DRAFT
ENVIRONMENTAL IMPACT STATEMENT

Volume 1

Thirty Meter Telescope Project

Island of Hawai‘i

Proposing Agency:
University of Hawai‘i at Hilo

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EXHIBIT A-148a

Preface

Standing 13,796 feet above sea level, Maunakea[1] – often translated into English as White Mountain for its snowy summit in the winter season – is the highest volcanic peak in the Hawaiian Islands. The now dormant Maunakea, together with Mauna Loa – a volcanic peak just to the south – left a saddling plateau built up from the abundant lava flows.

Traditional knowledge handed down over the generations reveals that Maunakea is of profound importance in Hawaiian culture. Also, due to its unique setting, Maunakea is the world's foremost location for astronomical observation and research. The observations conducted by the existing observatories contribute extensively to the advancement of science worldwide and to America's leadership in astronomy research. However, while of great importance to the world of science, Maunakea is of profound importance in Hawaiian culture.

"In Hawaiian culture, natural and cultural resources are one and the same."[2] The formation of the Hawaiian Islands and the presence of life on and around them are described by Native Hawaiian traditions. These traditions explain that all forms of the natural environment, from the oceans to the mountain peaks and the valleys and plains in between, are believed to be embodiments of Hawaiian gods and deities. The significance of Maunakea, and in particular its summit, is revealed through the direct application of meaningful place names to its landscapes and natural features. According to Native Hawaiian tradition, the "Kea" in Maunakea, is an abbreviation for Wākea, the great sky god, who, together with Papa-hānau-moku, the Earth mother, and various gods and natural forces, gave birth to the islands. Hawaiian tradition records that Hawai'i, the largest island in its archipelago, is also the first born of these islands, and Maunakea is known as "ka piko o ka moku" meaning "the navel of the island." Other natural features of the landscape, such as the cinder cones of the mountain, were named after ancient ancestors, many of whom were regarded as gods and goddesses. Some of the most prominent among these include Kūkahau'ula, the pink-tinted snow god; Poli'ahu, goddess of the snows of Maunakea; Waiau, goddess of the lake; and Līlīnoe, the goddess of mists.

The cultural attachment to the environment and nature bears direct relationship to the beliefs, practices, cultural evolution, and identity of a people. Maunakea bears much significance because it is believed that the points of highest altitude are sacred and open the gateways to heaven. Six main zones can be found on the slopes of Maunakea; Kuahiwi, the core summit area, is the highest and most sacred. Tradition tells us that access to the summit was limited to high chiefs and priests, where prayers could be offered in the utmost reverence to their gods, akua.

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[1] Maunakea is spelled as one word in this document because it is considered the traditional Hawaiian spelling (Ka Wai Ola, Vos. 25 No. 11). Maunakea is a proper noun, therefore spelled as one word in Hawaiian. This spelling is found in original Hawaiian language newspapers dating back to the late 1800s when the Hawaiian language was the medium of communication. In more recent years Maunakea has been spelled as two words, which literally mean "white mountain." Spelled as two words it is a common noun that could refer to any white mountain verses the proper name of this particular mountain on Hawai'i Island. The common "Mauna Kea" spelling is only used in this document where Mauna Kea is used in a proper name, such as the "Mauna Kea Science Reserve."

[2] Mauna Kea Science Reserve Master Plan, June 2000.

The sacred zone next to the Kuahiwi is known as Kualono and consists of the near-summit lands where few trees grow. As early as AD 1100, adze makers came in reverence to the Maunakea adze quarry, Keanakākoʻi (most of which is located in the Mauna Kea Ice Age Natural Area Reserve) and this practice continued through the 1700s up until the time of Western contact. In this area of the mountain, large deposits of a very hard, fine grained volcanic rock, known as basalt, were found that were used to produce high-quality adzes, or tools, for woodworking, canoe-making, and construction of other structures like shelters.

As part of the ritual associated with quarrying, craftsmen erected shrines (as evidenced by unique upright stone structures) to their gods. The two upper most sacred zones were also used for burials, with one puʻu, or cinder cone, having been confirmed to contain burials and four others considered likely to contain burials. Historical documents reveal that most shrines are located on the summit plateau (mostly on the north and northeast side of the mountain), not the core summit region or the tops of cinder cones, suggesting that the area was likely avoided because of its high degree of sacredness.

Other cultural practices on Maunakea include deposition of a baby's piko, or umbilical cord. In an account by Pualani Kanakaʻole Kanahele, the symbolism of this practice was described as:

> …the part of the child that connected the child back to the past. Connected the child back to the mama. And the mama's piko is connected back to her mama and so on. So it takes it back, not only to the wā kahiko [ancient times], but all the way back to Kumu Lipo…So it's not only the piko, but it is the extension of the whole family that is taken and put up in a particular place, that again connects to the whole family line. And it not only gives mana or life to that piko and that child, but life again to the whole family.[3]

For some families, the practice of piko deposition on Maunakea is a long-standing traditional cultural practice, requiring proper means for depositing and maintaining cleanliness and purity.

Following the summit and near summit lands are four zones in descending order: wao maʻu kele, a wet area of large koa; wao akua, an area of more varied forest – also referred to as the region of the gods for its remote desolate location where benevolent or malevolent spirits lived and people did not; wao kanaka, the lowest forested area most used as a cultural resource; and kula, the upland grassy plains. Hawaiians used the lower zones for everyday purposes, however, wao maʻu kele and wao akua are currently a part of the conservation district.

The year 1778 marked the first European contact with the islands upon the arrival of Captain James Cook. Since this contact, Maunakea's environment and cultural practices have significantly changed. For example, adze quarrying phased out shortly after Western contact when iron tools were introduced to the Hawaiians and replaced those made from basalt. New species of animals such as cattle and sheep were also introduced to the island, and upon the arrival of the Christian missionaries, the kapu system was abolished and certain traditional cultural practices were discouraged. The early 1900s brought additional changes in the landscape with the importation of trees and early road construction by the Civilian Conservation Corps (CCC) and U.S. Army around World War II. Improvement of the roads enhanced access to the mountain, especially with the connection of Hilo and Waimea through Saddle Road.

[3] Kumu Pono, 1999:A-376.

It wasn't until the early 1960s that interest grew in using the summit for Western astronomical observations. Prior to the introduction of astronomical observatories, Native Hawaiians used the stars, (in addition to knowledge of the wind, waves, currents, weather, fish, and birds) to navigate the open oceans through a skillful art known as wayfinding. Advancing this history and practice, the U.S. Air Force developed the first optical observatory on the mountain in 1964. Today, there are 11 observatories including the Keck, Subaru, and Gemini in the summit region; the VLBA radio telescope located at an elevation of roughly 12,200 feet. The observatories provide valuable teaching and research resources to the University of Hawai'i, and employ more than 600 County of Hawai'i residents.

Maunakea's unique setting and beauty also make it a popular recreation and tourism destination. Approximately 270 visitors per day ascend the mountain for sightseeing, hiking, and amateur astronomy. Many come to the mountain with guided commercial tours while some visit in personal vehicles. During the periods when the summit is covered with snow, visitors are drawn to Maunakea to sled, ski, snowboard, and enjoy the unique conditions.

The increased access to the mountain brought forward an awareness of the need to evaluate the cultural and environmental effects, and a number of environmental studies, including intensive archaeological studies and cultural resource surveys, have been conducted. The studies have recorded a number of findings, including the discovery of the Wēkiu bug, and have led to listing three areas as Traditional Cultural Properties by the State Historic Preservation Division. Also, 222 historic properties, including 147 ancient shrines have been identified within the Mauna Kea Science Reserve.

The recent development of the Mauna Kea Comprehensive Management Plan (CMP) is an important step in UH's continuing and ongoing efforts to protect and conserve Maunakea's cultural and natural resources. The CMP provides a framework for integrating culture, science, sustainability and education, intended to manage current and future uses and activities in a way that values the kūpuna who passed on knowledge and experience, and respects the natural resources provided by the mountain.

Executive Summary

This Draft Environmental Impact Statement (Draft EIS) has been prepared to provide the University of Hawaiʻi (UH), State decisionmakers, the public, and interested parties with information regarding the potential impacts of locating the proposed Thirty Meter Telescope (TMT) Project in Hawaiʻi. The Draft EIS discusses the natural environment, economic environment, social and community environment, and cultural and historical environment. The Draft EIS presents the existing environmental conditions, analyzes the potential effects of the Project, and identifies proposed measures to minimize potential adverse impacts. Reasonable alternatives to the Project are also discussed. The mitigation measures proposed in this Draft EIS will continue to be refined during the public Draft EIS review process, and the resulting final and committed mitigation measures will be outlined in the Final EIS.

The Action and Project

The proposed action is the issuance by the Board of Land and Natural Resources (BLNR) of a Conservation District Use Permit (CDUP) allowing construction and operation of select Project components within the State of Hawaiʻi Conservation District, resource subzone. The Project would consist of the construction and operation, and ultimate decommissioning of the TMT Observatory. The TMT Observatory would be built on the northern plateau of Maunakea at a location known as the 13N site within "Area E." Area E is part of the 525-acre Astronomy Precinct and has been identified in the 2000 Mauna Kea Science Reserve Master Plan as the preferred location for the future development of a Next Generation Large Telescope (NGLT). This location is considered preferred for a NGLT by UH because it provides suitable observation conditions with minimum impact on existing facilities, Wēkiu bug habitat, archaeology/historic sites, and viewplanes. The 13N site is at an elevation of roughly 13,150 feet and 1/2-mile northwest of the eight existing optical/infrared observatories located near the summit.

The TMT Observatory would consist of the telescope, adaptive optics (AO) system, and instruments all contained in a dome; support building; and parking area. These facilities would all be clustered within an approximately 5-acre site. The primary component of the telescope is the 98-foot (30-meter) segmented primary mirror, with 492 individual mirror segments that would function as a single mirror. The focal ratio (f/) of the telescope would be f/1.0, which translates to a shorter telescope and allows for a smaller dome size relative to a telescope with a larger focal ratio. The dome housing the telescope would be a Calotte-type enclosure with a total height of 180 feet, would appear rounded and smooth, and would have an aluminum-like exterior coating. The support building would be attached to the dome, and have an area of roughly 35,000 square feet spread over three levels terraced to match the area's natural slope. A small visitor viewing platform and visitor restrooms would be included in the design.

The Access Way, a permanent Project facility, would include a 0.6-mile road and utility improvements from existing facilities to the TMT Observatory. The Access Way would extend from a point across the road from the Smithsonian Astrophysical Observatory Submillimeter Array (SMA) building to the TMT Observatory. The Access Way would follow existing SMA roads and the 4-wheel drive road in Area E to the extent possible. The existing SMA facility to the west and the puʻu to the east limit the options for routing the Access Way. Three Access Way Options through or around the core of the SMA facility are being considered: (1) through the SMA, (2) near the SMA, and (3) following the existing 4-wheel drive road.

The TMT Mid-Level Facility would be located near and within Hale Pōhaku. Within Hale Pōhaku, the TMT Mid-Level Facility would consist of personnel facilities to initially support TMT Observatory construction, and those facilities would ultimately be turned over to UH for general use under the management of Mauna Kea Observatories Support Services (MKSS). Near Hale Pōhaku, the TMT Mid-Level Facility improvements would consist of adding a transformer to the Hawaiian Electric Light Company (HELCO) enclosure across Maunakea Access Road from Hale Pōhaku, in the saddle between Puʻu Kilohana and Puʻu Kalepeamoa.

The TMT Observatory and TMT Mid-Level Facility would be managed from a Headquarters in Hilo. The Headquarters would be a roughly 20,000 to 35,000 square-foot office building located in the UH Hilo University Park development where most other observatories have their headquarters.

A smaller Satellite Office may be established in Kamuela (Waimea) to provide additional support to the TMT Observatory and TMT Mid-Level Facility, and to facilitate close coordination with the partner-owned Keck and Canada-France-Hawaiʻi Telescope (CFHT) observatories, which have their headquarters in Waimea. The Satellite Office would be a permanent Project facility and could be placed at a commercially-zoned site, for example, the vacant lots behind the Parker Ranch Center.

The temporary facilities associated with the Project would include a construction staging area near the summit (known as the "Batch Plant Staging Area"), a construction staging area at the TMT Mid-Level Facility, and a construction staging area near the port where Project components would be received.

The Project also consists of the eventual decommissioning of the TMT Observatory and restoration of the 13N site. Decommissioning funds would be set aside annually, and decommissioning/restoration would meet the requirements present at the time of undertaking dismantling activities.

Project Purpose, Need, and Objectives

The proposed Project's overall purpose is to provide a 30-meter ground-based telescope, which was identified in the 2001 National Academy of the Sciences Decadal Survey for Astronomy as the most critical need for ground-based astronomy. Such a telescope would be a critical part of future astronomy facilities planned for 2015 and beyond.

The Project's primary objectives are to:

1. Locate the TMT in Hawaiʻi to help the U.S. maintain its 150-year-long leadership position in astronomy research, discovery, and innovation.
2. From a scientific viewpoint, the Project's objective is to provide astronomers with a powerful and precise tool capable of exploring almost every aspect of the Universe, as identified in the Decadal Survey. The Project could advance the pursuit to answer fundamental questions about the nature and workings of the universe. The TMT

Observatory could enable discoveries about the nature and origins of the physical world, from the first formation of galaxies in the distant past and distant regions of the Universe to the formation of planets and planetary systems today in our Milky Way Galaxy.

3. Leverage the capacity and abilities of the TMT partners' existing astronomy facilities in Hawai'i, including the Keck, Canada-France-Hawai'i Telescope (CFHT), and Subaru observatories. Leveraging, or pulling together, these facilities on Maunakea would provide opportunities to coordinate and create synergies in scientific programs and instrumentation that would otherwise not be possible.
4. Utilize the TMT Project as an important educational tool to attract students to the science and technology fields, and to UH and the TMT partner institutions. Astronomy is well known as a "gateway" science. Many students get their introduction to the scientific method and tools of science in astronomy classes and then continue into technical and science careers.
5. Integrate science, culture, sustainability, and education. The Project would help develop science, technology, engineering, and math (STEM) proficiencies among members of the local communities in collaboration with the local public, charter, and private K-12 schools, UH Hilo, and Hawai'i Community College (HawCC). The TMT partner institutions are also committed to proper environmental stewardship and the concept of sustainability planning for operations of the observatory.

Existing Conditions at Project Locations

The Project is comprised of five distinct components: the TMT Observatory, the Access Way, the TMT Mid-Level Facility, the Headquarters, and the Satellite Office.

Mauna Kea Science Reserve – TMT Observatory and Access Way

The 11,288-acre Mauna Kea Science Reserve (MKSR) has been identified as having sensitive cultural and natural resources.

Native Hawaiian traditions describe the Island of Hawai'i as the first-born island child of Wākea (referred to as the Sky Father) and Papa (referred to as the Earth Mother). The union of Wākea and Papa also gave rise to the other Hawaiian Islands and Hāloa, the first man and ancestor of the Native Hawaiian people. Maunakea is understood to be symbolic of the piko (umbilical cord) of the island-child Hawai'i that connects the land to the heavens; Maunakea, is known as "ka piko o ka moku" meaning "the navel of the island." Within the MKSR there are 222 historic properties, most of them shrines, but also burials. Two areas within the MKSR and one within the neighboring Mauna Kea Ice Age Natural Area Reserve (NAR) have been designated Traditional Cultural Properties (TCPs) – Kūkahau'ula, Pu'u Līlīnoe, and Waiau. Due to the spiritual and sacred attributes of Maunakea in Native Hawaiian traditions, traditional and customary cultural practices are performed in the summit region, including:

- Performance of prayer and ritual observances important for the reinforcement of an individual's Hawaiian spirituality.
- Collection of water from Lake Waiau for a variety of healing and other ritual uses.

- Deposition of piko (umbilical cords) at Lake Waiau and the summit peaks of Maunakea.
- Use of the summit region as a repository for human remains by means of releasing ashes from cremations.
- Practices associated with the belief in that the upper mountain region of Maunakea, from the Saddle area up to the summit, is a sacred landscape, personifying the spiritual and physical connection between one's ancestors, history, and the heavens.
- Practices associated with the unspecified traditional navigation practices and customs.

There are two ecosystems within the MKSR, the Alpine Stone Desert above 12,800 feet and the Alpine Shrublands and Grasslands from roughly 9,500 feet (the tree line) to 12,800 feet. The Alpine Stone Desert ecosystem supports lichens, mosses, and vascular plants, including ferns. The only resident faunal species in the Alpine Stone Desert ecosystem are arthropods, including at least 10 confirmed indigenous Hawaiian species, among them Wēkiu bugs (*Nysius wekiuicola*). Wēkiu bugs are generally concentrated on the cinder cones in the summit area, but also utilize other habitats. There are no currently-listed threatened or endangered species known to occur in the Astronomy Precinct. The Maunakea Silversword (*Argyroxiphium sandwicense*), an endangered species, is known to occur at lower elevations within the MKSR. The Wēkiu bug is currently a candidate for listing and the Douglas' bladderfern (*Cystopteris douglasii*) plant is currently considered a species of concern by the USFWS.

The MKSR is designated as part of a State of Hawai‘i Conservation District resource subzone. The climate, elevation, remoteness, and other qualities make Maunakea one of the premier locations for astronomy on Earth. In 1968, the State created the MKSR in recognition of Maunakea's scientific potential and leased the area to UH. Since that time, there have been a number of management plans and master plans for the management of activities on the mountain and development of observatories to advance Maunakea's scientific potential. The current plans are:

- Mauna Kea Comprehensive Management Plan for UH Management Areas (CMP), January 2009 (OMKM, 2009).
- Mauna Kea Science Reserve Master Plan (2000 Master Plan), June, 16, 2000 (UH, 2000).

As the CMP states "For the Hawaiian people Mauna Kea is their cultural connection or piko (umbilical cord) to Papa and Wākea, it is the beginning and the end. For the astronomical community Mauna Kea is the scientific umbilical cord to the mysteries of the universe." The CMP also explains that its goal is for "these two cultures [to] coexist in such a way that is mutually respectful and yet honors the unique cultural and natural resources of Mauna Kea." The 2000 Master Plan "provides the policy framework for the responsible stewardship and use of University-managed lands on Mauna Kea through the year 2020." It provides for "a new paradigm for the University's leased lands as a natural and Hawaiian cultural reserve in addition to being a Science Reserve." The 2000 Master Plan delineated two areas within the MKSR, a 525-acre Astronomy Precinct and a 10,763-acre Cultural/Natural Preservation Area. Currently, there are 11 observatories[4] and one separate telescope[5] within the MKSR – eight optical/infrared

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

observatories, three millimeter/submillimeter observatories, and one radio wavelength antenna telescope – only the radio antenna is outside of the Astronomy Precinct.

The proposed TMT Observatory and Access Way locations are within the MKSR and Astronomy Precinct on the northern plateau of Maunakea.

Hale Pōhaku – Mid-Level Facility

Similar to the MKSR, 19.3-acre Hale Pōhaku is designated as part of a State of Hawai'i Conservation District resource subzone, and leased by UH. MKSS operates facilities at Hale Pōhaku, which provide food and lodging for scientists and staff working at the observatories, operates the Visitor Information Station (VIS), and stores equipment needed for road maintenance, snow removal, and water delivery. The lower portion of Hale Pōhaku has been used for the staging of construction activities near the summit, and Keck and Subaru construction dorms and cabins are located within this area.

At an elevation of 9,200 feet, Hale Pōhaku is considered by some to be within the spiritual and sacred realm of Maunakea. Hale Pōhaku is just below the tree line in the māmane subalpine woodlands ecosystem. This ecosystem is home to some threatened and endangered species; the area is designated critical habitat for the palila bird. Few of these species have been observed within Hale Pōhaku; no palila were observed near Hale Pōhaku during a survey in 2007. The endangered Maunakea Silversword and other native species have been outplanted within the exclosure just outside of Hale Pōhaku behind the VIS.

Headquarters

The Headquarters would be located in Hilo on the UH Hilo campus, within the University Park of Science and Technology development where most existing observatories have their headquarters. Hilo is an urban area and land use plans and policies allow for the continued growth of the area. There are no known cultural, historic, or natural resources of significance in the areas being considered for the Headquarters.

Satellite Office

The Satellite Office would be located in Kamuela (Waimea); the options being considered include vacant commercially-zoned parcels behind the Parker Ranch Center. Kamuela (Waimea) is an urban area, and land use plans and policies allow for the development with office uses in the area. There are no known cultural, historic, or natural resources of significance in the areas being considered for the Satellite Office.

Potential Environmental Impacts

Hawai'i Administrative Rules (HAR) Title 11 Chapter 200, EIS Rules, direct the focus of the environmental analysis, whereby "special emphasis shall be placed on environmental resources

[5] 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.

that are rare or unique to the region and the project site (including natural or human-made resources of historic, archaeological, or aesthetic significance)." Pursuant to this guidance, this Draft EIS places the emphasis of the environmental analysis on the TMT Observatory and Access Way below the summit of Maunakea because of the area's rare and unique qualities and resources. The areas that would be affected by the Mid-Level, Headquarters, and Satellite Office Facilities are also discussed, but to a lesser degree unless a potential significant impact is identified.

The potential Project impacts are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the project type and location. Within the MKSR and Hale Pōhaku, this includes the CMP and upcoming sub plans required by BLNR conditions. To ensure compliance, the Project would (a) design its facilities to comply and/or facilitate compliance, (b) obtain all necessary permits, and (c) develop and implement a range of plans and programs outlined in this Draft EIS. These plans and programs would include policies and procedures to be employed during long-term operation as well as construction of the Project.

The plans and programs would include, but are not limited to:

- Cultural and Natural Resources Training Program
- Invasive Species Prevention and Control Program
- Waste Minimization Plan
- Materials Storage/Waste Management Plan and component Spill Prevention and Response Plan
- Workforce Pipeline Program
- Ride-Sharing Program

Permits required of the Project would include, but are not limited to: Conservation District Use Permit (CDUP); National Pollutant Discharge Elimination System Permit (NPDES), with associated best management practices (BMP) plan; Community Noise Permit and Noise Variance, and Oversize and Overweight Vehicles Permit (OOVP). The Project would comply with all permit conditions.

Investigations conducted during the preparation of this Draft EIS have confirmed initial beliefs based on work done for MKSR Master Plans: siting the TMT Observatory within Area E would result in minimal impact on existing facilities, Wēkiu bug habitat, archaeology sites, and viewplanes. The TMT Observatory and Access Way would disturb roughly 9 acres, of which roughly 2.5 acres have previously been disturbed by roads and other activity. Natural resources, such as habitat, species, and geology, are not unique or critical to the survival of any species in that area. In addition, there are no historic properties in the area. The "find spots" in the area have been examined and determined to not be historic properties; one initially appeared similar to a historic shrine but is believed to have been constructed in the last 10 years, the other appeared to be temporary habitations but was determined to likely be a natural geologic feature.

The operation of the Project, in accordance with the CMP and proposed mitigation measures, would not result in a significant adverse impact, unless Access Way Option 3 was selected. The Project would not significantly increase or reduce the existing level of cumulative impacts due to all past and present activities, which in some cases is significant. The potential impact associated with the Access Way Option 3 is considered significant because it would reshape, or "cut" the TCP of Kūkahauʻula, the summit cinder cones. Access Way Option 3 would also displace some "good" Wēkiu bug habitat, but, in compliance with the CMP, should Access Way Option 3 be chosen, a Habitat Restoration Plan would be prepared and implemented to compensate for this potential impact.

During the construction and decommissioning of the Project there would be temporary adverse impacts due to noise, traffic, dust, visual intrusion, and the increase in human presence on the mountain; possible adverse impacts during construction and decommissioning also include potential disturbance beyond the Project limits. As with other activities, there is a potential for accidents, including fire and the accidental release of hazardous materials or solid waste, including trash and construction materials. Through compliance with all applicable rules, regulations, and requirements for the project type and location, these potential temporary impacts associated with construction and decommissioning would be less than significant.

Potential Project impacts are summarized in Table ES-1.

Potential Beneficial Effects

The studies and analyses conducted for this Draft EIS provide additional documentation of Area E's current conditions. The archaeological, historical, biological, and geological characteristics of the area, along with its cultural significance, have been carefully studied and findings of these studies can now be used to expand upon the baseline data of Maunakea, and future decisionmaking.

Other potential benefits are primarily related to the employment opportunities created by the Project and to realizing the Project objectives. Project employment would generate direct and indirect socioeconomic benefits to the Island of Hawaiʻi and the State. Construction jobs would be created during the anticipated 8-year construction period, and additional jobs would be created through materials, goods, and services that would be purchased and contracted locally for this work. It is estimated that during its operations, the Project would employ approximately 140 full-time employees, and could create additional employment because the Project would contract with local companies for work and services, including precision machine shop work, among others. The employees of the Project would purchase local goods and services, as well as pay local and state taxes, which would provide additional benefits to the community. Also, during any decommissioning and site restoration, construction-related jobs would again be created. The Project would also pay local and state taxes and fees, as well as pay for utilities and other services for the TMT facilities, benefiting the community and the State.

The Project would partner with UH Hilo, HawCC, the Department of Education (DOE), and local union training centers to help develop, implement, and sustain a comprehensive, proactive, results-oriented Workforce Pipeline Program that would lead to a highly qualified pool of local workers who could be considered for hiring into all Project job classes and salary levels. This effort would support one of the Project objectives and include activities to develop STEM proficiencies among members of the local communities.

In addition, a higher education benefit package to provide funding for selected educational initiatives of UH Hilo and HawCC on the Island of Hawaiʻi, as well as a community benefit package to provide funding for locally-chosen and managed educational programs, would be negotiated between UH and TMT. These packages would provide adidtional benefits to the Island of Hawai‘i. They would be negotiated and would become part of a lease or sublease, if TMT decides to come to Hawai‘i. Provided an agreement is reached, details of the packages will be described in the Final EIS.

The siting of the Project at Maunakea would also contribute to furthering Hawai‘i’s goal of diversifying its economy, focusing on more sustainable market areas such as science and technology, and lessening its dependence on the volatile tourism market. The Project could add a point of focus to the Island of Hawai‘i’s efforts to encourage educational excellence that could form the basis for technology-based, innovation driven job-producing activities around complementary activities in energy, agriculture, and information technologies and scientific research and support. The skills and expertise developed for a large modern observatory like TMT through the Workforce Pipeline Program would be readily applicable to many areas of technology-based industries.

Proposed Mitigation Measures

To ensure compliance with applicable rules, regulations, and requirements, the Project would (a) design its facilities to comply and/or facilitate compliance, and (b) develop and implement a range of plans and programs outlined in this Draft EIS. These plans and programs would include, but are not limited to, a Cultural and Natural Resources Training Program, Invasive Species Prevention and Control Program, Waste Minimization Plan, Materials Storage/Waste Management Plan and component Spill Prevention and Response Plan, Workforce Pipeline Program, and Ride-Sharing Program.

Compliance requirements would include (a) designing the TMT Observatory to limit its visual and other potential impact; (b) a zero-discharge wastewater system at the TMT Observatory; and (c) implementing a Habitat Restoration Plan if a sensitive habitat is disturbed.

Additional proposed mitigation measures include (a) providing informational signs to manage public access; (b) furnishing Project facilities with items to provide a sense of place and remind personnel of Maunakea’s cultural sensitivity and spiritual quality; (c) helping fund the palila recovery effort; (d) using approved soil-binding stabilizers to control dust; and (e) paving the portion of the Access Way through the SMA core to control dust.

Compatibility with Land Use Plans and Policies

The Project would comply with all applicable land use plans and policies, including: Hawai‘i Revised Statutes (HRS) Chapter 205, State Land Use Law, which includes rules related to conservation district resource subzone areas; HRS Chapter 344, State Environmental Policy; the Hawai‘i State Plan; the 2000 Mauna Kea Science Reserve Master Plan; the Mauna Kea Comprehensive Management Plan (CMP), and County of Hawai‘i General Plan.

The building and operation of the TMT Observatory on Maunakea would require a sublease from UH, which leases this ceded land from the DLNR. If TMT chooses Hawai‘i as the site, they would be required to negotiate a sublease agreement with UH. The sublease would be subject to approval first by the UH BOR followed by approval by the BLNR. The sublease consideration would likely include benefits for the Island of Hawai‘i, as well as observing time for UH. The current UH lease expires in 2033 and the TMT Observatory would be required to be decommissioned and restore the site at that time, unless a new lease or a lease extension is obtained from the BLNR.

Unresolved Issues

Unresolved issues include:

- Selection of the Access Way Option through or around the SMA core. There are three Access Way Options being considered, and one of these options will be selected prior to the Final EIS.
- Selection of the Headquarters location. Multiple locations are being considered within the UH Hilo University Park development. One of these options will be selected prior to the Final EIS.
- Selection of the Satellite Office location. Various locations are being considered in Waimea; one of these options will be selected prior to the Final EIS.
- Selection of the level of reflectance for the TMT Observatory dome's proposed exterior finish has not yet been established. A selection will be made prior to the Final EIS.
- UH has not yet entered into a sublease agreement with the TMT Observatory Corporation; a sublease would be negotiated.
- The level of decommissioning/restoration cannot be selected until an environmental cost/benefit analysis and a cultural assessment are performed when the time of decommissioning approaches.

Alternatives to the Project

There are two alternatives for consideration in Hawai‘i. The first is one which could attain the objectives of the action: locating the TMT Observatory at another nearby site on Maunakea referred to as E2. The second is a no action alternative: not locating the TMT observatory at Maunakea. Either of these alternatives could be reviewed and selected in this environmental review process consistent with Hawai‘i law and regulation.

The No Action alternative would result in no construction, installation, or operation of the TMT Observatory and its ancillary facilities. Therefore, none of the potential impacts or potential benefits associated with the Project would occur. However, since Area E is identified for NGLT development in the 2000 Master Plan, it is possible that another observatory could be developed in Area E pursuant to the 2000 Master Plan in the future absent the Project.

The Maunakea E2 site is approximately 500 feet south-southeast of, and 50 feet higher than, the Project site. The only previous disturbance to the E2 site is a 600-foot segment of the existing 4-wheel drive road. There are only a few differences in environmental impacts between the E2 site and the Project site, and none of those differences are significant.

Table ES-1: Summary of Potential Environmental Impacts and Mitigation Measures

Subject	Potential Environmental Impact	Compliance and Mitigation Measures	Level of Impact After Mitigation
Cultural Resources (Section 3.2, page 3-6)	For the purposes of this discussion, the range of opinions regarding cultural impacts have been parsed into two broad views concerning the Project's potential impact on cultural resources: (a) that Hawaiian culture and astronomy can co-exist on Maunakea and potential impacts can be mitigated; and (b) any development on Maunakea would result in a significant adverse impact that could not be mitigated. Specific Project impacts include potential impacts related to Access Way Option 3, which would result in a significant impact due to impacts to the integrity of the Kūkahauʻula cinder cone, a Traditional Cultural Property (TCP).	A mandatory Cultural and Natural Resources Training Program would be implemented to educate employees to understand, respect, and honor Maunakea's cultural landscape and cultural practices. A Ride-Sharing Program would reduce traffic, dust, noise, and general movements in the summit region. Appropriate signage may be placed to guide visitors. The Project facilities would be furnished with items to provide a sense of place and acknowledge the cultural sensitivity and spiritual attributes of Maunakea.	In the view of those who believe cultural practices and astronomy can co-exist, the implementation of the identified mitigation measures would lessen the potential Project impacts.
Archaeologic/Historic Resources (Section 3.3, page 3-27)	No archaeological or historical properties were identified within Project area or within 200 feet of areas that would be disturbed by the Project. No significant impact would occur.	A Cultural and Natural Resources Training Program would be implemented to educate employees regarding historic properties and their sensitivity to damage, and the rules and regulations regarding the protection of historic properties.	No expected impact.
Biologic Resources (Section 3.4, page 3-36)	Potential long-term impacts include displacement of existing species and habitat; dust generated by vehicle traffic along the unpaved Project areas; and paving approximately 300 feet of the Access Way. These impacts are all expected to be less than significant. As with other similar activities, the potential for accidents may include the introduction of invasive species and vehicles potentially striking fauna.	A Cultural and Natural Resources Training Program and an Invasive Species Control Program would be implemented. These programs would educate employees regarding the status, condition, diversity, and protection afforded the natural resources present on the mountain. A Ride-Sharing Program would be implemented and reduce traffic, dust, noise in the summit region. A Habitat Restoration Plan would be implemented should Access Way Option 3 be selected. Dust control measures and participation in habitat restoration measures near Hale Pōhaku are also being considered.	Implementation of the identified mitigation measures would ensure that impacts would be less than significant.

Subject	Potential Environmental Impact	Compliance and Mitigation Measures	Level of Impact After Mitigation
Visual and Aesthetic Resources Section 3.5, page 3-54)	The TMT Observatory would be visible from 14% of the island area, restricted to the northern side of the island, including portions of Honokaʻa, Waimea, and Waikoloa. This represents approximately 15.4% of the island's population. Currently, from approximately 43% of the island area, at least one existing observatory is visible, with the Project that would increase by less than 1.2% of the island area, and impacts are expected to be less than significant.	The siting of the TMT Observatory is the primary impact avoidance measure, as it is north of and below the summit. The design of the observatory also mitigates the visual impact. The dome has been designed to fit very tightly around the telescope, and the telescope has been designed to be much shorter than usual. Also, the color/coating of the dome has been proposed to be reflective metallic, which during the day reflects the sky and reduces the visibility of the structure.	Implementation of the identified mitigation measures would ensure that impacts would be less than significant.
Geology, Soils, and Slope Stability (Section 3.6, page 3-76)	Hawaiʻi is a seismically active area and the Project could be affected by earthquakes. Surface geologic structures present in the Project areas, such as lava flow morphology and glacial features, would unavoidably be removed. These geologic features are neither unique nor exceptional and better examples exist elsewhere on Maunakea. Associated impacts would be less than significant.	The Project would comply with all applicable seismic safety regulations and standards. The Observatory would minimize the seismic risk to the telescope and equipment through extra design measures. Additional mitigation may include identifying noteworthy examples of glacial features near the Access Way.	Mitigation would further reduce the level of impact which would be less than significant prior to any mitigation.
Water Resources and Wastewater (Section 3.7, page 3-84)	Potential impacts could occur from new impervious surfaces, additional consumption of fresh (potable) water, and additional wastewater discharges. However, due to proposed design features and mandatory compliance with existing requirements and regulations, those impacts are expected to be less than significant.	Compliance measures would include collecting and transporting all wastewater down the mountain for treatment; no wastewater would be released to subsurface in the summit area. Items such as dry wells would be included to maximize groundwater recharge. Water efficient fixtures would be used and the Waste Minimization Program would also include audits of water use to reduce potable water use.	No mitigation necessary. Project impacts are expected to be less than significant.
Solid and Hazardous Waste and Material Management (Section 3.8, page 3-92)	While the Project would result in additional generation of solid and hazardous wastes, the associated impacts are expected to be less than significant due to mandatory compliance with existing requirements and regulations.	Regulatory compliance would include the implementation of a Waste Minimization Program (WMP) and a Materials Storage/Waste Management Plan, including a Spill Prevention and Response Plan. No additional mitigation would be required.	Less than significant expected impact.

Subject	Potential Environmental Impact	Compliance and Mitigation Measures	Level of Impact After Mitigation
Socioeconomic Conditions (Section 3.9, page 3-100)	Project effects are expected to be beneficial and include job creation during Project construction, operation, and decommissioning. During operation, the Project would employ approximately 140 full-time employees, and could create additional employment because the Project would contract with local companies for work and services. Project employees would purchase local goods and services, as well as pay local and state taxes, which would provide additional benefits to the community.	Employment opportunities would be filled locally to the greatest extent possible. In addition to its Public Information and Education Office, TMT would create a separate Community Outreach office with at least one full-time person dedicated to establishing and implementing the Workforce Pipeline Program and various mentoring and scholarship programs to maximize job opportunities for local residents.	Mitigation measures proposed would help maximize the level of beneficial impact.
Land Use Plans, Policies, and Controls (Section 3.10, page 3-105)	The Project would be in compliance with all applicable land use plans, policies, and controls for the project type and location. Impacts are expected to be less than significant.	Implementation of the Cultural and Natural Resources Training Plan would reduce potential conflicts with current uses by cultural practitioners. The portion of the Access Way through or near the SMA core would be paved to reduce dust that could impact their operation.	Mitigation would further reduce the level of impact which is expected to be less than significant prior to any mitigation.
Roadways and Traffic (Section 3.11, page 3-123)	Expected Project traffic would not result in a change in the level-of-service and would not warrant additional road improvements. Impacts are expected to be less than significant.	Mandatory participation in a Ride-Sharing Program using Project vehicles for TMT Observatory employees travelling beyond Hale Pōhaku would be implemented. Ride-sharing for travel to the Headquarters would be actively encouraged. Off-peak work hours for headquarters personnel would also be considered.	Mitigation would further reduce the level of impact which is expected to be less than significant prior to any mitigation.
Power and Communications (Section 3.12, page 3-129)	The Project's electricity use would not significantly impact other facilities on the mountain or island-wide. HELCO has ample generation capacity to service the Project. The use of bandwidth for communications would not exceed the Project's allotment. Impacts are expected to be less than significant.	Energy-conserving lighting, appliances, and systems would be used to reduce energy use. Additionally, a component of the WMP would be an annual audit of energy use by the Project. The audit would include examining methods available to reduce energy use.	Less than significant expected impact.

Subject	Potential Environmental Impact	Compliance and Mitigation Measures	Level of Impact After Mitigation
Noise (Section 3.13, page 3-132)	Noise associated with the Project would not detrimentally affect ambient noise levels or substantially degrade environmental quality.	Mandatory participation in a Ride-Sharing Program for TMT Observatory employees travelling beyond Hale Pōhaku, and encouragement of ride sharing for travel to Headquarters would reduce transient vehicular noise.	Mitigation would further reduce the level of impact which is expected to be less than significant prior to any mitigation.
Climate, Meteorology, Air Quality, and Lighting (Section 3.14, page 3-135)	Potential impacts related to dust and exhaust emissions from vehicular travel and emissions related to operation and maintenance activities would not substantially affect the existing air quality or climate. Sky illumination effects would be limited and not substantial. Impacts are expected to be less than significant.	Mandatory participation in a Ride-Sharing Program using Project vehicles for TMT Observatory employees travelling beyond Hale Pōhaku, and encouragement of ride sharing for travel to Headquarters and the Satellite Office would reduce emissions and dust generation. An approved soil-binding stabilizer or other measures may be used to minimize dust generated by travel along unpaved portions of the Project areas.	Mitigation would further reduce the level of impact which is expected to be less than significant prior to any mitigation.
Construction and Decommissioning (Section 3.15, page 3-141)	Through compliance with existing rules, regulations, and policies, Project construction is not expected to have a substantial adverse impact, as impacts would be temporary and less than significant.	A Ride-Sharing Program would be instituted for all workers at the construction site. The Project would endeavor to reduce noise in the vicinity of cultural practices. Connection to HELCO-supplied power would be sought early in the process to eliminate the need for generators, except for limited emergency use. A Fire Prevention and Response Plan would be developed and implemented.	Mitigation would further reduce the level of impact which is expected to be less than significant prior to any mitigation.
Cumulative – Cultural/Archaeology (Section 3.16, page 3-159)	The existing level of cumulative impact is considered substantial and adverse. The addition of the Project would have a small incremental impact; however, the level would continue to be substantial and adverse.	The Project would comply with all applicable requirements and regulations, as well as proposed mitigation measures.	Existing substantial level of adverse cumulative impact would continue.
Cumulative – Others (Section 3.16, page 3-166)	The existing level of cumulative impact on Geology and Visual/Aesthetics Resources is considered significant. The addition of the Project would have a small incremental impact; however, the existing level of impact would continue to be significant.	The Project would comply with all applicable requirements and regulations, as well as proposed mitigation measures	Existing substantial levels of adverse cumulative impacts would continue.

Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

List of Appendices, in Volume 1

List of Appendices, in Volume 2 (on CD in back cover slip)

List of Figures

List of Figures (Continued)

List of Tables

Acronyms and Abbreviations

Acronyms	Meaning
ACURA	Association of Canadian Universities for Research in Astronomy
ALMA	Atacama Large Millimeter Array
AO	Adaptive optics
ADT	Average Daily Traffic
ATV	All Terrain Vehicles
BLNR	Board of Land and Natural Resources
BMP	Best Management Practice
BOR	Board of Regents
Caltech	California Institute of Technology
CARA	California Association of Research in Astronomy
CCC	Civilian Conservation Corps
CDUA	Conservation District Use Application
CDUP	Conservation District Use Permit
CFD	Computational Fluid Dynamics
CFHT	Canada-France-Hawai‘i Telescope
CFR	Code of Federal Regulations
CIA	Cultural Impact Assessment
CMP	Comprehensive Management Plan
CSO	Caltech Submillimeter Observatory
CWRM	Commission on Water Resource Management
dB	Decibels
DIA	Declaractión de Impacto Ambiental
DLNR	Department of Land and Natural Resources (State of Hawai‘i)
DOE	Department of Education
DOFAW	Division of Forestry and Wildlife
EA	Environmental Assessment
E-ELT	European Extremely Large Telescope
EIS	Environmental Impact Statement
EISPN	Environmental Impact Statement Preparation Notice
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-To-Know Act
ESA	Endangered Species Act
ESO	European Southern Observatory

Acronyms and Abbreviations (Continued)

Acronyms	Meaning
GMT	Giant Magellan Telescope
GPS	Global Positioning System
GSMT	Giant Segmented Mirror Telescope
HAR	Hawai‘i Administrative Rules
HawCC	Hawai‘i Community College
HDOH	State of Hawai‘i Department of Health
HDOT	State of Hawai‘i Department of Transportation
HELCO	Hawaiian Electric and Light Company
HPS	High Pressure Sodium
HRS	Hawai‘i Revised Statutes
HVAC	Heating, Ventilating, and Air Conditioning
IfA	Institute for Astronomy
IRH	Indoor and Radiological Health
IRTF	Infrared Telescope Facility
JAC	Joint Astronomy Center
JCMT	James Clerk Maxwell Telescope
kV	Kilovolt
kW	Kilowatt
LLC	Limited Liability Company
LOS	Level-Of-Service
LPS	Low Pressure Sodium
LSST	Large Synoptic Survey Telescope
LUPAG	Land Use Pattern Allocation Guide
MEK	Methyl Ethyl Ketone
MKMB	Mauna Kea Management Board
MKSR	Mauna Kea Science Reserve
MKSS	Mauna Kea Observatories Support Services
MSDS	Material Safety Data Sheets
MSL	Mean sea level
MW	Megawatt
NAAQS	National Ambient Air Quality Standards
NAR	Natural Area Reserve
NASA	National Aeronautics and Space Administration
NAOJ	National Astronomical Observatory of Japan

Acronyms and Abbreviations (Continued)

Acronyms	Meaning
NEPA	National Environmental Policy Act
NGLT	Next Generation Large Telescope
NGST	Next Generation Space Telescope
NPDES	National Pollutant Discharge Elimination System Permit
NRAO	National Radio Astronomy Observatory
NSF	National Science Foundation
OCCL	Office of Conservation and Coastal Lands
OEQC	Office of Environmental Quality
OHA	Office of Hawaiian Affairs
OMKM	Office of Mauna Kea Management
OOVP	Oversize and Overweight Vehicles Permit
OSHA	Occupational Safety and Health Administration
Pan-STARRS	Panoramic Survey Telescope and Rapid Response System
PCSI	Pacific Consulting Services, Inc.
RCRA	Resource Conservation and Recovery Act
SHO	Safety and Health Officer
SHPD	State Historic Preservation Division
SHPO	State Historic Preservation Officer
SPRP	Spill Prevention and Response Plan
STEM	Science, technology, engineering, and math
SMA	Submillimeter Array
TCP	Traditional Cultural Property
TMK	Tax Map Key
TMT	Thirty Meter Telescope
UC	University of California
UH	University of Hawai‘i
UIC	Underground Injection Control
UKIRT	United Kingdom Infrared Telescope
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tanks
VLBA	Very Long Baseline Array
VLT	Very Large Telescope
VIS	Visitor Information Station

Acronyms and Abbreviations (Continued)

Acronyms	Meaning
VOG	Volcanic smog
WMP	Waste Minimization Plan

1.0 Introduction

1.1 Purpose of this Draft EIS

This Draft Environmental Impact Statement (Draft EIS) has been prepared to provide the University of Hawai‘i (UH), State decisionmakers, the public, and interested parties with information regarding the potential environmental effects of locating the proposed Thirty Meter Telescope (TMT) Project in Hawai‘i. The potential environmental impacts discussed in the Draft EIS encompass the natural environment, as well as economic welfare, social welfare, cultural practices of the community and State, and effects of the economic activities arising out of the proposed Project. Measures proposed to minimize potential adverse effects and alternatives to the proposed Project are also addressed.

The potential benefits and environmental impacts of the proposed Project are analyzed and disclosed in this Draft EIS. The potential impacts are evaluated, and mitigation measures to address the identified substantial impacts are outlined. Measures to avoid, minimize, rectify, or reduce the potential substantial adverse environmental impacts have been considered throughout the Project planning process and incorporated into the Project design and construction plans. The mitigation measures presented in this Draft EIS will continue to be refined during the public Draft EIS review process, and the resulting final and committed mitigation measures will be outlined in the Final EIS.

1.2 Legal Requirements

This Draft EIS has been prepared pursuant to Hawai‘i Revised Statutes (HRS) Chapter 343, Environmental Impact Statement Law and Chapter 200 of Title 11, Hawai‘i Administrative Rules (HAR), Department of Health, Environmental Impact Statement Rules. An EIS Preparation Notice/Environmental Assessment (EISPN/EA) prepared pursuant to HRS Chapter 343 was issued for this project on September 23, 2008. After distribution of the Draft EIS for public and agency review, public meetings will be held to receive comments from the public and agencies. A Final EIS will then be prepared, which will respond to the comments received during the Draft EIS review period. Following publication of the Final EIS, the Governor of Hawai‘i will act on the EIS.

1.3 Project Action

The proposed action is the issuance by the Board of Land and Natural Resources (BLNR) of a Conservation District Use Permit (CDUP) allowing: (a) the construction and operation of the proposed TMT Observatory and associated ancillary facilities within the Mauna Kea Science Reserve (MKSR; tax map key [TMK] 4-4-15: 9), (b) construction and operation of the TMT Mid-Level Facility within Hale Pōhaku (TMK 4-4-15: 12), and (c) construction of electrical and communications infrastructure near Hale Pōhaku, within the Mauna Kea Forest Reserve (TMK 4-4-15: 1). The entire MKSR, Hale Pōhaku, and the portions of the Mauna Kea Forest Reserve near Hale Pōhaku, are designated as part of the State of Hawai‘i Conservation District, resource subzone, and therefore, a CDUP is required before construction can begin.

1.4 Scope of the Project

The TMT Project, referred to as the "Project," would consist of the construction and operation, and ultimately decommissioning, of the TMT Observatory, with a 30-meter optical/infrared telescope, below the summit of Maunakea[6] and the associated permanent and temporary ancillary facilities. The permanent ancillary facilities would include an Access Way to the observatory; a Headquarters facility in Hilo to manage operation of the observatory; a Satellite Office in Kamuela (Waimea) to support operation of the observatory; and a TMT Mid-Level Facility consisting of personnel facilities and infrastructure near and within Hale Pōhaku to support TMT Observatory operation. Temporary facilities during construction would include a construction staging area near the summit, a construction staging area and housing for construction workers within Hale Pōhaku, and construction staging areas near the port where Project components would be received.

1.5 Scope of Chapter 343 Environmental Analysis

HAR Title 11 Chapter 200 directs the focus of the environmental analysis, whereby "special emphasis shall be placed on environmental resources that are rare or unique to the region and the project site (including natural or human-made resources of historic, archaeological, or aesthetic significance)." Accordingly, the emphasis of the environmental analysis in this Draft EIS is placed on the TMT Observatory and Access Way below the summit of Maunakea due to this area's rare and unique resources, including cultural, biological, and visual resources. Other areas that would be affected, such as areas within and near Hale Pōhaku and in the vicinity of the Headquarters, are also discussed, but to a lesser degree unless a potential significant impact is identified.

The purpose and need of the proposed Project, the Project's objectives, and a Project description are provided in Chapter 2.0. The environmental analysis in Chapter 3.0 contains a discussion of potential Project impacts, including those on cultural and archaeological resources; biological resources, including the Wēkiu bug; visual and aesthetic resources; and geologic resources. Potential Project effects on a range of other resources are also discussed in Chapter 3.0, including land use plans and policies, water resources and wastewater, socioeconomic conditions, air quality, traffic, noise, solid and hazardous waste management, and power and communications.

Alternatives to the Project are discussed in Chapter 4.0 of this Draft EIS. The alternatives to the Project include (1) a no action alternative: not constructing the TMT observatory at Maunakea; and (2) locating the TMT Observatory at another nearby site on Maunakea referred to as E2.

[6] Maunakea is spelled as one word in this document because it is considered the traditional Hawaiian spelling (Ka Wai Ola, Vos. 25 No. 11). Maunakea is a proper noun, therefore spelled as one word in Hawaiian. This spelling is found in original Hawaiian language newspapers dating back to the late 1800s when the Hawaiian language was the medium of communication. In more recent years Maunakea has been spelled as two words, which literally mean "white mountain." Spelled as two words it is a common noun that could refer to any white mountain verses the proper name of this particular mountain on Hawai'i Island. The common "Mauna Kea" spelling is only used in this document where Mauna Kea is used in a proper name, such as the "Mauna Kea Science Reserve."

1.6 Summary of EIS Scoping Activities

On September 23, 2008, UH published the EISPN/EA for the TMT Project (UH, 2008). The publication was announced by the Office of Environmental Quality (OEQC) in The Environmental Notice, also dated September 23, 2008 (OEQC, 2008). The publication in The Environmental Notice opened the 30-day scoping period. Copies of the EISPN/EA were distributed to governmental agencies and parties that expressed interest and signed up on the TMT environmental process mailing list.

1.6.1 Summary of Public Involvement

Prior to the opening of the 30-day scoping period, the forthcoming EISPN/EA was advertised and interested persons and organizations were solicited to sign up on the TMT environmental process mailing list. Advertisements were run in the Hawai‘i Tribune Herald, West Hawai‘i Today, Honolulu Advertiser, Honolulu Star-Bulletin, The Hawai‘i Filipino Chronicle, and Ka Wai Ola (Office of Hawaiian Affairs' newspaper). More than 110 persons and organizations signed up to be on the mailing list prior to the publication of the EISPN/EA. Copies of the EISPN/EA were sent to the persons and organizations on the mailing list, as well as to other organizations and persons known to have an interest in Maunakea due to their involvement in previous projects.

During the 30-day scoping period, multiple ways to submit input on the Project's environmental review process were provided, including:

- The TMT environmental process website (www.TMT-HawaiiEIS.org) included a comment feature;
- A TMT environmental process toll-free hotline (1-866-284-1716) where comments could be recorded;
- Direct mail to the Chancellor of UH Hilo; and
- Public meetings where the public oral comments were either captured by facilitators or recorded privately and written comments were collected. Public meetings were held as summarized in Table 1-1.

Table 1-1: Summary of Public Scoping Meetings

Date	Location	Approx. Number of Public in Attendance	Number of Speakers
Oct. 6, 2008	Kohala High School Cafeteria	15	1
Oct. 8, 2008	Kahilu Town Hall (Waimea Family YMCA)	70	13
Oct. 9, 2008	Kealakehe Elementary School Cafeteria	20	9
Oct. 13, 2008	Ka‘ū High/Pāhala Elementary School Cafeteria	15	4
Oct. 14, 2008	Keaukaha Elementary School Cafeteria	90	22
Oct. 15, 2008	Pāhoa High School Cafeteria	50	20
Oct. 16, 2008	Neal S. Blaisdell Center Pīkake Room	30	9

The public meetings were advertised as follows:

- On the TMT environmental process website (www.TMT-HawaiiEIS.org) and toll-free hotline (1-866-284-1716);
- In five newspapers: Hawai‘i Tribune Herald, West Hawai‘i Today, Honolulu Advertiser, Honolulu Star-Bulletin, and Hawai‘i Filipino Chronicle; and
- On the EISPN/EA distribution cover letter.

During the scoping period, a number of submissions were received, as follows:

Public scoping meeting, October 2008.

- 78 people provided oral comments at the public meetings;
- 68 people or organizations provided scoping comments via the commenting tool on the TMT environmental process website;
- 39 letters with scoping comments were received in the mail;
- 27 scoping comment forms, which were available at the public meetings, were either collected at the meetings or were mailed to the Chancellor of UH Hilo following the meetings;
- 3 people recorded scoping comments on the toll-free hotline; and
- 2 emails with scoping comments were received by TMT Observatory Corporation personnel.

1.6.2 Agencies, Organizations, and Individuals Consulted

Agencies, organization, and individuals were consulted during the production of this Draft EIS, per HRS Chapter 343 and HAR § 11-200-9. Consultations included sending a copy of the EISPN/EA to a party and requesting input from them and collecting comments at public meetings, at other small group meetings, through the website, on the hotline, and in the mail. Appendix A provides a list of agencies, organization, and individuals who participated in the process.

1.6.3 Issues Raised During the Scoping Process

A summary of the scoping comments received is provided in Appendix B. The most frequently raised issues during the scoping period include:

- Since Maunakea is considered sacred by Hawaiians, there is a need to involve, learn from, and respect the Hawaiian community so that the construction and operational activities would be conducted in a sensitive and appropriate manner, with awareness being at the forefront of all activities. Mitigation measures such as cultural education for construction and operation workers were suggested. These issues are addressed in Section 3.2, Cultural Resources.

- There is a concern for archaeological/historical sites of reverence on the mountain, including sacred and spiritual places such as the pu‘u, Lake Waiau, and the Adze Quarry. It was suggested that mitigation measures be developed, such as visitor education, so that impacts to such sites would be minimized. These issues, including archeological sites in the vicinity of the proposed TMT Observatory, are addressed in Section 3.3, Archaeologic/Historic Resources.
- There was concern regarding the plant and animal species, such as the Wēkiu bug, palila bird, U‘au (Hawaiian Petrel), and Silversword. These issues, including the species and habitats in the project area, are addressed in Section 3.4, Biologic Resources.
- It is important to consider the potential visual impact of the Project on cultural and natural landscape of Maunakea. These issues are addressed in Section 3.5, Visual and Aesthetic Resources.
- There is strong interest in the impact of the Project on the socioeconomic landscape of the island and the potential for local residents to work for the Project during construction and operation. This issue is addressed in Section 3.9, Socioeconomic Conditions.
- While the proposed Project is the construction, operation, and the ultimately decommissioning of the TMT Observatory below the summit of Maunakea, there was interest and request for information concerning Chile as a potential location. Available information, including an evaluation of environmental issues pursuant to the laws and requirements of Chile is provided in Chapter 5.0.

1.7 Draft EIS Public Review and Comment

The announcement of this Draft EIS by OEQC in The Environmental Notice opens the 45-day comment period. The Draft EIS review and comment process, now starting, is accessible to all. To ensure accessibility to all, the review and comment process includes the following elements and features:

- Direct mail of this Draft EIS to the person, organizations, and agencies on the mailing list (Appendix A);
- Placing the Draft EIS for public review at all public libraries in the state;
- Interactive website (www.TMT-HawaiiEIS.org) that includes a Project fact sheet and frequently asked questions, an electronic copy of Draft EIS that can be downloaded, a tool to input and upload comments, and contact information;
- A toll-free hotline (1-866-284-1716) where information about the public meetings and locations where the Draft EIS is available for review is available and comments can be recorded; and
- Public meetings, accessible to persons with handicaps, that will be held, including six meetings on the Island of Hawai‘i and one on the Island of O‘ahu. These meetings are scheduled as shown in Table 1-2.

Table 1-2: Public Draft EIS Review and Comment Meeting Locations and Dates

Date	Area	Location	Time
June 16 (Tue)	Waimea / Kamuela	Waimea Elementary School Cafeteria	5-8pm
June 17 (Wed)	Hilo	Hilo High School Cafeteria	5-8pm
June 18 (Thr)	Pāhoa / Puna	Pāhoa High School Cafeteria	5-8pm
June 22 (Mon)	Ka'ū	Ka'u High/Pāhala Elementary School Cafeteria	5-8pm
June 23 (Tue)	Hāwī / Kohala	Kohala Cultural Center	5-8pm
June 24 (Wed)	Kona	Kealakehe Elementary School Cafeteria	5-8pm
June 25 (Thr)	Honolulu	Farrington High School Cafeteria	5-8pm

The public meetings will be advertised as follows:

- On the website (www.TMT-HawaiiEIS.org) and toll-free hotline (1-866-284-1716);
- In five newspapers: Hawai'i Tribune Herald, West Hawai'i Today, Honolulu Advertiser, Honolulu Star-Bulletin, and Hawai'i Filipino Chronicle; and
- On the Draft EIS distribution cover letter.

The public meetings will consist of the following general components:

- 5:00 to 6:00 – Open House
- 6:00 to 6:30 – Presentations
- 6:30 to 8:00 – Facilitated public comment period

Comments are required to be submitted or postmarked by July 7, 2009. Comments can be submitted via the website (www.TMT-HawaiiEIS.org), the toll-free hotline (1-866-284-1716), at public meetings, or mailed to:

Original to:
TMT Observatory Project
Office of the Chancellor
University of Hawai'i at Hilo
200 W. Kāwili Street
Hilo, Hawai'i 96720-4091

Copy to:
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu, Hawai'i 96813

A comment form is provided in Appendix C; however, comments do not need to be submitted on this form. The form is provided for convenience only.

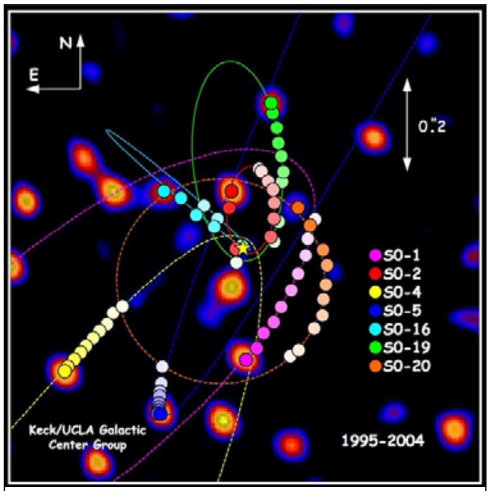
2.0 Project Description

This chapter presents the purpose and need of the proposed Project, the Project's objectives, and a Project description. Reasonable alternatives to the Project are discussed in Chapter 4.0 of this Draft EIS.

2.1 Project Background

The critical need for an optical/infrared[7] telescope[8] with a 30-meter primary mirror to continue the scientific advancement of the last decades was both identified by the U.S. scientific community and assigned a priority by the Canadian scientific community. In response to this need, the TMT Observatory Corporation was formed to manage initial planning, and then design, build, and operate the TMT Observatory[9] housing a 30-meter primary mirror telescope.

The TMT Observatory Corporation is a non-profit partnership of the University of California (UC), the California Institute of Technology (Caltech), and the Association of Canadian Universities for Research in Astronomy (ACURA). The National Astronomical Observatory of Japan (NAOJ) is also a collaborator and potential partner. This private partnership would fund Project construction and manage Project operations. No State of Hawai‘i funds are currently involved.



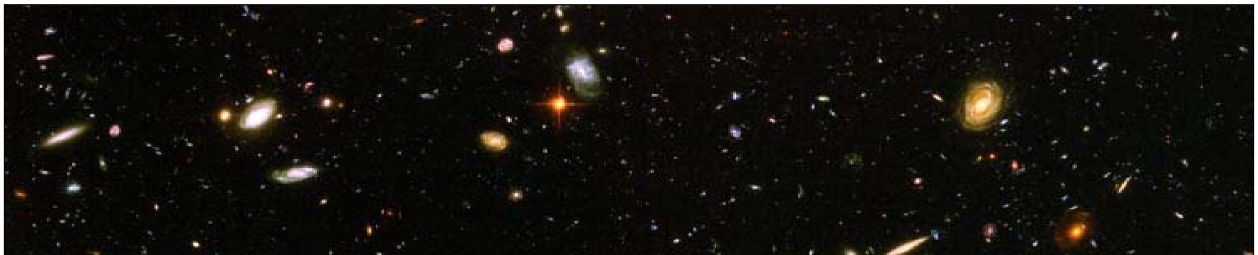
Analyzing the Central Milky Way supermassive black hole.
A. Ghez, UCLA

2.2 Purpose and Need

The Project's primary purpose is to locate the TMT in Hawai‘i and provide the most advanced and powerful ground-based observatory in the history of science for carrying out astronomical research to enable discoveries about the nature and origins of the physical world, from the first formation of galaxies in the distant past and distant 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 astronomy research for the last 150 years, and locating the TMT in

[7] 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
[8] 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.
[9] An observatory includes the telescope(s), the dome(s) that contain the telescope(s), and the instrumentation and support facilities for the telescopes that fall under a common ownership.

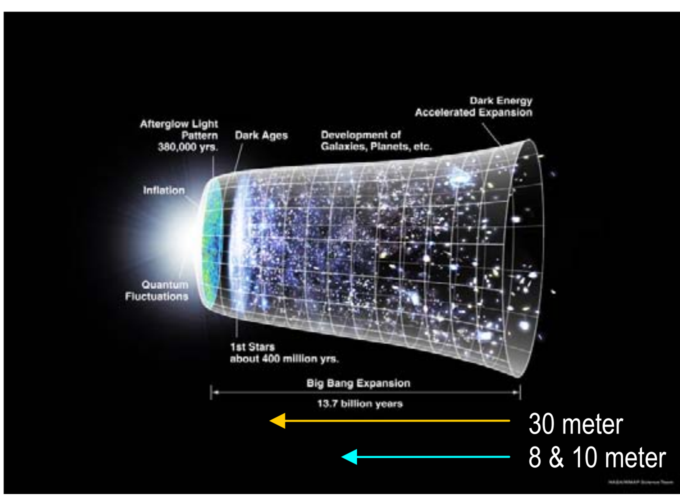


This image from the Hubble Space Telescope shows a portion of sky that is smaller than the largest impact crater on the Moon. All but a few of the sources seen are galaxies, some nearby, some in the distant reaches of the Universe. The currently-available 8- and 10-meter observatories can analyze the brighter objects in the image. With a 30-meter observatory, the fainter objects, that are the first to form after the Big Bang, could be analyzed.
Hubble news release STScl-2004-07. Image taken between Sept. 24, 2003 and Jan. 16, 2004.

Hawaiʻi would help maintain the U.S.' leadership in astronomy research, discovery, and innovation. Additionally, by bringing the Project to Hawaiʻi, the potential significant socioeconomic benefits, including employment and education, of the Project would be realized by the people of Hawaiʻi. The Project would require a CDUP for the TMT Observatory to be built and operated on Maunakea.

Example Spiral Galaxy
Chauvin et al. 2004

Since the dawn of human existence, people have been looking up into the sky and wondering about our universe. The quest to answer fundamental questions about the nature and workings of the universe has been pursued through the ages, and continues today. The Project would continue this quest. The TMT concept was developed to address the need to overcome the limitations of existing astronomical facilities. The TMT would push the frontier of technology, fully integrating the latest innovations in precision control, segmented mirror design, and adaptive optics (AO) to correct for the blurring effects of Earth's atmosphere. When used with an AO system, the TMT would provide sharper images than the most capable existing optical/infrared observatories by a factor of three, and greater sensitivity by a factor of ten or more. Its 30-meter segmented primary mirror would enable astronomers to



A 30-meter observatory could peer back in time much further than current 8- and 10-meter observatories, or space-based telescopes. This ability could help answer questions related to how the very first galaxies formed and evolved.

Source: NASA/WMAP Science Team

observe objects nine-times fainter than existing 10-meter telescopes in an equal amount of time. These improvements in capability would allow significant advances in most areas of astronomy research.

In some areas, the capabilities of the TMT would be uniquely important to making breakthrough discoveries. With the TMT, observations of the first stars and galaxies formed after the Big Bang would 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 would provide a giant step forward in capability. The combination of great sensitivity and unique spatial resolution of the TMT would be key 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 would also make TMT an extremely powerful observatory for the discovery and characterization of planets orbiting other stars.

The specific need for an observatory like the TMT to address the outstanding constraints in astronomy and astrophysics research was identified in the 2001 National Academy of the Sciences Decadal Survey for Astronomy:

> "The Giant Segmented Mirror Telescope (GSMT), the committee's top ground-based recommendation, is a 30-meter class ground-based telescope that will be a powerful complement to the Next Generation Space Telescope (NGST) in tracing the evolution of galaxies and the formation of stars and planets…GSMT will use adaptive optics to achieve diffraction limited imaging in the atmospheric window between 1 and 25 micrometers (μm) and unprecedented light-gathering power between 0.3 and 1 μm[10]."

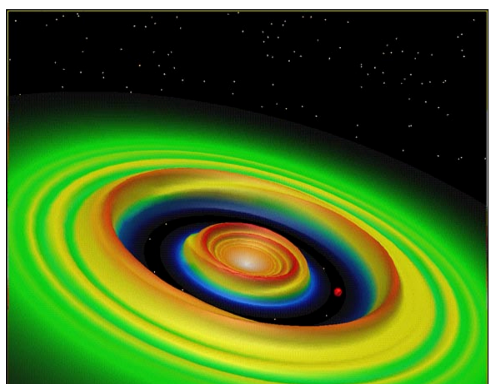
The TMT design has and will continue to follow these guidelines from the Decadal Survey. The TMT capabilities would complement those of the next-generation NASA James Webb Space Telescope, Atacama Large Millimeter Array (ALMA), and large imaging surveys of the sky. The TMT would be a critical part of future astronomy facilities planned for 2015 and beyond.

2.3 Project Objectives

The primary objects of the Project include:

Knowledge Growth. From a scientific standpoint, the Project's objective is to provide for astronomers a tool that is powerful and precise enough to explore virtually every aspect of the Universe, from the formation of the first star following the Big Bang to the current state of the Milky Way Galaxy. With TMT, many of the most fundamental questions of the coming decades could be addressed, including:

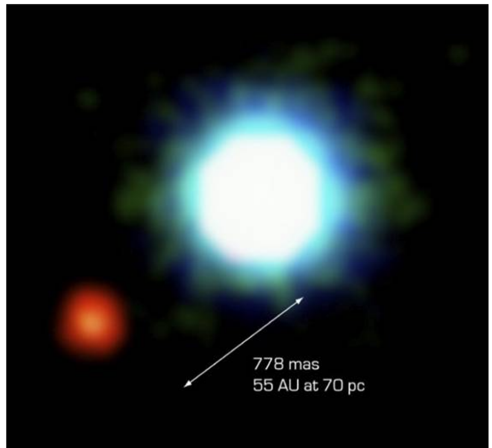
- What is the nature and composition of the Universe?



Simulation of new planet formed (red dot) around young star.
G. Bryden, CIT

[10] μm is a micrometer, which is one-millionth of a meter and also known as a micron.

- When did the first galaxies form and how did they evolve?
- What is the relationship between black holes and galaxies?
- How do stars and planets form?
- What is the nature of extra-solar planets?
- Is there life elsewhere in the Universe?



AO image of a planet 4 times the mass of Jupiter orbiting a brown dwarf star.
Chauvin et al. 2004

Education. The TMT partners and UH are all universities or closely allied with universities and have a primary commitment to education in all subject areas, but especially science and technology education. Astronomy is well known as a "gateway" science. Many students get their introduction to the scientific method and tools of science in astronomy classes and then continue into technical and science careers. Therefore, maintaining the U.S.' leadership in astronomy promotes not just astronomy but the larger science community. The objectives of the Project, therefore, include to utilize the TMT as an important educational tool and to attract top students and scholars in science to our institutions.

Synergy with Existing Hawai'i Observatories. An important objective of the Project is to leverage the capacity and abilities of the TMT partners' existing observatories, including the Keck, Canada-France-Hawai'i Telescope (CFHT), and Subaru. While these observatories, all located on Maunakea, are world-leading observatories today, their future scientific productivity could be increased through teaming with a next generation observatory, such as the TMT. For observatories co-located at the same mountain there would be many opportunities to integrate science programs and to develop complementary instrumentation.

Outreach and Community. To integrate science and education with culture and sustainability in the Project is also a core objective of the Project. The TMT partnership is committed to working with UH in achieving this objective. Sharing the scientific knowledge gained through the Project and using the wide interest in astronomy to introduce students and the general public to science, technology, engineering, and math (STEM), are core objectives. In addition, in order to build and maintain capable personnel in Hawai'i, the Project would help develop STEM proficiencies among members of the local communities in collaboration with the local public, charter, and private K-12 schools, and with UH Hilo and Hawai'i Community College (HawCC). The TMT partner institutions are also committed to proper environmental stewardship and the concept of sustainability planning for operations of the observatory.

2.4 Project Components

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

- "TMT Observatory" refers to the components of the Project located below the summit, in the upper elevations of Maunakea. 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 that would be provided to access and operate the TMT Observatory. Improvements in the Access Way would generally include a surface roadway and underground utilities.
- "TMT Mid-Level Facility" refers to facilities and improvements located within or near Hale Pōhaku. This would generally include replacing two existing construction dormitory/dining/recreation buildings, refurbishing existing construction cabins, grading areas for parking and construction staging areas, and upgrading electrical and communications equipment.
- "Headquarters" refers to the facility located in Hilo to manage activities at and support operation of the TMT Observatory and TMT Mid-Level Facility. This includes an office building with a parking area.
- "Satellite Office" refers to the smaller facility located in Kamuela (Waimea) to provide additional support to the TMT Observatory and TMT Mid-Level Facility. This includes an office building with a parking area.

2.5 Project Location and Design

The following sections describe the Project components' location and design.

2.5.1 TMT Observatory

Location

The TMT Observatory is proposed to be located on Maunakea within the MKSR on Hawaiʻi Island in the State of Hawaiʻi (Figure 2-1). The Island of Hawaiʻi is comprised of five volcanoes, one of them actively erupting. The island is politically the County of Hawaiʻi and had a population of approximately 149,000 during the 2000 census. The summit of Maunakea is situated at a distance of approximately 27 miles (40 miles by road) from Hilo and 20 miles (45 miles by road) from Waimea. Hilo is the seat of County government and a port town of roughly 41,000 residents, and Waimea is a town of approximately 7,000 residents[11] in the saddle between Maunakea and Kohala Mountain (Figure 2-1). Well maintained roads connect the summit of Maunakea with both Hilo and Waimea, although a portion of the road near the summit is unpaved.

[11] United States Census, 2000.

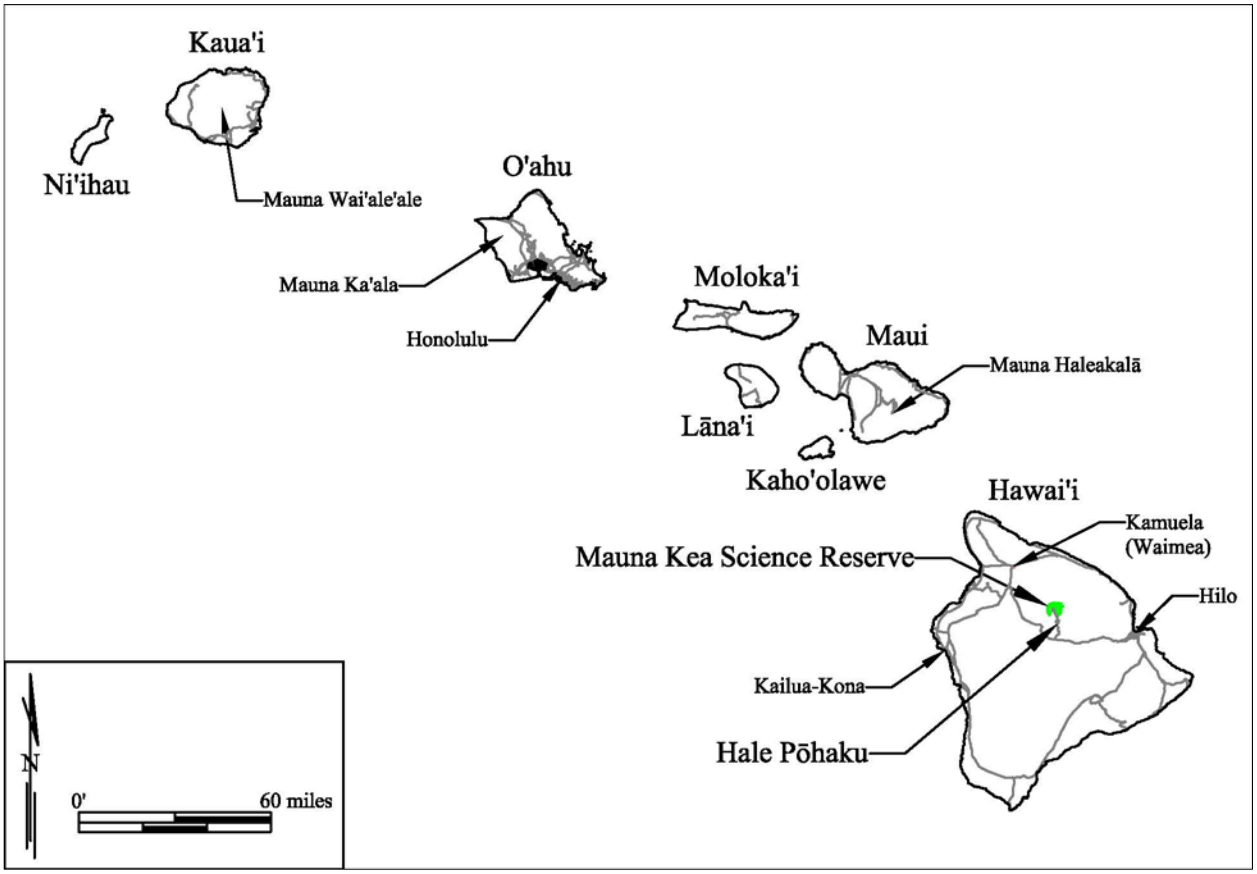


Figure 2-1: Project Location

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. The MKSR is also ceded land held in trust by the State of Hawai‘i, is managed by the State of Hawai‘i Department of Land and Natural Resources (DLNR), and is leased by DLNR to the UH. 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[12] (Figure 2-2).

[12] 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. This is not being pointed out to reduce the number of “observatories” present on Maunakea, it is merely a clarification of the terms.

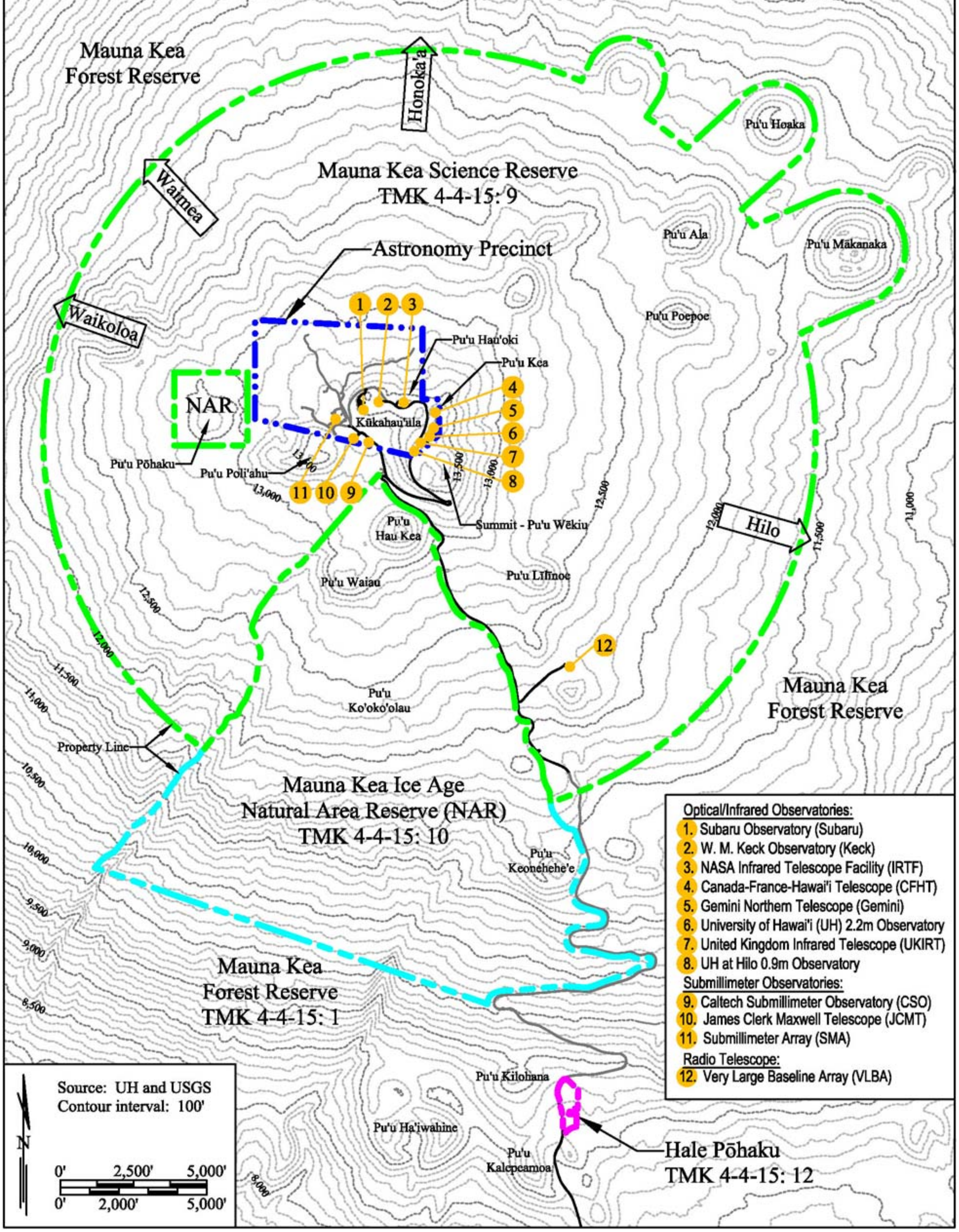


Figure 2-2: Maunakea Overview

The University of Hawai‘i prepared and adopted the Mauna Kea Science Reserve Master Plan (the 2000 Master Plan; UH, 2000) that includes a "Physical Planning Guide." The planning guide includes observatory siting areas and site selection criteria to be followed when planning a new observatory on Maunakea. UH also prepared a Mauna Kea Science Reserve Master Plan Final Environmental Impact Statement (UH, 1999) for the 2000 Master Plan. CMP Management Action FLU-1 states that future facility planning should follow the guidelines presented in the 2000 Master Plan.

The 2000 Master Plan limits future development to Areas A, B, C, D, E, and F within the Astronomy Precinct (Figure 2-3). By doing this the Master Plan removed the possibility of developing an observatory on an undeveloped pu‘u within the MKSR. Areas A and B are on the Kūkahau‘ula pu‘u but are already developed with eight optical/infrared observatories. The 2000 Master Plan indicates redevelopment or expansion of those existing facilities would be possible, but no new disturbance to the Kūkahau‘ula Traditional Cultural Property (TCP) or the cinder cone habitat should occur. Area C is already developed with three submillimeter observatories. The 2000 Master Plan indicates redevelopment of those existing facilities would be possible, but no new disturbance to Kūkahau‘ula or the cinder cone habitat should occur. However, Area C extends into the northern plateau area, beyond Kūkahau‘ula and the cinder cones, and the 2000 Master Plan indicates that expansion of the SMA could occur in that portion of Area C and also into adjoining Area D.

When it comes to siting new optical/infrared observatories on Maunakea, the 2000 Master Plan states "the first priority … will be the recycling of existing facilities that have aging technology." In Areas A and B the maximum height and diameter of a new observatory is limited to approximately 130 feet by the 2000 Master Plan; the plan also indicates new developments should not disturb additional areas of Kūkahau‘ula or cinder cone habitat. The height and diameter restrictions in Areas A and B are related to a number of factors, including visibility, potential impacts to existing observatories, and wind forces. "The second priority for siting [new optical/infrared observatories] will be at two new [areas] within the Astronomy Precinct, and only if a suitable summit ridge site cannot be utilized for redevelopment." The two new areas indentified in the 2000 Master Plan are Areas E and F.

Recycling an existing optical/infrared observatory in Area A or B is not an option for the TMT Observatory because the TMT Observatory would exceed the diameter and height requirements. In addition, none of the existing observatories has a large enough footprint for the development of the TMT Observatory without additional disturbance to Kūkahau‘ula or the cinder cone habitat. Therefore, the TMT Observatory would comply with the second priority as it is proposed to be sited in Area E.

Area E with 4-wheel drive accesss road
Photo by CSH

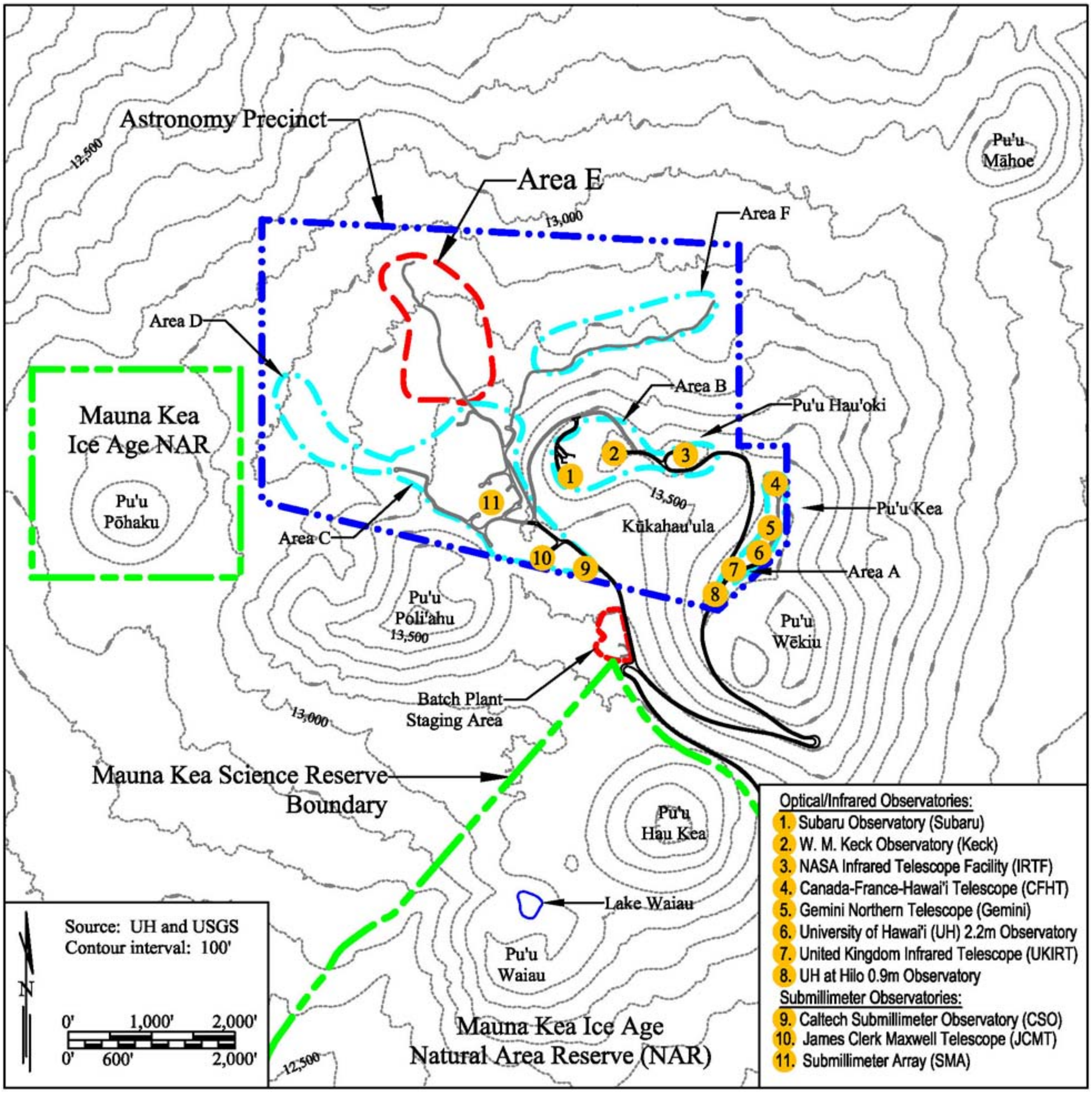


Figure 2-3: Maunakea Summit Region

The 2000 Master Plan provided a number of criteria to assist in the selection of an appropriate site for the Next Generation Large Telescope (NGLT). The TMT Observatory fits the definition of a NGLT: a ground-based telescope with a primary mirror of 25 to 50 meters in diameter. The site selection criteria include:

- Minimize visual impacts from significant cultural areas.
- Avoid archaeologic sites.
- Minimize impact of Wēkiu bug habitat.
- Avoid or minimize view from Waimea, Honoka‘a, or Hilo.

