300 (*Rules of Practice and Procedure Relating to Burial Sites and Human Remains*), and in accordance with the Office of Mauna Kea Management's (OMKM's) Burial Treatment Plan (BTP).

The preparation of an AMP and archaeological monitoring of the TMT is also required and authorized in the *Mauna Kea Comprehensive Management Plan* (CMP-Ho'ākea 2009) as well as in its archaeological sub-plan, the Cultural Resources Management Plan (CRMP-McCoy et al. 2009). In the Mauna Kea CMP, two Management Actions require on-site archaeological monitors during construction projects.

Management Action C-5 requires on-site monitors (e.g., archaeologist, cultural resources specialist) during construction (CMP-Ho'ākea 2009:7-51). Thus, an archaeological monitor shall be on-site to monitor any impacts, real or potential, on cultural resources.

Management Action C-6 requires preparation of an AMP to be reviewed and approved by SHPD and subsequent archaeological monitoring during construction projects. In the event that a human burial is inadvertently discovered during construction, the contractor will immediately stop work in the area and contact the State Historic Preservation Division (SHPD), the Office of Mauna Kea Management (OMKM), and the Kahu Kū Mauna (KKM). If an inadvertently discovered burial is determined to be historic in age, SHPD has jurisdiction over its treatment and disposition (CMP-Ho'ākea 2009: 7-51).

OMKM's Burial Treatment Plan (BTP), which will supersede Management Action C-6 when it is approved, indicates that determinations on the treatment and disposition of inadvertently discovered burial sites will be made by the Department of Land and Natural Resources (DLNR) in consultation with the OMKM, the Hawaii Island Burial Council (HIBC), the Office of Hawaiian Affairs (OHA), and any recognized descendants.

In a discussion on inadvertent discoveries in the CRMP, McCoy et al. (CRMP-2009:Section 4.3.2.2; pg 4-45) state that if any historic properties are found (including burial and non-burial sites) in the construction project's area of potential effect (APE-U.H. Hilo 2010a) they will be classified as inadvertent discoveries per HAR 13-280 now that the archaeological survey of the Science Reserve, including the Astronomy Precinct, has been completed. These two archaeological inventory surveys were completed in 2010 (McCoy and Nees 2010; McCoy et al. 2010a) and approved by SHPD.

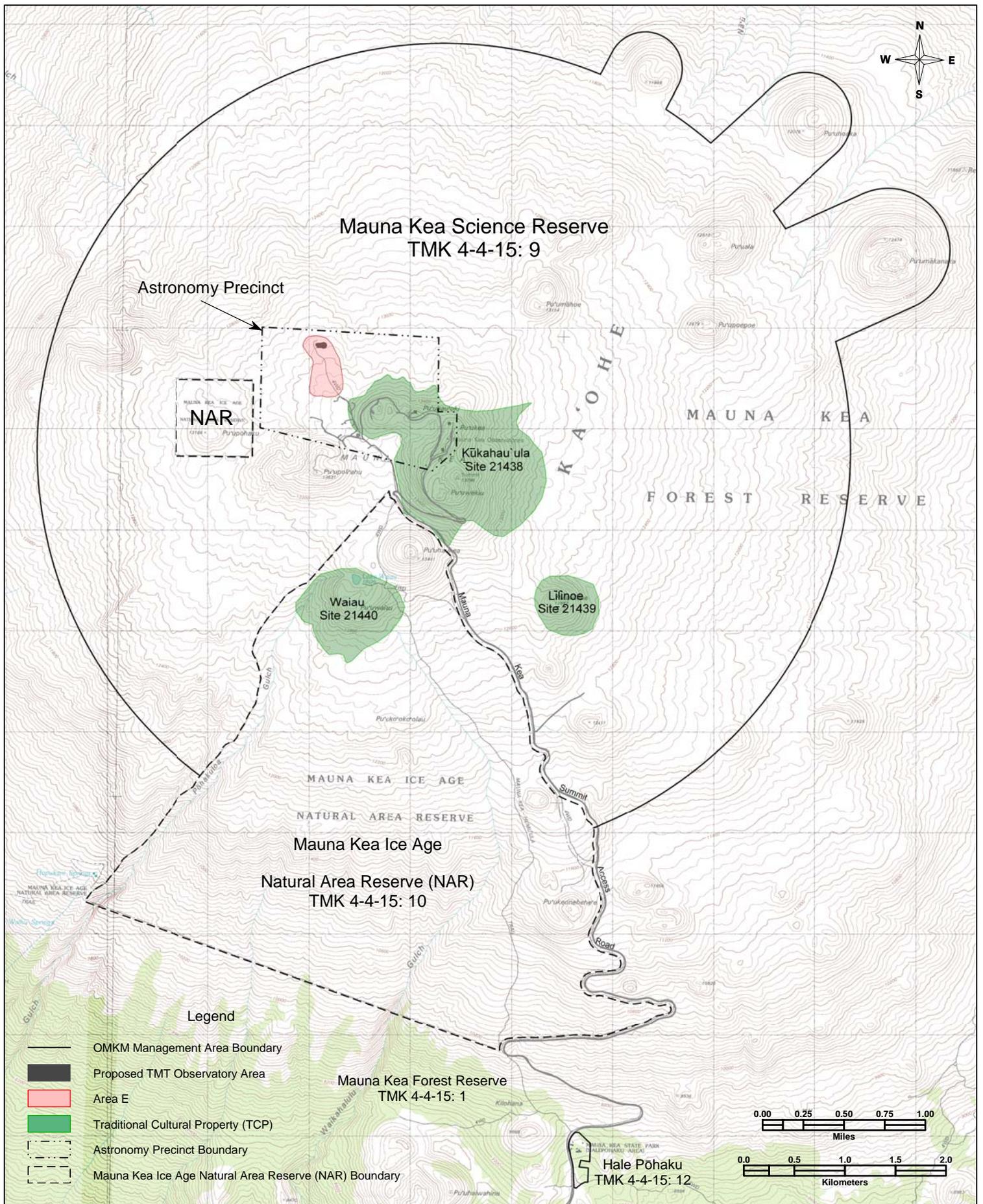


Figure 1. Project Area Location on U.S.G.S. 2002 Mauna Kea and Ahumoa Quadrangles.

It should be noted that, while burials are found on the rims of cinder cones in the Mauna Kea Science Reserve and the adjacent Mauna Kea Ice Age Natural Area Reserve (NAR), they are also found well away from cinder cones in lower elevations in both the Mauna Kea Science Reserve and in the NAR. The nearest burials to the proposed TMT Observatory site in Area E include a possible burial on Pu'u Wekiu, approximately 1.1 miles (1.75 kilometers) to the southeast and several burials on a flattened cinder cone approximately 1.25 miles (2.0 kilometers) to the west of Area E.

The proposed TMT Observatory site in Area E is not located in close proximity to a cinder cone, but the access way is situated along the base of one of the cinder cones located in Kūkahau'ula, a Traditional Cultural Property in the summit region.

PROJECT LOCATION AND DESCRIPTION

The TMT project area is located within the approximate 525-acre Astronomy Precinct on Mauna Kea. The Astronomy Precinct is located within the Mauna Kea Science Reserve within Ka'ōhe Ahupua'a in the Hāmākua District of Hawai'i Island (see Figure 1). The tax map key (TMK) for the Astronomy precinct is: (3) 4-4-015: 09 (por.). The Mauna Kea Science Reserve (TMK: (3) 4-4-15:09) was established in 1968 when the Board of Land and Natural Resources (BLNR) approved a 65-year lease (Lease No. S-4191) to the University of Hawai'i (UH) for a 13,321-acre scientific complex on the top of Mauna Kea. The Science Reserve, which encompasses all of the land above the roughly 12,000 ft elevation, has an average radius of 2.5 miles from the UH 88-inch telescope located on the summit. The boundary on the northeast side of the Science Reserve extends further down the mountain to include Pu'u Makanaka and two other large cinder cones which appear to have been viewed at the time as potential observatory sites. The TMT project's Area of Potential Effect (APE) consists of several component parts, including the observatory site itself, the Batch Plant Staging Area, TMT Access Way, and Hale Pōhaku. Figure 2 shows the locations of the APE components. These are described below.

TMT Observatory

The proposed footprint of the TMT Observatory consists of an approximate five-acre area located in the Mauna Kea Astronomy Precinct, near the end of an existing 4-wheel drive road (see Figure 2). The TMT Observatory will consist of the 30-meter telescope itself, the instruments that are attached to it to record data, the enclosing dome, the attached building housing support and maintenance facilities, and parking lot (U.H. Hilo 2010a). A half-acre of the five acres has previously been disturbed by an existing 4-wheel drive road and an equipment testing site. The TMT Observatory would be located on what is referred to as the 13-North (13N) site in TMT Observatory Site within the Astronomy Precinct of the MKSR. TMT Observatory Site is located about one-half mile northwest of the eleven existing observatories located on or near the Mauna Kea summit.

The Batch Plant Staging Area

The Batch Plant Staging Area is an approximate 4-acre area northwest of where the Mauna Kea Access Road forks to form the Loop Road near the summit (Figure 3; see Figure 2). It is just outside the boundaries of the Astronomy Precinct but within the Mauna Kea Science Reserve (TMK: [3] 4-4-015: Portion 09). The Batch Plant will be used as a construction staging area for temporary storage of building materials and for a concrete batch plant, as it has been during past construction projects (U.H. Hilo 2010a).



Figure 3. Photograph of Batch Plant Staging Area.



Figure 4. Photograph of HELCO Compound Near Hale Pōhaku.

The Batch Plant Staging Area is adjacent to the southwestern boundary of the Traditional Cultural Property (TCP) known as Kūkahau'ula (Site 21438; McCoy and Nees 2010). The Batch Plant area has undergone considerable ground disturbance over the years due to a series of construction-related activities.

No historic properties are known to be present in this area and none has been recorded during previous surveys. The locations of two traditional shrines – SIHP Nos. -16164 and -16165 – were originally recorded in 1982 more than 500 feet west of the disturbed area (U.H. Hilo 2010a); their locations were verified during the survey for the TMT Project (McCoy and Nees 2010; Hammatt 2010).

Hawaiian Electric Company (HELCO) Substation

The third area in which work associated with the TMT construction will occur is at the HELCO Substation (CDUP No. HA-1573, Tax Map Key 4-4-015:01) (see Figure 2). HELCO would upgrade the two transformers within its Hale Pōhaku Substation (Figure 4), which is located approximately 2,000 feet southwest of the main headquarters building at Hale Pōhaku and about 1,000 feet from Mauna Kea Access Road (U.H. Hilo 2010). The new transformers would replace the existing transformers, and the existing fenced compound would not be expanded. Thus, no new ground disturbance is required to implement this upgrade.

In addition to the work within the substation, HELCO plans to upgrade existing electrical service from the transformer compound near Hale Pōhaku to the existing utility boxes across the road from the Submillimeter Array (SMA) building. This will be accomplished by replacing existing wire conductors with new higher-capacity conductors in the existing underground conduits. The new wires would be pulled through the existing underground conduits. The conduits are located approximately 50 feet west of the Mauna Kea Access Road for most of the distance to the summit area; one portion of the power line alignment follows a former access road alignment that is now within the Mauna Kea Ice Age Natural Area Reserve (NAR). Because existing pull boxes are available approximately every 300 feet along the conduit, no new ground disturbance would result from these upgrades, but HELCO would need to access the pull boxes to install the new cable.

Since none of the work at the HELCO Substation or at the existing underground conduits requires ground disturbance, it is anticipated that no archaeological monitoring of these activities will be necessary.

TMT Access Way

Road access to the TMT observatory site in Area E will be provided by improving the existing 4-wheel drive road from the point where it diverges from the existing Mauna Kea Loop Road (U.H. Hilo 2010a). This includes one segment across the base of Pu'u Hau'oki and another that extends through the existing SMA complex and Area E (see Figure 2).

Currently, utility services exist along the Mauna Kea Access Road to a point near the intersection of the Mauna Kea Loop Road and the Submillimeter Array (SMA) roadway. The proposed TMT Access Way will start at that point and extend to the TMT Observatory. This access way will follow either existing 4-wheel drive roads or the wider roads that serve the SMA facility. The TMT Access Way will be limited to a single lane over the southernmost portion of the Access Way (the portion that crosses Pu'u Hau'oki; the remainder is two lanes (U.H. Hilo 2010a).

ENVIRONMENTAL BACKGROUND

TOPOGRAPHY & SOILS

Mauna Kea, the highest (13,796 ft above sea level) and second largest of the five shield volcanoes that form the island of Hawai'i, is estimated to be between 600,000 and 1.5 million years old (Moore and Clague 1992; DePaolo and Stolper 1996; Wolfe et al. 1997; Sharp and Renne 2003). The earliest stage of volcanism consists of a basaltic shield. The latest stage, which caps the mountain, consists of andesitic lavas (Macdonald and Abbott 1970:142; Wolfe and Morris 1996; Wolfe et al. 1997; Sherrod et al. 2007). Even though the last eruption occurred sometime between 4,580 and 8,200 years ago (Sherrod et al. 2007:470), the U.S. Geological Survey (USGS) considers Mauna Kea to be an active post-shield volcano (U.S. Geological Survey 2002).

The summit region resembles a stony alpine desert. The soils, like those in alpine environments generally, are poorly developed (Ugolini n.d.). In the absence of a vegetative cover and, thus, a surface organic layer, the ground surface in many places is a desert pavement (Ugolini 1974:189).

