FINAL ENVIRONMENTAL ASSESSMENT & FINDING OF NO SIGNIFICANT IMPACT, CALTECH SUBMILLIMETER OBSERVATORY DECOMMISSIONING

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PLANNING SOLUTIONS

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Appendix D. Biological Setting Analysis: Caltech Submillimeter Observatory Decommissioning

Biological Setting Analysis: Caltech Submillimeter Observatory Decommissioning

Final Report
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Acronyms

BMP	Best Management Practices
CMP	Comprehensive Management Plan
CSO	Caltech Submillimeter Observatory
DLNR	Department of Land and Natural Resources
DOFAW	Division of Forestry and Wildlife
EIS	Environmental Impact Statement
ISMP	Invasive Species Management Plan
OMKM	Office of Maunakea Management
SOP	Standard Operating Procedure

1 Introduction

This Biological Settings Analysis was prepared to support the biological discussion in the various documents associated with the Caltech Submillimeter Observatory decommissioning, most notably an Environmental Assessment and a Conservation District Use Application. The report describes the existing environment with regard to biological resources, outlines the restoration scenarios that may occur as part of the decommissioning process, describes the potential effects on biological resources for the deconstruction and restoration scenarios, and prescribes protocols and mitigation measures for the protection of biological resources to be incorporated into decommissioning planning. This report is not an approval document and does not endorse any particular alternative. Rather, this report is a disclosure document that discusses a range of possibilities, the likely impacts to biological resources, and informs the alternatives that will be analyzed in depth in an Environmental Assessment.

2 Affected Environment: Biological Resources

The Caltech Submillimeter Observatory (CSO) is located on a 0.75-acre site at 13,350 ft. elevation near the summit of Maunakea, Island of Hawaiʻi. The site is located within the Astronomy Precinct of the Maunakea Science Reserve, on State land that is leased by the University of Hawaiʻi and managed by the Office of Maunakea Management (OMKM). The project site was disturbed by grading and construction of the CSO in 1987. Other construction in the area during the same period included erection of the James Clerk Maxwell Telescope and a road to access these new observatories. These activities resulted in the sites being leveled and fill being deposited in the area around the project site.

2.1 Habitat

The CSO is located in the alpine stone desert ecosystem, which occurs above the 11,150 ft. elevation on Maunakea. The alpine stone desert is characterized by low precipitation, high rates of evaporation, high wind speeds, high solar radiation, regular freezing and thawing cycles, and a porous substrate. These characteristics limit the development of the plant and animal communities in this zone (Aldrich 2005). The CSO site is located on a lava flow composed mainly of basalt.

2.2 Lichens, Mosses, and Vascular Plants

The plant community in the alpine stone desert consists of species of lichens and mosses with sparsely distributed vascular plants.[1] Lichens are the dominant species present. About half of the lichens recorded on Maunakea have not been identified to the species level and thus are of unknown origin. Twenty three species of lichen and approximately twelve species of moss known to occur within the Maunakea alpine stone desert have been identified to the species level (Berryman and Smith 2011, Smith et al. 1982). All lichen and moss species identified on Maunakea to date are native to the Hawaiian Islands.

Vascular plants grow mainly at the base of larger rocks where soil and water accumulate and they are protected from the wind (Char 1999). The most abundant vascular species in Maunakea's alpine stone desert are two grass species, Hawaiian bentgrass (*Agrostis sandwicensis*) and *pili uka* (*Trisetum*

[1] All discussion on the plant community in general includes lichens. Although lichens are not plants they are often grouped into the vegetative community by land managers for consideration of species presence and effects of management activities.

glomeratum), and two fern species, *ʻiwa ʻiwa* (*Asplenium adiantum-nigrum*) and Douglas' bladderfern (*Cystopteris douglasii*). Of these four species, Hawaiian bentgrass is the most common.

Lichens, mosses, and vascular plants recorded in the alpine stone desert are listed in Table 1 (SRGII 2009 and Gerrish 2011). Gerrish (2011) conducted a botanical survey that by design documented all individual vascular plants, native and non-native, in the vicinity of the project site. None of the lichens, mosses, or vascular plants present within the alpine stone desert are currently listed or proposed for listing as threatened or endangered species.

To determine the presence, abundance and composition of lichens, mosses, and vascular plants throughout the entire project site, a survey was conducted that involved walking transects and recording species presence within and just outside of the site (Appendix A, Medeiros 2019). The survey report details the sparse nature of lichens and vegetation and their locations. Eleven clumps of lichens were observed. The most abundant vascular plant in and near the survey site was the endemic grass *pili uka* (*Trisetum glomeratum*). Most *pili uka* clumps were growing on topographically disturbed areas and one individual was found growing in a crack in the pavement driveway. Several individual *ʻiwa ʻiwa* ferns were found just outside of the east-to-south boundary of the subleased lands, none were found within the subleased lands. No other plant species were recorded.

Table 1. Lichen, Moss, and Vascular Plant Species Recorded in the Summit Region of Maunakea

Species Name	Hawaiian/ Common Name	Origin	Notes	Documented in the Vicinity of the CSO
Lichens				
Acarospora cf. depressa	---	Native	Uncommon	---
Baeomyces skottsbergii	---	Native	Abundance Unknown	Previously Recorded
Candelariella vitellina	---	Native	Common	---
Diploschistes lutescens	---	Native	Abundance Unknown	Previously Recorded
Lecanora muralis	---	Native	Common	---
Lecanora polytropa	---	Native	Abundance Unknown	Recorded during recent survey (Medeiros 2019)
Lecidea skottsbergii	---	Native	Common	Previously Recorded
Lecidea vulcanica	---	Native	Uncommon	---
Physcia dubia	---	Native	Common	---
Pseudephebe pubescens	---	Native	Common	---
Rhizocarpon geographicum	---	Native	Common	Previously Recorded
Umbilicariah hawaiiensis	---	Native	Common	Previously Recorded
Umbilicaria magnussonii	---	Native	Common	Previously Recorded
Umbilicaria pacifica	---	Native	Uncommon	---

Species Name	Hawaiian/ Common Name	Origin	Notes	Documented in the Vicinity of the CSO
Mosses				
Amphidium tortuosum	---	Native	Occasional	Previously Recorded
Andreaea acutifolia	---	Native	Occasional	Previously Recorded
Bryum caespiticum	---	Native	Uncommon	---
Bryum hawaiicum	---	Endemic	Uncommon	---
Encalypta rhabdocarpa	---	Native	Abundance unknown	Previously Recorded
Grimmia apocarpa var. *pulvinata*	---	Native	Occasional	---
Grimmia cf. pilifera	---	Native	Uncommon	---
Grimmia sp.	---	Native	Occasional	Previously Recorded
Pohlia cruda	---	Native	Common	Previously Recorded
Pohlia mauiensis	---	Endemic	Historical Records Only	---
Racomitrium lanuginosum	---	Native	Historical Records Only	Previously Recorded
Rosulabryum capillare	---	Native	Historical Records Only	---
Tortella humilis	---	Native	Uncommon	---
Zygodon tetragonostomus	---	Native	Uncommon	---
Herbs, Ferns, and Grasses				
Agrostis sandwicensis	Hawaiian bentgrass	Endemic	Grass	---
Asplenium adiantum-nigrum	*ʻiwa ʻiwa*	Native	Fern found on lava flows	Recorded during recent survey (Medeiros 2019)
Asplenium trichomanes	*ʻoāliʻi*	Native	Fern, uncommon	---
Cystopteris douglasii	Douglas bladderfern	Native	Fern that grows on weathered rock. USFWS Species of Concern	---
Hypochaeris radicata	hairy cat's ear	Non-Native	Herb	---
Scenecio madagascarensis	fireweed	Non-Native	Herb	Previously Recorded
Taraxicum officinale	common dandelion	Non-Native	Herb	---
Tetramolopium humile humile	alpine tetramolopium	Endemic	Herb	---
Trisetum glomeratum	*pili uka*	Endemic	Grass	Recorded during recent survey (Medeiros 2019)
Vaccinium reticulatum	*ʻōhelo ʻai*	Native	Shrub, unlikely to be in the vicinity of the site	---

2.3 Fauna

2.3.1 Arthropods

Arthropods are the most common fauna present in the alpine stone desert ecosystem. Both native and non-native arthropods inhabit the Astronomy Precinct. Surveys typically distinguish between resident and non-resident species. Resident arthropods are cold-adapted species that occur and survive on the mountain at higher elevations. Non-resident species are those that are brought to the summit by the aeolian drift process (i.e. blown up by the wind) or are inadvertently transported through human activity. Non-resident species die in the cold weather and provide an important food source for resident species.

While the diversity of resident native arthropod species present at the summit is low, arthropod surveys and invasive species monitoring within the Astronomy Precinct indicate that the abundance of resident native arthropods is much higher than resident non-natives (SRGII 2009, Kirkpatrick and Klasner 2015, and OMKM unpublished data). Native resident species include the wēkiu bug (*Nysius wekiuicola*), a noctuid moth (*Agrotis kuamauna*), a hide beetle (*Dermestes maculatus*), the Hawaiian lycosid wolf spider (*Lycosa hawaiiensis*), a bark louse (*Palistreptus inconstans*), and a centipede (*Lithobius* sp.) (Medieiros et al. 2019, Howarth and Stone 1982). Some taxa recorded within the Astronomy Precinct have not been identified to species level, and because both native and non-native species from these families are known to occur in Hawaiʻi, the origin is unknown. These include two sheet-web spiders (*Erigone* spp.), an unidentified linyphiid sheet-web spider (Family Linyphiidae), two slender springtails (Family Entomobryidae), and two species of mites (Families Anystidae and Eupodidae) (Howarth and Stone 1982).

Invasive species monitoring is conducted by OMKM annually at various locations at the summit and quarterly at all observatories with the goal of detecting new invasive species threats. Invasive arthropod monitoring at observatories involves placing traps within and around the facilities and retrieving them approximately seven days later. Hand searches around the perimeter of each observatory are also conducted. Specimens are identified to the lowest taxa necessary to determine if the arthropod represents a potential threat as an invasive not currently present at the summit. OMKM staff are responsible for identification. Identification may entail sending specimens to the Bishop Museum staff, Hawaiʻi Ant Lab staff, or Department of Land and Natural Resources Division of Forestry and Wildlife (DLNR DOFAW) entomologist for consultation, if necessary. Most invasive species found in perimeter searches or traps outside of observatories are already dead and believed to be products of aeolian drift. If live specimens of invasive species are detected outside of the observatories, further monitoring is done to determine the extent of the population and the potential for eradication. Rapid response protocols and plausible control methods by taxa are detailed in the *Maunakea Invasive Species Management Plan* (ISMP) (Vanderwoude et al. 2015). Table 2 lists arthropods found in and around the CSO during the past five years of invasive species monitoring.

An assessment of the arthropod fauna present at the CSO site was conducted prior to construction of the observatory as part of an Environmental Impact Statement (EIS) (Group 70 1982). Two species of springtails and four species of mites were found in the soil at the CSO site and Hawaiian lycosid wolf spiders (*Lycosa hawaiiensis*) and an anystid mite were found under rocks at the CSO site.

An arthropod survey conducted as part of this project involved sampling by trapping, hand searches, and specimen collection from ice on the north side of the CSO observatory (Table 3, Appendix A, Medieros 2019). The majority of species recorded, with the exception of three, were species not native to the aeolian desert on Maunakea. One native spider species (*Lycosa hawaiiensis*) and one native moth species

(*Agrotis kuamauna*) were recorded, along with one fly species from an unknown origin (*Bradysia* sp.). Arthropods from the *Aphis* genera were found in the traps but could not be identified to the species level. All *Aphis* species in Hawaiʻi are non-native. *Aphis* species have been previously recorded in the aeolian desert on Maunakea. One member of the survey team who samples arthropods regularly in the UH managed areas on Maunakea, reported previously noting native spiders and caterpillars at or near the CSO site although they were not common in this recent survey (Jesse Eiben, pers. comm. 2018).

None of the arthropods present in the alpine stone desert on Maunakea are currently listed or proposed for listing as threatened or endangered species. The wēkiu bug (*Nysius wekiuicola*), a flightless insect that occurs in the summit region of Maunakea, was listed as a candidate endangered species in 1999 (USFWS 1999). The species was removed from the list in 2011 after it was determined that conservation actions were helping to stabilize population numbers (USFWS 2011). Wēkiu bugs are not found on lava flows or in areas dominated by compacted ash/silt as the habitat is considered unsuitable (UH Hilo 2010, Englund et al. 2007, Porter and Englund 2006). While wēkiu bugs have not been found in the lava flow habitat around the CSO, they are found in the area called the Poi Bowl, directly to the east of the CSO. The Poi Bowl is considered prime habitat for the wēkiu bug and will not be subject to disturbance during CSO decommissioning and restoration activities.

Table 2. Arthropods Found In and Around the CSO During OMKM Invasive Species Monitoring (2013-2017)

Order	Family	Scientific Name	Common Name	Origin
Acari	Unknown	Unknown	mites	Native & Non-native
Araneae	Unknown	Unknown	spiders	Native & Non-native
Coleoptera	Coccinellidae	*Harmonia conformis*	ladybird beetle	Non-native
Coleoptera	Coccinellidae	*Hippodamia convergens*	ladybird beetle	Non-native
Coleoptera	Scarabaeidae	*Onthophagus nigriventris*	dung beetle	Non-native
Diptera	Various	Various	Flies	The majority of fly species are either non-native or of unknown origin.
Diptera	Calliphoridae	Unknown	blow flies	Non-native
Diptera	Sphaeroceridae	Unknown	dung flies	Native & Non-native
Diptera	Syrphidae	Unknown	hover flies	Non-native
Hemiptera	Aphididae	*Aphis* sp.	Aphids	Non-native
Hemiptera	Lygaeidae	*Nysius palor*	seed bug	Non-native
Hemiptera	Pentatomidae	*Bagrada hilaris*	shield bug	Non-native
Hemiptera	Psyllidae	Unknown	jumping plant louse	Native & Non-native
Hymenoptera	Braconidae	Unknown	braconid wasp	Native & Non-native
Lepidoptera	Pieridae	*Pieris rapae*	cabbage butterfly	Non-native
Psocoptera	Psocidae	Unknown	bark lice	Native & Non-native

Table 3. Arthropods Recorded Within the Project Area November/December 2018

Order	Family	Scientific Name	Common Name	Origin
Araneae	Lycosidae	*Lycosa hawaiiensis*	Hawaiian lycosid wolf spider	Endemic
Araneae	Trachelidae	*Meriola arcifera*	spider	Non-native
Coleoptera	Coccinellidae	*Hippodamia convergens*	convergens ladybird beetle	Non-native
Coleoptera	Dytiscidae	*Rhantus gutticollis*	diving beetle	Non-native
Dermaptera	Forficulidae	*Forficula auricularia*	European earwig	Non-native
Diptera	Agromyzidae	*Phytomyza plantaginis*	leaf miner fly	Non-native
Diptera	Calliphoridae	*Eucalliphora latifrons*	blue bottle fly	Non-native
Diptera	Ephydridae	*Hydrellia* sp.	ephydrid fly	Non-native
Diptera	Phoridae	*Diplonevra peregrina*	humpbacked fly	Non-native
Diptera	Sciaridae	*Bradysia* sp.	darkwinged fungus gnat	Unknown
Diptera	Syrphidae	*Allograpta exotica*	hover fly	Non-native
Hemiptera	Aphididae	*Aphis* sp.	Aphids	Non-native
Hemiptera	Psyllidae	*Acizzia uncatoides*	jumping plant louse	Non-native
Heteroptera	Lygaeidae	*Neacoryphus bicrucis*	whitecrossed seed bug	Non-native
Heteroptera	Lygaeidae	*Nysius palor*	seed bug	Non-native
Heteroptera	Miridae	*Coridromius variegatus*	plant bug	Non-native
Heteroptera	Nabidae	*Nabis capsiformis*	pale damsel bug	Non-native
Hymenoptera	Braconidae	*Apanteles* sp.	braconid wasp	Non-native
Hymenoptera	Braconidae	*Biosteres* sp.(?)	braconid wasp	Non-native
Hymenoptera	Ichneumonidae	*Diadegma insulare*	Ichneumon wasp	Non-native
Hymenoptera	Ichneumonidae	*Pristomerus spinator*	Ichneumon wasp	Non-native
Lepidoptera	Noctuidae	*Agrotis kuamauna*	noctuid moth	Endemic
Orthoptera	Gryllidae	*Metioche vittaticollis*	cricket	Non-native
Thysanoptera	Thripidae	*Frankliniella* sp.	Thrip	Non-native

2.3.2 Birds and Mammals

Two endangered birds, *ʻuaʻu* (*Pterodrama sandwichensis* or Hawaiian petrel) and *ʻakēʻakē* (*Oceanodroma castro* or band-rumped storm petrel), may utilize the alpine shrublands and grasslands on Maunakea, but there have been no recorded detections of birds or burrows in the vicinity of the CSO site. Although there are records of pigs and sheep occurring in the alpine stone desert, feral ungulates are not common as there are very few plants to browse. Rodents actively reproduce in the summit region and could be characterized as regularly encountered. The endangered *ʻōpeʻapeʻa* (*Lasiurus cinereus semotus* or Hawaiian hoary bat) has not been detected in the vicinity of the CSO site, but may occur at high elevations. The presence of *ʻōpeʻapeʻa* in the Lake Waiʻau area (~13,000 ft) is currently under investigation.

3 Habitat Enhancement and Restoration Activities

The *Mauna Kea Comprehensive Management Plan* (CMP) requires observatories to develop a restoration plan in association with decommissioning (Ku'iwalu 2009). Site restoration will occur as part of the CSO decommissioning process. Moderate or full restoration is the desired goal. As defined by the *Decommissioning Plan for the Mauna Kea Observatories* (SRGII 2010):

- Minimal restoration is the removal of all man-made materials and grading of the site, leaving the area in a safe condition.
- Moderate restoration goes beyond minimal to include enhancing the physical habitat structure to benefit the native arthropod community.
- Full restoration would return the site to its original pre-construction topography, as well as restoring arthropod habitat.

Moderate restoration would be accomplished by using native material to backfill all cavities remaining after structures and furnishings are removed. Moderate restoration would involve some grading to enhance the physical habitat structure. Some fill placed during construction of the CSO that is not used to backfill cavities may be removed from the project site and stored at a nearby offsite location for later use. The goal of moderate restoration is enhancement of habitat to benefit the native arthropod community, not restoration of the site to pre-CSO topography.

Full restoration would return the site to its original pre-CSO topography and restore arthropod habitat. Full restoration would be accomplished by using native material to backfill all cavities remaining after structures and furnishings are removed, and grading the site. Full restoration would require removal of excess fill placed during construction of the CSO. Excess fill would be removed by means of a loader and dump trucks to an off-site stockpile location on the summit, most likely the Batch Plant Storage Area. Excess fill would be available for use during other decommissioning projects as needed.

Under either restoration scenario, a combination of active and passive restoration techniques would be used. Active restoration includes removal of all manmade features, backfilling holes and trenches, and placing and removing fill to restore the topography and surficial material of the site. Under full restoration, restored topography and surface materials would mimic site conditions just prior to the CSO construction to the extent possible. A topographic map dated January 21, 1983 represents the site prior to construction. A second topographic map dated November 24, 2015 depicts existing site conditions. The 2015 map, along with other documents, indicates that some earthen material moved during construction activities at the summit in this area (i.e. CSO, James Clerk Maxwell Telescope and potentially road work) was pushed into elongated piles. All fill material used for backfilling and finishing would come from the piles around parts of the site's perimeter. Geological analysis has confirmed that this fill is consistent with other material at the summit. The only non-native species present in the fill would be those that are already part of the existing environment. Estimates of the volume of earthen material needed to backfill and finish the site indicate more material is available than needed. This phase of the restoration process aims to create the topographic conditions that provide sufficient conditions for passive restoration of the biological community.

Passive restoration through natural recruitment of lichens, mosses, and vascular plants as well as the arthropod community is expected once the site has been topographically restored. No out-planting of native species is recommended as few plants were present prior to construction of the CSO, and sparse plant populations are typical of lava flow habitat in the alpine stone desert. No transfer of arthropods, other than those already present in fill is recommended.

It is recommended that two points within the sub-lease footprint be selected for monitoring during the OMKM annual native/non-natives species monitoring program to evaluate if restoration goals are being achieved.

4 Potential Effects

Potential effects on biological resources would be same for all the deconstruction and restoration scenarios, except for a No Action Alternative. Under a No Action Alternative, biological resources would remain unimpacted, and both native and non-native species would continue to occupy the project footprint.

Effects Common to All Action Alternatives

Under all deconstruction and restoration scenarios lichens, mosses, and vascular plants present within the project footprint would be subject to disturbance and possible mortality as a result of heavy equipment use, and movement and placement of substrate fill. Adverse impacts include being crushed, buried, or covered in dust. Due to the sparse nature of lichens, mosses, and plants within the affected area and the presence of the same species on adjacent lands, the loss of some individuals does not represent a significant adverse effect nor does it represent a threat to the continued presence of these species on Maunakea. It is expected that lichens, mosses, and vascular plants would recolonize the site after removal of structures and placement of fill, as has been the case in other disturbed areas at the summit. Due to extreme environmental conditions at the summit, recolonization of disturbed areas takes longer than it does at lower elevations. Project protocols would be followed to minimize dust generation including using water to limit the amount of airborne dust and limiting activities during very windy conditions.

Under all deconstruction and restoration scenarios, invasive vascular plant species not currently present may be deposited either via wind or human activity and potentially grow in the newly disturbed areas. Mitigation measures and project protocols would be followed to prevent the establishment of any new invasive plant species. Significant adverse effects related to the introduction of new species of invasive vascular plants are not anticipated due to mitigation measures and extreme environmental conditions that prohibit rapid proliferation.

Under all deconstruction and restoration scenarios there will be some impacts to the arthropod habitat within the project footprint. Heavy equipment use can crush cinder and reduce the size and volume of voids beneath the ground surface, reducing habitat utilized by some native arthropod species. Mitigation measures and project protocols would be followed to minimize the amount of habitat disturbance. These include restricting all vehicles moving in and out of the CSO parcel and staging area to existing roads and driveways and establishing designated routes for large equipment travel when off-road travel must occur. Significant adverse impacts to arthropod habitat are not anticipated.

Under all deconstruction and restoration scenarios there would be some impacts to native and endemic arthropods. Some mortality to arthropods would occur due to use of heavy equipment and moving of substrate around the project footprint and from nearby areas. However, the level of mortality of arthropods is unlikely to significantly affect the metapopulation of any single native arthropod species within the Astronomy Precinct. The majority of arthropod species recorded at the CSO site are predominantly non-native. Arthropod surveys in areas around the summit have recorded the presence of native arthropods in many previously disturbed areas including around observatory structures, indicating a high likelihood of arthropods recolonizing the site after topographic restoration. Removal of the CSO would have no effect on the process of aeolian drift and thus would not diminish the food supply for resident arthropods. No adverse effects on wēkiu bugs would be anticipated as a result of the deconstruction and restoration activities as lava flows are not wēkiu bug habitat, and restoration activities would not require fill material to be taken from current wēkiu bug habitat. Significant adverse effects to the arthropod community due to CSO decommissioning activities are not anticipated.

The threat of importing new species of invasive arthropods must be considered under all deconstruction and restoration scenarios. However, there are several factors that minimize the likelihood of it happening in connection with decommissioning. Decommissioning involves bringing heavy machinery up to the summit to conduct the activities. There are no building materials or other similar construction items that would be transported from lower elevations on which invasive arthropods could "hitchhike" to the site. As detailed in the ISMP and the CSO decommissioning protocols, all heavy equipment, personal belongings, and vehicles must be cleaned at lower elevations before proceeding up the Maunakea Access Road, reducing the threat of introduction. Additionally, the extreme environmental conditions at the summit are not conducive for the establishment of most arthropod species not already present. The majority of new species of invasive arthropods that have been previously discovered at the summit were found dead. Extreme conditions limit the movement and potentially the reproduction of any new live arthropod species, providing opportunity for eradication. Mitigation measures and project protocols would be followed to prevent the establishment of any new invasive arthropod species. Significant adverse effects related to the establishment of new species of invasive arthropods are not anticipated due to mitigation measures and extreme environmental conditions.

Under all deconstruction and restoration scenarios there is the potential for biological organisms to be exposed to organic compounds (i.e. solids from cesspool) and inorganic chemicals (i.e. petroleum products) due to leaks from motorized equipment, decommissioning of the cesspool, or movement of substrate contaminated during previous hydraulic fluid leaks. Project protocols will detail how to avoid these impacts including installing BMPs to contain any spills, and proper use, storage, and disposal of all hazardous materials. The cesspool shall be removed along with solids present and any fill substrate polluted by cesspool contents. Solids would be tested for potential contaminants in order to determine what sanitary landfill they can be taken to for disposal. The empty cesspool site would be backfilled with native material from the site. In the event that it is unfeasible to remove some portion of cesspool solids, any residue present, and/or a portion of the cesspool rings, no significant adverse impacts to biological organisms are anticipated. Any remaining solids, residue, and/or portions of the cesspool rings would be buried underneath native material used to backfill the site. Any portion of the cesspool rings left would remain at the site where buried (would not move through the soil). Any solids or residue left onsite would be subject to decomposition, albeit very slowly due to the characteristics of the aeolian ecosystem. The only biological organisms likely to come in contact with any remaining solids, residue, and/or portion of the cesspool rings are invertebrates. Given that every effort will be made to remove as much material as possible and that any remaining material will occupy a very small amount of invertebrate habitat, if any (depending on depth), remains of solids, residue and/or portions of the cesspool rings do not represent a significant adverse impact.

A number of small hydraulic fluid leaks occurred at the CSO between 1990 and 2000 (SRGII 2009). These leaks were noted in the Phase I Environmental Site Assessment. Once the base of the CSO is removed, the substrate surrounding the building site would be tested for the presence of hydrocarbons as part of the Phase II Environmental Site Assessment. Any contaminated soil would be removed from the Astronomy Precinct, although none is anticipated as the fluid spills were contained to the cement pad around the observatory, were very small, and were cleaned up rapidly. Due to project protocols which would be followed, including the removal of any contaminated substrate from the Astronomy Precinct, no significant adverse impacts to biological organisms due to exposure to inorganic chemicals is anticipated.

Under all deconstruction and restoration scenarios adverse effects on native birds or mammals is highly unlikely, as none are known to frequent this part of the Science Reserve.

Effects Limited in Scope to Specific Action Alternatives

Outbuilding. Under a scenario where the outbuilding at the site is left in place, the effects common to all action alternatives would remain the same. The square footage of the area restored to natural conditions would be slightly lower. Existing impacts to biological organisms in the area around the outbuilding would remain.

Infrastructure capping. Under all alternatives the observatory foundation, including footers and slab, will be removed. Under the infrastructure capping scenario all underground utilities (water and electric) will be cut off and each line will be capped in place. Leaving the utility lines in place will not have any impact on biological resources.

5 Protocols and Mitigation Measures for Protection of Biological Resources

This section contains entry/exit protocols, operational protocols, and other measures to be incorporated into CSO decommissioning plans for the protection of biological resources at and near the site. As the target condition at the end deconstruction and restoration is topographic restoration of the site to facilitate passive recruitment of native lichens, mosses, vascular plants, and arthropods, these protocols and mitigation measures are mainly designed to avoid or decrease adverse impacts of decommissioning construction activities.

5.1 Mandatory Training

As required by the *Mauna Kea CMP*, all persons involved with construction activities, including planning, demolition, and site restoration, should participate in a mandatory training about the natural resources on Maunakea. All work will be performed in accordance with the principles and frequency established in the Maunakea User Orientation. The orientation must be repeated every three years. Any person not behaving in a manner consistent with the principles established in the Maunakea User Orientation will be required to leave the project site.

5.2 Minimize Habitat Disturbance

The rocks and cinder on the lava flow where the CSO is located are home to lichens, mosses, and endemic arthropods that can be adversely affected by disturbance, erosion, and dust. BMPs to minimize erosion and dust due to decommissioning activities will be employed. Disturbance should be minimized in the habitat surrounding the decommissioning site.

Minimize disturbance.

- Decommissioning activities will be limited to the CSO parcel and staging area to the greatest extent possible.
- All project materials will remain within the project site or staging area, and no cinder or other materials should be side-cast into adjacent habitat.
- Temporary fencing will be placed to ensure all project activities and material remain within the project site.
- Any necessary erosion control measures will be maintained in good condition throughout the duration of the project. Erosion control measures will be replaced if degradation is occurring.
- All vehicles moving in and out of the CSO parcel and staging area will use the existing roads and driveways.

Minimize dust generation and spread.

- Water will be applied to substrate to minimize dust generation during decommissioning activities. This includes fill operations where water will be applied directly to excavation sites and cinder fill.
- High winds can spread dust to surrounding habitat. Dust-generating activities will be suspended during high winds.

Establish designated routes for large equipment travel.

- The travel routes for distribution of substrate fill will be well planned prior to collection. This includes routes to be used to back fill the CSO site as well as routes to be used to stockpile any excess fill off site.

5.3 Avoid Introduction of Non-native Species

Introduction of non-native species is one of the main concerns associated with bringing in materials and equipment for decommissioning activities. Avoiding introduction of non-native invertebrates and plant species is a high priority due to the threat they present to native invertebrates and their habitat at or near the summit. Ants are especially threatening, and their introduction should be strictly prevented. Introduced plants can change the microhabitat conditions if they become established, thereby facilitating the establishment of other non-native species.

All Standard Operating Procedures (SOP) detailed in the *Maunakea Invasive Species Management Plan* (ISMP) will be followed to prevent the introduction of new invasive species as well as the spread of existing invasive species (Vanderwoude et al. 2015).[2]

As detailed in ISMP SOP 01 and SOP 02:

- Personal belongings and vehicles are to be cleaned and inspected by the operator prior to arrival at the Saddle Road / Maunakea Access Road junction. The operator of any personal vehicle must remove any plant, animal, or earthen material (i.e. weed seeds, ants, soil, mud, food scraps), that might harbor invasive animals or plant seeds.

[2] The *Maunakea ISMP* and SOP can be viewed online at http://www.malamamaunakea.org/environment/invasive-species

- Heavy equipment brought to Maunakea must be free of large deposits of soil, dirt, and vegetation debris that may harbor alien arthropods and weed seeds.
- Pressure-wash and/or otherwise remove alien arthropods and weed seeds from all equipment and materials before moving them from lower elevations and up the Maunakea Access Road. This cleaning can be done in baseyards in Hilo or Waimea before continuing up Saddle Road.
- Inspect large trucks, tractors, and other heavy equipment before proceeding up Maunakea Access Road. All large deliveries and vehicles and heavy equipment will be inspected by a DLNR-approved biologist for the presence of invasive invertebrates and/or weed seeds. Inspections will be performed below the Saddle Road junction prior to arrival at the project site. Any deliveries or vehicles or equipment found to have weed seeds or invasive invertebrates will be refused entry until deemed clear, at the contractor's expense.

CSO buildings targeted for demolition should be free of invasive species prior to deconstruction.

- OMKM will place traps inside the CSO facility a few weeks before decommissioning activities begin to confirm that there are no new invasive species present that may be released during deconstruction. Any invasive species present will be eradicated prior to decommissioning activities.

5.4 On-site Material Storage and Disposal

Equipment, materials, and trash being stored on site during the deconstruction process can be displaced by high winds or serve as an attractant to non-native species, both of which can possibly cause damage to biological resources.

Store loose tools and small equipment so that they do not damage resources.

- Loose tools or small equipment will not be left unattended and will be properly stored at the end of each day.

Secure deconstruction debris so that it does not damage resources.

- Cover deconstruction trash containers tightly to prevent construction waste from being dispersed by wind.
- Cover deconstruction materials stored at the site with tarps, or anchored them in place, so they are not susceptible to movement by wind.
- Collect any deconstruction materials and trash blown into surrounding habitat, with a minimum of disturbance and as soon as possible following dispersal.
- Ensure all deconstruction waste materials and trash receptacles are secured at the end of each day.
- All deconstruction waste material will be removed from the site and properly disposed of.

Secure personal trash so that it does not damage resources or attract non-native species.

- Outdoor trash receptacles will be provided for ready disposal of lunch bags, wrappers, and other personal trash. These receptacles will be secured to the ground, have attached lids and plastic liners, and be collected frequently to reduce food availability for alien predators.
- All perishable items including food, food wrappers, and containers, etc. will be removed from the site at the end of each day and properly disposed of.

Avoid, and if necessary, contain spills.

- Oil spills and other contaminating events have occurred at observatories in the past. While these spills have always been contained immediately and have not resulted in serious ecological damage, care must be taken to avoid any spills.
- Install BMPs to contain any spills of hydraulic fluid or other chemicals during decommissioning.
- Install BMPs to ensure petroleum products from large equipment will not drip onto the ground while in use or in storage.
- The project staff and contractors will keep a log of hazardous materials brought on-site and follow Federal guidelines specifying the use and disposal of oil, gasoline, dangerous chemicals, and other substances used during decommissioning activities.
- Report spills immediately to a designated project representative and the proper authorities.
- Contain and clean all spills following appropriate protocols.
- Equipment will not be cleaned on-site.

5.5 Monitoring for Invasive Species

Monitor the construction site and staging areas to detect new introductions of non-native arthropod and plant species. Should any new non-native arthropod or plant introductions be detected during monitoring, the current rapid response plan detailed in the ISMP would be followed to reduce adverse impacts. Non-native species of highest concern and plausible control methods are listed in the ISMP.

- Conduct monthly monitoring for invasive species at the site throughout the decommissioning process.
- Conduct quarterly monitoring for invasive species, as part of OMKM's monitoring of existing observatories, for a period of three years post project completion.[3]
- Should the outbuilding remain on-site, it should be monitored during OMKM's quarterly monitoring of observatories as long as the facility remains.
- Should a new invasive species be detected, a rapid response plan would be followed.
    - New invasive plant species would be hand pulled, bagged, and disposed of off-site.
    - If a new species of invasive arthropod is detected, additional traps would be set in the area surrounding the detection location. Additional traps would be used both to determine the size of population and the area occupied as well as serve as a method of potential eradication. Should the species prove to be persistent, DLNR DOFAW would be notified and coordination for eradication would be conducted under DLNR authority and rules. SOPs for monitoring and rapid response detailed in the ISMP would be followed: (http://www.malamamaunakea.org/uploads/environment/MKISMP/SOPC_Invertebrate_ThreatIDCollectionProcessGuide.pdf and http://www.malamamaunakea.org/uploads/environment/MKISMP/MaunakeaInvasiveSppMgmtPlan_PCSUTechR_v191.pdf).

[3] A monitoring period of three years is required per the *Decommissioning Plan for the Maunakea Observatories* (SRGII 2010).

6 References

Aldrich, P. 2005. *Biological Information for Mauna Kea*. Prepared for the Office of Mauna Kea Management by Patrick Aldrich, Zoology Department, University of Hawaiʻi, Honolulu, HI.

Berryman, S. and C.W. Smith. 2011. *Lichen and Bryophytes of Mauna Kea Within the TMT Footprint and Impact Area Summit of Mauna Kea*. December.

Char, W.P. 1999. *Botanical Resources, Mauna Kea Summit*. Appendix G of Mauna Kea Science Reserve Master Plan. Honolulu, HI.

Englund, R.A., A.E. Vorsino and H.M. Laederich. 2007. *Results of the 2006 Wekiu Bug (Nysius wekiuicola) Surveys on Mauna Kea, Hawaiʻi Island*. Final Report. Prepared for Office of Mauna Kea Management. Hawaii Biological Survey Report 2007-03. Hawaii Biological Survey, Bishop Museum Honolulu, HI.

Gerrish, G. 2011. *Botanical Baseline Survey of the University of Hawaiʻi's Managed Lands on Mauna Kea*. Prepared for Office of Maunakea Management. August.

Group 70. 1982. *A 10-Meter Telescope for Millimeter and Submillimeter Astronomy at Mauna Kea, Hamakua, Hawaii, California Institute of Technology, Final Environmental Impact Statement*. August.

Howarth, F.G. and F.D. Stone. 1982. *An assessment of the arthropod fauna and aeolian ecosystem near the summit of Mauna Kea, Hawaiʻi*. Prepared for Group 70, Honolulu, Hawaiʻi. 18 pp.

Medeiros, M. 2019. *Biological Inventory and Assessment Report, Fall 2018. Caltech Submillimeter Observatory, Maunakea, Hawaii*. Prepared for Sustainable Resources Group Intn'l, Inc. January.

Kirkpatrick, J. and F. Klasner. 2015. *2013 Invasive Species and Native Arthropod Monitoring Report*. Office of Maunakea Management.

Kuʻiwalu. 2009. *Mauna Kea Comprehensive Management Plan*. Prepared for University of Hawaiʻi. April.

Office of Maunakea Management (OMKM). Unpublished data 2014-2018. Standard Operating Procedure 10, *Invasive Invertebrate Early Detection Surveys of Facilities.*

Office of Maunakea Management (OMKM). Unpublished data 2014-2018. Standard Operating Procedure 12, *Maunakea Science Reserve Early Detection Arthropod & Vegetation Surveys.*

Porter, S.C. and R.A. Englund. 2006. *Possible geologic factors influencing the distribution of the Wekiu Bug on Mauna Kea, Hawaii*. Hawaii Biological Survey Report 2006-031. Prepared for the Office of Mauna Kea Management by S.C. Porter and R.A. Englund, Hawaii Biological Survey, Bishop Museum Honolulu, HI.

Smith, C.W., W.J. Hoe and P.J. O'Conner. 1982. *Botanical Survey of the Mauna Kea summit above 13,000 feet*. Prepared for Group 70. October.

Sustainable Resources Group Intn'l, Inc. 2009. *Natural Resources Management Plan for the UH Management Areas on Mauna Kea. A Sub-Plan of the Mauna Kea Comprehensive Management Plan*. September.

Sustainable Resources Group Intn'l, Inc. 2010. *Decommissioning Plan for the Mauna Kea Observatories. A Sub-Plan of the Mauna Kea Comprehensive Management Plan*. January.

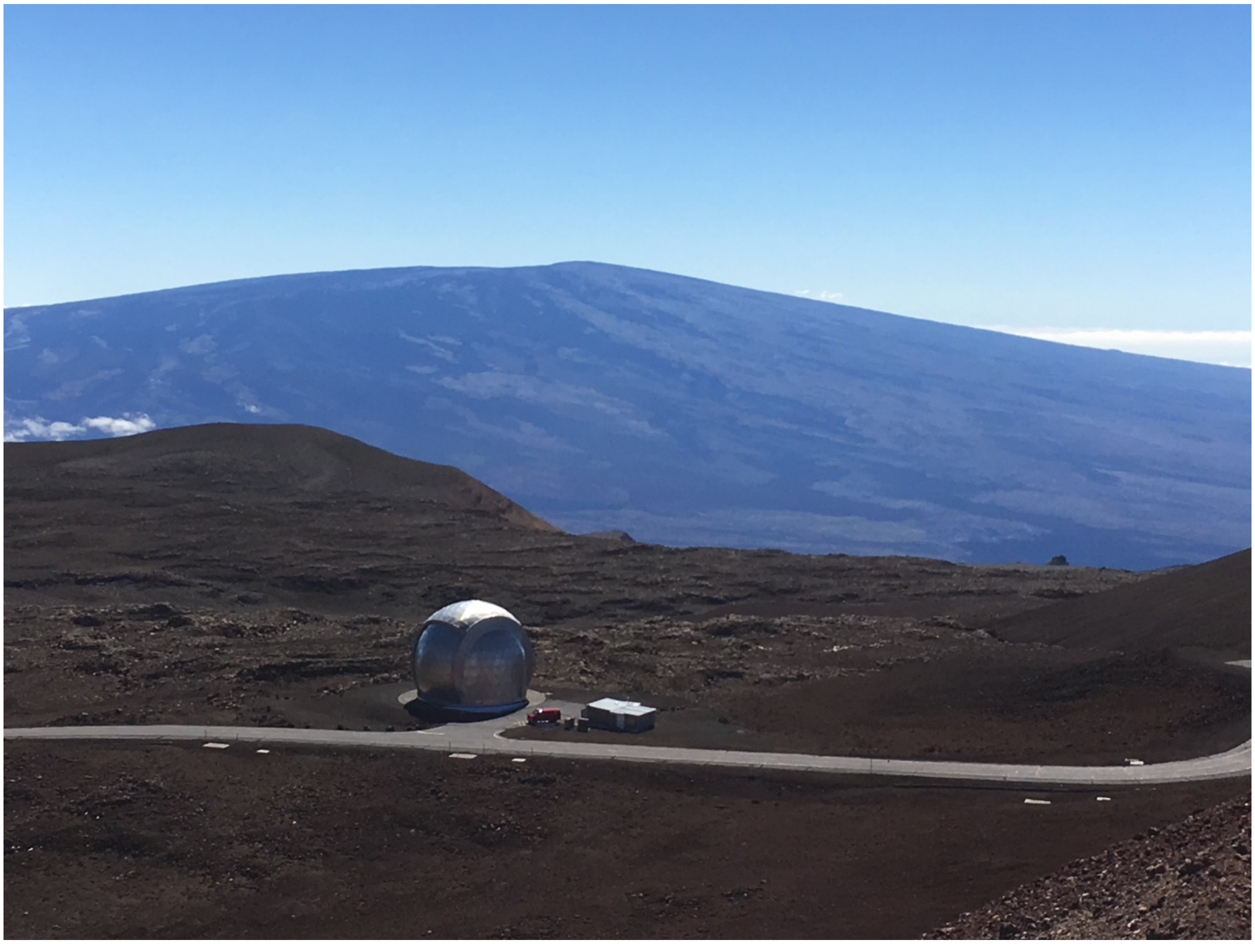
University of Hawaii Hilo. 2010. *Final Environmental Impact Statement Thirty Meter Telescope Project, Island of Hawaiʻi*. May.

U.S. Fish and Wildlife Service (USFWS). 1999. *Review of Animal and Plant Taxa That are Candidates or Proposed for Listing as Endangered or Threatened*. Federal Register (64)205: 57534-57547. https://www.govinfo.gov/content/pkg/FR-1999-10-25/pdf/99-27822.pdf.

U.S. Fish and Wildlife Service (USFWS). 2011. *Species Assessment and listing priority assignment form: Nysius wēkiuicola*. https://www.federalregister.gov/documents/2011/10/26/2011-27122/endangered-and-threatened-wildlife-and-plants-review-of-native-species-that-are-candidates-for

Vanderwoude, C., F. Klasner, J. Kirkpatrick, S. Kaye. 2015. *Maunakea Invasive Species Management Plan*. Prepared for the Office of Maunakea Management. February. http://www.malamamaunakea.org/environment/invasive-species

Biological Inventory and Assessment Report, Fall 2018
Caltech Submillimeter Observatory, Maunakea, Hawai‘i



April 2019

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TABLE OF CONTENTS

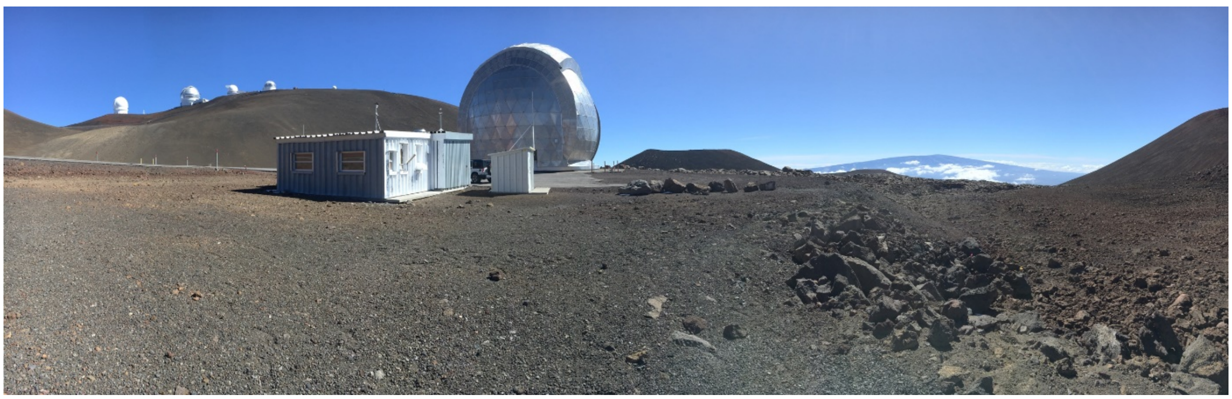
1 INTRODUCTION

1.1 Caltech Submillimeter Observatory Decommissioning

The Caltech Submillimeter Observatory (CSO) on Maunakea is in the process of decommissioning. A biological setting analysis is needed for use in the CSO decommissioning process as conducted under the *Decommissioning Plan for the Maunakea Observatories* (SRGII 2010). This analysis will present information on the existing abiotic and biotic features of the site, and analyze how changes resulting from decommissioning activities (deconstruction and restoration) will affect habitat form and function, and biologic assemblage and diversity. For example, if native insects are found in significant numbers at the CSO site, then restoration efforts could potentially have negative impacts on their populations.

1.2 Physical Setting

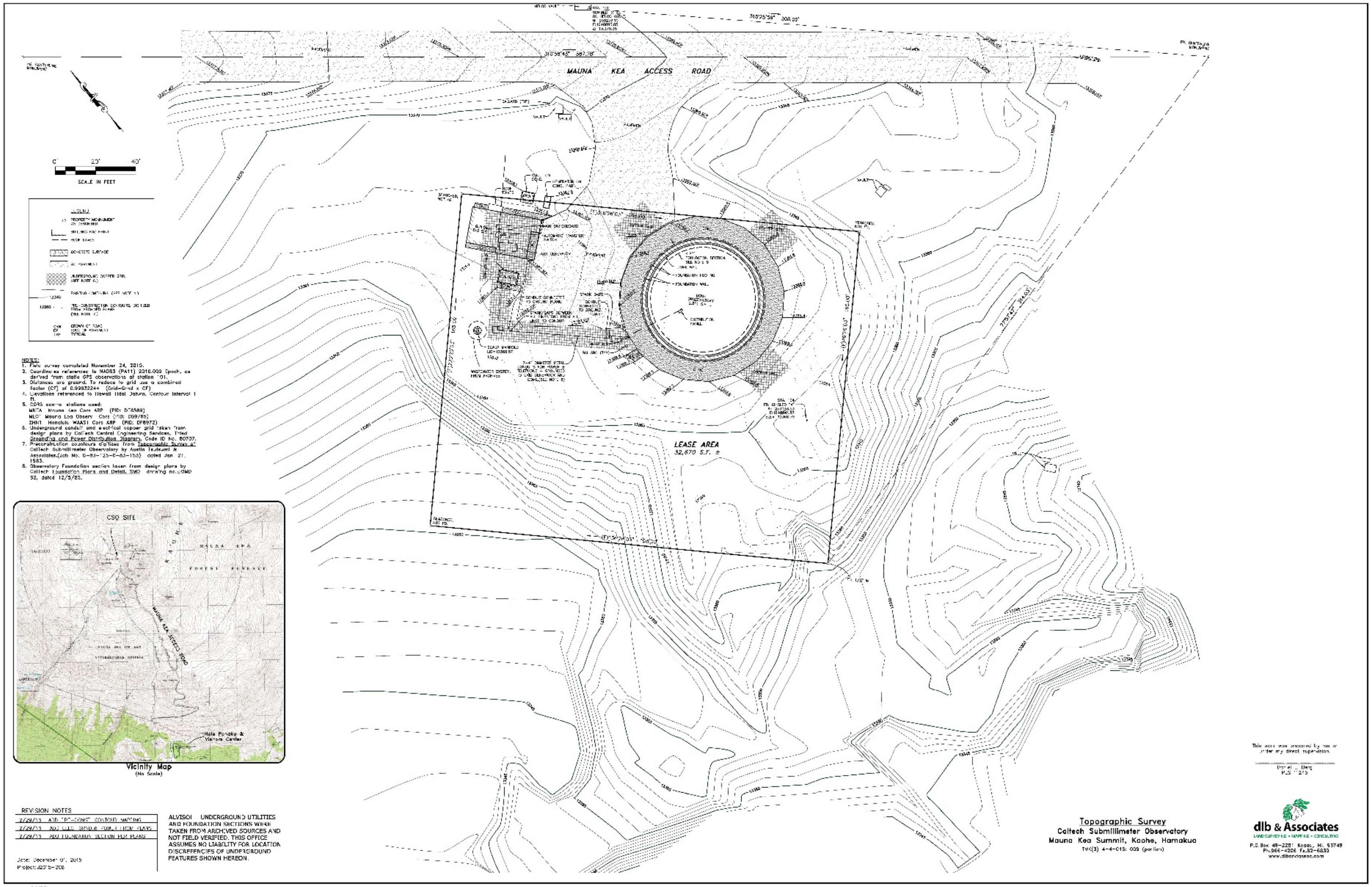
The CSO is located on Maunakea, Hāmākua District, Hawaiʻi Island, in a portion of Tax Map Key 4-4-15:9, and is part of the larger Maunakea Science Reserve. The CSO plot is a 32,670 sq. ft. rectangle 198 ft. long by 165 ft. wide (Figure 1). The base of the telescope is at approximately 13,370 ft. elevation. The substrate is mostly graded gravel and larger rocks that have been artificially leveled to provide a parking area and base of the telescope with several small adjacent buildings. The west side of the plot is topographically steeper, with piles of rock eventually meeting the previously existing substrate at approximately 13,360 ft. elevation (Figure 1).



Photograph 1. View from the northwest of the CSO plot, facing southeast. The entire 0.75 acre footprint of the plot is visible here. The large rocks in the foreground on the right side of the photograph correspond to the steep artificial topography viewable on the map (Figure 1).

Figure 1. Survey Area

Survey area as depicted by dlb & Associates, December 2015 (Berg 2015). Note existing contours (solid) vs. pre-construction contours (dotted). Subsequent maps in this report are taken from the center section of this map.



2 METHODS

2.1 Permit and Personnel

The Hawaiʻi Department of Land and Natural Resources (DLNR) issued a permit for this survey (Endorsement Number I1219) to Matthew Medeiros, with Jesse Eiben listed as a field assistant. The Office of Maunakea Management (OMKM) approved of, and oversaw, all field methods. Matthew Medeiros (Ph.D., UC Berkeley) is a biologist and high school teacher based at the University of Nevada Las Vegas and the Urban School of San Francisco, and has worked on-and-off in high elevation habitats in Hawaiʻi since 1995. Medeiros has published several studies of insects in these areas, including descriptions of new endemic moth species and their biology (mostly in the genera *Thyrocopa* and *Agrotis*). Jesse Eiben (Ph.D., University of Hawaiʻi (UH) Mānoa), is a professor at UH Hilo and has extensive experience working near the summit of Maunakea, in particular investigating the biology and conservation status of the wēkiu bug (*Nysius wekiuicola*).

2.2 Schedule

Field and lab work took place from 28 November 2018 until 2 December 2018. Field work was done on-site at the CSO. Lab work, including most specimen identification, was completed at the Teaching and Research Arthropod Collection (TRAC), UH Hilo, and the Bishop Museum, Honolulu, Hawaiʻi.

2.3 Nomenclature

The nomenclature used in this report follows the Hawaiian Terrestrial Arthropod Checklist, Fourth Edition (Nishida 2002). Hawaiian and scientific names are italicized. The following terms describe the status of various taxa:

Endemic – A species native to, or restricted to Hawaiʻi.
Indigenous – A species native to Hawaiʻi but that naturally occurs outside of Hawaiʻi as well.
Non-native – An introduced species living outside of its native distributional range. The introduction could be purposeful or accidental.
Unknown – Used in this report when a genus contains species that are both native and non-native, and the specimen could not be confidently identified to species level. For example, *Bradysia* flies.

2.4 Methodology for Inventorying Plants, Lichens, Non-arthropod Animals, and Abiotic Features

2.4.1 Transects: Floral and Abiotic Features

In order to determine the abundance and composition of the floral community, as well as observe any notable features of the abiotic environment and signs of use of the site by non-arthropod animals, transects were walked parallel to the boundary line running from the north corner to the east corner of the plot. Transects were spaced out just less than 2 m apart (1.93 m); 26 of these transects were walked to examine the entire plot. Transects were extended approximately 2-5 m from the north-to-west and east-to-south boundaries of the plot, allowing for observations just outside of the plot. Plants and lichens were observed, and their positions recorded on a topographic map of the plot. These transects were walked on November 28 & 29, 2018.

2.5 Methodology for Arthropod Sampling

2.5.1 Trapping: Wēkiu Bugs, Ants, and Flying Insects

To trap for wēkiu bugs and other crawling insects, ants, and flying insects along the perimeter of the plot, a compliment of three trap types were set up at each of six locations (numerals 1-6 in Figure 2). All three trap types are standard types suggested for use by OMKM (Kirkpatrick & Klasner 2015), with the exception of the ant traps, which were constructed using open vials rather than chopsticks. All procedures were carried out under the advice and supervision of Jesse Eiben.

Wēkiu bugs and other crawling insects were trapped for using live pitfall traps constructed of two clear plastic cups. Approximately 5 ml of water was placed in the bottom cup, to be absorbed by a wick running through the bottom of the top cup. The cups were then buried until the lip of the top cup was flush, or nearly so, with the substrate. Cups were weighted with rocks, baited with protein (canned tuna), and had a caprock placed above the cup that was baited on the underside with tuna.

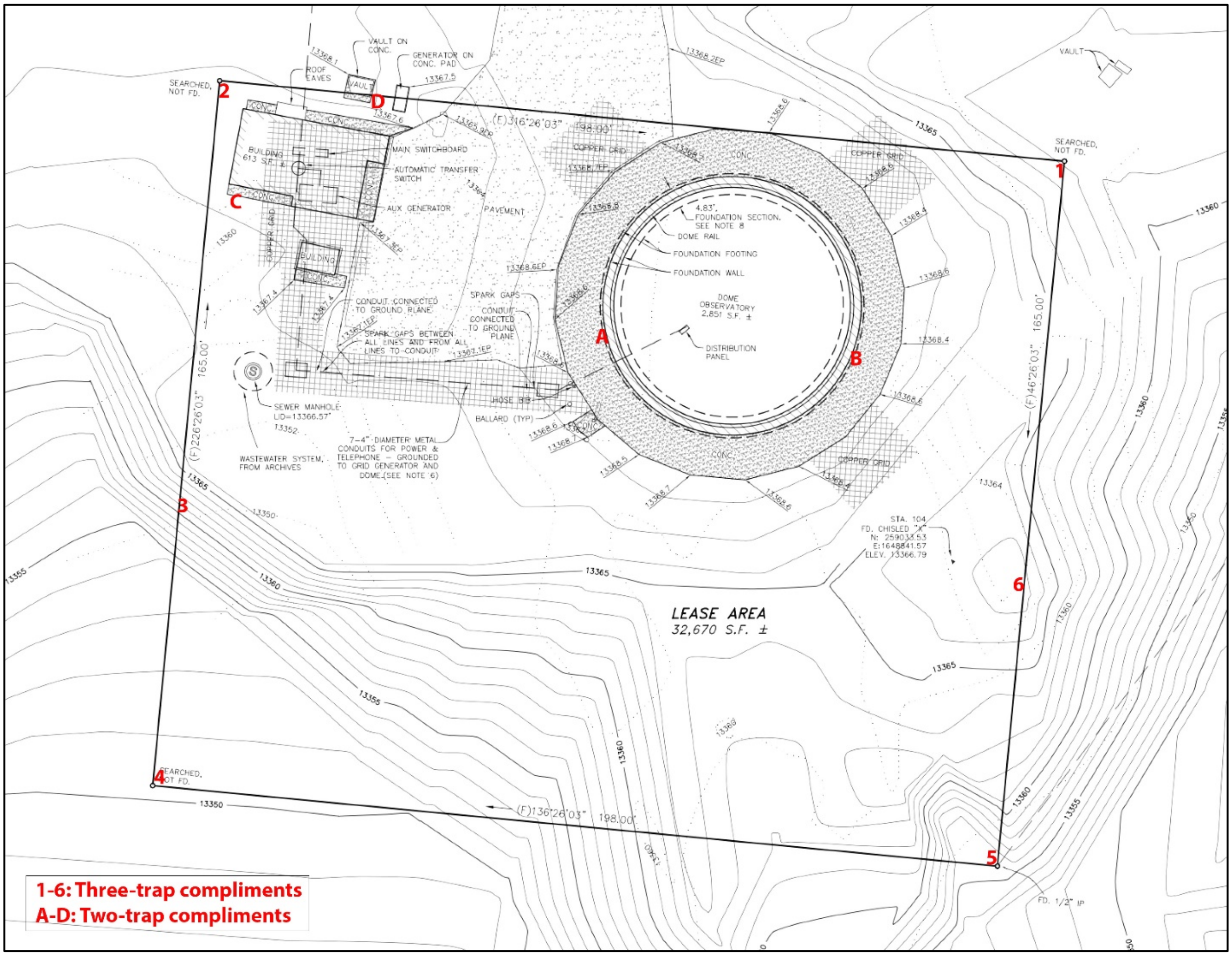
Ant surveys were conducted using small plastic specimen vials laid on their sides, and baited with carbohydrates, fats, and proteins (guava jelly, peanut butter, and tuna). Ant traps were only left open for approximately two hours per day, so as not to potentially feed any invasive species that may have been present.

Flying insects were captured using yellow pan traps. These traps are small yellow dishes filled with water and one drop of “additive free” dish soap to break the surface tension of the water. Traps were weighted with rocks.

These six trap compliments were placed in a diversity of substrate types. Trap compliments 1 and 2 were placed in graded and relatively flat areas with small pieces of cinder. Trap compliments 3, 5, and 6 were placed in topographically steep areas with boulders that had been piled during construction of the CSO and did not represent natural topography. Trap compliment 4 was placed in an area that was geologically undisturbed. Trap compliments were placed out on November 28, 2018 and retrieved on December 2, 2018. Arthropod catch is vouchered in the UH Hilo TRAC.

Figure 2. Trap Locations

Locations depicted with numerals indicate three-trap compliment surveys.
Locations depicted by letters indicate two-trap compliment surveys.



2.5.2 Trapping: Crawling Insects and Ants

To trap for crawling arthropods and ants near existing structures, compliments of two trap types were set up at each of four locations (letters A-D in Figure 2). All procedures were carried out under the supervision of Jesse Eiben.

Crawling arthropods were trapped with Hoy-Hoy brand cockroach sticky traps, baited with carbohydrates, fats, and proteins (guava jelly, peanut butter, and tuna). The traps were cut in half, placed under a plastic Tupperware container, and weighted with rocks. Sufficient space was left between the Tupperware container and parts of the substrate for arthropods to be able to access the bait. Ants were surveyed using the method described above (Section 2.5.1).

2.5.3 Hand Searching

A visual search for flying arthropods was conducted while walking the transects to determine floral abundance and composition (see Section 2.4.1). Additionally, a minimum of five randomly selected rocks per transect were turned over, so that the substrate below the rock, as well as the underside of the rock, could be examined for arthropods. During this assessment over 125 rocks, both large and small, were examined. Rocks were replaced immediately following examination.

2.5.4 Ice Collection

Ice was present along the north side of the telescope building. Aeolian processes resulted in deposition of an array of arthropods on the ice, which were then preserved on the surface. The species composition of the arthropods on the ice were inspected, and at least one individual of each morphospecies was collected.

Photograph 2. Removing dead insects trapped in ice on the north side of the CSO.

3 RESULTS

3.1 Plants and Lichens

3.1.1 Plants

The most abundant plant, by far, in and near the survey site was the endemic grass *pili uka* (*Trisetum glomeratum*). The locations of individual plants are marked in *green circles* in Figure 3. Most were growing on topographically disturbed areas (i.e. areas where rocks were piled up post-road construction) and one individual was found growing in a crack in the pavement driveway.

Several *ʻiwaʻiwa* (spleenwort, *Asplenium adiantum-nigrum*) individuals were found just *outside* the east-to-south boundary of the plot, but not within the plot. This species is indigenous to Hawaiʻi (Palmer 2003). The area where these individuals were found growing is marked with a *blue square* on Figure 3.

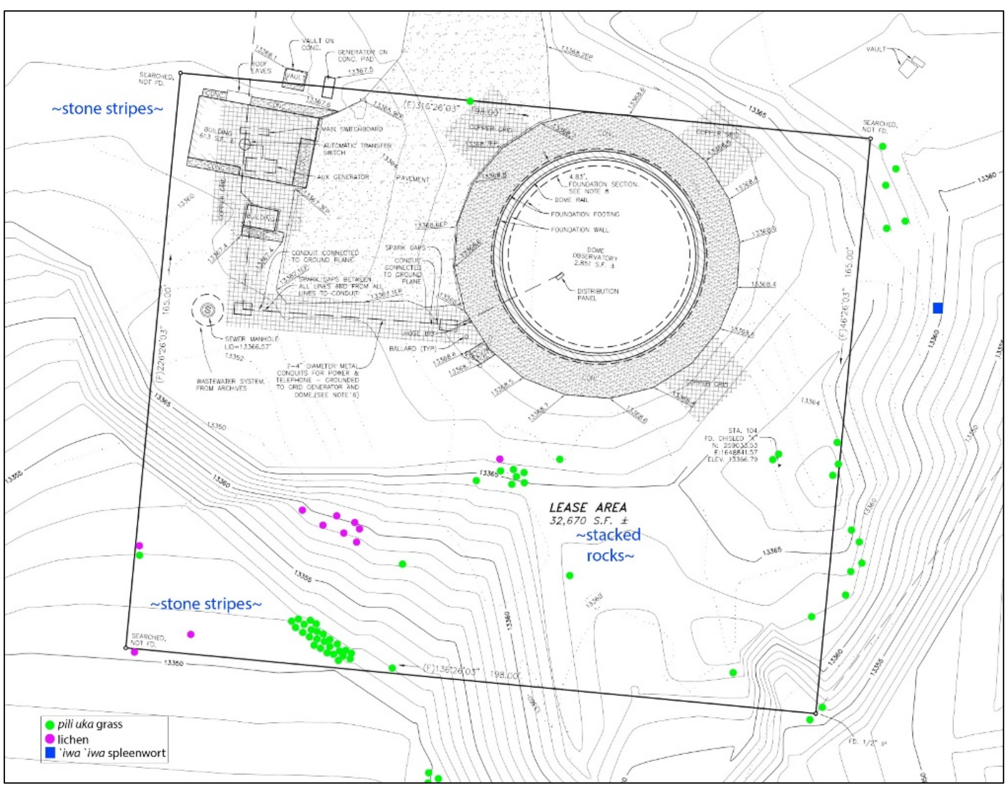
Photograph 3. Pili uka (*Trisetum glomeratum*) growing in artificially leveled substrate, from the survey site.