- Proximity to roads and existing infrastructure.
- Minimize impact on existing facilities.

In addition, the 2000 Master Plan indicates that Areas E and F have not been thoroughly tested to establish if potential observatory sites within them provide suitable astronomical "seeing" conditions. Therefore, site selection is contingent on positive findings during site testing to evaluate seeing conditions for the telescope.

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 elevation 13,796 feet. Area E is located approximately 1/2-mile northwest of the eight existing optical/infrared observatories located near the summit, at elevations of 13,600 to 13,775 feet (Figure 2-3).

Within Area E, the TMT Observatory would 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 (Figure 2-4). This site is known as 13N in reference to its elevation and its location on the northern plateau. Consideration of the 13N site for siting an observatory dates back to the 1960s, when both the 13N site and a site near the summit (the site of the existing UH 2.2 meter observatory) were tested for the placement of a new observatory. In the mid-1960s UH selected the summit site because "seeing indicators at the summit [were] slightly superior." [13]

Site testing performed by TMT (Section 4.1) confirmed that the 13N site has good astronomical seeing characteristics. Analysis performed by TMT indicates that areas closer to the Kūkahau'ula cinder cones, including the location within Area E specified for the NGLT in the 2000 Master Plan, likely have inferior seeing characteristics. Therefore, the 13N site is proposed for the TMT Observatory.

The building and operation of the TMT Observatory on Maunakea would require a sublease of the area from UH, which leases this ceded land from the DLNR. If TMT chooses Hawai'i as the site, they would be required to negotiate a sublease agreement with UH. The sublease would be subject to approval first by the UH BOR followed by approval by the Board of Land and Natural Resources (BLNR). The sublease consideration would likely include benefits for the Island of Hawai'i, as well as observing time for UH.

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[13] http://www.ifa.hawaii.edu/users/jefferies/Selecting_a_specific_site.htm

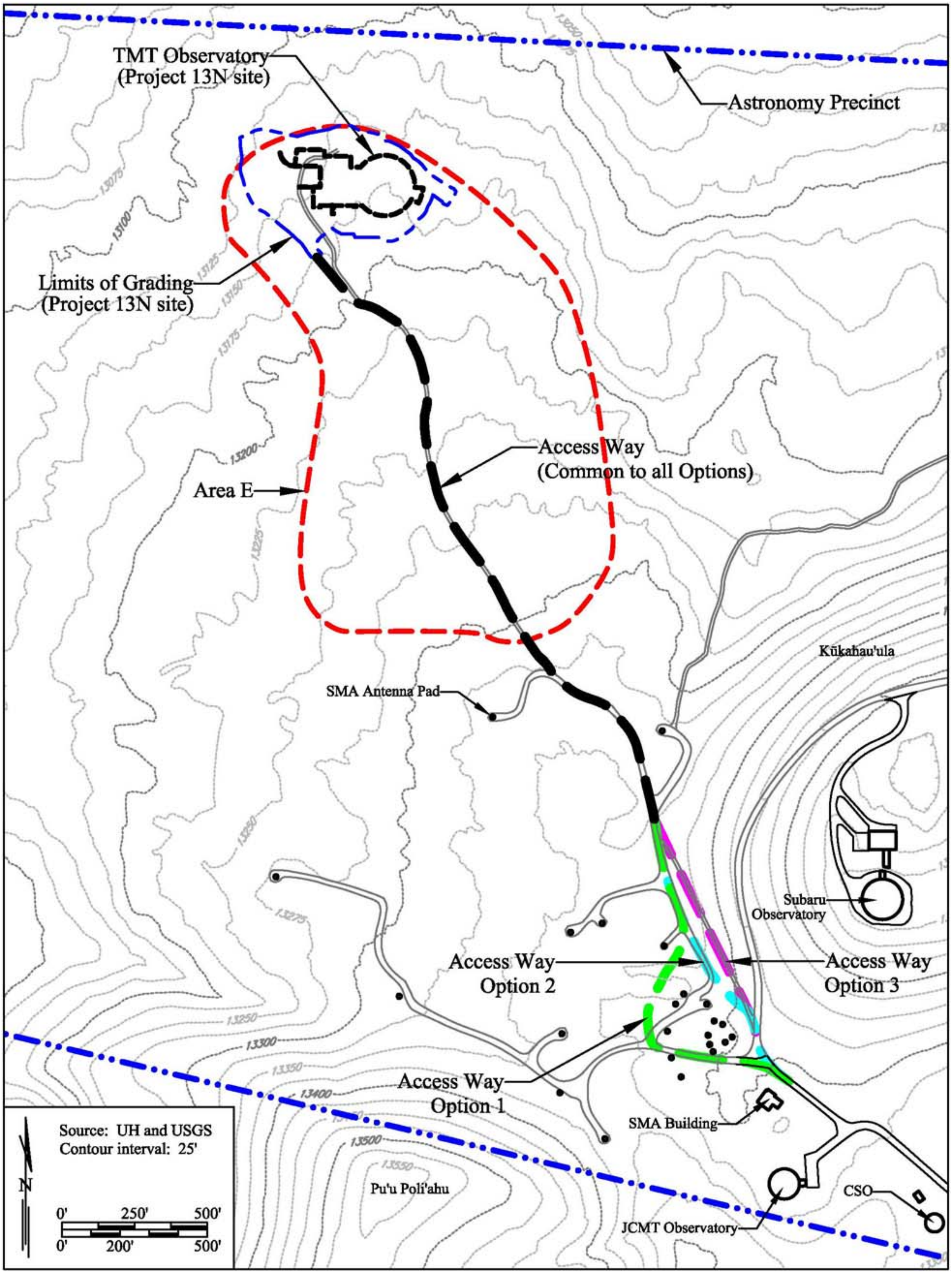


Figure 2-4: Proposed TMT Observatory and Access Way

Telescope Design

The core of the TMT Observatory is the 30-meter aperture telescope, referred to as the TMT. The telescope would consist of the following primary components:

1. The primary mirror – the "eye" of telescope– would be 98 feet (30 meters) in diameter. This mirror would be made up of 492 individual mirror segments operating as one to create a "segmented mirror" that functions as a single mirror.
2. The secondary mirror sits above the primary mirror and would direct the light collected by the primary mirror to the tertiary mirror.
3. The tertiary mirror sits in the middle of the primary mirror and would direct the collected light into different instruments for analysis.

Figure 2-5 illustrates the telescope assembly, with the numbered list above corresponding to the numbers on the figure.

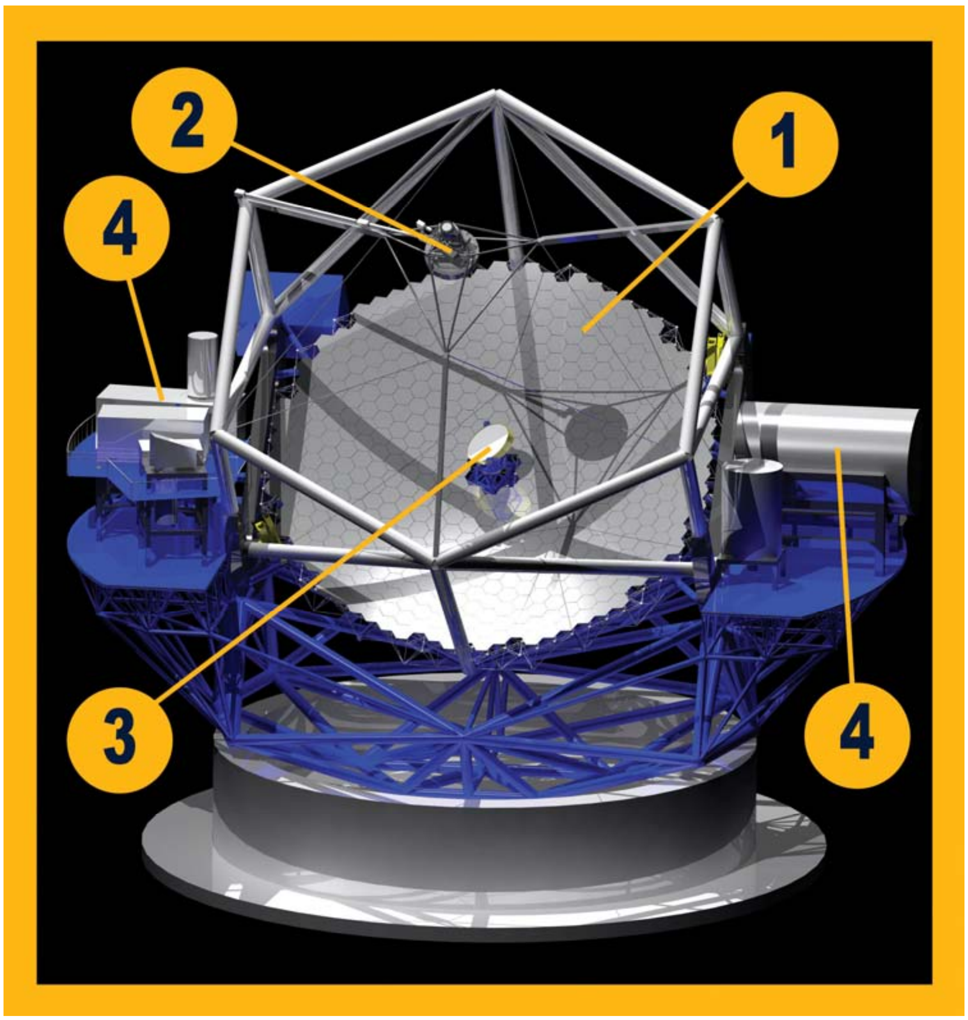


Figure 2-5: Proposed Thirty Meter Telescope Overview

TMT Observatory Design

The TMT Observatory design is being and will continue to be developed in consultation with OMKM through their design review process. Whenever possible, the Project would 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 is not complete and will continue in parallel with the Chapter 343 EIS process. No significant design changes, such as Project site or dome and support build size and height, are anticipated; however, adjustments to finer details could still take place. The proposed observatory would include the following:

- The telescope, described above. The surface of the primary mirror would 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 (number 4 in Figure 2-5).
- The TMT AO system. The TMT also would 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 AO system would 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 would generate each of these eight beams using a 25-watts laser; the laser light would appear yellow (0.589 microns – the sodium D2 line).
- The dome housing the telescope would be a Calotte type enclosure with the following characteristics (Figure 2-6 and Figure 2-7):
    - Total height of 180 feet above the ground surface, with an exterior radius of 108 feet.
    - The dome shutter would be 102.5 feet in diameter and it would retract inside the dome when opened.
    - The dome would 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.
    - The Calotte dome base, cap, and shutter structures would appear rounded and smooth and have a reflective aluminum-like exterior coating.
    - The fixed cylindrical structure below the rotating base would enclose 35,000 square feet, and extend to 25 feet above grade. The structure would be lava-colored.
    - The dome base structure and dome fixed structure would have a combination of 98 vents that would be closed during the day and would open at night. The vents would be used to maintain a temperature equilibrium between interior and exterior air at night and manage air flow through and around the dome.
- The support building attached to the dome would be a three-level building attached to the dome on two levels (Figure 2-6). The building design would use terracing, whereby three

ascending levels would match the natural contours of the site. The building would have a footprint of approximately 28,000 square feet, a total interior floor area of roughly 75,000 square feet, a flat roof, and be lava-colored. The support building would include the following spaces:

- Mirror coating and staging facility on the middle "observatory" level.
- Laboratory and shop spaces, including a computer room, engineering and electronics laboratories, and mechanical shop, on the observatory level.
- Utility spaces – including electrical services, chillers, a generator, two 44,000-gallon water tanks with pumps for fire suppression and other non-potable water needs, restrooms, two 5,000-gallon liquid waste storage tanks, and fluid dynamic bearing pumps that control the movement of the telescope - primarily on the lower "utility" level.
- Administration space on the upper "administration" level, including offices and a kitchenette.
- Visitor and public spaces located on the administration level, consisting of a lobby, restroom, and viewing platform.

• Parking area for observatory staff and delivery vehicles (Figure 2-7). Parking areas would be unpaved and located outside each level of the support facility. A double-walled 5,000-gallon fuel storage tank for an emergency generator and electric transformers would be located outside the utility level.

The entire footprint of the TMT Observatory dome, support building, and parking area would be roughly five acres, including the area of disturbance during construction. A small portion of this area has already been disturbed by the existing 4-wheel drive road and site testing equipment used in the past.

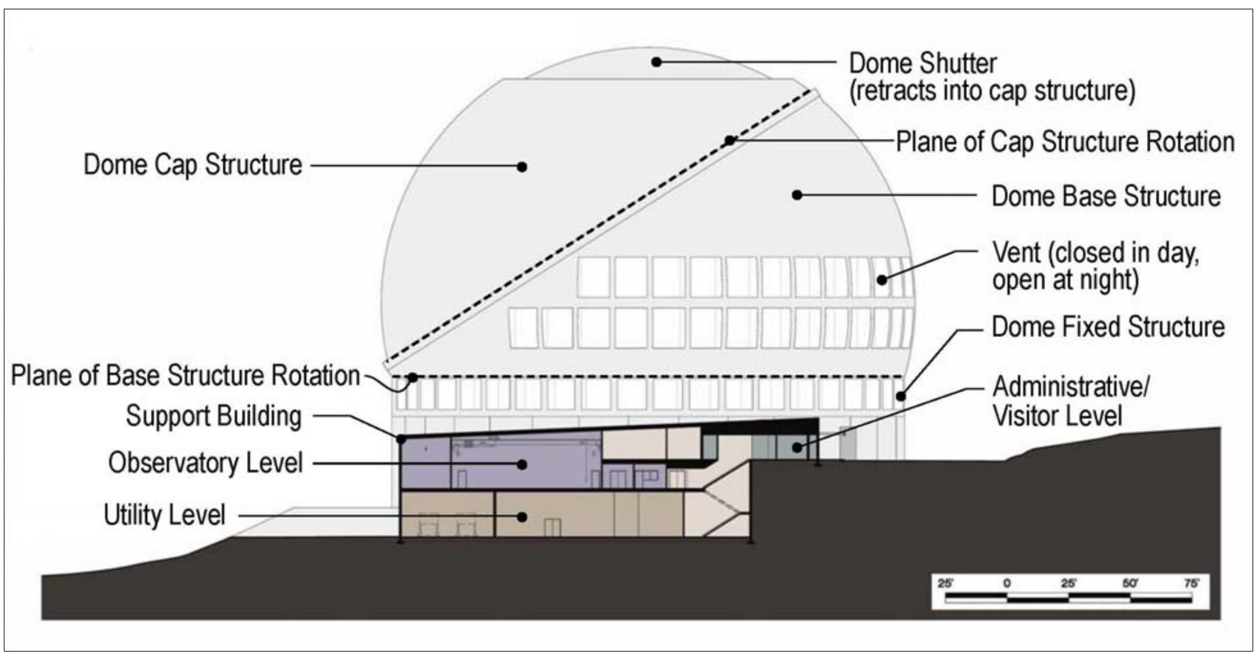


Figure 2-6: Proposed TMT Observatory Cross Section

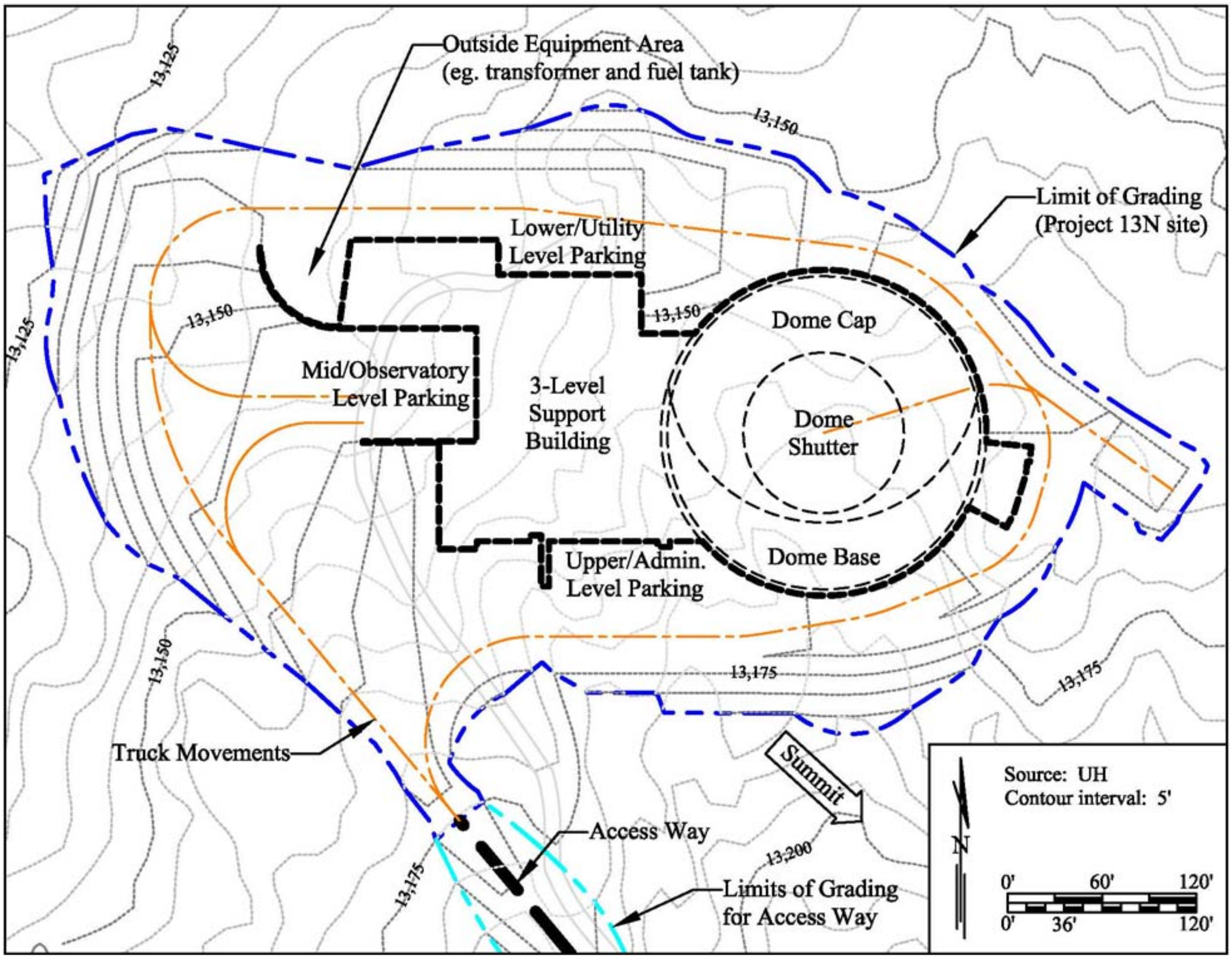


Figure 2-7: Proposed TMT Observatory Plan View and Grading Plan

2.5.2 Access Way

The Access Way would include a road and utility services to the TMT Observatory from existing facilities. Currently, utility services exist along the Maunakea Access Road to a point across the road from the SMA building. The Access Way would start at that point and extend to the TMT Observatory (Figure 2-4). The necessary switch boxes to provide power and communication to the TMT Observatory would be placed above ground next to the existing ones across the road from the SMA building. To the extent possible utilities from that point would be placed beneath the road to reduce the footprint of disturbance. Hawaiian Electric and Light Company (HELCO) would be granted an easement to maintain electrical service to the TMT Observatory.

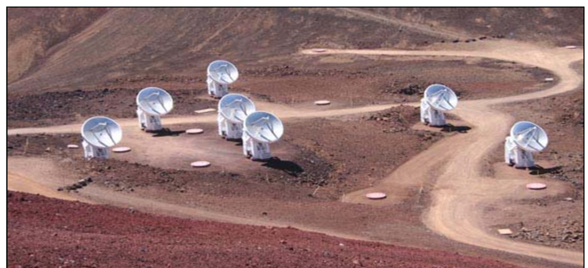
As with the TMT Observatory design, the Access Way design is being and will continue to be developed in consultation with OMKM through their design review process. The existing SMA facility to the west and the unnamed pu‘u to the east (on which Subaru sits) create a challenge to the route of the Access Way. Three options for the Access Way through or around the core of the SMA facility are being considered. Beyond the core of the SMA facility the route of the Access Way would follow the existing SMA roads and existing 4-wheel drive road to the extent possible. The Access Way beyond the SMA core would be roughly half a mile long, have a maximum slope of 10 percent, and be unpaved.

The Access Way would have the following general characteristics, regardless of the specific route option:

- An unpaved 24-foot wide travel surface with 12-inch shoulders for a total width of 26 feet;
- Banks graded to achieve a 2.5:1 slope; and
- Underground conduit with pull boxes and the necessary electric and communication cables.

All three of the Access Way options would be paved in the vicinity of the SMA core to avoid generating dust that could accumulate on the SMA antennas. Otherwise, each option would share the same general characteristics presented above. The three options are illustrated in Figure 2-4 and described in the following sections.

Option 1 – Through SMA



SMA Core

This option would follow the primary SMA road off the Maunakea Access Road, and then proceed through the lava flow before reconnecting with the SMA road. It is not possible to use the SMA road entirely because the first turn is too tight for large vehicles, such as construction trucks. This segment of the Access Way would be roughly 1,400 feet (quarter mile) long. Approximately 600 feet of this segment would be new road, with the remaining 800 feet using the existing SMA roads. The maximum slope of the road would be 6 percent.

Option 2 – Near SMA

This option would cut off the Maunakea Access Road between the SMA road and the currently blocked old 4-wheel drive road and connect with the SMA road once beyond the SMA core. This segment of the Access Way would be roughly 1,000 feet long. Approximately 275 feet of this segment would be new road, with the remaining 725 feet using existing SMA roads. Along the short section of the new road the maximum slope of the road would be 15 percent.

Blocked 4-wheel drive road (left) and SMA road (right).

Option 3 – 4-Wheel Drive Road

This option would follow the currently blocked old 4-wheel drive road and then connect with the SMA road. This segment of the Access Way would be roughly 1,000 feet long. This option would require widening of the old 4-wheel drive road over a distance of 760 feet. The maximum slope of the road would be 9 percent. Due to the steepness of the pu‘u, a retaining wall up to 8 feet high would be built along a 700-foot long portion of the road to avoid grading a large portion of the Pu‘u.

2.5.3 TMT Mid-Level Facility

Like the existing Maunakea observatories, Project personnel would utilize the existing Hale Pōhaku facilities, including the dorms, cafeteria, office space, and utility infrastructure. These facilities are located within Hale Pōhaku (TMK 4-4-15: 12) and are operated by Mauna Kea Observatories Support Services (MKSS). Some existing utilities are located nearby in the surrounding Mauna Kea Forest Reserve (TMK 4-4-15: 1). The Project would also build a new TMT Mid-Level Facility. The TMT Mid-Level Facility improvements would include both replacement and remodeling of facilities within Hale Pōhaku and infrastructure improvements nearby in the Mauna Kea Forest Reserve (Figure 2-8). The following sections describe the proposed TMT Mid-Level Facility improvements.

In Hale Pōhaku

The Project would upgrade facilities within Hale Pōhaku. The upgrades would initially support the construction-phase staff, which would be larger than the operational-phase staff.

Hale Pōhaku: Keck construction dorms and Subaru construction cabins in foreground, MKSS cafeteria in background.

The TMT Mid-Level Facility improvements within Hale Pōhaku would include (Figure 2-8):

- Replacing the existing vacant “Keck” construction dormitory facilities that are not up to current standards with new two-story dormitory/dining/recreation facilities that are up to standards. Remodeling the four “Subaru” construction cabins. These cabins are currently regularly used by the VIS personnel, rangers, and volunteers.
- Installing a new septic system to service the replacement and remodeled facilities.
- Grading the western portion of the lower part of Hale Pōhaku for parking and construction staging, as discussed in Section 2.6. The parking area would include parking for about 20 vehicles.

The design of these facilities would be reviewed by the OMKM design review committee to ensure their compliance with requirements. The planned improvements for the TMT Mid-Level Facility within Hale Pōhaku would disturb a roughly 3.2-acre area. The area has been previously disturbed, primarily by construction camps for Subaru and Keck observatories.

Upon completion of TMT Observatory construction, these facilities would become the property of UH. They would be transformed into useful space for the long-term needs of Hale Pōhaku and MKSR. MKSS would manage and use these facilities as they see fit.

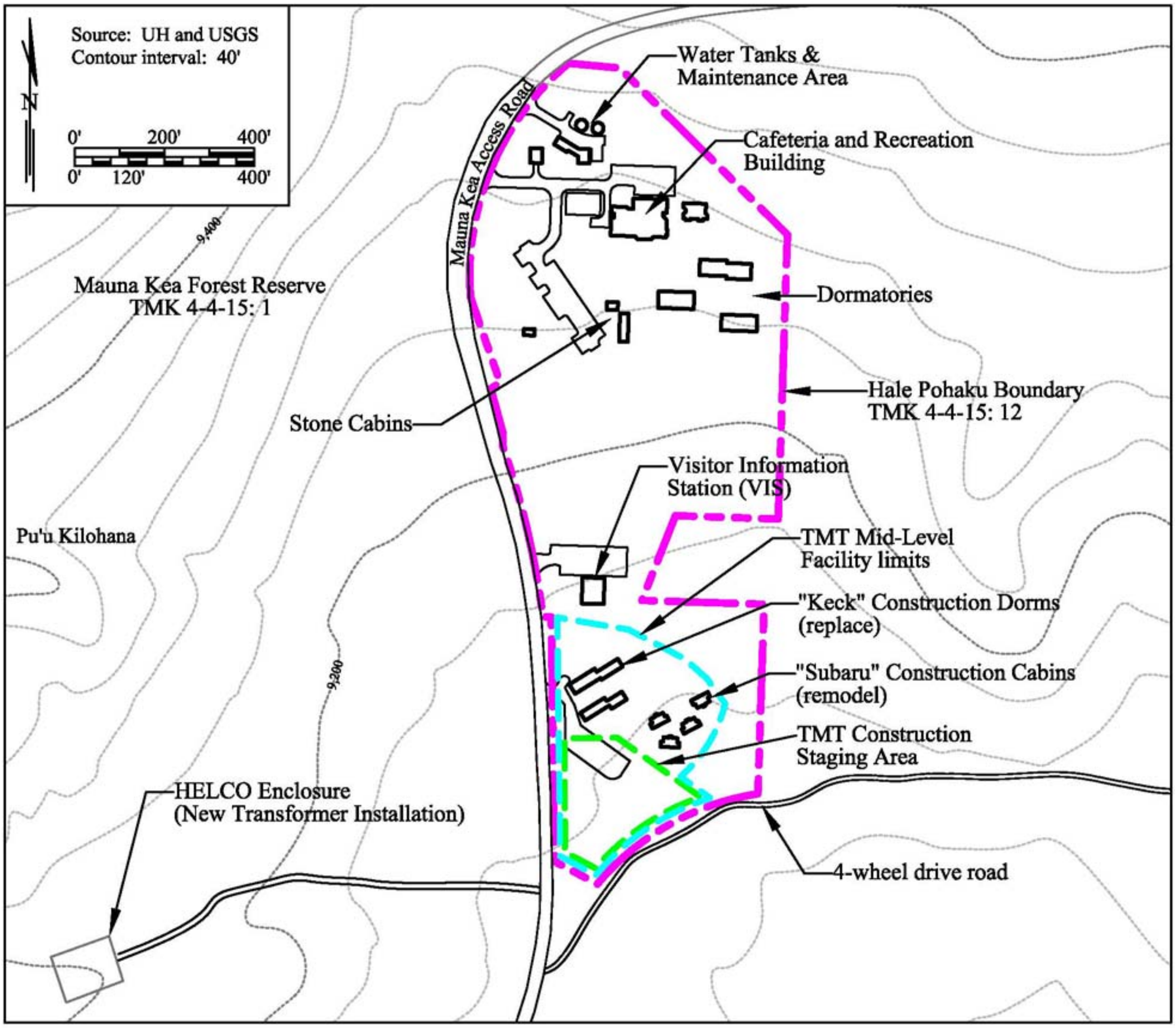


Figure 2-8: Existing and Proposed Hale Pōhaku Facilities

Near Hale Pōhaku

A new transformer would be installed in the HELCO compound, across Maunakea Access Road from Hale Pōhaku in the saddle between Pu‘u Kilohana and Pu‘u Kalepeamoa (Figure 2-8). The new transformer would be placed next to the existing transformers. The existing fenced compound would be expanded slightly to make room for the new transformer.

HELCO compound near Hale Pōhaku, from Pu‘u Kilohana.
Photo by CSH

In addition, electrical service from the transformer compound near Hale Pōhaku to the existing utility boxes across the road from the SMA building would be upgraded to support the TMT Observatory's power requirements. This would be done by placing new electric conducting wire in existing spare conduits. The existing conduit is located approximately 50 feet west of the Maunakea Access Road and has pull boxes located approximately every 300 feet along the conduit. Installing new wire in the conduit would not result in any new disturbance.

2.5.4 Headquarters

Due to the rigors of living and working at high elevation, observatories build headquarter facilities at lower elevations for the majority of their administrative and operations staff. Most of the staff does not need to directly access the telescope on a daily basis. TMT has planned its operation to minimize the number of activities needing to be done by staff at the TMT Observatory and plans to maintain and operate much of the equipment remotely from the Headquarters and/or Satellite Office. This reduces the number of trips to and people at the TMT Observatory.

The Headquarters would be located in Hilo on the UH Hilo campus, within the University Park of Science and Technology (University Park) development. University Park consists of portions of TMK 2-4-1: 7 and all of TMK 2-4-1: 41. Some existing observatories have their headquarters in University Park. The options being considered for the Project Headquarters within University Park are all within TMK 2-4-1: 7 and are (1) the reuse and/or improvement of the CSO Headquarters, or (2) a new facility on a lot behind the SMA Headquarters (Figure 2-9). The Headquarters would be an approximately 20,000 to 35,000 square foot office building; its architectural design would depend on the selected location.

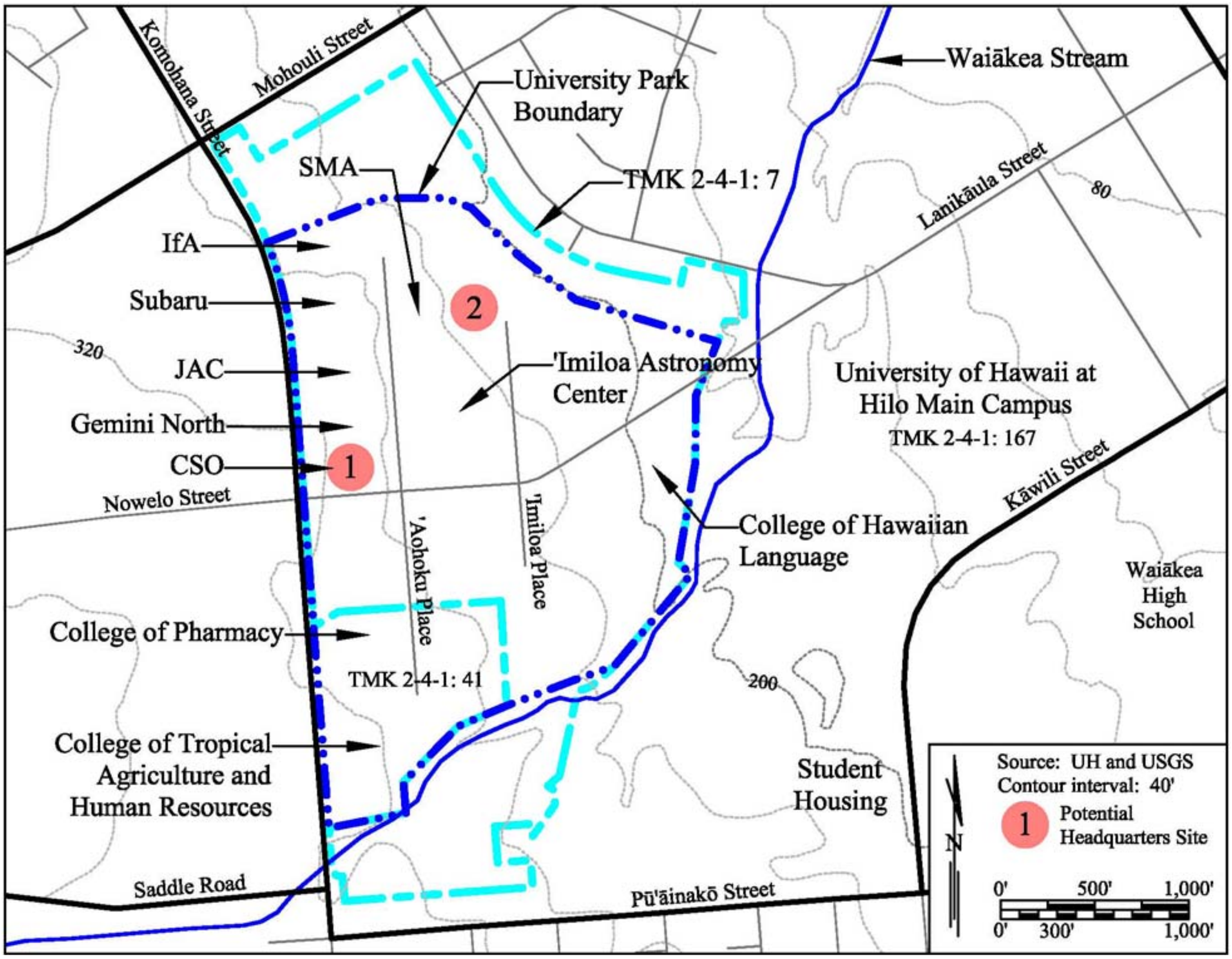


Figure 2-9: Possible Headquarters Location in Hilo

2.5.5 Satellite Office

The Satellite Office, in coordination with the Headquarters, would support operation of the TMT Observatory. The options being considered in Waimea include commercially-zoned vacant lots behind the Parker Ranch Center (Figure 2-10). The design of the Satellite Office would depend upon the selected location. The Satellite Office would be smaller than the Headquarters, and is currently estimated to be an office building of approximately 10,000 to 25,000 square feet.

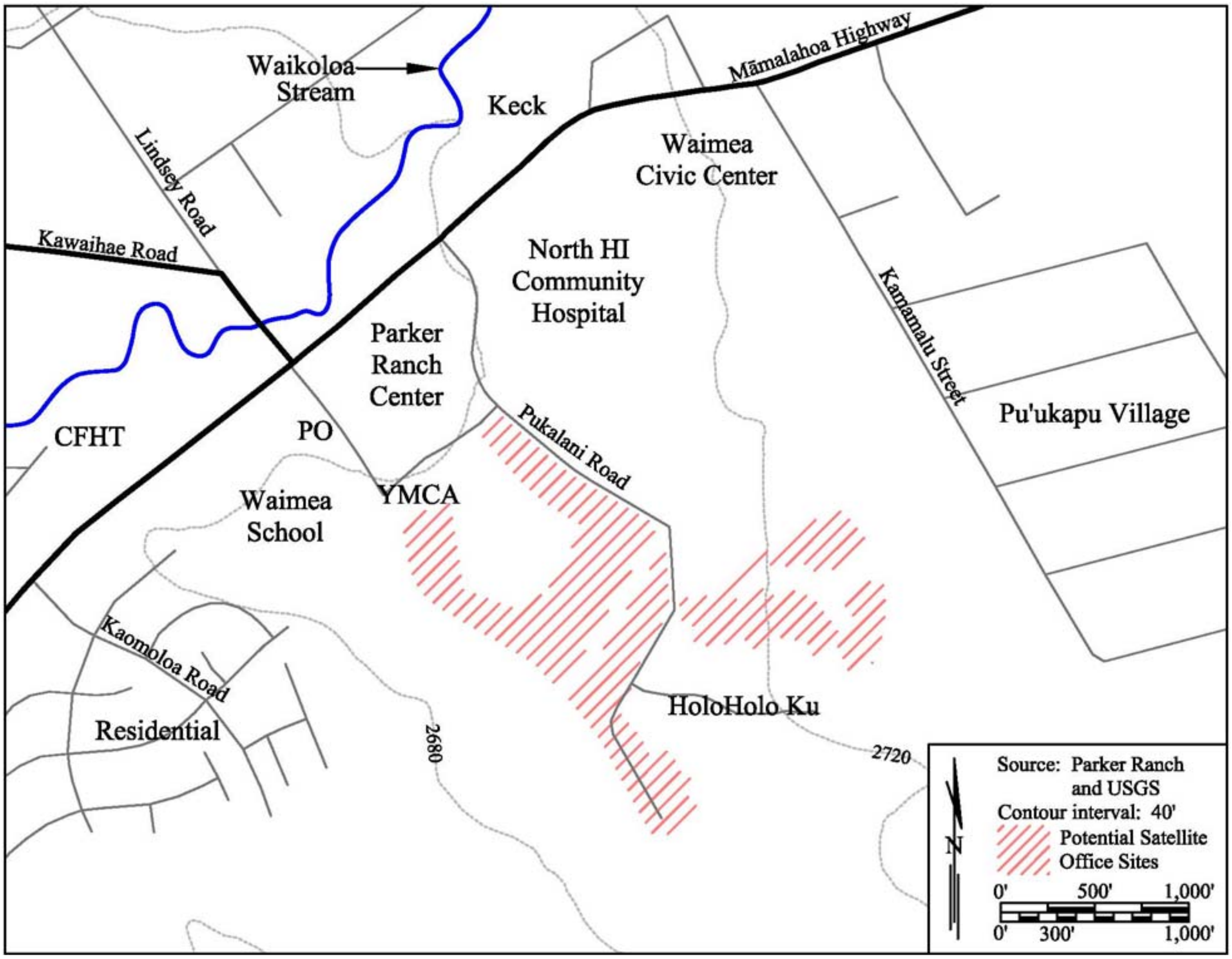


Figure 2-10: Possible Satellite Office Locations in Waimea

2.6 Construction Areas

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

- "Port Staging Area." An existing warehouse and/or yard near the port where Project components are received. This area would 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.
- "Hale Pōhaku Staging Area." A staging area in the western portion of the lower part of Hale Pōhaku, within the TMT Mid-Level Facility boundary shown on Figure 2-8. This area would be used for parking, vehicle washing and inspection prior to proceeding up to the observatory site, assembly of enclosure and telescope components to the extent possible prior to transport to the construction site, and the storage of materials needed for

construction work at Hale Pōhaku. This area has been used for similar purposes during the construction of other observatories.

- "Batch Plant Staging Area." A roughly 4-acre area northwest of where the Maunakea Access Road forks near the summit (Figure 2-3). This area would primarily be used for storing bulk materials and a concrete batch plant, as it has been in the past during construction of other observatories.

Batch Plant Staging Area

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

2.7 Project Phases and Activities

The TMT Observatory Project involves four major phases: planning and design, construction and testing, operation, and decommissioning of the TMT Observatory after it reaches the end of its planned useful life. Table 2-1 presents the overall conceptual phasing framework for the Project that would be updated on an ongoing basis and refined as the process moves forward. The following sections discuss activities anticipated during the various phases of the Project.

Table 2-1: Anticipated Activities Timeline

Phase	Start	End	Milestone
Planning and Design	**2003**	**2010**	
EISPN/EA			September 2008
Draft EIS			May 2009
Final EIS			January 2010
CDUP			August 2010
Construction and Testing	**2011**	**2018**	
Grading and foundation	2011	2012	
TMT Mid-Level Facility construction	2011	2012	
Observatory erection	2012	2016	
Observatory finish	2016	2017	
First light			September 2018
Telescope/instrument testing	2017	2018	
Operation	**2018**	To be determined	
Decommissioning	To be determined (18-month duration likely)		

2.7.1 Planning and Design

The TMT Observatory Corporation conducted an extensive worldwide study to evaluate potential locations for the TMT. 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 Board for further consideration. The considerations used by the TMT Board to narrow the field of potential sites is discussed in Section 4.1.

The Chapter 343 environmental review process for the Maunakea site is ongoing. This Draft EIS is the next step in the process, which is discussed in Chapter 1.0 of this EIS. Following the completion of the EIS process, planning work would continue in order to obtain the Conservation District Use Permit (CDUP) and other necessary permits prior to construction.

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. The design of the TMT Mid-Level Facility is also on-going. All planning and design work is anticipated to be completed by June 2010.

2.7.2 Construction and Testing

Project construction would begin in 2011 and take approximately seven years to complete. Construction would begin with TMT Mid-Level Facility and Access Way improvements. Those improvements would support construction of the TMT Observatory. Construction is detailed in Section 3.15.

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

First light, or the time when the TMT is first used to take an astronomical image, would be expected in 2018. Tests would then be conducted and adjustments to the telescope and instruments made for a period of time to gain optimum efficiency and seeing.

2.7.3 Operation

The first scientific results using the TMT Observatory would be expected in 2018. During the life of the TMT Observatory astronomical observations would be made by scientists from around the world. A staff of approximately 140 people would be necessary to operate and maintain the observatory. Each night, approximately 6 system operators would be present at the TMT Observatory, while observers and support astronomers would observe remotely from the Headquarters. During the day, an estimated 44 members of the staff would work at the TMT Observatory, with approximately 60 members of the staff working at the Headquarters and approximately 30 members of the staff working at the Satellite Office.

2.7.4 Decommissioning

The TMT Observatory would be dismantled and the site restored at the end of the TMT Observatory's life. Three levels of site restoration have been set forth in the Mauna Kea Comprehensive Management Plan for UH Management Areas (CMP) (OMKM, 2009). The level of restoration to be done at the TMT Observatory site would be determined at a later time and would be determined based on an environmental cost/benefit analysis overseen by OMKM, Kahu Kū Mauna, and other stakeholders. Decommissioning and restoration would meet all the requirements of the CMP Decommissioning sub plan being developed by OMKM and/or other applicable plans at the time of decommissioning. The three levels of site restoration currently envisioned in the CMP 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 physical habitat.

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 observatory's useful life has ended, develop a recycling and/or demolition 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 conduction site restoration in the future.
4. Once the observatory's useful life has ended, develop a site restoration plan, which would include an environmental cost-benefit analysis of the three levels of decommissioning (CMP Management Action SR-2). The cost-benefit analysis would consider restoration costs and related impacts, including a cultural assessment. In compliance with CMP Management Action FLU-4, the site restoration plan would include visual renderings of the site setting pre- and post-restoration for each of the three levels of restoration to facilitate analysis of potential impacts to view planes.

To address the first management action, the Project has (a) included in the design of the TMT Observatory and Access Way the storing of 99 percent of excavated material on those sites for reuse during site restoration, and (b) included in the planned Project operation budget annually setting aside funds that would be used for decommissioning of the TMT Observatory. The Project understands decommissioning and site restoration requirements will be included in the sublease. The Project is also committed to preparing other necessary plans once the observatory's useful life has ended or its lease expires. The current UH lease of the MKSR expires in 2033 and the TMT Observatory would be decommissioned and the site restored at that time, unless a new lease extension is obtained from the BLNR. It is anticipated that the decommissioning and restoration process would take approximately 18 months to complete.

3.0 Environmental Setting, Impact, and Mitigation

Maunakea is probably one of the most significant cultural and astronomical sites in the world. Hawaiians feel a cultural kinship with Maunakea; traditional genealogy account that Wakea (the sky-father) and Papa (the earth mother) gave birth both to the islands and the first man (Haloa), and from this ancestor all Hawaiian people are descended. Native Hawaiian traditions state that among the islands, Hawai‘i was first born and Maunakea represents the piko (umbilical cord) to Papa and Wākea. Maunakea is also exceptional for its quality for astronomical observations and is the scientific umbilical cord to the mysteries of the universe.

UH has been working to find ways for these two cultures to co-exist in such a way that is mutually respectful yet honors the unique cultural and natural resources of Maunakea. The most recent effort being the CMP recently approved by the BLNR and adopted by the UH BOR. The BLNR shares the belief that "these diverse interests can be accommodated," recognizing that Maunakea's summit area is unique and one of Earth's special places. Maunakea presents the steward of the land with an inexorable duty to conserve, protect, and preserve this unique and most special resource.

UH, UH Hilo, and TMT have gained an understanding of the cultural sensitivity of Maunakea through working with the community during the production of the CMP and this Draft EIS. It is the intention of all those involved to be good stewards of the land and avoid miscommunication or unintentional disrespect between the Project and the community.

This Chapter presents our understanding of the environmental setting in the region and at specific Project locations. Mitigation measures proposed in this Draft EIS have been developed to avoid, minimize, rectify, or reduce the Project's potential substantial adverse environmental impacts and be good stewards of the land. Mitigation measures have been considered throughout the Project planning process and incorporated into the Project design and construction plans. The mitigation measures presented in this Draft EIS will continue to be refined during the public Draft EIS review process, and the resulting final and committed mitigation measures will be outlined in the Final EIS.

3.1 Introduction

Each Section in this Chapter discusses (a) current conditions and/or management practices in the region and in the Project area related to the specific environmental subject, (b) the threshold used to determine the Project's level of impact, (c) the Project's potential long-term operation phase impacts related to the specific environmental subject, (d) the potential mitigation measures that could be implemented by the Project to avoid, minimize, rectify, or reduce potential substantial adverse environmental impacts, and (e) the Project's relative potential impact that would remain after the potential mitigation measures are implemented. Operation phase effects would occur consistently throughout the operational life of the Project, and would at least partially end upon decommissioning.

Short-term potential construction phase and decommissioning phase effects are discussed in a single section, Section 3.15, and would be temporary.

The mitigation measures presented in this Draft EIS are called “potential” mitigation measures, because the measures will continue to be refined during the public Draft EIS review process, and the resulting final and committed mitigation measures will be outlined in the Final EIS.

The information about existing conditions, potential Project impacts, and potential mitigation measures presented in this Chapter has been developed through (a) the review and use of existing information related to Maunakea, specifically information related to the UH Management Areas (the MKSR, a corridor along the Maunakea Access Road, and Hale Pōhaku), and other Project areas; and (b) new studies conducted for this Project. Existing information related to Maunakea is extensive, and includes the following principal sources:

- Mauna Kea Science Reserve Master Plan; June 16, 2000 (http://www.hawaii.edu/maunakea/)
- Mauna Kea Comprehensive Management Plan for UH Management Areas (CMP); January 2009 (http://www.maunakeacmp.com/overview/documents)
- Final Environmental Assessment (EA) for the Mauna Kea Comprehensive Management Plan (CMP); April 1, 2009 (http://oeqc.doh.hawaii.gov/Shared%20Documents/EA_and_EIS_Online_Library/Hawaii/2000s/2009-04-23-HA-FEA-Mauna-Kea-Comp-Management-Plan.pdf)

Each section also includes a list of references with additional sources of information used in the evaluation of the specific environmental subject.

Each environmental subject is discussed in this Draft EIS as outlined in the following sections.

Typical conditions within Area E.
Photo by CSH

3.1.1 Environmental Setting

“Environmental Setting” describes the existing environmental conditions in the Project areas and the region as it currently exists, before the commencement of the Project. This provides a baseline for comparing “before the Project” and “after the Project” environmental conditions.

3.1.2 Thresholds Used to Determine Level of Impact

“Thresholds Used to Determine Level of Impact” defines and lists specific criteria used to determine whether an impact is considered to be potentially significant. Hawai‘i Administrative Rules (HAR) Section 11-200-12 provides 13 “significance criteria” against which an action is to evaluate its potential impact. These criteria are:

1. Involves an irrevocable commitment to loss or destruction of any natural or cultural resource.
2. Curtails the range of beneficial uses of the environment.
3. Conflicts with the state's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders.
4. Substantially affects the economic welfare, social welfare, and cultural practices of the community or State.
5. Substantially affects public health.
6. Involves substantial secondary impacts, such as population changes or effects on public facilities.
7. Involves a substantial degradation of environmental quality.
8. Is individually limited but cumulatively has considerable effect upon the environment or involves a commitment for larger actions.
9. Substantially affects a rare, threatened, or endangered species, or its habitat.
10. Detrimentally affects air or water quality or ambient noise levels.
11. Affects or is likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters.
12. Substantially affects scenic vistas and viewplanes identified in County or State plans or studies.
13. Requires substantial energy consumption.

The thresholds established correspond to the above criteria and other environmental laws. Each section of this Draft EIS presents a significance threshold for its specific environmental subject; should the Project potentially cause an impact greater than the identified threshold then the potential impact would be considered to be significant.

3.1.3 Potential Project Impacts

The potential impacts are evaluated within the framework of the Project's compliance with all applicable rules, regulations, and requirements for its action type and location. The existing rules, regulations, requirements, and procedures applicable to the Project are considered a part of the existing regulatory environment. The applicable rules, regulations, and requirements include:

- Hawaiʻi Administrative Rules (HAR), including (but not limited to):
  - Title 4, Subtitle 6, Chapter 68, Noxious Weed Rules
  - Title 11, Chapter 23, Underground Injection Control
  - Title 11, Chapter 45, Community Noise Control
  - Title 11, Chapter 54, Water Quality Standards
  - Title 11, Chapter 55, Water Pollution Control

- Title 11, Chapter 60, Air Pollution Control
- Title 11, Chapter 62, Wastewater Systems
- Title 11, Chapter 68, Litter Control
- Title 11, Chapter 200, Environmental Impact Statement Rules
- Title 11, Chapter 260, Hazardous Waste Management General Provisions
- Title 11, Chapter 262, Standards Applicable to Generators of Hazardous Waste
- Title 13, Subtitle 1, Chapter 5, Conservation District
- Title 13, Subtitle 5, Chapter 107, Threatened and Endangered Plants
- Title 13, Subtitle 5, Chapter 124, Indigenous Wildlife, Endangered and Threatened Wildlife, and Introduced Wild Birds
- Title 13, Subtitle 13, Chapter 275-284, Historic Preservation Review Process
- Title 13, Subtitle 13, Chapter 300, Burial Sites and Human Remains

- Hawai‘i Revised Statutes (HRS), including (but not limited to):
    - Chapter 6E, Historic Preservation
    - Chapter 183C, Conservation District
    - Chapter 195D, Conservation of Aquatic Life, Wildlife, and Land Plants
    - Chapter 205, State Land Use Law
    - Chapter 226, Hawai‘i State Planning Act
    - Chapter 342D, Water Pollution Law
    - Chapter 342J, Hawai‘i Hazardous Waste Law
    - Chapter 343, Environmental Impact Statements
    - Chapter 344, Hawai‘i State Environmental Policy
- County of Hawai‘i rules and requirements, including (but not limited to):
    - County of Hawai‘i General Plan
    - South Kohala Development Plan
- Maunakea UH Management Area requirements:
    - Mauna Kea Science Reserve Master Plan; June 16, 2000
    - Mauna Kea Comprehensive Management Plan for UH Management Areas (CMP); January 2009. Including the upcoming required sub plan components:
        - Natural Resources Management Plan
        - Cultural Resource Management Plan
        - Public Access Plan
        - Decommissioning Plan, including financial plan
    - Final EA for the CMP; April 1, 2009

To ensure compliance, the Project would (a) design its facilities to comply and/or facilitate compliance, and (b) develop and implement a range of plans and programs outlined in this Draft EIS. These plans and programs would include policies and procedures to be employed during long-term operation as well as construction of the Project. The plans and programs would include:

- Cultural and Natural Resources Training Program (Sections 3.2.3, 3.3.3, and 3.4.3), this would be done to comply with applicable requirements, including CMP Management Actions CR-3, NR-6, EO-2, P-4, and IM-2;
- Invasive Species Prevention and Control Program (Section 3.4.3), this would be done to comply with applicable requirements, including CMP Management Action NR-2;
- Waste Minimization Plan (WMP) (Section 3.8.2), including an annual energy audit and assessment of water saving measures, this would be done to comply with applicable requirements, including CMP Management Actions IM-12 and IM-14;
- Materials Storage/Waste Management Plan and component Spill Prevention and Response Plan (SPRP) (Section 3.8.2),
- Workforce Pipeline Program (Section 3.9.4), and
- Ride-Sharing Program (Section 3.11.3).

The details of these programs and plans are presented in the following sections as applicable.

3.1.4 Mitigation Measures

"Mitigation Measures" identifies Project-specific measures that may be needed that go beyond compliance with applicable existing rules, regulations, and requirements, to reduce a potentially significant impact, as applicable. The compliance with existing applicable rules, regulations, and requirements is considered a part of the existing regulatory environment, and is described above. The mitigation measures proposed in this Draft EIS have been developed to avoid, minimize, rectify, or reduce the Project's potential substantial adverse environmental impacts. Mitigation measures have been considered throughout the Project planning process and incorporated into the Project design and construction plans. The mitigation measures presented in this Draft EIS will continue to be refined during the public Draft EIS review process, and the resulting final and committed mitigation measures will be outlined in the Final EIS.

3.1.5 Level of Impact after Mitigation

"Level of Impact after Mitigation" indicates what effect remains after application of mitigation measures, and whether the remaining effect would be considered to be significant, as applicable.

3.2 Cultural Resources

This section discusses the cultural resources in the region and specific Project areas, the potential impact of the Project on those resources, and mitigation measures the Project would employ to minimize those potential impacts. "Resource" is defined as the natural environment or human practices, values, and traditions and their physical manifestations. Some examples of what are regarded as "cultural resources" are archaeological sites, historic properties, spiritual places, cultural and religious practices, and historic objects. As this indicates, cultural resources include, but are not restricted to historic properties. Historic properties, including archaeological sites, are discussed in Section 3.3. This section focuses on other cultural resources, such as Native Hawaiian cultural practices and Maunakea's spiritual and sacred quality.

3.2.1 Environmental Setting

In Hawaiian culture, natural and cultural resources are one and the same. Native traditions describe the formation (literally the birth) of the Hawaiian Islands and the presence of life on, and around them, in the context of genealogical accounts. All forms of the natural environment, from the skies and mountain peaks, to the watered valleys and lava plains, and to the shore line and ocean depths are believed to be embodiments of Hawaiian gods and deities.

It was the nature of place that shaped the cultural and spiritual view of the Hawaiian people. "Cultural Attachment" embodies the tangible and intangible values of a culture – how a people identify with, and personify the environment around them. It is the intimate relationship (developed over generations of experiences) that people of a particular culture feel for the sites, features, phenomena, and natural resources, etc., that surround them - their sense of place. This attachment is deeply rooted in the beliefs, practices, cultural evolution, and identity of a people.[14]

The epic "Kumulipo," a Hawaiian Creation Chant, was translated by Martha Warren Beckwith (1951). The "pule" (prayer) was given, in ca. 1700, at the dedication of the new-born chief, Ka-'i-i-mamao, also known as Lono-i-ka-Makahiki. Beckwith described the pule as:

> The Hawaiian Kumulipo is a genealogical prayer chant linking the royal family to which it belonged not only to primary gods belonging to the whole people and worshiped in common with allied Polynesian groups, not only to deified chiefs born into the living world, the Ao, within the family line, but to the stars in the heavens and the plants and animals useful to life on earth, who must also be named within the chain of birth and their representatives in the spirit world thus be brought into the service of their children who live to carry on the line in the world of mankind ...[15]

This pule further demonstrates the relationship between the Hawaiian people and Hawaiian land – ʻāina, that which sustains the people. At the heart of this relationship is the kinship to the ʻāina that comes from the Hawaiian traditional genealogical account that Wākea (the sky-father) and Papa (the earth mother) gave birth both to the islands and the first man (Hāloa), and from this ancestor all Hawaiian people are descended. It was in this context of kinship, that the ancient

[14] cf. James Kent, "Cultural Attachment: Assessment of Impacts to Living Culture." September, 1995.
[15] Beckwith 1951:8

Hawaiians addressed their environment, and it is the basis of the Hawaiian system of land management and use.

Maunakea Summit Region

A number of research, studies, and impact assessments have been prepared in recent time concerning cultural resources on Maunakea. These include:

- Mauna Kea Comprehensive Management Plan for UH Management Areas (CMP). This plan provides information and management actions to protect, preserve, and enhance the cultural resources of Maunakea within the UH Management Areas. The management actions were formulated with input from the Native Hawaiian community, cultural practitioners, and families with lineal connections to Maunakea, as well as astronomers, scientists, and other interested parties. This plan was prepared by Kuʻiwalu, Inc. for UH (UH, 2009a).
- Mauna Kea-Ka Piko Kaulana o ka ʻĀina. This document (title translates to Maunakea-The Famous Summit of the Land) provides a review of historic records and information collected through oral history interviews with kūpuna and kamaʻāina pertaining to Maunakea. The purpose of the work was to provide a platform for informed discussions regarding cultural and historical resources, so that the use/presence of cultural, natural, and scientific resources of Maunakea could find some harmony. This document was prepared by Kumu Pono Associates LLC for OMKM (Kumu Pono, 2005).
- Mauna Kea Science Reserve Master Plan (UH, 2000) and associated Mauna Kea Science Reserve and Hale Pōhaku Complex Development Plan Update: Oral History and Consultation Study, and Archival Literature Research. Ahupuaʻa of Kaʻohe (Hāmākua District) and Humuʻula (Hilo District) (Kumu Pono, 1999).
- Final Environmental Impact Statement for the Outrigger Telescopes Project (NASA, 2005) and associated Cumulative Cultural Impact Study/Assessment, Desktop Study & Ethnographic Survey, NASA W.M. Keck Observatory Outrigger Telescopes, Mauna Kea, Kaʻohe & Humuʻula Ahupuaʻa, Moku of Hāmākua & Hilo, Hawaiʻi (Orr, 2004).

These documents provide a thorough description of the cultural resources of Maunakea on a whole, and this section provides an overview of the cultural resources primarily drawn from these sources. In addition, a Cultural Impact Assessment (CIA) process is on-going for the Project to gather community input and assist in the identification of cultural resources in the vicinity of the TMT Observatory and TMT Mid-Level Facility; an initial Draft CIA report is provided in Appendix D. To date, during the CIA process, 58 government agency or community organization representatives, or individuals such as long-time area residents and cultural practitioners have been contacted. Thirty persons responded, and 13 kūpuna (elders) and/or kamaʻāina (native-born) have been interviewed for more in-depth contributions to the cultural impact survey. The consultations, including additional interviews with the community members, will continue and solicit input representative of the community. The results of these consultations and interviews, and recommendations reflecting community input, will be documented in a final CIA report and the Final EIS.

Introduction

In any discussion of Hawaiian land – ʻāina, that which sustains the people – and its place in culture, it is also appropriate to briefly discuss traditional Hawaiian land terms, as the terms demonstrate an intimate knowledge of the environment about them. We observe once again, that in the Hawaiian mind, all aspects of natural and cultural resources are interrelated. Thus, when speaking of Maunakea – the piko (umbilical) of the first born island-child, Hawaiʻi, and the abode of the gods – its integrity and sense of place depends on the well-being of the whole entity, not only a part of it.

Hawaiian customs and practices demonstrate the belief that all portions of the land and environment are related. Indeed, just as place names tell us that areas are of cultural importance, so too, the occurrence of a Hawaiian nomenclature for the wao (an inland region) tells us that there was an intimate relationship between Hawaiians and their environment.

ʻĀina mauna, or mountain lands, reflects a term used affectionately by elder Hawaiians to describe the upper regions of all mountain lands surrounding, and including, Maunakea. The area was frequented by native practitioners and contained a native and cultural landscape that provided among other things:

- Places to worship
- Places to gather stones
- Kanu iwi (places to bury human remains)
- Kanu piko (places to bury umbilical cords)
- Places to traverse, i.e. for those who were crossing from one region to another
- Places to gather food, and catch birds
- Sacred and safe areas

Historic Socio-political Context and Land Use

The MKSR is entirely within the ahupuaʻa of Kaʻohe in the Hāmākua District. An Ahupuaʻa is a native land division or territorial unit generally equated with a community. The Kaʻohe ahupuaʻa has an uncharacteristically large land area with a small ocean frontage. In the mid-1800s, Kaʻohe was assigned to the government land inventory by King Kamehameha III, and only a few native tenants with claims for land rights were identified at the time; at the close of the Mahele, one native tenant was granted land in the lower region of Kaʻohe.

Records indicate that the inhabitants of Kaʻohe had the sole privilege to capture the "uwaʻu" or ʻuaʻu, the Hawaiian petrel (*Pterodrama sandwichensis*). The boundaries of Kaʻohe are debatable; in the late 1800s, persons appearing before the Commissioners of Boundaries appear to have differing accounts of the appropriate boundary between Kaʻohe and the neighboring Humuʻula ahupuaʻa, which was Crown land. There was some dispute regarding the boundary along a gulch called Kahawai Koikapue (presumably Pōhakuloa Gulch today), Keanakākoʻi (the adze quarry), Waiau, and Puʻuokūkahauʻula (the summit cinder cone complex). All of these areas are shown within the Kaʻohe ahupuaʻa on modern maps. Figure 3-1 illustrates a small portion of the boundary between Kaʻohe and Humuʻula ahupuaʻa.

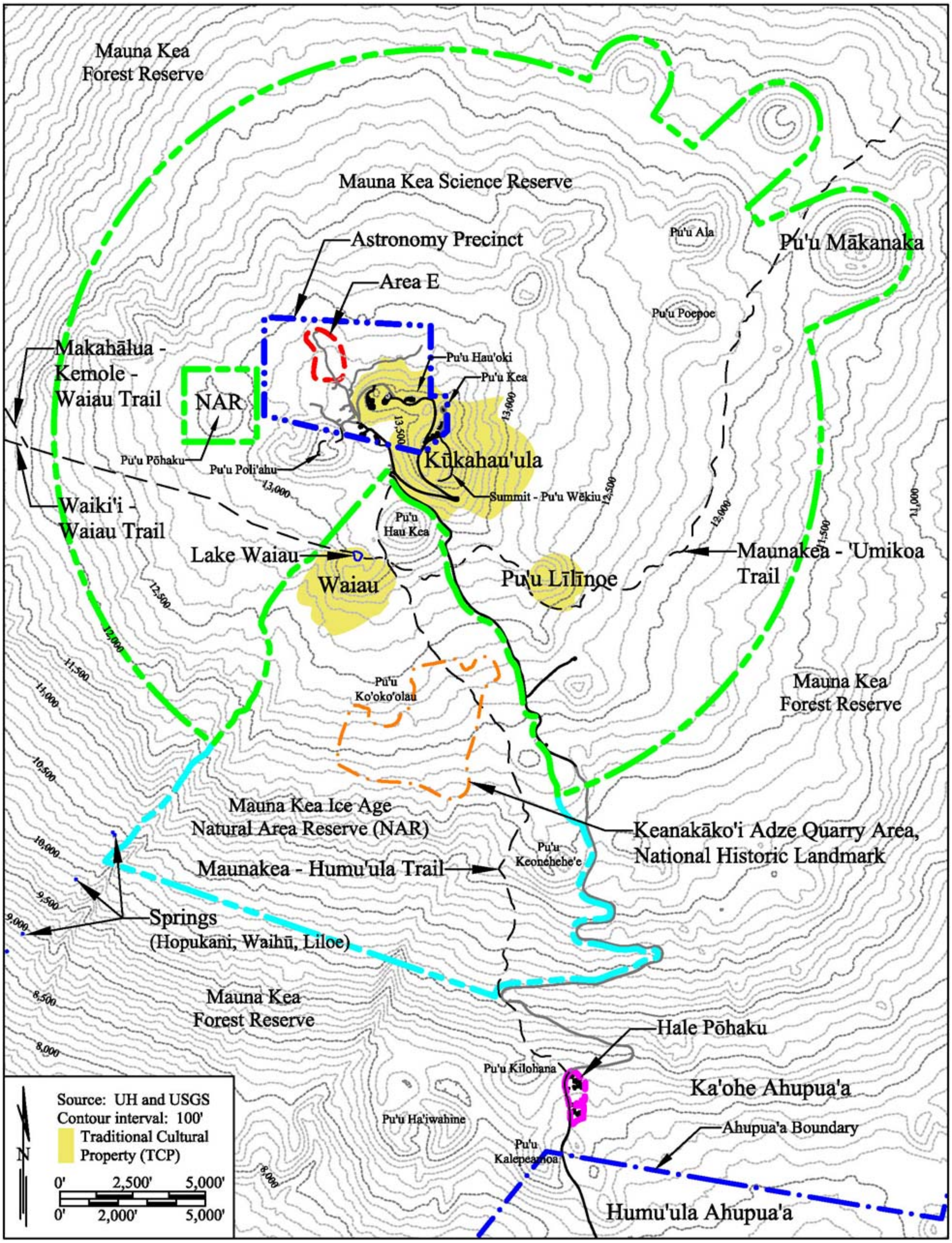


Figure 3-1: Cultural Resources in the Maunakea Summit Region

Little is known ethnographically about the uses of the alpine and subalpine zones on Maunakea, both within Kaʻohe and other ahupuaʻa, except for a few accounts of adze making and burials. Most of what is known regarding traditional land uses is the result of archaeological investigations undertaken since the mid-1970s.

Evidence also indicates that the area above the limits of agriculture and permanent settlement was a vast "wilderness", probably only known to a small number of Hawaiians engaged in special activities such as ceremonial practices, bird-catching, canoe making, adze making, and burial of the dead. Bird-catching and canoe making were likely concentrated in the upland forests, except for the capture of ʻuaʻu as these birds dug nests in the alpine and subalpine regions.

It is believed that the alpine region of Maunakea was known to early Hawaiians, though the only activity that is known with certainty to have occurred is the manufacture of stone adzes. Archaeological research indicates that the adze quarry, known as Keanakākoʻi, on the southern slope of Maunakea (concentrated between 11,500 and 12,400 feet) was exploited over a period as long as 700 years, between the years of 1100 and 1800. When the quarry was abandoned is unknown, but it may have occurred as late as Captain Cook's arrival in 1778, or soon thereafter.

Myths, Legends, Traditional Histories, and Place Names

The origins of Maunakea and its central place in Hawaiian genealogy and cultural geography are told in mele (poems, chants) and moʻolelo (stories, traditions). Native Hawaiian traditions state that ancestral akua (gods, goddesses, deities) reside within the mountain summit area. Several natural features in the summit region are named for, or associated with, Hawaiian akua; these associations indicate the importance of Maunakea as a sacred landscape. Each part of the mountain contributes to the integrity of the overall cultural, historical, and spiritual setting.

Maunakea has been referred to as Maunakea since at least 1823. Simply translated Maunakea means "White Mountain." The name Maunakea is also known in native traditions and prayers as Mauna a Wākea, "The Mountain of Wākea." In Hawaiian tradition, the island of Hawaiʻi is described as the first-born island child of Wākea (referred to as the Sky Father) and Papa (referred to as the Earth Mother). The union of Wākea and Papa also gave rise to the other Hawaiian Islands and Hāloa, the first man and ancestor of the Native Hawaiian people. In some native traditions, Maunakea is written Maunaakea (Mauna a Kea), literally, "Mountain of Wākea," and is said to be piko (umbilical cord) that connects the island-child Hawaiʻi to the heavens.

Some contemporary Native Hawaiian cultural practitioners continue to view Maunakea as the first-born of the Wākea and Papa union and, thus, revered as a connection to all Native Hawaiian people and gods. Two chants, Mele a Pakuʻi and ʻO Hānau ka Mauna a Wākea, were described by Pualani Kanakaʻole Kanahele and her now-deceased husband, Edward Kanahele, in 1998 to

> describe, respectively, the birth of Hawaiʻi island from the union of Papa and Wākea, the ancestors of Native Hawaiians, and the birth of "budding upward" of Mauna Kea a mountain named for Wākea. As the firstborn of Papa and Wākea, Hawaiʻi island is the hiapo, the respected older sibling of all Native Hawaiians. The mountain of Mauna Kea is the piko or origin point for the island, more specifically for the northern half, and therefore is a place of great mana. Because

> of the mana of the mountain and of Lake Waiau at its summit, Queen Emma went there to bathe in the water…[16]

A group of cinder cones make up the summit of Maunakea. Since the 1960s, these cinder cones have been referred to individually as Pu‘u Wēkiu, Pu‘u Hau‘oki, and Pu‘u Kea; one of the cinder cones has not been given a modern name (the one on which Subaru and Keck sit). Up until about 1932, these cinder cones were collectively referred to as Pu‘u Kūkahau‘ula (Figure 3-1). Evidence suggests that the name Kūkahau‘ula referred to both a legendary figure and a character in traditional histories and genealogies, including references to Kūkahau‘ula as the husband of Līlīnoe or as an ‘aumakua (family deity). Kūkahau‘ula is referred to as the pink-tinted snow god, and Kumu Pono reported (2005) that Kūkahau‘ula was "named for a form of the god Kū, where the piko of new-born children were taken to insure long life and safety."[17]

There are several myths concerning the goddesses Poli‘ahu and Līlīnoe, both of which have pu‘u named for them on Maunakea (Figure 3-1). It has been claimed that Poli‘ahu was one of four snow goddesses "who embodied the mythical ideas of spirits carrying on eternal warfare between heat and cold, fire and frost, burning lava and stony ice."[18] According to several legends, Poli‘ahu was the rival of the fire-goddess, Pele. Poli‘ahu is said to be the first daughter of Kāne and continues to be commonly referred to as the beautiful snow goddess of Maunakea. Contrary to popular belief, however, Poli‘ahu's name was attached to the present-day Pu‘u Poli‘ahu in 1892 by the surveyor W.D. Alexander, and not through Native Hawaiian traditions[19].

The goddess Līlīnoe is commonly referred to as the "goddess of the mists and younger sister of the more famous Poli‘ahu."[20] The pu‘u named after this goddess (Figure 3-1) does appear to be related to use by Native Hawaiians and is considered the abode of the goddess. It has been claimed that Līlīnoe was another of the four snow goddesses, together with Poli‘ahu. Līlīnoe has also appeared as a person in genealogies and legends, including a reference to her as the "wife of Nu‘u, the ‘Noah’, of the discredited Hawai‘i Loa legend involving a great flood." Līlīnoe has also been referred to as "the woman of the mountains" and the ancestress of Pea, a kahuna of Umi's time.

As described in the CMP, Waiau is also mentioned as a goddess in several legends. The pu‘u named for this goddess also appears to be related to use by Native Hawaiians and is considered the abode of the goddess. Waiau has been identified as another of the four snow goddesses, together with Poli‘ahu and Līlīnoe. Pualani Kanaka‘ole Kanahele has described that the three pu‘u-Poli‘ahu, Līlīnoe, and Waiau, are sister goddesses who are female forms of water, and that all three of the cinder cones or pu‘u are important religious sites. Lake Waiau, within Pu‘u Waiau, also appears within Hawaiian myth and is considered sacred by modern cultural practitioners.

McEldowney points out that while the myths and legends associated with the summit area do not figure prominently in traditional histories, those histories

[16] Langlas, 1999:7.
[17] Kumu Pono, 2005:vi.
[18] Westervelt, 1963:55.
[19] Kumu Pono, 2005.
[20] Pukui and Elbert, 1971:392.

> revolve mainly around the lives and exploits of prominent chiefs, as passed down through genealogies, chants, and stories, and recorded primarily in works by Fornander and Kamakau. No major events from their histories occur within the summit plateau of Mauna Kea.[21]

Ahu and Kūahu

Ahu are characterized as upright stones or a pile or mound of stones. Ahu may have served historically as altars or shrines, or as markers signifying a burial, ahupuaʻa boundaries, or trail routes. As discussed in Section 3.3.1, a number of ahu have been identified in the summit region; they have been characterized by archaeologists as shrines, burials or possible burials, or markers. More than 65 percent of the ahu in the summit region have been categorized as shrines. There is little information available about the traditional religious observances practiced in association with shrines. It is unknown if some of the shrines are actually kūahu (alter). Kealoha Pisciotta offers that "some of the shrines mark the birth stars of certain aliʻi … and also birth and death."[22]

The shrines within the MKSR have been divided by archaeologists into two categories: (1) occupational specialist shrines related to adze manufacture, and (2) all others, termed "non-occupational." The only thing that distinguishes the occupational shrines from the others is the presence of lithic scatters found either on the shrine or nearby. Archaeologist Pat McCoy believes that at least some of the shrines were used as locations for performing traditional ceremonies related to "rites of passage."

Kealoha Pisciotta is a cultural practitioner who has attempted to maintain a contemporary kūahu on Maunakea, representing a revival of a traditional cultural practice. Her efforts were reportedly undermined by repeated destruction and removal of the shrine. The ahu in the MKSR are recognized cultural resources with various functions that are both historic, though largely unknown, and contemporary. The contemporary functions are rooted in traditional beliefs.

The only ahu within 200 feet of the TMT Observatory, Access Way, and Batch Plant Staging Area is a shrine near the end of the 4-wheel drive road in Area E. This shrine is believed to have been constructed in the early 2000s; but its creator is unknown.

Burials

The subject of the presence of burials in the Maunakea summit region is a topic of considerable differences between the scientific, archaeological perspective, on the one hand, and the Native Hawaiian perspective, on the other. The archaeological evidence is fairly minimal concerning confirmed human burials in the summit region. Direct evidence suggests that there are only four confirmed burials, all at Puʻu Mākanaka. It was suggested in 1999 that

> there is good reason to expect that more burials are to be found in the Science Reserve on the tops of cinder cones, either in cairns or in a small rockshelter or overhangs. The basis for this prediction is that all of the known and suspected burial sites on the summit plateau are located on the tops of cinder cones and, or particularly, on the southern and eastern sides. No burials have been found on the

[21] McEldowney 1982:1.4.
[22] Orr, 2004:47.

> sides or at the base of a cone, or on a ridgetop amongst any of the shrines. There in fact appears to be a clear separation between burial locations and shrine locations.[23]

Following the work performed for the CMP from 2005 through 2008, 28 sites in the MKSR have been interpreted as burials or possible burials. Most of these sites are classified as possible burials by archaeologists for compelling reasons, such as the topographic location and morphological characteristics of the structures. None of the sites identified as known or possible burials are within Area E, along the proposed Access Way, or in the Batch Plant Staging Area.

On the other hand, there are perceptions among some Native Hawaiians, some of which are backed by various types of documentary evidence, that the summit area holds, or once held, many more burials than archaeologists have been able to document.

There are numerous historical references to human burials on the high elevation slopes of Maunakea. The Hawaiian practice of burying the dead in remote, high elevation areas may have been a common practice. One of the perhaps many reasons for taking the dead to remote areas was the fear that the bones might be used to make fishhooks.

Some early accounts indicate that there were burials in the vicinity of Puʻu Līlīnoe. One account indicated that in 1892 "At an elevation of nearly 13,000 feet, near Līlīnoe, a burying ground was found, where the ancient chiefs were laid to rest in the red volcanic sand."[24] Other visitors in the same year reported what they interpreted as graves on the top of Puʻu Līlīnoe. Today, archaeologists have identified at least one possible burial in this area.

Puʻu Mākanaka is perhaps the best known location of known or possible burials. Puʻu Mākanaka is located on the northeastern slope of Maunakea at an elevation of roughly 12,000 feet, and its name translates to "hill crowded with people." A USGS survey team found human remains on the summit of Puʻu Mākanaka in 1925-1926. Today, numerous oral history interviewees reveal that they have knowledge of burials located at a number of puʻu along Maunakea's slopes, including Ahumoa, Kemole, Pāpalekōkī, Mākanaka, Kihe, Kanakaleonui, Kaupō, and ʻŌʻō.

Some cultural practitioners have stated they are aware of practices related to ancient family burials atop Maunakea. Alexander Kananiʻalika Lancaster told Kepā Maly that he and his family members went up to Maunakea "for ceremonial. They go up there bless the whole mountain for all our ancestors who's buried up there … the old folks always said, 'Our family is up there.'"[25] As indicated in the CMP, because no documentation exists on traditional cultural practices relating to ancient Maunakea burials, it is unknown whether blessing ceremonies would be considered a traditional cultural practice or a contemporary cultural practice.

Scattering of Cremation Ashes

In pre-contact time cremation was not a common practice; it was a punishment and meant to defile the dead person when it was done. Nevertheless, some cultural practitioners reveal that they have participated in the practice of scattering the cremated remains of loved ones from atop

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[23] McCoy, 1999:28.
[24] Preston, 1895:601.
[25] Kumu Pono, 1999:240.

Maunakea. As described in the CMP, the scattering of cremation ashes today is a contemporary cultural practice that has taken the place of traditional interment practices. Debate over whether this practice has evolved from traditional practices and beliefs or whether it is a new practice based on modern customs and beliefs, still remains.

Pualani Kanakaʻole Kanahele has stated that while the scattering of cremation remains on Maunakea may be viewed by some as non-traditional, she feels "it may not be the ʻiwi [bones] itself, but the ashes are the essence of what is left of the ʻiwi. It doesn't matter, it's going back."[26] The CMP states on this debate that those Hawaiians who choose cremation in modern times do it as a respectful commitment to the loved ones, which is a traditional cultural practice and fundamental value based upon ʻohana.

Also others, not just Native Hawaiians, likely engage in the practice of scattering cremation ashes at or near the summit of Maunakea.

Piko Disposition

As described in the CMP, the phrase "piko kaulana o ka ʻāina," which translates as "the famous summit of the land," is used to describe Maunakea and expresses the belief that the mountain is a piko (the navel, the umbilical cord) of the island and therefore sacred. In this context, the significance of the cultural practice of transporting and depositing a baby's piko on Maunakea may be better understood. Pualani Kanakaʻole Kanahele has explained the symbolic importance of this practice, saying that

> the piko is the part of the child that connected the child back to the past. Connected the child back to the mama. And the mama's piko is connected back to her mama and so on. So it takes it back, not only to the wa kahiko [ancient times], but all the way back to Kumu Lipo … So it's not only the piko, but it is the extension of the whole family that is taken and put up in a particular place, that again connects to the whole family line. And it not only gives mana or life to that piko and that child, but life again to the whole family.[27]

The practice has been reported by many cultural practitioners. Some report depositing the piko in the Lake Waiau while others have reported digging a little hole and putting the piko in the summit ground. It has been reported and the CMP indicates that maintaining cleanliness and purity is an important component in this cultural practice. Kealoha Pisciotta has expressed concern that Lake Waiau has become polluted and she fears that "people won't put the piko of the baby in there if it's polluted."[28] Water quality in the region is discussed in Section 3.7.

Pilgrimage, Prayer, Offerings, and the Spiritual Resonance of Maunakea

The cultural importance of Maunakea is exemplified by the several pilgrimages made to the mountain by Hawaiian royalty to partake in ceremonial practices in the late pre-contact and early post-contact periods. King Kamehameha I (Paiʻea) is reported to have traveled to Maunakea to make a ceremonial offering close to Lake Waiau in the company of Kekūhaupiʻo; the king made this pilgrimage and left the pūʻolo (bundle offering) because he feared dissension and treachery

[26] Kumu Pono, 1999:A-337.
[27] Kumu Pono, 1999:A-376.
[28] Orr, 2004:45.

amongst some of his chiefs. In 1881 or 1882, Queen Emma visited Lake Waiau and swam across the lake, reportedly riding on the back of Waiaulima. It was a cleansing ceremony to help prove her genealogical connection to Wākea and Papa.

The CMP reports that some oral history interviewees, from a variety of studies, have indicated they saw or left pūʻolo at Lake Waiau and on the summit of Maunakea. Observed pūʻolo have included items wrapped in ti leaves and ʻōpihi shells.

The spiritual resonance of Maunakea has been demonstrated by the following statements made by interviewees during various studies:

> Libert Landgraf – "I looked at sites, the area, as the church. … In this instance maybe the summit of Mauna Kea represents to us what the church is, and the individual sites or the individual platforms is the alter."[29]
>
> Kealoha Pisciotta – "This is a really hard issue for Hawaiian people, because Hawaiian people have really no temples. [They're] in state and national parks. … So Mauna Kea represents one of the last kind of places where the practice can continue. … But for Mauna Kea, it's not a temple built by man. It's built by Akua…"[30]
>
> Pualani Kanakaʻole Kanahele – "Mauna Kea was always kūpuna to us. … And there was no wanting to go to top. You know, just to know that they were there … was just satisfying to us. And so it was kind of a hallowed place that you know it is there, and you don't need to go there. You don't need to bother it. … And it was always reassuring because it was the foundation for our island."[31] "If you want to reach mana, that [the summit] is where you go."[32]

Some persons have stated they still ascend Maunakea for prayer and restoration. According to the CMP, these statements demonstrate that Maunakea continues to be viewed as a realm of great spiritual and sacred importance by Native Hawaiians. This belief is rooted in Hawaiian tradition.

<u>Trails</u>

There are several ala hele (trails) traversing the Maunakea summit region (Figure 3-1). Traditional accounts suggest that some ancient trails were present in the summit region. It is unknown if the current trails follow the same route as the ancient trails. Trails in the summit region today include the following:

- Maunakea – Humuʻula Trail. This is probably the best known trail, and it apparently began in the Kalaieha area where the Humuʻula Sheep Station is located. The trail initially appears on maps made by the W.D. Alexander survey party in 1892. The trail originally went around the east side of Puʻu Keonehehe'e but in the 1930s, the Civilian Conservation Corps gave the trail a straighter course around the west side of the puʻu. The trail continues to Waiau, and on to the summit

[29] Orr, 2004:49.
[30] Orr, 2004,49.
[31] Kumu Pono, 1999:A-336.
[32] Kumu Pono, 1999:A-372.

- Maunakea – ‘Umikoa Trail. This trail is not mentioned in early accounts, and it first appears on maps in the 1920s. The trail may well be an ancient trail, but the name appears to be modern and likely derived from the ‘Umikoa Ranch. Horseback trips to Maunakea from the ranch took place in the early 1900s and perhaps earlier. The trail enters the MKSR between Pu‘u Mākanaka and Pu‘u Hoaka on the northeastern slope, passes below and west of Pu‘u Līlīnoe, and intersects the Humu‘ula Trail near Lake Waiau.
- Waiki‘i – Waiau Trail leads up to Waiau from the west.
- Makahālau – Kemole – Waiau Trail leads to Waiau from the northwest.

None of these trails are near the proposed TMT Observatory or Access Way. Today the Maunakea – Humu‘ula Trail essentially ends at the Maunakea Access Road near the Batch Plant Staging Area. From this point to the summit, people walk on the road until a trail leads to the summit from near the UH observatories. Some people park at the Batch Plant Staging Area to walk along the trail to Lake Waiau.

