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BOARD OF LAND AND NATURAL RESOURCES

FOR THE STATE OF HAWAI'I

IN THE MATTER OF A Contested Case Hearing Re Conservation District Use Permit (CDUP) HA-3568 for the Thirty Meter Telescope at the Mauna Kea Science Reserve, Kaohe Mauka, Hamakua District, Island of Hawaii TMK (3) 4-4-015:009	Case No. BLNR-CC-16-002 **TMT INTERNATIONAL OBSERVATORY, LLC's FINAL WITNESS LIST and WRITTEN DIRECT TESTIMONY OF WITNESSES; CERTIFICATE OF SERVICE**

TMT INTERNATIONAL OBSERVATORY, LLC's FINAL WITNESS LIST
<u>AND WRITTEN DIRECT TESTIMONY OF WITNESSES</u>

TMT INTERNATIONAL OBSERVATORY, LLC ("TIO") by and through its attorneys, WATANABE ING, hereby submits its final witness list, including the written direct testimony of each witness, which TIO expects to call at the evidentiary hearing in the above-referenced Contested Case matter.

1. Testimony of Edward C. Stone (Exhibit C-1);

2. Testimony of Gary H. Sanders (Exhibit C-2);

3. Testimony of Michel Bolte (Exhibit C-4), including the following reference material:

    a) New York Times news article, October 3, 2016 (Exhibit C-5);

4. Testimony of David Callies (Exhibit C-6);

5. Testimony of James E. Hallstrom (Exhibit C-7);

6. Testimony of Dr. Heather Kaluna (Exhibit C-8);

7. Testimony of Naea Stevens (Exhibit C-9);

8. Testimony of Amber Imai-Hong (Exhibit C-10);

9. Testimony of Robert B. Rechtman (Exhibit C-11), including the following reference materials:

    a) Thirty Meter Telescope Archaeological Report, October 2013 (Exhibit C-12);

    b) Letter dated 12/16/2013 to Robert Rechtman from DLNR Historic Preservation Division, approving TMT Archaeological Report (Exhibit C-13);

    c) Thirty Meter Telescope Monitoring Report re: Groundbreaking, September 2014 (Exhibit C-14);

    d) Field Reconnaissance of TMT Development Site (Exhibit C-15);

    e) Updated Field Reconnaissance of TMT Development Site (Exhibit C-16);

10. Testimony of Paul Coleman (Exhibit C-17)

DATED: Honolulu, Hawaii, October 11, 2016.

J. DOUGLAS ING
ROSS T. SHINYAMA
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TESTIMONY

OF

EDWARD C. STONE

My name is Edward C. Stone and I am the Executive Director of TMT International Observatory LLC.

I received my undergraduate education at Iowa's Burlington Junior College, I earned an M.S. and Ph.D in physics at the University of Chicago. I joined the staff of Caltech as a research fellow, and became a full faculty member in 1967, was named professor of physics in 1976, and chair of the Division of Physics, Mathematics, and Astronomy from 1983 to 1988. I also served as vice president for Astronomical Facilities from 1988 to 1990 and as director of Jet Propulsion Laboratory in Pasadena, California from 1991 to 2001. In the late 1980s through 2009, I also served as chairman and vice chairman of the Board of Directors of the California Association for Research in Astronomy, which has been responsible for building and operating the W.M. Keck Observatory with its two ten-meter telescopes on Mauna Kea, Hawaii.

I joined the Thirty Meter Telescope Corporation in 2004 and served as chairman and vice-chairman until May 2014 when I became Executive Director of the newly-founded TMT International Observatory (TIO) that was established to carry out the construction and operation phases of the TMT Project. The current Members of TIO are Caltech, UC, the National Institutes of Natural Science of Japan, the National Astronomical Observatories of the Chinese Academy of Sciences, the Canadian National Research Council and the Indian Department of Science and Technology. Major funding has been provided by the Gordon & Betty Moore Foundation.

Each of these Members or their affiliates had been associated with the TMT Observatory Corporation prior to the formation of TIO, had participated and collaborated in the planning for the TMT Project, had spent funds on the design of the TMT, and had expressed interest in forming an international partnership once the site at Mauna Kea received it's Conservation District Use Permit. TIO was thus formed with these members in May 2014. It is important to note that all of these members or their affiliates had been associated with TMT Observatory Corporation for several years.

TIO will pursue its purposes by designing, developing, constructing, and operating an observatory on Mauna Kea with a "state-of-the-art" thirty-meter, world class telescope, and in doing so, foster academic and scientific interaction among educational and other research institutions on a global basis.

TIO is organized exclusively for exempt purposes under Section 501(c)(3) of the Internal Revenue Code. TIO may not carry out activities that are not permitted by Section 501 (c)(3) of the Code. TIO is operated exclusively to further the charitable educational and/or scientific purposes within the meaning of Section 501 (c)(3). TIO is specifically organized and operated to provide for the observation and collection of images and information from deep space to advance human knowledge of astronomy and the origins of the universe by and through the TMT Project. TIO and its members seek to develop, design, finance, construct, commission, operate and decommission a next generation segmented mirror telescope and associated observatory on Mauna Kea in Hawaii.

Background

This has been a long journey for us. In spring 2003, we began a partnership to design and built a next generation large telescope. We developed a preliminary design for a segmented 30-meter-diameter astronomical telescope that is patterned after the twin Keck telescopes. We hoped then that our journey could be expanded to include not only the preliminary design phase, but also the final design, construction, commissioning, and operation of the observatory.

Value of the TMT Observatory

The critical need for an optical/infrared[1] telescope[2] with a 30-meter primary mirror to continue the scientific advancement of the last decades was identified by the U.S. scientific community and assigned a priority by the Canadian scientific community. In response to this need, the TMT Corporation was formed to manage initial planning, and then the design, development, and operation of the TMT Observatory,[3] which will house a 30-meter primary mirror telescope.

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[1] Optical or visual light encompasses the wavelengths from 320 nanometers (blue/ultra-violet) to 950 nanometers (red) (0.32 to 0.95 microns) including the U, B, V R, I, and Z bands in astronomy.

Infrared can be divided into near, mid, and far infrared wavelengths, generally as follows:
Near – 1,000 to 2,200 nanometers (1.0 to 2.2 micrometers or microns); includes the J, H, and K bands in astronomy.
Mid – 2,500 to 30,000 nanometers (2.5 to 30 microns); includes L M, N and Q astronomy bands.
Far – 30,000 to 400,000 nanometers (30 to 400 microns); also referred to as submillimeter.

[2] A telescope is defined as a movable structure and optics and/or reflectors used to select a viewing position on the sky, capture the radiation (visible light, infrared, or radio) from astronomical objects and focus that radiation into a focal plane.

[3] An observatory includes the telescope(s), the dome(s) that contain the telescope(s), and the instrumentation and support facilities for the telescope(s) that fall under a common ownership.

The TMT Project's primary purpose is to provide a much more advanced and powerful ground-based observatory than currently exists, one that will enable discoveries about the nature and origins of the physical world, from the first formation of galaxies in the distant past and remote regions of the Universe to the formation of planets and planetary systems today in our Milky Way Galaxy.

The United States has been the leader in astronomical research for the last 150 years, and locating the TMT Observatory in Hawai'i will maintain the United States' leadership in astronomical research, discovery, and innovation. The TMT Project will help to maintain this leadership by leveraging the capability of the existing observatories on Mauna Kea, including the W. M. Keck Observatory, the Canada-France-Hawai'i Telescope (CFHT), and the Subaru Telescope. While these observatories are world-leading observatories today, their future scientific productivity would be increased by the co-location of a next generation observatory, such as the TMT Observatory. Additionally, by bringing the TMT Project to Hawai'i, the potential significant socioeconomic benefits, including employment and education, of the TMT Project will be realized by the people of Hawai'i.

The quest to answer fundamental questions about the nature and workings of the Universe has been pursued through the ages, and continues today. The TMT Project will continue this quest. The TMT concept was developed to address the need to overcome the limitations of existing astronomical facilities. An observatory similar to the TMT Observatory has been envisioned by the scientific community for some time. It has been referred to generically as a Next Generation Large Telescope (NGLT) or Giant Segmented Mirror Telescope (GSMT) in various plans and surveys for the last 15 years.

With the TMT Observatory, observations of the first stars and galaxies formed after the Big Bang will be possible and the epoch of "First Light" in the Universe could be unveiled. Understanding the subsequent evolution of galaxies from this early time to the current era is another major research area for which TMT Observatory will provide a giant step forward. The combination of great sensitivity and unique spatial resolution of the TMT Observatory will be vital to learning more about the recently discovered phenomenon in which galaxy evolution and the growth of supermassive black holes in galaxy cores are tightly coupled. The combination of great sensitivity and unique spatial resolution will also make the TMT Observatory an extremely powerful observatory for the discovery and characterization of planets orbiting other stars.

Since 2003, work has greatly progressed on the design of the telescope, instruments and all aspects of the Observatory. The project has been named the Thirty Meter Telescope (TMT) and the effort has included the government agencies of Canada, China, Japan, India, and the University of California and the California Institute of Technology.

On July 21, 2009, after a multiyear evaluation of different sites and intensive visits and discussions with the various stakeholders in Hawaii, TMT collaborators selected Mauna Kea on Hawaii Island as the location of the telescope. In May 2010 a Final EIS for the Project was completed and accepted by the Governor of Hawaii. In September 2010, the UH applied for a Conservation District Use Permit to build the TMT Observatory in the Mauna Kea Science Reserve. In April 2013 following a lengthy contested case proceeding, this Board granted a Conservation District Use Permit to build and operate the TMT on Mauna Kea. In February 2014, the Board of Regents for the University of Hawaii approved the terms of a sublease to the TIO for the Project site. On December 2, 2015 the Hawaii Supreme Court ruled that the Board did not follow the correct procedure and should have held the contested case prior to their vote to grant the permit. The Supreme Court remanded the circuit court to further remand to the Board so that a new contested case hearing could be conducted.

In addition to the very large technical effort of observatory design, there have been concerted efforts in many other areas over the past seven years. These include the engagement of the Hawaii community in support of astronomy and in determining how TMT could more meaningfully involve and connect Hawaii Island residents with astronomy. In addition to the rent to be provided under the Sublease, TIO on its own initiative has committed to providing significant funding for education, outreach and training for STEM positions benefiting the Hawaiian community.

Pre-Construction and Construction at Mauna Kea

The TIO members have spent approximately $327 million through June 30, 2016, and have agreements, budget and/or plans for funding of the construction phase at $1.4 billion. Already the government of Japan has initiated procurement of telescope mirror blanks in Japan.

Following the approval of a permit, construction on the TMT Observatory at Mauna Kea is slated to begin in April 2018, with completion of the TMT enclosure and telescope structure expected in 2024 and initial operations three years later.

Decommissioning

In 2000, UH adopted the Mauna Kea Science Reserve Master Plan, which establishes the management structure for UH's stewardship of the areas it manages on Mauna Kea. In 2009 and 2010, UH adopted, and BLNR approved, the Mauna Kea Comprehensive Management Plan ("CMP") and its subplans; the Cultural Resources Plan, Natural Resources Management Plan, Public Access Plan, and Decommissioning Plan. These plans commit UH to exercise responsible stewardship of Mauna Kea and to ensure that astronomical activities are conducted in a manner that respects the cultural significance of Mauna Kea, protects the environment, and is responsive to the needs and concerns of Native Hawaiians and the public.
In May 2010, UH completed an Environmental Impact Statement for the TMT.

Once the TMT Project has expended its useful life, it will be decommissioned and the site will be restored as directed by OMKM. This is a requirement of the CMP and its subplans.

A Decommissioning Funding Plan (DFP) is also a requirement of the Office of Mauna Kea Management's ("OMKM's") Decommissioning Plan. The DFP contains a cost estimate for decommissioning, a description of the method for assuring that funds are available, and the method for adjusting the cost estimate and funding level over the life of the sublease. The DFP describes and documents the sublessee's assurance that a prescribed amount of funding is secured for decommissioning and site restoration. Initially this is based on a conceptual cost estimate and plan to fulfill these requirements. TIO provided to OMKM its initial DFP in 2014.

Summary

The TMT Observatory in Hawaii will not only provide scientists, researchers, and students access to a new telescope with greatly increased power that will provide currently unrivaled opportunities for exciting discoveries, but will highlight Hawaii as an outstanding platform for international collaborations with the largest nations and economies around the Pacific Rim. TMT will also provide opportunities for training, education and jobs in STEM fields.

Testimony of Gary H. Sanders

I am Gary H. Sanders, Project Manager for the Thirty Meter Telescope (TMT) Project.

I received a B.A. degree from Columbia University in 1967 in physics and a Ph.D. from M.I.T in 1971 in high-energy physics. I then spent two years as Postdoctoral fellow in the Princeton University Physics Department before becoming an Assistant Professor at Princeton from 1972 to 1978. I worked at Los Alamos National Laboratory from 1978-1994 in several positions, serving as Principal Investigator and Program Manager for High Energy Physics, 1990-1994. I was the Project Manager and Deputy Director, Laser Interferometer Gravitational Wave Observatory at the California Institute of Technology from 1994 – 2004. In 2004, I became the Project Manager for the Thirty Meter Telescope for the California Institute of Technology and the University of California, which formed the TMT Observatory Corporation (TMT Corporation).

I have been with the TMT Corporation since 2004 and since May 2014 with the TIO. I am responsible for managing the design and construction of the Thirty Meter Telescope. The TMT International Observatory (TIO) was formed on May 6, 2014 and I report to its board of directors.

The TMT International Observatory, LLC

TIO builds on the prior and ongoing efforts of TMT Observatory Corporation, a California non-profit public benefit corporation formed by the University of California and the California Institute of Technology for the purpose of fostering astronomy. TIO is comprised of the University of California, California Institute of Technology and governmental institutions from China, Japan, India and Canada.

I. TMT Project Components

An astronomical observatory encompasses a number of components. This section outlines the various components of the TMT Project and provides explanation for certain terms. The TMT Project is the sum of the following proposed components:

- "TMT Observatory" refers to the components of the TMT Project located on the upper elevations of Maunakea, but below the summit. The TMT Observatory generally consists of the 30-meter telescope, instruments, dome, attached building, and parking.
- The "Access Way" refers to the road and other infrastructure improvements that will be provided to access and operate the TMT Observatory. Improvements in the Access Way will generally include a surface roadway and underground utilities.

- Hale Pohaku work refers to Hawaiian Electric and Light Company (HELCO) Upgrades. The new transformers will replace the existing ones on a 1:1 basis, and the fenced compound will not be expanded.

- "Headquarters" refers to the facility located in Hilo to manage activities at and support operation of the TMT Observatory. This includes an office building with a parking area.

A. TMT Observatory

The TMT Observatory will be located on Maunakea within the Mauna Kea Science Reserve (MKSR) on Hawai'i Island in the State of Hawai'i.

The entire 11,288-acre MKSR (TMK 4-4-15: 9) is designated as part of the State of Hawai'i Conservation District resource subzone. It is managed by the State of Hawai'i Department of Land and Natural Resources (DLNR), though certain responsibilities are delegated to the University of Hawaii (UH) through the Comprehensive Management Plan (CMP) (UH 2009a). The MKSR is leased by DLNR to the UH; the current lease expires in 2033. Eight optical and/or infrared observatories are currently present in the MKSR's 525-acre Astronomy Precinct; the first Maunakea observatories were built in the 1960s. Optical/infrared telescopes use mirrors to collect and focus visible and infrared light. Each optical/infrared observatory consists of a single telescope, except the W. M. Keck Observatory which currently houses the two most powerful optical/infrared telescopes on Maunakea, each with a 10-meter diameter primary mirror. The MKSR also hosts three submillimeter observatories and a radio antenna[1] (Figure 1).

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[1] The Very Large Baseline Array (VLBA) antenna is a telescope but does not individually meet the definition of an observatory because it is only one part of a larger array, which stretches from the U.S. Virgin Islands to Maunakea. All the various antenna, instrumentation, and support facilities make up the VLBA antenna.

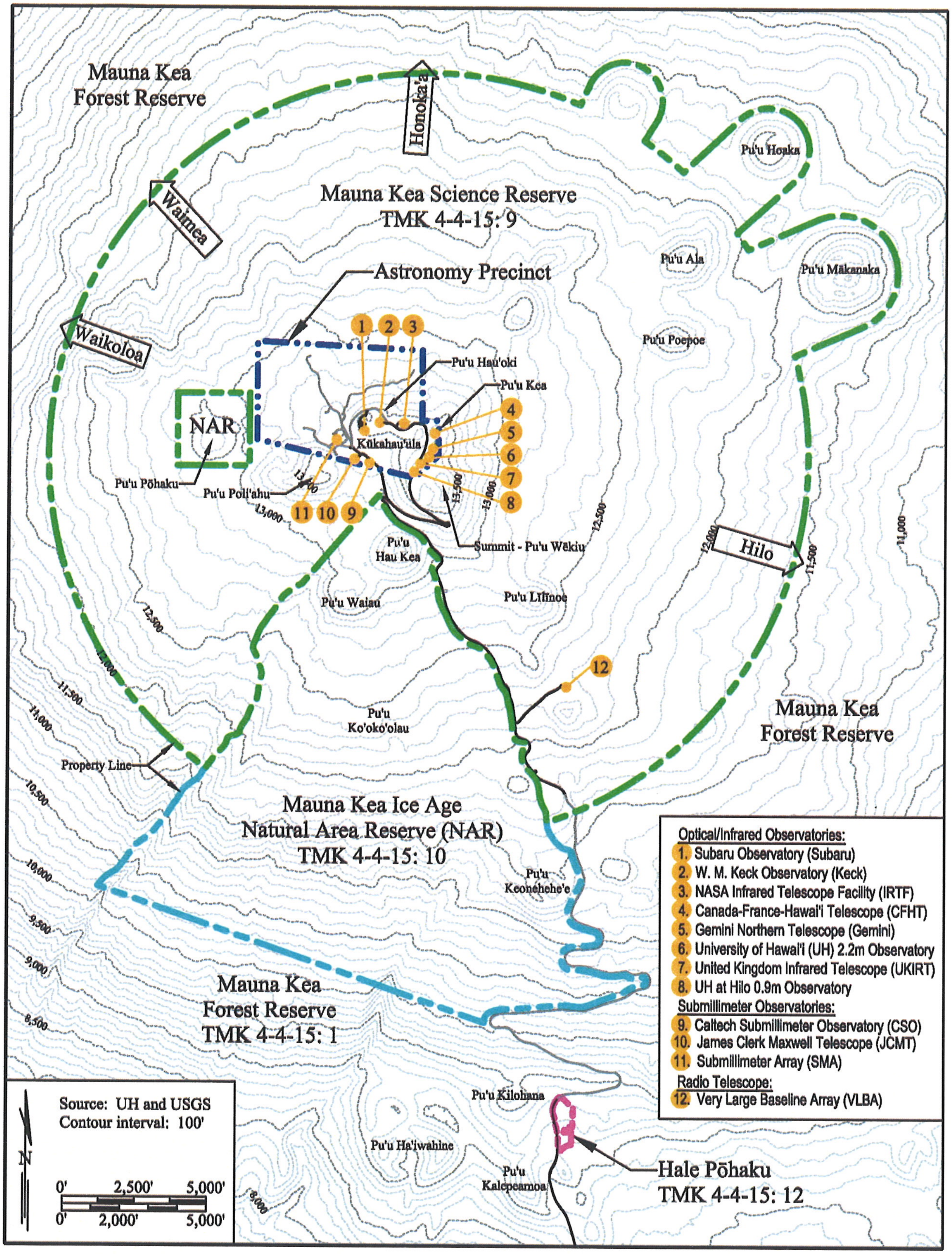


Figure 1: Maunakea Overview

The 2000 Master Plan specifies Area E as a preferred location for a NGLT. Area E was identified as a preferred location because it was anticipated to provide suitable observation seeing conditions with the minimum impact on existing facilities, wēkiu bug habitat, archaeological sites, and viewplanes. Area E ranges in elevation from 13,100 to 13,300 feet; the summit of Maunakea is at an elevation of 13,796 feet. Area E is located approximately 1/2-mile northwest of the eight existing optical/infrared observatories located near the summit. The elevations range from 13,600 to 13,775 feet. Thus, Area E is significantly lower in altitude than the summit region and the existing optical/infrared observatories.

Within Area E, the TMT Observatory will be located on a roughly 5-acre site near the end of the existing 4-wheel drive road, at an elevation of approximately 13,150 feet. This site is known as 13N in reference to its elevation and its location on the northern plateau.

B. TMT Observatory Design

The TMT Observatory design is being and will continue to be developed in consultation with the Office of Mauna Kea Management (OMKM) through their design review process. Whenever possible, the TMT Project will incorporate sustainable technologies and energy efficient technologies into facility design and operations, per CMP Management Action IM-11. The design details provided here represent the current design. The OMKM design review process has been in progress since 2008. No significant design changes, such as the TMT Project site or dome and support building size and height, are anticipated; however, adjustments to finer details could still take place. The TMT Observatory will include the following:

- The telescope, described above. The surface of the primary mirror will be located approximately 66 feet above the ground surface.

- The instruments mounted around the primary mirror used to see and analyze both the visible part of the spectrum and the infrared spectrum.

- The TMT Adaptive Optics (AO) system. The TMT Observatory will be the first optical/infrared observatory of its size to integrate AO into its original design. AO systems correct for the image distortion that is caused by the atmosphere. The TMT AO system will project up to eight laser beams into the atmosphere to create an asterism, or group, of "guide stars" that are used to determine the atmospheric distortion of the visible and infrared light from distant objects and thus correct for it. The TMT AO system will generate each of these eight beams using a 25-watt laser; the laser light will appear yellow (0.589 microns – the sodium D2 line).

- The dome housing the telescope will be a Calotte[2] type enclosure with the following characteristics (Figures 2 and 3).

    1. Total height of roughly 183.7 feet above the current ground surface, with an exterior radius of 108 feet.

    2. The dome shutter will be 102.5 feet in diameter and it will retract inside the dome when opened.

    3. The dome will rotate on two planes, one horizontal at the base structure 25 feet above the ground and the other at roughly 25 degrees as the cap structure, enabling the telescope to view from straight up into the sky to 65 degrees downwards toward the horizon.

    4. The Calotte dome base, cap, and shutter structures will appear rounded and smooth and have a reflective aluminum-like exterior coating.

    5. The fixed cylindrical structure below the rotating base will enclose 35,000 square feet, and extend to 25 feet above grade. The structure will be lava-colored.

    6. The dome base structure and dome fixed structure will have a combination of 88 vents that will be closed during the day and will open at night. The vents will be used to maintain temperature equilibrium between interior and exterior air at night and manage air flow through and around the dome.

[2] A Calotte type dome features a circular shutter and two planes of rotation. Standard observatory domes include a rectangular shutter and one plane of rotation. Benefits of a Calotte type dome include (a) overall smaller dome size, (b) improved air flow profile reducing air turbulence around the dome, (c) mechanically less complex, and (d) sheds snow better.

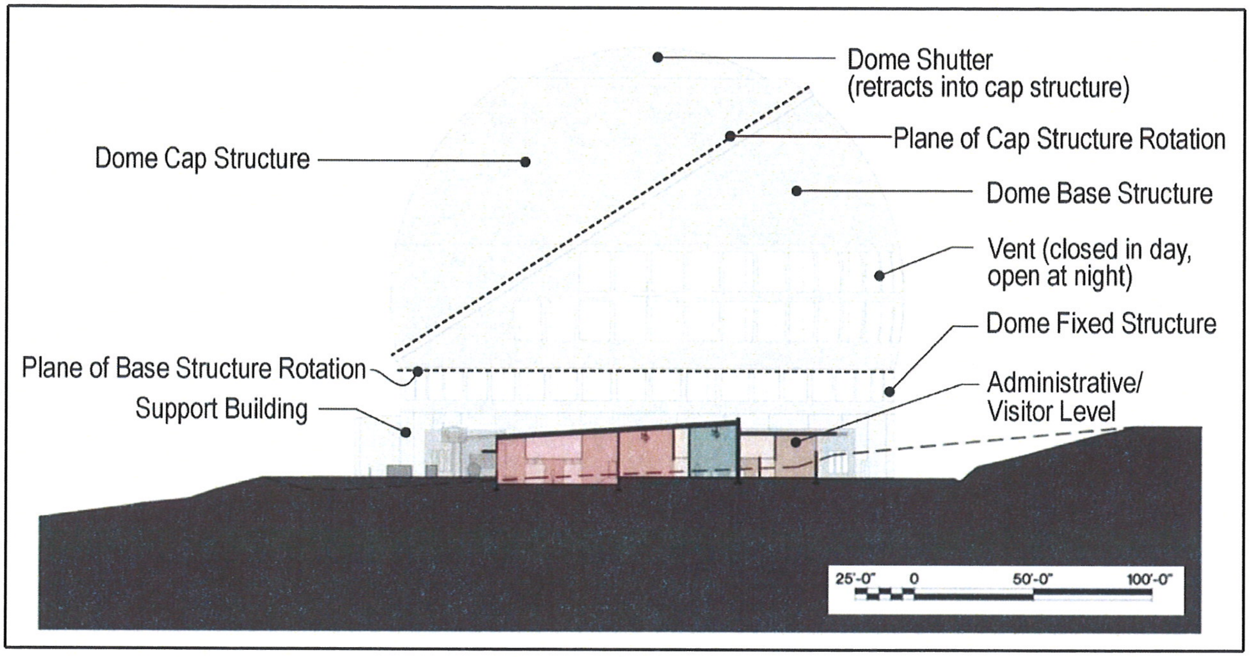


Figure 2: TMT Observatory Cross Section

- A support building will be attached to the dome (Figures 2 and 3). The building will have a roof area of approximately 21,000 square feet, a total interior floor area of roughly 18,000 square feet, a flat roof, and be lava-colored. The support building will include the following spaces:

    1. Mirror coating and staging area.

    2. Laboratory and shop spaces, including a computer room, engineering and electronics laboratories, and mechanical shop.

    3. Utility spaces – including electrical services, chillers, a generator, pumps for fire suppression and other non-potable water needs, restrooms, and fluid dynamic bearing pumps that control the movement of the telescope.

    4. Administration space, including offices and a kitchenette.

    5. Visitor and public spaces, consisting of a lobby, restroom, and viewing platform.

- A roughly 6,000 square foot exterior equipment area on the north side of the support building (Figure 3) will include two electrical transformers and electrical service switchboards; three 5,000-gallon underground storage tanks – one for water storage, one for domestic waste storage, and one double-walled for chemical waste storage; a 25,000-gallon underground storage tank for water storage as part of the fire suppression system; and one double-walled 2,000-gallon above-ground storage tank for diesel fuel to power the emergency generator.

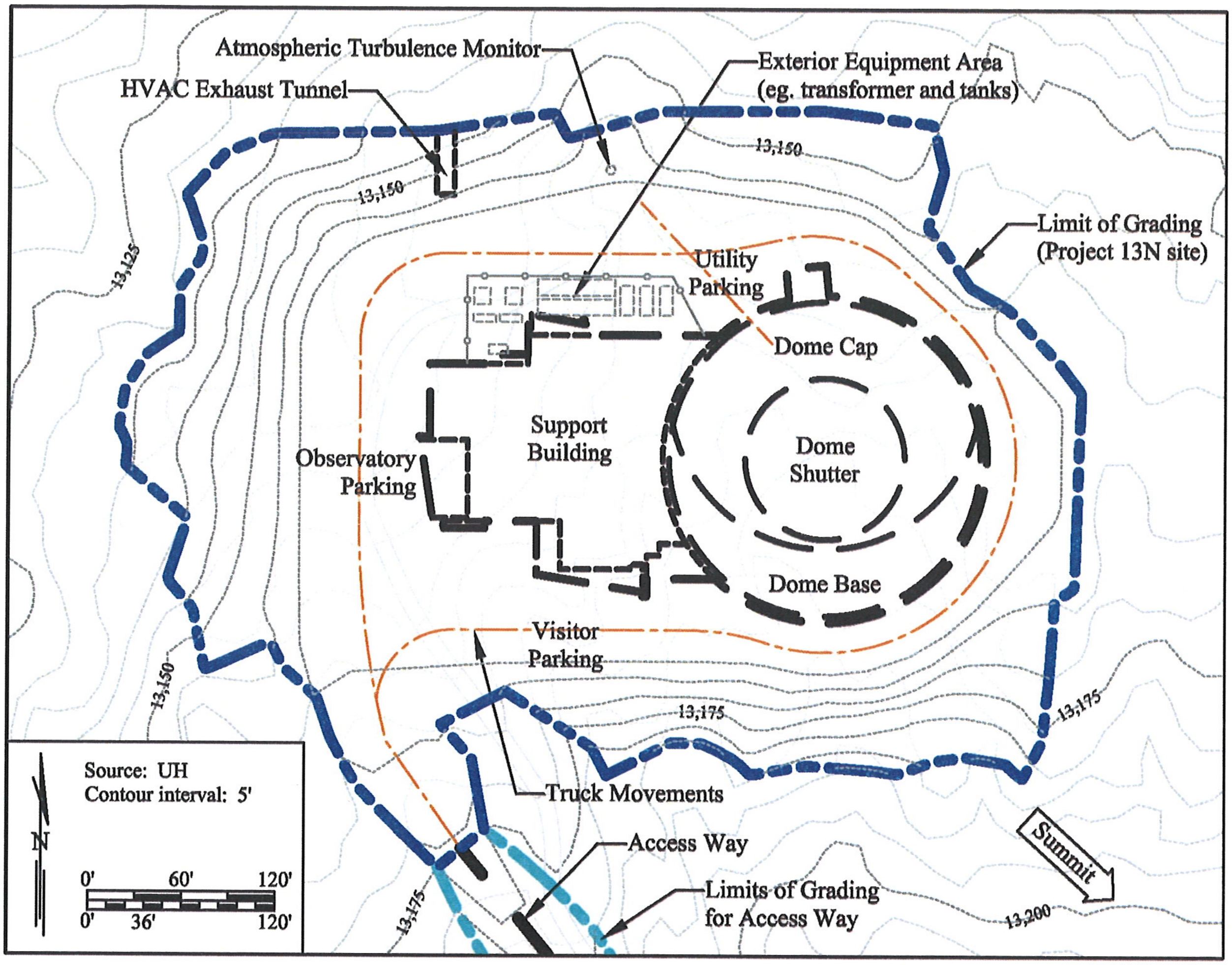


Figure 3: TMT Observatory Plan View and Grading Plan

- Parking area for observatory staff and delivery vehicles (Figure 3). Parking areas will be unpaved and located outside of the support facility. A guard rail will be placed along the top of the slope on the north and west sides of the graded area where there is a drop off.