Photograph 4. Pili uka (*Trisetum glomeratum*) growing in a crack on the asphalt, from the survey site.

Photograph 5. *ʻIwaʻiwa* spleenwort (*Asplenium adiantum-nigrum*) just outside the survey area.

Figure 3. Flora and Abiotic Features Locations.

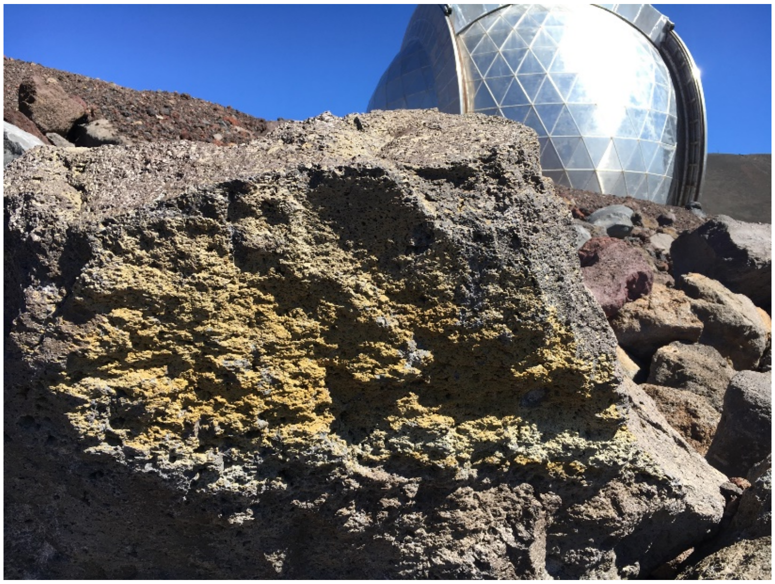
Pili uka grass (*Trisetum glomeratum*) individuals are marked with green circles; *ʻiwaʻiwa* spleenwort (*Asplenium adiantum-nigrum*) clump of several individuals with a blue square; lichens with purple circles; notable abiotic features in blue text.



3.1.2 Lichens

Many lichens present on Maunakea are either indigenous to Hawaiʻi, or are of unknown origin because the species cannot be determined to the species level (Gerrish 2013). Ten clumps of lichen were observed at the site with one just outside the site. Lichens were difficult to identify to species level. *Lecanora polytropa* appears to be present, with at least two or three other morphospecies. Lichens are marked with *purple circles* in Figure 3 and most were present in areas of disturbed topography (i.e. areas where rocks were piled up post-road construction).

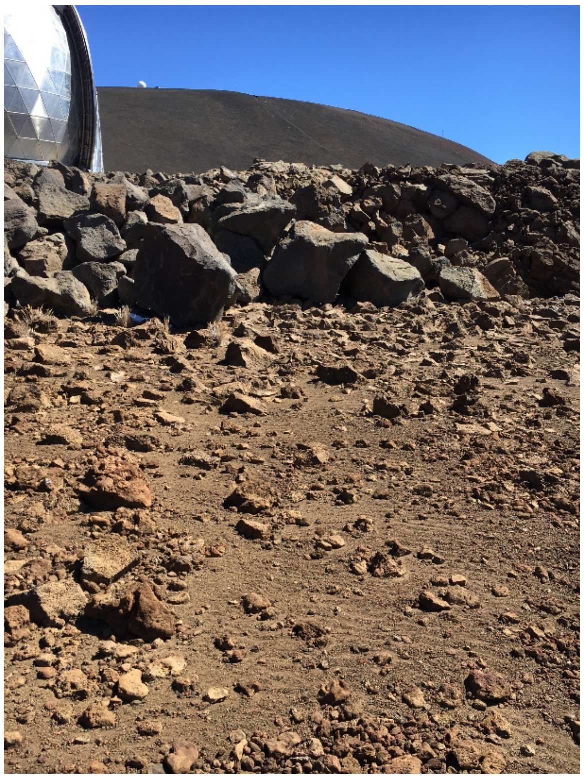
Photograph 6. Lichen from the survey site.



Photograph 7. Lichen from the survey site.

3.2 Abiotic Features

Two notable types of abiotic features were found during surveys. These are noted in *blue text* in Figure 3. The first is stone stripes. Stone stripes are created from freeze-thaw cycles, and are an unusual habitat type, even on Maunakea (OMKM orientation video; http://www.malamamaunakea.org/about-us/maunakea-orientation). Great care was taken not to disturb the stone stripes in any way. The stripes near the northern corner of the plot appear to have formed in substrate that was leveled during construction of the CSO, whereas the stripes near the western corner of the plot appear to occur in undisturbed substrate. The second feature was a pile of rocks that appear to be of anthropogenic origin. The pile occurs on an area that was bulldozed during the CSO's construction, so likely does not predate 1983.



Photograph 8. Stone stripes from the undisturbed west corner of the plot.

Photograph 9. Stacked rocks

3.3 Other Animals

A total of three humans (*Homo sapiens*) were observed walking across the plot during the survey, and one was observed sleeping for approximately two hours on the concrete slab next to the observatory building. Feces of a large mammal, probably a dog (*Canis lupus familiaris*), was also observed in a rocky area. The feces were not vouchered at TRAC and are therefore not available for DNA analysis. No other animals, or signs of animals, were observed in or near the survey site.

Photograph 10. Feces, probably from *Canis lupus familiaris*, at the survey site. Boot provided for scale.

3.4 Arthropod Sampling

3.4.1 Trapping: Wēkiu Bugs, Ants, and Flying Insects

Below are the total number and type of arthropod found in each trap compliment at the conclusion of the survey. No wēkiu bugs or ants were captured in any of the trap types.

Table 1. Arthropod Type by Trap Compliment (Wēkiu Bugs, Ants, and Flying Insects)

Trap Type	Count	Order	Family	Species	Nativity
Trap Compliment 1					
Live Pitfall		None	None	None	None
Ant		None	None	None	None
Pan	6	Hemiptera	Psyllidae	*Acizzia uncatoides*	Non-native
	1	Heteroptera	Lygaeidae	*Neacoryphus bicrucis*	Non-native
	1	Heteroptera	Miridae	*Coridromius variegatus*	Non-native
	1	Heteroptera	Lygaeidae	*Nysius palor*	Non-native
Trap Compliment 2					
Live Pitfall	1	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-native
Ant		None	None	None	None
Pan	3	Hemiptera	Psyllidae	*Acizzia uncatoides*	Non-native
	3	Diptera	Sciaridae	*Bradysia* flies	Unknown
	1	Diptera	Phoridae	*Diplonevra peregrine* fly	Non-native
	1	Diptera	Ephydridae	*Hydrellia* fly*	Non-native
	12	Heteroptera	Lygaeidae	*Nysius palor*	Non-native

Trap Type	Count	Order	Family	Species	Nativity
Trap Compliment 3					
Live Pitfall		None	None	None	None
Ant		None	None	None	None
Pan	47	Hemiptera	Psyllidae	*Acizzia uncatoides*	Non-native
	3	Hymenoptera	Braconidae	*Apanteles* wasps	Non-native
	5	Hemiptera	Aphididae	Aphids	Non-native
	1	Hymenoptera	Braconidae	*Biosteres* (?) wasp	Non-native
	1	Diptera	Sciaridae	*Bradysia* fly	Unknown
	1	Diptera	Phoridae	*Diplonevra peregrine* fly	Non-native
	3	Diptera	Ephydridae	*Hydrellia* fly*	Non-native
	3	Heteroptera	Lygaeidae	*Nysius palor*	Non-native
	2	Diptera	Agromyzidae	*Phytomyza plantaginis* flies	Non-native
Trap Compliment 4					
Live Pitfall		None	None	None	None
Ant		None	None	None	None
Pan	1	Hemiptera	Aphididae	Aphids	Non-native
Trap Compliment 5					
Live Pitfall		None	None	None	None
Ant		None	None	None	None
Pan	95	Hemiptera	Psyllidae	*Acizzia uncatoides*	Non-native
	5	Hemiptera	Aphididae	Aphids	Non-native
	5	Thysanoptera	Thripidae	*Frankliniella* thrips	Non-native
	1	Diptera	Ephydridae	*Hydrellia* fly*	Non-native
	1	Heteroptera	Lygaeidae	*Nysius palor*	Non-native
Trap Compliment 6					
Live Pitfall		None	None	None	None
Ant		None	None	None	None
Pan	26	Hemiptera	Psyllidae	*Acizzia uncatoides*	Non-native
	3	Hymenoptera	Braconidae	*Apanteles* wasps	Non-native
	2	Hemiptera	Aphididae	Aphids	Non-native
	2	Diptera	Sciaridae	*Bradysia* fly	Unknown
	1	Heteroptera	Miridae	*Coridromius variegatus* bug	Non-native
	1	Diptera	Calliphoridae	*Eucalliphora latifrons* (?) fly	Non-native
	2	Thysanoptera	Thripidae	*Frankliniella* thrips	Non-native
	2	Diptera	Ephydridae	*Hydrellia* fly*	Non-native
	2	Heteroptera	Lygaeidae	*Nysius palor*	Non-native
	1	Hymenoptera	Ichneumonidae	*Pristomerus spinator* wasp	Non-native

*Although *Hydrellia* also contains an endemic species, the specimens of this genus found were one of the two difficult-to-separate non-native species (either *H. tritici* or *H. williamsi*).

3.4.2 Trapping: Crawling Insects and Ants

Below are the total number and type of arthropod found in each trap compliment at the conclusion of the survey. No wēkiu bugs or ants were captured in any of the trap types. Note that three of the traps were missing, most likely taken by humans on December 1, 2018.

Table 2. Arthropod Type by Trap Compliment (Crawling Insects and Ants)

Trap Type	Count	Order	Family	Species	Nativity
Trap Compliment A					
Sticky		None	None	None	None
Ant		Trap Missing	Trap Missing	Trap Missing	Trap Missing
Trap Compliment B					
Sticky		None	None	None	None
Ant		None	None	None	None
Trap Compliment C					
Sticky		Trap Missing	Trap Missing	Trap Missing	Trap Missing
Ant		Trap Missing	Trap Missing	Trap Missing	Trap Missing
Trap Compliment D					
Sticky	2	Hemiptera	Psyllidae	*Acizzia uncatoides*	Non-native
	5	Hemiptera	Aphididae	Aphids	Non-native
	2	Heteroptera	Lygaeidae	*Nysius palor*	Non-native
Ant		None	None	None	None

3.4.3 Hand Searching

While walking transects, the following arthropods were observed.

Table 3. Arthropods Observed During Hand Searching

Species	Order: Family	Status	Quantity
Agrotis kuamauna	Lepidoptera: Noctuidae	Endemic	One live larva
Aphid bug	Hemiptera: Aphididae	Non-native	One live individual
Eucalliphora latifrons (?) flies	Diptera: Calliphoridae	Non-native	Four live individuals
Hippodamia convergens beetle	Coleoptera: Coccinellidae	Non-native	One dead individual
Lycosa spiders	Araneae: Lycosidae	Endemic	Three dead individuals
Meriola arcifera spider	Araneae: Trachelidae	Non-native	One live individual
Nysius palor bugs	Heteroptera: Lygaeidae	Non-native	Approximately twenty live individuals

3.4.4 Ice Collection

The following types of insects were seen dead on the ice, but only one or two vouchers of each morphospecies were collected and vouchered in TRAC; below is a list of diversity but not abundance. There was no way of knowing the exact timeframe that these insects took to become accumulated on the sheet of ice.

Table 4. Insects Collected on Ice

Species	Order: Family	Nativity
Acizzia uncatoides bugs	Hemiptera: Psyllidae	Non-native
Apanteles wasps	Hymenoptera: Braconidae	Non-native
Allograpta exotica fly	Diptera: Syrphidae	Non-native
Bradysia flies	Diptera: Sciaridae	Unknown
Diadegma insularis wasp	Hymenoptera: Ichneumonidae	Non-native
Forficula auricularia earwig	Dermaptera: Forficulidae	Non-native
Hydrellia flies	Diptera: Ephydridae	Non-native*
Metioche vittaticollis cricket	Orthoptera: Gryllidae	Non-native
Nabis capsiformis bug	(Heteroptera: Nabidae	Non-native
Neacoryphus bicrucis bug	Heteroptera: Lygaeidae	Non-native
Nysius palor bug	Heteroptera: Lygaeidae	Non-native
Rhantus gutticollis beetle	Coleoptera: Dytiscidae	Non-native

*Although *Hydrellia* also contains an endemic species, the specimens of this genus we found were one of the two hard-to-separate non-native species (either *H. tritici* or *H. williamsi*).

4 RECOMMENDATIONS

4.1 Comparison of Results to Previous Nearby Surveys

In July 2009, the nearby, and also highly disturbed, Batch Plant Parking Lot was surveyed for arthropods by the Hawaiʻi Biological Survey (Englund et al. 2010). The current survey utilized nearly identical methods to the 2009 Hawaiʻi Biological Survey: yellow pan traps, peanut butter traps, pitfall traps, and sticky traps. Both surveys found a similar assemblage of species, with one notable difference. In the 2009 survey the endemic *Trioza* bug (Hemiptera: Psyllidae) was found while the non-native *Acizzia uncatoides* bug (Hemiptera: Psyllidae was not. This survey found only a large abundance of *Acizzia uncatoides* and no *Trioza*. The only other definitively endemic species found in the 2009 survey was the *Lycosa* spider, which was also recorded in this survey. This survey found one endemic *Agrotis* (Lepidoptera) moth, whereas the 2009 survey did not. In conclusion, this site compares very closely to the nearby Batch Plant Parking Lot sampled approximately a decade earlier. It should be noted that this survey was conducted in late fall and the 2009 survey was conducted in early summer.

In terms of plants, Gerrish (2013) found three species of vascular plants within 100 m of the CSO study site during a summer survey in 2011: *pili uka* grass (*Trisetum glomeratum*), *ʻiwaʻiwa* spleenwort (*Asplenium adiantum-nigrum*), and bentgrass (*Agrostis sandwicensis*). This study recovered *Trisetum glomeratum* and *Asplenium adiantum-nigrum*. It is plausible that some specimens identified as *Trisetum glomeratum* were actually *Agrostis sandwicensis*, but were misidentified because the two species are morphologically similar. Based on the Gerrish 2013 survey in combination with this survey, all three species should be considered common to the study area.

4.2 Potential Effects of Site Restoration

The arthropods found at the CSO site during this survey are almost entirely non-native in nature, no wēkiu bugs were found. As this survey took place during late fall, it is possible that cold temperatures affected the abundance and diversity of arthropods captured. Few arthropod surveys have been conducted during this time of year anywhere on Maunakea. One notable survey included traps placed at the Puʻuhauʻoki cinder cone, near to the CSO plot, to assess wēkiu bug populations and microhabitat conditions (Kirkpatrick 2018). A portion of Kirkpatrick's survey was conducted during the fall and winter and during those periods, the number of wēkiu bugs trapped were as high, and in many cases higher, than at other times of the year. Wēkiu bugs are known to mainly inhabit cinder cones and the CSO was built on a lava flow, not a cinder cone. It is likely that the lack of wēkiu bugs captured at the CSO site is due to it not being suitable habitat, not that they were simply not seasonally present.

The CSO site and adjacent lands contain native grasses, lichens, and spleenworts in topographically disturbed areas. Despite some mortality to flora due to moving rocks and substrate during restoration it is highly likely these species will recolonize the area and negative long-term effects on the form or function of the habitat is unlikely. *Pili uka* (*Trisetum glomeratum*) grass is commonly found near the survey area (Gerrish 2013), so recruitment into topographically restored areas is likely to occur relatively quickly. Lichens were not particularly abundant on the site and it is possible that the lichens present in disturbed areas of the site were already growing on rocks moved around during the construction of the CSO. Lichens are also found in the immediate vicinity of the survey plot. Restoration of topography will not result in significant population declines of lichens.

4.3 Mitigation Strategies During Site Restoration

Although the high abundance of non-native arthropods and the lack of rare native plants at the site means there is low risk of wēkiu bugs or other species of concern being killed during restoration, mitigation strategies should be employed during decommissioning and site restoration activities. The largest risk to the site is the introduction of potentially harmful plants and animals, especially ants (along with wasps, spiders, and weeds). Mitigation strategies for decommissioning of the CSO and restoration of previous topography should include approval of plans by a qualified biologist as well as supervision by OMKM staff. Additionally, the following strategies adapted from Brenner (2009) should be followed:

Dust should always be minimized during construction activities. The possibility of petroleum based spills should be minimized and trash should be contained and carried offsite. Supplies should be protected from being carried away by the wind. Proper precautions should be taken to ensure that equipment and shipping containers are thoroughly cleaned before entering the site (soil and other vegetation and arthropods must be removed by washing at low elevation). After the work is completed, surveys should be conducted to check for the introduction of any noxious organisms, so that eradication efforts can begin immediately. No food, that might attract non-native predators, should be left unattended on site as it may attract non-native arthropods.

5 REFERENCES

Brenner, G. 2009. Arthropod and Botanical Inventory and Assessment: TMT Project Mauna Kea Science Reserve Northern Plateau and Hale Pōhaku Hāmākua District, Island of Hawai'i. Pacific Analytics, L.L.C. Corvallis, Oregon.

Brenner, G., and Eiben, J. 2012. Access Way Arthropod Monitoring Report: TMT Project Astronomy Precinct Mauna Kea Science Reserve Hāmākua District, Island of Hawai'i. Pacific Analytics, L.L.C. Scio, Oregon.

Englund, R. A., Preston, D. J., Myers, S., Englund, L. L., Imada, C., & Evenhuis, N. L. 2010. Results of the 2009 alien species and Wekiu bug (*Nysius wekiuicola*) surveys on the summit of Mauna Kea, Hawaii Island. *Final report. Honolulu: Bishop Museum*.

Berg, D.L. 2015. Topographic Survey, Caltech Submillimeter Observatory. dlb & Associates. Keaau, HI.

Gerrish, G. 2013. Botanical baseline survey (2011) of the University of Hawaii's managed lands on Mauna Kea. *Hilo, HI: University of Hawaii-Hilo*.

Kirkpatrick, J. A. 2018. *An Assessment of Nysius wekiuicola Populations and Thermal Microhabitat Conditions on Cinder Cones of the Maunakea Volcano, Hawai'i* (Masters Thesis, University of Hawai'i at Hilo).

Kirkpatrick, J. & Klasner, F. 2015. Annual Alien Invertebrate Early Detection & Wēkiu Bug Monitoring. Office of Maunakea Management.

Kirkpatrick, J. & Klasner, F. 2015. 2013 Invasive Species & Native Arthropod Monitoring Report. Office of Maunakea Management.

Nishida, G. 2002. *Hawaiian Terrestrial Arthropod Checklist*. Fourth edition. Bishop Museum, Honolulu, 313 pp.

Palmer, D.D. 2003. *Hawai'i's ferns and fern allies* (No. 2002-2010). University of Hawaii Press.

Sustainable Resources Group Intn'l, Inc. 2010. Decommissioning Plan for the Mauna Kea Observatories. *A Sub-Plan of the Mauna Kea Comprehensive Management Plan*. January.

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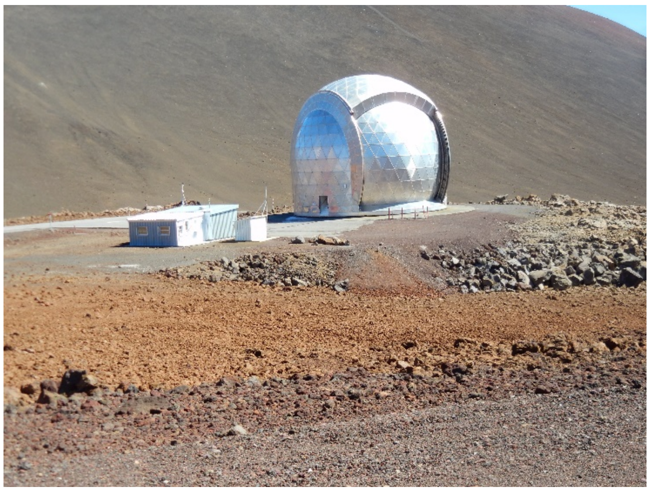
Appendix E. Hydrogeological and Geological Evaluation for the Decommissioning of the California Institute of Technology Submillimeter Observatory

HYDROGEOLOGICAL AND GEOLOGICAL EVALUATION

Decommissioning of the California Institute of Technology Submillimeter Observatory



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September 18, 2019

EXECUTIVE SUMMARY

The California Institute of Technology (Caltech) plans to decommission the Caltech Submillimeter Observatory (CSO), located near the summit of Maunakea, Hawai'i Island, Hawai'i. As part of the decommissioning process, Caltech is preparing an environmental assessment (EA). This report is intended to be part of the EA and provides a hydrogeological evaluation of Maunakea and a qualitative analysis of the potential impacts of wastewater from the CSO. This report also includes a geologic characterization of the rock fill material used in the CSO's foundation.

The regional groundwater body below the summit of Maunakea is probably a dike-impounded high-level aquifer (Figure 13; Izuka et al., 2018). The five aquifer systems that connect to the peak of Maunakea are Honokaa, Paʻauilo, Hakalau, Onomea and Waimea (Figure 17). There are also an unknown number of relatively small perched water bodies associated with buried glacial deposits and deposits of weathered ash or sediment. Lake Waiau is the surface expression of a shallow perched aquifer (Leopold et al., 2016).

One of the purposes of this report is to assess the potential for groundwater pollution from the onsite cesspool at the CSO. The cesspool is a minor source of pollution and will be closed and filled soon. Three general areas of potential concern were identified: 1) The public water systems in the regional aquifers surrounding Maunakea in Hilo, Waikoloa, Lālāmilo, Waikiʻi and Paʻauilo; 2) Potential impacts to the springs and water systems at Pōhakuloa; and 3) Lake Waiau.

Potential impacts to the regional aquifers were analyzed using published literature, by estimating travel times and attenuation, looking at nitrate data from water supply wells and by estimating dilution factors. Based on this analysis, there is virtually no possibility of impacts from wastewater on the surrounding regional aquifers.

Potential impacts to the springs and water sources of Pōhakuloa Gulch were analyzed by a literature search and by visual examination of the local topography. There is no indication that there is a direct groundwater connection between the CSO site and the springs of Pōhakuloa Gulch. It is highly unlikely that wastewater from the CSO would impact the springs. In addition, there is no indication of impacts in nitrate data from the springs.

Potential impacts to Lake Waiau were analyzed by reviewing scientific literature and through visual inspection of the area. Lake Waiau is not hydraulically connected to the CSO site via groundwater. There is also no surface water connection from the CSO site to Lake Waiau. There is no possibility that wastewater from the CSO is affecting Lake Waiau.

Approximately 2,335 cubic yards of fill were used to construct the CSO. Depending on the decommissioning alternative, Caltech may need to remove the fill. If the fill is removed, it may be considered necessary to return it to its source. INTERA conducted a geochemical analysis of samples from the fill and from a nearby lava flow. Based on the lithologic descriptions and geochemical analyses of the three fill samples and one sample from an adjacent a'a lava flow, the fill material at the CSO Site is determined to be sourced from Laupāhoehoe Volcanics which underlies Maunakea summit area. Much of the CSO Site fill was likely originally sourced from an excavation in a Laupāhoehoe lava flow during widening of the main road. Other components of the fill are probably tephra from one of the nearby Laupāhoehoe cinder cones.

DRAFT HYDROGEOLOGICAL AND GEOLOGICAL EVALUATION
Decommissioning of the California Institute of Technology Submillimeter Observatory

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ACROYNMS AND ABBREVIATIONS

bgs	below ground surface
Caltech	California Institute of Technology
CDUP	Conservation District Use Permit
COC	chain of custody
CSO	Caltech Submillimeter Observatory
CWRM	Commission on Water Resource Management
DLNR	(State of Hawai'i) Department of Land and Natural Resources
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ET	Evapotranspiration
ft	feet *or* foot
ft-msl	elevation in feet relative to mean sea level
gal/mo	gallons per month
gpd	gallons per day
GR	groundwater recharge
GW	groundwater use
HAR	Hawai'i Administrative Rules
HDOH	Hawai'i Department of Health
HDWS	Hawai'i Department of Water Supply
HI	human inputs
INTERA	INTERA Incorporated
kg/mo	kilograms per month
KP	Kahi Puka
LOI	loss on ignition
MCL	maximum contaminant level
mgd	million(s) of gallons per day
mg/L	milligrams per liter
NO_3	nitrate
NO_3-N	nitrate as nitrogen
OSDS	onsite sewage disposal system
PR	precipitation

PTA	Pōhakuloa Training Area
QA/QC	quality assurance and quality control
RO	runoff
RPD	relative percent difference
SAP	sample analysis plan
SWPP	Source Water Protection Plan
UH	University of Hawai'i
USGS	United States Geological Survey
WERF	Water Environment Research Foundation
WRPP	Water Resources Protection Plan
WSU	Washington State University
XRF	x-ray fluorescence

1.0 INTRODUCTION

The California Institute of Technology (Caltech) is moving forward with the decommissioning of the Caltech Submillimeter Observatory (CSO) per its “Notice of Intent to Decommission” submitted to the Office of Maunakea Management in November of 2015 (Stolper, 2015). Decommissioning involves removal of the structures and restoration of the site in accordance with its sublease and the 2010 Maunakea Decommissioning Plan (SRG, 2010). The CSO is located on a 0.75-acre site at 13,350 feet above mean sea level (ft-msl) altitude near the summit of Maunakea. The site is located within the Astronomy Precinct of the Maunakea Science Reserve (TMK: (3) 4-4-015:009) and is managed by the University of Hawai‘i (UH, 2009). Since 1983, the subject site has been used exclusively for the construction and scientific operation of the CSO. The CSO was constructed between 1983 to 1986; since that time, Caltech has operated the CSO on Maunakea. The CSO facility includes the telescope, dome foundation, other underground structures, and support structures. The foundation is composed of rock fill. In addition, there is a cesspool to dispose of waste from two toilets and a few sinks.

The Maunakea summit is in the Conservation Land Use District, Resource subzone. Pursuant to Hawai‘i Administrative Rules (§13-5-2 (4) (HAR)) ‘demolition’ of existing structures is an ‘identified land use’ in the Resource subzone of the Conservation Land Use District. A Conservation District Use Permit (CDUP) is required for certain land uses in the State Land Use Conservation District. State law (§343-5 (a) (2) (HRS)) requires that an Environmental Assessment (EA) be prepared “for any use within the land classified as a conservation district,” unless otherwise exempt. The EA addresses topics on the environmental effect of the project. One of the topics is the geological and hydrogeological setting. This report is intended to address this requirement.

INTERA Incorporated (INTERA) was selected to produce the report. INTERA was given the following tasks:

1. Prepare a general geological and hydrogeological assessment of Maunakea.

2. Prepare a qualitative analysis of the potential impacts of cesspool leachate flow.

3. Conduct a geologic characterization of the CSO fill material.

2.0 REGIONAL SETTING HAWAI'I

This chapter describes the regional climate, geology, and hydrology of Hawai'i and the Island of Hawai'i.

2.1 Climate

Hawai'i Island is in the tropics and the trade-wind belt of the North Pacific anticyclone. Hawai'i's climate varies seasonally and differs depending on the location (Giambelluca et al., 1986; 2013). The climate is diverse, including deserts, tropical rain forests and snow-capped mountains (Izuka et al., 2018). Hawai'i's diverse climate is attributed to the prevailing northeasterly trade winds that encounter the mountains, producing an orographic effect that forces moist air to rise, cool, condense and preferentially precipitate on the windward side and crests of mountain slopes rather than the leeward sides (**Figures 1** and **2**; Giambelluca et al., 2013; Izuka et al., 2018). Precipitation from orographic forcing is found at altitudes less than 7,000 ft-msl due to a thermal inversion at about 6,000 feet (ft), yielding desert conditions near the volcanic mountain summits (Giambelluca et al., 2013). Precipitation also varies spatially as a result of wind-mountain interactions, such as trade winds that wrap around the mountain slope and deposit precipitation on the southern side of Mauna Loa. Precipitation at the dry, leeward sides and mountain summits is largely sourced from storms, unrelated to orographic effect (Giambelluca et al., 2013). Strong diurnal heating and cooling in the summer produces convective rainfall precipitation at mid-altitudes in the afternoon (Giambelluca et al., 2013). Precipitation sourced from fog drip is associated with vegetated areas below 9,000 ft-msl and above 2,500 ft-msl **(Figure 3**; Engott, 2011). The effect climate and topography have on the distribution of vegetation on Hawai'i is shown on **Figure 4.**

2.2 Hawaiian Geology

The Hawaiian-Emperor Islands chain (archipelago) comprises basaltic shield volcanoes that formed over the last 75 to 80 million years as the Pacific Plate continues to migrate to the northwest over the Hawaiian Hotspot (Clague and Dalrymple, 1987). The hotspot is a conduit for magma flow from the Earth's mantle up through the oceanic crust (**Figure 5**). The main Hawaiian Islands formed in the last five million years, with the oldest (Kaua'i) found at the northwest, becoming younger towards the southeast, at which the youngest is the "Big Island" – Hawai'i. An idealized Hawaiian volcano evolves through four eruptive stages: pre-shield, shield, postshield and rejuvenated (**Figure 6**; Clague and Dalrymple, 1987; Clague and Sherrod, 2014). These stages are distinguished by lava composition, eruptive rate, style, and stage of development (Wolfe et al., 1997). An island can comprise more than one shield volcano. For example, Hawai'i Island is composed of five subaerial volcanos and two adjacent submarine volcanos: Loihi and Mahukona.

2.3 Hawai'i Island Geology

The land area of Hawai'i Island is composed of five subaerial shield volcanoes: Kohala, Hualālai, Mauna Loa, Maunakea and Kīlauea (**Figure 7**; **Table 1**; Izuka et al., 2018). Kohala, Maunakea and Hualālai volcanoes are in postshield stage, while Mauna Loa and Kīlauea are in the active shield stage (Clague and Dalrymple, 1987). Hawai'i Island volcanoes do not have known vents from the rejuvenated stage. Each volcano erupted contemporaneously (to some degree) with its neighboring volcanoes, resulting in complex interbedding (Wolfe and Morris, 1996; Wolfe et al., 1997). Wolfe et al. (1997) documented field evidence of interlayered strata from Mauna Loa, Maunakea and Hualālai at the saddle formed by the intersection of these volcanoes. **Figure 8** shows a simplified geologic map of Hawai'i Island with the major formations. The major formations of Hawai'i Island geology are summarized below, from youngest to oldest, from Izuka et al. (2018).

The subaerial volcanic and sedimentary rocks of Hawai'i Island can be divided into four main groups: lava flows (ʻaʻā and pāhoehoe), pyroclastic deposits and dikes (Wolfe et al., 1997). In addition, there are limited glacial and alluvial sedimentary deposits. The volume of sediments and tephra is small compared to the volume of lava flows in Hawai'i volcanos; however, part of the surficial geology on Maunakea is composed of tephra and glacial-related sediments **(Figure 8)**. ʻAʻā flows contain a solid central core between gravelly clinker layers. Pāhoehoe flows are typically characterized by a smooth, ropy texture. Lava flows typically form highly permeable aquifers. Thick-ponded flows are less permeable and can be impediments to groundwater flow. Even more impermeable to groundwater flow are dikes, which are tabular, vertical, or sub-vertical lava intrusions that function as groundwater "dams." Pyroclastic deposits originate from explosive volcanism and form tuff and ash beds (Wentworth and MacDonald, 1953). Ash deposits often rapidly weather and become less permeable.

Kohala Volcano is mostly formed by thin shield-stage basalt lava flows of the Pololū Volcanics from two rift zones trending northwest and southeast (**Figure 9**) that are now covered by younger, thicker rocks of the postshield stage Hāwī Volcanics. A summit caldera likely exists based on slightly curved faults near the summit and positive anomalies from gravity surveys. Dike swarms are exposed in the heads of large valleys on the northeast flank of the volcano. Subparallel faults formed a graben on the southeast flank, bordering Maunakea lavas.

Like Kohala, Maunakea is thought to be mostly composed of shield volcanics that are covered by the lower postshield Hāmākua Volcanics and upper postshield Laupāhoehoe Volcanics. The shield and lower postshield volcanics have similar hydrogeological properties; lower postshield volcanics differ mainly by geochemistry instead of structure. Laupāhoehoe Volcanics formed thicker flows than the Hāmākua Volcanics with many cinder cones. Discontinuous ash and soil layers are interbedded between some lava flows. Positive gravity anomalies indicate dense intrusive rocks, thousands of feet thick, exist beneath the summit (Kauahikaua et al., 2000; Flinders et al., 2013), interpreted by some as a buried caldera and associated dike complex (Stearns and Macdonald, 1946; Macdonald et al., 1983). Maunakea does not have clearly delineated rift zones, but rifts have been proposed by Stearns and Macdonald (1946), Fiske and Jackson (1972), and Macdonald et al. (1983), based on the distribution of cinder cones (**Figure 9**). Wolfe et al. (1997) suggested the distribution of cinder cones is unrelated to rift zones, which is consistent with nonconclusive interpretations from gravity surveys (Kauahikaua et al., 2000; Flinders et al., 2013). A few sedimentary (glacial till and glacial outwash) deposits exist on the summit and southern slope of Maunakea. Multiple cycles of glaciation between 280,000 and 9,080 years ago changed erosional and depositional patterns (Porter, 1979a,b) near the summit. No glaciers exist today, but permafrost was observed at the summit in 1969 (Woodcock, 1974) and persists in two locations (Schorghofer et al. 2017).

Hualālai is located on the west or Kona coast of Hawai'i Island. Hualālai is completely covered by postshield-stage volcanics of pāhoehoe and ʻaʻā flows (Moore et al., 1987). These deposits are collectively known as the Hualālai Volcanics. The postshield Hualālai Volcanics form a relatively thin veneer over the shield volcanics that ended 130,000 to 105,000 years ago (Moore and Clague, 1992). Hualālai Volcanics interbed with the Mauna Loa Volcanics to the north, east and south. The interpretation of rift zones associated with cinder cones are not conclusive based on gravity data. Hualālai is the only Hawai'i volcano without a positive gravity anomaly centered beneath the summit; instead, the anomaly is located several miles to the southwest (Kauahikaua et al., 2000).

Mauna Loa is the largest of Hawai'i's volcanoes, still in the shield stage, producing thin shield-stage, basalt lava flows. Rift zones are prominent to the northeast and southwest of the summit. Few dikes are exposed due to limited erosion, but many likely exist beneath the volcano based on gravity anomalies (Flinders et al., 2013). Kīlauea is an active volcano that has recently completed a near-continuous eruptive episode lasting more than 35 years and consists primarily of thin ʻaʻā and pāhoehoe flows with minor ash beds.

The Pāhala Ash is a loose term for pyroclastic deposits found throughout Hawai'i Island. They are primarily weathered and reworked ash layers (less than 55 ft thick). Ash is a glassy (no mineral structure) formation which can quickly weather into clayey soils. Radiometric dating has shown a wide range of ages: 3,000 to 39,000 years old (Sherrod et al., 2007). The Pāhala Ash is found on the slopes of Maunakea and southern slopes of Mauna Loa. The Pāhala Ash on Maunakea is likely derived from Laupāhoehoe or Hāmākua pyroclastic or hyaloclastic events.

Since Hawai'i is the youngest of the Hawaiian Islands, it has experienced the least amount of mass wasting and dissection by weathering. The limited erosion means that, even for the older volcanoes, the postshield volcanics obscures evidence of intrusive activity occurring over the constructional life of the volcano. The relative youth of the island also precludes formation of extensive reefs and caprock sequences found on the older islands due to its continuing rapid subsidence.

2.4 Groundwater

Historically, groundwater in Hawai'i Island has been considered in four general categories: (1) basal, (2) high-level or dike-impounded, (3) perched, and (4) sedimentary or caprock **(Figure 10)**. The hydrogeology of Hawai'i Island is unusual relative to the other islands due to active volcanoes, little weathering and absence of sedimentary caprock deposits. Drilling and research in the past 25 years has shown that this model may not be fully applicable to Hawai'i Island and possibly other islands (Thomas et al., 1996; Stolper et al., 2009; Thomas, 2016). Researchers have discovered deep freshwater aquifers in Hilo and Kona that do not fall into the four general categories. However, these four categories are still commonly used in Hawai'i hydrogeology. Hawai'i Island's hydrogeology is categorized by Izuka et al. (2018) into four principal settings **(Figures 10-12)**:

- Freshwater lens in highly permeable lava flows
- Dike-impounded groundwater associated with rift zones and calderas
- Perched groundwater associated with sediment or tephra deposited in between lava flows
- Stacked freshwater bodies located below sea level **(Figure 11)**.

Groundwater basal aquifers, also called freshwater lens systems, are an important source of drinking water in Hawai'i. Hawai'i basal aquifers can occur in basalt and other igneous rocks as well as in sedimentary formations, locally known as caprock. In a basal aquifer, lower density (lighter) fresh water can be thought of as floating on higher density (heavier) saltwater. The fresh water and saltwater are separated by a mixing or transition zone where salinity gradually increases from near-fresh to seawater concentrations (i.e., brackish water, **Figure 12**). The behavior of basal groundwater is a function of the geologic properties of the rock, groundwater recharge, the dynamics of the transition zone and groundwater pumping. The water level in feet above sea level of basal aquifers is generally less than 50 ft-msl. Basal groundwater (that is not pumped out of the ground) ultimately discharges into the ocean as seeps and/or springs.

Some groundwater is retained behind dikes on the upper slopes of the volcanos or along rift zones. Dike-impounded water is also called high-level water because groundwater can be impounded several thousand feet above sea level. There are no mapped dikes in the study area, but this is not surprising because dikes are subsurface features that are exposed by mass wastage or fluvial erosion and Maunakea is only slightly eroded. It is probable that dikes occur in the subsurface. Dike-impounded groundwater discharges or "leaks" into the basal groundwater, deeper groundwater systems or, in many cases, into streams. Dike-impounded groundwater is also a drinking water source on Hawai'i Island.

Perched water in Hawai‘i generally refers to relatively small aquifers situated on layers of weathered ash or soil above the basal or high-level aquifers. Perched aquifer systems either leak downward below the restrictive layers or discharge into streams and springs. Perched water is used for drinking water on Hawai’i Island.

The hydrogeologic framework of Hawai’i is not understood as well as the other islands due to the relatively large size of the island and the uneven distribution of lithological and hydrological data from wells that are generally clustered near the coastline (Mink and Lau, 1993; Whittier et al., 2004). Because of these data gaps, island-wide groundwater elevation contours cannot be made. A few scientific exploratory wells (i.e., PTA [Pōhakuloa Training Area], and the deep Hawaiian Scientific Drilling Project [HSDP] drill holes near Hilo, HSDP1 and HSDP2, see **Figure 8**) and geophysical studies (Zohdy and Jackson, 1969; Pierce and Thomas, 2009; Thomas, 2016) provide some subsurface information, but little or no subsurface hydrogeological data exists at the high-altitude interior, including beneath Maunakea.

The permeability or hydraulic conductivity of an aquifer are important parameters when considering contaminant transport or productivity. Permeability is a measure of how easily a subsurface material (i.e., different types of lava) transmits fluid. The parameter is used when variable density fluids are anticipated. Hydraulic conductivity, the common measure of fluid transmissivity in groundwater hydrology, accounts for fluid (i.e. density and salinity) and material properties (permeability of the rock).

Although permeability and hydraulic conductivity are technically different, the terms are commonly used interchangeably. The greater the hydraulic conductivity or permeability number, the easier water flows through the formation. Hydraulic conductivity is important in this study because, along with other aquifer parameters including porosity and gradient, it is used to estimate groundwater velocity. Velocity can be used to estimate groundwater travel time, which is a conservative measure for potential contaminant break though times. Groundwater velocity is a function of the hydraulic conductivity, groundwater gradient, and porosity. It is an expression of the speed at which groundwater flows through the geologic media or rock. Note that although hydraulic conductivity and velocity have the same units (distance/time), they denote different aquifer properties. Travel time is the elapsed time, in years, for water to travel from its place of origin, usually where it falls as rain, to its discharge point, the ocean or a water well.

Dike-impounded aquifers tend to have lower hydraulic conductivity because of the low-permeability intrusive dikes. Where lava flows are free of dikes, the shield and lower postshield-stage (i.e., Hāmākua Volcanics) are considered moderately to highly permeable, while the upper postshield stage volcanics (i.e., Laupāhoehoe Volcanics) are considered to have low to moderate permeability. Volcanic aquifers have a large range of hydraulic conductivity estimates in Hawai’i, from 270 to 34,000 ft/day. Field estimates of horizontal hydraulic conductivity have been determined based on pump testing in the following locales of Hawai'i Island:

- 2,885-6,670 ft/d in Kīlauea (Takasaki, 1993)
- 610-6,400 ft/d in Kohala (Underwood et al., 1995)
- 500-34,000 ft/d in the west coast of Hawai'i (Oki, 1999)
- 269-4,502 ft/d for the whole island (Rotzoll and El-Kadi, 2008)

Horizontal hydraulic conductivity estimates based on modeling include:

- 3,000-20,000 ft/d in Kīlauea (Gingerich, 1995)
- 918-3,116 ft/d about Maunakea (Whittier et al., 2004)

Lava intruded with dikes has lower hydraulic conductivity because dikes have very low permeability, and heat alteration of the rock reduces permeability. Dikes are vertical barriers which impede horizontal flow, causing high (i.e., impounded) groundwater levels (Stearns and Macdonald, 1946). Inland wells and springs with water levels greater than 1,000 ft-msl may represent groundwater impounded by dikes (Takasaki and Mink, 1985; Gingerich, 1995). Gingerich (1995) used model calibration based on tidal fluctuations to demonstrate that rift zone lava hydraulic conductivity is at least two orders of magnitude less than dike-free lava. Where rift zones are well delineated, dikes tend to parallel the trend (Takasaki and Mink, 1985; Whittier et al., 2004). Much uncertainty exists regarding the number of dikes and how thermal alteration varies spatially throughout rift zones (Izuka et al., 2018).

In dike-impounded groundwater, horizontal hydraulic conductivity estimates range as follows:

- <33 ft/day in the Kīlauea rift zone near the summit (Takasaki, 1993)
- 0.03-3.3 ft/day in Maunakea dike complexes (Whittier et al., 2004, based on numerical model calibration)
- 196-328 ft/day in Maunakea marginal dike complexes (Whittier et al., 2004)

Where sediment and tephra deposits exist, hydraulic properties are related to grain size and the degree of weathering. From a simple hydrogeological viewpoint, there are two types of tephra: coarse-grained and weathered fine-grained tephra. Coarse tephra (i.e., cinder) is highly permeable, but generally does not support aquifers (Stearns and Macdonald, 1946). Weathered fine tephra (i.e., ash) is associated with widespread perched aquifers on the Kohala and Maunakea windward-facing slopes where rainfall and recharge are abundant (**Figure 10**). The permeability of the weathered tephra is relatively low, and it tends to form a barrier to groundwater flow, creating a perched aquifer. Hydraulic conductivity values have not been quantified for tephra deposits.

Sedimentary deposits (i.e., glacial till) are considered to have low to moderate permeability, regardless of whether they are unconsolidated or consolidated (Stearns and Macdonald, 1946). Hydraulic conductivity values for sediments have been estimated on Maui at 0.38 ft/day in the vertical direction and 17 ft/day in the horizontal direction (Gingerich, 2008). Most deposits on Maunakea are poorly sorted gravel, sand, and silt deposited by fluvial, glacial, and landslide processes.

Recent research on the Island of Hawai'i indicates the presence of multiple stacked bodies of freshwater thousands of feet below sea level separated by seawater-saturated basalts (Thomas et al., 1996; Stolper et al., 2009). The deep HSDP drill holes near Hilo, HSDP1, and HSDP2 (**Figure 8**), revealed upper and lower freshwater-saturated aquifers **(Figure 11**, Thomas et al., 1996). They found a deep freshwater body about 400 ft thick, confined below a soil layer at 900 ft-bgs that marked the transition from Maunakea lavas below and younger overlying Mauna Loa lavas above in the HSDP1 borehole. The second, deeper HSDP2 borehole encountered this same deep freshwater aquifer at about 1,000 ft-bgs, as well as several, much deeper, freshwater-saturated aquifers extending from a depth of about 6,500 ft-bgs to more than 9,900 ft-bgs (Stolper et al., 2009).

Thomas et al. (1996) considered these stacked freshwater bodies as part of a deep groundwater system that receives water from approximately 7,000 ft elevation on the slopes of Maunakea, based on stable isotope and carbon-14 age dating. Stolper et al. (2009) estimated these fresh groundwater bodies account for as much as one third of the rainfall recharge from the windward, mid-altitude slopes of Maunakea. Scientists continue to investigate these systems.

Groundwater velocities are useful for estimating the time and distance contaminants can be transported. Groundwater velocities have been measured near the coast at Lahaina on Maui using fluorescein tracer, based on the time it took 50% of the dye mass to arrive (Craig et al., 2013). Groundwater velocity measurements varied from 1 to 31 ft/day and averaged 8.2 ft/day; however, these velocity values were probably higher than the natural velocity because the high injection rates during the study (3 mgd) increased the groundwater head gradient. Lau and Mink (2006) report a typical groundwater velocity of 1 ft/day for the Hawaiian Islands. Groundwater velocity parameters for the aquifers in Honolulu varied from 0.5 ft/day to 5.0 ft/day at Molokai (Liu, 2007). These values are representative of groundwater flow in the dike-free highly permeable lavas on Oahu.

2.5 Water Budget for Hawai'i Island

An understanding of the water budget provides information on groundwater availability and the potential for dilution of contaminants. A schematic of a water budget showing components for Hawai'i Island's hydrologic system, representative of recent conditions, is shown on **Figure 13**

(Izuka et al., 2018). A water budget is based on the concept that inputs must equal outputs plus changes in storage. For example, for natural conditions, precipitation should equal evapotranspiration plus runoff and groundwater recharge.

Precipitation includes rain, snow, and fog drip. Evapotranspiration is the water that is either evaporated directly into the atmosphere or that which is used by plants and transpired back into the atmosphere. Runoff is the component that contributes to streamflow. Groundwater recharge is the component of precipitation that percolates into the subsurface and is not lost to the atmosphere via evapotranspiration.

Estimates for each of Hawai'i Island's water budget components are provided in **Table 1**. Average precipitation for Hawai'i Island is 14,402 million gallons per day (mgd) from snow, rain, and fog drip. About 45% of the precipitation goes to groundwater recharge (6,595 mgd). A map of the fraction of precipitation that becomes recharge is shown on **Figure 14**, while actual recharge rates are shown on **Figure 15.** Recharge is highly variable throughout the island. Most of the groundwater recharge is modeled to naturally discharge to the ocean (6,492 mgd), with a relatively minor component extracted for human use (103 mgd). Most of the precipitation that does not recharge the groundwater system (approximately 55%) transfers back to the atmosphere as evapotranspiration (6,175 mgd), and the remaining 1,686 mgd is transported as runoff (RO) to the coast. A map view of the runoff zones and stream systems used in the Engott (2011) water budget is shown on **Figure 16.** A map of Hawai'i Island's aquifer systems and State of Hawai'i sustainable yield estimates are shown on **Figure 17** (CWRM, 2008).

Table 1. Water Budget Components for the Island of Hawai'i.

Inputs (mgd)			Outputs (mgd)			
Precipitation (PR)	Human Inputs (HI)	Groundwater Recharge (GR)	Evapo-transpiration (ET)	Runoff (RO)	Groundwater use (GW)	Discharge (ND)
14,402	57	6,595	6,175	1,686	103	6,492

Notes: Source: Engott, 2011.

HI: Human inputs (injection, irrigation, wastewater)

PR: precipitation, including rain, snow and fog.

GR: groundwater recharge

ET: evapotranspiration.

RO: runoff (i.e., streams and floods).

GW: groundwater withdrawals (i.e., pumping wells).

ND: net discharge. Submarine discharge, springs, seeps and stream baseflow.

3.0 MAUNAKEA

This chapter focuses on the climate, geology and hydrology of Maunakea. The CSO is located near the peak of Maunakea (**Figure 4**).

3.1 Climate

The climate of Maunakea is variable from sea level up to the summit at approximately 13,350 ft-msl. Orographic rainfall from the prevailing trade winds on the windward (northeast) side of the mountain causes abundant (greater than 100 inches/year) precipitation at the middle elevations, approximately 2,500 to 7,000 ft-msl. On the leeward side, where the trade winds are blocked, ocean-land temperature and pressure differences generate local diurnal variations in the wind. Surface heating causes upslope winds during the day that result in convective rainfall in the afternoon. Wind direction reverses at night, as cooled mountain air moves downslope. Higher temperatures during the summer cause more convective rainfall (Giambelluca et al., 2013). Above 9,000 ft-msl, near the summit of Maunakea, the climate is that of alpine desert where mean annual precipitation is less than 10 inches/year. The estimated mean annual rainfall at the CSO is 8.0 inches/year (Giambelluca et al., 2013).

3.2 Geology

Maunakea last erupted between 3,600 and 4,600 years ago (Porter et al., 1977; Lockwood, 2000). There are three known geologic formations in Maunakea. They are, from youngest (top) to oldest (bottom), the Laupāhoehoe, Hāmākua and shield-stage volcanics. The stratigraphy, or layering, of Maunakea Volcanics is shown in **Figure 18** (Wolfe et al., 1997). The Pāhala Ash, which is found intercalated with the Laupāhoehoe Volcanics, has been discussed previously.

Much of the surface of Maunakea is covered in Holocene-Pleistocene age Laupāhoehoe Volcanics which are composed of relatively thick flows of alkalic rocks (West et al., 1992), consisting of hawaiite, mugearite and benmoreite (Wolfe et al., 1997). The Laupāhoehoe Volcanics are composed of more viscous lavas that are often dense and thickly bedded with relatively low permeability.

The contact between Laupāhoehoe and Hāmākua Volcanics has been mapped and noted in boreholes like the PTA well at the saddle between Maunakea and Mauna Loa (**Figure 8**). Rock core from the PTA well drilled at 6,353 ft-msl elevation revealed Laupāhoehoe in the upper 425 ft below ground surface (bgs), which was distinguished from the underlying Hāmākua Volcanics based on a baked volcanic soil layer (Thomas and Haskins, 2013; Thomas, 2018).

The Pleistocene-age Hāmākua Volcanics, emplaced as relatively thin lava flows with tholeiitic basalt composition (low silica), are found stratigraphically below the Laupāhoehoe. Shield-stage lavas are stratigraphically below the Hāmākua and have similar lithology but are not exposed at land surface. The Hāmākua Volcanics are exposed in deep erosional canyons (Porter et al., 1977). Ash and soil layers in the Hāmākua and shield-stage volcanics form low permeability layers which impede vertical groundwater flow. These layers may also form small perched aquifers. There is no clear boundary between the shield and postshield lavas, due to intercalated tholeiitic and alkalic lava flows (Frey et al., 1991). Both the Hāmākua and underlying shield-stage lavas are composed of relatively thin-bedded ʻaʻā and pāhoehoe lava flows and are highly permeable.

Dikes, with magma sourced from the shield or postshield volcanics, extend through the Hāmākua Volcanics and very likely the Laupāhoehoe Volcanics, in a zone that is approximately 3 miles wide at the summit of Maunakea (Don Thomas, 2018). The dike-intruded lavas are significantly less permeable, due to the dikes themselves and heat alteration of the surrounding lavas.

The volcanic formations, ash layers, and glacial/alluvial deposits comprising the surficial geology of Maunakea are shown on **Figure 19.** The glacial deposits shown on **Figure 19** coincide with an ice cap that was approximately 27 square miles in area, extending down to 12,000 ft-msl elevation, 13,000 to 40,000 years ago (Lockwood, 2009).

3.3 Groundwater

The regional groundwater body below the summit of Maunakea is probably a dike-impounded high-level aquifer (**Figure 13**; Izuka et al., 2018). It is "probable" because there is no direct confirmation of high-level water from drilling. Ground water hydrologic units have been established by the Commission on Water Resource Management to provide a consistent basis for managing ground water resources (CWRM, 2008). The five aquifer systems that connect to the peak of Maunakea are Honokaa, Paʻauilo, Hakalau, Onomea and Waimea **(Figure 17)**. There are also an unknown number of relatively small perched water bodies associated with buried glacial deposits and deposits of weathered ash or sediment. Lake Waiau is the surface expression of a shallow perched aquifer (Leopold et al., 2016).

There are several factors affecting the vulnerability of an aquifer. They include potential flow pathways of groundwater recharge, the occurrence of potential contaminating activities, and physical and geochemical conditions in the vadose zone that may affect contaminant transport (Whittier et al., 2010; Eberts et al., 2013). Contaminant transport is affected by attenuation factors. These include adsorption, biological action, chemical action (cation and anion exchange or precipitation), filtration, and dilution. These natural geochemical and physical conditions also influence the viability and transport of bacteria. For example, slightly elevated temperatures may increase biological activity and accelerate alteration of organic contaminants and nutrients. Other important factors in the phreatic zone include travel time and dilution. Dilution of contaminants will be greater in areas with high groundwater recharge. Travel time is a function of groundwater velocity and distance between recharge areas and discharge areas. There is more potential for attenuation during longer travel times. Multiple groundwater flow pathways are a function of the geology, recharge and hydrogeology of the region. Travel time and attenuation is affected by longer or shorter flow paths.

One of the purposes of this report is to assess the potential for groundwater pollution from the onsite cesspool at the CSO (Section 4.1). The cesspool is a minor source of pollution and will be closed and filled. INTERA has formulated a conceptual groundwater model of the region. A conceptual model is a simplified graphical representation of the relevant geology and hydrogeology of a site.

The depth to groundwater is important in determining possible recharge flow pathways. There is no direct information on the regional groundwater table below the summit of Maunakea, but data exist at the PTA in the saddle between Maunakea and Mauna Loa from the scientific boring at PTA Test Well 1 (**Figure 20**) (Thomas and Haskins, 2013). Perched groundwater was encountered at two depth intervals in the PTA Test Well 1: 500-540 and 700-1,181 ft bgs. The regional water table was encountered at 1,806 ft bgs, or at about 4,500 ft-msl.

Geophysical surveys have also indicated elevated groundwater levels at the lower slopes of the eastern flank of Maunakea (Pierce and Thomas, 2009; Thomas, 2016). Zones of low resistivity observed in magnetotelluric surveys collected about the eastern flank of Maunakea suggest the frequency and extent of perched or high-level groundwater bodies is higher than previously anticipated (Thomas, 2016).

This information indicates that the regional groundwater level below Maunakea is at the deepest 9000 ft bgs (4,500 ft-msl). If known water levels in other Hawai'i summit areas are extrapolated, the regional water level below the summit is probably significantly higher. We have assumed an average depth to groundwater below the summit area of 3,000 ft bgs (10,000 ft-msl). The regional groundwater below the summit is probably dike impounded, so water levels will vary significantly in different dike compartments.

Groundwater travel time is also a factor in assessing aquifer vulnerability. Another scientific boring of the HSDP, Kahi Puka 1 (KP-1), in Hilo revealed important age-dating information on groundwater encountered at 1050 ft bgs (Thomas et al., 1996). Freshwater sampled in this interval was determined to have an age of approximately 2,200 years (elapsed time since it originated as rainfall), based on carbon dating of dissolved bicarbonate. Stable isotopic data suggested that the water originated at about the 7000 ft-msl elevation, about 18.5 miles away from Hilo. This indicated an average groundwater velocity in this deep flow system of at least 44 ft/year. This velocity was derived from data on the deep groundwater flow system at about 1000 ft below sea level, and it provides an indication of flow velocity. It is likely that groundwater originating from the peak of Maunakea enters the deep flow system. These findings suggest it would take at least 3,000 years for groundwater to travel from the summit of Maunakea to the shoreline of Hilo (Thomas, 2018b).

Based on these and other data, the Maunakea groundwater system is represented by Cross Section A-A’ on **Figure 21**. Cross Section A-A’ depicts the groundwater system for approximately 24 miles between the CSO (Maunakea peak) and Hilo. The Laupāhoehoe Volcanics are assumed to extend approximately 1,000 ft bgs in the summit area and become a thinner veneer downslope. The Hāmākua Volcanics are lumped with the shield volcanics because they have similar hydrogeological properties (i.e., relatively high hydraulic conductivity), while the Laupāhoehoe Volcanics have distinctly lower hydraulic conductivity. Groundwater levels in the dike-impounded zone beneath the CSO are thought to vary around an average of 10,000 ft-msl in the 3-mile wide rift zone (**Figure 21**).

We depict two major flow paths for regional groundwater flow originating in the summit area. The upper arrow depicts overflow or spill from the dike compartments. This water would flow through other high-level aquifers in areas that are potentially not fully saturated. The lower arrow shows a flow path for water discharging at or below sea level from the dike compartments and flowing as basal or deep groundwater towards the ocean. Recharge at higher elevations will be pushed to deeper levels in the saturated zone by recharge occurring at lower elevations. This will result in deeper groundwater flow paths for higher elevation recharge. Contaminants transported in groundwater from higher elevations will also tend to be pushed deeper in the aquifer. The flow paths will be discussed in more detail in Section 4.3.

The dike-impounded groundwater beneath the summit of Maunakea is a leaky system that flows radially in all directions away from the summit and CSO. This distribution of flow directions means a contaminant that is introduced to the dike-impounded groundwater system could be transported radially, in several directions from the Maunakea summit area.

The “may not be fully saturated” labeled zone between 20,000 and 100,000 ft (horizontal) on **Figure 21** is in a zone where extensive perching likely exists with alternating saturated and unsaturated zones (Thomas, 2018). If high level water discharges into this zone the flow would be both saturated and unsaturated.

Dilution is another factor in assessing the vulnerability of an aquifer to contamination. The rate of groundwater recharge and the surface area over which the recharge occurs affects dilution. The recharge above 9,000 ft elevation is less than 10 inches/year. The recharge at the mid-elevation trade wind high rainfall zone between 2,000 and 6,000 ft elevation is greater than 100 inches/year (**Figure 21**). As groundwater moves radially downslope from the summit area, the surface area that is receiving recharge from rainfall increases and the total volume of recharge also increases. Consequently, groundwater recharge from the summit is diluted many times as it flows seaward.

Groundwater levels are high in the dike-impounded zone despite the lower recharge due to the low average hydraulic conductivity of the dike intruded rock that limits outflows **(Figure 21)**. The groundwater gradient (slope) between the dike impounded water of the summit and the basal water beneath Kaūmana and Hilo is considered to be relatively uniform due to the very high recharge rates (>100 in/yr) that help maintain high water levels in this area. This distribution of groundwater levels is supported by geophysical surveys of Thomas (2016) and water tables observed in the following wells (**Figure 20):**

- PTA Test Well 1, 8-4532-002, at an elevation of approximately 6,500 ft-msl, has a water table of around 4,500 ft-msl.
- Saddle Road well, 8-4110-001, at an elevation of approximately 2000 ft-msl and 7 miles from shoreline, has a water table of around 950 ft-msl.
- The Kaūmana test well, 8-4010-001, at an elevation of approximately 1800 ft-msl and 6.5 miles from shoreline, has a reported water table of 997 ft-msl.
- The Pi'ihonua Deepwell C, 8-4208-001, at an elevation of approximately 975ft-msl and 3.7 miles from shoreline, has a reported head of 26 ft-msl.

3.4 Surface Water and Lake Waiau

Other hydrologic systems to consider are perched groundwater and surface water. A map showing the watersheds, surface water and aquifer systems near the summit of Maunakea is shown in **Figure 22.** The Pōhakuloa and Waikahalulu Gulches are the most highly developed gulches on the upper mountain slopes **(Figure 22)**. There are three known major springs near Pōhakuloa gulch: the Hopukani, Waihū, and Liloe springs (collectively "Pōhakuloa Springs").

Pōhakuloa Gulch originates on the southwest side of Maunakea. The watershed includes the CSO and Lake Waiau. The surficial geology in the higher elevations is comprised of lava flows, pyroclastic deposits and glacial deposits. There is little or no soil and vegetation. The gulch likely formed due to scouring from melting glaciers (Macdonald et al., 1983; Lockwood, 2000; Porter, 2005). These melt waters are thought to have contributed to the initial filling of Lake Waiau (Sherrod et al., 2007).

INTERA visited Lake Waiau and walked the upper portion of the Pōhakuloa Gulch watershed on November 9, 2018. The lake was filled and overflowing into the gulch (**Figures 23** and **24**). The watershed around the lake is mostly rock rubble, red weathered lava rock, and slightly weathered lava flows. Occasional tufts of grass grew in the weathered material. The lake was pigmented green from algae, and the perimeter of the lake was surrounded by grass. Although the lake was overflowing, the soil was dry and there was no indication of recent precipitation or surface water inflows, indicating that the lake is an expression of perched groundwater.

INTERA noted that there are green algae in the lake. This implies the presence of nutrients. Nutrients and algae have been documented in Lake Waiau in 1977 to 1978 before the CSO was constructed (Laws and Woodcock, 1982). Laws and Woodcock (1982) noted that there were hypereutrophic conditions in the lake and found elevated levels of chlorophyll a in the lake during a drought. Patrick and Kauahikaua (2015) also noted that the lake was green during a period of low water levels in September 2013.

Lake Waiau is a culturally significant feature of Hawai’i, named after one of the snow goddesses of Maunakea, located approximately 4,000 ft south of the CSO (**Figure 22**). Lake Waiau is a perched alpine lake that fluctuates in size with precipitation and has recently been shrinking in overall size (Patrick and Delparte, 2014); although it was at full volume in November 2018. It is a perennial body of water in the crater of a cinder cone that was occupied by ice during past glaciations. Water remains in the lake despite being situated atop porous volcanics, due a fine-grained ash or glacial till layer that perches groundwater (Leopold et al., 2016).