<u>Traditional Cultural Properties and Proposed Historic District</u>

Traditional Cultural Properties (TCPs) are designated by the State Historic Preservation Officer (SHPO); in Hawai‘i the SHPO is the Director of the Board of Land and Natural Resources (BLNR), under which is the State Historic Preservation Division (SHPD). A TCP is a property or a place that is eligible for inclusion on the National Register of Historic Places because of its association with cultural practices and beliefs that are (1) rooted in the history of a community, and (2) are important to maintaining the continuity of that community’s traditional beliefs and practices. Three places on Maunakea have been identified by the SHPD as TCPs (Figure 3-1). These are:

- Kūkahau‘ula, SPHD Site 21438. The designated TCP area includes the summit cinder cones, traditionally collectively referred to as Kūkahau‘ula, but in recent times referred to separately as Pu‘u Wēkiu, Pu‘u Kea, and Pu‘u Hau‘oki.
- Pu‘u Līlīnoe, SHPD Site 21439. The designed TCP includes the entire Pu‘u Līlīnoe cinder cone.
- Waiau, SHPD Site 21440. The designed TCP includes the entire Pu‘u Waiau, including Lake Waiau. Waiau is located in the Ice Age NAR.

Other places on Maunakea have been identified as potentially eligible for TCP designation; however, only the three places listed above are the currently designated TCPs.

The Maunakea summit region has been proposed to be designed as a historic district. However, to date, no official application has been made; as such no review or determination has been made. The Maunakea summit region is not currently a historic district although it may be eligible and the CMP discusses it as such.

Summary of Cultural Practices

Cultural practices in the Maunakea summit region at this time are broadly (1) traditional and customary practices and beliefs, and (2) contemporary cultural practices. The following practices and beliefs have been considered traditional and customary in previous studies[33]:

- Performance of prayer and ritual observances important for the reinforcement of an individual's Hawaiian spirituality.
- Collection of water from Lake Waiau for a variety of healing and other ritual uses.
- Deposition of piko (umbilical cords) at Lake Waiau and the summit peaks of Maunakea.
- Use of the summit region as a repository for human burial remains, by means of interment, particularly on various pu'u, during early times, and more recently by means of releasing ashes from cremations.
- Belief in that the upper mountain region of Maunakea, from the Saddle area up to the summit, is a sacred landscape – as a personification of the spiritual and physical connection between one's ancestors, history, and the heavens.
- Association of unspecified traditional navigation practices and customs with the summit area.

Contemporary cultural practices were defined in the 2000 Master Plan EIS as those based on modern beliefs. These are said to include "prayer and ritual observances, construction of new altars and subsistence and recreational hunting."[34]

Hale Pōhaku

Due to its location on the slopes of Maunakea, Hale Pōhaku is a part of the spiritual resonance of Maunakea. Hale Pōhaku is along the route of the historic Maunakea – Humu'ula Trail; today there is a trail head for this trail at the upper end of Hale Pōhaku. Archaeologists have identified a stone tool quarry/workshop complex in and around Hale Pōhaku. The complex is referred to as the Pu'u Kalepeamoa complex, and is believed to be a multifunctional site consisting of several temporary camp sites where the manufacture of adzes and octopus lure sinkers took place. Two shrines, located just to the south of Hale Pōhaku and both related to sinker manufacture, are a part of this complex.

Headquarters

During the development of University Park, cultural assessments of the area reveal that the area does not appear likely to have been used or is currently used for gathering, access, or other customary activities by Native Hawaiians. There were archaeological sites in the area, though none in the vicinity of the sites being considered for the Headquarters, and those that were identified were noted to be more agricultural in nature. No trails were identified, and the botanical resources in the area were, and remain unlikely to have been culturally important for gathering. It has been determined that there are no traditional Hawaiian cultural or historical resources in this area.

[33] PHRI, 1999:39.
[34] Kumu Pono, 1998; PHRI, 1999:40.

Satellite Office

The land in many parts of Waimea has a long history of exclusive dedication to ranching. While the exact location of where the Satellite Office would be located is not yet finalized, the parcels being considered remain undeveloped; surrounding parcels have been developed for a range of uses. Since surrounding areas have developed or are designated for development, environmental assessments have been conducted and based on information gathered, it is anticipated that no valued natural, cultural, or historical resources would be identified on any of the potential sites. There has been no evidence of traditional activities within the area, whether for gathering, ceremonial, or access purposes; likewise, there are no historic cultural resources related to the ranching history of the area on any of the parcels.

3.2.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact if it involves an irrevocable commitment to loss or destruction of any natural or cultural resource. Therefore, a significant impact would occur if the Project resulted in the loss or destruction of any cultural resource. The Project could also have a significant impact if it resulted in denial or undue restrictions on performance of cultural or religious practices.

3.2.3 Potential Environmental Impacts

The potential impacts of the Project are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the Project type and location. This includes requirements of the CMP and HRS Chapter 6E, the State Historic Preservation law. Both the CMP and Chapter 6E require that no historic properties, such as historic shrines, be altered or destroyed.

Potential construction-phase impacts, including the inadvertent discovery of human remains, are discussed in Section 3.15. Potential impacts to archaeological/historic resources, such as shrines and burials, are discussed in Section 3.3.3. Cumulative impacts are discussed in Section 3.16. This section focuses on the potential impacts to spiritual places and cultural and religious practices.

Maunakea Summit Region

In discussing potential cultural impacts on Maunakea many find it is difficult to separate the impacts of the existing developments (cumulative impacts, discussed in Section 3.16.2) from the impacts associated with an individual project. The powerful emotional attachment Native Hawaiians have for Maunakea, and the impacts to its cultural resources to date make it difficult to evaluate a new project. Furthermore, as many consider the entire summit of Maunakea as one cultural property, it is difficult to separate the impacts of one action from all other past and present actions or specify a level of significance for the impacts related to just one action.

There are diverse opinions concerning the Project's potential impact on cultural resources. This diversity is illustrated by the various opinions shared in interviews performed during the Project's CIA process thus far (Appendix D) and other cultural assessments conducted during the preparation of the 2000 Master Plan, Outrigger EIS, and CMP. For the purposes of this discussion, the diverse range of opinions has generally been found to fall into one of two broad categories:

1. The Hawaiian culture and Astronomy can co-exist on Maunakea. Many people who hold this view also continue to feel that the general community, including the astronomy community, did not fully understand or appreciate how significant Maunakea is to the Hawaiian people. This opinion generally holds that, while the development of the Project would constitute an adverse cultural impact, that impact could be mitigated to lessen or minimize its significance.
2. Any development or disturbance of Maunakea by someone other than a Native Hawaiian following proper protocols is a significant desecration to the spiritual and sacred quality of the mountain and impacts the cultural practices performed on the mountain. Those who hold this opinion feel the development of the Project at any location on Maunakea would be a significant adverse cultural impact. Those expressing this opinion generally feel that are no mitigation measures that could offset the adverse cultural impact of any development at Maunakea, including that of the Project.

Both of these broad opinions are enumerated in the Project's initial Draft CIA (Appendix D) to varying degrees. The initial Draft CIA documents the responses of thirty persons who have participated in its process thus far, and represents the views of those Hawaiian and kamaʻāina individuals. A range of opinions, falling into the broad categories above, were also expressed during the Project scoping period and have been recorded in other documents about Maunakea and its cultural significance.

The opinion that culture and astronomy can co-exist is demonstrated by a statement Mr. Daniel Akaka Jr. made during the Project's CIA process: "The future of Maunakea is that, yes, it can serve as an educational center and a place for man to view the stars and the universe, but it has to remain a sacred and holy place. It's like stepping into a sanctuary, a very sacred place of peace, a place that one can learn the things beyond what man knows now." Those who prepared the CMP also embrace the hope that culture and astronomy, among other uses, can co-exit on Maunakea. It states that "Cultural understanding and information to appreciate Mauna Kea from a cultural perspective will assist in avoiding miscommunications or unintentional disrespect. … if a person is culturally oriented about how valuable and vulnerable the cultural and natural resources are on Mauna Kea, they will become better stewards of Mauna Kea." Thus, one of the primary management actions called for the CMP is the education of those working and visiting the summit region regarding its spiritual and sacred quality and the cultural sensitivity of the landscape.

The other general opinion concerning development on Maunakea is demonstrated by a statement Kuʻulei Keakealani during the Project's CIA process: "I think my first and foremost thoughts would be that it doesn't need to be done. Not because more research isn't needed or anything along those lines. The latest technology and research helps educate all of us, but at the same time, it's about the location. When is enough, enough?" She goes on to say, "I just think that, that Thirty Meter Telescope and all of those observatories up there have just overstepped the bounds of going into what is a sacred realm. I don't know how many people can go to the summit of Mauna a Wākea and not acknowledge that you are in a different realm. That truly is the realm of the goddess Poliʻahu and of all these other incredibly stronger forces above and beyond us as humans." Those holding this opinion frequently call for all astronomy facilities to be removed from Maunakea.

The following sections attempt to focus, to the extent possible, on the potential impact of the Project on cultural resources related to its location, footprint, and operations within the Maunakea summit region.

Cultural Practices

The CMP generally allows for continued cultural practices provided they do not result in the alteration or destruction of historic properties. Additional policy recommendations are being developed in consultation with cultural authorities and practitioners for the use of sacred places.

There are two ways the Project could impact cultural practices: (1) to deny or restrict cultural practices beyond the limits of the Project developments; (2) through Project development, alter or remove a location where cultural practices occur; (3) isolate cultural resources practices or beliefs from their setting; or (4) introduce elements which may alter the setting in which cultural practices take place. The CMP requires that observatory operations do not deny or unduly restrict cultural practices from taking place. The Project would comply with this requirement as a matter of policy and train TMT employees to respect, honor, and not interfere with cultural or religious practices. The Cultural and Natural Resources Training Program would be developed in consultation with OMKM, Kahu Kū Mauna, and others consistent with the CMP requirements. The overall goal of the program would be to culturally sensitize TMT personnel to cultural, historical, and natural resources in the summit region. As discussed in the CMP, the Cultural and Natural Resources Training Program would include educational instruction and materials designed to:

- Impart an understanding of Maunakea's cultural landscape, including cultural practices, historic properties and their sensitivity to damage, and the rules and regulations regarding the protection of historic properties.
- Impart an understanding of the Polynesian perspectives in astronomy and way-finding.
- Provide guidance and information as to what constitutes respectful and sensitive behavior while in the summit area.
- Instruct that Native Hawaiian traditional and customary practices shall not be restricted.

The training program would be updated regularly to incorporate UH Management Area-wide updates by OMKM. All persons involved in TMT Observatory operation and maintenance activities, including but not limited to scientists and support staff, shall receive the training on an annual basis. By implementing this program, the Project operations would limit its impact on cultural or religious practices in the view of those who believe cultural practices and astronomy can co-exist.

Based on numerous previous studies, Area E was selected in Master Plans to be a suitable location for observatory development because, for one, it would have either a limited or no adverse impact on physical cultural resources such as archaeological and historic resources. Within Area E, the proposed site of the TMT Observatory, known as the 13N site, was selected in part because it is the portion of Area E most disturbed by previous activity. The proposed Access Way maximizes the use of previously disturbed areas as well. Overall, roughly 6.3 acres of previously undisturbed land would be disturbed by the proposed TMT Observatory and Access Way; should Access Way Option 3 be selected, an additional area of roughly 0.4-acre area would be disturbed. The only physical evidence of cultural practices taking place in the vicinity of these areas is the construction of a modern shrine near the end of the 4-wheel drive road in Area E. The construction of new altars has been classified as a contemporary cultural practice.

Repeated archaeological inventory surveys in the area indicate that the shrine was erected in the early 2000s (Section 3.3.1); interviews and research conducted has not revealed who constructed this new shrine. Based on the research conducted to date, the shrine is not eligible for consideration as a historic property because it is less than 50 years old. Dismantling the one new shrine is considered an adverse but limited impact.

Kahu Kū Mauna, in consultation with other Native Hawaiian organizations, will develop protocols for the development of new cultural features consistent with CMP Management Action CR-7.

Spiritual and Sacred Quality of Maunakea

The Project has the potential to impact the spiritual and sacred quality of Maunakea. The types of potential impacts are based on review of existing information and input obtained from interviews conducted thus far during the CIA process. The Project could impact the spiritual and sacred quality of Maunakea by (a) degrading the integrity of a cinder cone; (b) adding a man-made structure on the northern plateau that would create a substantial visual disturbance; (c) placing employees in the northern plateau; (d) the potential accidental release of wastewater into the environment; (e) the potential accidental release of hazardous substances in the environment; and (f) generating dust and noise. Any one of these could detract from the spiritual setting and sacred quality of Maunakea. Each is discussed below.

Integrity of Cinder Cones

Kūkahauʻula, Puʻu Līlīnoe, and Waiau have been designated as TCPs. In general, all cinder cones, or puʻu, are considered important features. The Project would not impact any cinder cone if Access Way Option 1 is selected. Access Way Option 2 would disturb an approximately 1.3-acre area of Kūkahauʻula, of which roughly 1.0 acre has previously been disturbed by roads. Access Way Option 3 would disturb an approximately 1.6-acre area of Kūkahauʻula, of which roughly 0.9 acre has previously been disturbed by roads. These disturbances would occur on the western most extent of Kūkahauʻula at the base of the cinder cone near the SMA.

The potential impact associated with Access Way Option 2 would be associated with the small 0.3-acre area of new disturbance, and primarily consist of improving an existing road. No retaining walls would be necessary but some grading would be required. Kūkahauʻula would retain its overall shape but the small portion of the existing unpaved road at the base would be paved. If Access Way Option 2 were selected it would require mitigation to replace Wēkiu bug habitat at a 1:1 ratio (Section 3.4.3), this required mitigation could take the shape of restoring a portion of the habitat degraded by the existing 4-wheel drive road (where option 3 is shown). This habitat restoration could also have an incremental benefit to the integrity of Kūkahauʻula by restoring the scar made by the old road, potentially offsetting the impact of implementing Access Way Option 2.

Access Way Option 3 would improve the existing old 4-wheel drive road, which is currently blocked. The road was originally built in the 1960s to access the 13N site. Because the existing road is only one lane wide, to improve the road would require grading and a retaining wall on the upslope side of the Access Way. It has been indicated by cultural practitioners that the grading and retaining wall included in the design of Access Way Option 3 would reshape – or "cut," or "scar," Kūkahau'ula. Therefore, the potential impact of Access Way Option 3 is considered to be significant and not mitigatable.

Visual Impact of Man-made Structure

The visual impact of the Project is described in detail in Section 3.5.3. The TMT Observatory would not be visible from the summit of the TCP Kūkahau'ula, referred to as Pu'u Wēkiu in modern times. This is due to the presence of the northern ridge of Kūkahau'ula blocking the view from the summit peak. The TMT Observatory would also not be visible from the TCPs Pu'u Līlīnoe and Waiau.

The TMT Observatory would add a new visual element to the northern plateau area that would be visible to varying degrees from the shrines along the northern and eastern slopes of Maunakea. The TMT Observatory would appear in the view directly toward the summit from only a few of the shrines on the northern plateau.

In an interview with kupuna Leningrad Elarionoff conducted by Cultural Surveys Hawai'i Inc. for the proposed TMT Project CIA (Appendix D), Mr. Elarionoff offered the following statement in regards to the visual beauty and sacredness on Maunakea:

> I think we should recycle the sites. If an outdated structure is identified and there is a need to build another telescope on the mountain, tear down the old structure and build the new one on the same footprint. The Mountain is valuable and respected by us. Do not sacrifice our cultural monuments for expedience or budget concerns. Another structure can be another unnecessary intrusion that detracts from the beauty and majesty of Maunakea.

The following statement from Hawai'i County Councilman Kelly Greenwell, is also from the TMT Project CIA (Appendix D). In this statement, Mr. Greenwell stresses the importance of maintaining the beauty of Maunakea, should the proposed TMT project proceed with locating at Maunakea:

> I want to see it built … to see some respect for what is [being] built. I don't think it needs to impact the aesthetics of the mountain itself … To me; respect for nature is not to deface it. You can enhance it, but not deface it … When it comes to the bottom line, the only thing that really counts is that it is done in an appropriate manner, the alternative of that is inappropriate and this is not religious or any other than mechanical. What I have against windmills, they're ugly and I don't like them whirling about. It's the same as solar panels, if we can come up with a way that's not obtrusive, then I might warm up for it.

The Project has attempted to reduce the TMT Observatory's visual impact as described in Section 3.5.4. Mr. Elarionoff brought up a subject that is frequently broached; however, as outlined in Section 2.5.1, the Physical Plan in the 2000 Master Plan specifies that the Project is not eligible to replace an older optical/infrared observatory on the summit. The 2000 Master

Plan indicates that placing a NGLT (like the TMT), in Area E, instead of on the summit, would reduce its potential visual and other impacts. The 2000 Master Plan does allow for the redevelopment of existing observatory sites, as Mr. Elarionoff suggests, however, it was not deemed feasible for a NGLT. Through compliance with the 2000 Master Plan, the visual impact to the spiritual and sacred quality of the summit area would be limited in the view of those who believe cultural practices and astronomy can co-exist.

Employees in the Northern Plateau

Native Hawaiians have expressed that just knowing that Maunakea is there is sufficient; there is not a strong need to visit. In this framework, the regular presence of any people is not considered a normal condition for Maunakea and could affect its spiritual and sacred quality. It is estimated that approximately 100 employees currently work at the observatory facilities within MKSR. It is expected that 50 employees, at most, would work at the TMT Observatory on a regular basis (up to 44 during the day and 6 at night). As discussed in Section 2.5.4, the Project has been planned and is being designed to minimize the number of people and activities performed at the TMT Observatory. With TMT, the number of employees within the MKSR would increase to 150. In compliance with the CMP requirements, TMT employees would be trained to respect, honor, and not restrict or interfere with cultural and religious practices, and would be taught ways to reduce their impact on the cultural resources of the mountain. In the view of those who believe cultural practices and astronomy can co-exist, these CMP-required steps would reduce the potential impact related to the addition of the TMT employees on the spiritual and sacred quality of the mountain.

Accidental Release of Wastewater or Hazardous Substances

Some Native Hawaiians have indicated that the practice of releasing domestic wastewater into the subsurface through septic systems by current observatories desecrates the spiritual and sacred quality of the mountain. The same has been said regarding the potential accidental spillage of wastewater or hazardous substances. For these reasons the CMP requires that all new uses remove all domestic wastewater from the mountain for treatment. As detailed in Section 3.7.3, the Project would comply with this requirement and would not utilize a septic system to dispose of domestic wastewater. No wastewater would be released and all wastewater would be trucked off the mountain for disposal. As detailed in Section 3.8.2, the Project would, in compliance with applicable rules, regulations, and requirements, also implement measures to reduce the potential for accidental spills of wastewater and hazardous substances and reduce the potential impact of those events should they occur. By implementing these required steps, plans, and programs, the potential impacts to cultural resources related to the generation and disposal of domestic wastewater and the storage, use, and disposal of hazardous substances on the spiritual and sacred quality of the mountain would be limited.

Noise and Dust

Noise and dust could have an impact on the spiritual and sacred quality of the mountain and disturb those engaged in cultural practices; these impacts are discussed in detail in Sections 3.13.3 and 3.14.3, respectively. The conditions and required control measures discussed in those sections would limit the level of impact to the spiritual and sacred quality of the mountain.

Hale Pōhaku

At an elevation of approximately 9,000 feet, Hale Pōhaku is considered by some to be within the larger cultural property that is Maunakea. Therefore, the two general schools of thought described previously for the Maunakea summit region apply to Hale Pōhaku as well. The proposed TMT Mid-Level Facility would involve development within previously disturbed areas and areas previously used for similar purposes. Therefore, the TMT Mid-Level Facility would not result in any new impacts to cultural resources in the area.

Headquarters

Based on studies performed for the University Park as a whole and for individual developments within it, development of the Headquarters at University Park would not adversely affect cultural practices or beliefs.

Satellite Office

Based on available evidence, it is not believed that development of the Satellite Office in Waimea would adversely affect cultural practices or beliefs. A site-specific study would be conducted in coordination with SHPD upon final selection of a parcel to ensure that there would be no adverse effect on cultural practices or beliefs.

3.2.4 Mitigation Measures

In addition to compliance with the CMP requirements, whereby TMT employees would be trained to respect, honor, and not restrict or interfere with cultural and religious practices, and would be taught ways to reduce their impact on the cultural resources of the mountain, the following measure would also be implemented. The TMT Observatory, TMT Mid-Level Facility, Headquarters, and Satellite Office would be furnished with items to provide a sense of place and encourage and remind personnel of the cultural sensitivity and spiritual quality of Maunakea. This would be done to serve as a constant reminder of the lessons learned during the required training to respect, honor, and not restrict or interfere with cultural or religious practices.

The Project would continue consultation with SHPD and Kahu Kū Mauna Council to assess the new shrine in the vicinity of the TMT Observatory site and establish appropriate protocols for dismantling it. In addition, the Project would perform archaeological data recovery for the shrine, notwithstanding that it has been determined not to be historic properties.

As detailed in Section 3.11.4, TMT would implement a Ride-Sharing Program to reduce the number of vehicle trips between Hale Pōhaku and the TMT Observatory. This step could further reduce the Project’s impact to the spiritual and sacred quality of Maunakea by reducing dust, transient noise, and general movements in the summit region.

Signs may be placed at the beginning of the Access Way that could read “Dead End”, “No Trail Head”, “Access to TMT Observatory Only”, “Stay on Road”, and/or other similar warnings. These signs would be intended to deter visitors from unnecessarily traveling down the Access Way or beyond the TMT Observatory into areas where they could impact cultural resources.

Signs would be installed sparingly and designed to OMKM specifications so as to not detract from the landscape.

Proposed mitigation measures related to construction are discussed in Section 3.15 and include actions such as cultural and archaeological monitoring.

3.2.5 Level of Impact after Mitigation

For those that hold that cultural practices and astronomy can co-exist, the mitigation for the cultural impacts outlined above would incrementally reduce the Project's potential impact on cultural resources.

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3.3 Archaeologic/Historic Resources

This section discusses the archaeological and historical resources in the region and specific Project areas, the potential impact of the Project on those resources, and mitigation measures the Project would employ to mitigate those potential impacts. Archaeological Assessments were performed for the Project; technical reports related to these studies are provided in Appendix E and Appendix F.

3.3.1 Environmental Setting

Maunakea Summit Region

Multiple archaeological surveys have been conducted in the MKSR, as outlined in Table 3-1.

Table 3-1: Summary of Archaeological Surveys and Fieldwork in the MKSR

Year	Project/Area	Survey Type	New Sites	Reference
1975-76	Mauna Kea Adze Quarry	Reconnaissance and inventory	3	McCoy 1977
1981	Kitt Peak National Observatory	Reconnaissance	0	McCoy 1981
1982	Institute for Astronomy (IfA) / 1,000 acres of the summit and north slope	Reconnaissance	21	McCoy 1982a
1982	CSO	Reconnaissance	0	McCoy 1982b
1983	Maunakea Observatory Power Line	Reconnaissance	0	Kam and Ota 1983
1984	Summit Region	Reconnaissance	21	McCoy 1984
1987	Summit Road Improvement	Reconnaissance	0	Williams 1987; McCoy 1999b
1988	VLBA Observatory / 115 acres for VLBA	Reconnaissance	4	Hammatt and Borthwick 1988
1990	Subaru Observatory / 5.1 acres on pu'u	Reconnaissance	0	Robins and Hammatt 1990
1990	Gemini Observatory / 2 acres on Pu'u Kea	Reconnaissance	0	Borthwick and Hammatt 1990
1991	Pu'u Mākanaka	Reconnaissance	1	McCoy field notes
1992	SMA Observatory	Finding of two known sites	0	McCoy 1993
1995	SHPD site relocation and GPS recording	Reconnaissance	18	McCoy 1999a
1997	SHPD transect survey	Reconnaissance	29	McCoy 1999a
1999	SHPD survey of Pu'u Wēkiu	Reconnaissance	1	McCoy 1999a
2005	PCSI survey of the Science Reserve	Inventory	12	McCoy et al. 2005
2006	PCSI survey of the Science Reserve	Inventory	73	McCoy and Nees 2006
2007	PCSI survey of the Science Reserve	Inventory	40	McCoy and Nees in prep
2008	TMT / 36 acre Area E	Assessment	0	Appendix C

The archaeological surveys within the MKSR have identified and recorded 222 historic properties of various types, as listed in Table 3-2. Most of the identified sites are single-feature sites.

Table 3-2: Site Types in the MKSR

Site Type	Number	Percent Total
Traditional Cultural Properties (TCP)	2	0.9
Shrines	149	67.1
Burials and Possible Burials*	26	11.7
Stone Tool Quarry/Workshop Complex	1	0.5
Adze Quarry Ritual Center	1	0.5
Isolated Adze Manufacturing Workshops	17	7.7
Isolated Artifacts	3	1.4
Stone Markers/Memorials	10	4.5
Temporary Shelters	3	1.4
Historic Campsites	1	.5
Unknown Function	9	4.1
TOTAL	**222**	**100.0**

Note: * = burials or possible burials are not illustrated on figures in this report of the CMP.

All the buildings in the MKSR, including observatories, are less than 50 years old; therefore, there are no historic buildings in the MKSR. The discussion below focuses on conditions in Area E and along the Access Way. The CMP and other documents discuss the conditions throughout the MKSR. An archaeological assessment of Area E was performed for the preparation of this EIS (Appendix C). The survey confirmed the results of previous surveys in the area; the new survey did not encounter any previously unidentified sites.

Three historic shrines are present in the vicinity of Area E and the Access Way. One is located north of Area E and the Project 13N site and two are located southeast of Area E, additional shrines are located at greater distance from Area E. These three shrines were originally identified in 1982. These three shrines were located during the survey for this Project and their location confirmed and mapped. The location of the three shrines is illustrated in Figure 3-2. The shrines are at least 100 feet from Area E and the existing roads and more than 200 feet from any Project area.

Twenty-six sites in the MKSR have been interpreted as burials or possible burials. Most of these are classified as possible burials; they have been classified as such by archaeologists for compelling reasons, such as the topographic location and morphological characteristics of the structures. None of the sites identified as known or possible burials are within Area E, along the proposed Access Way, or in the Batch Plant Staging Area.

Two TCPs have been designated within the MKSR; they are Kūkahauʻula and Puʻu Līlīnoe. A third TCP, Waiau, is located in the neighboring Ice Age NAR. These are discussed in more detail in Section 3.2.1 and illustrated on Figure 3-2. All of Maunakea down to the 6,000 foot elevation has been suggested as a TCP.

Two "find spots," or potential historic properties, were identified within Area E (Figure 3-2). One was initially interpreted to be a possible pre-contact shrine, consisting of two upright stones, located in the northwestern portion of the survey area. The second was initially interpreted to be a possible pre-contact temporary habitation complex, consisting of a C-shaped enclosure and two

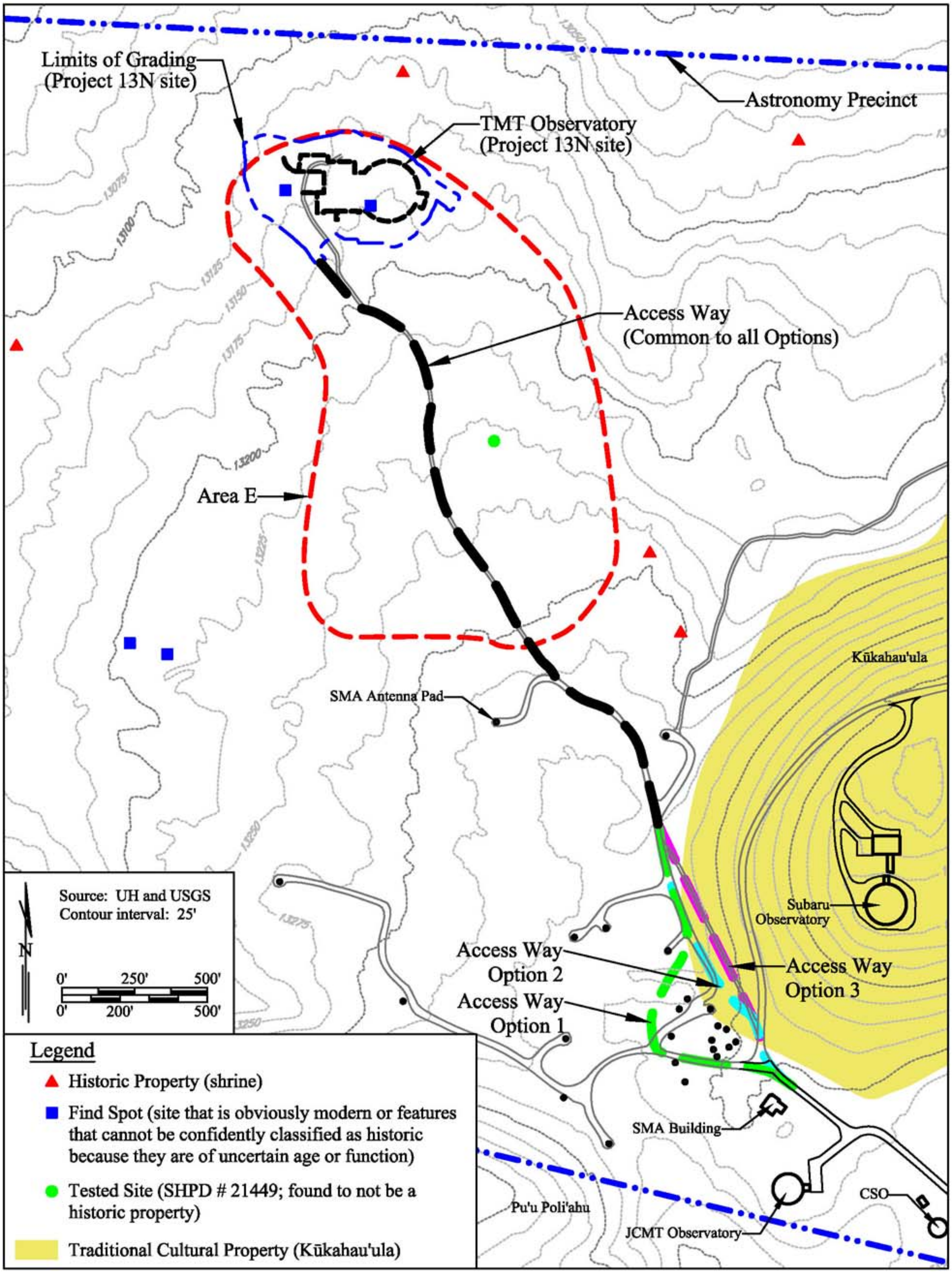

Figure 3-2: Known and Potential Historic Sites near Area E and the Access Way

small terraces, located within a lava channel in the northern portion of Area E. Upon completion of the initial pedestrian survey, a site visit was conducted with SHPD staff and Dr. Patrick McCoy to discuss the significance of the two finds in Area E. Following discussions, neither was determined to warrant historic property designation. The possible shrine was determined to most likely be a modern structure, likely constructed within the last 10 years. This determination was based on prior surveys undertaken by McCoy within the survey area that did not identify the feature. The possible temporary habitation complex was determined to most likely be a natural geological feature that only appeared to have been man-made.

Another feature thought to be a potential historic property was recorded by McCoy during survey work in Area E in preparation of the CMP. Its location is illustrated in Figure 3-2, and was issued SHPD site number 21449. Due to doubts about its nature and in consultation with SHPD, a subsurface testing program was carried out. During the testing process no evidence of historic origin was encountered. Therefore, this feature, although illustrated on figures in the CMP, is not a historic property within Area E.

The Batch Plant Staging Area has been disturbed by a variety of construction activities over the years and no surveys have encountered a historic property there. The nearest historic properties are two shrines over 500 feet to the west.

Upon careful survey, research, and consideration no historic properties were identified within Area E, along the Access Way, or in the Batch Plant Staging Area.

Hale Pōhaku

Multiple archaeological surveys and field work have been conducted in Hale Pōhaku, as outlined in Table 3-3.

Table 3-3: Summary of Archaeological Investigations at Hale Pōhaku

Year	Project	Investigation	Reference
1979	Hale Pōhaku Mid-Level Facilities Complex Development Plan	Reconnaissance survey	McCoy 1979
1984-85	Supplemental EIS for Construction Laborer Camp	Reconnaissance survey	McCoy 1985
1986	HELCO transmission line and substation	Reconnaissance survey	Bonk 1986
1987	HELCO transmission line and substation	Reconnaissance survey	Sinoto 1987
1987	HELCO substation and surrounding area	Data recovery	McCoy 1981
1990	Subaru Observatory Construction Dormitories	Reconnaissance survey	Robins and Hammatt 1990
1993	Subaru Observatory Construction Dormitories	Data recovery	Hammatt and Shideler 2002
2005	Septic tank excavations	Monitoring	McCoy 2005
2009	TMT Mid-Level Facility	Assessment	Appendix D

An archaeological assessment of the TMT Mid-Level Facility area was performed for the preparation of this EIS (Appendix D). The TMT Mid-Level Facility area is roughly six acres and includes the southern/lower portion of Hale Pōhaku and an area around the HELCO substation. The survey confirmed the results of previous surveys in the area; the new survey did not encounter any previously unidentified sites.

Two "Lithic Scatters" were identified in Hale Pōhaku in 1985 and determined to be part of the Pu'u Kalepeamoa site complex. The Pu'u Kalepeamoa site complex has been categorized as a Stone Tool Quarry/Workshop Complexes. Initially, the Institute for Astronomy (IfA) planned to preserve the two lithic scatters, however, dormitory construction increased erosion in the vicinity and, in consultation with SHPD, a data recovery program was agreed to. Based on data recovery in 2002 it was concluded that the sites were modest, out-lying, open, lithic workshop sites with octopus lure sinker manufacture of both "coffee-bean" and "bread-loaf" morphological types. Also part of the Pu'u Kalepeamoa site complex are two shrines located south, across the 4-wheel drive road from, and at least 190 feet away from Hale Pōhaku and the TMT Mid-Level Facility.

While there are areas where physical evidence of human activity was observed in the TMT Mid-Level Facility area during the recent survey, there were good grounds for concluding that the specific constructions were less than fifty years old and hence the physical evidence of human activity was regarded as inappropriate for designation as a historic property. All but one of these findings was located completely outside the TMT Mid-Level Facility areas, though some fell within 200 feet of the areas. In order to provide a more complete record, and to avoid any possible misunderstandings, these cases were documented and are shown in Appendix D. Three previously identified historic properties that are outside of Hale Pōhaku but in the vicinity of the TMT Mid-Level Facility were confirmed as being outside of the TMT Mid-Level Facility area.

Upon careful survey, research, and consideration no historic properties were identified within the TMT Mid-Level Facility area.

Headquarters

The University Park area was surveyed for archaeological resources during the preparation of the University of Hawai'i at Hilo University Park Final Environmental Impact Statement (DAGS, 1997). Four rock mounds and a portion of a stacked boulder wall were identified, and determined to have been constructed and maintained historically as part of Waiākea Mill Co.'s sugar cane operations. The construction and maintenance of the mounds and wall were done to increase the cultivatable soil area by removing rocks from the fields and piling them into mounds and/or along field edges (e.g., the wall). The features were included within State Site number 50-10-35-18670, and no further work was recommended.

These sites are not within the area being considered for Headquarters development in the University Park, and thus there are no historic properties identified within this location.

Satellite Office

The potential Satellite Office site has not been narrowed down sufficiently to deem an archaeological/historical resources survey at this time. When a site is selected in Waimea, it will be surveyed. Generally, the commercial district of Waimea is not known to have a high density of archaeological sites and even undeveloped lands have been highly disturbed by ranching activities in the past.

3.3.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact if it involves an irrevocable commitment to loss or destruction of any natural or cultural resource. Therefore, a significant impact would occur if the Project resulted in the loss or destruction of any archaeologic/historic resource.

3.3.3 Potential Environmental Impacts

The potential impacts of the Project are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the Project type and location. This includes requirements of the CMP. As no archaeological or historical properties were identified in any of the Project areas or within 200 feet of any areas that would be disturbed by the Project, no historic properties would be affected. With this determination, no significant impact is expected.

To help assure this, a Cultural and Natural Resources Training Program would be developed and implemented. As discussed in the CMP, the Cultural and Natural Resources Training Program would include educational instruction and materials designed to:

- Impart an understanding of Maunakea’s cultural landscape, including cultural practices, historic properties and their sensitivity to damage, and the rules and regulations regarding the protection of historic properties.
- Make it clear that any disturbance of a historic property is a violation of HRS Chapter 6E-11 and punishable by fine.
- Provide guidance and information as to what constitutes respectful and sensitive behavior while in the summit area.

The training program would be updated regularly to incorporate UH Management Area-wide updates by OMKM. All persons involved in TMT Observatory operation and maintenance activities, including but not limited to scientists and support staff, would receive the training on an annual basis.

3.3.4 Mitigation Measures

Implementation of the management procedures, such as the Cultural and Natural Resources Training Program, and compliance with existing regulations and requirements would ensure that Project impact would not have a significant impact on historic resources, and no additional mitigation is required.

Notwithstanding the finding that no historic properties would be affected, the Project would continue consultation with SHPD and Kahu Kū Mauna Council to assess the new shrine in the vicinity of the TMT Observatory site and establish appropriate protocols for dismantling it. In addition, the Project would perform archaeological data recovery for the two find spots – the modern shrine and the site that initially appeared to be a temporary habitation – notwithstanding that they have been determined not to be historic properties.

Proposed mitigation measures related to construction are discussed in Section 3.15 and include items such as cultural and archaeological monitoring.

3.3.5 Level of Impact after Mitigation

No archaeological or historical properties were identified in any of the Project areas and the recommendation by Cultural Surveys Hawai‘i‘ was a “no historic properties affected” determination, this, along with the mitigation measures discussed result in the Project having no significant impact on archaeological and/or historical resources.

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3.4 Biologic Resources

This section discusses the biologic resources (flora and fauna, including rare, threatened, and endangered species) in the region and in the Project areas, the potential impacts of the Project on those resources, and mitigation measures the Project would employ to mitigate those potential impacts. Impacts associated with construction and decommissioning activities are discussed in Section 3.15 of this EIS.

3.4.1 Environmental Setting

Maunakea Summit Region

Detailed information about Project area inventories and assessments may be found in the Biological Resources Technical Report in Appendix G.

<u>Flora</u>

There are two general vegetation types/ecosystems or habitats in the Maunakea summit region (Figure 3-3):

- Alpine Shrublands and Grasslands. This is generally the area from 9,500 feet (the tree line) to 12,800 feet.
- Alpine Stone Desert. This is the area above 12,800 feet.

Vegetation generally decreases in diversity, density and size towards the summit of the mountain, moving from alpine shrublands and grasslands above the treeline, at roughly 9,500 feet, to a stone desert above 12,800 feet. Area E, the Access Way, and the Batch Plant Staging Area are located in the alpine stone desert.

The alpine shrublands and grasslands vegetation on Maunakea begins just above Hale Pōhaku. Alpine shrubs and grasses grow predominantly on ʻaʻa lava flows, cinder cones, and air-fall deposits of lapilli and ash. The most common vascular plants[35] that occur here include pūkiawe (*Styphelia tameiameiae*), nohoanu (*Geranium cuneatum*), and ʻohelo (*Vaccinium reticulatum*), but various other native shrubs, grasses, sedges, and ferns can also be found. The alpine shrublands and grasslands are also home to the Maunakea Silversword (*Argyroxiphium sandwicense*), an endangered species. A fence exclosure surrounds the largest known population, about 30 plants near 9,350 feet elevation above the Wailuku river basin. Except for a single plant near the Maunakea Access Road that is also enclosed in protective fencing, the Maunakea Silversword is rare and does not occur near astronomy activity.

[35] Vascular plants are those that have lignified (woody) tissues for conducting water, minerals, and photosynthetic products through the plant. Vascular plants include ferns, conifers, and flowering plants.

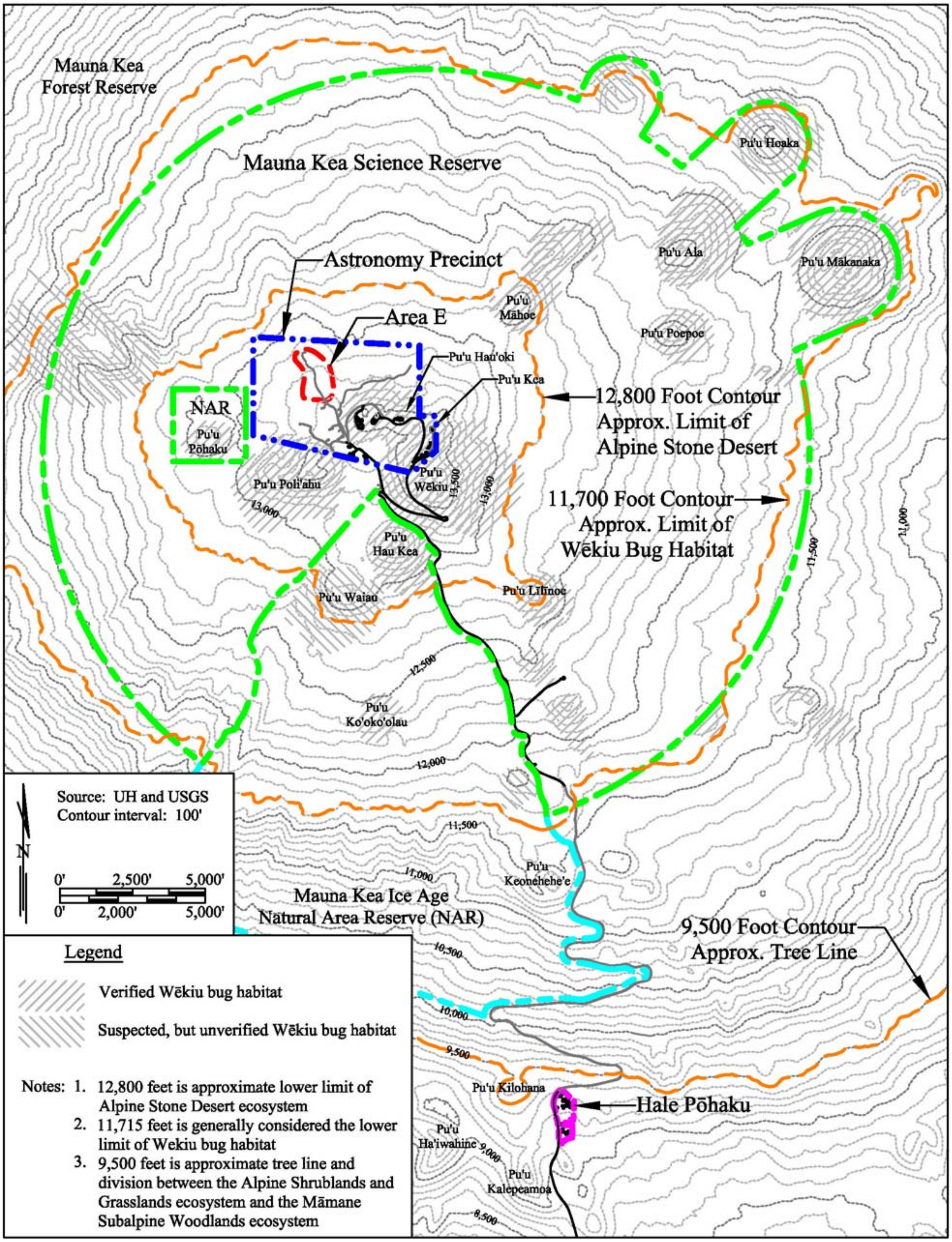


Figure 3-3: Overview of Maunakea Ecosystems

The plant community in the alpine stone desert consists of several species of mosses and lichens, and a limited number of vascular plants.

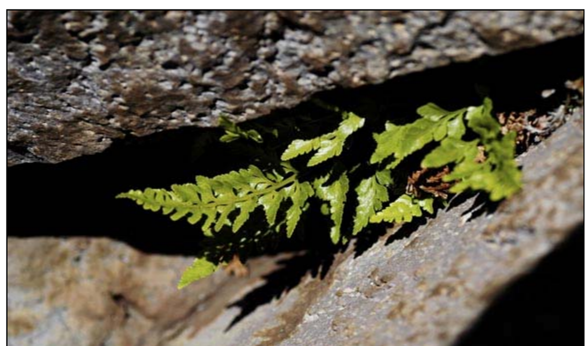
Lichen colony in Area E.

- **Lichens**. The highest densities and diversity of the 21 known species of lichens tend to grow on north and west facing rocks in protected locations away from direct early morning sun exposure. Areas to the southwest of the major cinder cones support a lower density and diversity of lichens than other areas, likely due to a rain shadow effect created by the cinder cones. Some species of lichens occur only in the numerous small caves and collapsed lava tubes found throughout the Maunakea summit region.

  A recent survey of Area E detected 10 lichens species (Appendix G). All of the species encountered also occur at somewhat lower elevations and none are unique to Hawai‘i. The low diversity and extremely low cover (less than 1 percent) may be due to a lack of suitable habitat. There is a greater abundance of lichens at the same elevation elsewhere in the Maunakea summit region where there are mounds of rocks rather than the solid flows present in Area E.

- **Mosses**. The 12 species of mosses reported to be present in the alpine stone desert occur in habitats partially protected by rock overhangs, or in deeply shaded pockets and crevices. Availability of water appears to be the most important factor determining the distribution of mosses. Even the most drought tolerant genus, *Grimmia*, is always associated with small runoff channels where moisture is available.

  Two species of mosses were detected during the recent botanical survey of Area E (Appendix G). Both species are indigenous[36] to Maunakea, and occur elsewhere Hawai‘i and the world.



‘Iwa‘iwa fern in Area E.

- **Vascular Plants**. Vascular plants that survive in the alpine stone desert occur mainly at the base of rock outcrops where there is an accumulation of soil and moisture, and some protection from wind. Six species are reported from the summit region: two Hawaiian endemic grasses, Hawaiian bentgrass (*Agrostis sandwicensis*) and pili uka (*Trisetum glomeratum*); two naturally occurring

[36] The status of species are defined as:
Endemic – A species native to, or restricted to Hawai’i.
Indigenous – A species native to Hawai’i but that naturally occurs outside of Hawai’i as well.
Non-indigenous – A species not native to Hawai’i.
Adventive – Not native, a species transported into a new habitat by natural means or accidentally by human activity.
Purposely introduced – A species released in Hawai’i for a particular purpose, usually to control a weedy plant or another insect.

ferns, ‘iwa‘iwa (*Asplenium adiantum-nigrum*) and Douglas’ bladderfern (*Cystopteris douglasii*); and two exotic daisies, Hairy cat’s ear (*Hypochoeris radicata*) and common dandelion (*Taraxacum officinale*).

Seven vascular plant species were detected in Area E during the recent botanical survey, all present in low abundance (Appendix G). The endemic spleenwort, ‘oāli‘i (*Asplenium trichomanes* subsp. *densum*) was uncommon in Area E, occurring in crevices of rocks. This species, not previously reported from the alpine stone desert, is locally abundant in full sunlight in open areas on lava fields and in kīpuka from 3,950 to 8,850 feet on East Maui and Hawai‘i. The Hawaiian endemic Douglas’ bladderfern was observed and is known to occur at high elevations on Haleakalā and Maunakea but also occurs in moist forests on Kaua‘i, O‘ahu, Lāna‘i, and Maui, and is a U.S. Fish and Wildlife Service (USFWS) species of concern. In the summit region, this fern is more common to the east, in the vicinity of Area F, near an existing unimproved dirt roadway, where several patches occur.

Fauna

The only resident faunal species in the Alpine Stone Desert ecosystem above 12,800 feet on Maunakea are arthropods. At least 10 confirmed resident species of indigenous Hawaiian arthropod species have been collected near the summit including: Wēkiu bugs (*Nysius wekiuicola*), lycosid wolf spiders (*Lycosa* sp.), two sheetweb spiders (genus *Erigone*), two mites (Family *Aystidae* and Family *Eupodidae*: both species unknown), two springtails (Family *Entomobryidae*: two species unknown), a centipede (*Lithobius* sp.[37]), a noctuid moth (*Agrotis* sp.). Several other indigenous Hawaiian species have also been collected near the summit but their resident status is unconfirmed. Additional arthropod species, non-indigenous to Hawai‘i, are thought to be resident to the summit area cinder cones. One of the indigenous arthropods, the Wēkiu bug, is proposed as a candidate species for Federal listing under the Endangered Species Act.

Wēkiu bug lives only in loose cinder habitats on the cinder cones above 11,715 feet on Maunakea. There is a similar species, *Nysius aa*, that occurs in the upper elevations on Mauna Loa. The Wēkiu bug is a small “true bug” that has made a remarkable adaptation in feeding behavior. Many true bugs, including most of those found elsewhere in Hawai‘i, are herbivores and feed on seeds and plant juices. The Wēkiu bug is a scavenger that uses its straw-like mouth to feed on insects blown up to the summit area from the surrounding lowlands. These aeolian insects accumulate in protected pockets on the cinder cones; they quickly become moribund in the cold and thus easy prey for foraging Wēkiu bugs who have adapted to the harsh conditions of the summit area.

Wēkiu bugs are generally concentrated on the cinder cones in the summit area, but also utilize other habitats. Six arthropod habitat types have been identified in the alpine stone desert.

[37] The abbreviation “sp.” is used when the actual specific name cannot be specified.

- Type 1 – Snow patches: Seasonal patches of snow accumulate insects that are blown up the mountain from lower elevations. Wēkiu bugs are thought to exploit the edges of these patches, feeding on aeolian insects as they emerge from the melting snow.

Wēkiu Bug
Photo by Greg Brenner

- Type 2 – Tephra ridges and slopes: On cinder cones, where tephra cinders are large enough (≥1 cm), Wēkiu bugs, spiders, caterpillars (*Agrotis* sp.) and smaller arthropods are able to move within the interstitial spaces and utilize humid, protected microhabitats among the tephra. This is the habitat where Wēkiu bugs are observed in greatest abundance. Smaller arthropods, like springtails (*Collembola*), and mites inhabit smaller (≤1cm) tephra cinders.
- Type 3 – Loose, steep tephra slopes: The unstable steep outside slopes of cinder cones where tephra cinders are smaller and subject to downward creep. Wēkiu bugs are present in low abundance in this habitat.
- Type 4 – Lava flows: ‘a‘a and pāhoehoe lava flows with large outcrops of andesitic rocks. This is the principal habitat for lichens and mosses, lycosid wolf spiders, and centipedes. Wēkiu bugs are uncommon in this habitat, presumably because of the lack of suitable microhabitat.
- Type 5 – Talas slopes and highly fractured rock outcrops: Usually found as islands within Type 4 habitat, these are areas of talas slopes, highly fractured rock outcrops, and depressions between lava flows with glacially deposited, rounded cobbles and rocks lie on fine loess. Small voids provide suitable microhabitats for Wēkiu bugs which can occur in moderate abundance during times of high population outbreaks.
- Type 6 – Compacted ash, silt, and mud: Found on roadways, disturbed areas, and where fine aeolian loess accumulates. The interstitial spaces are mostly filled with fine-grained material and therefore not suitable for Wēkiu bugs and lycosid spiders. Springtails and mites are the most abundant arthropods in this habitat type.

About 5 percent of the lava flow terrain of Area E and other Access Way areas can be classified as Type 5 Wēkiu bug habitat, with the remainder being Type 4. During a 1982 arthropod survey Wēkiu bugs were present in low density in Type 5 habitats within Area E, based on captures in 14 traps placed in the area. Wēkiu bug have not been collected in Area E or similar nearby habitat since, despite three subsequent intensive collecting efforts. Twenty-five traps were set in 1997/1998 along the 13N access road but no Wēkiu bugs were captured in any of those traps. No Wēkiu bugs were collected during the 2008 sampling effort, which included 20 sampling points within Area E and along the Access Way (Figure 3-4). Wēkiu bugs were not found during the 2009 sampling effort within Area E (6 sample points) but were found in the cinder along Access Way Option 2 and 3 (6 sample points).

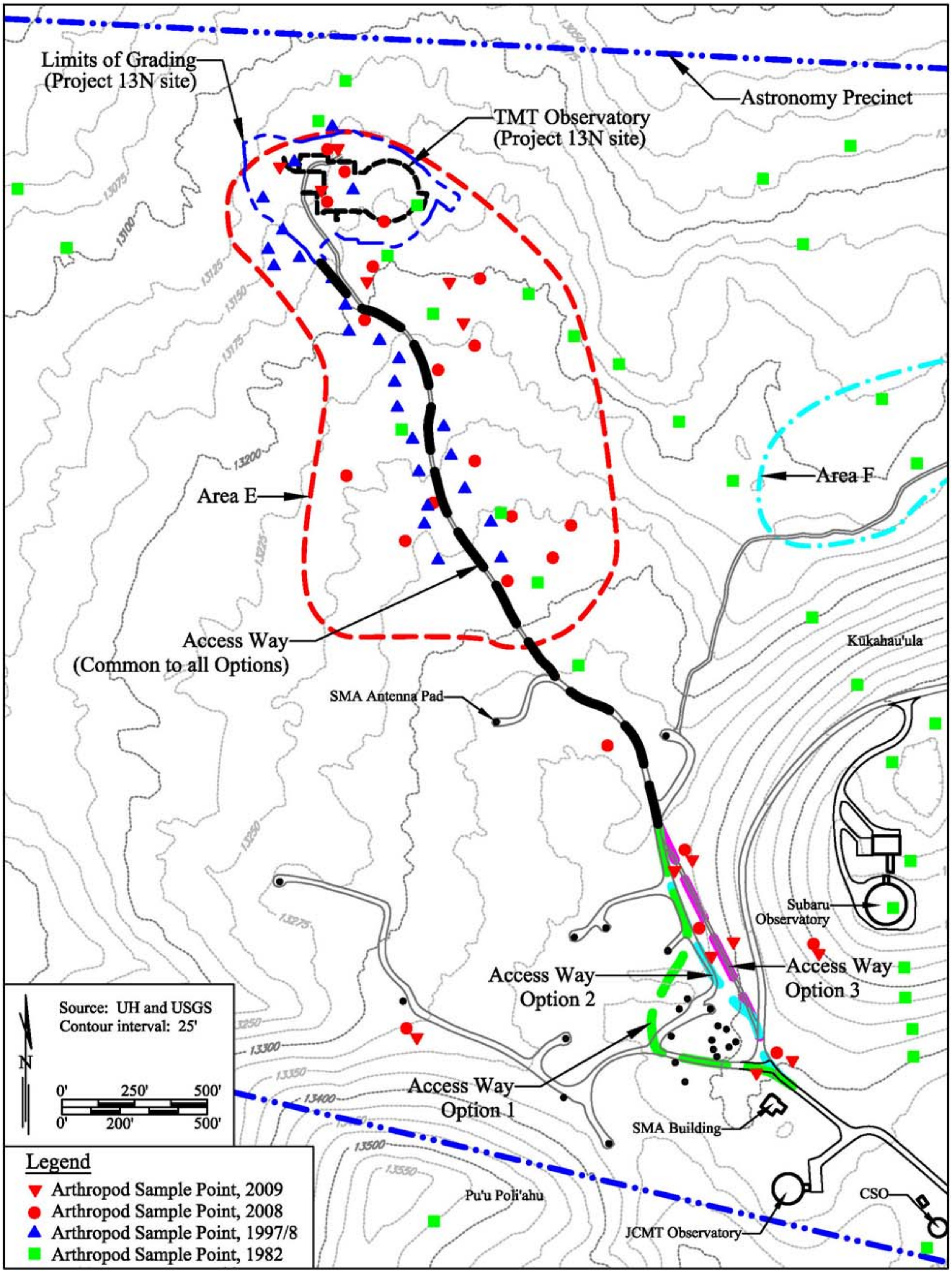


Figure 3-4: Arthropod Sampling in Vicinity of Area E and the Access Way

The undisturbed area along the Access Way Option 1 alignment is habitat similar to the lava flow terrain in Area E (Types 4 and 5) while the rest is Type 6 habitat.

Access Way Options 2 and 3 comprises a combination of Type 3 and Type 6 habitat. Wēkiu bugs are present in low abundance in the Type 3 habitat at the base of the unnamed pu‘u (the northwestern extent of Kūkahau‘ula). Although Wēkiu bugs were not found in this area in 2008, they were found in the spring of 2009 in abundances similar to those in other nearby cinder cone habitat.

Threatened and Endangered Species

There are no currently-listed threatened or endangered[38] species known to occur in the Astronomy Precinct. The Maunakea Silversword (*Argyroxiphium sandwicense*), an endangered species, is known to occur at lower elevations and is discussed below in the Hale Pōhaku section. A recent arthropod and botanical survey of the Project areas in the Maunakea summit region did not encounter any species listed as endangered or threatened under either Federal or State of Hawai'i endangered species statutes.

One species that is currently a candidate for listing, the Wēkiu bug (*Nysius wekiuicola*). Wēkiu bugs were not found in Area E during studies for the Project, but were found during Project studies in the Spring of 2009 in Type 3 habitat along Access Way Options 2 and 3. Wēkiu bugs are known to occur on a number of cinder cones above an elevation of 11,700 feet; they are most common in Type 2 habitat but are also known to frequent Type 3 habitat.

One species currently considered a species of concern by the USFWS, the Douglas' bladderfern (*Cystopteris douglasii*), are known to occur in the Maunakea summit region. The Douglas' bladderfern was found throughout Area E; it is known to be widespread, occurring on all main Hawaiian Islands and on Maunakea is more common to the east, in the vicinity of Area F. Area E is not considered critical habitat for the Douglas' bladderfern.

The ‘ua‘u (*Pterodrama sandwichensis*) the endangered Hawaiian petrel, may have historically utilized the lower portions of the alpine shrublands and grasslands on Maunakea, but none have been observed near Project sites.

Hale Pōhaku

Detailed information about Project area inventories and assessments may be found in the Biological Resources Technical Report in Appendix G.

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[38] There are several terms that are used to describe the status of species. These include:
Endangered species – Any species which is in danger of extinction throughout all or a significant portion of its range, as listed in the Endangered Species Act (ESA) or HRS Chapter 195D.
Threatened species – Any species which is likely to become endangered within the foreseeable future, as listed in the ESA or HRS Chapter 195D.
Candidate species – Any species being considered by the Secretary of the Interior for listing as an endangered or a threatened species, but not yet the subject of a proposed rule.
Species of Concern – Those species about which regulatory agencies have some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the ESA.
Rare species – Those species that occur very infrequently, but are not classified threatened or endangered.
Sensitive species – Those species which rely on specific habitat conditions that are limited in abundance, restricted in distribution, or are particularly sensitive to development.

Flora

Hale Pōhaku is located in the māmane subalpine woodlands ecosystem that extends down to the Saddle Road (Figure 3-3). The subalpine woodlands are dry most of the year, and māmane trees (*Sophora chrysophylla*) intercept fog that provides them and other plant species with the small amounts of moisture they need to survive.

The understory of the māmane subalpine woodland near Hale Pōhaku is comprised largely of native shrubs like ‘āheahea (*Chenopodium oahuense*), pūkiawe (*Styphelia tameiameiae*), and less abundant are nohoanu (*Gernium cuneatum*), two native mints, *Stenogyne microphylla* and mā‘ohi‘ohi (*Stenogyne rugosa*), and the Hawaiian catchfly (*Silene hawaiiensis*), a threatened species. Pili uka (*Trisetum glomeratum*) and hairgrass (*Deschampsia nubigena*) are the most abundant indigenous grasses.

The TMT Mid-Level Facility would be located in the southern portion of Hale Pōhaku. Portions of the area are compacted ash and rock, with little vegetation and have been used for construction staging and parking for several of the observatories on Maunakea. Māmane trees are present in the proposed TMT Mid-Level Facility site, but are less dense than in the surrounding forest, which is the Mauna Kea Forest Reserve. The ground cover of the TMT Mid-Level Facility site consists of a mixture of non-indigenous plants, dominated by needlegrass (*Nassella cernua*) growing between common groundsel (*Senecio vulgaris*), fireweed (*Senecio madagascariensis*), pin clover (*Erodium cicutarium*), woolly mullein (*Verbascum thapsus*), evening primrose (*Oenothera stricta*), and telegraph plant (*Heterotheca grandiflora*).

In a recent survey, only a few native plant species were present in the TMT Mid-Level Facility area: māmane trees (*Sophora chrysophylla*), ‘aheahea (*Chenopodium oahuense*), hinahina (*Geranium cuneatu*m), mā‘ohi‘ohi (*Stenogyne rugosa*), littleleaf stenogyne (*Stenogyne microphylla*), Hawaiian bent grass (*Agrostis sandwicensis*), pili grass (*Trisetum glomeratum*), and another grass (*Deschampsia australis*). All of these species occur over a wide range and most on other islands in Hawai‘i and none are considered rare or threatened. (Appendix G).

Fauna

The open-canopied māmane forest is home to the palila (*Loxiodes bailleui*), a native Hawaiian bird listed as endangered. The māmane forest on Maunakea has a diverse arthropod fauna. More than 200 arthropod species have been collected there. The arthropod fauna includes several species of *Plagithmysus* (a genus of native Hawaiian long-horn beetles), seven species of small native caterpillars (*Cydia* spp.) that live in māmane pods and are important prey of palila, the Kamehameha butterfly (*Vanessa tameamea*) – the official state insect of Hawai‘i, and the koa bug (*Coleotichus blackburniae*).

Thirty-three species of arthropods and two snails were observed on or near the TMT Mid-Level Facility within Hale Pōhaku. Fifteen of the species detected are endemic to Hawai‘i, seventeen are purposeful or adventives non-indigenous species, and three are of unknown origin. The arthropod fauna at the TMT Mid-Level Facility consists mostly of non-indigenous species and common endemic species that are abundant throughout the māmane forest, and occur on other islands. None of the species found are designated as serious pests, and no ants were detected during the sampling (Appendix G).

Threatened and Endangered Species

A number of threatened, endangered, or species of concern are potentially present in the māmane subalpine woodlands. These include:

- Flora
    - Maunakea Silversword (*Argyroxiphium sandwicense* subspecies *sandwicense*), an endangered species. There are no wild individuals of this species near Hale Pōhaku. However, they are being outplanted within an exclosure behind the Visitor Information Station.
    - Hawaiian catchfly (*Silene hawaiiensis*), a threatened species. A small population of the Hawaiian catchfly was reported in rocky areas on the steep slopes adjacent to and above the maintenance area in the northern/upslope portion of Hale Pōhaku by Char in 1985.
    - ‘Akoko (*Chamaesyce olowaluana*), na‘ena‘e (*Dubautia arborea*), Hawai‘i black snakeroot (*Sanicula sandwicensis*), and Douglas’ bladderfern (*Cystopteris douglasii*); all State species of concern. These species are all potential present in the habitat surrounding Hale Pōhaku but have not been detected during surveys within the Hale Pōhaku boundaries.
- Fauna
    - Palila (*Loxiodes bailleui*), a native Hawaiian bird listed as endangered. Hale Pōhaku is within the boundaries of palila critical habitat, but no palila were detected there during surveys in 2007.
    - ‘Amakihi (*Hemignathus virens*), ‘apapane (*Himatione sanguine*), ‘i‘iwi (*Vestiaria coccinea*) are bird species of concern. These species have been observed in māmane subalpine woodlands but only ‘amakihi and ‘apapane were detected during the 1979 and 1985 bird surveys near Hale Pōhaku. ‘I‘iwi were observed at Hale Pōhaku in 2006 but have been described as seasonal, uncommon visitors to the area.
    - ‘Akiapola‘au (*Hemignathus munroi*), an endangered bird. The ‘akiapola‘au are found primarily in koa-ōhi‘a forests and therefore not likely in the Hale Pōhaku area.
    - ‘Io (*Buteo solitaries*), the endangered Hawaiian Hawk. ‘Io use a broad range of forest habitats and are not frequent visitors to the māmane subalpine woodlands, but could pass through occasionally.
    - Nēnē (*Branta sandvicensis*), the endangered Hawaiian goose. Nēnē may inhabit high elevation grasslands and dry forests during breeding season, but evidence suggests that this species no longer utilizes the area around Hale Pōhaku.
    - ‘Ope‘ape‘a (*Lasiurus cinerus semotus*), the endangered Hawaiian hoary bat. The ‘ope‘ape‘a, has been observed in *māmane* subalpine woodlands on Maunakea, but the status of this species at Hale Pōhaku is unknown.
    - Koa bug (*Coleotichus blackburniae*), a species of concern, is not likely to be present at Hale Pōhaku because its common host plants koa (*Acacia koa*) and a‘ali‘i (*Dodonea viscose*) do not occur there.

- Black-veined Agrotis noctuid moth (*Agrotis melanoneura*), a species of concern, has not been collected at Hale Pōhaku and may be extinct.
- Two yellow-faced bees (*Hylaeus difficilis* and *H. flavipes*), both species of concern. Only *H. flavipes*, a federal and state species of concern, has been confirmed from Hale Pōhaku.
- Two species of snails (*Succinea konaensis* and *Vitrina tenella*), both species of concern, have been collected at Pu‘u La‘au from elevations ranging from 6,200 to 8,600 feet.

A recent arthropod and botanical survey at the proposed TMT Mid-Level Facility site found no species listed as endangered, threatened, or that are currently proposed for listing under either Federal or State of Hawai'i endangered species statutes. The Yellow-footed yellow-faced bees, the Difficult yellow-faced bee (*Hylaeus difficillis*) and the Yellow-footed yellow-faced bee (*H. flavipes*), and a succineid snail (*Succinea konaensis*) were the only Federal or State species of concern detected during the arthropod survey. The Difficult yellow-faced bee was observed only during the Spring 2009 sampling period and normally may forage at higher elevations during warmer weather. This species also occurs on Maui, Lāna‘i, and Moloka‘i. The Yellow-footed yellow-faced bee was observed during both sampling periods foraging on māmane; this species also occurs on Maui and Lāna‘i. Little is known about the distribution of the succineid snail; however, it is known to occur near Pu‘u La‘au on the western slopes of Maunakea.

Headquarters

A botanical study conducted of the University Park area in 1992 found the area to be characterized by ōhi‘a trees and matted uluhe ferns. Guava thickets were also present. The birds found in the area are mostly completely non-indigenous introduced species. Endangered bird species may fly over University Park occasionally between the months of April and October; these species include the Hawaiian Hawk or ‘io (*Buteo solitarius*), the Short-eared Owl or pueo (*Asiofiammeus sandwichensis*), the ‘ua‘u (*Pterodrama sandwichensis*) the endangered Hawaiian petrel, and the Newell's Shearwater or ‘ao (*Puffinus newelli*).

Based on the study, none of the plants inventoried were listed as threatened or endangered species, nor were any proposed as candidate for such status. The area is not considered critical habitat for any species.

Satellite Office

This general area was formerly a koa/ōhi‘a montane mesic forest but is now primarily abandoned cattle pasture dominated by Kikuyu grass and various introduced weeds. The only native plant likely present is ‘ilima. The area is not known to contain any valuable ecosystems or offer suitable habitat for protected species. No threatened, endangered, candidate, or species of concern are known to be present in the area, although some endangered bird species may occasionally fly over the area.

3.4.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant effect to the existing biological resources if it (1) caused/involved an action that irrevocably commits a natural resource, (2) curtails the range of beneficial uses of the environment, or (3) or substantially affects a rare, threatened, or endangered species, or its habitat.

Therefore, a significant adverse impact would occur if the Project caused long-term loss or impairment of a substantial portion of local habitat of indigenous Hawaiian species; caused a substantial reduction in the population of a protected species, as designated by Federal and State agencies, or a species with regional and local significance; introduced or increased the prevalence of undesirable non-native species; curtailed the range of a native Hawaiian species; or otherwise reduced the range of beneficial uses of the environment. This can occur with a reduction in numbers; by alteration in behavior, reproduction, or survival, or by loss or disturbance of habitat.

3.4.3 Potential Environmental Impact

The potential impacts of the Project are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the project type and location. This includes requirements of the CMP, the 2000 Master Plan, the Endangered Species Act, USFWS Species Recovery and Conservation Plans, and the State of Hawaiʻi Environmental Policy (HRS 344).

Impacts on biological resources were evaluated by assessing the sensitivity, significance, or rarity of each resource that could be adversely affected by the Project. The significance may be different for each habitat or species and is based on the resource's rarity or sensitivity and the level of impact that would result from the proposed Project. Most impacts on high sensitivity resources are considered significant, while the determination of significance for impacts on the moderate and low sensitivity resources is based more on site-specific factors, such as the habitat quality and population size, as well as the nature and extent of the expected impact.

Potential long-term impacts associated with the Project include; (a) the replacement of existing habitat with the TMT Observatory, Access Way, TMT Mid-Level Facility, Headquarters, and Satellite Office; (b) dust generated by vehicles traveling along the unpaved Access Way and parking at the TMT Observatory and TMT Mid-Level Facility; and (c) paving a roughly 300-foot section of the Access Way.

Each of these potential impacts is discussed below. As a general measure to avoid impacts to natural resources during operations, the Project would implement a Cultural and Natural Resources Training Program as required by the CMP. The program would be used to raise awareness and appreciation of the area being experienced. As discussed in the CMP, the Cultural and Natural Resources Training Program would include educational instruction and materials designed to:

- Describe the status, condition, and diversity of natural resources present on the mountain, including biotic and physical elements.
- Outline the potential and existing threats to the natural resources.
- Summarize the protection afforded the natural resources in various rules and regulations.
- Provide expectations and requirements to avoid habitat damage, include but not limited to:
    - A prohibition on off-road vehicle use.

- The requirements of the Invasive Species Prevention and Control Program detailed below.
- Watch for and avoid impact with nēnē along the roads.
- Restrictions on smoking and other potential sources of fire.

- Steps to take and consider regarding personal safety and potential hazards of working on the mountain.

The training program would be updated regularly to incorporate UH Management Area-wide updates by OMKM. All persons involved in TMT Observatory operation and maintenance activities, including but not limited to scientists and support staff, shall receive the training on an annual basis.

The CMP requires (Management Action FLU-5) that an airflow analysis be performed on the design of proposed structures to assess potential impacts to aeolian ecosystems. The aeolian ecosystem is related to the Wēkiu bug and the fact that its food supply consists of insects blown from lower elevations to the summit, where they come to rest and become Wēkiu bug prey. Because the TMT Observatory is not located on a cinder cone and Wēkiu bugs are not normally present in the area, this requirement is not applicable to the Project.

Species or Habitat Displacement

Species and habitats that would be displaced by the Project include:

- TMT Observatory: Roughly 4.7 acres of alpine stone desert would be displaced. Roughly 0.5 acre of the 5.2-acre TMT Observatory site has previously been disturbed by roads and site testing.
- Access Way: At least 1.3 acres of habitat similar to that at the TMT Observatory site would be displaced. Roughly 1.2 acres of the 2.5-acre Access Way area, north of the point where the Access Way Options come together, has previously been disturbed by roads. The following additional habitat could be displaced, depending on which Access Way Option is selected:
    - Option 1: Another 0.3 acre of habitat similar to the TMT Observatory site could be displaced; roughly 1.0 acre of the 1.3-acre Option 1 area has previously been disturbed by roads (Wēkiu bug habitat type 6).
    - Option 2: 0.3 acre of cinder cone habitat (Wēkiu bug habitat type 3) associated with the puʻu could be displaced; roughly 1 acre of the 1.3- acre Option 2 area has previously been disturbed by roads (Wēkiu bug habitat type 6).
    - Option 3: 0.7 acre of cinder cone habitat (Wēkiu bug habitat type 3) associated with the puʻu could be displaced; roughly 0.9 acre of the 1.6-acre Option 3 area has previously been disturbed by roads (Wēkiu bug habitat type 6).
- TMT Mid-Level Facility: All of the roughly 3.2-acre TMT Mid-Level Facility area has previously been disturbed by construction activities for other observatories. A few māmane trees and other species exist within or around the parameter of the area.
- Headquarters: An unknown area of abundant low-land habitat that does not harbor any species of concern would be displaced.

- Satellite Office: An unknown area of abundant low-land habitat that does not harbor any species of concern would be displaced.

The potential impact of Access Way Option 3 is the greatest concern. Overall, the displacements by other Project components would not have a significant impact on biological resources because species and habitat of these areas are not unique to the Project sites and are found elsewhere on Maunakea and/or on other islands in Hawaiʻi. The following sections discuss each of these areas individually.

TMT Observatory and Common Access Way

The six acres of new habitat displacement would not have a significant impact on biological resources. The botanical species and habitat of these areas are not unique to the Project sites and are found elsewhere on Maunakea and/or on other islands in Hawaiʻi. The habitat is not considered critical habitat for any species and floral, lichen, moss, and arthropod species present occur in greater abundance in other nearby areas. Roughly 5.7 acres of Type 4 Wēkiu bug habitat and 0.3 acre of Type 5 Wēkiu bug habitat would be displaced. The mix of Type 4 and 5 habitats is not considered optimal for Wēkiu bugs; they may only occupy this area during extreme population explosions that push the insects into marginal habitats. Lycosid wolf spiders, centipedes, lichens, and mosses regularly occupy this habitat. The potential amount of habitat that would be disturbed represents only a small portion (less than 0.5 percent) of the total Wēkiu bug habitat available on Maunakea and would have a less than significant impact on Wēkiu bug populations.

Access Way Options

Option 1 would displace about 0.3 acre of Type 4 habitat and small areas of Type 5 habitat. As with the TMT Observatory, this is not prime habitat. In addition, since the amount of habitat that would be displaced is small, and these species are more abundant elsewhere in the Maunakea summit region, the impact of Option 1 would be less than significant.

Option 2 would displace about 0.3 acre of Type 3 habitat contiguous with the puʻu cinder cone. The cinder here is considered to be good, but not optimal Wēkiu bug habitat. Wēkiu bugs have been reported in low abundance in Type 3 habitat. No Wēkiu bugs were collected in the Option 2 area during the 2008 sampling, but were collected during the Spring 2009 sampling. While this option would require grading the cinder cone and Wēkiu bug habitat, but because this option disturbs and displaces a relatively small area of good Wēkiu bug habitat, the overall potential impact to Wēkiu bugs and other Maunakea summit region arthropods would be less than significant.

Option 3 would displace about 0.7 acre of Type 3 habitat contiguous with the puʻu cinder cone. The cinder here is considered to be good, but not optimal Wēkiu bug habitat. Wēkiu bugs have been reported in low abundance in Type 3 habitat. No Wēkiu bugs were collected in the Option 3 area during the 2008 sampling, but were collected during the Spring 2009 sampling. This option would require cutting into the cinder cone and Wēkiu bug habitat and adding a retaining wall to prevent cinder from encroaching on the new road. Because this option disturbs and displaces a relatively small area of good Wēkiu bug habitat, the overall potential impact to Wēkiu bugs and other Maunakea summit region arthropods would be less than significant.

Although the Option 2 or 3 impact is evaluated to be less than significant, to comply with the CMP (Management Action FLU-6), the Project would prepare and implement a Habitat Restoration Plan to compensate for the loss of Type 3 Wēkiu bug habitat should the Access Way Option 2 or 3 be selected. Habitat would be restored at a 1:1 basis; therefore, roughly 0.3 acres of habitat would be restored should Option 2 be selected and 0.7 acres of habitat would be restored should Option 3 be selected. At this time it is envisioned that, should Option 2 be selected, at least a portion of the area disturbed by the old 4-wheel drive road would be restored (the area where Option 3 is located). Should Option 3 be selected, it is envisioned that the disturbed area below the Subaru Observatory would be restored using methods described in the Outrigger Habitat Restoration Plan, which was never implemented. The restoration plan would focus on the creation of new Wēkiu bug habitat, and would include two to five years of monitoring to assess restoration results.

TMT Mid-Level Facility

Less than one acre of māmane subalpine forest could be displaced by the TMT Mid-Level Facility. No palila have been detected at Hale Pōhaku during recent surveys, and the māmane forest on the site is less dense than that found outside the limits of Hale Pōhaku. Six species of indigenous Hawaiian plants grow on this Project site. Three species identified as Federal or State species of concern were also observed in this area: the Difficult yellow-faced bee (*Hylaeus difficillis*), the Yellow-footed yellow-faced bee (*H. flavipes*), and a succineid snail (*Succinea konaensis*). All of these species, except the succineid snail, are known to occur over a wide range and most occur on other islands in Hawaiʻi. Little is known about the distribution of the succineid snail other than it is also present at Puʻu Laʻau. Due to the distribution of these species and the small area of potential habitat displacement, the impacts from habitat displaced by the TMT Mid-Level Facility would be less than significant.

Headquarters

The Headquarters would be in an urban setting where no species of concern or critical habitats are present. Therefore, this displacement would not have a significant impact on biological resources.

Satellite Office

The Satellite Office would be in an urban setting where no species of concern or critical habitats are present. Therefore, this displacement would not have a significant impact on biological resources.

Dust from Operations

It is estimated that about 50 employees would commute daily to the TMT Observatory and there would also be occasional freight pickups and deliveries to support operations. Generation of excessive dust from vehicle traffic on the unpaved Project areas, including the Access Way, TMT Observatory parking area, and TMT Mid-Level Facility parking area, could impact biological resources, particularly in the Maunakea summit region. Wind-blown dust that covers plants, lichens and mosses, deprives them of needed sunlight. The potential impact of excessive dust could have a moderate effect on the flora in habitats adjacent and downwind of the Access Way and TMT Observatory. However, because the lichens, mosses, and plants that would be impacted are found elsewhere in the Maunakea summit region and Hawaiʻi, the overall impact to the flora would be less than significant.

Wind-blown dust can also impact arthropod habitats by filling interstitial spaces and microhabitats where arthropods reside. It is not likely that the amount of dust generated from vehicle traffic during operation of the TMT Observatory would be sufficient to affect spiders and centipedes in adjacent or downwind habitats, but there is a potential for impacting Wēkiu bugs. However, Wēkiu bugs only occupy habitats downwind of the Project sites during periods of high population, an uncommon event, and generally are more abundant elsewhere in the Maunakea summit region that would not receive dust from the Project areas. Thus the overall impact to arthropods due to dust generated by Project operations in the Maunakea summit region would be less than significant.

Paved Road through SMA Core Area

Paving the Access Way through the SMA core area would have little impact on the flora and fauna of the Maunakea summit region. The species that are most abundant in habitats adjacent to the road would likely not be affected. Wēkiu bugs have been seen crossing dirt roads, but none have been observed crossing paved roads. Only Wēkiu bugs that occasionally cross the dirt road while dispersing during periods of high population could be impacted by the pavement. Therefore the number of Wēkiu bug likely to be impacted would be small. Paving the Access Way through the SMA core area would not have a significant impact. In fact, paving the road could reduce dust generated by vehicle traffic on the road thereby protecting nearby habitats.

Impacts Associated with Potential Accidents

In addition to the long-term Project impacts, as discussed above, there would be a potential for impacts that may occur if there were to be an accident associated with the Project. These potential impacts are discussed below.

Accidental Introduction of Invasive Species

Movement of vehicles, personnel, and equipment to the Project areas may accidentally introduce invasive, non-indigenous species to the Maunakea summit region or Hale Pōhaku. Invasive plant species can displace indigenous species and thereby reduce their populations. Arthropods introduced outside of their natural range can represent a threat to natural systems because they can deplete indigenous arthropod food resources and/or prey on indigenous species. Non-indigenous arthropod species that successfully establish populations within the Mauna Kea Science Reserve could out-compete or exclude indigenous species, such as the Wēkiu bug, lycosid wolf spider, and other native resident arthropods. Alien arthropods can arrive at Project sites from localities on the Island of Hawaiʻi where they are already established, or in crates, boxes, or containers that are shipped from off the Island.

The Project, as required by the CMP, would reduce the probability for invasive species being introduced to the environment by implementing an Invasive Species Prevention and Control Program. The program would be developed in coordination with OMKM and also be in place during construction activities, as discussed in Section 3.15. The portions of the program applicable to TMT operations would include:

- Requirements that everyone who plans to pass beyond Hale Pōhaku brush down their clothes and shoes to remove invasive plant seeds and invertebrates.
- Regular inspections and washing of TMT vehicles and other items that are regularly transported between the TMT Observatory and lower elevations.
- Regular monitoring of the habitat along the Access Way and around the TMT Observatory and TMT Mid-Level Facility, and the interior of the TMT Observatory and TMT Mid-Level Facility for invasive species, and eradication of such species when found using methods that would not impact indigenous resident species.
- Inspection, by a biologist, of major shipments of new equipment bound for the TMT Observatory prior to transportation beyond the Headquarters.

Thus the potential impacts due to invasive non-indigenous species are likely to be less than significant.

Accidental Vehicle Impacts

There are reports of nēnē killed by vehicles on the Maunakea Access Road below Hale Pōhaku. Nēnē may utilize the lower portions of this road, especially during breeding season, and inattentive drivers may strike these birds. Nēnē are not often seen on the Maunakea Access Road and occur elsewhere on the island in greater abundance, however the taking of endangered species is serious. While the overall impact of Project traffic on the Maunakea Access Road would be less than significant to the nēnē population of Hawaiʻi, to avoid the potential for such an accident, the TMT personnel would be informed of the potential impact to nēnē during the required cultural/natural resources training and required to take precautions at all times while traveling on this segment of the road.

3.4.4 Mitigation Measures

The Project would comply with existing regulations and requirements, which would mitigate many of the potential impacts, as discussed above. The Project's policies to comply with applicable rules and regulations would include the following CMP Management Actions detailed above:

- Implementation of a Cultural and Natural Resources Training Program. This program, detailed in Section 3.4.3, would require that TMT personnel receive an annual orientation regarding natural resources.
- Implement an Invasive Species Prevention and Control Program. This program, detailed in Section 3.4.3, would outline steps to be taken to avoid the potential impacts associated with invasive species.
- Implement a Habitat Restoration Plan should Access Way Options 2 or 3 be selected. The restoration plan would comply with CMP Management Action FLU-6.

Mitigation measures being considered by TMT that go beyond what is required by the CMP and other applicable requirements include habitat restoration and dust control measures.

TMT would either (a) prepare and implement a Habitat Restoration Plan to compensate for the minimal loss of māmane subalpine forest habitat displaced by the TMT Mid-Level Facility development, or (b) help fund the palila recovery effort. These are both being considered. Because the minimal loss of habitat as a result of the TMT Mid-Level Facility is not considered significant and an offsetting restoration plan would provide minimal benefit, TMT is considering providing funding equal to such a restoration effort to the palila recovery effort instead.

TMT would implement a Ride-Sharing Program, described in Section 3.11.4. This program would result in about 14 vehicle trips a day to the summit, including pickup and deliveries. Dust generated along unpaved section of the Maunakea Access Road and the Access Way would be reduced relative to the number of trips reduced by the program.

TMT may elect to use soil-binding stabilizers to control dust along the unpaved portion of the Access Way. Several dust-suppressing soil stabilizers are considered "environmentally friendly" and appear to be free of residuals that can harm native arthropod populations. This would only be implemented following the approval of OMKM. Soil stabilizers would not be used indiscriminately, nor would they ever be applied beyond the unpaved Access Way travel way. Application of soil stabilizers would only be performed at intervals recommended by the manufacturer and then applied under light wind conditions to prevent drift into adjacent habitat.

3.4.5 Level of Impact after Mitigation

Potential impact on biological resources would be less than significant with implementation of the Cultural and Natural Resources Training Program and Invasive Species Prevention and Control Program.

Implementation of the additional mitigation measures, including the implementation of the Ride-Sharing Program and use of soil-binding stabilizers, would further reduce the potential impact of the Project.

3.4.6 References

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3.5 Visual and Aesthetic Resources

This section describes the existing visual conditions on the Island of Hawai‘i and Maunakea, discusses the visual impacts the Project may have, and identifies how the Project mitigates its potential visual impacts. For a more thorough discussion of the Project's potential impacts on visual and aesthetic resources see the Visual Impact Assessment Technical Report (Appendix E).