RAINFALL & VEGETATION

The climate of the higher elevations on Mauna Kea is like all mountain climates – kaleidoscopic -- consisting of a great number of individual elements that are continually changing through space and time. It exhibits all of the universal changes that occur in the atmosphere with increasing altitude (e.g., decreasing temperature, air density and water vapor) in addition to local effects directly related to latitude and the "mountain mass effect" (Barry 1981; Price 1981).

The summit region climate is both dry and cold, but there are few available statistics for evaluating annual and cyclical variability. At this latitude (19-20 degrees N) there is little difference in the mean minimum and mean maximum temperature ranges throughout the year in contrast to pronounced diurnal variation. Precipitation at the higher elevations frequently averages less than one inch in every month of the year, primarily in the form of sleet, hail and snow, which rarely accumulates below the 3,050 m elevation, however. The prevailing winds are from the east-northeast. Fog and other forms of ground condensation are not uncommon and appear to be generally associated with increased cloudiness at midday (Powers and Wentworth 1941).

The modern climate is periglacial, a term that is inconsistently used with reference to a variety of cold climates as well as geomorphologic regimes (Davies 1972:9; Embleton and King 1975:2). Mauna Kea is an example of what Tricart (1970) has called the "low latitude mountain variety" of periglacial climate. There are frequent frosts but they are of low magnitude or intensity, penetrating to only shallow depths (Davies 1972:13).

Features attesting to a modern periglacial environment include permafrost (Woodcock 1974), gelifluction lobes and terraces (Ugolini n.d.), stone stripes and polygons, and pot-lid or ring crack fractures on smoother rock surfaces. Intensive freeze-thaw cycles are also evidenced in the splitting and upheaving of rocks on the edges of lava flows that also exhibit the plucking and abrasive effects of glacial ice movement (Gregory and Wentworth 1937; Wentworth and Powers 1941).

HISTORICAL BACKGROUND

Located within Ka'ōhe Ahupua'a in the Hāmākua District of Hawai'i Island, the summit of Mauna Kea was traditionally described as an abode of the ancestral *akua* (gods, goddesses, deities). Native Hawaiians believed that the *pu'u* (cinder cones) and other features of the summit such as Lake Waiau were the physical manifestations of these deities. The Mauna Kea Summit Region Historic District includes a concentration of significant historic properties that are linked through their setting, historic use, traditional associations, and ongoing cultural practices. The historic properties recorded during the archaeological inventory survey (McCoy and Nees 2010) include shrines, adze quarry complexes and workshops, burials, stone markers/memorials, temporary shelters, historic campsites, traditional cultural properties (TCPs), a historic trail, sites of unknown function, and isolated artifact finds.

Much of what is known concerning the traditional culture history of the summit region of Mauna Kea was summarized by Holly McEldowney in a 1982 report, based on a review of early journal accounts and maps, ethnographic collections, and the Boundary Commission Book for Hawai'i (McEldowney 1982). More recent research by Kepa Maly (1998, 1999) and Charles Langlas (Langlas et al. 1997; Langlas 1999), both of whom have conducted oral interviews in addition to archival research, have provided additional information on the traditions associated with Mauna Kea and its cultural and spiritual significance for Hawaiians today. A major compilation of native traditions, historical accounts, and oral history interviews on Mauna Kea and surrounding lands can be found in a study entitled "Mauna Kea—Ka Piko Kaulana o Ka 'Aina (Mauna Kea—the Famous Summit of the Land) by Maly and Maly (2005), which was commissioned by the Office of Mauna Kea Management (OMKM). The overview that follows is based on these studies, which should be consulted for more detailed information.

TRADITIONAL LAND USE HISTORY

The place names in the summit region are a mix of traditional names and modern names (see discussion in McEldowney 1982 and Tables 1.1 and 1.2 from her report). The origin and meaning of some names is unknown. The name Mauna Kea itself is open to various interpretations. The commonly accepted, literal translation as "White Mountain" appears in this early account by the Rev. William Ellis who toured the island of Hawai'i in 1823:

The snow on the summit of the mountain, in all probability, induced the natives to call it Mauna-Kea, (mountain white), or, as we should say, white mountain. They have numerous fabulous tales relative to its being the abode of the gods, and none ever approach the summit—as, they say, some who have gone there have been turned to stone. We do not know that any have been frozen to death; but neither Mr. Goodrich, nor Dr. Blatchely and his companion, could persuade the natives, whom they engaged as guides up the side of the mountain, to go near its summit (Ellis 1979:292).

As already noted, the reference to Mauna Kea as the abode of the gods is emphasized in some native Hawaiian traditions in which the word "Kea" is taken to be an abbreviated form of Wākea, the male god who procreated with Papa to form the mountain. In an account of Queen Emma's trip to the lake in 1881 or 1882 and the *mele* that were written about that trip, Kihei and Mapuana de Silva present some more detail about the names of the mountain and the lake. They note, following Puakea Nogelmeier, that Emma's poets refer to the summit as Piko o Wākea and that:

Although Maunakea is popularly translated as “white mountain,” Kea is also an abbreviated form of Wākea, the sky father who, with Papa, the earth mother, stands at the apex of Hawaiian genealogy. Mauna Wākea is thus viewed traditionally as the sacred meeting point of sky and earth, father and mother, Wākea and Papa. Emma’s poets were well-acquainted with the older name and its lasting significance; they refer to Waiau as “ka piko on Wākea”—as the mountain’s navel/genital/umbilical/connecting-point/center (de Silva and de Silva 2006: footnote 7).

The name for the summit, which unlike many mountain summits does not consist of a single peak, is now widely accepted as Kūkahau‘ūla (“Kūkahau‘ūla of the red-hewed dew or snow”) instead of the formerly used name Pu‘u Wekiu. On present evidence the name Kūkahau‘ūla referred to both a legendary figure and to a character in traditional histories and genealogies. The latter includes references to Kūkahau‘ūla as the husband of Lilinoe and as an *‘aumakua* (family deity) of fishermen (Hibbard 1999). The place name evidence indicates that the “summit” was at the very least a legendary place or *wahi pana* (Pukui and Elbert 1971). Maly and Maly (2005:vi) give the name as Pu‘u o Kūkahau‘ūla, which they say was “named for a form of the god Kū, where the *piko* of new-born children were taken to insure long life and safety. This practice is still participated in at the present time.” According to Maly and Maly (2005:vi):

The name Pu‘u o Kūkahau‘ūla is the traditional name of the summit cluster of cones on Mauna Kea, appearing in native accounts and cartographic resources until c. 1932. The recent names, Pu‘u Wekiu, Pu‘u Hau‘oki and Pu‘u Haukea, have, unfortunately, been used since the 1960s (since the development of astronomy on Mauna Kea), and have displaced the significant spiritual and cultural values and sense of place associated with the traditional name, Pu‘u o Kūkahau‘ūla.

Other traditional place names that appear on the earliest maps and in journal accounts include Pu‘u Līlinoe and Pu‘u Waiau (Table 2.1). Contrary to popular belief, Pu‘u Poli‘ahu is a modern name applied by the surveyor W.D. Alexander in 1892 (McEldowney 1982:114).

HISTORIC & RECENT LAND USE HISTORY

At the completion of the Māhele in 1848, King Kamehameha III executed two additional legal instruments covering lands under his control. These instruments created what are known as Crown Lands and Government Lands (Chinen 1958: 25-26). During the Māhele, only four native tenants who made claims for land rights for Ka‘ohe Ahupua‘a were identified, and all of these claims were well below the summit at lower elevations. By the close of the Māhele, one native tenant was granted land in lower portions of Ka‘ohe Ahupua‘a.

On present evidence the slopes of Mauna Kea, above the limits of agriculture and permanent settlement, were a vast montane “wilderness” probably known to only a small number of Hawaiians engaged in primarily “special purpose” activities, such as bird-catching, canoe making, stone-tool manufacture, or burial of the dead (McEldowney 1982). Ethnographic information relating to a specific locality in this and other mountainous regions in Hawai‘i is either incomplete, or, as is more frequently the case, lacking altogether.

Little is known ethnographically about the uses of the alpine and sub-alpine zones on Mauna Kea except for brief accounts about adze manufacture and burials. Most of what is known regarding traditional land uses is the result of archaeological investigations undertaken since the mid-1970s.

PREVIOUS ARCHAEOLOGICAL STUDIES

There have been numerous archaeological studies conducted on Mauna Kea, including the Mauna Kea Science Reserve, the Astronomy Precinct, and the Mauna Kea Access Road easement corridor. These studies are summarized in Table 1 and briefly discussed below. The locations of these studies are not presented in this AMP. The reader is referred to McCoy and Nees (2010: Section 3) for more detailed results and detailed maps showing the location of these studies.

In a discussion on astronomy and the existing observatories in the CRMP, McCoy et al. (2009:4-21) states that:

...while no archaeological surveys were conducted prior to the construction of the summit road in the mid-1960s there is no indication that any archaeological sites on the summit were destroyed at that time, or any time thereafter in the construction of the 13 existing observatories (McCoy 1999a:31). This conclusion is based in part on interviews conducted by Kepa Maly with people involved in the construction of the summit road. His informants did not recall any historic properties being found on the summit during the construction of the first jeep road (Maly 1999: Appendix A-123).

The boundaries of the Science Reserve changed in 1981 when 2,033.2-acres of land were withdrawn from the lease for the creation of the Mauna Kea Ice Age Natural Area Reserve (NAR). The Science Reserve now encompasses an area of roughly 11,288 acres.

The first archaeological investigations in the Mauna Kea Science Reserve were carried out in 1975-76 in the context of a National Science Foundation funded research project on the Mauna Kea Adze Quarry (McCoy 1977, 1990; Cleghorn 1982; Allen 1981; Williams 1989). A reconnaissance survey undertaken in 1975 to determine the boundaries of the quarry, a National Historic Landmark, found one site just inside the Science Reserve boundaries on the eastern side of the summit road, between the ca. 12,250 and 12,300 ft elevations. The site, Site No. 50-10-23-16204 (Site 18204) as defined at the time, using the site definition criteria employed in the quarry project, consists of five shrines, 25 open-air enclosures (shelters) and a diffuse lithic scatter of adze manufacturing by-products (McCoy 1977, 1999b). Two other sites were found in the Science Reserve in the 1976 field season, which involved more intensive survey and site recording. Site 16163 is a shrine with a diffuse scatter of flakes located on a ridge top at the ca. 12,880 ft elevation. The second site, Site 16195, are the remains of two stone mounds on the rim of Pu'u Lilinoe. These would appear to be the remnants of the burial interment features noted by W.D. Alexander's survey party in 1892.

The first major survey in the Science Reserve was conducted by the Bishop Museum over 5 1/2 days between July 12 and 17, 1982 for the Hawaii Institute for Astronomy (IfA) and encompassed roughly 1,000 acres of land on the summit and northern slope of the mountain, down to the ca. 13,000-ft elevation. Few, if any, archaeological sites were predicted to occur within the boundaries of the project area, given the high altitude

Table 1. Previous Archaeological Research and Cultural Resource Management Studies in the Mauna Kea Science Reserve and Astronomy Precinct.

Year	Project	Study	Location	References
1975-76	NSF Research Project on the Mauna Kea Adze Quarry	Reconnaissance and inventory survey	MKSR & NAR	McCoy 1977, 1978, 1990; Cleghorn 1982; Allen 1981; Williams 1989
1981	Kitt Peak National Observatory	Reconnaissance	MKSR	McCoy 1981
1982	Hawaii Institute for Astronomy	Reconnaissance	MKSR	McCoy 1982a; McEldowney 1982
1982	Caltech Telescope	Reconnaissance	MKSR	McCoy 1982b
1983	Mauna Kea Observatory Power Line	Reconnaissance	MKFR, MKSR and NAR	Kam and Ota 1983
1984	NSF Grant-in-Aid Survey	Reconnaissance	MKSR	McCoy 1984
1987	Summit Road Improvement	Reconnaissance	MKSR & Access Rd.	Williams 1987; McCoy 1999b
1988	VLBA Telescope	Reconnaissance	MKSR	Hammatt and Borthwick 1988
1990	Subaru Telescope	Reconnaissance	MKSR	Robins and Hammatt 1990
1990	Gemini Telescope	Reconnaissance	MKSR	Borthwick and Hammatt 1990
1991	Independent Research	Reconnaissance of Pu`u Makaanaka	MKSR	McCoy field notes
1992	Smithsonian Astrophysical Observatory	Relocation of two known sites	MKSR	McCoy 1993
1995	SHPD site relocation and GPS recording	Reconnaissance	MKSR	McCoy 1999a

Table 1. Previous Archaeological Research and Cultural Resource Management Studies in the Mauna Kea Science Reserve and Astronomy Precinct.				
Year	Project	Study	Location	References
1997	SHPD transect survey	Reconnaissance	MKSR	McCoy 1999a
1999	SHPD survey of Pu'u Wekiu	Reconnaissance	MKSR	McCoy 1999a
1999	Hawaii Defense Access Road and Saddle Road	TCP Assessment	Mauna Kea summit region	Langlas 1999
1999	Mauna Kea Science Reserve Master Plan	Cultural Impact Assessment	MKSR	PHRI 1999
2000	Mauna Kea Science Reserve Master Plan	Draft HPP	UH Management Areas	SHPD 2000
2000	Mauna Kea Science Reserve Master Plan	Summary Report	MKSR	McCoy 1999a
2005	EIS for Keck Outrigger Telescopes	Burial Treatment Plan	MKSR	NASA 2005
2005-2007	PCSI AIS of the Science Reserve including Astronomy Precinct	Inventory Survey	MKSR	McCoy and Nees 2010; McCoy et al 2010a
2008	Cultural Resource Management Plan	CRMP	UH Management Areas	McCoy et al. 2009
	PCSI AIS of the Ice Age NAR	Inventory Survey	NAR	McCoy and Nees 2012 (Draft Report)

MKSR=Mauna Kea Science Reserve; MKFR=Mauna Kea Forest Reserve, NAR=Natural Area Reserve

location and presumed absence of exploitable resources, including adze-quality stone, which was believed to be restricted to the south slope of the mountain. A total of 22 sites were recorded in this survey (McCoy 1982a). For field purposes, all but one site, an open-air shelter, were classified as "shrines," earlier defined by Buck (1957:527) as "a convenient term to designate a simple altar without a prepared court." The open-air shelter, which contained modern debris, was later deleted from the historic places inventory because of the belief that it is a modern feature. The number of historic properties found in the 1982 survey has thus been changed to 21.