- Weather instruments will be mounted on a roughly 30 foot tall tower. The atmospheric turbulence monitor will be on a 7-meter tower and located just outside the guardrail at the northwest corner of the level area (Figure 3).

The footprint of the TMT Observatory dome, support building, parking area, and area disturbed during construction will be roughly five acres. A 0.5-acre portion of this area has previously been disturbed by the existing 4-wheel drive road and site testing equipment; the original disturbance occurred during site testing in the 1960s, site testing was also performed in the 2000s, and geotechnical studies in 2013/14 within the five acre TMT site. Finally, some site preparation for the TMT groundbreaking was done in 2015 also within the TMT site boundaries.

C. Access Way

The Access Way will include a road and utility services to the TMT Observatory from existing services. 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 Access Way will start at that point and extend to the TMT Observatory; it will follow either existing 4-wheel drive roads or the wider roads that serve the SMA facility. The Access Way that the TMT Project has proposed is limited to a single lane over the southernmost portion of the Access Way (i.e., the portion that crosses Pu'u Hau'oki and through the SMA array); the remainder is two lanes. The vast majority of the Access Way route follows and goes over an existing single-lane, 4-wheel drive road that was previously developed for access and testing of the 13N site in the 1960s. A portion of the route was graded during construction of the SMA facility as well. Some work was done on the Access Way to facilitate the geotechnical studies and TMT groundbreaking.

The switch boxes needed to extend electrical power and communication service to the TMT Observatory will be placed above ground next to the existing ones across the road from the SMA building. To the extent possible, utilities from that point northward to the TMT Observatory site will be placed beneath the road to reduce the footprint of disturbance, with pull boxes located to the side of the road in already disturbed locations where possible. UH will ensure that any easement required for this utility is obtained.

D. Hale Pōhaku

Two transformers within the HELCO compound will be upgraded by the local electrical utility company. The HELCO compound is located across Mauna Kea Access Road from Hale Pōhaku. The new transformers will be placed in the same location as the existing transformers and the existing fenced compound will not be expanded.

In addition, electrical service from the transformer compound near Hale Pōhaku to the existing utility boxes across the road from the SMA building will be upgraded by the local electrical utility company to support the TMT Observatory's power requirements. This will be done by removing existing conducting wire and placing new electric conducting wire in existing underground conduits.

The existing conduit is located approximately 50 feet west of the Mauna Kea Access Road within UH Management Areas for portions of the distance to the summit area; however, in areas the electrical conduit is located along a former access road alignment that is now within the Ice Age NAR (Figure 4).

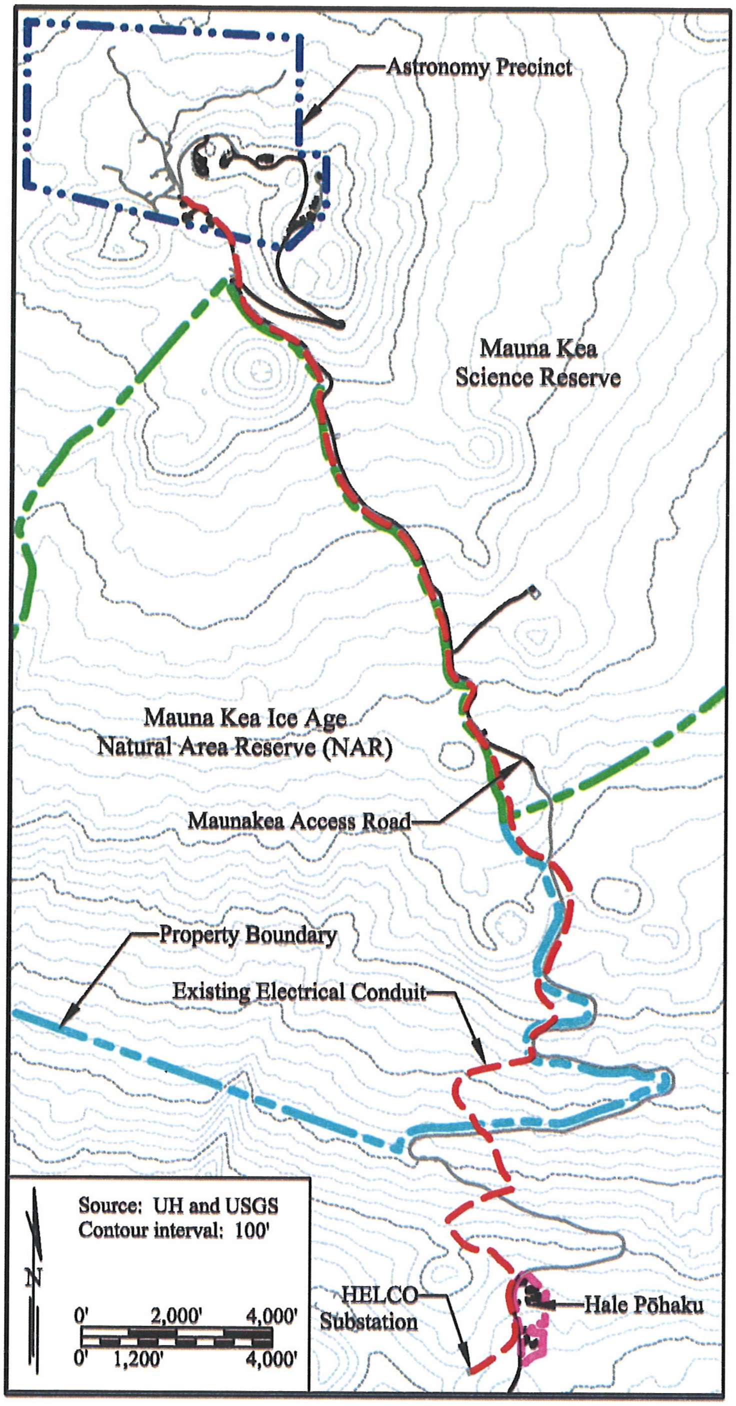


Figure 4: Route of Electrical Conduit

There are pull boxes located approximately every 300 feet along the conduit. Installing new wire in the conduit will not result in any new disturbance but the local utility company will need to access the pull boxes to install the new cable.

II. Construction Areas

During construction, additional areas will temporarily be utilized and/or disturbed. Construction baseyards required for the construction of the telescope and observatory will include:

- "Port Staging Area." An existing warehouse and/or yard near the port where the TMT Project components are received. This area will be used for receiving materials and assembly of those materials to the extent possible prior to transport to either another staging area or the construction site.

- "Batch Plant Staging Area." A roughly 4-acre area northwest of where the Mauna Kea Access Road forks near the summit. This area will primarily be used for storing bulk materials and a concrete batch plant, as it has been in the past during construction of other observatories.

- The area within the TMT Observatory and Headquarters sites not occupied by structures will also be utilized as staging areas during construction of those facilities. These areas will be utilized for materials needed in the short term and final pre-assembly of components prior to installation.

III. TMT Project Phases and Activities

The TMT Project involves four major phases: planning and design, construction and testing, operation, and decommissioning. The following sections discuss activities anticipated during the various phases of the TMT Project.

A. Planning and Design

The TMT Corporation conducted an extensive worldwide study to evaluate potential locations for the TMT Observatory. After narrowing the potential observatory sites to five, site testing was performed to evaluate observation conditions at each of the five sites. Based on testing results and other factors, Maunakea in the United States was identified by the TMT Corporation board as the preferred site.

The Hawaii Revised Statutes Chapter 343 environmental review process for the TMT Project at the Maunakea site is completed. The design of the TMT Observatory has been ongoing, and has included design of the telescope; instruments, including the AO system; and the dome and attached building.

B. Construction and Testing

Project pre-construction could begin in 2018, with construction to follow if a CDUP was approved. It would take approximately seven years to complete. Construction would begin with Access Way improvements. These improvements provide access to and support construction of the TMT Observatory.

It is anticipated that the construction crew at the TMT Observatory site will average 50 to 60 crew members through the life of construction; during certain phases, a crew of more than 100 will be working at the site. Construction is expected to take place six days a week, 10 hours a day; however, some operations or construction phases will require longer work hours. It is also expected that winter weather conditions at the TMT Observatory site will interrupt construction at times.

First light, or the time when the TMT Observatory is first used to take an astronomical image, is expected no earlier than 2024. Tests will then be conducted and adjustments to the telescope and instruments made for a period of time to gain optimum efficiency and seeing.

C. Operation

The first scientific results using the TMT Observatory are expected no earlier than 2024. During the life of the TMT Observatory, astronomical observations will be made by scientists from around the world. A staff of up to 140 people will be necessary to operate and maintain the observatory. It is expected that an average of 24 employees will work at the TMT Observatory during daytime operations, with a minimum of 15 and a maximum of 43 possible depending on activities. Each night a nighttime staff of up to 6, but typically 2 to 3 operators, will be present at the TMT Observatory, while observers and support astronomers will observe remotely from the Headquarters. All other members of the staff will work at the Headquarters.

D. Decommissioning

The TMT Observatory and the extent of the Access Way exclusively used to access the TMT Observatory will be dismantled and the site restored at the end of the TMT Observatory's life, in compliance with the Decommissioning Plan for the Mauna Kea Observatories, a Sub-Plan of the Mauna Kea Comprehensive Management Plan (Decommissioning Plan) (OMKM, 2010a). Deconstruction and site restoration efforts will be managed by the TMT Project staff with oversight by OMKM. A process similar to the Mauna Kea Management Board (MKMB) approved Project Review Process will be established to review, guide, and recommend the disposition of a site, including site restoration. Reviewers will include OMKM, Kahu Kū Mauna, and the MKMB Environment Committee, with MKMB approval required. Options include:

- Complete infrastructure removal – the entire facility, including all underground utilities, pilings, and foundation would be removed to the extent practicable; or

- Infrastructure capping – all or part of the underground portion of the facility would be left in place, capped with an impermeable material, and topped with materials similar to the surroundings.

1. Site Restoration Plan (SRP)

The SRP will present specific targets for site restoration and describe the methodology for restoring disturbed areas after the demolition/construction activities described in the SDRP are completed. The Decommissioning Plan (OMKM, 2010a) states that the two primary objectives of site restoration are (1) restoring the look and feel of the summit prior to construction of the observatories, and (2) providing habitat for the aeolian arthropod fauna.

The level of restoration to be performed and the potential impact of the restoration activities on natural and cultural resources during and post-activity must be carefully evaluated in the SRP. Specific factors that need to be considered during the development of the SRP include cultural sensitivity.

Three levels of site restoration have been set forth in the CMP (UH, 2009a) and the Decommissioning Plan (OMKM, 2010a). Establishing three levels recognizes that in addition to the potential benefits of site restoration, there are also potential impacts. The three levels of site restoration are:

1. Minimal – would include the removal of all man-made materials and the grading of the site.

2. Moderate – would include the removal of all man-made materials, grading of the site, and enhancing the structure of the physical habitat to benefit the arthropod (insect) community.

3. Full – would include return of the site to its original topography and restoration of the arthropod habitat.

The level of restoration to be performed by TMT will be negotiated between TMT, UH, and DLNR according to the sublease terms.

Site restoration activities may involve using stockpiled material or materials similar to the surroundings either to fill holes or to reconstruct topography. Consideration will be given to where fill material will come from, how excavation and removal of materials will impact the collection area and any habitat surrounding the restoration area, and what the cultural considerations are for bringing materials from a different place to Maunakea.

Upon the completion of site restoration, monitoring of the restoration activities will begin and continue for at least three years. Results of monitoring activities will be submitted to OMKM.

2. Management Actions

The CMP also lays out several decommissioning management actions, they are:

1. Consider future decommissioning during project planning and include provisions in subleases that require funding of full restoration (CMP Management Action SR-3).

2. Once the TMT Observatory's useful life has ended, develop a recycling and/or demolition plan (referred to as a SDRP and SRP in the Decommissioning Sub Plan) that considers items such as waste management and demolition best management practices (BMPs) (CMP Management Action SR-1).

3. CMP Management Action FLU-3 requires cataloguing the initial site conditions for use when conducting site restoration in the future.

4. Once the TMT Observatory's useful life has ended, develop a SRP in association with the SDRP, which will include an environmental cost-benefit analysis and a cultural assessment (CMP Management Action SR-2). The cost-benefit analysis of the three levels of restoration will consider restoration costs and related impacts, including the cultural assessment.

To address the first management action, the TMT Project has (a) included in the design of the TMT Observatory and Access Way the use of almost all excavated material on those sites so that it will be available for use again during site restoration, and (b) included in the planned TMT Project operation budget annually setting aside funds that will be used for decommissioning of the TMT Observatory. The TMT Project anticipates decommissioning and site restoration requirements will be included in the sublease.

The TMT Project is committed to preparing the necessary plans, such as the SDRP, and SRP, in accordance with the general timeline presented in the Decommissioning Plan and providing an opportunity for the public to comment on the plans.

IV. TMT Project's Educational and Employment Plans

A. Community Benefits Package

The TMT Project has committed to a **Community Benefits Package** (CBP). The CBP will be funded by the TIO and will be administered via The Hawaii Island New Knowledge (THINK) Fund Boards of Advisors. The THINK Fund Boards of Advisors will consist of local Hawaii Island community representatives. A portion of the CBP funding commenced in 2014 upon the start of the TMT Project construction and was committed to continue throughout the TMT

Observatory's presence, so long as the CDUP is not invalidated or construction is not stayed by court order. However, even though the TMT CDUP has been invalidated, TIO has continued the CBP. As part of the CBP, the TMT Corporation has provided $1 million annually during such period to the THINK Fund; the dollar amount is adjusted annually using an appropriate inflation index. The funding is divided; $750,000 distributed through the Hawaii Community Foundation and $250,000 through the Pauahi Foundation. To date TIO has remitted $630K to the Pauahi Foundation, and $1.8 Million to the Hawaii Community Foundation, a total of approximately $2.5 million.

The $2.5 million remitted to date has funded over sixty scholarships and $100,000 in small grants for classroom projects for twenty seven classrooms. The THINK Fund was the originator and initial contributor to the STEM Grant Learning Partnership program, giving $400,000 in the first two years for this endeavor. Programs supported focus on key elements of building a strong STEM education system. Educational initiatives are focused on K-5, 6-8, 9-12, and college. The program includes support for students to visit 'Imiloa Astronomy Center and the Maunakea observatories.

B. Workforce Pipeline Program (WPP)

The TMT Project is committed to partner with UH Hilo, Hawai'i Community College (HawCC), and the Department of Education (DOE) to help develop, implement, and sustain a comprehensive, proactive, results-oriented WPP that will lead to a highly qualified pool of local workers who could be considered for hiring into most job classes and salary levels. Special emphasis will be given to those programs aimed at preparing local residents for science, engineering, and technical positions commanding higher wages. Therefore, there will be a significant component in the WPP for higher education on the Island of Hawai'i.

The TMT Project began to refine the WPP with a workforce roundtable in September 2009. The roundtable initiated information exchanges and close coordination with current and new programs on Hawai'i Island. A dedicated TMT Project WPP manager will coordinate the program.

In addition, the TMT Project is participating in a County of Hawai'i Workforce Investment Board initiative with the Mauna Kea Observatories to introduce focused programs within the Hawai'i Island community to provide the observatories with a broader and stronger qualified local labor pool for careers in the local astronomy enterprise

The program will continue focus on long term investments to strengthen the current STEM skills infrastructure, programs, and curricula at UH Hilo, HawCC, and Big Island K-12 education organizations, especially those serving lower income and first-generation college attending populations. Examples could be the development or support of astronomy, other sciences, and engineering education at UH Hilo as well as programs at HawCC that could provide well-qualified mechanical and electrical technicians. The scope of these investments will include strengthening language and culture programs and their integration with science and engineering to broaden the appeal of STEM disciplines to Hawai'i Island college students while earning and retaining community support.

Initial efforts for the WPP began in 2008, and will ramp up during the early construction phase so that local youth of today have the qualifications and could be considered for hiring into most job classes and salary levels with the TMT Project when the operational phase begins.

VI. TMT Project Mitigation Measures

A. TMT Observatory Location

The TMT Observatory has been sited at the 13N site, within Area E, north of and below the summit. Therefore the TMT Observatory:

- Will not be visible from culturally sensitive locations, such as the summit of Kūkahau'ula, Lake Waiau, and Pu'u Līlīnoe;
- Will not block the view of Haleakala from Pu'u Poli'ahu, is approximately 0.78 miles from the summit of Pu'u Poli'ahu, and is several hundred feet below it;
- Is more than 200 feet from known historic properties;
- Is not visible from Pu'u Wekiu, the very summit of Maunakea;
- Will not be visible from Hilo and the southern portion of the island; and
- Is outside of the wēkiu bug's preferred habitat.

B. TMT Access Way Design

The Access Way's physical and visual impacts have been mitigated by:

- Designing the Access Way to minimize the disturbed area and to reduce the potential for both physical and visual impacts to the historic properties and potential impacts to natural resources known to be in the vicinity.
- Limiting the southern 750 foot long portion of the Access Way to a single-lane even though such a configuration is not desirable from an operational standpoint.

- Aligning the bulk of the Access Way to follow an existing single-lane, 4-wheel drive road that was built in the 1960s for access and testing of the 13N site.

- Paving the portion of the Access Way within the boundaries of Kūkahau'ula on the flank of Pu'u Hau'oki, and, therefore, within the alpine cinder cone habitat, in order to reduce dust.

- Coloring the pavement and guardrail a reddish color that blends with the surrounding area.

- Placing the utilities to the TMT Observatory within the Access Way and beneath the paved roadway instead of on a different or parallel alignment that would cause more ground disturbance.

C. Cultural and Natural Resources Training Program

Institute a Cultural and Natural Resources Training Program. The content of the training program will be determined by OMKM. All TMT Project staff and all construction workers have been and will continue to be trained annually regarding:

- Potential impact to cultural practices and archaeological/historic resources and the measures to prevent such impacts.

- Potential impacts to natural resources and the measures to prevent such impacts.

D. Development of Exhibits

The TMT Project will support, through financial contributions and utilization of its outreach office, the development of educational exhibits related to Mauna Kea. The exhibits will be:

- Developed in coordination with OMKM and 'Imiloa.

- Address the following subjects: cultural, natural, and historic resources.

- Developed for use at the Visitor Information Station (VIS), 'Imiloa, TMT facilities, and other appropriate locations.

- Include informational materials that explore the connection between Hawaiian culture and astronomy.

E. Restoration of Pu'u Poli'ahu

The TMT Project will fund the restoration of the closed access road on Pu'u Poli'ahu per a plan submitted by the Institute for Astronomy and approved by DLNR (SPA HA-10-04).

F. Camouflage Utility Boxes

The TMT Project will camouflage utility boxes that are visually distracting or intrusive at the summit of Mauna Kea and other key locations visible from other portions of Kūkahau'ula. The method of camouflage will be determined through consultation with Kahu Kū Mauna and may include one of the following options:

- Painting the lids to match the surrounding natural colors.
- Affixing stones and cinders from nearby to the exposed utility box.

G. Sense of Place

- The TMT Project facilities will be furnished with items to provide a sense of place and acknowledge the cultural sensitivity and spiritual attributes of Mauna Kea.
- Will be a constant reminder of the lessons learned during the required annual cultural training to respect, honor, and not restrict or interfere with cultural or religious practices.

H. Cultural History

The TMT Project will support, through financial contributions and utilization of its outreach office:

- The translation of chants and mele and use their teachings; the focus here will include both (a) translation, and (b) developing programs that go to schools to spread what is learned about Hawaiian science and genealogy.
- The hosting of an annual cultural event or training. Examples of how this measure will be implemented include activities such as a star-gazing program at the annual Makahiki festival, workshops of stone adze-making, and workshops on how to recognize archaeological sites and to assess their importance.
- The translation of modern astronomy lessons into Hawaiian language for use at Hawaiian language charter schools.

I. Cultural Outreach

The TMT Project will:

- Have an open door policy so that the TMT Project's outreach management can be contacted by the Native Hawaiian community to discuss various issues.

- Provide initial and then annual or as-needed tours of the TMT Observatory, with the Native Hawaiian community invited at least two weeks prior to the tour. Insofar as practicable, these tours will be scheduled on the days (up to four each year) on which cultural events are scheduled.

- Request permission to attend meetings of the Kahu Kū Mauna council on a quarterly basis. A TMT Project representative will be available on an ongoing basis to review cultural impact issues, should there be any related to the TMT Project. By attending the meetings the TMT Project representative would become aware of other cultural resource issues on the mountain and then implement any necessary changes in TMT Project policies to address potential similar issues at the TMT Observatory.

- Work with ʻImiloa and Native Hawaiian groups to support/fund programs specific to Hawaiian culture and archaeological resources.

J. Cultural Observance

On up to four days per year, to be identified by Kahu Kū Mauna, the TMT Project will minimize daytime activities in observance of Native Hawaiian cultural practices. While the observatory will be operated during these periods, this measure will involve having only a skeleton crew at the observatory, minimizing vehicle traffic reducing noise, and prohibiting visitors to the TMT Observatory.

K. Cultural Protocols

Continue consultation with the State Historic Preservation Division and Kahu Kū Mauna Council regarding the appropriate protocols for the relocation of the modern shrine at the 13N site.

L. Arthropod Monitoring

Arthropod monitoring will be performed prior to, during, and for two years following construction in the area of the Access Way on the alpine cinder cone habitat (the flank of Puʻu Hauʻoki).

M. Wēkiu Bug

The TMT Project will work closely with OMKM to develop and implement a wēkiu bug habitat restoration study.

N. Invasive Species Prevention and Control

Develop and implement invasive species prevention and control program that will include:

- Materials control and reduction.
- Washing/cleaning.
- Inspections.
- Monitoring.
- Species control and education/training.

O. Visual Impact

The TMT Observatory has been designed to mitigate its visual impact by:

- Reducing the size of the dome through the use of a Calotte type dome.
- Designing the telescope to be much shorter than usual using a focal ration of f/1.0 to allow for the smallest dome possible, minimizing the height, and thus the visual impact.
- Designing the dome to fit very tightly around the telescope, leaving just enough room for a person, only about 20 inches, between the telescope and the dome. In comparison, the Keck Observatory consists of two telescopes with mirrors 33 feet in diameter with a focal ration of f/1.75; the diameter of each Keck dome is 121. If the TMT were to use the same ratio of mirror to dome size it would result in a dome with a diameter of 364 feet.
- Finishing the dome with a reflective aluminum-like surface similar to that on the Subaru Observatory, which during the day reflects the sky and reduces the visibility of the structure.
- Finishing the support building and fixed structure exterior with a lava color.

- Figure 5 shows visual impact mitigations, Figure 6 shows mirror and dome size comparisons with current and planned observatories. Note that TMT is ~30 feet taller than Gemini.

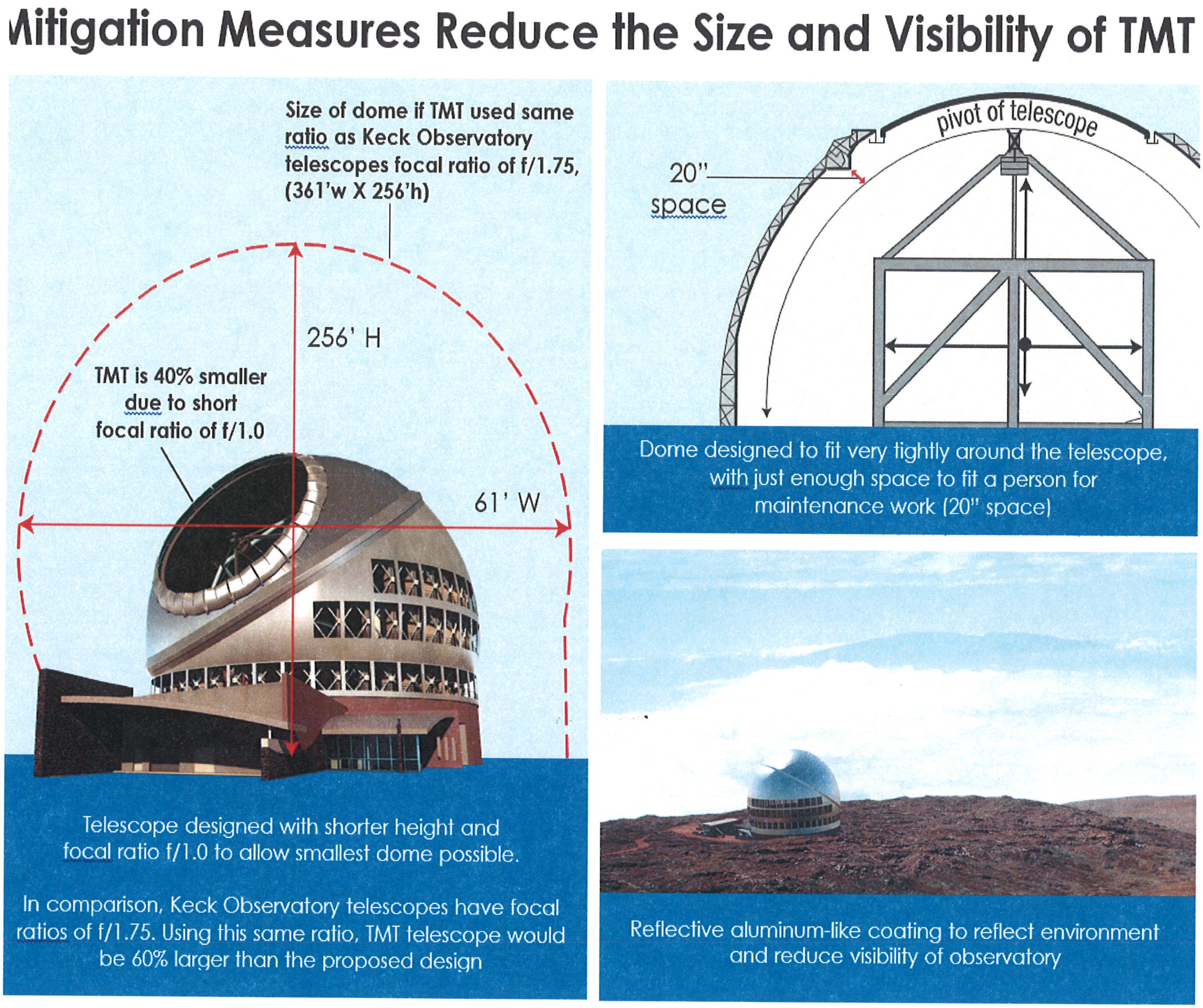


Figure 5: Visual Impact Mitigation

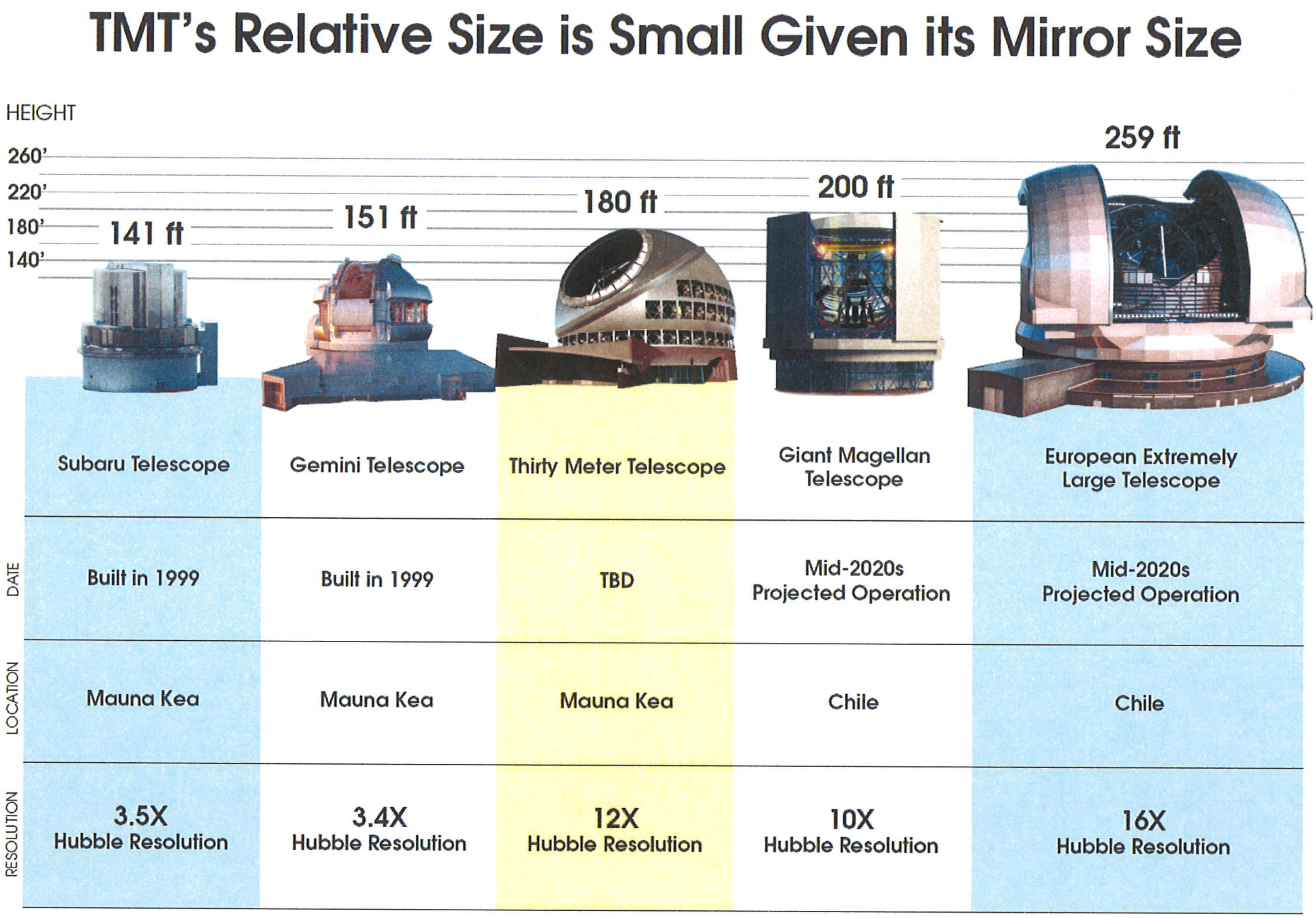


Figure 6

P. Wastewater Treatment

A zero-discharge wastewater system will be installed at the TMT Observatory. All wastewater generated at the TMT Observatory will be transported to an approved treatment facility for treatment and disposal. The discharge of wastewater within the summit region has been identified as an impact on cultural resources and is one of the reasons for this measure.