3.5.1 Environmental Setting

The Island of Hawai'i's landscape and visual resources are varied. On the northern tip, the coast is rugged, covered in dense vegetation and dotted with waterfalls and rivers. Inland, around the town of Waimea, at an elevation of 4,000 feet, the landscape is comprised of rolling pastures used for cattle ranching. The western side of the island consists of popular resorts and beaches, but lacks vegetation. The southern and southeastern portions of the island experience high rainfall and are covered with lush vegetation; Volcanoes National Park is located in this area. The eastern portion of the island consists of steep terrain with dramatic views of the rainforest and cliffs along the coast.

The Hawai‘i County General Plan (County of Hawai‘i, 2005) includes a chapter on Natural Beauty that recognizes the importance of preserving the island's natural and scenic beauty. The chapter includes goals, policies and standards to identify and protect scenic vistas and viewplanes. One goal is to "Protect scenic vistas and view planes from becoming obstructed." The General Plan also provides guidelines for designating sites and vistas of extraordinary natural beauty to be protected, and includes the standard "Distinctive and identifiable landforms distinguished as landmarks, e.g. Maunakea, Waipio Valley." Around the island of Hawai‘i the following natural beauty sites have been identified that include Maunakea:

- View of Maunakea and Mauna Loa from Pāhoa-Kea‘au, Volcano-Kea‘au Roads, and various Puna subdivisions
- Viewpoint of Hilo Bay with Maunakea in background
- Mauna Kea State Park area

In addition, the South Kohala Development Plan (County of Hawai‘i, 2008) includes a policy to preserve Waimea's sense of place. To do this, the plan recommends the strategy to "protect the pu‘u of Waimea that have cultural, historical and visual importance" and which have "grand views of Mauna Kea."

Maunakea Summit Region

In contrast to the lush coastal areas, the summit of Maunakea is an alpine ecosystem. Above the tree line, at roughly 9,500 feet, there is little more than low shrubs and above 12,800 feet vegetation consists of little more than lichens, moss, and small ferns. A small alpine lake, Lake Waiau, is situated on the upper southern flank of the mountain. The summit of Maunakea is often obscured by vog, a volcanic smog formed when sulfur dioxide and other volcanic gases emitted by Kīlauea mix with oxygen, moisture, and sunlight. The vog has been especially thick since February 2008 when gas emissions from Kīlauea dramatically increased.

There are 11 observatories on Maunakea within the Astronomy Precinct. Some of these existing observatories are visible from locations around the island such as Hilo, Honokaʻa, and Waimea. On the west coast of the island, the existing observatories appear most visible at sunset, when they are lit by the setting sun; on the east coast they appear most visible at sunrise.

The 2000 Master Plan includes a discussion of a NGLT. The Master Plan recognizes that the size of a NGLT makes the visual impact considerations very important, and recommends siting such a facility within Area E of the Astronomy Precinct because it would "minimize its visibility."

Viewer Groups and Viewpoints

The people that view the island of Hawaiʻi, and more specifically Maunakea, can be described as, residents, sightseers and cultural practitioners, each with a different expectation of their visual experience.

Seventeen representative viewpoints within the northern portion of the island have been identified as places that are of visual significance to the three viewer groups. The viewpoints are all located in the northern portion of the island because the proposed location of the TMT Observatory is such that it would not be visible from the southern portion. Table 3-4 provides the viewpoint name, description, the viewer group expected, and the primary view direction. The viewpoints and the direction of the primary view from each viewpoint are mapped in Figure 3-5.

Figure 3-6 illustrates the combined visibility of the existing 11 observatories near the summit within the Astronomy Precinct, where the top of at least one of the existing observatories is visible. From approximately 43 percent of the island area a viewer would be able to see at least one existing observatory. According to 2000 U.S. Census data, 72 percent of the population of the Island of Hawaiʻi, or about 107,000 people reside within the viewshed of the existing observatories.

Hale Pōhaku

The existing support facilities at Hale Pōhaku are not visible from other locations on the island. The 2000 Master Plan provides a number of design guidelines to maintain the visual aesthetics of Hale Pōhaku. These guidelines aim at maintaining the proportions of developments in Hale Pōhaku and help them blend into the physical landscape.

Headquarters

There are no designated or recognized visual resources associated with University Park of UH Hilo.

Satellite Office

There are no designated or recognized visual resources associated with the commercial district of Waimea.

Table 3-4: Description of Viewpoint, Viewer Group and Primary View Direction

Viewpoint	Location	Description	Viewer Group	Primary View
1	Hualālai Resort	Exclusive, luxury residential community and hotel.	Residents / Sightseers	West toward the ocean (makai)
2	Pu‘u Waawaa	Summit of cinder cone that is of cultural importance to Native Hawaiians.	Cultural Practitioners	Panoramic
3	Big Island Country Club	Independent (non-resort affiliated) daily-fee golf course. The club includes views of the coastline and of Maunakea.	Residents / Sightseers	Panoramic
4	Waikoloa/Mauna Lani	Resort development.	Sightseers	West makai
5	Hāpuna Beach	Public beach near a resort.	Sightseers / Residents	West makai
6	Puukohola Heiau	National historic site and Spencer Beach Park, which includes camping and picnic areas along a beach.	Residents / Sightseers	West makai
7	DHHL Kawaihae at Route 250	Summit of Highway 250 between Waimea and Hāwī.	Residents	Southeast toward Maunakea (mauka)
8	Route 250 Pu‘u Overlook	Gravel shoulder where cars can pull off of the highway and view Maunakea and North Kona/South Kohala.	Sightseers	Southeast mauka
9	DHHL Lalamilo	Residential neighborhood within Waimea.	Residents	Southeast mauka
10	Waimea Park	Athletic facilities for sports such as baseball and tennis; near a school.	Residents	Southeast mauka
11	DHHL Pu‘u Kapu	Residential neighborhood within Waimea.	Residents	Southeast mauka
12	DHHL Waikoloa-Waialeale	Along Old Māmalahoa Highway through ranch lands.	Residents	South mauka
13	Waipio Valley Lookout	Formal lookout with parking lot and trail to scenic view.	Sightseers	Northwest along the coast
14	Honoka‘a	Main road into town.	Residents	Northwest up the coast
15	Laupāhoehoe Point	State park with parking lot and picnic facilities along the coast.	Sightseers	Northeast makai
16	Maunakea Summit	Highest point on Maunakea. Recognized as a sacred place to Native Hawaiians.	Cultural Practitioners	Panoramic
17	Lake Waiau	Small lake near the summit of Maunakea, accessible by a trail. Waters used for healing and worship practices in Hawaiian culture.	Cultural Practitioners	West over the lake

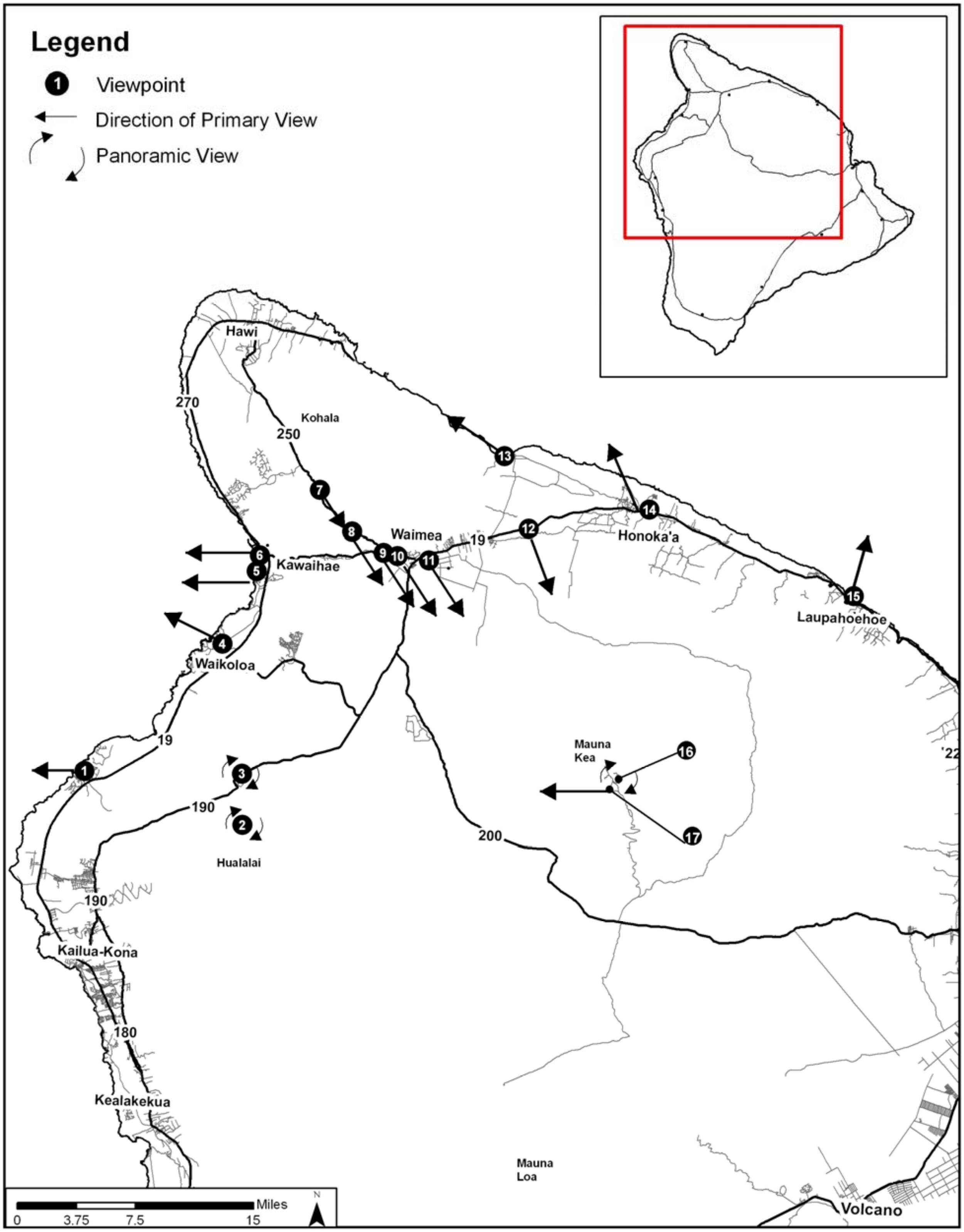

Figure 3-5: Viewpoints and Primary View Direction from Viewpoints

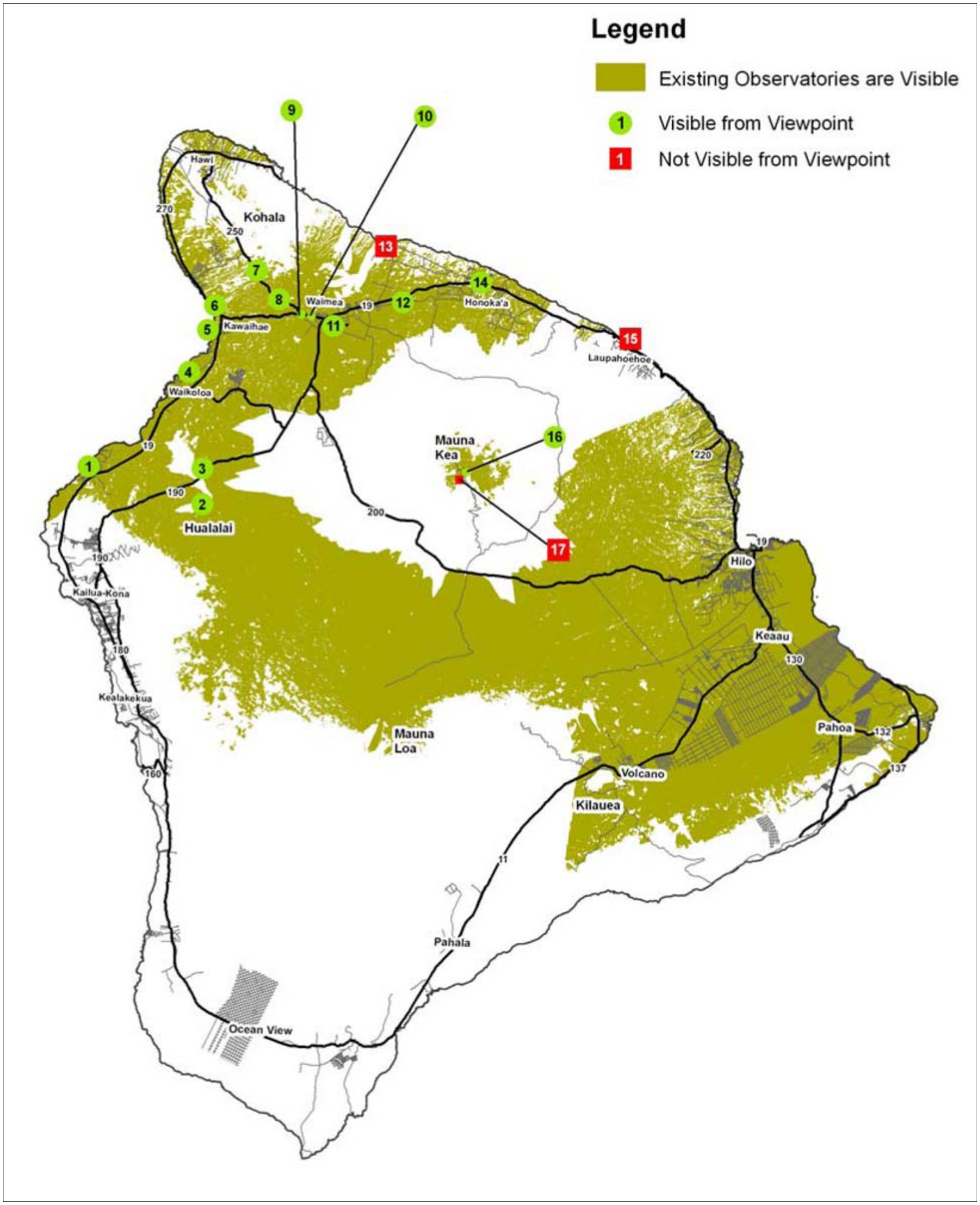

Figure 3-6: Combined Visibility of Existing Observatories on Maunakea

3.5.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact if it substantially affects scenic vistas and viewplanes identified in County or State plans or studies. Therefore, the Project would have a significant impact if it would block or substantially obstruct a vista by placing a structure in the foreground so as to prevent a view of an identified resource from an identified area or create a structure that would be incongruous with existing structures currently in the vista or viewplane. Thus, the impact would be considered to be significant if it would affect any of the following identified views:

- View of Maunakea from Pāhoa-Kea‘au, Volcano-Kea‘au Roads, and various Puna subdivisions
- Viewpoint of Hilo Bay with Maunakea in background
- Mauna Kea State Park area

In addition, the South Kohala Development Plan includes a policy to preserve Waimea's sense of place. The plan recommends the strategy to "protect the pu‘u of Waimea that have cultural, historical and visual importance" and which have "grand views of Mauna Kea."

3.5.3 Potential Environmental Impact

The potential impacts of the Project are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the Project type and location. This includes requirements of the CMP. This analysis primarily focuses on the potential visual impacts that would occur from locating the TMT Observatory at the proposed 13N Site on Maunakea. Due to the topography of the area, the existing facilities at Hale Pōhaku are not visible from other locations on the island, and thus, the new TMT Mid-Level Facility buildings would also not be visible at this location. The TMT Mid-Level Facility would also be designed in consultation with OMKM to comply with design standards and reduce potential visual impact. Therefore, those facilities would not result in an adverse visual impact.

The proposed Headquarters at Hilo is not expected to have an adverse visual impact as there are no designated or recognized visual resources associated with the University Park in Hilo; the same applies to the proposed Satellite Office in the commercial district of Waimea.

Scenic Vistas and Viewplanes

Locating the TMT Observatory on Maunakea would not substantially affect scenic vistas and viewplanes identified in the Hawai‘i County General Plan or the South Kohala Development Plan. The TMT Observatory would not be visible in the view of Maunakea from Pāhoa-Kea‘au, Volcano-Kea‘au Roads, and various Puna subdivisions or from locations where Hilo Bay is visible with Maunakea in the background. Although the TMT Observatory may be visible in the view of Maunakea from portions of the South Kohala district and the area around Waimea, it would not block or substantially obstruct the views and viewplanes of the mountain. Therefore, the project would not exceed significance criteria 12 as stated in §11-200-12 of the HAR.

Visibility of the TMT Observatory

The TMT Observatory's AO system would utilize laser guide stars (Section 2.5.1). The multiple overlapping laser beams could be faintly visible to the naked eye as a single beam on moonless nights for a distance of up to 9 miles from the observatory. The area where the laser may be visible consists primarily of ranchlands and forest reserve which are not populated. The Federal Aviation Administration requires that the lasers be shuttered when aircraft are present in the area of the sky where the laser beams are pointed. Aircraft would be detected automatically using multiple camera systems, supplemented initially by human spotters, if necessary. Therefore, the laser system would not significantly impact visual resources.

A viewshed analysis was conducted based on topography to assess which areas of the island may have a view of the proposed TMT Observatory. According to the viewshed analysis, the TMT Observatory would be visible from roughly 14 percent of the island area, as depicted in Table 3-5. According to 2000 U.S. Census data, approximately 15.4 percent of the island of Hawai'i's population, or 23,000 people would live within the viewshed of the TMT Observatory. The results of this analysis are shown in Figure 3-7. As shown in the Figure 3-7, the shaded portions of the island are areas where at least the top of the TMT Observatory may be visible. For the 17 representative viewpoints, a green circle shows that the TMT Observatory would be visible and a red square indicates it would not be visible.

Table 3-5: Visibility of the TMT Observatory

Visibility	Area of Island (%)	Hawai'i's Population	
		%	People
Visible	14%	15.4%	23,000
Not Visible	86%	84.6%	125,000

Of the 12 viewpoints where the TMT Observatory may be visible, it would not be within the primary view of four: the Hualālai Resort (1), Waikoloa/Mauna Lani (4), Puukohola Heiau (6) and Honoka'a (13). At these coastal locations, the primary view is makai. The TMT Observatory could be visible and in the primary view direction from viewpoints along Highway 250 (7 and 8) and around the town of Waimea (9, 10, 11 and 12). The TMT Observatory could also be visible from the Big Island Country Club (3) and from the summit of Pu'u Waawaa (2), where the panoramic view would be important to the viewer.

Table 3-6 divides the viewshed, and the population within the viewshed, into five areas: Waimea, Honoka'a, Hāwī, Waikoloa and Kawaihae, and Hualālai. Of these, the TMT Observatory would be visible in the primary view direction only from the area around Waimea. Of the island's population, 5.5 percent, or 8,100 people reside within the area around Waimea and may be able to see the TMT Observatory.

Table 3-6: Visibility of the TMT Observatory within the Primary View Direction

Location	Hawai'i's Population		Primary View Direction?
	%	People	
Waimea	5.5%	8,100	Yes
Honoka'a	2.8%	4,200	No
Hāwī	2.6%	3,900	No
Waikoloa and Kawaihae	4.3%	6,400	No
Hualālai	0.2%	303	No

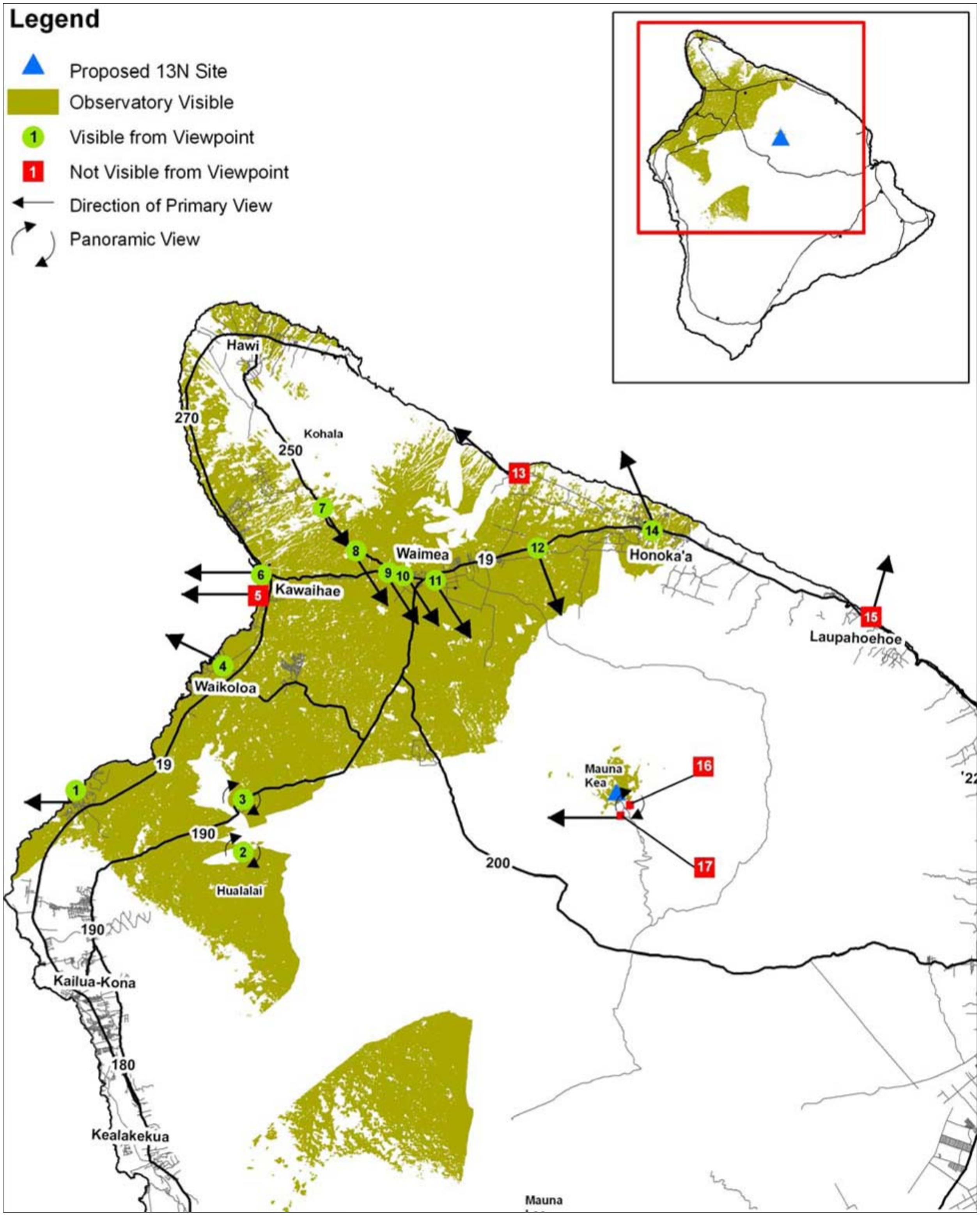

Figure 3-7: Viewshed and Primary View Analysis

For the 12 representative viewpoints where the TMT Observatory may be visible, a silhouette analysis was conducted to determine whether the view of the facility would be a full or partial silhouette against the sky, or whether it would be seen against the backdrop of Maunakea. Table 3-7 summarizes the silhouette analysis for the TMT Observatory and the potential long-term impact to visual and aesthetic resources.

Table 3-7: Proposed TMT Observatory - Summary of Potential Visual Impacts

Viewpoint	Location	Visual Impact				
		Is the TMT visible?	Visible in primary view?	Visible in silhouette?		
				No	Partial	Full
1	Hualālai Resort	Yes	No	--	164 feet (50 m)	--
2	Pu'u Waawaa	Yes	N/A[1]	--	58 feet (17 m)	--
3	Big Island Country Club	Yes	N/A[1]	--	82 feet (25 m)	--
4	Waikoloa/Mauna Lani	Yes	No	--	164 feet (50 m)	--
5	Hāpuna Beach	No	No	N/A		
6	Puukohola Heiau	Yes	No	--	164 feet (50 m)	--
7	DHHL Kawaihae at Route 250	Yes	Yes	X	--	--
8	Route 250 Pu'u Overlook	Yes	Yes	X	--	--
9	DHHL Lalamilo	Yes	Yes	--	49 feet (15 m)	--
10	Waimea Park	Yes	Yes	--	89 feet (27 m)	--
11	DHHL Pu'u Kapu	Yes	Yes	--	98 feet (30 m)	--
12	DHHL Waikoloa-Waialeale	Yes	Yes	--	164 feet (50 m)	--
13	Waipio Valley Lookout	No	N/A	N/A		
14	Honoka'a	Yes	No	--	82 feet (25 m)	--
15	Laupāhoehoe Point	No	N/A	N/A		
16	Maunakea Summit	No	N/A	N/A		
17	Lake Waiau	No	N/A	N/A		

[1] The primary view criterion is not applicable because at these viewpoints the panoramic view is important.

TMT Observatory Dome Finish

As stated in Section 2.5.1, the proposed finish for the TMT Observatory dome is a reflective aluminum-like finish. The precise level of reflectance is still being considered; options could range from a reflectance similar to the shiny side of aluminum foil to a duller finish similar to a flat-finish aluminum paint. Other finishes are also being considered, including white and brown-colored finishes; the brown color is being considered because it was suggested in the 2000 Master Plan indicated a NGLT in Area E should be a "color [to] blend into the site." The preferred choice of using a reflective aluminum-like finish was based on the following considerations (1) visibility of the dome, (2) optimum performance of the observatory, and (3) reduced need of cooling air within the dome during the day. Each of these considerations is discussed below.

Visibility of the TMT Observatory Dome. A reflective aluminum-like finish reflects the colors of the sky and the ground, which helps the dome blend into its setting and reduces the visual impact whether the summit is bare or covered with snow. The results of photo simulations using the three different colors are presented below. The brown color appeared to protrude out more than a reflective finish, particularly with snow on the summit because snow would not stick to the observatory dome. White color appeared to blend in with the surroundings when there is snow present, however, without snow the white color appears more obtrusive. The reflective aluminum-like finish appears to reduce the visual impact in all conditions.

Optimum Performance of the Observatory. The performance of the TMT in observing in visible and infrared wavelengths is affected by any difference in temperature of the surface of the dome and the surrounding air. Air in contact with the surface of the dome is heated to above or below the temperature of the surrounding air, resulting in turbulence in the air. When this turbulent air passes across the path of light reaching the telescope, distortion of the image results. Temperature differentials of the dome surface with the surrounding air are usually caused by radiation of heat in the dome surface to colder air in the upper atmosphere. This effect can be greatly reduced by using surface materials with low emissivity[39]. As shown in Figure 3-8, materials shown at the bottom of the figure have the lowest emissivity, and hence, the best performance; finishes in the higher portion of the figure (high emissivity) have poorer performance.

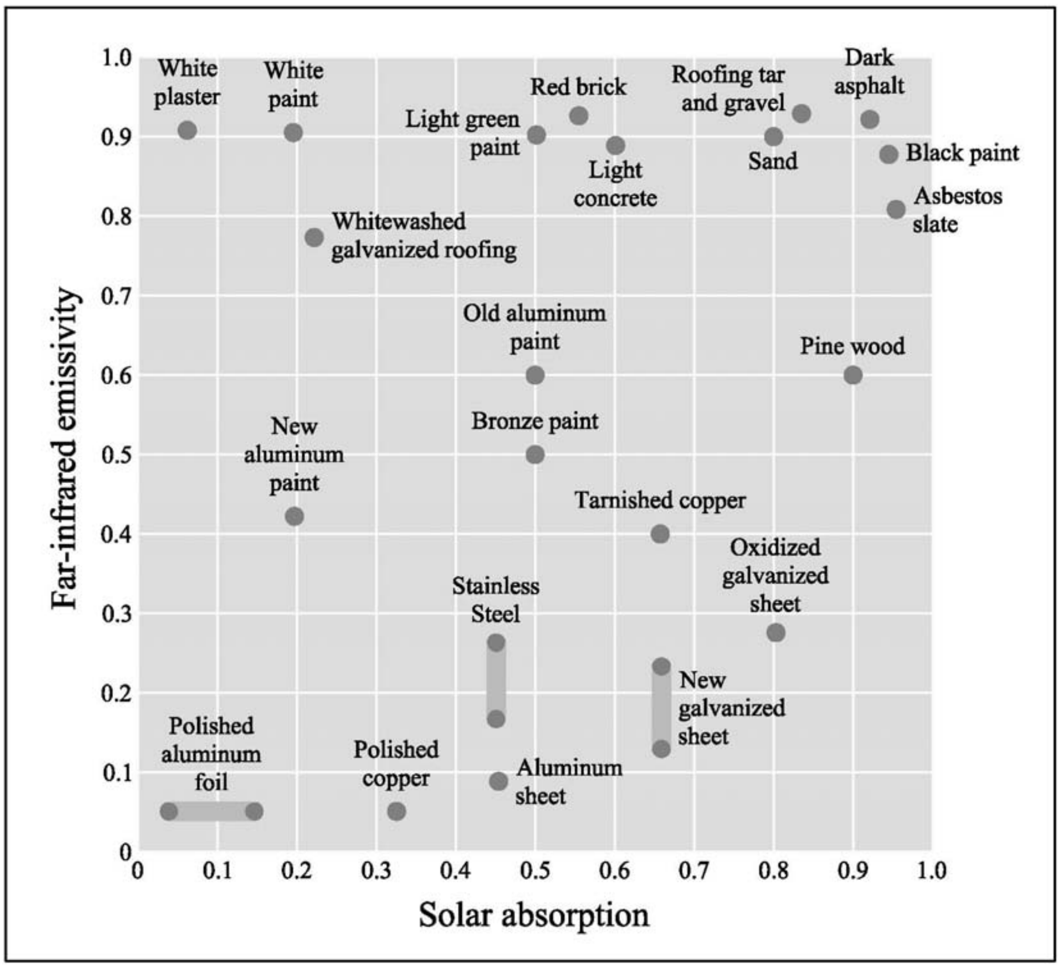

Figure 3-8: Finish Emissivity and Absorption

[39] The emissivity of a material is the ratio of energy radiated by the material to energy radiated by a black body at the same temperature. It is a measure of a material's ability to radiate absorbed energy. The lower the number, the less energy the material will radiate to the upper atmosphere (or other colder objects).

Polished aluminum foil, polished copper, and aluminum sheet are the three best materials for low emissivity, as shown on the figure; the proposed reflective aluminum-like finish would have similar properties to the polished aluminum foil. As the figure shows, white paint has a high infrared emissivity and thus, performs poorer than a reflective aluminum-like finish. A brown finish would be similar to the red brick or sand shown in the upper right portion of the figure; it would have a high emissivity, similar to white paint, that performs poorer than a reflective aluminum-like finish.

Reduced Need for Cooling Air within the Dome. Air within the dome of modern observatories is cooled during the day to the level of the forecasted nighttime temperature. This improves "seeing" for the telescope by reducing the amount of distortion related to differences in air temperature inside the dome and the surfaces of the telescope and the dome interior. The need of extensive cooling of the dome interior air is substantially reduced when the exterior surface has low solar absorption[40]. Materials on the left side in Figure 3-8 perform best by staying cool, with poorer performance materials shown to the right of the figure. Polished aluminum foil and white plaster are the two best materials shown on this figure; the proposed reflective aluminum-like finish would have similar properties. White paint would be similar to a reflective aluminum-like finish, but brown paint would be similar to the red brick or sand shown in the figure further to the right. Because a brown finish would absorb more energy it would require more energy to cool the dome compared to a white or reflective aluminum-like finish. The additional energy required is estimated to be equivalent to the energy required to power between 4 and 40 homes in Hilo, depending on weather conditions outside the TMT Observatory.

Photo Simulations

In compliance with CMP Management Action FLU-4 the Project has prepared visual renderings of the project setting. Photo simulations of the TMT Observatory were created using photographs of the summit of Maunakea that were taken with a 600 mm/5.6 telephoto lens resulting in a "binocular view." For comparison purposes a "naked eye view", without the aid of binoculars or a telephoto lens, photo is also provided. The naked eye view has been sized so that if the page is held at arm's length the size and spacing of the existing observatories appears as it would when standing at the location the photo was taken.

An example of the naked eye view of Maunakea from Waimea is shown in Figure 3-9. Figure 3-10 is a binocular view simulation of the TMT Observatory, with a version of the aluminum-like reflective coating on the dome enclosure, from Waimea, where there is no snow on Maunakea. Figure 3-11 and Figure 3-12 show the same binocular view from Waimea, but with the dome having a white and brown finish, respectively.

Figure 3-13, Figure 3-14, and Figure 3-15 are simulations of the TMT Observatory with an aluminum-like reflective, white, and brown coating, respectively, when there is snow present on Maunakea. This photograph was taking from another location within Waimea so the perspective is slightly different.

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[40] Solar absorption is a measure of a surface's ability to absorb heat from the sun. A lower number is preferred as less solar heat is absorbed, which in turn requires less air conditioning to keep the dome interior temperature at the forecast nighttime temperature.

Figure 3-9: Naked Eye View of Maunakea from Waimea

Figure 3-10: Simulation of TMT Observatory, Proposed Aluminum-Like Finish – "Binocular" View from Waimea with no Snow

Photo Credit: CFHT

Figure 3-11: Simulation of TMT Observatory, White Finish – "Binocular" View from Waimea with no Snow
Photo Credit: CFHT

Figure 3-12: Simulation of TMT Observatory, Brown Finish – "Binocular" View from Waimea with no Snow
Photo Credit: CFHT

Figure 3-13: Simulation of TMT Observatory, Proposed Aluminum-Like Finish – "Binocular" View from Waimea with Snow

Photo Credit: Charles R. West Photography

Figure 3-14: Simulation of TMT Observatory, White Finish – "Binocular" View from Waimea with Snow

Photo Credit: Charles R. West Photography

Figure 3-15: Simulation of TMT Observatory, Brown Finish – "Binocular" View from Waimea with Snow

Photo Credit: Charles R. West Photography

These simulations from Waimea illustrate how the TMT Observatory would be below the summit of Maunakea and the existing observatories. From the view presented, the lower portion of the TMT Observatory would be obscured behind a rise of Maunakea and located in front of one of the domes of the existing Keck or Subaru Observatory. Roughly the top 90 feet of the observatory dome would be visible from the Waimea area, as listed for viewpoints 9, 10, and 11 in Table 3-7. These simulations show the proposed reflective aluminum-like finish appears less obtrusive than the white finish when there is no snow.

Figure 3-16, Figure 3-17, and Figure 3-18 are binocular views from near Honokaʻa with simulations of the TMT Observatory dome finished in the proposed reflective aluminum-like, white, and brown finishes, respectively. In these photos, taken near viewpoint 12 (Figure 3-5), the summit of Maunakea is covered in snow. As is the case from Waimea, the lower portion of the TMT Observatory would be obscured behind a rise of Maunakea. Roughly the top 160 feet of the observatory dome would be visible from near viewpoint 12, while less than 90 feet would be visible from Honokaʻa proper (Table 3-7). As shown, the aluminum-like exterior finish reflects the colors of the sky and ground, which helps the dome blend into its setting and reduces the visual impact whether the summit is bare or covered in snow. These simulations show the proposed reflective aluminum-like finish appears less obtrusive than the brown finish when there is snow.

Figure 3-16: Simulation of the TMT Observatory, Proposed Aluminum-Like Finish – "Binocular" View near Honoka'a

Figure 3-17: Simulation of the TMT Observatory, White Finish – "Binocular" View near Honoka'a

Figure 3-18: Simulation of the TMT Observatory, Brown Finish – "Binocular" View near Honoka'a

Figure 3-19, Figure 3-20, and Figure 3-21 are binocular views from Waikoloa village with simulations of the TMT Observatory dome finished in the proposed reflective aluminum-like, white, and brown finishes, respectively. In these photos, the summit of Maunakea is partially covered in snow. As is the case from Waimea, the lowest portion of the TMT Observatory, including the support building and parking area, would be obscured behind a rise of Maunakea. Roughly the top 160 feet of the observatory dome would be visible from the Waikoloa area (Table 3-7). As shown, the aluminum-like exterior finish reflects the colors of the sky and ground, which helps the dome blend into its setting and reduces the visual impact whether the summit is bare or covered in snow. These simulations show the proposed reflective aluminum-like finish appears less obtrusive than the brown finish when there is snow.

Figure 3-19: Simulation of the TMT Observatory, Proposed Aluminum-Like Finish – "Binocular" View from Waikoloa
Photo Credit: Charles R. West Photography

Figure 3-20: Simulation of the TMT Observatory, White Finish – "Binocular" View from Waikoloa
Photo Credit: Charles R. West Photography

Figure 3-21: Simulation of the TMT Observatory, Brown Finish – "Binocular" View from Waikoloa

Photo Credit: Charles R. West Photography

Overall Long-Term Visual Impact

As discussed above, while the TMT Observatory would be a new visual element within the views of Maunakea (for approximately 14 percent of the island area and could be seen by approximately 15.4 percent of the population, or approximately 23,000 people), it would not obstruct or block existing views of Maunakea from around the island of Hawai'i. Existing observatories are visible in most of this area. The new area where the TMT Observatory would be visible and where currently none of the existing observatory can be seen is approximately 1.2 percent of the area of the island. Using the 2000 U.S. Census average household size of 2.75 people for the County of Hawaii, 72 people live in this new area. Therefore, the project would not exceed the applicable significance criteria in §11-200-12 of the HAR. Thus, the TMT Observatory would have a less than significant impact on the visual experience of the viewer groups on the island.

The proposed reflective aluminum-like finish would (a) be less visible throughout the year than a white or brown finish; (b) provide optimum observatory performance relative to other finishes; and (c) reduce the need for cooling the air within the dome throughout the day.

3.5.4 Mitigation Measures

The proposed location for the TMT Observatory is the primary mitigation for the Project's potential visual impacts. Because the proposed location of the TMT Observatory is north of and below the summit of Maunakea it would be substantially less visible than if it were to be placed in a more visible location, such as the summit ridge or pu'u.

The visual impacts of the TMT Observatory, which would house a telescope with a primary mirror 98 feet (30 meters) in diameter, are also due to the size of the dome enclosure. The proposed diameter of the dome is 216 feet. Because the center of the dome would be placed only 36 feet above grade, the observatory would have a height of approximately 180 feet above grade level. While this would be the tallest observatory on Maunakea, it has been designed to minimize the height of the structure, in turn minimizing the visual impacts. The telescope itself has been designed to be much shorter, with a focal ratio[41] of f/1.0, to allow for the smallest dome possible. In addition, the enclosure has been designed to fit very tightly around the telescope, leaving just enough room for a person, only about 20 inches, between the telescope and the dome (Figure 3-22). For comparison purposes, the Keck Observatory consists of two telescopes each with mirrors 33 feet in diameter with a focal ratio of f/1.75; the diameter of each Keck dome is 121 feet. If the TMT Observatory were to use the same ratio of mirror-to-dome size, it would result in a dome with a diameter of 364 feet, almost twice what is proposed (Figure 3-23).

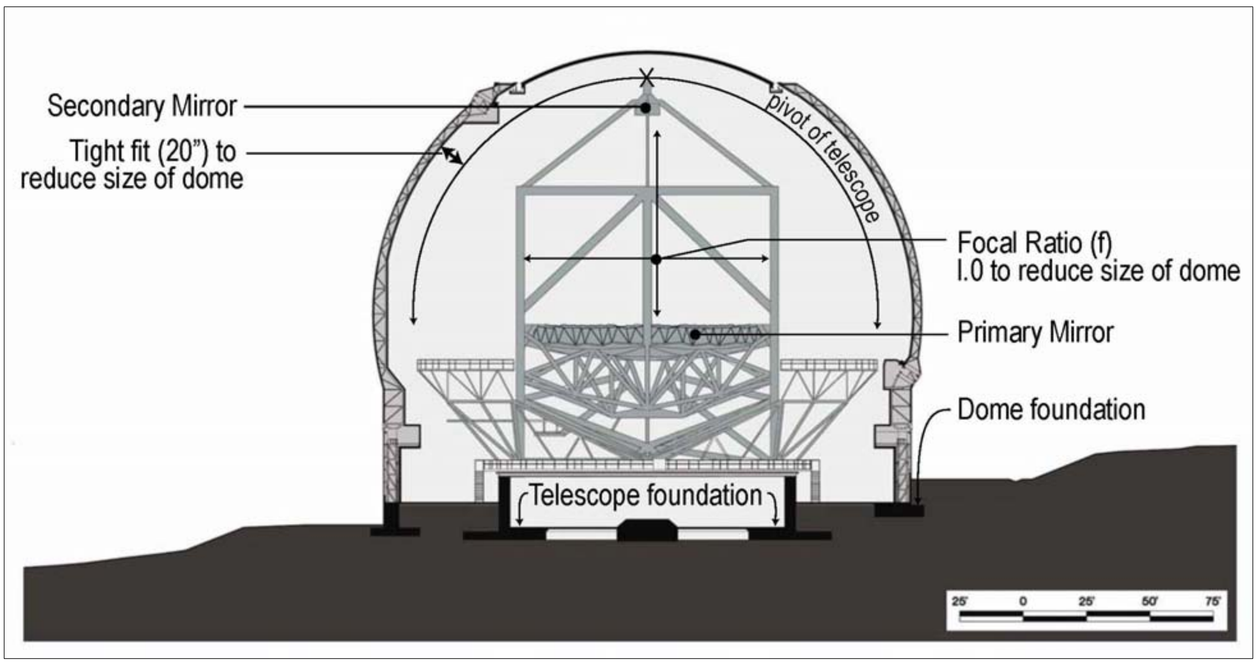

Figure 3-22: Overview of TMT and Dome Design

Finally, the color, or coating, of the dome enclosure has substantial visual implications. The proposed coating of the dome enclosure is an aluminum-like coating, similar to that used on the Gemini Observatory. In general, an aluminum-like coating reflects the morning sunrise and evening sunset light and stands out during this period, however, during most of the day the coating reflects the sky, and reduces the visibility of the observatory.

The support building attached to the observatory dome has also been designed to reduce its visibility, both from below and from Kūkahauʻula, the summit cinder cone that is a TCP. The building design would use terracing, whereby three ascending levels would match the natural contours of the site. The building would have a flat roof, and be lava-colored. Parking areas

[41] Focal ratio (f/) is defined as the ratio of the focal length of the mirror to its diameter.

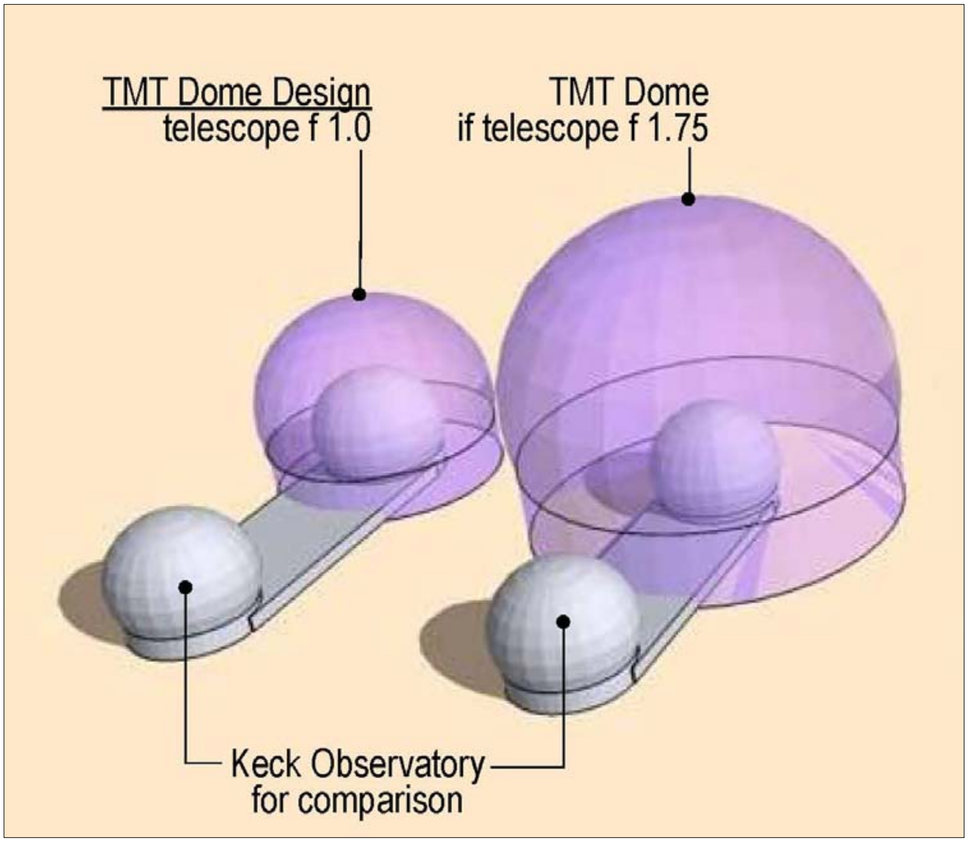

Figure 3-23: Comparison of Observatory Dome Sizes to Telescope Focal Ratios

would not be visible from below or Kūkahau‘ula, except the visitor parking area outside the upper most level of the building.

In summary, the location and design of the TMT Observatory incorporate measures that mitigate the potential visual impacts; no further visual mitigation measures are proposed.

3.5.5 Level of Impact after Mitigation

The mitigation for the impacts to visual and aesthetic resources is incorporated into the Project’s design. Therefore, the level of the visual impact after mitigation is the same as described in Section 3.5.3. The direct long-term visual impact of the TMT Observatory would be less than significant.

3.5.6 References

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3.6 Geology, Soils, and Slope Stability

This section discusses the geology, soils, and slope stability in the region and specific Project areas, the potential impact of the Project on those characteristics, and mitigation measures the Project would employ to mitigate those potential impacts.

3.6.1 Environmental Setting

Maunakea is one of five volcanoes comprising the Island of Hawai‘i (Figure 3-24). This dormant[42] shield volcano is the highest of the five, and the highest mountain in the interior Pacific basin. Because of its elevation, Maunakea's summit was repeatedly glaciated during the past few hundred thousand years, and preserves the best glacial record of any oceanic volcano on Earth. Maunakea has erupted 12 times within the last 10,000 years, and though it has been at least 4,600 years since its last eruption it is expected that the volcano will erupt again some time in the future; such an eruption would likely occur on the flanks of the volcano, below the summit.

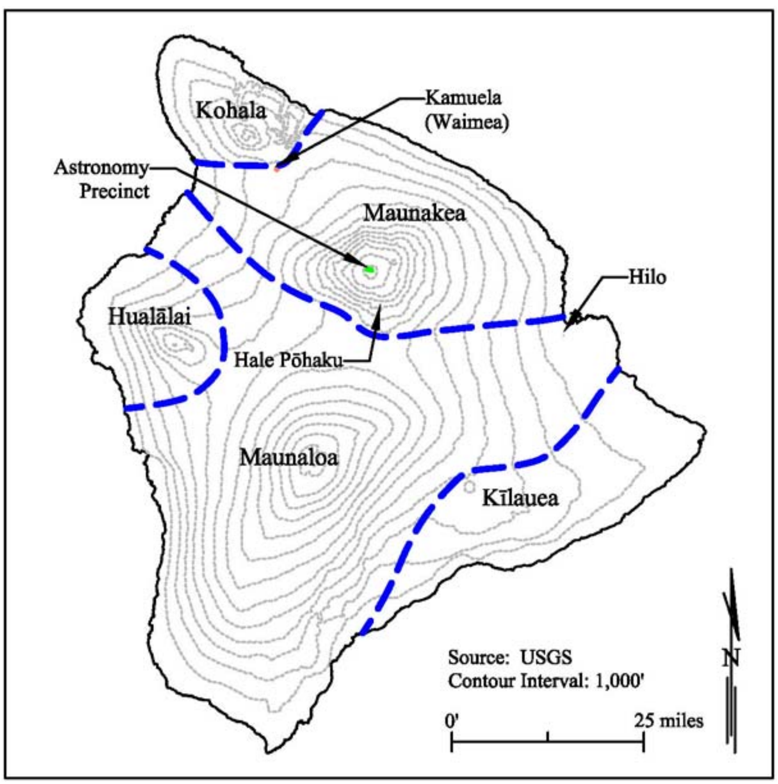


Figure 3-24: Volcanoes of the Island of Hawai‘i

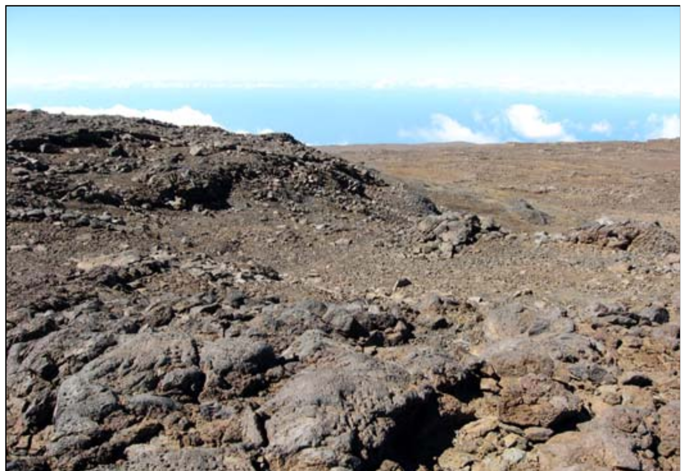
[42] "Dormant" volcanoes are distinguished from (a) "active" ones by the fact that active volcanoes have ongoing eruptions, such as Kīlauea; and (b) "extinct" ones by fact that the intervals between a dormant volcano's prehistoric eruptions (recurrence interval) is greater than the time since the last eruption to present.

Maunakea Summit Region

Detailed information regarding geologic resources in Project areas may be found in the Geological Technical Report summarizing studies conducted specifically for the Project, in Appendix H.

Geology

Area E was designated in the 2000 Master Plan as a location for future facilities development, and includes the limits of sites being considered for the location of the TMT Observatory. It is entirely underlain by a single lava flow, and consists of uniformly dense, fine-grained lavas. The flow was emplaced as viscous pāhoehoe, although some ‘a‘a fragmental material may have originally overlain the surface. The eruption that produced this overall flow likely produced multiple flow layers that overlaid one another as the eruption progressed; multiple complex layers may be found at depth during excavation.



Typical topography and rock surface in Area E.
Photo by CSH

Surface features indicate that most of this flow was emplaced beneath glacial ice or snow. In contrast, the source vent for this flow shows no evidence of interaction with water, meaning fire fountains at the source must have melted through overlying ice during the eruption so that lava fountaining took place and made contact with the air, producing numerous air-cooled volcanic bombs. The flows from this vent traveled down slope to the northwest, beneath a thin glacier; the flows preserve many features that document sub-glacial origin. Lava flowage beneath the ice was concentrated in irregular lava channels typically 3-8 feet deep and beneath ridges that are oriented in fan shapes roughly radial to the principal axis of the flow. A single chemical analysis of this lava flow shows the flow to be of typical “hawaiite” composition (a type of alkali-rich basalt).

The glacial features found on Maunakea are unique to glaciated terrains, and are found at no other oceanic volcano in the Pacific. However, the features in Area E are not unique on Maunakea, and better examples are widely distributed in other areas of the summit above the elevation of about 12,000 feet. The degree of glacial polishing is related to the thickness of the overlying ice that was present; because the glacial ice cap that overlaid Area E was less thick than the glacier overlying the lower elevations southeast of the summit, glacial polishing and striations are less developed on the flow in Area E and the Access Way area.

Most molten lava was supplied by flowage beneath a solidified layer of frozen lava, but where the layer was breached, especially at flow margins south and east of Area E, bulbous lava protrusions formed rounded structures, termed mega-pillows. These unique structures consist of especially fine-grained, flinty lava with interstitial glass on marginal surfaces. These flinty rocks are similar in texture to the materials quarried by Hawaiian toolmakers at sites near Pu’u Koko‘olau on Maunakea’s south flank; however, they were likely obscured by snow during the cooler weather of the past, and would not have been exposed for possible use during the period of active quarrying at lower elevations.

Following the emplacement and cooling of the flow, ice continued to cover the Maunakea summit, and down slope movement of the glaciers that formed modified lava flow surfaces through the erosive power of flowing melt water and associated rock debris. Any fragmental material originally at the surface was eroded away by torrents of sub glacial melt water, leaving typically irregular surfaces that reveal the structures of the underlying dense lava. In areas where moving ice directly overlaid lava, the hard surfaces were scoured by rock debris, which polished high-standing areas and left glacial striations. During the eruption, some of the lava channels may have formed small pyroducts, or lava tubes, but if once present, the thin coverings that enclosed them have generally been removed by glacial erosion.

The last glaciers melted in the area 10,000-13,000 years ago, boulders once being transported in the ice were left standing on high places as the ice melted. These boulders, called glacial erratics, give testament to the carrying power of the ice that once flowed above Area E. Such glacial erratics and other debris form extensive deposits of glacial till about a mile down slope, but the glaciers were never extensive enough to form such spectacular glacial moraines as are preserved on the south flank of Maunakea.

Glacial erratic in Area E.
Photo by Geohazards Consultants International

It is estimated that the aggregate thickness of all lava flow layers from the time of the eruption that placed the lava currently present at the surface in the vicinity of the proposed TMT Observatory site is at least 75 feet. Because lava flows tend to travel along pre-existing depressions, it is likely that most of the flow is thicker than this, especially in the center, and more likely is over 100 feet thick. The pre-existing ground surface in this area evidently sloped to the northwest, so that the flow surface slopes in this direction, as well as to the north. Judging from older rocks exposed down slope from Area E, it is possible that this flow overlies a rubbly surface consisting of loose lava fragments and windblown cinders from summit cones, although such material may have been eroded away by glacial activity before flow emplacement.

Soils and Slope Stability

No soils in the conventional sense are present in Area E, as the only fragmental material present has not had sufficient time for weathering to become soil in the arid, alpine environment. This fragmental material is present in most low-lying areas though, and could be classified as a non-weathered soil. This material consists of unconsolidated debris derived from glacial erosion and mechanical weathering of the adjacent lavas and nowhere is more than a foot or two in thickness. Because these materials have no internal strength, they must be removed before overlain by heavy structures.

The lava flow at the surface and extending to an estimated depth of 75 feet in Area E is composed of dense, fine-grained lava of exceptional strength, and slope stability will not be a problem for well-anchored structures. There are typically few gas bubbles in this lava, except in the uppermost sections of flows. During the flow emplacement, most lava was supplied by subsurface lava tubes, but these structures appear to have mostly been filled up during late eruption stages. Some voids might be encountered at depth within the lavas during excavation, but are likely small and not extensive. The estimated combined thickness of these flows should allow basement foundations to rest on solid lava and not on the more fragmented materials that might lie at greater depths.

Geologic Hazards

The potential for renewed volcanic activity in this region is extremely remote. Maunakea last erupted about 4,600 years ago, and the volcano is considered to be dormant. In 1997, Wolfe and others mapped a dozen separate post-glacial (post- 10,000 year old) eruptive vents on Maunakea's middle flanks, but none younger than 40,000 years were found in the summit area. These findings support the theory that future eruptions will likely occur well below the summit and will not pose any direct threat to astronomical facilities.

The most significant geologic hazard is seismic activity. Hawai‘i Island is one of the most seismically active areas on Earth, and about two dozen earthquakes with magnitude 6 or greater have been documented on Hawai‘i since the devastating earthquakes of 1868; those that caused damage are listed in Table 3-8. The approximate epicenter of those earthquakes and the predicted Modified Mercalli Intensity Scale seismic intensities are illustrated on Figure 3-25. The earthquake in 2006 caused minor damage to the Keck, Subaru, UH 2.2m, and CFHT observatories. Some auxiliary equipment was damaged, but the telescopes' mirrors and overall facility structural integrity were not affected.

Earthquakes will continue to impact the Maunakea summit area in the future, and any future construction must include design considerations for significant seismic forces. The summit of Maunakea is susceptible to seismic intensities of up to VII on the Modified Mercalli Intensity Scale.

Table 3-8: Summary of Damage Causing Earthquakes

#	Date	Epicenter Location	Maximum Intensity Mag	Magnitude	No. of Deaths	Damage	Repair Cost
1	03-28-1868	Southern Hawai‘i	IX	7.0	0	Extensive-S. Hawai‘i	Unknown
2	04-02-1868	Southern Hawai‘i	XII	7.9	81	>100 houses destroyed in tsunami	Unknown
3	10-05-1929	Hualālai	VIII	6.5	0	Extensive-Kona	Unknown
4	08-21-1951	Kona	VIII	6.9	0	Extensive-Kona	Unknown
5	04-26-1973	North of Hilo	VIII	6.2	0	Extensive-Hilo	$5.6M
6	11-29-1975	Kalapana	VIII	7.2	2	Extensive-Hilo	$4.1M
7	11-16-1983	Ka‘oiki	IX	6.7	0	Extensive-S. Hawai‘i	>$6M
8	06-25-1989	Kalapana	VII	6.2	0	Southeast Hawai‘i	almost $1M
9	10-15-2006	Kiholo Bay	VIII	6.7&6.0	0	NW Hawai‘i	>$100M

Approximate epicenter location illustrated on Figure 3-25.

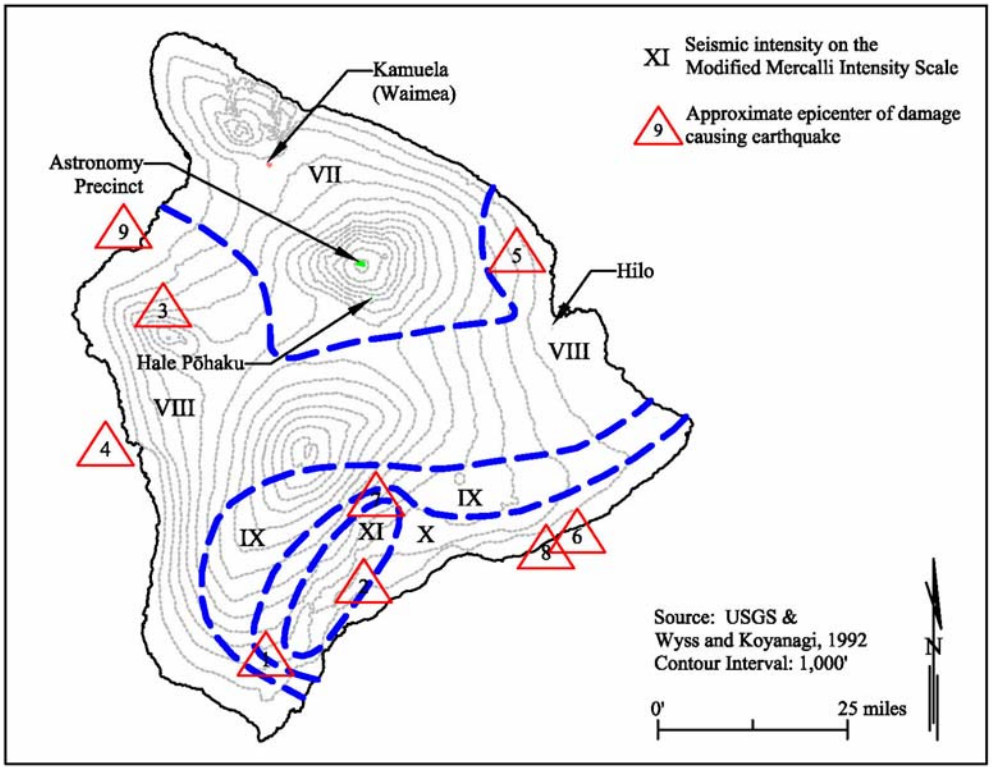


Figure 3-25: Seismic Intensities (Modified Mercalli Intensity Scale) and Estimated Epicenters of Damage Causing Earthquake (1868 to present) on the Island of Hawai'i

Hale Pōhaku

Detailed information regarding geologic resources in Project areas may be found in the Geological Technical Report summarizing studies conducted specifically for the Project in Appendix H. This area is comprised of a loose mixture of sand, gravel, and blocks, and deeper volcanic tephra, that has been extensively impacted by frost action and overlain by soil alteration zones where not disturbed. Because this material is unconsolidated, it is subject to erosion and gullying by flowing surface water during heavy rainfall.

The TMT Mid-Level Facility area in the southern/down-slope portion of Hale Pōhaku has been extensively modified by construction around buildings, and is impacted by minor gullying, especially in the upper portions where water runoff is concentrated from parking areas and roof drainage. The undisturbed surfaces are covered with loose volcanic blocks overlying fine grained sand of volcanic origin; clumps of vegetation have trapped high mounds of wind-blown sand. Slopes are as steep as 8 degrees southward in the upper area, but less than 2 degrees on the south/lower portion of the TMT Mid-Level Facility area.

The HELCO transformer substation is located in a natural saddle, or dip, between Pu'u Kalepeamoa to the south and a cinder cone and crater associated with Pu'u Kilohana to the north. The HELCO enclosure is mostly sited on a thick layer of imported gravel fill, and has had no impact on surrounding geologic structures. The surface underlying this fill consists of unconsolidated sand and gravel that has been unaffected by surface water runoff. The adjoining cinder cone slopes are covered with debris from volcanic eruptions, mostly broken volcanic bombs.

Similar to the summit area, earthquakes have and will continue to impact Hale Pōhaku. The area is susceptible to seismic intensities of up to VII on the Modified Mercalli Intensity Scale.

Headquarters

The soil type along University Park is pāhoehoe lava flow, a classification characterized by a relatively smooth surface with little to no soil covering it. The University Park area slopes from west to east, with site slopes ranging from 6 to 15 percent; along Komohana Street slopes are between 10 and 15 percent. There are no unique geologic features present on the site. Hilo is susceptible to seismic intensities of up to VIII on the Modified Mercalli Intensity Scale.

Satellite Office

There are two soil types present within the areas being considered for the Satellite Office in Waimea. Kikoni very fine sandy loam is not highly erodible, and has slight slopes from 0 to 3 percent. Waimea very fine sandy loam is potentially erodible, and has slopes ranging from 6 to 12 percent. The general characteristic of the area is gently rolling and not likely to experience impacts due to erosion. There are no unique geologic features present in the commercial area of Waimea. Waimea is susceptible to seismic intensities of up to VII on the Modified Mercalli Intensity Scale.

3.6.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact if it affects or is likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters. Therefore, a significant impact would occur if the Project affected or suffered damage by being located in an environmentally sensitive area.

3.6.3 Potential Environmental Impacts

The TMT Observatory and the Access Way would unavoidably remove any surface geologic structures present, such as lava flow morphology and glacial features. However, such geologic features are not unique on Maunakea and are better developed at many other areas, especially on the southern summit area adjacent to the Maunakea Access Road in the MKSR Natural/Cultural Preserve Area and the Ice Age NAR. The Access Way Options 2 and 3 are adjacent or within steep terrain. Designs for these options include grading, in the case of Option 2, and grading plus the installation of a retaining wall, in the case of Option 3. The design is in compliance with applicable standards and would mitigate slope stability concerns.

The areas being considered for the TMT Mid-Level Facility are entirely underlain by unexceptional volcanic materials that characterize much of the lower slopes of Maunakea, and there are no geologically unique features in the area.

Similarly, the areas being considered for the Headquarters and Satellite Office are not geologically exceptional.

Because Hawai'i Island is in a seismically active area, the Project would comply with applicable regulations and standards, with the design for all structures meeting all applicable seismic safety codes to ensure life safety of personnel and visitors.

Therefore, the Project's impact to geologic resources, soils, and slope stability would be less than significant.

3.6.4 Mitigation Measures

There are noteworthy examples of glacial features near the proposed Access Way, and such features are presently unappreciated. A possible mitigation effort could be to identify these features along the Access Way to enhance public interpretation/education efforts; this could be done in coordination with OMKM and to assist in the realization of CMP Management Action EO-4.

The Project would comply with applicable seismic safety regulations and standards in the design of structures to meet applicable codes to ensure life safety of personnel and visitors. In addition, the design of the Observatory would incorporate techniques to minimize the seismic risk of potential damage to the telescope and associated equipment. With these measures, the likelihood of damage would be lessened, and the risk would be less than significant.

3.6.5 Level of Impact after Mitigation

The mitigation measures proposed would further reduce the level of impact to geologic resources, which is considered less than significant without any mitigation, and ensure compliance with seismic safety standards.

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3.7 Water Resources and Wastewater

This section discusses the water resources and wastewater management practices in the region and in the Project area and the potential impacts of the Project on those resources, and mitigation measures the Project would employ to mitigate those potential impacts.

3.7.1 Environmental Setting

Maunakea Summit Region

Surface Water

There are no regularly flowing or perennial streams in the Mauna Kea Science Reserve. The Wailuku River is the only river whose numerous gulches extend along the upper flanks of Maunakea, and stream flow is considered to be perennial where the gulches come together, downslope near the elevation of 10,000 feet. The only surface water regularly present in the summit region is Lake Waiau within the adjacent Mauna Kea Ice Age Natural Area Reserve (NAR). Figure 2-3 illustrates the location of the lake.

Lake Waiau is located at the bottom of Puʻu Waiau and is one of Hawaiʻi's few confined surface water bodies and one of the highest alpine lakes in the Unites States. The lake freezes almost entirely during colder times of the year and has never been known to dry up. Lake Waiau is believed to have formed approximately 15,000 years ago following the last glacial retreat, and is revered by many Native Hawaiians as a pool created for the snow Goddess Poliʻahu by her father, Kāne. The lake is heart-shaped, 300 feet in diameter, reaches approximately 7.5 feet depth at full capacity, and sits at an elevation of 13,020 feet on the southern flank of Maunakea. Topography limits the lake's watershed to about 35 acres. The lake's water is derived from snow melt and precipitation within the watershed, not relic layers of ice or permafrost within the ground. The presence of Lake Waiau is attributable to an impermeable layer within Puʻu Waiau that creates a perched[43] aquifer, which is a limited aquifer that occurs above the regional aquifer. In the absence of this impermeable layer, the rainwater and snowmelt would continue its downward migration to the regional aquifer, which is much deeper.

Lake Waiau lies roughly 1.5 miles south of the TMT Observatory site, which would be on the opposite flank of Maunakea from the lake. The Project's Batch Plant Staging Area, roughly 3,000 feet upslope of Lake Waiau, would not be located within the Lake Waiau watershed.

Groundwater Aquifers

The regional aquifer beneath the summit is what is referred to in Hawaiʻi as "high-level," which means that the aquifer is entirely fresh water, not fresh water floating on salt water, and geologic structures, such as a volcanic sills and dikes, isolate the water. Although groundwater is the primary source of drinking water in Hawaiʻi, there are no wells extracting groundwater near the summit, since it is considered uneconomical to drill a well deep enough to reach the groundwater

[43] A perched aquifer is an aquifer that occurs above the regional water table, in the unsaturated zone. This occurs when there is an impermeable layer of rock or sediment (known as an aquiclude) or relatively impermeable layer (known as an aquitard) above the main aquifer but below the surface of the land.

and pump it to the surface. The nearest well is located approximately 12 miles away in Waiki‘i Ranch along Saddle Road; the ground elevation at the well is 4,260 feet above mean sea level (MSL) and the static water level in the well was measured at 1,280 feet above MSL in 1988. The Astronomy Precinct, and, therefore, the TMT Observatory site and Batch Plant Staging Area site, is located entirely above the Waimea Aquifer (Figure 3-26), which has a sustainable yield of 24 million gallons a day.

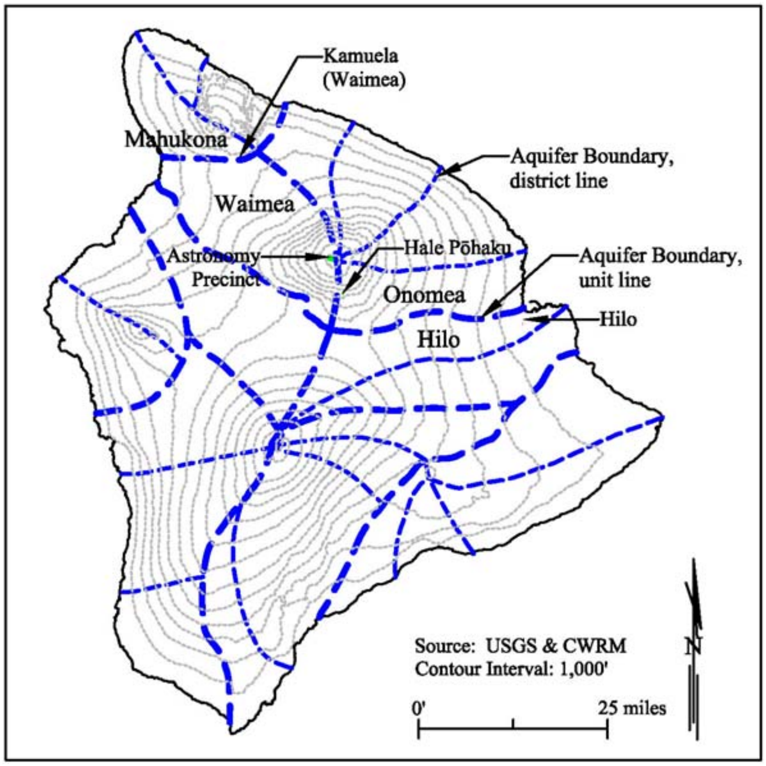

Figure 3-26: Groundwater Aquifers on the Island of Hawai‘i

Potable Water

MKSS contracts with a trucking company to deliver potable water from Hilo to the summit observatories in their 5,000-gallon-capacity tank trailers. Each observatory stores its own water and is responsible for the maintenance of its water tanks; observatories also use 5-gallon water jugs for drinking water. Water is trucked to the summit about twice a week for an annual total of approximately 502,500 gallons, which indicates a combined daily use of roughly 1,400 gallons.

Wastewater Collection, Treatment, and Disposal

Domestic wastewater and refuse liquids, including mirror washing wastewater, are the primary sources of wastewater generated by activities in the MKSR. Keck, CFHT, Gemini, Subaru, and the UH 2.2-meter observatories have facilities to conduct mirror washing and/or recoating activities. The other observatories bring their mirrors to one of those observatories for washing and recoating. All mirror washing effluent is collected and trucked off the mountain for off-site treatment and disposal.

Each observatory operates its own wastewater system to collect and treat domestic wastewater, pursuant to the permits issued by the Hawai'i State Department of Health (HDOH).

Existing restroom facilities at the summit available for visitor use include four portable toilets and the restrooms located in the Keck Observatory. The portable toilets are located at two different parking areas and are moved between the sites as needed. Portable toilets are serviced weekly and pumping is done on-site.

Drainage

Drainage at the summit occurs through percolation of rainfall through the cinder and broken rock substrates. Runoff from paved surfaces is directed to lined channels that conduct the water to collection basins or dry wells, where it then percolates. This system assists in the prevention of surface erosion.

Hale Pōhaku Facilities

Surface Water

There are no regularly flowing or perennial streams in the vicinity of Hale Pōhaku. Only during times of heavy rainfall will a few of the normally dry channels nearby have flowing water.

Groundwater Aquifers, Seeps, and Springs

As evidenced by modest spring and seeps, shallow groundwater does exist in the mountain's flanks below the summit area. The most prominent of these springs and seeps are the series of springs found near Pōhakuloa and Waikahalulu Gulches. The gulches are on Maunakea's south flank at a distance of approximately 3.25 and 1.25 miles west of Hale Pōhaku, respectively. Scientific dating tests of the spring's water indicate that it is recent, meaning that the water is not from the melting of ancient subsurface ice or permafrost, and analyses of the water shows it to be identical to rainfall at the summit. This indicates that at least some of the rainfall and snow melt at the summit percolates downward to a perching layer to ultimately discharge at the ground surface as a spring or seep.

Hale Pōhaku is located above the Onomea Aquifer system (Figure 3-26). There are no wells in the vicinity of Hale Pōhaku, because, similar to the summit area, the groundwater is at such a great depth that it is not considered economical to use it.

Potable Water

MKSS contracts with a trucking company to deliver potable water from Hilo to Hale Pōhaku in 5,000-gallon-capacity tank trailers that are owned by MKSS. Data gathered by MKSS indicates that the Hale Pōhaku facilities currently require approximately 30,000 gallons of water per week or roughly 4,300 gallons per day.

Wastewater Collection, Treatment, and Disposal

Currently, Hale Pōhaku has three small capacity cesspools[44] and six septic[45] systems. At Hale Pōhaku's main common building, dormitories B and C, and the VIS the wastewater systems have been upgraded to septic tanks that use the old cesspools instead of leach fields to discharge septic tank effluent. Dormitory D was constructed with a septic system and no modifications have been made to date. A septic tank with a leach field is present at the newer construction camp site below VIS. The wastewater systems at the older construction camp, dormitory A, and utility buildings between the cafeteria and the VIS use the original small-capacity cesspools for wastewater disposal. Figure 2-8 provides an overview of Hale Pōhaku facilities.

Drainage

Pōhakuloa and Waikahalulu Gulches, over a mile away, are the most developed drainage channels along the upper slopes of the mountain. These channels likely formed following large-scale scouring and movement of materials down the present day gulch alignment from a process initiated by melting glaciers. There is no developed drainage system at Hale Pōhaku. The low annual rainfall and permeability of the subsurface make a drainage system unnecessary. Rainfall is allowed to runoff building roofs and the paved parking area to an unpaved area and percolate into the subsurface.

Headquarters

The Headquarters site within the University Park would be located outside any flood boundary. The nearest surface body of water would be Waiākea Stream approximately 1,000 feet to the east. University Park is located above the Hilo Aquifer System (Figure 3-26). Storm drain drywells and landscaping/grading are used by other facilities and roads in University Park to control storm water and recharge the aquifer. Domestic water is provided by the UH Hilo system and University Park is hooked up to the regional wastewater system.

Satellite Office

Waimea town is located above the Waimea and Mahukona Aquifer System (Figure 3-26). Waikoloa Stream meanders through Waimea town and is present directly behind the Keck Headquarters facility, while Lanimaumau Stream is present within the vicinity of the sites being considered for the Satellite Office. The County of Hawaiʻi Department of Water Supply provides domestic water in the area. There is no central sewer system in Waimea; individual wastewater systems are employed in the area. Storm drain drywells and landscaping/grading are generally utilized to manage stormwater runoff.

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[44] A cesspool is either a sealed tank (modern definition) used to temporarily store domestic wastewater or a dry well (old definition) used to store or dispose of domestic wastewater. In Hawaiʻi cesspools typically refer to dry wells; dry wells allow liquids to drain into the underlying soil and domestic wastewater solids typically are broken down by bacteria in the dry well.

[45] A septic system generally consists of a septic tank connected to either a dry well or a leach field. Domestic wastewater solids settle in the tank and are anaerobically digested. The wastewater liquid flows out of the septic tank relatively clear and is discharged to the soil through the leach field or dry well.

3.7.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact to water resources and wastewater if it involves a substantial degradation of environmental quality and/or detrimentally affects water quality.

Therefore, a significant water quality impact would occur if the Project affected water resources so that their quality was degraded to the point that they were no longer fit for their designed use and/or the chemical composition exceeded applicable regulatory water quality standards.

3.7.3 Potential Environmental Impact

The Project would result in new impervious surfaces, additional consumption of fresh (potable) water, and additional wastewater discharges. The potential impacts of the Project are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the project type and location. This includes requirements of the HDOH, the County of Hawaiʻi, and the CMP.

Impervious Surfaces

Paved areas and buildings are impervious surfaces that prevent rainwater from naturally percolating into the subsurface and recharging the underlying groundwater aquifer. They may also increase the volume of stormwater runoff. The Project would create new impervious surfaces at the TMT Observatory, portions of the Access Way, the TMT Mid-Level Facility, the Headquarters, and the Satellite Office. The new impervious area at the TMT Observatory would be roughly 1.4 acres, which accounts for the dome and support buildings. The parking areas would not be paved and would remain pervious allowing rain to percolate naturally. A maximum 500-foot portion of the Access Way would be paved, generating up to 0.3-acre of new impervious surface. The amount of new impervious area at the TMT Mid-Level Facility, Headquarters, and Satellite Office would depend on the final design of those facilities.

The impact due to new impervious surfaces would be limited due to the permeability of the surrounding ground surface and the area of natural land downslope of the TMT Observatory, Access Way, and TMT Mid-Level Facility. The impact at the Headquarters and Satellite Office facilities would be limited due to the high permeability of the ground surfaces and the presence of drainage systems in the areas. Also, in compliance with existing regulations and requirements, TMT facilities would be designed to maximize groundwater recharge to the extent possible. Site grading and landscaping would be designed to direct storm water to pervious areas so that it may percolate into the ground. Storm drain drywells may also be utilized at the Headquarters and Satellite Office facilities, but would not be necessary at the TMT Observatory or TMT Mid-Level Facility where rainfall is low and permeability is high. New drywells would be designed by a professional engineer, permitted per HDOH requirements, and maintained properly. Therefore, the potential impact associated with impervious surfaces would be less than significant.

Potable Water

Freshwater is a limited resource on Hawaiʻi Island. The sustainable use of freshwater from all island aquifers has been estimated by the Commission on Water Resource Management

(CWRM) at 2,410 million gallons a day. Currently the approximate daily groundwater pumpage is about 32 million gallons. The Project would slightly increase the amount of freshwater used island-wide due to water use by employees at the various Project facilities. Assuming a maximum daily use of 20 gallons a day per person at the work place, the following daily uses of potable water are estimated: 1,000 gallons at the TMT Observatory, 200 gallons at the TMT Mid-Level Facility, 1,200 gallons at the Headquarters, and 600 gallons at the Satellite Office. This represents less than 0.01 percent of the current island-wide daily potable water pumpage, and 0.0001 percent, of the estimated sustainable use of freshwater from the island's aquifers. Also, in compliance with the existing requirements, water efficient fixtures would be installed and water efficient practices implemented to reduce the demand on freshwater resources. Therefore, this impact would be less than significant.

A component of the Project's Waste Minimization Plan (WMP) would be an assessment of potential water saving measures at all Project facilities; this plan is discussed in detail in Section 3.8.3. This would both reduce water use and reduce the volume of wastewater generated, particularly at the TMT Observatory where all wastewater would be collected and transported off the mountain for treatment.

Wastewater and Spillage

The discharge of domestic wastewater via a septic system has the potential to degrade surface and groundwater resources. In compliance with CMP Management Action FLU-7, TMT would instead install a zero-discharge waste system at the Observatory. Therefore, there would be no discharge of any wastewater, including domestic wastewater and mirror washing wastewater, at the summit. All wastewater would be collected and transported off the mountain for treatment and disposal.

The use of the existing Hale Pōhaku facilities by TMT personnel would increase the discharge of domestic wastewater via septic systems at Hale Pōhaku. It is expected that the existing Hale Pōhaku facilities would be able to accommodate the slight increase in volume generated by TMT use. A new wastewater system would be installed as part of the TMT Mid-Level Facility development in the lower portion of Hale Pōhaku. No adverse impact is expected because that system would be designed and permitted per applicable rules and regulations administered by the HDOH.

The Headquarters would be connected to the regional wastewater collection system and wastewater would be treated at the Hilo Wastewater Treatment Plant. The University Park infrastructure has been designed for a development such as the Headquarters facility so no adverse impact is expected. The hook up to the University Park wastewater system would be designed and reviewed as required by applicable rules.

An individual wastewater system would be utilized for the Satellite Office in Waimea, but no adverse impact is expected because it would be designed and permitted per applicable rules and regulations administered by the HDOH.

The release of fuel or chemicals, including mirror washing wastewater, from an accidental spill could degrade surface and groundwater resources. Like existing observatories, all mirror washing wastewater generated at the TMT Observatory would be collected and trucked off the mountain for off-site treatment and disposal. Although transportation of the mirror washing wastewater off the mountain would alleviate concerns regarding the degradation of water resources, it would increase the chance that an accident could occur as the wastewater was transported from the TMT Observatory to the treatment and disposal facility. Similar wastewater generated at the existing observatories has been transported off the mountain for treatment since 2002 without incident. The wastewater would only be transported off the mountain from the TMT Observatory when 2,000 gallons had accumulated. It is estimated that such removal would occur approximately once a month, and the likelihood of an accident is slight.

Also, in compliance with existing regulations and requirements, a Spill Prevention and Response Plan (SPRP) would be developed and implemented; this plan is described in detail in Section 3.8.2. Facility engineering measures would also be taken to provide proper chemical and fuel storage enclosures. Both the SPRP and the engineering measures would protect against the release of chemicals or fuel to the environment. Engineering measures would include draining all potentially chemically-impacted wastewater, such as mirror washing wastewater, in double-walled pipes and capturing it in double-walled storage tanks within the TMT Observatory. Fuel storage and piping would also be double-walled and be equipped with leak monitors. The SPRP would require inspections to ensure that systems are working properly, no leaks are occurring, and any necessary maintenance measures are taken. Therefore, this impact is considered less than significant.

3.7.4 Mitigation Measures

Through compliance with existing regulations and requirements, Project impacts would be less than significant and no additional mitigation is required. The Project's design features and policies to comply with applicable rules and regulations would include:

- The use of stormwater dry wells and grading to maximize groundwater recharge;
- The installation of water efficient fixtures and the implementation of a water saving practices to reduce the demand for freshwater resources;
- In compliance with CMP Management Action FLU-7, a zero-discharge waste system at the TMT Observatory so there would be no discharge of any wastewater at the summit;
- Facility engineering measures to provide proper chemical and fuel storage enclosures to protect against the release of chemicals or fuel to the environment, including double-walled piping and tanks for fuel and mirror washing wastewater; and
- The development and implementation of a SPRP that would outline measures to appropriately use and store chemicals and require inspections to ensure that systems are working properly and any necessary maintenance measures are taken.

3.7.5 Level of Impact after Mitigation

Mandatory compliance with existing regulations and requirements would ensure that the Project would not result in a significant impact on water resources or water quality.

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3.8 Solid and Hazardous Waste and Material Management

This section discusses the solid and hazardous waste and materials management practices at Maunakea, including the Project area and potential impacts of the Project on those practices. Measures that would be implemented by the Project to reduce the possible impacts of solid and hazardous waste on the environment are also presented.

3.8.1 Environmental Setting

There are two landfills on the Hawaiʻi Island, the South Hilo Landfill in Hilo, East Hawaiʻi and the Puʻuanahulu Landfill in North Kona, West Hawaiʻi. The South Hilo Landfill has an estimated remaining capacity of 400,000 cubic yards and is expected to close operations in about four years. As of 2002, the Puʻuanahulu landfill had more than 12,000,000 cubic yards of permitted air space, which would accommodate the current waste stream from West Hawaiʻi for about 40 years.

Maunakea Summit Region

Solid Waste

Solid waste, as defined under Section 1004(27) of the Resource Conservation and Recovery Act (RCRA), refers to any discarded solid, semisolid, liquid, or contained gaseous materials.

Solid waste and trash at the existing observatories is primarily generated from three sources: construction activity, visitors, and ongoing observatory operational and maintenance activities. The summit area is maintained and kept free of trash, debris, and other wastes through regular maintenance and the proper removal and disposal of all solid waste from the mountain. All trash containers are required to be covered and secured to prevent providing a food source for invasive fauna and to reduce the possibility of escaping debris, which can occur during periods of high winds that occur frequently.

The solid waste generated by each of the existing 11 observatories and one radio telescope was estimated to range from about 4 cubic feet per week generated by the Joint Astronomy Center (JAC) to up 160 cubic feet per week at the Keck Observatory. Each facility puts its trash in standard containers for transport and disposal off the mountain.