A survey of the Caltech Telescope site was conducted at the same time as the larger survey. No sites were found within the proposed project area, but two sites were found in close proximity (McCoy 1982b).

In 1983 SHPD conducted a reconnaissance survey of a proposed underground power line from Hale Pohaku to the summit. The survey, which did not identify any historic properties, was undertaken before the final alignment had been determined, however.

Archaeological survey of the Science Reserve was resumed in 1984 by the Bishop Museum with the support of a National Historic Preservation Grant-in-Aid. The 1984 survey, which was carried out over a period of six days between July 23 and 28, was aimed at completing an inventory of archaeological remains on the east-southeast flank of the mountain adjoining the proposed northern boundary of the Mauna Kea Adze Quarry (McCoy 1978). The survey strategy and methodology were the same as those employed in the 1982 fieldwork. A total of 21 dispersed and aggregated sites was recorded in the survey (McCoy 1984), which covered ca. 1,000 acres on the eastern slope of the mountain. Time did not permit survey of the upper slopes and summit of Pu'u Mahoe as originally planned.

In 1988 Cultural Surveys Hawaii, Inc. conducted a reconnaissance survey of two areas that were being considered as alternative sites for the National Radio Astronomy Observatory (now called the Very Long Base Array). No archaeological sites were found in the survey of the first area, an area of about 15 acres located between the 11,560 and 11,840 ft elevations near the junction of the summit road and a utility road (Hammatt and Borthwick 1988:1). Four archaeological sites were recorded in the survey of the second alternative site, an area of some 100 acres located on the east side of the summit road at the 12,100 to 12,225 ft elevations. Three of the sites (11076, 11077, and 11079) were interpreted as possible shrines; the fourth site (11078) is a small rock shelter (Hammatt and Borthwick 1988:21).

Two archaeological surveys were undertaken in the Science Reserve in 1990, both by Cultural Surveys Hawaii, Inc. The first involved a resurvey of a portion of Pu'u Hau'oki for the proposed Japan National Large Telescope (JNLT-- later renamed the Subaru Telescope). No sites were found in this survey, which covered an area of 5.1 acres (Robins and Hammatt 1990). The second survey was done for the proposed Galileo Telescope; two alternative locales were inspected, both of them located on what the authors called the "summit ridge" (Borthwick and Hammatt 1990). One of the observatory sites was utilized by the Gemini Observatory after the Galileo team selected a site outside of Hawai'i for their telescope (Paul Gillett, personal communication, May 31, 2012). No archaeological sites were found in either area.

In 1991 an unofficial one-day reconnaissance of the top of Pu'u Makanaka was undertaken by Holly McEldowney and Marc Smith of SHPD and Patrick McCoy (Mountain Archaeology Research Corp.) to re-find previously reported burials. The survey, which was interrupted by bad weather, found a number of burials, none of which

were mapped, however (McCoy 1991 field notes). A single state site number was assigned to the burials on the *pu'u* at that time.

As part of their Section 106 compliance, Mountain Archaeology Research Corp. was contracted by the Smithsonian Institution Astrophysical Observatory in December 1992 to re-find two previously recorded sites in the general vicinity of one of the pads. The two sites (Sites 16164 and 16165), which were found in the 1982 survey and described as shrines were found to be located well outside of the observatory footprint. Flagging of the two sites was recommended as a precautionary measure (McCoy 1993).

In 1995 the State Historic Preservation Division, with financial support from the Hawaii Institute for Astronomy, initiated a project designed to result in a historic preservation management plan for the Science Reserve. The first task, which was begun in 1995, involved the re-finding and GPS mapping of the sites recorded in the 1982 and 1984 surveys. In the course of the fieldwork 18 new sites were found and recorded (McCoy 1999a).

In 1997 SHPD undertook a reconnaissance survey of five previously un-surveyed areas aimed at obtaining a better idea of site distribution patterns for both management and research purposes. The 1997 survey area included three transects on the north, northwest and southwest slopes of the mountain from the summit area to the lower boundary of the Science Reserve at the ca. 12,000 ft elevation and two other areas—Pu'u Poepoe and a small piece of land located near the Science Reserve boundary down slope of the CalTech observatory. A total of 29 new sites were found in the 1997 project, which was conducted over a period of six days (McCoy 1999a).

The 1997 survey also began the process of recording what were initially referred to as "locations" but are now being termed "find spots"—a general term referring to man-made remains that are either obviously modern features (e.g., camp sites with tin cans, pieces of glass and other modern material culture items), or features that cannot be classified with any level of confidence as historic sites because of their uncertain age and function (e.g., a pile of stones on a boulder).

Archaeological surveys undertaken between 1975 and 1999 identified a total of 93 sites (McCoy 1977, 1982a, 1984, 1990, 1999a; Hammatt and Borthwick 1988; Borthwick and Hammatt 1990) in an area encompassing some 3,711 acres, which represents roughly 33% of the 11,288 acre Science Reserve. With the exception of a survey undertaken as part of a research project on the Mauna Kea Adze Quarry Complex, all of these surveys were reconnaissance level studies, which by definition are limited in terms of coverage and completeness.

The need for an archaeological inventory survey of the entire Mauna Kea Science Reserve, including the Astronomy Precinct, was recognized by the Office of Mauna Kea Management (OMKM) early in 2005. PCSI was contracted by OMKM in 2005 to undertake such a survey and to develop a cultural resource management plan. The survey was undertaken over a period of 14 weeks in the summers of 2005-2007. A total of 263 historic properties were found during the survey (McCoy and Nees 2010). This included 95 previously recorded sites and two Traditional Cultural Properties (TCP), including Kūkahau'ula (Site 21438) and Pu'u Līlinoe (Site 21439) which were given site numbers by SHPD in 1999. The locations of historic properties, including TCP's, and "find spots" in the Science Reserve are shown in Figure 5.

In late 2009, Cultural Surveys Hawaii conducted an archaeological inventory survey for Area E, the designation for the proposed locale for the construction of the TMT

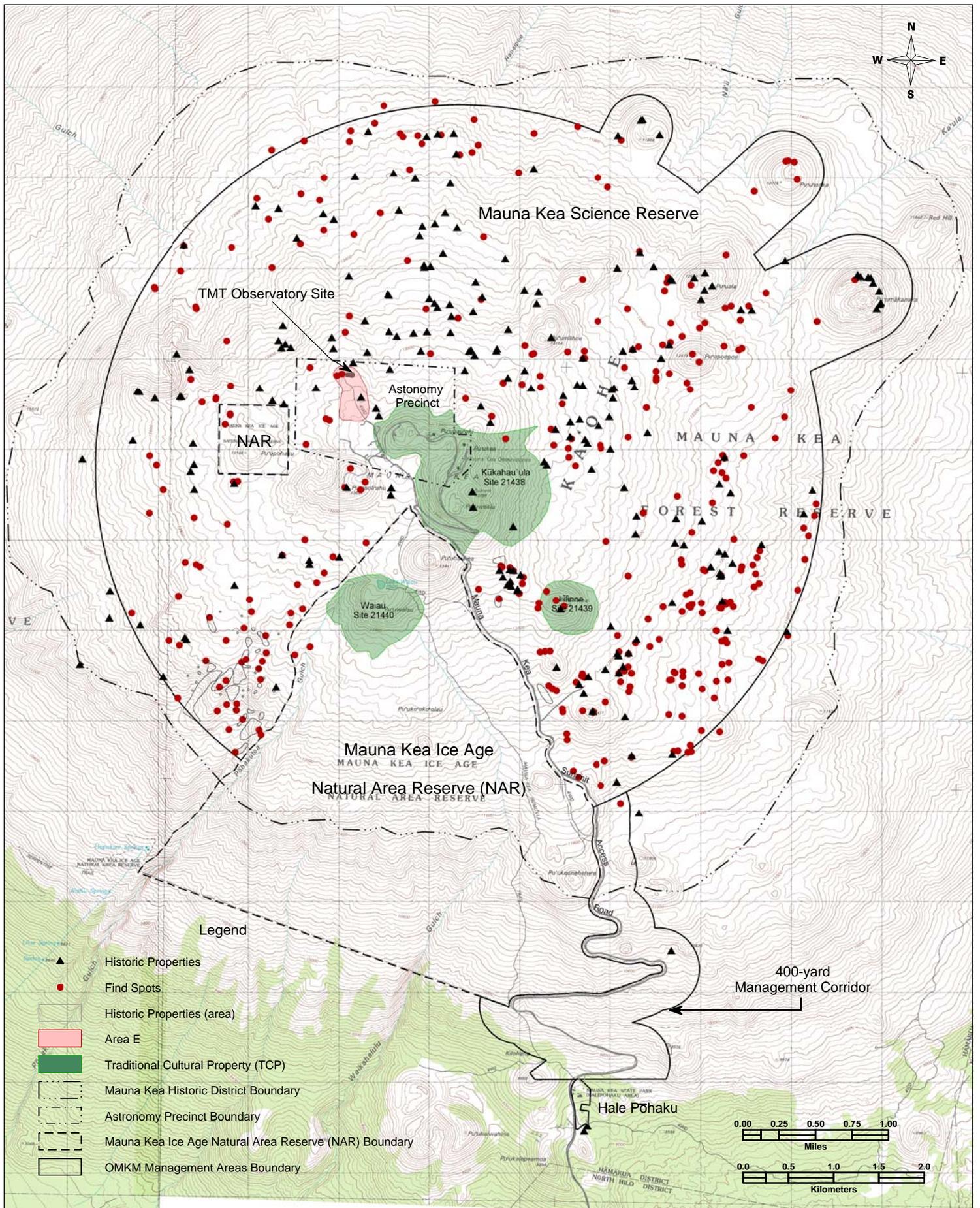


Figure 5. Location of Historic Properties, including Traditional Cultural Properties, and Find Spots in the Mauna Kea Science Reserve.

(Hammatt 2010 in U.H. Hilo 2010b), and the Batch Plant Staging Area. While no new historic properties were found, two potential historic properties were encountered in Area E or in the Batch Plant Staging Area. After consultation with Dr. Patrick McCoy of PCSI, Hammatt concluded that they were not historic properties, and therefore were not assigned SIHP numbers.

Hammatt (2010: 56) concluded that the proposed TMT project would not impact any specific archaeological sites. He noted that that the nearest sites, Sites 16166, 16167, and 16172 (all shrines) were at a distance of over 200 feet from the project, and thus there would be no adverse impacts to these three sites. Hammatt also discusses physical and visual impacts to Kūkahau‘ūla (Site 21438) as well as off-site measures to mitigate these impacts.

Historic Properties in the Astronomy Precinct

Construction of the TMT will primarily affect two areas within the Astronomy Precinct. The site proposed for the TMT Observatory is nearly one-half mile northwest of the TCP named Kūkahau‘ūla, and the Access Way leading to the observatory would intersect the northwestern edge of the TCP for approximately 800 feet. Kūkahau‘ūla has been described and referred to as a traditional cultural property (TCP) by the SHPD.

Kūkahau‘ūla includes the summit cinder cones (referred to separately as Pu‘u Wēkiu, Pu‘u Kea, and Pu‘u Hau‘oki) and covers roughly 463 acres, of which nearly one third is within the Astronomy Precinct. The Kūkahau‘ūla TCP is associated with the activities of Native Hawaiian deities as identified in numerous legends and oral histories, and plays an important role in ongoing traditional and religious practices carried out by modern-day Native Hawaiians. Kūkahau‘ūla is a contributing property to the Mauna Kea Summit Region Historic District (McCoy and Nees 2010; McCoy et al. 2010a).

Six archaeological sites were located within the boundaries of the Astronomy Precinct (McCoy and Nees 2010; McCoy et al. 2010a). Table 2 below summarizes the four previously recorded sites, Sites 16166, 16167, 16169, and 16172, and two newly recorded sites, Sites 21447 and 21449. Figure 6 shows the location of historic properties and find-spots in the Astronomy Precinct.

Table 2. Find-Spots in the Astronomy Precinct.