Q. Water Saving

The TMT Project will install water efficient fixtures and implement water saving practices to reduce the demand for freshwater resources.

R. Waste Minimization and Recycling

The TMT Project will implement a Waste Minimization Plan (WMP) and institute an annual WMP audit, which will include an examination of:

- Waste produced by the TMT Project and how that waste could be reduced, reused, or recycled.
- Water use by the TMT Project and how that use could be reduced.
- Energy use by the TMT Project and how that could be reduced.
- The TMT Project will recycle solid and non-hazardous waste material and reuse them to the extent possible.

S. Materials Storage/Waste Management and Spill Prevention and Response Plan

The TMT Project will implement a Materials Storage/Waste Management Plan, including a Spill Prevention and Response Plan. The plan will require:

- Daily inspections of equipment handling hazardous materials.
- Mandatory training of all personnel handling hazardous materials and wastes.
- Regular inspections by a Safety and Health Officer.
- That all solid waste be collected in secured and covered storage containers.
- That all wastes be transported down the mountain for proper disposal at an off-site disposal facility.

Michael Bolte

Professor of Astronomy and Astrophysics, University of California, Santa Cruz
Director Emeritus, University of California Observatories

I am a faculty member in the Department of Astronomy and Astrophysics at the University of California, Santa Cruz (UCSC). I am also the former Director of the University of California Observatories. This is a University of California multi-campus research unit that manages the UC optical/infrared facilities: Lick Observatory, the W.M. Keck Observatory (jointly managed with Caltech) and extensive laboratory facilities. I am a member of the Board of Governors of TIO.

Astronomy

Astronomy is one of the oldest of the sciences. It is the study of the contents, origin, evolution and fate of the Universe. Astronomy research has played a large role in defining humankind's place in the Universe. With the unaided eye, it is possible to see a few thousand stars from any one dark location on Earth. Studies of the heavens in this way were the basis of timekeeping and navigation going back at least 5000 years. However, the invention of the first small telescope and its use by Galileo to explore the heavens in much greater detail fundamentally changed our understanding of the Universe and the context of the Earth in that Universe. As telescopes became larger and instruments more sensitive, we have come to the realization that the Earth is one of billions of planets in a galaxy of approximate 300 billion stars and that galaxy is one of approximately 100 billion galaxies in the observable Universe. Astronomy and astrophysics research have led to the elucidation of the fundamental laws of physics. Tools developed for astronomical research have also been the basis of many "spinoff" technologies. Recent examples are the use of adaptive optics, originally developed to remove the blurring of the atmosphere for astronomical observations, to greatly aid many areas of vision science and eye disease research and the use of computer algorithms designed to discover large scale structure in the Universe to make very early detection of breast cancer tumors in mammogram images.

Astronomy is also the science that has most captured the public's interest and imagination. Newspaper and web-based news articles about astronomy discoveries outnumber those for all other sciences. More university students in the US take introductory astronomy classes (estimated at 200,000 students per year) than any of the other sciences and astronomy is considered an important "gateway" science for interesting students in science and technology fields. This has been identified as a key national need. At my university we sponsor a series of public lectures on recent astronomy discoveries that are wildly successful and even using the largest venues available, we routinely turn people away. Astronomy research is an extension of centuries of humankind's exploration of the environment in which we live.

In the US, there are approximately 6000 professional astronomers. It is estimated that between 300,000 and 500,000 people in the US are members of amateur astronomy clubs or groups or regularly use their own telescopes. The number estimated to attend planetarium shows is substantial, in the tens of millions worldwide.

Astronomy From Maunakea

The observatories on Maunakea are among the best in the world - located at one of the best locations in the world for astronomy. They have contributed to some of the very most important scientific findings of our time. These have advanced our understanding of the nature of the Universe, and our place therein. They have helped us find some of the earliest objects that formed in the Universe, over 13 billion years ago, and also helped us explore planets orbiting stars in our own Milky Way galaxy.

These discoveries have not only excited astronomers, but have enamored the world as a whole. Recently in an article in the New York Times - http://www.nytimes.com/interactive/2016/10/03/science/hawaii-mauna-kea-telescope-discoveries.html?_r=0 - a Maunakea "top five" was presented, each of which were enabled by the outstanding and unique capabilities of the observatories in Hawaii:

- Dark Energy and the Accelerating Universe

Two teams of astronomers used the telescopes in Hawaii to study objects known as type IA supernovae, which result from the collapse of white dwarf stars. They demonstrated that as the universe expands, its rate of expansion is increasing. For this work the leaders of both teams were awarded the Nobel Prize in physics in 2011.

- Looking Back Towards the Beginning of Time

The telescopes on Maunakea offer an opportunity to look back in time and study some of the very first objects to form in the Universe. Using the Keck telescope, astronomers determined the distance to a galaxy that came into existence only six hundred seventy million years after the Big Bang. It is one of the earliest galaxies for which a reliable distance has been measured.

- The Black Hole at the Center of the Milky Way

At the center of our galaxy lies a massive black hole, with a mass of as much as four million times the mass of our own Sun. Using adaptive optics at the Keck observatory on Maunakea, Andrea Ghez (UCLA) and other astronomers were able to demonstrate the existence of and calculate the mass of this black hole.

- Seeing Planets Around Other Stars

Using the adaptive optics at the Gemini North and Keck telescopes on Maunakea, astronomers provided one of our first-ever direct images of planets around another star. There are as many as five planets that orbit the star known as HR 8799, approximately 130 light-years from Earth.

- Life Everywhere?

Thousands of planets and planet candidates have been revealed by NASA's Kepler observatory. The planet Proxima b, which orbits our nearest neighboring star, could even be Earth-like and habitable. The Keck telescopes have been the premiere observatories for confirming candidate planets and enabling studies of their properties.

The Role of the TMT

Because the vast majority of our knowledge of the Universe has been inferred from very faint light sources often at enormous distances, progress in our understanding of the Universe has depended on advancements in astronomy facilities starting with Galileo's first use of a telescope to establish the sun centered model for the solar system. The TMT is the next step on a path that began with Galileo. TMT will allow astronomers to explore virtually every field of astrophysics, from the creation of the universe to exoplanets (planets around stars other than our sun). The resolution and sensitivity provided by TMT's large aperture and adaptive optics systems, combined with a flexible and powerful suite of instruments, will enable us to address the most fundamental questions of the coming decades. These include:

- What is the nature and composition of the Universe?
- When did the first galaxies form and how did they evolve?
- How do stars and planets form?
- What is the nature of planets around other stars?
- Is there life elsewhere in the Universe?

Studies of TMT capabilities have shown that it should be possible to detect so-called "bio-markers" in some extra-solar planets. These are the chemical signatures of life in the atmospheres of the exoplanets. Now I will admit that we don't know for certain TMT will be the telescope that first finds bio-markers outside our solar system. The thing that excites me, however, is that it's possible. And this is only one example of the cutting-edge, frontier science that TMT will enable. I do not think it's an exaggeration to say that finding evidence of life outside our solar system will be a transformative moment in human history. As our view changed with Copernicus – moving the Earth from the center of the universe – so may it change as we find evidence for life outside of our own planet.

TMT - An International, Pan-Pacific Observatory

The TMT at Maunakea would create an astronomical ecosystem with enormous capability. The TMT partners have other telescopes that would continue to be powerful in their own right and work together with the TMT. The most interesting systems would be identified by the existing telescopes for follow-up at the highest spatial resolution and sensitivities with the TMT.

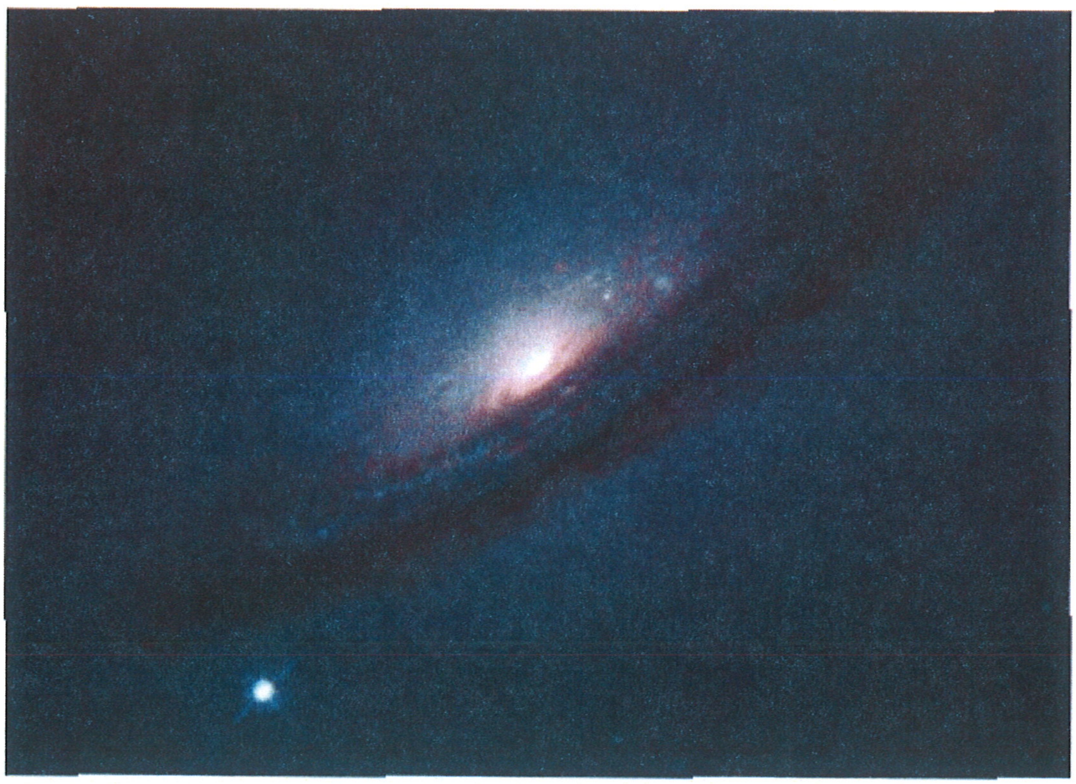
I've dedicated a significant fraction of my career working on the TMT concept. In recent years, my commitment to TMT has been reaffirmed by my colleagues throughout astronomy. Not only has the U.S. astronomical community affirmed a thirty-meter class telescope as a top priority for this decade, but we have been joined by colleagues around the world, including Canada, Japan, China and India. It is personally gratifying to see that this project is embraced around the world, and leading technology nations are partners in the project. If built, it will be one of the great science facilities of this century.

The New York Times, Oct. 3, 2016
From Hawaii's Mauna Kea,
A Universe of Discoveries

http://www.nytimes.com/interactive/2016/10/03/science/hawaii-mauna-kea-telescope-discoveries.html

By DENNIS OVERBYE and MICHAEL ROSTON

Mauna Kea is a sacred place for native Hawaiians. For astronomers, it is also a vital location. From the top of this dormant volcano, telescopes have helped advance important discoveries in humanity's study of the universe. The observatories on Hawaii have contributed to several recent important scientific findings.



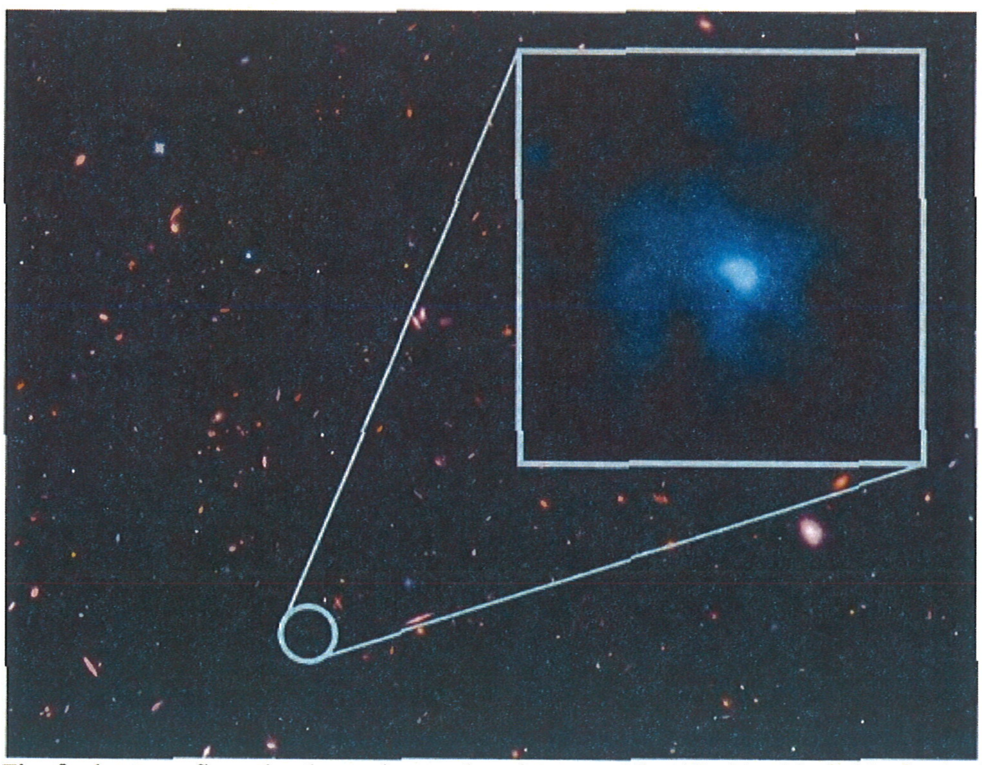
In the outskirts of disk galaxy NGC 4526 is supernova 1994d in the bottom left corner. It is a type IA exploding star, which astronomers use to estimate the speed of the expansion of the universe.
Credit: High-Z Supernova Search Team/HST/NASA

Dark Energy and the Accelerating Universe

All of the galaxies in the universe are going places, and they're in a hurry to get there. Seemingly driven by mysterious dark energy or vacuum energy, astronomers observed that as the universe expanded, it was speeding up. And the Keck observatory at Mauna Kea played a crucial role in making this discovery.

Two rival teams of astronomers used the telescopes in Hawaii to examine a large inventory of distant type IA supernovae, which result from the collapse of white dwarf stars. The uniform brightness of these supernovae make them ideal beacons for measuring cosmic distances, which allows scientists to accurately estimate the speed of cosmic expansion.

While the competition between the two groups of researchers was fierce, leaders of both teams were awarded with the Nobel Prize in physics in 2011.



The farthest confirmed galaxy observed to date was identified in this field of galaxies recorded by the Hubble telescope.
Credit NASA/European Space Agency/Yale/University of California, Santa Cruz

□The Universe in Its Infancy

Six hundred seventy million years may seem like a long time, but that many years after the Big Bang, the universe was a mere infant. Somehow a galaxy called EGS-zs8-1 bloomed into existence at that point. It is one of the earliest galaxies for which a reliable distance was measured.

This former galactic youngster, now billions of years old, was first observed by other telescopes. To confirm its age, astronomers used a powerful spectrograph at Mauna Kea called Mosfire. This device measured the redshift, or its light broadening to longer wavelengths, of EGS-zs8-1. Studying early galaxy formation is one objective of the stalled Thirty Meter Telescope project.

This infrared image from NASA's Spitzer Space Telescope shows the center of the Milky Way galaxy, where a black hole may lurk.

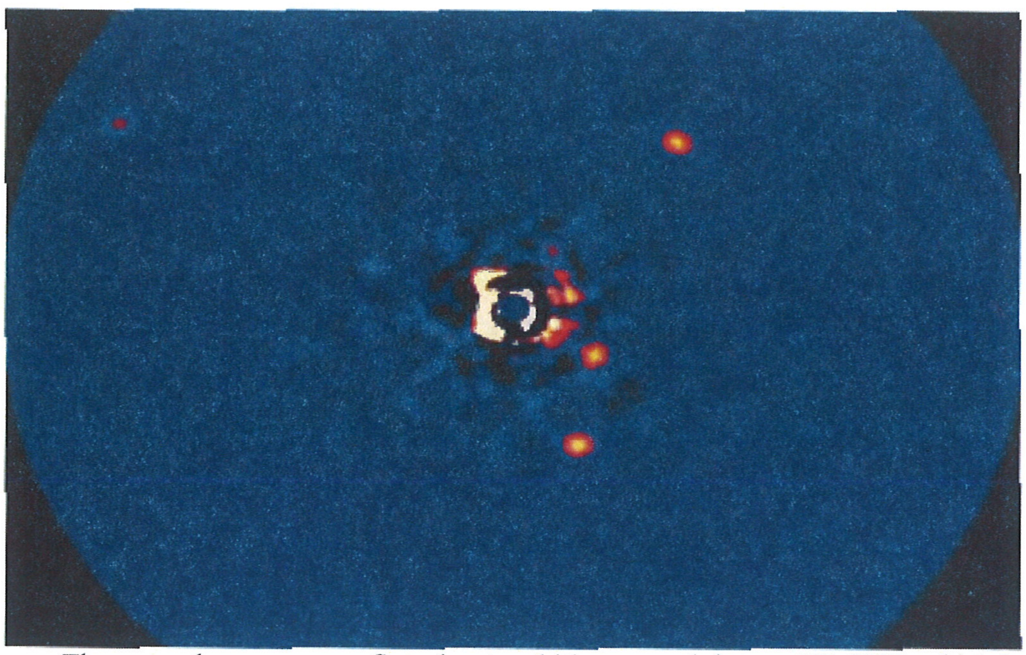
Credit

NASA/JPL-Caltech

Measuring the Milky Way's Central Behemoth

At the center of our galaxy probably lies a monstrous black hole. This supermassive trapdoor has a steady diet of matter, and it has a mass of as much as four million suns.

To determine the size of this object at the center of the Milky Way, Andrea Ghez of U.C.L.A. has studied the motions of stars as they orbit this object. Using adaptive optics on the tennis-court-size telescopes at the Keck observatory on Mauna Kea, Dr. Ghez and other astronomers were able to scrutinize stars that were much closer to the galactic center than previously observed and calculate the mass hiding in its black hole.



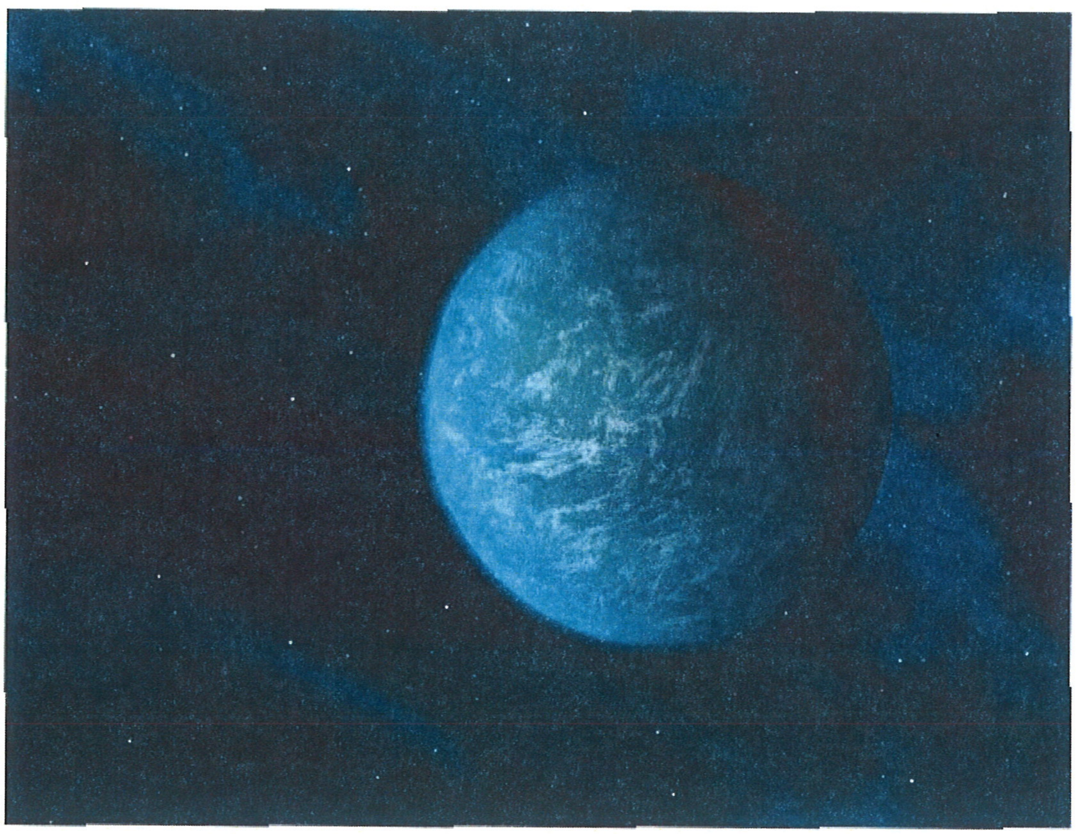
There may be as many as five planets orbiting around the star HR 8799, which is 130 light-years from our solar system.

Credit National Research Council of Canada, Christian Marois & Keck observatory

‘First Glimpse of Planets Around Another Star

There are planets around our sun. One can assume there are many more planets around many other stars. Science does not assume. Astronomers had detected the existence of planetary bodies well beyond our solar system. But seeing is believing, and studies of HR 8799, a star 130 light-years from our world, gave us one of our first glimpses of extrasolar planets.

These giants - the smallest of the three is six times the size of Jupiter - were captured using the adaptive optics of the Gemini North and Keck telescopes on Mauna Kea. There may be as many as five planets orbiting the star.



An artist’s rendering of Kepler-22b. Astronomers believe the planet lies in the habitable zone of a sunlike star, and used the Keck observatories to help confirm its radius.

Potential Habitats in the Billions

In the last two decades, planets outside the solar system have been detected by the bushel. Proxima b, which orbits our nearest neighboring star, could even be Earth-like.

Proxima b is probably far from alone among potentially habitable worlds in the universe. With NASA's Kepler spacecraft, thousands of additional Sun-like stars have been surveyed, and one team of researchers found that as many as 22 percent of them could have Earth-size planets in their goldilocks zones, meaning not too hot and not too cold. That could mean as many as 40 billion habitable worlds in our galaxy alone.

The Keck telescopes in Hawaii have served as the main tools for examining and confirming exoplanet candidates detected by Kepler. These eyes on the ground back up what scientists first think they see from the telescopes in space.

Testimony of David Callies

Q Please state your name and background.

A My name is David Callies. I currently hold the position of Benjamin A. Kudo Professor of Law at the William S. Richardson School of Law, University of Hawaii at Manoa, where I teach courses in state and local government, land use, and property law. My teaching focuses on land use planning and development permitting at the local, state, and national levels, with a particular emphasis on land use controls in Hawaii.

I hold law degrees from the University of Michigan (J.D.) and Nottingham University (L.L.M., planning law) and am a past foreign fellow (research on customary law) and life member of Clare Hall, Cambridge University.

I am the coauthor of two legal casebooks, one on land use (6th edition) and one on real property (fifth edition). I have also coauthored a monograph on land use and eminent domain published in 2008 by LexisNexis, and an edited collection of case studies on eminent domain (with Kotaka) entitled *Taking Land: Compulsory Purchase and Regulation in Asian-Pacific Countries*, which was published in 2002 by the University of Hawaii Press, republished in updated form by Nichols on Eminent Domain in 2004, and republished in Japanese in 2008. I coauthored (with Orebech, Bosselman, Bjarup, Chanock, and Peterson) the book, *The Role of Customary Law in Sustainable Development*, which was published by the Cambridge University Press in 2005, and then published as a paperback in 2010.

As an elected member of the American Law Institute (ALI), I served on the consultative committee which reviewed, commented on, and amended the Restatement of Property, Third. I am currently on the advisory committee which meets annually to review and comment on drafts of the Restatement of the Law, Property, 4th. I am also an elected member of the American Institute of Certified Planners (AICP) and of its College of Fellows (FAICP), an elected member of the American College of Real Estate Lawyers, past chair of the Hawaii State Bar Association Section on Real Property and Financial Services, past chair of the American Bar Association Section on State and Local Government Law and recipient of its Jefferson Fordham Lifetime Achievement Award in 2006, and past chair of the American Association of Law Schools Section on State and Local Government Law.

I am also the co-editor of the annual Land Use and Environmental Law Review, which publishes the best law review articles on land use and environmental law, based on a 2-level review board process.

My most recent book, published in July of 2010, is a rewritten second edition of my Hawaii land use law treatise, Regulating Paradise: Land Use Controls in Hawaii, which details the complexity of the land development process in Hawaii.

I am a regular invited lecturer at the annual conference of the American Planning Association and the Hawaii Congress of Planning Officials. Additionally, I co-chair and lecture at the biennial land use conference of the Hawaii State Bar Association's Section on Real Property and Financial Services, where I speak primarily on topics of the public trust doctrine, customary law, planning, land development conditions, eminent domain, development and annexation agreements, and vested rights.

Q Are you familiar with the Thirty Meter Telescope ("TMT") Project?

A Yes. I have reviewed numerous documents related to the conservation district use application ("CDUA") for TMT, with a focus on the planning and land use issues. I have also reviewed all of the appellate court pleadings and opinions on this matter, and I am well-aware of the issues presented to the Board of Land and Natural Resource ("BLNR") and the Hearings Officer on remand. I most recently visited the TMT site in August 2016.

Q In your capacity as one of the foremost recognized experts in planning and land use in Hawaii, can you please generally describe your understanding of the public trust doctrine?

A The public trust doctrine provides that the State holds public trust resources in trust for the benefit of the people. The history and origins of the public trust doctrine make it crystal clear that the public trust doctrine does not require pristine and absolute preservation. Instead, the public trust doctrine requires a balancing process between protection and conservation of public trust resources, on the one hand, and the development and utilization of these resources, on the other. Thus, the public trust doctrine contemplates a balancing of use, both public and private, and not the elimination of one at the expense of the other. Under the doctrine, a resource that is subject to the public trust doctrine generally may not be conveyed to a private owner.

However, a designation as a public trust doctrine resource does not foreclose private uses of that public trust doctrine resource.

Q **What is the relationship between the public trust doctrine and Article XI, section 1 of the Hawaii State Constitution?**

The public trust doctrine in Hawaii appears to have been "constitutionalized" to the extent that once a resource like water or submerged land is impressed with the public trust doctrine, Article XI Section 1 of the state constitution reinforces the obligation of state and county agencies in their decision-making to carefully examine any proposed use of or on that resource to insure that the public use of that resource remain paramount and intact. Thus, for example, the Conservation District statute was enacted to "conserve, protect, and preserve the important natural resources of the State." Haw. Rev. Stat. § 183C-1 The administrative rules implementing the Conservation District statute are for "for the purpose of conserving, protecting, and preserving the important natural resources of the State through appropriate management and use to promote their long-term sustainability and the public health, safety and welfare." Haw. Admin. R. §13-5-1. One of those rules within that chapter, HAR § 13-5-30(c), sets forth the framework (often referred to as the Eight Criteria) by which the BLNR evaluates a CDUA. The Eight Criteria embody the policy goals and objectives of the public trust doctrine. For instance, HAR § 13-5-30(c)(4) assesses whether "[t]he proposed land use will not cause substantial adverse impact to existing natural resources within the surrounding area, community, or region." HAR § 13-5-30(c)(6) considers whether "[t]he existing physical and environmental aspects of the land, such as natural beauty and open space characteristics, will be preserved or improved upon, whichever is applicable." HAR § 13-5-30(c)(8) is concerned with whether "[t]he proposed land use will not be materially detrimental to the public health, safety, and welfare." Therefore, to the extent the public trust doctrine and/or Article XI, section 1 of the Hawai'i Constitution applies to a resource, the doctrine's and the state constitution's public use requirements are implemented.

Q **Based on your review of the facts of this case, does the public trust doctrine apply to the TMT project?**

A No. The public trust doctrine has traditionally been exclusively connected to water. The Hawaii Supreme Court has interpreted the scope of the doctrine to include all water resources. Based on my review of the documents related to the CDUA, there is no evidence that the proposed project would restrict or otherwise impair any water resource. No court in Hawai'i has ever applied the public trust doctrine to a land use that did not implicate the availability and use of water for the benefit of the public, and in my professional opinion as a land use expert, there is no reason that the proposed TMT construction necessitates an extension of the public trust doctrine.

Furthermore, if the proposed land use is public or quasi-public, then the public trust doctrine would not require a balancing between public and private uses at all. Public use means use by the public, whereas quasi-public use means a use that is public in nature but may affect other public uses in or on public trust doctrine resources. In this case, the TMT project is an observatory that will be managed by a consortium of research institutions and will result in benefits to the public in the form of educational, research, and economic opportunities. Based on my experience, the TMT project easily qualifies as public or quasi-public use and is thus consistent with most, if not all, other public uses so that the need to balance public and private uses does not apply.

Q Please explain the analysis behind your conclusion that the public trust doctrine should not be extended beyond its traditional application to water issues in this matter.

A A review of the applicable literature demonstrates that the public trust doctrine has almost never been extended beyond its traditional association with water, and for good reason. To extend the public trust doctrine to any land that is held or "owned" by the State of Hawai'i such as the top of a mountain would represent a breathtakingly huge leap from a legal perspective, and would send a shockwave through the planning community.

The public trust doctrine has always traditionally applied to water due to the unique interplay between public and private uses on land adjacent to or submerged under water. Those considerations are not transferable to a mountain top.

Moreover, once land is impressed with and bound by the public trust doctrine, it cannot be transferred. This would be an absurd result if applied to all land and resources held or "owned" by the state of Hawaii - or indeed any other state.

Q Can you further elaborate on your conclusion that TMT Project is a public or quasi-public use of land and the implications of this conclusion?

A Yes. The proposed construction of the TMT is clearly contemplated by both the lease to the University of Hawaii of land for an astronomy precinct and the sublease from the University to the Thirty Meter Telescope International Observatory LLC ("TIO") for the construction of the TMT. TIO's membership is comprised of the California Institute of Technology, the National Astronomical Observatories of the Chinese Academy of Sciences, the National Institutes of Natural Sciences/National Astronomical Observatory of Japan, the University of California, the Department of Science and Technology of India, and the National Research Council Canada. In my experience, this would be considered a public or perhaps quasi-public use of land.