Woodcock (1980) suggested that Lake Waiau water levels are related to rainfall and suggested that winter storms play an important role in the lake water budget, meaning that winter storms help recharge the lake. Woodcock (1980) also conducted a comparative study of tritium concentrations in lake, groundwater, and spring water. The results indicated that Lake Waiau water discharges into the Pōhakuloa Springs. Woodcock (1980) also suggested that relict ice may be blocking groundwater flow and that when the ice melts the lake may not be sustainable. Woodcock (1974) discovered permafrost near the summit crater, but there is no direct evidence of permafrost near Waiau. Leopold et al. (2016) also found no indication of ice through geophysical analysis. In addition, Woodcock (1974) did not show permafrost below Lake Waiau.

Ehlmann et al. (2005) analyzed hydrologic and isotopic data over a three-year period. They concluded that winter storms are the primary source of water for Lake Waiau. They also derived watershed and drainage channels from field and topographic data. The watershed and drainage calculations indicate the land surrounding the CSO does not drain into Lake Waiau. Runoff from the CSO area would flow into Pōhakuloa Gulch below Lake Waiau (**Figure 25**, Plate 1 from Ehlmann et al., 2005). This is corroborated from field observations by INTERA. **Figure 26** shows a view looking southwest towards Pōhakuloa Gulch (C), Lake Waiau (B) and the CSO (A). Surface water flow appears to go west and then south around the lake.

Ehlmann et al. (2005) concluded that Lake Waiau is fed by a small 135,000 square meter circular basin and is isolated from the surface drainage of the telescopes. They concluded that precipitation is sufficient to fill and sustain the lake. There is no indication that the small aquifer and watershed that feeds Lake Waiau are hydraulically connected to the CSO site via surface water or groundwater.

Based on published studies and INTERA's field visit, a conceptual model of the area under the CSO and Lake Waiau was constructed, as shown on Cross-Section B-B' (**Figure 27**). Dike-impounded groundwater is depicted in the 10,000 ft-msl range, about 3,000 ft bgs. The perched Lake Waiau water is depicted in a cinder cone of the Laupāhoehoe Volcanics. The CSO, Lake Waiau and the dike-impounded groundwater are hydraulically disconnected. There is no potential for surface or groundwater to reach Lake Waiau.

3.5 Water Budget

As mentioned in Section 2, the distribution of groundwater recharge varies significantly along the eastern flank of Maunakea (**Figures 15** and **21**). The recharge at the peak, near the CSO, is less than 10 inches/year, while the recharge at the 2,000 to 6,000 ft elevation is greater than 100 inches/year. The average precipitation at the CSO is 8.0 inches/year (Giambelluca et al., 2013), indicating that the recharge is less than 8 inches/year. The State of Hawai'i, Commission on Water Resource Management (CWRM) calculated water budgets as part of the Water Resource Protection Plan (WRPP) (CWRM, 2008). The United States Geological Survey (USGS) have calculated water budgets for the Onomea Aquifer System (Engott, 2011). The Onomea Aquifer System is the hydrologic unit of interest in this study because it is between the CSO and Hilo (**Figure 15**). Similar water budget components as those presented in **Table 1** for the Island of Hawai'i are presented for the Onomea Aquifer System in **Table 2:**

Table 2. Water Budget Components for the Onomea Aquifer System (Engott, 2011).

Inputs (mgd)	Outputs (mgd)					Sustainable Yield (mgd)
Precipitation (PR)	Groundwater Recharge (GR)	Evapo-transpiration (ET)	Runoff (RO)	WRRP Recharge	Water Use 2005	WRRP Sustainable Yield
1,310	417	412	481	335	0.372	147

Notes:

Precipitation is calculated as sum of rainfall and fog from Table 7 of Engott, 2011.
Evapotranspiration is sum of ET and CEvap from Table 7 of Engott, 2011.

WRRP = CWRM (2008)

The State of Hawai'i has calculated a baseline recharge rate of 335 mgd for the Onomea aquifer (CWRM, 2008; **Figure 17**), while the USGS (Engott, 2011) calculated 417 mgd (24% higher). **Figures 14** and **15** illustrate the spatial distribution of groundwater recharge values used in the USGS estimate for the Onomea aquifer.

4.0 WASTEWATER LEACHATE

The public has voiced concern over the potential for the wastewater leachate from the onsite wastewater disposal system (OSDS) to contaminate aquifers. This section describes the CSO facility, leachate associated with the facility's cesspool, a conceptual model for transport in the subsurface, as well as a comparative study of cesspools and water quality in the downhill community of Kaūmana in Hilo. A map of the CSO cesspool in the context of the others on Hawai'i Island is presented on **Figure 28.**

4.1 CSO Facility

The site has been used exclusively for construction and scientific operation of the CSO since 1983 (Stolper, 2015). The CSO telescope was constructed between 1983 and 1986, on a 0.75-acre site at 13,350 ft-msl, 200 ft below the summit of Maunakea (**Figure 29**). The CSO is located within the Astronomy Precinct of the Maunakea Science Reserve. The CSO site has been subleased to Caltech by the University of Hawai'i (UH) and the State of Hawai'i Department of Land and Natural Resources (DLNR) and has been operated since 1986, subject to a CDUP, issued by the DLNR, and an Operating Agreement between Caltech and UH.

The CSO facility includes a small wastewater system to dispose of waste from two toilets and a few sinks. The initial application for the CDUP (application submitted June 10, 1982) notes: "It is estimated that when the telescope becomes operational an average of five to seven persons will be present on the mountain at one time, operating in two shifts per day at the telescope site. The additional personnel are expected to generate an additional 1,100 to 1,500 gallons per month (gal/mo) of liquid sewage." Consistent with these prior estimates and review of a sampling of water delivery to the CSO over the years, it appears that the average monthly water delivery to CSO was 1,250 gal/mo. An as-built figure of the cesspool in the context of the CSO is shown on **Figure 30**, with a cesspool-specific drawing on **Figure 31** (Stolper, 2015). The cesspool is seven (7) ft in diameter, ten (10) ft tall and the discharge occurs through the bottom and side perforations.

The 1982 Environmental Impact Statement (EIS), prepared prior to the construction of CSO, notes that, "disposal of 1,100-1,500 gal/mo of liquid sewage into an 850-gallon septic tank is not expected to impact the hydrology of the area or pollute Lake Waiau." The EIS further noted, "The combined factors of relatively low effluent flow, evaporation losses from the cesspool tank, storage within the underlying lava rock or permafrost, probable downward dispersion (in event of a deep permafrost layer) and estimated negligible flow rate combined with significant purification within a few hundred feet of the source–lead to the conclusion of no impact on Lake Waiau."

The intent of Section 4.3 is to discuss and test the conclusions of the original assessment of the potential impact of the cesspool on the ground and surface water resources of Maunakea.

4.2 Leachate

Cesspool leachate contain nutrients (i.e., nitrogen) and potentially pathogens. Nitrogen compounds are commonly used to determine if leachate has contaminated surface water and/or groundwater. Nitrogen content is often used in wastewater quality assessments because it is a limited nutrient and because it can be harmful to humans. The federal maximum contaminant level (MCL) for nitrate (NO_3) is 10 mg/L (NO_3 as N or NO_3-N). Nitrogen and other nutrients can also cause eutrophication in streams, other freshwater bodies and coastal waters (Cummings and Babcock, 2012). The typical background nitrate level in Hawai'i groundwater is less than 3 milligrams per liter (mg/L) NO_3-N (Hawai'i Department of Health [HDOH], 2018).

Figure 32 shows the typical sequence of transformations that nitrogen undergoes after being introduced to the environment as wastewater (organic nitrogen). Organic nitrogen is first transformed into ammonium by microbes in the soil. If sufficient oxygen is present, ammonium will convert to nitrate. Most of the aquifers used for potable water supply in Hawai'i contain enough oxygen to allow nitrate to be the stable form of nitrogen (HDOH, 2018). Thereafter, in the absence of oxygen, microbes can consume nitrate and release nitrogen back to the atmosphere as nitrous oxide. It is important to note that nitrate and ammonium can transform back and forth repeatedly, depending on oxygen content at various zones of an aquifer. Typically, there is less oxygen with increasing depth in an aquifer.

Cesspools at public facilities generally have higher nitrogen concentrations (about 110 mg/L) than those at residential properties (about 80 mg/L), probably because of less dilution associated with the washing machines, showers, and numerous sinks found at residences (Figure 4-2 from Cummings and Babcock, 2012). An average nitrogen concentration of 87 mg/L in cesspool effluent was determined based on sampling and an assumed average effluent discharge rate of 9,580 gal/mo in Maui (Whittier and El-Kadi, 2014; HDOH 2017b, 2018; Delevaux et al., 2018). The CSO did not have as many visitors as a typical public facility, therefore the 87 mg/L nitrogen concentration from Delevaux et al. (2018) is most likely present in the CSO cesspool effluent because the facility lacked washing machines, and other facilities etc. that contribute to lower concentrations at residence cesspools.

The estimated cesspool leachate discharge rate, based on water delivery records, is 1,250 gal/mo. We calculate an average nitrogen loading rate of 0.41 kg/month for the CSO cesspool, based on the 87 mg/L N concentration. In Kaūmana, the average effluent and nitrate loading rate for a single cesspool is 20,100 gal/mo and 4.5 kg/mo, respectively. The nitrogen loading rate at the CSO is significantly lower than a typical cesspool because of the low total effluent discharge.

4.3 Potential Transport Pathways

INTERA developed Cross Sections A-A' and B'B' (**Figure 20**) to illustrate possible flow and transport pathways from the CSO to areas where there might be impacts to humans or the coastal environment. INTERA analyzed two potential transport pathways at regional and local scales. The larger scale flow pathway is via the regional groundwater flow system (**Figure 21**). The three components of the regional flow system are labeled A, B and C on **Figure 21.**

For example, if the leachate were to impact the regional groundwater system in Hilo, it must first percolate through the 3,000 ft thick vadose (unsaturated) zone beneath the summit of Maunakea (A) and then travel 120,000 ft (about 23 miles, the first 20 miles of which have no monitoring wells) of straight-line (horizontal) distance towards Hilo through the basal or shallower flow system (B) and/or the deep aquifer (C).

It has been suggested that there might be a smaller scale surface-groundwater flow system that connects the CSO to surface water features near the summit of Maunakea (i.e., Lake Waiau) or Pōhakuloa Gulch (**Figure 22**). There is no indication that Lake Waiau is connected via surface water or groundwater. The approximate straight-line horizontal travel distance from the CSO to the springs in Pōhakuloa Gulch is 12,000 ft. This local scale flow path is limited to the shallow depths of the vadose zone (Component A from **Figure 21,** depicted with larger scale in **Figure 27**) and areal extent shown on **Figure 22.** Hopukani, Waihū, and Liloe Springs are located between three and four miles downhill from the CSO, along Pōhakuloa Gulch. Surface water runoff from the CSO and Lake Waiau flows through Pōhakuloa Gulch, near these springs.

4.3.1 Regional Scale (CSO to Hilo)

Figure 21 shows a diagram the conceptual flow system from the CSO to Hilo. The regional dike-impounded groundwater is about 3,000 ft below ground surface. Groundwater recharge, along with the leachate, must percolate through this unsaturated zone to reach the regional flow system. The unsaturated zone includes the vertical extent of the Laupāhoehoe formation and some of the Hāmākua or shield-stage volcanics.

INTERA used the graphical software package VS2DI to model the vertical flow of leachate through the unsaturated zone. VS2DI simulates fluid flow and solute or energy transport through variably saturated porous media (USGS, 2000). INTERA constructed a conservative model that does not account for low permeability zones that would slow groundwater flow. The model did not simulate any saturated zones, although they may be present. Additionally, the model did not simulate dispersion.

Aquifer parameters are required to model groundwater flow. In this case saturated hydraulic conductivity, porosity, residual moisture content, and van Genuchten parameters: alpha and beta (van Genuchten, 1980) were included in the simulation, while dispersion, , which would reduce leachate concentrations as the plume travels more distance, was not.

A porosity of 0.1 was assumed (within the published range of 0.05-0.5 for volcanic rocks). The model is very sensitive to porosity. Porosity is a measurement of the open space in the rock that can contain water. The higher the porosity, the more water that can be contained in the formation. Higher porosity results in slower downward groundwater velocity. We used a relatively low estimate of porosity because we assume only a fraction of all the pore spaces are interconnected to transmit fluid. This is a conservative estimate and could result in an overestimate of the vadose zone groundwater velocity.

We assume 0.15 ft/day hydraulic conductivity in the vertical and horizontal directions. We used this hydraulic conductivity value for two reasons: (1) It is in the range of horizontal hydraulic conductivity values (0.03-3.3 ft/day) typical for dike complex basalts (Whittier et al., 2004), and (2) it is equal to the CSO leachate loading rate. This is the rate at which the subsurface must transmit leachate flow to prevent ponding of waste in the cesspool. The hydraulic conductivity must be greater than the leachate loading rate or there would have been evidence of overflow from the cesspool. The 0.15 ft/day leachate loading rate is calculated by converting the 1,250 gal/mo loading rate to cubic feet, dividing by the cross-sectional area of the cesspool (38 ft^2) and converting to day units. It is probable that the actual hydraulic conductivity of the various formations (Laupāhoehoe, Hāmākua, shield stage) is much more variable, but there is no direct information on the hydraulic characteristics of the geologic features in these formations, except for observational evidence indicating that the Laupāhoehoe Volcanics are likely less permeable than the Hāmākua and shield volcanics.

The residual moisture content and van Genuchten parameters were chosen based on assumptions of how much of the pore space contains water when drained and how rapidly the pore spaces saturate. 5% residual moisture content was assumed, based on the conceptual model of the geology in which the fraction of pore spaces that are interconnected are considered relatively large in diameter. Larger diameter pore spaces have less capillary suction to resist groundwater flow. The alpha and beta parameters were specified as 1.3 and 3.1, respectively. The alpha and beta van Genuchten parameters represent pore spaces that fill and drain relatively rapidly, consistent with the nature of fractured basalt.

No attenuation factors were considered in this simple model solution to be conservative. The leachate would have been subject to several attenuation factors. These include adsorption, biological action, chemical action (cation and anion exchange or precipitation), filtration, and dilution. There is simply not enough information to adequately model these parameters. But it is probable that that these parameters act on the leachate and reduce the concentrations of pathogens and nutrients. In particular, dilution and biodegradation are significant components not considered in this conceptual model that would reduce the concentrations of leachate material (i.e., pathogens and nitrate). The predicted concentrations are likely to be higher (conservative) than actual concentrations since the model does not account for these attenuation factors.

The model simulated 35 years of CSO operation. The model domain consisted of a grid 3,000 ft tall and 100 ft by 100 ft wide with 0.1 foot vertical and 1-foot horizontal resolution. For the top boundary condition, we represented cesspool discharge as pure leachate (i.e., concentration = 1) and the surrounding ground surface as recharging at 0.00014 ft/day of pure water (i.e., leachate concentration = 0), based on the <8 inches/year recharge rate at the summit of Maunakea.

The results indicate the leachate plume would travel downward to the dike-impounded groundwater level 3,000 ft below ground surface in 34 years (**Figure 33**). This travel time was determined based on the time it took for the unit concentration (i.e., the red color of **Figure 33**) to reach the bottom of the model boundary, representing the groundwater table depth. This equates to a vertical velocity of about 88 ft/year. Any leachate that percolated to the dike impounded groundwater table(s) would become part of the regional aquifer system between the CSO and Hilo (**Figure 21**).

Estimation of the travel time through the unsaturated zone is the first step. Next, we need to show the travel time though the saturated or phreatic zone. **Figure 21** illustrates two flow paths through the saturated zone. The range of estimated velocities and travel times for the vadose zone, the saturated or phreatic zone basal aquifer (Lau and Mink, 2006; Liu, 2007, Thomas et al., 1996), are shown in **Table 3.**

The estimated travel time for leachate from the CSO cesspool to the basal aquifer beneath the Hilo-Kaūmana area is estimated to range between 72 years to 412 years, based on the sum of travel times through Components A and B from **Figure 21** and **Table 3.** Regarding the deep aquifer flow path (Component C from **Figure 21** and **Table 3**), the groundwater travel time is estimated about 3,000 years from the peak of Maunakea to Hilo based on the age dating of groundwater from Thomas et al. (1996). The mean velocity of 50 ft/year for groundwater transport through Component C (**Table 3**) is a conservative estimate based on findings from Thomas et al. (1996). The earliest estimated arrival time for effluent from the Maunakea Summit in Hilo is 72 years. In other words, no effluent from the cesspool, even in miniscule amounts, has reached Hilo.

Table 3. Groundwater Velocity and Travel Time Estimates for Components of Regional Groundwater System Between the CSO and Hilo.

Component	Groundwater Velocity (feet/year)			Travel Distance (feet)	Travel Time (years)		
	Mean	Minimum	Maximum		Mean	Minimum	Maximum
A -Vadose zone	88	--	--	3,000	34	--	--
B - Basal aquifer	1,747	318	3,176	120,000	208	38	378
C - Deep aquifer	50	--	--	120,000	3,000	--	--

Notes:

Source for vadose zone: this report.

Sources for basal aquifer: Lau and Mink, 2006; Liu, 2007; Whittier, 2018b.

Source for deep aquifer: Thomas et al., 2016.

Groundwater recharge in the Onomea Aquifer System is very high when compared to the potential human-induced recharge of the cesspool at the CSO facility. The CSO cesspool may contribute up to 1,250 gal/mo or 0.0000417 mgd. The input from the CSO represents about 0.0000100% of the total recharge in the aquifer. Based on the groundwater recharge, hypothetical inflow from the CSO cesspool would be too diluted to measure when it reaches drinking water wells in the Hilo area.

4.3.2 Regional Scale Aquifers Surrounding CSO

We must also consider potential impacts to the environment and other drinking water sources around Maunakea. Groundwater flow emanates radially from the Maunakea peak. The regional flow path between the CSO and Hilo is analogous to other flow paths emanating radially outward from the CSO to the northwest and northeast (**Figure 34**).

For example, the Waimea Aquifer System is northwest of the Maunakea peak. The sustainable yield of the Waimea Aquifer System is 24 mgd (CWRM 2008). Engott (2011) estimated that the groundwater recharge is 35.62 mgd. Public water supply wells owned by the Waikoloa Water Company (PWS 135) and the Hawai'i Department of Water Supply (PWS 160) currently exist in the Aquifer. These wells are approximately 120,000 ft from the CSO (the wells are widely separated so this represents an average). The wells are potentially downgradient from the CSO and are in the Waimea aquifer system. Based on the basal groundwater velocities presented in **Table 3**, we estimate the minimum groundwater travel times from the CSO to these public water supply wells to be in the range of 70 to 400 years (similar to the Hilo travel times). Nitrate data from wells sampled from public water systems (PWS) #135, 160 are shown on **Tables 4** and **5,** respectively. Nitrate (as nitrogen) concentrations are consistently between 1 and 2 mg/L, still well below the MCL of 10 mg/L. Nitrate levels are also lower than the Hawai'i natural background level of 3 mg/L. Based on this information, there is no indication of impacts from the CSO cesspool. There are also no discernable impacts from other cesspools and OSDS in the Waimea Aquifer System.

Table 4. Nitrate results from municipal water supply wells in PWS 135 of Waikoloa Village, 1997-2013.

	PWS 135					
	8-5745-002	8-5745-003	8-5546-001	8-5546-002	8-5545-001	8-5745-004
	Parker 4	Waikoloa 1	Waikoloa 2	Waikoloa 3	Waikoloa 6	Waikoloa 7
Date Sampled	Nitrate as Nitrogen (mg/L)					
11/18/1997	--	1.3	1.3	1.3	--	--
7/28/1998	--	1.2	1.2	1.3	--	--
12/9/1998	--	--	--	1.3	--	--
5/11/1999	--	--	--	1.3	--	--
8/9/1999	--	1.2	1.2	1.3	--	--
10/4/1999	--	--	--	< 0.3	--	--
3/1/2000	--	--	1.2	1.3	--	--
3/8/2000	--	1.2	--	--	--	--
3/27/2001	--	1.2	1.3	1.4	--	--
4/15/2002	--	1.2	1.2	1.3	--	--
6/18/2003	--	1.2	< 0.3	1.3	--	--
6/15/2004	--	--	1.3	1.4	--	--
10/11/2004	--	1.2	--	--	--	--
5/24/2005	--	1.3	1.2	1.4	--	--
7/12/2006	--	1.3	1.2	1.3	--	--
3/28/2007	--	1.2	1.2	1.3	--	--
8/18/2008	--	--	--	--	1.1	--
2/10/2009	--	--	--	--	1.0	--
10/18/2010	1.4	--	--	--	--	--
1/18/2011	1.5	--	--	--	--	--
7/15/2013	--	--	--	--	--	1.4

Table 5. Nitrate Results from Municipal Water Supply Wells in PWS 160 Owned by the Hawai'i Department of Water Supply, 1998-2007.

	PWS 160						
	8-5946-001	8-5946-002	8-5946-003	8-5946-004	8-5846-001	8-5846-002	8-5846-003
	Lālāmilo A	Lālāmilo B	Lālāmilo C	Lālāmilo D	Parker 1	Parker 2	Parker 3
Date Sampled	**Nitrate as Nitrogen (mg/L)**						
7/28/1998	1.2	1.2	1.2	1.2	--	--	--
8/16/1999	1.2	1.2	1.2	--	--	--	--
10/20/1999	--	--	--	--	--	1.2	--
12/13/1999	--	--	--	--	--	1.2	--
2/23/2000	1.2	1.2	1.2	--	--	1.2	--
8/15/2000	--	--	--	--	1.2	--	--
4/17/2001	0.8	1.2	1.2	1.1	--	--	--
3/19/2002	1.3	1.3	1.3	1.2	--	1.3	--
9/17/2002	--	--	--	--	1.2	--	--
11/5/2003	1.2	1.2	1.2	--	1.2	1.2	--
12/9/2003	--	--	--	--	1.3	--	--
4/20/2004	1.2	1.2	1.2	--	1.2	1.2	--
6/15/2005	--	1.2	1.2	--	--	1.2	--
6/29/2005	--	--	--	--	1.2	--	--
12/5/2005	1.2	--	--	--	--	--	--
11/14/2006	1.2	1.2	--	1.2	--	1.2	--
3/21/2007	1.2	--	1.2	1.2	--	1.2	--
9/26/2007	--	1.3	--	--	--	--	--
4/21/2008	--	--	--	--	--	1.2	--
5/19/2008	--	--	--	--	1.2	--	--
1/26/2009	--	--	--	--	1.2	--	--
10/26/2010	--	--	--	--	--	--	1.3
1/18/2011	--	--	--	--	--	--	1.4

Waiki'i Ranch is located about 12 miles (66,000 ft) from the Maunakea peak. Based on the basal groundwater velocities presented in **Table 3,** we estimate the minimum groundwater travel times from the CSO to these public water supply wells to be in the range of 55 to 240 years. Nitrate levels (**Table 6**) in the Waiki'i Ranch wells are less than 2 mg/L NO_3-N. There is no indication of elevated nitrate levels.

Table 6. Nitrate Results from Municipal Water Supply Wells in PWS 162 of Waikoloa Village, 1998-2007.

	PWS 162	
	8-5239-001	8-5239-002
	Waiki'i 1	Waiki'i 2
Date Sampled	Nitrate as Nitrogen (mg/L)	
11/4/1997	1.5	--
7/27/1998	1.6	--
8/17/1998	1.6	1.7
11/24/1998	1.1	1.7
12/8/1998	1.1	1.7
8/11/1999	1.7	1.7
8/17/1999	1.7	1.6
3/8/2000	1.5	1.7
4/10/2001	1.6	1.8
4/8/2002	1.4	1.7
7/16/2003	1.4	1.7
6/28/2004	1.5	1.7
4/11/2005	1.4	1.7
8/2/2006	1.7	1.7
3/28/2007	1.4	1.6

To the northeast, Pa'auilo is about 85,000 ft downgradient from the CSO. The sustainable yield of the Pa'auilo Aquifer System is 60 mgd (CWRM 2008) and the estimated recharge is 120.86 mgd (Engott 2011). The estimated groundwater travel times from the CSO to Pa'auilo are between 60 and 300 years based on the maximum and minimum groundwater velocities from Table 3 and 85,000 ft straight-line distance between the two locations. Nitrate data from the municipal Pa'auilo supply well are consistently 1.4 mg/L (**Table 7**), indicating no impact from the CSO cesspool.

Table 7. Nitrate Results from Municipal Water Supply Wells in PWS 134 of Waikoloa Village, 1998-2007.

	PWS-134
	8-6223-001
	Pa'auilo
Date Sampled	Nitrate as Nitrogen (mg/L)
5/5/2004	1.4
4/13/2005	1.4
10/23/2006	1.4
2/28/2007	1.4

It is extremely unlikely that leachate from the CSO will impact the regional aquifer beneath Hilo and the other regional aquifers near the communities of Waikoloa Village and Pa'auilo (**Figure 34**). The dike-impounded groundwater beneath the summit of Maunakea is a leaky system that flows radially in all directions away from the summit and CSO. This distribution of flow directions means a contaminant that is introduced to the dike-impounded groundwater system could be transported radially, in several directions from the Maunakea summit area. Abundant groundwater recharge would dilute the contaminants introduced in the summit area. Additionally, biodegradation processes would result in some uptake of nitrogen.

It is unlikely that any pathogens from the CSO will reach the regional aquifer system. Pathogens from wastewater have been known to degrade by 10^{-5} (five orders of magnitude) within 92 days of travel time (Crockett, 2007). This means that the unit concentration of pathogens would be 0.00001 after 92 days. During this time, the attenuation factors mentioned above would reduce the mass of the leachate. Any leachate flowing through the regional aquifer system would be subject to dispersion with more travel distance. Below approximately 7,000 ft-msl elevation, groundwater recharge is substantial (~100 inches/year) and would dilute any leachate (i.e., nitrate) that manages to travel that far. It is extremely unlikely that leachate from the CSO would affect drinking water sources in Hilo. This report discusses cesspools and drinking water quality data from the Kaūmana study in Section 4.4.

4.3.3 Local Scale (CSO to Lake Waiau and Springs)

There is concern that leachate from the CSO may impact the culturally significant Lake Waiau or impact Hopukani, Waihū and Liloe springs (collectively the "Pōhakuloa Springs"; (**Figure 22**), which is adjacent to the Pōhakuloa Gulch There is a concern that during large rainfall, surface water from the CSO site may discharge into Pōhakuloa Gulch. Ehlmann et al. (2006) found, based on topographic watershed analysis, that the CSO is not in the Waiau drainage basin, but in the Pōhakuloa Gulch watershed. There is no direct evidence of a saturated groundwater connection between the CSO site and Pōhakuloa Gulch, but the surface water connection indicates that there may be a hydraulic connection during heavy rainfall and runoff periods. Note that there is no documentation that surface water runoff from the CSO reaches the gulch, but it is theoretically possible as ascertained from analysis of topographic data.

The potential for groundwater hydraulic connection between Lake Waiau and the downslope springs (i.e., Waihū) was first proposed by Woodcock (1980). In addition, Woodcock found a correlation between Lake Waiau water levels and flow from the springs. INTERA observed overflow from Lake Waiau into the gulch on November 9, 2018.

There is a possibility that there is a surface water connection between the CSO and the Pōhakuloa Springs. If this is the case, then there is a possibility that leachate from the cesspool may reach the groundwater supplying the springs. If leachate is significantly affecting water quality in the springs, then there should be indications in spring water quality. INTERA obtained nitrate data from the HDOH. Nitrate water quality data sampled from the springs six times between 2009 and 2013 range between 0.3 and 0.58 mg/L (**Table 8**). Natural background nitrate in Hawai'i is probably about 0.5 mg/L, although in some places it may be as high as 4 mg/L (HDOH, 2018). Nitrate levels in the springs are at background level and do not show influence from contamination.

Table 8. Nitrate in the Pōhakuloa Springs.

	Nitrate as Nitrogen	Nitrate + Nitrite
Date Sampled	(mg/L)	
4/29/2009	0.48	--
9/9/2009	0.30	0.30
2/22/2010	0.49	0.49
5/23/2011	0.56	0.56
3/6/2012	0.57	0.57
6/4/2013	0.58	0.58

Source: Rob Whittier of the State of Hawai'i Department of Health Safe Drinking Water Branch (email October 12, 2018)

4.4 Kaūmana OSDS Comparison

The influence of potential contaminant flux from the single CSO cesspool on the regional aquifer is small compared to the total contaminant flux from cesspools and other OSDSs. The following section includes calculations of the contaminant flux from cesspools in the Kaūmana area of Hilo. In addition, we look at nitrate data in neighboring wells. It is important to note that the CSO cesspool is not currently in use and is slated for closure and filling, but the cesspools in Kaūmana and adjacent regions are still in operation. There are nearly 88,000 known cesspools in the State of Hawai'i. The total effluent discharge from these cesspools is about 53 mgd. About 49,300 cesspools serve 82,000 housing units on Hawai'i Island (HDOH, 2017). Cesspool effluent can be a significant threat to human health and to sensitive ecosystems. Cesspool effluent has not been formally treated in an engineered system and contains pathogens and nutrients such as nitrogen and phosphorus. Cesspool effluent may percolate into the groundwater system and enter water supplies or discharge via groundwater to streams and coastal waters. The Hawai'i legislature has begun to address the challenge of upgrading cesspools by prioritizing the hazard from cesspools and initiating methods to help encourage people to upgrade their cesspools to safer ODSDs.

In order to constrain our comparison of the discontinued CSO cesspool with the cesspool challenge on Hawai'i Island we have limited our study area to the cesspools in the potential impact area of four public water supply wells (**Figure 20**). These wells belong to the Hawai'i Department of Water Supply (HDWS) and include Saddle Road Deepwell (8-4110-001), Pi'ihonua #1 C (8-4208-001), and Pi'ihonua #3 A&B (8-4306-001 and 002). The Saddle Road Deepwell and Pi'ihonua #1 are the furthest inland and are less subject to contamination from cesspools. Pi'ihonua #3 A & B are downgradient of numerous cesspools, indicating that these are more vulnerable to contamination, if there is any measurable impact. **Figure 35** shows the area used for our comparison in Kaūmana and neighboring communities.

We created a polygon encompassing the cesspools that may influence the HDWS wells introduced in the previous paragraph (**Figure 35**). There are about 1,000 cesspools (class IV OSDS) in this part of Kaūmana. We did not consider other types of OSDS, only cesspools. The HDOH has calculated the effluent loading rates from these cesspools. The effluent (leachate) loading rates vary from 200 to 1,400 gallons per day (gpd) (6,000 to 42,000 gal/mo) from each cesspool. The average nitrogen loading rate from a single cesspool varies from 0.05-0.32 kg/day. The total discharge from the cesspools in our Kaūmana study area is 680,000 gallons/day of effluent (**Figure 35**). This discharge includes 155 kg/day of nitrogen (**Figure 36**). For comparison, the assumed cesspool leachate discharge rate at the CSO was 42 gpd, with a range of nitrogen loading rates of 0.01 kg/day to 0.017 kg/day (0.014 kg/day on average). The discharge rate of the CSO was de minimis compared to the total discharge in the Kaūmana area.

Despite the large effluent and nutrient flux from the cesspools in the Kaūmana area, there is no discernable impact to nitrate concentrations in the HDWS wells. **Table 9** shows recent nitrate levels in our study area wells. The nitrate levels in wells were all under 0.5 mg/L, which is at the lower end of nitrate background (i.e., natural) levels in Hawai'i groundwater (HDOH, 2018). Nitrate background levels in Hawai'i are less than 3 mg/L NO_3-N. The state and federal maximum contaminant level (MCL) for nitrate in drinking water is 10 mg/L (as nitrogen). The maximum nitrate concentrations from the wells in our study area were between 1997 - 2017 were 0.42 mg/L, with mostly non-detect results (<0.05 mg/L) (**Table 9**). These low concentrations are most likely the consequence of the enormous amount of recharge in the Onomea Aquifer System. Engott (2011) estimated the baseline recharge at 417 mgd. The lower nitrate concentrations observed in Kaūmana water supply wells suggests that dilution from high groundwater flows is an important factor in mitigating the impact of cesspools. Whittier and El Kadi (2014) also concluded that dilution is an important factor in determining risk from cesspools.

Table 9. Nitrate Results from Municipal Water Supply Wells in Kaūmana, 1998-2007.

	State Well ID / Name			
	8-4110-001	8-4306-001	8-4306-002	8-4208-001
	Saddle Road	Pihonua #3 A	Pihonua #3 B	Pihonua #1 C
Date Sampled	Nitrate as Nitrogen (mg/L)			
5/19/1998	--	--	--	0.30
7/15/1998	--	< 0.30	0.38	0.31
6/22/1999	--	0.39	0.38	0.31
10/11/1999	--	--	< 0.30	--
2/22/2000	--	0.38	0.38	0.30
3/28/2001	--	0.38	0.38	< 0.30
6/18/2003	0.40	0.38	0.40	0.32
4/19/2004	0.40	0.37	0.38	< 0.30
11/8/2004	< 0.30	< 0.30	0.38	< 0.30
3/30/2005	0.41	0.38	< 0.30	0.30
6/19/2006	0.42	0.38	0.38	0.31
2/27/2007	0.42	0.38	0.38	0.31

Source: Rob Whittier of the State of Hawai'i Department of Health Safe Drinking Water Branch (email October 12, 2018)

4.5 Leachate Conclusions

There is concern that regional and local water supplies may be affected by the CSO cesspool. Potentially affected wells include water supply wells located around Maunakea, including drinking water wells in Hilo. Closer to the CSO, there is also concern that local surface water and shallow groundwater of nearby Lake Waiau and the Pōhakuloa Springs may be affected by the cesspool.

There is virtually no potential for leachate impact to drinking water supplies of Hilo or other communities around Maunakea, based on the long groundwater travel times, and the substantial amount of groundwater recharge and dilution. Despite the more than 1,000 cesspools located in Kaūmana **(Figures 35** and **36**), water supply wells in the area have nitrate (as nitrogen) concentrations less than 0.5 mg/L, which is lower than both the general Hawai'i background level of less than 3 mg/L, and the Federal MCL of 10 mg/L.

In addition, nitrate data from water supply wells in the communities surrounding Maunakea show no sign of impact. Leachate transport through the 3,000 ft of unsaturated volcanics separating the CSO from the dike-impounded groundwater is calculated to take a minimum of 34 years. This calculation does not consider perching layers, dispersion, adsorption, chemical attenuation, or biodegradation factors. Thereafter, if any leachate were to enter the dike-impounded groundwater, contaminants would have to travel 12 to 24 miles to drinking water wells while getting significantly diluted from recharge and groundwater underflow. For example, the estimated travel times to Hilo vary from 72 to 3000 years. Slower groundwater velocities have been calculated for the deep groundwater flow systems system of Maunakea that were discovered below Hilo. Groundwater flowing between the CSO and Hilo is subject to substantial amounts of recharge, which would dilute potential contamination.

There is virtually no potential for leachate impact to Lake Waiau or the Pōhakuloa Springs based on the lack of hydraulic connection between these water bodies and the CSO and the low nitrate levels from the springs.

5.0 FILL ANALYSIS

5.1 Introduction

Approximately 2,335 cubic yards of fill were used to construct the CSO, and the maximum depth of the fill is about 10 ft deep on the downhill side of the facility. The origin of the fill was not documented and, depending on the decommissioning alterative implemented, the CSO permit conditions may require the fill to be removed from the CSO site. It is possible that the fill used was from the summit area (Laupāhoehoe Volcanics), but it is also possible that the fill came from further down the mountain in the Hāmākua Volcanics or from a quarry in Mauna Loa lavas. The problem is that the fill may have to be returned to the volcano from where it originated. The generally accepted hypothesis is that the fill came from the Laupāhoehoe Volcanics of Maunakea, near the summit.

A total of four (4) samples were obtained for geochemical analysis (**Figure 37**). Three (3) samples were obtained from the underlying fill. These provide information to characterize the geochemical composition of the fill. One (1) sample was obtained from a lava flow that was immediately adjacent to the CSO site to provide compositional data on the Laupāhoehoe Volcanics. The four (4) samples were collected and analyzed in accordance with the Sampling and Analysis Plan (SAP) (INTERA, 2018).

5.2 Methods

5.2.1 Field Sampling and Descriptions

Field sampling occurred on November 9, 2018 by a Professional Geologist, Kevin Gooding of INTERA, using the "Judgmental Sampling" methodology (EPA, 2002). Sample selection was made based on knowledge of the geology and fill under investigation. Four (4) samples were collected: three (3) from the fill (CSO-F-1, CSO-F-2, and CSO-F-3) and one (1) from an adjacent native lava flow (CSO-N-1) (**Figure 37** and **Table 10**). The fill samples were located around the CSO property and all samples were collected from hand dug holes, one (1) foot bgs on average. The native lava flow sample location was chosen based on recommendation from Mr. Fritz Klasner. Mr. Klasner noted that a portion of the lava flow adjacent to the CSO Site had been removed in order to widen the access road at about the same time the CSO was constructed.

Table 10. Sample Types and Locations.

Sample	Location	Type	Location Description
CSO-F-1	19.822490° - 155.475771°	Fill	Approximately 70 feet west of the CSO
CSO-F-2	19.822693° - 155.475739°	Fill	Approximately 90 feet north northwest of the CSO; 28 feet north of the cesspool manhole.
CSO-F-3	19.822366° - 155.475380°	Fill	Approximately 18 feet southeast of the CSO.
CSO-N-1	19.822440° - 155.474727°	Lava flow	North side of the Maunakea Road, 250 feet downhill (east) of the centerline of the CSO driveway.

The general lithology of the fill material was determined with observations from six (6) randomly located holes dug to various depths, ranging from 0.8 to 1.5 ft below the top of the fill surface. Fill-clast lithology was described using terminology consistent with Compton (1985) and Wentworth and MacDonald (1953). Lithology of the native lava flow sample (CSO-N-1) was also described. Lithologic descriptions of the four (4) samples are presented in Section 1.3.1. These three (3) fill and one (1) native rock samples were stored in double-bagged Ziploc® packaging and labeled for shipment for geochemistry analyses. Duplicate field samples were not necessary.

5.2.2 Geochemical Analyses

The four (4) samples were shipped to the Washington State University (WSU) GeoAnalytical Lab in Pullman, Washington, via overnight freight (FedEx) with a chain-of-custody (COC) form for major and minor oxide and trace element geochemical analysis using x-ray fluorescence (XRF). Samples were dried prior to submittal to the WSU GeoAnalytical Lab. XRF analysis was conducted using a low (2:1) lithium-tetraborate fused bead technique developed in-house at the WSU GeoAnalytical Lab (Johnson et al., 1999) to get percent composition (by weight) for 29 elements: silicon, aluminum, titanium, iron, manganese, calcium, magnesium, potassium, sodium, phosphorus scandium, vanadium, nickel, chromium, barium, strontium, zirconium, yttrium, rubidium, niobium, gallium, copper, zinc, lead, lanthanum, cesium, thorium, neodymium, and uranium. These elements are reported in oxide (mineral) form because this is a byproduct of the ignition process used to get percent composition. A duplicate lab analysis was made on fill sample CSO-F-2 for quality assurance and quality control (QA/QC).

5.3 Results

Sample lithology descriptions and geochemical compositions for the four (4) samples collected at the CSO Site (**Figure 37)** are presented in this section.

5.3.1 Field Descriptions

Lithological descriptions of the fill material from CSO-F-1 through CSO-F-3 rock samples are as follows.

5.3.1.1 CSO-F-1

This sample was collected from 0.5 ft below the top of the fill surface (**Figures 38** and **39**). The fill was composed of crushed compacted cinders with occasional fragments of dense lava. Three (3) approximately 4-inch diameter rocks were encountered. The sample submitted to the WSU GeoAnalytical Lab was an aphanitic piece of vesicular basalt, with very small glassy, green phenocrysts that appear to be olivine.

5.3.1.2 CSO-F-2

This sample was collected from approximately 1 foot below the top of the fill surface (**Figure 340**). The fill was composed of compacted cinders and dense lava fragments with fragments up to five (5) inches in diameter. Three (3) pieces of dense, aphanitic black dense lava that were 2 to 4 inches in diameter were collected.

5.3.1.3 CSO-F-3

This sample was collected from 1.3 ft below the top of the fill surface (**Figures 41** and **42**). The fill was composed of compacted dense lava fragments and cinders. Two (2) boulder-sized fragments were encountered in the hole, with the larger fragment being greater than 1-ft diameter.

5.3.1.4 CSO-N-1

This sample was collected from an a’a lava flow exposed approximately 250 ft east of the CSO Site (**Figures 43** through **45**). A portion of this lava flow was excavated (removed) to widen the existing road about the same time as the CSO facility was built. The central portion of this a’a lava flow consists of dense, aphanitic, fine-grained lava with very small plagioclase phenocrysts, which impart a silvery sheen to fresh hand samples. This a’a lava flow has ice polishing on its undisturbed upper surfaces. The top of this flow consists of flow-generated clinker (a’a lava) that is very porous and could be mistaken for cinders (air-fall tephra). The sample was collected in-situ, and jointed lava immediately below the clinker flow top. The texture of the selected sample was vesicular and aphanitic.

5.3.2 Geochemistry

The unnormalized percent composition (by weight) of major oxides are listed in **Table 11** along with the sum of percentages and loss-on-ignition (LOI) percentages. The ten (10) major oxides listed in descending order of abundance are: silicon (Si), aluminum (Al), iron (Fe), titanium (Ti), manganese (Mn), magnesium (Mg), calcium (Ca), sodium (Na), potassium (K), and phosphorus (P). Selected major oxides proved to be diagnostic for the purposes of this investigation (see below).

Table 11. Unnormalized Percent Composition of Major Elements for Each of the CSO Rock Samples.

	Sample			
	CSO-F-1	CSO-F-2	CSO-F-3	CSO-N-1
Major Oxide	Unnormalized Percent Composition (by weight)			
SiO2	52.27	52.06	49.23	50.97
TiO2	2.36	2.33	2.86	2.44
Al2O3	17.36	17.20	17.55	17.34
FeO*	9.61	9.63	11.05	10.08
MnO	0.22	0.22	0.21	0.22
MgO	3.02	3.40	3.96	3.39
CaO	6.34	6.19	6.78	6.23
Na2O	4.97	4.79	4.10	4.87
K2O	2.09	2.11	1.65	2.06
P2O5	0.95	0.96	0.87	0.99
Sum	99.22	98.89	98.26	98.59
LOI	0.28	0.32	1.01	0.79

The LOI values indicate how much mass was lost during analyses. Typically, LOI values greater than 1.5% suggest the sample may have experienced significant alteration. All four (4) samples were considered acceptable. As a QA/QC check for laboratory analyses, we compare the relative percent difference (RPD) in percent composition for each major oxide in the CSO-F-2 sample versus a duplicate analysis. The unnormalized baseline and duplicate percent compositions and RPDs for CSO-F-2 are provided in **Table 12.** The ® denotes that a duplicate bead made from the same rock powder and analyzed.

Table 12. Baseline and Duplicate (®) CSO-F-2 Unnormalized Percent Compositions for Each Major Oxide with Corresponding Relative Percent Differences. (RPD)

	Sample		
	CSO-F-2	**CSO-F-2®**	**RPD**
Major Oxide	Percent (%)		
SiO2	52.06	52.01	0.10
TiO2	2.33	2.34	0.43
Al2O3	17.20	17.17	0.17
FeO	9.63	9.58	0.52
MnO	0.22	0.22	0.00
MgO	3.40	3.38	0.59
CaO	6.19	6.20	0.16
Na2O	4.79	4.79	0.00
K2O	2.11	2.11	0.00
P2O5	0.96	0.96	0.00
Sum	98.89	98.76	0.13
LOI	0.32	0.32	0.00

RPDs for all major oxides are well below 1%, indicating the laboratory analytical approach meets the QA/QC criteria. Since the data meet field and lab QA/QC requirements, we can normalize percent compositions relative to the mass remaining after analysis, as shown on **Table 13.**

Table 13. Normalized Percent Composition of Major Oxides for Each of the CSO Rock Samples.

	Sample			
	CSO-F-1	CSO-F-2	CSO-F-3	CSO-N-1
Major Oxide	**Normalized Percent Composition (by weight)**			
SiO2	52.69	52.65	50.11	51.69
TiO2	2.38	2.36	2.92	2.47
Al2O3	17.50	17.39	17.86	17.58
FeO	9.69	9.74	11.25	10.23
MnO	0.22	0.22	0.21	0.23
MgO	3.05	3.43	4.03	3.44
CaO	6.39	6.26	6.90	6.32
Na2O	5.01	4.84	4.17	0.94
K2O	2.11	2.13	1.68	2.09
P2O5	0.96	0.97	0.88	1.01
Total	100.00	100.00	100.00	100.00

Normalized percent compositions are most suitable for comparison of samples. CSO-F-3 has the lowest amount of SiO_2 and highest amount of FeO. The comparison of subtle differences between each sample's elemental composition is most intuitively done with a plot, presented and discussed in the following section.

5.4 Discussion

5.4.1 Geochemistry

Wolfe et al. (1997) used the classification scheme of Le Bas et al. (1986) to define Maunakea lava flow types. This classification system plots total alkali (Na_2O + K_2O) versus silica ($Si0_2$). We plotted total alkali (Na_2O + K_2O) versus silica ($Si0_2$) for the four (4) samples collected in this study on the diagram used by Wolfe et al. (1997; Figure 5 on p. 17) to distinguish Hāmākua and Laupāhoehoe Volcanics. We also added the "general field extents" of the Hāmākua and Laupāhoehoe Volcanics defined by Wolfe et al. (1997) to our **Figure 46.** All four (4) analyzed CSO samples plot within the Laupāhoehoe Volcanics field defined by Wolfe et al. (1997). Samples CSO-F-1, CSO-F-2, and CSO-N-1 are fairly closely clustered, suggesting that they are very likely "related", possibly even produced by the same eruptive event. Sample CSO-F-3 doesn't cluster with the other three (3) samples and is compositionally different enough to suggest that it isn't related to the other three (3) samples. For example, CSO-F-3 (**Table 11**) has much higher TiO_2, FeO, MgO, & CaO and lower SiO_2, Na_2O, K_2O, & P_2O_5 than the other three (3) samples – which makes it a Hawaiite, while the other three (3) samples are mugearite. This Hawaiite sample may represent a piece of tephra from one of the adjacent cinder cones. All four (4) samples likely came from the area around the CSO facility, since two (2) of the three (3) fill samples are compositionally similar to the nearby Laupāhoehoe lava flows. Lastly, we compare these findings via geochemical analyses with rock descriptions from the field campaign.

5.4.2 Field Descriptions

The determination that all three (3) fill samples and the native lava flow sample belong to the Laupāhoehoe Volcanics (hawaiite and mugearite) using geochemical analyses is consistent with the general field lithologic descriptions of the samples. The road-cut through the Laupāhoehoe lava flow is likely the main source of the fill. This supports the interpretation that fill material is sourced from local, native volcanics adjacent to the CSO Site near the summit of Maunakea.

5.5 Conclusion

Based on the lithologic descriptions and geochemical analyses of the three (3) fill samples and one (1) sample from an adjacent a'a lava flow, the fill material at the CSO Site is determined to be sourced from Laupāhoehoe Volcanics which underlies Maunakea summit area. Much of the CSO Site fill was likely originally sourced from an excavation in a Laupāhoehoe lava flow during widening of the main road. Other components of the fill are probably tephra from one of the nearby Laupāhoehoe cinder cones.

6.0 REFERENCES

Clague D.A. and Dalrymple, G.B. 1987. The Hawaiian-Emperor volcanic chain in R.W. Decker, Wright, T.L. and P.H. Stauffer. 1987. Volcanism in Hawai'i. U.S. Geological Survey Professional Paper 1350. United States Government Printing Office, Washington.

Clague, D.A., and Sherrod, D.R., 2014, Growth and degradation of Hawaiian volcanoes, in M.P. Poland, Takahashi, J.T. and Landowski, C.M. Characteristics of Hawaiian Volcanoes: U.S. Geological Survey Professional Paper 1801, p. 97–146.

Commission on Water Resource Management (CWRM). 2008. Water resource protection plan. Prepared by the Wilson Okamoto Corporation. June.

Commission on Water Resource Management (CWRM). 2018. Downloaded from http://files.hawaii.gov/dlnr/cwrm/maps/gwhu_hawaii.pdf on November 11, 2018.

Compton, R.R. 1985. Geology in the Field, John Wiley & Sons, New York.

Craig, C.R., Whittier, R.B., Dailer, M.L., Dulaiova, H., El-Kadi, A.I., Fackrell, J., Kelly, J.L., Waters, C.A., Sevadjian, J. 2013. Lahaina groundwater tracer study, Lahaina, Maui, Hawai'i. Final Report. Prepared for State of Hawai'i Department of Health, U.S. Environmental Protection Agency, U.S. Army Engineer Research and Development Center. June.

Crockett, C. S. 2007. The role of wastewater treatment in protecting water supplies against emerging pathogens. Water Environmental Research, vol. 79, no. 3, pp. 221-232.

Cummings, M. and R. Babcock Jr. 2012. Condition assessment survey of onsite sewage disposal systems (OSDS) in Hawai'i. University of Hawai'i at Manoa. December.

Delevaux, J.M.S., Whittier, R., Kostantinos, A.S., Bremer, L.L., Jupiter, S., Friedlander, A.M., Poti, M., Guannel, G., Kurashima, N., Winter, K.B., Toonen, R., Conklin, E., Wiggins, C., Knudby, A., Goodell, W., Burnett, K., Yee, S., Htun, T., Oleson, K.L.L., Wiegner, T. and T. Ticktin. 2018. A linked land-sea modeling framework to inform ridge-to-reef management in high oceanic islands. PLoS ONE, v. 13, no. 3.

Eberts, S.M., Thomas, M.A., and Jagucki, M.L., 2013, The quality of our Nation's waters—Factors affecting public-supply-well vulnerability to contamination—Understanding observed water quality and anticipating future water quality: U.S. Geological Survey Circular 1385, 120 p. Available online at https://pubs.usgs.gov/circ/1385/.

Ehlmann, B. L. Raymond E. Arvidson, Bradley L. Jolliff, Sarah S. Johnson, Brian Ebel, Nicole Lovenduski, Julie D. Morris, Jeffery A. Byers, Nathan O. Snider, and Robert E. Criss. 2005. Hydrologic and Isotopic Modeling of Alpine Lake Waiai, Mauna Kea, Hawai'i. Pacific Science (2005), vol 59, no. 1:1-15, University of Hawai'i Press.

Engott, J.A. 2011. A water-budget model and assessment of groundwater recharge for the Island of Hawai'i. U.S. Geological Survey, Scientific Investigations Report 2011-5078.

Environmental Protection Agency (EPA). 2002. Guidance on choosing a sampling design for environmental data collection. For use in developing a quality assurance project plan. EPA QA/G-5S. December.

Fiske, R.S. and E.D. Jackson 1972. Orientation and growth of Hawaiian volcanic rifts: the effect of regional structure and gravitational stresses. Procs. Royal Society, London, England. 329, 299-326.

Flinders, A.F., Ito, G., Garcia, M.O., Sinton, J.M., Kauahikaua, J., and B. Taylor. 2013, Intrusive dike complexes, cumulate cores, and the extrusive growth of Hawaiian volcanoes. Geophysical Research Letters, v. 40, p. 3,367–3,373, doi: 10.1002/grl.50633.Frey, F.A., Garcia, M.O., Wise, W.S., Kennedy, A., Gurriet, P. and F. Albarede. 1991. The evolution of Mauna Kea volcano, Hawai'i: Petrogenesis of tholeiitic and alkalic basalts. Journal of Geophysical Research, v. 96., no B9., pp. 14,347-14,375. August 10.

Giambelluca, T.W., Nullet, M.A., and Schroeder, T.A. 1986. Rainfall atlas of Hawai‘i: Hawai‘i Department of Land and Natural Resources, Division of Water and Land Development Report R76, 267 p.

Giambelluca, T.W., Chen, Q., Frazier, A.G., Price, J.P., Chen, Y.-L., Chu, P.-S., Eischeid, J.K., Delparte, D.M. 2013. Online rainfall atlas of Hawai'i. Bulletin of American Meteorological Society, vol. 94, pp. 313-316.

Gingerich, S.B. 1995. The hydrothermal system of the lower east rift zone of Kilauea Volcano—Conceptual and numerical models of energy and solute transport: Honolulu, University of Hawai‘i, Ph.D. dissertation, 215 p. Gingerich, S.B. 2008. Ground-Water availability in the Wailuku Area, East Maui, Hawai'i. U.S. Geological Survey Scientific Investigations Report 2008-5236.

______.2008, Ground-water availability in the Wailuku area, Maui, Hawai‘i: U.S. Geological Survey Scientific Investigations Report 2008-5236, 95 p. [http://pubs.usgs.gov/sir/2008/5236/].

Gingerich, S.B. and V.I. Clifford. 2005. Three-dimensional variable-density flow simulation of a coastal aquifer in southern Oahu, Hawai'i, USA. Journal of Hydrogeology, vol. 13, pp. 436-450.

HDOH Hawai'i Department of Health, 2017. Report to the twenty-ninth legislature state of Hawai'i 2018 regular session relating to cesspools and prioritization for replacement. The State of Hawai'i Department of Health, December 2017.

HDOH Hawai'i Department of Health. 2018. Upcountry Maui Groundwater Nitrate Investigation Report Maui, Hawai'i, Draft. Hawai'i Department of Health, Safe Drinking Water Branch, February 2018.

INTERA, Inc. 2018. Sampling & Analysis Plan (SAP) Caltech Submillimeter Observatory (CSO) Decommissioning Geochemical Sampling. Maunakea, Hawai’i. Prepared for California Institute of Technology. November.

Izuka, S.K., Engott, J.A., Rotzoll, K., Bassiouni, M., Johnson, A.G., Miller L.D., Mair, A. 2018. Volcanic aquifers of Hawai’i—hydrogeology, water budgets, and conceptual models. U.S. Geological Survey, Scientific Investigations Report 2015-5164 Version 2.

Johnson, D. M., Hooper, P.R., and R.M. Conrey. 1999. XRF Analysis of Rocks and Minerals for Major and Trace Elements on a Single Low Dilution Li-tetraborate Fused Bead. GeoAnalytical Laboratory, Washington State University, Pullman, WA 99164. JCPDS International Centre for Diffraction Data, pp.843-867.

Kauahikaua, J., Hildenbrand, T., and M. Webring. (2000). Deep Magmatic Structures of Hawaiian volcanoes imaged by three-dimensional gravity models. Geology. 28. 883-886. 10.1130/0091-7613(2000)28<883: DMSOHV>2.0.CO; 2.

Lau, S.L. and J.F Mink. 2006. Hydrology of the Hawaiian Islands. University of Hawai’i Press. Honolulu, HI, p. 129.

Laws, E.A. and A.H. Woodcock. 1982. Hypereutrophication of a Hawaiian Alpine Lake. Pacific Science (1981), vol 35, no. 3. The University of Hawai’i Press.

Lebas, M.J., Lemaitre, R.W., Streckeisen, A. and Zanettin, B. (1986). A Chemical Classification of Volcanic-Rocks Based on the Total Alkali Silica Diagram. Journal of Petrology 27(3): 745-750.

Leopold, M., Morelli, A., Schorghofer, N. 2016. Subsurface architecture of two tropical alpine desert cinder cones that hold water. Journal of Geophysical Research: Earth Surface, vol. 121, pp. 1148-1160.

Liu, C.C.K. 2007. RAM2 modeling and the determination of sustainable yields of Hawai’i basal aquifers. Water Resources Research Center University of Hawai’i at Manoa.

Lockwood, J.P. 2000. Mauna Kea Science Reserve Geologic Resources Management Plan – Appenxi “H” in Group 70, 2000, Mauna Kea Science Reserve Master Plan, Honolulu, HI.

Lockwood, J.P. 2009. Geologic Technical Report Thirty Meter Telescope Project Island of Hawai’i. Prepared for Parson Brinckerhoff. April.

Macdonald, G.A., Abbott, A., Peterson, F.L. 1983. Volcanoes in the Sea: The Geology of Hawai’i. University of Hawai’i Press; 2nd Edition, July 1.

Mink, J.F. and L.S. Lau. 1993, Aquifer identification and classification for the island of Hawai‘i: Groundwater protection strategy for Hawai‘i. University of Hawai’i, Water Resources Research Center Technical Report 191, 108 p.

Moore, J.G., 1987, Subsidence of the Hawaiian Ridge, in Decker, R.W., Wright, T.L, and Stauffer, P.H., eds., Volcanism in Hawai'i. U.S. Geological Survey Professional Paper 1350, v. 1, p. 85–100.

Moore, J.G., and Clague, D.A. 1992, Volcano growth and evolution of the island of Hawai'i. Geological Society of America Bulletin, v. 104, p. 1,471–1,484.

Oki, D.S. 1999. Geohydrology and numerical simulation of the ground-water flow system of Kona, Island of Hawai'i. U.S. Geological Survey Water-Resources Investigations Report 99–4070, 49 p.

Patrick, M.R., and Kauahikaua, J., 2015, Satellite monitoring of dramatic changes at Hawai'i's only alpine lake—Lake Waiau on Mauna Kea volcano: U.S. Geological Survey Scientific Investigations Report 2015–5076, 16 p., http://dx.doi.org/10.3133/sir20155076.

Patrick, M.R. and D. Delparte. 2014. Tracking dramatic changes at Hawai'i's only alpine lake. Eos, v. 95, no. 14, p. 117–118.

Pierce, H.A. and D.M. Thomas. 2009. Magnetotelluric and Audiomagnetotelluric Groundwater Survey Along the Humu'ula Portion of Saddle Road Near and Around the Pōhakuloa Training Area, Hawai'i, USGS Open File Report 2009–1135, 160 p.

Porter, S.C., Stuiver M., Yang, I.C. 1977. Chronology of Hawaiian glaciations. Science, vol. 195, no. 4273, pp. 61-63.

Porter, S.C. 1979a, Quaternary stratigraphy and chronology of Mauna Kea, Hawai'i—A 380,000-Year Record of Mid-Pacific Volcanism and Ice-Cap Glaciation. Geological Society of America Bulletin, Part II, v. 90, p. 908–1093.

Porter, S.C. 1979b, Hawaiian Glacial Ages: Quaternary Research, v. 12, p. 161–187.

Porter, S.C. 2005. Pleistocene snowlines and glaciation of the Hawaiian Islands. Quaternary International, vol. 138-139, pp. 118-128.

Rotzoll, K. and A.I. El-Kadi. 2008. Estimating hydraulic conductivity from specific capacity for Hawai'i aquifers, USA. Hydrogeology Journal, v 16, p. 969–979

Schorghofer, N., Leopold, M., Yoshikawa, K. 2017. State of High-Altitude Permafrost on Tropical Maunakea Volcano, Hawaii. Permafrost and Periglacial Processes, vol 28, pp 685-697.

Sherrod, D.R., Sinton, J.M., Watkins, S.E., Brunt, K.M. 2007. Geologic map of the State of Hawai'i. U.S. Geological Survey, Open-File Report 2007-1089, version 1.0.

Simkin, T., Tilling, R.I., Vogt, P.R., Kirby, S.H., Kimberly, P. and D.B. Stewart. 2006. This dynamic planet. World map of volcanoes, earthquakes, impact craters, and plate tectonics (third edition). Geologic Investigations Map I-2800.

State of Hawai'i Department of Health (HDOH). 2017a. Report to the twenty-ninth legislature State of Hawai'i 2018 regular session relating to cesspools and prioritization for replacement, in response to Act 125, 2017 regular sessions (House Bill 1244, HD1, SD2, CD1). December.

State of Hawai'i Department of Health (HDOH) Safe Drinking Water Branch (SDWB). 2017b. Work Plan and Sampling and Analysis Plan for Upcountry Maui Groundwater Nitrate Investigation. Honolulu, HI, USA.

State of Hawai'i Department of Health (HDOH) Safe Drinking Water Branch (SDWB). 2018. Appendix VI Upcountry Maui Groundwater Flow and Nitrogen Transport Model Report, Maui, Hawai'i. Draft. March.

State of Hawai'i Commission on Water Resource Management (CWRM). 2018. Water Resource Protection Plan 2019 Update. Public Review Draft October.

Stearns, H.T., and Macdonald, G.A. 1946. Geology and groundwater resources of the island of Hawai'i. Hawai'i Division of Hydrography Bulletin, vol. 9, p. 363.

Stolper, E.M., Depaolo, D.J. and D.M. Thomas. 2009. Deep drilling into a mantle plume volcano—The Hawai'i Scientific Drilling Project. Scientific Drilling, vol. 4, pp. 4-14.

Stolper, E.M. 2015. Notice of Intent to Decommission Caltech Submillimeter Observatory. November 18.

Sustainable Resources Group (SRG) International, Inc. 2010. Decommissioning Plan for the Mauna Kea Observatories. A sub-plan of the Mauna Kea Comprehensive Management Plan. Prepared for Office of Mauna Kea Management, University of Hawai'i-Hilo. January.

Takasaki, K.J. and J.F. Mink. 1982. Water resources of southeastern Oahu, Hawai'i. U.S. Geological Survey Water-Resources Investigations 82-628. Prepared in cooperation with the Board of Water Supply City and County of Honolulu. Honolulu, Hawai'i. November.

Takasaki, K.J. and J.F. Mink. 1985. Evaluation of major dike-impounded ground-water reservoirs, Island of Oahu with a section on flow hydraulics in dike tunnels in Hawai'i. U.S. Geological Survey Water-Supply Paper 2217. Prepared in cooperation with the Board of Water Supply City and County of Honolulu.

Takasaki, K.J. 1993. Ground water in Kilauea volcano and adjacent areas of Mauna Loa volcano, island of Hawai'i. U.S. Geological Survey Open-File Report 93–82, 28 p.

Thomas, D.M., Paillet, F.L., Conrad, M.E., 1996. Hydrogeology of the Hawai'i Scientific drilling project borehole KP-1—2. Groundwater geochemistry and regional flow patterns. Journal of Geophysical Research, vol. 101, pp. 11,683-11,694.

Thomas, D.M. and E. Haskins. 2013. Analysis of the hydrologic structures within an ocean island volcano using diamond wireline core drilling. Poster, American Geophysical Union 2013 Fall Meeting, San Francisco, USA.

Thomas, D.M. 2016. Final Report on: Magnetotelluric and AudioMagnetolluric Surveys on Department of Hawaiian Home Lands Mauna Kea East Flank.