Year. No.	Approximate Elevation (ft. asl)	Description	Function
Previously Recorded Find-Spots			
1997.07	13,308	Stacked (2) rocks on a boulder	Marker
Newly Recorded Find-Spots			
2005.03	13,271	Stacked (3) rocks	Marker
2005.05	13,220	Stacked rocks	Marker
2005.06	13,202	Possible upright	Unknown
2005.07	13,000	Possible uprights	Unknown
2005.08	13,140	Two uprights near weather station	Unknown
2005.09	13,016	Stacked rocks	Marker

Four previously identified sites and one previously identified find-spot were re-found during the archaeological inventory survey of the Astronomy Precinct. The previously identified sites, all of which were found during the 1982 reconnaissance survey (McCoy1982a; McEldowney 1982), were evaluated in terms of the completeness and adequacy of the existing maps and descriptions. A number of the maps were either redrawn or annotated with new observations.

Four archaeological sites are located near the proposed Access Way and TMT Observatory. Three historic shrines, first identified during a 1982 survey, are in the vicinity, as well as one terrace:

1. SIHP No. -16172 is located about 225 feet north of the proposed TMT Observatory site and consists of a single upright shrine with several support stones.
2. SIHP No. -16167 is located approximately 500 feet east of the Access Way and about 1,300 feet southeast of the proposed TMT Observatory site and is a shrine consisting of one, possibly two, uprights placed in a bedrock crack. In 1995, the site was revisited and both stones were found in a vertical position.
3. SIHP No. -16166 is approximately 350 feet east of the Access Way and 1,600 feet southeast of the proposed TMT Observatory site and is a multi-feature shrine with a total of eight, possibly nine uprights arranged in two groups. When the site was revisited in 1999 it was noted that several of the uprights had been reset in a vertical position along the edge of the outcrop.
4. SIHP No. -21449 was documented in 2005; it is located in Area E approximately 200 feet east of the Access Way and 700 feet south of the proposed TMT Observatory site. This site was tested to determine the presence/absence of cultural materials and to hopefully obtain information that would aid in determining the site's function. No cultural materials or features were encountered during excavation, and no human burials or isolated human skeletal remains were present. After the excavation, it was concluded that the terrace was likely a natural gelifluction terrace (McCoy and Nees 2010a: 6-1).

"Find spots" are cultural resources that are either obviously modern features (e.g., camp sites with tin cans, pieces of glass and other modern material culture items), or features that cannot be classified with any level of confidence as historic sites because of their uncertain age and function (e.g., a pile of stones on a boulder). Seven find-spots were identified in the Astronomy Precinct in 2005 (see Figure 6), including a previously identified find-spot found during a 1997 survey (McCoy 1999a). This find-spot was relocated during the 2005 survey. The number of such finds, which the State Historic Preservation Division (SHPD) first started to record in 1997 as a way of tracking changes in the cultural landscape and distinguishing old from new cultural remains ("sites"), appears to be increasing, especially in areas close to existing roads.

Historic Properties in the Mauna Kea Access Road Management Corridor and near the HELCO Substation

An archaeological inventory survey of the 400-yard wide easement along the Mauna Kea Access Road (TMK: [3] 4-4-015: por. 01), managed by the University of Hawaii (UH), was undertaken by PCSI for the Office of Mauna Kea Management in 2009 (McCoy et al. 2010b). One previously recorded site (50-10-23-10,314) and three new

sites (50-10-23-27,867, 27,868 and 27,869) were identified in 2009. Table 3 below is from McCoy et al. (2010b) and summarizes the documented sites in the access road corridor. Figure 7 shows the locations of historic properties in the Mauna Kea Access Road corridor.

Table 3. Historic Properties Recorded in the Mauna Kea Access Road Corridor.

Site No.	Site Type	Number of Features	Site Function
50-10-23-10314	Lithic scatter	1	Adze and octopus lure sinker workshop
50-10-23-27867	Mounds	4	Possible burial
50-10-23-27868	Mound	1	Possible burial
50-10-23-27869	Mounds	2	Possible burial

The previously recorded site is a lithic scatter comprised of the by-products of adze manufacture and octopus lure sinker manufacture. The site, which is interpreted as a workshop, is part of the larger Pu'u Kalepeamoia Site Complex (Site 50-10-23-16,244) that has been interpreted as a logistical support camp occupied on the ascent and descent from the Mauna Kea Adze Quarry Complex (Site 50-10-23-4136-McCoy et al. 2010b). The three new sites are inferred to be possible burials based on their location, architectural characteristics of the structural remains, size and morphological similarity to known and suspected burial features in the higher elevation areas on Mauna Kea.

Other features that are either modern or cannot be classified with any level of confidence as historic sites because of their uncertain age, such as many of the rock piles, were recorded as "find spots," following a practice begun by the State Historic Preservation Division (SHPD) during a reconnaissance survey of selected areas of the Mauna Kea Science Reserve in 1997 (McCoy et al. 2010b).

Forty-four (44) find-spots were identified in the Access Road Corridor; Figure 8 shows their locations and Table 4 summarizes these structures and items. About half of these were found on top of a cinder cone just above Hale Pōhaku. According to McCoy et al. (2010b), the number of "find spots" is not wholly surprising given the proximity of this area to locales frequented by the public. The large number found at one location near Hale Pōhaku is unusual, but again not totally unexpected.

The 19.3-acre site at Hale Pōhaku (Tax Map Key 4-4-015:012) encompasses the Onizuka Center for International Astronomy (OCIA), the Visitor Information Station, and an old construction laborer camp. No activities related to construction of the TMT will take place within this parcel.

A number of archaeological investigations have been conducted at Hale Pōhaku, both in and outside of Parcel 012, beginning with a one-day reconnaissance survey by the Bishop Museum in 1979 for the Hale Pōhaku Mid-Level Complex Development Plan. No sites were found at that time (McCoy 1979).

Three more surveys were conducted by the Bishop Museum between July 1984 and June 1985 as part of the preparation of a supplemental Environmental Impact Statement (EIS) for a permit to build a new construction laborer camp (McCoy 1985b). Two shrines and five lithic scatters comprised of adze manufacturing by-products and octopus sinker manufacturing by-products were recorded in the surveys, which encompassed roughly

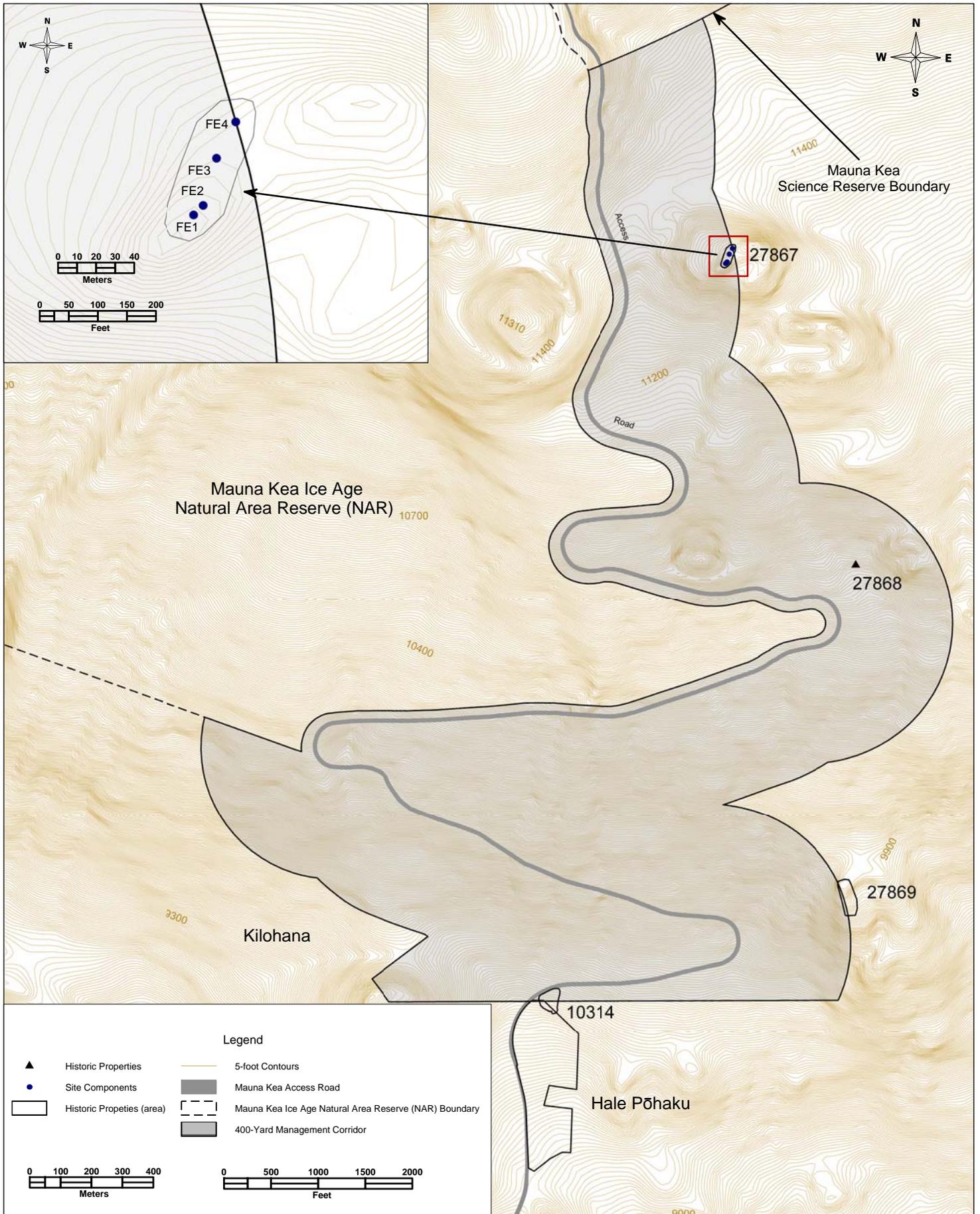


Figure 7. Location of Historic Properties in the Mauna Kea Access Road Management Corridor.

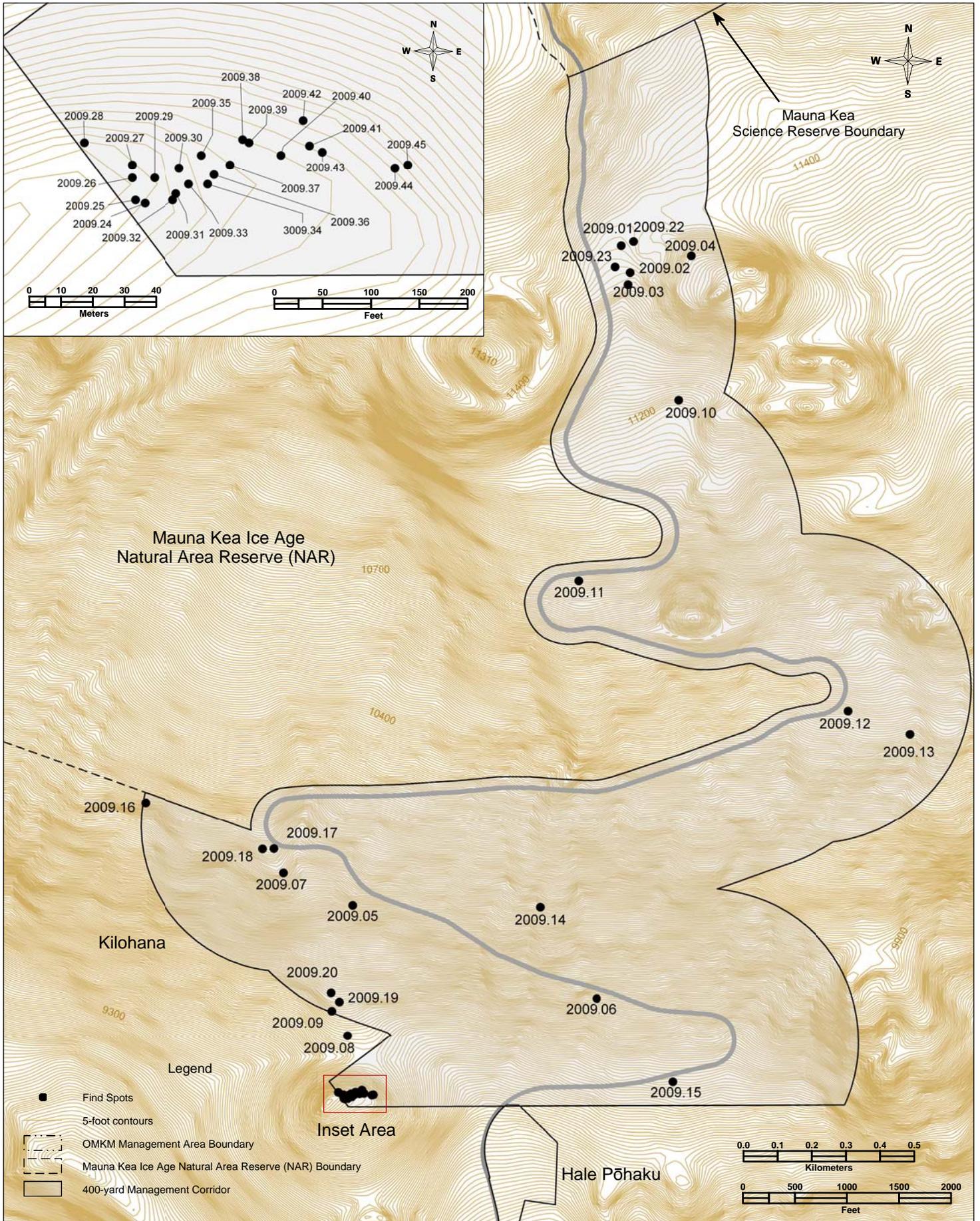


Figure 8. Location of Find Spots in the Mauna Kea Summit Access Road Management Corridor.