Hazardous Material and Waste

Hazardous materials are used at the summit observatories for a variety of maintenance and cleaning operations. Each observatory has a written procedure for safely, handling, and disposing of hazardous materials and emergency procedures for attending to spills. Table 3-9 identifies the hazardous materials used and stored within UH Management Areas, as well as the quantities of those materials normally stored or used. The best available information suggests that while mercury spills have occurred, spilled amounts occurred inside during mirror handling activities and were small. To date, there have been no mercury spills in the outside environment at the Maunakea summit. Also, since the 2000 Master Plan's new rules were put in place, there have been no spills inside any of the existing observatories. Certain observatories also have fuel tanks for emergency generator diesel fuel which is stored on site. The size of the tanks varies with the size of the facility and associated generator. Potential secondary sources of contamination from generator equipment include waste oil and coolant (e.g., ethylene glycol). In the past, there have been instances in which cinder was contaminated and then excavated to contain the potential effects of the spill.

All telescope mirror washing activities are done in accordance with the current wastewater management protocols. The waste is contained and transported off the mountain for treatment and disposal. The mirror washing activities do not generate hazardous waste.

Hazardous waste, as defined by the EPA (Title 40 of the CFR, Chapter 1, Subchapter I-Solid Wastes, Part 261-299), refers to substances that have "imminent and substantial danger to public health and welfare or the environment." The regulations provide criteria to define a waste a "characteristic" hazardous waste and a listing of "listed" hazardous wastes. Only small quantities of hazardous waste are generated by the observatories and are periodically transported to permitted treatment and disposal facilities.

Hale Pōhaku

Solid Waste

Solid waste at Hale Pōhaku is generated from construction activity, visitors, staff residing in the dormitories, and maintenance activities; on average, about 250 cubic feet of waste is produced weekly. All trash containers are required to be covered and secured to prevent providing a food source for invasive fauna and to reduce the possibility of escaping debris. Trash from Hale Pōhaku is taken off the mountain daily by the MKSS housekeeping staff and brought to the main Hilo office, where it is removed by the subcontractors.

Hazardous Materials and Waste

Hazardous materials are used at Hale Pōhaku for a variety of maintenance and cleaning operations. Fuels are also stored for use in motor vehicles and emergency generators. Table 3-9 identifies the hazardous materials used and stored within UH Management Areas, as well as the quantities of those materials normally stored or used.

Hale Pōhaku has three underground storage tanks (USTs): an 11,500 gallon tank for diesel fuel and a 2,000 gallon tank and 4,000 gallon tank for gasoline. The USTs are located in front of the maintenance utilities shop and are believed to be approximately 25 years old. In 1997 the USTs were retrofitted with a 24-hour a day leak sensor monitoring system that is checked daily. No releases have been reported from any of these USTs.

All hazardous wastes generated on UH Management Areas are placed in containers and removed from the mountain by licensed transport, treatment and disposal contractors to an offsite disposal facility. No hazardous wastes are disposed of within UH Management Areas.

Headquarters

The UH Hilo campus generates solid waste form everyday activities associated with its facilities and programs. The campus has an active recycling program. Numerous recyclable material collection stations have been in places throughout the existing campus, with collection service provided through contract with a private refuse hauling company.

Table 3-9: Hazardous Materials Used and Stored at Observatories and Hale Pōhaku

	UH (0.6 m and 2.2m)	Hale Pōhaku	SMA	Subaru	Gemini North	W.M. Keck
Hydraulic Fluid	400 gal (1,500 l) in use, 150 gal (570 l) in storage; replaced every 5 years	Hale Pōhaku normally has less than 55 gal (208 l) on hand; recycle 760 l (200 gal) yearly	100 gal (380 l) in use, 40 gal (150 l) in storage	690 gal (2,600 l) reservoir, 55 gal (208 l) in storage	400 gal (1,500 l) in use; replaced as needed every several years	1,200 gal (4,500 l) in 55 gal use, (208 l) in storage
Paint and Related Solvents	About 38 10 gal (38 l) on site, mostly spray cans; several used per month as needed	Solvent, 50 gal (190 l) mostly in parts washer; recycled.	Paint and primer 12 gal (45 l) in use and storage; mineral spirits 2 g (7.6 l) in use and storage	None on site.	About 20 gal (76 l) in storage; thinner, several liters in storage; used maybe once per week.	Various amounts on site; used as needed
Oil and Lubricant	Lube, 20 to 30 gal (76 to 114 l)	Oil, less than 100 gal (380 l) in storage	Engine oil, 9 gal (34 l) in use, 10 gal (38 l) in storage; lubricant 10 lb (4.5 kg) in use, 10 lb (4.5 kg) in storage	Lubricant for periodic service of backup generator, none stored onsite	Grease, about 50 lb (23 kg), and oils about 100 gal (380 l) in storage	Oil, 1,000 gal (3,800 l) in use, 100 gal (380 l) in storage
Mercury	Primary mirror support for 2.2-m (7.2ft) only, 30 lb (13.6 kg) in use, 20 lb (9.1 kg) in storage	No mercury used	No mercury used	No mercury used	No mercury used, other than a few thermometers	1.4-m (4.6ft) secondary mirror support; 13 lb (5.9 kg) in use, 17 lb (7.7 kg in storage

Source: Mauna Kea CMP Draft EA, 2009.

According to the Department of Environmental Management, Solid Waste Division, the existing municipal landfill currently has adequate capacity for disposal of solid wastes. However, there are plans to close the landfill and operate a solid waste transfer station in its place for processing and recompaction, prior to hauling waste to the Puʻuanahulu landfill.

Satellite Office

Presently, solid waste is hauled by individuals or hired haulers from business and residences to a solid waste transfer station, located next to the Department of Public Works corporation yard, off Kawaihae Road. The municipal waste is transferred from there to the Puʻuanahulu landfill for disposal.

Table 3-9 (Continued)

	VLBA	JCMT	CSO	UKIRT	IRTF	CFHT
Hydraulic Fluid	28 gal (106 l) in use, 20 gal (76 l) in storage; replaced yearly	Less than 30 gal (114 l) in use in both UKIRT and JCMT; less than 5 gal (19 l) in storage	100 gal (380 l) in use, 5 gal (19 l) in storage; added to equipment as needed	Less than 30 gal (114 l) in use in both UKIRT and JCMT; less than 5 gal (19 l) in storage	90 gal (340 l) in use, 5 gal (19 l) in storage; replaced as needed	300 gal (1,135 l) in use, 600 gal (2,100 l) in storage; systems replenished once in past 10 years
Paint and Related Solvents	Acrylic roof coating 5 gal (19 l), spot repairs, once per year.	Less than 5 gal (19 l) onsite	Paint, 22 gal (83 l) on site for cosmetic touch up; thinner, 2 gal (7.6 l) on site	Less than 5 gal (19 l) onsite	50 gal (189 l) on site; used on monthly, basis depending on job requirements	10 gal (38 l) paint on site, used for occasional touch up
Oil and Lubricant	Gear lube 5 gal (19 l) grease, 15 gal (57 l), and motor oil 2 gal (7.6 l)	Between UKIRT and JCMT, about 20 gal (76 l) stored on site	Grease, about 50 lb (23 kg) and lubricants, 12 gal (45 l) stored on site	Between UKIRT and JCMT, about 20 gal (76 l) stored on site	30 gal (114 l) stored on site.	Oil and lube, 25 gal (95 l) in storage
Mercury	No mercury used	No mercury used	No mercury used	No mercury used	About 112 lb (51 kg) in support tube for primary mirror, none held in reserve	Mercury used in radial support tube for secondary mirror: 17 lb (7.7 kg) in use, 21 lb (9.5 kg in reserve

3.8.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact if it substantially affects the public health, involves a substantial degradation of environmental quality, and/or detrimentally affects air or water quality. Therefore, if the generation, storage, use, transportation, or disposal of hazardous materials, solid waste, or hazardous waste by the Project resulted in the degradation of air, soil, or water quality to the point it no longer could be used for its intended purpose, or contained pollutants or toxic elements exceeding allowable levels, a significant impact would occur.

3.8.3 Potential Environmental Impact

The Project would result in additional generation of solid and hazardous wastes. The potential impacts of the Project are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the Project type and location. This includes requirements of the U.S. Environmental Protection Agency, HDOH, the County of Hawai'i, and the CMP. Key regulations and requirements regarding solid and hazardous waste include:

- Occupational Safety and Health Administration (OSHA), Title 29, Code of Federal Regulations, Section 1910.120
- Resource Conservation and Recovery Act (RCRA)
- Emergency Planning and Community Right-To-Know Act (EPCRA)
- Hazardous Waste Operations and Emergency Response
- HRS Chapter 342J, Hawai'i Hazardous Waste Law
- HAR Title 11, Chapter 260, Hazardous Waste Management General Provisions
- HAR Title 11, Chapter 262, Standards Applicable to Generators of Hazardous Waste
- HAR Title 12, Chapter 74.1, Hawai'i Occupational Safety and Health
- The CMP

The Project would develop and implement a WMP and a Materials Storage/Waste Management Plan, which would include a SPRP. These plans would be overseen by a safety and health officer (SHO). The duties of the SHO would include regular inspection of all Project facilities to evaluate compliance with guidance, rules, and regulations; inspection of equipment and storage areas to detect any inappropriate practices and items needing maintenance; and developing new policies and practices as new rules, regulations, and techniques are developed, including waste minimization practices that could eliminate or replace the use of chemicals in Project's operation. These plans and policies would be used to manage hazardous materials, solid waste, and hazardous waste. With implementation of these plans and actions, detailed below, the impact of the Project's hazardous materials, solid waste, and hazardous waste would be less than significant.

The Project's WMP would follow the State of Hawai'i's WMP and develop procedures for efficient operation through the use of appropriate planning techniques and methods and utilizing the best available technologies for operations to reduce solid waste generation. The WMP would be regularly updated to include the most current methods to reduce the amount of waste generated at the facility, as new products and practices become available. The WMP would call for the removal of all unnecessary packaging materials at the Headquarters receiving dock before transporting items to the summit. This would reduce the generation of solid waste at the TMT Observatory. The TMT waste minimization planning has found ways to avoid the use of materials that contain certain hazardous materials, including acetone and methyl ethyl ketone (MEK).

The Materials Storage/Waste Management Plan and component SPRP would spell out protocols for proper handling, storage, use, and disposal of liquid and solid materials and wastes. Standard practices and emergency procedures would be outlined in compliance with applicable rules and regulations. The plan would outline steps to be taken to ensure that the accidental occurrence of a spill is minimized and, that if a spill did occur, that it would be quickly managed. Should a spill occur, observatory spill response procedures would include the notification of the OMKM of any release or spill of a reportable quantity of any hazardous material. Written safety procedures for both the handling and disposing of hazardous materials would be included in the plan along with emergency procedures for attending to spills of hazardous waste. All workers involved in the handling of hazardous materials would undergo specialized training, including proper implementation of all plan procedures and actions. Material Safety Data Sheets (MSDS) and warning and handling data would be collected and kept on file at the location of use and storage. The plans would also require inspections to ensure that systems are working properly, no leaks are occurring, and any necessary maintenance measures are taken.

The Project's design plus implementation of the plans and programs, all designed to comply with applicable rules and requirements, would result in the Project's impact related to solid waste, hazardous materials, and hazardous waste less than significant.

Solid Waste

Trash and other solid waste generated as part of the activities associated with the TMT at both the TMT Observatory and at Hale Pōhaku would result in a minor increase in the generation and disposal of solid waste from Maunakea. It is anticipated that the TMT would generate trash at a rate similar to that of the Keck observatory, approximately 120 cubic feet per week. Solid waste and trash generated by the daily operation would be primarily composed of waste paper, spent containers, and limited amounts of food waste.

Like the existing observatories, in compliance with the existing regulations, the Project's waste or leftover material would be recycled and reused to the extent possible. Scrap metal, plastic, and glass would be collected for recycling, and the remaining solid waste rubbish would be removed and trucked off the mountain for disposal in a landfill. Between pickups, rubbish would be stored indoors in lidded trash containers. Cans, plastic, and glass bottles, paper and cardboard, and scrap metal would be collected in separate containers and transported to Headquarters for reuse or recycling. Wastes such as used oil and glycol, would be removed to also be recycled by licensed contractors. No solid waste would be disposed of at the summit.

Hazardous Materials and Waste

Like the existing observatories, normal operations and maintenance of the TMT Observatory would utilize vehicle and generator fuel, alcohols used for optics and general cleaning, liquid adhesives for optics bonding, various metals used for coating deposition materials, lubricants, hydraulic fluid, glycol coolants, and small quantities of acids, paints, and solvents. Instead of toxic solutions, a non-toxic ethylene glycol solution of 35 to 40 percent by volume would be used for the chilled water system. The TMT Observatory's emergency generator would be served by a 5,000 gallon capacity diesel fuel tank located outside and above-ground in a protected area. No mercury would be used by the Project. To minimize the potential of an accidental spill or release of the hazardous materials or wastes, all such materials would be stored in a secondary containment area and inspected daily for leaks.

The primary maintenance activities associated with the Project are those related to the telescope primary and secondary mirrors, or mirror washing. It is expected that mirror maintenance activities would occur continuously. TMT Observatory design includes a separate mirror laboratory for mirror washing. The laboratory is designed to collect waste from the mirror washing and coating area floor drain and laboratory sinks into double contained piping. The piping would drain by gravity to a holding tank. The tank would either be double wall or would be placed in a concrete basin. The tank would be sized to accommodate at least one week's worth of normal use, as well as the volume needed to allow for fire-suppression sprinkler discharge. Each point of exit from the mirror stripping area would have a trench drain that would drain to the storage tank. All exposed concrete in areas of chemical use would have a chemical resistant coating applied. A leak detection system would be installed and would monitor the double contained pipes and tank. A level control system would monitor the tank and be equipped with an overfill alarm in the event that the level in the tank reaches 90 percent capacity.

The waste collected from the mirror washing process would be collected, removed, and transported off site for treatment and disposal. The mirror washing wastewater would not be a hazardous waste.

To minimize the potential for an accidental spill while wastes are in transit down the mountain to the proper disposal site, no tank or containers being transported would be filled to the top. To further ensure the safe transport and disposal and hazardous waste, the Project would utilize only EPA-permitted and licensed contractors to transport hazardous wastes. More frequent removal of hazardous waste would also be examined to reduce the total amount of hazardous material on the mountain at any given time.

3.8.4 Mitigation Measures

Implementation of the design and engineering features, techniques, and management procedures, and compliance with existing regulations and requirements would ensure that Project impact would be less than significant, and no additional mitigation is required. The Project's design features and policies to comply with applicable rules and regulations would include:

- Collecting all solid waste in secured and covered storage containers and trucking it down the mountain for proper disposal at an off-site disposal facility.
- Instituting a WMP.
- Storing a minimal amount of hazardous materials on site.
- Implementation of a Materials Storage/Waste Management Plan and component SPRP.
- Recycling solid and non-hazardous waste material and reusing them to the extent possible.
- Designs that include specialized space and contained system to collect chemical waste from the mirror stripping, coating, and washing area floor drain and laboratory.
- Leak detention systems and daily inspection of equipment handling hazardous materials.
- Mandatory training of all personnel handling hazardous materials and waste.

- Regular inspections by a SHO.

3.8.5 Level of Impact after Mitigation

Mandatory compliance with existing regulations and requirements would ensure that the Project would not result in a significant impact due to its solid and hazardous waste management.

3.8.6 References

Harding ESE. 2002. Update to the Integrated Solid Waste Management Plan for the County of Hawai‘i.

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3.9 Socioeconomic Conditions

This section discusses the socioeconomic conditions in the region and in the Project areas, and the potential long-term socio-economic impacts of the Project. Impacts related to construction and decommissioning of the proposed TMT Project are discussed in Section 3.15 of this EIS.

3.9.1 Environmental Setting

The MKSR and Hale Pōhaku on Maunakea are located in the District of Hāmākua. The district is a relatively sparsely populated area; in 2000, the 6,108 residents represented approximately 4 percent of the county's total population of 148,677. The County of Hawai‘i has been experiencing a population growth rate of approximately 2.4 percent per year; however, this growth rate is projected to decline steadily to 1.2 percent by the year 2030, when the county's population is expected reach 261,030.

In 2007, the county had an estimated labor force of 86,300 residents, and an unemployment rate of 3.3 percent. In 2008, unemployment had increased to 3.8 percent and in 2009 it has reached 10.2 percent. In 2006, annual salaries in the county averaged $33,960; in 2005, it was estimated that 13.5 percent of the county's population was below the poverty level.

Findings of an economic and workforce study conducted by the Hawai‘i Science and Technology Council in 2008[46], demonstrated a significant growth of the State's science and technology industries and their increasing contribution to the state's economy. In 2007, State of Hawai‘i's private technology sector contributed about $3 billion to the economy, approximately 5 percent of the State's total $61 billion economy. About $97.8 million of that contribution was generated by private sector technology companies in the County of Hawai‘i. In addition to the $3 billion direct economic benefit, an additional $2 billion was indirectly generated through purchases of goods and services by the technology companies and their employees. Together, these contributions represented more than 8 percent of the state's economy in 2007.

Within the technology sector, astronomy is the smallest market segment, but it is one of the most prominent science activities that occurs on the island. Activities occurring in the MKSR and Hale Pōhaku that generate revenues within the County of Hawai‘i are primarily astronomy and tourism[47].

The IfA conducts research in astrophysics and planetary science and is responsible for the development of astronomical facilities and programs in the MKSR. The IfA operates several observatories on Maunakea that are used for the study of planets, stars, and galaxies. Through its service organization, MKSS, the IfA provides the common services required by all the astronomy facilities on Maunakea. Table 3-10 summarizes socioeconomic information about the existing facilities.

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[46] Hawai‘i Science and Technology Council, Fact Sheet, 2008.
[47] Final Environmental Assessment for the Mauna Kea Comprehensive Management Plan, 2009.

Table 3-10: Summary Maunakea Observatories Costs and Employment (2008)

Facility	Annual Operating Cost ($ million)	Capital Cost ($ million) (a)	County of Hawai'i Based Staff	Year Operational
UH 0.9m	Unknown	0.3	Unknown	1968
UH 2.2m	1.2	5	7	1970
CFHT	7.5	30	49	1979
NASA IRTF	4.0	10	16	1979
UKIRT	3.3	5	27	1979
CSO	2.6	10	11	1986
JCMT	3.8	32	27	1986
Keck	13.0	170	130	1992/1996
VLBA	0.3	7	2	19992
SMA	5.0	80	27	2003
Subaru	18.4	170	96	1999
Gemini	13.3	92	105	1999
MKSS	(b) 3.9	n/a	30	n/a
Total	**72.4**	**611**	**527**	**-**

Source: IfA Fact Sheet March 3, 2009.
a: Historical cost, not adjusted for inflation, and not including subsequent capital improvements.
b: Not included in the total since derived from facility operating costs.
n/a: not applicable

The observatories provide continuous employment for astronomers, a wide range of engineers and engineering technicians (mechanical, electrical, and optical), software and information technology engineers, staff to maintain and operate the equipment under the extremely difficult conditions of the summit, and administrative personnel.

According to the 2007 survey conducted by the Hawai'i Science & Technology Council, 885 jobs were supported by the Maunakea observatories[48], with the island's astronomy segment growing 7.3 percent per year between 2002 and 2007 (Table 3-11). These jobs include private-sector firms involved in astronomy, most of which are located on the island and employ engineers and technicians to design, construct, and help maintain the equipment used in the observatories.

Table 3-11: Estimates of Astronomy Market Segment, Year 2007

Astronomy Market Segment	State of Hawai'i
Employment (all astronomy jobs)	885
Employment (private-sector astronomy jobs)	342
Annual private-sector employment growth rate (2002-2007)	7.3%
Average earnings	$70,951
Average earnings – private-sector only	$83,654
Establishments	28

Source: The Hawai'i Science & Technology Council, Innovation and Technology in Hawai'i: An Economic and Workforce Profile, October, 2008

These employees earned about 50 percent more than the average worker in the state, with an average annual salary of $70,951 in 2007. These higher salaries generate higher tax revenues for

[48] Draft Astronomy and Space Science & Technology, Research and Economic Analysis Division, February 2009.

the state. Additionally, employment projections suggest that the technology sector is likely to grow nearly 50 percent faster than the rest of the State of Hawai‘i's economy over the next decade[49].

3.9.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact if the Project substantially affects the economic or social welfare of the community or state. Therefore a significant socioeconomic impact would occur if the Project adversely affected the revenue, employment, or overall economic conditions of the island community or the state as a whole.

3.9.3 Potential Environmental Impact

The operations of the proposed Project would provide additional long-term potential employment on the island for astronomers, a wide range of engineers and engineering technicians (mechanical, electrical, and optical), software and information technology engineers, staff to maintain and direct equipment at the observatory, scientific support, public outreach, and management and administrative personnel, including cultural and education outreach specialists. The current estimate for observatory operations anticipates the need for 140 full-time employees.

In addition to the direct employment through these jobs, the Project would result in the creation of additional employment opportunities by contracting for work and services with local companies for a variety of services ranging from precision machine shop work to website design. The Project would also generate direct revenues associated with payments for electricity, communication infrastructure, and local and state taxes. The annual labor budget for the Project is estimated at approximately $13.0 million, with a non-labor budget of about $12.8 million per year, for a total annual operating cost of $25.8 million, contributing to the state and local economies.

In addition, it is planned to locate TMT's Instrument Development Office in Hawai‘i which would manage and coordinate the construction of new instruments worth $20 million per year. This would offer additional employment opportunities and experience with on-going astronomical development projects.

Those employed by the Project and their facilities would purchase local goods and services and pay local and state taxes, further contributing to the socioeconomic welfare of the island community and the state.

The Project would substantially enhance the current socioeconomic benefits of the established observatories on Maunakea. The Project would provide access to UH scientists and researchers through a guaranteed fraction of the observing time. The TMT Observatory would allow the UH system to enhance its astronomy program and thereby retain its substantial role in the nation's astronomy program. As the TMT Observatory would be the most powerful ground-based observatory on earth, it is anticipated that it would generate interest and could lead to increased tourism related to the observatories and astronomy. Additional visitors would generate additional revenue for local and state economies, and in turn, additional local employment.

[49] Hawai‘i Science & Technology Council, Fact Sheet.

Overall, the Project would result in a beneficial socioeconomic impact by directly and indirectly generating new revenues for local and state economies, contributing to the state's gross domestic product, and generating new employment opportunities for local residents and the state.

3.9.4 Mitigation Measures

TMT 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 Workforce Pipeline Program that would lead to a highly qualified pool of local workers who could be considered for hiring into all 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. Key elements of the planned pipeline program include:

- Initiation of a TMT workforce committee including members from UH Hilo, HawCC, DOE, and Hawai‘i Island workforce development groups.
- Identification of specific TMT job requirements that UH Hilo, HawCC, and DOE can use to create education and training programs.
- TMT support of the education and training programs, including at least 4 internships per semester, apprenticeships, and at least 10 summer jobs for students.
- Creation of a partnership between UH Hilo and TMT partner organizations, such as Caltech, the UC system, and Canadian universities to attract and develop top talent. This would include internships, degree programs, and student exchanges.
- Support of and active participation in on-going efforts to strengthen science, technology, engineering and math (STEM) education in Hawai‘i Island K-12 schools and informal learning organizations. Examples would be the Science and Engineering Fair, FIRST robotics competitions, and ‘Imiloa Astronomy Center of Hawai‘i.

A dedicated TMT Workforce Pipeline Program manager would coordinate this effort. The program would be focused on long term investments to strengthen the current STEM skills infrastructure at UH Hilo, HawCC, and Big Island K-12 education organizations serving lower income and first-generation college attending populations. One example could be the development of an engineering school at UH Hilo. Another could be the development or support of programs at HawCC that would provided 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 first time college attendee families while earning and retaining community support.

In addition to the Workforce Pipeline Program effort discussed above, the following measures would be implemented by the Project to ensure that the economic benefit potential for the community and the State is realized:

- To the greatest extent feasible, employment opportunities would be filled locally.
- At least two full-time positions would be established for community outreach.
- A mentoring program for children would be developed to provide support for those interested in astronomy, technology, engineering, and math during the entire elementary

school-to-university graduate school educational path, with an ultimate goal of strengthening STEM skills throughout Hawai‘i Island.

- Scholarship programs for students interested in careers in astronomy, engineering, science, and technology would be established.

3.9.5 Level of Impact after Mitigation

The mitigation measures proposed would increase the Project’s benefit to the island community and the State. Beyond these important collateral employment and economic impacts, increased STEM capacity of the K-16 educational institutions associated with the Workforce Pipeline Program, the Project would provide Hawai‘i Island with a magnet of educational excellence that could form the basis for technology-based, innovation driven job-producing activities around complementary activities in energy, agriculture, and information technologies and scientific research and support. The skills and expertise developed for a large modern observatory like TMT are readily applicable to many areas of technology-based industries and a wide range of additional employment opportunities could be developed on Hawai‘i Island.

Put together, the Workforce Pipeline Program and mitigation measures would help to maximize the number of local residents qualified for all level of Project jobs or other high tech projects on Hawai‘i Island.

3.9.6 References

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The Center for Regional Economic Competitiveness. 2008. Innovation and Technology in Hawai‘i: An Economic and Workforce Profile. Prepared for The Hawai‘i Science and Technology Institute (HiSciTech).

University of Hawai‘i. 2009. Draft Environmental Assessment for the Mauna Kea Comprehensive Management Plan.

3.10 Land Use Plans, Policies, and Controls

This section discusses the land use plans, regulations, and existing uses in the region and in the Project areas, and the Project's potential land use planning effects and its compatibility with existing land uses.

3.10.1 Environmental Setting

This section discusses the land plans and uses in the region and in the Project areas.

State land use plans, policies, and controls that apply to all Project areas include:

- Hawai'i State Plan, HRS Chapter 226. Adopted in 1978 and last revised in 1991, the plan establishes a set of themes, goals, objectives, and policies meant to guide the long-term growth and development within the state. The three themes are individual and family self-sufficiency, social and economic mobility, and community and social well-being.
- State Land Use Law, HRS Chapter 205. Administered by the Land Use Commission. All lands in the State of Hawai'i are classified into one of four major land use districts: urban, rural, agricultural, and conservation. Each category has a range of allowable uses.
- Environmental review, HRS Chapter 343 and Hawai'i Administrative Rules (HAR) Section 11-200. The statute and rules establish a system of environmental review and provide that environmental concerns are considered for all proposed actions on State and county lands.
- State Environmental Policy, HRS Chapter 344. The broad goals of this policy are to conserve natural resources and enhance the quality of life in the State. It encourages productive and enjoyable harmony between people and their environment to promote efforts which will prevent or eliminate damage to the environment and biosphere, stimulate the health and welfare of humanity, and enrich the understanding of the ecological systems and natural resources important to the people of Hawai'i.

County land use plans, policies, and controls would apply only to the Headquarters and Satellite Office facilities, located in Hilo and Waimea. Applicable County requirements include those in the County of Hawai'i General Plan as well as associated zoning regulations. The General Plan is a policy document expressing the broad goals and policies for the long-range development of the island; it is organized into thirteen elements with policies, objectives, standards, and principles for each. The plan was adopted by ordinance in 1989 and revised in 2005. This plan, and its associated policies and controls do not apply to the TMT Observatory or TMT Mid-Level Facility because they are located on state-owned conservation lands.

Federal rules, such as the National Environmental Policy Act (NEPA), do not apply to the Project because no Federal agency is involved in the Project, no Federal funding is being used for the Project, and the Project does not use Federal land.

Maunakea Summit Region and Hale Pōhaku

Formed as a shield volcano, Maunakea rises nearly 33,000 feet from the ocean floor to an elevation of 13,796 feet, making it the highest point in Pacific Polynesia. Maunakea has consistently been recognized for its aesthetic beauty, and was listed as a National Natural Landmark in 1972. In 1968 the State created the MKSR in recognition of Maunakea's scientific potential. In the 2000 Master Plan the UH designated 95 percent of the Science Reserve as a Natural/Cultural Preservation Area in recognition of Maunakea's natural and cultural significance.

Land Classification

All land within the State of Hawai'i is classified as one of four major land use districts: conservation, agriculture, rural, or urban. Beginning at an elevation of approximately 7,000 feet and extending to the summit, the lands of Maunakea are classified as a conservation district. This classification is the most restrictive of the four, and permits a very limited range of land uses (HRS §205-2). The objective is to conserve, protect, and preserve the state's natural resources through appropriate management and use meant to promote their long-term sustainability and the public health, safety, and welfare. Permitted uses of lands are administered by the DLNR through the State Office of Conservation and Coastal Lands (OCCL) (HRS §183C-3).

Conservation district lands are categorized into five subzones (HAR §13-5-10): protective, limited, resource, general, or special (Figure 3-27). The MKSR, Hale Pōhaku, and the majority of the Mauna Kea Forest Reserve are classified as resource subzone. Portions of the Ice Age Natural Area Reserve (NAR) are also classified resource subzone, but much of Ice Age NAR and remaining portions of the Mauna Kea Forest Reserve are classified as protective subzone. Through proper management, the objective of the resource subzone is to develop areas to ensure sustained use of the natural resources. Land uses potentially allowed within the resource subzone include astronomy facilities, commercial forestry, and mining and extraction.

The construction and operation of astronomy facilities within a resource subzone requires a Conservation District Use Permit (CDUP) (HAR § 13-5-34). A CDUP is issued through the BLNR of DLNR. An approved site-specific management plan must be in place prior to the construction and operation of an astronomy facility within a resource subzone (HAR § 13-5-39); a BLNR-approved CMP must also be developed prior to construction and operation of such a facility.

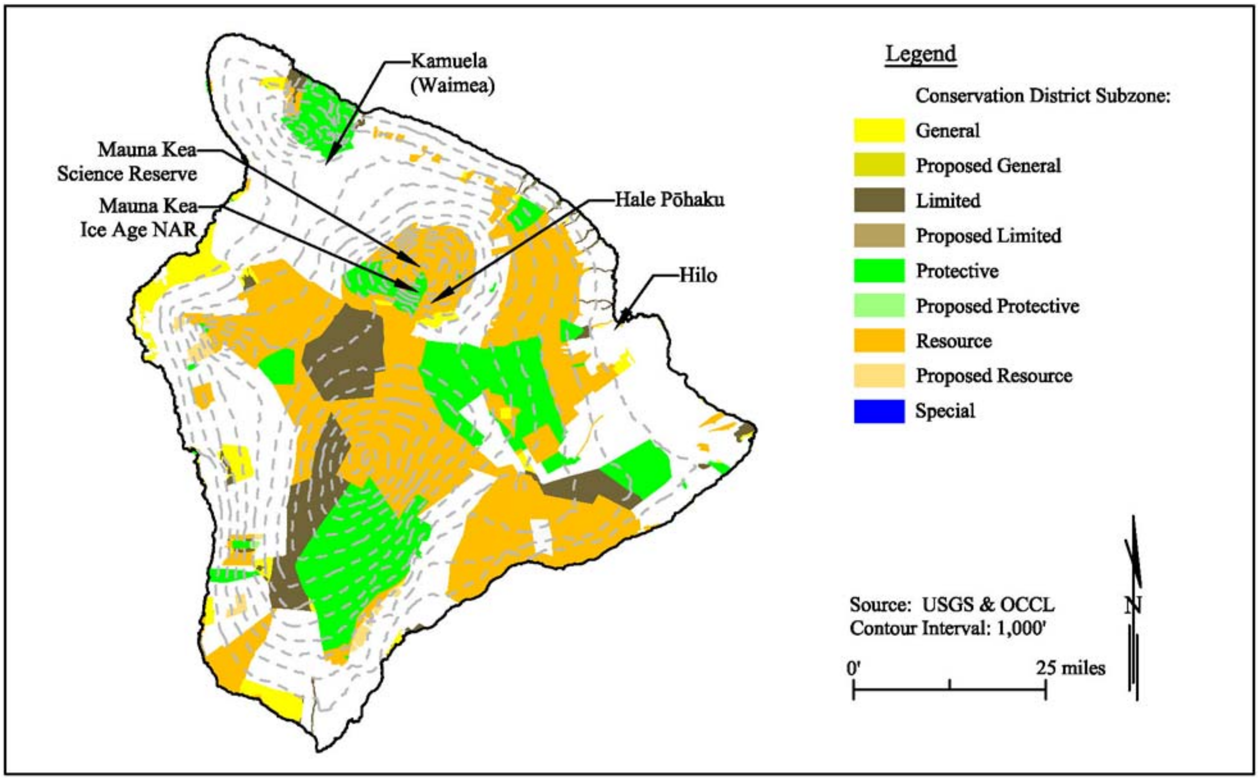

Figure 3-27: Conservation District and Subzones on Island of Hawai'i

Land Ownership and Leases

MKSR, Hale Pōhaku, the Ice Age NAR, and Mauna Kea Forest Reserve are all considered "ceded" lands. Ceded lands are those crown, public, and government lands that were once held by the Kingdom of Hawai'i. The Republic of Hawai'i took control of these lands after the overthrow of the Hawaiian monarchy. The United States annexed Hawai'i in 1898 and the Republic of Hawai'i ceded 1.8 million acres of public lands to the Federal government. The United States Supreme Court recently held that when Hawai'i joined the Union in 1959 as the 50th state, the Federal government granted absolute title to approximately 1.2 million acres of ceded lands to the State. These lands, together with the proceeds from the sale or other disposition and income there from, are held by the State as a public trust. The Office of Hawaiian Affairs (OHA) has sought to enjoin the sale or transfer of these ceded lands until OHA's claim to revenue from those lands has been resolved. That case is currently pending before the Hawai'i Supreme Court.

The State holds the ceded lands in a public trust for (1) the support of the public schools and other public educational institutions, (2) the betterment of the conditions of native Hawaiians, as defined in the Hawaiian Homes Commission Act, (3) the development of farm and home ownership on as widespread a basis as possible, (4) for the making of public improvements, and (5) the provision of lands for public use (The Admission Act Section 5(f)).

The DLNR manages the majority of the undeveloped ceded lands, including the Mauna Kea Ice Age NAR and Mauna Kea Forest Reserve. In 1968, BLNR granted UH a 65-year lease (General Lease No. S-4191) for the area consisting of approximately all land above 12,000 feet elevation.

The MKSR is approximately circular, with a 2.5-mile radius that is centered on the UH 2.2-meter observatory near the summit, except for those areas that were withdrawn and designated as part of the NAR in 1981. The lease states that the MKSR is to be used “as a scientific complex, including without limitation thereof an observatory, and as a scientific reserve being more specifically a buffer zone to prevent the intrusion of activities inimical[50] to said scientific complex.” Through this general lease, UH subleases areas within the MKSR for observatory facilities.

UH was also granted a separate lease for a 19.3-acre parcel located at an elevation of 9,200 feet on the southern slope of Maunakea (Lease No. S-5529) by the BLNR. This parcel, known as Hale Pōhaku, has numerous uses and is currently home to the UH IfA’s facilities that support operations of observatories.

UH also has a Grant of Easement (No. S-4697) for the Maunakea Access Road that extends from Hale Pōhaku to the boundary of the MKSR at approximately 11,500 feet.

Land Management

The MKSR is managed pursuant to the policies set forth in the General Lease S-4191 between BLNR and UH, the DLNR Administrative Rules Title 13, and the conditions imposed by BLNR on CDUPs.

A series of plans have been prepared for Maunakea since the 1970s, including development plans, master plans, and management plans. The current plans include the 2000 Master Plan and the CMP.

Prior to the 2000 Master Plan, the 1995 Management Plan expanded UH’s management area along the Maunakea Access Road to include approximately 400 yards on either side of the road, except for the western side of the road where that width would have extended into the Mauna Kea Ice Age NAR. Since the 1995 Management Plan, all master and management plans have addressed UH’s management areas to include the access road and the 400-yards on either side as outlined above, the MKSR (TMK 4-4-15:9), and Hale Pōhaku (TMK 4-4-15:12).

The 2000 Master Plan outlined responsible stewardship and use of university managed lands on Maunakea through 2020 and created OMKM. OMKM is housed within UH Hilo and is the local management authority for Maunakea. One of the fundamental management measures of the 2000 Master Plan separated the 11,288-acre MKSR into a 10,763-acre Natural/Cultural Preservation Area and the 525-acre Astronomy Precinct. The 2000 Master Plan did not identify a “carrying capacity” but it provided a framework for guiding future observatory development. It limited future development to the Astronomy Precinct; prohibited development on undisturbed pu‘u; limited the siting of new development on undisturbed land to areas off Kūkahau‘ula; and limited development on Kūkahau‘ula to recycling of existing sites.

Areas within the Astronomy Precinct preferred for future astronomy facilities were also identified, including Area E for the NGLT. The 2000 Master Plan was adopted by the UH Board of Regents (BOR). The Master Plan requires all projects undergo a design review and approval process with final UH approval by the BOR. All new land uses on Mauna Kea, including the TMT, are subject to BLNR approval through the CDUA process.

[50] Unfavorable

The CMP provides the framework for managing existing and future uses and activities, including astronomy, recreational and commercial activities, scientific research, and cultural and religious activities within the UH management area – which consists of the MKSR, Hale Pōhaku, and the Maunakea Access Road between Hale Pōhaku and the MKSR (Figure 3-28). The CMP was approved by the BLNR and the UH BOR accepted responsibility to implement the CMP.

OMKM is charged with the day-to-day management of the MKSR. OMKM works closely with the Mauna Kea Management Board (MKMB), the Kahu Kū Mauna Council, and several advisory committees. Seven members of the community who are nominated by the UH Hilo Chancellor and approved by the UH BOR comprise the MKMB. MKMB guides the operations of OMKM and advises the Chancellor on activities, operations, and development. Kahu Kū Mauna – in Hawaiian, Guardians of the Mountain – is a nine-member council named by MKMB, and advises the MKMB, OMKM, and the UH Hilo Chancellor on cultural matters. Other advisory councils formed to advice the MKMB include an Environment Committee, a Hawaiian Culture Committee, a Public Safety and Conduct Committee, and a Wēkiu Bug Scientific Committee.

OMKM will oversee compliance with CDUP conditions and lease requirements; this oversight includes semi-annual inspections of all observatories. OMKM manages a ranger program to facilitate visitor safety and education on Maunakea; ranger activities include advising and educating visitors, providing emergency assistance when necessary, performing site maintenance activities, and assisting OMKM with compliance matters.

OMKM also oversees compliance with the CMP which utilized the Ka Paʻakai analytical framework. The CMP was developed based on the Hawaiʻi Supreme Court analytical framework to ensure that traditional and customary Native Hawaiian rights are preserved and protected. Ka Paʻakai, 94 Hawaiʻi at 52, 7 P.3d at 1089. The three components of Ka Paʻakai are:

1. The identity and scope of the valued cultural, historical, or natural resources that are found within the UH Management Areas, including the extend to which traditional and customary Native Hawaiian rights are exercised in the areas.
2. The extent to which those resources – including traditional and customary Native Hawaiian rights – will be affected or impaired by the proposed action
3. The feasible action, if any, to be taken by the agency to reasonably protect Native Hawaiian rights if they are found to exist

MKSS is responsible for providing support to the observatory facilities, including managing the facilities at Hale Pōhaku, maintaining the Maunakea Access Road, providing utility support and safety and emergency services, and maintaining the communication network. MKSS also manages the VIS.

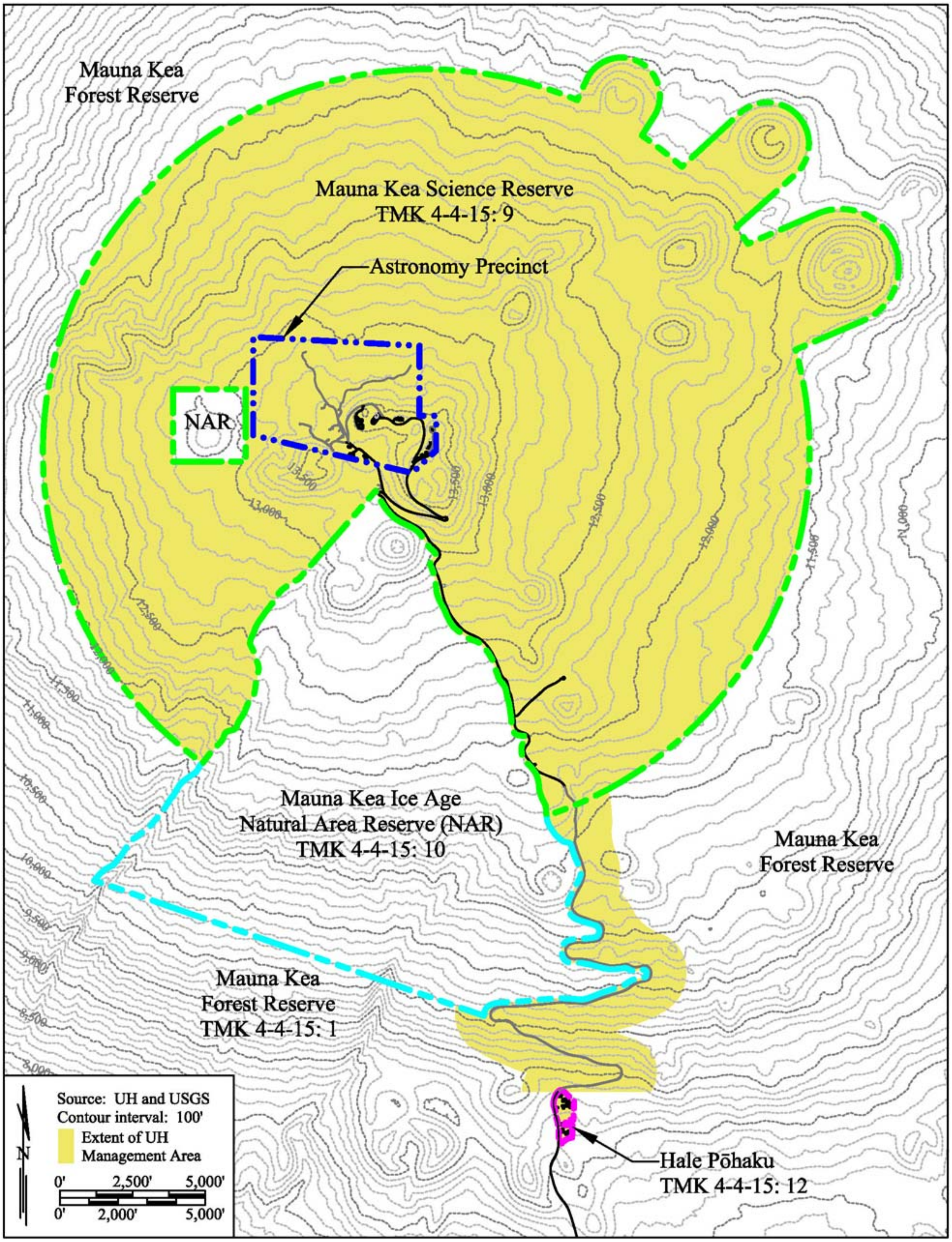

Figure 3-28: UH Management Areas

The Ice Age NAR is managed by the Division of Forestry and Wildlife (DOFAW), within DLNR. DOFAW has a general management plan for the NAR, which includes non-native animal control, non-native plant pest control, restoration and habitat enhancement, monitoring, public information and education, and research. In 2008, BLNR, DOFAW, and OMKM reached a tentative agreement to formalize coordinated management of cross-boundary issues. Under the agreement, OMKM rangers would provide visitor assistance, engage in joint research and educational efforts with NAR staff, and report violations occurring in the NAR.

The 52,500-acre Mauna Kea Forest Reserve, which surrounds the MKSR, the Ice Age NAR, and Hale Pōhaku, is under the jurisdiction and management of the DOFAW. The Forest Reserve System is managed under the guidance of the Hawaiʻi State Constitution, HRS (Chapter 183), and associated HAR (Chapter 104).

Cultural and Religious Activities

As discussed in Section 3.2, Maunakea continues to be utilized by Native Hawaiians for prayer and ritual observances, including the construction of new altars and other contemporary practices. Lake Waiau and the Adze Quarry within the Ice Age NAR are destinations of interest, as is the summit cluster of cones, traditionally known as Puʻu Kūkahauʻula (lately known as Puʻu Wēkiu), and other locations on the mountain lands.

Astronomy

The summit of Maunakea is one of the earth's premier locations for astronomical research. The atmosphere on the summit is exceptionally stable providing extremely dry and cloud free conditions that are exceptional for making astronomical observations. The summit is also far removed from any city lights which could cause interference, allowing for clear dark skies. Due to the location of the Hawaiian Islands within the northern hemispheric tropics, astronomers can observe the entire northern sky and nearly 80 percent of the southern sky from the summit. These conditions are the primary reason that there are currently 11 observatories operating within the Astronomy Precinct near the summit of Maunakea (Figure 2-3), drawing astronomers from around the world. The IfA is one of the most respected in the world, attracting some of the most highly talented faculty and students from around the world. One of the primary reasons for IfA's success is its access to the world class observatories located on Maunakea. As part of their sublease agreements with UH, the observatories agree to provide UH with a guaranteed share of observation time, which is typically between 10 to 15 percent of the observatory's total viewing time. It is the access to these observatories that sets IfA apart and solidifies its outstanding international reputation.

In the 1960s, UH initiated an astronomy research program to attract global interest in constructing and operating observatories in Hawaiʻi; since, fourteen facilities operated by 11 countries have been built on Maunakea. Currently there are 12 facilities (11 observatories and one separate telescope) located on Maunakea (Table 3-12, Figure 2-3). The 13N Site and a site near the summit, the site of the existing 2.2-meter UH observatory, were tested in the 1960s for the placement of a new observatory; the summit site was selected because the seeing indicators were slightly superior.

Table 3-12: Facilities Currently Operating on Maunakea

Facility	Primary Mirror Size	Primary Use	Sponsors	Year of Operation
Optical and Infrared Observatories				
UH Hilo 0.9-meter	0.9 m (3 ft/36")	Optical	UH	1968
UH 2.2-meter	2.2 m (7.2 ft/88")	Optical/Infrared	UH	1970
NASA Infrared Telescope Facility (IRTF)	3.0 m (10 ft)	Infrared	NASA	1979
Canada-France-Hawai'i Telescope (CFHT)	3.6 m (12 ft)	Optical/Infrared	Canada / France / UH	1979
United Kingdom Infrared Telescope (UKIRT)	3.8 m (12.5 ft)	Infrared	United Kingdom	1979
W.M. Keck Observatory (Keck I and II)	Two 10 m (33 ft) telescopes	Optical/Infrared interferometer	Caltech / UC / California Association of Research in Astronomy (CARA)	1992 & 96
Subaru (Japan National Large Telescope)	8.2 m (27 ft)	Optical/Infrared	Japan	1999
Gemini North Telescope	8.1 m (26.2 ft)	Optical/Infrared	NSF / United Kingdom / Canada / Argentina / Australia / Brazil / Chile	1999
Millimeter / Submillimeter Observatories				
Caltech Submillimeter Observatory (CSO)	10.4 m (34 ft)	Millimeter / Submillimeter	Caltech / NSF	1986
James Clerk Maxwell Telescope (JCMT)	15 m (49 ft)	Millimeter / Submillimeter	United Kingdom / Canada / Netherlands	1986
Submillimeter Array (SMA)	Eight 6 m (20 ft) antennas	Submillimeter	Smithsonian Astrophysical Observatory / Taiwan	2002
Radio Array Telescope (Facility Outside the Astronomy Precinct)				
Very Long Baseline Array (VLBA)	25 m (82 ft)	Centimeter Wavelength	National Radio Astronomy Observatory (NRAO) / National Science Foundation (NSF)	1992

Source: UH IfA, (http://www.ifa.hawaii.edu/mko/telescope_table.htm)

The northern portion of Hale Pōhaku houses facilities that provide sleeping accommodations, offices, lounge areas, and a cafeteria for observatory scientists, and staff. A library and small labs are also available to support the scientific activity that takes place on the mountain. The central portion of Hale Pōhaku is home to the VIS, where visitors to Maunakea can use public telescopes, register for a summit tour, sightsee, and acclimate to the elevation. The headquarters for MKSS, including water tanks and a maintenance area, is located in the upper-most portion of Hale Pōhaku.

Hale Pōhaku has also served as a construction staging area for all observatory-related projects within the MKSR. Stone cabins in the "old" construction camp were used for the first observatories on Maunakea in the late 1960s until the 1980s. It is these original stone cabins, just below the modern main buildings, which gave rise to the location's name, Hale Pōhaku, which is Hawaiian for "stone house." The "new" construction camp is located below the VIS building and includes buildings used during the construction of the Subaru and Keck Observatories (Figure 2-8). The camps are used for limited storage at the new camp by VIS and ranger personnel; the new construction camp area is also used as a parking area.

Additional Educational Purposes

IfA's access to the observatories on Maunakea is a unique resource for education and state-of-the-art astronomical research. UH at Mānoa offers both master's and doctorate degrees in astronomy, while UH Hilo offers a bachelor's degree in astronomy. Graduates majoring in astronomy at UH Hilo have gone on to work at the existing observatories and have been accepted to the UH at Mānoa graduate program. University Park is also home to the ʻImiloa Astronomy Center of Hawaiʻi. The ʻImiloa Astronomy Center features interactive exhibits, a planetarium, and offers field trips as well as student and family tours which explore both Maunakea's world-famous observatories as well as the rich traditions of Hawaiian culture. Additionally, every year thousands of high school and elementary students receive an introduction to astronomy unlike any other as part of the educational outreach programs provided through the observatories on Maunakea.

The isolated location, high elevation, unique set of natural resources, and dry atmosphere attract scientists of numerous disciplines other than astronomy to Maunakea from around the world. Geologists come to study the volcanic and glacial history of the mountain; meteorologists come to study the unique weather patterns and stable atmosphere, particularly in the summit region; biologists come to study the native ecosystems and rare species of plants and animals located on the mountain. University professors also bring their students to the mountain for scientific studies, as well as to study Native Hawaiian culture and language.

Recreational Activities

Numerous recreational activities take place on Maunakea, and other than for commercial activities, public access to the summit is currently unrestricted. The VIS serves to inform visitors, providing information on safety and hazards, astronomy, the observatories, and the natural and cultural resources of Maunakea. Figure 3-29 illustrated the parking and restroom facilities available to the public to facilitate recreation activities in the summit region.

Sightseeing & Stargazing. Numerous visitors come to Maunakea each year to sightsee, view the stars, and tour the world-class observatories. The VIS offers guided tours of the summit that include a stop in at least one observatory and a stargazing program at Hale Pōhaku where visitors are able to view the stars through a telescope while guided by a staff member. Visitors also have the opportunity to use their private vehicles to explore the summit. Summit access by private vehicles may be restricted due to high volume of traffic, safety, or other concerns. "Off-roading" recreational activities are not allowed in the MKSR or the NAR. Trails at lower elevations provide additional access points to the mountain. In mid 2007, DOFAW opened up two existing trails to off-highway recreational use. Both trails are used by hikers, mountain bikers, ATVs, hunters, motorcycles, horses, and 4-wheel-drive vehicles.

Hiking. The unique topography, location, and views draw many hikers to Maunakea. Hikers typically drive up the mountain for a distance before parking and hiking. Hikers are encouraged to register at the VIS and check back in once they have completed their hike. The Maunakea – Humuʻula Trail is accessible from the VIS. There are no camping facilities within the MKSR or Hale Pōhaku. There are a few established, but unmarked, trails in the summit region and other trails at lower elevations. According to OMKM, there were a total of 5,718 hikers on Maunakea in 2007.

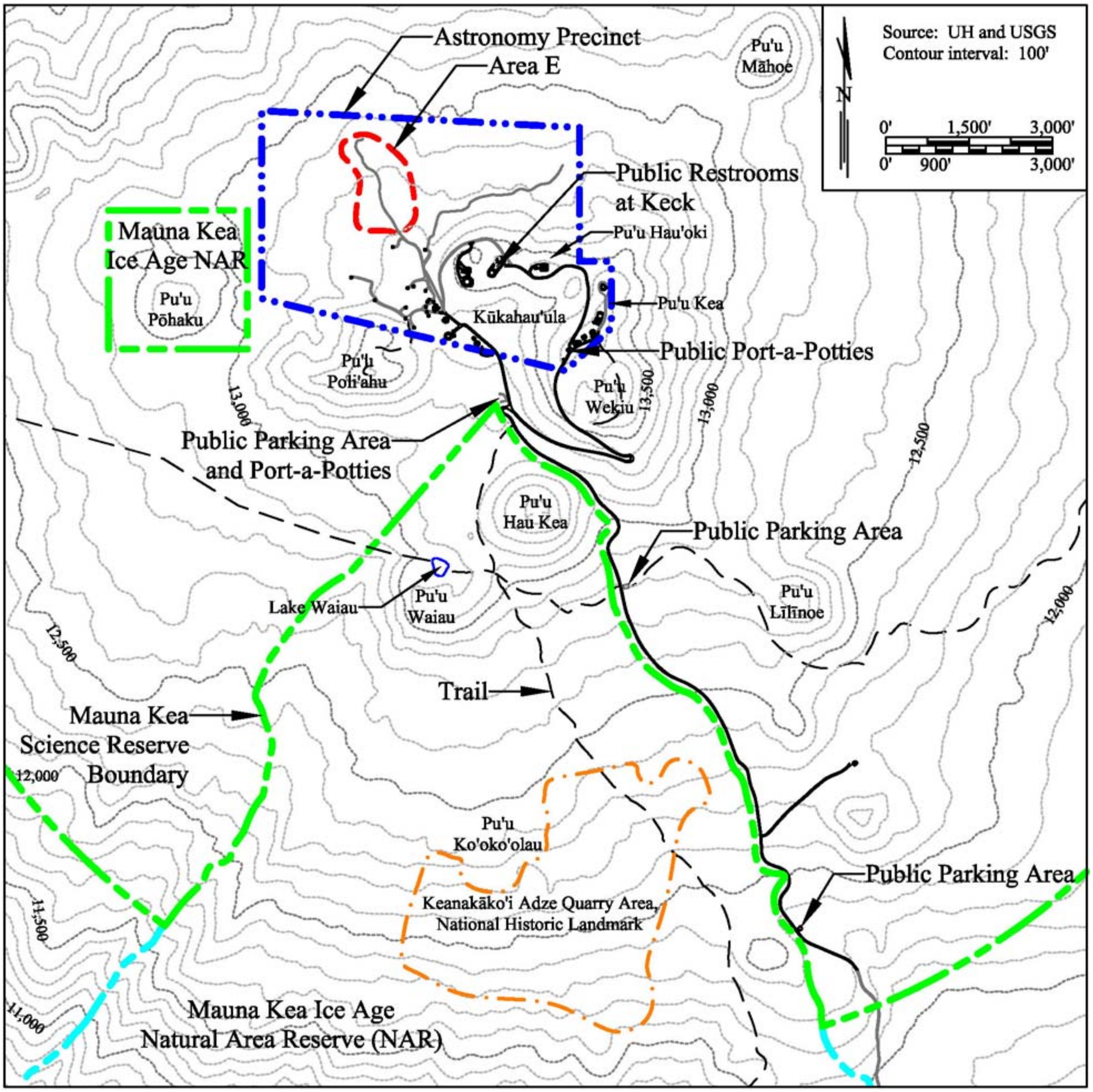

Figure 3-29: Parking and Restroom Facilities in the MKSR

Skiing and Snow Play. Weather patterns dictate where snow related activities can take place, but when snow does fall it typically covers the northern slope of Kūkahauʻula (Pu'u Hauʻoki and the unnamed puʻu) first and remains there the longest. However, snow play activities are generally concentrated in the "Poi Bowl" area immediately east of the CSO, which is a southern facing slop of Kūkahauʻula. The Maunakea Access Road is kept clear of snow by MKSS, and provides access to skiing and other winter activities on the summit. The ski run known as Poi Bowl is the most popular ski area because it is accessible by roads at both the top and the bottom of the run. If snowfall is heavy enough, the area to the east of the summit, known as King Kamehameha run, can be used for longer ski runs. However, as the bottom of the run is not accessible by vehicles, skiers must hike back to a roadway. At times it is possible to ski from the summit to the edge of the MKSR. Based on the CMP, rangers are now to restrict snow-play activities to areas with a layer of snow deep enough to provide protection to resources – determined to be a minimum of eight inches deep.

Hunting. Hunting may often be viewed as a recreational activity, but can also be viewed as part of the culture and subsistence of area residents. There are approximately 3,000 licensed hunters living on the island. Pigs, sheep, goats, and a variety of game birds, including turkeys, pheasants, quails, chukars, and francolins are hunted in the 36 hunting units concentrated in the central portion of the island. The Mauna Kea Forest Reserve, from an elevation above 7,000 feet, is a hunting unit where game may be hunted with bow and arrows and firearms.

<u>Commercial Uses</u>

Commercial Tours. Commercial tours bring visitors to the mountain to view the summit area. Most tour operators entertain visitors on six to eight-hour trips that can include an observatory tour and dinner, along with narratives on the area's vegetation and natural history. OMKM issues a limited number of Commercial Activity Permits to tour operators and these tour operators must register at Hale Pōhaku each time they ascend the mountain. On average, there are 302 commercial operator trips to the summit per month. The evening, or sunset, tours are limited to 18 vans and an average of 150 participants per evening. Commercial tours are not allowed to lead hikes to Lake Waiau within the Ice Age NAR and OMKM has requested that commercial tours not lead hikes to the summit of Pu'u Wēkiu,

Filming. Because of Maunakea's unique natural landscape, commercial film activities are popular on the mountain. Film activities, including still photography, video, digital cameras, and high definition digital recordings that will be performed for the purpose of sale, video production, or television transmission must first acquire a permit from OMKM and the State of Hawai'i Film Office.

Headquarters

University Park is home to a number of observatory headquarters, including UKIRT, JCMT, CSO, Subaru, Gemini, and IfA, as well as the 'Imiloa Astronomy Center, the U. S. Department of Agriculture's Institute for Pacific Island Forestry, and the Komohana Agricultural Complex. The College of Pharmacy and the College of Hawaiian Language are currently either being built or planned.

The County of Hawai'i General Plan notes that the UH Hilo Long Range Development Plan, which was last updated in 1996, emphasizes the "spine" concept that organizes all campus structures along a main pedestrian access way, which Nowelo Street provides. The Land Use Pattern Allocation Guide (LUPAG) within the General Plan indicates University Park is classified as University Use.

County of Hawai'i zones a portion of University Park as Agricultural District with a minimum building site of 1 acre (A-1a) and a portion as Single-family Residential District with a minimum building site area of 10,000 square feet (RS-10). A new University District zoning category was approved by the County Council per Hawai'i County Ordinance No 07-104, effective August 1, 2007. UH Hilo may include the University Park area in an application for a change of zone to this more appropriate district at some time in the future. University Park is not within the County's special management area.

Satellite Office

Waimea is a small town, but home to the headquarters for the Keck and CFHT observatories. There is a commercial center, roughly between the two observatory headquarters, and residential uses in the surrounding area.

The LUPAG within the General Plan indicates the central area of Waimea is classified as both Low Density Urban and Medium Density Urban. County of Hawai'i zoning in the central part of Waimea, including the Keck and CFHT headquarters, is Village Commercial District with a minimum land area of 7,500 square feet for each building site (CV-7.5).

3.10.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, impact is considered to be significant if the Project would conflict with the adopted applicable land use plans and policies and /or state land use policies or goals and guidelines as expressed in Chapter 344 HRS.

3.10.3 Potential Environmental Impacts

The potential impacts of the Project are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the project type and location.

Consistency with Land Use Plans, Policies, and Controls

The following sections examine the Project's compliance with applicable land use plans and policies.

<u>Chapter 343, Hawai'i Revised Statutes</u>

HRS Chapter 343, the State of Hawai'i EIS Law, requires that any proposed use within a conservation district be subject to review. As part of this review, this EIS has been prepared to ensure that environmental concerns are given appropriate consideration in decision making, along with economic and technical considerations.

<u>Chapter 344, State Environmental Policy</u>

Like all other uses on Maunakea, the Project would abide by the guidelines promulgated by HRS §344-4(1)–(10), including, but not limited to, encouraging management practices which conserve natural resources, protection of endangered species of indigenous plants and animals, adoption of guidelines to alleviate environmental degradation caused by motor vehicles, and encouraging the efficient use of energy resources.

<u>Chapter 205, State Land Use Law</u>

The Project would be an allowable use within the resource subzone (HAR §13-5-24) of a conservation district (HRS §205-2), and be consistent with the objectives of the resource subzone.

Hawaiʻi State Plan

The Project would contribute to the diversification of the State's economic base by generating economic benefits associated with a stable, high technology industry, protecting significant natural, cultural, and historic sites on Maunakea; and providing for educational access to the its facilities, thereby supporting research programs and activities that enhance the education programs of the State. The combination of generating new revenues to the state and local economies, providing new and stable employment opportunities, and enhancing educational opportunities would enhance the quality of life as well as the community and social well-being on the island. Therefore, the Project would be consistent with the Hawaiʻi State Plan objectives.

2000 Mauna Kea Science Reserve Master Plan

The Master Plan goals are to protect natural resources, protect historic and Hawaiian cultural resources and practices, protect and enhance education and research, and protect and enhance recreational opportunities. The Project is an astronomical observatory facility which is a land use consistent with the guidelines for future development in the Astronomy Precinct. The proposed Project is a 30-meter aperture telescope that meets the definition of the NGLT envisioned in the 2000 Master Plan. The primary land use policy applicable to the TMT Observatory is that it should be located in Area E. The Project's proposed location is in Area E, consistent with this land use policy.

The 2000 Master Plan also set forth many design guidelines for observatories and support buildings. The following sections discuss the Project's design characteristics and their consistency with the guidelines. The Project's compliance with the design guidelines and land use policies laid out in the 2000 Master Plan would be monitored and evaluated through the OMKM design review and approval process (Section 3.19, Required Approvals and Permits).

TMT Observatory and Access Way

The preliminary design concept for the NGLT in the 2000 Master Plan was to employ a sliding dome mirror enclosure and a sub-grade foundation, with the lower half of the observatory below grade to minimize the apparent height and mass of the facility. However, it has been determined that placing the telescope mirror below grade would significantly limit the area of the sky that could be viewed. In addition, the subsurface location would suffer because the air near the ground is more turbulent and dusty; and this would degrade the quality of images obtained by the telescope. Furthermore, the volume of rock that would need to be excavated, on the order of 70,000 cubic yards, runs counter to new OMKM policies to reduce the movement of rock. It would also make it more difficult to decommission the observatory per new OMKM policies due to the amount of material excavated. Therefore, the proposed TMT Observatory design places the primary mirror roughly 66 feet above the ground surface in order to minimize these adverse effects. As discussed in Section 2.5.1, TMT Observatory Design, and detailed in Section 3.5, Visual and Aesthetic Resources the TMT Observatory has been designed as to minimize the above-grade height and total width to the extent possible.

Also it was suggested in the 2000 Master Plan that the half of the NGLT observatory above grade be shaped and colored to simulate a puʻu to blend with the landscape. Because the TMT Observatory's primary mirror would be located above ground, the shape of the above-ground enclosure could not be made to be shaped like a puʻu unless it covered a much larger area. Such a structure would not be feasible because it would disturb the cultural and natural resources to a significantly larger extent than the proposed design. As proposed, the rotating dome of the Observatory would be an aluminum-like color. This color is proposed because it appears to blend with the natural environment year-round better than white or mottled brown (see Section 3.5, Visual and Aesthetic Resources), and it reduces energy use relative to using a mottled brown color.

Consistent with the design goals, the Project design keeps the support facilities in the summit area to a minimum and includes terracing, whereby the components of the facility are located on three ascending levels, to match the natural contours of the site. The site would be graded so that much of the base and office structure be built blending into the existing slopes to minimize the disturbance to existing landform and visual impact from both the summit and off-mountain areas. This design maximizes the use of the natural landform. Also, the observatory dome structure would be shaped using curved forms, rather than angular geometries to further minimize impact. The building attached to the dome would use materials, colors, and patterns to blend into the mottled red and brown tones of the surrounding landscape. All concrete utility boxes and other miscellaneous structures would be lava-colored.

The parking area would be built into the existing southern slopes, and designed to retain any natural landforms present to the extent possible.

The Access Way would be located along an existing roadway and designed to minimize slope cutting. The utility corridor would be located within the Access Way to minimize disturbance, and all utility lines would be buried to minimize interference with the natural landscape.

Hale Pōhaku

Facilities at Hale Pōhaku would be a maximum of two stories, and designed to appear like one story structures through the use of techniques such as building into attic spaces, as the existing buildings have done. The design, architecture, color, and materials used at Hale Pōhaku would be compatible with those used in existing facilities and serve to merge the new facility into the natural landscape. Wood and other native plant materials may be used as appropriate to relate the facility to the natural and cultural setting. Also, particularly steep areas would be avoided to minimize the potential for erosion or the interruption of drainage patterns in the area. Parking areas would be designed to fit into the existing landscape and sensitive to the existing topography of the area. Also, vegetation or natural landforms would be incorporated into the site design and retained to the extent feasible.

<u>Mauna Kea Comprehensive Management Plan (CMP)</u>

On April 9, 2009, the BLNR approved the CMP, subject to conditions. One condition is that within one year of the BLNR approval of the CMP, or the submission of a Conservation District Use Application (CDUA), whichever occurs sooner, UH shall submit for review and approval the following sub plans:

1. A Cultural Resources Management Plan. OMKM is in the process of developing a CRMP that identifies the resources, threats to the resources, and management actions to protect and preserve the cultural resources. Management actions contained in the CRMP will be consistent with the CMP, in particular, Management Actions CR-1 to CR-14.

2. A Natural Resources Management Plan (NRMP). OMKM is also in the process of developing a NRMP that, like the CRMP, identifies the resources, threats to the resources, and management actions to protect and the preserve the natural resources. Management actions contained in the NRMP will also be consistent with the CMP, in particular Management Actions NR-1- to NR-18).
3. A decommissioning plan, including a financial plan. OMKM will be developing a plan that addresses the process for the decommissioning of observatories when they reach the end of their useful life. It is envisioned that this plan will address site restoration and a requirement that all existing observatories commit to complying with the conditions of their existing subleases and to a financial plan for meeting the costs of decommissioning and site restoration. The decommissioning plan will be consistent with the CMP, in particular, Management Actions SR-1 to SR-3 and FLU-3.
4. A public access plan. OMKM has initiated the development of a public access plan. The goal of the plan is to protect the resources, protect the health and safety of people visiting Maunakea and accommodate access for those wishing to engage in their traditional and customary practices. The plan will be consistent with access provisions of existing rules and regulations and with the constitutionally protected right to access to engage in traditional and customary practices. The CMP contains provisions for access, in particular, Management Actions ACT 1 to ACT-12. The CMP also includes access provisions of the BLNR approved 1995 Management Plan which has been incorporated into the CMP.

Prior to the submission of the Project's CDUA, UH will have submitted those four plans to BLNR. The CMP and sub plans will identify the management actions necessary to address the various management needs of the full range of uses on Maunakea. The Project would ensure that all requirements of the CMP and sub plans are met by including those requirements in the facility siting, design standards, features, and operational procedures, and by developing and implementing the mitigation measures outlined in this EIS.

In addition, the Project would comply with the BLNR's requirement that no CDUA be submitted prior to UH completing the four sub plans.

The TMT acknowledges and would adopt, where relevant, provisions in the CMP and the four sub plans.

County of Hawaiʻi General Plan

Consistent with the General Plan, the Project would contribute to the field of astronomy, which has become one of Hawaiʻi's best known industries. Consistent with the General Plan, the Project would contribute to the Plan's support of the continued expansion of the University system and the UH Hilo campus and encouraging educational programs throughout the community. Also included is policy to encourage the implementation of existing State and University of Hawaiʻi plans for the continued development of the University Park "Research and Technology Park" on the UH Hilo campus. The Project would avoid impacts to historic and natural resources.

Consistency Summary

Overall, since the Project would be consistent with all applicable land use regulation and would not conflict with the applicable land use plans, it would not result in a significant land use planning impact in the State of Hawaiʻi or on the Island of Hawaiʻi. The Project would develop and implement a range of plans and programs, outlined in this EIS, including a Cultural and Natural Resources Training Program (Sections 3.2.3, 3.3.3, and 3.4.3), Invasive Species Prevention and Control Program (Section 3.4.3), WMP (Section 3.8.2) and component annual energy audit, a Materials Storage/Waste Management Plan and component SPRP (Section 3.8.2), and Ride-Sharing Program (Section 3.11.4) to ensure ongoing compliance.

TMT Observatory Lease

The building and operation of the TMT Observatory on Maunakea would require a sublease from UH, which leases this ceded land from the DLNR. If TMT chooses Hawaiʻi as the site, they would be required to negotiate a sublease agreement with UH. The sublease would be subject to approval first by the UH BOR followed by approval by the BLNR. The sublease would be negotiated and would be consistent with the existing Master Lease between UH and the BLNR, adopted under HRS Chapter 171. The sublease consideration would include a community benefits packages and a higher education package for the Island of Hawaiʻi, as well as observing time for UH. The sublease consideration would likely include benefits for the Island of Hawaiʻi, as well as observing time for UH. The current UH lease expires in 2033 and the TMT Observatory would be required to be decommissioned and restore the site at that time, unless a new lease or a lease extension is obtained from the BLNR.

It is very probable that TMT, along with the existing observatories, would request UH seek a lease extension beyond 2033. Any lease extension would be subject to BLNR approval at a publicly noticed meeting under HRS Chapter 171. It is also very probable that any lease extension would generate considerable public discussion on the issue of compensation for the use of State ceded lands, including appropriate distribution to the Office of Hawaiian Affairs (OHA). However, any discussion of lease extension would be at the discretion of UH and BLNR.

Compatibility with Existing Uses

The Project staff would be trained to not interfere with cultural and religious practices, and the Project would not impede any traditional cultural or religious practices. The Project would benefit the educational uses of the mountain by providing the most advanced tool for astronomical research in the world and providing opportunities for the public to visit and learn about the high-technology science taking place and the discoveries made.

Recreational and commercial uses would not be significantly impacted by the Project. No hiking trails would be affected and the TMT Observatory and Access Way are outside of snow play areas. The Project is anticipated to result in a beneficial effect on tourism, stargazing, and sightseeing since many people may want to see the world's most advanced observatory and the most powerful ground based telescope on earth.

Because the Access Way would be near or through the core of the SMA facility, dust from Project vehicles could collect on the SMA antennas and potentially impact the operations of the

SMA. The Project is sufficiently removed from other observatories so that they would not be impacted by the Project.

Overall, the Project would not result in a significant impact on current land use in the MKSR or Hale Pōhaku, both of which are located within the conservation district, resource subzone. Similarly, the development of the Headquarters in Hilo and Satellite Office in Waimea would not cause a significant impact to existing land uses. Overall, the Project would be in compliance with HRS Chapter 344 and other applicable land use plans, policies, or controls. Therefore the Project would not result in a significant adverse land use impact.

The Project's use of Hale Pōhaku would be consistent with existing uses. However, a small portion of the Keck construction-phase facilities at Hale Pōhaku that would be replaced are currently used for storage by VIS personnel and the Subaru cabins that would be remodeled by the Project are currently used by rangers, VIS staff, and volunteers. Upon completion of Project construction, the management of the TMT Mid-Level Facility would fall to MKSS. It is likely that the TMT Mid-Level Facility could ultimately serve to improve the space available for the current uses.

3.10.4 Mitigation Measures

The Project would comply with existing regulations and requirements, which would reduce potential impacts as discussed above. This would include developing and implementing the various plans outlined in this EIS, such as a Cultural and Natural Resources Training Program (Sections 3.2.3, 3.3.3, and 3.4.3), Invasive Species Prevention Plan (Section 3.4.3), WMP (Section 3.8.2) and component annual energy audit, a Materials Storage/Waste Management Plan and component SPRP (Section 3.8.2), and Ride-Sharing Program (Section 3.11.4).

The building and operation of the TMT Observatory on Maunakea would require a sublease from UH, which leases this ceded land from the DLNR. The sublease, to include higher education and community benefit packages for the Island of Hawai‘i, as well as observing time for UH, would be negotiated. The higher education and community benefit packages would become a part of a lease or sublease, if TMT decides to come to Hawai‘i. Provided an agreement is reached, details of the benefit packages will be described in the Final EIS.

In addition, an approximately 300 foot portion of the Access Way would be paved to mitigate the potential impact to the SMA observatory due to dust from vehicles traveling on the Access Way through or near the core of the SMA. The paved section would extend from the current end of pavement near the SMA building to a location north of the SMA core. The Project would also coordinate the replacement and remodeling of the Keck construction dorms and Subaru construction cabin facilities with those currently using them. Arrangements would be made, in coordination with OMKM and MKSS, to address the potential future reuse of these facilities for the needed space and uses.

3.10.5 Level of Impact after Mitigation

The implementation of the mitigation measures identified would serve to further reduce any potential impacts the Project may have on land use.

3.10.6 References

County of Hawai‘i Planning Department. 2005. County of Hawai‘i General Plan. Website: http://www.hawaii-county.com/la/gp/2005/main.html. Accessed January 18, 2009.

DAGS. 1997. Final Environmental Impact Statement, University of Hawai‘i at Hilo, University Park.

DLNR, 1997. Management Policies of the Natural Area Reserves System. Natural Area Reserves System Commission, Division of Forestry and Wildlife, Department of Land and Natural Resources, State of Hawai‘i. Website: http://plonedev.hawaii.gov/dlnr/dofaw/nars/NARS%20Management%20Policies%20no%20appendices.pdf. Accessed February 9, 2009.

National Aeronautics and Space Administration. 2005. Final Environmental Impact Statement for the Outrigger Telescopes Project¸ National Aeronautics and Space Administration, Universe Division, Science Mission Directorate, Washington, D.C.

UH Hilo, Department of Geography. 1998. Atlas of Hawai‘i. 3rd ed. Honolulu: University of Hawai‘i Press.

UH. 1999. Final Environmental Impact Statement, Mauna Kea Science Reserve Master Plan.

3.11 Roadways and Traffic

This section discusses the roadways and traffic in the region and specific Project areas, the potential impacts of the Project on this infrastructure, and the mitigation measures the Project would employ to mitigate those potential impacts.

3.11.1 Environmental Setting

Hawai'i Island has a number of State and County highways that connect the towns. The towns and highways are concentrated in the coastal area. The primary highways are the Hawai'i Belt Road, Route 19, and Māmalahoa Highway, Route 190. Saddle Road, Route 200, connects Hilo to Māmalahoa Highway near Waimea and gets its name because it crosses the island through the saddle between Maunakea and Maunaloa. Saddle Road reaches an elevation of 6,632 at its highest. Near that location Maunakea Access Road branches off toward Maunakea. Saddle Road is undergoing an extensive improvement and realignment.

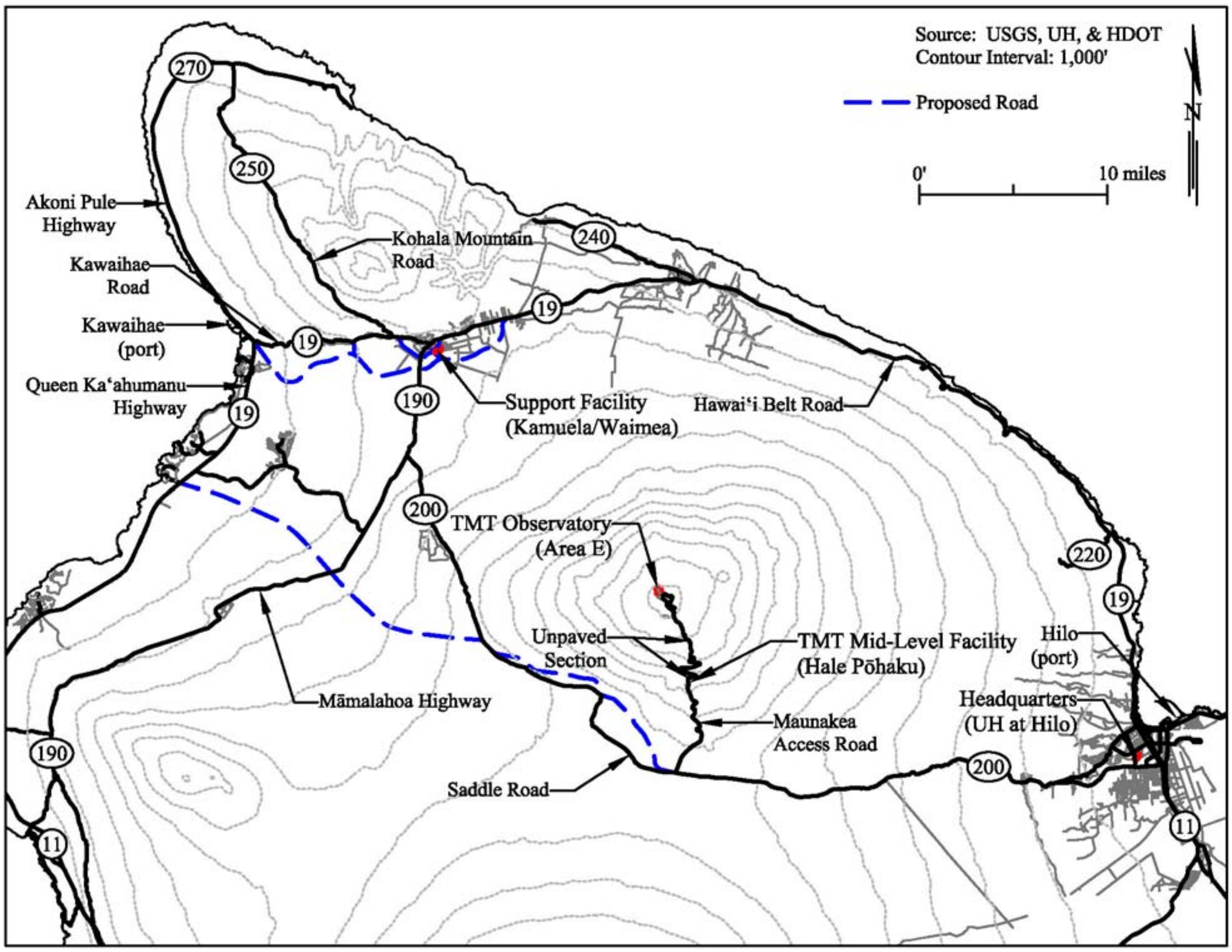

Figure 3-30: Roadways in Vicinity of Maunakea

Maunakea Summit Region and Hale Pōhaku

Access to Hale Pōhaku and Maunakea is from the Maunakea Access Road off Saddle Road discussed above. From Saddle Road past Hale Pōhaku, Maunakea Access Road extends to near the summit and loops along the Puʻu Kea, Puʻu Hauʻoki, and an unnamed puʻu cinder cones to reach the existing observatories. The Maunakea Access Road is 16.3 miles long, Hale Pōhaku is approximately 6 miles up Maunakea Access Road from Saddle Road, and the 4.6 mile long segment just past Hale Pōhaku is unpaved. The road is paved again above 11,600 feet. A portion of the loop is unpaved between the Keck Observatory and the SMA.

The existing observatories have mostly short paved or unpaved driveways off the main road. The unpaved SMA service roadways are the most extensive roads other than the main Maunakea Access Road. One branch of the SMA road extends toward Area E. Where the SMA road ends, an unimproved 4-wheel drive trail extends into and runs through the middle of Area E to the 13N site, where it ends.

In 1994, the average daily traffic (ADT) on Saddle Road was 900, in 2006 the ADT was 1,150, and the ADT is projected to grow to 14,000 by 2014. Saddle Road is undergoing an extensive improvement and realignment in order to service the forecast increase in ADT. Construction work north of the Maunakea Access Road is ongoing. Southern portions of the project have been complete but modifications to the plan are ongoing for the section north of mile post 42, which is north of the Maunakea Access Road intersection.

In 2008, observatory vehicles accounted for roughly 11,800 trips, visitors for 13,700 trips, and commercial operators for 5,200 trips. A 4-wheel drive vehicle is recommended, but not required, for trips beyond Hale Pōhaku on Maunakea Access Road. That is an average of 32 observatory trips and 52 other trips per day, or roughly seven percent of the 2006 ADT on Saddle Road. Observatory vehicle counts include two potable water deliveries per week and one trip per month to remove mirror washing wastewater. There is a possibility that the number of trips from existing observatories will decline as remote access and control of the telescopes continues to improve. More astronomers are likely to access data and control telescopes remotely, reducing the number of trips to the observatories.

Vehicle and visitor traffic to the summit may be particularly high on snow days, especially when they fall on weekends. Many people, especially local residents, visit the mountain only when there is snow. During the nineteen days documented by OMKM Rangers as snow days in 2007, a total of 2,547 vehicles were recorded on the mountain (134 per day). Presently, during periods of heavy snow, Rangers keep the road closed at Hale Pōhaku until they receive confirmation that conditions are safe for visitors to precede up the mountain. Even though UH could restrict traffic on the Maunakea Access Road, the road is not closed or limited to daylight hours.

There is no data available for the number of vehicles making the trip from Saddle Road to Hale Pōhaku via the Maunakea Access Road, but is likely that it is more than double the number proceeding beyond Hale Pōhaku to the summit, as this accounts for the people that work at Hale Pōhaku and visitors that go the VIS but do not proceed to the summit.

There are three visitor parking areas along the Maunakea Access Road above Hale Pōhaku. Parking Area 1 is located just after the paved road begins; Parking Area 2 is near the trailhead to Lake Waiau; and Parking Area 3 is just past the junction of the access road and the summit loop, and is also known as the Batch Plant Staging Area. These areas are shown on the map included in the safety brochure available to workers and visitors, but are not identified by signage on-site. At the summit, many visitors park near the UH 2.2-meter observatory if they plan to hike the summit trail. During the winter, before roads are fully cleared of snow and when there are large numbers of private vehicles in the summit area, parking becomes congested and visitors park their vehicles along the road wherever there is space. Commercial tour vehicles usually park in the area around the UH 2.2-meter observatory and Gemini observatory during the sunset viewing times. Observatory vehicles park in designated areas near their buildings. Most parking areas are graded but unpaved.

There are three main parking areas at Hale Pōhaku (a) the cafeteria parking lot, (b) the dormitory parking lot, and (c) the VIS parking lot. There are other unpaved areas used for parking, including an area used by tours across the road from the VIS.

Headquarters

Komohana Street is a two-lane county roadway and serves as one of several major cross-town roads. Nowelo Street runs in an east-west direction and provides the main entry to University Park from Komohana Street (Figure 2-9). The intersection of Komohana Street with Nowelo Street includes auxiliary turn lanes. A‘ohōkū Street and ‘Imiloa Place run parallel to Komohana Street and provide access to the lots within University Park. All roads within University Park are paved with asphalt concrete and have concrete gutters, curbs, and sidewalks.

Satellite Office

Māmalahoa Highway is the lone thoroughfare through Waimea, running in a roughly east-west direction (Figure 24). The highway is paved with asphalt concrete, though only portions have curbs and swales. A key reason for the congestion in Waimea is that all traffic passing through the town must travel through one intersection at Lindsey Road and Māmalahoa Highway. As there is no alternative to this route, there is congestion during the morning, mid-afternoon, and afternoon peak periods of the day, mostly experienced as travel delay due in large part to traffic queues, which are lines that form as cars wait to turn or must wait at traffic lights. Another problem intersection has been identified at Kamāmalu Street and Māmalahoa Highway. It has been determined that much of the congestion is caused by traffic originating in or destined for Waimea.

In response to the current congestion and planned growth in Waimea and North Kona/South Kohala in general a number of road improvement projects are in the planning stages currently. These include (Figure 3-31):

- Waimea Bypass. A State highway project that would stretch from Māmalahoa Highway near the airport on the southern side of Waimea to Hawai‘i Belt Road at Mud Lane on the east side of Waimea. The bypass would be a limited access highway around the town of Waimea.