Traditionally, under the public trust doctrine, the most common permitted uses are private piers and wharves that extend into water (or on submerged land) that are held by the state under the public trust doctrine. Contrast this with the TMT Project on Mauna Kea, which involves a lease from the State of Hawaii (through its Department of Land and Natural Resources) to the University of Hawaii, a state university and entity, and a further sublease to a nonprofit consortium of research institutions for the construction of the TMT. The TMT Project is not simply a private undertaking that is in conflict with the public trust resources. Rather, the TMT Project involves public and quasi-public entities for an educational use that will benefit the public and is consistent with the designated conservation use of that area. In my experience and to my knowledge, under the public trust doctrine, this type of situation has never been treated as conflicting with protection of a resource – usually water – or use by the public. Therefore, the public trust doctrine is inapplicable.

Q What effect would it have on the public trust doctrine if the TMT Project were viewed as a private use of land?

A If property is impressed with the public trust doctrine any private use of that property must be consistent with the public's right to use and enjoy the property. Therefore, the fact that a given natural resource is held by the state under the public trust doctrine operates to restrict what would otherwise be absolute private property rights to that resource. As discussed above, the classic example involves piers and wharves: The public's right to use the ocean burdens-but does not foreclose - the littoral right of beachfront landowners to build a pier.

Even if one were to concede both that the public trust doctrine is applicable to the summit of Mauna Kea and that the proposed TMT Project constitutes a private use of that public trust resource, it is well-established that (1) the public trust doctrine encompasses both private and public uses, the latter being usually described as use by the public, and (2) private uses are not in conflict with the basic principles and purpose of the public trust doctrine if they do not diminish the public use of the public trust doctrine property and/or enhance public use on the public trust property. The Board then would have to perform a fact-specific inquiry to balance the alleged private use with the public's use of the resource. As I mentioned earlier, the public trust doctrine has only been applied to water resources in Hawaii. There is no evidence of any impairment to the public's use of a water resource due to the TMT project. The absence of adverse impacts combined with the obvious benefits of the project to the public leads me to conclude that, even if the TMT project were to be viewed as a private use, the TMT project is consistent with the public trust doctrine.

Q What is your opinion with respect to the native Hawaiian traditional and customary rights on the subleased site of the proposed TMT Project?

A It is not altogether clear that the standard set forth in the Ka Pa'akai case applies to a public or quasi-public proposed use on state land that is specifically leased and designated for astronomy uses. TIO is not a private developer, and its partner and sublessee, the University of Hawaii, is clearly a public institution.

Even if one were to apply the Ka Pa'akai standard to such a public/quasi-public institutional use, it is also unclear what traditional and customary rights are adversely affected by the construction of the TMT. The main sites on Mauna Kea where cultural access and gathering have been shown to take place - Lake Waiau and the nearby adze quarry - are some distance away from the proposed site of the TMT Project. To my knowledge, there is no evidence whatsoever that TMT construction will adversely affect access to either site, either for quarrying purposes (not demonstrably done for decades), or for visiting the lake.

There are a number of both recent and older stone assemblages that could arguably be described as religious sites, but, as with the adze quarry and Lake Waiau, there is no indication that access to these will be impeded by the construction of the TMT, or that the TMT will in any way interfere with whatever traditional or customary rights might be practiced at these assemblages.

While the state has a recognized duty to protect native Hawaiian traditional and customary rights on undeveloped land, in the context of fully developed land, the duty to protect such rights is much less burdensome and inconsistent with private ownership. In my experience, the duty to protect native Hawaiian rights in substantially developed areas is analogous to the less stringent protections for "fully developed land." Thus, the constitutional protections for native Hawaiian traditional and customary rights in substantially developed areas should focus on the additional impacts, if any, of the proposed use on native Hawaiian traditional and customary rights in light of the preexisting conditions.

Here, the summit of Mauna Kea and other parts of Mauna Kea are substantially developed. There are thirteen telescopes and related roads, structures, and buildings on the summit of Mauna Kea, together with a food service and dormitory facility for 500 and a visitors center at the approximately 9,000 foot elevation, as well as other parking facilities, roadways and trails. Given that all of this development is located in one of the State Conservation District's less restrictive subzones, there is no credible evidence that the addition of a 14th telescope affects any native Hawaiian traditional and customary rights more than those already on the summit.

Finally, TMT and the University of Hawaii have proposed an array of mitigation measures to lessen, if not eliminate, the effects on whatever constitutionally-protected traditional and customary rights might be affected by the proposed TMT Project.

Q **What is your opinion with respect to the proposals to mitigate adverse effects, if any, to native Hawaiian rights?**

A Even assuming that there are traditional and customary rights being exercised on Mauna Kea that could potentially be affected adversely by the proposed TMT, the University of Hawaii and TIO have proposed a series of localized and area-wide mitigation measures.

The University and TIO employed project design elements to minimize the visual impact of the TMT Project for cultural practitioners. For instance, the telescope employed the smallest dome possible to reduce the size and height of the observatory. The project site was specifically chosen so that the observatory would be at a lower elevation and the top of the dome would actually be at a lower altitude than other observatories on Mauna Kea. Moreover, the project site is intentionally located away from known historic properties and cultural resources.

In addition to those mitigation measures at the project-level, the State Administration has also proposed area-wide mitigation measures, including:

1. Formally and legally binding itself to the commitment that this is the last area on the mountain where a telescope project will be contemplated or sought.
2. Decommission – beginning this year – as many telescopes as possible with at least 25 percent of all telescopes gone by the time TMT is ready for operation.
3. Restart the EIS process for the university's lease extension and conduct a full cultural impact assessment as part of that process.
4. Move expeditiously the access rules that significantly limit and put conditions on non-cultural access to the mountain.
5. Require training in the cultural aspects of the mountain and how to be respectful to the cultural areas for anyone going on the mountain.
6. Substantially reduce the length of its request for a lease extension from the Board of Land and Natural Resources.
7. Voluntarily return to full DLNR jurisdiction all lands (over 10,000 acres) not specifically needed for astronomy.
8. Ensure full use of its scheduled telescope time.
9. Make a good faith effort to revisit the issue of payments by the existing telescope now as well as requiring it in the new lease.

As part of this effort the University of Hawaii President and the Chair of the Board of Land and Natural Resources co-signed a letter confirming the University's commitment to implementing its Comprehensive Management Plan for the stewardship and management of Mauna Kea. The University also formally announced its commitment to decommission the Caltech Submillimeter Observatory, Hoku Kea and the United Kingdom Infra-Red Telescope ("UKIRT"). These actions go beyond simply addressing the impact of the TMT Project. They will substantially mitigate any adverse impact of the astronomy site on Mauna Kea as a whole on native Hawaiian traditional and customary rights.

In my experience, the use of mitigation measures is a universally recognized and widely adopted means of lessening adverse impacts in land use projects. The University of Hawaii and the TMT consortium have made prudent and diligent efforts to mitigate potential adverse impacts of the TMT Project, through strategic locationing, design, and other mitigation commitments. Short of abandoning the TMT project altogether – an alternative never endorsed by the Hawaii Supreme Court or any other Hawaii court – the University of Hawaii and the TMT consortium appear to be satisfying and exceeding all standards in an effort to mitigate effects on any native Hawaiian traditional and customary rights.

Q **What is your opinion regarding the allegations that Hawaii County's subdivision ordinance applies to the subleased parcel atop Mauna Kea?**

A I disagree with such allegations. The CDUA states that the University intends to sublease part of the Science Reserve to TIO. My opinion is that such a sublease does not create a subdivision. Some parties opposed to a CDUP for the TMT on Mauna Kea's summit have suggested that Hawaii County's subdivision ordinance applies to the subleased parcel upon which the TMT is proposed to be constructed. It does not. As set forth in my books, Regulating Paradise: Land Use Controls in Hawaii 54-56 (1984) and Cases and Materials on Land Use 465-468 (6th ed. 2012), subdivision codes like Hawaii County's evolved from state planning enabling statutes and plat acts as a method of simplifying the descriptions of lots in multi-lot residential developments, in order to avoid the complication of describing each lot in a proposed subdivision by metes and bounds. Subdivision ordinances also are the means by which land development conditions relating to public facilities are applied and levied upon landowners and developers proposing such a development. Lastly, subdivision ordinances are the primary means for ensuring the streets, roads, water and wastewater facilities on a subdivided parcel link up to such facilities outside the site.

None of these purposes are relevant to the proposed TMT construction on a subleased parcel of land owned by the State of Hawaii and leased to the University of Hawaii for an astronomy precinct. The inclusion of a legal description of the parcel to be subleased does not transform the sublease into a subdivision. Every transfer of an interest in land, however, either contains such a description or (in the case of easements on land) displays such an interest on a map showing its location. Converting every such description of an interest in land, however slight, into a subdivided parcel falling under a county subdivision code would subject every real property transaction in the county to an ordinance that is designed to regulate residential development, regardless of whether the subject property is actually being used for a residential purpose.

TESTIMONY
OF
JAMES E. HALLSTROM, Jr. MAI, CRE

Good afternoon. My name is James E. Hallstrom, Jr. I am the Managing Director, Valuation & Advisory Group of CBRE Hawaii, and am here to testify regarding our analysis of the ground lease rents for the site underlying the "Thirty Meter Telescope."

Background

The Thirty Meter Telescope (TMT) is a multinational venture seeking to construct "the world's most advanced and capable ground-based, optical, near-infrared and mid-infrared observatory". The facility will be located at the summit of Mauna Kea, within the University of Hawaii-administered (UH) Mauna Kea Science Reserve (MKSR), on conservation land owned by the State of Hawaii.

Our assignment was to determine whether the contractual ground lease rent structure is appropriate, rational, and supportable by market standards.

Based on our analysis of the site, its planned use, the sublease, and assessment of Big Island real estate sectors, we concluded the contractual sub-lease rents are appropriate, rational, supportable in an economic context, and provide a superior return to the underlying conservation-classified real estate.

My testimony summarizes the ground lease terms and rents, and the focal considerations contributing to our conclusions. The brief discussion is from a real estate market perspective; we acknowledge there are cultural, environmental and academic issues best addressed by others.

The Subject Property

The TMT leasehold site contains a gross land area of 8.664 acres, comprised of 5.999 acres of useable area (the observatory site) and a 2.665 acre non-exclusive access easement. It is currently vacant, unimproved and un-serviced with access available only from an unpaved summit roadway to the point at which the easement will extend to the observatory site.

The holding has "conservation" land use classifications, and the observatory will be built under a Conservation District Use Permit specifically for the project.

Apart from its proposed development with the TMT, the property, one of the most remote on the Big Island, has no meaningful economic potentials through urban (commercial, industrial, residential, resort), agricultural (crop, grazing) or other uses. It would be a small component within an 11,215 acre parcel.

Were it a freestanding holding, it is difficult to envision any market demand for the subject property, and its value on a fee simple basis would be that of other rural, conservation/open-classified properties that currently have prices in the range of $500 to $1,500 per acre.

Due to its elevation, isolation and climate, it is unlikely there would be interest in leasing it for agricultural, ranching or recreational purposes; and, even were there interest, rents would of necessity be nominal.

However, the extremely favorable and rare characteristics of the Mauna Kea summit for astronomical observation, coupled with the willingness of the international scientific community to develop telescopic facilities on a not-for-profit basis, indicates the subject property has some level of "value" beyond conservation use from an academic/research perspective.

Despite the unimproved natural condition of the site and the high costs of constructing, operating and maintaining the observatory, which limit the residual value of the underlying land within a market context, TMT has committed to pay substantial ground rents for the opportunity to pursue its scientific objectives. This is a major evolution as historically observatories worldwide have paid no or nominal ground rents.

The potential for the subject property as the TMT development site within the MKSR is the specialized Highest and Best Use for the holding.

The Ground Sublease

The agreement, a sublease, is summarized as follows:

Fee Owner/Master Lessor:	State of Hawaii Department of Land and Natural Resources
Master Lessee/Sublessor:	University of Hawaii (via General Lease No. S-4191)
Sublessee:	TMT International Observatory, LLC
Demised Area:	A total of 8.664 acres, which is comprised of a useable area (Observatory Site) of 5.999 acres, and Non-Exclusive Access Easement covering an additional 2.665 acres.
Term:	Initial -- Through December 31, 2033.
	Extension -- Sublessee has the option to extend the lease term through December 31, 2079.
Rents:	The contract ground rents escalate from $300,000 to $900,000 per year during the 10-year construction period of the TMT, and stabilize at a current value of $1,080,000 annually in Year 11 and thereafter.

The rents will escalate from the contract levels beginning in 2015 at the annual rate of inflation of the Consumer Price Index (CPI) for "All Urban Consumers, US City Average".

The chart below summarizes the "contract" and estimated "actual" rents which are to be paid by TMT.

TMT GROUND SUBLEASE RENT			
Year	Contract Base	CPI Adjustment	Annual Rent
2014 (por)	$129,041	1.00000	$129,041
2015	$300,000	1.00000	$300,000
2016	$297,900	1.00000	$297,900
2017	$400,000	1.02410	$409,640
2018	$400,000	1.04878	$419,512
2019	$600,000	1.07406	$644,434
2020	$600,000	1.09994	$659,965
2021	$700,000	1.12645	$788,515
2022	$700,000	1.15360	$807,518
2023	$900,000	1.18140	$1,063,259
2024	$1,080,000	1.20987	$1,306,660

From 2017 and beyond the compounded annual CPI growth rate was estimated to be 2.41%.

In keeping with the non-market academic/research basis for the Mauna Kea Science Reserve, the sublease ground rents, though substantial, are not intended to generate substantive land returns (profits) for UH, but enable it to fund its programs as conservator of the summit area.

The site will also be encumbered by a "Scientific Cooperation Agreement" describing the going-forward responsibilities between the parties in regards to shared objectives, access to existing infrastructure and facilities on the mountain, and their operation and maintenance. Under the agreement, TMT will contribute $6,600,000 towards the extension/upgrading of the existing MKSR infrastructure systems necessary for their observatory, and contribute a pro rata share to UH operation and maintenance of the systems and support facilities on the basis of "no profit, no loss."

Value of the Ground Lease

The present value of the leased fee position held by the UH/State in the ground lease can be estimated by projecting the CPI-escalating future rents over the duration of the agreement (initial and extension terms) and then discounting them back to a current date at an appropriate rate.

In analysis of urban Honolulu leased fee interest purchases of commercial real estate, the prices paid indicate an 8.0 annual discount rate coupled with an underlying 3.0 percent annual appreciation rate, both compounded, as being representative of the market.

As TMT will be an immensely expensive facility financed by an international consortium, there will be a lower risk associated with the non-payment of ground rent being made relative to the general real estate market; a lower discount rate is appropriate. And, we are assuming CPI escalations of only 2.41 percent annually.

We have used a discount rate of 7.0 percent compounded yearly for our analysis; it clearly could be lower (resulting in a higher value for the leased fee interest) given the risk of non-payment and foreclosure. It is not an urban commercial site, but a highly specialized remote conservation holding that will bear a substantial asset.

The calculations for the total 66-year lease term, from 2014 through 2079, are shown on the following Table attached to this testimony.

QUANTIFICATION OF THE PRESENT VALUE OF THE TMT GROUND SUBLEASE
Analysis of the TMT Ground Sublease
Mauna Kea Summit, Hamakua, Hawaii

LEASE SUMMARY

Fixed Periods								
Commencing	Terminating	Years		Annual Rent		Present Value Factor(2)		Present Value
07/28/2014	12/31/2014	0.43014	*	$129,041	x	1.0000	=	$129,041
01/01/2015	12/31/2015	1.00	*	$300,000	x	0.9713	=	$291,390
01/01/2016	12/31/2016	1.00	*	$297,900	x	0.9078	=	$270,434
01/01/2017	12/31/2017	1.00		$409,640	x	0.8484	=	$347,539
01/01/2018	12/31/2018	1.00		$419,512	x	0.7929	=	$332,631
01/01/2019	12/31/2019	1.00		$644,434	x	0.7410	=	$477,525
01/01/2020	12/31/2020	1.00		$659,965	x	0.6925	=	$457,026
01/01/2021	12/31/2021	1.00		$788,515	x	0.6472	=	$510,327
01/01/2022	12/31/2022	1.00		$807,518	x	0.6049	=	$488,468
01/01/2023	12/31/2023	1.00		$1,063,259	x	0.5653	=	$601,060
01/01/2024	12/31/2024	1.00		$1,306,660	x	0.5283	=	$690,309
01/01/2025	12/31/2025	1.00		$1,338,151	x	0.4938	=	$660,779
01/01/2026	12/31/2026	1.00		$1,370,400	x	0.4615	=	$632,440
01/01/2027	12/31/2027	1.00		$1,403,427	x	0.4313	=	$605,298
01/01/2028	12/31/2028	1.00		$1,437,249	x	0.4031	=	$579,355
01/01/2029	12/31/2029	1.00		$1,471,887	x	0.3767	=	$554,460
01/01/2030	12/31/2030	1.00		$1,507,360	x	0.3520	=	$530,591
01/01/2031	12/31/2031	1.00		$1,543,687	x	0.3290	=	$507,873
01/01/2032	12/31/2032	1.00		$1,580,890	x	0.3075	=	$486,124
01/01/2033	12/31/2033	1.00		$1,618,989	x	0.2874	=	$465,298
INITIAL GROUND LEASE TERMINATES DECEMBER 31, 2033						**SUBTOTAL**		**$9,617,968**
01/01/2034	12/31/2034	1.00		$1,658,007	x	0.2686	=	$445,341
01/01/2035	12/31/2035	1.00		$1,697,965	x	0.2510	=	$426,189
01/01/2036	12/31/2036	1.00		$1,738,886	x	0.2346	=	$407,943
01/01/2037	12/31/2037	1.00		$1,780,793	x	0.2192	=	$390,350
01/01/2038	12/31/2038	1.00		$1,823,710	x	0.2049	=	$373,678
01/01/2039	12/31/2039	1.00		$1,867,662	x	0.1915	=	$357,657
01/01/2040	12/31/2040	1.00		$1,912,672	x	0.1790	=	$342,368
01/01/2041	12/31/2041	1.00		$1,958,768	x	0.1673	=	$327,702
01/01/2042	12/31/2042	1.00		$2,005,974	x	0.1563	=	$313,534
01/01/2043	12/31/2043	1.00		$2,054,318	x	0.1461	=	$300,136
01/01/2044	12/31/2044	1.00		$2,103,827	x	0.1365	=	$287,172
01/01/2045	12/31/2045	1.00		$2,154,529	x	0.1276	=	$274,918
01/01/2046	12/31/2046	1.00		$2,206,453	x	0.1193	=	$263,230
01/01/2047	12/31/2047	1.00		$2,259,629	x	0.1114	=	$251,723
01/01/2048	12/31/2048	1.00		$2,314,086	x	0.1042	=	$241,128
01/01/2049	12/31/2049	1.00		$2,369,855	x	0.0973	=	$230,587
01/01/2050	12/31/2050	1.00		$2,426,969	x	0.0910	=	$220,854
01/01/2051	12/31/2051	1.00		$2,485,459	x	0.0850	=	$211,264
01/01/2052	12/31/2052	1.00		$2,545,358	x	0.0795	=	$202,356
01/01/2053	12/31/2053	1.00		$2,606,702	x	0.0743	=	$193,678
01/01/2054	12/31/2054	1.00		$2,669,523	x	0.0694	=	$185,265
01/01/2055	12/31/2055	1.00		$2,733,859	x	0.0649	=	$177,427
01/01/2056	12/31/2056	1.00		$2,799,745	x	0.0606	=	$169,665
01/01/2057	12/31/2057	1.00		$2,867,218	x	0.0567	=	$162,571
01/01/2058	12/31/2058	1.00		$2,936,318	x	0.0529	=	$155,331
01/01/2059	12/31/2059	1.00		$3,007,084	x	0.0495	=	$148,851
01/01/2060	12/31/2060	1.00		$3,079,554	x	0.0462	=	$142,275

QUANTIFICATION OF THE PRESENT VALUE OF THE TMT GROUND SUBLEASE
Analysis of the TMT Ground Sublease
Mauna Kea Summit, Hamakua, Hawaii

LEASE SUMMARY

Fixed Periods Commencing	Fixed Periods Terminating	Years	Annual Rent		Present Value Factor(2)		Present Value
01/01/2061	12/31/2061	1.00	$3,153,772	x	0.0432	=	$136,243
01/01/2062	12/31/2062	1.00	$3,229,777	x	0.0404	=	$130,483
01/01/2063	12/31/2063	1.00	$3,307,615	x	0.0378	=	$125,028
01/01/2064	12/31/2064	1.00	$3,387,329	x	0.0353	=	$119,573
01/01/2065	12/31/2065	1.00	$3,468,963	x	0.0330	=	$114,476
01/01/2066	12/31/2066	1.00	$3,552,565	x	0.0308	=	$109,419
01/01/2067	12/31/2067	1.00	$3,638,182	x	0.0288	=	$104,780
01/01/2068	12/31/2068	1.00	$3,725,862	x	0.0269	=	$100,226
01/01/2069	12/31/2069	1.00	$3,815,656	x	0.0252	=	$96,155
01/01/2070	12/31/2070	1.00	$3,907,613	x	0.0235	=	$91,829
01/01/2071	12/31/2071	1.00	$4,001,786	x	0.0220	=	$88,039
01/01/2072	12/31/2072	1.00	$4,098,229	x	0.0205	=	$84,014
01/01/2073	12/31/2073	1.00	$4,196,997	x	0.0192	=	$80,582
01/01/2074	12/31/2074	1.00	$4,298,144	x	0.0179	=	$76,937
01/01/2075	12/31/2075	1.00	$4,401,730	x	0.0168	=	$73,949
01/01/2076	12/31/2076	1.00	$4,507,811	x	0.0157	=	$70,773
01/01/2077	12/31/2077	1.00	$4,616,450	x	0.0146	=	$67,400
01/01/2078	12/31/2078	1.00	$4,727,706	x	0.0137	=	$64,770
01/01/2079	12/31/2079	1.00	$4,841,644	x	0.0128	=	$61,973
OPTION/EXTENSION TERM WILL EXTEND TO DECEMBER 31, 2079					**SUBTOTAL**		**$8,999,842**

Indicated Total Value of Proposed Ground Lease Rents $18,617,810

Rounded **$18,618,000**

Gross Site Acreage	**8.6640**	**Useable Site Acreage**	**5.9990**
Value per Gross Acre	**$2,148,892**	**Value per Net Acre**	**$3,103,517**
Value per Square Foot	**$49.33**	**Value per Square Foot**	**$71.25**

*Actual Rents Paid

(1) Rents are paid annually in advanced.
(2) 7.00% discount rate employed.

There will be some residual value in the site after termination of the lease and removal of the TMT observatory and restoration of the site, as called for in the agreement. However, whether there will be another site will be 'another rent-paying obervatory constructed or the site will revert back to conservation use is unknown; and it it is so far in the future the present value of the reversionary interest is nominal.

Source: Sublease & The Hallstrom Group | CBRE, Inc. as of July 28, 2014.

The indicated present value of the UH/State leased fee interest in the TMT holding will be $18,618,000. This is the equivalent to $3.1 million per acre and $71.25 per square foot for the net usable area of the site, which is how the market would view the indicator; or $2.15 million per acre and $49.33 per square foot for the gross site area.

Our calculations do not include the present value of the reversionary interest in the holding following termination of the lease after 2079, at which time the observatory will be dismantled and the parcel restored to its present condition at cost to TMT, per the agreement. This is because it is unknown whether there will be another rent-paying observatory or other scientific facility leasing the property or it will revert back to a vacant conservation status. Regardless, the reversion is so distant its present value impact is nominal.

At $71.25 per net usable square foot under the lease, the subject property would become more valuable than any off water resort, commercial or industrial land on the Big Island. As summarized on Table 2, this figure exceeds the most valuable resort and commercial land indicators in Kailua-Kona, the highest-priced sector in the county; even for oceanfront hotels.

RESORT AND COMMERCIAL LAND TRANSACTION SUMMARY Analysis of the TMT Ground Sublease Mauna Kea Summit, Hamakua, Hawaii								
Tax Map Key	Location	Existing/Proposed Use	Zoning	Land Area Sq. Ft.	Instrument	Transaction Date	Indicated Price Total	$/Sq. Ft.
Interior								
7-5-18-58	75-120 Lunapule Rd	Vacant	CV-10	8,246	Sale	27-Apr-15	$279,000	$33.83
7-5-3-29	Hale Kapili St	Vacant	CG-20	43,354	Active Listing	7-Dec-14	$1,300,000	$29.99
7-5-18-97	75-5915 Walua Rd	Convenience Store/Res. Condo	CV-10	11,541	Deed	14-Apr-14	$400,000	$34.66
3-7-5-4-38	75-5699 Kopiko St	The Club	CG-20	60,243	Grd. Rent Reneg.	1-Mar-14	$2,108,500	$35.00
3-7-5-6-15	75-5652 Kikana Ln	Kona Seaside Hotel (por)	V-.75	22,522	Ground Rent Reneg.	1-Nov-13	$563,050	$25.00
7-5-18-92	75-5915 Walua Rd	Public TV Station	CV-10	10,486	Deed	7-May-13	$379,050	$36.15
7-5-5-86 to 89	75-5608 Kuakini Hwy	Big Island Honda	CV-10	326,177	Ground Rent Reneg.	1-Jan-13	$7,854,720	$24.08
7-5-6-16 & 17	75-5646 Kuakini Hwy	Kona Seaside Hotel (por)	V-.75	96,137	Ground Rent Reneg.	1-Oct-12	$3,412,864	$35.50
7-5-4-28	75-5621 Palani Rd	Kia - Harley Davidson	CG-20	41,788	Ground Rent Reneg.	1-Sep-12	$1,411,765	$33.78
7-5-5-61	75-5644 Palani Rd	American Savings Bank	CV-10	18,997	New Lease	1-Mar-12	$845,746	$44.52
7-5-5-90	75-5580 Kuakini Hwy	West Hawaii Today	CV-10	110,642	Ground Rent Reneg.	1-Nov-11	$3,117,647	$28.18
7-5-18-92	75-5915 Walua Rd	Walua Rd	CV-10	22,802	Deed	31-Mar-11	$515,000	$22.59
Resort and Oceanfront								
7-5-9-8	75-5852 Alii Drive	Royal Kona Resort - Parcels 8, 12, & 42	V-.75	57,458	Ground Rent Reneg.	1-Jan-13	$2,039,218	$35.49
7-5-9-47	75-5852 Alii Dr	Royal Kona Resort - Parcel 47	V-.75	25,975	Ground Rent Reneg.	1-Apr-12	$1,142,900	$44.00
7-5-9-46	75-5852 Alii Dr	Royal Kona Resort - Parcel 46	V-.75	13,646	Ground Rent Reneg.	1-Aug-11	$573,130	$42.00

Compiled by The Hallstrom Group | CBRE, Inc.

The ground lease clearly represents a "top of the market" rent structure.

Additional Value Considerations

Beyond the high ground rents, the sub-lessee will bear exceptional additional costs not typical of the general market.

In the general market, a landowner, as developer of a master planned project, will:

1. Bear the entire expense, timing and risks of obtaining all entitlements.
2. Be responsible for all funding necessary to meet land use conditions, obligations and requirements.
3. Incur the entire costs of design, engineering and infrastructure emplacement.

4. Provide the final purchaser/lessee or intended user with a fully "finished" net building lot (exclusive of roadways, features or open space) that is well-located and readily accessible.

At the subject property, which is essentially a raw building site within a master planned specialized scientific development project, the efforts required of the developer and the end-product provided, fall well-short of general market parameters. Yet, the ground rents to be paid are significantly higher than those found in any Big Island industrial or commercial park offering finished, net building sites.

The TMT ground lease results in:

a. The sublessee, not the master developer, paying for fundamental portions of the entitlement process (specifically preparation of the EIS and consultants throughout).

b. The sublessee, not the master developer, paying for the costs of infrastructure to service the site by committing a minimum of $6.6 million (early 2013 dollar estimate), as well potentially-needed electrical main upgrades.

c. The sublessee bearing all risks and timing impacts of the entitlement process and infrastructure emplacement.

d. Being provided not with a finished urban building site, but an unimproved and natural gross acreage parcel that is unserved and expensive to develop, operate and maintain land in a harsh remote location.

The Percentage Rent Issue

The lease agreement does not call for a percentage rent component. We have evaluated whether some form of percentage rent payments should be included. Our analysis indicates additional percentage (or "overage") rents would be an inappropriate inclusion in the TMT lease.

A limited number of State and DLNR ground leases contain provisions for additional rents above the fixed (or "minimum") amount based on a percentage of gross operating revenues of the lessee or tenants. The additional rents are paid only to the extent they exceed the minimum rent level.

An example is the lease for the re-opening term at Sea Life Park, where the additional rents are set at 1.5% of gross revenues against the base rent.

However, these are revenue-producing, market-based, for-profit entities, with a primary goal of creating proceeds above operating costs and consistent positive returns through development of a state-owned holding.

Under such circumstances, within a market environment, the opportunity of the fee owner to share in the cash flow is not an unreasonable expectation in Hawaii real estate; and, this is typically accomplished by coupling at or below market minimum rents with additional percentage overage rents paid once revenues reach a natural "breaker point".

The UH and MKSR are the antithesis of this situation:

1. They are not market-based, for-profit entities.
2. The rents are not intended to produce a positive annual cash flow for the underlying land owners and master lessee/developer. They are an attempt to fund the obligations of MKSR with all proceeds "spent on the mountain".

3. The end-user/sublessee (TMT) does not operate in a market environment and is not pursuing positive returns on their investment. It is an academic environment focused on education and the acquisition of scientific knowledge requiring significant capital expenditures.

4. There are no profits at any stage of the operation for UH at MKSR, and in fact it incurs a substantial yearly "loss" (in the form of a cost against the University budget).

5. The contractual ground rents which TMT will pay will be significantly above the rent levels for property on the Big Island, and it would be appropriate they be lowered considerably if a "base plus percentage rents" formula was emplaced.

There is no annual gross revenue against which to assess a percentage rent.

Reduced Rents During Construction

Reduced ground lease rents during construction are typical for major projects. The TMT agreement calls for ground rents to start at $300,000 annually at the commencement of construction, escalate up to $1,080,000 per year by its completion in Lease Year 10, and reach maximum/stabilized levels in Year 11 and thereafter at $1,080,000 (subject to an annual CPI adjustment).

Although a ten-year construction period is long, due to the size and complexity of the TMT facility, the concept is appropriate in the island's real estate market. We are aware of other new, recent ground leases for developments which provide for no or discounted rents during construction.

We appreciate the opportunity to testify in this regards to this prominent facility.