Table 4. Find Spots Recorded in the Mauna Kea Access Road Survey Area.

Year. No.	Temporary Field No.	Approximate Elevation (ft. amsl)	Description	Function
2009.01	VP-2009-01	11,514	Stacked cobbles on outcrop	Marker
2009.02	VP-2009-02	11,498	Two sets of stacked cobbles on boulder	Marker
2009.03	VP-2009-03	11,482	Piled Rock	Marker
2009.04	VP-2009-04	11,606	Piled and stacked mound	Marker
2009.05	VP-2009-05	9,971	Wall	Unknown
2009.06	VP-2009-06	9,741	Stacked cobbles and one boulder on outcrop	Marker
2009.07	VP-2009-07	10,069	Mound	Marker
2009.08	VP-2009-08	9,673	Stacked boulders and cobbles on outcrop	Marker
2009.09	VP-2009-09	9,717	Upright wrapped in twine; enclosure; manuport (waterworn cobble); possible cupboard	Modern cultural practices
2009.10	RN-2009-03	11,289	Piled rock	Marker
2009.11	RN-2009-04	11,045	Stacked cobbles	Marker
2009.12	RN-2009-05	10,677	Rock pile; Metal pipe	Marker
2009.13	RN-2009-06	10,633	Piled rock	Marker
2009.14	RN-2009-07	10,089	Piled rock	Marker
2009.15	RN-2009-08	9,557	Piled rock	Marker
2009.16	RN-2009-09	10,159	Piled rock	Marker
2009.17	RN-2009-10	10,160	Piled rock	Marker
2009.18	RN-2009-11	10,164	Piled rock	Marker
2009.19	RN-2009-12	9,731	Rock Alignment	Unknown
2009.20	RN-2009-13	9,744	Offering area (modern)	Modern cultural practices
2009.21	This number was not assigned to a find spot.			
2009.22	RN-2009-01	11,530	Piled Rock	Marker
2009.23	RN-2009-02	11,495	Piled Rock	Marker
2009.24	RN-2009-027	9,600	Piled Rock (Scattered)	Marker
2009.25	RN-2009-028	9,600	Piled Rock (Scattered)	Marker
2009.26	RN-2009-029	9,600	Rock Alignment (Circular)	Unknown
2009.27	RN-2009-030	9,600	Piled Rock	Marker
2009.28	RN-2009-031	9,600	Piled Rock on a Boulder	Marker
2009.29	RN-2009-032	9,600	Rock Enclosure (with rock-alignment writing)	Marker
2009.30	RN-2009-033	9,600	Rock Alignment ("Y" shaped)	Marker

Table 4. Find Spots Recorded in the Mauna Kea Access Road Survey Area.

Year. No.	Temporary Field No.	Approximate Elevation (ft. amsl)	Description	Function
2009.31	RN-2009-034	9,600	Cremation inside Rock Alignment (Circular)	Burial; Burial Marker
2009.32	RN-2009-035	9,600	C-Shape with Rock Alignment across entrance	Unknown
2009.33	RN-2009-036	9,600	Piled Rock (Scattered)	Marker
2009.34	RN-2009-037	9,600	Scattered Cobbles	Unknown
2009.35	RN-2009-038	9,600	Piled Rock (Scattered, Rectangular)	Marker
2009.36	RN-2009-039	9,600	Piled Rock (Scattered)	Unknown
2009.37	RN-2009-040	9,600	Piled Rock (x2) Connected by an Alignment	Unknown
2009.38	RN-2009-041	9,600	Piled Cobbles	Unknown
2009.39	RN-2009-042	9,600	Piled Rock (Circular)	Marker
2009.40	RN-2009-043	9,600	Piled Rock (Scattered)	Marker
2009.41	RN-2009-044	9,600	Broken Cobbles	Unknown
2009.42	RN-2009-045	9,600	Cobble Alignment	Unknown
2009.43	RN-2009-046	9,600	Piled Rock (Scattered, Roughly Circular)	Unknown
2009.44	RN-2009-047	9,600	Possible Burial Mound	Burial; Burial Marker
2009.45	RN-2009-048	9,600	Piled Rock (Roughly Triangular)	Marker

40 acres on the west and east sides of the Mauna Kea Observatory Access Road between the ca. 9,080 and 9,200 ft elevations. The lithic scatters and shrines, one of which has octopus manufacturing by-products on it that have been interpreted as offerings, were designated the Pu'u Kalepeamoia Site (Bishop Museum site number 50-Ha-G28-87) after the name of one of the large cinder cones at Hale Pōhaku (McCoy 1985a, 1985b). This cone, through which the Access Road Corridor passes, is the source of the stone (primarily dunite and gabbro) used in the manufacture of the sinkers.

The two shrines and some of the lithic scatters found in the 1984-85 work are located outside of the Mid-Level facility parcel, as are some other 9 recorded lithic scatters found in later work. SHPD arbitrarily assigned SIHP numbers to the two shrines and 12 lithic scatters (Cordy 1994) and to the site complex as a whole (Site 16244) which corresponds to the BPBM site number (Figure 9).

The subsequent discovery of lithic artifacts in the vicinity of the HELCO Hale Pōhaku Substation on Parcel 001 led to a data recovery project that involved additional survey and surface collections at 11 different lithic scatters and limited test excavations of two of the scatters (McCoy 1991). A total of 2,364 artifacts and 129 faunal remains were collected. In addition to the debris related to adze and octopus sinker manufacture some 20 special purpose bird cooking stones called *pohaku 'eho* were found. Three radiocarbon dates from charcoal recovered in fire pits indicate that the site, which has

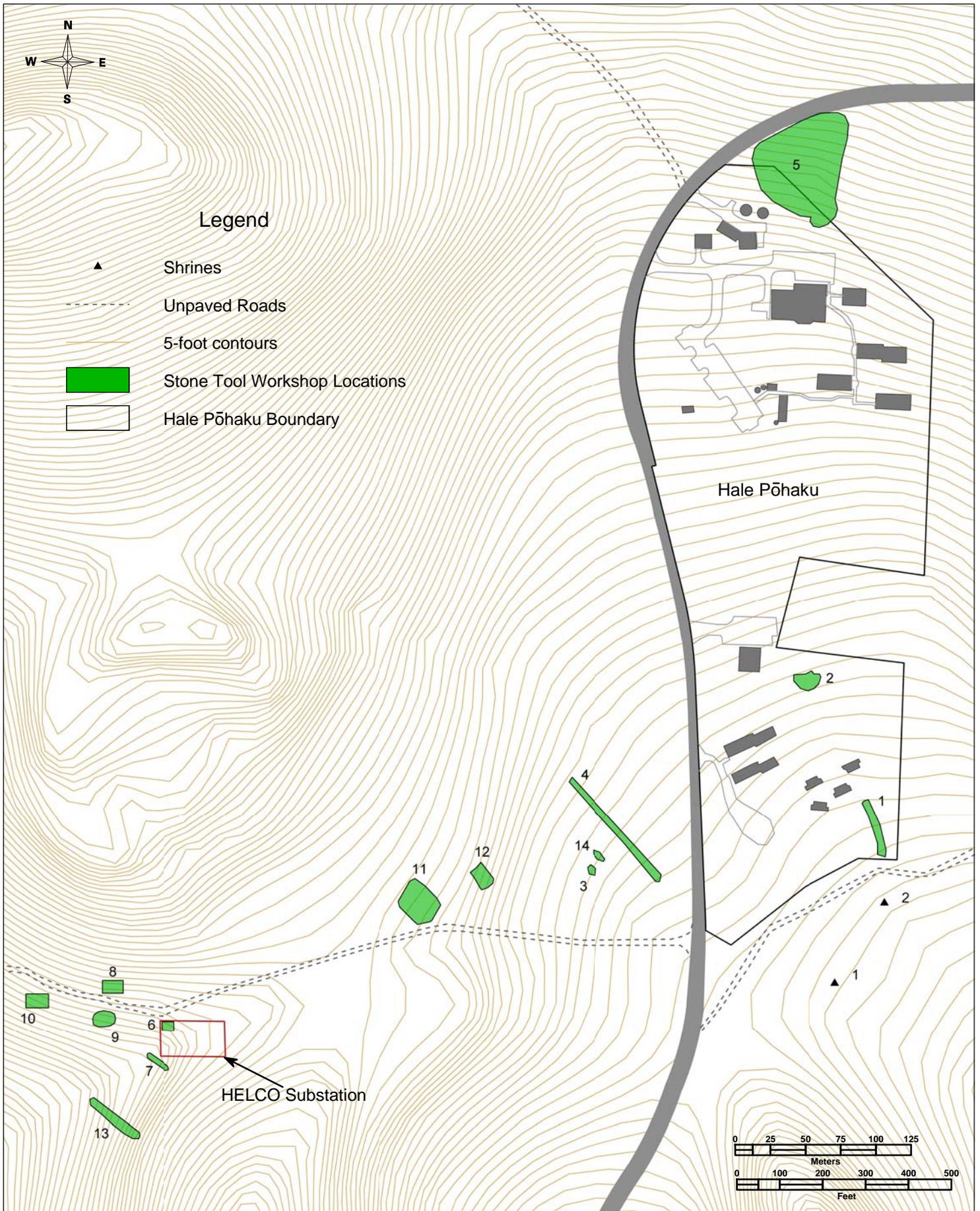


Figure 9. Locations of Historic Properties (Site 16244, Features 1-14) in the Hale Pōhaku Area.

been interpreted as a temporary camp occupied on the ascent to and descent from the Mauna Kea Adze Quarry, is of late pre-contact age (ca. AD 1600-1700).

Cultural Surveys Hawaii conducted another reconnaissance survey at Hale Pōhaku (Parcel 012) on August 9, 1990. The survey, which was done in conjunction with the construction of dormitories for the Japan National Large Telescope (later renamed the Subaru Telescope), covered a portion of the area surveyed by the Bishop Museum in 1985. The survey, which relocated two lithic scatters, recommended data recovery investigations prior to construction of the dormitories (Robins and Hammatt 1990). The data recovery work was conducted October 19-20, 1993 by Cultural Surveys Hawaii. Two radiocarbon dates were obtained that support the idea of a late prehistoric camp site (Hammatt and Shideler 2002).

In March 2005 four septic tank excavations at Hale Pōhaku on Parcel 012 were monitored. The monitoring report noted that while all of the known surface features in the lease area have undergone data recovery and no longer exist, there is a possibility that buried cultural deposits might exist in some undisturbed areas (McCoy 2005).

There is one other historic property, the stone cabins constructed by the CCC in the 1930's, in the Mid-Level Facility parcel that have recently been documented at the inventory survey level. The inventory forms for these buildings (Walden and Park 2010) have been reviewed and approved by SHPD.

ARCHAEOLOGICAL MONITORING PROCEDURES

This section describes the procedures to be used during archaeological monitoring of TMT construction activities that have a potential to impact historic properties on Mauna Kea.

ANTICIPATED FINDS

In view of the prior archaeological findings within the MKSR, pre-Contact and/or historic properties that have not been identified in past studies may be present within one or more portions of the project area. Such properties may include the following: isolated artifacts such as adzes or worked stone fragments; archaeological sites such as shrines, workshops, or camp sites; buried archaeological deposits; and buried human skeletal remains.

EXTENT OF ARCHAEOLOGICAL MONITORING

A qualified archaeologist will conduct **on-site full time monitoring** of all ground-disturbing activities potentially extending into previously undisturbed ground during construction of the TMT and Access Way. Table 5, derived in part from the Conservation District Use Application (CDUA- U.H. Hilo 2010b) provides a list of ground disturbing activities, estimated depths of these activities, and whether or not they require archaeological monitoring. It should be noted that archaeological monitoring of excavations that exceed 10.0 feet (ft), or 3.0 meters (m) in depth will not be necessary since the probability of encountering subsurface archaeological materials and features at this depth is considered to be minimal.

Table 5. List of Specific Activities that Require Archaeological Monitoring.

Ground Disturbing Activity	Estimated Excavation Depths in Meters (m) and Feet (Ft)	Monitoring Necessary?
Drilling exploratory borings at the TMT Observatory site	3.1-50.3 m (10.0-165.0 ft)	Yes
Cutting new access roads for boring locales	0.9-3.1 m (3.1 – 10.0 ft)	Yes
Performing excavation activities and grading at the TMT Observatory site	0.9-10.7 m (3.0 to 35.0 ft)	Yes
Performing fill activities in areas at the TMT Observatory site that require ground disturbing activities before they are filled (beyond where excavation activities took place)	0.9-3.1 m (3.0 – 10.0 ft)	Yes
Performing excavation activities for the Access Way	2.1 m (7.0 ft)	Yes
Excavation of utility trenches along the Access Way	0.8-1.5 m (2.5-5.0 ft)	Yes
Performing fill activities in areas along the Access Way that require ground disturbing activities before they are filled (beyond where excavation activities took place)	0.9-3.1 m (3.0 – 10.0 ft)	Yes
Ground disturbance in areas that have been previously disturbed through construction and/or use (e.g., existing facilities or parking areas)	NA	No
Replacing transformers at existing HELCO facility	NA	No
Replacing conductors in existing conduits	NA	No

Figures 10 through 14 show five sections of the design plans for the TMT project and provides the locations of areas where ground disturbing activities will be occurring along the Access Way and within the TMT observatory site. Activities to be monitored include excavation and grading activities, cutting access roads, excavation of utility trenches that are scheduled to occur in previously undisturbed areas, and some fill activities where ground disturbing is expected to occur (see Table 5).