Thomas, D.M. 2018. Interview conducted by Mr. Kevin Gooding of INTERA Incorporated with Dr. Donald Thomas, of the University of Hawai'i. Interview notes on file. INTERA Incorporated: Hawai'i. October 29.

Thomas, D.M. 2018a. Presentation: New Insights: Old Water Two Decades of Groundwater Research in Hawaii, Hawaii Institute of Geophysics and Planetology, Center for the Study of Active Volcanoes.

Todd, D.K. 1980. Groundwater Hydrology, 2nd Edition. New York: John Wiley & Sons.

Underwood, M.R., Meyer, W., and W.R. Souza. 1995. Ground-water availability from the Hawai'i aquifer in the Kohala area, Hawai'i. U.S. Geological Survey Water-Resources Investigations Report 95–4113, 57 p.

University of Hawai'i (UH). 2009. Mauna Kea Comprehensive Management Plan UH Management Areas. Prepared by Ho'akea, LLC dba Ku'iwalu.

U.S. Geological Survey (USGS). 2000. VS2DI - A Graphical Software Package for Simulating Fluid Flow and Solute or Energy Transport in Variably Saturated Porous Media. https://wwwbrr.cr.usgs.gov/projects/GW_Unsat/vs2di/.

van Genuchten, M. Th. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. Soil Science Society of America Journal. v. 44. pp. 892-898.

Water Environment Research Foundation (WERF). 2009. State of the Science: Review of Quantitative Tools to Determine Wastewater Soil Treatment Unit Performance. Water Environment Research Foundation, Alexandria, Va. 196 p.

West, H.B, Garcia, M.O., Gerlach, D.C. and J. Romano. 1992. Geochemistry of tholeiites form Lanai, Hawai'i. Contributions to Mineralogy and Petrology, v. 112, pp. 520-542.

Wentworth, K.W. and G.A. Macdonald. 1953. Structures and forms of basaltic rocks in Hawai'i. U.S. Geological Survey—Bulletin 994, pp. 98.

Whittier, R.B., Rotzoll, K., Dhal, S., El-Kadi, A.I., Ray, C., Chen, G., and D. Chang. 2004, Hawai'i source water assessment program report—Volume II, Island of Hawai'i source water assessment program report. Water Resources Research Center, University of Hawaiʻi at Mānoa, Honolulu, Hawaiʻi, 65 p.

Whittier, R.B., Rotzoll, K., Dhal, S., El-Kadi, A.I., Ray, C., and D. Chang. 2010, Groundwater source assessment program for the state of Hawai'i, USA—Methodology and example application. Hydrogeology Journal, v. 18, no. 3, p. 711–723.

Whittier, R.B. and A.I. El-Kadi. 2014. Risk-ranking of on-site sewage disposal systems for the Hawaiian Islands of Kauai, Molokai, Maui and Hawai'i. Prepared for State of Hawai'i Department of Health Safe Drinking Water Branch. September.

Whittier, R.B. 2018a. Interview conducted by Mr. Kevin Gooding of INTERA Incorporated with Mr. Robert Whittier, of Hawai'i Department of Health, Safe Drinking Water Branch. Interview notes on file. INTERA Incorporated: Hawai'i. October 19.

Whittier, R.B. 2018b. Interview (email) conducted by Mr. Kevin Gooding of INTERA Incorporated with Mr. Robert Whittier, of Hawai'i Department of Health, Safe Drinking Water Branch. Interview notes on file. INTERA Incorporated: Hawai'i. December 10.

Wolfe, E.W., Wise, W.S., Dalrymple, G.B. 1997. The geology and petrology of Maunakea volcano,
Hawai'i: a study of post shield volcanism. U.S. Geological Survey, Professional Paper 1557: 129 p., 4 plates (maps) in slipcase.

Wolfe, E.W., and Morris, Jean, 1996, Geologic map of the Island of Hawaii: U.S. Geological Survey Miscellaneous Investigations Series Map, I-2524-A, scale 1:100,000

Woodcock, A.H. 1974. Permafrost and Climatology of a Hawai'i Volcano Crater, Arctic and Alpine Research, 6:1, 49-62

Woodcock, A.H. 1980. Hawaiian alpine lake level, rainfall trends, and spring flow. Pacific Science. Vol. 24, no. 2. The University Press of Hawai'i.

Zohdy, A.A.R, and D. B. Jackson. 1969. Application of Deep Electrical Soundings for

Groundwater Exploration in Hawai'i. Geophysics, Vol. 34, No. 4, pp. 584-600.

7.0 FIGURES

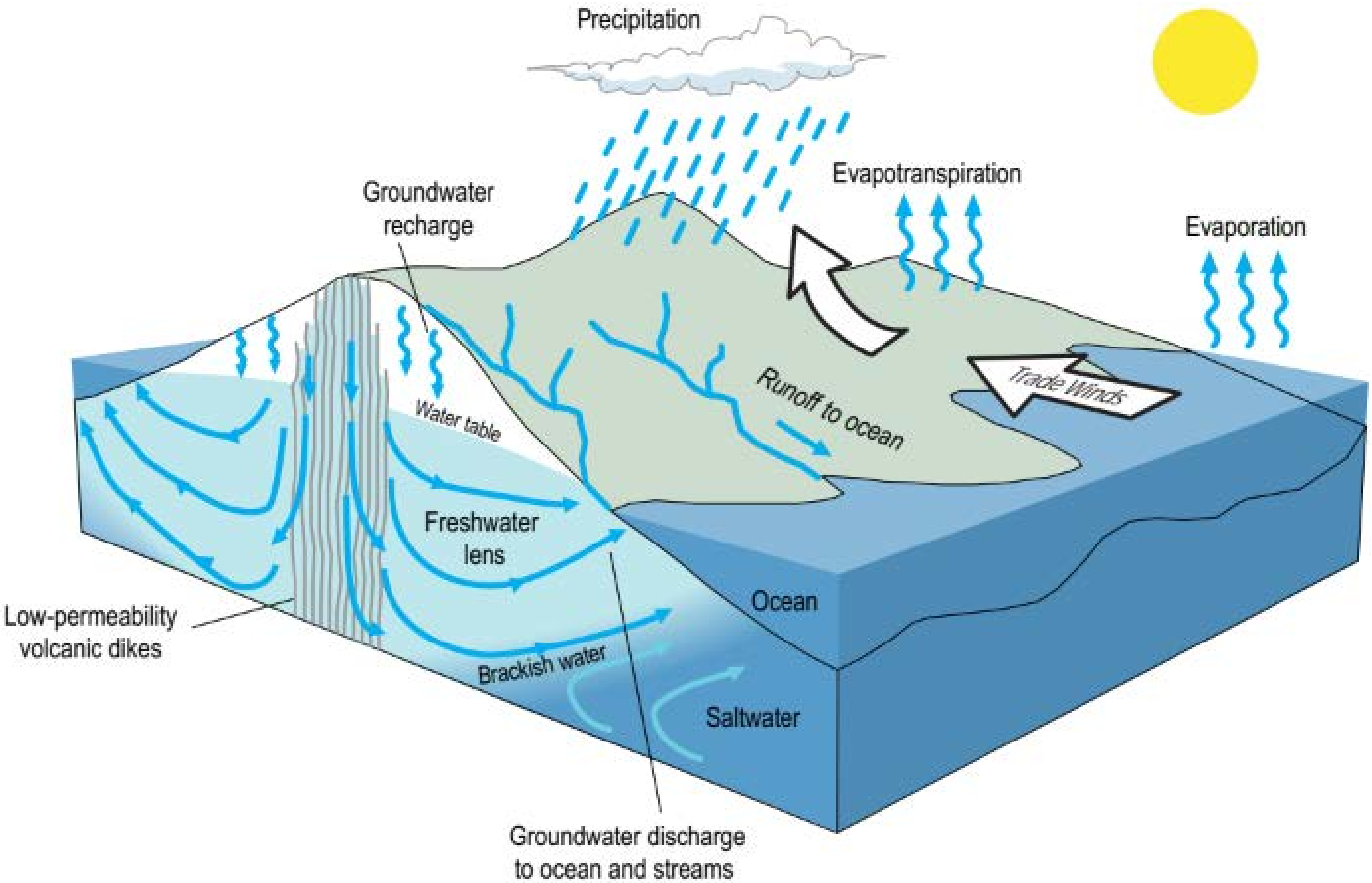

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Figure 1. Conceptual Model of Hawaiian Island Hydrologic Cycle (Izuka et al., 2018).

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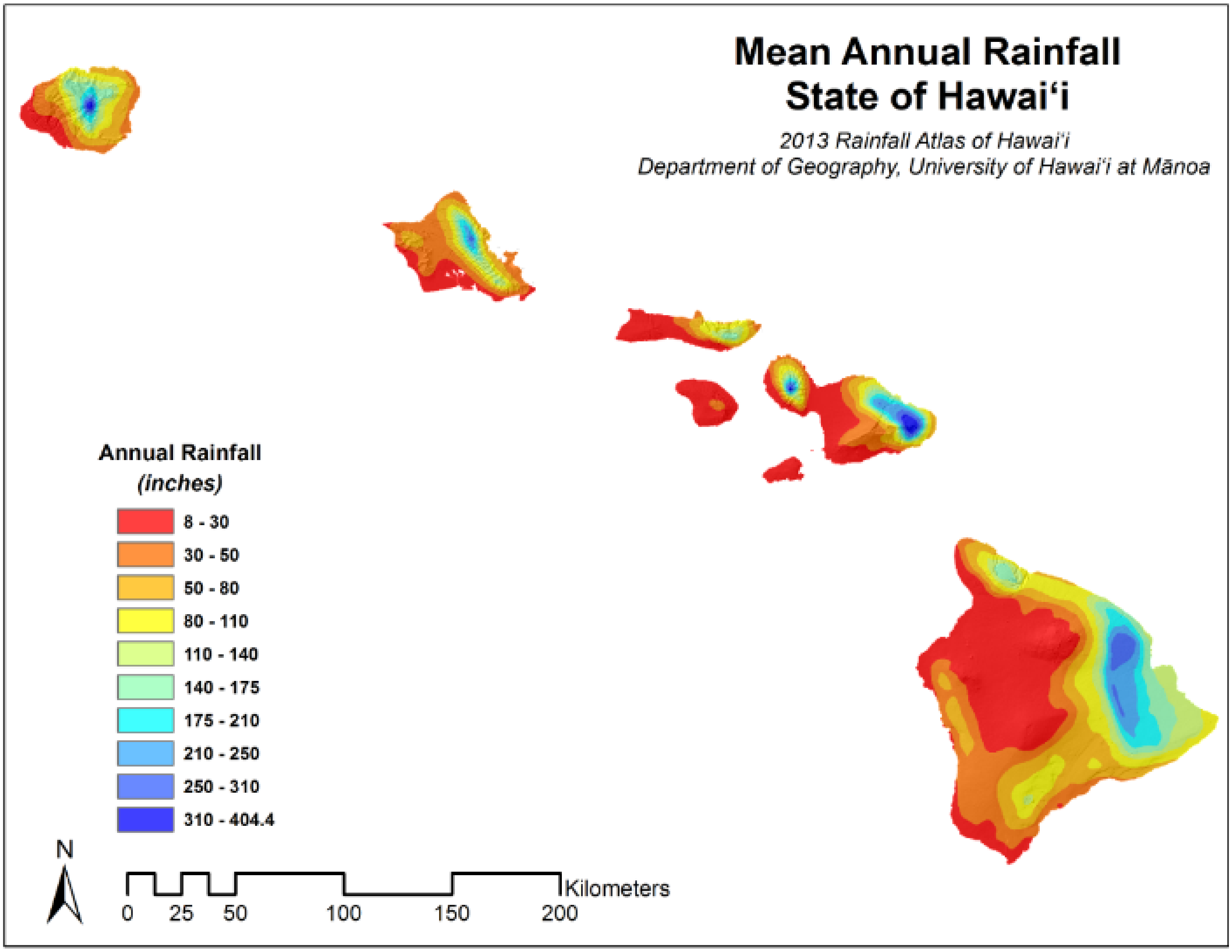

Figure 2. Distribution of Rainfall Throughout the Hawaiian Islands (Giambelluca, et al. 2013).

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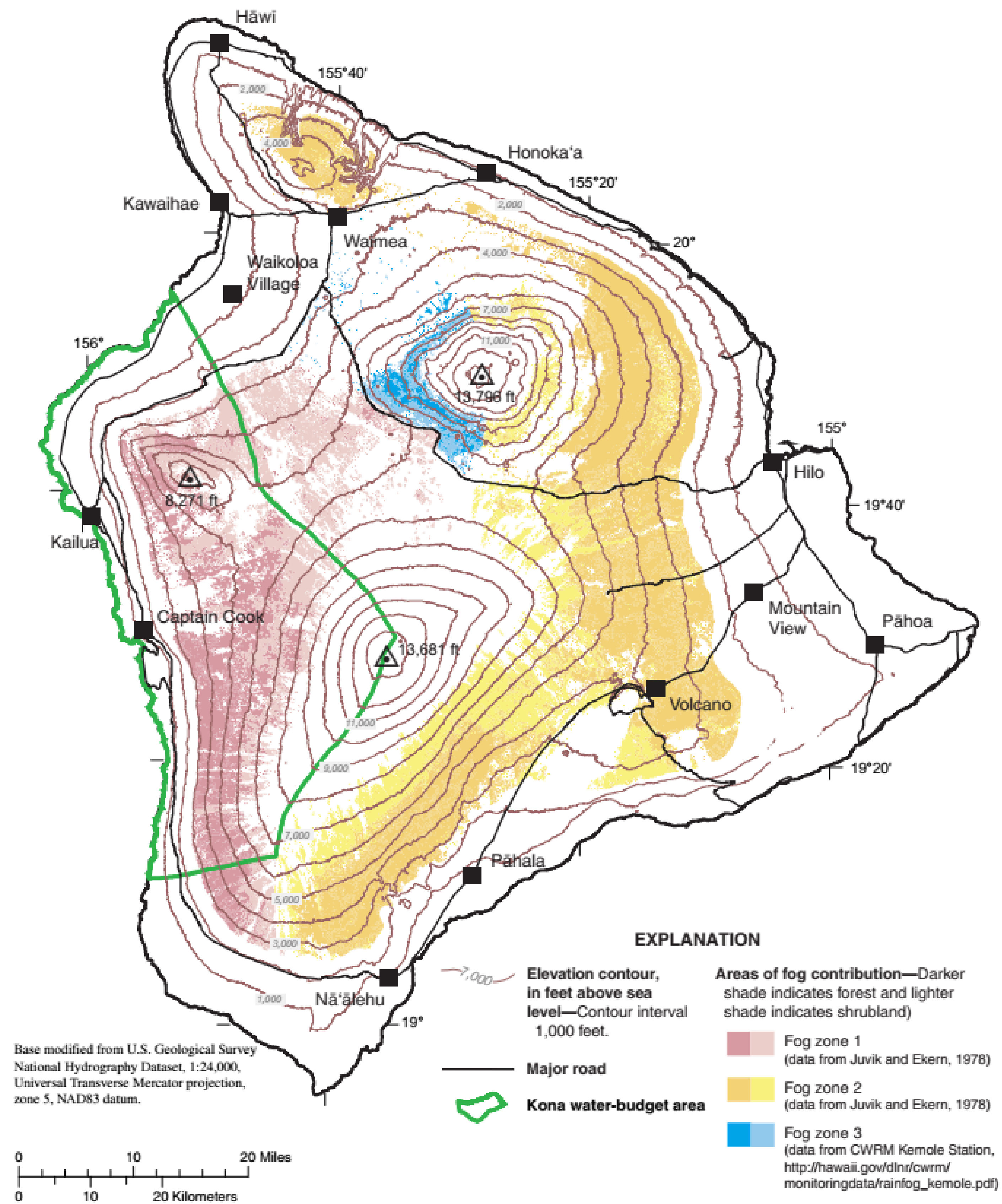

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Figure 3. The Distribution of Fog Zones on Hawai'i Island (Engott, 2011).

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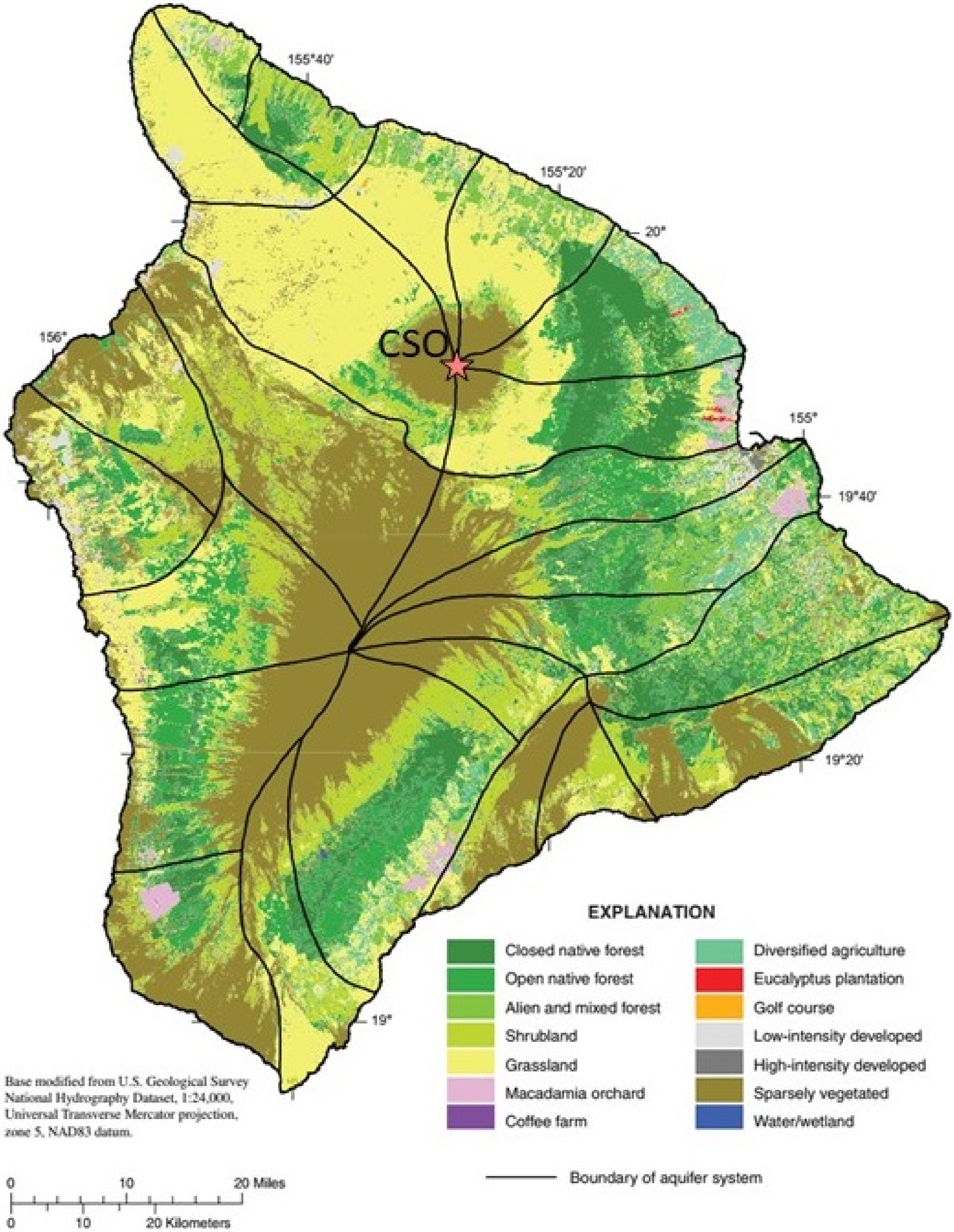

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Figure 4. The Distribution of Vegetation on the Island of Hawai'i (Engott, 2011).

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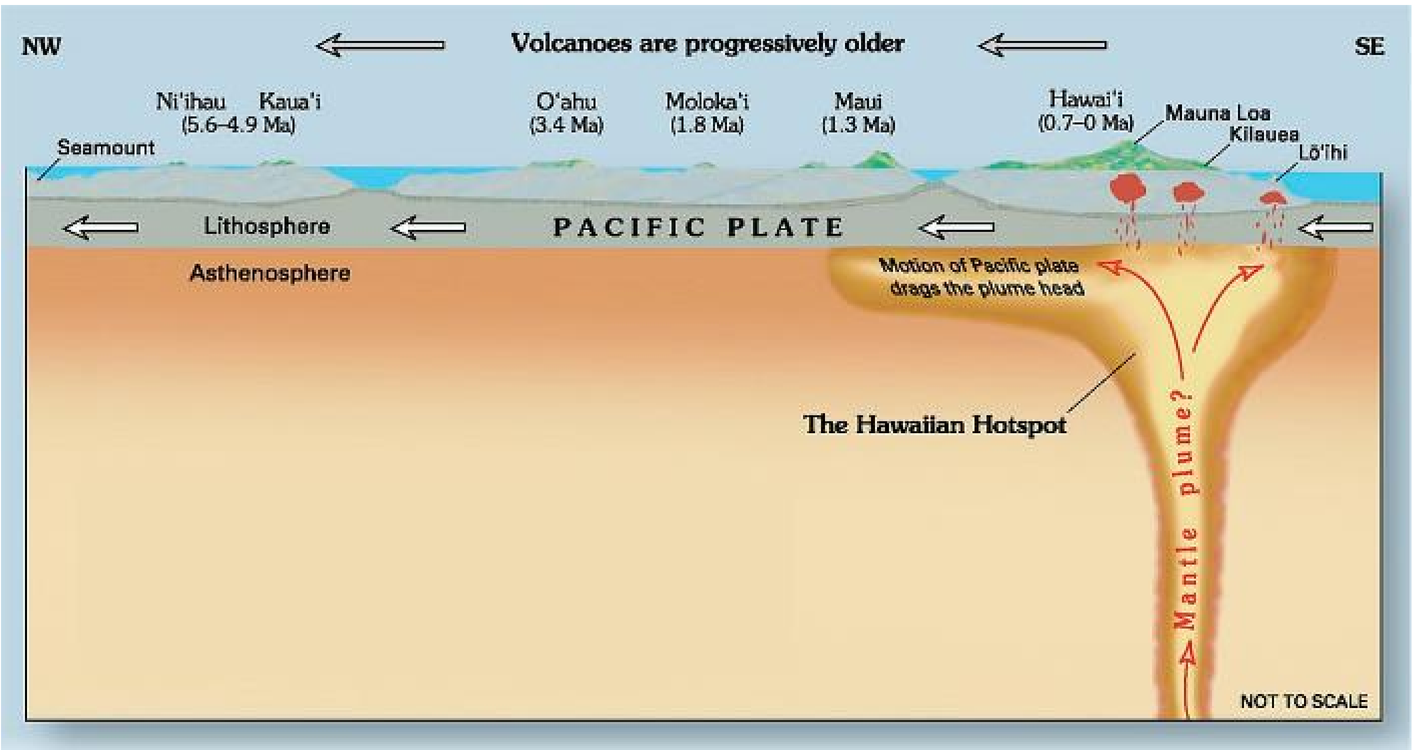

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Figure 5. Conceptual Model for the Hawaiian Hot Spot (Thomas 2018a)

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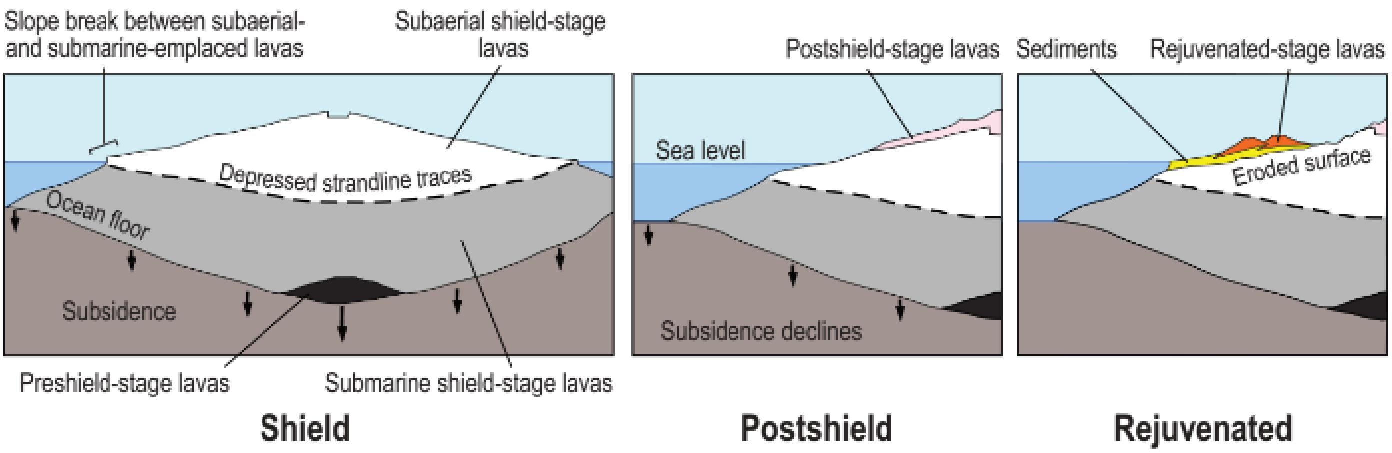

Figure 6. Conceptual Model for Stages of Hawaiian Volcanism (Izuka et al., 2018).

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Decommissioning of the Caltech Submillimeter Observatory

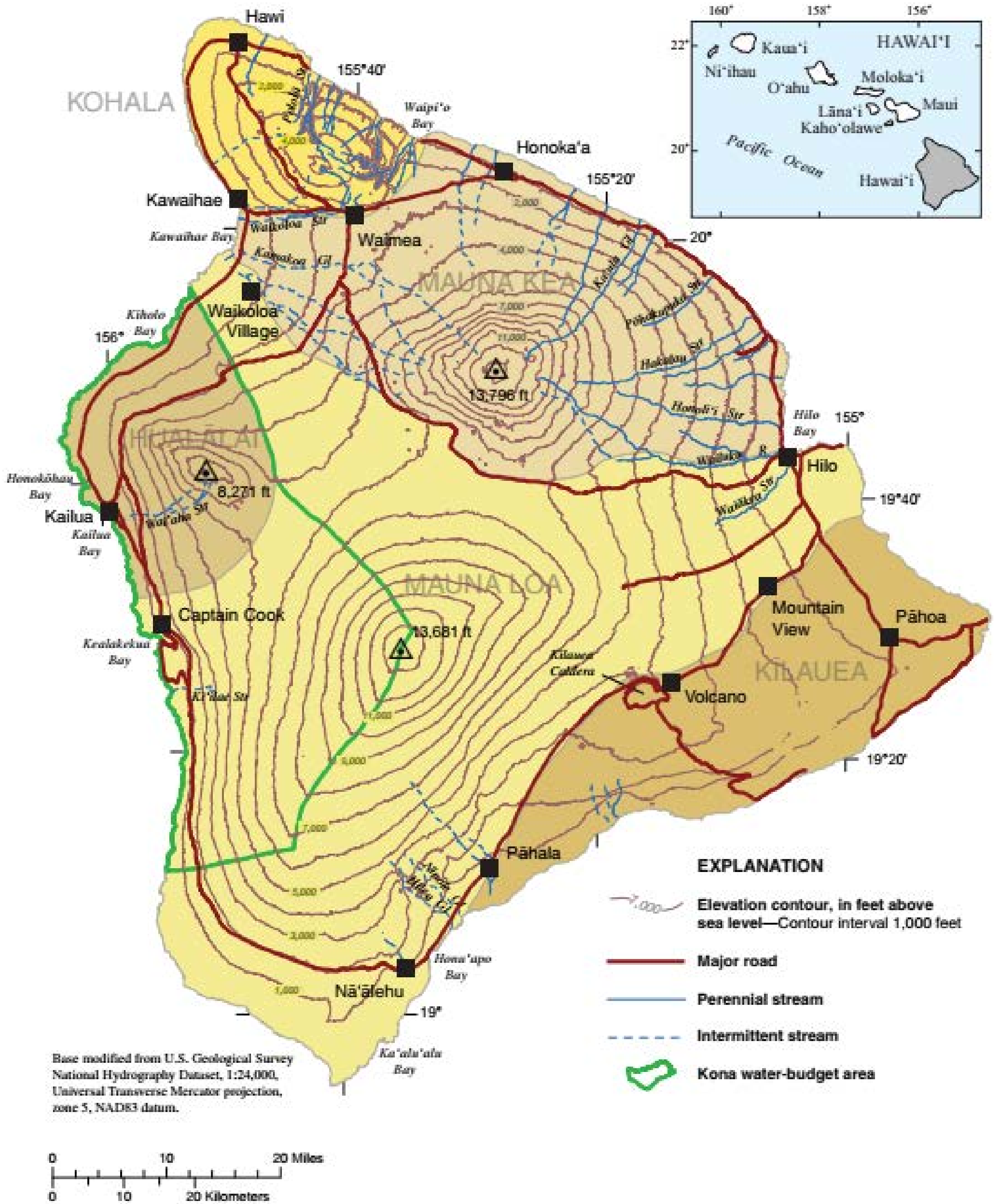

Figure 1. Major geographical features and the generalized extent of the surface rocks of the five volcanoes (colors) that form the Island of Hawai'i. (Modified from State of Hawai'i, 2008).

Figure 7. Physiologic Map with Streams for Island of Hawai'i (Engott, 2011).

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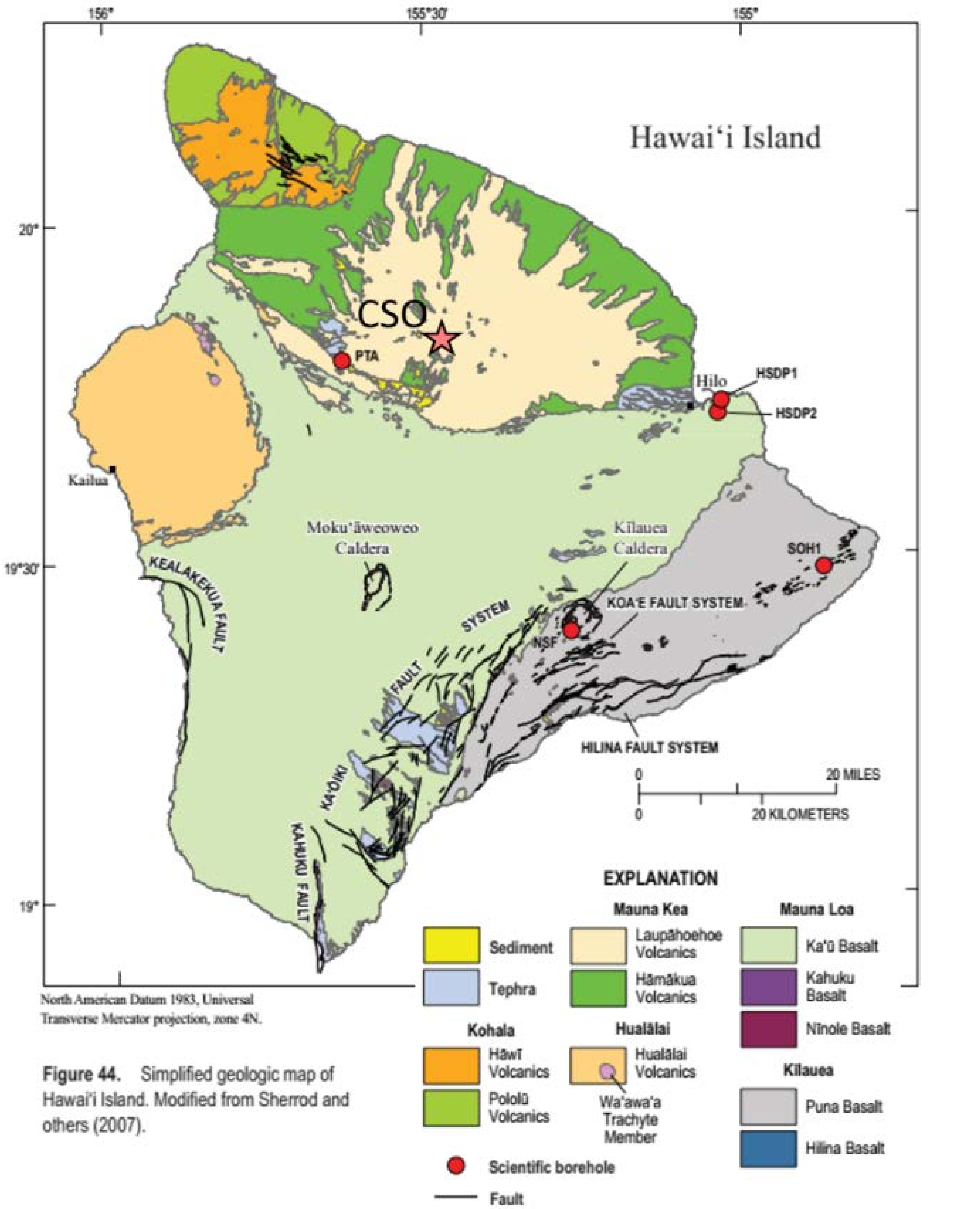

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Figure 8. Simplified Geology Map with Locations of Scientific Borings (Izuka et al. 2018).

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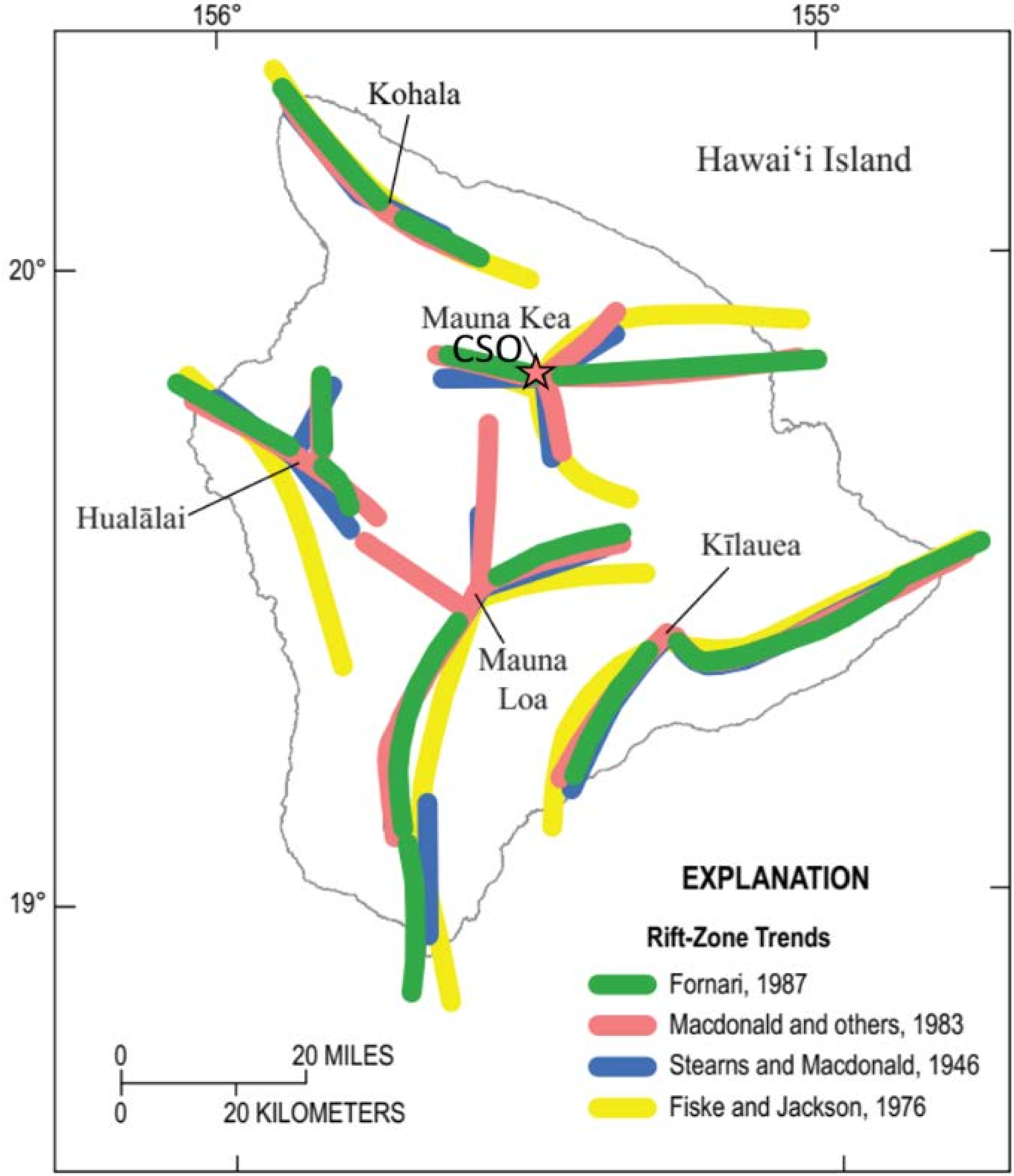

North American Datum 1983, Universal Transverse Mercator projection, zone 4N.

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Figure 9. Island of Hawai'i Rift Zones (Izuka et al., 2018).
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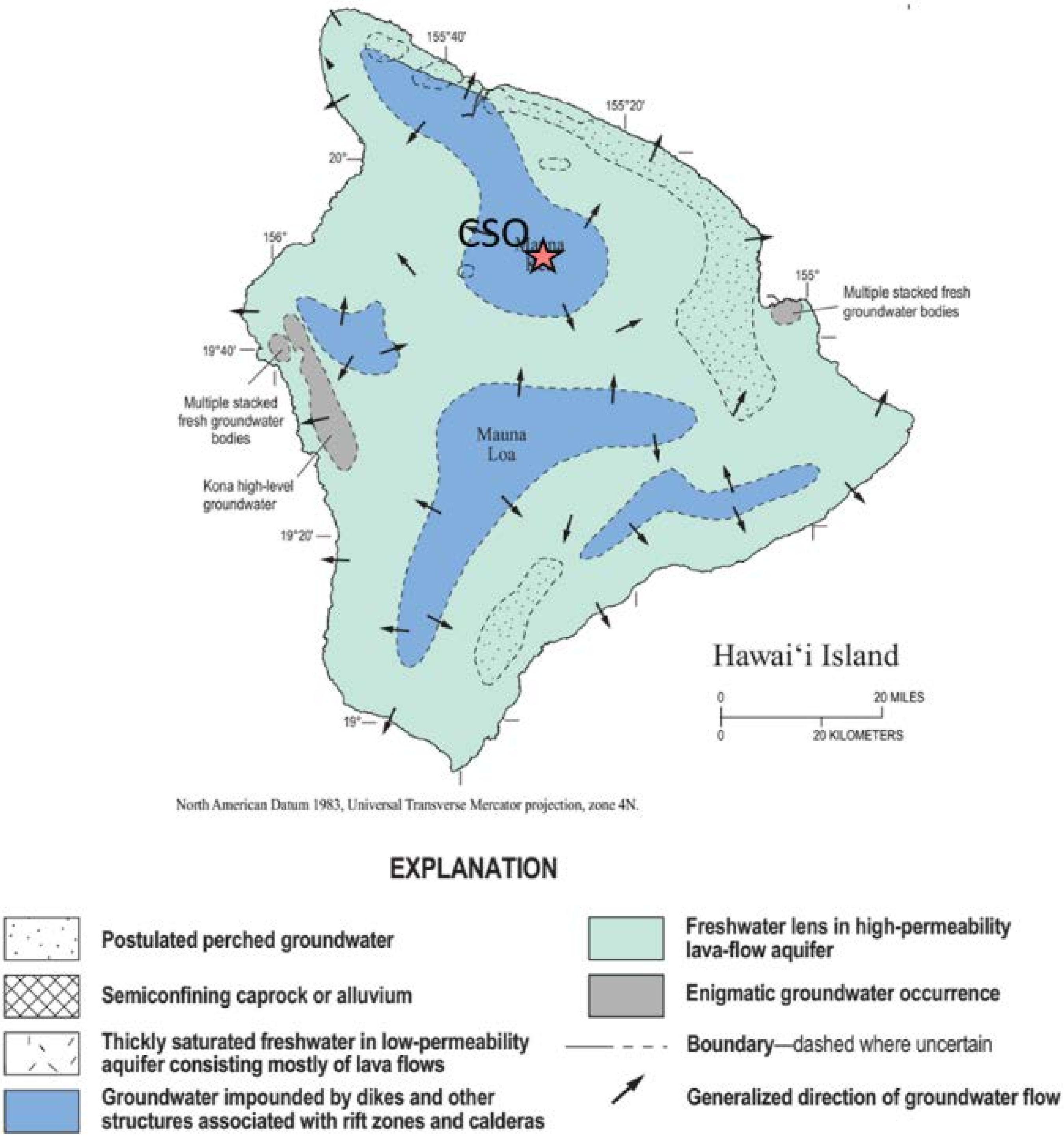

Figure 10. Conceptual Model of Groundwater Systems Throughout the Island of Hawai'i (Izuka et al., 2018).

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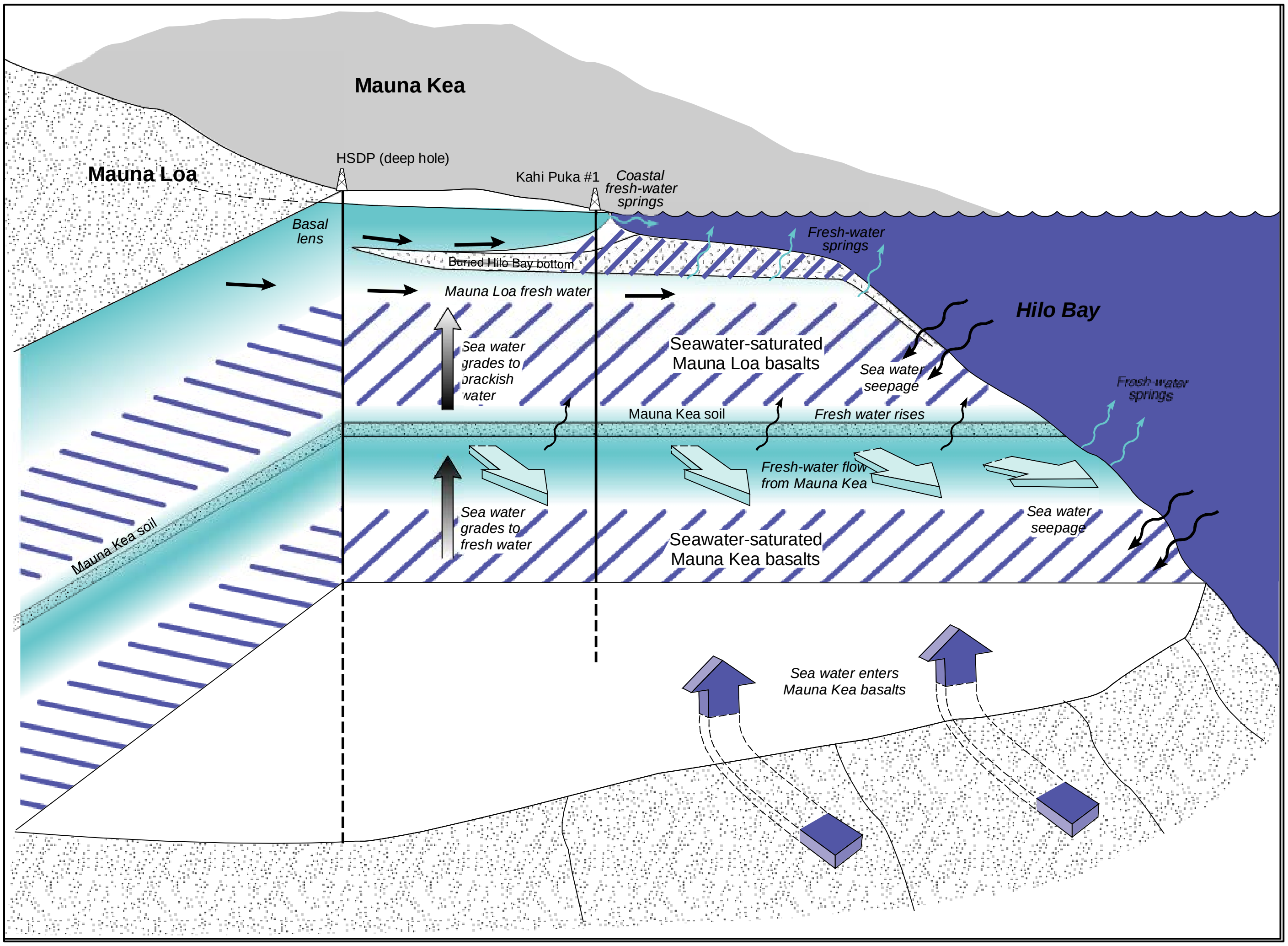

Figure 11. Conceptual Model of Stacked Freshwater Bodies (Thomas 2018a).

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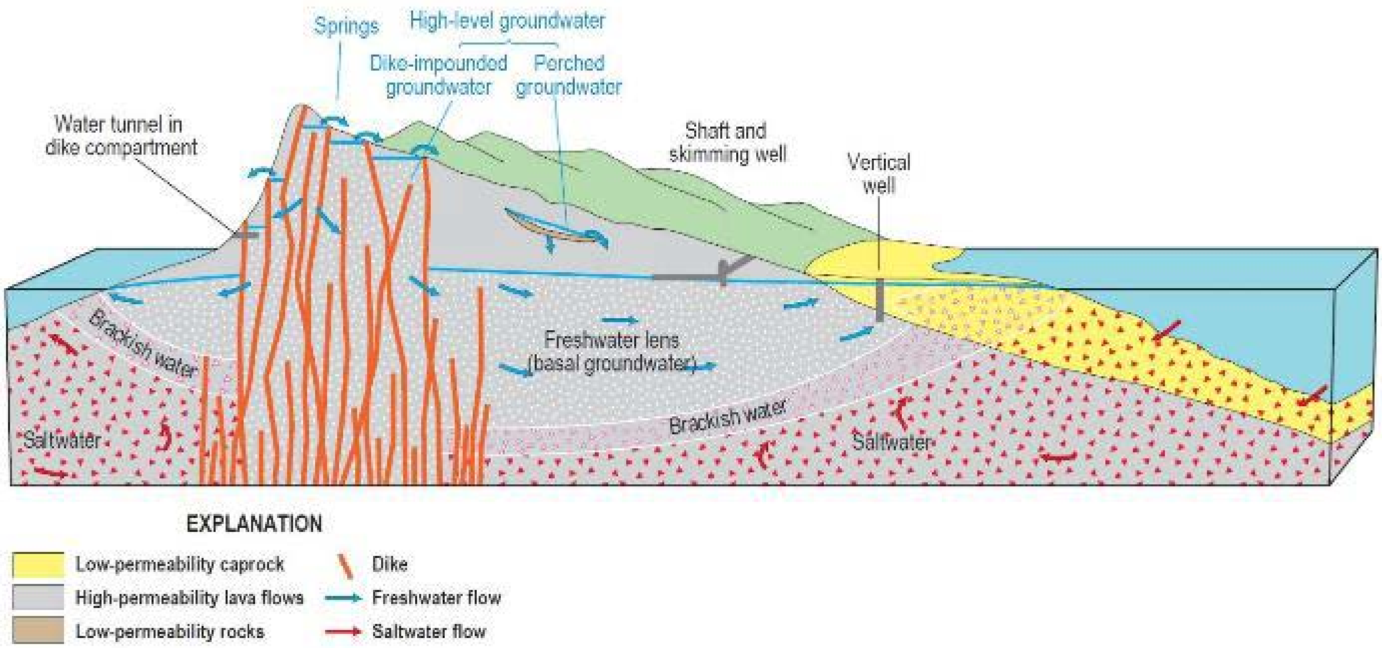

Figure 12. Conceptual Model of Groundwater Occurrence and Flow in Hawai'i Developed in the Middle 20th Century (Izuka et al., 2018).

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Decommissioning of the Caltech Submillimeter Observatory

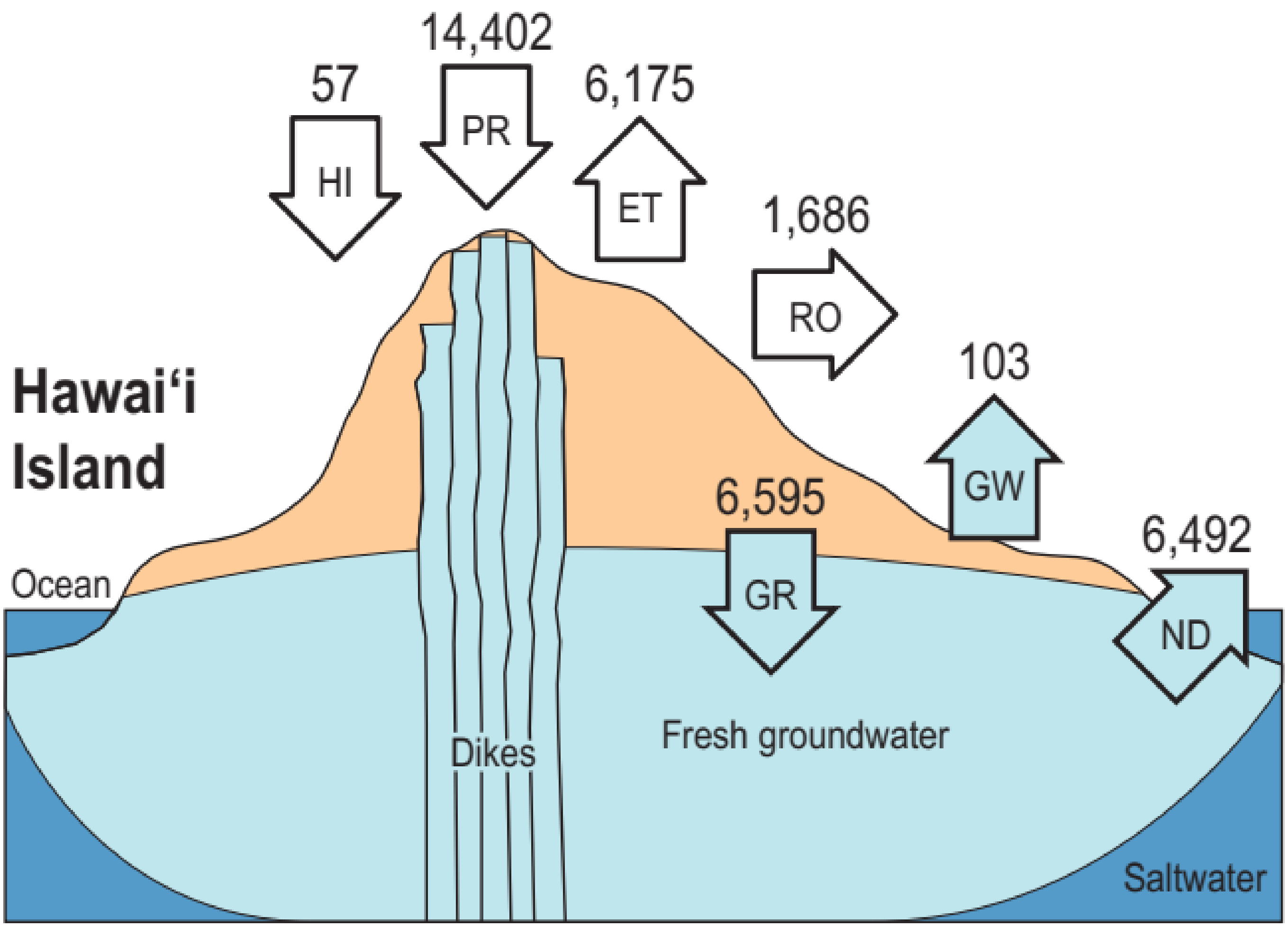

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Figure 13. Water Budget Schematic for Hawai’i Island (Izuka et al., 2018).

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Decommissioning of the Caltech Submillimeter Observatory

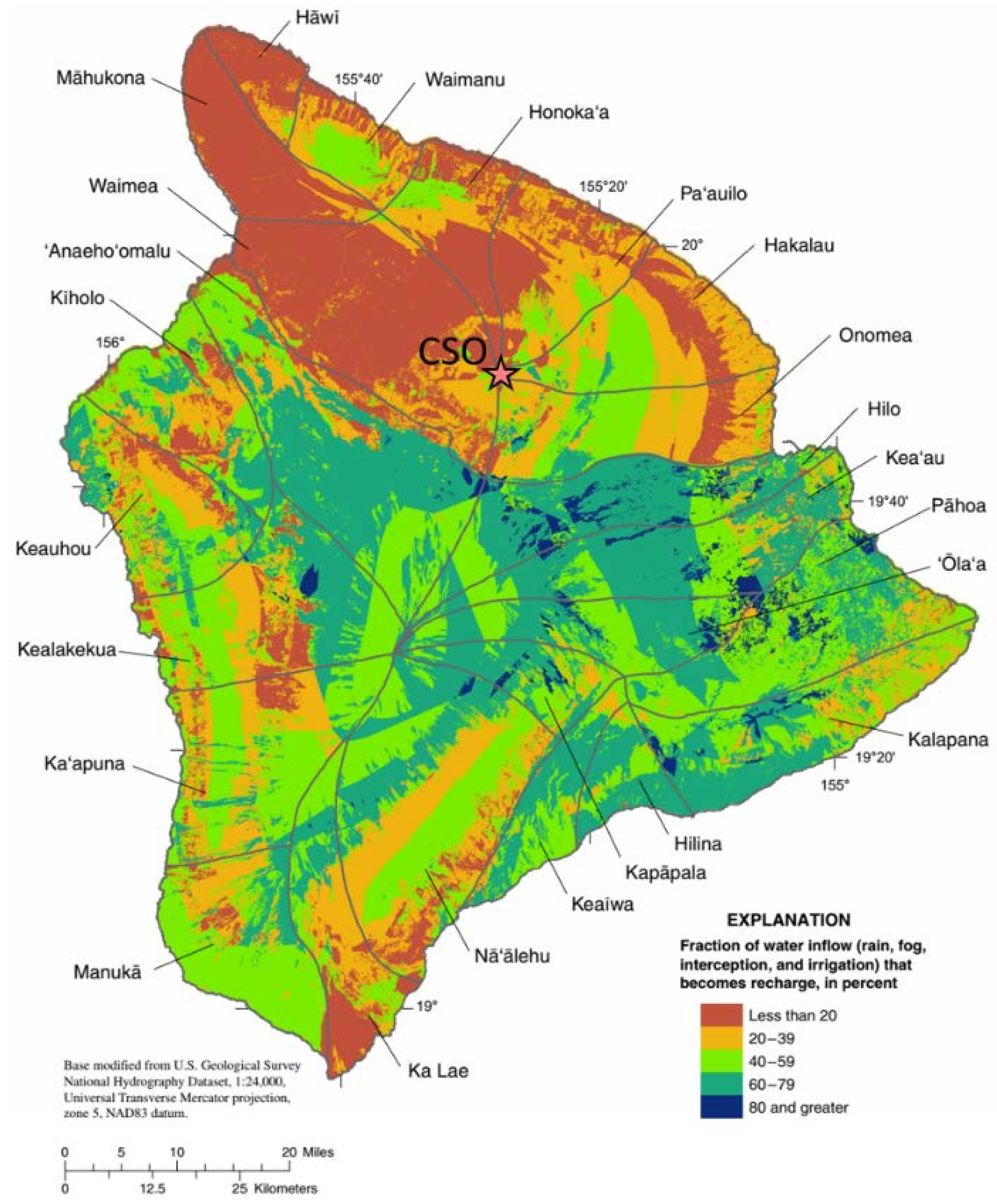

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Figure 14. Fraction of Precipitation that Becomes Recharge on Hawai'i Island (Engott, 2011).

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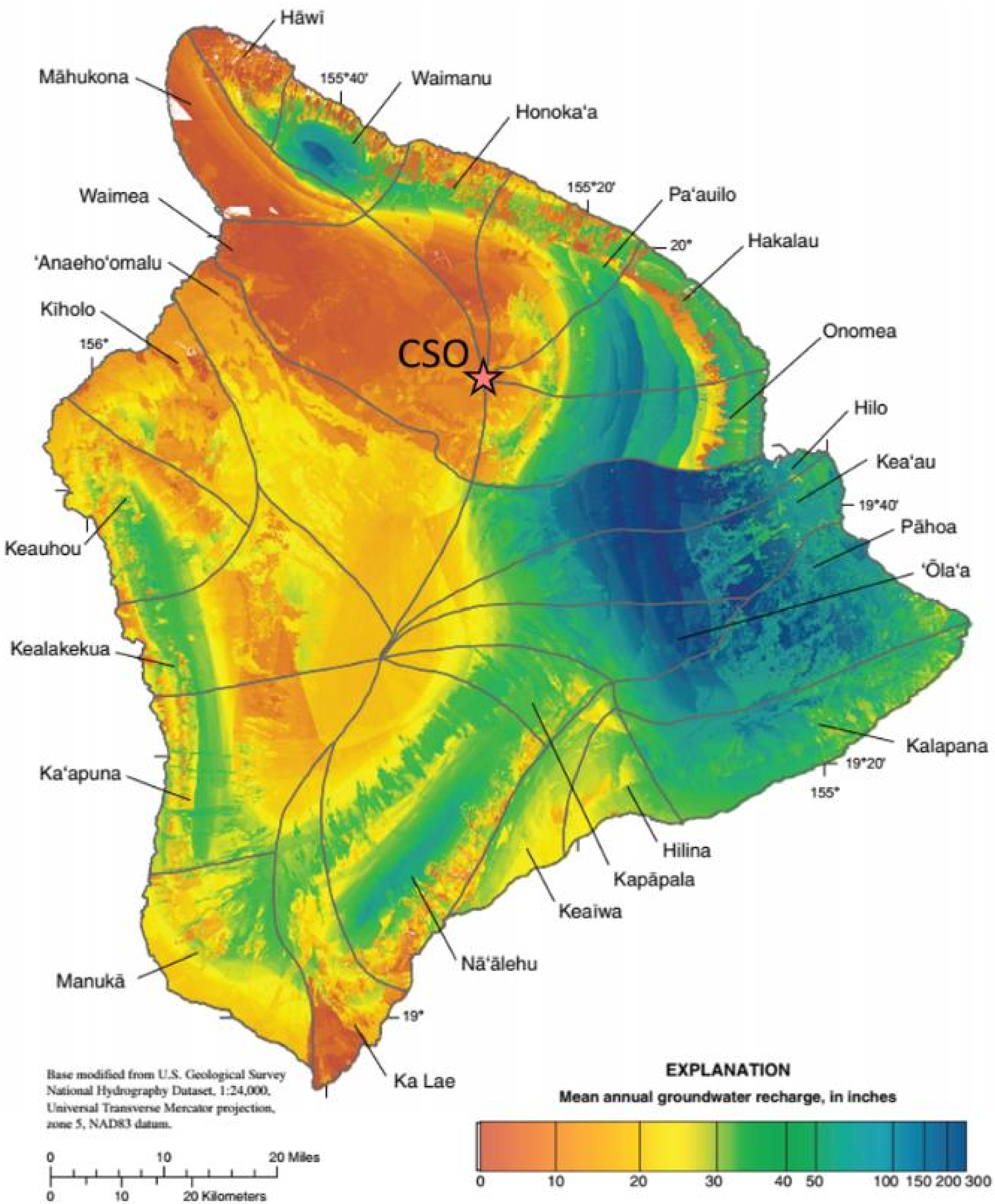

Figure 15. Distribution of Recharge through Hawai'i Island (Engott, 2011).

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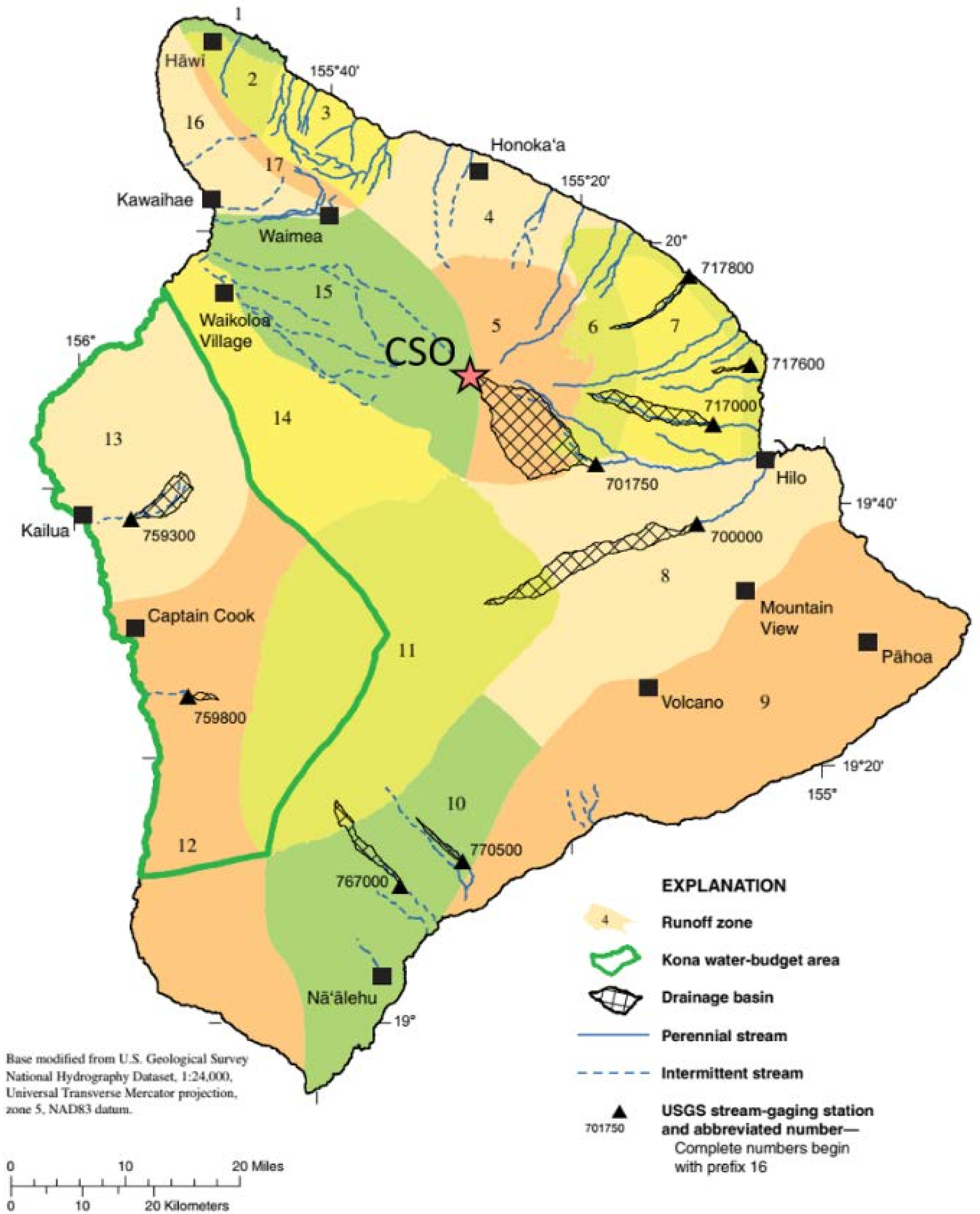

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Figure 16. Zonation Used for Hawai'i Island Water Budget by the U.S. Geological Survey (Engott, 2011).