PROFESSIONAL QUALIFICATIONS OF JAMES E. HALLSTROM, JR., MAI, CRE, FRICS

Business Affiliation

Managing Director — The Hallstrom Group | CBRE, Inc.
Valuation & Advisory Services
Honolulu, Hawaii (2015 – Present)

President — The Hallstrom Group, Inc.
Honolulu, Hawaii (1980 - 2014)

National Designations and Memberships

- FRICS Designation (2015)–Royal Institution of Chartered Surveyors
- CRE Designation (1998) - The Counselors of Real Estate
- MAI Designation (1976) - American Institute of Real Estate Appraisers
- SRPA Designation (1975) - Society of Real Estate Appraisers

The American Institute of Real Estate Appraisers (AIREA) and the Society of Real Estate Appraisers (SREA) consolidated in 1991, forming the Appraisal Institute (AI).

Education

- M.S. (Real Estate Appraisal and Investment Analysis) 1971, University of Wisconsin at Madison
- B.A. (Economics) 1969, Brigham Young University at Provo
- Numerous specialized real estate studies in connection with qualifying for national professional designations, and uninterrupted Continuing Education.
- Completed Continuing Education requirements with the Appraisal Institute - Current.

Professional Involvement

- Past President and Officer of Hawaii AIREA and SREA Chapters
- Past Instructor for Society of Real Estate Appraisers
- Contributing Author to the "Hawaii Real Estate Investor"
- Lecturer at many professional seminars and clinics.
- Appointed numerous times as an Arbitrator and Mediator.

Qualified Expert Witness

Federal and State Courts
State Land Use and County Hearings
Arbitration Proceedings

State of Hawaii Certification

Certified General Appraiser
License No. CGA-178
Exp. Date: December 31, 2017

Territory of Guam - Non-Resident Real Estate Certified Appraiser, License No. CA-06-035, Exp. Date March 19, 2013.

Community Service

Active registered member of the Boy Scouts of America. Former Director of Le Jardin Academy, Advisory Board Member of the School of Business-Brigham Young University-Hawaii Campus, and Director of Hawaii Reserves, Inc.

Email Address

JEH@HallstromGroup.com | James.Hallstrom@cbre.com

Testimony of Dr. Heather Kaluna

My name is Heather Maria Kaluna, and I am the daughter of Clement Kahele and Cathy Spirz Kaluna. My father and his family originate from a village in Kapoho that was covered during the 1960 Kilauea eruption. My twin brother and I were born and raised in Pahoa. My father was a longtime fisherman, so after our birth, our father took our piko, placed it in a bottle and put it into the ocean. This created a lifelong bond between the us and the ocean. As I child, I watched as Pele came down the pali and made her way through the town of Kalapana. Thus I have a great appreciation for Pele and her presence in my home community.

In 2002, I graduated from Pahoa High School and spent my first semester of college at the University of Hawaiʻi Manoa in the fall of 2002. After taking a pair of astronomy and physics courses that semester, I immediately fell in love with astronomy decided to pursue the astronomy degree at the University of Hawaiʻi at Hilo (which was the only place in the islands that offered an undergraduate degree at that time), and transferred the next semester. During my time at UH Hilo, I was an intern for the Panoramic Survey Telescope and Rapid Response System (PanSTARRS) project and was tasked with leading public outreach efforts and educating the community about near-Earth asteroids. In the summer of 2007, I was also an Akamai intern at the University of California, Santa Cruz where I investigated far away galaxies and their companions. I also served as an intern under Dr. Marianne Takamya for the Keaholoa STEM program, and studied the structures of galaxies. The Keaholoa STEM program was designed to provide research and training opportunities for minority students and also educated participants on local cultural perspectives. I received my Bachelors of Arts in Physics and Mathematics in the spring of 2008.

In 2008, I was accepted into the astronomy program at UH Manoa (IfA), where I spent seven years studying water on asteroids and trying to understand a possible source of Earths water. Having such a strong connection to the ocean, I was very passionate about studying the evolution of water in our solar system. As a graduate student I conducted many observations using the UH 2.2m, Subaru, Keck, Gemini and IRTF telescopes. I applied for and utilized time that was appropriated to UH by each of the observatories. I completed my dissertation and received my PhD in 2015. I am now in a post-doctoral fellow at the Hawaii Institute of Geophysics and Planetology. I am working with Paul Lucey on research conducted with the AEOS telescope on Haleakala as well as data collected with NASA's Dawn spacecraft of the asteroids Vesta and Ceres.

My growing relationship with Maunakea

In 2003, I was invited to join a field trip to Maunakea, and it was the first time I went up the mountain. The mountain felt so different from the rest of the island and honestly, made me feel a bit uncomfortable. In 2006, I started volunteering at the Visitor Information Station (VIS) and helped run the nightly star gazing program. During this time, I also spent a lot of time doing community outreach with Gary Fujihara, the IfA Hilo outreach specialist, and learned a lot about the cultural significance of

Maunakea from him. It was then that I truly started to develop a relationship with the mauna, and during my graduate studies, I began to give offerings and prayers at the ahulele behind the VIS. It was during this time that I spent the most my most cherished nights on the summit and really started to feel a special connection to the mauna. Nothing compares to the early morning twilight hours I have spent on the mauna, where I am greeted by the stark beauty and stillness of the mauna.

After I started to spend time on the mountain, my father shared with me his involvement in building the foundation for the Canada France Hawaiʻi Telescope. He was very proud of my involvement in astronomy and on the mountain. I also have other family members who work on the mountain, one of my cousins currently works for the Subaru Telescope and another is one of the local engineers for the TMT facility.

Hopes

I see Maunakea as a special place that allows us to understand and study our origins. As one's origin and geneology are critical aspects of Hawaiian culture, I view the pursuit of astronomy on Maunakea to be a beautiful blend of culture and science. To maintain a balance between culture and science, I also believe it important to limit the development of facilities on the mauna. I have never seen as many Native Hawaiians on the mauna as I have when the protests were occurring, and I hope to see these people continue to build a relationship with the mauna and have a more established presence there through a cultural center near Hale Pohaku. When I recently returned home and spent some time at the VIS, I was shocked at the significant increase in the number of people at the visitor's center. The 9,000 ft. elevation is home to some very rare native birds and plants, so I am greatly concerned about the impact that such heavy traffic will have on the mountain's delicate ecosystem.

Testimony of Naea Stevens

1. My name is Dashiel Naea Stevens. I currently work on Maunakea. I was born in San Francisco in 1994.
2. I graduated with my degree in linguistics from Ka Haka ʻUla o Keʻelikōlani, the College of Hawaiian Language at the University of Hawaiʻi at Hilo in May of 2016. My ancestry is of mixed Hawaiian and European descent; Hawaiian on my father's side and European on my mother's. I came to Hawaiʻi island years ago to learn about my heritage, to be with family, and to study at the University of Hawaiʻi.
3. My father's family is Hawaiian, hailing from Hawaiʻi island. My great grandfather, Robert Naea Stevens Jr., was born in 1896 in Kamuela, in the Republic of Hawaiʻi; his father before him, in 1875 also in Kamuela (known as Waimea in my family records) in the Kingdom of Hawaiʻi. His wife, Luka Kaualokuokamaile Lincoln was born in Kamuela in 1877; I can trace her lineage back to Keawemaʻuhili, aliʻi nui of the Hilo ahupuaʻa during the 18th C. CE, half-brother to Kalaniʻōpuʻu (mōʻī of Hawaiʻi island) and cousin of Keōua Kalanikupuapaʻīkalaninui Ahilapalapa (father of Paiʻea, or Kamehameha Nui); and before that to ʻUmi-a-Līloa, the man who first unified Hawaiʻi island whose father was Līloa: aliʻi nui of the Hāmākua ahupuaʻa. My great grandfather, and his father before him, were *paniolo* with Parker Ranch.

4. My family, being ali'i and ali'i nui on Hawai'i island, has deep ties to Maunakea. In fact, one of my ancestors bore the name of Kekaulikeikawēkiuonālani, which referenced the summit of Maunakea itself. During, and in the time preceding, the Kingdom of Hawai'i, the ali'i and kahuna were the only Hawaiians allowed to go to the summit of Maunakea. Even the workers who quarried and shaped the adzes at Keanakāko'i were almost exclusively kahuna, as the class included expert craftsmen. It was after the breaking of the *ai kapu*, or the kapu placed on eating, when Kalaninui kua Liholiho i ke kapu 'Iolani (Alexander Liholiho, Kamehameha II) ate a woman's meal prepared by his mother (Keōpūolani) and father's favorite wife (Ka'ahumanu), that the kapu system broke down and the maka'āinana were allowed to travel to the summit area of Maunakea.

5. Maunakea holds a special place in my heart. In my initial trips there, I learned a great deal with regards to astronomy and I was sparked by an intense, burning passion to learn of my ancestry and the ancient ways of wayfinding and navigation. If it weren't for the access offered by the astronomy community (proper roads, etc.), my ability to travel and experience the mana on the mountain would be greatly decreased. In fact, it is thanks to the astronomy community and the decision to bring astronomy to Hawai'i island that people can easily, freely, and safely travel to Maunakea to practice cultural practices and share in the grandeur of the mountain. As well, when I was young, my mother taught me to

share; being able to share astronomy, a fundamental science aimed not only to the future but at the past, is a great and intense joy of mine and I take great pride that Hawaiʻi is seen in the science community as the premier spot to practice astronomy (as well as geology, entomology, archaeology, and botany) - something that would have been restricted under the old ways because commoners were not allowed near the summit. Astronomy, as mentioned, is a way of looking back as well as forward. Modern astronomy is able to look back at Pō, the primordial night from whence sprung all of creation in Ke Kumulipo, the Hawaiian creation chant, and study the heavens above just like the kilo hōkū (star watchers) of antiquity.

6. That we here in Hawaiʻi are able to practice our culture is a joy to behold when so many native practices the world over have been restricted by various groups: we are able to take the traditional Humuʻula trail to the summit and pray at the ahu and bask in the sight of beautiful Lake Waiau. Astronomy in a way is spiritual as well, and not just to modern scientists: my ancestors placed heiau at clear spots so the kilo hōkū could observe the heavens and help the hoʻokele to navigate across the vast and empty Pacific Ocean. Modern day practitioners are allowed easy access to Maunakea because of the roads maintained by the astronomy community. If anything, astronomy has managed to be a fantastic boon to the Hawaiian community by not only introducing a stable element to the economy but

continuing to grant access so that we, as Hawaiians, may safely enjoy the grandeur of Maunakea.

Direct Testimony of Amber Imai-Hong

My name is Amber Imai-Hong. I was born in Hilo and raised in Kea`au on Hawai`i Island. I attended Kea`au Elementary and Midddle School, then transferred to Waiakea High School in 2003 to participate in after school robotics and band. I graduated from the University of Hawaii at Manoa with a Bachelor of Science in Electrical Engineering with a specification in Electrophysics

I have had several internships including one at the Joint Astronomy Center when I was in high school and learned database programming in Perl. I wanted to work in the astronomy field, and was happy with the internship that was paid for by the Women in Technology Grant through the Hawaii Island Economic Development Board. I worked on a program that would parse scientific papers and journal articles that included data that was collected by one of JAC's telescopes, the James Clerk Maxwell Telescope or the United Kingdom Infrared Telescope, and store it in a database.

During the five and a half years that I was working on my undergraduate degree, I was in the Native Hawaiian Science and Engineering Mentorship Program, run by Joshua Ka`akua. The purpose of this program was to attract Native Hawaiian students to the STEM fields and keep them in it. One part of the program was the "Summer Bridge Program" which included working in UH College of Engineering labs on hands-on projects such as small satellites. I did not participate in this because I was interning with JAC, however, I did serve as a mentor for this program. They encouraged me to participate in the Akamai Workforce Initiative.

In 2008 I was an Akamai Intern at the Canada France Hawaii Telescope where I was part of the Observatory Automation Project (OAP) and I was in charge of initiating the Audio/Video section. I helped to set up the cameras and design the code to ensure the data needed is preserved. I presented the results of my work at a symposium in Hilo. I also participated in a mainland-based program "The Society for Advancement of Chicanos and Native Americans in Science" (SACNAS) to present the results of my research. I gave a scientific poster presentation on creating a database system to remotely monitor the functions at a telescope.

I had just graduated from high school when I first heard about the Thirty Meter Telescope project. Hawaii Island is my home, and I aspire to work at one of the observatories on Maunakea that are the leaders in their field. I have always been a supporter of TMT because I want more Science, Technology, Engineering, and Math (STEM) opportunities on Hawaii Island. This is why I focused my studies around optics and instrumentation. I tried to find optical engineering courses, and did as much project work as I could to gain the needed experience for the instrumentation engineer position.

I have been part of various small satellite teams at UH Manoa since 2007. I was a part of the student team run by Dr. Wayne Shiroma for three and a half years. After the completion of the NanoSat 6 competition, I joined the Hawaii Space Flight Lab and started working on their first satellite, HiakaSat. While working on this project, I designed the support system for the primary payload called the Super Compact Hyperspectral Imager (SUCHI), and lead subsystem and system level integration and testing.

HiakaSat launched from the Pacific Missile Range Facility at Barking Sands, Kauai on the Super Strypi rocket on November 3, 2015, however due to issues with the rocket, it did not get to orbit. I work as an avionics engineer at HSFL currently.

Mauna a Wakea

My great grandfather Kahihikolo was from Ni'ihau and raised his family in Keaukaha. My father grew up on Hawaii Island. My dad took me to Maunakea, to the visitor station to look at the skies. Every year, we would watch the Perseid meteor shower from the dark skies of Maunakea. I was so small then, and the universe was so vast! It reminded me of how small the challenges I faced really were. My father lost his mother at a very young age and felt there was a connection to his family, when observing the stars. He spoke of navigation and Native Hawaiians ability to navigate without instruments. He told me the legends of the constellations and their Hawaiian names. He felt that learning about the universe was a way to honor our Native Hawaiian heritage. I feel that TMT both honors the heritage of our ancestors and provides a path for future generations of scientists and engineers to make amazing discoveries in the classroom and the science field. My ohana has taught me that our ancestors took what they needed from the land respectfully; they efficiently used their resources to protect our island home. I feel that TMT has embraced this by conducting the EIS, listening to the concerns of the community for the past eight years, and through The Hawaii Island New Knowledge (THINK) Fund.

TESTIMONY OF ROBERT B. RECHTMAN

I am Robert B. Rechtman. I have been an archaeologist and principal of ASM Affiliates with an office in Hilo since 2013. Prior to that I had my own firm, Rechtman Consulting LLC, which was established in Hawai'i in 2000.

My education and professional background briefly follows:

I received my Ph.D. from the University of California, Los Angeles in 1992 and I am currently the Vice President-Hawai'i for ASM Affiliates (ASM). Prior to joining ASM, I founded and was the Principal Archaeologist of Rechtman Consulting, LLC, a cultural resources management firm that successfully completed more than 800 cultural resources management projects throughout the State of Hawai'i. The range of projects included Section 106 Compliance, Cultural Impact Assessments, Archaeological Assessments, Reconnaissance Surveys, Inventory Surveys, Site Testing, Data Recovery, Preservation Planning, Burial Treatment Planning, and Archaeological Monitoring. These projects were been conducted for private landowners and developers, and county, state, and Federal agencies. Before forming Rechtman Consulting, LLC, Dr. I was a Senior Archaeologist with PHRI for three years. And before that, from 1995 to 1997, I served as the Cultural Resources Manager for the U.S. Army's National Training Center at Fort Irwin; for which I received the Secretary of the Army Environmental Award. Collateral responsibilities included historic preservation advisor to the California Military Environmental Coordination Committee and the California Biodiversity Council, and lead cultural resources person for the Mojave Ecosystem National Performance Review Project, for which I received a National Performance Review Award. My 38 years of professional archaeological experience includes work on archaeological projects in the Hawaiian Islands dating back to 1989.

At the request of TMT Observatory Corporation and TMT International Observatory LLC, I have conducted and prepared several reports concerning the TMT Project site. These include the following:

1. Archaeological Monitoring Report: Geotechnical Boring for the Proposed Thirty Meter Telescope (TMT) in the Astronomy Precinct of Mauna Kea, TMK: (3)4-4-15:009 Ka'ohe Ahupua'a Hamakua District, Island of Hawai'i 2013.

2. Archaeological Monitoring Report for the Construction of a Graded Site Pad for the Thirty Meter Telescope (TMT) Groundbreaking Ceremony, September 2014.

3. Field Reconnaissance of TMT Development Site, July 2015.

4. Updated Field Reconnaissance of the TMT Development Site, December 2015.

The above referenced investigations were conducted by me and were under my supervision. No burials and no historic properties were found on the TMT Project site.

RC-0869

Archaeological Monitoring Report: Geotechnical Boring for the Proposed Thirty Meter Telescope (TMT) in the Astronomy Precinct of Mauna Kea

(TMK: 3-4-4-15:009)

Ka'ohe Ahupua'a
Hāmākua District
Island of Hawai'i

FINAL VERSION

PREPARED BY:

Genevieve L. Glennon B.A.
and
Robert B. Rechtman, Ph.D.

PREPARED FOR:

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

October 2013

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ARCHAEOLOGICAL, CULTURAL, AND HISTORICAL STUDIES

RC-0869

Archaeological Monitoring Report: Geotechnical Boring for the Proposed Thirty Meter Telescope (TMT) in the Astronomy Precinct of Mauna Kea

(TMK: 3-4-4-15:009)

Ka'ohe Ahupua'a
Hāmākua District
Hawai'i Island

RECHTMAN CONSULTING

MANAGEMENT SUMMARY

At the request of TMT Observatory Corporation, Rechtman Consulting, LLC conducted archaeological monitoring of ground-altering activities associated with the geotechnical boring, and the construction of an associated access road for the proposed Thirty Meter Telescope (TMT) within the astronomy precinct of Mauna Kea. As identified in the monitoring plan, historic archaeological resources are known to exist in the general project vicinity; thus the necessity for archaeological monitoring. The archaeological monitoring adhered to procedures outlined in Hawai'i Administrative Rules 13§13-279 *Rules Governing Minimal Standards for Archaeological Monitoring Studies and Reports*. This report details the procedures that were followed during monitoring as well as presents the results of the monitoring fieldwork. There were no previously identified archaeological sites impacted by the development activity nor were there any new archaeological resources encountered during monitoring.

CONTENTS

FIGURES

TABLE

INTRODUCTION

At the request of TMT Observatory Corporation, Rechtman Consulting, LLC has prepared this archaeological monitoring report, which details the procedures that were followed during the monitoring of ground-disturbing activities associated with the geotechnical boring, and the construction of an associated access road for the proposed Thirty Meter Telescope (TMT) within the astronomy precinct of Mauna Kea. The proposed TMT development area is located in Area E of the Astronomy Precinct within the Mauna Kea Science Reserve, in TMK: 3-4-4-15:009, in Ka'ohe Ahupua'a, Hāmākua District, Hawai'i Island (Figures 1 and 2). Pacific Consulting Services, Inc. prepared a monitoring plan (Collins et al. 2013), which was submitted to and approved by DLNR-SHPD. The archaeological monitoring effort described in the current report adhered to procedures described in the approved monitoring plan and those outlined in Hawai'i Administrative Rules 13§13-279 *Rules Governing Minimal Standards for Archaeological Monitoring Studies and Reports*.

ANTICIPATED REMAINS

As noted in the Archaeological Monitoring Plan (Collins et al. 2013), six previously recorded historic sites were located within the boundaries of the Astronomy Precinct, as well as seven "find spots" (modern features), and two Traditional Cultural Properties (TCP). Of the six archaeological sites within the precinct, three are situated relatively close to the access road and the TMT development area (see Figure 2). These include: SHIP Site 50-50-10-16166, eight (possibly nine) uprights arranged in two groups (Figure 3); SHIP Site 50-50-10-16167, an upright set in a crack (Figure 4); and SHIP Site 50-50-10-16172, a single upright (Figure 5). None of these sites were in danger of disturbance during the geotechnical boring. The two traditional cultural properties include the summit cinder cones collectively known as Kukahau'ula (SHIP Site 50-50-10-21438) and Pu'u Līlīnoe (SHIP Site 50-50-10-21439) (see Figure 1). The current access way to the TMT development area intersects with the northwestern edge of Site 21438; a bore hole (B-9) was augured to a depth of 10 feet along this portion of the road.

Mauna Kea and its summit cinder cones to this day still play an important role in religious and cultural practices to many native Hawaiians and non-native Hawaiians alike. Family shrines (consisting mainly of upright boulders set on end) and rock piles are still constructed in and around the summit area, and these more modern features have been labeled as "find-spots." In light of this, there is a possibility that new find spots may be located within the project area. The possibility also exists for the discovery of isolated subsurface artifacts, particularly adzes, flakes, or worked stone, and, although less likely, the discovery of subsurface human remains.

THE MONITORING EFFORT

On August 21, 2013, prior to the commencement of ground-disturbing activities, Robert Rechtman, Ph.D. (Principal Investigator), as well as Genevieve L. Glennon (primary monitor) and Ashton Dirks (secondary monitor) attended the Office of Mauna Kea Management's (OMKM) cultural orientation, held at the Imiloa Astronomy Center. The various environmental, cultural, and safety issues concerning Mauna Kea and the construction of the TMT were presented to the attendees. A preconstruction conference was held on August 27, 2013 at the Hale Pohaku facility; in attendance were the road construction crew (Isemoto Contracting Inc.), the geotechnical contractor representatives (URS, Inc.), and TMT staff. At this preconstruction conference Dr. Rechtman provided an archaeological orientation, explaining the nature of potential cultural resources that might be encountered. It was also explained that the monitoring archaeologist has the authority to halt construction activities in the event that any such resources are encountered. The procedures to be followed in case of an inadvertent discovery of human skeletal remains were also outlined. Also present at this conference was Wally Ishibashi, the cultural monitor working on behalf of the OMKM. Additional on-site archaeological briefings were provided to the drilling crew (Taber Drilling) on an as need basis by the primary archaeological monitor.

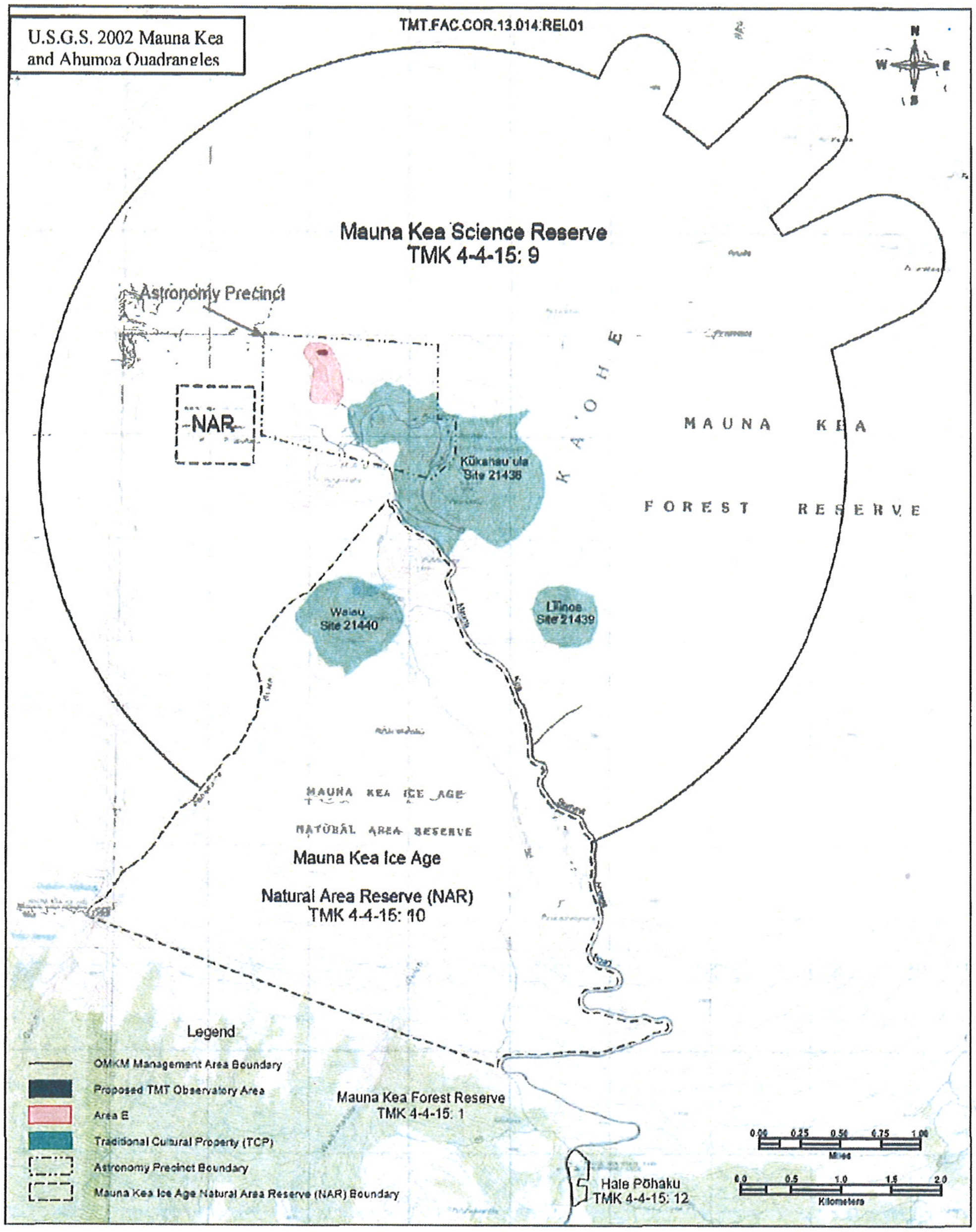

Figure 1. Project Area Location.

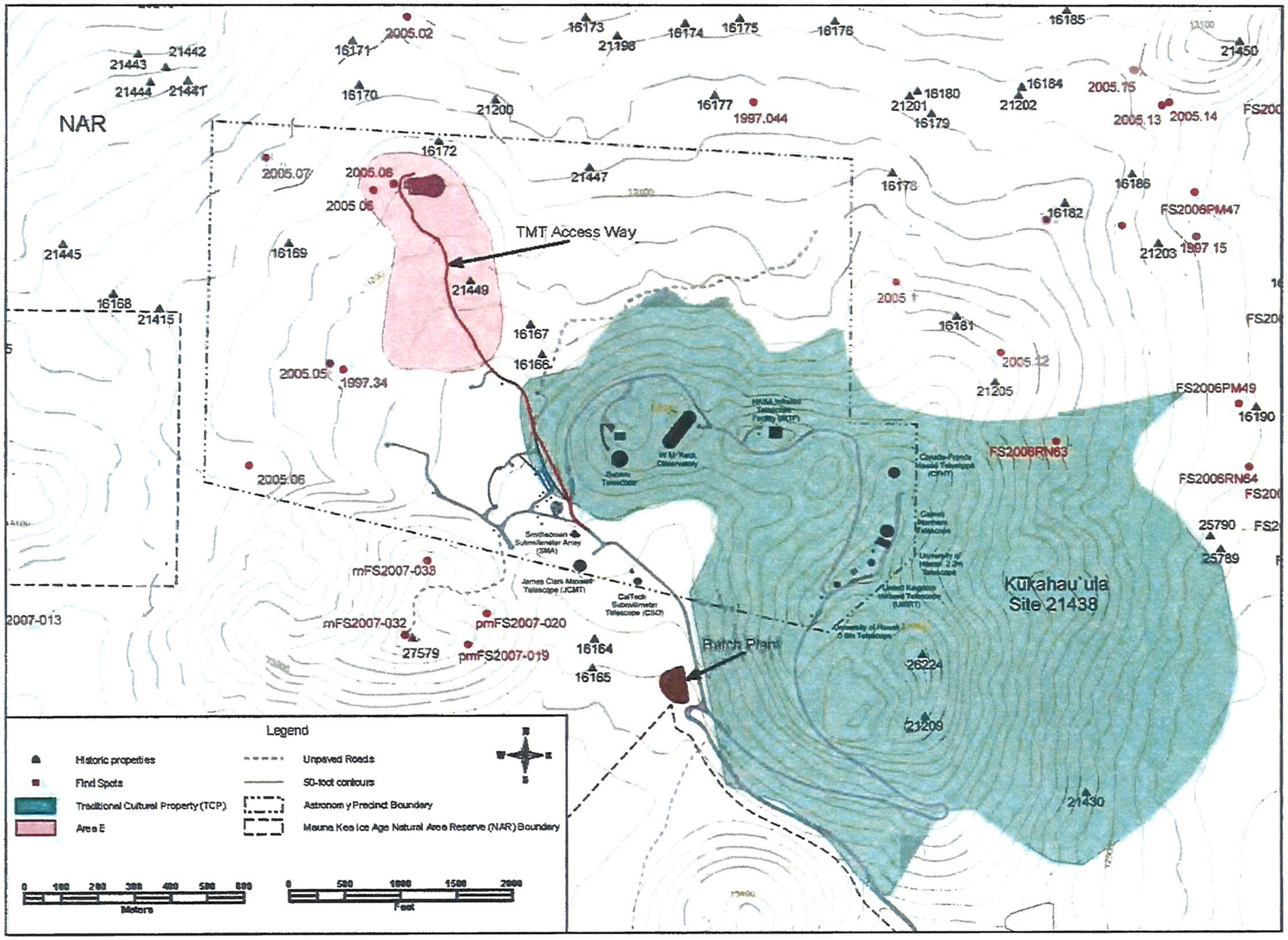

Figure 2. Historic properties in the Astronomy Precinct and vicinity of the proposed TMT Location.