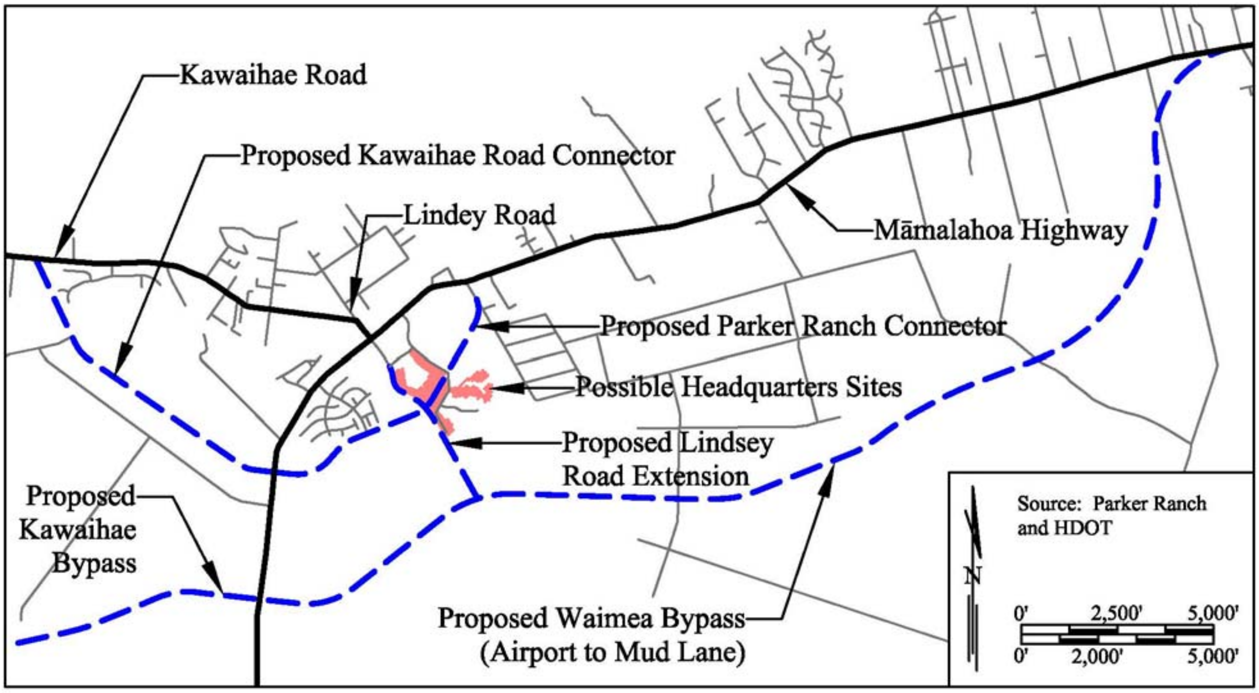

Figure 3-31: Proposed Roadways in Vicinity of Waimea

- Parker Ranch Connector and Lindsey Road Extension. These roads that would provide circulation routes within Waimea between Māmalahoa Highway, Lindsey Road, and the planned Waimea Bypass. They would also serve the planned expansion of Waimea's commercial area.
- Kawaihae Road Connector. This local road would provide connections within Waimea similar to the Parker Ranch Connector and provide ways to avoid the Lindsey Road and Māmalahoa Highway intersection.

Studies have shown that these new roads would significantly reduce congestion and delay in Waimea.

3.11.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact if it involves a substantial degradation of environmental quality. Therefore, the Project impact would be considered to be significant if it would increase traffic resulting in a substantial deterioration of traffic conditions and/or requiring additional road improvements beyond minor modifications at the access point and those already identified and planned for the region.

3.11.3 Environmental Impacts

Approximately 50 TMT staff would work at the TMT Observatory, 44 during the day and 6 at night. If each TMT Observatory staff member drove separately, this would result in 50 round trips a day to the TMT Observatory; however, this is very unlikely due to the wear and tear that would occur to individual's vehicles. TMT staff would more likely share rides to access the

TMT Observatory from the Headquarters and Satellite Office, which would reduce the number of trips to the summit area, even if the Project did not require ride sharing. Roughly 2 additional round trips a day to the TMT Observatory would occur due to (a) the transport of equipment between the TMT Observatory and Headquarters or Satellite Office, and (b) additional demand for potable water and wastewater pick-up, plus deliveries. The TMT Observatory would require a potable water delivery every five days, a domestic wastewater removal once every two days, and require mirror washing wastewater removal roughly once every month. This additional traffic would result in a maximum potential increase of 52 round trips a day, or a 62 percent increase over existing traffic volumes. However, traffic on the Maunakea Access Road would remain light, roughly 136 trips a day, on a roadway that could accommodate many times that number of trips a day and remain congestion free. Therefore, it is expected that the associated impact would be negligible and less than significant.

The addition of TMT's use of the facilities at Hale Pōhaku could result in a slight increase in the number of trips made by MKSS personnel. The Project's potential impact on Saddle Road, the addition of up to 52 trips a day, represents roughly 4 percent of the current Saddle Road ADT and 0.3 percent of the projected ADT. With Saddle Road being improved to handle a projected ADT of 14,000, the Project would have a less than significant impact on traffic along Saddle Road.

Anticipated traffic associated with the approximately 60 employees at the Headquarters and the 30 employees at the Satellite Office would not result in a significant traffic impacts or warrant additional road improvements in the areas, other than those discussed above. Some of the staff would work off-peak hours to operate the telescope at night. The additional traffic generated by the staff would be negligible in relation to the existing traffic volumes, and would not lead to substantial congestion and/or deterioration of existing conditions, or a need for roadway improvements to provide additional capacity to accommodate Project-related traffic.

3.11.4 Mitigation Measures

The Project would institute a Ride-Sharing Program for the TMT Observatory as well as the Headquarters and Satellite Office employees. The program would be mandatory for TMT Observatory employees to travel beyond Hale Pōhaku, and would support ride sharing for Headquarters and Satellite Office employees.

TMT Observatory personnel would meet at various locations around the island and travel to the summit in observatory vehicles. The locations would include the Headquarters, Satellite Office, and/or park-and-ride lots. There would be approximately 10 vehicles for the day shift and 2 for the night shift, with 5 persons per vehicle. With the implementation of the Ride-Sharing Program and other trips, it is estimated there would be an average of 14 trips to the TMT Observatory daily, a 17 percent increase over the existing number of trips beyond Hale Pōhaku.

TMT would also consider off-peak work hours for Headquarters and Satellite Office personnel, if warranted, at the time of completion of the facilities.

3.11.5 Level of Impact after Mitigation

Project impact level prior to mitigation would be less than significant. With the mitigation measures proposed, the less than significant level of impact would be further reduced.

3.11.6 References

County of Hawaiʻi. 2007. Waimea Traffic Circulation Study.

DAGS. 1997. Final Environmental Impact Statement, University of Hawaiʻi at Hilo University Park. University of Hawaiʻi at Hilo. 2008. Final Environmental Assessment, University of Hawaiʻi at Hilo College of Pharmacy.

State of Hawaiʻi Department of Transportation (HDOT). 1999. Final Environmental Impact Statement, Saddle Road (State Route 200), Māmalahoa Highway (State Route 190) to Milepost 6.

HDOT. 2004. Environmental Impact Statement Preparation Notice, Hawaiʻi Belt Road, Mud Lane to the Kamuela Racetrack (Waimea Bypass).

HDOT. 2007. Supplemental Environmental Impact Statement Preparation Notice, Saddle Road, (State Route 200), Māmalahoa Highway (State Route 190) to Milepost 42.

OMKM. 2009. OMKM Ranger Report, Reports: 366. May 8, 2009.

3.12 Power and Communications

This section discusses the power and communications facilities in the region and specific Project areas, the potential impact of the Project on those facilities, and mitigation measures the Project would employ to mitigate those potential impacts.

3.12.1 Environmental Setting

HELCO experienced a peak island-wide demand of approximately 203 megawatts (MW) during December 2006. HELCO has the generating capacity to provide 20 percent above that peak demand. Alternative renewable sources, such as wind, solar, and geothermal account for roughly 30 percent of the generating capacity. Currently the largest consumer of power on Hawaiʻi Island is the Hilton at Waikoloa which reaches a peak demand of 4 to 5 MW.

Maunakea Summit and Hale Pōhaku

Power

A 69 kilovolt (kV) overhead transmission line feeds the Hale Pōhaku substation, located across Maunakea Access Road from Hale Pōhaku, in the saddle between Puʻu Kalepeamoa and Puʻu Kilohana. The substation consists of two 3,000 kilovolt-ampere (kVA) transformers, with a total capacity of 6,000 kVA (or 5,400 kilowatts (kW) assuming a system power factor of 0.9). An underground 12.47 kV dual loop feed system from the substation services the observatory facilities, including the SMA, the closest facility to Area E. The existing peak demand load documented by HELCO at the substation, including all the observatories and the Hale Pōhaku facilities, is 2,230 kW, approximately less than half of the capacity of the substation. Of this current use, the Keck observatory currently uses approximately 350 kW of power on average.

Certain observatories also have emergency diesel generators to serve as backup in the event of a power outage on the HELCO power distribution system.

Communications

The first underground communications system was installed on the mountain at the same time the underground power distribution grid was installed. In the mid-1990s, the installation of underground fiber optic lines provided high speed communications capability to the observatories using a Hawaiian Telcom fiber cable. The fiber optic communications system services the same facilities as the power distribution system, and allows for data flow between the summit and off-mountain base facilities, thereby supporting remote observing.

Headquarters

The University Park is served by the existing HELCO power distribution system serving Hilo, as are all existing campus facilities. HELCO's system has ample capacity and no capacity shortage has occurred to date.

Satellite Office

The residential and commercial areas are connected to the existing HELCO power distribution system serving Waimea. HELCO's system serves all existing development and no capacity shortage has occurred to date.

3.12.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact if it requires substantial energy consumption. Therefore, a significant impact would occur if the Project required provisions for additional capacity beyond that already available or planned.

3.12.3 Potential Environmental Impacts

The potential impacts of the Project are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the Project type and location.

Power

Preliminary design electrical load estimates indicate that the TMT Observatory would operate with a "Peak Demand" (defined as the single highest demand electrical load required during any observatory operating period of time) load of 2.4 MW. However, the average power usage at the TMT Observatory is likely to be similar to the average power usage at the Keck observatory, 350 kW, because the two facilities would be similar in size when you consider both of the Keck domes. To adequately support the peak power requirement, including coincidental and intermittent loads, a new transformer would be installed at the existing HELCO substation. The electrical service from the substation near Hale Pōhaku to the existing electrical utility manholes across the road from the SMA building would also be upgraded to support the TMT Observatory. The upgrade would involve the installation of new electric cable in an existing empty conduit.

In the Access Way a new 12.47 kV distribution feeders/circuits would be installed in new underground conduit to complete electrical service to the TMT Observatory. The TMT Observatory would also have an emergency generator powered by diesel fuel.

Energy consumption at the TMT Mid-Level Facility is expected to be minor and would be supplied through the existing HELCO power distribution system at Hale Pōhaku. The 20,000 to 35,000 square foot Headquarters and 10,000 to 25,000 square foot Satellite Office, with a combined 90 employees, could consume 60 kW hours per month, based on the average electric bill for the Keck Observatory Headquarters. Electric power to the Headquarters and Satellite Office facilities would be supplied by the HELCO power distribution system available in Hilo and Waimea.

The electricity use associated with the TMT Observatory, TMT Mid-Level Facility, Headquarters, and Satellite Office would not have a significant impact on other facilities on the mountain or island-wide. The Project's average electrical power use represents less than one percent of the generating capacity of HELCO, and is less than the electrical power use associated with a number of different commercial facilities, including resort hotels. HELCO reports that they can generate 20 percent more power than the maximum demand; adding this new demand to the island-wide electrical power distribution system would not require additional capacity.

Communications

New fiber optic lines would be installed within the Access Way to serve the TMT Observatory from the existing network that serves the current observatories. The Project's communication demands would be well within the expected capacity which would be provided by the existing communications system. No significant impact would result.

3.12.4 Mitigation Measures

Energy-conserving lighting, appliances, and systems would be used in the TMT Observatory, TMT Mid-Level Facility, Headquarters, and Satellite Office to reduce energy use. Additionally, a component of the WMP outlined in Section 3.8.2 would be an annual audit of energy use by the Project. The audit would include examining methods available to reduce energy use.

3.12.5 Level of Impact after Mitigation

Even without mitigation the Project's energy consumption would have a less than significant impact. The proposed mitigation measures would serve to further reduce the impact of the Project on energy grids and resources.

3.12.6 References

NASA. 2005. Final Environmental Impact Statement for the Outrigger Telescopes Project, Mauna Kea Science Reserve, Island of Hawai'i. National Aeronautics and Space Administration (NASA), Universe Division, Science Mission Directorate, Washington, D.C.

HELCO. August 8, 2008. Personnel communication.

3.13 Noise

This section discusses the noise conditions in the region and in the Project areas, the potential impacts of the Project on those conditions, and the mitigation measures the Project would employ to mitigate those potential impacts.

3.13.1 Environmental Setting

Sound levels are expressed on a logarithmic scale of decibels (abbreviated as dB), in which a change of 10 units on a decibel scale reflects a 10-fold increase in sound energy. A 10-fold increase in sound energy roughly translates to a doubling of perceived loudness. In evaluating human response to noise, acousticians compensate for people's response to varying frequency or pitch components of sound. The human ear is most sensitive to sounds in the middle frequency range used for human speech, and is less sensitive to lower and higher-pitched sounds. The "A" weighting scale is used to account for this sensitivity. Thus, most community noise standards are expressed in decibels on the A-weighted scale, abbreviated dBA. Zero on the decibel scale is set roughly at the threshold of human hearing. As an example, human speech at 10 feet is about 60-70 dBA. Noise-sensitive uses include residences, hospitals, schools, parks, and similar uses. Noise could also be a sensitive issue for cultural practices and nature-watching activities.

Maunakea Summit Region and Hale Pōhaku

The Maunakea summit region and Hale Pōhaku areas are removed from urban areas and their associated noise. While it is generally assumed that the ambient noise levels at the summit and Hale Pōhaku are low. The primary activities that produce sounds above the natural background level include: vehicular travel, observatory operations, and construction operations. Other potential contributors to noise levels are the Army's Pohakuloa Training Area, Bradshaw Army Airfield, and local and tourist-related air travel; nothing has been documented in literature to suggest that military-related noise is an issue at the MKSR or Hale Pōhaku. Existing observatories operating on the summit generate minimal noise and the quiet of these mountain areas is affected primarily by the wind and transient noise from vehicles traveling the mountain roads. Estimates by the rangers indicate an average of about 30 non-commercial visitors a day to the summit, most of them staying less than 30 minutes. The existing observatories average about 36 vehicle trips a day. No one resides at the summit; the scientists and observatory staff use the Hale Pōhaku dormitories. Tourists and other visitors leave the summit before nightfall.

Pursuant to HAR §11-46-3, land such as the MKSR, which is zoned as a conservation district, would be classified as a Class A district. A maximum noise level of 55 dBA during daytime hours (7 a.m. to 10 p.m.) and 45 dBA during nighttime hours (10 p.m. to 7 a.m.) is allowed in a Class A district. Noise levels are not to exceed these maximum permissible levels for more than 10 percent of the time within any twenty-minute period, except by permit or variance.

Headquarters

Vehicular traffic is the major noise generator in urban areas, and noise in Hilo is generally associated with traffic from busy roads, particularly Komohana Street at this area in Hilo. The University Park area is relatively quiet, with traffic on the adjacent streets generating most noise.

The operations of the existing UH Hilo facilities generate limited noise, primarily from internal vehicle trips of staff and employees.

Pursuant to HAR §11-46-3 land such as an office park where the Headquarters would be located would be classified as a Class B district. A maximum noise level of 60 dBA during daytime hours (7 a.m. to 10 p.m.) and 50 dBA during nighttime hours (10 p.m. to 7 a.m.), as measured at the property line is allowed in a Class B district. Noise levels are not to exceed these maximum permissible levels for more than 10 percent of the time within any twenty-minute period, except by permit or variance.

Satellite Office

Vehicular traffic is the major noise generator in urban areas, and noise in Waimea is generally associated with traffic from busy roads, particularly Māmalahoa Highway in Waimea.

Pursuant to HAR §11-46-3 land such as the commercially-zoned lots where the Satellite Office would be located would be classified as a Class B district. A maximum noise level of 60 dBA during daytime hours (7 a.m. to 10 p.m.) and 50 dBA during nighttime hours (10 p.m. to 7 a.m.), as measured at the property line is allowed in a Class B district. Noise levels are not to exceed these maximum permissible levels for more than 10 percent of the time within any twenty-minute period, except by permit or variance.

3.13.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact if it detrimentally affects ambient noise levels, and that could then lead to substantial degradation in environmental quality. Therefore, a significant noise impact would occur if the Project would result in increased ambient noise levels to the extent that noise-sensitive receptors would be exposed to noise exceeding regulatory levels.

3.13.3 Potential Environmental Impacts

The potential impacts of the Project are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the project type and location. This includes state noise standards under HAR Section11-46, requirements of the Occupations Health and Safety Administration (OSHA), and the CMP.

Traffic and the associated incidence of transient noise would occur due to Project personnel commuting to and from the TMT Observatory, TMT Mid-Level Facility, Headquarters, and Satellite Office. Along the main roads of Hilo, Waimea, and the Saddle Road the noise generated by the relatively slight increase in traffic resulting from the Project would be negligible. Through the conservation district from Hale Pōhaku to the TMT Observatory, the increase in traffic related to the Project would generate transient noise during shift changes only.

The noise generated by the TMT Observatory during the day would be restricted to heating, ventilation, and air conditioning (HVAC) equipment. The HVAC equipment would be located inside the observatory facility; and noise associated with the HVAC exhaust would be minimal. The HVAC units are designed to cool the dome in the daytime and exhaust from the lowest level of the TMT Observatory and be directed to the north, away from the visitor area and the summit.

The noise generated by the TMT Observatory would be well below the Class A criteria at a distance of 50 feet from the HVAC exhaust. Therefore, anyone standing beyond the area graded for the TMT Observatory would not be exposed to noise exceeding the Class A standard.

At night, the bulk of the HVAC equipment would not operate. The motors used to rotate and open the dome would be the only source of noise at night. Those motors would be located inside the observatory building and enclosed by the structure's walls. With the walls providing a noise barrier, the motors would not be audible from outside. Therefore, noise at night would not exceed the Class A standard.

At the TMT Mid-Level Facility, the HVAC equipment installed would replace the existing equipment at the Keck cabins with more modern equipment. Thus, these systems have no potential to generate additional noise that would substantially increase the ambient noise levels or exceed the applicable noise standards.

The noise impacts due to the Headquarters and Satellite Office would be similar to those generated by any office buildings of similar sizes. Noise from these facilities would not exceed the applicable noise standard.

Overall, the Project would not detrimentally affect the ambient noise levels or result in a substantial degradation of environmental quality, and therefore it would result in a less than significant impact.

3.13.4 Mitigation Measures

The Project operations would not cause a significant noise impact, and no mitigation measures beyond compliance with applicable regulations, requirements, and standards, are required. However, the Project would institute a Ride-Sharing Program for both TMT Observatory and Headquarters employees. The program, detailed in Section 3.11.4, would be mandatory for TMT Observatory employees to travel beyond Hale Pōhaku and encouraged for Headquarters and Satellite Office employees. There would be approximately 10 vehicle trips for the day shift and two for the night shift, assuming five per vehicle.

3.13.5 Level of Impact after Mitigation

The implementation of the mitigation measures identified would serve to further reduce the noise impact of the Project. It is expected that the operation of the TMT would result in a negligible increase in noise and a minor increase in vehicular traffic noise at Hale Pōhaku and along the Maunakea Access Road.

3.13.6 References

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3.14 Climate, Meteorology, Air Quality, and Lighting

This section discusses the air quality, climatic, and sky illumination conditions in the region and specific Project areas, the potential impact of the Project on those resources, and mitigation measures the Project would employ to mitigate those potential impacts.

3.14.1 Environmental Setting

This section discusses the air quality, climatic, and sky lighting conditions in the region and specific Project areas.

Maunakea Summit Region

Air Quality

Air quality and climate are very important siting considerations for observatories, as unique visibility conditions are required for astronomical observations. Although many studies have been performed to evaluate astronomical seeing conditions, traditional air quality monitoring has not been actively undertaken at the summit of Maunakea. Traditional air quality monitoring consists of monitoring for ozone, carbon monoxide, particulate matter – including respirable particular matter, and particular matter less than 2.5 microns in diameter, nitrogen dioxide, sulfur dioxide, lead, and visibility-reducing particles.

Air quality monitoring has been performed at the Mauna Loa Observatory at an elevation of approximately 11, 140 feet since its construction in 1956. This monitoring station provides data most representative of the conditions at Maunakea. The data gathered at this station indicate that the air quality at the Mauna Loa Observatory is excellent and in attainment status with State and National Ambient Air Quality Standards (NAAQS). Given the similarities between the two locations (Maunakea and Maunaloa), it has been inferred that the overall air quality at Maunakea is excellent as well.

The Maunakea summit area rises well above the atmospheric temperature inversions that occur around 7,000 feet. Particulates and aerosols like vog (volcanic gas), smog, dust, smoke, salt particles, and water vapors generated below the inversion level are "capped" by the temperature inversion, so they do not rise above the inversion level and do not cause any interference at the summit. Locally generated contributors to air pollution above the inversion level include vehicle exhaust, chemical fumes from construction and maintenance activities, and fugitive dust from road grading and construction or other activities conducted on unpaved surfaces. Rapid dispersion of pollutants is aided by strong winds.

Climate

There are two seasons in Hawaiʻi, winter (October–April) and summer (May-September), with the trade winds blowing approximately 80 percent of the time in the summer and 50 percent of the time in the winter. Winter temperatures on Maunakea range from 25 to 40 degrees Fahrenheit, but wind chill can bring the temperature to below zero; summertime temperatures recorded at the summit area range from 40 to 60 degrees.

In the summit region, annual precipitation ranges from approximately 20 inches at the Very Long Baseline Array (VLBA) at an altitude of 12,600 feet to approximately 15.5 inches (including snowfall) at the Subaru Observatory at an altitude of 13,575 feet. Storms, including wintertime cold-fronts, upper-level and surface low-pressure systems, tropical depressions, and hurricanes provide the majority of annual precipitation over a very short period of time. Although no data on average snowfall is available, it is known that from November through March varying amounts of snow and ice regularly fall near the summit.

Wind velocities usually range from 10 to 30 miles per hour in the summit region. During severe winter storms though, winds can exceed 100 miles per hour on exposed summit areas, such as the tops of cinder cones.

Some of the Maunakea summit's other unique characteristics include its minimal cloud cover, with about 325 days per year being cloud free, and the low water vapor level, which means the atmosphere is more transparent for infrared observations. The dry and breezy conditions facilitate high rates of evaporation at the summit and maintain the cool, dry atmosphere.

Sky Lighting

Another characteristic that makes Maunakea one of the best sites in the world for astronomical observations is the very dark sky. This results from the summit's remoteness from urban development, as well as the County of Hawaiʻi's island-wide lighting ordinance requirements. Three main types of high-intensity outdoor lighting are used in cities: low pressure sodium (LPS), high pressure sodium (HPS), and mercury vapor lamps. Of these, LPS is the choice of astronomers because light from LPS bulbs is concentrated in a very narrow part of the spectrum, leaving all other wavelengths uncontaminated. Therefore, light and radiation in other parts of the spectrum from stars, galaxies, and planets can be viewed and be valuable for astronomers. HPS or mercury vapor lamps contaminate much of or the entire spectrum that astronomers study, and areas that are brightly illuminated by these kinds of lights are unusable for astronomical measurements. The absence of air pollution and the absence of large, brightly-lit cities on the Island of Hawaiʻi give astronomers some of the deepest views into the universe that can be achieved at ground based observatories.

Hale Pōhaku

Air Quality

Air quality at the Hale Pōhaku facilities is similar to that at the summit because it is also located above the temperature inversion level.

Climate

Average temperatures at Hale Pōhaku, at 9,200 feet, range between 30 and 70 degrees Fahrenheit throughout the year. Average wind speeds at 8,530 feet at Puʻu Laʻau, near Hale Pōhaku, range between 2.7 to 3.6 miles per hour. Annual precipitation ranges from 12 to 20 inches, with most rain occurring between November and March. Fog is common, while snow is rare.

Headquarters

Currently, no routine ambient air monitoring is conducted by HDOH in the Hilo area. Historical monitoring during the 1970s and 1980s indicated very low pollutant levels in Hilo. Recent increase in volcanic activity has led to higher than average levels of vog, although the western side of the island is affected more than Hilo.

Hilo is located on the eastern, or windward, side of the island and is usually subjected to northeasterly trade winds during the day. These wind speeds predominantly range from 4 to 12 miles per hour. Daytime temperatures range from the upper 70s to low 80s in degrees Fahrenheit, while temperatures at night range from the low 60s to the upper 70s. The annual rainfall in Hilo averages about 141 inches. Although the wet season usually occurs from October through April, rain falls approximately 280 days of the year.

Hilo, and the rest of the island, uses only LPS bulbs for outdoor lighting.

Satellite Office

The mean annual rainfall in the Waimea area is 31 inches per year, and the rainfall distribution is highly variable; the drier, more leeward, portions of Waimea receive 20 inches per year, while the wetter, more windward, portions receive approximately 75 inches per year. The average wind speed is 20 miles per hour from the east-northeast trade wind direction, though the wind speed exceeds 20 miles per hour more than 50 percent of the time. The average monthly temperature in Waimea varies from 61 to 67 degrees Fahrenheit.

Waimea, and the rest of the island, uses only LPS bulbs for outdoor lighting.

3.14.2 Thresholds Used to Determine Level of Impact

In accordance with the Chapter 343 significance criteria, the Project would result in a significant impact if it would result in a detrimental effect on air quality leading to a substantial degradation in environmental quality. Thus, the Project impact would be considered to be significant if it would result in emissions of air pollutants that could substantially impair the existing air quality through generation of substantial pollutant concentrations and/or lead to the area becoming a non-attainment area for State and NAAQS.

3.14.3 Potential Environmental Impact

Air pollutants emissions associated with the Project would include dust (or particulate matter) and exhaust fumes from vehicular travel, plus emissions related to maintenance activities. Dust would be the primary air quality concern along the unpaved portion of the Maunakea Access Road and the Access Way. The Observatory staff of approximately 44 day-time personnel and six night-time personnel would travel to the TMT Observatory daily. Deliveries and pickups, including trips made for equipment, supplies, water, and waste, would generate additional trips to and from the TMT Observatory.

Potential air quality and climate impacts resulting from fugitive dust include decreased surface albedo[51], and associated increased rate of snow melt at higher elevations; disruptions to photosynthesis by vascular plants due to dust fall out; potential impacts on Wēkiu bug habitat; reduced clarity of view for both the human eye and for astronomical technologies; and safety concerns. Potential air quality and climate impacts resulting from vehicle exhaust emissions include reduced health within the lichen and moss communities, and reduced clarity of view for both the human eye and for astronomical technologies.

The potential dust-related impacts to biological resources, such as plants, lichen, moss, and Wēkiu bugs are discussed in Section 3.4.3. The potential for increased snow melt due to dust would only be an issue along the unpaved portion of the Access Way; and this potential for slightly quicker melting of snow along the Access Way due to dust is not considered significant because the longevity of the snow or rate of melting does not change the fate of the melt water (groundwater recharge) and no species rely on the presence of the snow. Also, the potential increased melt rate may be offset by the snow along the Access Way being thicker once the road is plowed clear.

The small number of daily vehicular trips beyond Hale Pōhaku has no potential to generate air pollutant emissions that could substantially impair the existing air quality or affect the health of lichen and moss communities. The vehicles would be in compliance with industry emission standards and regularly maintained. In addition, the potential impacts to air quality from pollutants other than dust are likely to be temporary because the nearly constant winds at the summit would quickly disperse them.

The Headquarters in Hilo is anticipated to have a staff of approximately 60 employees; the Satellite Office in Waimea is anticipated to have a staff of approximately 30 employees. The vehicular traffic associated with employee travel and typical deliveries and pickups at these facilities would represent slight increases over the current traffic conditions in the areas. Those trips would generate minor amounts of exhaust emissions with no potential to impair the existing air quality because those vehicles would be in compliance with applicable emissions standards.

The ongoing standard maintenance of the Project's facilities would not involve any activities that could generate substantial air pollutant emissions. In the rare instances that the emergency generator may be required, minor diesel exhaust emissions would occur. The Project would comply with existing requirements to limit the emissions from the generator, and the generator would meet Federal emissions standards, while the diesel fuel used would meet Federal requirements regarding sulfur content and cetane index. Therefore, occasional use of the emergency generator has no potential to result in air pollutant concentrations at the summit that could impair the existing air quality.

Overall, the impact of the Project on air quality and the climate would be less than significant. The excellent air quality due to the island's climatic conditions, including winds that rapidly disperse pollutants and prevent their concentration, would not be degraded. The Project does not include any features or activities that could substantially change either precipitation, temperature, wind velocities, inversion levels, cloud cover, water vapor or any other climate factors at Maunakea or the Island of Hawai‘i.

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[51] Albedo is the surface reflectivity of the sun's radiation; the lower the albedo of an object the more radiation it absorbs.

The Project would comply with lighting standards for outdoor lighting. This would include minimizing the use of exterior lighting, and using LPS lighting with suitable shielding for all necessary outdoor lighting. At the TMT Observatory, there would be no outdoor lighting because it would interfere with observatory operations. The TMT Observatory's AO system would utilize laser guide stars. The multiple overlapping laser beams could be faintly visible to the naked eye as a single beam on moonless nights for a distance of up to 9 miles from the observatory. The area where the laser may be visible consists primarily of ranchlands and forest reserve which are not populated. The Federal Aviation Administration requires that the lasers be shuttered when aircraft are present in the area of the sky where the laser beams are pointed. Aircraft would be detected automatically using multiple camera systems, supplemented initially by human spotters if necessary. Therefore, the Project would not illuminate the sky or significantly impact nighttime conditions on the island.

3.14.4 Mitigation Measures

TMT would prepare and implement a Ride-Sharing Program, as outlined in Section 3.11.4. The program would require all personnel working at the TMT Observatory to ride-share in observatory vehicles beyond Hale Pōhaku, or a lower elevation location, to the summit area. The observatory vehicles would be selected based on balancing the needs for fuel efficiency, low emissions, and safety for transportation to the summit. Approximately 10 vehicles would be used for day-time trips and two for night-time trips. This required ride sharing would reduce the total number of Project trips beyond Hale Pōhaku to the summit area to approximately 14 trips per day (12 staff trips and 2 other trips, such as deliveries), and would further reduce the potential impact of the Project on air quality.

There is a possibility the Project would employ a soil-binding stabilizer, such as DuraSoil, to control dust on the unpaved section of the Access Way between the SMA and the TMT Observatory. This would reduce dust generated along the short 3,000 foot (0.6 mile) section of unpaved Access Way. This is primarily being considered to mitigate possible impacts to biologic resources due to dust in the summit area, but would also benefit air quality. Soil-binding stabilizers would be used sparingly, and would never be applied to habitat adjacent to the road or parking areas. Prior to the use of a soil-binding stabilizer the Project would coordinate with OMKM and Kahu Kū Mauna and only proceed with their concurrence.

In addition, the Project's Ride-Sharing Program would encourage and support the establishment of ride sharing by its Headquarters and Satellite Office staff. This would further reduce the potential impacts associated with the Project. TMT may also consider flexible hours for staff at these facilities, as necessary, to further reduce the potential impact.

The TMT Observatory would also coordinate the use of its AO laser guide stars with the other observatories on Maunakea using the existing Laser Traffic Control software system to minimize the interference between the various guide star systems in use, as well as their impact on other astronomical observations.

3.14.5 Level of Impact after Mitigation

The Project would not have a significant impact on air quality or climate, even without mitigation. Compliance with existing requirements would ensure that the air quality would remain in compliance with the State and NAAQS and therefore no significant impacts are expected. The outlined mitigation measures would further reduce the Project's minor impact on air quality in the summit area.

3.14.6 References

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3.15 Construction and Decommissioning

This section discusses the potential construction and decommissioning phase impacts related to the natural and built environment and the potential mitigation measures that could be employed. Construction and decommissioning effects would be temporary.

Construction work details would be developed during final design of the Project. The conceptual Project construction schedule is presented in Table 2-1. Project construction could begin as early as 2011and take approximately seven years to complete. No unusual construction techniques or materials are anticipated for the construction of the TMT Mid-Level Facility, Headquarters, or Satellite Office; these Project components would be relatively standard office/warehouse facilities. Construction would begin with the TMT Mid-Level Facility, within Hale Pōhaku, in order to provide a base of operations during construction of the TMT Observatory and Access Way. Access Way preparation and TMT Observatory site grading would then take place followed by TMT Observatory foundation work.

Project construction would require the excavation of rock from the TMT Observatory site and along the Access Way. The need to excavate rock is primarily governed by the need to place a foundation for the TMT (the telescope) and the observatory dome. A Rock Movement Plan would be developed prior to construction in compliance with CMP Management Action C-3. The plan would detail excavation and grading activities. TMT would balance the excavated (cut) material with the need for fill (material brought in to raise the ground level) so that there would be a slight amount of excess cut material.

The total volume of excavated material is estimated to be 96,000 cubic yards. This estimate is based on geotechnical assumptions concerning the subsurface in the area and could change following the completion of geotechnical borings. Roughly 95,000 cubic yards of the cut material would be reused at the TMT Observatory site or Access Way. Approximately 1,000 cubic yards of material would be excess cut and would be stored at a location designated by OMKM for use as determined by OMKM. By using 99 percent of the material on the TMT Observatory site and Access Way, that material would be available for later use to restore the TMT Observatory site during decommissioning.

There would be no soil or cinder transported from off the mountain used as fill on Maunakea.

The areas that would be affected by the excavation and fill are shown in Figure 2-4, and would be along the length of the Access Way, and at the TMT Observatory site. An enlarged view of the proposed final grading plan of the TMT Observatory site is shown in Figure 2-7.

The grading at the TMT Observatory site would be performed in two phases. The first phase would provide for construction access for a crane required for erection of the rotating portion of the dome. Once the rotating dome was installed, the grading would be completed to the contours shown in Figure 2-7.

The TMT pier foundation would consist of a continuous shallow spread footing bearing on the soil at depths varying from 15 to 23 feet below the finished floor grade, with a central shallow concrete pad for a support bearing, used to hold the telescope in place when at rest, at a depth of 16 feet below finished floor grade and connected with six radial concrete spokes to the telescope pier outer wall and footing. A utility tunnel bearing on the soil at a depth of 21.5 feet below the finished floor elevation would connect the telescope pier with the mechanical equipment room on the utility level of the support building.

The dome foundation would be shallow continuous spread footings bearing at a varying depth of 6 to 22 feet below surrounding grade, depending on the depth of original rock when the foundation would be located in fill. Floors would be concrete slabs-on-grade bearing on a six-inch layer of material obtained from excavated (cut) material. Some utility piping and conduit would be located below the concrete floor slabs.

The support building foundation would consist of shallow spread footings bearing at approximately 6 feet below the finished floor grade. Floors would be concrete slabs-on-grade bearing on a six-inch layer of material obtained from excavated (cut) material. Concrete retaining walls would be located on three sides of the building.

A trench for electrical and communications lines would be excavated along one side of the road. The conduits would be encased in concrete per governing code requirements. Excavated material would be used to raise the Access Way road surface where required to improve grades on the road and to provide a smooth driving surface where a rough surface from excavation would otherwise be exposed.

Following foundation work, the dome and telescope would be built. A 300-ton crawler crane, in combination with a 200-ton assisting crawler crane, would be used to erect the dome. Once the dome was complete, the telescope would be assembled inside the dome. When dome and telescope construction was complete, the site would be regraded and a three-level support building built that would be attached to the dome on two levels.

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

Other than the planned development areas, construction staging areas would be utilized and staffed at varying levels during construction (Section 2.6). These include the Batch Plant Staging Area, the Hale Pōhaku Staging Area, and a Port Staging Area. The Batch Plant Staging Area, a roughly 4 acre area, would primarily be used for storing bulk materials and a cement batch plant during the grading and foundation work (a period of roughly 1.5 years). The Batch Plant stating Area could also be used for storing bulk material during later stages of construction. The Hale Pōhaku Staging Area would be used for parking, vehicle washing and inspection prior to proceeding up to the observatory site, assembly of enclosure and telescope components to the extent possible prior to transport to the construction site, and the storage of materials needed for construction work at Hale Pōhaku. The Hale Pōhaku Staging Area would be roughly 1.5 acres and would be used throughout the roughly eight year construction period. The Port Staging Area would be used primarily during the roughly four year observatory erection process when telescope and dome components are being shipped to the island. Items received would be inspected, repackaged, assembled to the extent possible, and prepared for transportation in the Port Staging Area.

During all construction related activities, TMT would comply with the CMP which adopted BLNR management actions that call for an on-site construction monitor who would have authority to order any and all construction activity cease if and when, in the construction monitor's judgment, (a) there has been a violation of the permit that warrants cessation of construction activities, or (b) that continued construction activity would unduly harm cultural resources; provided that the construction monitor's order to cease construction activities be for a period not to exceed seventy two (72) hours for each incident. All orders to cease construction issued by the construction monitor would immediately be reported to OMKM and, if it is a violation of the CDUP, notice would be reported to DLNR.

Similarly, whenever construction, operations or maintenance activities include earth movement or disturbance, a trained archaeologist, selected by OMKM and approved by DLNR, would be on site to monitor any impacts, real or potential, of construction activities on archaeological and historical resources. The archaeological monitor would be funded by TMT. This provision is consistent with the CMP and previous conditions on CDUPs approved by BLNR.

Likewise, prior to the entry into the Maunakea UH Managements Areas, all construction materials, equipment, crates, and containers carrying materials and equipment would be inspected by a trained biologist, selected by OMKM and approved by DLNR, who would certify that all materials, equipment, and containers are free of any and all flora and fauna that may potentially have an impact on the Maunakea summit ecosystem. This provision is consistent with the CMP and previous conditions on CDUP's approved by BLNR.

In compliance with the CMP (CMP Management Actions SR-1 and SR-2) and its Decommissioning sub plan, the Project would develop a demolition plan and site restoration plan as the end of TMT Observatory's useful life nears. Those plans would assess and document the potential impacts associated with decommissioning and the three levels of site restoration, including an environmental cost-benefit analysis and a cultural assessment to select the appropriate level of restoration (minimal, moderate, or full). It is anticipated that decommissioning of the TMT Observatory would require a similar process to that required to build it; however, the exact method that would be used is not known at this time. The areas required, equipment used, and temporary impacts would likely be similar to those used during construction. The time required to remove the structure and restore the site would likely be less than the time required to build the TMT Observatory. The primary difference in impacts between the three levels of restoration would likely be the duration of the impact, with minimal providing the shortest duration of impact and full restoration being the longest period of impact. Because more material would likely be moved with the higher levels of restoration, there may be more construction equipment involved and a higher potential for dust and noise production.

In compliance with CMP Management Action FLU-3 and in order to aid in the eventual restoration of the area, the TMT Observatory site would be documented prior to the start of construction. This would be accomplished with high-resolution surface and aerial photography to document existing natural conditions.

3.15.1 Potential Environmental Impacts

Impacts during construction and decommissioning would be similar. The time period of decommissioning impacts would be less than those associated with construction; both are temporary in nature. Unless specifically called out, the decommissioning impacts are assumed to be similar enough to the construction impacts that they do not warrant separate discussion.

The potential construction and decommissioning phase impacts are evaluated within the framework of compliance with all applicable rules, regulations, and requirements for the project type and location. Applicable rules, regulations, and requirements would include OSHA, the CMP (particularly Section 7.3.2 – Construction Guidelines), and necessary permits. To maintain compliance, the Project would develop and implement the various plans and programs outlined in this EIS. These plans and programs would include policies and procedures to be employed during construction and decommissioning as well as long-term operation. The plans and programs that would contain construction phase policies include:

- Reporting Plan, a plan would be developed and implemented in coordination with OMKM to require contractors to provide information from construction activities to OMKM (CMP Management Action C-4).
- Safety and Accident Prevention Plan
- Cultural and Archaeological Monitoring Plan, which would require an independent construction monitor who would have oversight and authority to insure that all aspects of ground based work comply with protocols and permit requirements (CMP Management Actions C-1, C-5, and C-6).
- Cultural and Natural Resources Training Program (operation phase policy described in Sections 3.2.3, 3.3.3, and 3.4.3), construction workers would be required to receive the same annual training as operation personnel (CMP Management Actions C-7 and C-8)
- Invasive Species Prevention and Control Program (operation phase policy described in Section 3.4.3), construction materials would be inspected prior to being moved to the summit area (CMP Management Action C-9).
- Waste Minimization Plan (operation phase policy described in Section 3.8.2)
- Materials Storage/Waste Management Plan and component Spill Prevention and Response Plan (operation phase policy described in Section 3.8.2)
- Ride-Sharing Program (operation phase policy described in Section 3.11.4)
- Fire Prevention and Response Plan
- Rock Movement Plan (CMP Management Action C-3)

The construction phase policy that would be included in these programs and plans is outlined in this section. In addition, the necessary construction-phase permits would be obtained and complied with. The necessary construction permits include (Section 3.19):

- National Pollutant Discharge Elimination System (NPDES) and component Best Management Practice (BMP) plan (CMP Management Action C-2),
- Noise permit,
- Noise variance, and
- Oversize and Overweight Vehicles Permit (OOVP).

The following sections discuss the various potential construction phase impacts and how they would be limited by the applicable rules, regulations, and requirements and how the Project would incorporate those rules and requirements into the various Project plans and programs.

Cultural/Archaeological/Historic Resources

This section discusses the potential impacts to cultural, archaeological, and historical resources during Project construction. Potential impacts during the construction phase include:

- Construction could alter or destroy a cultural/archaeological/historic property or resources, including the inadvertent discovery of human remains.
- The potential disturbance of land beyond the planned limits of disturbance could impact cultural/archaeological resources that otherwise would not be impacted.
- Fire could originate at a construction or staging area and impact cultural resources. This is primarily a concern at the TMT Mid-Level Facility where the dry forest is susceptible to fire impacts. This potential impact is discussed in the Biological Resources section below because the cultural resources that could be impacted by fire are biological in nature.
- Noise generated during construction could affect cultural practices in the summit area. This potential impact is discussed in the Noise section below.
- Dust generated by grading and preparation activities, and from vehicles traveling along the unpaved areas may affect cultural resources. This is primarily a concern in areas of low rainfall such as the Maunakea summit region and Hale Pōhaku. This potential impact is discussed in the Air Quality, Climate, and Lighting section below.
- Trash and construction materials could litter the area and degrade resources. This potential impact is discussed in the Solid and Hazardous Materials and Waste section below.
- The release of hazardous materials during construction could impact cultural resources. This potential impact is discussed in the Solid and Hazardous Materials and Waste section below.

Per the 2000 Master Plan and CMP, a buffer would be maintained between Project construction activities within the MKSR and Hale Pōhaku and archaeological resources. Two items would limit the potential impact due construction activities disturbing additional area:

1. The NPDES BMP plan would outline steps to prevent disturbance of land beyond that which is necessary. The BMP plan would require flagging of the planned limits of disturbance by surveyors prior to the start of construction.
2. Cultural and Archaeological Monitoring Plan. This construction phase plan would require that any ground disturbing construction activity be monitored by both a cultural observer and an archaeologist.
3. The Cultural and Natural Resources Training Program would require all construction managers, contractors, supervisors, and all construction workers be trained regarding the potential impact to cultural and archaeological resources and the measures to prevent

such impact. This would be the same training outlined for operations personnel in Sections 3.2.3 and 3.3.3.

These steps would ensure that during TMT Observatory, Access Way, and TMT Mid-Level Facility construction, all disturbances would remain at least 200 feet from archaeological resources and impact to cultural resources would be minimized.

The Cultural and Archaeological Monitoring Plan would be implemented, as required by OMKM, even though the Project has been planned so as to avoid impact to cultural and archaeological resources. Although no burials have been encountered during developments thus far in the astronomy precinct, there are no burial markers or surface indicators of burials present in the Project disturbance areas, and the absence of caves in the area and the general desert pavement geology of the Project disturbance areas would not be conducive for burial location selection, cultural observers and the archaeologist would be present to watch for inadvertent discovery of human remains, as well as other cultural/archaeological resources. The cultural observer and archaeologist would have the ability to stop activities in an area if human remains or other cultural/archaeological resources are encountered. The Project would comply with HRS Chapter 6E concerning human remains and the discoveries of human remains would immediately be reported to SHPD and other required authorities.

In Hilo, there are no historic resources on either of the sites being considered for the Headquarters. In Waimea, no resources have been identified and none are anticipated on the sites being considered for the Satellite Office; however, if any are encountered during subsequent surveys, a buffer would be established around them. The buffer would be established in consultation with SHPD.

Overall, through compliance with existing rules and policies, Project construction would not have an adverse impact on cultural, historical, or archaeological resources.

Biological Resources

This section discusses the potential impacts to biological resources during Project construction. Potential impacts during the construction phase include:

- The potential disturbance of habitat beyond the planned limits of disturbance would further impact habitat and species.
- Invasive species could accidentally be carried to construction and staging areas and may become established and displace native species. This is primarily a concern for the māmane subalpine forest surrounding the TMT Mid-Level Facility and the alpine stony desert in the Maunakea summit region.
- Fire could accidentally originate at a construction or staging area and impact habitat and species. This is primarily a concern at the TMT Mid-Level Facility where the surrounding māmane subalpine forest, which is habitat for threatened and endangered species, is susceptible to fire impacts.
- Dust generated by grading and preparation activities, and from vehicles traveling along the unpaved areas may affect habitat and species. This is primarily a concern in areas of low rainfall such as the Maunakea summit region and Hale Pōhaku. This potential impact is discussed in the Air Quality and Lighting section below.

- Trash and construction materials could blow into and impact habitats. This potential impact is discussed in the Solid and Hazardous Materials and Waste section below.
- The accidental release of hazardous materials during construction could impact sensitive species or habitat. This potential impact is discussed in the Solid and Hazardous Materials and Waste section below.
- Vehicles could accidentally impact nēnē on the lower portions of the Maunakea Access Road.

To address all of these potential impacts, the Project, in compliance with the CMP, would have a training biologist selected by OMKM and approved by the DLNR on site to monitor activities during earth movement or disturbance within MKSR or Hale Pōhaku. In addition, per the CMP and Project's Cultural and Natural Resources Training Program, all construction managers, contractors, supervisors, and all construction workers would be trained regarding natural resources. This would be the same training outlined for operations personnel in Section 3.4.3.

The following sections discuss the potential impacts to biological resources associated with additional disturbance, invasive species, and fire.

<u>Additional Disturbance</u>

There is the potential for construction equipment to disturb areas beyond the limits of the disturbance needed or planned for the facility. This is especially a concern in Area E where the landscape is uniform and there are no obvious boundaries. The associated impact would be similar to the impact discussed in the above sections related to the displacement of current conditions with the Project facilities. The level of impact would be relative to the area of additional land disturbed. This potential impact would be addressed in the NPDES BMP plan. The BMP plan would outline steps to prevent disturbance of lands beyond that which is necessary. The BMP plan would require flagging of the planned limits of disturbance by surveyors prior to the start of construction. Therefore, the potential impact is slight and not significant.

<u>Accidental Introduction of Invasive Species</u>

Movement of construction materials, earthmoving equipment, and vehicles to the construction areas may introduce non-indigenous weedy flora or invasive fauna pests to the Maunakea summit region or Hale Pōhaku. These alien species can out-compete and displace native species and thereby reduce their populations. The CMP requires this potential impact be addressed by new developments. Packaging material would be redone at the Port Staging Area prior to continuing up the mountain. To comply, the Project would develop and implement an Invasive Species Prevention and Control Program to address this potential impact. Components of the program during the construction phase would include:

- **Materials Control and Reduction**. All shipments would be repacked at the Port Staging Area so that only essential packing material is used for the final transportation to the construction site. This would reduce the volume of material potentially harboring invasive species, aid inspection, and minimize the waste generated at the construction sites. In addition:

- Contractors would be required to inspect shipping crates, containers, and packing materials before shipment to Hawaiʻi.
- Pallet wood would be free of bark and treated to prevent the transport of alien species.
- Items that could serve as a food source for invasive species, such as food waste and food wrappers, would be collected separately from other debris and removed from the Maunakea summit region construction sites at the end of each day.

- **Washing/Cleaning**. Materials and clothing would be washed or otherwise cleaned prior to proceeding above Saddle Road. This could include:
  - Require that everyone brush down their clothes and shoes to remove invasive plant seeds and invertebrates.
  - Require that waste containers be regularly pressure-washed using steam and/or soap to reduce odors that may attract bugs.
  - Require pressure wash-down of all construction vehicles and heavy equipment.
- **Inspections**. Prior to proceeding beyond the Saddle Road, all construction materials, equipment, crates, and containers carrying materials and equipment would be inspected and certified free of invasive species by a trained biologist, selected by OMKM and approved by the DLNR.
- **Monitoring**. Construction areas above Saddle Road, including the TMT Mid-Level Facility, Batch Plant Staging Area, Access Way, and TMT Observatory sites would be monitored weekly for the presence of invasive species. The monitoring would be carried out by a trained biologist.
- **Control**. Invasive species identified during monitoring would be controlled to prevent spread.
- **Education/Training**. The plan would include an educational component to the Cultural and Natural Resources Training Program (Section 3.4.3). It would require that construction personnel be trained to understand the sensitivity of the alpine environment and to follow the above steps, as applicable to their position.

The implementation of this plan would reduce the potential for accidental introduction of non-indigenous species and reduce the likelihood of adverse impacts associated with invasive species. Many invasive species are already well established at the potential Headquarters and Satellite Office sites and those sites are not unique or critical habitat. The plan would be implemented for these construction sites only the extent necessary to prevent new invasive species from becoming established and would not include inspections by a biologist. Thus the potential impact due to invasive species by construction activities would be small and not significant.

<u>Accidental Fire</u>

The Hale Pōhaku, and the planned TMT Mid-Level Facility, is surrounded by designated critical habitat for the endangered palila (*Loxioides bailleui*). Firefighting in this rugged habitat would be difficult. A fire would destroy large portions of habitat before it could be controlled. Fire is also a threat to the small population of the Hawai‘i catchfly in rocky areas on the steep slopes adjacent to and above the Hale Pōhaku maintenance area.

The principal locality for palila is at Pu‘u La‘au more than 10 miles to the west of the TMT Mid-Level Facility, and palila are rarely seen near Hale Pōhaku. While these threatened and endangered species occur elsewhere, the potential impact of fire caused by Project construction on their populations could be significant. Mitigation measures to address accidental fire are presented in the Section 3.15.2, Mitigation Measures, below.

Fire would not pose a significant threat during the construction of the Headquarters or Satellite Office facilities. While it is a possibility, with the correct construction practices in place, it is minimal and unlikely to occur. Also, regardless of the site chosen, it could be accessed by the local fire department and would not harm threatened or endangered species or habitats.

Accidental Vehicle Impacts with Nēnē

There are reports of nēnē being killed by vehicles on the Maunakea Access Road. Nēnē may utilize the lower portions of this road, especially during breeding season and inattentive drivers may strike these birds. Nēnē are not often seen on the Maunakea Access Road and occur elsewhere on the island in greater abundance, however the taking of endangered species is serious. The impact of traffic on the Maunakea Access Road is likely to be small and not significant to the nēnē population of Hawai‘i.

Nēnē education and driver awareness would be a component of the Cultural and Natural Resources Training Program. A refresher briefing regarding the nēnē would be given to all drivers at the beginning of the nēnē breeding season, on or before November 1 of each year. This would reduce the likelihood of vehicles harming nēnē on the Maunakea Access Road.

Visual and Aesthetic Resources

Temporary visual impacts from Project construction, and future decommissioning, of the TMT Observatory would be associated with the presence of construction equipment and workers, material stockpiles, debris, and staging areas. Temporary visual impacts are not expected to be a concern at the Headquarters and Satellite Office construction sites.

Most of the construction staging and material storage would occur in the Batch Plant Staging Area and the Hale Pōhaku Staging Area, and would not be visible from other areas of the island. Dust and glare emanating from construction activities on the construction site would also have a temporary visual impact. Dust is discussed in detail in the Air Quality and Lighting section below. To minimize this impact, construction activities would be efficiently phased to ensure the shortest durations possible. This temporary impact is expected to be minimal and not significant.

Erosion and Water Quality

Construction activities have the potential to cause erosion and degrade stormwater quality. Sediment loading of stormwater could occur when unstabilized, exposed soil at excavations and stockpiles are exposed to heavy rain. Sediment-laden stormwater could create unacceptable levels of turbidity and high sedimentation rates, and contaminated stormwater could impact surrounding waters.

Other water sources, chemicals, or fuel could flow into natural streams or stormwater collection systems if not properly controlled; these include water used to control dust, water used to wash concrete trucks, chemicals used during construction such as paints and adhesives, and petroleum products such as fuel and oil. The handling of chemicals and petroleum products to address this potential impact is discussed in the Solid and Hazardous Materials and Waste section below.

Portable toilets would be utilized at all construction sites. These facilities would be properly maintained and serviced by a licensed and permitted contractor.

Prior to the start of construction at any location a NPDES permit for construction would be obtained from the HDOH. Separate permits may be obtained for activities at the TMT Observatory, TMT Mid-Level Facility, Headquarters, and Satellite Office, depending on the timing of construction at these locations. Project and site-specific BMP plan would be prepared and submitted with the NPDES permit. BMPs would include methods to mitigate possible pollution, soil erosion, and turbidity cause by stormwater runoff from all sources. Agency reviews conducted as part of the NPDES permit process would ensure that proper control techniques are identified in the permit and implemented during construction. Stormwater BMPs overlap with air quality mitigation measures, discussed below, to a degree and could include the following:

- Minimize land disturbance.
- Stabilize or cover the surface of soil piles.
- Maintain stabilized construction site ingress/egress areas.
- Wash or clean trucks prior to leaving the construction site.
- Install silt fences and stormwater intake filters.
- Prevent off-site stormwater from entering the construction site.

The NPDES permit would also address other sources of water and their proper management, including water used to wash concrete trucks and control dust.

The removal of the Project structures would have the potential to release chemicals, such as paints or adhesives, in the form of flakes or chips that could be loosened while the structure is being dismantled. The handling of these materials is discussed in the below section.

The potential for Project construction activities to impact water resources is slight and not significant due to compliance with applicable rules and regulations; no adverse impacts are expected.

Solid and Hazardous Materials and Waste

If not properly managed, solid and hazardous materials and waste used and stored in construction areas could impact cultural resources, biological resources, aesthetic and visual characteristics, and water quality in the surrounding area.

To minimize the potential for contamination, the Project would prepare and implement a Materials Storage/Waste Management Plan and component SPRP. These plans would be components of the overall BMP plan included with the NPDES permit. Construction phase components of the plans would include:

- **Materials and Waste Storage**. Materials would be stored in a manner so as to minimize their potential impact on the surrounding environment. Measures could include:
  - "Roll off" containers would be equipped with secure tops and lids to ensure no debris escape.
  - Outdoor trash receptacles would be secured to the ground and have attached lids and plastic liners.
  - Hazardous materials, fuel, and wastes would be stored in designated areas in containers suitable based on label guidelines and applicable rules and regulations. Storage areas would be located away from stormwater and other water resources.
  - Construction materials and supplies would be covered with heavy tarps; steel cables attached to anchors that are driven into the ground may also be used to hold materials down. Materials would be secured at the close of each work day, and throughout the day during periods of high wind.
- **Waste Management**. Waste would be managed so as to minimize the potential impact on the surrounding environment. Measures could include:
  - Waste would be collected on a regular basis before containers become completely full.
  - Waste would be picked up and transported by licensed contractors and disposed of appropriate facilities.
- **Inspection**. Inspections would be performed to minimize the potential impact on the surrounding environment. Measures could include:
  - Regular vehicle inspections to ensure they are operating safety and identify any mechanical issues, such as leaks; these inspections should be done prior to vehicles being moved above Saddle Road when they are being inspected for invasive species and regularly thereafter.
  - Hazardous materials and waste storage areas and containers would be inspected daily for signs of leakage.
- **Spill Response**. The SPRP would include measures to minimize the potential impact of a spill or unintentional release on the surrounding environment. Measures could include:
  - Require that appropriate spill response materials be stored at sites where hazardous materials and fuel are stored and used, including transport vehicles.
  - Include copies of MSDS, which include spill response measures, for all materials.
  - Provide a check list to be followed in the event of a spill, including those that should be contacted and how.
- **Education/Training**. The plan would outline required employee training. All employees would be trained to comply with the Materials Storage/Waste Management Plan and component SPRP. Employees in the MKSR and Hale Pōhaku would also receive the training outlined in the Cultural and Natural Resources Training Program.

With the implementation of these measures, the presence and use of hazardous materials on the Project construction sites would have a less than significant impact on the environment.

Socioeconomic Conditions

Depending on the final Project schedule and other economic factors, the Project costs may exceed $1 billion. A substantial portion of the construction cost would be spent on specialized equipment, components, and material that must be fabricated and procured from locations in many countries. However, to the extent practicable, when suitable construction material is available in Hawai‘i it would be procured locally. During construction, the Project would establish an office on the island to support on-site engineering, administration, business, and project management needs. Positions needing to be filled for the Project office would include administrative and financial services, software and information technology engineering, mechanical engineering, and installation and service technicians.

It is expected that the contractors and service providers for the Project would require skilled trade employees such as carpenters, steelworkers, electricians, plumbers, heavy equipment operators, laborers, supervisors, shipping and trucking service workers, caterers, paramedics, security personnel, and vehicle mechanics. Construction crew personnel are expected to receive Union scale wages. The TMT Mid-Level Facility would provide housing and support services at Hale Pōhaku for the TMT Observatory certain construction personnel choosing to take advantage of such a facility. Equipment and sourcing needs would likely include excavating and grading equipment, trucks, cranes, lifts, welding machines, and miscellaneous construction consumables, as well as subcontracts to local steel fabricators, machine shops, trucking companies and other suppliers and vendors.

Project construction would generate a number of jobs directly through employment of trades' people in the construction sector. Construction equipment and personnel would be sourced locally to the maximum extent feasible. Construction would also generate indirect employment, which are jobs created in other sectors of the economy as a result of the construction, such as increases in the food services sector to support the increased construction employment. Direct and indirect employment also induces additional employment due to the overall expansion of the regional economy.

Potential socioeconomic impacts during the construction of the Project are expected to be positive, on both the county- and state-wide levels.

Land Use

Temporary land use impacts may occur during construction, including possible delays in accessing the summit area due to the movement of observatory components, heavy machinery, and construction equipment. This potential impact is discussed in the Roadways and Traffic section below. Dust due to grading operations could also impact SMA operations; this potential impact is discussed in the Air Quality and Lighting section below. All Project construction activities would be conducted in a manner that would allow the surrounding areas to remain accessible for all existing activities. Access to Hale Pōhaku, the summit area, and recreational areas would not be restricted. The Headquarters and Satellite Office facilities would not result in an adverse impact to land use. Overall, no significant adverse impacts to land use are anticipated during Project construction.

Roadways and Traffic

Construction of the TMT Observatory and TMT Mid-Level Facility could impact roadways and traffic along the Saddle Road and Maunakea Access Road. Increases in traffic along those roads due to construction could include:

- Workers commuting to and from the construction sites. It is estimated that an average of 50 to 60 workers would be required at the TMT Observatory construction site. Certain workers could elect to reside at the TMT Mid-Level Facility.
- Equipment and materials moving to and from the construction sites. This would include equipment such as excavators and cranes plus materials such as concrete, partially assembled telescope and dome materials, water for dust control, and waste. There would be brief peaks in the movement of equipment and materials, such as concrete pours, but on average it is estimated there would be two large trucks a day.

It is expected that some of the machines and partially assembled components would exceed weight, height, or size restrictions for the roadways and, therefore, an OOVP would be required by the HDOT. Special accommodations may be required in order to move these loads through town, as standard lane widths may not be sufficient to allow for normal traffic flows and patterns. The largest components of the telescope mirror cell component at approximately 69 feet long by 23 feet wide; the heaviest components are the vent modules at 18 tons each.

Dome and telescope components would be shipped to Hilo or Kawaihae Harbor. From the port, they would be transported to a nearby Port Staging Area. This area would be used for receiving and assembling these materials to the extent possible prior to transport to either another staging area or the construction site. Upon completion of pre-assembly, the components would be trucked to the TMT Observatory site by a route determined through the OOVP permit process.

The impact associated with transporting items to Hale Pōhaku or MKSR would be minimized by complying with OOVP conditions. It is anticipated that the permit would require transporting these items during non-peak traffic hours. Most other construction materials, not requiring a permit, would also be transported during non-peak traffic hours. At this time, it is proposed that the trucks would leave the Port Staging Area in the early morning before peak traffic in Hilo so as to reach the construction site at 7 a.m. Trucking would be coordinated with OMKM to reduce the potential impact to observatory vehicles.

With an increase in vehicle traffic, an increase in the potential for vehicular accidents could occur. The Project's Safety and Accident Prevention Plan would include specific driver training and certification for all staff plus measures to ensure compliance with applicable Commercial Divers License (CDL) requirements and policies to reduce the likelihood of an accident. In addition, the Materials Storage/Waste Management Plan and component SPRP would require vehicles to carry spill response materials in case of accidents. The increased and heavy traffic on the unpaved portions of the Maunakea Access Road could also speed the deterioration of the dirt road surface.

The anticipated traffic impacts due to Project construction would be temporary and intermittent, and are not expected to significantly impact or alter existing conditions.

Power and Communication

Power and communication required during construction electricity would consist of energy necessary to power construction equipment and transport construction crews and equipment to and from the construction sites. Required energy would be provided by engines in construction equipment and trucks, portable generators, and HELCO. A connection to HELCO-supplied power would be achieved early in the construction process to reduce the need for generators. Use of HELCO-supplied power during Project construction would be less than that used during operation and would be obtained exclusively through the new transformer and power lines installed for the Project. No significant impact on the availability of power on the summit or island-wide is expected.

No out-of-the-ordinary communication needs would exist during construction and bandwidth requirements would be less than during Project operation. A connection to the existing Maunakea communications system would be sought as soon as feasible due to the lack of cell phone coverage at the TMT Observatory site. Project construction would not have a significant impact on communication infrastructure.

Noise

Noise during construction would be bothersome and annoying to nearby residents, visitors, tourists, and businesses. Construction noise could also affect cultural practices in the summit area. The nearest facility to the TMT Observatory construction site, where construction noise would have the longest duration, is the Subaru Observatory roughly 2,500 feet away. Project construction would generate noise from the engine-powered equipment being used and traffic. Traffic due to construction would be cyclic in manner and are therefore would not result in a significant impact.

Noise would result from construction activities such as excavation, trenching, grading, pouring of foundations, and erection of structures. These activities would involve the use of standard heavy excavation machinery, including trucks, cranes, bulldozers, earth movers, backhoes, trenchers, and paving equipment, as well as portable petroleum-powered generators and compressors. Figure 3-32 shows the range of noise levels that can be expected from different types of construction equipment. Short periods of blasting may also be necessary to dig foundations for the TMT Observatory.

Construction noise decreases at a rate of 6 to 8 dBA per doubling of the distance from the source once more than 50 feet from the source. For example, as illustrated in Table 3-13, if the noise level is 90 dBA at 50 feet from a jackhammer, it would be reduced to approximately 83 dBA at 100 feet and 76 dBA at 200 feet. Doubling the number of noise sources would increase the noise level by 3 dBA. In the above example, two jackhammers operating together would generate a noise level of 93 dBA at 50 feet. This assumes no other noise in area and no wind.

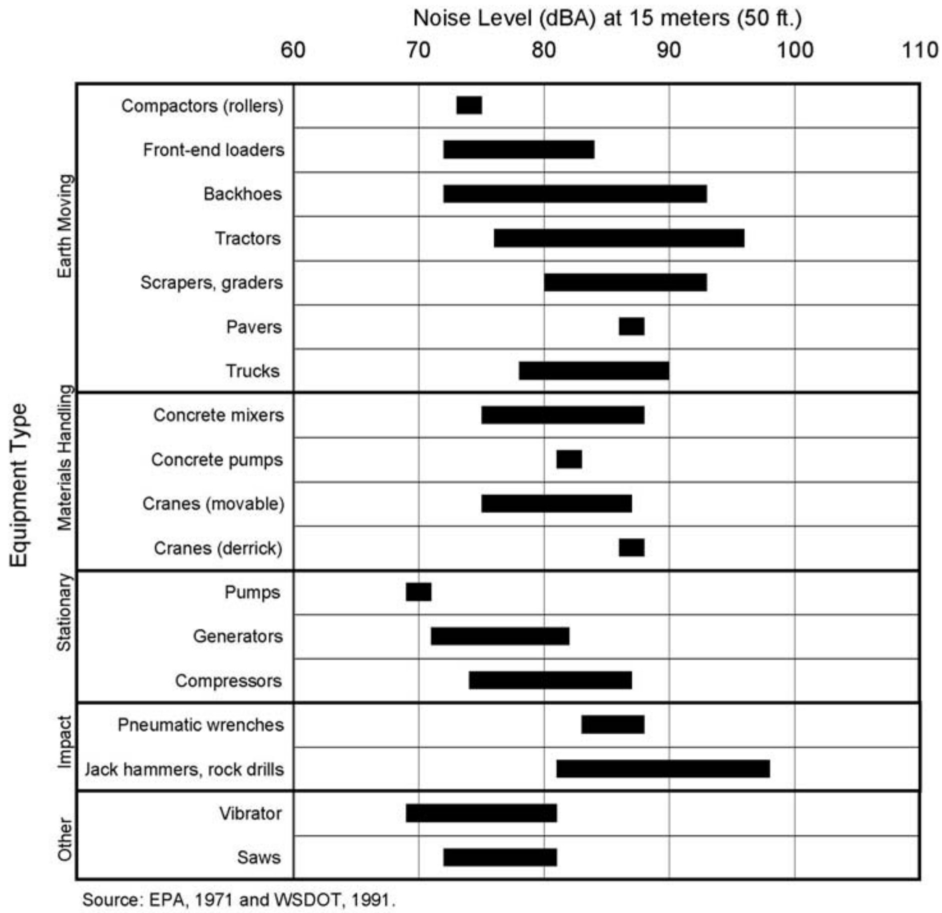

Figure 3-32: Typical Construction Equipment Noise Levels

Table 3-13: Example of Noise Reduction over Distance

Distance from Source (feet)	Noise Level (dBA)
50	90 dBA
100	83 dBA
200	76 dBA
400	69 dBA
800	62 dBA
1600	55 dBA

A noise permit would be obtained, per regulations from the HDOH, under HAR §11-46-7 to temporarily allow noise levels to exceed those typically permitted. A noise variance would also be obtained under HAR §11-46-8 for construction of the TMT Observatory so that work could be performed beyond normal work hours. Noise impacts associated with construction would be mitigated through compliance with conditions set forth in Noise Permits and the Noise Variance obtained by the Project for construction activities. The following measures are examples of what could be incorporated into the permit and variance conditions:

- Conduct noise-emitting activities during normal work ours to the extent possible;

- Reduce or substitute power operations/processes through the use of proportionally sized power equipment necessary only for tasks at hand;
- Maintain all powered mechanical equipment and machinery in good operating condition with proper intake and exhaust mufflers;
- Turn off or shut down equipment and machinery between active operations; and
- Strategically place or erect temporary noise curtains around stationary equipment, such as compressors and generators.

Additionally, construction contractor(s) would be required to strictly comply with all Federal OSHA regulations, applicable noise regulations under HAR §11-46, and State of Hawaiʻi occupational noise exposure safeguards stipulated under HAR §12-200.1.

Construction noise at the TMT Observatory site is likely to be inaudible from a relatively short distance from the source due to the existing background noise associated with the strong wind conditions at the summit.

The distance from any occupied area, the strong wind, and compliance with permit and variance conditions would lessen the temporary potential noise impact from TMT Observatory construction to a level less than significant.

Noise impacts associated with Headquarters and Satellite Office construction would be temporary, minimal, and not significant. All applicable permits would be obtained, and rules and regulations followed. Both locations are within town limits and acknowledged as busy during the regular hours of workdays. Also, construction would not require nearly the amount of equipment necessary for construction of the TMT Observatory.

Air Quality and Lighting

The generation of excessive dust from the construction areas is the primary air quality concern and could impact cultural and botanical resources. This is primarily a concern in areas of low rainfall, such as the Maunakea summit region (TMT Observatory, Access Way, and Batch Plant Staging Area) and Hale Pōhaku (TMT Mid-Level Facility). Dust could land on and accumulate on plants, lichens, and mosses, depriving them of needed sunlight. Dust could also be deposited in Wēkiu bug habitat, degrading the habitat by filling voids in the cinder utilized by the bugs. Plants and habitat adjacent to unpaved roads and construction sites are the most susceptible to impact from dust. Other potential air quality impacts are associated with emissions from engines such as carbon monoxide and sulfur.

Dust could be generated (a) during site preparation and by vehicles traveling around construction sites and along the unpaved portion of the Access Way, (b) by increased traffic and heavy trucks traveling on the unpaved portion of the Maunakea Access Road between the TMT Mid-Level Facility and the TMT Observatory, and (c) by storms and accompanying high winds can arise quickly at the summit that can raise dust from recently exposed cinder and ash.

The State of Hawaiʻi regulates air pollutant emissions (HAR 11-60.1), including fugitive dust (HAR 11-60.1-33). The Project would comply with these regulations. Examples of precautions the Project would take to prevent the generation of dust include:

- Use of water to control dust during grading operations;
- Application of water to control dust from roads and stockpiles;
- Covering of all moving, open-bodied trucks transporting materials that could produce dust, such as cinder and ash;
- Maintaining the roadway at the construction site egress in a clean manner; and
- Suspending dust generating activities during periods of high winds.

To minimize the potential mobile source impact from vehicle and equipment emissions during construction, all potential sources would be maintained and inspected regularly.

During certain construction events or phases of construction lighting may be necessary. The use of exterior lighting would be kept to a minimum, coordinated with other observatories, and used in compliance with applicable requirements.

Construction impacts on air quality and lighting would be less than significant with the implementation the required control measures outlined above.

3.15.2 Mitigation Measures

Mitigation measures during construction and decommissioning would be similar. Unless specifically called out, the decommissioning mitigation measures would be similar enough to the construction mitigation measures that they do not warrant separate discussion.

In compliance with CMP Management Action FLU-3 and in order to aid in the eventual restoration of the area, the TMT Observatory site would be documented prior to the start of construction. This would be accomplished with high-resolution surface and aerial photography to document existing natural conditions.

The Project would comply with applicable regulations and requirements, in order to mitigate potential impacts as discussed above. This would include developing and implementing the various plans outlined in this EIS, including compliance with NPDES requirements, such as the site-specific BMP plan related to storm water and non-storm water as outlined above.

Noise

The Project would meet with OMKM and Kahu Kū Mauna to identify cultural events that would be sensitive to construction noise in the vicinity of the TMT Observatory site and the Batch Plant Staging Area. On up to four days identified by Kahu Kū Mauna the Project would endeavor to reduce construction noise and activities in the vicinity of cultural practices; the four days identified by Kahu Kū Mauna are the summer and winter solstice and the spring and fall equinox. In addition, a connection to HELCO-supplied power would be sought early in the construction process to reduce the need to operate generators.

Ride-Sharing Program

The Project would institute a Ride-Sharing Program. Participation would be required for workers at the TMT Observatory construction site. The program would require that construction workers use designated contractor vehicles to travel beyond Hale Pōhaku. This measure is designed to limit traffic on the Maunakea Access Road and limit the potential introduction of invasive species. With an average construction crew of 50 to 60, it is estimated nine or 10 vehicles would be required to transport the crew on a daily basis.

Roadways

Due to the expected increase of heavy traffic during construction there is a chance for more rapid deterioration of the unpaved portions of the Maunakea Access Road surface, TMT would arrange for the more frequent grading of the unpaved roadway.

Fire Prevention

The Project would develop and implement a Fire Prevention and Response Plan. The plan would be developed in coordination with OMKM and outline steps to be taken during construction activities to decrease the potential for fire at the TMT Mid-Level Facility, and hence the threat to cultural and natural resources in the surrounding māmane dry forest. Elements of the plan could include:

- Welding and grinding within the Hale Pōhaku Staging Area would be restricted to designated areas at least 20 feet from any combustible materials, including dry grass, and would not be performed during periods of high wind that could blow sparks beyond this 20 foot buffer. Barriers may also be used to isolate welding and grinding activities from combustible materials.
- Smoking would be restricted at construction sites to avoid starting fires. Smoking would be restricted to areas at least 20 feet from any combustible material, including dry grass. Ash trays would be provided and their use required; cigarette butts would be properly extinguished and disposed.
- Motorized equipment would be properly maintained and inspected regularly for possible ignition sources. Carburetors and motors would be required to have protective screens and covers to reduce the likelihood of heat sources starting fires.
- Motorized equipment would be equipped with fire extinguishers. The extinguishers would be appropriately sized to respond to that piece of equipment catching fire for any reason.
- Contractors would also be required to notify the local fire department of activities and coordinate with them on a regular basis. Construction personnel would be required to have cell phones or other communication equipment that provides coverage at the work site that can be used to contact the fire department immediately in the event of a fire.

3.15.3 Level of Impact after Mitigation

Prior to the implementation of the mitigation measures described above, the potential impact was found to be less than significant, with the possible exception of the potential impact of a fire in the māmane dry forest. The implementation of the mitigation measures would serve to further reduce the potential impacts related to Project construction, include fire, to a level less than significant.

3.16 Interrelationships and Cumulative Environmental Impacts

A cumulative impact occurs when two or more individual effects taken together are either substantial or they compound or increase other environmental impacts. Thus, cumulative impacts can result from an action that is individually limited but cumulatively has considerable effect upon the environment when added to other individually minor, but collectively significant, actions taking place over time. Hence, a cumulative impact would occur when the incremental environmental effects of the Project added to other past, present, and reasonably foreseeable future actions result in substantial significant impacts.

The cumulative effects are discussed below for each environmental area to provide detail; however, all these effects are interrelated and none occurs in isolation. For example, each of the uses generates visitors and/or employees who come to the mountain for recreation, hunting, scientific research, sightseeing, maintenance and services, cultural practices, and other activities. Thus roadways have been created for vehicles, which affected the geological features of the land, but also its biological and cultural resources. Vehicular travel on unpaved roads generates dusts, which in turn can affect moss, lichen, and other flora and fauna; as well as air quality and the mountain's ambiance. This in turn could affect some cultural and religious uses. Continued hiking and walking over the cinder cones crushes small, individual pieces of cinder leaving footpaths and trails that may adversely affect the viewshed, but also reduce air space in the cinder that could be utilized by arthropods plus create dust-sized particles that may settle on the existing habitats. The discussion below describes those interrelations that result from many cumulative sources and uses to the extent possible.

3.16.1 Past Activities

Table 3-14 identifies activities on or adjacent to the MKSR and Hale Pōhaku that have contributed to the level of cumulative impact. The general locations of many of the past activities that occurred above Hale Pōhaku are illustrated on Figure 3-33.

Table 3-14: Past and Present Activities

Activity	Location	Sponsor	Description	Dates
Adze Quarry Activity	Southern Slopes of Maunakea		Radiocarbon dates from adze quarry sites document Native Hawai'i Use of quarries.	1100 to 1800
Cattle and other ungulates graze	Maunakea		First cattle introduced through a gift from Captain Vancouver to Kamehameha I. Continues with cattle and sheep ranches, and feral ungulates for hunting	1793 to 1936 (some feral ungulates still present)
Hawai'i Forest Reserve system established	Maunakea	Territory of Hawai'i	System established to protect forests against fire and grazing – inspired by fires in Hāmākua.	established in 1903

Activity	Location	Sponsor	Description	Dates
Civilian Conservation Corps (CCC) activities	Maunakea	CCC	CCC plants trees and constructs horse and truck trails; trail around Maunakea at 7,000 feet elevation completed in 1935; stone cabins built at Hale Pōhaku.	1930s
Mauna Kea Forest Reserve fenced	Maunakea	Territory of Hawai'i	Fence erected around the Mauna Kea Forest Reserve to keep sheep and goats out; more than 40,000 sheep and goats are exterminated within the forest reserve.	1935-1936
Saddle Road paved	Saddle Road		Paving of Saddle Road is complete, increasing access to Maunakea.	1949
Maunakea Access Jeep Trail established	Maunakea southern slope	Territory of Hawai'i	First road is bulldozed to facilitate astronomy development, originally built to support astronomical testing on Maunakea.	1964
University of Arizona 0.3-m Site Test Telescope	Pu'u Poli'ahu	University of Arizona	0.3-m (12-in) site test telescope; erected on Pu'u Poli'ahu and used intensively for a 6-month test program, all equipment was removed upon completion of testing.	1964-1964
Site testing for UH 2.2-m Observatory	13N (Area E), Pu'u Poli'ahu, and Pu'u Kea (Area A)	UH	Site testing was performed at the 13N location (the proposed location for the TMT Observatory), Pu'u Poli'ahu (former location of Arizona test telescope), and on Pu'u Kea (the current location of the UH 2.2m observatory). Jeep trails were built to access the test sites.	1965-1967
UH 0.9-m Observatory	Astronomy Precinct, Area A	UH	Observatory consisted of a 0.6-m (24-in) optical telescope; was built by the U.S. Air Force and transferred to UH; upgraded with a 0.9-m telescope in 2008; is now used primarily for teaching and research by UH Hilo.	1968-present
Planetary Patrol 0.6-m Observatory	Astronomy Precinct, Area A	Lowell Observatory	Observatory consisted of a 0.6-m (24-in) optical telescope; was used for long-term monitoring of the planets in the solar system until facility was removed to make way for Gemini North.	1968-1990s
UH 2.2-m Observatory	Astronomy Precinct, Area A	UH	Observatory consists of a 2.2-m (88-in) optical/infrared telescope; was funded by NASA, now entirely funded and operated by UH.	1970-present
Maunakea Access Road Improved	Maunakea southern slope		Original jeep trail realigned to remove some sharp corners and improve access.	1975

Activity	Location	Sponsor	Description	Dates
United Kingdom Infrared Telescope (UKIRT)	Astronomy Precinct, Area A	United Kingdom	Observatory consists of a 3.8-m (12.5-ft) infrared telescope; operated by the Joint Astronomy Center (JAC) with headquarters in Hilo.	1979-present
NASA Infrared Telescope Facility (IRFT)	Astronomy Precinct, Area B	NASA	Observatory consists of a 3.0-m (10-ft) infrared telescope; operated and managed for NASA by UH.	1979-present
Canada-France-Hawai‘i Telescope (CFHT)	Astronomy Precinct, Area A	Canada/ France/ UH	Observatory consists of a 3.6-m (12-ft) optical/infrared telescope; jointly funded by Canada, France and the State of Hawai‘i through UH, headquarters located in Waimea.	1979-present
Hale Pōhaku Expansion	Hale Pōhaku	UH	The original construction camp, including stone cabins and temporary buildings, has been progressively upgraded and expanded to include dormitory and support facilities to accommodate astronomers and visitors to the summit of Maunakea.	1983-present
Maunakea Access Road	Maunakea southern slope	State of Hawai‘i and MKSS	Access road improved to allow for safer access to the summit. Portions paved and the alignment further straightened.	1985
Caltech Submillimeter Observatory (CSO)	Astronomy Precinct, Area C	Caltech/ NSF	Observatory consists of a 10.4-m (34-ft) millimeter/submillimeter telescope; operated by Caltech under a National Science Foundation (NSF) contract and managed from CSO headquarters in Hilo.	1986-present (planned removal in 2016)
James Clerk Maxwell Telescope (JCMT)	Astronomy Precinct, Area C	United Kingdom/ Canada/ Netherlands	Observatory consists of a 15-m (49-ft) millimeter/submillimeter telescope; operated by the JAC from its headquarters in Hilo.	1986-present
Installation of power and communications utilities	Saddle Road to the Astronomy Precinct	UH, with individual observatories	UH funded the design and installation of the power and communication lines connecting the HELCO system at Saddle Road to the summit distribution loop. Lines are overhead from Saddle Road to near Hale Pōhaku and then underground from there to the summit area.	Mid-1980s
Very Long Baseline Array (VLBA)	MKSR, outside Astronomy Precinct	NRAO/ AUI/ NSF	25-m (82-ft) centimeter-wavelength antenna; is an aperture-synthesis radio telescope consisting of ten remotely operated antennas, funded by the NSF and managed from New Mexico.	1992-present

Activity	Location	Sponsor	Description	Dates
W.M. Keck Observatory	Astronomy Precinct, Area B	Caltech/ University of California/ CARA	Observatory consists of two 10-m (33-ft) optical/infrared telescopes; used individually for most of the time, about 10 percent of the time they are used together as an interferometer, managed by non-profit CARA and headquartered in Waimea.	1992 (Keck I) / 1996 (Keck II) - present
GTE Fiber Optic Cable Installation	Saddle Road to Hale Pōhaku	IfA	A fiber optic telecommunications line was installed connecting the Maunakea observatories to the GTE Hawaiian Telephone Company fiber optic system.	1998
Subaru Observatory	Astronomy Precinct, Area B	Japan	Observatory consists of a 8.2-m (27-ft) optical/infrared telescope; formerly known as the Japan National Large Telescope (JNLT), operated by the National Astronomical Observatory of Japan and headquartered in Hilo.	1999-present
Gemini North Observatory	Astronomy Precinct, Area A	USA/ UK/ Canada/ Argentina/ Australia/ Brazil/ Chile	Observatory consists of a 8.1-m (26.2-ft) optical/ infrared telescope; is the twin to the Gemini South Observatory located in Chile, NSF was the Federal agency for the project, and is headquartered in Hilo.	1999-present
Jeep Trail Closure	Pu‘u Poli‘ahu	OMKM	A 300- to 400-yard trail that extended up to Pu‘u Poli‘ahu was closed to vehicles to minimize disturbance to cultural sites.	2001
Submillimeter Array (SMA)	Astronomy Precinct, Area C	Smithsonian Astrophysical Observatory/ Taiwan	Observatory consists of a eight 6-m (20-ft) submillimeter antennas; operated from a base facility in Hilo.	2002-present
Saddle Road improved	Saddle Road	HDOT	Saddle Road is being realigned and improved, increasing access to Maunakea.	2005

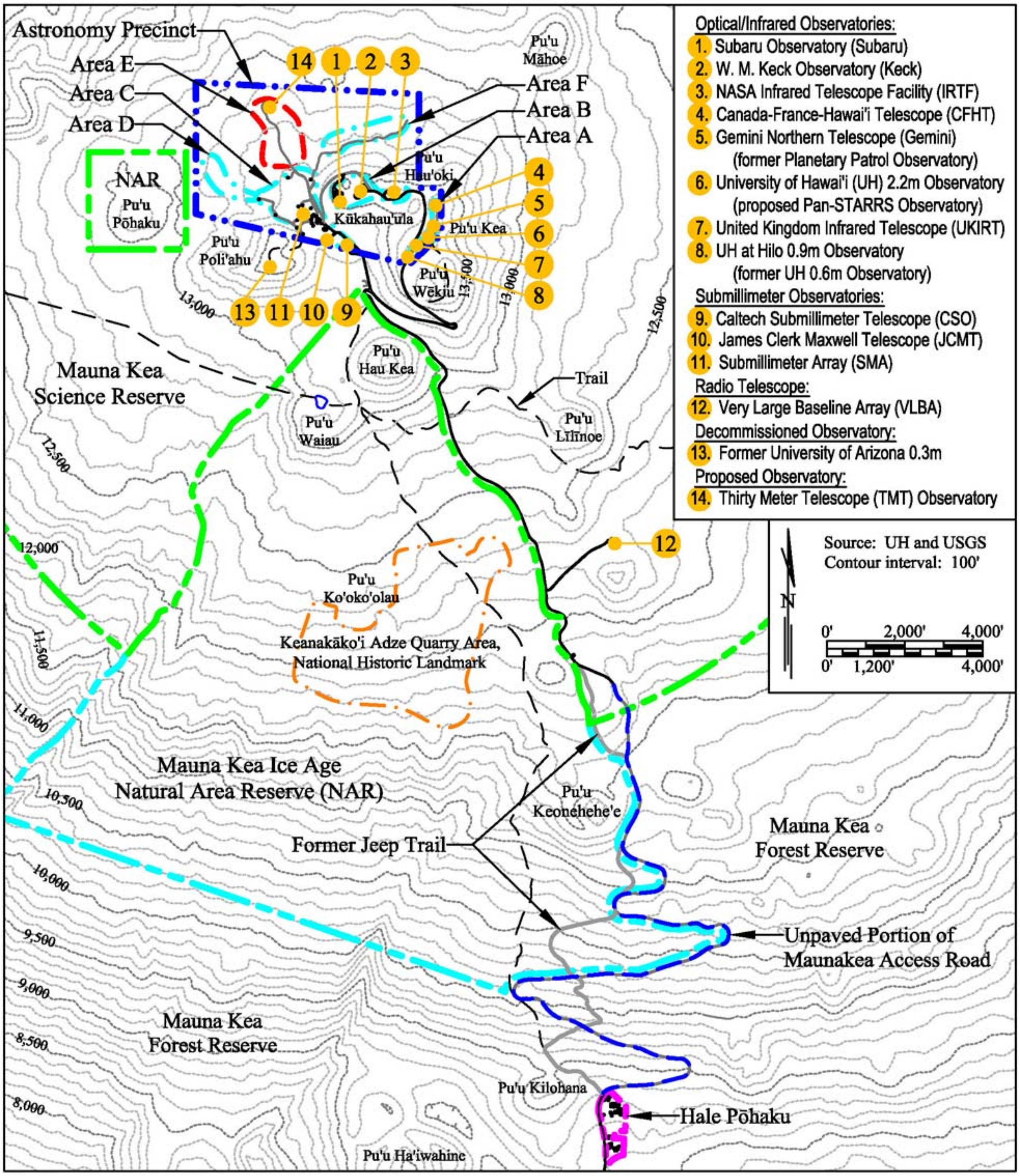

Figure 3-33: Past and Foreseeable Future Action

3.16.2 Level of Existing Cumulative Impact

Cultural, Archaeological, and Historic Resources

Maunakea Summit Region and Hale Pōhaku

Prior to contact with Europeans, Hawaiians engaged in a number of activities in the summit region. Except for the activities at the adze quarry, those activities were generally small in scale, without long-lasting adverse effects, and resulted in a minimal impact to the mountain landscape.