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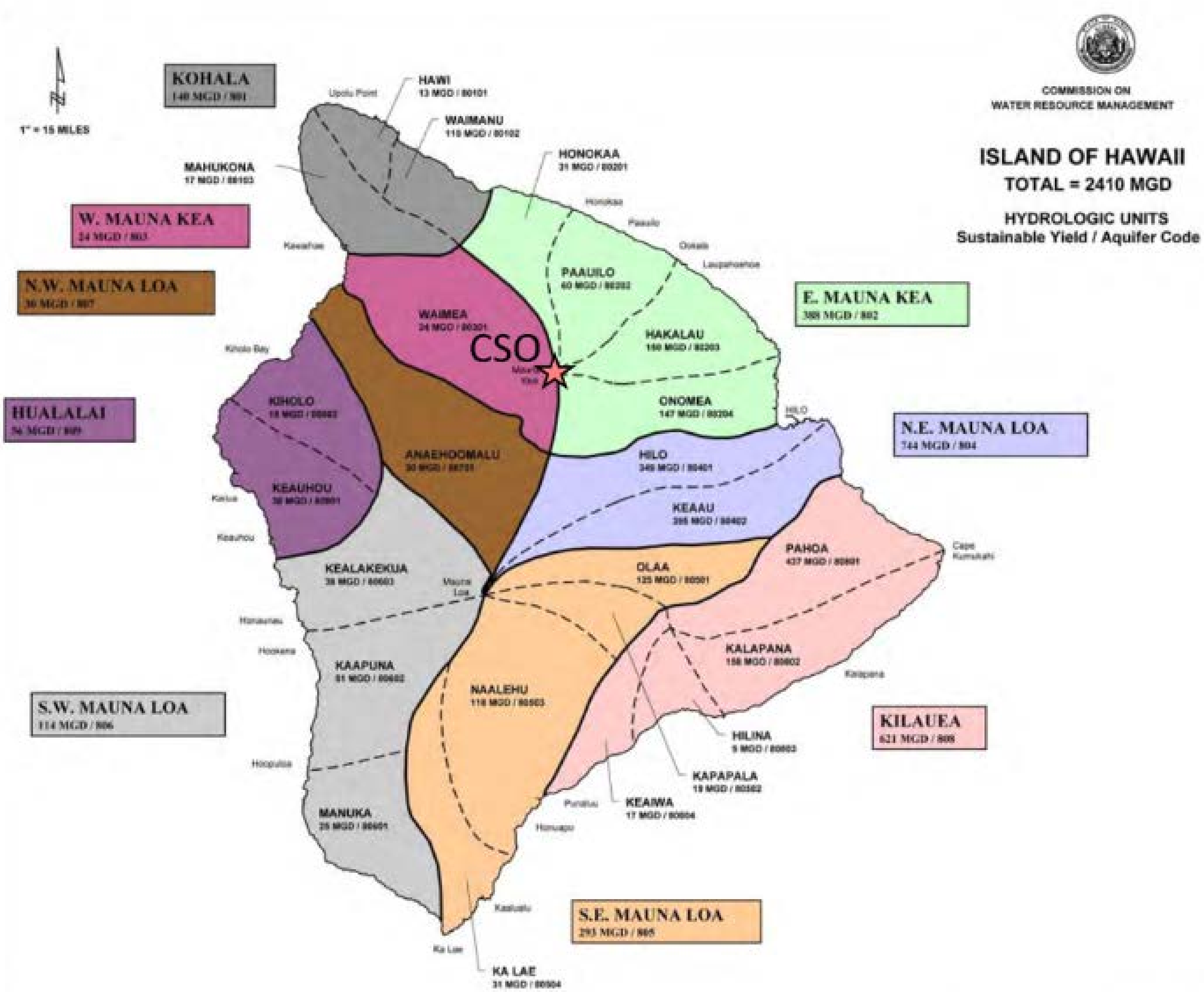

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Figure 17. Island of Hawai'i Hydrologic Units and Sustainable Yield (CWRM, 2008).

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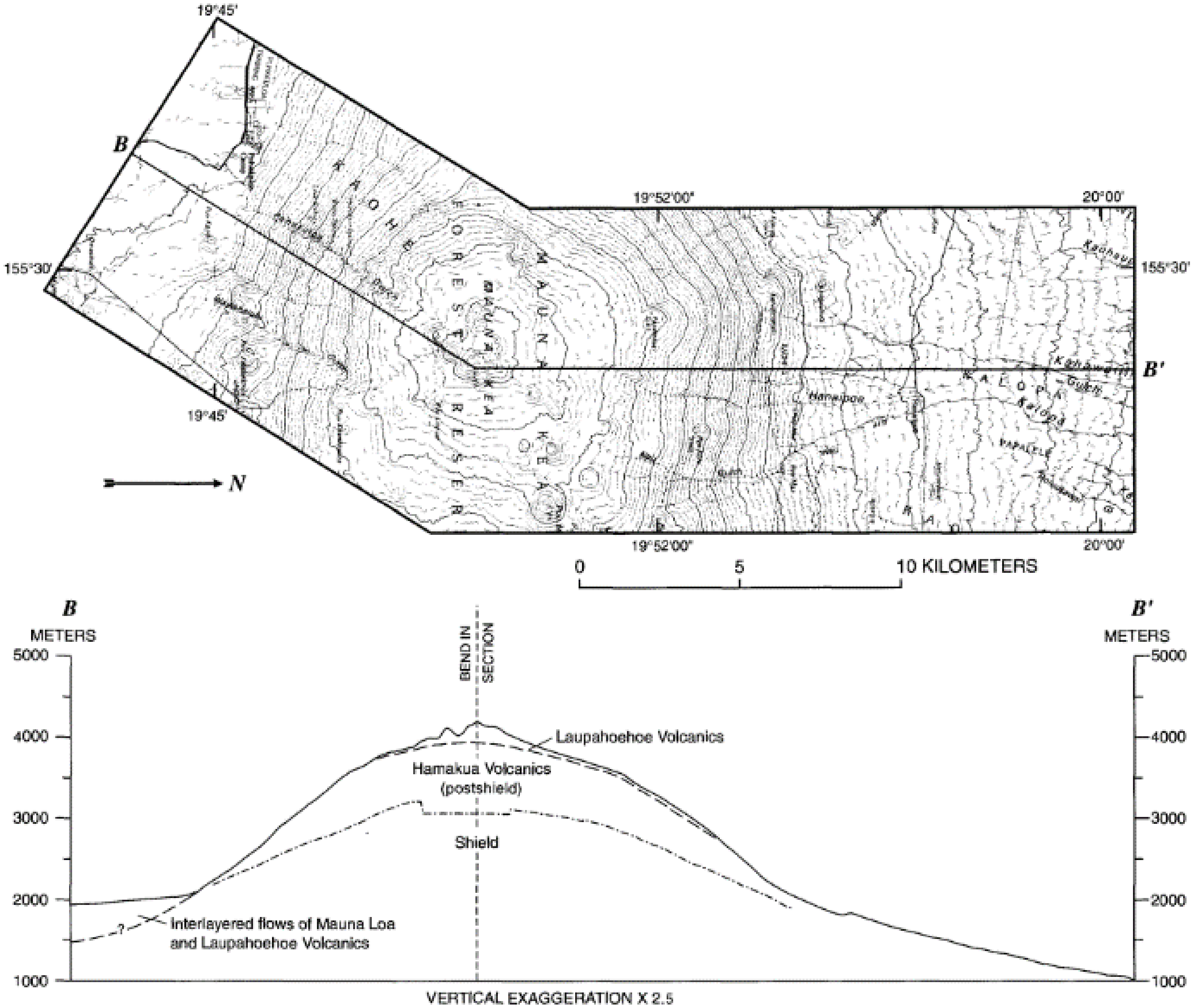

Figure 18. Cross-Section and Location Map of Maunakea (Wolfe et al., 1997).

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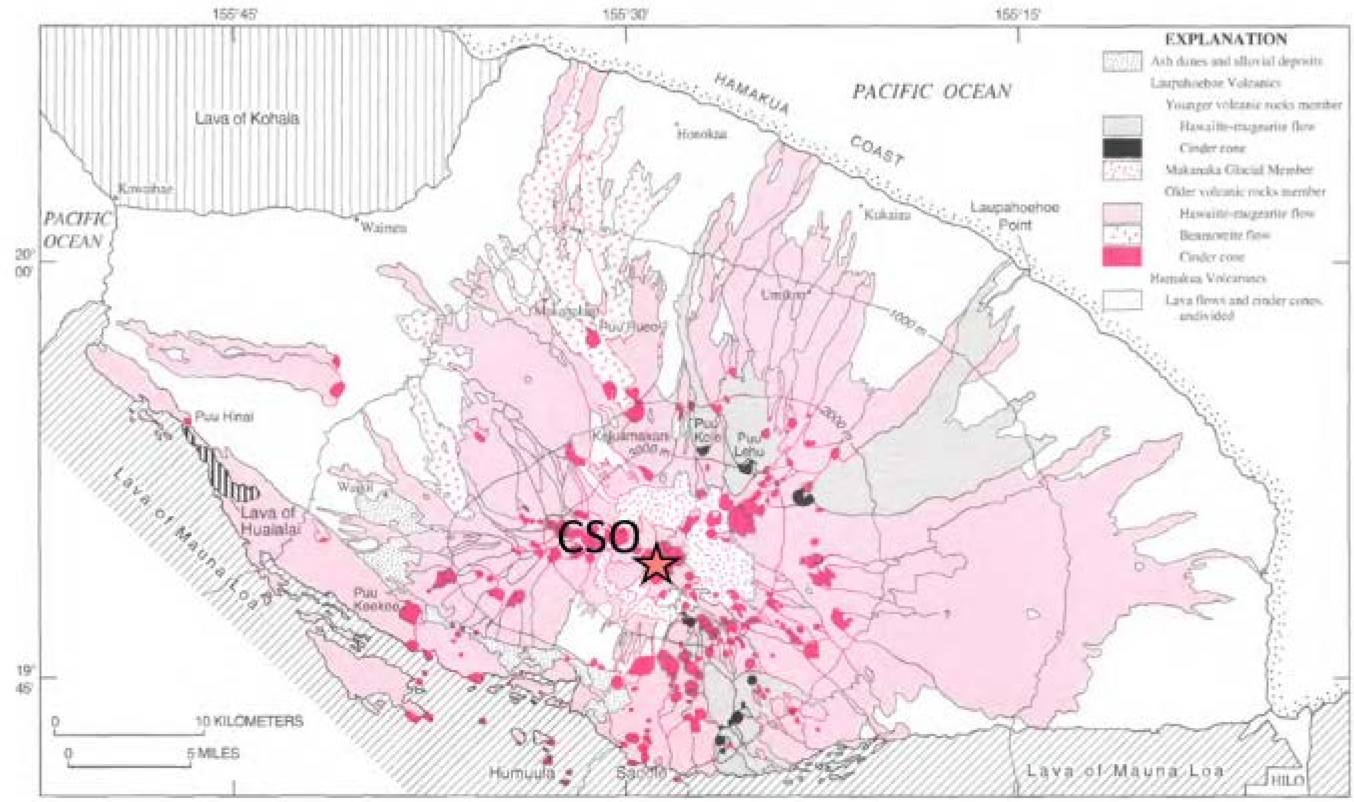

Figure 19. The Distribution of Maunakea Lava Flows, Cinder Cones and Makanaka Glacial Deposits (modified from Wolfe et al., 1997).

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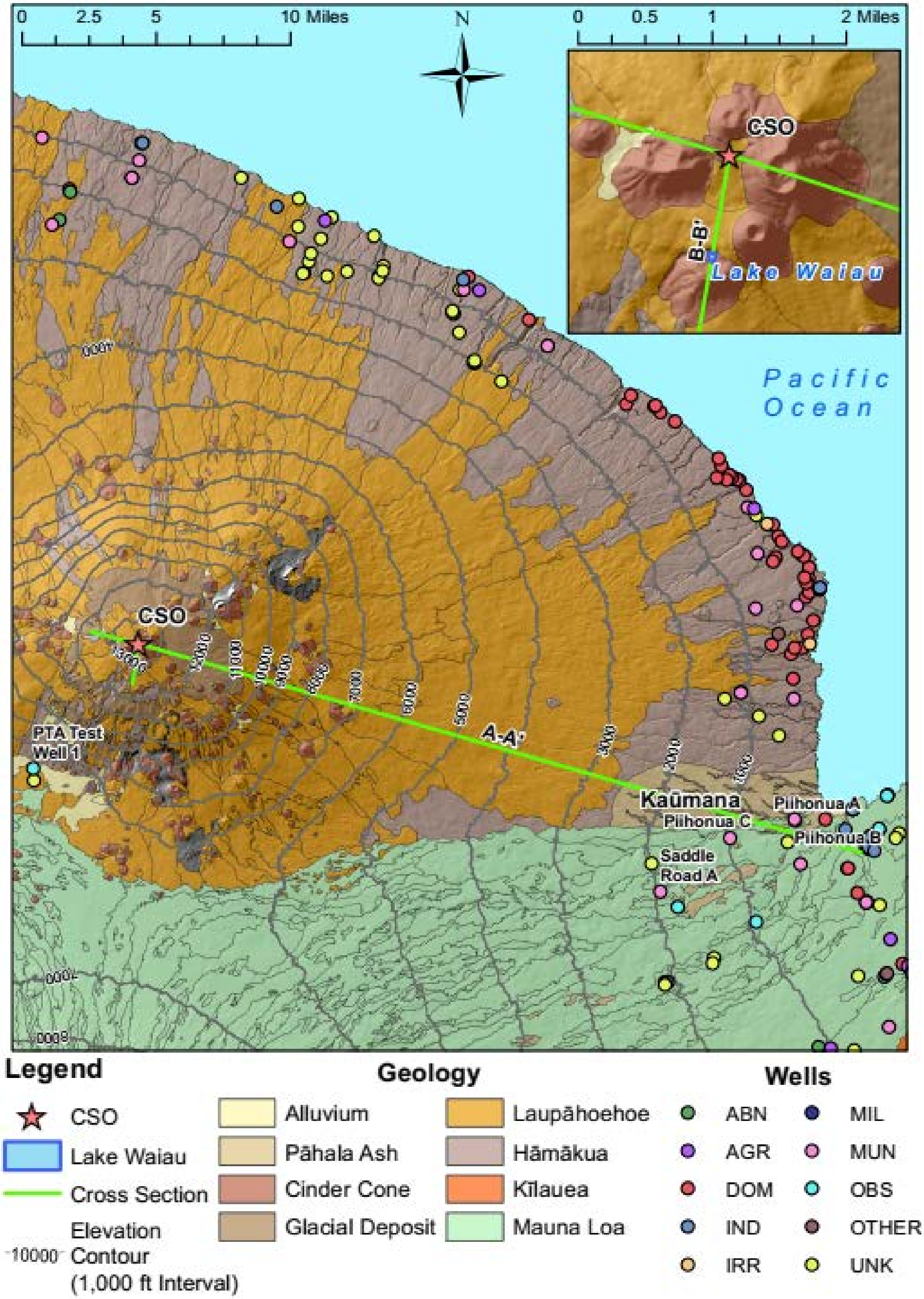

Figure 20. Geologic Map with Cross-Section A-A' and Locations.

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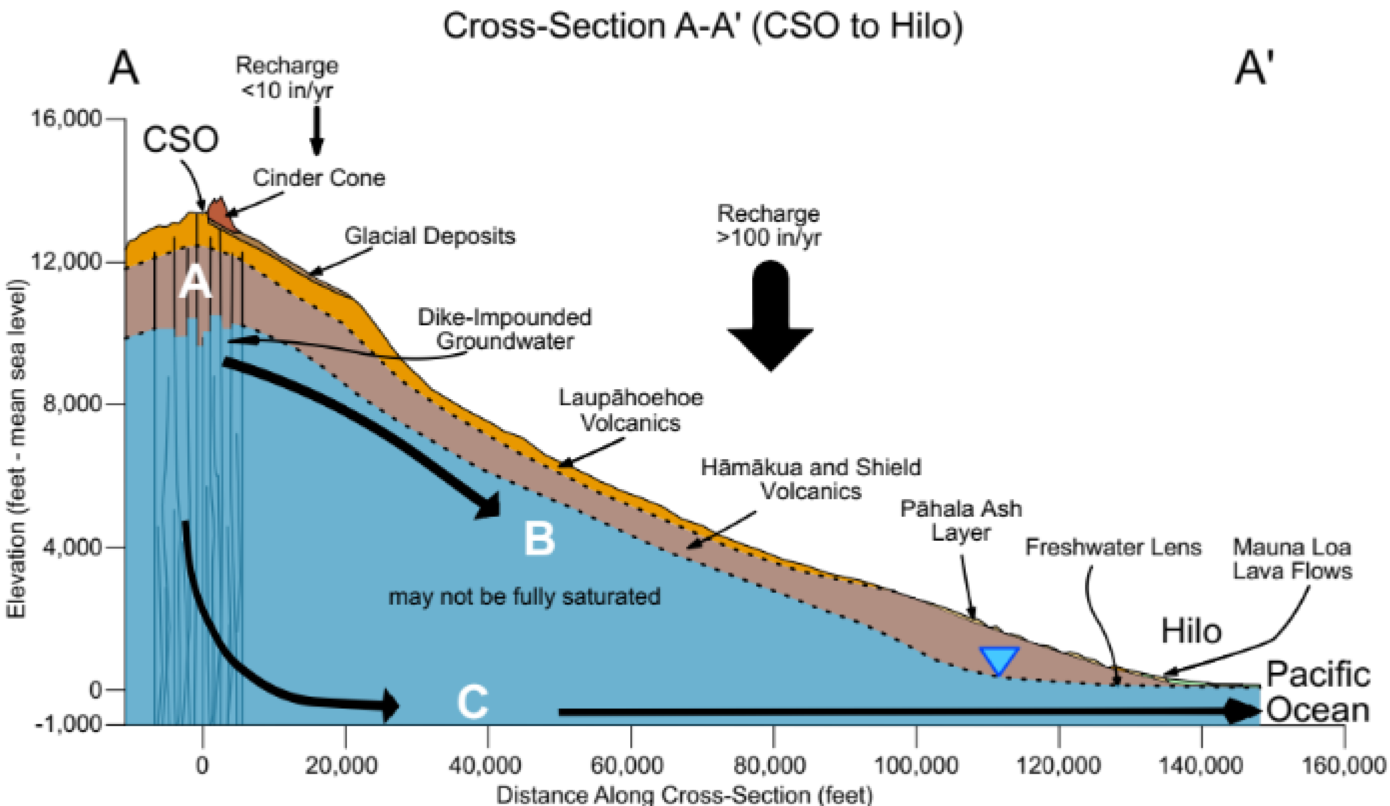
Decommissioning of the Caltech Submillimeter Observatory



Notes:
1) 5x vertical exaggeration.
2) Subsurface contacts are approximate based on Maunakea cross-sections from:
Wolfe et al., 1997. The Geology and Petrology of Maunakea Volcano, Hawaii--A Study of Postshield Volcanism. *U.S. Geological Survey Professional Paper 1557*.
3) Surface geology is from Trusdell, Wolfe and Morris, 2005. Digital Database of the Geologic map of the island of Hawaii.
4) Topography is from 10-m spatial resolution USGS digital elevation model.

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Figure 21. Cross Section A-A.
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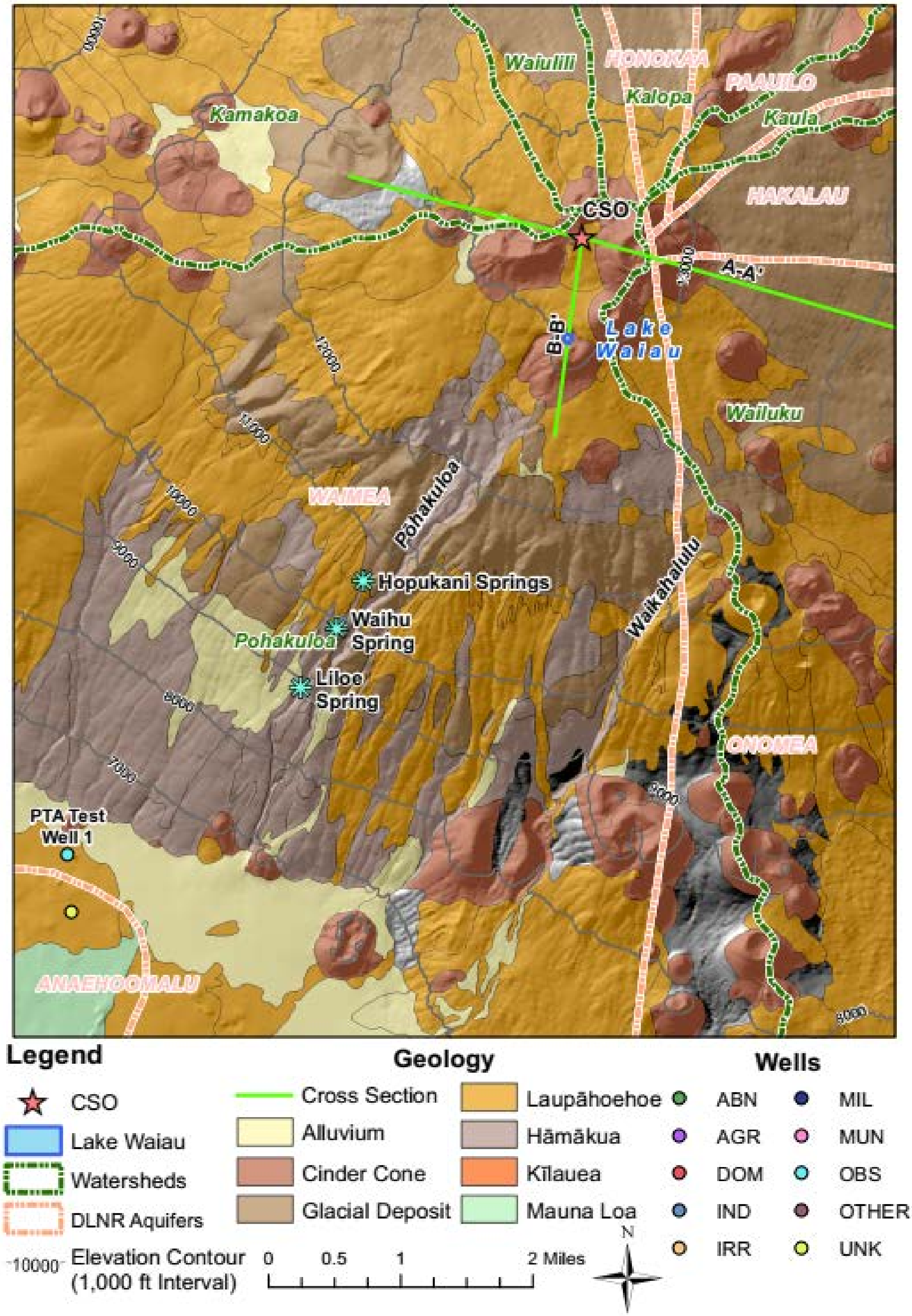

Figure 22. Geologic Map showing the Department of Land and Natural Resources aquifer systems, watersheds, PTA Test Well 1 and the Springs in relation to the CSO and Lake Waiau.

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Figure 23. Photo of Lake Waiau Taken on November 9, 2018 Looking Southeast.

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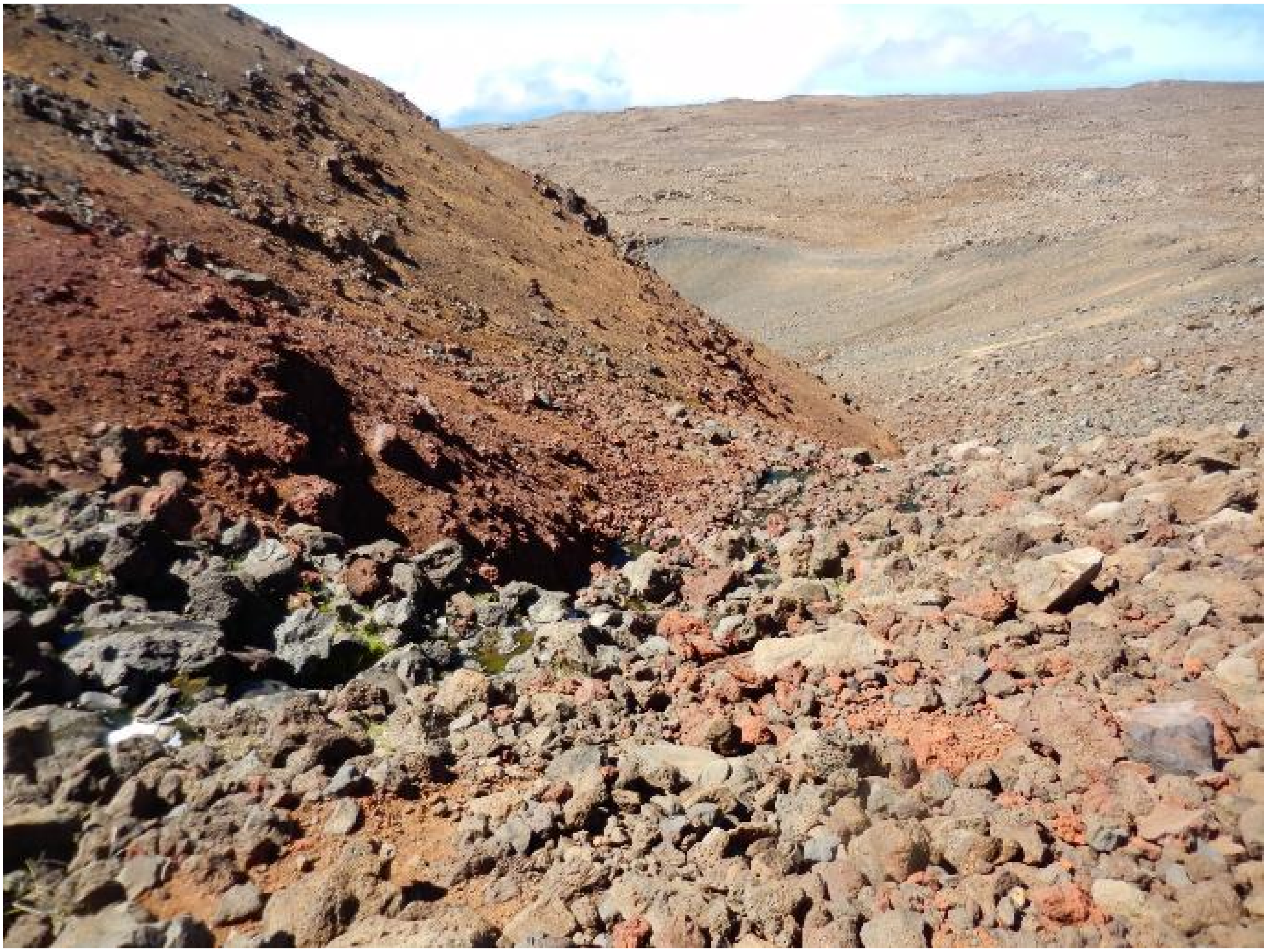


Figure 24. Water Cascading from Lake Waiau Towards Pōhakuloa Gulch (11/9/18).
Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

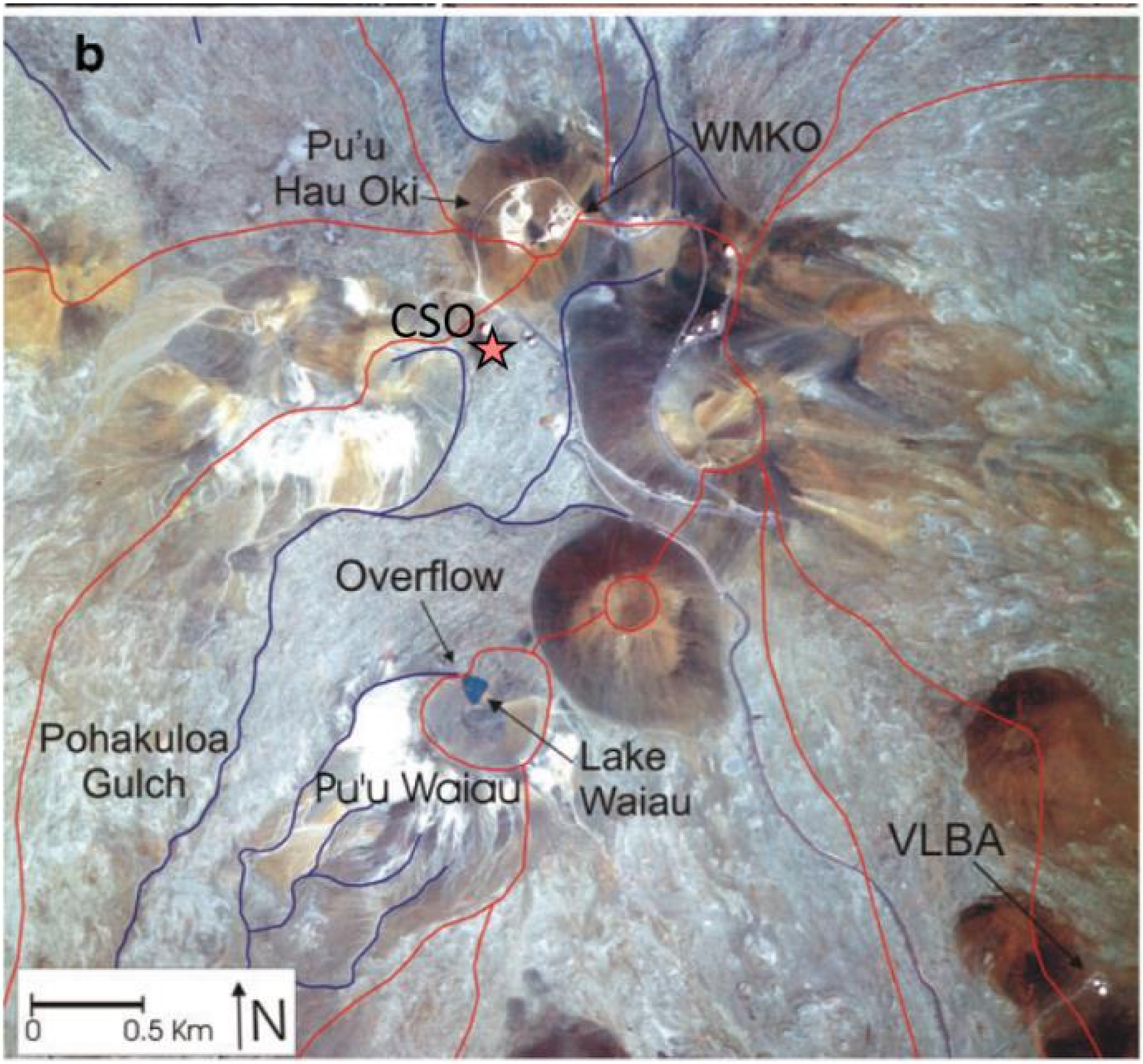
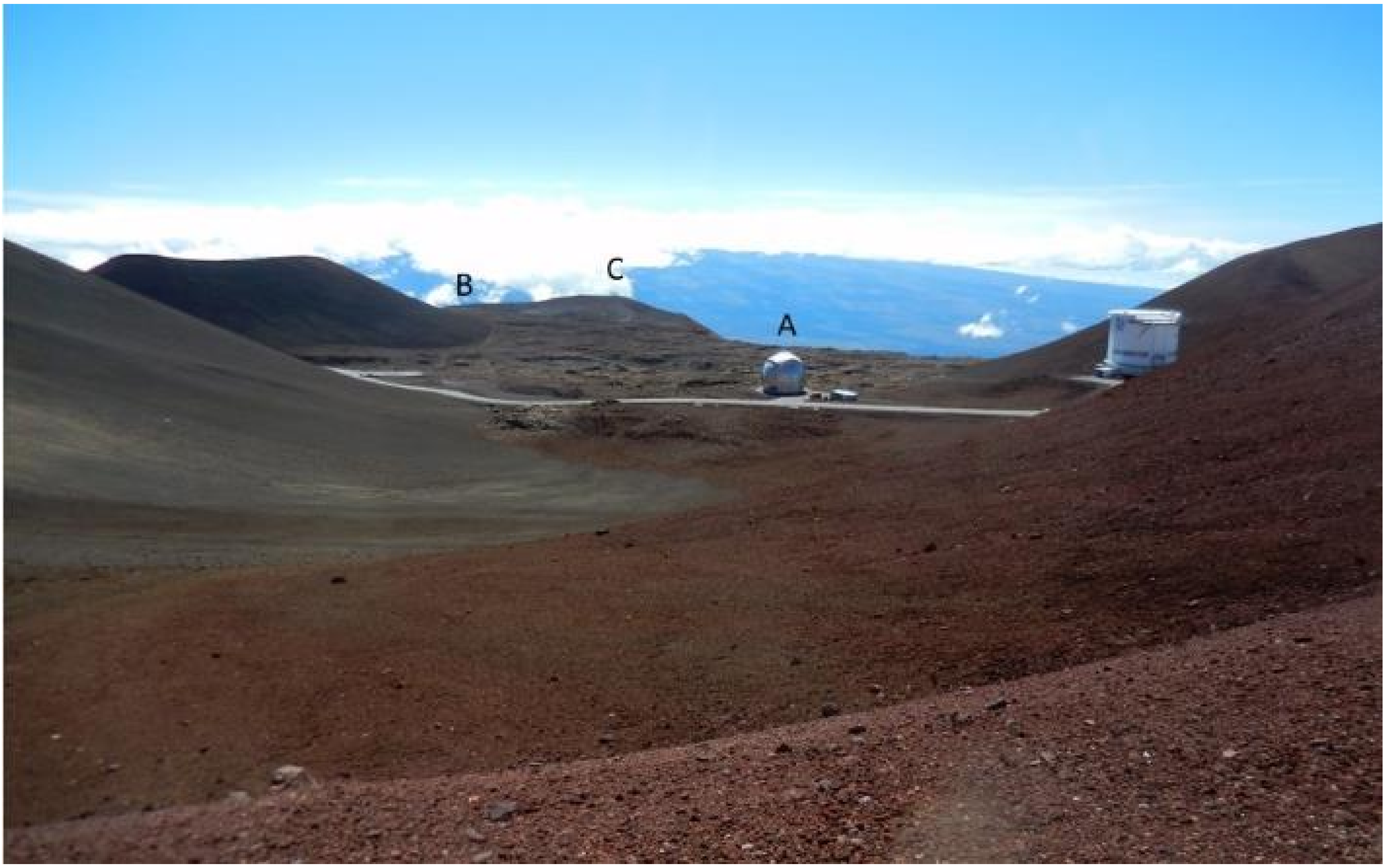


Figure 25. Figure showing flow lines (blue) and watershed boundaries (red) (Ehlmann et al., 2006).
Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory



“A” is the CSO. “B” is the approximate location of Lake Waiau. The flow from the CSO goes behind “C” and flows into Pōhakuloa Gulch.

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Figure 26. Looking Southwest Towards the CSO and Mauna Loa.
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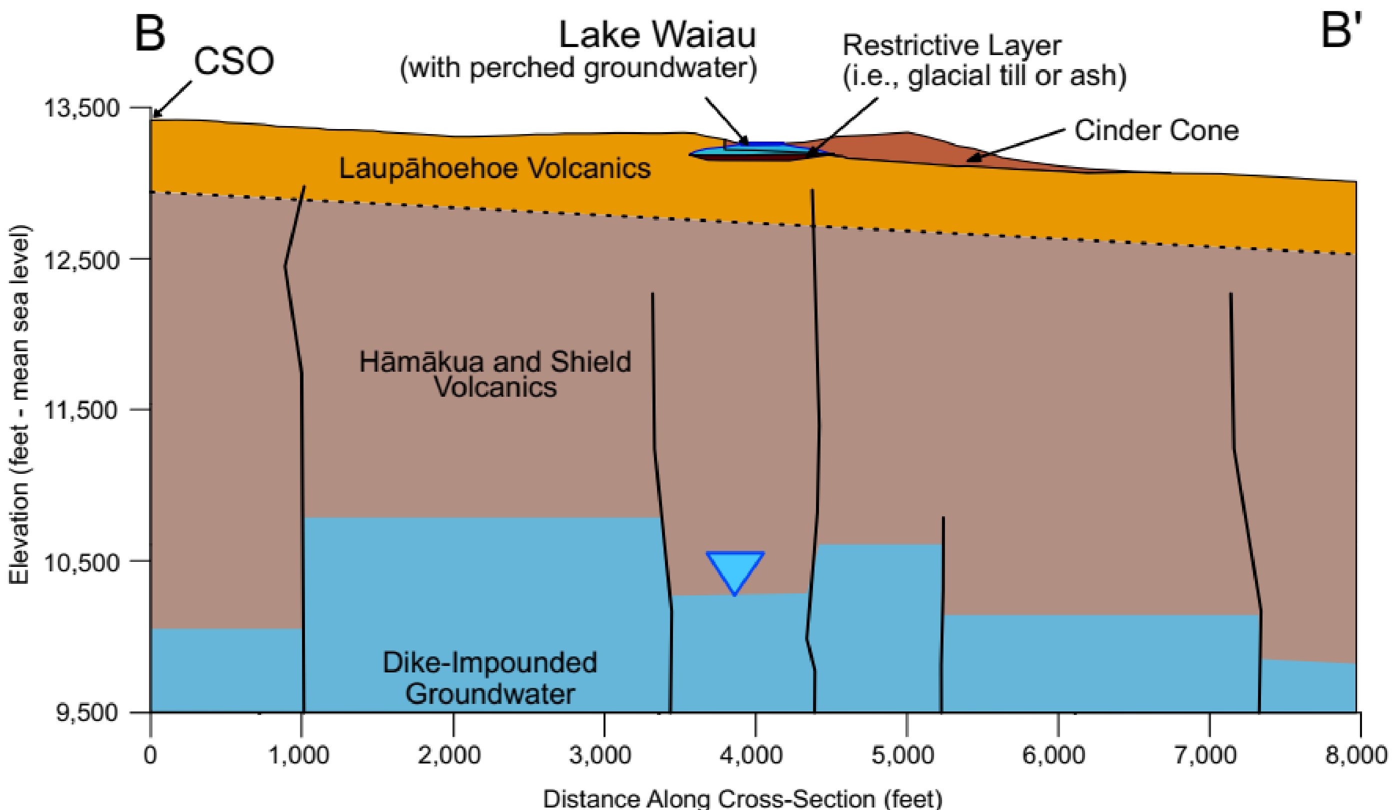
Cross-Section B-B' (CSO to Lake Waiau)



Notes:
1) No vertical exaggeration.
2) Subsurface contacts are approximate based on Maunakea cross-sections from:
Wolfe et al., 1997. The Geology and Petrology of Maunakea Volcano, Hawaii--A Study of Postshield Volcanism. *U.S. Geological Survey Professional Paper 1557*.
3) Surface geology is from Trusdell, Wolfe and Morris, 2005. Digital Database of the Geologic map of the island of Hawaii.
4) Topography is from 10-m spatial resolution USGS digital elevation model.

Figure 27. Cross-Section B-B.
Hydrogeological and Geological Evaluation
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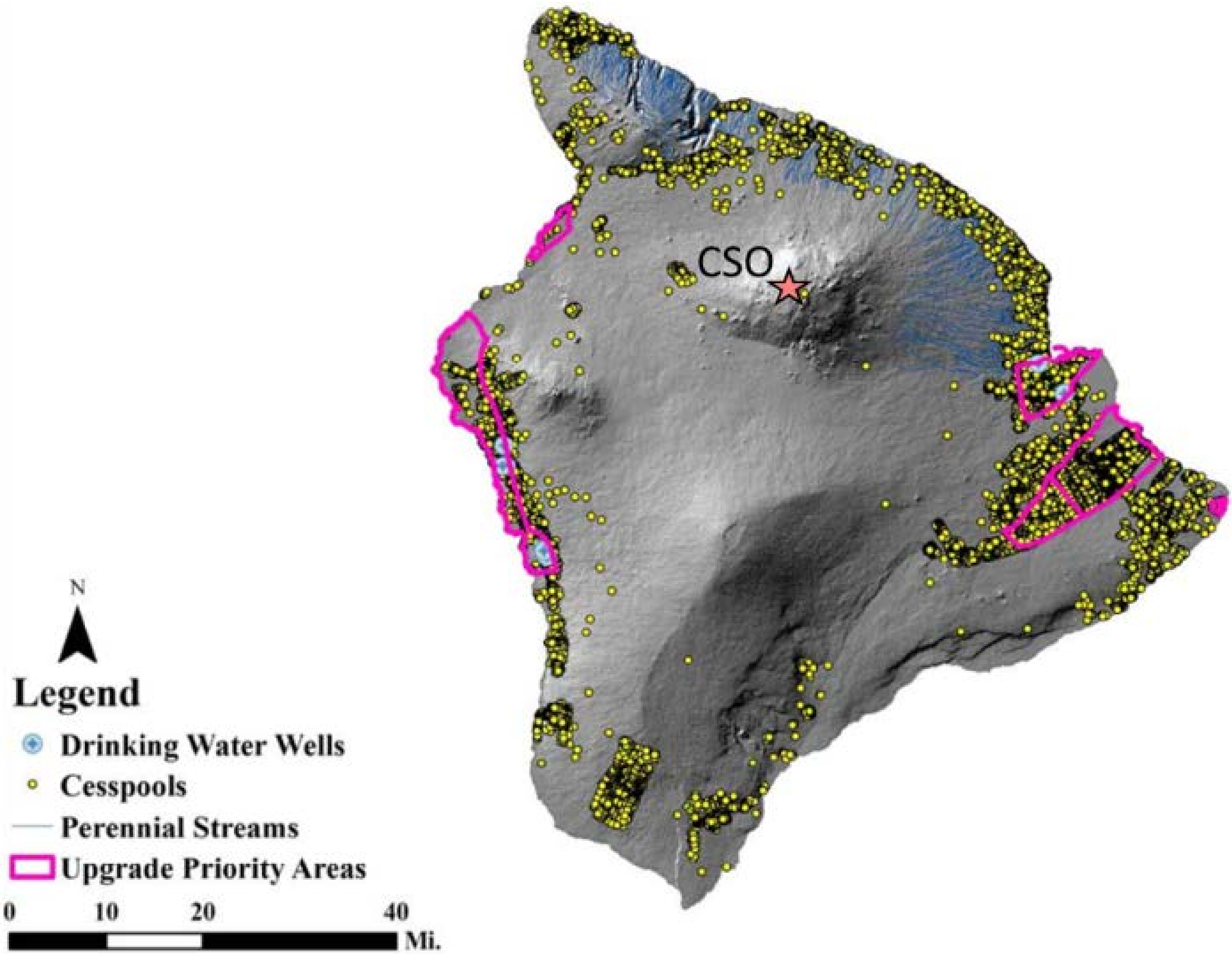

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Figure 28. Map of Cesspools Throughout Hawai'i Island (Act 125 Legislature Cesspool Report).

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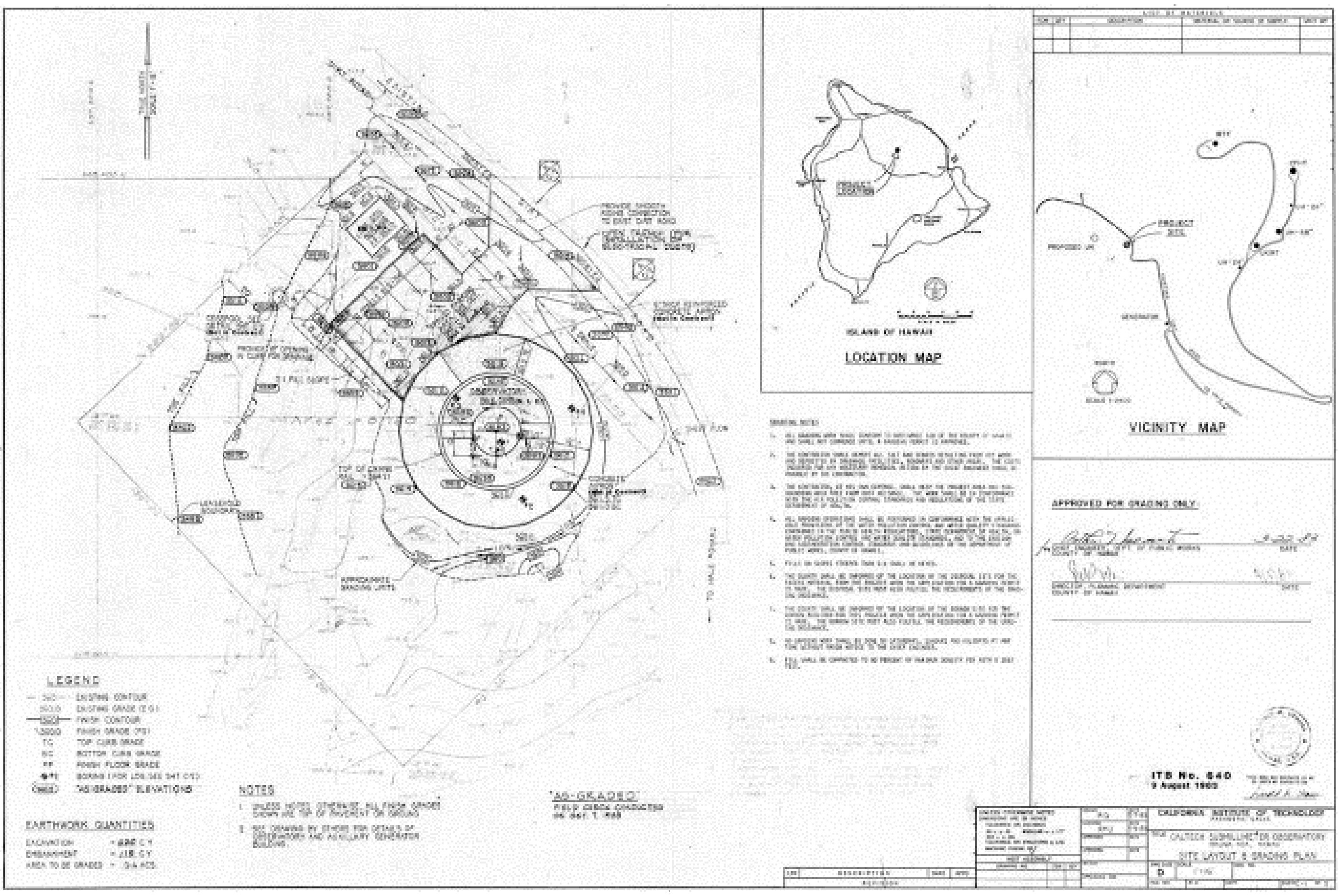

Figure 29. Facility Map 1
(2015 CSO Decommissioning Report).
Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

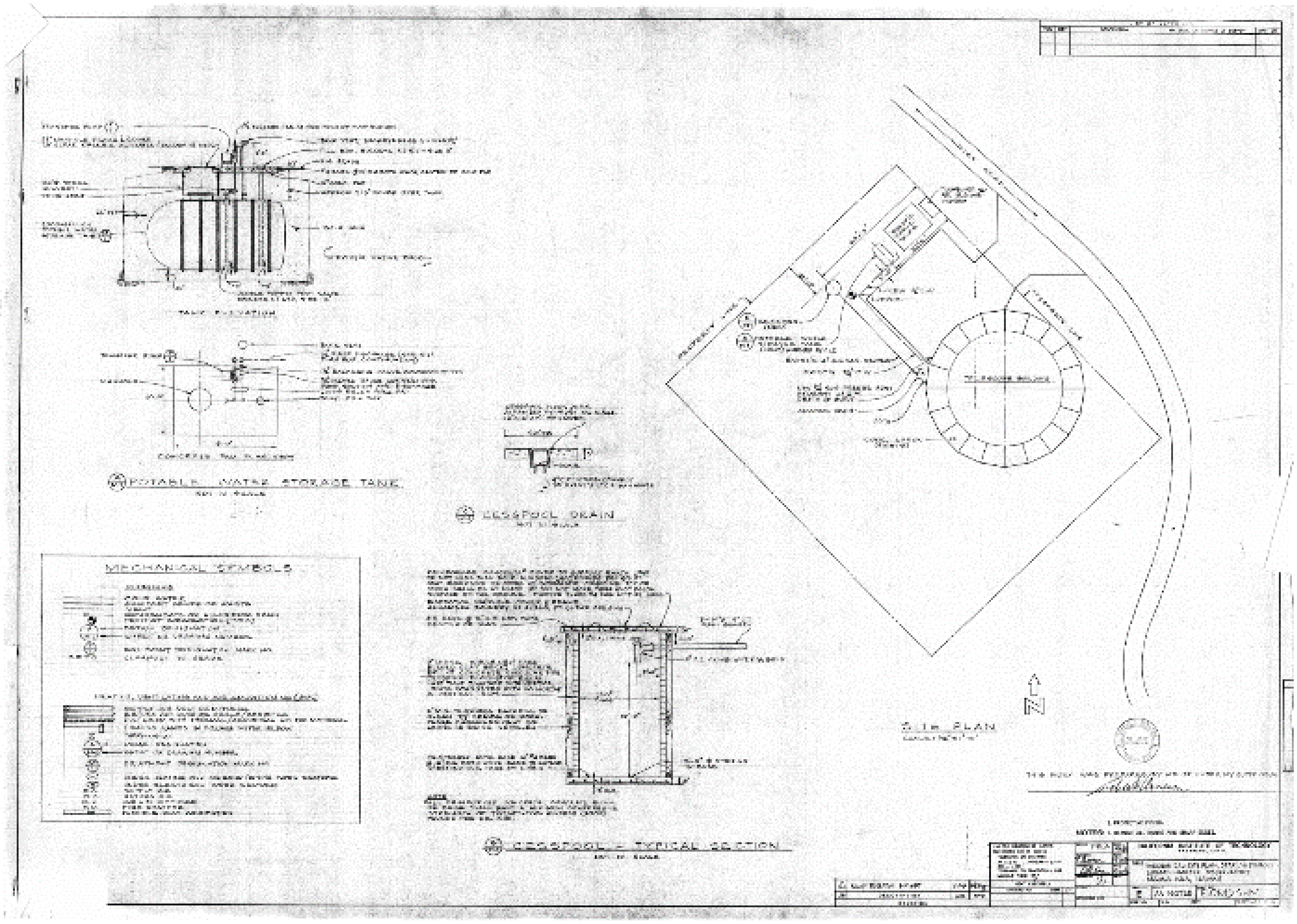

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Figure 30. Facility Map Showing Cesspool in Relation to CSO (2015 Decommissioning Report).

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Decommissioning of the Caltech Submillimeter Observatory

REPORT ON INDIVIDUAL WASTEWATER SYSTEM

PROPERTY OWNER: California Institute of Technology
Address: Mauna Kea, Hawaii
Lot Size: 198.00' X 165.00'
CONTRACTOR: Constructors Hawaii Inc.
OWNER'S AGENT: Robert E. Arneson, P.E.
Mailing Address: 1116 Donna Beth Avenue
West Covina, CA 91791
Telephone: (818) 9193304
(213) 8252853

ROBERT E. ARNESON
REGISTERED PROFESSIONAL ENGINEER
No. 5592
MECHANICAL
HAWAII, U.S.A.

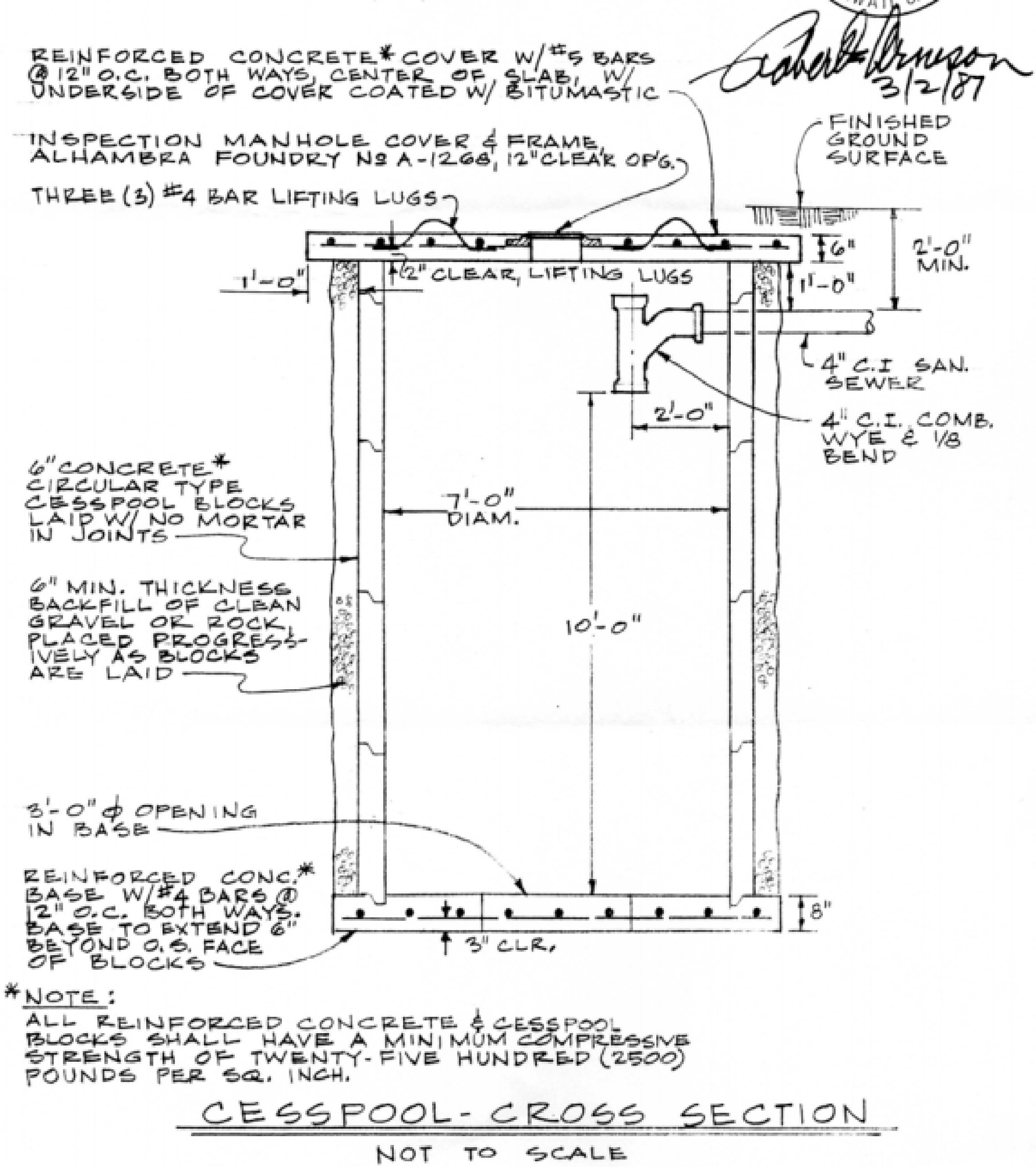

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Figure 31. Cesspool Schematic (2015 CSO Decommissioning Report).

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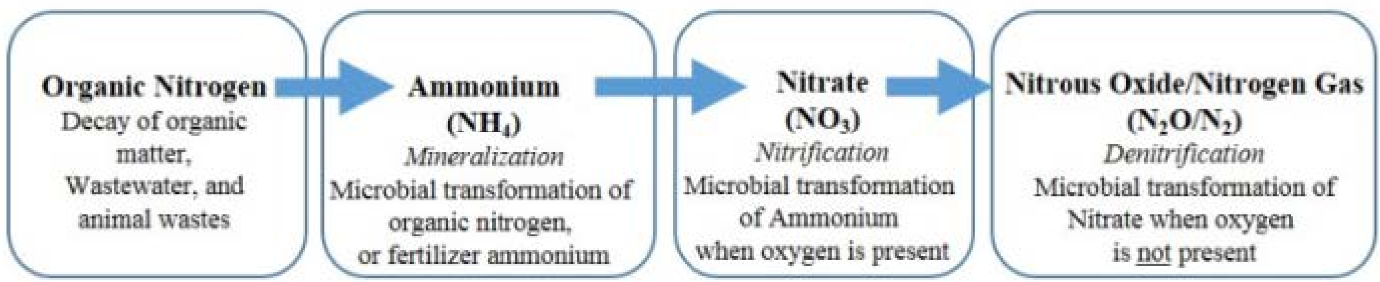

Diagram modified from WERF (2009a) Figure 2-1

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Figure 32. A Typical Nitrogen Cycle for Waste Effluent (Organic Nitrogen). Source: WERF (2009); HDOH (2018).

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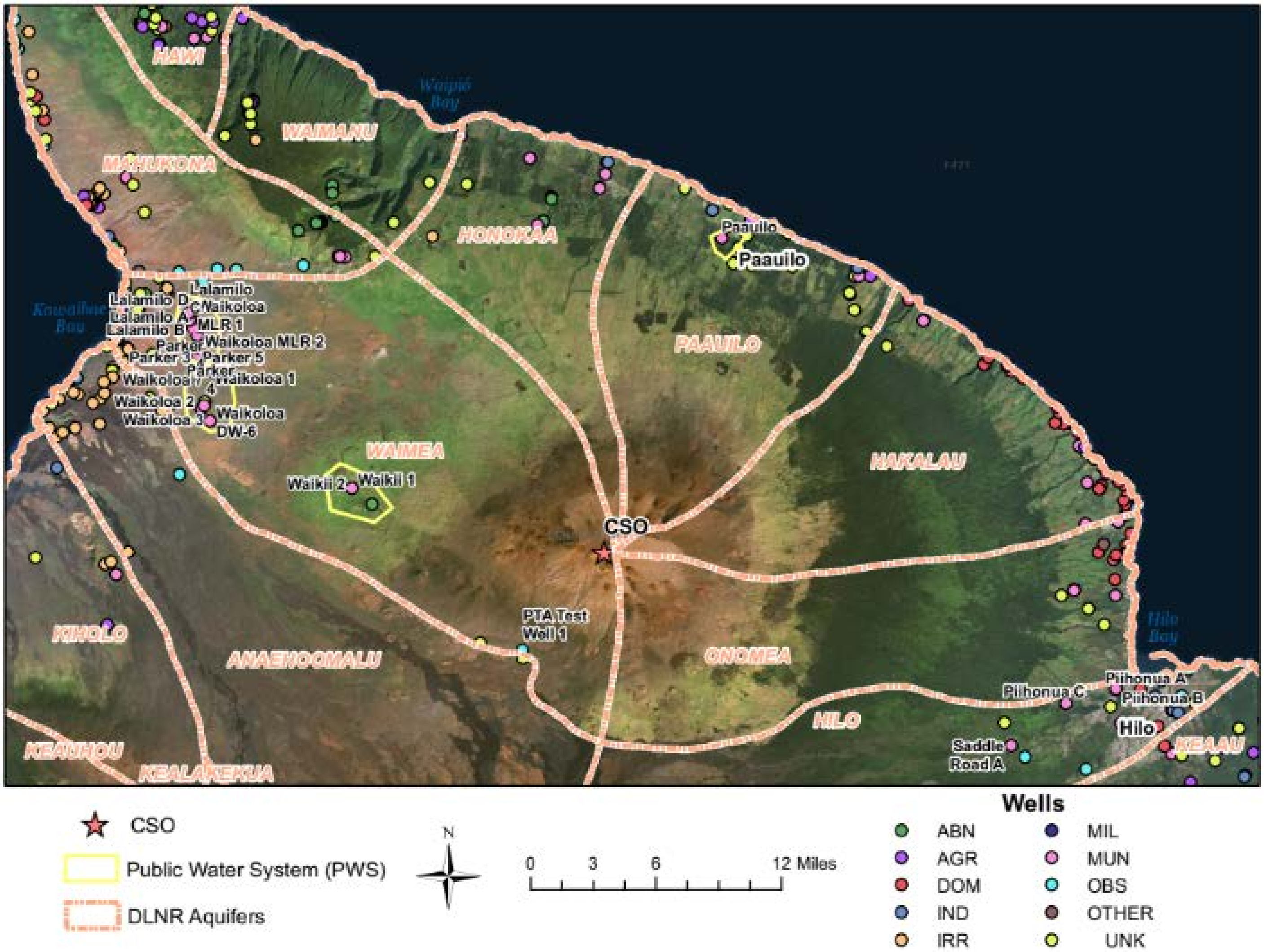

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Figure 33. Wells from Waikoloa Village and Paauilo Public Water Systems (PWS) with Nitrate Sample Data from the State of Hawai'i (see tables 4-7).