TREATMENT OF CULTURAL MATERIALS

If any archaeological materials are encountered during the monitoring of ground-disturbing activities, work will be stopped immediately in that area, and the monitoring archaeologist will investigate the nature of the discovery. If an intact cultural layer, living surface, structural components (e.g., foundations), archaeological sub-surface features (e.g., hearths, pits, postholes, etc.), artifacts, charcoal, or midden deposits/trash pits are encountered, then the following actions will be taken:

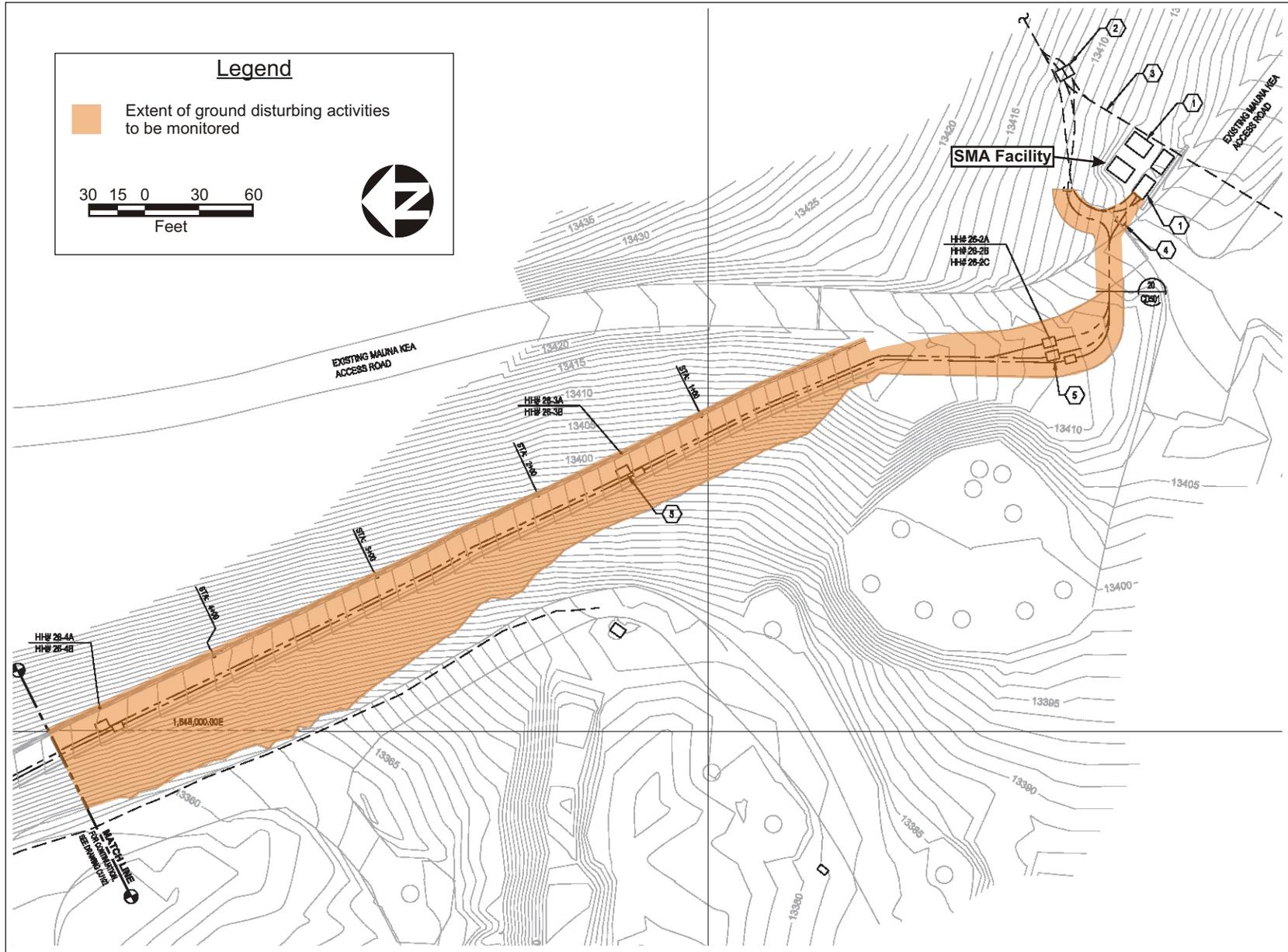


Figure 10. Section 1, Design Plans for the Mauna Kea Access Way to the Thirty Meter Telescope in the Astronomy Precinct on Mauna Kea.

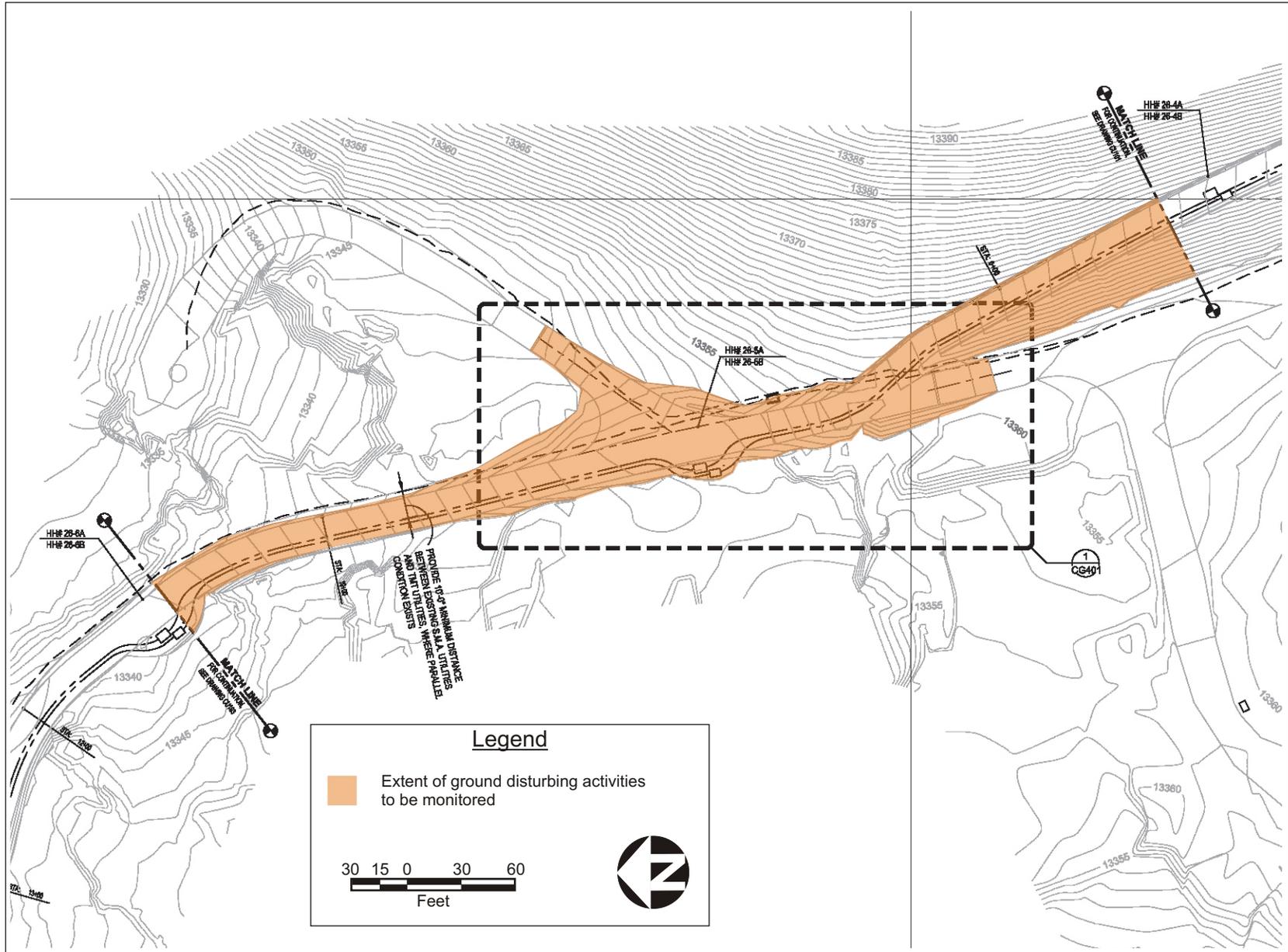


Figure 11. Section 2, Design Plans for the Mauna Kea Access Way to the Thirty Meter Telescope in the Astronomy Precinct on Mauna Kea.

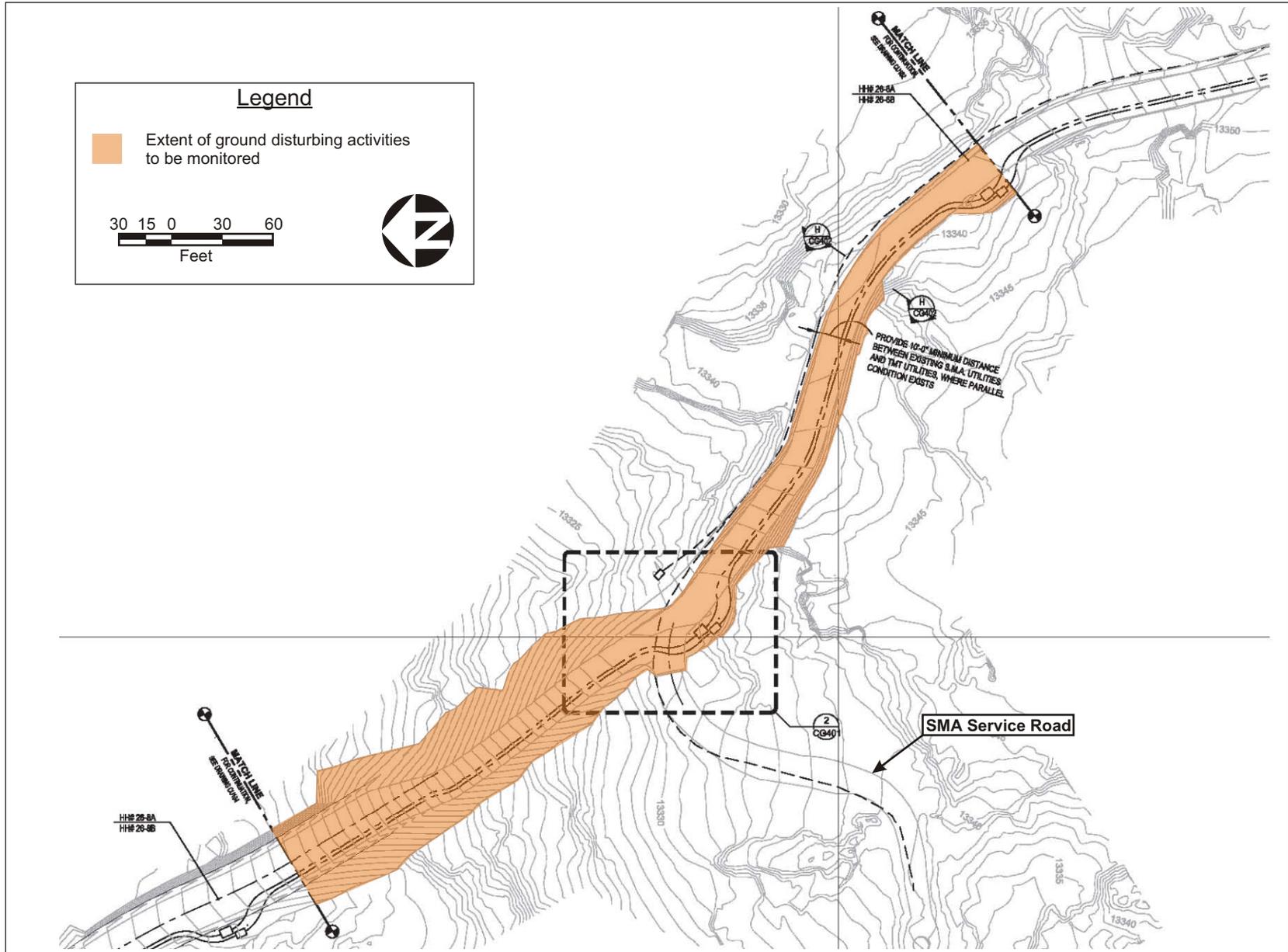


Figure 12. Section 3, Design Plans for the Mauna Kea Access Way to the Thirty Meter Telescope in the Astronomy Precinct on Mauna Kea.