The period between contact with Europeans and the development of observatories on Maunakea saw a change in the nature and intensity of the impacts on Maunakea. The introduction of cattle and sheep severely affected resources used by Hawaiians. The grazing animals lead to the near disappearance of the silversword and impacts to the subalpine māmane forests and alpine shrublands and grasslands habitats; this resulted in the total loss or severe population drops of several native bird species. The current policies to control or eliminate feral ungulates in large areas, such as the MKSR, Ice Age NAR, and Mauna Kea Forest Reserve, have the potential to reverse some of the historical impacts of both managed and feral animals on cultural resources that can regenerate, such as flora and fauna.

Increased Access

After the initial contact with Europeans it is reported that visits by Native Hawaiian to the summit greatly decreased; few foreigners are documented as visiting the summit area during that time as well. In the later 19th century and early 20th century the number of visitors to the summit area increased due to the popularity of horseback excursions to the summit area. Native Hawaiians, kamaʻāina, and visitors are reported to have visited the summit in this way. Trails worn by the horses and visitors had a minimal impact on the mountain and apparently followed the two primary trails, the Maunakea – Humuʻula Trail and the Maunakea – ʻUmikoa Trail.

Access to the summit was made easier over the years with the paving of Saddle Road and the road to Hale Pōhaku following World War II.

In 1964, the first road to the summit was cut, making the construction of the observatories possible and also providing a relatively easy means of access to the general public. The increased number of visitors increased the potential for disturbance to cultural, archaeological, and historical resources. The road also facilitated access by cultural practitioners and allowed Native Hawaiians and scientists easier access to identify, record, and propose measures to protect cultural resources and culturally important natural resources.

The number of visitors and workers and the fact they have largely been unaware of the cultural significance of Maunakea increased the potential for impact to cultural resources. For example, in the past some engaged in off-road driving in the summit area; this has largely been curtailed by road improvements and OMKM rangers. Others have unknowingly impacted archaeological resources, disrupted the ambiance necessary for Native Hawaiian religious observances, or otherwise defiled a sacred realm.

Archaeological Resources

Prior to 1982, few archaeological surveys were conducted, so it is not known whether development on the mountain damaged subsurface resources. There is no indication that any archaeological sites in the summit region were destroyed during the construction of the Maunakea Access Road or the early observatories. Since 1982 the number and thoroughness of archaeological surveys undertaken prior to the construction of new observatory facilities has increased. Surface sites found in the vicinity of development projects have been flagged and protected during construction; monitoring during construction to identify possible subsurface cultural deposits or human burials was not undertaken in most cases.

Some of the historic shrines have been altered in the recent past. Some have been defaced with modern writing and symbols, while portions of others have been repositioned. Consultations conducted during the development of the CMP indicate that some cultural practitioners believe they have the right to modify the historic shrines, while others disagree. The accumulation of offerings have reportedly become obtrusive and distracting to the point that they have an adverse effect on historic properties in some cases.

Cultural Practices

Access and use rights are among important factors in allowing for cultural practices. As mentioned earlier, the roads built to the summit have facilitated access by cultural practitioners. Outside of not allowing vehicle access beyond Hale Pōhaku due to hazardous road conditions and requiring people to depart the summit region within 15 minutes of sunset, there are no known instances of limiting access for cultural practices. Families are building new shrines, practitioners are visiting the adze quarry and Lake Waiau to conduct cultural and religious rituals, and there have been spiritual observances of the winter solstice and other events. Despite this, the existing observatories have disrupted the ambiance necessary for Native Hawaiian religious observances.

There is also the possibility that existing observatories altered or removed a location where cultural practices once occurred. It has been reported that during construction of the existing facilities no archaeological sites or burials were encountered. Due to the lack of information concerning cultural practices taking place prior to the development of the observatories it is unknown if they directly altered or removed a location where cultural practices once took place.

Spiritual and Sacred Quality of Maunakea

The construction of observatories near and on the slopes of the cinder cones that comprise what SHPD now recognizes as the TCP of Kūkahauʻula, spiritually the most important area of the mountain, greatly affected traditional cultural resources. Little consideration was given to the TCP during previous projects because the significance was not understood at the time. Observatory construction has resulted in the moving of more than 10,000 cubic yards of material, grading and flattening of Kūkahauʻula ridges, and placement of man-made structures on Kūkahauʻula, affecting the views to and from the summit. The development of observatories within the Astronomy Precinct substantially altered the appearance of the summit, and the presence of these observatories continues to affect the performance of religious and cultural practices.

As evidence of this affect, Kealoha Pisciotta has said regarding Kūkahauʻula: "Unfortunately though, Poliʻahu's image and bodily form is being destroyed. They are altering the images of our deities because the puʻu[s] are being leveled and the telescopes are being built on top of her."[52]

Kumu Pono also suggests that the use of the new individual names (Puʻu Wēkiu, Puʻu Kea, and Puʻu Hauʻoki) for the cinder cones at the summit "have displaced the significant spiritual and cultural values and sense of place associated with name Puʻu o Kūkahauʻula."[53]

The Kūkahauʻula TCP has been adversely affected, not only by astronomy, but by all public and commercial activities, including snow play.

Although none of the observatories are visible from the shores of Lake Waiau, a number of them are visible from the summit of Puʻu Waiau and the summit of Puʻu Līlīnoe.

Maunakea Summit Region and Hale Pōhaku Summary

The existing level of cumulative impact on cultural, archaeological, and historical resources is substantial and adverse.

Headquarters and Satellite Office

The development of the University Park has not disturbed any cultural, archaeological, or historical resources. In Waimea, no development has taken place on the land being proposed for the Satellite Office. In both areas, there has been no cumulative impact on cultural, archaeological, or historical resources.

Biological Resources

Maunakea Summit Region and Hale Pōhaku

There are three main ecosystems within this area. The highest ecosystem is the alpine stone desert in the area above 12,800 feet and includes the summit cinder cones. The 11 observatories are located in this area. Some cinder cones with similar habitat to the summit cinder cones exist down to an elevation of 11,715 feet; due to their similarities with the alpine stone desert they are considered part of that ecosystem. Below the alpine stone desert is the alpine shrublands and grasslands ecosystem, which extend from 9,500 feet (the tree line) to 12,800 feet. The VLBA telescope and the Maunakea Access Road are located in this area. The māmane subalpine woodlands ecosystem is below the alpine shrublands and grasslands ecosystem and extends from the tree line down to Saddle Road. Hale Pōhaku and the lower portions of the Maunakea Access Road are located in this area.

Alpine Stone Desert Ecosystem

The summit of Maunakea is an island within an island, separated from other ecosystems by not only vast oceans, but high elevations as well. The upper elevations of the MKSR receive almost no rainfall and snow accumulates only during the winter season. Temperatures often drop below

[52] Na Maka o ka ʻĀina, 2008.
[53] Kumu Pono, 2005:vi.

freezing at night and reach up to 50 degrees Fahrenheit during the day. Solar radiation is extreme, and evaporation rates are high. The harsh environmental conditions limit the composition of the resident floral and faunal communities found there. Under these harsh conditions, only hardy lichens, mosses, ferns, and scattered grasses can survive[54].

The bulk of human activity has occurred on the cinder cones near the summit of Maunakea, where eight of the existing observatories are located. Human activities have had a very limited impact on the relatively extensive habitats beyond the summit cinder cones. Therefore, human activity has not had a significant cumulative impact on species that dwell in these other habitats, such as lichens, mosses, and vascular plants. Due to the level of development that has occurred within the relatively small area of summit cinder cones, many studies have been conducted to evaluate if that development has impacted natural inhabitants of the cinder cone habitat.

The Wēkiu bug, which lives only in loose cinder habitats on the cinder cones above 11,715 feet on Maunakea[55], has been identified as the species most closely related to and reliant on the cinder cone habitat. There is a similar species, *Nysius aa*, that occurs in the upper elevations on Mauna Loa[56].

Of more than 20 cinder cones in the MKSR, five show signs of human modification from construction of existing observatories and supporting infrastructure. To ascertain the state of the Wēkiu bug, numerous studies have been, and continue to be, conducted in the MKSR.

In the 1999 study[57], Wēkiu bugs were more abundant in disturbed areas compared to non-disturbed areas, which led the investigators to suggest "the possibility that observatory construction had not impacted Wēkiu bug or lycosid spider distributions at the summit, outside of the immediate vicinity of paved and covered areas." That study demonstrated that Wēkiu bug were still fairly abundant in the cinder of the pu‘u on which Keck and Subaru sit in the areas of the inner crater walls and crater bottom that had been modified during construction of the Subaru Observatory. This suggests that the Wēkiu bugs are able to recolonize the previously disturbed areas.

From October, 2002 through April, 2007, four reports of arthropod research were completed by the B.P. Bishop Museum considering the results of sampling over a large portion of the MKSR[58]. The purpose of these studies was to gather information about the distribution of Wēkiu bugs throughout the MKSR. The four studies, which involved extensive trapping and tests, found Wēkiu bugs on at least 15 cinder cones ranging in elevation from 11,715 feet to 13,796 feet. The studies generally concluded that Wēkiu bugs are restricted to rims and inner craters of cinder cones where loose cinders provide interstitial spaces large enough to allow movement through the cinder habitat. Surveys have shown that Wēkiu bugs are still abundant and are found in previously disturbed areas and undisturbed areas of their cinder cone habitat. The researchers advanced a hypothesis that weather, abiotic factors, temperature, and substrate moisture all may influence Wēkiu bug activity.

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[54] Cuddihy, 1989
[55] Porter and Englund, 2006
[56] Polhemus 1998
[57] Howarth and others, 1999
[58] Englund and others 2002, 2005, 2006, 2007

A fifth report[59] details the accounts of a study on possible geologic factors that may influence Wēkiu bugs. That study found that the Wēkiu bugs appear to prefer non-glaciated cinders and lava spatter in areas where glacial erratics are lacking. The study concluded that "Because the [Wēkiu] bugs apparently do not like bedrock substrates, telescopes sited on the glacially modified lava flows in the summit region may have little or no local impact on the bugs…"

A long-term baseline monitoring study was also started in February 2002, for the then-proposed W.M. Keck Observatory's Outrigger Telescopes Project[60]. The study was comprised of ten pitfall live-traps at permanent sampling stations inside the pu'u crater northwest and below the Keck Observatory and another ten at permanent sampling stations inside Pu'u Wēkiu. Sampling was conducted quarterly from February 2002 through May 2006. Microclimate data were collected to make inferences about the relationship between Wēkiu bug abundance and habitat temperature. Over the four-and-a-half years of sampling, 7,912 Wēkiu bugs were collected. Wēkiu bugs were found to be more abundant on the pu'u Keck sits on than on Pu'u Wēkiu. The results of this study supported the conclusion of the previous 1999 study – that observatory construction had not impacted Wēkiu bug and lycosid spider distributions at the summit, outside of the immediate vicinity of paved and covered areas. The study also found that Wēkiu bug activity appeared to vary with temperature and that Wēkiu bug populations fluctuated year to year.

The wealth of current data from long-term monitoring studies indicates that the existing observatories have not impacted Wēkiu bug and lycosid spider distributions at the summit, outside of the immediate vicinity of paved and covered areas. The pavement and covered area associated with the existing observatories (63 acres) resulted in cumulative displacement of no more than 3.3 percent of the total known Type 2 and 3 Wēkiu bug habitat. The total known and suspected Type 2 and 3 habitat is illustrated on Figure 3-3, and constitutes roughly 1,900 and 775 acres, respectively.

Based on the available information it is not possible to determine the magnitude or significance of past human activity on Wēkiu bugs or other biological resources that inhabit the alpine cinder cone ecosystem.

Alpine Shrublands and Grasslands and Māmane Subalpine Woodlands

Below 11,700 feet is an alpine shrublands and grasslands ecosystem growing on 'a'a lava flows, cinder cones, and air-fall deposits of lapilli and ash. Native shrubs, grasses, sedges, and ferns grow well above the tree line, and become sparser with increasing elevation.

Below the alpine shrub zone are the māmane subalpine woodlands that extend down to Saddle Road. The open-canopied māmane woodland is home to the endangered bird, palila (*Loxiodes bailleui*). Māmane trees also act to intercept fog that provides them and other species nearby with the small amounts of moisture they need to survive[61]. The understory of the subalpine forest is comprised largely of native shrubs, and in undisturbed areas clumps of native grasses are the most abundant ground cover. The māmane forest on Maunakea has a diverse arthropod fauna; over 200 arthropod species have been collected there.

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[59] Porter and Englund, 2006
[60] Brenner, 2002 – 2006
[61] Gerrish, 1979

While construction at Hale Pōhaku has resulted in the removal of small areas of māmane woodlands, the past has seen the greatest and most devastating impacts to the māmane subalpine forest and alpine shrublands and grasslands ecosystems on Maunakea through the intentional maintenance of feral ungulates (hoofed mammals such as wild sheep, pigs, boars, and deer) during past ranching and more recently for recreational hunting. These ungulates nearly destroyed the māmane woodlands and have reduced the once abundant Maunakea silversword populations to nearly zero. The impact of ungulates on the natural resources in these ecosystems far outweighs any other impact from human activities within the subalpine and alpine environments. The portion of cumulative impact related to development of Hale Pōhaku and observatory facilities in general is less than significant; however, due to past ungulate management practices, the cumulative impact on these ecosystems has been significant and adverse.

Headquarters and Satellite Office

According to previous studies, the development of University Park did not result in a significant impact to biological resources. The potential Satellite Office location in Waimea is within a commercial area, with no impact on biological resources.

Visual and Aesthetic Resources

Maunakea Summit Region and Hale Pōhaku

The astronomical observatories are prominent visual elements on the summit of Maunakea. On a cloud-free day, some of these existing observatories are visible from locations around the island such as Hilo, Honokaʻa, and Waimea. On the west coast of the island, the existing observatories appear most visible at sunset, when they are lit by the setting sun; on the east coast they appear most visible at sunrise. All eight existing optical/infrared observatory structures are colored white or silver to minimize the difference in temperature between day and night and the associated cooling needs as much as possible. Most of the structures are rounded, but the Subaru observatory has a cylindrical paneled structure. The cylindrical panels of the Subaru observatory make it less visible during most of the day; however, at sunset, it appears bright due to the reflection of sunlight from its flat surfaces. After conducting a viewshed analysis based on topography, at least one of the existing observatories is visible from roughly 43 percent of the island. According to 2000 U.S. Census data, 72 percent of the population, or about 107,000 people, reside within that viewshed area. At the summit, the existing observatories obscure portions of the 360-degree panoramic view from the summit area.

Maunakea is often veiled by clouds formed by the inversion layer and obscured by vog; this shrouds the summit from view from low elevation areas around the island, as well as the views from the summit to the island below.

The existing support facilities at Hale Pōhaku are not visible from other locations on the island due to the terrain of this area. The Hale Pōhaku mid-elevation support facilities were specially designed with the structures sited and built to follow the contours of the mountain, and colored to blend with the surrounding natural features and terrain.

The existing development on Maunakea does not block or obstruct any of the identified views in the County of Hawaiʻi General Plan or the South Kohala Development Plan. They are, however, visible within the viewplanes from Hilo, Waimea, and the summit. Overall, the existing level of the cumulative visual impact from past projects at the summit is substantial and considered to be significant.

Headquarters and Satellite Office

The development of the University Park thus far has not resulted in a significant visual impact. There are no designated or recognized visual resources associated with UH Hilo or the commercial district of Waimea.

Geology, Soils, and Slope Stability

Maunakea Summit Region and Hale Pōhaku

Within the MKSR, most of the changes associated with local geology are due to wind, the movement of ice, snow, and water, and human activity. The main human activities that disturb cinder and other geologic features include road grading and travel by vehicles; hiking and off-road vehicle use; and activities associated with infrastructure improvements.

The development of each existing observatory required localized site work that significantly modified the preexisting terrain, and impacted geologic structures and slope stability. Pu‘u Hau‘oki and an unnamed cinder cone to the west (where Keck and Subaru observatories are located) have undergone the most significant alterations as connecting roads were built and the tops of the cones were flattened to serve as foundations for the facilities. Most of the material that was removed was transported away for use elsewhere or placed on the floor of the pu‘u crater northwest of Keck, but some material was pushed over the sides of the cones. As a result, these areas have steeper slopes than would naturally occur, and because they consist of poorly consolidated material they are more susceptible to disturbance. As a result of the low amount of precipitation and high porosity of the ground surface at the summit there is no evidence of erosion by surface runoff.

Following the construction of the Maunakea Access Road, erosion of materials next to the roadway has been an issue during heavy rainfall or rapid snow erosion. Past episodes have transported loose material as much as 300 feet downslope from the road, but the construction of settling basins along the roadway has largely mitigated this occurrence. To maintain the road, grading of the unpaved areas is conducted approximately three times per week.

At Hale Pōhaku erosion impacts appear to be more extensive due to greater visitor counts and concentrations.

The existing level of cumulative impact on geology, soils, and slope stability is substantial and is considered to be significant, primarily due to the alteration of the cinder cone morphology.

Headquarters and Satellite Office

The development of University Park thus far has not resulted in significant impacts on geology, soils, or slope stability. The commercial area in Waimea has not generated impacts associated with geology, slope stability, or soils.

Water Resources and Wastewater

Maunakea Summit Region and Hale Pōhaku

The drainage patterns on the summit have been minimally impacted by the past development. On the cinder cones, the introduction of impervious surfaces has not resulted in surface runoff, as the cinder is so pervious that the capacity to absorb water has always been greater than the rate of precipitation. Maunakea Access Road does create surface runoff and slightly alters the path of natural surface runoff. There are numerous points of discharge along the road and the rates of discharge at each are fairly small, so the resulting erosion and deposition of materials are minor. Also, the surface runoff does not extend to or below an elevation of 6,000 feet, which means that the majority of the water ultimately ends up percolating and becoming groundwater recharge with only a small amount lost to evaporation.

The existing wastewater systems at Hale Pōhaku, and the individual wastewater systems operated by each observatory on Maunakea have all been designed to meet the HDOH permit requirements for sanitary waste systems. Domestic type wastewater is discharged into these approved systems, and there is no direct discharge into the ground. The collected solids are pumped out of the systems on a regular basis, hauled off the mountain, and disposed of in approved facilities. The natural nutrient removal that takes place over the decades-long travel time from the summit to the Waikiʻi wells results in no impact to the wells due to the introduction of the domestic wastewater. The wastewater generated during mirror washing is no longer directed into any of these systems and instead, is fully containerized and hauled down the mountain for disposal. It has been shown that the past disposal practices of mirror washing wastewater have not had a significant impact on water quality.

The existing level of cumulative impact on water quality is negligible and less than significant.

Headquarters and Satellite Office

The development of the University Park thus far has increased the amount of impervious surfaces in the area, thereby increasing the volume of storm runoff. The drainage system was designed and built to properly capture, collect, and transport the runoff from the area. The developed commercial area in Waimea is served by an existing drainage system, while undeveloped parcels are not connected to the system.

The connection of the existing facilities in the University Park to the regional wastewater system resulted in a minimal increase in the volume of wastewater treated by the Hilo Wastewater Treatment Plant. In Waimea, the wastewater from the developed commercial area is discharged to individual wastewater systems permitted by the HDOH.

The existing level of cumulative impact on water quality is negligible and less than significant.

Solid and Hazardous Materials and Waste

Maunakea Summit Region and Hale Pōhaku

Human activities, including astronomy, tourism, and recreation, generate trash and other solid waste that has been collected in containers, removed regularly, and disposed of at authorized landfills. In the past, researchers reported occurrences of a considerable amount of trash left around the mountain and in response, MKSS began collecting the trash, including that left by visitors to the summit, and it is now rarely seen within the MKSR.

Observatory operations on Maunakea have required the use of hazardous materials, and generated waste from such materials; these include paint, solvents, vehicle and generator fuel, lubricants, hydraulic fluid, glycol coolants, acids, and mercury. A small number of mercury spills have occurred since observatory operations began; the best available information regarding such occurrences suggests that none of the spills reached the outside environment.

The existing level of cumulative impact due to solid and hazardous materials and waste is small and less than significant.

Headquarters and Satellite Office

The development of the University Park thus far has involved the use of hazardous materials, and generated waste from such materials; these include paint, solvents, vehicle and generator fuel, lubricants, and hydraulic fluid. Operations of facilities within the Park generate trash and solid waste, which is collected and regularly picked up and disposed of at a landfill. Overall, impact due to solid and hazardous materials and waste is small and not significant.

The developed commercial area in Waimea generates trash that is disposed of at a landfill, while the undeveloped parcels generate no wastes.

Socioeconomic Conditions

Maunakea Summit Region and Hale Pōhaku

Astronomy has become a local industry, and has provided significant economic and educational benefits to the State and local communities. The majority of the funding for the construction and operation of the observatories has been provided by organizations outside of the state. At least one-third of the funds for construction were spent on local services; more than 80 percent of the operating funds are spent in Hawai‘i, mostly within the County of Hawai‘i. Payments of fees and tax obligations by the observatories flow into the State and the County on an annual basis, as do payments for utilities and other services. The staff and other employees contribute to the local economy directly through income tax and other payments, and indirectly through purchases of local goods and services.

Of the approximately 600 persons currently employed by the existing observatories, it is estimated that roughly half moved to Hawai‘i, and about half of the employees were already in Hawai‘i when they began working for the observatories. This relatively small (roughly 300 employees plus family for a total of 825 people or 0.6 percent of the County’s population) addition of people to the County of Hawai‘i for observatory employment has not adversely affected the social fabric of the island communities. The astronomy sector of the local economy has provided the County of Hawai‘i with many beneficial social and education opportunities that otherwise would not exist. These include programs such as the Observatory Directors Lecture Series, the Universe Tonight program at the VIS, the Astronomy Educators in the Classroom program, the activities and facilities at ‘Imiloa, the Doing Astronomy with Kupuna program, and astronomy internship programs. In addition, the astronomy community helps sponsor a number of non-astronomy events in the community.

Overall, the existing level of cumulative impact on socioeconomic conditions is substantial and beneficial.

Headquarters and Satellite Office

The University Park facilities contribute to the economy of the State and the County through payment of utility and other fees and purchase of local goods and services. The staff and employees contribute directly through income tax and other payments and indirectly by purchasing local goods and services.

The developed commercial area in Waimea generates sales tax and other direct and indirect fiscal benefits to the State and the County, while undeveloped parcels do not contribute to the economic welfare.

Land Use Plans, Policies, and Controls

Maunakea Summit Region and Hale Pōhaku

The construction and operation of observatories in the MKSR, the mid-level support facilities at Hale Pōhaku, and access roadways have all been consistent with State and local land use policies and land use designations, including the CMP that provides the framework for managing existing and future activities, including astronomy, recreational and commercial activities, scientific research, and cultural and religious activities within the UH management area – which consists of the MKSR, Hale Pōhaku, and the Maunakea Access Road between Hale Pōhaku and the MKSR. Each of the existing observatories on the summit underwent required permitting processes and reviews. As such, this past development has not resulted in conflict with existing land use plans, policies, or controls for the conservation district, resource subzone.

Other cumulative land use-related impacts, including those on cultural and religious uses, visual effects, the mountain's natural ecosystems, its geology, water quality, and other areas, are each addressed in this section under its type of environmental issue area.

Headquarters and Satellite Office

The development of the University Park has been consistent with the applicable land use plans and policies. This development is subject to the regulations of these plans and policies, preventing the potential for land use planning conflict.

The commercial development in Waimea is subject to the County land use regulations, and the mandatory compliance with those regulations ensures no conflict with land use planning.

Roadways and Traffic

Maunakea Summit Region and Hale Pōhaku

The creation of Maunakea Access Road that provided for the relative ease of accessing the summit, has led to increased traffic on the mountain. Traffic associated with recreation and tourism has increased over the past several decades; this has included an increase in the number of organized commercial and educational tours. As detailed in Section 3.11, more than 100,000 people have visited the mountain per year over the past few years. In 2008, the total number of visitations in vehicles on the mountain was over 30,058, with over 10,000 visiting 4-wheel drive vehicles and 11,000 observatory vehicles. While on average this represents about 28 visitor and 30 observatory vehicular trips per day, the cumulative level of vehicular trips is considered significant for the Maunakea environment. The impact related to this number of visitors is demonstrated by the level of impact on biological and other natural resources, including the natural setting of the mountain. However, the existing roads are sufficient to handle this level of traffic and it does not represent a significant impact to the roads or level of traffic.

Headquarters and Satellite Office

The development of the University Park has increased traffic on the surrounding streets during peak rush hours; however, the overall level of traffic has not resulted in a substantial cumulative impact on the existing roadway system.

Waimea's development and constrained roadway system has resulted in congested conditions at some locations, particularly at the intersection at Lindsey Road and Māmalahoa Highway, as all traffic passing through the town must pass through that intersection. As there is no alternative to this route, there is congestion during the morning, mid-afternoon, and afternoon peak periods of the day, mostly experienced as travel delay due in large part to traffic queues waiting at traffic lights. Another problem intersection has been identified at Kamāmalu Street and Māmalahoa Highway. Much of the congestion is caused by traffic originating in or destined for Waimea. Therefore, while overall, the existing roadway system operates at acceptable levels, the existing level of cumulative effects at those locations is considered to be significant.

Power and Communication

Maunakea Summit Region and Hale Pōhaku

The construction of power lines began in 1985, and once the lines reached Hale Pōhaku additional work was performed to provide the summit with power through an underground distribution system. This work was completed in 1988, and in 1995 an upgrade to the system added an underground distribution loop at the summit and provided service to the SMA observatory.

The communications system was installed together with the power system in 1985. Fiber optic cables were added in the 1990s, and the existing communication system allows for real-time communication between the summit facilities and on- and off-island headquarters offices, as well as an internet connection.

The provision of power and communication systems to serve the existing uses and activities on Maunakea has not resulted in a substantial cumulative effect on the capacity or supply of electricity and communication systems on the mountain or island-wide.

Headquarters and Satellite Office

Both University Park and the Waimea commercial area are served by the existing HELCO power distribution system and Hawaiian Tel communication network. These systems service the entire island. No power or communication capacity shortage has occurred to date.

Noise

Maunakea Summit Region and Hale Pōhaku

Ambient sound levels at Maunakea are low, with vehicle traffic and wind providing the dominant background. Observatory operations generate minimal noise. Noise associated with a relatively small numbers of visitors (estimates by rangers indicate an average of about 28 non-commercial visitors a day to the summit, most of them staying less than 30 minutes) and vehicle trips (the existing observatories average about 30 vehicle trips a day) is relatively limited. While people's sensitivity to noise vary, no one is habitually exposed to noise at the summit; the scientists and observatory staff use the Hale Pōhaku dormitories, and tourists and other visitors leave the summit before nightfall. While construction activities create intermittent, though sometimes significant disruptions, the existing ambient noise levels remain low and fully within the applicable noise standards of 55 dBA during daytime hours and 45 dBA during nighttime hours. Thus, the overall level of cumulative noise impact is less than significant.

Headquarters and Satellite Office

Vehicular traffic is the major noise generator in urban areas, and noise in Hilo and Waimea is generally associated with traffic from busy roads: Komohana Street in Hilo and Māmalahoa Highway in Waimea. The University Park area is relatively quiet, with traffic on the adjacent streets generating most noise. The operations of the existing UH Hilo facilities generate limited noise, primarily from internal vehicle trips of staff and employees. The overall ambient noise levels are within standards consistent with types of existing uses and level of development and the cumulative noise impact is less than significant.

Air Quality, Climate, and Lighting

Maunakea Summit Region and Hale Pōhaku

Maunakea's geographic and meteorological isolation produces excellent air quality. With the summit area rising well above the atmospheric temperature inversions, that occur around 7,000 feet, air pollutants are "capped" and do not cause any interference at the summit. Locally generated contributors to air pollution above the inversion level include vehicle exhaust, chemical fumes from construction and maintenance activities, and fugitive dust from road grading and construction or other activities conducted on unpaved surfaces. Strong winds aid the rapid dispersion of these pollutants, helping to maintain Maunakea's excellent air quality, in attainment status with all ambient air quality standards. The level of cumulative air quality impact associated with past and current development and activities is small and not significant.

The past and existing uses and activities on Maunakea have not changed the climate on the island; however, they have incrementally contributed to the planet-wide global climate change associated with the use of fossil fuels and global warming practices. It is unlikely that those uses and activities were contributing proportionally more to climate change than those occurring at other elevations in Hawai'i, or at other locations on the planet.

One of the characteristics of Maunakea, which makes it one of the best sites in the world for astronomical observations, is the very dark sky. This results from the summit's remoteness from urban development, as well as the County of Hawai'i's island-wide lighting ordinance requirements that have resulted in the exclusive use of LPS outdoor lighting. The absence of air pollution, the absence of large, brightly-lit cities on the island of Hawaiʻi, and the absence of high intensity illumination of existing facilities at Maunakea have resulted in a low level of sky illumination all through the mountain areas. The level of cumulative sky illumination impact associated with past and current uses and activities is small and less than significant.

Headquarters and Satellite Office

The air quality within the entire island, including the University Park and Waimea, is excellent; with no exceedences of ambient air quality standards resulting in a low level of cumulative impact. All development and uses are subject to the County of Hawaiʻi's island-wide lighting ordinance requirements resulting in a low level of cumulative impact.

3.16.3 Reasonably Foreseeable Future Actions

Over time, there have been many conceptual ideas and plans for astronomical facility development in the future, as well as for projects to support various other uses, including recreational uses. The cumulative impact evaluation addresses possible future projects that may be reasonably foreseeable. The following projects may be reasonably foreseeable future projects within the Astronomy Precinct:

- The Project – the TMT Observatory would be built and operated at the 13N site in Area E (Section 2.5.1), and the Access Way would be built improving an existing 4-wheel drive road (Section 2.5.2). The TMT Observatory would be decommissioned at the end of its life.
- Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) would replace the existing UH 2.2-meter telescope in Area A. Pan-STARRS is expected to consist of four 1.8-meter telescopes, each with a 3-degree field of view and a 1.4-billon pixel camera, all in a single enclosure. The Pan-STARRS would be able to observe the entire available sky several times during the dark portion of each lunar cycle. The new technology planned for Pan-STARRS would enable remote and/or robotic operation.
- Smithsonian Astrophysical Observatory is considering adding 2 antenna pads and 1 antenna in Areas C and/or D to the existing 24-pad, 8-antenna SMA system.
- Decommissioning and removal of the Caltech Submillimeter Observatory (CSO), which was built in 1987 in Area C.
- The paving of the remaining dirt portions of the Maunakea Access Road above Hale Pōhaku (roughly 4.6 miles long between 9,300 feet to 11,800 feet). CMP Management Action IM-8 outlines a policy to assess the feasibility of paving the road.

The general locations of these foreseeable future actions are illustrated in Figure 3-33.

Another foreseeable event is the end of UH's lease of the MKSR. UH's current lease will expire in 2033. Because there is a range of possible outcomes or actions related to this event, it is discussed separately in Section 3.16.5.

Foreseeable actions within Hale Pōhaku include the Project TMT Mid-Level Facility, which would primarily consist of remodeling and replacing existing structures (Section 2.5.3). In Hilo and Waimea, the UH Hilo campus and surrounding area plus the Waimea commercial area are expected to continue to develop with infill developments, such as the proposed Project Headquarters (Section 2.5.4) and Satellite Office (Section 2.5.5).

3.16.4 Level of Future Cumulative Impact with the Project and Reasonably Foreseeable Future Actions

The potential impacts, and hence cumulative impact, of the Project and reasonably foreseeable future actions are evaluated within the framework of compliance with all applicable rules, regulations, and requirements applicable to the action type and location. This includes the requirements of the CMP.

The Headquarters and Satellite Office developments, and other similar developments nearby, would add to the cumulative impact of the further development of UH Hilo and the Waimea commercial area. However, the expansion of both areas would be consistent with land use plans and policies and their further development is not anticipated to have a significant negative cumulative impact on the environment.

Cultural, Archaeological, and Historic Resources

The existing level of cumulative impact on cultural, archaeological, and historical resources is considered substantial and adverse. This section describes cumulative impact associated with the Project and the foreseeable actions.

<u>Maunakea Summit Region and Hale Pōhaku</u>

Generally, through compliance with the CMP, the Project and other foreseeable action within MKSR and Hale Pōhaku, would result in a small incremental increase in the cumulative impact on cultural resources. The limited extent of the impact is primarily because:

- Archaeological surveys would be performed prior to any ground-modifying work to ensure minimal impact to archaeological resources.
- Ground-modifying activities would be monitored by a qualified archaeologist.
- Consultations would be conducted with representatives of the Native Hawaiian community, including Kahu Kū Mauna, during planning activities and prior to construction.
- Construction and installation activities would be monitored by a cultural observer.
- Construction workers, operational staff, and visitors would be educated to understand the sacredness of the summit, to understand and recognize the sensitivity of the cultural resources, the importance of not disturbing the resources or disturbing cultural and religious practices, and ways to conduct their daily activities that would avoid the potential for disturbance.

There are some opportunities to reduce the level of impact during the implementation of some of the foreseeable projects, most notably the decommissioning of the CSO.

Increased Access

The paving of the 4.6 mile segment of the Maunakea Access Road above Hale Pōhaku could result in increased trips and visitors to the summit area. As part of the CMP, an access plan is being prepared that may address overall access to the summit area. With the implementation of the access and education plans called for in the CMP, impact due to increased access would not significantly increase the impact on resources in the summit area.

The development of the Project and foreseeable actions in the summit area would increase access within the summit region. At least 4-wheel drive roads already exist in the vicinity of all foreseeable actions, except in the expansion area of the SMA in Area D. The existing roads would be improved, and new roads added in the case of the SMA expansion, and the presence of observatories along those roads could draw more visitors to travel along those roads. The presence of an improved road in Area F could have the additional effect of increasing snow play activities on the north side of Kūkahauʻula because it would provide a clear route that could be used to access the top of the runs known as Aliʻi Run and Warrior's Run. All the roads have the potential to tempt visitors to access areas previously not normally visited, but this possibility is considered low because Areas D, E, and F do not provide views, access to trails, or opportunities for experiences that cannot be achieved along currently existing roadways, other than visiting the new observatories.

The Project and other foreseeable actions may attract more visitors to the summit region to see the observatories. The presence of these additional visitors and the additional employees of the Project and other foreseeable actions could impact cultural resources. However, because Maunakea will continue to be a remote destination, these increases are likely to be slight relative to the existing level of visitors and employees. With existing programs and the implementation of the concepts presented in the CMP including the ranger program and increased education programs, the impact to cultural resources by visitors and employees is likely to be reduced relative to current conditions.

Cultural Practices

With the implementation of the policies laid out in the CMP, the potential impact to cultural and religious practices by operations of the new uses would be minimal. The primary concern, therefore, is the potential for the Project or foreseeable actions to alter or remove a location where cultural or religious practices occur. This is particularly a concern where previously undisturbed areas would be used for projects. The Project in Area E and the 2 new SMA antenna pads could alter or remove a location where cultural practices occur. However, with each project required to go through the steps outlined for project development by OMKM, including consultations with Kahu Kū Mauna, the likelihood of this occurring is low.

The decommissioning of the CSO provides an opportunity to reduce the level of impact on cultural practices; however, it is not evident that cultural practices occurred at this location prior to the CSO development.

Spiritual and Sacred Quality of Maunakea

The integrity of the TCPs, including Kūkahauʻula, Puʻu Līlīnoe, and Waiau, is the most significant factor to the spiritual and sacred quality of Maunakea. The Project and foreseeable actions would not have a significant impact on the integrity of the TCPs, unless Access Way Option 3 for the Project is selected. Should the Pan-STARRS project redevelop the existing UH 2.2-meter observatory location on Kūkahauʻula, a slight change to the impact related to that existing observatory could occur; Pan-STARRS design and operation concept would reduce the visual impact, as well as the number of staff at the observatory.

The visual impact of man-made structures is another one of the factors affecting the spiritual and sacred quality of Maunakea. Overall visual impact is discussed in a Visual and Aesthetic Resources section below.

Maunakea Summit Region and Hale Pōhaku Summary

The addition of the Project and other foreseeable actions to the existing environment would have a small incremental impact; however, the level of cumulative impact on cultural, archaeological, and historic resources would continue to be substantial and adverse.

Headquarters and Satellite Facility

Further development of the University Park or Waimea commercial area is not anticipated to significantly contribute to the existing less than significant cumulative impact on cultural, archaeological, or historic resources.

Biological Resources

Maunakea Summit Region and Hale Pōhaku

Generally, through compliance with the CMP, the Project and others, including the reasonably foreseeable ones, within MKSR and Hale Pōhaku would not result in a negative cumulative impact on biological resources. This is primarily because (a) any future development would have to replace any sensitive habitat, such as Wēkiu bug habitat type 2 or 3, it would disturb at a minimum 1:1 ratio; and (b) all staff and visitors would be educated to understand the sensitivity of the biological resources, the importance of not disturbing them or their habitats, and ways to avoid impacting them during their daily activities.

Overall, the current policies to control or eliminate feral ungulates in large areas, such as the MKSR, Ice Age NAR, and Mauna Kea Forest Reserve, have the potential to begin reversing the historical impact of both managed and feral animals.

Alpine Stone Desert Ecosystem

The Astronomy Precinct is entirely above 12,800 feet and therefore within the alpine stone desert ecosystem. The TMT Observatory and other foreseeable actions would be located within the Astronomy Precinct of the MKSR. There are no currently-listed threatened or endangered species known to occur in the Astronomy Precinct. One species that is currently a candidate for listing, the Wēkiu bug (*Nysius wekiuicola*), and one species currently considered a species of concern by the USFWS, the Douglas' bladderfern (*Cystopteris douglasii*), are known to occur in the Maunakea summit region, including the Astronomy Precinct.

Douglas' Bladder Fern. The Douglas' bladder fern is present in the Astronomy Precinct, including Areas C, D, E and F, but it also occurs throughout the MKSR, on Maui, and on the eastern slopes of Mauna Loa. Other species that live in the lava flow habitat of Areas C, D, E, and F are also widespread. Development of the TMT Observatory and Access Way plus the two new SMA antenna pads would displace less than 0.5 percent of this habitat and not result in a significant cumulative impact because this area does not represent a unique habitat essential for the fern's or other species' survival[62].

Wēkiu Bug. The Wēkiu bug, which lives only in loose cinder habitats on the cinder cones above 11,715 feet on Maunakea[63], has been identified as the species most closely related and reliant on the cinder cone habitat.

The development of the TMT Observatory, Access Way, and new SMA pads would not have a significant cumulative impact on the Wēkiu bug. The lava substrate in these areas is primarily Type 4 Wēkiu bug habitat with roughly 5 percent Type 5 habitat; these types of habitat are considered to be marginal Wēkiu bug habitat[64], which is apparently occupied only during extreme population outbreaks. The amount of this habitat that would be displaced by construction and installation of the TMT Observatory, Access Way, and new SMA pads would be about a quarter (0.25) of one percent (roughly 10 acres of the more than 4,000 acres) of the total lava flow (Type 4 and 5) habitat above 11,700 feet. Should Access Way Options 2 or 3 be selected and Type 3 Wēkiu bug habitat disturbed, an area at least equal to the disturbance would be restored to provide similar or better habitat for the Wēkiu bug. Thus the individual contribution of the Project to the cumulative impact would be small and not significant.

The contribution to the cumulative impact by other foreseeable action (decommissioning of CSO and Pan-STARRS) would be less than significant; and could potentially result in a beneficial impact to Wēkiu bug habitat in comparison with the existing conditions. This is because the future decommissioning of CSO, with subsequent habitat restoration, could increase the amount of available Wēkiu bug habitat, thereby reducing the cumulative impact of the observatories in the Maunakea summit region. Pan-STARRS redevelopment would occur within the existing footprint of the UH 2.2-meter observatory and therefore, would add little, if any, to the cumulative impact.

Alpine Shrublands and Grasslands and Māmane Subalpine Forest Ecosystems

The paving of the Maunakea Access Road would reduce the amount of dust generated within these ecosystems. This would benefit these ecosystems.

As with the existing development at Hale Pōhaku, the Project's TMT Mid-Level Facility would remove a small area of māmane subalpine forest, none of the other foreseeable action involves additional development at Hale Pōhaku. All the area that would be disturbed by the TMT Mid-Level Facility has been disturbed in the past and would not result in a significant cumulative impact. The slight increase in traffic related to the Project and other foreseeable actions, which could generate slightly more dust than the current level of traffic until the road is paved, would not result in a significant cumulative impact either.

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[62] Char, 1990
[63] Porter and Englund, 2006
[64] Howarth and Stone 1982, Howarth and others 1999, Brenner and Lockwood 2005

Summary

While overall the Project and the potential future actions would result in less than significant cumulative impacts, the existing level of cumulative impacts would not be significantly reduced.

Visual and Aesthetic Resources

As detailed in Section 3.5.4, the location and design of the TMT Observatory incorporate measures to reduce its potential visual impacts. Most significantly, the TMT Observatory would not be visible from the southern portion of the island, including Hilo. Although the TMT Observatory may be visible in the view of Maunakea from portions of the South Kohala district and the area around Waimea, it would not block the views and viewplanes of the mountain. From some viewpoints, the TMT Observatory would be located in front of one of the domes of the existing Keck or Subaru Observatories and/or the lower portion obscured behind a rise of Maunakea.

The TMT Observatory would add a new visual element within the views of Maunakea for approximately 14 percent of the island area. However, current observatories can already be seen in most of that area. Figure 3-34 shows the visibility/viewshed of the existing observatories on Maunakea combined with the viewshed of the TMT Observatory. The green shaded area indicates where the existing observatories on Maunakea are visible, which is approximately 43 percent of the island. Roughly 72 percent of the island of Hawai'i's population, or 107,000 people, live within the green shaded area. The portions of the island that are shaded in red in Figure 3-34 are areas where the TMT Observatory would be visible and where currently none of the existing observatories can be seen. The new area where an observatory would be visible is roughly 1.2 percent of the area of the island. Using the 2000 U.S. Census average household size of 2.75 people for the County of Hawaiʻi, the estimated number of people living in this area is 72.

The visual impacts of the foreseeable actions can be summarized as follows:

- Decommissioning of the CSO facility would result in a minimal decrease in the cumulative visual impact. The CSO is only visible from approximately 5 percent of the island; it is not visible from Lake Waiau or Puʻu Līlīnoe, but is visible from Kūkahauʻula's and Puʻu Waiau's summits. Therefore, there would be an incremental decrease in the visual impact from the summit of Puʻu Waiau and Kūkahauʻula.
- The addition of new SMA pads and antenna would not result in substantial new visual impacts as the individual antennas are small and would most likely be largely hidden from view by the placement on the northern plateau behind the change in slope. The SMA area is visible from Kūkahauʻula's summit, but the addition of one antenna to the existing eight would be a small incremental impact. The area is not visible from Puʻu Līlīnoe or Waiau.

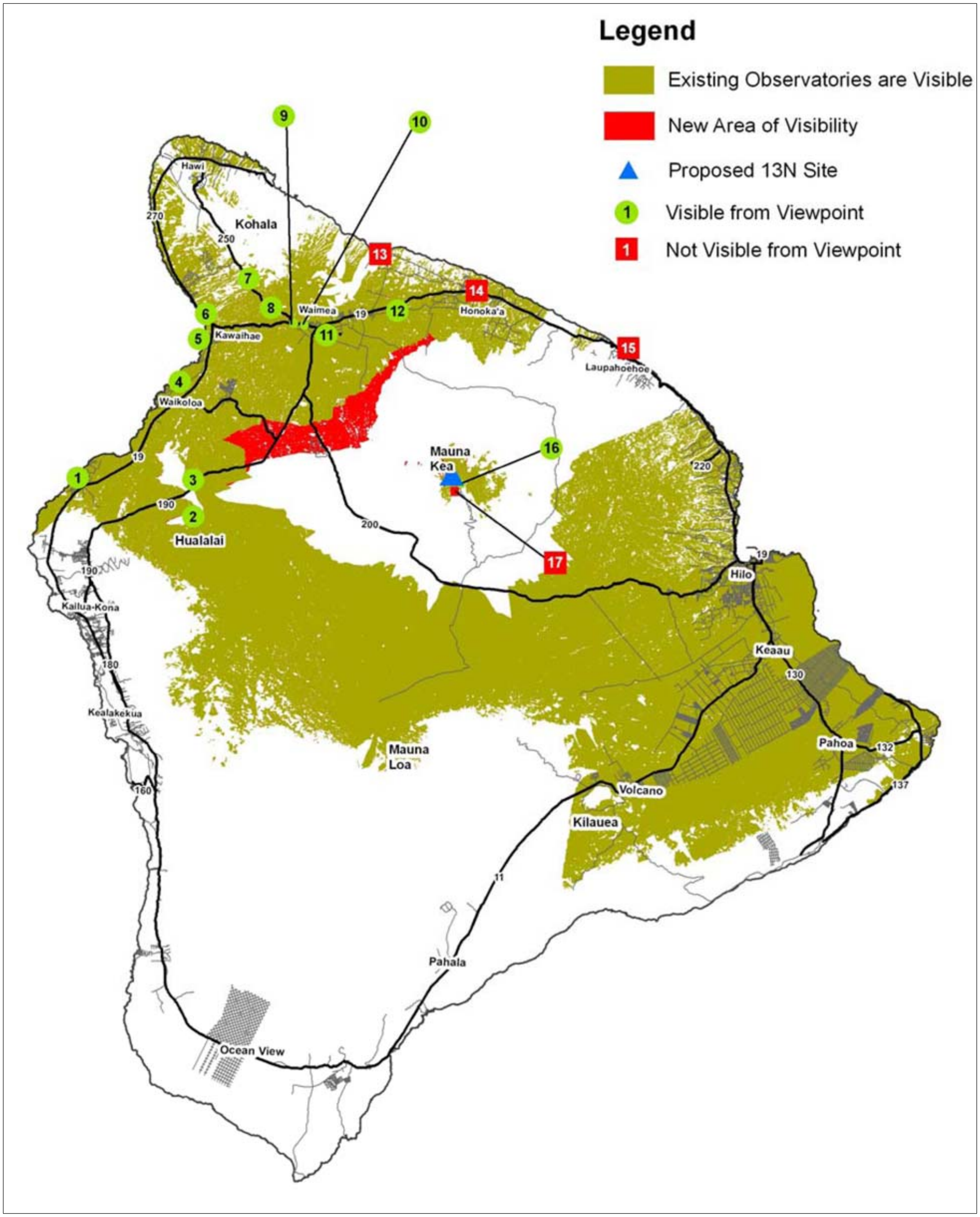

Figure 3-34: Cumulative Viewshed Analysis

- Pan-STARRS would alter an existing element in the viewshed (redevelopment of the existing UH 2.2 meter observatory). The UH 2.2 meter observatory is seen from roughly

36 percent of the island, including the summits of Kūkahauʻula, Puʻu Līlīnoe, Puʻu Waiau. The Pan-STARRS viewshed would be smaller than that of the existing UH 2.2 meter observatory because its dome would be roughly 15 feet shorter. The Pan-STARRS dome is being designed, through the OMKM design review process, to blend in with surroundings and be less obtrusive than that of the UH 2.2 meter observatory; therefore, a small incremental benefit would be realized.

- The paving of the Maunakea Access Road is not expected to have an additional cumulative visual impact; the road is present today and road grades and embankments would not need to be modified significantly to allow paving.

The incremental increase in cumulative visual impact due to both the Project and the foreseeable actions would be less than significant. Nonetheless, when combined with the existing conditions, the cumulative visual impact of development on and near the summit of Maunakea would continue to be significant.

Due to the limited visibility of Hale Pōhaku, the low level of foreseeable actions in Hale Pōhaku, and the compliance of those actions with OMKM design review guidelines, the Project and other foreseeable actions would not significantly affect Visual and Aesthetic Resources in the area.

Geology, Soils, and Slope Stability

The Project and other foreseeable actions would involve construction of the facilities, access roadways, and vehicle travel during operation. With the implementation of proper construction techniques and procedures, and mitigation measures to reduce vehicle travel, the Project by itself or in combination with other foreseeable actions would not result in a significant impact on geology, soils, or slope stability. The Project and other foreseeable actions, including redevelopment of the current UH 2.2 meter observatory site by Pan-STARRS, would not further level the ridge or top of any cinder cone or displace large volumes of cinder.

Potential increases in human foot traffic, due to an increase in recreational visitors, can accelerate degradation of cinder cone slopes and disturb natural habitats. These impacts can be reduced by educating visitors regarding the sensitive nature of the ecosystem and encouraging them to stay on roadways and established trails, as envisioned in the CMP.

The incremental increase in cumulative impact related to the foreseeable actions would be small. However, when added to the existing level of cumulative impact, the level of cumulative impact on geology, soils, and slope stability would continue to be significant, primarily due to the alteration of cinder cone morphology along the ridges of Kūkahauʻula.

Water Resources and Wastewater

The Project would slightly alter the drainage pattern along the Access Way and at the TMT Observatory. The addition of two small SMA antenna pads would not disrupt drainage patterns and the redevelopment of the UH 2.2 meter observatory site by Pan-STARRS would not change the current drainage pattern. Precipitation in these areas is limited and the ground very permeable; therefore, these actions are not anticipated to significantly modify drainage patterns.

The paving of the 4.6-mile currently unpaved section of the Maunakea Access Road would increase runoff along the road. Paving the road would reduce the volume of sediment carried off the road surface and downslope. With proper design the small increases in runoff volume would be addressed so that this project would be an improvement over existing conditions.

The TMT Observatory would contain all domestic and mirror washing wastewater, and thus would not contribute to any discharge of wastewater at the summit area. The Project would not substantially alter or disturb surface water or drainages. The use of potable water associated with the Project would be relatively limited and would not substantially affect supply capacity.

The decommissioning and removal of the CSO would remove its use of potable water and its wastewater generation and discharge. The additional antenna at the SMA would not generate wastewater nor consume potable water. The operations plan for Pan-STARRS would result in a reduction in the volume of potable water used and, therefore, would generate less wastewater because fewer people would be needed to operate and maintain Pan-STARRS relative to the current UH 2.2 meter observatory. In addition, because Pan-STARRS is classified as a major project, OMKM would require that all wastewater generated by the facility be removed from the mountain instead of discharging to a septic system as currently done at the UH 2.2 meter observatory. Thus, the addition of the Project together with the future foreseeable project would have a relatively small incremental impact; and the level of cumulative impact on water quality and resources would continue to be less than significant.

Solid and Hazardous Materials and Waste

The TMT Observatory would dispose of all waste in compliance with the existing regulations and requirements and thus would not contribute to any discharge of solid or hazardous waste at the summit. No mercury would be stored or used. The Project would develop and implement a WMP, a Materials Storage/Waste Management Plan and a component SPRP. Facility engineering measures would also be taken to provide proper chemical and fuel storage enclosures. Both the SPRP and the engineering measures would protect against the release of chemicals or fuel to the environment. Engineering measures would include draining all potentially chemically-impacted wastewater, such as mirror washing wastewater, in double-walled pipes and capturing it in double-walled storage tanks within the TMT Observatory. Fuel storage and piping would also be double-walled and be equipped with leak monitors. The SPRP would require inspections to ensure that systems are working properly, no leaks are occurring, and any necessary maintenance measures are taken.

The decommissioning and removal of the CSO would remove its associated generation of hazardous and solid wastes, while the operation of additional antenna at the SMA would generate minimal wastes. Pan-STARRS would replace a facility (the UH 2.2 meter observatory) that currently uses mercury. Overall, Pan-STARRS use of hazardous materials and generation of waste would be similar to that of the current UH 2.2 meter observatory, but would not include mercury. Like the Project, the foreseeable future actions would dispose of all waste in compliance with the existing rules and regulations and, therefore, would not contribute to any discharge of solid or hazardous waste at the summit.

The paving of the 4.6-mile currently unpaved section of the Maunakea Access Road would make the road safer and reduce the likelihood of accidents. Therefore, the release of fuel and oil from vehicles involved in accidents would be reduced and the likelihood of a material or waste being spilled during transport would also be reduced.

Thus, the addition of the Project together with the future foreseeable actions would have a small incremental impact; and the level of cumulative impact would continue to be not significant.

Socioeconomic Conditions

The Project would provide both construction and operational employment opportunities. Full-time astronomy employment levels would increase by about 23 percent with the addition of about 140 positions to the 611 jobs currently directly provided by the existing observatories. Additional direct and indirect economic benefits to the County and State would be generated through local and state tax revenues and fees paid by TMT and the TMT personnel, locally obtained goods and services, and potential additional Federal funding to support for the premier astronomy programs at UH Hilo, Mānoa, and on Maui. Thus, the Project's contribution to the cumulative socioeconomic impact in the future would be substantial and beneficial to both local communities and the State. Other foreseeable actions, such as the decommissioning of CSO, Pan-STARRS, the addition of an antenna at SMA, and paving of the Maunakea Access Road would generate construction employment opportunities and revenues associated with purchases of good and services. This cumulative socioeconomic impact would be beneficial. Removal of the CSO and redevelopment of the UH 2.2 meter observatory with Pan-STARRS would eliminate some full-time jobs and relocate others among the remaining facilities; the creation of new employment by the Project would result in an overall increase in the number of jobs at the astronomy facilities.

The Project, together with these future foreseeable actions, would result in an incremental beneficial cumulative effect, and the level of cumulative socioeconomic impact would continue to be substantial and beneficial.

Land Use Plans, Policies, and Controls

The CMP identifies the management actions necessary to properly address the needs of the full range of uses on Maunakea. The Project would ensure that all requirements of the CMP are met by appropriately including those requirements in the facility siting, design standards, features, and operational procedures, as well as through implementation of the mitigation measures outlined in this EIS. Other foreseeable actions of decommissioning of CSO, Pan-STARRS, and the addition of an antenna at SMA, would all be required to comply with the CMP and other existing requirements, ensuring that no land use planning conflict would occur. Paving the remainder of the Maunakea Access Road could increase the potential for land use conflicts by improving access to the summit region. It is assumed that the CMP and its components could be adjusted to address potential conflicts resulting from improved access. Therefore, the cumulative effect related to land use plans, policies, and controls would be less than significant.

Roadways and Traffic

The additional traffic generated by the Project would result in a minor increase in existing traffic volumes, and would not result in a change in level-of-service (LOS) along Saddle Road or Maunakea Access Road. The implementation of the Ride-Sharing Program would reduce the number of Project-related trips to the summit area.

The removal of the CSO facility would result in fewer trips to the summit. The addition of antennas at the SMA would generate minimal and infrequent trips because the maintenance of new antennas could be performed by the current personnel. The redevelopment of the UH 2.2 meter observatory with the Pan-STARRS project would reduce the number of trips to the summit because the planned remote and/or robotic operations would require fewer people and visits. In addition, as technology allowing remote access and control of telescopes continues to improve, more astronomers are likely to access data remotely, decreasing the amount of traffic travelling to the summit.[65]

The paving of the 4.6-mile currently unpaved section of the Maunakea Access Road could make the road safer and reduce the likelihood of accidents. It could also raise the speed at which vehicles travel along the road, potentially reducing safety. To truly improve safety it may be necessary to police compliance with a speed limit. Paving the road would also increase the accessibility to the summit region. Visitors are the most likely to take advantage of this accessibility; however, it is not known if this project would result in rental car companies lifting their restrictions of their vehicles travelling beyond Hale Pōhaku. Maunakea would continue to be a remote destination requiring a large part of the day to visit. The potential increase in traffic related to the paving of the road is not expected to result in a change in the LOS along the access road.

Therefore, the cumulative effect of the Project together with foreseeable future actions would be less than significant as the existing roads are sufficient to handle this level of traffic, and it does not represent a significant impact to the roads and level of traffic. However, the existing cumulative impact of vehicular trips from visitors, observatories, and others is considered significant for the Maunakea environment. The impact related to the number of visitors is demonstrated by the level of impact on biological and other natural resources.

Power and Communications

The Project facilities would use electricity and communication systems. To convey electricity, a new transformer would be installed at the HELCO site. In compliance with existing requirements, energy-conserving lighting, appliances, and systems would be used in the TMT Observatory, TMT Mid-Level Facility, Headquarters, and Satellite Office to reduce energy use. Additionally, as a component of the Waste Minimization Plan, an annual audit of energy use by the Project would be conducted and include examining methods available to reduce energy use. The TMT Observatory would utilize the communications system present in the summit area.

Decommissioning of the CSO facility would result in a decrease in energy use within the Astronomy Precinct. The addition of an antenna at SMA and the Pan-STARRS observatory would only incrementally increase the energy use at those facilities. These projects would not significantly increase communications demand in the summit area. Overall, the addition of Project together with these foreseeable future actions would result in a small incremental impact that is not substantial, and the future level of cumulative impact would continue to be less than significant.

Noise

Traffic and the associated incidence of transient noise would occur due to Project personnel commuting to and from the TMT Observatory and other facilities plus additional visitors that

[65] Mauna Kea Comprehensive Management Plan Environmental Assessment

may be attracted to the summit area by the new observatories. Through the conservation district from Hale Pōhaku to the TMT Observatory the increase in traffic related to the Project would generate transient noise during shift changes only. The noise generated by the TMT Observatory during the day would be limited to HVAC equipment. At night, the bulk of the HVAC equipment would not operate, only the motors used to rotate and open the dome would generate noise at night. Those motors would be located inside the observatory building and enclosed by the structure's walls and would not be audible from outside. Project generated noise would not exceed the Class A standard. Overall, it is anticipated that the operation of the TMT Observatory would result in a negligible increase in noise and a minor increase in vehicular traffic noise at Hale Pōhaku and along the Maunakea Access Road.

The removal of the CSO facility would end its operational noise and reduce noise associated with current vehicle trips to that observatory. An additional antenna at the SMA facility would generate minimal noise, as would the operations of the Pan-STARRS telescopes at the UH facility. Increased access related to paving the remainder of the Maunakea Access Road could increase transient noise from vehicles. However, this could be offset by using smaller and more fuel efficient vehicles to reach the summit instead of the currently required 4-wheel drive vehicles, which tend to generate more noise.

Overall, ambient noise levels would not be significantly increased with the addition of the Project and the foreseeable projects.

Air Quality, Climate, and Lighting

The existing air quality at Maunakea is excellent. The Project would generate minimal air pollutant emissions during it operations, primarily from vehicle travel by its personnel. Those exhaust emissions would be small and would not significantly affect air quality. Removal of the CSO facility would reduce vehicular emissions currently associated with staff trips to the facility, and the additional antenna at the SMA facility would generate minimal emissions, primarily associated with standard maintenance. The Pan-STARRS development would replace the existing UH 2.2 meter observatory; the difference in air pollution due to this replacement would be minimal, if any. Paving the Maunakea Access Road could result in increases in vehicle emissions, which could be offset by the ability to use smaller and more fuel efficient vehicles to reach the summit area. Paving the road would also reduce the generation of fugitive dust, improving air quality. In the short-term, the Project together with the foreseeable actions would generate dust and air pollutant emissions associated with construction. However, even with the addition of such emissions, the cumulative impact would be less than significant due to Maunakea's geographic and meteorological isolation, the temperature inversions, and strong winds that aid rapid dispersion of these pollutants. Attainment status with all ambient air quality standards would continue.

Potential threats from climate change involve alteration of weather patterns, such as changes in rainfall or wind. While the impacts of climate change on MKSR are unknown, results of some general climate circulation model runs suggest that the trade winds inversion will be more persistent. With more persistent inversion, the capping of local air pollutants at about 7,000 feet would continue. Weather pattern changes are also expected to result in a reduction in the number of storm events and subsequently lower annual precipitation on Maunakea's summit and upper slopes. Such a change may impact the volume of the annual snowpack and its persistence.

This in turn is expected to alter the special distribution and density of flora and fauna in both alpine and subalpine ecosystems of Maunakea. It is unlikely that the human-use activities occurring on Maunakea are contributing proportionally more to climate change than those occurring at other elevations in Hawai'i, or at other locations on Earth. All human activities that involve consumption of fossil fuels are contributing to global climate change, and any activities that can reduce this consumption would help reduce the impacts of climate change.

The Project includes a range of measures that would help reduce its consumption of fossil fuels either directly or indirectly. Among those are the Waste Minimization Plan and component annual energy audit, Ride-Sharing Program, use of energy efficient lighting and other features and processes, and overall consideration of sustainable practices in operations.

The Project, together with the foreseeable actions, would not change the island's climate; however, as all human activities do, they would incrementally contribute to the cumulative global climate change effects. It is unlikely that those projects would contribute proportionally more to climate change than those occurring at other elevations in Hawaiʻi, or at other locations on the planet.

The addition of Project together with the foreseeable actions would not change the characteristics of Maunakea that make it one of the best sites in the world for astronomical observations, including its very dark sky. This results from the summit's remoteness from urban development, as well as the County of Hawaiʻi's island-wide lighting ordinance requirements that have resulted in the exclusive use of LPS outdoor lighting. The level of cumulative sky illumination impact associated with past, current, and foreseeable future uses and activities would be small and less than significant.

3.16.5 End of Lease

The current lease UH holds on the MKSR will end in the year 2033. As it is unknown at the present what will transpire at that time, the following two possible scenarios are considered:

1. UH, or some other entity, would extend the lease or enter into a new agreement that would allow all observatories (both the existing and those that are potentially foreseeable actions) to continue operation beyond 2033. The observatories would continue to implement the necessary environmental protections and mitigation measures required by the CMP and all other applicable rules, regulations, and requirements.
2. All observatories, support buildings, and underground structures within the MKSR would be decommissioned and completely removed; Maunakea Access Road and the Hale Pōhaku facilities would remain. The decommissioning activities would be conducted in accordance with applicable rules, regulations, and requirements, so that impacts to cultural and biological resources would be minimized. The appropriate level of restoration would be determined for each decommissioned site. The three levels of restoration are:
    - Minimal – would include the removal of all man-made materials and the grading of the site.
    - 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.

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

Scenario 1

Pursuant to this scenario, the level of cumulative impact would remain the same as that discussed above in Section 3.16.4. Continued operation of the observatories beyond the year 2033 would have little to no new adverse incremental impacts; the level of cumulative impact would continue as described above. Similarly, astronomy would continue to provide substantial beneficial effects to the local and State economies, employment, and education. Maunakea would remain a premier ground-based astronomy location in the world and the nation, and Hawaiʻi would continue to attract the best astronomers and astronomical research projects and programs.

Although the only foreseeable observatory decommissioning at this time is the decommissioning of the CSO and restoration of its site, it is likely that by 2033 other observatories would be reaching the end of their useful life and either (a) be replaced as envisioned in the 2000 Master Plan, or (b) decommissioned without replacement.

Under this scenario, the number of employees at and visitors to the MKSR would likely remain similar to those anticipated if the potential foreseeable actions are realized.

Scenario 2

Should all the observatories be dismantled at the end of the current lease in 2033, there would not be enough surplus cinder on Maunakea to provide for moderate or full restoration of all the observatory sites. If moderate or full restoration were to be desired for each existing observatory site, cinder would have to be imported from off-mountain locations. If imported material was found to be unacceptable, then each site would be restored to the extent possible, and left clean with adequate drainage controls installed to prevent erosion at any of the minimally restored sites. Decommissioning activities would be phased over a number of years to avoid potential significant impacts to other uses on Maunakea. With careful phasing and planning, many potential adverse impacts to the various resources on the mountain from activities involved in the dismantling of the observatories would be mitigated during the decommissioning process. Overall, impacts of decommissioning and restoration activities are expected to be temporary, transient, and not significant.

Pursuant to this scenario, the number of employees in the summit region of Maunakea would be significantly reduced and likely only include rangers, once decommissioning activities were complete. Local residents would still likely visit the summit area in similar numbers as they presently do for recreational activities - such as snow play, and cultural and religious practices. Visits to the summit region by tourists would likely decrease slightly; however, ecotourism and other tour activities, including star gazing, would likely continue, if allowed.

The ultimate cumulative impact of the resulting restoration of the sites of current observatories would be beneficial, particularly in terms of visual and landform effects, and the effects on the physical habitat. The cumulative impact of decommissioning and restoration is discussed in more detail in the following sections.

Cultural/Archaeological Resources

All observatories would be required to implement appropriate measures and precautions to ensure that known cultural resources in the surrounding area would be protected, and to allow for the protection of potential unknown resources that could be found during decommissioning activities. Because the observatory sites have been disturbed during construction, cultural resources should not be directly or adversely impacted during decommissioning. Vibrations caused by demolition equipment could indirectly impact the stability of shrines and other physical features on the mountain; such resources would have to be considered when developing a decommissioning plan for each individual observatory. Cultural practices on Maunakea would likely be impacted due to the presence of decommissioning and restoration workers, vehicles, and equipment and the decommissioning activities; this impact would continue for the duration of decommissioning of all observatories.

Should observatory sites be restored minimally, and no off-mountain cinder imported, the topography of Kūkahau‘ula could not be restored. Thus, a substantial adverse cumulative impact to the spiritual and sacred nature of Kūkahau‘ula would persist following decommissioning and restoration.

Should off-mountain cinder be imported and full restoration be done, the topography of Kūkahau‘ula would be restored. However, some have suggested that the import of off-mountain cinder would not be appropriate and even though the topography were restored, a substantial adverse cumulative impact to the spiritual and sacred nature of Kūkahau‘ula would persist.

The expected reduction in the number of employees at and visitors to the summit region would reduce the potential for impact on physical cultural/archaeological resources, but not directly reduce the existing level of cumulative impact on those resources. The reduced number of employees and visitors could, however, reduce the level of impact on cultural practices following the decommissioning.

Biological Resources

The flora of the mountain would likely not be subject to long-term adverse impacts due to decommissioning activities. The observatory sites were previously disturbed during construction, and it is expected that little flora would be directly impacted by the decommissioning activities. Nearby flora and Wēkiu bug habitat may be subject to fugitive dust, but careful attention to dust control measures would minimize possible impacts to these resources. Vibrations caused by demolition equipment could impact the stability of the pu‘u and Wēkiu bug habitat, and work in these areas would require careful planning and mitigation measures to prevent the loosening of cinder and destabilizing the slopes of the pu‘u.

Minimal restoration of the observatory sites would not restore Wēkiu bug habitat on the alpine cinder cone. Therefore, the level of existing cumulative impact on the alpine cinder cone ecosystem would continue at its current level. Should moderate or full restoration be completed using imported off-mountain cinder, the level of cumulative impact to the alpine cinder cone ecosystem could be incrementally reduced.

A reduction in the number of employees and visitors in the summit region could reduce the further incremental impact to habitat caused by walking over cinder, or walking off trails in general.

Visual and Aesthetics

Upon the complete removal of all observatory components and minimal restoration of all sites, all machinery and debris would be removed and the visual impact would be significantly reduced. The original topography of the mountain would not be fully restored however, and sites could still show evidence that they had been the locations of large structures.

Should new cinder be imported from off-mountain and full restoration performed, the visual impact could be further reduced. However, it is unlikely that imported cinder would match the color of native cinder, and thus such cinder could look out of place.

In either case, the cumulative visual impact following decommissioning would be significantly reduced, but since the original topography and appearance could not be fully restored, a moderate level of cumulative impact would continue for on-mountain users.

Geology, Soils, and Slope Stability

Minimal restoration of the observatory sites would not result in a change to the existing substantial and significant cumulative impact, which is primarily due to the alteration of the cinder cone morphology.

If off-mountain material is imported and full restoration is performed so that puʻu topography is restored to preconstruction condition, there is a possibility for impacts due to the imported material not having settled naturally and being less stable than the material below it. Cinder may loosen and in traveling to the base of the puʻu, could impact the area around it, and the slope stability of the puʻu would not be able to be fully restored. Although the full site restoration could reverse the existing significant adverse cumulative impact to the puʻu cinder cone morphology, the introduction of non-native cinder and slope stability concerns could result in a continued significant adverse cumulative impact.

Solid Waste

Due to the number and size of the observatories on Maunakea, their removal would generate an extremely large amount of solid waste. Some of the materials could and would be reclaimed or recycled, but it is anticipated that a large amount of the material would need to be disposed of at a landfill. However, the daily generation of solid waste by observatory operations would cease. Therefore, the current less than significant level of cumulative solid waste impact would be incrementally reduced.

Socioeconomics

The removal of the observatories would effectively remove astronomy from Maunakea resulting in an adverse impact to local and State economies, as well as employment and educational opportunities. The State and local economies benefit from approximately $72.4 million per year currently infused into them by astronomy. It is likely that this amount would increase between now and 2033 due to the Project and other foreseeable actions, but it would cease after the year 2033 pursuant to this scenario. The current 885 long-term astronomy jobs together with additional jobs created by the Project and other foreseeable actions would be lost, along with those indirect jobs that astronomy generates throughout the local and State economies. Many of these jobs are in highly skilled occupations that would be lost to the State and local job bases.

The educational opportunities provided to the students and residents of the community and community at-large by the astronomy facilities and programs, would no longer be available. Maunakea would no longer be the premier host of astronomy, and the activities conducted there, and their associated benefits, would likely move to other locations around the world. Because the observatories provide funding for the support activities on Maunakea, such as road maintenance, Hale Pohaku facilities and the Visitor Information Station, other sources would need to be found to continue these operations. In addition, other sources of funding would need to be found to continue the ranger and cultural interpretive programs.

The socioeconomics impact due to decommissioning would be adverse and substantial, essentially eliminating the existing cumulative benefit.

Roadways and Traffic

Demolition workers, same as construction workers, would be required to carpool to the summit, reducing the amount of traffic generated from decommissioning activities. The number of trucks travelling to the summit area during decommissioning would be controlled by phasing so that the same heavy machinery and equipment would be used for the duration of the decommissioning of all observatories on the summit. There would still be heavy trucks accessing the mountain, including water trucks and trucks to haul demolition debris down the mountain from the sites. All reasonable efforts would have to be made to coordinate accessing the demolition sites with times of low traffic to reduce the likelihood of delays for those attempting to access Maunakea.

Additional trucks would be travelling on Maunakea Access Road should cinder be imported to facilitate full restoration. More than 10,000 cubic yards of cinder would need to be imported to fully restore all the observatory sites, resulting in a substantial number of additional truck trips.

After the decommissioning is finalized, the number of trips to the summit area would be reduced, incrementally reducing the cumulative impact to roadways and traffic.

Noise

The removal of the observatories would generate localized noise for the duration of the decommissioning process. In the long-term, the noise in the summit area would be reduced due to elimination of trips to and from observatories and absence of the observatories HVAC systems. Therefore, the current less than significant level of cumulative noise impact would be incrementally reduced.

Other Resources

Following decommissioning of the observatories, the demand for potable water in the summit area would be substantially reduced. Hazardous materials and hazardous waste would no longer be used or generated in the summit area and domestic wastewater would no longer be disposed of using septic systems.

Land use plans, policies, and controls would not be substantially impacted by the removal of the observatories. The land would remain ceded lands, classified as Conservation, Resource subzone, and all other activities would continue to be allowed.

Power and communications would not be significantly affected by the decommissioning of the observatories. The power used by the observatories represents a small fraction of the power generated on the island. The communications system would continue to operate normally for the island.

Climate, meteorology, air quality, and lighting would not be significantly affected by decommissioning. The reduction in the number of trips and visitors to the summit area due to removal of the observatories could reduce the production of fugitive dust in the long-term.

3.16.6 Cumulative Impact Conclusions

From a cumulative perspective, the impact of past, present, and the Project together with other reasonable foreseeable future actions on cultural resources is substantial, adverse, and significant. The cumulative impact to geologic resources in the astronomy precinct has been substantial, adverse, and significant. The cumulative impact to the alpine shrublands and grasslands and māmane subalpine woodlands has also been substantial, adverse, and significant, primarily due to grazing by hoofed animals. The magnitude or significance of cumulative impact to the alpine stone desert ecosystem is not yet fully determined.

The cumulative socioeconomic impact is substantial and beneficial.

In general, the Project would add a small increment to the level of cumulative impact, but would not tip the balance of any specific cumulative impact from a less that significant level to a significant level.

3.17 Relationship of Short-Term Uses and Long-Term Productivity

Short-term uses are those that would occur during the lifetime of the Project, while long-term productivity is in reference to the timeframe beyond the completion of the life cycle of the Project.

The TMT Observatory would occupy approximately 5 acres of land within Area E of the Astronomy Precinct in the MKSR. Any Project effect on the Native Hawaiian cultural environment and the visual environment would cease upon the decommissioning of the TMT Observatory, and the long-term productivity of the area would be restored to the preconstruction level. The use of the land for an astronomical observatory would be in compliance with existing land use policies; when the Project reached the end of its life cycle, the land would be available for other beneficial uses in the future and remain consistent with the land use policies for the Astronomy Precinct. The Project would not result in a substantial adverse effect to the long-term productivity of the environment because the Project would not be sited in an area considered to be exceptional or unique with respect to natural resources. The use of water, electricity, and roadways would result in a slight increase in demand in the short-term, but the long-term productivity and capability of these resources would not be inhibited by the Project.

Short-term, the Project would introduce a prominent scientific institution to Hawai‘i, serving to enhance its leadership role in the field of astronomy. The Project would also boost the growing research and development industry while providing unique employment and educational opportunities for residents. Upon the completion of the Project, other viable technology-based opportunities or businesses may have arisen and could remain as long-term opportunities for residents.

The short-term use of resources by the Project represents a valuable effort to conduct groundbreaking astronomical research, and would not result in a substantial adverse impact to the long-term productivity of any resources.

3.18 Irreversible and Irretrievable Commitments of Resources

The Project would require the commitment of natural, physical, and human resources to plan, design, and develop; to construct and operate; and ultimately to decommission the TMT Observatory. A commitment of resources is irreversible when primary or secondary impacts limit the future options for a resource; an irretrievable commitment refers to the use or consumption of resources that are neither renewable nor recoverable for future use.

The Project would result in such commitments of some resources. The electrical power that would be used by the Project would be supplied largely through fossil-fuel power generation by HELCO, though it is important to note that some power supplied by HELCO originates from renewable resources and that percentage could increase over the life of the Project. Also, relatively limited amounts of natural and propane gas and diesel fuel would be used during various stages of the Project. Building materials would be used for the Project facilities; some of those materials could ultimately be recycled for reuse in the future, those that are not would be expended. Solid waste generated by the Project would occupy space at a landfill; even with the implementation of waste minimization, recycling, and sustainable practices outlined, some solid waste would be generated and require disposal at a landfill. The human labor required during construction, operation, and decommissioning/site restoration would be expended and unable to be recovered. However, none of these resources are considered to be in short supply, and the commitment of them to the Project would not have an adverse effect on the continued availability of these resources.

The Project would not result in such commitments in multiple areas. Regarding cultural, archaeological, and historical resources, any potential impacts due to the Project would cease upon the decommissioning. While the TMT Observatory site may be suitable habitat for moss, lichen, or ferns that occur in the Alpine Stony Desert ecosystem, there is substantial habitat for these species, and the area would be returned to suitability habitat upon completion of decommissioning. The visual and aesthetic impact would likewise come to a close once the TMT Observatory was decommissioned. It is planned that the geology of the site would be restored using the previously excavated materials, to the extent practicable. Water would be used by the Project, but would be treated at a wastewater treatment plant and returned to the naturally occurring cycle after treatment. Any noise associated with the Project would stop once the Project was decommissioned, as would any impacts to air quality. The Project would not have an adverse effect on the future options for any resource, and any uses of those resources would be renewable or recoverable.

3.19 Required Approvals and Permits

This section provides information about the necessary approvals required for the Project from governmental agencies, boards, or commissions or other similar groups with jurisdiction over specific components and/or activities of the Project. The status of each identified approval is discussed.

The acceptance of the EIS pursuant to HRS, Chapter 343 by the Office of the Governor is a requirement for the Project in its entirety. Below, required permits are listed specifically by Project development.

3.19.1 TMT Observatory and TMT Mid-Level Facility

A set of approvals that cover all Project activities on conservation land leased by the UH including the TMT Observatory below the summit and TMT Mid-Level Facility at Hale Pōhaku, would be required. The required approvals include:

- **State Historic Preservation, Chapter 6E Consultation**. The State of Hawaiʻi, DLNR, SHPD and SHPO are jointly responsible for participating in this coordination process. The consultation has been taking place and will continue to take place in parallel with the Chapter 343 EIS process.
- **Office of Mauna Kea Management (OMKM) 2000 Mauna Kea Science Reserve Master Plan Project Review/Approval Process**. The Master Plan Project Review/Approval Process consists of a number of steps designed to keep projects in compliance with the Master Plan. The MKMB has designated the Project a major project and began the Master Plan Review/Approval process. The "pre-design" phase of the review has been performed by a Design Review Committee; the "schematic" design review phase has begun but is not complete. Future process steps include a design development review/approval by the Design Review Committee, followed by required approvals from the MKMB, UH Hilo Chancellor, the UH President, and the UH BOR prior to the submittal of the CDUP application. Input from Kahu Kū Mauna is sought throughout the Master Plan Review/Approval process.
- **Conservation District Use Permit (CDUP)**. The CDUP is triggered by the use of conservation lands. Approval of this permit lies with the State of Hawaiʻi BLNR. The permit process is managed by the DLNR, Office of Conservation and Coastal Lands (OCCL). The CDUP process has not begun yet but would commence once the Project Final EIS is accepted and the required CMP sub plans had been submitted to the BLNR.
- **National Pollutant Discharge Elimination System Permit (NPDES)**. The NDPES general permit covering discharge of storm water associated with construction activities would be required because the construction area would exceed one acre of disturbed land. The HDOH is responsible for administering, reviewing and approving this permit, pursuant to the Clean Water Act, Section 402.
- **Community Noise Permit and Noise Variance**. The Noise Permit is required for any standard construction activity. The noise variance would be required for Project construction activities generating noise above the allowable levels and/or construction

activities taking place outside of normal work hours. The HDOH Indoor and Radiological Health (IRH) Branch administers the Community Noise Permit and Noise Variance.

- **Oversize and Overweight Vehicles Permit (OOVP)**. The State of Hawaiʻi DOT administers the OOVP, which would be required for a number of the loads transported from port facilities to the TMT Observatory.

3.19.2 Headquarters and Satellite Office Facilities

Because the Headquarters and Satellite Office would not be located in the conservation district a CDUP would not be required. Similarly the Master Plan Review would not be required because the Headquarters and Satellite Office would not be located in an area administered by OMKM. Approvals that would be required, with some variation depending on whether Headquarters (Hilo) or the Satellite Office (Waimea) is being discussed, include:

- **State Historic Preservation, Chapter 6E Consultation**
- **NPDES**
- **Community Noise Permit**
- **Underground Injection Control (UIC)**. A UIC permit would be triggered by storm drain dry wells (Headquarters and Satellite Office) and/or wells used for the subsurface disposal of wastewater (Satellite Office). The HDOH Safe Drinking Water Branch manages the UIC permit process.
- **General Permit for Treatment Works** (Satellite Office only)
- County of Hawaiʻi, Department of Public Works:
    - **Building Division Approval and Building Permit**
    - **Grading and Driveway Permit**
    - **Drainage Approval**
- County of Hawaiʻi, Planning Department
    - **Plan Approval**
    - **Planning Director Height Variance** (Headquarters only)

Actions to obtain all these required approvals and permits would commence once final locations for the Headquarters and Satellite Office are selected and the level of study and/or design is sufficient to support the necessary submittals.

3.20 Unavoidable Adverse Impacts

Probable long-term unavoidable and adverse impacts related to Project operation include the following:

- Two "find spots" would be displaced by Project developments (Section 3.3.3).
- Flora and fauna at the Project sites would be displaced by Project developments (Section 3.4.3).
- A new element would be added to the view of Maunakea from the northern portion of the island, including Honoka'a, Waimea, and Waikoloa (Section 3.5.3).
- Geologic resources would be displaced by Project developments and topography would be modified to allow Project developments (Section 3.6.3).
- Consumption of and demand on potable water (most likely obtained from groundwater resources) would increase slightly (Section 3.7.3).
- Wastewater requiring treatment would be generated (Section 3.7.3); however, none would be discharged within the MKSR.
- Project personnel coming and going to work and Project-related deliveries would add to the number of vehicles on the roads (Section 3.11.3).
- Trucks and vehicles travelling on the unpaved portions of the Access Way and Maunakea Access Road would generate small dust particles. Mitigation measures would be employed to reduce dust generation, but some soil would occasionally be subject to erosion during periods of high winds.
- Increased truck and vehicle traffic would generate emissions. These emissions would be localized and would not impact local or regional air quality (Section 3.14.3).
- Increased truck and vehicle traffic during construction, operation, and decommissioning plus on-site construction and decommissioning activities would generate noise. Noise impacts would be intermittent and/or temporary.