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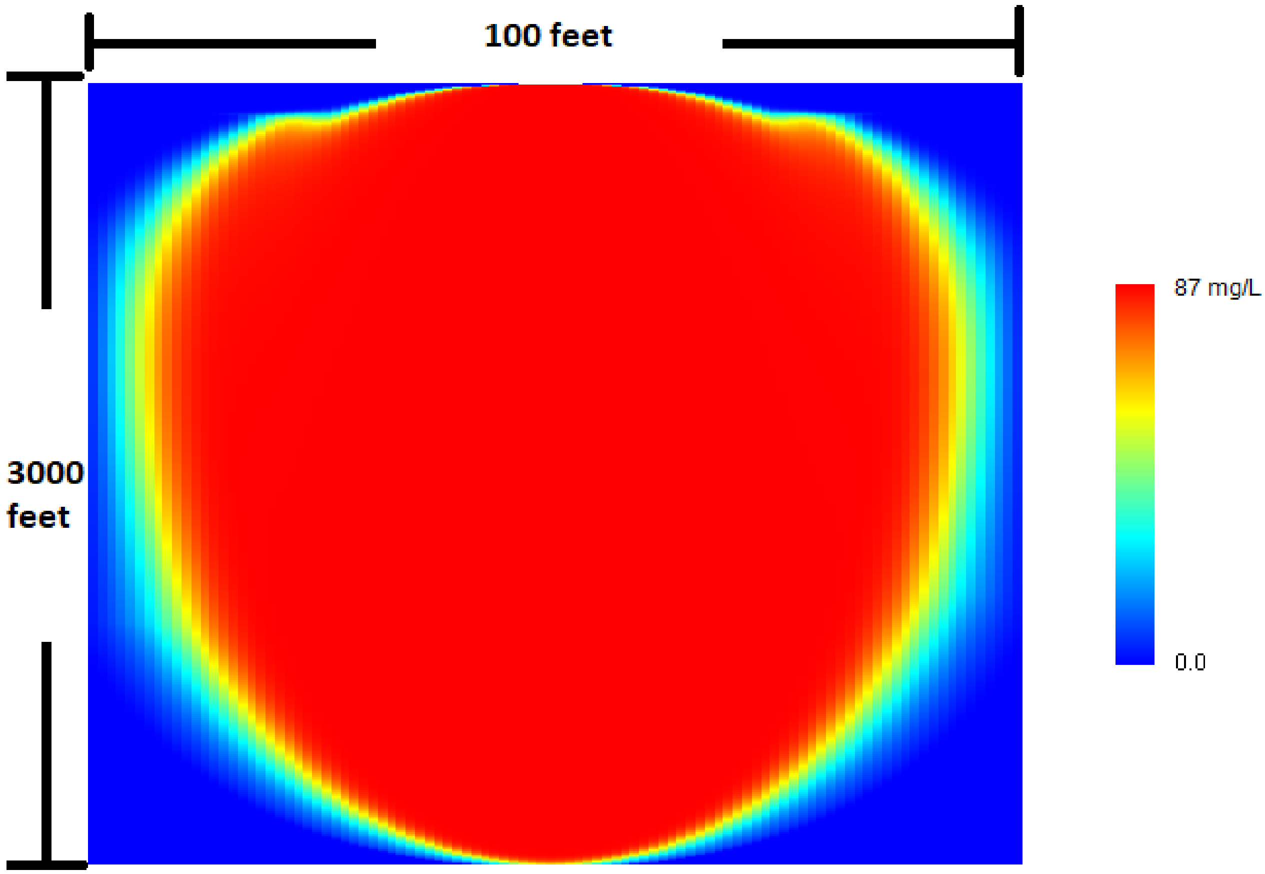

Time = 12594.921

Mass Balance Error	Total for Simulation	Rate for this step
Fluid	0.00%	7.90%
Solute	0.03%	8.43%

The colorbar represents relative concentration and time is in days. Mass balance error is attributed to the fluid and solute leaving the model domain.

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Figure 34. VS2DI Transport Model of the Subsurface below the CSO.
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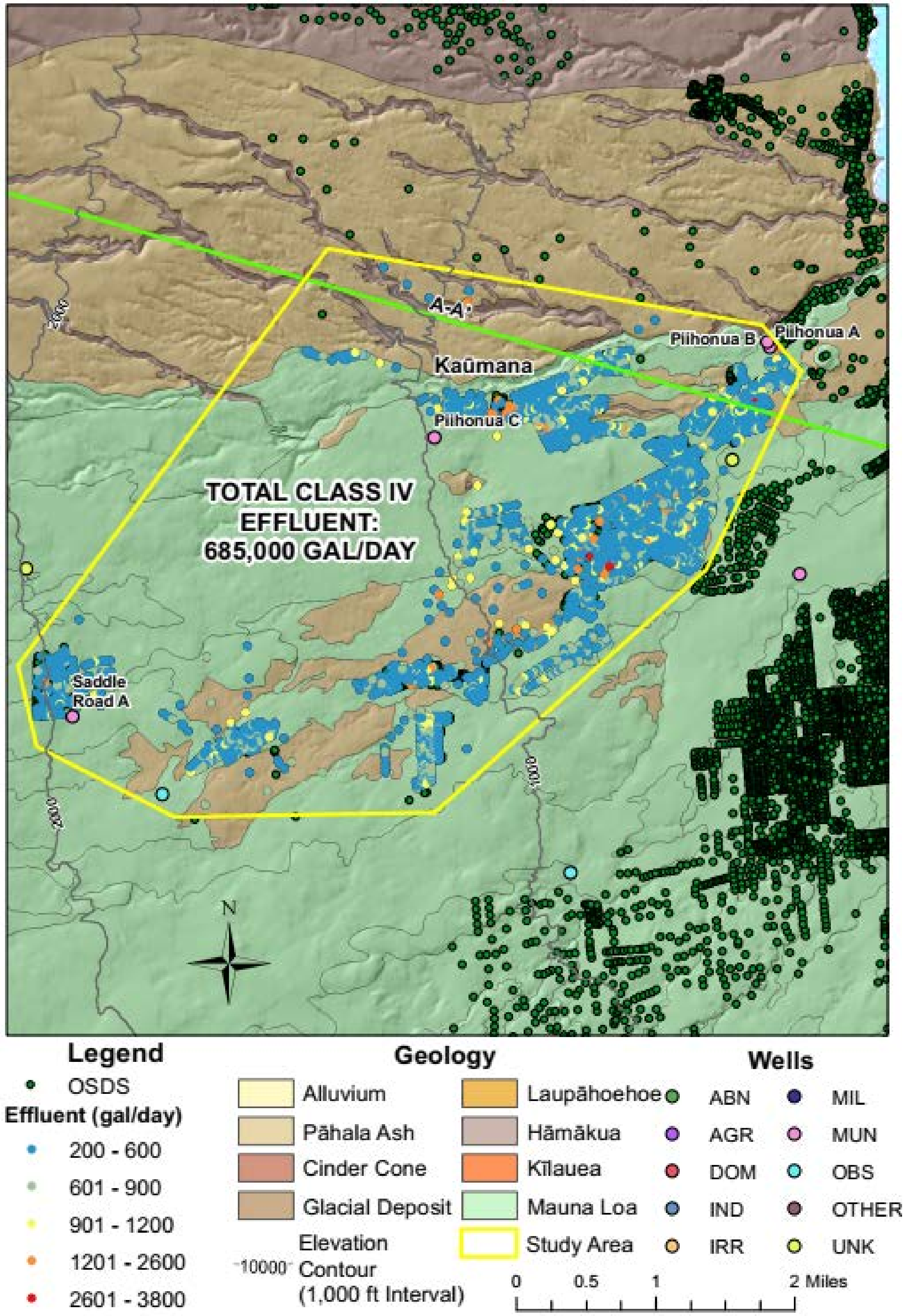
Decommissioning of the Caltech Submillimeter Observatory



Dark green dots represent on-site disposal systems (OSDS) that are outside the study area or non-cesspool OSDS for those located within the study area.

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Figure 35. Kaūmana Total Nitrogen Loading Rate Map.

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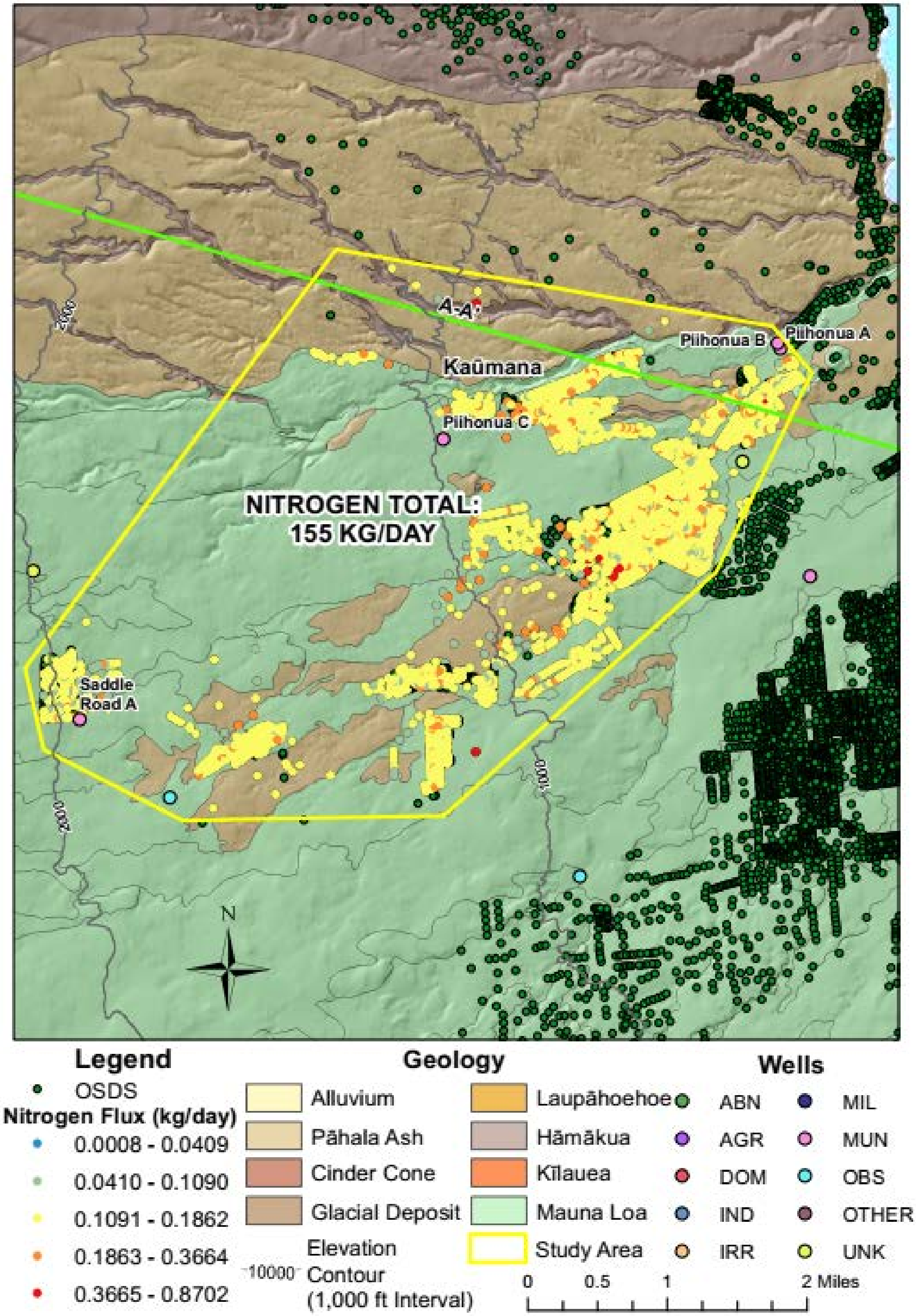
Decommissioning of the Caltech Submillimeter Observatory



Dark green dots represent on-site disposal systems (OSDS) that are outside the study area or non-cesspool OSDS for those located within the study area.

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Figure 36. Kaūmana Total Nitrogen Loading Rate Map.
Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

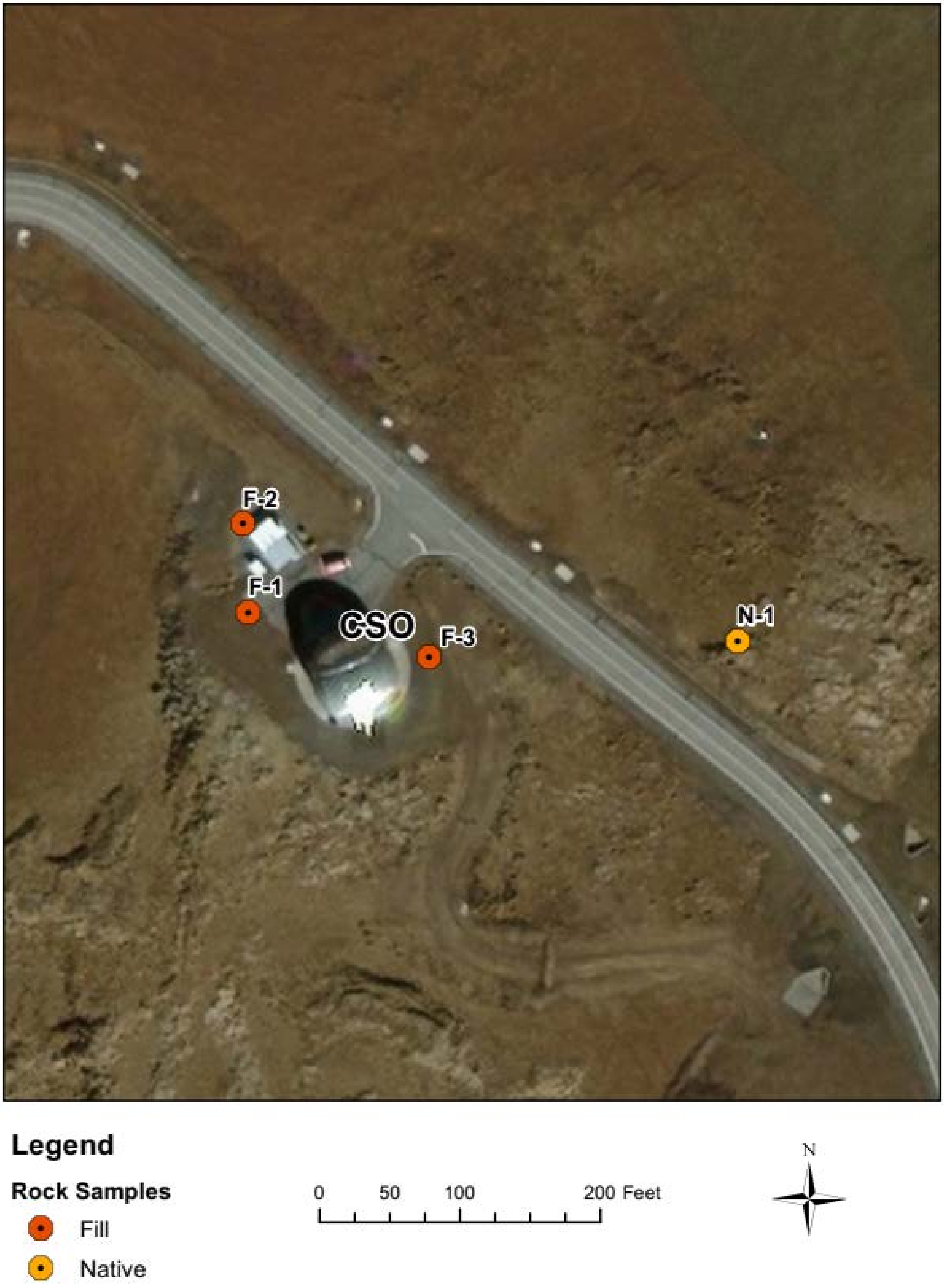

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Figure 37. CSO Fill and Native Rock Sample Locations.
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Figure 38. CSO-F-1 Sampling Hole.
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Figure 39. CSO-F-1 Sample Location.
Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

Figure 40. CSO-F-2 Sample Hole.
Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

Figure 41. CSO-F-3 Sample Hole.
Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

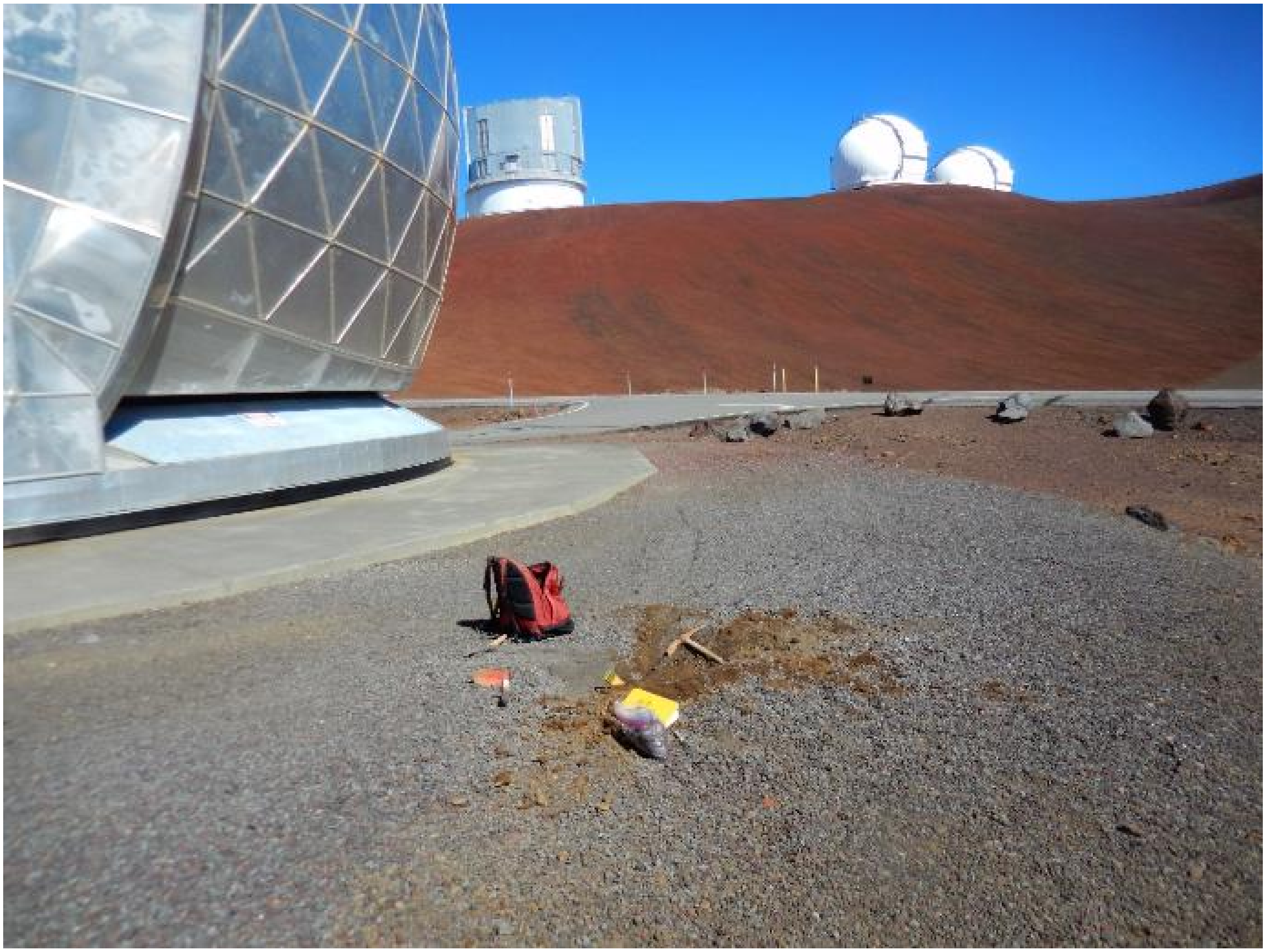

Figure 42. CSO-F-3 Sample Location.
Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

Figure 43. Volcanic Flow in Relationship to CSO from which CSO-N-1 Sample was Collected from the Left-Back Area Shown in this Photo.

Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Figure 44. CSO-N-1 Sample.
Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

Figure 45. CSO-N-1 Sample Area.
Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

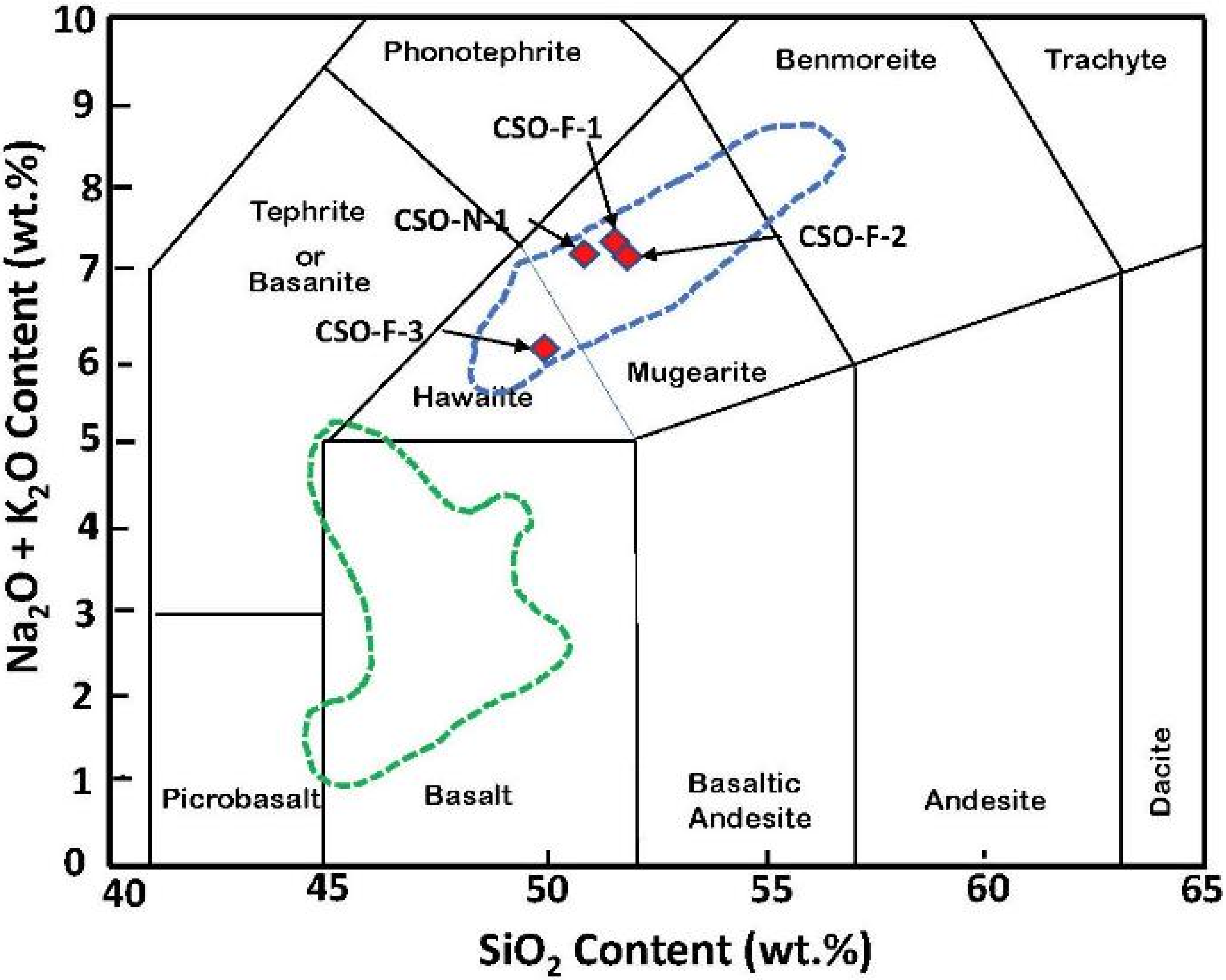

Diagram was used by Wolfe et al. (1997) to compositionally classify Mauna Kea lavas. The green dashed line denotes the approximately extent and range of geochemically analyzed older Hāmākua Volcanics and the blue dashed line denotes the approximately extent and range of geochemically analyzed younger Laupāhoehoe Volcanics as reported by Wolfe et al. (1997, p. 17, Figure 5). The 4 samples collected and analyzed for this investigation (red diamonds) all fall within the Laupāhoehoe Volcanics extent.

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Figure 46. Total Alkali Versus Silica Contents Diagram (Le Bas et al., 1986).

Hydrogeological and Geological Evaluation
Decommissioning of the Caltech Submillimeter Observatory

Appendix F. Transportation Management Plan for California Institute of Technology Submillimeter Observatory Decommissioning, Mauna Kea, Hawai‘i

TRANSPORTATION MANAGEMENT PLAN FOR CALIFORNIA INSTITUTE OF TECHNOLOGY SUBMILLIMETER OBSERVATORY DECOMMISSIONING

Mauna Kea, Hawaii

DRAFT FINAL

September 24, 2019

Prepared for:

California Institute of Technology
1200 E California Boulevard
Pasadena, CA 91125

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Civil Engineers • Surveyors
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Honolulu, Hawaii 96817-5031
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Honolulu • Wailuku • Hilo, Hawaii

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Honolulu • Wailuku • Hilo, Hawaii

September 24, 2019

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TRANSPORTATION MANAGEMENT PLAN FOR CALIFORNIA INSTITUTE OF TECHNOLOGY SUBMILLIMETER OBSERVATORY DECOMMISSIONING

Mauna Kea, Hawaii

1. INTRODUCTION

This Transportation Management Plan (TMP) provides recommendations to reduce and minimize the construction-related traffic impacts on effected transportation corridors from the California Institute of Technology (Caltech) Submillimeter Observatory (CSO) decommissioning (hereinafter referred to as the "Project"). This TMP includes analysis of construction-related impacts to general traffic on public roadways below Hale Pohaku, including the visitor center. The Site Deconstruction and Removal Plan (SDRP) and Site Restoration Plan (SRP) completed by M3 Engineering addresses construction vehicle logistics and management above Hale Pohaku and at the summit.

According to criteria in the Hawaii Department of Transportation, Highways Division (HDOT) "Determination of a Significant Highway Project" flow chart, this Project was determined to be a Level 1 "Project". Refer to the TMP Determination in Appendix A.

1.1 Roles And Responsibilities

TMP Manager: To be determined by General Contractor

Author: Austin, Tsutsumi & Associates, Inc. (ATA)

2. PROJECT DESCRIPTION

2.1 Project Type

Caltech is proposing to decommission their submillimeter observatory on Mauna Kea, which involves removal of the physical structure and restoration of the site. This Project is funded by the Caltech.

2.2 Project Area/Corridor

The CSO is located on a 0.75-acre site near the summit of Mauna Kea. The site is located within the Astronomy Precinct of the Mauna Kea Science Reserve managed by the University of Hawaii.

Saddle Road provides access to the summit of Mauna Kea via Mauna Kea Access Road and provides regional connectivity between Hilo and Waimea. Saddle Road also provides access to the designated recycling center, Hilo Solid Waste Recycling & Transfer Station, located roughly 45 miles east of the summit, the designated landfill, Puuanahulu Landfill, located roughly 56 miles west of the summit, Kawaihae Harbor, located roughly 62 miles west of the summit, and Hilo Harbor, located roughly 45 miles east of the summit. . Mauna Kea Access Road also provides access to the Mauna Kea Visitor Information Station and Construction Camp at Hale Pohaku. The surrounding area is mainly public land and part of the Forest Reserve System. There is a military base located about 7.5 miles north of the Saddle Road/Mauna Kea Access Road intersection.

See Figure 2.1 for the Project Location Map.

2.3 Proposed Construction Phasing/Staging

There are varying levels of deconstruction/removal and restoration that may occur. According to the Office of Mauna Kea Management (OMKM) Decommissioning Plan the following options exist with regards to deconstruction and removal:

- Complete Infrastructure Removal - involves removing all man-made structures above and below grade.
- Infrastructure Capping – involves removing of all man-made structures above grade while all or some of man-made structures below grade may remain.

According to the OMKM Decommissioning Plan the following options exist with regards to restoration:

- Minimal Restoration - involves removing all man-made materials and grading of the site.
- Moderate Restoration – goes beyond minimal restoration to also include physical habitat structure enhancements that benefit the native arthropod community
- Full Restoration - involves restoring the topography to pre-construction conditions including restoring the habitat for the native arthropod community.

For the various deconstruction/removal and restoration levels, construction will require temporary road closures and escorts along Mauna Kea Access Road during the mobilization and demobilization of the crane and office trailer. Escorts may also be required for various semi-truck load trips, but a full roadway closures is likely not needed. During construction hours, barricades and portable barriers will be used to restrict traffic from entering construction and staging areas.

CALTECH SUBMILLIMETER OBSERVATORY (CSO) DECOMMISSIONING TMP

Austin Tsutsumi & Associates, Inc.
Engineers & Surveyors

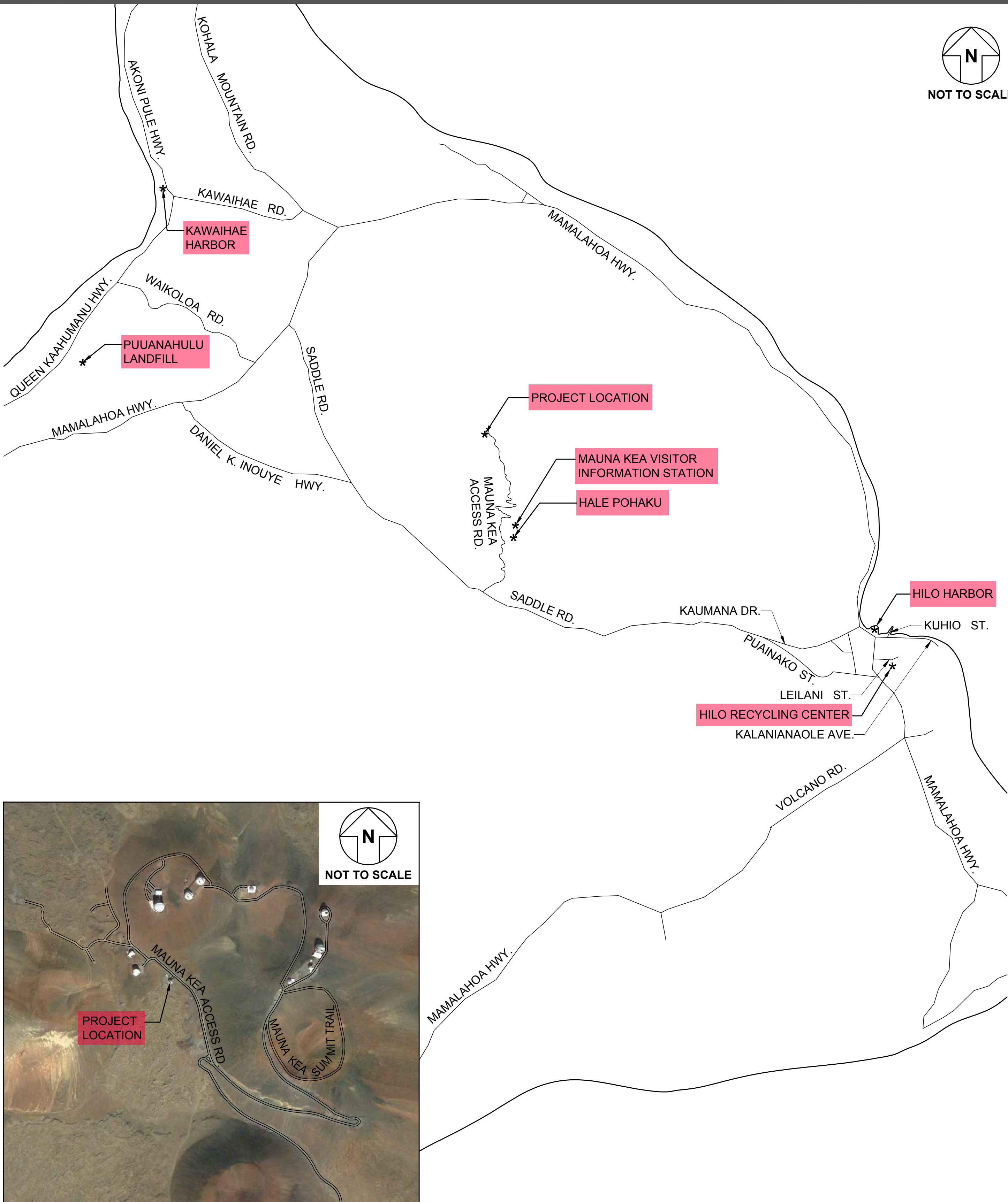


FIGURE 2.1

LOCATION MAP

2.4 General Schedule and Timeline

The construction is expected to start in the beginning of 2021 and is estimated to be completed by in the summer of 2021.

3. EXISTING CONDITIONS

3.1 Roadway Characteristics

This section provides descriptions of the existing roadways that may be impacted by the Project. These roadway conditions reflect the existing conditions at the time of this report. First, the following roadways provide access to the summit of Mauna Kea:

- Mauna Kea Access Road –is generally a north-south, two-way, two-lane undivided road with a posted speed limit of 40 miles per hour (mph). This roadway provides access to the summit of Mauna Kea and is mostly paved and transitions to a gravel road after the Mauna Kea Visitor Information Station, which is located 8.5 miles south of the summit.
- Saddle Road – Saddle Road is generally an east-west, two-way, two-lane undivided, minor arterial with a posted speed limit of 55 mph in the vicinity of the Project. Saddle Road is a State roadway that begins at the outskirts of Hilo and travels west before terminating at its intersection with Mamalahoa Highway near Waimea.

Second, the following roadways provide access from the summit of Mauna Kea to the designated landfill site, Puuanahulu Landfill and Kawaihae Harbor:

- Daniel K. Inouye Highway (Route 200) – is generally an east-west, two-way, three-lane, undivided State roadway that connects Saddle Road and Mamalahoa Highway. Daniel K. Inouye (DKI) Highway is a minor arterial with a posted speed limit of 45 mph, near the intersection with Saddle Road.
- Mamalahoa Highway (Highway 190) – is generally a north-south, two-way, two-lane, undivided State roadway. Mamalahoa Highway (Hwy 190) travels between Waimea and Kailua-Kona. Mamalahoa Highway is a minor arterial with a posted speed limit of 55 mph, near the intersection with DKI Highway.
- Waikoloa Road – is generally an east-west, two-way, two-lane, undivided roadway that connects Mamalahoa Highway and Queen Kaahumanu Highway. The roadway has a posted speed limit of 35 mph near Waikoloa Village, but the posted limit increases to 45 mph near Queen Kaahumanu Highway and 55 mph near Mamalahoa Highway.
- Queen Kaahumanu Highway (Route 19) – is generally a north-south, two-way, two-lane, undivided roadway with a posted speed limit of 45 mph, near the intersection with Waikoloa Road. This roadway travels between Kawaihae and Kailua-Kona. Queen Kaahumanu Highway is a State roadway and is part of the National Highway System (NHS).
- Akoni Pule Highway – is generally a north-south, two-way, two-lane, undivided roadway with a posted speed limit of 35 mph, near Kawaihae Harbor. The roadway travels between Kawaihae and Pololu Valley. Akoni Pule Highway is a State roadway and is part of the NHS, near Kawaihae Harbor.

Finally, the following roadways provide access from the summit of Mauna Kea to the designated recycling center, Hilo Solid Waste Recycling & Transfer Station and Hilo Harbor:

- Puainako Street (Route 2000) - is generally an east-west, two-way, two-lane, undivided major collector that connects Saddle Road and Mamalahoa Highway (Highway 11) in Hilo. Puainako Street is a State roadway with a posted speed limit of 35 mph and 55 mph east and west of Komohana Street, respectively.
- Mamalahoa Highway (Highway 11) – is generally a north-south, two-way, two to three-lane, divided principal arterial with a posted speed limit of 35 mph near Leilani Street. This roadway travels between Hilo and Kailua-Kona. Mamalahoa Highway (Hwy 11) is a State roadway and is part of the NHS.
- Leilani Street - is generally an east-west, two-way, two-lane, undivided roadway with a posted speed limit of 30 mph. Leilani Street provides access to the Hilo Solid Waste Recycling & Transfer Station.
- Kalanianaole Avenue – is generally an east-west, two-way, two-lane, undivided roadway with a posted speed limit of 35 mph, near Hilo Harbor. Kalanianaole Avenue is a State road and is part of the NHS, near Hilo Harbor.
- Kuhio Street – is generally a north-south, two-way, two-lane, undivided roadway with a posted speed limit of 25 mph. This roadway provides access to the Port of Hilo.

3.2 Existing and Historical Traffic Data

Most recently available traffic volume data from HDOT and previous traffic studies within the study area were used to evaluate the potential impact of construction activity related to the CSO decommissioning.

Based on previous studies, there are roughly 30-40 vehicles per day (vpd) traveling on the Mauna kea Summit Access Road, but there can be up to 200 vpd on busy days likely when there is snowfall.[1]

Based on available HDOT traffic volume data[2] there are roughly:

- 4,500 vpd traveling along Saddle Road (east of Ua Nahele Street),
- 4,600 vpd traveling along Saddle Road (east of Mamalahoa Highway),
- 5,200 vpd traveling along Mamalahoa Highway (south of DKI Highway),
- 4,800 vpd traveling along Waikoloa Road (east of Paniolo Avenue),
- 9,000 vpd traveling along Waikoloa Road (east of Queen Kaahumanu Highway),
- 17,600 vpd traveling along Queen Kaahumanu Highway (south of Waikoloa Road),
- 6,000 vph traveling along Akoni Pule Highway (north of Kawaihae Road),
- 6,900 vpd traveling along Puainako Street (west of Komohana Street),
- 18,700 vpd traveling along Puainako Street (west of Mamalahoa Highway),
- 38,700 vpd traveling along Mamalahoa Highway (north of Puainako Street),
- 15,600 vpd traveling along Kalanianaole Avenue (east of Mamalahoa Highway), and
- 2,500 vpd traveling along Kuhio Street (north of Kalanianaole Highway).

Figure 3.1 shows the existing traffic volumes. The traffic count data is included in Appendix B.

---

[1] *Final Environmental Assessment: Infrastructure Improvements at Mauna Kea Visitor Information Station*, University of Hawaii Hilo with Sustainable Resource Group Intn'l, Inc., August 2017.

[2] *Hawaii Traffic Station Map – Island of Hawaii*, State of Hawaii Department of Transportation, 2016.

CALTECH SUBMILLIMETER OBSERVATORY (CSO) DECOMMISSIONING TMP

Austin Tsutsumi & ASSOCIATES, INC. Engineers & Surveyors

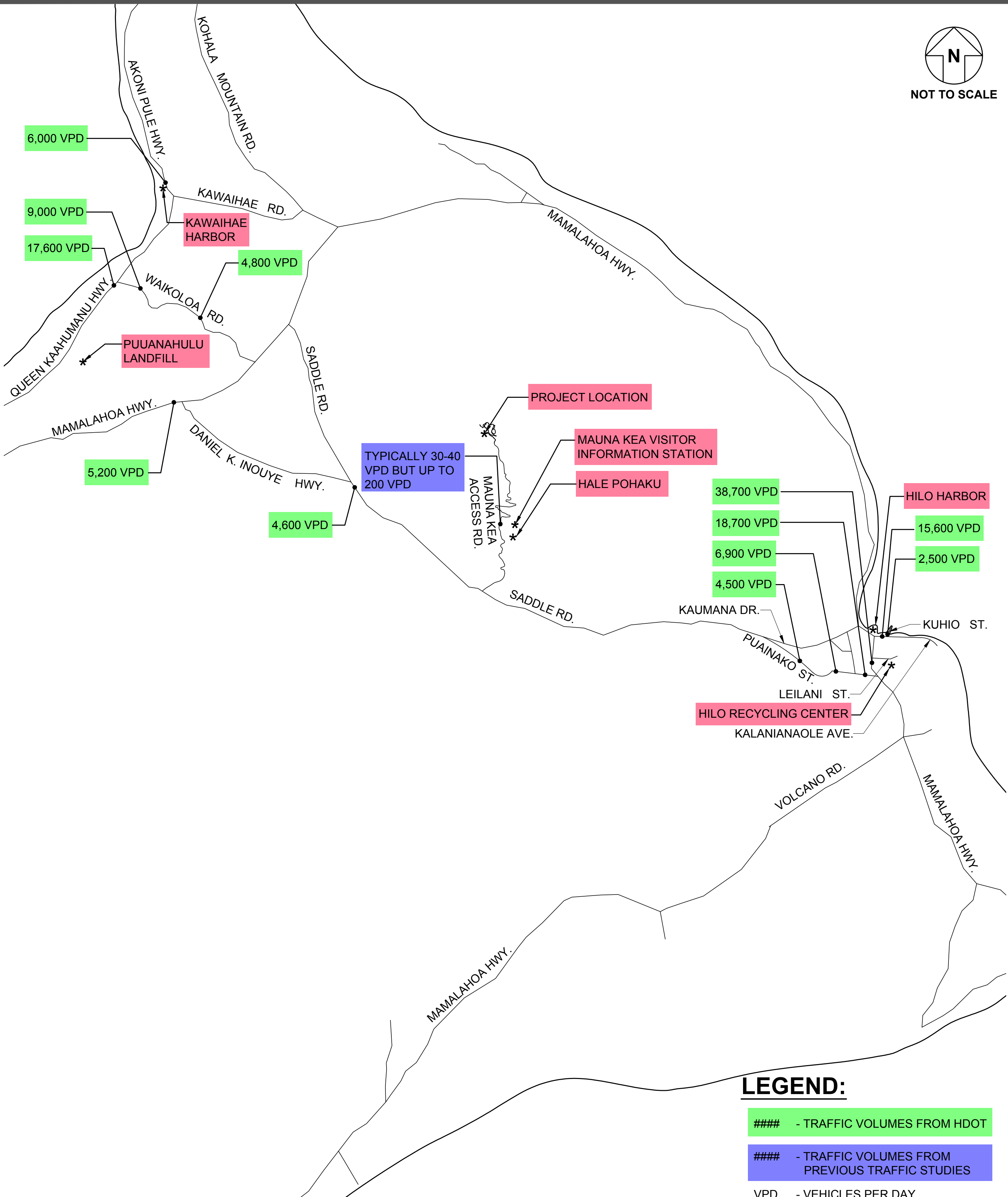


FIGURE 3.1

EXISTING TRAFFIC VOLUMES

4. CONSTRUCTION IMPACTS

4.1 Construction-Related Traffic

Typically, 1,000 pc/ln/hr (passenger cars per lane per hour) is used as a threshold to determine if there is a significant impact on traffic. There would be no significant impacts to traffic, if the existing traffic volumes including construction vehicles remain under 1,000 pc/ln/hr on effected corridors. As a general rule of thumb, the PM peak hour of traffic (the hour of the day when traffic volumes are typically the highest) is roughly 10 percent of the daily traffic volume.

Preliminary decommissioning alternatives were developed by Caltech based on the potential combinations of the OMKM Decommissioning Plan deconstruction/removal and restoration levels. The number of construction trips and crew size used in this TMP is based on construction activities outlined in the SDRP and SRP. Table 4.1 shows the maximum number of construction trips expected in a single day for each preliminary decommissioning alternative. The construction trip data is included in Appendix C.

Table 4.1: Daily Construction-Related Trips

Preliminary Decommissioning Alternatives	Total Construction-Related Trips (Construction Staff Trips)
No Action	0 (0)
Complete Removal/Full Restoration	36 (30)
Completed Removal/Moderate Restoration	36 (30)
Completed Removal/Minimal Restoration	36 (30)
Infrastructure Capping/Moderate Restoration	36 (30)
Infrastructure Capping/Minimal Restoration	36 (30)

As shown above in Table 4.1, all preliminary decommissioning alternatives are expected add up to 36 construction-related trips in a single day, which indicates that the impacts to traffic is expected to be the same regardless of the level of deconstruction/removal and restoration activities.

The construction staff trips will likely occur during the AM and PM peak hours of traffic, while the construction vehicle trips may occur at any time during construction working hours. A work schedule has not been established for this Project, but construction working hours is typically between 7:00 AM and 4:00 PM. Construction crews will either 1) drive individually each day to Hale Pohaku, then vanpool to the construction site, 2) drive individually each day to the summit and park at the Batch Plant, or 3) drive individually each day to a designated site in Hilo, then vanpool to the construction site. Under Option 1 and Option 2, Mauna Kea Access Road would experience a higher increase in traffic volume, as all construction-related traffic would travel along this roadway, when compared to Option 3. However, regardless of the commute option selected for construction crews, given the low anticipated construction volume added by the Project, the impact to existing traffic is expected to be minimal.

Peak periods of traffic throughout the day along Mauna Kea Access Road generally align with various activities on the summit including commercial tours for sunrise viewing, observatory works commuting to/from the summit, and both independent and commercial tours for sunset viewing. Assuming all construction-related traffic will travel along Mauna Kea Access Road, the number of daily trips along Mauna Kea Access Road would double with the additional construction-related trips, but the total volume would be less than 100 vpd. If all 36 construction-related trips occurred on the busiest day for Mauna Kea Visitor Information Center or summit, there would be roughly 230 to 240 vpd or 23-24 vehicles during the PM peak hour, which is still considerably less than the 1,000 pcplph threshold. Since the existing volumes on Mauna Kea Access Road are low, the potential increase in construction traffic on Mauna Kea Access Road is not expected to have a significant impact.

Since construction staff will travel from various origins and construction trips will be split between the Puuanahulu Landfill, Hilo Solid Waste Recycling & Transfer Station, Hilo Harbor, and Kawaihae Harbor, the remaining roadways will only serve a portion of the additional construction-related trips. As a conservative evaluation, if all 36 construction-related trips are added to the remaining roadways identified in Section 3, the additional construction traffic would account for less than 1% of the average daily volume for each roadway. Thus, the increase in construction traffic is not expected to have a significant impact.

It is important to note that construction activities at the summit related to the Thirty Meter Telescope (TMT) will likely be underway at the same time as the CSO Decommissioning. Coordination between TMT and the CSO Decommissioning construction activities will be addressed in the SDRP and SRP.

4.2 Roadway Closures

As mentioned above, temporary road closures will be required along Mauna Kea Access Road during the mobilization and demobilization of the crane and office trailer. However, the duration of the temporary closure is expected to be short and is not expected to have a significant impact on traffic.

5. SELECTED WORK ZONE IMPACTS MANAGEMENT STRATEGIES

5.1 Temporary Traffic Control Devices

This section provides an overview of strategies that will be employed to improve the safety and mobility of work zones and reduce the work zone impacts on communities and businesses.

Table 5.1 provides a summary of the various work zone management strategies that will be used for this Project.

Table 5.1 - Additional Traffic Management Strategies

Temporary Traffic Control	Needed
Traffic Control Devices	
1. Temporary signs	✓
2. Changeable message boards	✓
3. Channelizing devices	✓
4. Flaggers and uniformed traffic control officers	✓
5. Barricades	✓
6. Portable barriers	✓
7. Escort Vehicles	✓

6. TMP MONITORING DURING CONSTRUCTION

The TMP Manager shall monitor all phases of the construction work and shall document any problems, issues, or recommendations for use by future projects.

7. REFERENCES

1. State of Hawaii Department of Transportation Highways Division, Work Zone Safety and Mobility Process, October 2007.
2. Federal Highway Administration (FHWA), Traffic Analysis Tools Volume IX: Work Zone Modeling and Simulation, December 2000.

APPENDIX

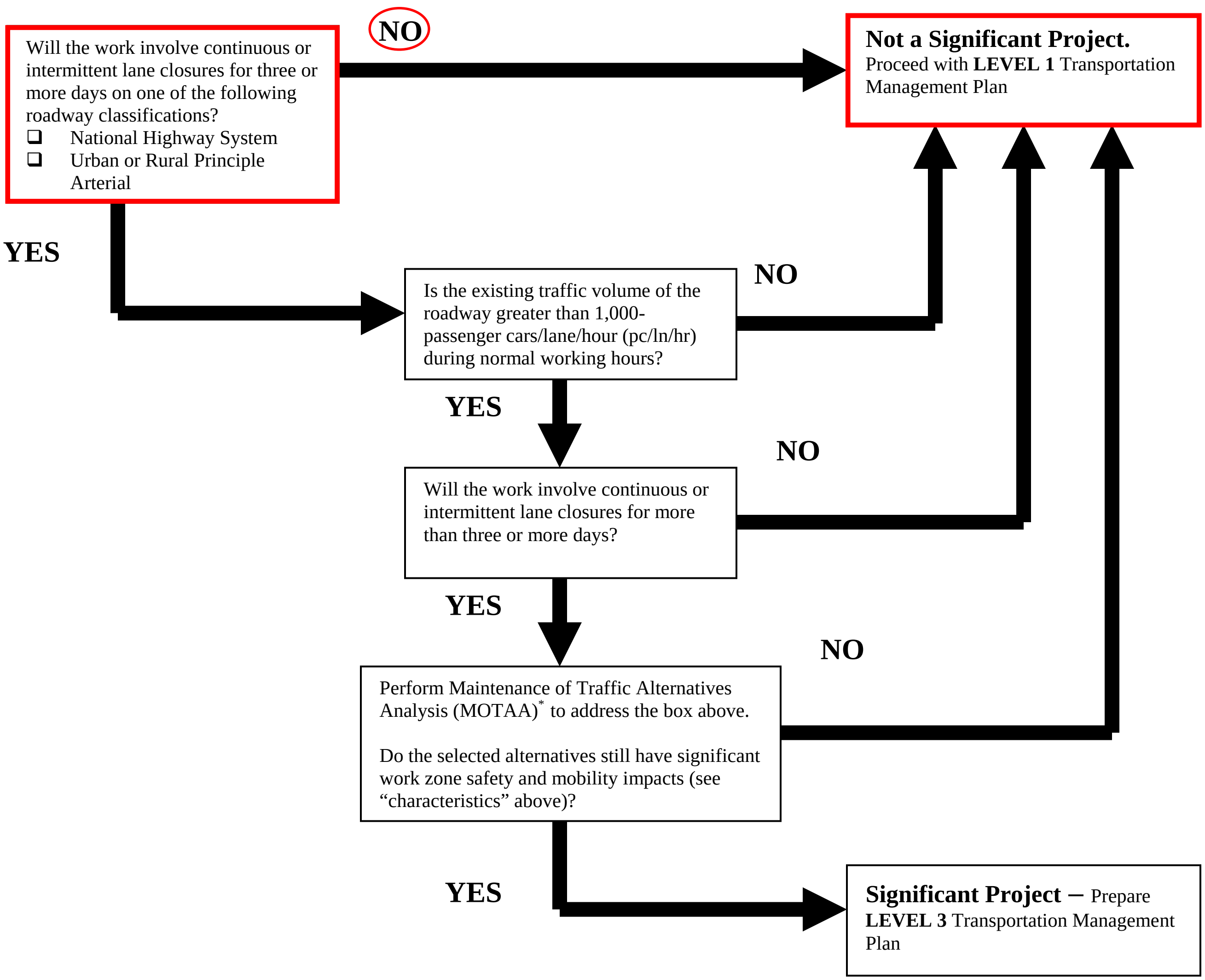
Appendix A: TMP Determination Worksheet

r10-3-07

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATON
HIGHWAYS DIVSION

DETERMINATION OF A SIGNIFICANT HIGHWAY PROJECT

C&C of Honolulu and Counties of Hawaii, Kauai, and Maui Projects



* Notes:

The MOTAA should be conducted during analysis of detailed alternatives, before a final alternative is selected to proceed to design. Each alternative's ability to confirm with the Work Zone Mobility Policy should be reviewed at this stage. Guidance on performing a MOTAA can be obtained from the HDOT - Design Branch or the Traffic Branch.

Appendix B: Traffic Count Data

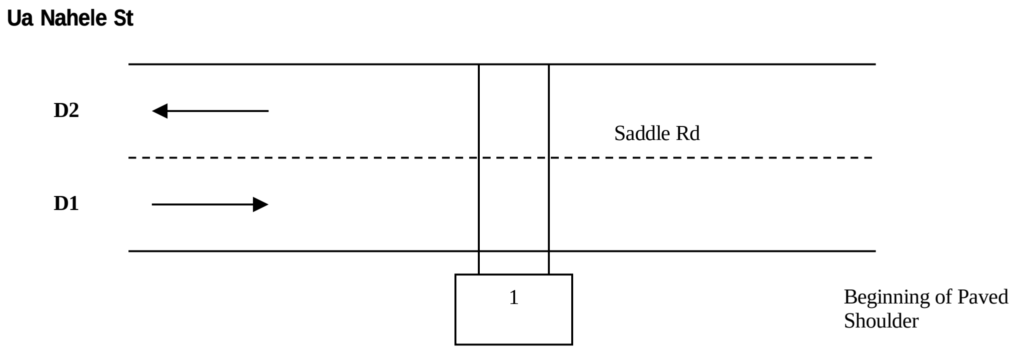
Traffic Data Service

Traffic Station Sketch

N

Island: Hawaii
Area: Hilo

Section ID/Station #: B71020000015



Meter #	File Name	GPS
1. BT35	D0216001_B71020000015	19.68157, -155.18519
2.	D0216002_B71020000015	

Station Description: Saddle Rd**: Ua Nahele St to** Beginning of Paved Shoulder

Survey Beginning Date/Time: 2/26/2016 @ 0000			Survey Ending Date/Time: 3/11/2016 @ 2400	
Survey Method:	Road Tube	Data Type:	Class	
Survey Crew:	LM		C1B	
Sketch Updated:			SR	
Remarks:	1292			

FACILITY NAME	JURI	FUNC CLASS	AREA TYPE	ROUTE NO.	ROUTE MILE
Saddle Rd		6		0200	

D1= Direction to End — D1: Beginning of Paved Shoulder / Mamalahoa Highway

D2= Direction to Begin — **D2: Ua Nahele St /** Hilo Urban Boundary

Run Date: 2017/08/11

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71020000015 **Town:** Hawaii **DIR 1:** +MP **DIR 2:**-MP **Final AADT:** 4600

Functional Class: RURAL:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 200

Location: Saddle Rd - Ua Nahele St to beginning of paved shoulder

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
DATE : 12/13/2016															
12:00-12:15	1	3	4	06:00-06:15	49	6	55	12:00-12:15	30	36	66	06:00-06:15	12	65	77
12:15-12:30	1	5	6	06:15-06:30	57	11	68	12:15-12:30	28	23	51	06:15-06:30	25	35	60
12:30-12:45	2	5	7	06:30-06:45	57	14	71	12:30-12:45	34	22	56	06:30-06:45	13	43	56
12:45-01:00	0	3	3	06:45-07:00	57	9	66	12:45-01:00	11	29	40	06:45-07:00	26	19	45
01:00-01:15	0	2	2	07:00-07:15	48	30	78	01:00-01:15	30	31	61	07:00-07:15	12	18	30
01:15-01:30	0	4	4	07:15-07:30	38	15	53	01:15-01:30	26	15	41	07:15-07:30	13	13	26
01:30-01:45	1	1	2	07:30-07:45	30	19	49	01:30-01:45	33	18	51	07:30-07:45	13	22	35
01:45-02:00	0	1	1	07:45-08:00	43	26	69	01:45-02:00	28	59	87	07:45-08:00	8	21	29
02:00-02:15	1	3	4	08:00-08:15	44	16	60	02:00-02:15	29	29	58	08:00-08:15	12	21	33
02:15-02:30	3	1	4	08:15-08:30	43	22	65	02:15-02:30	33	40	73	08:15-08:30	15	20	35
02:30-02:45	4	1	5	08:30-08:45	36	25	61	02:30-02:45	22	27	49	08:30-08:45	19	16	35
02:45-03:00	1	1	2	08:45-09:00	35	28	63	02:45-03:00	35	41	76	08:45-09:00	18	19	37
03:00-03:15	4	2	6	09:00-09:15	35	18	53	03:00-03:15	32	23	55	09:00-09:15	14	15	29
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03:45-04:00	14	3	17	09:45-10:00	27	11	38	03:45-04:00	37	64	101	09:45-10:00	6	12	18
04:00-04:15	7	1	8	10:00-10:15	31	43	74	04:00-04:15	42	60	102	10:00-10:15	4	16	20
04:15-04:30	10	0	10	10:15-10:30	31	37	68	04:15-04:30	33	50	83	10:15-10:30	6	15	21
04:30-04:45	18	1	19	10:30-10:45	31	34	65	04:30-04:45	33	66	99	10:30-10:45	5	3	8
04:45-05:00	32	1	33	10:45-11:00	27	28	55	04:45-05:00	29	63	92	10:45-11:00	1	8	9
05:00-05:15	46	3	49	11:00-11:15	19	52	71	05:00-05:15	30	36	66	11:00-11:15	1	5	6
05:15-05:30	59	5	64	11:15-11:30	26	32	58	05:15-05:30	35	90	125	11:15-11:30	0	5	5
05:30-05:45	67	5	72	11:30-11:45	34	35	69	05:30-05:45	25	70	95	11:30-11:45	2	14	16
05:45-06:00	68	7	75	11:45-12:00	13	25	38	05:45-06:00	34	57	91	11:45-12:00	3	10	13

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:15 AM to 07:15 AM			PM - PEAK HR TIME	05:15 PM to 06:15 PM		
AM - PEAK HR VOLUME	219	64	283	PM - PEAK HR VOLUME	106	282	388
AM - K FACTOR (%)			6.49	PM - K FACTOR (%)			8.89
AM - D (%)	77.39	22.61	100.00	PM - D (%)	27.32	72.68	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	05:15 AM to 06:15 AM	08:00 AM to 09:00 AM		PM - PEAK HR TIME	03:45 PM to 04:45 PM	05:15 PM to 06:15 PM	
AM - PEAK HR VOLUME	243	91		PM - PEAK HR VOLUME	145	282	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:15 AM to 07:15 AM			PM - PEAK HR TIME	05:15 PM to 06:15 PM		
AM - PEAK HR VOLUME	219	64	283	PM - PEAK HR VOLUME	106	282	388
AM - K FACTOR (%)			6.49	PM - K FACTOR (%)			8.89
AM - D (%)	77.39	22.61	100.00	PM - D (%)	27.32	72.68	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	01:30 PM to 02:30 PM		
PEAK HR VOLUME	123	146	269
DIRECTIONAL PEAK			
PEAK HR TIME	09:00 AM to 10:00 AM	01:45 PM to 02:45 PM	
PEAK HR VOLUME	132	155	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	881	598	1,479
AM 12-HR PERIOD (00:00-12:00)	1,234	659	1,893
PM 6-HR PERIOD (12:00-18:00)	729	1,055	1,784
PM 12-HR PERIOD (12:00-24:00)	976	1,494	2,470
24 HOUR PERIOD	2,210	2,153	4,363
D (%)	50.65	49.35	100.00

Run Date: 2017/08/11

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71020000015 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 4600

Functional Class: RURAL:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 200

Location: Saddle Rd - Ua Nahele St to beginning of paved shoulder

DATE : 12/14/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	0	9	9	06:00-06:15	55	11	66	12:00-12:15	22	36	58	06:00-06:15	22	45	67
12:15-12:30	0	3	3	06:15-06:30	57	6	63	12:15-12:30	32	27	59	06:15-06:30	29	38	67
12:30-12:45	0	7	7	06:30-06:45	54	15	69	12:30-12:45	25	19	44	06:30-06:45	23	57	80
12:45-01:00	0	2	2	06:45-07:00	52	10	62	12:45-01:00	29	42	71	06:45-07:00	20	16	36
01:00-01:15	4	3	7	07:00-07:15	37	31	68	01:00-01:15	29	26	55	07:00-07:15	11	12	23
01:15-01:30	1	4	5	07:15-07:30	38	24	62	01:15-01:30	19	38	57	07:15-07:30	13	12	25
01:30-01:45	0	0	0	07:30-07:45	33	13	46	01:30-01:45	28	17	45	07:30-07:45	12	20	32
01:45-02:00	1	1	2	07:45-08:00	32	30	62	01:45-02:00	30	44	74	07:45-08:00	21	13	34
02:00-02:15	2	0	2	08:00-08:15	50	25	75	02:00-02:15	31	37	68	08:00-08:15	12	24	36
02:15-02:30	3	2	5	08:15-08:30	59	26	85	02:15-02:30	38	30	68	08:15-08:30	15	22	37
02:30-02:45	3	1	4	08:30-08:45	40	10	50	02:30-02:45	32	43	75	08:30-08:45	19	15	34
02:45-03:00	2	0	2	08:45-09:00	34	35	69	02:45-03:00	42	30	72	08:45-09:00	21	22	43
03:00-03:15	4	0	4	09:00-09:15	36	30	66	03:00-03:15	24	20	44	09:00-09:15	12	18	30
03:15-03:30	7	1	8	09:15-09:30	31	34	65	03:15-03:30	30	51	81	09:15-09:30	10	11	21
03:30-03:45	4	1	5	09:30-09:45	31	23	54	03:30-03:45	29	78	107	09:30-09:45	6	13	19
03:45-04:00	7	3	10	09:45-10:00	38	38	76	03:45-04:00	43	49	92	09:45-10:00	5	7	12
04:00-04:15	3	1	4	10:00-10:15	34	1	35	04:00-04:15	31	59	90	10:00-10:15	4	9	13
04:15-04:30	8	0	8	10:15-10:30	37	55	92	04:15-04:30	29	33	62	10:15-10:30	7	18	25
04:30-04:45	26	0	26	10:30-10:45	14	33	47	04:30-04:45	50	38	88	10:30-10:45	3	7	10
04:45-05:00	29	3	32	10:45-11:00	31	21	52	04:45-05:00	41	43	84	10:45-11:00	3	10	13
05:00-05:15	37	2	39	11:00-11:15	26	47	73	05:00-05:15	41	119	160	11:00-11:15	0	16	16
05:15-05:30	66	5	71	11:15-11:30	23	18	41	05:15-05:30	30	83	113	11:15-11:30	0	7	7
05:30-05:45	62	3	65	11:30-11:45	39	40	79	05:30-05:45	33	55	88	11:30-11:45	2	14	16
05:45-06:00	53	5	58	11:45-12:00	20	55	75	05:45-06:00	36	69	105	11:45-12:00	2	10	12

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	08:00 AM to 09:00 AM			PM - PEAK HR TIME	05:00 PM to 06:00 PM		
AM - PEAK HR VOLUME	183	96	279	PM - PEAK HR VOLUME	140	326	466
AM - K FACTOR (%)			6.23	PM - K FACTOR (%)			10.41
AM - D (%)	65.59	34.41	100.00	PM - D (%)	30.04	69.96	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	05:15 AM to 06:15 AM	07:00 AM to 08:00 AM		PM - PEAK HR TIME	04:30 PM to 05:30 PM	05:00 PM to 06:00 PM	
AM - PEAK HR VOLUME	236	98		PM - PEAK HR VOLUME	162	326	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	08:00 AM to 09:00 AM			PM - PEAK HR TIME	05:00 PM to 06:00 PM		
AM - PEAK HR VOLUME	183	96	279	PM - PEAK HR VOLUME	140	326	466
AM - K FACTOR (%)			6.23	PM - K FACTOR (%)			10.41
AM - D (%)	65.59	34.41	100.00	PM - D (%)	30.04	69.96	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	01:45 PM to 02:45 PM		
PEAK HR VOLUME	131	154	285
DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM	11:00 AM to 12:00 PM	
PEAK HR VOLUME	143	160	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	901	631	1,532
AM 12-HR PERIOD (00:00-12:00)	1,223	687	1,910
PM 6-HR PERIOD (12:00-18:00)	774	1,086	1,860
PM 12-HR PERIOD (12:00-24:00)	1,046	1,522	2,568
24 HOUR PERIOD	2,269	2,209	4,478
D (%)	50.67	49.33	100.00