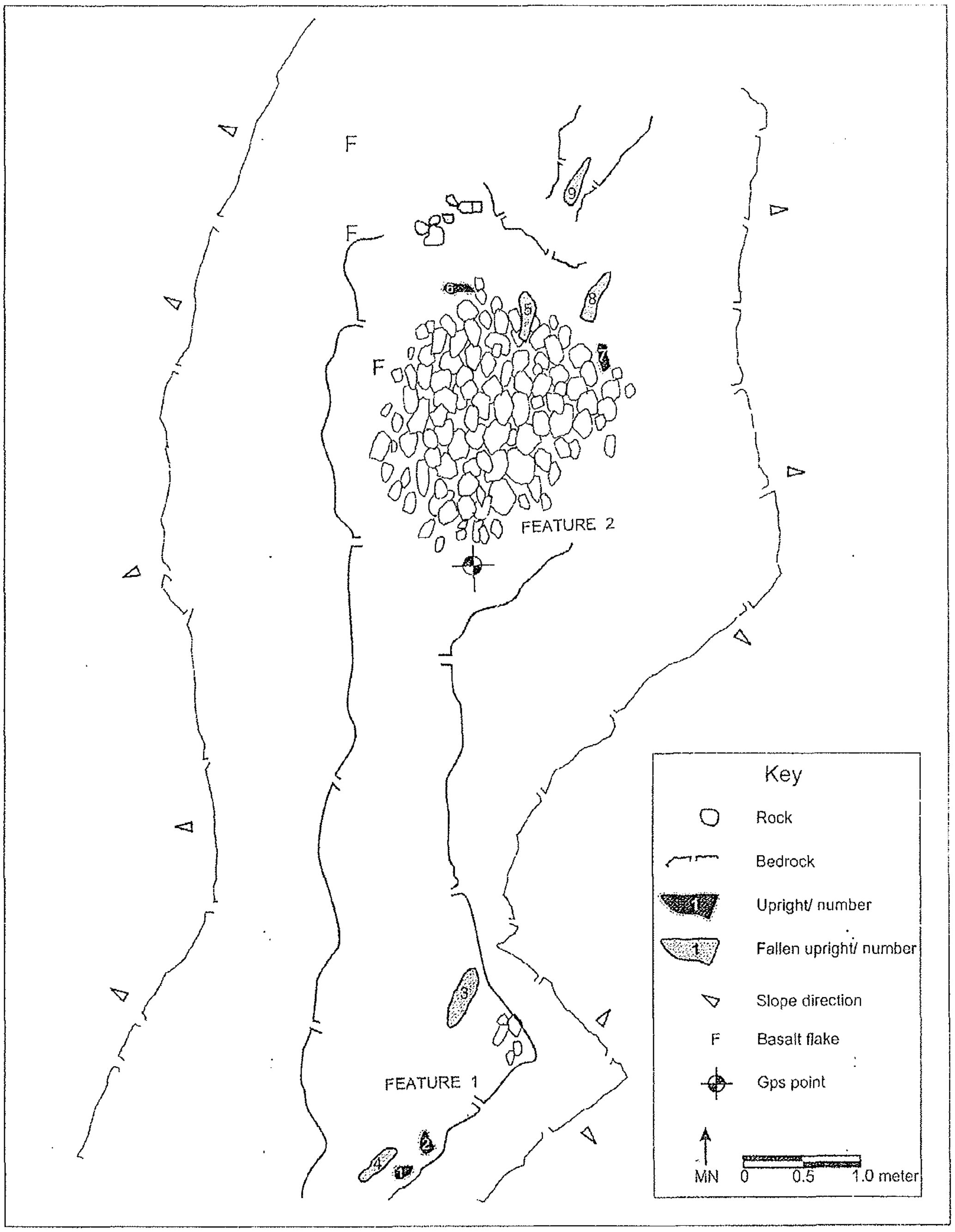

Figure 3. Site 16166 plan view (from McCoy et. al 2010).

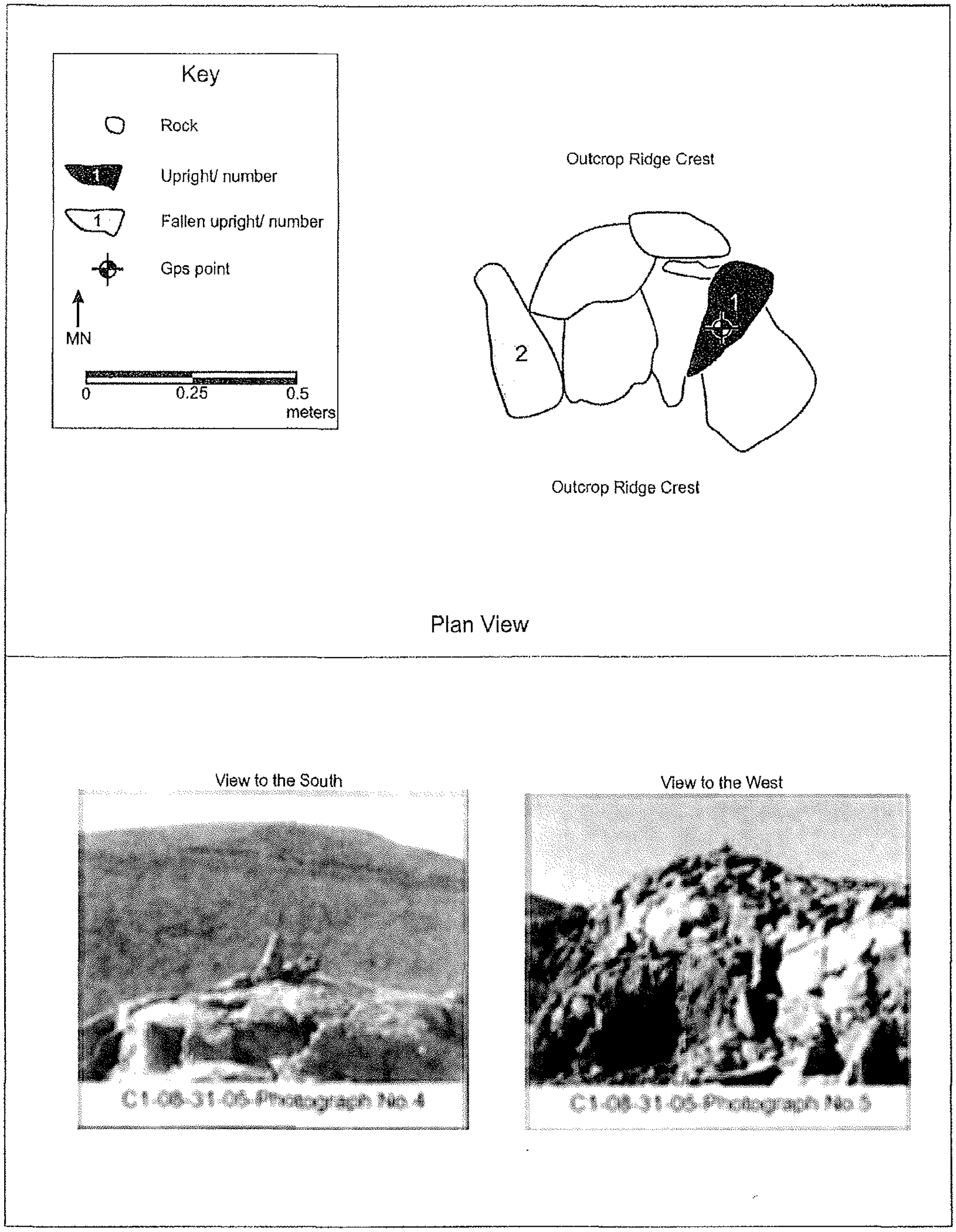

Figure 4. Site 16167 plan view and photos (McCoy et al. 2010).

Figure 5. Site 16172, view to the north.

FIELD METHODS AND FINDINGS

Archaeological monitoring for the current project commenced on August 26, 2013 and was completed on October 18, 2013. Robert B. Rechtman, Ph.D. served as Principal Investigator and Genevieve L. Glennon, B.A. was the primary archaeological monitor. All of the field records generated during this project are archived with Rechtman Consulting, LLC.

The project area is located within the Mauna Kea Science Reserve, in Area E of the Astronomy Precinct (see Figure 2). The Geotechnical Boring for this phase of construction for the TMT consisted of grading and improving an existing access road, as well as creating a new road extension, and drilling/auguring for the extraction of core samples and percolation testing. Sixteen holes were drilled/augured along the access road and within the footprint of the proposed TMT development area (Figure 6). Twelve of these holes (B-1, B-2, B-2b, B-3, B-3b, B-4, B-5, B-6, B-7, B-8, B-9, and B-10) were drilled in order to retrieve core samples, and four (P-1, P-2, P-3, and P-4) were augured for percolation testing. Additional testing that took place during this process included thermal resistivity and conductivity, and seismic refraction. The proposed TMT observatory location is at the northern end of an existing 4WD road. This road runs roughly north/south and provides access from the summit loop road to the proposed development area. The southern section of this access road runs along a portion of the northwestern edge of the defined Kukuhau'ula TCP site (SIHP Site 21438). A Komatsu WA500 Loader and a Komatsu 275AX bulldozer were used to cut, grade, fill and generally improve the existing road in some areas (Figure 7 and 8). This was done to provide safe and easier access for the drill rig, water trucks, and other vehicular traffic to the site area. An extension to the road was also created in order to secure access to the boring locations within the proposed TMT observatory development area. This new road was cut roughly six meters wide with the Komatsu 275AX bulldozer, and formed a loop through the proposed TMT observatory area. No surface or subsurface cultural material was observed during this activity.

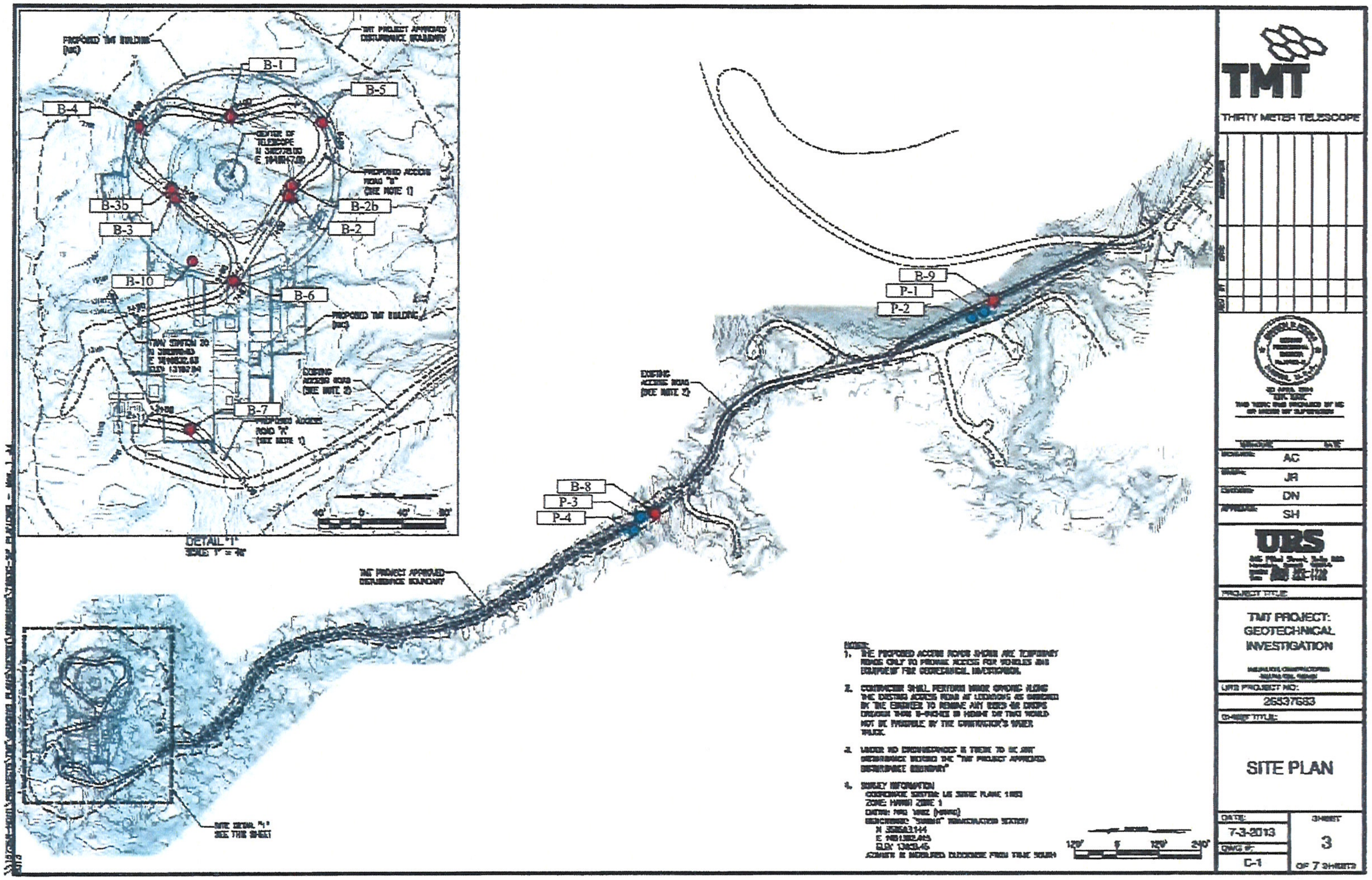

Figure 6. Map of Boring Locations and Road Work.

Figure 7. Komatsu 275AX bulldozer and Komatsu WA500 loader grading the existing 4WD road, note observatories in background.

Figure 8. Komatsu 275AX bulldozer ripping existing 4WD road, Pu'u Pohaku in background.

Boring activities began on September 4, 2013 and continued intermittently until October 18, 2013. Taber Drilling (working as a subcontractor under URS) used a limited access CME 55 HD crawler drill rig mounted on rubber tracks (Figure 9) to drill and auger the holes. The drilling depths for the core sampling ranged from 10 feet to 80 feet. Two samples (B-8, and B-9) were taken along the access road, while the remaining samples (B-1 to B-7 and B-10) were located within the footprint of the proposed TMT observatory development area (see Figure 6). The individual depths of B-1 to B-10 are listed in Table 1. During the drilling process an auger (Figure 10) was used in areas of looser material (mainly consisting of clinkers and cinder); and in areas of more compact rock, a standard diamond bit core barrel was utilized. The core samples were extracted and packaged in roughly 5 foot sections (Figure 11). Five of the bore holes (B-6, B-2, B-2b, B-3, and B-3b) had grouted PVC casings inserted for the seismic refraction testing. The four percolation test holes were each augured to a depth of 2.5 feet (Figure 12). No cultural material was observed during the drilling/auguring activities.

Table 1. Individual bore hole depths.

Hole #	*Depth (ft.)*
B-1	50
B-2	70
B-2b	70
B-3	60
B-3b	60
B-4	36.5
B-5	50
B-6	80
B-7	30
B-8	10
B-9	10
B-10	50

Figure 9. CME 55 HD crawler drill rig.

Figure 10. Auger being used at B-9.

Figure 11. Core sample box from B-3.

Figure 12. Percolation testing.

Although no historic properties were observed during the monitoring of the geotechnical test activities described in this report, there were a few instances of "new" construction (Find Spots) and modern cultural items placed in the work area. These included the erection of two small upright boulders and placement of a ti leaf bracelet at the northern outlying boundary of the TMT observatory development area (Figure 13), the placement of a second braided ti leaf bracelet by the drill rig while located at B-3b (Figure 14), and a the placement of a bouquet of *'ōhelo* at the northern end of the access roadway. The two uprights were later dislodged by OMKM staff.

Figure 13. Newly placed upright boulders and ti leaf bracelet at the northern boundary of the TMT area.

Figure 14. Ti leaf bracelet placed at B-3b.

Worthy of note and a brief discussion are a series of natural geological features that number in the hundreds if not thousands within the general TMT development area. These features have variously been called "gelifluction terraces," "solifluction terraces," "stone-banked gelifluction lobes," and "stone nets or polygonbodens" (Davies 1972; Embleton and King 1975; Washburn 1956, 1979, Gregory and Wentworth 1937). One such natural feature was recorded in 2005 as a possible archaeological site and designated SIHP Site 21449, but was later subject to subsurface testing that indicated the feature was completely natural (McCoy et al. 2010). As McCoy et al. reported, "[e]xcavation of Site 21449 (a terrace) in 2008 did not recover any cultural remains and the terrace is now thought to be a natural gelifluction terrace" (2010:6-1). These terraces have the appearance of constructed features (Figure 15) in various shapes and sizes, and can be observed widely throughout the area. Gregory and Wentworth (1937) described a process whereby terraced features ("stone nets") form in a periglacial environment through the slow downslope movement of water-saturated sediment as part of a recurrent freezing and thawing cycle (a phenomenon that still occurs daily on the summit terrain of Mauna Kea). This process (gelifluction) involves the transport and sorting of localized ground material, creating a pattern of banks/retaining walls of larger rock material with associated leveled interiors consisting of trickled down sediment and smaller rock and gravel material (Huddart and Stott 2010).

During construction of the loop road extension, one such terrace was bisected by bulldozing (Figure 16) exposing an interior profile of fine silt (weathered rock and cinder) and small to medium clinker pebbles and cobbles. The sorted nature of the material was clearly visible in the profile.

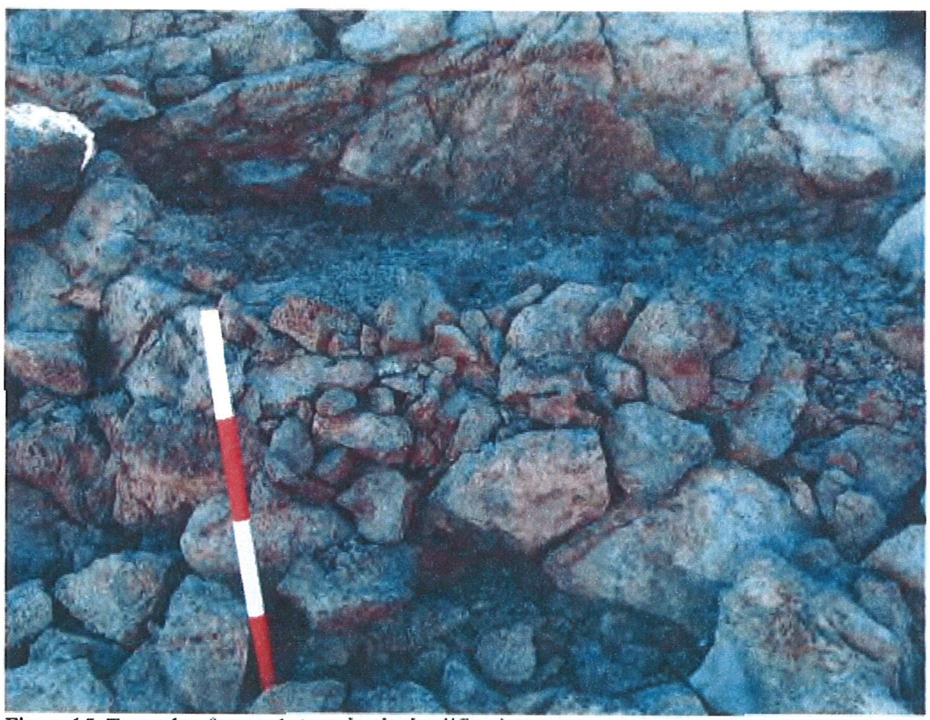

Figure 15. Example of natural stone-banked gelifluction terrace.

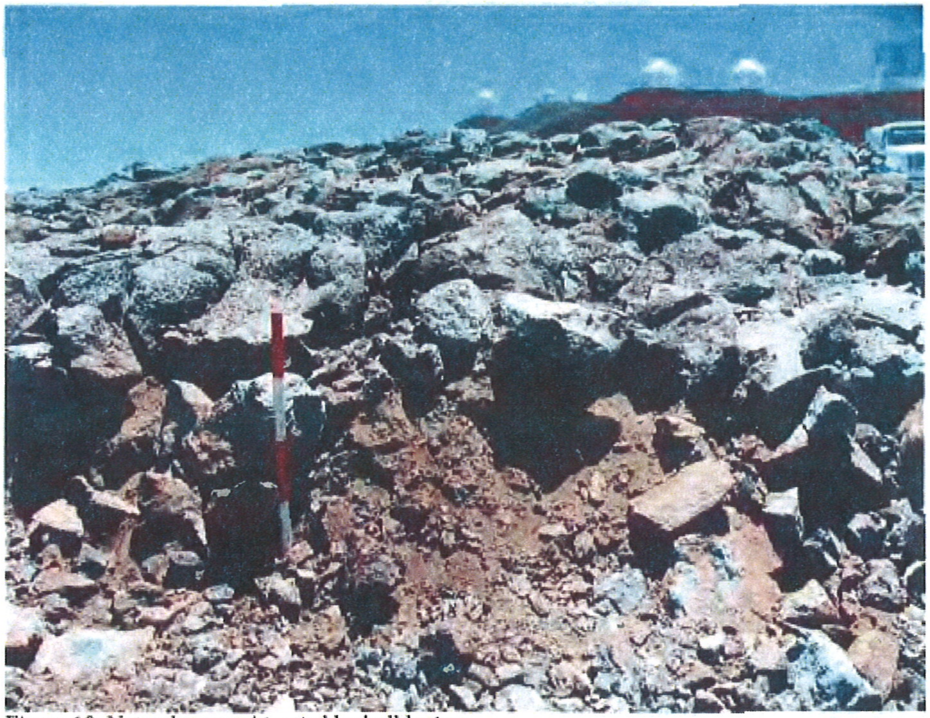
Figure 16. Natural terrace bisected by bulldozing.

SUMMARY

Rechtman Consulting, LLC conducted archaeological monitoring of geotechnical testing associated with the proposed TMT observatory development area within the Astronomy Precinct on Mauna Kea. The current work included grading and cutting of an already existing 4WD access road, cutting of a new extension loop for the access road, as well as the drilling/auguring of sixteen bore holes ranging in depth from 2.5 to 80 feet. During the course of the monitoring all exposed soil was inspected and core samples were examined for cultural material. No surface archaeological features were observed; nor were there any cultural deposits, artifacts, or human skeletal remains encountered during this project.

REFERENCES CITED

Collins, S., P. McCoy, and S. Clark
2013 Archaeological Monitoring Plan in Support of Construction of the Thirty Meter Telescope in the Astronomy Precinct on Mauna Kea. Ka'ohe Ahupua'a, Hāmākua District, Hawai'i Island, State of Hawai'i. Pacific Consulting Services, Inc. report. prepared for TMT Observatory Corporation, Pasadena, CA.

Davies, J.
1972 *Landforms of Cold Climates*. Australian National University Press, Canberra

Embleton, C., and C. King
1975 *Periglacial Geomorphology*. John Wiley and Sons, New York.

Gregory H., and C. Wentworth
1937 General Features and Glacial Geology of Mauna Kea. *Bulletin of the Geological Society of America* Vol. 48: 1720-1737.

Huddart, D., and T. Stott
2010 *Earth Environment: Past, Present and Future.* John Wiley and Sons Inc., New York.

McCoy, P., R. Nees, and S. Clark
2010 Archaeological Inventory Survey of the Astronomy Precinct in the Mauna Kea Science Reserve, Ka'ohe Ahupua'a, Hāmākua District, Hawai'i Island, Hawai'i. Pacific Consulting Services, Inc. report. Prepared for Office of Mauna Kea Management, Hilo, HI.

Washburn, A.
1956 Classification of Patterned Ground and Review of Suggested Origins. *Geological Society of America Bulletin* Vol 67: 823-865.

1979 *Geocryology: A Survey of Periglacial Processes and Environments.* Edward Arnold, London.

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LAND
STATE PARKS

HISTORIC PRESERVATION DIVISION
DEPARTMENT OF LAND AND NATURAL RESOURCES

601 Kamokila Boulevard, Suite 555
Kapolei, HI 96806

December 16, 2013

Robert B. Rechtman, Ph. D.
Rechtman Consulting, LLC
507-A East Lanikaula Street
Hilo, Hawai'i 96720
(bob@rechtmanconsulting.com)

LOG NO: 2013.6310
DOC NO: 1312SN09

Dear Dr. Rechtman:

SUBJECT: **Chapter 6E-42 Historic Preservation Review –**
Archaeological Monitoring Report, Geotechnical Borings for the Proposed Thirty Meter Telescope, Astronomy Precinct of Mauna Kea (RC-0869)
Ka'ohe Ahupua'a, Hāmākua District, Island of Hawai'i
TMK: (3) 4-4-015:009

Thank you for the opportunity to review the report titled *Archaeological Monitoring Report: Geotechnical Boring for the Proposed Thirty Meter Telescope (TMT) in the Astronomy Precinct of Mauna Kea, TMK: (3) 4-4-015:009.* This report was received by our office on November 12, 2013.

The report details the monitoring activities carried out during ground-disturbing activities associated with the geotechnical boring, and the construction of an associated access road for the TMT, in accordance with the SHPD approved archaeological monitoring plan (*Log 2012.2764 Doc. 1304SN17*; Collins et al., 2012). This work took place within Area E of the Astronomy Precinct within the Maunakea Science Reserve.

The project area is located within the Mauna Kea Summit Region Historic District (SIHP 50-10-23-26869); previous inventory surveys of the project area identified no additional historic properties within the area of direct impacts for this project. No additional archaeological sites or cultural deposits were encountered during monitoring activities.

We believe that this report meets the minimum requirements of HAR 13-279 and is accepted by SHPD. Please send one hardcopy of the document, clearly marked FINAL, along with a copy of this review letter and a text-searchable PDF version on CD to the Kapolei SHPD office, attention SHPD Library.

Please contact Sean Nāleimaile at (808) 933-7651 or Sean.P.Naleimaile@Hawaii.gov if you have any questions or concerns regarding this letter.

Aloha,

Theresa K. Donham
Archaeology Branch Chief

Archaeological Monitoring Report for the Construction of a Graded Site Pad for the Thirty Meter Telescope (TMT) Groundbreaking Ceremony

TMK: (3) 4-4-15:009

Ka'ohe Ahupua'a
Hāmākua District
Island of Hawai'i

FINAL VERSION

Prepared By:
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and
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Prepared For:

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

September 2014

ASM affiliates
Archaeology • History • Ethnography • Architectural History
Office: (808) 969-6066 • Fax: (808) 443-0065

ASM Project Number 22990.01

Archaeological Monitoring Report for the Construction of a Graded Site Pad for the Thirty Meter Telescope (TMT) Groundbreaking Ceremony

TMK: (3) 4-4-15:009

Ka'ohe Ahupua'a
Hāmākua District
Island of Hawai'i

ASM affiliates

MANAGEMENT SUMMARY

At the request of TMT Observatory Corporation, ASM Affiliates, Inc. conducted archaeological monitoring of ground-altering activities associated with the construction of a graded site pad for the groundbreaking ceremony for the Thirty Meter Telescope (TMT) within the astronomy precinct of the Mauna Kea Science Reserve (MKSR). As identified in the monitoring plan, archaeological resources are known to exist in the general project vicinity, thus the necessity for archaeological monitoring The archaeological monitoring adhered to procedures outlined in Hawai'i Administrative Rules 13§13-279 *Rules Governing Minimal Standards for Archaeological Monitoring Studies and Reports*. This report details the procedures that were followed during monitoring as well as presents the results of the monitoring fieldwork. There were no previously identified archaeological sites impacted by the development activity nor were there any new archaeological resources encountered during monitoring.

CHAPTERS

FIGURES

TABLE

1. INTRODUCTION

At the request of TMT Observatory Corporation, ASM Affiliates, Inc. (ASM) has prepared this archaeological monitoring report, which details the procedures that were followed during the ground-disturbing activities associated with the construction of a graded site pad for the groundbreaking ceremony of the proposed Thirty Meter Telescope (TMT) within the Astronomy Precinct on Mauna Kea. The proposed TMT development area is located in Area E of the Astronomy Precinct within the Mauna Kea Science Reserve (MKSR), in TMK: (3) 4-4-015:009, in Ka'ohe Ahupua'a, Hāmākua District, Hawai'i Island (Figures 1 and 2). Pacific Consulting Services, Inc. prepared a monitoring plan (Collins et al. 2013), which was submitted to and approved by DLNR-SHPD. An earlier archaeological monitoring project had been completed by Rechtman Consulting, LLC (Glennon and Rechtman 2013) for ground disturbing work associated with the Geotechnical Boring phase of the TMT development project. During that project no historic properties were impacted or identified when the existing access road surrounding the current groundbreaking pad site and a new extension loop were improved and newly graded, respectively. The current project area was subject to intensive archaeological survey (McCoy et al. 2005) and while there were no archeological sites recorded within the TMT development area, a few features interpreted to be of modern origin were observed. One of these features, identified as Find Spot 2005.08, although interpreted as modern in origin by all of the archaeologists who have investigated it, is currently under investigation by DLNR-SHPD with respect to its origin and significance.

Prior to the commencement of the ground-disturbing work and in compliance with a DLNR-SHPD request (DOC NO.: 1406SN23), ASM installed interim protection measures for Find Spot 2005.08. At a distance of 15 feet around Find Spot 2005.08 a highly visible rope and flagging tape barrier was created and cautionary signs placed (Figure 3). This barrier remained in place until all ground-disturbing activity associated with the current monitoring project ceased and the machinery was removed.

The current archaeological monitoring effort adhered to procedures outlined in the archaeological monitoring plan (Collins et al. 2013) and was conducted in accordance with Hawai'i Administrative Rules 13§13-279 *Rules Governing Minimal Standards for Archaeological Monitoring Studies and Reports*.

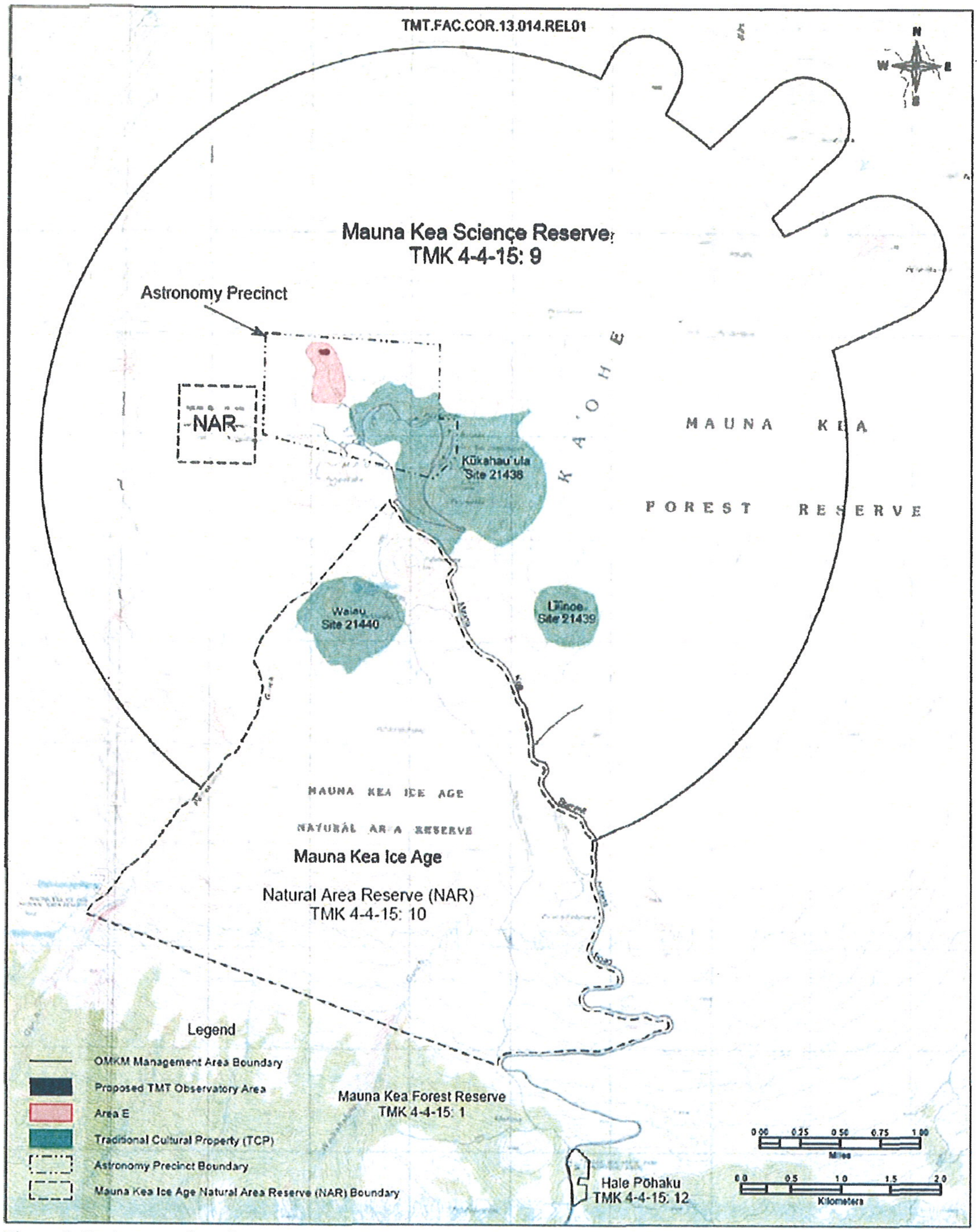

Figure 1. Project area location.