Probable short-term unavoidable and adverse impacts related to Project construction (Section 3.15.1) and decommissioning include the following:

- Small amounts of natural flora and fauna and geological features would be removed during construction, such as in the construction staging areas (these areas have previously been disturbed).
- Soil exposed during construction could experience increased erosion and minor amounts of soil could be carried beyond the limits of construction sites. BMPs would be employed to limit this impact.
- Construction equipment and activities would affect the visual quality of the area.
- The transport of large construction equipment and large TMT Observatory components during construction and decommissioning would impede traffic temporarily along roads utilized. Compliance with OOVP conditions would mitigate this probable impact.

- Increased truck and vehicle traffic and the operation of heavy equipment on construction sites would generate emissions. These emissions would be localized and not impact local or regional air quality.
- Heavy construction equipment operation at construction sites, excavation/grading activities, and trucks and vehicles travelling on the unpaved portions of the Access Way and Maunakea Access Road would generate small dust particles. BMPs would be employed to reduce dust generation, but some soil would occasionally be subject to erosion during periods of high winds.
- Increased truck and vehicle traffic plus on-site construction and decommissioning activities would generate noise. Noise impacts would be intermittent and/or temporary. Compliance with Noise Permit and Noise Variance requirements would mitigate this impact.

Although these potential impacts are considered to be unavoidable at a certain level, compliance with rules, regulations, and requirements plus the proposed mitigation measures would minimize the level of impact and that level would be less than significant.

Notwithstanding these unavoidable impacts, the Project should proceed because the Project would (a) be in compliance with existing land use plans, policies, and controls (Section 3.10.3); (b) provide a socioeconomic benefit to the island community and state (Section 3.9.3 and 3.9.4); and (c) provide for the public good by achieving its purposes and objectives (Sections 2.2 and 2.3).

3.21 Unresolved Issues

Unresolved issues include:

- Selection of the Access Way Option through or around the SMA core. There are three Access Way Options, as described in Section 2.5.2 and illustrated on Figure 2-4. One of the options will be selected prior to the Final EIS.
- Selection of the Headquarters location. Headquarter locations are being considered in Hilo, as discussed in Section 2.5.4 and illustrated in Figure 2-9. One of the options will be selected prior to the Final EIS.
- Selection of the Satellite Office location. Satellite Office locations are being considered in Waimea, as discussed in Section 2.5.5 and illustrated in Figure 2-10. One of the options will be selected prior to the Final EIS and additional cultural and archaeological surveys for the selected location would be performed prior to site development.
- Selection of the TMT Observatory dome exterior finish. A reflective finish is proposed but the level of reflectance to be used has not been established. A selection will be made prior to the Final EIS.
- The mitigation measures presented in this Draft EIS are considered proposed measures to address the potential adverse impacts of the Project. The mitigation measures presented in this Draft EIS will continue to be refined during the public Draft EIS review process, and the resulting final and committed mitigation measures will be outlined in the Final EIS.
- UH has not yet entered into a sublease agreement with the TMT Observatory Corporation. UH, the holder of the MKSR master lease and Project proposing agency, is negotiating with the TMT Observatory Corporation in good faith and has determined it is prudent to proceed with Project planning. The sublease would be negotiated and would include a higher education benefit package to provide funding for selected educational initiatives of UH Hilo and HawCC on the Island of Hawai‘i; a community benefit package to provide funding for locally-chosen and managed educational programs; and observing time for UH. The benefit packages would become a part of a lease or sublease, if TMT decides to come to Hawai‘i. Provided an agreement is reached, details of the benefit packages will be described in the Final EIS.
- The level of decommissioning cannot be selected until OMKM, Kahu Kū Mauna, and other stakeholders evaluate conditions and needs and a cost/benefit analysis is performed as the decommissioning approaches. This Draft EIS evaluates the potential impacts associated with all three levels of decommissioning.

4.0 Alternatives to the Project

This Chapter describes the Project background and history, and the alternatives to the Project, including a No Action Alternative. The potential environmental effects together with the alternative's feasiblity and capablity of achieving the purpose, need, and objectives of the Project are discussed. The environmental effects of each alternative after full compliance with applicable requirements and regulations and implementation of mitigation measures are used as a basis for comparison.

4.1 Project Background and History

The search for the best locations for astronomical observations has been ongoing for more than 50 years and has involved conducting multiple surveys to identify and evaluate potential observatory sites around the world. The TMT Observatory Corporation used these existing surveys and studies, as well as satellite studies of cloud cover and water vapor, and data from established observatory sites in the search.

4.1.1 Location Evaluation

A number of criteria are used to evaluate the quality of a site for astronomical observations and research. The physical characteristics of the site and how they affect the ability to make accurate astronomical observations are a primary concern. A second major consideration is the potential for optimizing scientific productivity based on factors other than the physical characteristics of the site. Another factor of significance includes feasibility and administrative or policy related factors.

Physical Characteristics of a Site

The ideal site for astronomical observation would be perfectly clear every night, the atmosphere stable and dry, the temperature constant, and the wind speed low; a telescope located at such a site could have good observing conditions each and every night. However, this ideal combination of attributes does not exist anywhere on Earth; therefore, the existing physical characteristics at a given site are evaluated to estimate how many days of the year a telescope could make high quality astronomical observations as well as how good the observations would be, on average. The following sections discuss the most important physical characteristics and how they affect observational quality.

Fraction of Clear Nights

A desirable site has a large fraction of clear nights, meaning nights with no cloud cover, during the year. Cloudy nights prevent astronomical observations altogether. More clear nights per year results in being able to make observations over a larger fraction of the time. The fraction of nights suitable for astronomical observations can be determined using historical data for those sites that have hosted observatories for many years, as well as analyzing satellite data that has been compiled over the last 25 years, and measurements that were taken during the TMT site testing process.

Stability of the Atmosphere above the Site

The atmosphere above a ground-based telescope affects the light from astronomical sources in several ways. The constantly moving and varying atmosphere above the telescope bends the light before it reaches the telescope, resulting in the light traveling slightly different paths from one moment to the next. This is what causes stars to appear to twinkle, and for astronomical observations made over periods as short as seconds it results in larger and less detailed images, or blurring. The more turbulent the atmosphere is, the more pronounced this effect is. This effect is called "seeing" and is measured in units of angle called arcseconds (3,600 arcseconds equal one degree of angle). Historically, a site for which the typical seeing image sizes were less than 1 arcsecond was considered a very good site. With the technical advances in new telescopes and the imaging quality expected of current telescopes, sites for which the image size is routinely smaller than 0.75 arcsecond are essential. Sites meeting these conditions are rare.

Poor seeing degrades the quality of observations, adding to the time required to obtain the desired scientific results from an observation. Some types of scientific observations and research become difficult or impossible with poor seeing. Thus, great importance is placed on selecting a site where there is a high percentage of time with good seeing.

Good astronomical sites are typically located on isolated mountains. It is important for the telescope to be above as much of the lower, more turbulent atmosphere, as possible. In addition, the flow of winds over an isolated mountain tends to be more smooth and stable.

There are additional, more subtle characteristics of the atmospheric turbulence above a site that are also important; of particular significance are those affecting the ability to correct for atmospheric blurring using adaptive optics (AO) systems. The two most important characteristics, in addition to the seeing itself, are the length of time during which the image does not change (coherence time) and the area of the sky over which the image does not change (isoplanatic angle). In simple terms this means that the more the atmosphere above the telescope remains constant (or stable), both over the longest period of time and over the largest angle of the sky, the better it is for observations. With longer coherence times and larger isoplanatic angles, the AO-based correction is easier and can be done more effectively. It is possible for one site to have slightly worse "seeing" but better coherence time and a larger isoplanatic angle, and be a better site for a telescope with an AO-based correction system.

Mean Temperature and Temperature Variability

Low mean temperatures are better for observing at infrared[66] wavelengths, which include all wavelengths from 1,000 to 400,000 nanometers (1 to 400 microns). Infrared radiation is emitted from all objects; the more radiation being emitted, the higher the temperature of the object. All parts of the telescope emit infrared radiation and this combines with the actual image of the desired object. The effects of the additional radiation must be removed, which requires more observing time. In some cases, the observations become difficult or impossible. Locating the telescope at a cooler site reduces this effect.

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[66] 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

When different parts of the telescope and enclosure are at different temperatures, heat-induced turbulence occurs. To eliminate this heat-induced turbulence in the observatory dome, the telescope components, including the primary mirror, and the air inside the dome, are actively controlled during the day to match predicted nighttime temperatures. At locations with large day-night temperature fluctuations, this climate control can be very costly.

Telescope systems and instruments need to be optimized to operate within the expected temperature range at the site, as temperature fluctuations can adversely affect the performance of the telescope. This optimization is more difficult and costly when the day-night temperature fluctuations, as well as the annual temperature fluctuations, are large.

Precipitable Water Vapor

Observations of the near and mid infrared wave spectrum (1,000 – 30,000 nanometers) are strongly affected by absorption, or blocking, of the infrared light by water vapor in the Earth's atmosphere. Higher-altitude sites have lower precipitable water vapor, making them the preferred locations for observations of the infrared spectrum.

Latitude

Objects in the sky that can be seen at an observatory are dependent on the latitude, or the location of the observatory with respect to the earth's equator. This affects the science and research that can be conducted. Most important is the availability of specific astronomical observation targets, such as planets, stars, galaxies, and clusters, seen at different latitudes. For example, the nearest dwarf galaxies to the Milky Way Galaxy, the Large and Small Magellanic Clouds, are only observable efficiently from south of the equator. On the other hand, the nearest large spiral galaxy similar to the Milky Way Galaxy, Messier 31, is best observed from north of the equator. Other astrophysical objects, like the Galactic Center, can be observed from either hemisphere.

Importance of Particular Physical Characteristics

In some cases, the importance of a particular physical characteristic varies with the type of astronomical observations to be performed. For example, low water vapor above the site is crucial for observations in the near- to mid-infrared, but is not as important for visible-light observations. The TMT would be used to carry out astronomical observations at wavelengths from near ultra violet light (320 nanometers) to the mid-infrared wavelength (30,000 nanometers). It is anticipated that the mix of TMT observations would emphasize the near- and mid-infrared, focusing on 1,000 to 30,000 nanometer.

Scientific Productivity and Synergy

Another important factor is the potential for increased scientific productivity through synergy with other astronomical observatories and facilities.

There are many potential scientific synergies between the TMT and other existing and planned astronomical facilities. Smaller optical/infrared observatories can provide observation targets for the TMT and carry out supporting science programs that do not require the large light-gathering power and fine diffraction limit of the TMT. Facilities that observe at radio wavelengths would also be able to provide targets for TMT observations and collect supporting complementary scientific information. This synergy increases productivity in conducting science when compared to a single observatory operating independently. Observatories that share common partners are more likely to collaborate and go to greater lengths to work together, including designing and installing complementary suites of instruments on individual telescopes.

Feasibility, Administration, and Policy

Additional important factors include:

Environmental Considerations

It is the policy of the TMT Observatory Corporation to avoid, minimize, or mitigate potential environmental impacts of the Project. The presence of existing infrastructure and partner facilities generally reduces the level of environmental impact a new observatory would cause and increases the feasibility of siting a new observatory at that location.

The physical attributes of the site can affect the level of environmental impact. For example, the geotechnical characteristics of a site, including the type of bedrock, rock formation and stability, and seismic characteristics affect how the site needs to be prepared, what depth and size of foundations need to used, and other similar factors.

Site-dependent Construction Costs

There are differences in the estimated costs of constructing the TMT at different sites. These are based on the presence or lack of existing roads, power and communications infrastructure, local costs of services, and factors that affect the number of annual work days (e.g. weather).

Operating Costs of the Observatory

The annual cost of operating the observatory depends on a number of factors. Local workforce costs and the workforce model, costs of generating or purchasing power, tax obligations, and the ability to share operations with existing partner facilities all effect the annual costs of operating an observatory.

Site-dependent Ability to Attract and Retain Staff

There would be a staff of roughly 140 persons working for the Project in Hawai‘i during operations. Many of the positions require specialized skills in computing, optical-mechanical engineering, and other technical areas; the availability of a local workforce with the requisite skills is a very strong plus for a site. The unique technical systems that make up the observatory make it desirable to have long-term employees, so the availability of housing, quality schools and medical care, and opportunities for spousal employment are also important factors in attracting and retaining employees.

4.1.2 Selection of Maunakea for Further Consideration

The TMT Observatory Corporation used the considerations described above to evaluate potential locations. In June 2008, the TMT Observatory Corporation Board selected Maunakea as the best site in the northern hemisphere; this is the proposed Project which is the subject of this DEIS.

4.2 Alternatives to the Project

Once Maunakea was selected by the TMT Board as a potential location for the TMT Observatory, alternative locations on Maunakea were considererd. Modeling of wind flow over Maunakea indicates that the best conditions for astronomy research may be on the summit ridge, where the existing optical/infrared observatories are located. However, as described in Section 2.5.1, in compliance with the 2000 Master Plan, which outlines cultural, biological, and visual impact concerns, a site in Area A or B on the summit ridge or another cinder cone was not considered for the Project.

TMT evaluated other areas within the 36-acre Area E identified for development of a NGLT in the 2000 Master Plan. Four sites, which were distributed from north to south along the access road within Area E, were considered; the furthest north being the 13N site, which is the proposed Project site, and the furthest south being near the southern boundary of Area E. The southern sites were considered because of the potential reduction in environmental impact associated with a shorter access road to the TMT Observatory when compared to the Project site (the 13N site).

Nearby structures and landforms can produce turbulent wakes that disrupt airflow, resulting in worse seeing conditions, even when considering sites which are close to one another. The cinder cones around the summit of Maunakea can cause such turbulence. The TMT Observatory Corporation performed a computational fluid dynamics (CFD) analysis in which typical westerly (wind from the east) airflow over the summit was modeled to evaluate the effects of turbulence on seeing conditions at the four alternative sites within Area E. The CFD analysis showed that the 13N site and its immediate neighbor to the south, referred to as the E2 site, would provide similar astronomical observational quality. Seeing at the two southern sites within Area E was found to be degraded by between 10 percent and 20 percent. This degradation in image quality is significant and would result in increases of more than 20 percent in the time required to complete a given program. Put another way, such a reduction would essentially render a 30-meter telescope at one of the southern sites equivalent to a 27-meter telescope at the Project's 13N site.

As a result, for this exceptionally unique Project (as defined in Chapter 2), the following are considered to be reasonable alternatives:

- No Action alternative
- Another site at Maunakea, referred to as the E2 site

4.2.1 No Action Alternative

The "No Action" alternative, required to be evaluated in the EIS process, considers existing conditions as well as what would be reasonably expected to occur in the foreseeable future absent the proposed Project, based on current land use plans.

Facilities

Pursuant to this alternative, TMT would not fund construction, installation, or operation of the TMT Observatory and its supporting facilities at Maunakea. However, the 36-acre Area E is identified for development of a Next Generation Large Telescope (NGLT) in the Mauna Kea Science Reserve Master Plan. Therefore, it is possible that absent the proposed Project, another observatory could be developed within Area E pursuant to the Master Plan. Any other future observatory would require the construction of an observatory, headquarters, and support facility, as well as infrastructure improvements. Since Area E is designated for a NGLT facility, it is likely that a possible future observatory would be similar in size and scope to the TMT.

Environmental Effects

Pursuant to this alternative, the proposed TMT Observatory would not be sited at the 13N site, the proposed TMT Mid-Level Facility would not be built at Hale Pōhaku, and the proposed Headquarters and Satellite Office would not be built. Thus, the potential Project environmental impacts evaluated in this EIS would not occur.

The No Action alternative would result in forgoing Project economic benefits to the State of Hawaiʻi and the County of Hawaiʻi because construction and operation funds would not be spent, the required taxes would not be paid, and the direct and indirect effects of generating additional employment and revenues associated with the Project would not be realized. UH would not receive the no-cost observing time at the TMT Observatory. Potential community benefits associated with construction employment opportunities and long term operation-related employment opportunities would not be realized. Community outreach and mentoring programs, support of science programs, scholarship opportunities for local students to attend college, and internship opportunities for local students at Project facilities would also not be realized.

While the environmental effects associated with the Project would not occur pursuant to the No Action alternative, it is possible that in the absence of the proposed TMT Observatory, another observatory could be sited within Area E pursuant to the 2000 Master Plan, which designates the area for astronomy uses and a NGLT. Environmental effects associated with such a future facility might be similar to those associated with the Project due to the existing physical characteristics of Area E, and because it is likely that any possible future facility would be a NGLT consistent with the current land use designation. Any NGLT would likely be similar in scope, function, and operational characteristics to the proposed TMT Observatory. Any possible future facility would require construction of the observatory and its supporting infrastructure, and support and headquarters facilities. Therefore, pursuant to the No Action alternative, environmental impacts associated with the use of land consistent with the Master Plan may still occur in the future absent the proposed Project.

Relation to Project Objectives

The No Action alternative would not achieve major Project objectives that include integrating science and education with culture and sustainability in the Project. Without the public outreach component of the Project, the children of Hawaiʻi and the nation would not be exposed to astronomy, and science in general, to the same degree as with the Project at Maunakea. Without the operation and continued development of the Project's capabilities, the resultant number of jobs in Hawaiʻi in the areas of computer science, engineering, electronics, and optics would not be provided. The potential contribution of the Project to maintaining UH as a leading institution in astronomical studies, and the nation as a leader in astronomical research in the world, would not be realized without the Project. The potential for a substantial scientific synergy between the existing observatories at Maunakea and the Project would not be realized, and the resultant potential for superior science and in substantially higher scientific productivity by the integrated observatories would not be achieved.

4.2.2 Maunakea Alternative E2 Site

The Maunakea E2 site is located roughly 500 feet south-southeast of and 50 feet higher than the Project site. Figure 4-1 illustrates the E2 site location. This alternative is considered a reasonable alternative to the Project and has not been eliminated from consideration.

Physical Site Characteristics for Observations

Nearby structures and landforms can produce turbulent wakes that disrupt airflow, resulting in worse seeing conditions, even for sites which are close to one another. The cinder cones around the summit of Maunakea can cause such turbulence. TMT performed a computational fluid dynamics (CFD) analysis in which typical westerly (wind from the east) airflow over the summit was modeled to evaluate the effects of turbulence on seeing conditions within Area E. The CFD analysis showed that the 13N site and the E2 site would provide similar astronomical observational quality; however, the sites evaluated south of site E2 showed significant degradation in quality. However, the confidence in the seeing quality at the E2 is not as high as it is for the Project 13N site because site testing was not performed at the E2 site and the E2 site is closer to the southern sites where the CFD analysis indicates seeing conditions are inferior.

The CFD analysis is a computer model that predicts site conditions based on a variety of inputs including the terrain. Should the direction of wind swing slightly to the south, which it historically does roughly 15 percent of the time, the analysis indicates slight deterioration in the quality of seeing attributed to the upwind terrain. Although the CFD analysis indicates the E2 site may be similar to the 13N site in most characteristics, the level of confidence is greater at the 13N site because that is where physical testing was performed, and because the 13N site is farther removed from the two more southerly sites which showed significant degradation in observational quality.

Scientific Productivity and Synergy

This component of site selection would be the same for the E2 site as the Project 13N site. On Maunakea, partners and potential partners of the TMT Observatory Corporation currently operate the Keck, Canada-France-Hawaiʻi Telescope (CFHT), and Subaru observatories. If the TMT were also sited at Maunakea, these existing observatories would provide many opportunities for supporting and balancing observations and capabilities with the TMT, to the same extent at the Project 13N site and the alternative E2 site. Because of these common partners, the possibilities for realizing synergies in science programs and scientific instrument systems are particularly promising at Maunakea. With UH having access to all the observatories on Maunakea, including the TMT, additional synergy is possible. With these synergies, a superior and more productive system of integrated observatories that can coordinate observations and other science could emerge. The scientific productivity of such an integrated system would be greater than that of a single observatory.

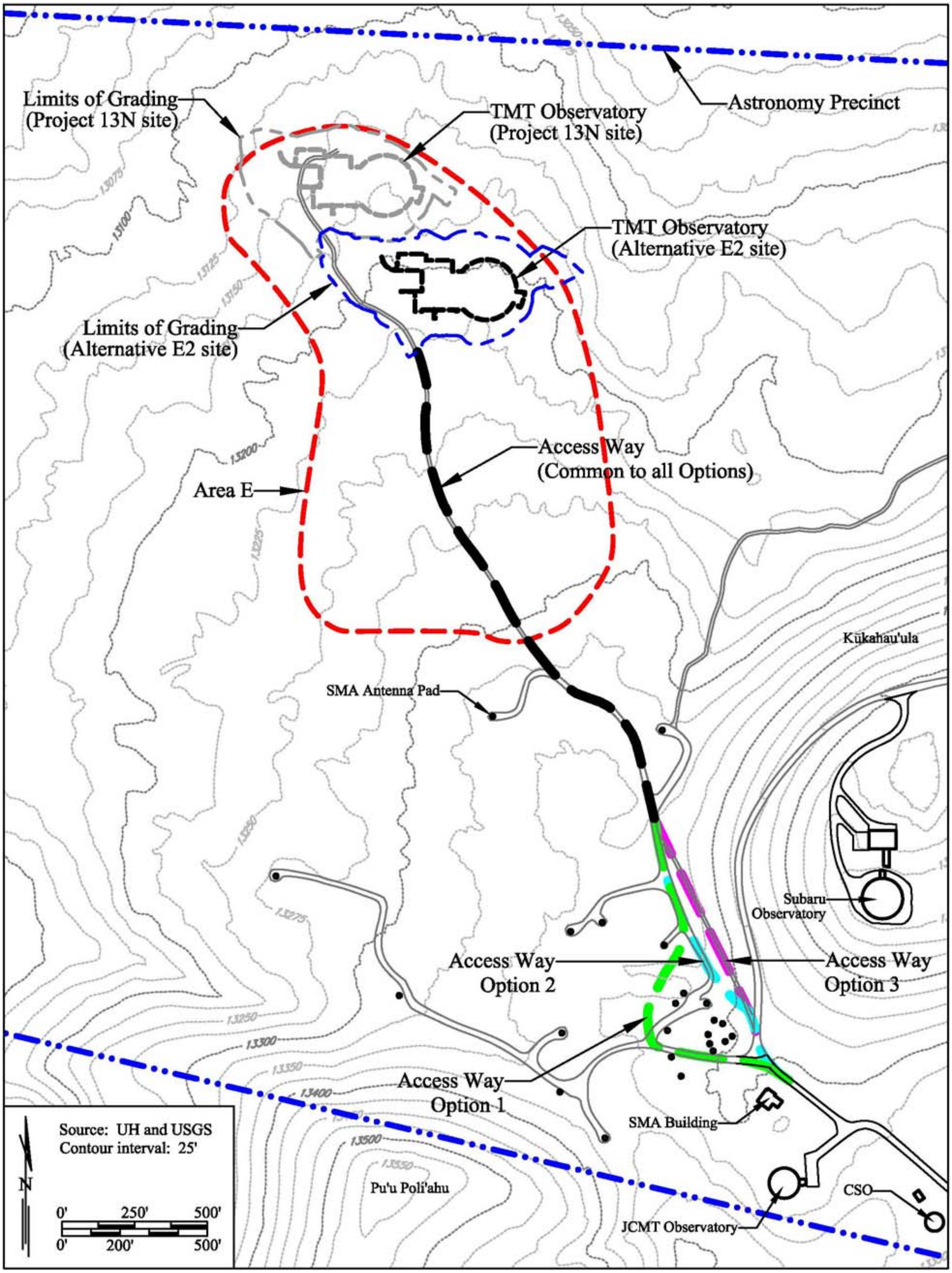

Figure 4-1: Maunakea E2 Alternative Site

There are three NGLTs currently in the design phase, the Giant Magellan Telescope (GMT), the European Extremely Large Telescope (E-ELT), and the TMT. Each of these NGLTs would have a primary mirror larger than 25 meters in diameter. The GMT has already selected a site in the southern hemisphere and most of the principal sites under consideration for the E-ELT are also in the southern hemisphere. In this context, the TMT at Maunakea would provide complementary sky coverage to these other NGLTs, and would provide unique scientific opportunities for those astronomical objects only visible through observations in the northern hemisphere.

TMT Facilities and Policies

Other than the location and elevation of the E2 site, all other aspects of the TMT Observatory design (Section 2.5.1), construction (Section 2.7.2), operation (Section 2.7.3), and decommissioning (Section 2.7.4) would be the same as at the Project13N site, except that the Access Way (Section 2.5.2) would be roughly 520 feet shorter (Figure 4-1). One of the Access Way Options (Section 2.5.2) would still need to be selected for the segment of the Access Way through or near the SMA core. The TMT Mid-Level Facility (Section 2.5.3), Headquarters (Section 2.5.4), and Satellite Office (Section 2.5.5) would be identical to the facilities discussed for the Project.

As discussed throughout Chapter 2.0 and Chapter 3.0, should the TMT Observatory be sited at the alternative E2 site instead of the 13N site, all applicable regulations, rules, and requirements would be complied with, including those outlined in the CMP and its four sub plans being prepared.

Environmental Setting and Potential Impacts

The environmental setting at the E2 site is comparable to the Project 13N site; both are located within Area E and are on the same lava flow with similar topography. Thus, the potential environmental impacts of locating the TMT Observatory at the E2 site would be comparable to impacts associated with the proposed Project 13N site. As with the Project 13M site, most impacts of this alternative, including geology, water quality, land use, traffic, noise, air quality, power and communications, and solid and hazardous waste would be less than significant. The principal differences between the Project 13N site and the alternative E2 site are discussed in the following sections.

<u>Cultural Resources</u>

The cultural setting of the E2 site is the same as that described in Section 3.2.1, as it describes the cultural setting of the summit region and Area E. The only difference in setting between the Project 13N site and the alternative E2 site is associated with an ahu (shrine) near the end of the 4-wheel drive road in Area E (Figure 4-2). This shrine is believed to have been constructed in the early 2000s; but its creator is unknown. This shrine is more than 200 feet from the extent of grading for the TMT Observatory should it be placed at the E2 site.

The potential cultural impacts associated with siting the TMT Observatory at the of the E2 site would be the same as those associated with siting the TMT Observatory at the Project 13N site, described in Section 3.2.3, except that the modern shrine would not be disturbed. Moving the TMT Observatory 500 feet would not change its visual impact from culturally sensitive locations, such as the three TCPs – Kūkahauʻula, Puʻu Līlīnoe, and Waiau. Potential cultural impacts would primarily be associated with Access Way Option 3. Should the E2 site be selected, the same mitigation measure proposed in Section 3.2.4 would be employed. Therefore, the level of impact would the same as for the Project 13N site, less than significant unless Access Way Option 3 is selected.

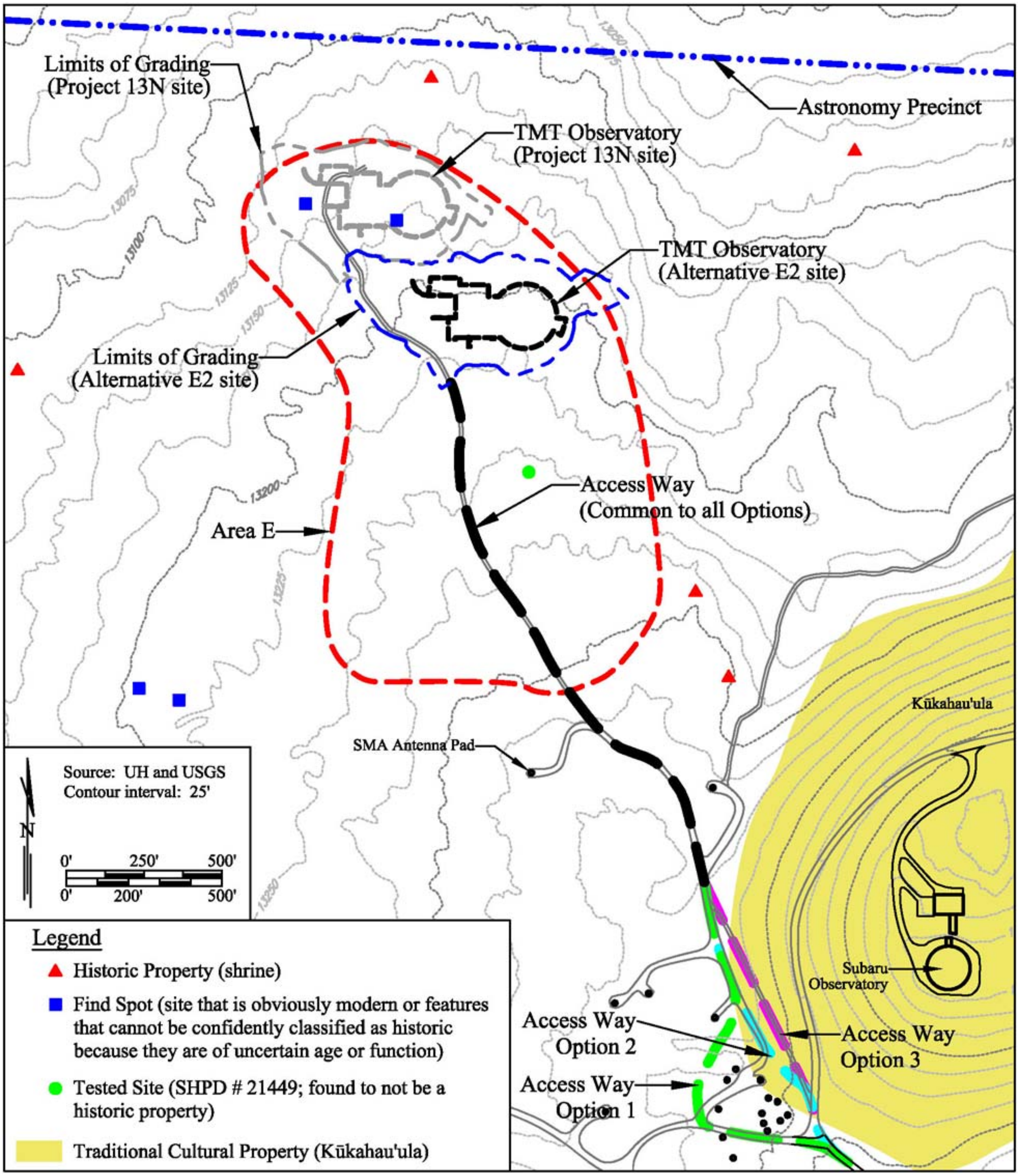

Figure 4-2: Cultural and Archaeological Resources in Vicinity of E2 Site

Archaeological/Historic Resources

The archaeological and historic setting of the E2 site is the same as that described in Section 3.3.1, which describes the setting of the summit region in general and Area E. Three historic shrines are present in the vicinity of Area E and the Access Way. One is located north of Area E and the Project 13N site and two are located southeast of Area E. Other shrines are located at a greater distance from Area E (Figure 4-2). The shrines are at least 100 feet from Area E and the existing roads and more than 200 feet from the E2 site and other proposed Project improvements. No burials are known to be present in Area E. Two "find spots," or potential historic properties, were identified within Area E (Figure 4-2). One was initially interpreted to be a possible pre-contact shrine and the other initially interpreted to be a possible pre-contact temporary habitation complex. Following coordination with others, neither find spot was determined to warrant historic property designation. Another feature thought to be a potential historic property was recorded by McCoy during survey work in Area E in preparation of the CMP. Its location is illustrated in , and was issued SHPD site number 21449. Due to doubts about its nature and in consultation with SHPD, a subsurface testing program was carried out. During the testing process no evidence of historic origin was encountered. Therefore, this feature, although illustrated on figures in the CMP, is not a historic property within Area E.

As discussed in Section 3.3.3 for the Project, no archaeological or historical properties would be disturbed should the TMT Observatory be placed at the E2 site. Furthermore, no archaeological or historical properties are present within 200 feet of any disturbances. Therefore, no historic properties would be affected. With this determination, no significant impact is expected. Should the E2 site be selected, the same mitigation measure proposed in Section 3.3.4 would be employed, except that no data recover of the two find spots would be performed because they would not be disturbed. Therefore, the level of impact would the same as for the Project 13N site, less than significant.

Biological Resources

The biological resources setting of the E2 site is the same as that described in Section 3.4.1, as it describes the biologic setting of the summit region and Area E. Biologic studies performed for the TMT Project encompassed the entirety of Area E. There was no discernible difference between the habitat in the vicinity of the Project 13N site and that in the vicinity of the alternative E2 site. The density of flora, including lichens, mosses, and vascular plants, was the same with no evidence of the habitat in the vicinity of the 13N site or E2 being preferred. Similarly, there was no discernible difference in fauna density and variety at the two sites. Both sites are comprised of Type 4 and 5 Wēkiu bug habitat, as is all of Area E, with Type 5 being present at roughly 5 percent of the area. A similar number of sampling points were placed in the vicinity of each of the two sites (Figure 4-3) and no Wēkiu bugs were found in any of the sampling points at either the 13N site or the E2 site.

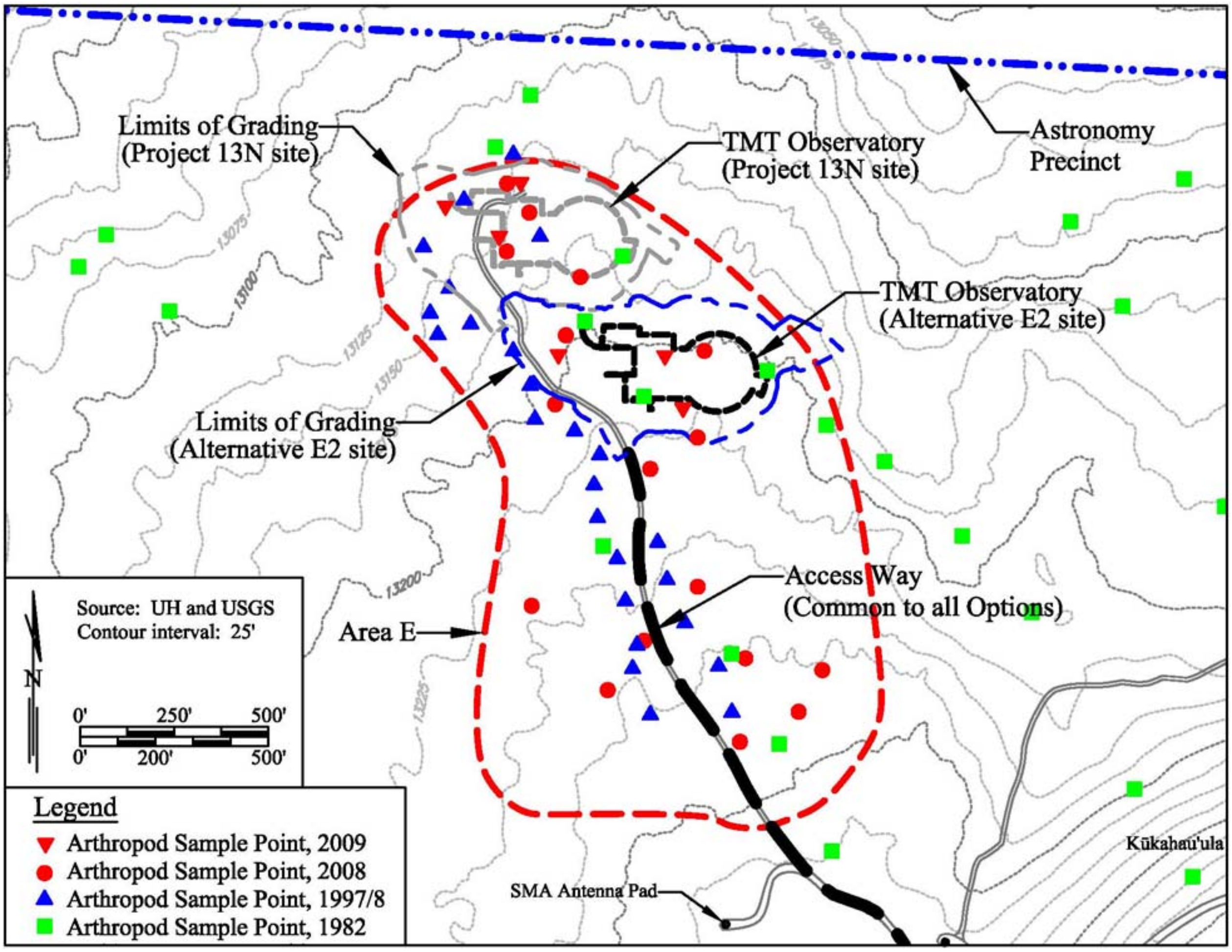

Figure 4-3: Arthropod Sampling in Vicinity of Alternative E2 Site

The potential biological impacts associated with siting the TMT Observatory at the of the E2 site would be similar to that associated with siting the TMT Observatory at the Project 13N site, described in Section 3.4.3, except that the area of displaced habitat would be slightly different. It is estimated that should the TMT Observatory be sited on the Project 13N site, roughly 4.7 acres of alpine stone desert would be displaced by the TMT Observatory and 1.6 acres of similar habitat would be displaced by the Access Way, should Access Way Option 1 be selected. Should the TMT Observatory be sited at the alternative E2 site, roughly 5.3 acres of alpine stone desert would be displaced by the TMT Observatory and 0.75 acre of similar habitat would be displaced by the Access Way, should Access Way Option 1 be selected. Therefore, the alternative E2 site would result in 0.25 acre less, or four percent less, new disturbance relative to the Project 13N site. In either case, this impact is evaluated to be less than significant because the habitat is not considered critical habitat for any species and floral, lichen, moss, and arthropod species present occur in greater abundance in other nearby areas.

Other potential biological impacts associated with other aspects of the Project, should the TMT Observatory be located at the E2 site, would be the same as those associated with siting the TMT

Observatory at the Project 13N site, described in Section 3.4.3, and are primarily associated with Access Way Options 2 and 3.

Should the E2 site be selected, the same mitigation measure proposed in Section 3.4.4 would be employed. Therefore, the level of impact associated with the alternative E2 site would the same as for the Project 13N site, less than significant.

Visual and Aesthetic Resources

The visual and aesthetic resources setting of the E2 site is the same as that for the Project 13N site described in Section 3.5.1. The potential visual and aesthetic impacts associated with siting the TMT Observatory at the of the E2 site would be very similar to those associated with siting the TMT Observatory at the Project 13N site, described in Section 3.2.3. Moving the TMT Observatory 500 feet would result in very minor changes to the TMT Observatory's viewshed and would not change its visual impact from culturally sensitive locations on Maunakea, such as the three TCPs – Kūkahauʻula, Puʻu Līlīnoe, and Waiau.

As with the Project, locating the TMT Observatory at the E2 site would not substantially affect scenic vistas and viewplanes identified in the County of Hawaiʻi's General Plan or the South Kohala Development Plan. The Observatory would not be visible in the view of Hilo Bay with Maunakea in the background. In addition, although the TMT Observatory may be visible in the view of Maunakea from portions of the South Kohala district and the area around Waimea, it would not block the views and viewplanes of the mountain. The viewshed analysis (Figure 4-4) indicates that because it would be located north of and below the summit of Maunakea, the TMT Observatory at the E2 site would not be visible in the southern portion of the island; this includes the large cities of Hilo and Kailua-Kona.

At the E2 site, the TMT Observatory would be visible from about 13 percent of the island area, while at the Project 13N site it would be visible from about 14 percent of the island area. Approximately 15.1 percent of the island's population, or approximately 22,500 people, reside within the viewshed of the E2 site; slightly less than the 15.4 percent, or about 23,000 people that reside in the viewshed of the Project 13N site. In comparison with the Project site, at the E2 site the TMT Observatory would not be visible from the viewpoint used for Honokaʻa, but it would be visible from the viewpoint used for Hāpuna Beach. These differences are due to slight changes in the precise viewpoint location; if the viewpoints were moved slightly but kept within Honokaʻa and Hāpuna Beach, the reverse effect could occur.

The silhouette analysis for the E2 site generally shows that the extent of the TMT Observatory that would be visible in silhouette would be similar to that at the Project 13N site (see Appendix I, the Visual Impact Assessment Technical Report). Photo simulations were not conducted separately for the E2 site because the displacement between the two sites (500 feet) would not result in a discernible difference from the perspectives of Honokaʻa, Waimea, and Waikoloa, which are over 15 miles away. Overall, as with the Project, the visual impact of the TMT Observatory at the E2 site would be less than significant.

Should the E2 site be selected, the same mitigation measure proposed in Section 3.5.4 would be employed. Therefore, the level of impact associated with the alternative E2 site would the same as for the Project 13N site, less than significant.

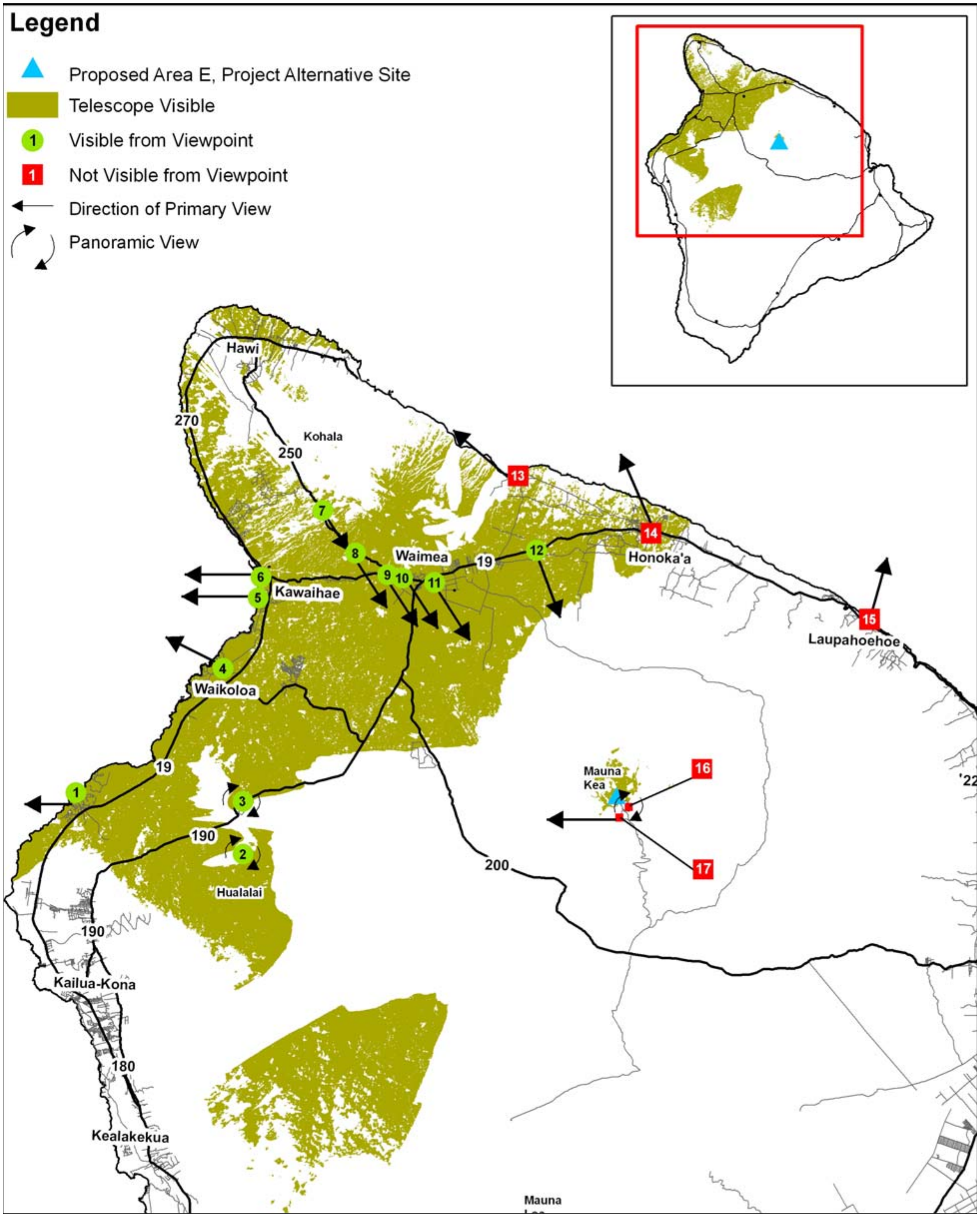

Figure 4-4: Viewshed of TMT Observatory at E2 Site

Geology, Soils, and Slope Stability

The geologic setting of the E2 site is the same as that described in Section 3.6.1, as it describes the geologic setting of the summit region and Area E. Geologic studies performed for the TMT Project encompassed the entirety of Area E. There was no discernible difference between the geologic resources in the vicinity of the Project 13N site and that in the vicinity of the alternative E2 site.

The potential impacts to geologic resources associated with siting the TMT Observatory at the of the E2 site would be similar to that associated with siting the TMT Observatory at the Project 13N site, described in Section 3.6.3, except that the area of displaced habitat would be slightly different. As discussed above the in the Biological Resources section above, the alternative E2 site would result in 0.25 acre less, or four percent less, new disturbance relative to the Project 13N site. In either case, this impact is evaluated to be less than significant because the geologic resources in Area E are not unique on Maunakea and are better developed at many other areas, especially on the southern summit area.

Should the E2 site be selected, the same mitigation measure proposed in Section 3.6.4 would be employed. Therefore, the level of impact associated with the alternative E2 site would the same as for the Project 13N site, less than significant.

Other Environmental Factors

Related to other environmental factors, siting the TMT Observatory at the E2 site would not result in different conditions, different impacts, or require different mitigation measures relative to the Project 13N site. This can be said for other subjects discussed in Chapter 3.0, including: Water Resources and Wastewater; Solid and Hazardous Waste and Material Management; Socioeconomic Conditions; Land Use Plans, Policies, and Controls; Roadways and Traffic; Power and Communications; Noise; Climate, Meteorology, Air Quality, and Lighting; and Construction and Decommissioning.

Cumulative Effects

The incremental cumulative impacts associated with locating the TMT Observatory at the E2 site would be comparable to those of the Project 13N location. Therefore, the cumulative impact associated with past, present, and other foreseeable actions would remain as described in Section 3.16.4, including a continuing significant cumulative effect on cultural resources, certain biological resources, and certain geological features.

The incremental cumulative visual impact of locating the TMT Observatory at the E2 site would be slightly less pursuant to this alternative due to the E2 site's location further back from (south of) the change in Maunakea's northern slope when compared to the Project's 13N site. From the E2 site, the new area where an observatory would be visible is roughly 0.9 percent of the area of the island (Figure 4-5), versus slightly less than 1.2 percent of the area from the 13N site (Figure 3-34). The estimated number of people living in this area of new observatory visibility is about 28 versus 72 people that reside within the new area of the observatory visibility from the 13N site. Nonetheless, as with the Project, when combined with the past, present, and reasonably foreseeable future actions, the cumulative visual impact of development at and near the summit of Maunakea would continue to be significant pursuant to the E2 site alternative as well.

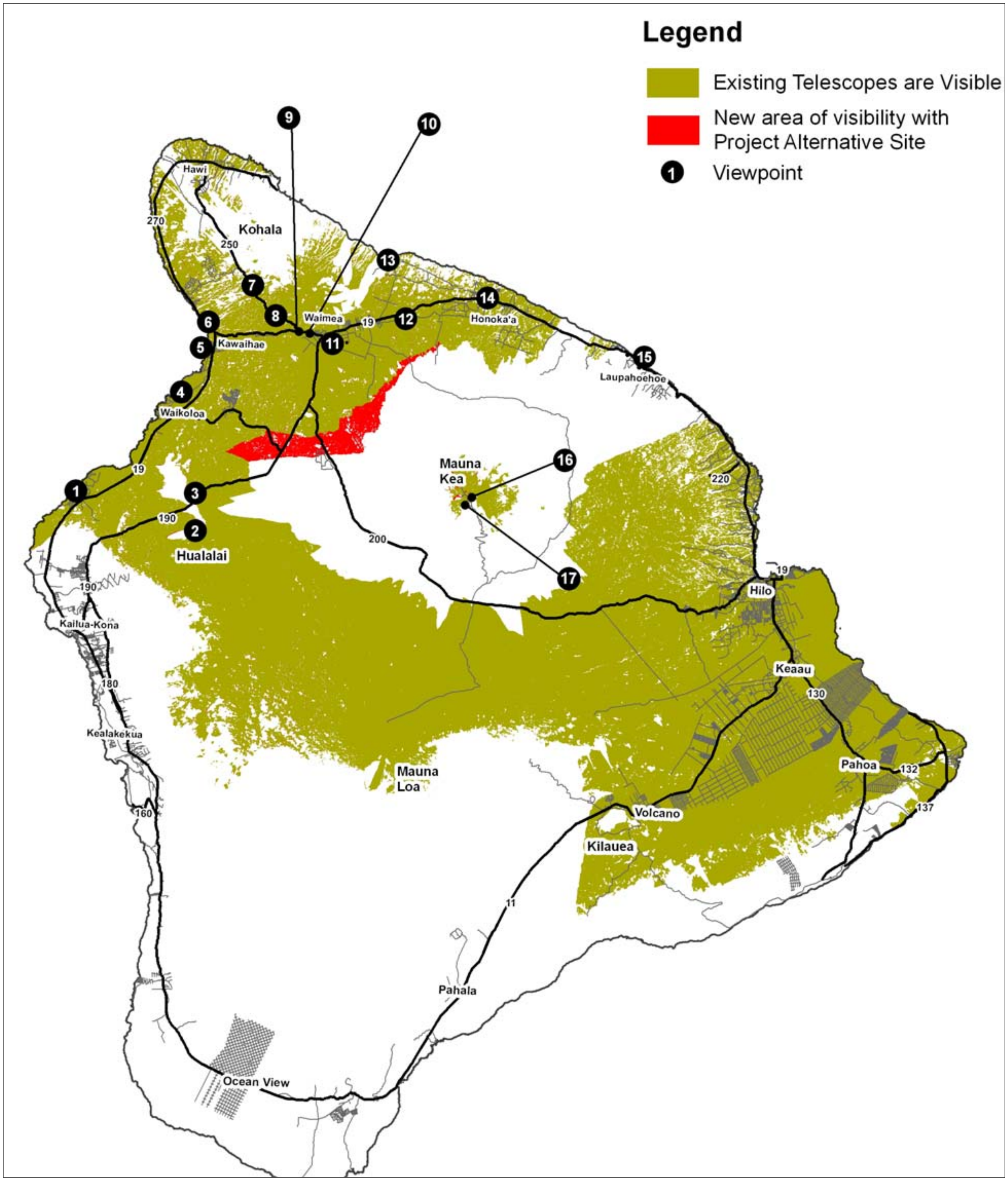

Figure 4-5: Site E2 Cumulative Viewshed Analysis

Relation to Project Objectives

This alternative would achieve all major objectives of the Project; however, the confidence in the seeing quality is not as high as it is for the Project 13N site and scientific goals could suffer if the CFD analysis are not accurate and the seeing quality at the alternative E2 site is inferior.

5.0 Additional Information in Response to Scoping Comments

The TMT Observatory Corporation Board is also evaluating and considering a site in northern Chile, known as Cerro Armazones. Although the Cerro Armazones site is being considered by the TMT Board, it is not considered an "alternative" for UH because UH cannot approve locating the TMT in Chile. The Cerro Armazones site is discussed here to inform the community regarding this location, as requested in scoping comments.

The Cerro Armazones site is located within the jurisdiction of the government of Chile and requires a different environmental process and approvals pursuant to the laws and requirements of Chile. The potential impacts of the TMT at Cerro Armazones that have been evaluated in compliance with those laws and requirements are summarized here.

The Cerro Armazones is located in the Atacama Desert at an elevation of 10,100 feet. It is one of many mountains in the Coastal Range, and is located roughly 22 miles from the coast. There are many similar mountains nearby, including Cerro Paranal, which is 13.4 miles to the west and hosts ESO's Very Large Telescope (VLT). The Cerro Armazones site is located 67 miles south of the closest city, Antofagasta (Figure 5-1). Antofagasta is the provincial capital and a town of approximately 280,000 residents. The town is primarily a housing and services area for the region's mines. Good roads lead from the town to near Cerro Armazones; there is currently only a steep and narrow switch-back dirt path from the base of the mountain to the summit.

At Cerro Armazones, physical characteristics that affect astronomical observations are similar to those at the proposed Project's site. For some individual criteria the Cerro Armazones site has more favorable characteristics, such as the number of clear nights. In others, the proposed Project's site has more favorable characteristics, such as the precipitable water vapor and the coherence time and angle of the atmospheric seeing. Considering all physical characteristics and the TMT's mix of observations, overall there is no significant difference in the quality of observations between the Cerro Armazones site and the site of the proposed Project.

In the southern hemisphere, the European-run VLT is located approximately 31 miles (by road) to the west of Cerro Armazones. This facility has four 8-meter optical/infrared telescopes. The Atacama Large Millimeter Array (ALMA), a radio telescope array, is under construction in northern Chile, and is expected to be fully operational by the year 2013. The Large Synoptic Survey Telescope (LSST), an 8-meter optical/infrared survey telescope, is in the design phase for a site located approximately 350 miles south of Cerro Armazones. While the ALMA and LSST could potentially help identify astronomical observation targets for the TMT, none of those observatories is operated by the TMT partners and they are scattered over a large geographic area. Thus, the potential for synergy between those facilities and TMT, or for a system of integrated observatories leading to greater scientific productivity, is lower than for the Project site.

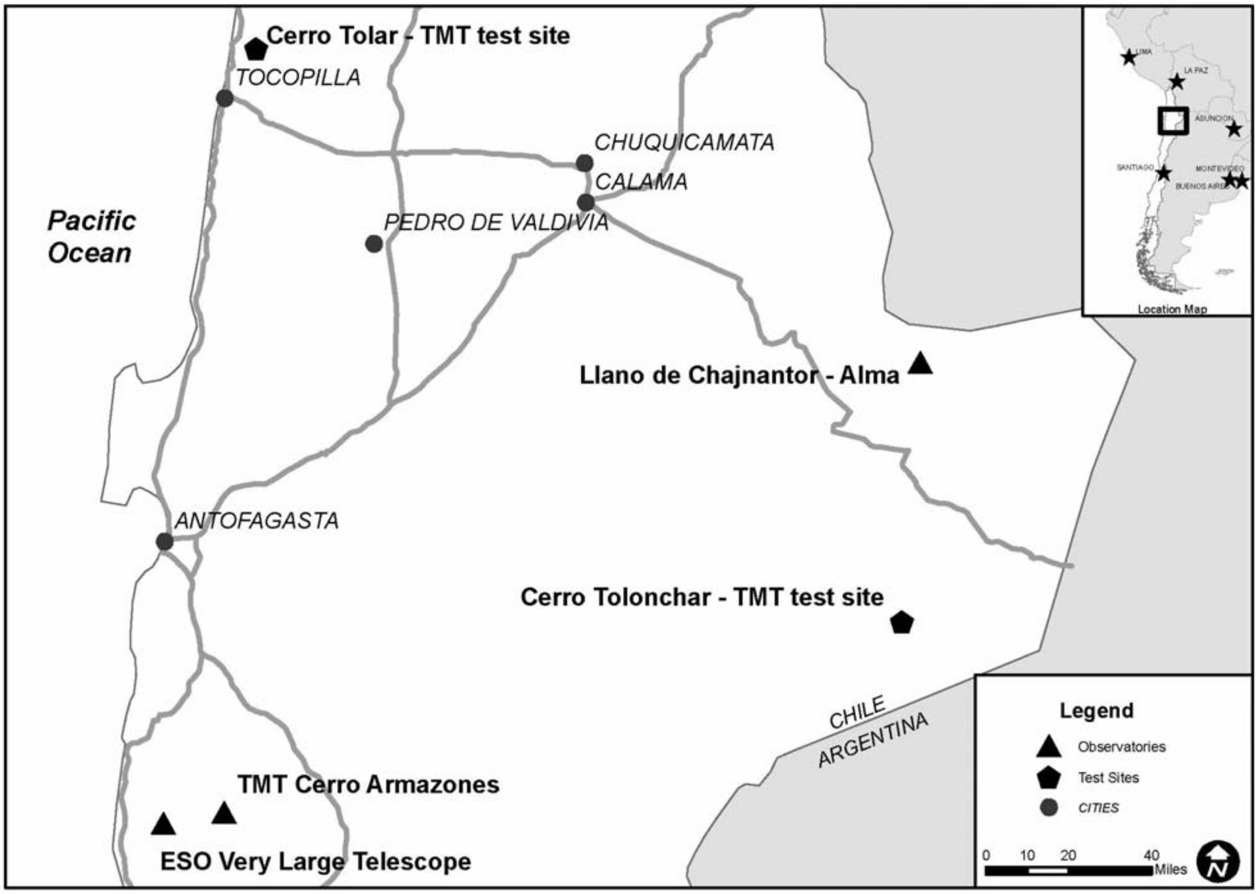

Figure 5-1: Cerro Armazones Location

Facilities

Observatory: The observatory would house a telescope identical to that of the proposed Project (see description in Section 2.5.1). The observatory would be sited on the summit of Cerro Armazones and because the summit area is small, it would require leveling to roughly 36 feet below the current high point. The disturbance area would be roughly 20 acres. The mountain is remote and there are no established cities, towns, or resident communities within the surrounding area, so there are no visual receptors. Thus, while the dome would a Calotte structure, the location of the site allows the design to vary and be less sensitive to distant or nearby viewers.

Support Facility: Because there is no power grid or existing facilities at Cerro Armazones, new infrastructure and the support facility would have to be provided. The support facility would be at the base of the mountain, or approximately 1,200 feet below the summit. It would include housing, recreation, and cafeteria facilities for workers; infrastructure, such as power generators, water tanks, sewage treatment facility, and satellite communication station; and operation spaces, including warehouse space, administrative offices, laboratory, and maintenance and utility shops. The area of disturbance for those facilities would be approximately 22 acres.

Access Way: A new 13.5-mile road would need to be built from an existing paved public road to the support facility. A new 3.6-mile access road would also need to be built from the support facility to the summit observatory. The road would be a 24-foot wide unpaved surface, except for the last 0.6-mile where it would have an asphalt surface.

Headquarters: A Headquarters facility similar to that described in Section 2.5.4 would be in Antofagasta. Antofagasta is the nearest town, approximately 1.5 hours, or 70 miles by road, away from Cerro Armazones.

Temporary Facilities: Construction baseyards would be required during construction of the observatory. These would include use of an existing warehouse and yard in the port city of Antofagasta for receiving materials and some assembly work, a five-acre staging area next to the support facility, and the area within the roughly 20-acre summit site not occupied by buildings.

Environmental Effects

The TMT Observatory Coorporation prepared a Declaractión de Impacto Ambiental (DIA) for the Cerro Amazones site pursuant to the applicable Chile environmental laws and regulations. The DIA was accepted by the government of Chile.

The following sections summarize the findings of the DIA.

<u>Cultural Resources</u>

The DIA reports that there are no records of archaeological sites in the immediate and surrounding areas of the Cerro Amazones site. The information that does exist for the area includes the presence of predominantly coastal archaeological sites representative of a maritime and collection economy. The following recorded archaeological sites were discussed in the DIA:

View from Cerro Armazones

- Punta Grande, Caleta Norte. Located approximately 39 miles southwest of Cerro Armazones, this site is a ceramic cemetery with separately aligned buried bodies every 6.5 feet and spreads over an area of about 1,200 square yards. Objects made of gold, silver, and copper, projectile point, trowels, and necklaces were found.
- Puesto Olivia. Located approximately 48.5 miles southwest of Cerro Armazones, this site is a ceramic cemetery where stone knives, trowels, necklaces, pipes, and copper plates were found.
- Alero Loreto. Located approximately 16 miles southwest of the Cerro Armazones this site has a surface area of about 120 square yards. The site consists of rocked eaves with

cave art, with a 3-foot thick midden[67] in its scarp; mollusks' shells remains, projectile points, fines, and shell hooks were found.

- Pinturas de Quebrada El Médano. Located approximately 14 miles southwest of Cerro Armazones, this site is a blocks field with cave art, fishing scenes paintings on walls that belong to the "Cañón El Medano", for about 2 miles. No archaeological contexts were found.
- Punta de Las Conchas. Located approximately 52 miles to the southwest of Cerro Armazones, this site is an archaic midden with several occupation layers containing hooks, weights, mortars, pestle, and harpoons.

A field study was also performed for the DIA; the study covered approximately 8,900 acres and included the Cerro Armazones hill and potential access road from the west. The study area was extensively traveled and there was good surface visibility. There were no remains of cultural or heritage value found at the base of the mountain, and the access road and summit are too vertical and were found to have no remains either. Special attention was paid to the summit for the presence of any place of worship, as it is the highest point in the area. The remainder of the access road was inspected and only rocks and natural stone chips were found. The study team postulated that the prehistoric pattern of settlements that shows preference for the conjunction of resources found at the coast, specifically close to fresh water runoffs, likely explained the lack of findings in the site study area. The only findings of heritage value found were located outside of the direct influence area, and these roadside shrines would not be affected by construction activities. The study team recommended that during excavations or earth moving, an archaeologist should be present at the site to supervise the work and that a Protocol for Archaeological Findings be developed prior to construction.

The DIA concludes that there are no human communities in the area of Cerro Amazones that have traditions, communal interests or feelings of attachment towards the land. It also states that sites with anthropological, archaeological, historical, or cultural heritage would not be affected.

Natural Resources

As part of the DIA, the biology of the Cerro Armazones site was researched using secondary resources of official statistics along with information collected in the field. The DIA field study area was approximately 2,150 acres and covered Cerro Armazones hill and the potential future access road.

While 82 percent of the study area was determined to be land without vegetation, or barren, there were five floristic species found within the study area. These species were all of the *Magnoliophyta* Division. *Adesmia atacamensis*, *Calandrinia salsoloides*, *Cistanthe arancioana*, *Nolana sessiliflora*, and *Cryptantha sp.* are not listed for preservation or have been determined to be out of danger. *Adesmia atacamensis* and *calandrinia salsoloides* are species that live mainly in ravines and intermittent water courses. *Cistanthe arancioana* and *nolana sessiliflora* are species that develop in bumps and rocky outcroppings.

[67] Midden, in archaeological terms, is a mound or deposit containing shells, animal bones, and other refuse that indicates the site of a human settlement.

- Eighteen percent of the study area was found to be comprised of ravines and intermittent water courses, favorable to *Adesmia atacamensis* and *calandrinia salsoloides*; the two species develop together in most cases. Where these species were found, the coverage density never exceeded 5 percent and therefore the main proportion of the habitat was barren at sight; *adesmia atacamensis* was the dominant species. Conditions of both species found varied from dead individual to healthy vegetation, though only dead specimens were found at the sunny slope of the hill, at the southwest of Cerro Armazones, and at the shady side of high gradient slopes.
- Only 0.6 percent of the area of influence was found to be colonized by *cistanthe arancioana* and *nolana sessiliflora* species that develop exclusively in rocky environments. These areas were found at elevations of approximately 8,860 and 9,190 feet (below the summit) on the north face of the Cerro Armazones area. The coverage did not exceed 10 percent, and both live and dead specimens were found.
- *Cryptantha sp.* was found in only two sectors of the study area, and in both areas the specimen were found dead. The individuals could not be identified at the species level.

The fauna study considered all land vertebrate groups, including birds, micromammals, and reptiles. Three species of invertebrates were found in the study area, one belonging to the micromammals group and two bird species; no traces of greater mammals or reptiles were seen.

- The micromammal found was a leaf-eared mouse (*phyllotis darwini*), of the *Rodentia* Order, and is considered a species with reduced population density, though the species is found throughout the country and does not have conservation problems. Evidence of this species was registered at the temporary site-testing summit facilities and was seen several times inside the camp at the base of the hill used by existing facilities.
- The two birds were the Grayish Miner (*geositta maritime*), of the *Passeriformes* Order, and the Black-winged Ground-Dove (*metriopelia melanoptera melanoptera*), of the *Columbiformes* Order; both are considered species good for the silvoagricultural activity. Both bird species were seen in the camp; only the *geositta maritime* was seen at the summit.

The presence of some insects was also noted. Two species of the *Orthoptera* Order were found, and correspond to locusts and grasshoppers. These insects are an indicator of the presence of another type of animal, such as birds and micromammals, because they are a part of the food chain for such animals and allow for their development and presence in the study area.

The DIA concludes that there would be no interference with or exploition of native vegetation or wild animal life whose conservation status is indicated on the national list as endangered, vulnerable, rare, or insufficiently known. The DIA states that no biological diversity or its capacity for regeneration would be affected.

Visual/Aesthetic Resources

The DIA considers the visual impact from the point of view of a tourist. It concludes that from the point of view of the tourist, a new observatory would be a contribution to astronomy infrastructure already in place in the area, and would not obstruct access to elements in the region with scenic or tourist value.

Socioeconomic

The DIA states the amount of money expected to be invested in Chile during construction would be $150 million (U.S.) over a period of 8 years. During the construction phase, it is anticipated that 170 people would be employed, 20 of whom would be foreigners. During the operation phase, it is expected that approximately 100 people would be employed with long-term contracts; any given day there would be about 40 people working at Cerro Armazones. The DIA states that this would not cause any significant socioeconomic changes in the population, including level of education or employment levels.

Other Environmental Topics

The DIA also considers land use policies; water resources in the area; water consumption and water supply source; erosion; power and communications; waste generation and disposal; air pollutant emissions; the generation of noise; lighting; and geographic and demographic characteristics, among other topics. The DIA states that no adverse impacts to human health, the environment, or existing infrastructure were anticipated.

Environmental Effects Conclusion

The DIA concludes that an observatory would generally comply with all applicable rules and regulations and that a higher level of environmental study is not warranted.

6.0 List of Preparers

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Consultant to the Lead Agency

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Jack Lockwood

Responsibility: Preparation of Geologic Inventory and Assessment.

7.0 References

National Research Council (NRC), 2001. *Astronomy and Astrophysics in the New Millennium*. By NRC; Commission on Physical Sciences, Mathematics, and Applications; Board on Physics and Astronomy-Space Studies Board; Astronomy and Astrophysics Survey Committee. National Academy Press, Washington D.C. 2001.

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Appendix A. Mailing List

Federal Agencies

U.S. Army Corps of Engineers

U.S. Department of Agriculture – National Resources Conservation Service

U.S. Department of Commerce – National Oceanic and Atmospheric Administration

U.S. Department of Energy

U.S. Department of Homeland Security

U.S. Department of Interior
- Fish and Wildlife Service
- National Parks Service
- U.S. Geological Survey

U.S. Department of Transportation

U.S. Environmental Protection Agency

National Aeronautics and Space Administration – Office of Space Science, Astronomy and Physics Division

State Agencies

Department of Accounting and General Services

Department of Agriculture

Department of Budget and Finance

Department of Business, Economic Development and Tourism (DBEDT); Energy and Planning Divisions

Department of Defense

Department of Education

Department of Hawaiian Home Lands

Department of Health

Department of Land and Natural Resources

Department of the Attorney General

Department of Transportation

Hawai‘i State Civil Defense

Office of Hawaiian Affairs

University of Hawai‘i

Center for Hawaiian Studies

College of Agriculture, Forestry, and Natural Resource Management (Hilo)

College of Hawaiian Language (Hilo)

College of Tropical Agriculture and Human Resources (Mānoa)

Environmental Center

‘Imiloa Astronomy Center of Hawai‘i

Institute for Astronomy

Mauna Kea Support Services

Office of Mauna Kea Management

Kahu Kū Mauna

Mauna Kea Management Board

Water Resources Research Center

County of Hawai‘i

Big Island Visitors Bureau

Civil Defense Agency

Department of Design and Construction

Department of Environmental Management

Department of Finance

Department of Parks and Recreation

Department of Planning

Department of Public Works

Department of Research and Development

Department of Transportation Services

Department of Water Supply

Fire Department

Mass Transit Agency

Office of Housing and Community Development

Office of the County Clerk

Office of the Prosecuting Attorney

Police Department

Elected Officials

U.S. Senator Daniel K. Inouye
U.S. Senator Daniel K. Akaka
U.S. Congressperson Neil Abercrombie (1)
U.S. Congressperson Mazie Hirono (2)
Governor, State of Hawai‘i, Linda Lingle
State Senator Dwight Takamine (1)
State Senator Russell S. Kokubum (2)
State Senator Josh Green (3)
State Representative Mark M. Nakashima (1)
State Representative Jerry L. Chang (2)
State Representative Clift Tsuji (3)
State Representative Faye P. Hanohano (4)
State Representative Robert N. Herkes (5)
State Representative Denny Coffman (6)
State Representative Cindy Evans (7)
Mayor, County of Hawai‘i, Billy Kanoi
Hawai‘i County Councilperson Dominic Yagong (1)
Hawai‘i County Councilperson Donald Ikeda (2)
Hawai‘i County Councilperson J Yoshimoto (3)
Hawai‘i County Councilperson Dennis Onishi (4)
Hawai‘i County Councilperson Emily I. Naeole (5)
Hawai‘i County Councilperson Guy Enriques (6)
Hawai‘i County Councilperson Brenda Ford (7)
Hawai‘i County Councilperson, Kelly Greenwell (8)
Hawai‘i County Councilperson, Pete Hoffmann (9)

Local Schools

Connections
DeSilva Elementary
Ha‘aheo Elementary
Hawai‘i Academy of Arts and Sciences
Hawai‘i Prepatory Academy
Hilo High
Hilo Intermediate
Hilo Union
Holualoa Elementary
Honaunau Elementary
Honoka‘a Elementary
Honoka‘a High and Intermediate
Ho‘okena Elementary
Innovations
Ka ‘Umeke Ka‘eo
Kahakai Elementary
Kalanianaole Elementary and Intermediate
Kanu o ka ‘Āina
Kapi‘olani Elementary
Ka‘ū High and Pāhala Elementary
Kaumana Elementary
Ke Ana La‘ahana
Ke Kula Nawahiokalaniopuu Iki Lab
Ke Kula ‘o ‘Ehunuikaimalino
Kea‘au Elementary
Kea‘au High
Kea‘au Intermediate
Kealakehe Elementary
Kealakehe High
Kealakehe Intermediate
Keaukaha Elementary
Keonepoko Elementary
Kohala Elementary
Kohala High
Kohala Intermediate
Konawaena Elementary
Konawaena High
Konawaena Intermediate
Kua o ka La
Laupāhoehoe High and Elementary
Mountain View Elementary

Na‘alehu Elementary and Intermediate
Pa‘auilo Elementary and Intermediate
Pāhoa Elementary
Pāhoa High and Intermediate
Volcano School of Arts and Sciences
Waiākea Elementary
Waiākea High
Waiākea Intermediate
Waiakeawaena Elementary
Waikoloa Elementary
Waimea Elementary
Waimea Middle
Waters of Life
West Hawai‘i Explorations Academy

Libraries

Hawai‘i State Library
DBEDT Library
Hawai‘i Island Libraries:

- Bond Memorial
- Hilo
- Hōlualoa
- Honoka‘a
- Kailua - Kona
- Kea‘au
- Kealakekua
- Laupāhoehoe
- Mt. View
- Nā‘ālehu
- Pāhala
- Pāhoa
- Thelma Parker

Kaua‘i Island Libraries:

- Hanapēpē
- Kapa‘a
- Kōloa
- Līhu‘e
- Princeville
- Waimea

Lāna‘i Island – Lāna‘i
Maui Island Libraries:

- Hāna
- Kahului
- Kīhei
- Lahaina
- Makawao
- Wailuku

Moloka‘i Island – Moloka‘i
O‘ahu Island Libraries:

- ‘Aiea
- ‘Āina Haina
- ‘Ewa Beach
- Hawai‘i Kai
- Kahuku
- Kailua
- Kaimukī
- Kalihi-Pālama
- Kāne‘ohe
- Kapolei
- LBPH
- Liliha
- Mānoa
- McCully-Mō ‘ili‘ili
- Mililani
- Pearl City
- Salt Lake
- Wahiawā
- Waialua
- Wai‘anae
- Waikīkī-Kapahulu
- Waimānalo
- Waipahu

University of Hawai‘i at Mānoa Hamilton Library
University of Hawai‘i at Hilo Library
Hawai‘i Community College Library
Legislative Reference Bureau

News Media

Honolulu Advertiser
Honolulu Star Bulletin
Hawai‘i Tribune Herald
West Hawai‘i Today

Organizations

‘Ahahui Ku Mauna
‘Ahahui Mālama I Ka Lōkahi
American Friends Service Committee
Association of Hawaiian Civic Clubs
Bishop Museum

Center for Biological Diversity
Conservation Council for Hawai‘i
Earthjustice
Edith Kanaka‘ole Foundation
Environment Hawai‘i
Environmental Defense
EnviroWatch
Friends of Haleakala National Park
Hawai‘i - La‘ieikawai Association
Hawai‘i Institute for Human Rights
Hawai‘i People's Fund
Hawai‘i Audubon Society
Hawai‘i Conservation Alliance
Hawai‘i Ecotourism Association
Hawai‘i Island Chamber of Commerce
Hawai‘i Island Economic Development Board
Hawaiian Ecosystems at Risk
Hawaiian Historical Society
Hawai‘i’s Thousand Friends
Healthy Hawai‘i Coalition
Historic Hawai‘i Foundation
Ka‘ū Preservation
KAHEA
Kanaka Council Moku O Keawe
Kilakila o Haleakalā
Kohala Center
Kohanaiki ‘Ohana
Kona-Kohala Chamber of Commerce
Life of the Land
Malama O Puna
Maui Tomorrow Foundation, Inc.
Mauna Kea Anaina Hou
Na Maka o ka ‘Āina
Native Hawaiian Advisory Council
Native Hawaiian Chamber of Commerce
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Pele Defense Fund
Pulama Ia Kona Heritage Preservation Council
Royal Order of Kamehameha I
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Kat Brady
Rosie Braun
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Anna Cariagu
Jerry Carr
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Keomailani Case
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Wheeler Cole
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Duane Erway
Cindy Evans
Kali Fernandez
June Fernandez
Mike Fitzgerald
Dennis Florer
Roy and Allie Forbes
Rick Frazier
Fred Fukuchi
Jody Fulford
Clayort Gamazut
Paul Gessert
T. Ilihia Gionson
Mark Goldman
David & Anne Gomes
William Golisch
Debbie Goodwin
Mima Goto
Leah Gourker
Linda Gregoire
Charles Grogan
Kale Gumapae
Richard Ha
John & Ginger Hamilton
Val Hanohano
Cory Harden
Janice Harvey
Masa Hayasui
John Hayes
William Healy
Walter Heen
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Inge Heyer
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William Hoohuli
Clyde Hugh
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Jamila Jarman
Rick Johnston
Luana Jones
Jim Jurvik
Russell Kackley
Ekela Kahwami
Jo-Ann Kalamau
Lei Kalamau
Herriag Kalua
Ciro Kamai
Nahoku Kamakawiwoole
Jeitn Kanu
Ana Kariaga
Kaiko Kaunale
Luana Kawelu
L.V. Kelly
Reynold Kemalauiul
W.D. Keomailani-Case
Mike Kido
Jo Kim
Lester Kimura
Ka‘iu Kimura
Lei Kimura
Malia Kipapa
Pohai & Larry Kirkland
Jim Klyman
Wiley Knight
Graham Knopp
Paul Koehla
Klement Kondratovich
Rich Koval
Manuel Kuloloio
Tony Ladwig
Kerstin Lampert
Joan Lander
Evelyn Lane
Lloyd Lane
Fred Lau
Betty Lau
Kimo Lee
Noa Lincoln-Chong

Denise Lindsey
Paul Lowe
Christy Luce
Jim LuPiba
Jim Lyke
Barney Magrath
Gail Makaukanelindi
Al Martinez
Anthony Marzi
Bob Masuda
Theo & Mose Mauga
J. Mauhili
Ruby McDonald
Nancy McGilvray
Kawika McKegan
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Thomas Orton
Johni Ota
Christian Pa
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Brittany Pierce
Kimo Pihana
Kealoha Pluiotte
Herbert Poepoe
Gerald Pozen
Jackie Prell
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Ed Pskowski
Pauline Pule
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Paul Rambaut
Tyrone Reinhardt
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Aaron Stene
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Wayne Taneh
Jack Telaneus
Taro Togo
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Appendix B. Summary of Scoping Comments

Responses to individual scoping comments were not prepared; responses are within the body of the Draft EIS document. Copies of all scoping comments submitted are available upon request to the Proposing Agency, UH Hilo, Office of the Chancellor (see contact information in Section 1.7). This section provides a summary of the substantive scoping comments received.

Cultural, Archaeological, and Historical Resources

Numerous comments were received regarding cultural resources, and while the comments expressed a wide range of sentiments, all made it clear that Maunakea is a sacred place revered by many. There were multiple statements condemning the past development of Maunakea as desecration and abuse. Some emphasized the need for cultural sensitivity and awareness training for anyone wishing to visit the summit, so as to fully understand and recognize the importance of the mountain and its features. Many comments underscored the need for the protection of cultural sites, resources, and practices, as well as the maintenance of access to the summit. Some comments expressed the sentiment that due to the lack of respect shown in the past and by other projects, many Native Hawaiians stand opposed to any further projects on the mountain, regardless of whether the project would or would not have impacts. Others stated that the development of a cultural affairs team or office, made up of Native Hawaiians with extensive knowledge of the mountain or lineal ties to it, within the TMT Observatory Corporation may help the Project connect with local and Native Hawaiian groups, and allow for continued cooperation and collaboration for the duration of the Project. Some comments likened the observatory and its research to the ancient Native Hawaiian practice of navigating by the stars. Numerous comments supported the TMT Observatory Corporation funding cultural programs already in place. Some commentors were appreciative of the efforts made by the TMT Observatory Corporation to meet with local and Native Hawaiian groups and maintain an open dialogue with them.

Biological Resources

Comments pertaining to the biological resources of Maunakea focused on the Wēkiu Bug, palila, māmane, and Silversword, as well as their respective habitats. Many of the comments discussed the need for protecting these species and ensuring that their habitats remain healthy.

Visual and Aesthetic Resources

The comments regarding visual and aesthetic resources mainly focused on requests to see simulations of what the Project would look like on the mountain, including a preliminary design of the structure, with approximate dimensions. Other comments discussed the adverse impact of the existing observatories on the summit on cultural practitioners and residents. Some commentors wondered if TMT could perhaps be painted or coated with something other than white or reflective coating, in an effort to minimize the visual impact. Another suggestion was to bury the observatory, at least partially, to lessen the amount that is visible.

Water Resources and Wastewater

The most frequent comment about water resources and wastewater was that there should be no discharge of wastewater to the mountain; instead, all of it should be collected and trucked down off the mountain.

Solid Waste and Hazardous Waste Management

The comments received discussing solid and hazardous waste were almost entirely focused on the hazardous wastes that could be produced by the Project, including all chemicals and products that could be potentially harmful. The mirror-coating process to be used by the TMT was another large focus that was brought up. Some comments suggested the creation of a hazardous material and waste officer whose duty would be to oversee all such activities.

Socioeconomic Conditions

A number of comments were received regarding the social and economic conditions, and possibilities due to the Project. One of the most frequent statements expressed the need for the consideration of future generations of Hawai‘i, and how the Project could benefit the existing and coming generations. Multiple suggestions were given, including establishing, or supporting existing, scholarship and/or internship programs; providing on-the-job training or vocational training programs at the local college to encourage the involvement of local residents with the Project; and performing outreach efforts to local schools and community groups to raise interest in astronomy and the research performed in the observatories. Other ideas to benefit the community included funding of community centers, health clinics, or research efforts not necessarily associated with the Project. There were also concerns raised, in particular about the low level of local hiring and that most of the high-paying jobs at the observatories are held by people not originally from Hawai‘i. Multiple comments asked for detailed and precise information about the positions to be created by the Project with their associated salaries, and how these positions are anticipated to be distributed between Native Hawaiians, long-term residents of Hawai‘i, and people brought into the state; another suggestion was to break the employment information down by educational or vocational requirement. Some expressed concerns about the implications of creating a number of new, high-paying jobs on the island’s communities, in that those jobs would then lead to possible rises in property values and taxes, prices of goods, and other increases.

Land Use Plans, Policies, and Controls

Many of the comments pertaining to land use focused on the siting of the Project. Some comments suggested the dismantling of an older observatory and using that site for the TMT. Other comments focused on placing the TMT as close to existing facilities and infrastructure as possible, in order to minimize the amount of new disturbance to the mountain. Some questioned whether the Project would qualify for a Conservation District Use Permit (CDUP).

Roadways and Traffic

The main concern about traffic was that the Project could lead to more traffic on the mountain, which already experiences periods of congestion, particularly during times of snow. One suggestion that was provided was to pave the unpaved section of Maunakea Access Road as a means of mitigation for the Project.

Power and Communications

The sole comment received regarding power and communications sought information about how much electrical power the Project would use.

Climate, Meteorology, Air Quality, and Lighting

The possible effects of climate change, and impacts of such changes on the Project, were brought up a few times in the comments. The other focus was on the vog currently being experienced by the island, and whether it would have any impact on the Project.

TMT Project

Comments were largely related to what the TMT would be able to accomplish, and what made it so different from existing telescopes. Related to this, some comments also wanted to see objectives, missions, and priorities for the TMT, including what types of research would be performed. A comment that was received multiple times involved whether or not the military would have access to or interest in the TMT. The location of the Headquarters was asked by a few commentors. Other frequent comments focused on the request for a complete life-cycle analysis of the Project, from construction through operation to dismantling. Another comment was about the restoration plan for the site; that it needs to be prepared and include evidence that funding for the restoration work would be there when needed. A complete comparison between siting TMT on Maunakea and in Chile was asked for a few times, including all associated costs, impacts, and the analysis used to arrive at the conclusion of which site would be best to make the investment in. The past analysis from the sites surveyed that narrowed it down to the final two choices was of interest to some commentors. Some comments indicated that the same information from the Outrigger EIS should be used for the cumulative impacts analysis for the TMT project.

Other Comments

Numerous comments were received that, while valid and important, are not within the scope of environmental analysis of this Draft EIS. Many of these comments expressed concern and disappointment with the amount of rent paid by the existing observatories for the use of the mountain. Another comment's concern was the expiration date of the lease that allows the lands to be used and subleased by the University of Hawai‘i (UH). Some comments stated that UH has proven to be a poor steward of the mountain by past actions and occurrences, and that the trust of many on the island has been broken. The last-approved management plan limited the number of telescopes to 13, which has been reached, and the point was brought up that any new development would exceed that maximum. The decommissioning of older, less advanced telescopes was a comment that was made numerous times, as well. Comments focused on the

Comprehensive Management Plan (CMP) were also numerous and wide-ranging. The most frequent one was that the CMP being done by UH would not meet the legal requirements pertaining to the document, and that without a proper CMP an EIS would not be able to be completed. Another comment made was about the ownership of ceded lands, which include the Project site; that the ownership is still unclear and therefore, the lands should not be used in this manner.

Appendix C. Comment Form

COMMENT FORM

Thirty Meter Telescope Project

The University of Hawaiʻi encourages comments on the Thirty Meter Telescope (TMT) project. The 45-day Draft EIS comment period opened with the notice of availability published in the OEQC Environmental Notice on May 23, 2009. Comments are required to be submitted or postmarked by July 7, 2009. Comments can be submitted via the website (www.TMT-HawaiiEIS.org), the toll-free hotline (1-866-284-1716), at public meetings, or by mailing written comments to the address on this form. This form is provided for convenience only; to submit this form by mail, please fold and staple, and affix proper postage (see reverse side for guide). Any letter or other printed comments not using this form are also welcome.

All comments received will be responded to individually with both the comment and responses included in the Final EIS.

Name: ______________________ **Address:** ______________________

Phone: ______________________ ______________________

E-mail: ______________________ ______________________

Comments: ____

(use additional sheets if appropriate)

Fold Here

Return Address:

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Place
Postage
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University of Hawai‘i at Hilo
Office of the Chancellor
200 W. Kāwili Street
Hilo, Hawai‘i 96720-4091

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