Run Date: 2017/08/11

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71020000015 **Town:** Hawaii **DIR 1:** +MP **DIR 2:**-MP **Final AADT:** 4600

Functional Class: RURAL:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 200

Location: Saddle Rd - Ua Nahele St to beginning of paved shoulder

DATE : 12/15/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	1	4	5	06:00-06:15	54	11	65	12:00-12:15	32	30	62	06:00-06:15	29	44	73
12:15-12:30	1	2	3	06:15-06:30	42	8	50	12:15-12:30	31	19	50	06:15-06:30	26	16	42
12:30-12:45	5	2	7	06:30-06:45	50	12	62	12:30-12:45	27	30	57	06:30-06:45	14	49	63
12:45-01:00	3	4	7	06:45-07:00	49	13	62	12:45-01:00	28	33	61	06:45-07:00	17	31	48
01:00-01:15	1	2	3	07:00-07:15	46	18	64	01:00-01:15	21	31	52	07:00-07:15	16	20	36
01:15-01:30	2	3	5	07:15-07:30	33	17	50	01:15-01:30	27	36	63	07:15-07:30	11	23	34
01:30-01:45	1	3	4	07:30-07:45	44	12	56	01:30-01:45	21	32	53	07:30-07:45	8	17	25
01:45-02:00	1	1	2	07:45-08:00	37	16	53	01:45-02:00	28	30	58	07:45-08:00	13	18	31
02:00-02:15	2	2	4	08:00-08:15	44	34	78	02:00-02:15	33	28	61	08:00-08:15	14	21	35
02:15-02:30	3	2	5	08:15-08:30	44	25	69	02:15-02:30	20	46	66	08:15-08:30	7	16	23
02:30-02:45	4	1	5	08:30-08:45	27	22	49	02:30-02:45	33	32	65	08:30-08:45	13	14	27
02:45-03:00	1	1	2	08:45-09:00	38	24	62	02:45-03:00	34	46	80	08:45-09:00	17	21	38
03:00-03:15	3	0	3	09:00-09:15	43	22	65	03:00-03:15	27	46	73	09:00-09:15	17	28	45
03:15-03:30	4	0	4	09:15-09:30	34	41	75	03:15-03:30	37	54	91	09:15-09:30	7	19	26
03:30-03:45	8	1	9	09:30-09:45	33	32	65	03:30-03:45	37	44	81	09:30-09:45	6	9	15
03:45-04:00	7	0	7	09:45-10:00	10	40	50	03:45-04:00	50	48	98	09:45-10:00	6	4	10
04:00-04:15	10	0	10	10:00-10:15	46	23	69	04:00-04:15	41	52	93	10:00-10:15	12	10	22
04:15-04:30	13	0	13	10:15-10:30	35	28	63	04:15-04:30	33	71	104	10:15-10:30	7	14	21
04:30-04:45	24	5	29	10:30-10:45	32	43	75	04:30-04:45	38	68	106	10:30-10:45	4	10	14
04:45-05:00	31	2	33	10:45-11:00	30	27	57	04:45-05:00	29	59	88	10:45-11:00	2	11	13
05:00-05:15	45	2	47	11:00-11:15	22	42	64	05:00-05:15	37	70	107	11:00-11:15	0	10	10
05:15-05:30	60	5	65	11:15-11:30	34	19	53	05:15-05:30	38	53	91	11:15-11:30	0	12	12
05:30-05:45	63	4	67	11:30-11:45	15	36	51	05:30-05:45	31	51	82	11:30-11:45	2	9	11
05:45-06:00	55	8	63	11:45-12:00	24	29	53	05:45-06:00	22	55	77	11:45-12:00	0	4	4

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	05:15 AM to 06:15 AM			PM - PEAK HR TIME	04:15 PM to 05:15 PM		
AM - PEAK HR VOLUME	232	28	260	PM - PEAK HR VOLUME	137	268	405
AM - K FACTOR (%)			5.96	PM - K FACTOR (%)			9.29
AM - D (%)	89.23	10.77	100.00	PM - D (%)	33.83	66.17	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	05:15 AM to 06:15 AM	08:00 AM to 09:00 AM		PM - PEAK HR TIME	03:15 PM to 04:15 PM	04:15 PM to 05:15 PM	
AM - PEAK HR VOLUME	232	105		PM - PEAK HR VOLUME	165	268	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	08:45 AM to 09:45 AM			PM - PEAK HR TIME	04:15 PM to 05:15 PM		
AM - PEAK HR VOLUME	148	119	267	PM - PEAK HR VOLUME	137	268	405
AM - K FACTOR (%)			6.13	PM - K FACTOR (%)			9.29
AM - D (%)	55.43	44.57	100.00	PM - D (%)	33.83	66.17	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	120	152	272
DIRECTIONAL PEAK			
PEAK HR TIME	10:00 AM to 11:00 AM	02:00 PM to 03:00 PM	
PEAK HR VOLUME	143	152	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	866	594	1,460
AM 12-HR PERIOD (00:00-12:00)	1,214	648	1,862
PM 6-HR PERIOD (12:00-18:00)	755	1,064	1,819
PM 12-HR PERIOD (12:00-24:00)	1,003	1,494	2,497
24 HOUR PERIOD	2,217	2,142	4,359
D (%)	50.86	49.14	100.00

Run Date: 2017/08/11

Hawaii Department of Transportation
Highways Division
Highways Planning Survey Section

Vehicle Classification Data Summary
2016

Site ID: B71020000015 **Route No:** 200 **Date From:** 2016/12/05 0:00

Town: Hawaii **Direction:** +MP **Date To:** 2016/12/18 23:45

Location: Saddle Rd - Ua Nahele St to beginning of paved shoulder

Functional Classification: 6 RURAL:MINOR ARTERIAL

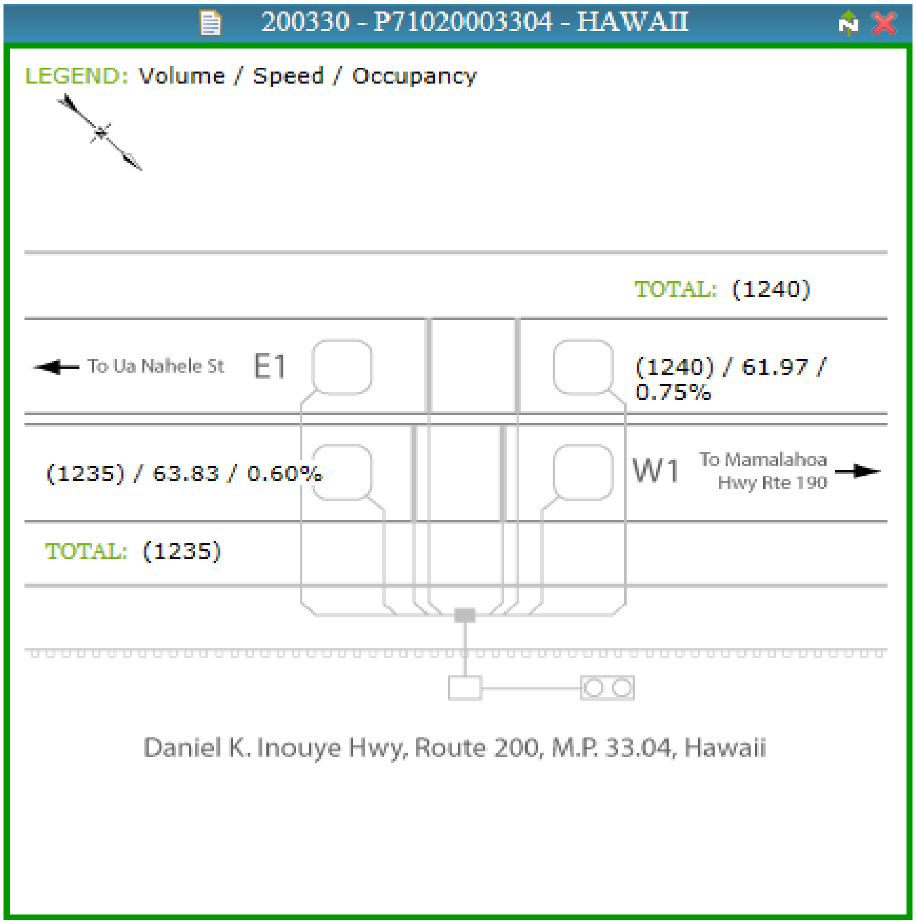
REPORT TOTALS - 336 HOURS RECORDED

	VOLUME	%	NUMBER OF AXLES
Cycles	337	0.54%	675
PC	43869	70.24%	87738
2A-4T	16217	25.97%	32434
LIGHT VEHICLE TOTALS	60423	96.75%	120846
HEAVY VEHICLES			
Bus	317	0.51%	793
SINGLE UNIT TRUCK			
2A-6T	516	0.83%	1032
3A-SU	305	0.49%	915
4A-SU	24	0.04%	96
SINGLE-TRAILER TRUCKS			
4A-ST	75	0.12%	300
5A-ST	563	0.90%	2815
6A-ST	30	0.05%	180
MULTI-TRAILER TRUCKS			
5A-MT	159	0.25%	795
6A-MT	37	0.06%	222
7A-MT	8	0.01%	56
HEAVY VEHICLE TOTALS	2034	3.26%	7204
CLASSIFIED VEHICLES TOTALS	62457 (A)	100.00%	128050 (B)
UNCLASSIFIED VEHICLES TOTALS	-1	-0.00%	

AXLE CORRECTION FACTOR (A/C) = 0.976

ROADTUBE EQUIVALENT(B/2) = 64025 (C)

PEAK HOUR VOLUME : 470 2016/12/09 16:00	PEAK HOUR TRUCK VOLUME	% TOTAL PEAK HOUR VOLUME	24 HOUR TRUCK VOLUME	AADT	% OF AADT	HPMS K-FACTOR (PEAK/AADT) (ITEM 66)
SINGLE UNIT TRUCKS (TYPE 4-7)	3	(65A-1) 0.64%	82	4600	(65A-2) 1.78%	10.22%
COMBINATION (TYPE 8-13)	5	(65B-1) 1.06%	62		(65B-2) 1.35%	10.22%



200330 - P71020003304 - HAWAII
LEGEND: Volume / Speed / Occupancy
TOTAL: (1240)
To Ua Nahele St
E1
(1240) / 61.97 / 0.75%
(1235) / 63.83 / 0.60%
W1
To Mamalahoa Hwy Rte 190
TOTAL: (1235)
Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii

STATION: 200330
STATION DESCRIPTION: 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
YEAR: 2016 - 2016
LOC'N 19.793044 -155.627412

Hawaii
DIRECTION 01 (D1): To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 (D2): To Ua Nahele St, MOV 3

MONTH	MON	TUE	WED	THU	FRI	SAT	SUN	WEEKDAY AVERAGE	MONTHLY AVERAGE	AADT MON AVE	AADT AVE WKDY
January	4496	4382	4555	4500	4879	4970	3848	4562	4519	1.02540	1.01555
February	4388	4568	4679	4753	4767	5457	4005	4631	4660	0.99437	1.00048
March	4598	4605	4768	4778	4860	5325	4365	4722	4757	0.97402	0.98128
April	4162	4333	4363	4398	4845	4980	4017	4420	4442	1.04296	1.04824
May	4163	4332	4307	4434	4839	5060	4133	4415	4467	1.03726	1.04944
June	4412	4462	4724	4715	4906	5121	4005	4644	4621	1.00274	0.99776
July	4812	4983	5219	5129	5356	5731	4770	5100	5143	0.90093	0.90853
August	4493	4607	4816	4907	5369	5417	4363	4838	4853	0.95472	0.95763
September	4398	4467	4639	4543	4901	5064	4231	4590	4606	1.00592	1.00954
October	4262	4429	4669	4739	5009	4945	4078	4621	4590	1.00944	1.00258
November	4240	4175	4467	4478	4777	4933	4006	4428	4440	1.04365	1.04648
December	4102	4681	4906	4592	4790	4538	3914	4614	4503	1.02888	1.00415
AVERAGE	4377	4502	4676	4664	4941	5128	4145	AVERAGE	D1+D2 AADT		
								4632	4633		

K-FACTOR 10.86%
K-FACTOR PERIOD PM
D-FACTOR 59.84%

STATION: 200330
STATION DESCRIPTION: 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
YEAR: 2016 - 2016
LOC'N 19.793044 -155.627412

DIRECTION 01 (D1): Hawaii
To Mamalahoa Hwy Rte 190, MOV 7

MONTH	MON	TUE	WED	THU	FRI	SAT	SUN	WEEKDAY AVERAGE	MONTHLY AVERAGE	AADT / MON AVE	AADT / AVE WKDY
January	2290	2199	2286	2286	2486	2541	1877	2309	2281	1.02980	1.01706
February	2248	2311	2366	2439	2426	2744	1994	2358	2361	0.99488	0.99621
March	2327	2289	2424	2434	2518	2721	2102	2398	2402	0.97786	0.97935
April	2114	2195	2204	2233	2470	2548	1948	2243	2244	1.04647	1.04715
May	2128	2189	2166	2254	2495	2644	1983	2246	2265	1.03678	1.04567
June	2258	2267	2396	2406	2487	2617	1911	2363	2334	1.00613	0.99409
July	2475	2457	2659	2640	2739	2956	2410	2594	2619	0.89678	0.90557
August	2296	2321	2461	2517	2743	2772	2131	2468	2463	0.95367	0.95187
September	2282	2277	2366	2319	2550	2627	2096	2359	2359	0.99551	0.99579
October	2192	2247	2355	2417	2523	2535	1966	2347	2319	1.01276	1.00091
November	2183	2125	2252	2325	2411	2558	1908	2259	2251	1.04324	1.03974
December	2099	2381	2484	2354	2434	2331	1915	2350	2285	1.02777	0.99939
AVERAGE	2241	2271	2368	2385	2523	2633	2020	AVERAGE 2358	D1 AADT 2349		

STATION: 200330
STATION DESCRIPTION: 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
YEAR: 2016 - 2016
LOC'N 19.793044 -155.627412

DIRECTION 02 (D2): Hawaii To Ua Nahele St, MOV 3

MONTH	MON	TUE	WED	THU	FRI	SAT	SUN	WEEKDAY AVERAGE	MONTHLY AVERAGE	AADT MON AVE	AADT AVE WKDY
January	2206	2183	2269	2214	2393	2429	1971	2253	2238	1.02092	1.01401
February	2141	2258	2313	2314	2341	2713	2011	2273	2299	0.99386	1.00491
March	2271	2316	2344	2344	2343	2604	2263	2323	2355	0.97010	0.98326
April	2048	2138	2159	2165	2375	2432	2069	2177	2198	1.03937	1.04936
May	2035	2143	2142	2181	2344	2417	2149	2169	2201	1.03774	1.05333
June	2153	2196	2328	2309	2419	2504	2094	2281	2286	0.99927	1.00156
July	2338	2526	2560	2490	2617	2775	2361	2506	2524	0.90524	0.91160
August	2198	2285	2356	2390	2626	2646	2232	2371	2390	0.95580	0.96363
September	2116	2190	2273	2224	2351	2438	2135	2231	2247	1.01685	1.02408
October	2069	2183	2314	2323	2485	2411	2112	2275	2271	1.00604	1.00432
November	2058	2051	2215	2153	2366	2376	2099	2169	2188	1.04407	1.05351
December	2004	2300	2422	2238	2356	2207	1999	2264	2218	1.03002	1.00909
AVERAGE	2136	2231	2308	2279	2418	2496	2125	AVERAGE 2274	D2 AADT 2285		

January, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	D-02	D-01	D-02	1+2	D-01	D-02	1+2	D-01	D-02	D-01	D-02	1+2	D-01	D-02
1/1/2016	Fri	*		50.2	49.8	1685	1670	3355	480	566	1046	116	131	1205	1104	2309	125	172
1/2/2016	Sat			50.3	49.7	2480	2447	4927	912	793	1705	198	175	1568	1654	3222	175	273
1/3/2016	Sun			50.0	50.0	1982	1980	3962	708	560	1268	154	145	1274	1420	2694	109	220
1/4/2016	Mon			51.0	49.0	2417	2321	4738	1030	812	1842	141	157	1387	1509	2896	167	275
1/5/2016	Tue			50.7	49.3	2364	2297	4661	1078	795	1873	150	162	1286	1502	2788	169	291
1/6/2016	Wed			50.4	49.6	2322	2289	4611	971	858	1829	132	195	1351	1431	2782	156	272
1/7/2016	Thu			51.1	48.9	2397	2294	4691	1058	860	1918	161	160	1339	1434	2773	189	231
1/8/2016	Fri			50.4	49.6	2436	2399	4835	992	764	1756	149	137	1444	1635	3079	198	351
1/9/2016	Sat			50.9	49.1	2546	2454	5000	1042	764	1806	196	165	1504	1690	3194	175	264
1/10/2016	Sun			47.1	52.9	1779	2002	3781	681	560	1241	166	141	1098	1442	2540	119	214
1/11/2016	Mon			51.4	48.6	2273	2153	4426	1015	808	1823	148	154	1258	1345	2603	157	306
1/12/2016	Tue			49.7	50.3	2152	2175	4327	997	846	1843	158	155	1155	1329	2484	158	289
1/13/2016	Wed			49.8	50.2	2203	2224	4427	975	883	1858	143	184	1228	1341	2569	174	261
1/14/2016	Thu			50.9	49.1	2228	2153	4381	980	815	1795	139	160	1248	1338	2586	146	334
1/15/2016	Fri			51.4	48.6	2567	2432	4999	1032	873	1905	149	172	1535	1559	3094	202	301
1/16/2016	Sat			52.1	47.9	2657	2444	5101	1127	874	2001	216	200	1530	1570	3100	189	241
1/17/2016	Sun			49.9	50.1	2015	2023	4038	775	554	1329	189	114	1240	1469	2709	147	225
1/18/2016	Mon	*		49.4	50.6	2337	2390	4727	1124	753	1877	191	172	1213	1637	2850	162	302
1/19/2016	Tue			50.4	49.6	2178	2141	4319	1022	853	1875	148	158	1156	1288	2444	146	228
1/20/2016	Wed			50.4	49.6	2324	2285	4609	1005	898	1903	137	188	1319	1387	2706	209	258
1/21/2016	Thu			50.5	49.5	2300	2258	4558	1030	874	1904	168	170	1270	1384	2654	166	275
1/22/2016	Fri			51.5	48.5	2464	2320	4784	1036	772	1808	151	161	1428	1548	2976	187	296
1/23/2016	Sat			50.9	49.1	2502	2416	4918	953	899	1852	185	188	1549	1517	3066	177	211
1/24/2016	Sun			48.0	52.0	1790	1939	3729	614	622	1236	142	137	1176	1317	2493	135	221
1/25/2016	Mon			50.4	49.6	2180	2144	4324	979	838	1817	132	149	1201	1306	2507	142	249
1/26/2016	Tue			49.8	50.2	2102	2119	4221	937	786	1723	145	155	1165	1333	2498	156	250
1/27/2016	Wed			50.2	49.8	2293	2278	4571	994	935	1929	135	208	1299	1343	2642	176	277
1/28/2016	Thu			50.8	49.2	2219	2152	4371	993	812	1805	136	155	1226	1340	2566	173	270
1/29/2016	Fri			50.6	49.4	2478	2420	4898	972	809	1781	134	153	1506	1611	3117	179	279
1/30/2016	Sat			51.4	48.6	2522	2382	4904	959	940	1899	180	197	1563	1442	3005	194	219
1/31/2016	Sun			48.8	51.2	1821	1909	3730	583	623	1206	130	163	1238	1286	2524	151	178

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

February, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
2/1/2016	Mon			51.6	48.4	2159	2022	4181	993	808	1801	130	144	1166	1214	2380	142	237
2/2/2016	Tue			50.5	49.5	2184	2144	4328	990	819	1809	119	168	1194	1325	2519	156	251
2/3/2016	Wed			51.4	48.6	2370	2243	4613	991	850	1841	110	191	1379	1393	2772	170	263
2/4/2016	Thu			50.2	49.8	2346	2330	4676	1029	843	1872	143	159	1317	1487	2804	154	326
2/5/2016	Fri			50.1	49.9	2537	2531	5068	1078	782	1860	183	144	1459	1749	3208	171	321
2/6/2016	Sat			48.7	51.3	2908	3068	5976	1175	957	2132	219	196	1733	2111	3844	219	338
2/7/2016	Sun			52.0	48.0	1806	1666	3472	750	507	1257	149	120	1056	1159	2215	115	157
2/8/2016	Mon			51.0	49.0	2397	2300	4697	1016	867	1883	152	181	1381	1433	2814	138	294
2/9/2016	Tue			51.1	48.9	2288	2187	4475	1006	832	1838	159	151	1282	1355	2637	196	284
2/10/2016	Wed			50.1	49.9	2426	2414	4840	1018	935	1953	164	168	1408	1479	2887	167	302
2/11/2016	Thu			53.9	46.1	2514	2147	4661	1049	923	1972	158	175	1465	1224	2689	203	182
2/12/2016	Fri			52.6	47.4	2223	2000	4223	835	514	1349	131	93	1388	1486	2874	198	276
2/13/2016	Sat			52.0	48.0	2997	2761	5758	1192	946	2138	249	210	1805	1815	3620	213	284
2/14/2016	Sun			49.3	50.7	2263	2324	4587	850	660	1510	207	158	1413	1664	3077	166	276
2/15/2016	Mon	*		48.3	51.7	2419	2590	5009	1043	759	1802	192	181	1376	1831	3207	158	317
2/16/2016	Tue			51.0	49.0	2450	2354	4804	1079	887	1966	162	151	1371	1467	2838	182	303
2/17/2016	Wed			50.2	49.8	2352	2331	4683	1045	931	1976	165	171	1307	1400	2707	185	262
2/18/2016	Thu			50.0	50.0	2451	2454	4905	1054	946	2000	152	175	1397	1508	2905	197	286
2/19/2016	Fri			50.3	49.7	2518	2492	5010	986	935	1921	135	209	1532	1557	3089	233	263
2/20/2016	Sat			50.2	49.8	2524	2507	5031	1008	981	1989	170	220	1516	1526	3042	178	238
2/21/2016	Sun			49.0	51.0	2022	2106	4128	725	647	1372	172	146	1297	1459	2756	147	248
2/22/2016	Mon			51.3	48.7	2326	2209	4535	1074	846	1920	152	155	1252	1363	2615	171	294
2/23/2016	Tue			49.7	50.3	2320	2346	4666	998	875	1873	139	188	1322	1471	2793	210	259
2/24/2016	Wed			50.5	49.5	2314	2265	4579	976	903	1879	149	167	1338	1362	2700	200	279
2/25/2016	Thu			51.2	48.8	2445	2326	4771	1084	877	1961	165	154	1361	1449	2810	175	282
2/26/2016	Fri		1	51.0	49.0	2582	2482	5064	1030	810	1840	161	147	1552	1672	3224	229	271
2/27/2016	Sat			50.3	49.7	2547	2514	5061	985	961	1946	195	217	1562	1553	3115	197	245
2/28/2016	Sun			49.1	50.9	1883	1949	3832	645	641	1286	134	159	1238	1308	2546	167	213
2/29/2016	Mon			50.9	49.1	2108	2032	4140	949	817	1766	136	148	1159	1215	2374	162	269

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

March, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	D-02	D-01	D-02	1+2	D-01	D-02	1+2	D-01	D-02	D-01	D-02	1+2	D-01	D-02
3/1/2016	Tue			49.0	51.0	2117	2200	4317	938	863	1801	126	148	1179	1337	2516	179	277
3/2/2016	Wed			51.1	48.9	2259	2159	4418	935	852	1787	111	180	1324	1307	2631	178	257
3/3/2016	Thu			50.5	49.5	2332	2289	4621	1028	871	1899	151	151	1304	1418	2722	201	292
3/4/2016	Fri			52.9	47.1	2501	2227	4728	1037	741	1778	148	128	1464	1486	2950	207	267
3/5/2016	Sat			50.5	49.5	2659	2608	5267	1144	943	2087	203	208	1515	1665	3180	201	279
3/6/2016	Sun			49.1	50.9	2062	2134	4196	741	626	1367	159	136	1321	1508	2829	157	224
3/7/2016	Mon			51.7	48.3	2220	2070	4290	978	818	1796	166	117	1242	1252	2494	177	221
3/8/2016	Tue			49.6	50.4	2240	2276	4516	1017	881	1898	175	157	1223	1395	2618	175	283
3/9/2016	Wed			50.4	49.6	2302	2262	4564	963	908	1871	133	161	1339	1354	2693	198	243
3/10/2016	Thu			50.7	49.3	2316	2252	4568	1042	863	1905	135	174	1274	1389	2663	155	284
3/11/2016	Fri			50.8	49.2	2362	2292	4654	980	773	1753	167	161	1382	1519	2901	200	281
3/12/2016	Sat			53.0	47.0	2777	2464	5241	1202	836	2038	263	156	1575	1628	3203	211	235
3/13/2016	Sun			47.1	52.9	2001	2248	4249	677	702	1379	170	168	1324	1546	2870	153	231
3/14/2016	Mon			50.5	49.5	2176	2136	4312	998	823	1821	145	158	1178	1313	2491	152	227
3/15/2016	Tue			49.7	50.3	2343	2373	4716	1044	873	1917	171	161	1299	1500	2799	182	289
3/16/2016	Wed			50.7	49.3	2524	2458	4982	1063	953	2016	164	199	1461	1505	2966	187	284
3/17/2016	Thu			50.4	49.6	2472	2429	4901	1037	919	1956	154	179	1435	1510	2945	179	309
3/18/2016	Fri			51.7	48.3	2690	2509	5199	1037	837	1874	147	169	1653	1672	3325	225	296
3/19/2016	Sat			51.7	48.3	2875	2681	5556	1125	993	2118	203	232	1750	1688	3438	213	237
3/20/2016	Sun			48.2	51.8	2242	2408	4650	914	688	1602	210	144	1328	1720	3048	165	263
3/21/2016	Mon			50.6	49.4	2476	2417	4893	1086	922	2008	153	184	1390	1495	2885	149	261
3/22/2016	Tue			50.3	49.7	2483	2453	4936	1079	954	2033	172	195	1404	1499	2903	190	259
3/23/2016	Wed			52.2	47.8	2507	2297	4804	1078	980	2058	188	198	1429	1317	2746	174	234
3/24/2016	Thu			52.8	47.2	2555	2288	4843	1075	808	1883	172	150	1480	1480	2960	212	244
3/25/2016	Fri	*		51.0	49.0	2645	2541	5186	1086	811	1897	206	157	1559	1730	3289	240	313
3/26/2016	Sat			49.1	50.9	2571	2664	5235	1091	880	1971	209	188	1480	1784	3264	161	265
3/27/2016	Sun	*		48.0	52.0	1823	1972	3795	551	706	1257	109	177	1272	1266	2538	166	152
3/28/2016	Mon			49.7	50.3	2434	2461	4895	1062	956	2018	144	186	1372	1505	2877	175	256
3/29/2016	Tue			49.8	50.2	2262	2277	4539	966	909	1875	144	166	1296	1368	2664	168	219
3/30/2016	Wed			49.9	50.1	2528	2543	5071	981	1134	2115	138	240	1547	1409	2956	227	254
3/31/2016	Thu			50.3	49.7	2496	2462	4958	991	1025	2016	139	220	1505	1437	2942	187	238

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

April, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
4/1/2016	Fri			49.9	50.1	2411	2424	4835	962	903	1865	152	164	1449	1521	2970	215	286
4/2/2016	Sat			51.9	48.1	2685	2487	5172	979	1110	2089	186	251	1706	1377	3083	207	212
4/3/2016	Sun			51.0	49.0	2203	2116	4319	809	624	1433	172	129	1394	1492	2886	163	213
4/4/2016	Mon			51.1	48.9	2123	2035	4158	975	778	1753	142	137	1148	1257	2405	149	234
4/5/2016	Tue			50.3	49.7	2255	2229	4484	1067	807	1874	173	136	1188	1422	2610	149	262
4/6/2016	Wed			50.1	49.9	2228	2216	4444	991	849	1840	124	163	1237	1367	2604	174	259
4/7/2016	Thu			50.9	49.1	2350	2263	4613	1068	882	1950	171	169	1282	1381	2663	179	239
4/8/2016	Fri			50.4	49.6	2398	2358	4756	991	800	1791	174	134	1407	1558	2965	185	282
4/9/2016	Sat			51.3	48.7	2555	2428	4983	1030	896	1926	220	172	1525	1532	3057	193	203
4/10/2016	Sun			47.4	52.6	1828	2028	3856	624	645	1269	112	129	1204	1383	2587	140	219
4/11/2016	Mon			50.4	49.6	2167	2131	4298	1012	861	1873	121	172	1155	1270	2425	139	239
4/12/2016	Tue			50.6	49.4	2180	2126	4306	1048	791	1839	163	128	1132	1335	2467	162	243
4/13/2016	Wed			51.1	48.9	2198	2104	4302	985	788	1773	154	140	1213	1316	2529	171	242
4/14/2016	Thu			50.9	49.1	2184	2107	4291	983	816	1799	156	144	1201	1291	2492	162	250
4/15/2016	Fri			51.7	48.3	2489	2321	4810	1041	750	1791	175	148	1448	1571	3019	197	280
4/16/2016	Sat			51.1	48.9	2560	2445	5005	1041	940	1981	218	168	1519	1505	3024	203	218
4/17/2016	Sun			48.2	51.8	1829	1969	3798	686	544	1230	153	112	1143	1425	2568	136	253
4/18/2016	Mon			51.2	48.8	2055	1960	4015	987	756	1743	205	90	1068	1204	2272	134	228
4/19/2016	Tue			51.4	48.6	2194	2076	4270	1037	779	1816	156	141	1157	1297	2454	178	262
4/20/2016	Wed			50.3	49.7	2199	2175	4374	1003	809	1812	155	157	1196	1366	2562	187	269
4/21/2016	Thu			51.1	48.9	2317	2218	4535	1031	862	1893	132	172	1286	1356	2642	162	258
4/22/2016	Fri			52.0	48.0	2600	2396	4996	1017	845	1862	163	170	1583	1551	3134	204	310
4/23/2016	Sat			50.7	49.3	2542	2472	5014	1164	832	1996	232	185	1378	1640	3018	173	238
4/24/2016	Sun			47.2	52.8	1931	2162	4093	670	659	1329	135	163	1261	1503	2764	168	238
4/25/2016	Mon			50.5	49.5	2109	2067	4176	980	862	1842	192	96	1129	1205	2334	143	217
4/26/2016	Tue			50.4	49.6	2152	2121	4273	1006	781	1787	165	133	1146	1340	2486	167	251
4/27/2016	Wed			50.6	49.4	2190	2142	4332	984	869	1853	141	189	1206	1273	2479	164	235
4/28/2016	Thu			50.1	49.9	2080	2071	4151	963	733	1696	152	117	1117	1338	2455	158	238
4/29/2016	Fri			50.8	49.2	2451	2377	4828	1043	774	1817	170	143	1408	1603	3011	183	263
4/30/2016	Sat			50.8	49.2	2400	2328	4728	942	797	1739	162	150	1458	1531	2989	173	221

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

May, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	D-02	D-01	D-02	1+2	D-01	D-02	1+2	D-01	D-02	D-01	D-02	1+2	D-01	D-02
5/1/2016	Sun			48.8	51.2	1805	1892	3697	627	583	1210	149	114	1178	1309	2487	130	181
5/2/2016	Mon			50.9	49.1	2053	1983	4036	985	776	1761	225	102	1068	1207	2275	140	222
5/3/2016	Tue			50.8	49.2	2106	2040	4146	1017	756	1773	136	148	1089	1284	2373	147	242
5/4/2016	Wed			50.1	49.9	2183	2171	4354	965	849	1814	138	156	1218	1322	2540	200	257
5/5/2016	Thu			50.9	49.1	2266	2189	4455	1047	802	1849	153	144	1219	1387	2606	172	249
5/6/2016	Fri			51.8	48.2	2409	2241	4650	1056	731	1787	150	140	1353	1510	2863	175	254
5/7/2016	Sat			51.5	48.5	2621	2469	5090	1104	856	1960	231	168	1517	1613	3130	184	226
5/8/2016	Sun			45.4	54.6	1806	2172	3978	692	568	1260	157	133	1114	1604	2718	128	252
5/9/2016	Mon			51.6	48.4	2158	2021	4179	1046	836	1882	226	109	1112	1185	2297	137	215
5/10/2016	Tue			50.5	49.5	2163	2120	4283	1019	760	1779	152	140	1144	1360	2504	169	221
5/11/2016	Wed			50.6	49.4	2150	2103	4253	959	792	1751	149	148	1191	1311	2502	141	241
5/12/2016	Thu			50.8	49.2	2264	2189	4453	1071	822	1893	155	157	1193	1367	2560	164	227
5/13/2016	Fri			50.8	49.2	2418	2341	4759	1017	792	1809	165	149	1401	1549	2950	204	309
5/14/2016	Sat			52.0	48.0	2550	2357	4907	1155	878	2033	178	157	1395	1479	2874	181	235
5/15/2016	Sun			48.4	51.6	1983	2110	4093	745	622	1367	157	137	1238	1488	2726	148	250
5/16/2016	Mon			51.3	48.7	2145	2033	4178	1040	783	1823	222	81	1105	1250	2355	124	225
5/17/2016	Tue			50.3	49.7	2155	2130	4285	1011	796	1807	196	100	1144	1334	2478	149	233
5/18/2016	Wed			50.3	49.7	2182	2156	4338	1007	824	1831	160	140	1175	1332	2507	162	232
5/19/2016	Thu			50.6	49.4	2156	2108	4264	1008	805	1813	137	154	1148	1303	2451	167	233
5/20/2016	Fri			49.9	50.1	2386	2392	4778	954	808	1762	148	155	1432	1584	3016	179	262
5/21/2016	Sat			51.7	48.3	2526	2360	4886	1172	796	1968	199	155	1354	1564	2918	185	197
5/22/2016	Sun			47.9	52.1	1893	2057	3950	710	666	1376	179	146	1183	1391	2574	122	201
5/23/2016	Mon			50.6	49.4	2157	2102	4259	1038	837	1875	226	95	1119	1265	2384	144	220
5/24/2016	Tue			50.4	49.6	2164	2128	4292	1000	794	1794	147	142	1164	1334	2498	159	259
5/25/2016	Wed			50.1	49.9	2148	2136	4284	967	835	1802	137	157	1181	1301	2482	149	225
5/26/2016	Thu			51.0	49.0	2329	2236	4565	1054	831	1885	196	101	1275	1405	2680	165	245
5/27/2016	Fri			53.5	46.5	2765	2403	5168	1100	839	1939	183	176	1665	1564	3229	218	267
5/28/2016	Sat			53.7	46.3	2878	2480	5358	1271	800	2071	234	170	1607	1680	3287	160	228
5/29/2016	Sun			49.1	50.9	2430	2516	4946	890	886	1776	213	150	1540	1630	3170	229	202
5/30/2016	Mon	*		44.5	55.5	1947	2428	4375	711	762	1473	146	192	1236	1666	2902	146	278
5/31/2016	Tue			50.6	49.4	2355	2299	4654	1043	908	1951	151	163	1312	1391	2703	162	244

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

June, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
6/1/2016	Wed			51.2	48.8	2385	2277	4662	1064	895	1959	138	199	1321	1382	2703	180	260
6/2/2016	Thu			50.3	49.7	2292	2262	4554	1027	847	1874	137	153	1265	1415	2680	156	260
6/3/2016	Fri			51.0	49.0	2436	2337	4773	1022	798	1820	148	147	1414	1539	2953	183	267
6/4/2016	Sat			50.4	49.6	2326	2293	4619	982	781	1763	187	177	1344	1512	2856	173	256
6/5/2016	Sun			47.8	52.2	1876	2050	3926	710	645	1355	154	144	1166	1405	2571	121	194
6/6/2016	Mon			51.6	48.4	2276	2136	4412	1075	822	1897	151	150	1201	1314	2515	149	249
6/7/2016	Tue			51.4	48.6	2308	2184	4492	1011	787	1798	144	139	1297	1397	2694	137	267
6/8/2016	Wed			50.5	49.5	2429	2377	4806	1053	931	1984	146	184	1376	1446	2822	172	269
6/9/2016	Thu			51.1	48.9	2474	2368	4842	1050	864	1914	162	162	1424	1504	2928	179	275
6/10/2016	Fri	*		53.2	46.8	2632	2316	4948	1156	730	1886	202	169	1476	1586	3062	153	282
6/11/2016	Sat			50.3	49.7	2433	2401	4834	1121	713	1834	195	135	1312	1688	3000	126	268
6/12/2016	Sun			46.6	53.4	1872	2145	4017	661	668	1329	164	154	1211	1477	2688	150	214
6/13/2016	Mon			51.3	48.7	2223	2107	4330	1021	814	1835	162	147	1202	1293	2495	150	230
6/14/2016	Tue			50.2	49.8	2155	2139	4294	1050	879	1929	147	162	1105	1260	2365	149	263
6/15/2016	Wed			50.2	49.8	2305	2286	4591	975	891	1866	137	174	1330	1395	2725	170	259
6/16/2016	Thu			51.6	48.4	2310	2164	4474	990	781	1771	172	150	1320	1383	2703	155	278
6/17/2016	Fri			50.2	49.8	2517	2492	5009	1036	896	1932	164	161	1481	1596	3077	178	299
6/18/2016	Sat			51.9	48.1	2805	2600	5405	1054	1082	2136	191	203	1751	1518	3269	224	198
6/19/2016	Sun			48.5	51.5	1886	2006	3892	684	573	1257	141	128	1202	1433	2635	126	218
6/20/2016	Mon			51.4	48.6	2257	2132	4389	1010	818	1828	129	160	1247	1314	2561	155	229
6/21/2016	Tue			51.0	49.0	2343	2255	4598	1043	869	1912	182	146	1300	1386	2686	174	260
6/22/2016	Wed			51.0	49.0	2454	2358	4812	1038	896	1934	156	178	1416	1462	2878	190	273
6/23/2016	Thu			52.0	48.0	2428	2241	4669	1043	849	1892	168	161	1385	1392	2777	167	257
6/24/2016	Fri			50.8	49.2	2508	2427	4935	980	810	1790	143	153	1528	1617	3145	166	275
6/25/2016	Sat			51.6	48.4	2903	2723	5626	1185	1119	2304	223	214	1718	1604	3322	208	227
6/26/2016	Sun			48.0	52.0	2009	2176	4185	648	693	1341	146	163	1361	1483	2844	161	242
6/27/2016	Mon			50.4	49.6	2277	2238	4515	984	885	1869	152	167	1293	1353	2646	136	290
6/28/2016	Tue			50.6	49.4	2261	2204	4465	1039	789	1828	155	150	1222	1415	2637	129	259
6/29/2016	Wed			50.7	49.3	2405	2343	4748	1036	885	1921	170	162	1369	1458	2827	174	296
6/30/2016	Thu			50.1	49.9	2526	2512	5038	1051	940	1991	168	186	1475	1572	3047	196	283

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

July, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
7/1/2016	Fri			51.9	48.1	2683	2487	5170	1067	822	1889	162	155	1616	1665	3281	160	309
7/2/2016	Sat			53.6	46.4	3118	2701	5819	1014	1103	2117	213	205	2104	1598	3702	230	208
7/3/2016	Sun			52.9	47.1	2752	2453	5205	948	783	1731	214	178	1804	1670	3474	191	222
7/4/2016	Mon	*		48.9	51.1	1886	1974	3860	749	570	1319	151	120	1137	1404	2541	127	193
7/5/2016	Tue			47.0	53.0	2480	2801	5281	1089	1045	2134	137	229	1391	1756	3147	151	313
7/6/2016	Wed			50.4	49.6	2633	2589	5222	1064	957	2021	142	182	1569	1632	3201	203	272
7/7/2016	Thu			50.5	49.5	2581	2525	5106	1064	938	2002	162	149	1517	1587	3104	173	261
7/8/2016	Fri			50.6	49.4	2858	2789	5647	1075	1051	2126	170	190	1783	1738	3521	192	290
7/9/2016	Sat			51.1	48.9	3014	2890	5904	959	1335	2294	175	253	2055	1555	3610	236	193
7/10/2016	Sun			50.2	49.8	2344	2324	4668	689	790	1479	164	165	1655	1534	3189	245	179
7/11/2016	Mon			50.6	49.4	2394	2333	4727	1076	905	1981	211	90	1318	1428	2746	162	257
7/12/2016	Tue			49.6	50.4	2345	2380	4725	1040	889	1929	143	166	1305	1491	2796	144	243
7/13/2016	Wed			51.4	48.6	2618	2474	5092	1102	951	2053	151	174	1516	1523	3039	173	270
7/14/2016	Thu			52.4	47.6	2617	2382	4999	1153	913	2066	178	170	1464	1469	2933	181	268
7/15/2016	Fri			49.9	50.1	2726	2740	5466	1135	869	2004	178	158	1591	1871	3462	178	344
7/16/2016	Sat			50.6	49.4	2783	2721	5504	1003	1149	2152	173	257	1780	1572	3352	193	219
7/17/2016	Sun			49.4	50.6	2233	2291	4524	759	759	1518	154	167	1474	1532	3006	165	209
7/18/2016	Mon			51.6	48.4	2411	2262	4673	1046	881	1927	138	162	1365	1381	2746	147	271
7/19/2016	Tue			50.5	49.5	2450	2403	4853	1046	939	1985	136	170	1404	1464	2868	193	228
7/20/2016	Wed			51.2	48.8	2692	2566	5258	1102	1046	2148	151	235	1590	1520	3110	205	274
7/21/2016	Thu			51.9	48.1	2766	2559	5325	1159	945	2104	147	203	1607	1614	3221	188	303
7/22/2016	Fri			51.6	48.4	2692	2530	5222	1125	867	1992	169	152	1567	1663	3230	184	259
7/23/2016	Sat		3	50.2	49.8	1173	1165	2338	590	394	984	120	85	583	771	1354	59	126
7/24/2016	Sun		3	49.4	50.6	1745	1785	3530	598	547	1145	129	171	1147	1238	2385	140	166
7/25/2016	Mon			52.0	48.0	2619	2418	5037	1096	949	2045	140	180	1523	1469	2992	156	243
7/26/2016	Tue			50.3	49.7	2551	2521	5072	1083	963	2046	133	189	1468	1558	3026	192	266
7/27/2016	Wed			50.8	49.2	2692	2610	5302	1100	983	2083	146	191	1592	1627	3219	163	305
7/28/2016	Thu			51.0	49.0	2594	2493	5087	1100	906	2006	147	167	1494	1587	3081	164	287
7/29/2016	Fri			51.9	48.1	2736	2539	5275	1143	829	1972	163	156	1593	1710	3303	192	286
7/30/2016	Sat			51.0	49.0	2907	2788	5695	1217	917	2134	232	218	1690	1871	3561	164	277
7/31/2016	Sun			49.3	50.7	2310	2374	4684	854	806	1660	164	184	1456	1568	3024	158	257

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

August, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	D-02	D-01	D-02	1+2	D-01	D-02	1+2	D-01	D-02	D-01	D-02	1+2	D-01	D-02
8/1/2016	Mon			50.8	49.2	2307	2230	4537	1004	845	1849	233	97	1303	1385	2688	151	270
8/2/2016	Tue			51.1	48.9	2405	2299	4704	1063	808	1871	170	151	1342	1491	2833	126	280
8/3/2016	Wed			51.2	48.8	2477	2361	4838	1063	886	1949	158	179	1414	1475	2889	168	257
8/4/2016	Thu			51.3	48.7	2457	2330	4787	1031	866	1897	124	190	1426	1464	2890	153	248
8/5/2016	Fri			50.9	49.1	2746	2648	5394	1126	867	1993	180	138	1620	1781	3401	178	329
8/6/2016	Sat			51.3	48.7	2876	2726	5602	1105	876	1981	199	213	1771	1850	3621	176	275
8/7/2016	Sun			49.9	50.1	2201	2206	4407	824	666	1490	169	144	1377	1540	2917	148	241
8/8/2016	Mon			51.8	48.2	2343	2181	4524	1011	812	1823	222	85	1332	1369	2701	147	255
8/9/2016	Tue			50.6	49.4	2439	2383	4822	1043	863	1906	127	174	1396	1520	2916	166	288
8/10/2016	Wed			51.3	48.7	2469	2340	4809	1001	912	1913	140	169	1468	1428	2896	155	261
8/11/2016	Thu			50.0	50.0	2533	2533	5066	1064	845	1909	141	158	1469	1688	3157	169	289
8/12/2016	Fri			52.0	48.0	2879	2654	5533	1265	839	2104	185	134	1614	1815	3429	190	304
8/13/2016	Sat			51.9	48.1	2667	2473	5140	1140	818	1958	225	185	1527	1655	3182	196	246
8/14/2016	Sun			48.9	51.1	2082	2172	4254	744	663	1407	152	150	1338	1509	2847	135	224
8/15/2016	Mon			51.0	49.0	2306	2214	4520	1026	840	1866	209	94	1280	1374	2654	126	237
8/16/2016	Tue			50.2	49.8	2346	2330	4676	1006	852	1858	142	161	1340	1478	2818	156	256
8/17/2016	Wed			50.3	49.7	2452	2420	4872	1036	910	1946	140	177	1416	1510	2926	167	262
8/18/2016	Thu			51.3	48.7	2557	2424	4981	1052	828	1880	142	148	1505	1596	3101	190	295
8/19/2016	Fri	*		51.9	48.1	2867	2653	5520	1248	845	2093	230	182	1619	1808	3427	195	285
8/20/2016	Sat			51.4	48.6	2786	2638	5424	1039	938	1977	183	190	1747	1700	3447	174	329
8/21/2016	Sun			46.0	54.0	2083	2444	4527	749	665	1414	143	165	1334	1779	3113	146	269
8/22/2016	Mon			50.6	49.4	2283	2230	4513	1025	921	1946	144	186	1258	1309	2567	176	230
8/23/2016	Tue			49.9	50.1	2178	2189	4367	1012	749	1761	192	79	1166	1440	2606	140	269
8/24/2016	Wed			51.5	48.5	2444	2301	4745	1004	905	1909	156	184	1440	1396	2836	170	261
8/25/2016	Thu			52.6	47.4	2521	2272	4793	1087	868	1955	177	142	1434	1404	2838	173	273
8/26/2016	Fri			50.3	49.7	2605	2575	5180	1050	905	1955	143	169	1555	1670	3225	194	274
8/27/2016	Sat			50.1	49.9	2758	2745	5503	1132	918	2050	196	201	1626	1827	3453	185	265
8/28/2016	Sun			50.6	49.4	2157	2106	4263	774	656	1430	171	114	1383	1450	2833	142	215
8/29/2016	Mon			51.2	48.8	2239	2133	4372	1038	842	1880	210	116	1201	1291	2492	130	253
8/30/2016	Tue			50.1	49.9	2238	2226	4464	1030	835	1865	205	110	1208	1391	2599	168	266
8/31/2016	Wed		3	50.4	49.6	1015	998	2013	672	424	1096	125	45	343	574	917	75	73

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

September, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
9/1/2016	Thu		3	51.7	48.3	1753	1637	3390	737	505	1242	110	117	1016	1132	2148	92	215
9/2/2016	Fri			53.7	46.3	2439	2101	4540	948	742	1690	130	141	1491	1359	2850	210	227
9/3/2016	Sat			55.1	44.9	2562	2091	4653	1191	607	1798	270	140	1371	1484	2855	223	139
9/4/2016	Sun			50.7	49.3	2228	2169	4397	934	577	1511	237	123	1294	1592	2886	137	239
9/5/2016	Mon	*		44.1	55.9	1995	2531	4526	747	828	1575	145	224	1248	1703	2951	123	263
9/6/2016	Tue			51.1	48.9	2318	2216	4534	1097	819	1916	238	88	1221	1397	2618	174	248
9/7/2016	Wed			50.9	49.1	2363	2280	4643	1025	877	1902	132	158	1338	1403	2741	149	259
9/8/2016	Thu			50.6	49.4	2329	2272	4601	1042	847	1889	148	143	1287	1425	2712	150	248
9/9/2016	Fri			52.4	47.6	2571	2336	4907	1019	674	1693	184	80	1552	1662	3214	215	287
9/10/2016	Sat			51.4	48.6	2650	2507	5157	1070	879	1949	182	173	1580	1628	3208	195	235
9/11/2016	Sun			47.3	52.7	1855	2068	3923	635	617	1252	140	137	1220	1451	2671	137	209
9/12/2016	Mon			52.0	48.0	2267	2095	4362	1075	811	1886	229	90	1192	1284	2476	134	251
9/13/2016	Tue			51.1	48.9	2265	2167	4432	1039	864	1903	226	78	1226	1303	2529	172	249
9/14/2016	Wed			52.2	47.8	2393	2193	4586	1088	841	1929	152	169	1305	1352	2657	137	251
9/15/2016	Thu			51.7	48.3	2270	2122	4392	1062	757	1819	186	101	1208	1365	2573	132	251
9/16/2016	Fri			50.9	49.1	2637	2547	5184	1098	771	1869	166	136	1539	1776	3315	184	382
9/17/2016	Sat			51.9	48.1	2748	2543	5291	1225	841	2066	238	148	1523	1702	3225	189	235
9/18/2016	Sun			47.6	52.4	2036	2238	4274	730	637	1367	141	141	1306	1601	2907	149	242
9/19/2016	Mon			51.6	48.4	2395	2249	4644	1078	892	1970	211	101	1317	1357	2674	171	251
9/20/2016	Tue			50.2	49.8	2269	2248	4517	1065	863	1928	201	127	1204	1385	2589	148	266
9/21/2016	Wed			50.2	49.8	2392	2375	4767	1102	886	1988	169	190	1290	1489	2779	169	289
9/22/2016	Thu			50.6	49.4	2394	2341	4735	1050	881	1931	225	106	1344	1460	2804	152	248
9/23/2016	Fri			51.2	48.8	2519	2404	4923	1098	792	1890	192	122	1421	1612	3033	185	286
9/24/2016	Sat			49.4	50.6	2546	2609	5155	1023	938	1961	179	197	1523	1671	3194	175	247
9/25/2016	Sun			52.3	47.7	2263	2066	4329	747	686	1433	133	160	1516	1380	2896	185	206
9/26/2016	Mon			52.1	47.9	2184	2005	4189	1020	826	1846	254	69	1164	1179	2343	129	250
9/27/2016	Tue			51.5	48.5	2257	2128	4385	1034	783	1817	224	84	1223	1345	2568	176	254
9/28/2016	Wed			50.8	49.2	2314	2244	4558	1044	867	1911	151	166	1270	1377	2647	142	245
9/29/2016	Thu			51.4	48.6	2282	2162	4444	1032	765	1797	215	73	1250	1397	2647	147	270
9/30/2016	Fri			52.2	47.8	2584	2366	4950	1134	689	1823	171	129	1450	1677	3127	170	308

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

October, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	D-02	D-01	D-02	1+2	D-01	D-02	1+2	D-01	D-02	D-01	D-02	1+2	D-01	D-02
10/1/2016	Sat			51.4	48.6	2409	2275	4684	963	772	1735	167	164	1446	1503	2949	141	242
10/2/2016	Sun			47.9	52.1	1736	1889	3625	620	544	1164	112	117	1116	1345	2461	125	233
10/3/2016	Mon			51.7	48.3	2111	1972	4083	1025	748	1773	230	96	1086	1224	2310	133	238
10/4/2016	Tue			50.0	50.0	1934	1935	3869	909	664	1573	199	78	1025	1271	2296	127	241
10/5/2016	Wed			51.3	48.7	2247	2136	4383	1056	756	1812	218	83	1191	1380	2571	141	250
10/6/2016	Thu			51.4	48.6	2318	2196	4514	1059	763	1822	161	151	1259	1433	2692	161	258
10/7/2016	Fri			50.4	49.6	2380	2344	4724	1016	751	1767	212	81	1364	1593	2957	225	260
10/8/2016	Sat			51.1	48.9	2315	2213	4528	834	982	1816	121	199	1481	1231	2712	178	195
10/9/2016	Sun			49.5	50.5	2143	2184	4327	748	703	1451	154	153	1395	1481	2876	177	206
10/10/2016	Mon			50.9	49.1	2482	2398	4880	1020	857	1877	150	164	1462	1541	3003	151	281
10/11/2016	Tue			50.8	49.2	2470	2388	4858	1082	867	1949	157	171	1388	1521	2909	139	282
10/12/2016	Wed			50.2	49.8	2580	2557	5137	1101	975	2076	162	171	1479	1582	3061	190	288
10/13/2016	Thu			50.7	49.3	2632	2561	5193	1089	862	1951	156	169	1543	1699	3242	194	371
10/14/2016	Fri			49.3	50.7	2809	2890	5699	1153	1022	2175	185	180	1656	1868	3524	200	338
10/15/2016	Sat			50.5	49.5	2676	2626	5302	1041	865	1906	188	183	1635	1761	3396	190	252
10/16/2016	Sun			47.6	52.4	2128	2342	4470	721	720	1441	152	171	1407	1622	3029	178	239
10/17/2016	Mon			51.8	48.2	2317	2158	4475	1059	839	1898	255	82	1258	1319	2577	146	264
10/18/2016	Tue			51.2	48.8	2362	2250	4612	1104	800	1904	228	101	1258	1450	2708	166	297
10/19/2016	Wed			49.9	50.1	2266	2279	4545	1059	916	1975	227	100	1207	1363	2570	177	238
10/20/2016	Thu			50.7	49.3	2384	2315	4699	1018	916	1934	158	162	1366	1399	2765	167	240
10/21/2016	Fri			50.8	49.2	2597	2513	5110	1054	851	1905	137	172	1543	1662	3205	222	297
10/22/2016	Sat			52.0	48.0	2956	2731	5687	1195	1043	2238	222	191	1761	1688	3449	232	272
10/23/2016	Sun			48.4	51.6	2044	2181	4225	728	669	1397	168	143	1316	1512	2828	161	236
10/24/2016	Mon			52.1	47.9	2198	2018	4216	1050	799	1849	223	94	1148	1219	2367	145	238
10/25/2016	Tue			50.7	49.3	2220	2157	4377	1001	829	1830	157	142	1219	1328	2547	169	269
10/26/2016	Wed			50.4	49.6	2325	2284	4609	998	911	1909	146	176	1327	1373	2700	163	270
10/27/2016	Thu			51.2	48.8	2332	2219	4551	1066	816	1882	166	137	1266	1403	2669	178	262
10/28/2016	Fri			51.3	48.7	2307	2194	4501	995	740	1735	148	136	1312	1454	2766	176	263
10/29/2016	Sat			51.2	48.8	2317	2208	4525	943	793	1736	182	160	1374	1415	2789	164	201
10/30/2016	Sun			47.6	52.4	1781	1962	3743	631	689	1320	140	123	1150	1273	2423	141	181
10/31/2016	Mon			50.7	49.3	1854	1800	3654	884	700	1584	215	72	970	1100	2070	121	235

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

November, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
11/1/2016	Tue			50.5	49.5	2039	1996	4035	965	713	1678	208	78	1074	1283	2357	145	266
11/2/2016	Wed			50.3	49.7	2229	2206	4435	997	802	1799	212	81	1232	1404	2636	153	264
11/3/2016	Thu			51.9	48.1	2271	2103	4374	1056	766	1822	156	145	1215	1337	2552	124	275
11/4/2016	Fri			50.2	49.8	2409	2391	4800	1074	808	1882	163	139	1335	1583	2918	163	294
11/5/2016	Sat			50.8	49.2	2593	2507	5100	1203	773	1976	193	163	1390	1734	3124	137	293
11/6/2016	Sun			48.5	51.5	1901	2019	3920	602	675	1277	127	139	1299	1344	2643	155	192
11/7/2016	Mon			51.8	48.2	2232	2075	4307	1028	829	1857	230	70	1204	1246	2450	148	262
11/8/2016	Tue	*		50.7	49.3	2105	2049	4154	1058	705	1763	153	122	1047	1344	2391	150	279
11/9/2016	Wed			51.4	48.6	2331	2208	4539	1081	870	1951	132	192	1250	1338	2588	153	267
11/10/2016	Thu			52.0	48.0	2409	2222	4631	1027	778	1805	226	84	1382	1444	2826	210	239
11/11/2016	Fri	*		53.8	46.2	2717	2330	5047	1203	766	1969	243	150	1514	1564	3078	199	260
11/12/2016	Sat			53.4	46.6	2887	2520	5407	1345	748	2093	266	158	1542	1772	3314	185	264
11/13/2016	Sun			45.3	54.7	2041	2461	4502	818	643	1461	203	122	1223	1818	3041	124	299
11/14/2016	Mon			52.0	48.0	2369	2188	4557	1089	786	1875	144	152	1280	1402	2682	132	306
11/15/2016	Tue			50.1	49.9	2123	2117	4240	1039	820	1859	218	85	1084	1297	2381	151	261
11/16/2016	Wed			49.7	50.3	2154	2180	4334	981	837	1818	152	156	1173	1343	2516	164	259
11/17/2016	Thu			51.8	48.2	2295	2135	4430	1036	784	1820	150	146	1259	1351	2610	167	293
11/18/2016	Fri			50.7	49.3	2412	2341	4753	1026	755	1781	159	129	1386	1586	2972	208	272
11/19/2016	Sat			51.9	48.1	2437	2261	4698	929	935	1864	159	205	1508	1326	2834	198	226
11/20/2016	Sun			49.5	50.5	1893	1935	3828	670	650	1320	142	139	1223	1285	2508	151	193
11/21/2016	Mon			51.0	49.0	2087	2004	4091	1028	760	1788	227	77	1059	1244	2303	129	247
11/22/2016	Tue			52.2	47.8	2254	2067	4321	1027	770	1797	210	88	1227	1297	2524	145	278
11/23/2016	Wed			50.9	49.1	2479	2393	4872	969	800	1769	150	138	1510	1593	3103	190	280
11/24/2016	Thu	*		51.4	48.6	1547	1464	3011	509	614	1123	129	169	1038	850	1888	103	120
11/25/2016	Fri		3	52.3	47.7	2474	2256	4730	975	741	1716	196	162	1499	1515	3014	167	261
11/26/2016	Sat			51.1	48.9	2313	2214	4527	872	785	1657	164	172	1441	1429	2870	143	212
11/27/2016	Sun			47.5	52.5	1795	1980	3775	626	591	1217	127	150	1169	1389	2558	130	234
11/28/2016	Mon			51.0	49.0	2042	1964	4006	955	735	1690	218	87	1087	1229	2316	112	258
11/29/2016	Tue			50.7	49.3	2082	2023	4105	986	742	1728	191	90	1096	1281	2377	126	264
11/30/2016	Wed			49.8	50.2	2069	2087	4156	963	765	1728	198	79	1106	1322	2428	136	269

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

December, 2016

STATION NO 200330 STATION DESCRIPTION 200330 Daniel K. Inouye Hwy, Route 200, M.P. 33.04, Hawaii
Hawaii

DIRECTION 01 To Mamalahoa Hwy Rte 190, MOV 7
DIRECTION 02 To Ua Nahele St, MOV 3

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
12/1/2016	Thu			51.2	48.8	1943	1852	3795	911	689	1600	177	79	1032	1163	2195	142	194
12/2/2016	Fri			52.0	48.0	2330	2152	4482	989	661	1650	167	132	1341	1491	2832	176	277
12/3/2016	Sat			53.7	46.3	2691	2319	5010	995	718	1713	229	132	1696	1601	3297	234	185
12/4/2016	Sun			46.5	53.5	2094	2412	4506	660	879	1539	138	239	1434	1533	2967	190	247
12/5/2016	Mon			50.7	49.3	1986	1934	3920	905	774	1679	188	89	1081	1160	2241	127	212
12/6/2016	Tue			50.8	49.2	2166	2101	4267	1029	768	1797	219	84	1137	1333	2470	151	273
12/7/2016	Wed			50.6	49.4	2158	2103	4261	963	806	1769	220	76	1195	1297	2492	153	271
12/8/2016	Thu			51.6	48.4	2225	2086	4311	1039	812	1851	140	145	1186	1274	2460	178	246
12/9/2016	Fri			50.1	49.9	2269	2257	4526	1015	735	1750	131	161	1254	1522	2776	156	268
12/10/2016	Sat			50.6	49.4	2335	2283	4618	931	818	1749	197	167	1404	1465	2869	205	194
12/11/2016	Sun			50.3	49.7	1971	1949	3920	692	612	1304	176	132	1279	1337	2616	153	210
12/12/2016	Mon			50.6	49.4	1998	1954	3952	953	741	1694	196	84	1045	1213	2258	148	245
12/13/2016	Tue			50.5	49.5	2294	2250	4544	1060	787	1847	155	148	1234	1463	2697	136	299
12/14/2016	Wed			49.9	50.1	2396	2405	4801	1074	843	1917	148	171	1322	1562	2884	139	304
12/15/2016	Thu			51.5	48.5	2327	2190	4517	1052	771	1823	130	158	1275	1419	2694	203	222
12/16/2016	Fri			50.8	49.2	2323	2247	4570	987	661	1648	151	101	1336	1586	2922	178	278
12/17/2016	Sat			52.8	47.2	2539	2267	4806	994	792	1786	200	177	1545	1475	3020	190	233
12/18/2016	Sun			47.6	52.4	1669	1835	3504	664	614	1278	132	158	1005	1221	2226	157	192
12/19/2016	Mon			52.1	47.9	2312	2123	4435	1005	742	1747	150	153	1307	1381	2688	143	259
12/20/2016	Tue			51.1	48.9	2460	2353	4813	1080	864	1944	161	169	1380	1489	2869	150	285
12/21/2016	Wed			51.2	48.8	2584	2458	5042	1084	914	1998	168	170	1500	1544	3044	178	273
12/22/2016	Thu			51.5	48.5	2671	2519	5190	1110	826	1936	183	180	1561	1693	3254	179	306
12/23/2016	Fri			50.9	49.1	2617	2528	5145	987	835	1822	136	210	1630	1693	3323	198	244
12/24/2016	Sat			49.3	50.7	2141	2206	4347	657	858	1515	148	198	1484	1348	2832	174	193
12/25/2016	Sun			51.7	48.3	1926	1800	3726	519	659	1178	145	157	1407	1141	2548	152	162
12/26/2016	Mon	*		51.2	48.8	2569	2448	5017	790	975	1765	170	241	1779	1473	3252	205	229
12/27/2016	Tue			51.1	48.9	2605	2495	5100	976	911	1887	147	204	1629	1584	3213	178	282
12/28/2016	Wed			50.7	49.3	2796	2723	5519	1042	1011	2053	177	222	1754	1712	3466	193	305
12/29/2016	Thu			50.6	49.4	2602	2544	5146	1011	889	1900	160	215	1591	1655	3246	184	262
12/30/2016	Fri			50.3	49.7	2631	2596	5227	953	921	1874	172	212	1678	1675	3353	224	244
12/31/2016	Sat			49.9	50.1	1949	1960	3909	649	710	1359	146	150	1300	1250	2550	187	184