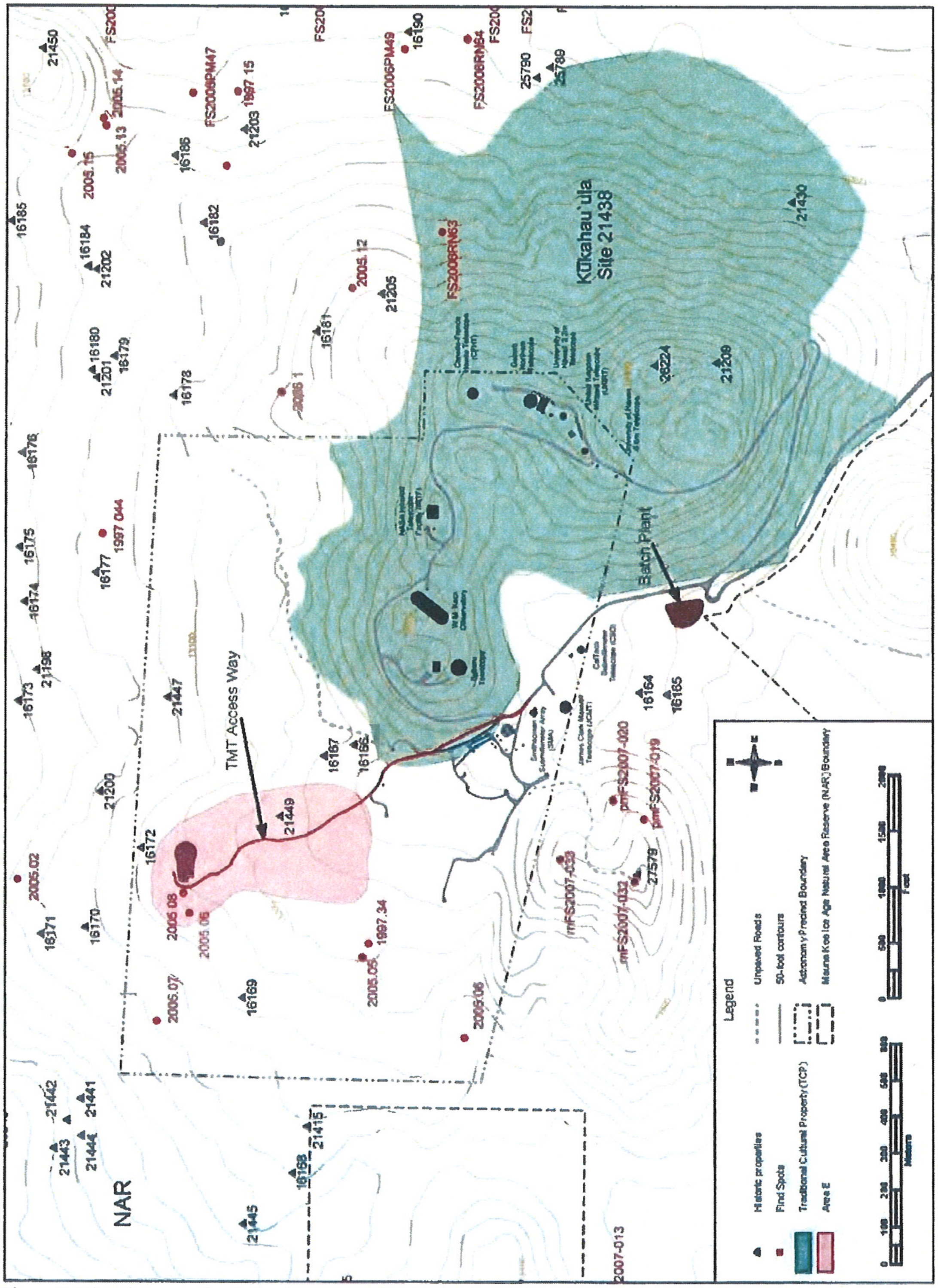

Figure 2. Historic properties in the Astronomy Precinct and vicinity of the proposed TMT Location.

Figure 3. Find Spot 2005-08 protection barrier.

2. ANTICIPATED REMAINS

As noted in the Archaeological Monitoring Plan (Collins et al. 2013), six previously recorded historic sites were located within the boundaries of the Astronomy Precinct, as well as seven "find spots" (modern features), and two Traditional Cultural Properties (TCP). Of the six archaeological sites within the precinct, three are situated relatively close to the access road and the TMT development area (see Figure 2). These include: SIHP Site 50-50-10-16166, eight (possibly nine) uprights arranged in two groups (Figure 4); SIHP Site 50-50-10-16167, an upright set in a crack (Figure 5); and SIHP Site 50-50-10-16172, a single upright (Figure 6). None of these sites were in danger of disturbance during the construction of the TMT groundbreaking ceremonial site pad. The two traditional cultural properties include the summit cinder cones collectively known as Kukahau'ula (SIHP Site 50-50-10-21438) and Pu'u Līlīnoe (SIHP Site 50-50-10-21439) (see Figure 1). The current access way to the TMT development area intersects with the northwestern edge of Site 21438. A bore hole (B-9) was augured to a depth of 10 feet along this portion of the road during the previous monitoring effort associated with the geotechnical boring phase of the project (Glennon and Rechtman 2013).

Mauna Kea and its summit cinder cones, to this day, continue to play an important role in religious and cultural practices to many native Hawaiians and non-native Hawaiians alike. Family shrines (consisting mainly of upright boulders set on end) and rock piles are still constructed in and around the summit area, and these more modern features have been labeled as "find-spots." In light of this, there is a possibility that new find spots may be located within the project area. The possibility also exists for the discovery of isolated subsurface artifacts, particularly adzes, flakes, or worked stone, and, although less likely, the discovery of subsurface human remains.

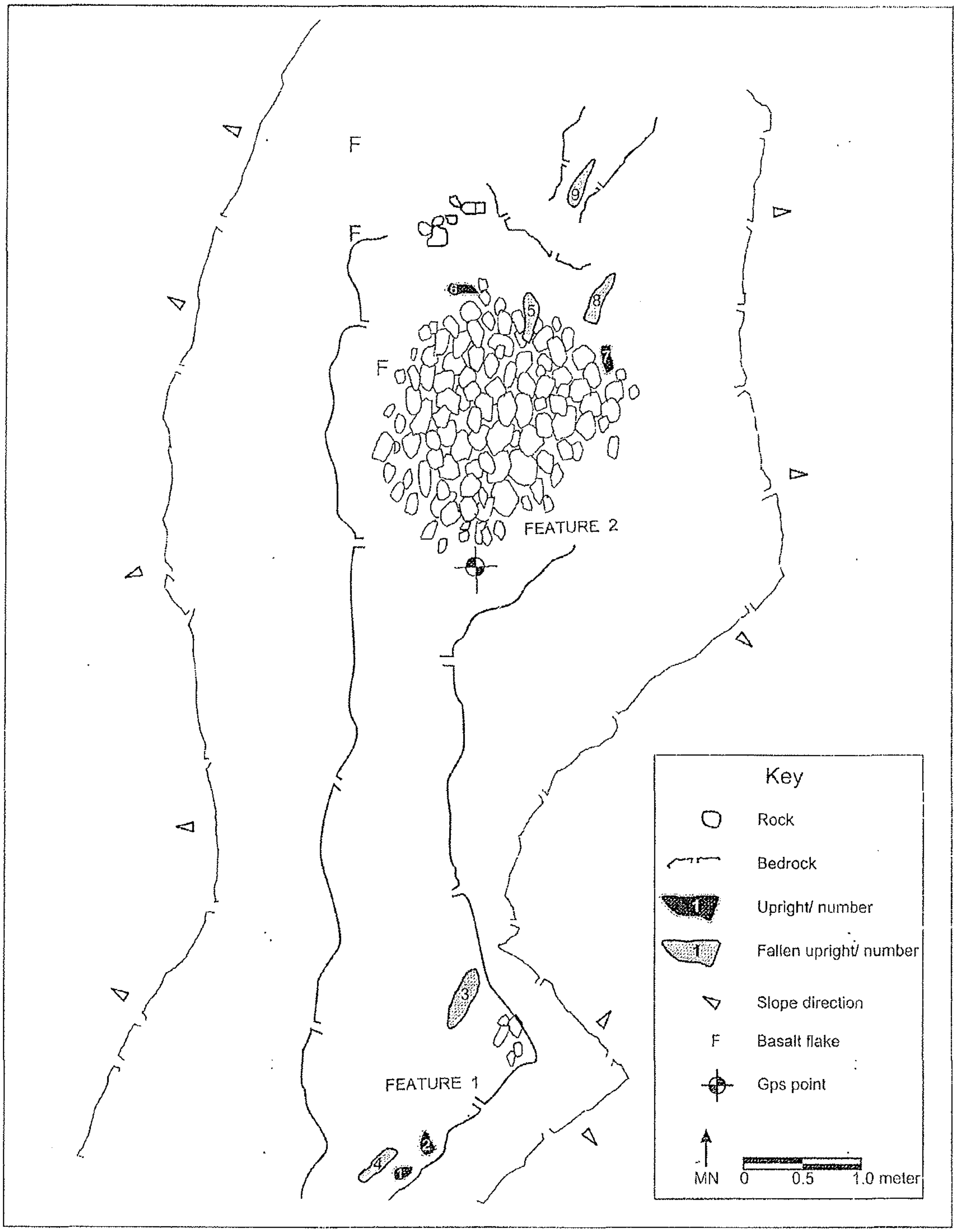

Figure 4. Site 16166 plan view (from McCoy et. al 2010).

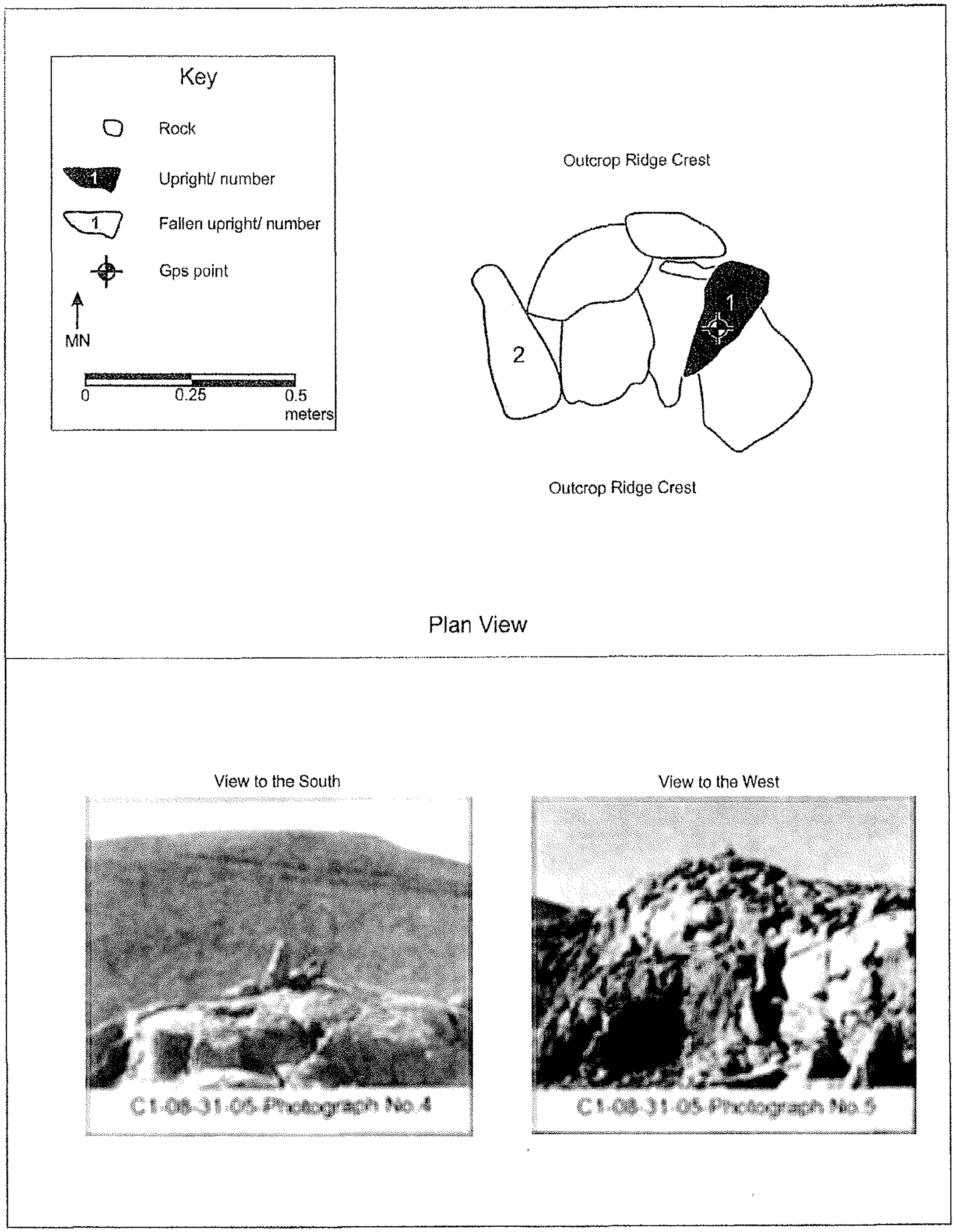

Figure 5. Site 16167 plan view and photos (McCoy et al. 2010).

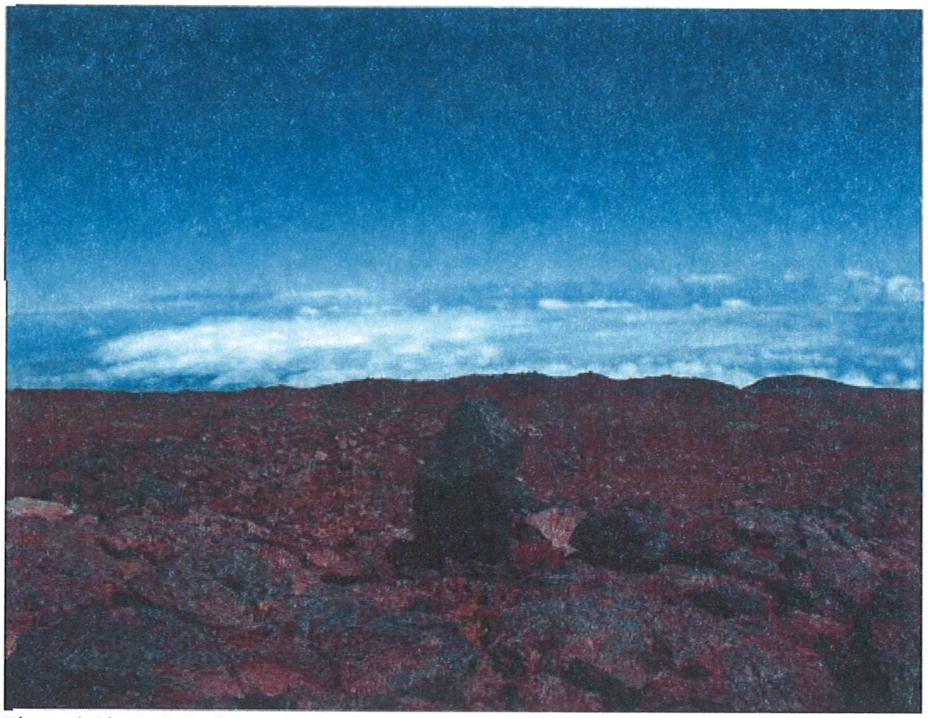

Figure 6. Site 16172, view to the north.

3. THE MONITORING EFFORT

On September 16, 2014, Robert Rechtman, Ph.D. (Principal Investigator), and Kamuela Plunkett (primary monitor) attended a pre-construction conference, held at the Hale Pōhaku facility; in attendance were representatives from the general contractor Goodfellow Bros., Inc. (GBI), Mauna Kea Observatory Support Services (MKSS), the Big Island Invasive Species Committee (BIISC), as well as the project coordinator for TMT; also present at this conference was Wally Ishibashi, the cultural monitor working on behalf of the OMKM (Table 1). The purpose of this meeting was to acquaint the representatives of key organizations working on the project with each other, and to explain each person's role. Various environmental, cultural, political, and safety issues pertaining to Mauna Kea and the construction of the TMT were addressed and presented to the attendees by the OMKM.

At this pre-construction conference, Dr. Rechtman provided an archaeological orientation, explaining the nature of potential cultural resources that might be encountered. It was also explained that the monitoring archaeologist has the authority to halt construction activities in the event that any such resources are encountered. The procedures to be followed in case of an inadvertent discovery of human skeletal remains were also outlined.

Table 1. Preconstruction meeting key attendees.

Organization	Representative	Role
TMT	Paul Gillet	Project Coordinator
OMKM	Wally Ishibashi	Construction and Cultural Monitor
GBI	Clifford Cox	Construction Foreman
GBI	Don Weisgerber	Project Manager
MKSS	Stewart Hunter	MKSS Manager
BIISC	Springer Kaye	Biological Monitoring
ASM	Robert Rechtman	Archaeological Monitoring
ASM	Kamuela Plunkett	Archaeological Monitoring

4. FIELD METHODS AND FINDINGS

Archaeological monitoring for the current project commenced on September 17, 2014 and was completed on September 19, 2014. Robert B. Rechtman, Ph.D. served as Principal Investigator and Kamuela Plunkett, B.A. was the primary archaeological monitor. All of the field records generated during this project are archived with ASM Affiliates, Inc.

The project area is located within the Mauna Kea Science Reserve, in Area E of the Astronomy Precinct (see Figure 2). This phase of the TMT development included construction of a groundbreaking ceremonial pad and improvement to the existing access road surrounding the pad and its previously constructed extended loop road, requiring the cutting, filling, and grading of a naturally occurring rock shelf (Figures 7 and 8). Construction began on this shelf on September 17, 2014 using a Hitachi 470 excavator and a Caterpillar D-6 Dozer for grading. The most intensive ground disturbance occurred on the eastern edge of the ground breaking site pad using the excavator (Figure 9) with its bucket, ripper, and hammer attachments. After excavation, fill and crushed material (excavated boulders) were spread by a D-6 Caterpillar Dozer to a finished grade (Figure 10). No surface or subsurface cultural material was observed during this activity.

Figure 7. Naturally occurring rock shelf to be cut, filled, and graded to create groundbreaking pad. Existing access road in foreground facing east-southeast with observatories in background.

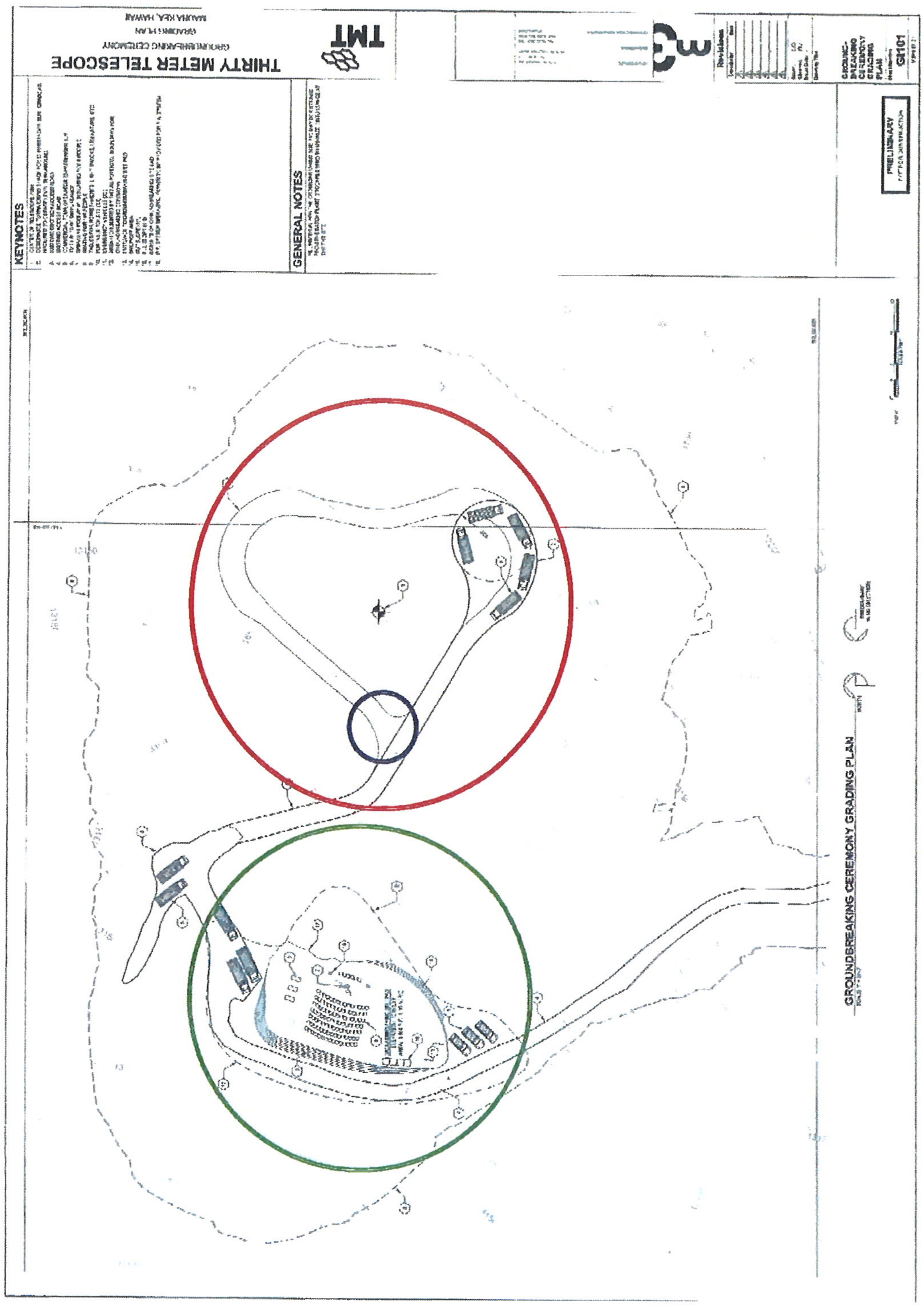

Figure 8. Grading Plan for groundbreaking pad (circled green), and loop road extension (circled red).

Figure 9. Hitachi 470 Excavator cutting eastern slope of groundbreaking ceremonial site pad.

Figure 10. Groundbreaking pad excavated and partially graded.

Road improvements to the existing access road and extended loop road began on September 18, 2014. Only the juncture at which the extension loop road meets itself (circled in purple in Figure 8) required new ground disturbance (excavation) for widening (Figure 11). All other road improvements involved the moving, crushing, and grading of previously excavated rock laying alongside the access and extension loop road (Figure 12).

Figure 11. Juncture where extension loop road connects with itself (circled in purple on Figure 8).

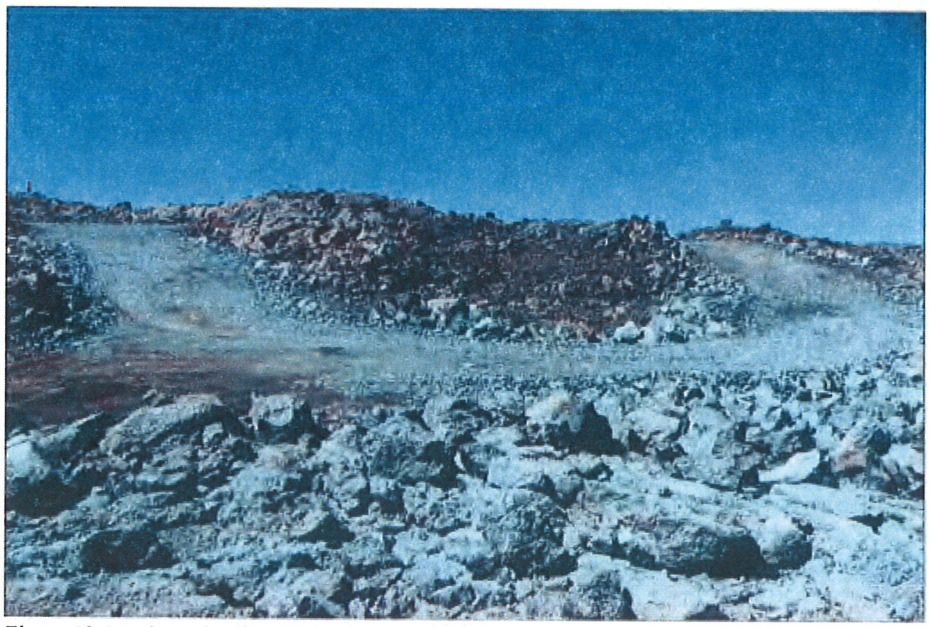

Figure 12. Northern tip of extension loop road.

Construction was completed on September 19, 2014, after all excavated and graded surfaces for this project were sprayed with water and compacted with a 20-ton Caterpillar roller (Figure 13). No cultural material was observed while monitoring the construction of the groundbreaking ceremonial site pad, nor during improvements made to the access and extension loop road.

Figure 13. Completed groundbreaking ceremonial site pad.

5. SUMMARY

ASM Affiliates, Inc. conducted archaeological monitoring of the construction of a ceremonial groundbreaking site pad associated with the TMT observatory development area within the Astronomy Precinct on Mauna Kea. The current work included cutting, filling, and grading of the groundbreaking ceremonial site pad, as well as grading and widening improvements to the already existing access and extension loop road. During the course of the monitoring, all excavated, graded, and crushed materials were examined for cultural material. No surface archaeological features were observed; nor were there any cultural deposits, artifacts, or human skeletal remains encountered during this project.

REFERENCES CITED

Collins, S., P. McCoy, and S. Clark

2013 Archaeological Monitoring Plan in Support of Construction of the Thirty Meter Telescope in the Astronomy Precinct on Mauna Kea. Ka'ohe Ahupua'a, Hāmākua District, Hawai'i Island, State of Hawai'i. Pacific Consulting Services, Inc, report. Prepared for TMT Observatory Corporation, Pasadena, CA.

Glennon, G., and R. Rechtman

2013 Archaeological Monitoring Report: Geotechnical Boring for the Proposed Thirty Meter Telescope (TMT) in the Astronomy Precinct of Mauna Kea, TMK: (3) 4-4-15:009, Ka'ohe Ahupua'a, Hāmākua District, Island of Hawai'i. Rechtman Consulting Project Number RC-0869. Prepared for TMT Observatory Corporation, Pasadena, California.

McCoy, P., D. Gosser, R. Nees, and R. Yamasato

2005 Mauna Kea Science Reserve Archaeological Inventory Survey, Ka'ohe, Hāmākua, Island of Hawai'i, Interim Report No. 1. Prepared for the Office of Mauna Kea Management.

McCoy, P., R. Nees, and S. Clark

2010 Archaeological Inventory Survey of the Astronomy Precinct in the Mauna Kea Science Reserve, Ka'ohe Ahupua'a, Hāmākua District, Hawai'i Island, Hawai'i. Pacific Consulting Services, Inc. report. Prepared for Office of Mauna Kea Management, Hilo, HI.

FIELD RECONNAISSANCE OF TMT DEVELOPMENT SITE

At the request of the TMT Observatory Corporation, ASM Affiliates conducted a thorough reconnaissance of the 5-acre development site and graded access road associated with the proposed construction of the Thirty Meter Telescope (TMT) within the astronomy precinct of the Mauna Kea Science Reserve (MKSR), in TMK: (3) 4-4-015:009, Ka'ohe Ahupua'a, Hāmākua District, Island of Hawai'i. Fieldwork for the current study was conducted on July 7, 2015 by Robert B. Rechtman, Ph.D., and Lauren Kepa'a. The purpose of the reconnaissance was to identify any constructions that could be interpreted as recent find spots within the proposed development site. The boundaries of the study area were identified using GPS coordinates provided by TMT Observatory Corporation, and were clearly marked by pins in the field. As a result of the survey, five constructions were identified (Ahu 1, Ahu 2, Ho'okupu Spot 1, Ho'okupu Spot 2, and Rock Stack), four of which appear to have been constructed recently and could be interpreted as potential new find spots, while the fifth is likely associated with the former location of a meteorological station. The locations of the five identified constructions are shown on Figure 1 (and attached .kmz file) and descriptions and GPS coordinates of each are presented below.