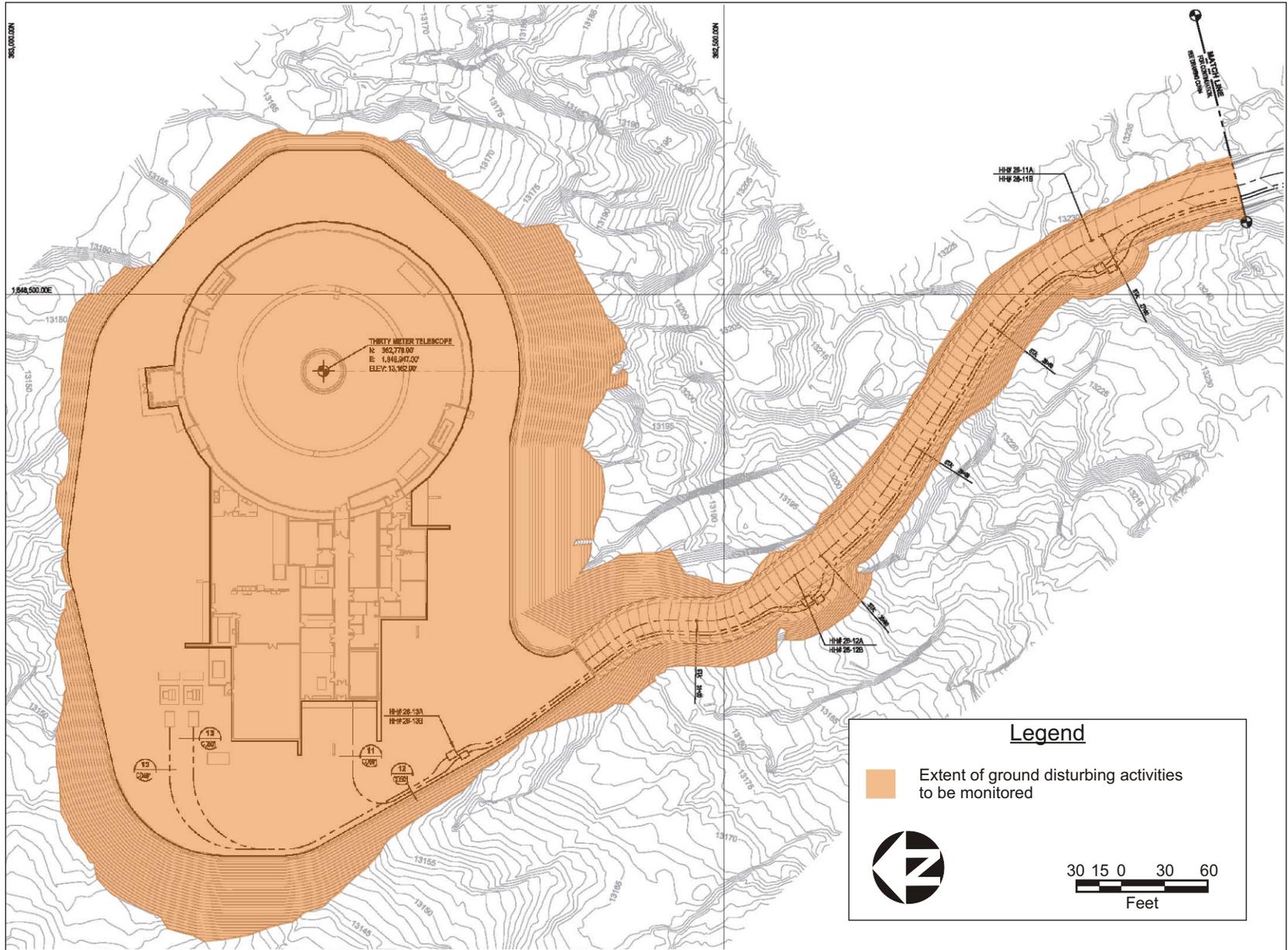


Figure 14. Section 5, Design Plans for the Mauna Kea Access Way and Observatory Site of the Thirty Meter Telescope in the Astronomy Precinct on Mauna Kea.

1. Selected, sorted charcoal samples from discrete fire features will be collected for radiocarbon analysis where appropriate (particularly if the charcoal appears in a prehistoric context).
2. Bulk samples of midden material will be collected, such as shell, bones, etc.
3. All prehistoric artifacts will be collected.
4. All historic artifacts will be collected unless large trash or refuse pits are encountered, in which case only diagnostic samples will be taken, such as bottle and ceramic bases containing maker's marks.
5. Standard documentation will be carried out, including scale maps, profiles, photographs, detailed soil and provenience descriptions, and interpretation.
6. Photographs of excavations will be included in the monitoring report even if no historically significant sites are documented during the monitoring field work.

TREATMENT OF HUMAN REMAINS

If human remains are identified, work will immediately stop in the area that the archaeologist determines could contain the remains and related materials such as grave goods. Determinations on the treatment and disposition of the remains will be made by the DLNR in consultation with the OMKM, HIBC, OHA, and any recognized descendants. SHPD/DLNR and the OMKM will be notified immediately of the find.

No further work will take place in that locale—including screening of back dirt, cleaning and/or excavation of the burial area, or exploratory work of any kind—unless explicitly requested by the SHPD. SHPD/DLNR, in consultation with the OMKM, the Kahu Kū Mauna, OHA, and the Hawai'i Island Burial Council, will determine if it is appropriate to remove and relocate any human remains encountered. If SHPD/DLNR authorizes removal of the human remains, the archaeological monitor will remove and inventory the remains in accordance with Hawaii Administrative Rules 13-300, and the remains will be stored temporarily at the SHPD/DLNR Hawai'i Island office until re-interment plans are finalized.

If a re-interment plan is needed, the company conducting the archaeological monitoring will prepare the re-interment plan and submit the plan to SHPD for review and approval. The re-interment site will be established in accordance with the HAR governing activities in the Conservation District (HAR 13-5), and with the concurrence of the Kahu Kū Mauna Council, the OMKM, and the SHPD.

The location of any authorized reburial site must be recorded by GPS, and reasonably detailed descriptions, including photographs, of the reburial sites must be provided to OMKM and to the SHPD for their records.

HALTING OF EXCAVATION ACTIVITY

The archaeological monitor has the authority to halt construction in the vicinity of the find, so that the provisions of the AMP can be carried out. The archaeological monitor and the TMT Site Superintendent will make it clear to the construction personnel that the archaeologist is authorized to halt work when it is deemed appropriate.

PRE-CONSTRUCTION CONFERENCE

Before works begins on the project, the on-site archaeological monitor will, with the cultural resource specialist (described below in Section VI), participate in a pre-construction conference. At that conference, the archaeological monitor will explain to the entire construction crew what materials may be encountered and the procedures to follow if archaeological materials are found, as well as the role of the archaeological monitor. At this time the archaeological monitor and the TMT Site Superintendent will make it clear to construction supervisors and all other members of the construction team that the archaeological monitor has the authority to stop work *immediately*, if necessary. Before supervisors, subcontractors, or other construction workers not present at the pre-construction conference are assigned to work on ground disturbing activities, they will meet with/be briefed by the on-site archaeological monitor so that they receive the same guidance as those who were present at the pre-construction conference. Additional steps during the pre-construction phase may also include having a land surveyor flag the limits of ground disturbance prior to the start of work in order to indicate clearly the areas that are off-limits to construction equipment and personnel.

LABORATORY WORK

Artifacts will be cataloged and analyzed, along with any samples of midden materials that were collected. Charcoal and other datable materials will be submitted for dating analysis, provided samples were collected in-situ from prehistoric contexts that show no signs of intermixing with historic materials; e.g., charcoal obtained from distinct fire features in solely pre-contact deposits.

In the event human remains are inadvertently discovered and SHPD/DLNR authorizes their removal and relocation, as noted above, the human remains and associated items will be treated in accordance with Hawaii Administrative Rules (HAR) §13-300-32, and the remains will be stored temporarily at the SHPD/DLNR Hawai'i Island office until re-interment plans are finalized.

REPORT PREPARATION

The archaeological monitor will compile daily monitoring logs. These logs will minimally include a description of daily activities, sites or features cleared and recorded, personnel on-site, problems encountered, and corrective action taken. Reports will be filed as appropriate with the SHPD detailing any new sites or features identified within the project area boundaries, if necessary and appropriate. Copies of all reports will also be provided to OMKM and Kahu Ku Mauna.

Following completion of monitoring fieldwork and any required laboratory analyses, a draft archaeological monitoring report will be prepared in conformance to HAR §13-279-5, and submitted to SHPD/DLNR, OMKM, and the Kahu Kū Mauna for review. The archaeological monitor will submit a final archaeological monitoring report after receiving any comments on the draft report.

COLLECTIONS ARCHIVING

All burial remains and associated materials will be given to the SHPD/DLNR Hawai'i Island office for curation until re-interment plans are finalized. Non-burial materials will be stored temporarily at OMKM's facilities until an appropriate curation facility is available on Hawai'i Island.

CULTURAL MONITORING

In accordance with the CMP and with the commitments described in the FEIS for the TMT (FEIS-U.H. Hilo 2010), TMT Observatory Corporation will hire a cultural resource specialist to work in conjunction with the archaeological monitor at all times and in all places or situations where on-site archaeological monitoring is required. Currently, there are no statutory or regulatory mandates for cultural resource specialist or monitors, nor are there any recognized policies or guidelines that set out standards for cultural monitoring. However, preliminary consultations with Kahu Kū Mauna have led to the following basic recommendations for the cultural resource specialist and monitoring during TMT construction work:

- A cultural monitor will be present on-site at all times whenever the archaeological monitor is present.
- Individuals selected to be cultural monitors will have the appropriate background in order to serve as a cultural monitor and as a cultural resource specialist for cultural matters. Such individuals are to serve as mediators among the various stakeholders.
- Cultural monitors will not be affiliated with the archaeological firm that is hired to provide archaeological monitoring support.
- Cultural monitors will participate in any pre-construction briefings with the archaeological monitors. In addition, cultural monitors will maintain regular records of attendance and activity on the job site.
- Cultural monitors will provide the Kahu Kū Mauna and OMKM with a report of activities and findings, if any, on a weekly basis.

INADVERTENT DISCOVERIES

If any historic properties should be found in the APE as defined above they will be classified as inadvertent discoveries per HAR 13-280 since the archaeological survey of the Science Reserve, including the Astronomy Precinct, has been completed (McCoy and Nees 2010). The process that will be followed if inadvertent discoveries are made during construction projects will involve:

- Stopping all construction within the immediate vicinity of the property.
- Notifying SHPD, having the significance of the property assessed, and proposing appropriate mitigation measures.
- If the property cannot be avoided due to construction or design constraints, it will be thoroughly documented before being destroyed.
- If it can be saved, appropriate measures are needed to protect the historic property during the remainder of the construction phase and when the facility is in use.
- Interested members of the Native Hawaiian community will be consulted for properties believed to be associated with Native Hawaiians (SHPD 2000:23).

REFERENCES CITED

- Allen, Melinda Sue
1981 *An Analysis of the Mauna Kea Adze Quarry Archaeobotanical Assemblage*. Master's thesis, University of Hawai'i.
- Barry, Roger G.
1981 *Mountain Weather and Climate*. Methuen. New York.
- Borthwick, Douglas F., and Hallett H. Hammatt
1990 *Archaeological Reconnaissance Survey of the Proposed Galileo Telescope Sites C and D, Summit of Mauna Kea Hawaii Island, Hawaii* (TMK 4-4-015:09). Prepared for MCM Planning.
- Buck, Sir Peter
1957 *Arts and Crafts of Hawaii*. Bernice P. Bishop Museum Special Publication 45. Honolulu.
- Chinen, Jon J.
1958 *The Great Māhele: Hawaii's Land Division of 1848*. Honolulu: University of Hawaii Press.
- Cleghorn, Paul Lodge
1982 *The Mauna Kea Adze Quarry: Technological Analyses and Experimental Tests*. Unpublished Doctoral Dissertation, University of Hawaii.
- Cordy, Ross
1994 *A Regional Synthesis of Hamakua District Island of Hawai'i*. Department of Land and Natural Resources, Historic Preservation Division.
- Davies, J.L.
1972 *Landforms of Cold Climates*. Australian National University Press, Canberra.
- DePaolo, D.J. and E.M. Stolper
1996 Models of Hawaiian Volcano Growth and Plume Structure: Implications of results from the Hawaii Scientific Drilling Project. *Journal of Geophysical Research* 101(B5):11643-11654.
- de Silva, Kihei, and Mapuana
2006 *E Ho'ka Nani I Mana*. Ka'iwakiloumoku-Hawaiian Cultural Center, University of Hawaii at Manoa, Honolulu. 8/2/2007. <http://hccp.ksbe.edu/kaleinamanu/8-ehoikanani.php>.
- Ellis, William
1979 *Journal of William Ellis: Narrative of a Tour of Hawaii, or Owhyhee; with Remarks on the History, Traditions Manners, Customs, and Language of the Inhabitants of the Sandwich Islands*. Charles E. Tuttle Company, Inc. Rutland, Vermont.
- Embleton, C., and C.A.M. King
1975 *Periglacial Geomorphology*. John Wiley and Sons, New York.

- Gregory, Herbert E., and Chester K. Wentworth
 1937 General Features and Glacial Geology of Mauna Kea, Hawaii. *Bulletin of the Geological Society of America* 48:1719-42.
- Ho'ākea Communications, LLC dba Ku'iwalu
 2009 Mauna Kea Comprehensive Management Plan UH Management Areas. Prepared for the University of Hawai'i.
- Hammatt, Hallett, H.
 2010 "Archaeological Inventory Survey for the Thirty-Meter Telescope (TMT) Observatory Project, Maunakea, Ka'ohē Ahupua'a, Hamakua District, Hawaii Island." Appendix G in Final Environmental Impact Statement for the TMT. Prepared for PB Americas by Cultural Surveys Hawaii, Inc., Kailua.
- Hammatt, Hallett, and Douglas Borthwick
 1988 Archaeological Reconnaissance of Two Proposed Antenna Sites for the National Radio Astronomy Observatory, Mauna Kea, Hawaii.
- Hammatt, Hallett H., and David W. Shideler
 2002 Data Recovery Report for Two Archaeological Lithic Scatters, Sites 50-10-23-10,310 and 50-10-23-10,311 at The Pu'u Kalepeamoā Complex, Hale Pohaku, Ka'ohē Ahupua'a, Mauna Kea, Hawaii Island (TMK 4-4-15:12). Prepared for The Institute for Astronomy, University of Hawaii.
- Hibbard, Don
 1999 Letter of May 3, 1999 to Dr. Robert McLaren (IfA) Regarding Historic Preservation Review of the Proposed W.M. Keck Outrigger Telescopes Project.
- Kam, Wendell, and Jason Ota
 1983 Archaeological Reconnaissance Survey of Mauna Kea Observatory Powerline: Upper Portions, Mauna Kea, Hamakua, Hawaii. State Historic Preservation Division Office. Prepared for University of Hawaii. On file at State Historic Preservation Office.
- King, Thomas F.
 2003 Declaration of Thomas F King, Ph.D. Exhibits A-B in Office of Hawaiian Affairs vs. NASA and University of Hawaii Institute for Astronomy.
- Langlas, Charles
 1999 Supplement to Archaeological, Historical and Traditional Cultural Property Assessment for the Hawai'i Defense Access Road A-AD-6(1) and Saddle Road (SR200) Project.
- Langlas, Charles, Thomas R. Wolforth, James Head, and Peter Jensen
 1997 Archaeological Inventory Survey and Historical and Traditional Cultural Property Assessment for the Hawai'i Defense Access Road A-AD-6(1) and Saddle Road (SR200) Project, Districts of South Kohala, Hamakua, North Hilo and South Hilo, Island of Hawai'i. Paul H. Rosendahl Ph.D., Inc., Hilo. Prepared for RUST Environmental and Infrastructure Inc., Phoenix, Arizona.

Macdonald, Gordon A., and Agatin T. Abbott

- 1970 *Volcanoes in the Sea: The Geology of Hawaii*. University of Hawaii Press, Honolulu.

Maly, Kepa

- 1998 "Mauna Kea—Kuahiwi Ku Ha'ō Malie." A Report on Archival and Historical Documentary Research, Ahupua'a of Humu'ula and Ka'ōhe, Districts of Hilo and Hamakua, Island of Hawai'i. Kumu Pono Associates. Hilo.
- 1999 "Mauna Kea Science Reserve and Hale Pohaku Complex Development Plan Update: Oral History and Consultation Study, and Archival Literature Research. Ahupua'a of Ka'ōhe (Hamakua District) and Humu'ula (Hilo District), Island of Hawai'i. In Mauna Kea Science Reserve Master Plan (Appendix I), Group 70 International, Inc. Honolulu.

Maly, Kepa, and Onaona Maly

- 2005 Mauna Kea—Ka Piko Kaulana o Ka 'Aina (Mauna Kea—The Famous Summit of the Land: A Collection of Native Traditions, Historical Accounts, and Oral History Interviews for: Mauna Kea, the Lands of Ka'ōhe, Humu'ula and the 'Aina Mauna on the Island of Hawai'i. Prepared for the Office of Mauna Kea Management. Kumu Pono Associates LLC. Hilo.

McCoy, Patrick C.

- 1977 The Mauna Kea Adz Quarry Project: A Summary of the 1975 Field Investigations. *Journal of the Polynesian Society* 86(2):233-244.
- 1978 The B.P. Bishop Museum Mauna Kea Adz Quarry Project . Prepared for the Historic Preservation Office, Department of Land and Natural Resources. Department of Anthropology, Bishop Museum.
- 1979 Letter Report Dated August 22, 1979 to Mr. Francis Oda on archaeological reconnaissance survey of two alternative locations for the Proposed Mauna Kea Mid-Elevation Facilities. Department of Anthropology, Bishop Museum.
- 1981 Letter Report Dated June 9, 1981 to J. Jeffries on archaeological survey for the proposed Kitt Peak National Observatory. Department of Anthropology, Bishop Museum.
- 1982a Archaeological Reconnaissance Survey, In Patrick C. McCoy and Holly McEldowney, Cultural Resources Reconnaissance of the Mauna Kea Summit Region. Department of Anthropology, Bishop Museum.
- 1982b Archaeological Survey of the Proposed Site of the Caltech 10-Meter Telescope on Mauna Kea, Hawaii. Prepared for Group 70, Inc. Department of Anthropology, Bishop Museum.
- 1984 Mauna Kea Summit Region Survey: A Summary of the 1984 Fieldwork. Ms. on file at the Department of Anthropology, Bishop Museum.
- 1985a Biogeoclimatic Factors of Production in a Hawaiian Alpine Desert Adze Quarry. Paper Presented at the 50th Annual Meeting of the Society for American Archaeology, Denver, Colorado.

- 1985b Preliminary Archaeological Survey of the Pu'u Kalepeamoia Site, Mauna Kea, Hawaii. Appendix C of the Amendment to the Mauna Kea Science Reserve Complex Development Plan. Draft Supplemental Environmental Impact Statement for Construction Camp Housing at Hale Pohaku, Hamakua, Hawaii. University of Hawaii.
- 1990 Subsistence in a "Non-Subsistence" Environment: Factors of Production in a Hawaiian Alpine Desert Adze Quarry. In *Pacific Production Systems: Approaches to Economic Prehistory*, edited by D.E. Yen and J.M.J. Mummery, pp. 85-119. Occasional Papers in Prehistory, No. 18, Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra.
- 1991 Survey and Test Excavations of the Pu'u Kalepeamoia Site, Mauna Kea, Hawai'i. Prepared for Facilities Planning and Management Office, University of Hawaii. Ms. on file in the Department of Anthropology, Bernice P. Bishop Museum. Honolulu.
- 1993 Letter Report on the Inspection of Two Sites Located in the Vicinity of the Smithsonian Submillimeter Array. Submitted to the Smithsonian Institution Astrophysical Observatory.
- 1999a *Mauna Kea Science Reserve Archaeological Site Inventory: Formal, Functional, and Spatial Attributes*. In *Mauna Kea Science Reserve Master Plan* (Appendix K), Group 70 International, Inc. Honolulu.
- 1999b Neither Here Nor There: A Rites of Passage Site on the Eastern Fringes of the Mauna Kea Adze Quarry, Hawai'i. *Hawaiian Archaeology* 7:11-34.
- 2005 Archaeological Monitoring of Four Septic Tank Excavations at the Mid-Level Facilities Located at Hale Pohaku, Mauna Kea, Ka'ohē, Hamakua. Island of Hawai'i (TMK: [3]:4-4-015:012). Prepared for the University of Hawaii Institute for Astronomy.
- McCoy, Patrick, Sara Collins, Stephan D. Clark, and Valerie Park
 2009 *A Cultural Resource Management Plan for the University of Hawai'i Management Areas on Mauna Kea: A Sub-Plan for the Mauna Kea Comprehensive Management Plan, Ka'ohē Ahupua'a, Hāmākua District, Island of Hawai'i TMK: (3) 4-4-012, 015*. Prepared for the Office of Mauna Kea Management by Pacific Consulting Services Inc.
- McCoy, Patrick and Richard Nees
 2010 *Archaeological Inventory Survey of the Mauna Kea Science Reserve, Ka'ohē Ahupua'a, Hāmākua District, Island of Hawai'i TMK: (3) 4-4-015: 01 (por.)*. Prepared for the Office of Mauna Kea Management by Pacific Consulting Services Inc.
- McCoy, Patrick, Richard Nees, and Stephan D. Clark
 2010a *Archaeological Inventory Survey of the Astronomy Precinct in the Mauna Kea Science Reserve, Ka'ohē Ahupua'a, Hāmākua District, Island of Hawai'i TMK: (3) 4-4-015: 01 (por.)*. Prepared for the Office of Mauna Kea Management by Pacific Consulting Services Inc.

- McCoy, Patrick, Richard Nees, and Melanie Mintmier
 2010b *Archaeological Inventory Survey of the Mauna Kea Access Road Management Corridor Ka`ohe Ahupua`a, Hāmākua District, Island of Hawai`i* (TMK: (3) 4-4-015: 01 (por.) Prepared for the Office of Mauna Kea Management by Pacific Consulting Services Inc.
- McEldowney, Holly
 1982 Ethnographic Background of the Mauna Kea Summit Region. Report 1. In *Cultural Resources Reconnaissance of the Mauna Kea Summit Region*. Bishop Museum Department of Anthropology ms.
- Moore, James G., and D.A. Clague
 1992 Volcano growth and the evolution of the island of Hawaii. *Geological Society of America Bulletin* 104(10):1471-1484.
- NASA (National Aeronautics and Space Administration)
 2005 *Final Environmental Impact Statement for the Outrigger Telescopes Project*. Vols. 1 and 2. Washington, D.C.
- PHRI (Paul H. Rosendahl, Ph.D., Inc.)
 1999 Cultural Impact Assessment Study: Native Hawaiian Cultural Practices, Features, and Beliefs Associated with the University of Hawai`i Mauna Kea Science Reserve Master Plan Project Area. Prepared for University of Hawaii Institute for Astronomy. In Mauna Kea Science Reserve Master Plan (Appendix N).
- Powers, W. E., and C. K. Wentworth
 1941 Air Movements and Weather in the Mauna Kea-Mauna Loa Saddle, Hawaii. *Bulletin of the Geological Society of America* 56:267-74.
- Price, Larry W.
 1981 *Mountains and Man: A Study of Process and Environment*. University of California Press. Berkeley.
- Pukui, Mary Kawena, and Samuel Elbert
 1971 *Hawaiian Dictionary*. University Press of Hawaii, Honolulu.
- Robins, Jennifer, and Hallett H. Hammatt
 1990 Archaeological Reconnaissance for Summit and Mid-Level Facilities for the Proposed Japan National Large Telescope. Prepared for MCM Planning, Honolulu.
- Sharp, W.D. and P.R. Renne
 2003 The 40 Ar/39 Ar dating of core recovered by the Hawaii Scientific Drilling Project (phase 2), Hilo, Hawaii. *Geochemistry, Geophysics, Geosystems* 6 (no. Q04G17): doi:10.1029/2004GC000846).
- Sherrod, D.R., J.M. Sinton, S.E. Watkins and K.E. Brunt
 2007 *Geologic Map of the State of Hawaii*. U.S. Geological Survey Open-File Report 2007-1089.

State Historic Preservation Division

- 2000 Mauna Kea Historic Preservation Management Plan Management Components. In *Mauna Kea Science Reserve Master Plan* (Appendix F), Group 70 International, Inc. Honolulu.

Tricart, J.

- 1970 *Geomorphology of Cold Environments*. Translated by Edward Watson. Macmillan, London.

Ugolini, F.C.

- 1974 Hydrothermal Origin of the Clays From the Upper Slopes of Mauna Kea, Hawaii. *Clays and Clay Minerals* 22:189-194.

n.d. Soils of the high elevations of Mauna Kea, Hawaii. Unpublished manuscript.

U.S. Geological Survey

- 2002 Mauna Kea: Hawaii's Tallest Volcano. From <http://hvo.wr.usgs.gov/volcanoes/maunakea>.

University of Hawai'i, Hilo

2010a Final Environmental Impact Statement, Thirty Meter Telescope Project, Island of Hawai'i; Proposing Agency: University of Hawaii at Hilo.

2010b Conservation District Use Permit Application, Thirty Meter Telescope Project, Island of Hawai'i; Applicant: University of Hawaii at Hilo.

Walden, Jackie and Valerie Park

- 2010 *Architectural Inventory Survey of Hale Pōhaku Rest Houses 1 and 2 and Comfort Station, Ka'ōhe Ahupua'a, Hāmākua District, Island of Hawai'i TMK: (3) 4-4-015:12 (por.)*. Prepared for the Office of Mauna Kea Management by Pacific Consulting Services Inc.

Wentworth, Chester K., and William E. Powers

- 1941 Multiple Glaciation of Mauna Kea, Hawaii. *Bulletin of the Geological Society of America*. 52:1193-1216.

Williams, Scott S.

- 1987 Post-field Letter Report Dated July 7, 1987 to Mr. Clyde Akita on the Archaeological Reconnaissance Survey of the Summit Road Between Halepohaku and the Stockpile Area, Mauna Kea, Hawai'i Island. Bishop Museum, Honolulu, Hawai'i.
- 1989 *A Technological Analysis of the Debitage Assemblage from Ko'oko'olau Rockshelter No. 1, Mauna Kea Adze Quarry, Hawai'i*. Unpublished M.A. Thesis, Washington State University.

Wolfe, Edward W., and Jean Morris, Compilers

- 1996 *Geologic Map of the Island of Hawaii*. U.S. Geological Survey, Miscellaneous Investigation Series. Washington, D.C.

Wolfe, Edward W., William S. Wise, and G. Brent Dalrymple

1997 *The Geology and Petrology of Mauna Kea Volcano, Hawaii—A Study of Postshield Volcanism*. U.S. Geological Survey Professional Paper 1557, Washington, D.C.

Woodcock, A.H.

1974 Permafrost and Climatology of a Hawaii Volcano Crater. *Arctic and Alpine Research* 6(1):49-62.