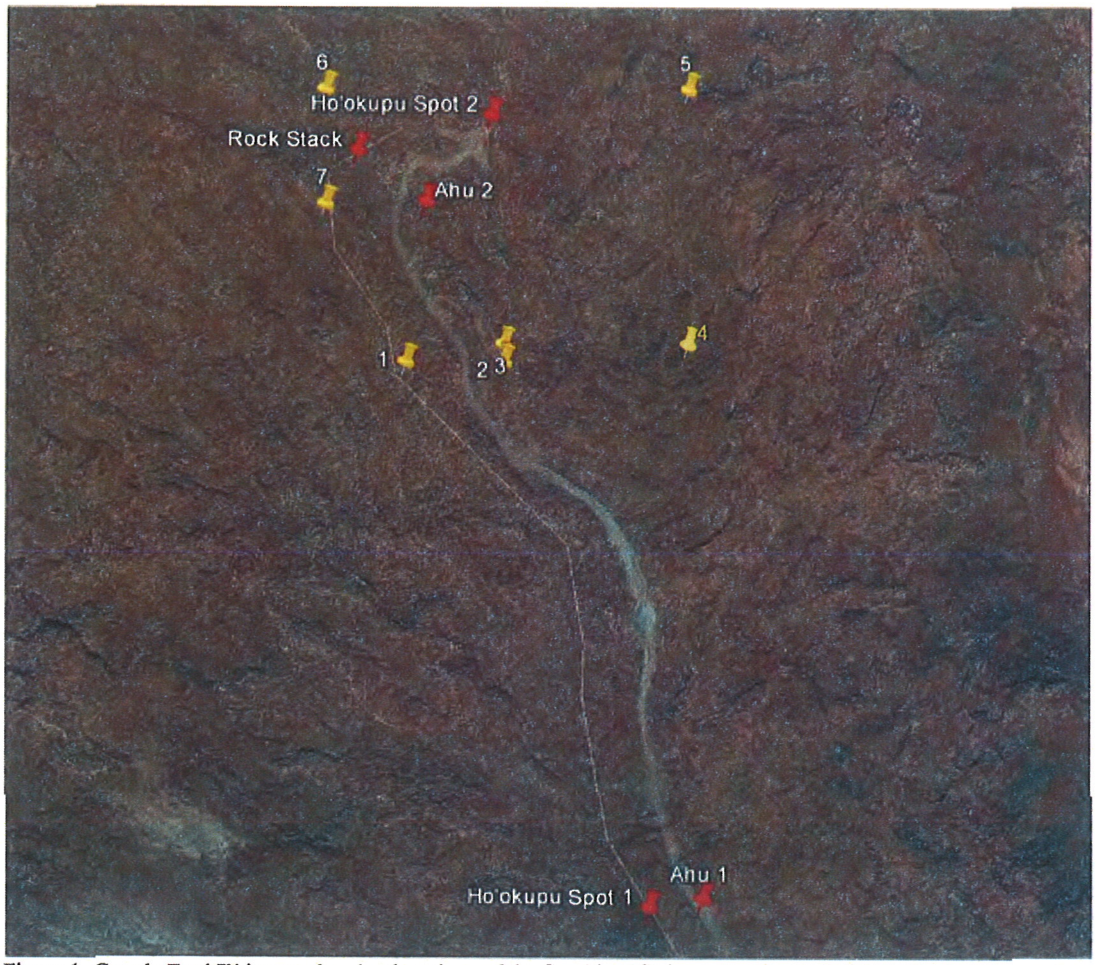

Figure 1. Google Earth™ image showing locations of the five identified constructions relative to the development site.

AHU 1

Ahu 1 was constructed in the middle of the graded access road leading to the development site (Figure 2). A variety of *ho'okupu* (offerings), both traditional and "new age," were placed on top of this construction. It was reportedly built with a core of local basalt and a facing of water rounded beach boulders.

GPS Coordinates (UTM Zone 5N NAD 83)

Easting: 0240202

Northing: 2194475

Figure 2. Ahu 1, view to the northwest.

AHU 2

Ahu 2 was constructed in the graded area (Figure 3) that was prepared for the ground-breaking ceremony, within the 5-acre development site. Along with the three upright stones, there a few traditional *ho'okupu* placed on top of the construction. This *ahu* was built entirely of local rocks.

GPS Coordinates (UTM Zone 5N NAD 83)

Easting: 0240061

Northing: 2194837

Figure 3. Ahu 2, view to the west.

HO'OKUPU SPOT 1

On the ridge to the west of Ahu 1 was a small *ho'okupu* (ti leave wrapped offering) placed on an angular boulder and held down with a smaller rock (Figure 4).

GPS Coordinates (UTM Zone 5N NAD 83)

Easting: 0240173

Northing: 2194471

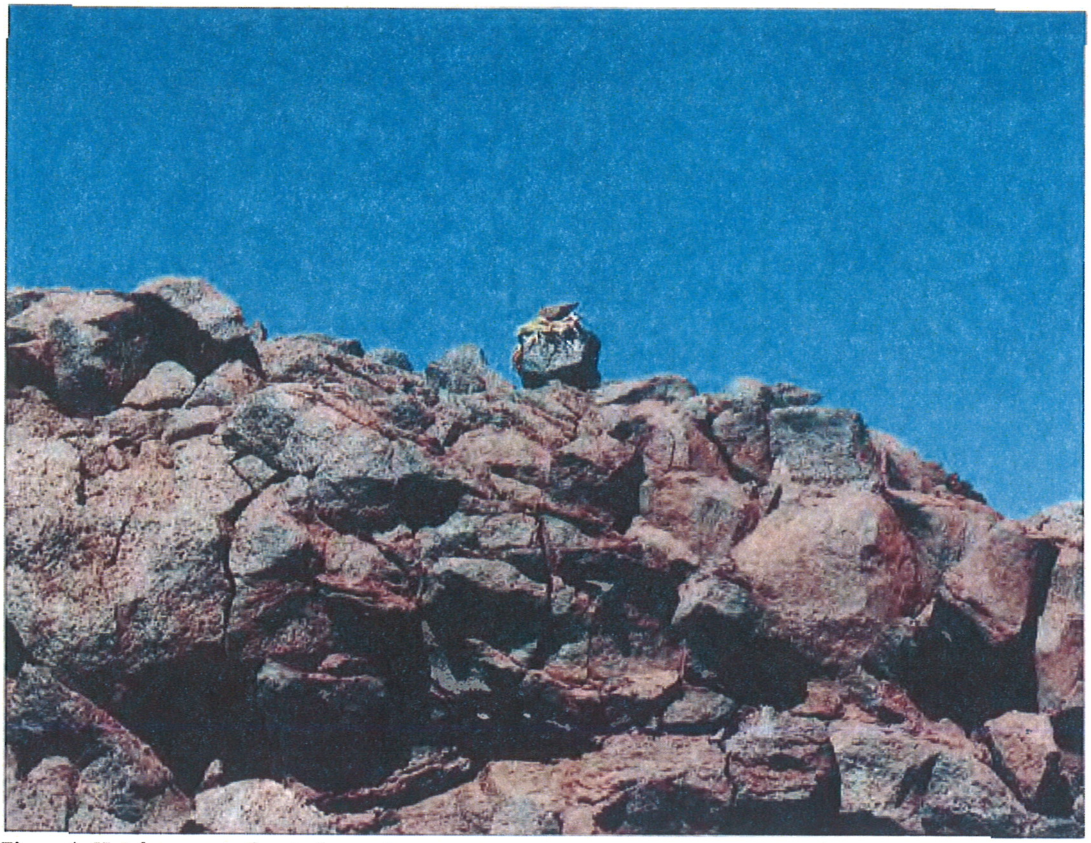

Figure 4. *Ho'okupu* spot, view to the west.

HOʻOKUPU SPOT 2

Located adjacent to the graded road in the northern portion of the development area, a second *hoʻokupu* spot was identified that consists of a ti leaf held down by two small cobbles (Figure 5).

GPS Coordinates (UTM Zone 5N NAD 83)

Easting: 0240096

Northing: 2194881

Figure 5. Hoʻokupu Spot 2, overview.

ROCK STACK

A few stacked rocks were observed in the northwestern portion of the development area in the immediate vicinity of a metal anchor bolt (Figure 6) that was likely placed in association with a former meteorological station. The rock stack was likely also associated with the former placement of the scientific equipment, and does not appear to have been related to recent cultural activity.

GPS Coordinates (UTM Zone 5N NAD 83)

Easting: 0240025

Northing: 2194864

Figure 6. Rock stack, view to the southeast.

UPDATED FIELD RECONNAISSANCE OF THE TMT DEVELOPMENT SITE

At the request of the TMT Observatory Corporation, ASM Affiliates conducted an updated archaeological reconnaissance as well as a Botanical Survey of the 5-acre development site and graded access road associated with the proposed construction of the Thirty Meter Telescope (TMT) within the astronomy precinct of the Mauna Kea Science Reserve (MKSR), in TMK: (3) 4-4-015:009, Ka'ohe Ahupua'a, Hāmākua District, Island of Hawai'i. The Botanical Survey is attached as a separate document prepared by H.T. Harvey & Associates (Shahin Ansari, Ph.D.). Archaeological fieldwork for the current study was conducted on December 11, 2015 by Robert B. Rechtman, Ph.D., Matthew R. Clark, B.A., Teresa Gotay, M.A., and Lauren Kepa'a. The purpose of the updated reconnaissance was to identify any constructions that could be interpreted as recent find spots within the proposed development site that were erected subsequent to the initial reconnaissance survey conducted by ASM Affiliates on July 7, 2015. The boundaries of the study area were identified using GPS coordinates provided by TMT Observatory Corporation, and were clearly marked by pins in the field. As a result of the survey, the five constructions identified during the previous fieldwork (Ahu 1, Ahu 2, Ho'okupu Spot 1, Ho'okupu Spot 2, and Rock Stack 1) were relocated, and one new construction was identified (Rock Stack 2). Rock Stack 2 appears to have been constructed recently, and could be interpreted as a potential new find spot. The location of the newly identified construction is shown in Figure 1 (and attached .kmz file), and its description and GPS coordinates are presented below.

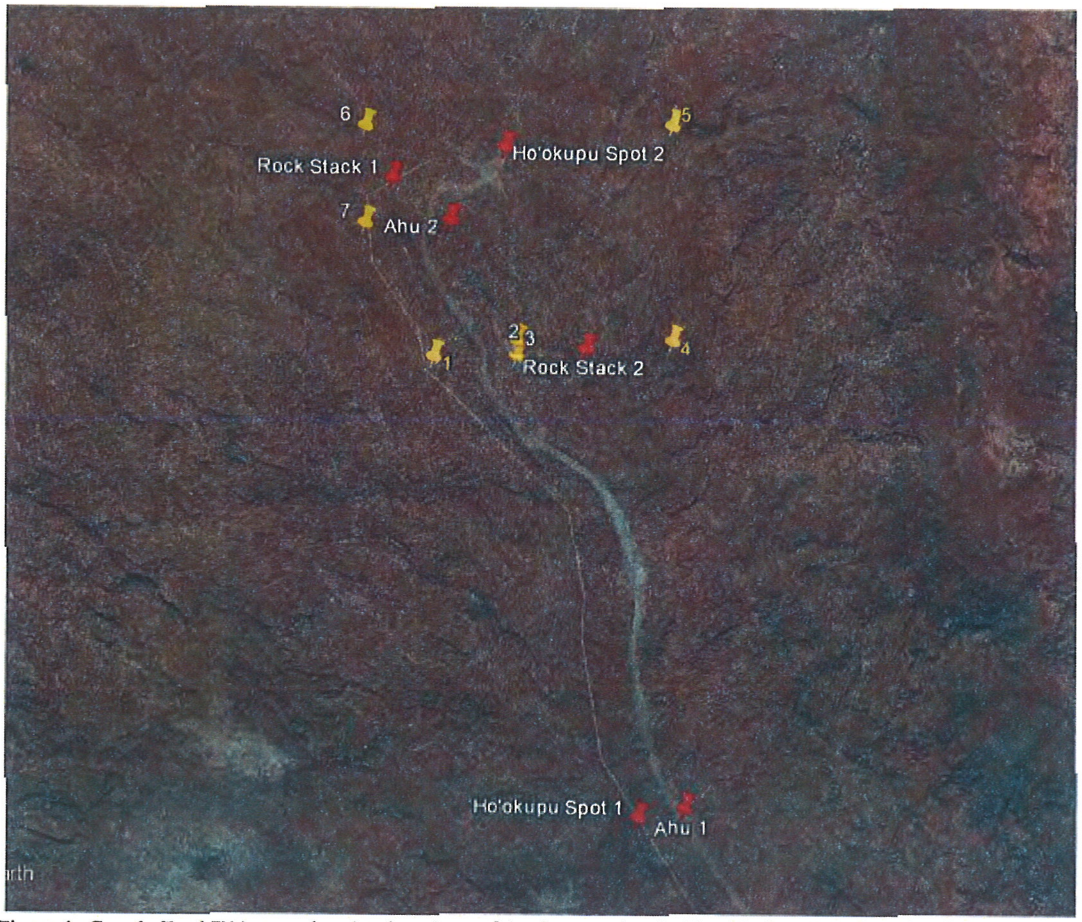

Figure 1. Google Earth™ image showing locations of the five previously identified constructions in addition to the newly identified construction relative to the development site.

C-16
Case No. BLNR-CC-16-002

ROCK STACK 2

A rock stack consisting of a few rocks assembled around a ti leaf was observed atop a bedrock outcrop located along the southern boundary of the development area, between boundary corner points 3 and 4 (Figures 2 and 3).

GPS Coordinates (UTM Zone 5N NAD 83)

Easting: 240145 / Northing: 2194758

Figure 2. Rock Stack 2, view to the southeast.

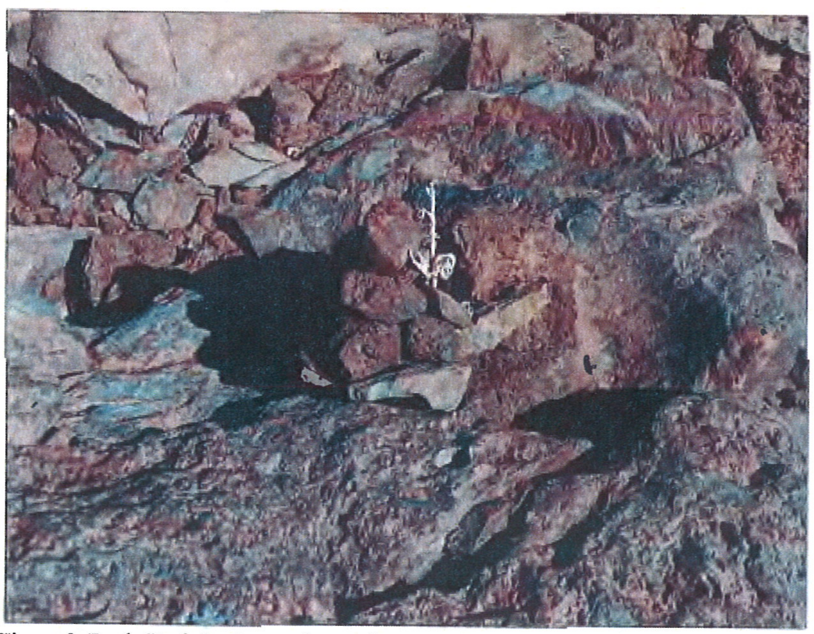

Figure 3. Rock Stack 2, view to the north.

BOTANICAL SURVEY ATTACHMENT

H. T. HARVEY & ASSOCIATES
Ecological Consultants

January 5, 2016

Bob Rechtman
Vice President
ASM Affiliates
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Hilo, HI 96720

Subject: Report of Findings—Botanical Survey on Mauna Kea

Dear Bob:

Thirty Meter Telescope (TMT) is planning to remove its equipment from the summit of Mauna Kea, on the Big Island of Hawai'i, and required baseline archaeological and botanical inventories of the project site. To assist ASM Affiliates in meeting this need, H. T. Harvey & Associates botanist Dr. Shahin Ansari conducted a botanical survey of the approximately 6-acre project site in the Mauna Kea Science Reserve, near the Smithsonian Observatory. This letter report summarizes the findings of the botanical survey, which was performed on December 11, 2015.

The objectives of the botanical survey were as follows:

- To identify and document the presence and relative abundance of plant species and vegetation communities found on the project site.
- To record photos and Global Positioning System coordinates of any Mauna Kea silversword (*Argyroxiphium sandwicense* ssp. *sandwicense*), which is the only federally listed endangered plant species found in the alpine vegetation community of the project area.

The botanist walked the project site and documented all observed plant species. Clear, dry, and sunny conditions with moderate to high winds prevailed during the survey period. The terrain undulates markedly in most parts of the project site, with cinder and lava covering the ground surface. The plants observed and recorded during the survey reflect the season ("rainy" versus "dry") and the environmental conditions at the time of the survey.

No plant species that are state or federally listed as threatened, endangered, or candidates for listing (USFWS 2015), nor any rare native Hawaiian plant species, were observed on the project site during the survey. Six plant species were recorded (Table 1). Of these, three are endemic, one is indigenous, and two are introduced to the Hawaiian Islands (Table 1). The plant community at the project site can be described as alpine stone desert with extremely low plant density (Figure 1). The few scattered plants found were restricted to the base of rocky outcrops, where some soil and moisture accumulates and plants are somewhat protected from wind. Although scattered sparsely throughout the project site, Hawaiian bentgrass (*Agrostis sandwicensis*) was the most common of the six observed species. Only a few individuals of the remaining five species were observed on the site.

Project-related disturbances, such as removal of equipment from the project site, are not expected to have a significant adverse impact on any plant species that is state or federally listed as threatened or endangered, or on species that are candidates for listing, or on other species of concern. However, given the naturally low abundance of plants and the harsh climatic conditions for plant recruitment and establishment, H. T. Harvey & Associates recommends that, wherever possible, the project should avoid causing disturbance of established native plants (i.e., those identified as indigenous or endemic in Table 1) on the project site.

Table 1. Plant Species Observed

Scientific Name and Author	Common Name	Status[1]	Qualitative Relative Abundance on Site[2]
Ferns and Fern Allies			
Aspleniaceae			
Asplenium adiantum-nigrum L.	'Iwa'iwa	I	R
Asplenium trichomanes L. ssp. *densum* (Brack.) W. H. Wagner	Olali'i	E	R
Monocots			
Poaceae			
Agrostis sandwicensis Hillebr.	Hawaiian bentgrass	E	U
Trisetum glomeratum (Kunth) Trin.	Pili uka, mountain pili	E	R
Dicots			
Asteraceae			
Conyza bonariensis (L.) Cronquist	Hairy horseweed	X	R
Taraxacum officinale W. W.Weber ex F. H. Wigg.	Common dandelion	X	R

Notes: The plant names are arranged alphabetically by family, then by species, into each of three groups: ferns and fern allies, monocots, and dicots. The taxonomy and nomenclature of ferns and fern allies is in accordance with Palmer (2003) and Evenhuis and Eldredge (2011). The flowering plants are in accordance with Wagner et al. (1999); recent name changes are those recorded in Wagner and Herbst (1999) and Wagner et al. (2012).

[1] **Status designations:** E = endemic, occurring only in the Hawaiian Islands; I = indigenous, occurring naturally in the Hawaiian Islands but also elsewhere in the world; X = introduced or alien (all those plants brought to the Hawaiian Islands by humans, intentionally or accidentally, after Western contact (i.e., Cook's arrival in the islands in 1778).

[2] **Qualitative Relative Abundance on Site:** U = uncommon, scattered sparsely throughout the area or occurring in a few small patches; R = rare, only a few isolated individuals in the survey area.

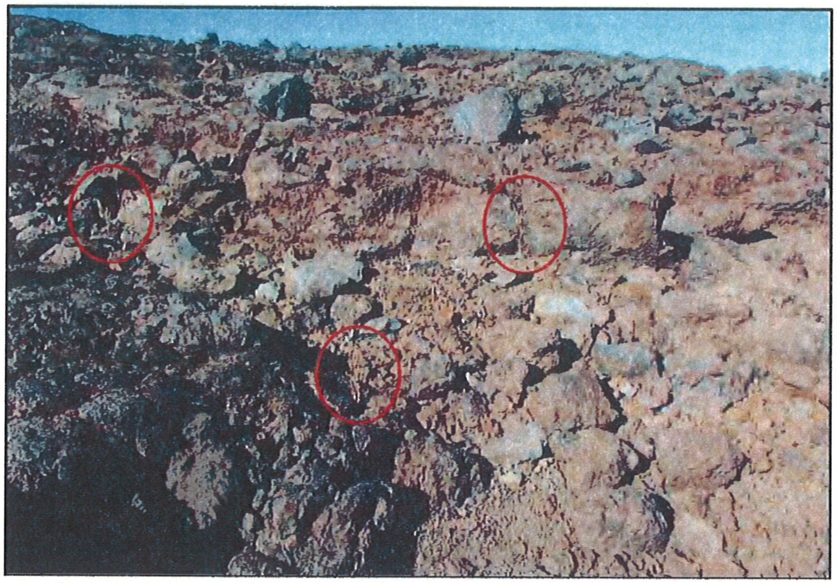

Figure 1. Alpine Stone Desert Community with Extremely Low Density of Plants (Circled in Red) at the Project Site

References

Evenhuis, N. L., and L. G. Eldredge. 2011. Taxonomic changes in Hawaiian ferns and lycophytes. Records of the Hawai'i Biological Survey for 2009-2010. Bishop Museum Occasional Papers 110:11–16.

Palmer, D. D. 2003. Hawaii's Ferns and Fern Allies. University of Hawai'i Press, Honolulu.

[USFWS] U.S. Fish and Wildlife Service. 2015. ECOS: Environmental Conservation Online System, Listed Species Believed to or Known to Occur in Hawai'i. <http://ecos.fws.gov/tess_public/reports/species-listed-by-state-report?state=HI&status=listed>. Accessed December 18, 2015.

Wagner, W. L., and D. R. Herbst. 1999. Supplement to the manual of the flowering plants of Hawai'i. Pages 1855–1918 *in* W. L. Wagner, D. R. Herbst, and S. H. Sohmer, editors, Manual of the Flowering Plants of Hawai'i. University of Hawai'i Press and Bishop Museum Press, Honolulu.

Wagner, W. L., D. R. Herbst, N. Khan, and T. Flynn. 2012. Hawaiian Vascular Plant Updates: A Supplement to the Manual of the Flowering Plants of Hawai'i and Hawai'i's Ferns and Fern Allies. Version 1.3.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999. Manual of the Flowering Plants of Hawai'i. Two volumes. Revised edition. University of Hawai'i Press and Bishop Museum Press, Honolulu.

Please feel free to contact me (sansari@harveyecology.com; 808.499.9092) if you have questions or concerns regarding this letter report. Thank you for giving H. T. Harvey & Associates the opportunity to offer ecological services in support of your project.

Sincerely,

Shahin Ansari, Ph.D.
Project Manager, Senior Plant Ecologist

PAUL COLEMAN

Education and Background:

My Hawaiian `ohana comes from three main groups who were in Kohala, Hawai`i; Makua and Kahana, O`ahu; and Ka`anapali, Maui. If we follow my maternal line, we can trace back to Mele Makini (4th great tutu) who was related to Kalakaua and Liliuokalani. Coincidentally, she married the Chinese entrepreneur and businessman Hu Pak Sing, who for a time owned one of the sugar mills on Hawai`i, owned the ahupua`a containing Kahana valley, and was the first association president of the Manoa Chinese Cemetery. As an astrophysicist who specializes in cosmology, this connection to the Kalakaua line afforded to me through tutu Mele, connects me to the Kumulipo and therefore back to the Big Bang! So for me, using the TMT which will allow us to look back in time as far as possible, is in the Hawaiian sense, literally investigating my ancestors.

When I graduated from St. Louis High School, there were two things I wanted to do – play football and study theoretical general relativity – the physics that Einstein invented. I knew that I would have to say goodbye to Hawai`i as there was no option to do both here at the level I wanted. I went to the University of Notre Dame to accomplish both those goals.

I graduated with a BS in physics and a few broken fingers. Notre Dame won two national championships in football while I was there (no thanks to me). Next, I applied to the graduate program at the University of Pittsburgh where one of the true geniuses of Relativity (Professor Ezra "Ted" Newman) was a faculty member. He advised me that since I was a Hawaiian, perhaps I could shift my interests slightly to astrophysics and physical cosmology. He knew that new telescopes were being built on Maunakea and thought that this might give me the chance to go back home. He also confided in me that if he were just starting out in physics, as I was, he would do exactly this. Ted is one of the smartest men I have ever met – so of course I took his advice.

After earning my PhD in physics, I began applying for jobs back home in Hawai`i. The Institute for Astronomy was moving along and becoming one of the best astronomy institutes in the world – this meant that I would have to do pretty well also in order to be considered for any jobs back home. There were six telescopes on Maunakea at that time and one of them (the James Clerk Maxwell Telescope – JCMT) was the only telescope in the world which could answer a problem in extragalactic astrophysics that I was interested in. Access to telescopes on Maunakea depends on your affiliation. If you are a member of an institute which has guaranteed time, you may apply for that time. You will, of course, have to beat the competition by having a highly rated observing proposal.

I didn't get either of the jobs I applied for in Hawai`i back then, but I was hired as an Institute Postdoc at the University of Groningen in the Netherlands. What was originally supposed to be only a 2 year job turned into a permanent position which I left after 8 years. During those years, I unsuccessfully applied for jobs in Hawai`i many, many times. As the years went by, my record of my work and experience, papers published, etc. got better and better.

Fortunately, the Netherlands is one of the partner countries in the UK telescopes on Maunakea which meant that I could also apply for time for those telescopes. I used to joke that I had to go almost to the other side of the Earth in order to be able to use the telescopes in Hawai`i because the competition for telescope time was so tough. Since coming home to the IfA, the competition has gotten much less. I only have to compete with the 40 plus astronomers here for telescope time – instead of the thousands in the rest of the world. Every second of time on Maunakea is used and I find it almost laughable when I hear people say that we don't use the time allocated for us. If they only knew how precious telescope time is on Maunakea (with typical oversubscription factors of five to ten – meaning that as many as ten different projects are applying for the same time on the telescope that you are).

Hawaiian Cultural Practices and Mauna Kea

My first professional visit to Maunakea happened in 1987 as I started the project with the JCMT – which lasted six years. There were no cultural practices being followed on the mountain at that time. At that time few people other than astronomers and support crews, ascended above the Hale Pohaku level. Nowadays, there are many visitors and it seems anyone older than 15 with a 4 wheel drive vehicle can visit the summit.

In 1988 I began my own research on cultural significance of Maunakea, talking with my Tutu and other elders (including GTE workers who spent many hours at the high altitudes on Mauna Loa and Maunakea). From those sources, I learned some of the stories of the mountain and the special relationship of Poliahu and her sisters. I even published a paper in 1993 describing our astronomy project and the goddesses of the snow mantles. During those years, I talked to as many elders as I could find and read as much of the published materials on Maunakea that I could get my hands on. My Tutu was especially helpful as she pointed out good places to start and corrected me when I went astray.

I learned that Maunakea was a special place, to be treated with all due respect. Most of the old Hawaiians I spoke with were concerned that the place remain open to hunters who helped control the populations of wild pua`a and goats. The only other cultural activities were concerned with Lake Waiau. There were no "sightline" ceremonies, no equinox celebrations, and with the exception of the treatment of piko in Waiau, no cultural practices at all. The reason is that it is just too hard to get to the summit! No one would want to endure all the hardship necessary to get to the summit for a ceremony which could be better done at lower elevation. It is only thanks to the access road being built, that these other ceremonial events happen at all.

How sacred is Maunakea? How important is it to the Hawaiian people? These are questions which must be answered by each Hawaiian, but my answer is simple. My auntie Momi Mo`okini Lum is the kahuna nui of the Mo`okini luakini heiau in Kohala and I consider that heiau to be more important than the summit of Maunakea to our people. In fact, I can point to many other places which I consider to be much more important than Maunakea.

Maunakea is not mentioned in the Kumulipo – contrary to some popular misconception. This can be easily checked by looking at any of the versions of the Kumulipo (two of which are on line and searchable).
As a people, we are extremely proud of our multilingual, educated past. We were one of the most literate countries in the world for the approximate century that the Hawaiian Kingdom existed. At the time of the overthrow, many Hawaiian language newspapers and magazines had been in existence for decades and were available to the general public. Thankfully many were saved by the Bishop Museum, Mission House Museum, and others. These volumes of written history have recently been digitized and made searchable with modern computer technology by various groups.

Every effort that I am familiar with, to search these large repositories of knowledge, have found **no** mention of Mauna o Wakea. In fact, only passing mention of Mauna Kea in a handful of articles usually describing a visit by a dignitary to the summit, have been found in all the hundreds of written texts. The stories often highlight the difficulties involved in travel by horseback – no mention of the sacredness of the mountain can be found! This lack of historical support for the "sacredness" of the mountain is in direct contradiction to the claims of the protesters.

I believe Maunakea is a sacred place, but not so sacred that it cannot be used for the betterment of our people. The old Hawaiians had ways of removing Kapu on things if the people could benefit from those rules being removed. For example, some Ali`i were so sacred, that the normal person could not even talk to them without incurring a penalty of death. The Hawaiian's solution was to invoke an oli which removed the penalties temporarily, thus allowing the ruler to converse with his or her subjects. The restrictive rule was set aside for the benefit of the people.

Now, allowing astronomy on Maunakea is definitely one of those things which brings benefits to Hawaiians. It provides proven economic benefit to Hawai`i. It diversifies the economy so we do not have to rely on the economic vagaries of tourism. It instills pride, fosters educational benefits, and provides a source of income in a clean green field.

If the TMT comes to Maunakea, it will guarantee that Hawai`i is the leader in world astronomy for the next thirty or so years. We will be able to attract the best young scientists and continue our programs of outreach and teaching which are doing so well. It takes more than 10 years of post-high school education to get to the astronomer level (and a few years beyond that to be competitive in the field of astronomy), but we can continue to "grow our own" and literally take over astronomy in Hawai`i.

I find this very appealing since I know that the defining characteristic of a Hawaiian is astronomy. Our mastery of astronomy, and its application – long distance voyaging – is the one thing that separates us Hawaiians from our other Polynesian brothers. It represents coming full circle from being masters of astronomy in the past to being the masters of astronomy in the future. I seriously urge all parties involved to support astronomy in general and the TMT in particular in order to allow our children to have a future which is really very much in keeping with our most important Hawaiian cultural traditions. Let's take astronomy back!!!

BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAIʻI

Contested Case Hearing Re Conservation District Use Application (CDUA) HA-3568 for the Thirty Meter Telescope at the Mauna Kea Science Reserve, Kaʻohe Mauka, Hāmakua, Hawaiʻi, TMK (3) 4-4-015:009	BLNR Contested Case HA-16-002 **CERTIFICATE OF SERVICE**

CERTIFICATE OF SERVICE

The undersigned hereby certifies that the attached document was served upon the following parties by the means indicated:

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