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

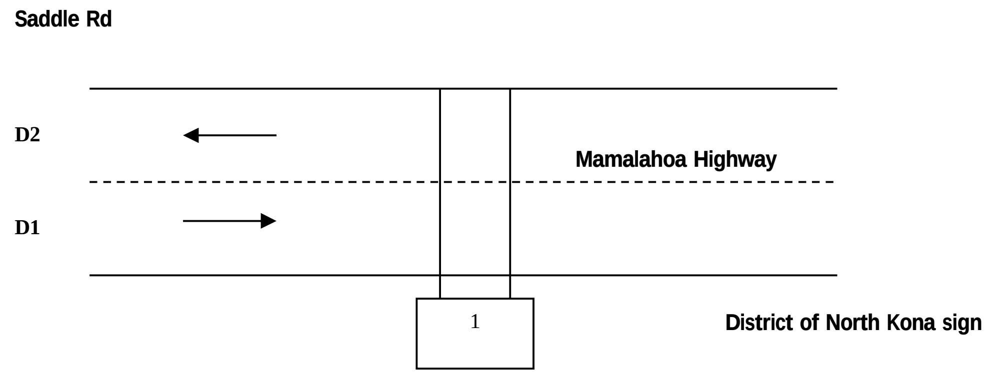
Traffic Data Service

Traffic Station Sketch

N

Island: Hawaii
Area: Holualoa

Section ID/Station #: **B71019001380**



Meter #	**File Name**	**GPS**
1. bt11	D1203009_B71019001380	19.84386, -155.749886
2.	D1203010_B71019001380	

Station Description:
Mamalahoa Highway: Saddle Rd to District of North Kona sign

Survey Beginning Date/Time: 12/3/2016 @ 0000				Survey Ending Date/Time: 12/17/2016 @ 2400		
Survey Method:	Road Tube		Data Type:	Class		
Survey Crew:	LM			C1B		
Sketch Updated:			By:	SR		
Remarks:	973					
FACILITY NAME	JURI	FUNC CLASS	AREA TYPE	ROUTE NO.		MILE
Mamalahoa Highway		16		0180		

D1= Direction to End — D1: District of North Kona sign/ Mamalahoa Hwy (Rte 190)

D2= Direction to Begin — D2: Saddle Rd / Kuakini Hwy

Run Date: 2017/08/11

Hawaii Department of Transportation

Highways Division — Highways Planning Survey Section

2016 Program Count - Summary

Site ID: B71019001380 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 6000

Functional Class: RURAL:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 190

Location: Mamalahoa Highway: Saddle Rd to District of North Kona Sign

DATE : 12/13/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	2	4	6	06:00-06:15	17	48	65	12:00-12:15	37	26	63	06:00-06:15	24	41	65
12:15-12:30	1	4	5	06:15-06:30	37	72	109	12:15-12:30	35	42	77	06:15-06:30	25	40	65
12:30-12:45	2	2	4	06:30-06:45	33	53	86	12:30-12:45	40	34	74	06:30-06:45	20	41	61
12:45-01:00	1	1	2	06:45-07:00	36	44	80	12:45-01:00	22	35	57	06:45-07:00	28	22	50
01:00-01:15	0	0	0	07:00-07:15	41	44	85	01:00-01:15	36	37	73	07:00-07:15	25	23	48
01:15-01:30	0	1	1	07:15-07:30	37	41	78	01:15-01:30	39	36	75	07:15-07:30	20	10	30
01:30-01:45	0	0	0	07:30-07:45	42	32	74	01:30-01:45	35	34	69	07:30-07:45	13	20	33
01:45-02:00	0	1	1	07:45-08:00	46	35	81	01:45-02:00	50	36	86	07:45-08:00	16	17	33
02:00-02:15	1	1	2	08:00-08:15	43	35	78	02:00-02:15	52	43	95	08:00-08:15	7	13	20
02:15-02:30	0	0	0	08:15-08:30	25	41	66	02:15-02:30	45	41	86	08:15-08:30	18	20	38
02:30-02:45	0	4	4	08:30-08:45	49	39	88	02:30-02:45	48	39	87	08:30-08:45	20	14	34
02:45-03:00	1	2	3	08:45-09:00	41	38	79	02:45-03:00	40	47	87	08:45-09:00	15	11	26
03:00-03:15	1	1	2	09:00-09:15	52	32	84	03:00-03:15	50	40	90	09:00-09:15	14	20	34
03:15-03:30	1	0	1	09:15-09:30	41	49	90	03:15-03:30	56	36	92	09:15-09:30	12	15	27
03:30-03:45	2	5	7	09:30-09:45	35	34	69	03:30-03:45	47	65	112	09:30-09:45	11	10	21
03:45-04:00	1	5	6	09:45-10:00	43	36	79	03:45-04:00	53	67	120	09:45-10:00	9	7	16
04:00-04:15	1	4	5	10:00-10:15	37	40	77	04:00-04:15	90	56	146	10:00-10:15	3	9	12
04:15-04:30	3	2	5	10:15-10:30	44	38	82	04:15-04:30	63	69	132	10:15-10:30	6	8	14
04:30-04:45	6	6	12	10:30-10:45	34	37	71	04:30-04:45	52	51	103	10:30-10:45	5	5	10
04:45-05:00	2	12	14	10:45-11:00	43	38	81	04:45-05:00	59	55	114	10:45-11:00	4	7	11
05:00-05:15	5	13	18	11:00-11:15	27	31	58	05:00-05:15	55	57	112	11:00-11:15	2	2	4
05:15-05:30	13	23	36	11:15-11:30	34	41	75	05:15-05:30	54	44	98	11:15-11:30	5	7	12
05:30-05:45	22	34	56	11:30-11:45	35	22	57	05:30-05:45	52	62	114	11:30-11:45	1	1	2
05:45-06:00	21	38	59	11:45-12:00	30	32	62	05:45-06:00	35	47	82	11:45-12:00	4	3	7

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:15 AM to 07:15 AM			PM - PEAK HR TIME	03:30 PM to 04:30 PM		
AM - PEAK HR VOLUME	147	213	360	PM - PEAK HR VOLUME	253	257	510
AM - K FACTOR (%)			7.17	PM - K FACTOR (%)			10.16
AM - D (%)	40.83	59.17	100.00	PM - D (%)	49.61	50.39	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM	06:00 AM to 07:00 AM		PM - PEAK HR TIME	04:00 PM to 05:00 PM	03:30 PM to 04:30 PM	
AM - PEAK HR VOLUME	168	217		PM - PEAK HR VOLUME	264	257	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:15 AM to 07:15 AM			PM - PEAK HR TIME	03:30 PM to 04:30 PM		
AM - PEAK HR VOLUME	147	213	360	PM - PEAK HR VOLUME	253	257	510
AM - K FACTOR (%)			7.17	PM - K FACTOR (%)			10.16
AM - D (%)	40.83	59.17	100.00	PM - D (%)	49.61	50.39	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	185	170	355
DIRECTIONAL PEAK			
PEAK HR TIME	01:45 PM to 02:45 PM	02:00 PM to 03:00 PM	
PEAK HR VOLUME	195	170	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	902	952	1,854
AM 12-HR PERIOD (00:00-12:00)	988	1,115	2,103
PM 6-HR PERIOD (12:00-18:00)	1,145	1,099	2,244
PM 12-HR PERIOD (12:00-24:00)	1,452	1,465	2,917
24 HOUR PERIOD	2,440	2,580	5,020
D (%)	48.61	51.39	100.00

Run Date: 2017/08/11

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71019001380 **Town:** Hawaii **DIR 1:** +MP **DIR 2:**-MP **Final AADT:** 6000

Functional Class: RURAL:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 190

Location: Mamalahoa Highway: Saddle Rd to District of North Kona Sign

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
DATE : 12/14/2016															
12:00-12:15	2	1	3	06:00-06:15	21	48	69	12:00-12:15	42	34	76	06:00-06:15	32	39	71
12:15-12:30	3	2	5	06:15-06:30	25	51	76	12:15-12:30	38	31	69	06:15-06:30	48	35	83
12:30-12:45	3	1	4	06:30-06:45	42	49	91	12:30-12:45	46	41	87	06:30-06:45	21	31	52
12:45-01:00	2	0	2	06:45-07:00	29	48	77	12:45-01:00	33	27	60	06:45-07:00	20	23	43
01:00-01:15	3	1	4	07:00-07:15	41	54	95	01:00-01:15	42	30	72	07:00-07:15	23	34	57
01:15-01:30	0	1	1	07:15-07:30	42	36	78	01:15-01:30	53	45	98	07:15-07:30	25	23	48
01:30-01:45	0	1	1	07:30-07:45	49	41	90	01:30-01:45	40	30	70	07:30-07:45	16	23	39
01:45-02:00	0	0	0	07:45-08:00	39	31	70	01:45-02:00	50	29	79	07:45-08:00	16	26	42
02:00-02:15	1	3	4	08:00-08:15	36	51	87	02:00-02:15	50	50	100	08:00-08:15	19	12	31
02:15-02:30	1	1	2	08:15-08:30	46	35	81	02:15-02:30	31	23	54	08:15-08:30	9	16	25
02:30-02:45	1	3	4	08:30-08:45	46	42	88	02:30-02:45	48	45	93	08:30-08:45	8	11	19
02:45-03:00	0	0	0	08:45-09:00	38	41	79	02:45-03:00	35	36	71	08:45-09:00	9	13	22
03:00-03:15	0	1	1	09:00-09:15	45	35	80	03:00-03:15	67	48	115	09:00-09:15	10	35	45
03:15-03:30	1	0	1	09:15-09:30	42	48	90	03:15-03:30	59	45	104	09:15-09:30	9	18	27
03:30-03:45	1	3	4	09:30-09:45	48	46	94	03:30-03:45	57	64	121	09:30-09:45	9	18	27
03:45-04:00	1	5	6	09:45-10:00	38	38	76	03:45-04:00	60	50	110	09:45-10:00	7	15	22
04:00-04:15	2	4	6	10:00-10:15	50	39	89	04:00-04:15	70	55	125	10:00-10:15	7	11	18
04:15-04:30	4	4	8	10:15-10:30	41	18	59	04:15-04:30	62	44	106	10:15-10:30	4	8	12
04:30-04:45	4	11	15	10:30-10:45	42	52	94	04:30-04:45	69	63	132	10:30-10:45	9	12	21
04:45-05:00	3	16	19	10:45-11:00	31	38	69	04:45-05:00	50	56	106	10:45-11:00	6	4	10
05:00-05:15	4	13	17	11:00-11:15	34	27	61	05:00-05:15	59	44	103	11:00-11:15	2	3	5
05:15-05:30	5	29	34	11:15-11:30	37	21	58	05:15-05:30	48	44	92	11:15-11:30	6	3	9
05:30-05:45	23	36	59	11:30-11:45	47	42	89	05:30-05:45	38	49	87	11:30-11:45	3	2	5
05:45-06:00	26	33	59	11:45-12:00	36	51	87	05:45-06:00	44	45	89	11:45-12:00	2	4	6

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:30 AM to 07:30 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	154	187	341	PM - PEAK HR VOLUME	261	212	473
AM - K FACTOR (%)			6.63	PM - K FACTOR (%)			9.20
AM - D (%)	45.16	54.84	100.00	PM - D (%)	55.18	44.82	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:00 AM to 08:00 AM	06:15 AM to 07:15 AM		PM - PEAK HR TIME	03:45 PM to 04:45 PM	04:00 PM to 05:00 PM	
AM - PEAK HR VOLUME	171	202		PM - PEAK HR VOLUME	261	218	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	09:15 AM to 10:15 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	178	171	349	PM - PEAK HR VOLUME	261	212	473
AM - K FACTOR (%)			6.78	PM - K FACTOR (%)			9.20
AM - D (%)	51.00	49.00	100.00	PM - D (%)	55.18	44.82	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	09:15 AM to 10:15 AM		
PEAK HR VOLUME	178	171	349
DIRECTIONAL PEAK			
PEAK HR TIME	01:15 PM to 02:15 PM	09:15 AM to 10:15 AM	
PEAK HR VOLUME	193	171	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	945	982	1,927
AM 12-HR PERIOD (00:00-12:00)	1,035	1,151	2,186
PM 6-HR PERIOD (12:00-18:00)	1,191	1,028	2,219
PM 12-HR PERIOD (12:00-24:00)	1,511	1,447	2,958
24 HOUR PERIOD	2,546	2,598	5,144
D (%)	49.49	50.51	100.00

Run Date: 2017/08/11

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71019001380 **Town:** Hawaii **DIR 1:** +MP **DIR 2:**-MP **Final AADT:** 6000

Functional Class: RURAL:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 190

Location: Mamalahoa Highway: Saddle Rd to District of North Kona Sign

DATE : 12/15/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	2	1	3	06:00-06:15	21	46	67	12:00-12:15	44	42	86	06:00-06:15	38	40	78
12:15-12:30	3	3	6	06:15-06:30	37	68	105	12:15-12:30	29	34	63	06:15-06:30	35	37	72
12:30-12:45	1	3	4	06:30-06:45	20	49	69	12:30-12:45	47	37	84	06:30-06:45	25	29	54
12:45-01:00	1	2	3	06:45-07:00	34	51	85	12:45-01:00	36	33	69	06:45-07:00	22	31	53
01:00-01:15	2	1	3	07:00-07:15	45	36	81	01:00-01:15	56	37	93	07:00-07:15	22	16	38
01:15-01:30	1	0	1	07:15-07:30	47	56	103	01:15-01:30	48	30	78	07:15-07:30	13	13	26
01:30-01:45	0	0	0	07:30-07:45	35	40	75	01:30-01:45	44	35	79	07:30-07:45	19	21	40
01:45-02:00	4	2	6	07:45-08:00	32	39	71	01:45-02:00	56	29	85	07:45-08:00	9	23	32
02:00-02:15	0	1	1	08:00-08:15	31	50	81	02:00-02:15	48	41	89	08:00-08:15	10	25	35
02:15-02:30	0	2	2	08:15-08:30	38	31	69	02:15-02:30	45	41	86	08:15-08:30	17	16	33
02:30-02:45	1	1	2	08:30-08:45	45	39	84	02:30-02:45	63	35	98	08:30-08:45	8	20	28
02:45-03:00	2	1	3	08:45-09:00	38	51	89	02:45-03:00	54	58	112	08:45-09:00	12	18	30
03:00-03:15	1	0	1	09:00-09:15	33	47	80	03:00-03:15	42	40	82	09:00-09:15	7	10	17
03:15-03:30	1	2	3	09:15-09:30	49	63	112	03:15-03:30	63	57	120	09:15-09:30	15	15	30
03:30-03:45	2	3	5	09:30-09:45	46	38	84	03:30-03:45	56	49	105	09:30-09:45	15	13	28
03:45-04:00	4	5	9	09:45-10:00	33	56	89	03:45-04:00	57	61	118	09:45-10:00	17	15	32
04:00-04:15	2	1	3	10:00-10:15	37	36	73	04:00-04:15	68	54	122	10:00-10:15	8	4	12
04:15-04:30	5	4	9	10:15-10:30	26	40	66	04:15-04:30	61	49	110	10:15-10:30	8	7	15
04:30-04:45	4	7	11	10:30-10:45	26	51	77	04:30-04:45	76	57	133	10:30-10:45	11	16	27
04:45-05:00	4	15	19	10:45-11:00	40	24	64	04:45-05:00	39	53	92	10:45-11:00	9	8	17
05:00-05:15	14	12	26	11:00-11:15	39	38	77	05:00-05:15	60	49	109	11:00-11:15	7	5	12
05:15-05:30	9	25	34	11:15-11:30	47	35	82	05:15-05:30	47	57	104	11:15-11:30	4	2	6
05:30-05:45	15	39	54	11:30-11:45	36	30	66	05:30-05:45	57	54	111	11:30-11:45	8	1	9
05:45-06:00	22	36	58	11:45-12:00	42	40	82	05:45-06:00	47	51	98	11:45-12:00	3	2	5

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:45 AM to 07:45 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	161	183	344	PM - PEAK HR VOLUME	262	221	483
AM - K FACTOR (%)			6.55	PM - K FACTOR (%)			9.20
AM - D (%)	46.80	53.20	100.00	PM - D (%)	54.24	45.76	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:45 AM to 07:45 AM	06:00 AM to 07:00 AM		PM - PEAK HR TIME	03:45 PM to 04:45 PM	03:15 PM to 04:15 PM	
AM - PEAK HR VOLUME	161	214		PM - PEAK HR VOLUME	262	221	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	08:30 AM to 09:30 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	165	200	365	PM - PEAK HR VOLUME	262	221	483
AM - K FACTOR (%)			6.95	PM - K FACTOR (%)			9.20
AM - D (%)	45.21	54.79	100.00	PM - D (%)	54.24	45.76	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	210	175	385
DIRECTIONAL PEAK			
PEAK HR TIME	01:45 PM to 02:45 PM	09:00 AM to 10:00 AM	
PEAK HR VOLUME	212	204	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	877	1,054	1,931
AM 12-HR PERIOD (00:00-12:00)	977	1,220	2,197
PM 6-HR PERIOD (12:00-18:00)	1,243	1,083	2,326
PM 12-HR PERIOD (12:00-24:00)	1,585	1,470	3,055
24 HOUR PERIOD	2,562	2,690	5,252
D (%)	48.78	51.22	100.00

Run Date: 2017/08/11

Hawaii Department of Transportation
Highways Division
Highways Planning Survey Section

Vehicle Classification Data Summary
2016

Site ID: B71019001380 **Route No:** 190 **Date From:** 2016/12/03 0:00

Town: Hawaii **Direction:** +MP **Date To:** 2016/12/16 23:45

Location: Mamalahoa Highway: Saddle Rd to District of North Kona Sign

Functional Classification: 6 RURAL:MINOR ARTERIAL

REPORT TOTALS - 336 HOURS RECORDED

	VOLUME	%	NUMBER OF AXLES
Cycles	157	0.21%	314
PC	47149	62.99%	94298
2A-4T	25035	33.44%	50070
LIGHT VEHICLE TOTALS	72341	96.64%	144682
HEAVY VEHICLES			
Bus	546	0.73%	1365
SINGLE UNIT TRUCK			
2A-6T	743	0.99%	1486
3A-SU	260	0.35%	780
4A-SU	60	0.08%	240
SINGLE-TRAILER TRUCKS			
4A-ST	181	0.24%	724
5A-ST	538	0.72%	2690
6A-ST	81	0.11%	486
MULTI-TRAILER TRUCKS			
5A-MT	39	0.05%	195
6A-MT	15	0.02%	90
7A-MT	51	0.07%	357
HEAVY VEHICLE TOTALS	2514	3.36%	8413
CLASSIFIED VEHICLES TOTALS	74855 (A)	100.00%	153095 (B)
UNCLASSIFIED VEHICLES TOTALS	1	0.00%	

AXLE CORRECTION FACTOR (A/C) = 0.978

ROADTUBE EQUIVALENT(B/2) = 76548 (C)

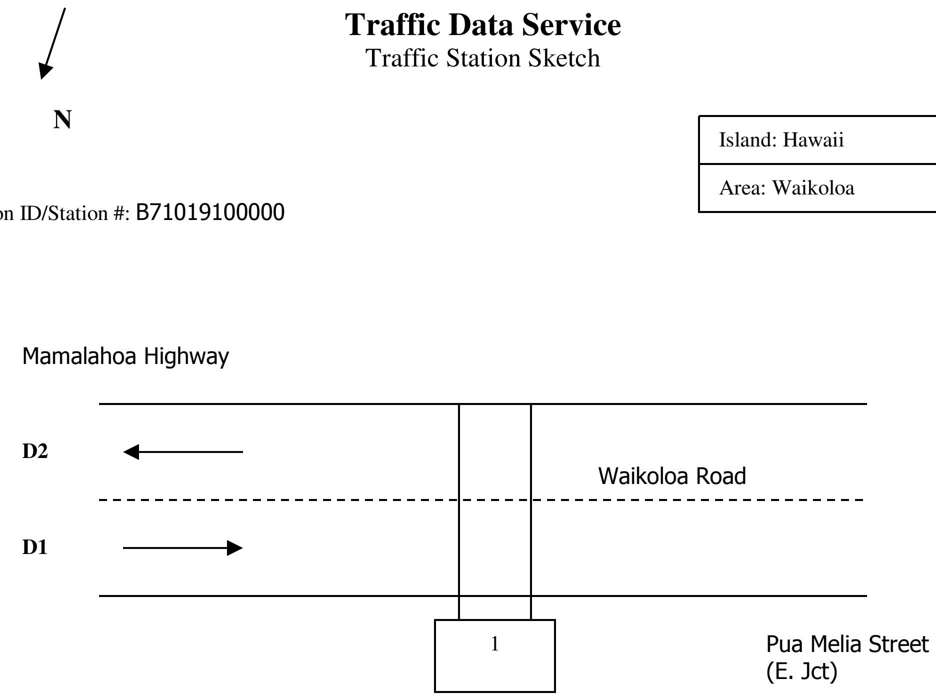
PEAK HOUR VOLUME : 596 2016/12/07 16:00	PEAK HOUR TRUCK VOLUME	% TOTAL PEAK HOUR VOLUME	24 HOUR TRUCK VOLUME	AADT	% OF AADT	HPMS K-FACTOR (PEAK/AADT) (ITEM 66)
SINGLE UNIT TRUCKS (TYPE 4-7)	8	(65A-1) 1.34%	114	6000	(65A-2) 1.90%	9.93%
COMBINATION (TYPE 8-13)	3	(65B-1) 0.50%	64		(65B-2) 1.07%	9.93%

Traffic Data Service

Traffic Station Sketch

Island: Hawaii	
Area: Waikoloa	

Section ID/Station #: B71019100000



Meter #	File Name	GPS
1. w189	D0419005_B71019100000 D0419006_B71019100000	19.9242, -155.7806

Station Description:

Waikoloa Road: Mamalahoa Highway to Pua Melia Street (E. Jct)

Survey Beginning Date/Time: 4/19/16 @ 0000		Survey Ending Date/Time: 4/20/16 @ 2400	
Survey Method:	Road Tube	Data Type:	Class
Survey Crew:	LM		C1B
Sketch Updated:		By:	SR
Remarks:	1021		

FACILITY NAME	JURI	FUNC CLASS	AREA TYPE	ROUTE NO.	ROUTE MILE
Waikoloa Road		6		0191	

D1= Direction to End
D2= Direction to Begin

D1: Pua Melia Street (E. Jct) / Queen Kaahumanu Highway
D2: Mamalahoa Highway / Mamalahoa Highway

Run Date: 2017/07/26

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71019100000 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 4700

Functional Class: RURAL:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 191

Location: Waikoloa Rd - Mamalahoa Hwy to Pua Melia St (E Jct)

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
DATE : 04/19/2016															
12:00-12:15	1	4	5	06:00-06:15	37	28	65	12:00-12:15	34	30	64	06:00-06:15	40	23	63
12:15-12:30	0	1	1	06:15-06:30	55	20	75	12:15-12:30	40	32	72	06:15-06:30	36	17	53
12:30-12:45	0	2	2	06:30-06:45	43	44	87	12:30-12:45	33	28	61	06:30-06:45	28	19	47
12:45-01:00	0	0	0	06:45-07:00	31	37	68	12:45-01:00	28	16	44	06:45-07:00	33	8	41
01:00-01:15	2	1	3	07:00-07:15	33	59	92	01:00-01:15	36	39	75	07:00-07:15	25	11	36
01:15-01:30	0	0	0	07:15-07:30	35	64	99	01:15-01:30	33	19	52	07:15-07:30	16	13	29
01:30-01:45	1	1	2	07:30-07:45	62	59	121	01:30-01:45	29	37	66	07:30-07:45	17	15	32
01:45-02:00	0	1	1	07:45-08:00	36	46	82	01:45-02:00	36	35	71	07:45-08:00	16	13	29
02:00-02:15	1	1	2	08:00-08:15	35	59	94	02:00-02:15	34	38	72	08:00-08:15	10	4	14
02:15-02:30	0	0	0	08:15-08:30	32	43	75	02:15-02:30	31	41	72	08:15-08:30	14	9	23
02:30-02:45	0	1	1	08:30-08:45	20	49	69	02:30-02:45	38	45	83	08:30-08:45	25	7	32
02:45-03:00	0	0	0	08:45-09:00	35	42	77	02:45-03:00	39	60	99	08:45-09:00	24	14	38
03:00-03:15	1	0	1	09:00-09:15	20	48	68	03:00-03:15	27	47	74	09:00-09:15	17	6	23
03:15-03:30	3	1	4	09:15-09:30	27	39	66	03:15-03:30	65	71	136	09:15-09:30	21	7	28
03:30-03:45	3	1	4	09:30-09:45	25	34	59	03:30-03:45	35	65	100	09:30-09:45	19	8	27
03:45-04:00	5	0	5	09:45-10:00	33	46	79	03:45-04:00	47	69	116	09:45-10:00	24	4	28
04:00-04:15	8	2	10	10:00-10:15	29	46	75	04:00-04:15	42	66	108	10:00-10:15	13	4	17
04:15-04:30	2	5	7	10:15-10:30	34	42	76	04:15-04:30	47	64	111	10:15-10:30	10	4	14
04:30-04:45	7	4	11	10:30-10:45	40	37	77	04:30-04:45	52	62	114	10:30-10:45	10	3	13
04:45-05:00	12	3	15	10:45-11:00	35	29	64	04:45-05:00	59	48	107	10:45-11:00	3	6	9
05:00-05:15	6	12	18	11:00-11:15	31	28	59	05:00-05:15	42	53	95	11:00-11:15	3	4	7
05:15-05:30	10	7	17	11:15-11:30	26	30	56	05:15-05:30	56	36	92	11:15-11:30	2	3	5
05:30-05:45	9	15	24	11:30-11:45	33	24	57	05:30-05:45	56	33	89	11:30-11:45	1	1	2
05:45-06:00	31	15	46	11:45-12:00	40	24	64	05:45-06:00	40	34	74	11:45-12:00	2	4	6

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM		
AM - PEAK HR VOLUME	168	228	396
AM - K FACTOR (%)			8.52
AM - D (%)	42.42	57.58	100.00
DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM	07:00 AM to 08:00 AM	
AM - PEAK HR VOLUME	168	228	

PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
PM - PEAK HR TIME	03:15 PM to 04:15 PM		
PM - PEAK HR VOLUME	189	271	460
PM - K FACTOR (%)			9.90
PM - D (%)	41.09	58.91	100.00
DIRECTIONAL PEAK			
PM - PEAK HR TIME	04:45 PM to 05:45 PM	03:15 PM to 04:15 PM	
PM - PEAK HR VOLUME	213	271	

AM PERIOD (00:00-12:00)			
TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM		
AM - PEAK HR VOLUME	168	228	396
AM - K FACTOR (%)			8.52
AM - D (%)	42.42	57.58	100.00

PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK			
PM - PEAK HR TIME	03:15 PM to 04:15 PM		
PM - PEAK HR VOLUME	189	271	460
PM - K FACTOR (%)			9.90
PM - D (%)	41.09	58.91	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	142	184	326
DIRECTIONAL PEAK			
PEAK HR TIME	11:30 AM to 12:30 PM	02:00 PM to 03:00 PM	
PEAK HR VOLUME	147	184	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	827	977	1,804
AM 12-HR PERIOD (00:00-12:00)	929	1,054	1,983
PM 6-HR PERIOD (12:00-18:00)	979	1,068	2,047
PM 12-HR PERIOD (12:00-24:00)	1,388	1,275	2,663
24 HOUR PERIOD	2,317	2,329	4,646
D (%)	49.87	50.13	100.00

Run Date: 2017/07/26

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71019100000 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 4700

Functional Class: RURAL:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 191

Location: Waikoloa Rd - Mamalahoa Hwy to Pua Melia St (E Jct)

DATE : 04/20/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	0	1	1	06:00-06:15	29	28	57	12:00-12:15	28	25	53	06:00-06:15	30	31	61
12:15-12:30	1	4	5	06:15-06:30	59	27	86	12:15-12:30	36	34	70	06:15-06:30	49	26	75
12:30-12:45	2	1	3	06:30-06:45	40	36	76	12:30-12:45	24	47	71	06:30-06:45	34	17	51
12:45-01:00	0	0	0	06:45-07:00	36	32	68	12:45-01:00	41	33	74	06:45-07:00	28	14	42
01:00-01:15	4	0	4	07:00-07:15	28	53	81	01:00-01:15	42	36	78	07:00-07:15	23	8	31
01:15-01:30	1	2	3	07:15-07:30	58	70	128	01:15-01:30	37	38	75	07:15-07:30	29	12	41
01:30-01:45	3	2	5	07:30-07:45	64	45	109	01:30-01:45	26	38	64	07:30-07:45	25	9	34
01:45-02:00	0	0	0	07:45-08:00	52	51	103	01:45-02:00	27	47	74	07:45-08:00	21	9	30
02:00-02:15	0	1	1	08:00-08:15	34	62	96	02:00-02:15	41	44	85	08:00-08:15	21	10	31
02:15-02:30	2	0	2	08:15-08:30	31	44	75	02:15-02:30	36	33	69	08:15-08:30	11	4	15
02:30-02:45	0	1	1	08:30-08:45	29	51	80	02:30-02:45	32	43	75	08:30-08:45	18	9	27
02:45-03:00	1	0	1	08:45-09:00	32	47	79	02:45-03:00	45	52	97	08:45-09:00	19	13	32
03:00-03:15	1	0	1	09:00-09:15	24	46	70	03:00-03:15	35	58	93	09:00-09:15	33	6	39
03:15-03:30	4	2	6	09:15-09:30	24	38	62	03:15-03:30	45	70	115	09:15-09:30	21	9	30
03:30-03:45	4	0	4	09:30-09:45	30	35	65	03:30-03:45	36	74	110	09:30-09:45	26	3	29
03:45-04:00	5	2	7	09:45-10:00	33	47	80	03:45-04:00	47	82	129	09:45-10:00	16	5	21
04:00-04:15	7	0	7	10:00-10:15	30	36	66	04:00-04:15	52	66	118	10:00-10:15	14	4	18
04:15-04:30	4	6	10	10:15-10:30	22	45	67	04:15-04:30	43	60	103	10:15-10:30	10	6	16
04:30-04:45	5	6	11	10:30-10:45	42	44	86	04:30-04:45	62	68	130	10:30-10:45	12	6	18
04:45-05:00	4	6	10	10:45-11:00	41	28	69	04:45-05:00	46	42	88	10:45-11:00	7	8	15
05:00-05:15	5	10	15	11:00-11:15	39	33	72	05:00-05:15	47	47	94	11:00-11:15	9	6	15
05:15-05:30	11	6	17	11:15-11:30	32	40	72	05:15-05:30	48	36	84	11:15-11:30	6	5	11
05:30-05:45	11	11	22	11:30-11:45	17	28	45	05:30-05:45	50	32	82	11:30-11:45	4	7	11
05:45-06:00	18	18	36	11:45-12:00	31	30	61	05:45-06:00	45	32	77	11:45-12:00	5	1	6

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	208	228	436	PM - PEAK HR VOLUME	204	276	480
AM - K FACTOR (%)			9.02	PM - K FACTOR (%)			9.93
AM - D (%)	47.71	52.29	100.00	PM - D (%)	42.50	57.50	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM	07:15 AM to 08:15 AM		PM - PEAK HR TIME	03:45 PM to 04:45 PM	03:15 PM to 04:15 PM	
AM - PEAK HR VOLUME	208	228		PM - PEAK HR VOLUME	204	292	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	208	228	436	PM - PEAK HR VOLUME	204	276	480
AM - K FACTOR (%)			9.02	PM - K FACTOR (%)			9.93
AM - D (%)	47.71	52.29	100.00	PM - D (%)	42.50	57.50	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	154	172	326
DIRECTIONAL PEAK			
PEAK HR TIME	10:30 AM to 11:30 AM	09:45 AM to 10:45 AM	
PEAK HR VOLUME	154	172	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	857	996	1,853
AM 12-HR PERIOD (00:00-12:00)	950	1,075	2,025
PM 6-HR PERIOD (12:00-18:00)	971	1,137	2,108
PM 12-HR PERIOD (12:00-24:00)	1,442	1,365	2,807
24 HOUR PERIOD	2,392	2,440	4,832
D (%)	49.50	50.50	100.00

Run Date: 2017/07/26

Hawaii Department of Transportation
Highways Division
Highways Planning Survey Section

Vehicle Classification Data Summary
2016

Site ID: B71019100000 **Route No:** 191 **Date From:** 2016/04/19 0:00

Town: Hawaii **Direction:** +MP **Date To:** 2016/04/20 23:45

Location: Waikoloa Rd - Mamalahoa Hwy to Pua Melia St (E Jct)

Functional Classification: 6 RURAL:MINOR ARTERIAL

REPORT TOTALS - 48 HOURS RECORDED

	VOLUME	%	NUMBER OF AXLES
Cycles	31	0.33%	63
PC	6435	67.89%	12870
2A-4T	2605	27.48%	5210
LIGHT VEHICLE TOTALS	9071	95.71%	18143
HEAVY VEHICLES			
Bus	56	0.59%	140
SINGLE UNIT TRUCK			
2A-6T	142	1.50%	284
3A-SU	55	0.58%	165
4A-SU	0	0.00%	0
SINGLE-TRAILER TRUCKS			
4A-ST	78	0.82%	312
5A-ST	53	0.56%	265
6A-ST	6	0.06%	36
MULTI-TRAILER TRUCKS			
5A-MT	16	0.17%	80
6A-MT	1	0.01%	6
7A-MT	0	0.00%	0
HEAVY VEHICLE TOTALS	407	4.29%	1288
CLASSIFIED VEHICLES TOTALS	9478 (A)	100.00%	19431 (B)
UNCLASSIFIED VEHICLES TOTALS	-0	-0.00%	

AXLE CORRECTION FACTOR (A/C) = 0.976

ROADTUBE EQUIVALENT(B/2) = 9715 (C)

PEAK HOUR VOLUME : 447 2016/04/20 15:00	PEAK HOUR TRUCK VOLUME	% TOTAL PEAK HOUR VOLUME	24 HOUR TRUCK VOLUME	AADT	% OF AADT	HPMS K-FACTOR (PEAK/AADT) (ITEM 66)
SINGLE UNIT TRUCKS (TYPE 4-7)	11	(65A-1) 2.46%	126	4700	(65A-2) 2.68%	9.51%
COMBINATION (TYPE 8-13)	2	(65B-1) 0.45%	76		(65B-2) 1.62%	9.51%

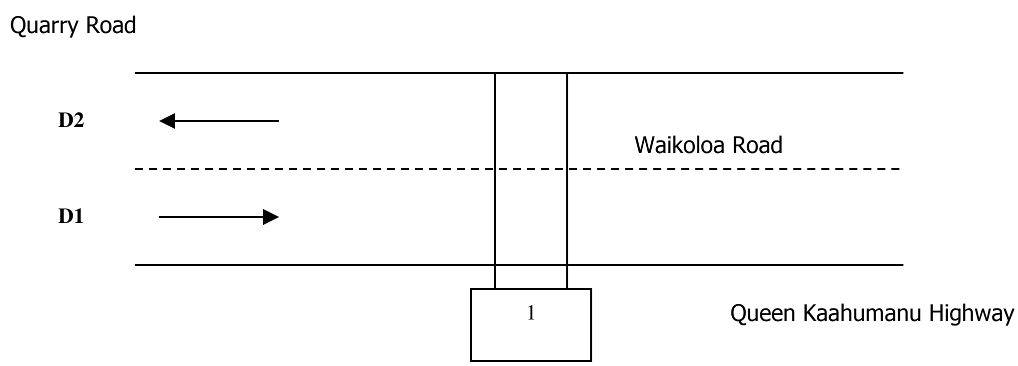
Traffic Data Service

Traffic Station Sketch

N

Island: Hawaii	
Area: Waikoloa Village	

Section ID/Station #: B71019100719



Meter #	File Name	GPS
1. bw59	D0419003_B71019100719	19.91458, -155.8355
2.	D0419004_B71019100719	

Station Description:
Waikoloa Road: Quarry Road to Queen Kaahumanu Highway

Survey Beginning Date/Time: 4/19/16 @ 0000		Survey Ending Date/Time: 4/20/16 @ 2400	
Survey Method:	Road Tube	Data Type:	Class
Survey Crew:	LM		C1B
Sketch Updated:		By:	SR
Remarks:	1020		

FACILITY NAME	JURI	FUNC CLASS	AREA TYPE	ROUTE NO.	ROUTE MILE
Waikoloa Road		16		0191	

D1= Direction to End — D1: Queen Kaahumanu Highway / Queen Kaahumanu Highway (Rte 19)
D2= Direction to Begin — D2: Quarry Road / Mamalahoa Highway (Rte 190)

Run Date: 2017/07/26

Hawaii Department of Transportation

Highways Division — Highways Planning Survey Section

2016 Program Count - Summary

Site ID: B71019100719 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 8900
Functional Class: URBAN:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 191
Location: Waikoloa Rd - Quarry Rd to Queen Kaahumanu Hwy

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
DATE : 04/19/2016															
12:00-12:15	6	1	7	06:00-06:15	16	90	106	12:00-12:15	57	61	118	06:00-06:15	73	27	100
12:15-12:30	17	1	18	06:15-06:30	29	106	135	12:15-12:30	64	60	124	06:15-06:30	83	28	111
12:30-12:45	7	0	7	06:30-06:45	26	162	188	12:30-12:45	49	48	97	06:30-06:45	70	26	96
12:45-01:00	6	1	7	06:45-07:00	19	147	166	12:45-01:00	53	70	123	06:45-07:00	89	29	118
01:00-01:15	3	1	4	07:00-07:15	25	121	146	01:00-01:15	60	61	121	07:00-07:15	75	25	100
01:15-01:30	3	1	4	07:15-07:30	43	137	180	01:15-01:30	60	58	118	07:15-07:30	78	26	104
01:30-01:45	7	3	10	07:30-07:45	33	149	182	01:30-01:45	73	48	121	07:30-07:45	60	29	89
01:45-02:00	3	1	4	07:45-08:00	29	104	133	01:45-02:00	77	72	149	07:45-08:00	46	11	57
02:00-02:15	0	2	2	08:00-08:15	29	122	151	02:00-02:15	79	61	140	08:00-08:15	41	19	60
02:15-02:30	3	0	3	08:15-08:30	32	123	155	02:15-02:30	98	45	143	08:15-08:30	50	19	69
02:30-02:45	1	0	1	08:30-08:45	28	122	150	02:30-02:45	98	72	170	08:30-08:45	50	15	65
02:45-03:00	0	1	1	08:45-09:00	43	115	158	02:45-03:00	104	59	163	08:45-09:00	52	23	75
03:00-03:15	1	1	2	09:00-09:15	37	93	130	03:00-03:15	117	48	165	09:00-09:15	53	23	76
03:15-03:30	2	2	4	09:15-09:30	40	130	170	03:15-03:30	129	38	167	09:15-09:30	50	19	69
03:30-03:45	3	11	14	09:30-09:45	39	115	154	03:30-03:45	108	51	159	09:30-09:45	58	24	82
03:45-04:00	3	6	9	09:45-10:00	36	63	99	03:45-04:00	138	68	206	09:45-10:00	48	15	63
04:00-04:15	2	12	14	10:00-10:15	48	64	112	04:00-04:15	154	42	196	10:00-10:15	53	20	73
04:15-04:30	1	13	14	10:15-10:30	31	73	104	04:15-04:30	129	60	189	10:15-10:30	56	10	66
04:30-04:45	4	31	35	10:30-10:45	55	61	116	04:30-04:45	131	54	185	10:30-10:45	37	15	52
04:45-05:00	6	26	32	10:45-11:00	39	60	99	04:45-05:00	122	54	176	10:45-11:00	30	4	34
05:00-05:15	4	31	35	11:00-11:15	44	69	113	05:00-05:15	123	59	182	11:00-11:15	25	1	26
05:15-05:30	6	46	52	11:15-11:30	51	51	102	05:15-05:30	112	69	181	11:15-11:30	23	2	25
05:30-05:45	5	64	69	11:30-11:45	43	61	104	05:30-05:45	111	62	173	11:30-11:45	9	2	11
05:45-06:00	13	72	85	11:45-12:00	60	50	110	05:45-06:00	85	45	130	11:45-12:00	14	3	17

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:30 AM to 07:30 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	113	567	680	PM - PEAK HR VOLUME	552	224	776
AM - K FACTOR (%)			7.53	PM - K FACTOR (%)			8.59
AM - D (%)	16.62	83.38	100.00	PM - D (%)	71.13	28.87	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM	06:30 AM to 07:30 AM		PM - PEAK HR TIME	03:45 PM to 04:45 PM	04:45 PM to 05:45 PM	
AM - PEAK HR VOLUME	134	567		PM - PEAK HR VOLUME	552	244	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:30 AM to 07:30 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	113	567	680	PM - PEAK HR VOLUME	552	224	776
AM - K FACTOR (%)			7.53	PM - K FACTOR (%)			8.59
AM - D (%)	16.62	83.38	100.00	PM - D (%)	71.13	28.87	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	379	237	616
DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM	09:00 AM to 10:00 AM	
PEAK HR VOLUME	379	401	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	875	2,388	3,263
AM 12-HR PERIOD (00:00-12:00)	981	2,715	3,696
PM 6-HR PERIOD (12:00-18:00)	2,331	1,365	3,696
PM 12-HR PERIOD (12:00-24:00)	3,554	1,780	5,334
24 HOUR PERIOD	4,535	4,495	9,030
D (%)	50.22	49.78	100.00

Run Date: 2017/07/26

Hawaii Department of Transportation

Highways Division | **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71019100719 | **Town:** Hawaii | **DIR 1:** +MP | **DIR 2:** -MP | **Final AADT:** 8900

Functional Class: URBAN:MINOR ARTERIAL | **Count Type:** CLASS | **Counter Type:** Tube | **Route No:** 191

Location: Waikoloa Rd - Quarry Rd to Queen Kaahumanu Hwy

DATE : 04/20/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	13	1	14	06:00-06:15	13	81	94	12:00-12:15	72	51	123	06:00-06:15	91	35	126
12:15-12:30	10	2	12	06:15-06:30	24	127	151	12:15-12:30	61	62	123	06:15-06:30	85	26	111
12:30-12:45	7	3	10	06:30-06:45	27	143	170	12:30-12:45	58	70	128	06:30-06:45	65	36	101
12:45-01:00	7	0	7	06:45-07:00	27	189	216	12:45-01:00	69	54	123	06:45-07:00	71	27	98
01:00-01:15	7	0	7	07:00-07:15	22	97	119	01:00-01:15	64	46	110	07:00-07:15	70	27	97
01:15-01:30	2	2	4	07:15-07:30	39	139	178	01:15-01:30	72	66	138	07:15-07:30	74	41	115
01:30-01:45	2	1	3	07:30-07:45	34	117	151	01:30-01:45	91	69	160	07:30-07:45	74	22	96
01:45-02:00	3	3	6	07:45-08:00	26	144	170	01:45-02:00	73	62	135	07:45-08:00	75	26	101
02:00-02:15	1	1	2	08:00-08:15	30	107	137	02:00-02:15	74	56	130	08:00-08:15	62	24	86
02:15-02:30	2	0	2	08:15-08:30	32	94	126	02:15-02:30	82	71	153	08:15-08:30	56	16	72
02:30-02:45	1	2	3	08:30-08:45	36	102	138	02:30-02:45	84	49	133	08:30-08:45	59	24	83
02:45-03:00	3	2	5	08:45-09:00	31	65	96	02:45-03:00	100	70	170	08:45-09:00	50	19	69
03:00-03:15	2	6	8	09:00-09:15	39	94	133	03:00-03:15	126	64	190	09:00-09:15	43	20	63
03:15-03:30	0	4	4	09:15-09:30	30	107	137	03:15-03:30	117	56	173	09:15-09:30	43	30	73
03:30-03:45	1	8	9	09:30-09:45	39	75	114	03:30-03:45	101	64	165	09:30-09:45	59	24	83
03:45-04:00	2	7	9	09:45-10:00	50	81	131	03:45-04:00	144	57	201	09:45-10:00	61	18	79
04:00-04:15	1	16	17	10:00-10:15	47	80	127	04:00-04:15	132	50	182	10:00-10:15	64	14	78
04:15-04:30	3	18	21	10:15-10:30	33	80	113	04:15-04:30	139	44	183	10:15-10:30	51	19	70
04:30-04:45	5	26	31	10:30-10:45	36	65	101	04:30-04:45	119	53	172	10:30-10:45	33	13	46
04:45-05:00	6	20	26	10:45-11:00	37	94	131	04:45-05:00	96	55	151	10:45-11:00	37	8	45
05:00-05:15	4	33	37	11:00-11:15	45	63	108	05:00-05:15	107	64	171	11:00-11:15	36	8	44
05:15-05:30	9	41	50	11:15-11:30	50	74	124	05:15-05:30	103	68	171	11:15-11:30	30	6	36
05:30-05:45	6	62	68	11:30-11:45	43	63	106	05:30-05:45	112	51	163	11:30-11:45	23	1	24
05:45-06:00	11	50	61	11:45-12:00	42	48	90	05:45-06:00	99	29	128	11:45-12:00	10	1	11

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:30 AM to 07:30 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	115	568	683	PM - PEAK HR VOLUME	534	204	738
AM - K FACTOR (%)			7.54	PM - K FACTOR (%)			8.15
AM - D (%)	16.84	83.16	100.00	PM - D (%)	72.36	27.64	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM	06:30 AM to 07:30 AM		PM - PEAK HR TIME	03:45 PM to 04:45 PM	03:00 PM to 04:00 PM	
AM - PEAK HR VOLUME	129	568		PM - PEAK HR VOLUME	534	241	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:30 AM to 07:30 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	115	568	683	PM - PEAK HR VOLUME	534	204	738
AM - K FACTOR (%)			7.54	PM - K FACTOR (%)			8.15
AM - D (%)	16.84	83.16	100.00	PM - D (%)	72.36	27.64	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	340	246	586
DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM	09:00 AM to 10:00 AM	
PEAK HR VOLUME	340	357	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	832	2,329	3,161
AM 12-HR PERIOD (00:00-12:00)	940	2,637	3,577
PM 6-HR PERIOD (12:00-18:00)	2,295	1,381	3,676
PM 12-HR PERIOD (12:00-24:00)	3,617	1,866	5,483
24 HOUR PERIOD	4,557	4,503	9,060
D (%)	50.30	49.70	100.00

Run Date: 2017/07/26

Hawaii Department of Transportation
Highways Division
Highways Planning Survey Section

Vehicle Classification Data Summary
2016

Site ID: **B71019100719** **Route No:** **191** **Date From:** 2016/04/19 0:00

Town: **Hawaii** **Direction:** +MP **Date To:** 2016/04/20 23:45

Location: **Waikoloa Rd - Quarry Rd to Queen Kaahumanu Hwy**

Functional Classification: **16 URBAN:MINOR ARTERIAL**

REPORT TOTALS - 48 HOURS RECORDED

	VOLUME	%	NUMBER OF AXLES
Cycles	194	1.07%	387
PC	9250	51.13%	18500
2A-4T	7858	43.44%	15716
LIGHT VEHICLE TOTALS	17302	95.64%	34603
	HEAVY VEHICLES		
Bus	58	0.32%	145
SINGLE UNIT TRUCK			
2A-6T	71	0.39%	142
3A-SU	190	1.05%	570
4A-SU	299	1.65%	1196
SINGLE-TRAILER TRUCKS			
4A-ST	11	0.06%	44
5A-ST	66	0.36%	330
6A-ST	51	0.28%	306
MULTI-TRAILER TRUCKS			
5A-MT	9	0.05%	45
6A-MT	23	0.13%	138
7A-MT	10	0.06%	70
HEAVY VEHICLE TOTALS	788	4.36%	2986
CLASSIFIED VEHICLES TOTALS	18090 (A)	100.00%	37589 (B)
UNCLASSIFIED VEHICLES TOTALS	0	0.00%	

AXLE CORRECTION FACTOR (A/C) = 0.962

ROADTUBE EQUIVALENT(B/2) = 18795 (C)

PEAK HOUR VOLUME : 746 2016/04/19 16:00	PEAK HOUR TRUCK VOLUME	% TOTAL PEAK HOUR VOLUME	24 HOUR TRUCK VOLUME	AADT	% OF AADT	HPMS K-FACTOR (PEAK/AADT) (ITEM 66)
SINGLE UNIT TRUCKS (TYPE 4-7)	18	(65A-1) 2.41%	309	8900	(65A-2) 3.47%	8.38%
COMBINATION (TYPE 8-13)	2	(65B-1) 0.27%	85		(65B-2) 0.96%	8.38%

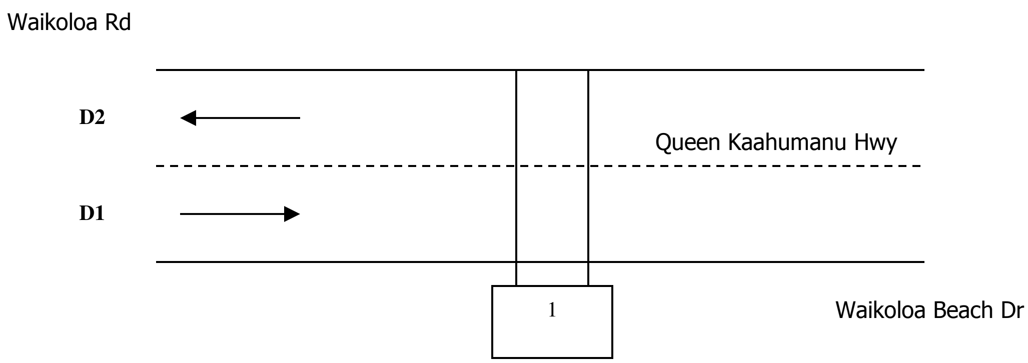
Traffic Data Service

Traffic Station Sketch

N

Island: Hawaii
Area: Puako

Section ID/Station #: B71001907467



	Meter #	**File Name**	**GPS**
1.	bw69	D0418029_B71001907467 D0418030_B71001907467	19.91402, -155.8712

Station Description:

Queen Kaahumanu Hwy: Waikoloa Rd to Waikoloa Beach Dr

Survey Beginning Date/Time: 4/19/16 @ 0000			Survey Ending Date/Time: 4/20/16 @ 2400		
Survey Method:	Road Tube		Data Type:	Class	
Survey Crew:	LM			C1B	
Sketch Updated:			By:	SR	
Remarks:					

FACILITY NAME	JURI	FUNC CLASS	AREA TYPE	ROUTE NO.	ROUTE MILE
Queen Kaahumanu Hwy		14		19	

D1= Direction to End
D2= Direction to Begin

D1: Waikoloa Beach Dr / Palani Rd (Rte 190)
D2: Waikoloa Rd / entrance to Kuhio Wharf

Run Date: 2017/07/26

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71001907467 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 17400
Functional Class: URBAN:PRINCIPAL ARTERIAL - OTHER **Count Type:** CLASS **Counter Type:** Tube **Route No:** 19
Location: Queen Kaahumanu Hwy - Waikoloa Rd to Waikoloa Beach Dr

DATE : 04/19/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	4	10	14	06:00-06:15	151	34	185	12:00-12:15	135	98	233	06:00-06:15	83	130	213
12:15-12:30	2	21	23	06:15-06:30	183	67	250	12:15-12:30	123	161	284	06:15-06:30	79	122	201
12:30-12:45	1	7	8	06:30-06:45	221	80	301	12:30-12:45	133	118	251	06:30-06:45	64	107	171
12:45-01:00	3	8	11	06:45-07:00	240	68	308	12:45-01:00	140	126	266	06:45-07:00	88	109	197
01:00-01:15	2	4	6	07:00-07:15	190	78	268	01:00-01:15	129	130	259	07:00-07:15	91	114	205
01:15-01:30	2	4	6	07:15-07:30	209	96	305	01:15-01:30	132	144	276	07:15-07:30	61	93	154
01:30-01:45	3	11	14	07:30-07:45	211	106	317	01:30-01:45	116	154	270	07:30-07:45	62	81	143
01:45-02:00	0	5	5	07:45-08:00	178	90	268	01:45-02:00	145	148	293	07:45-08:00	51	78	129
02:00-02:15	5	2	7	08:00-08:15	175	103	278	02:00-02:15	158	163	321	08:00-08:15	44	74	118
02:15-02:30	4	5	9	08:15-08:30	196	129	325	02:15-02:30	134	181	315	08:15-08:30	40	87	127
02:30-02:45	3	2	5	08:30-08:45	155	111	266	02:30-02:45	172	162	334	08:30-08:45	39	78	117
02:45-03:00	3	3	6	08:45-09:00	159	111	270	02:45-03:00	173	179	352	08:45-09:00	47	87	134
03:00-03:15	2	1	3	09:00-09:15	134	129	263	03:00-03:15	155	208	363	09:00-09:15	52	84	136
03:15-03:30	9	5	14	09:15-09:30	152	110	262	03:15-03:30	154	178	332	09:15-09:30	36	86	122
03:30-03:45	13	2	15	09:30-09:45	131	124	255	03:30-03:45	172	205	377	09:30-09:45	28	103	131
03:45-04:00	14	2	16	09:45-10:00	144	102	246	03:45-04:00	156	232	388	09:45-10:00	33	88	121
04:00-04:15	22	4	26	10:00-10:15	119	118	237	04:00-04:15	118	249	367	10:00-10:15	34	89	123
04:15-04:30	32	3	35	10:15-10:30	140	134	274	04:15-04:30	144	240	384	10:15-10:30	24	80	104
04:30-04:45	57	5	62	10:30-10:45	156	128	284	04:30-04:45	117	225	342	10:30-10:45	17	58	75
04:45-05:00	63	5	68	10:45-11:00	124	129	253	04:45-05:00	115	185	300	10:45-11:00	11	40	51
05:00-05:15	51	14	65	11:00-11:15	122	140	262	05:00-05:15	124	206	330	11:00-11:15	8	46	54
05:15-05:30	68	13	81	11:15-11:30	142	134	276	05:15-05:30	110	179	289	11:15-11:30	5	40	45
05:30-05:45	90	25	115	11:30-11:45	136	138	274	05:30-05:45	113	181	294	11:30-11:45	2	17	19
05:45-06:00	113	27	140	11:45-12:00	137	138	275	05:45-06:00	93	130	223	11:45-12:00	6	12	18

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:45 AM to 07:45 AM			PM - PEAK HR TIME	03:30 PM to 04:30 PM		
AM - PEAK HR VOLUME	850	348	1198	PM - PEAK HR VOLUME	590	926	1516
AM - K FACTOR (%)			6.80	PM - K FACTOR (%)			8.61
AM - D (%)	70.95	29.05	100.00	PM - D (%)	38.92	61.08	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:30 AM to 07:30 AM	08:00 AM to 09:00 AM		PM - PEAK HR TIME	03:00 PM to 04:00 PM	03:45 PM to 04:45 PM	
AM - PEAK HR VOLUME	860	454		PM - PEAK HR VOLUME	637	946	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:45 AM to 07:45 AM			PM - PEAK HR TIME	03:30 PM to 04:30 PM		
AM - PEAK HR VOLUME	850	348	1198	PM - PEAK HR VOLUME	590	926	1516
AM - K FACTOR (%)			6.80	PM - K FACTOR (%)			8.61
AM - D (%)	70.95	29.05	100.00	PM - D (%)	38.92	61.08	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	637	685	1322
DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM	02:00 PM to 03:00 PM	
PEAK HR VOLUME	637	685	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	3,905	2,597	6,502
AM 12-HR PERIOD (00:00-12:00)	4,471	2,785	7,256
PM 6-HR PERIOD (12:00-18:00)	3,261	4,182	7,443
PM 12-HR PERIOD (12:00-24:00)	4,266	6,085	10,351
24 HOUR PERIOD	8,737	8,870	17,607
D (%)	49.62	50.38	100.00

Run Date: 2017/07/26

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71001907467 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 17400

Functional Class: URBAN:PRINCIPAL ARTERIAL - OTHER **Count Type:** CLASS **Counter Type:** Tube **Route No:** 19

Location: Queen Kaahumanu Hwy - Waikoloa Rd to Waikoloa Beach Dr

DATE : 04/20/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	2	23	25	06:00-06:15	131	43	174	12:00-12:15	122	110	232	06:00-06:15	86	134	220
12:15-12:30	7	7	14	06:15-06:30	206	68	274	12:15-12:30	134	125	259	06:15-06:30	67	146	213
12:30-12:45	5	8	13	06:30-06:45	222	69	291	12:30-12:45	134	126	260	06:30-06:45	69	110	179
12:45-01:00	1	14	15	06:45-07:00	276	82	358	12:45-01:00	116	157	273	06:45-07:00	77	113	190
01:00-01:15	3	7	10	07:00-07:15	178	61	239	01:00-01:15	137	147	284	07:00-07:15	68	108	176
01:15-01:30	2	1	3	07:15-07:30	197	103	300	01:15-01:30	126	140	266	07:15-07:30	79	96	175
01:30-01:45	2	9	11	07:30-07:45	188	102	290	01:30-01:45	141	188	329	07:30-07:45	46	98	144
01:45-02:00	2	3	5	07:45-08:00	191	85	276	01:45-02:00	145	163	308	07:45-08:00	56	122	178
02:00-02:15	2	3	5	08:00-08:15	170	87	257	02:00-02:15	137	175	312	08:00-08:15	46	117	163
02:15-02:30	2	3	5	08:15-08:30	128	105	233	02:15-02:30	164	147	311	08:15-08:30	43	94	137
02:30-02:45	3	5	8	08:30-08:45	161	116	277	02:30-02:45	156	170	326	08:30-08:45	30	88	118
02:45-03:00	1	4	5	08:45-09:00	150	87	237	02:45-03:00	141	181	322	08:45-09:00	56	87	143
03:00-03:15	10	5	15	09:00-09:15	150	130	280	03:00-03:15	151	196	347	09:00-09:15	39	68	107
03:15-03:30	4	2	6	09:15-09:30	161	127	288	03:15-03:30	132	211	343	09:15-09:30	54	86	140
03:30-03:45	10	2	12	09:30-09:45	122	145	267	03:30-03:45	139	183	322	09:30-09:45	41	95	136
03:45-04:00	10	1	11	09:45-10:00	143	120	263	03:45-04:00	139	216	355	09:45-10:00	33	111	144
04:00-04:15	24	1	25	10:00-10:15	148	129	277	04:00-04:15	123	232	355	10:00-10:15	31	85	116
04:15-04:30	34	8	42	10:15-10:30	149	92	241	04:15-04:30	134	268	402	10:15-10:30	31	80	111
04:30-04:45	55	7	62	10:30-10:45	136	96	232	04:30-04:45	108	224	332	10:30-10:45	24	53	77
04:45-05:00	52	9	61	10:45-11:00	120	111	231	04:45-05:00	155	157	312	10:45-11:00	16	46	62
05:00-05:15	50	14	64	11:00-11:15	127	111	238	05:00-05:15	112	180	292	11:00-11:15	15	50	65
05:15-05:30	67	19	86	11:15-11:30	167	129	296	05:15-05:30	129	174	303	11:15-11:30	12	51	63
05:30-05:45	102	21	123	11:30-11:45	133	124	257	05:30-05:45	99	179	278	11:30-11:45	8	30	38
05:45-06:00	110	33	143	11:45-12:00	124	102	226	05:45-06:00	96	163	259	11:45-12:00	12	20	32

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:30 AM to 07:30 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	873	315	1188	PM - PEAK HR VOLUME	504	940	1444
AM - K FACTOR (%)			6.76	PM - K FACTOR (%)			8.21
AM - D (%)	73.48	26.52	100.00	PM - D (%)	34.90	65.10	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:15 AM to 07:15 AM	08:00 AM to 09:00 AM		PM - PEAK HR TIME	03:00 PM to 04:00 PM	03:45 PM to 04:45 PM	
AM - PEAK HR VOLUME	882	395		PM - PEAK HR VOLUME	561	940	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:30 AM to 07:30 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	873	315	1188	PM - PEAK HR VOLUME	504	940	1444
AM - K FACTOR (%)			6.76	PM - K FACTOR (%)			8.21
AM - D (%)	73.48	26.52	100.00	PM - D (%)	34.90	65.10	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	598	673	1271
DIRECTIONAL PEAK			
PEAK HR TIME	01:45 PM to 02:45 PM	01:30 PM to 02:30 PM	
PEAK HR VOLUME	602	673	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	3,878	2,424	6,302
AM 12-HR PERIOD (00:00-12:00)	4,438	2,633	7,071
PM 6-HR PERIOD (12:00-18:00)	3,170	4,212	7,382
PM 12-HR PERIOD (12:00-24:00)	4,209	6,300	10,509
24 HOUR PERIOD	8,647	8,933	17,580
D (%)	49.19	50.81	100.00

Run Date: 2017/07/26

Hawaii Department of Transportation
Highways Division
Highways Planning Survey Section

Vehicle Classification Data Summary
2016

Site ID: B71001907467 **Route No:** 19 **Date From:** 2016/04/19 0:00

Town: Hawaii **Direction:** +MP **Date To:** 2016/04/20 23:45

Location: Queen Kaahumanu Hwy - Waikoloa Rd to Waikoloa Beach Dr

Functional Classification: 14 URBAN:PRINCIPAL ARTERIAL - OTHER

REPORT TOTALS - 48 HOURS RECORDED

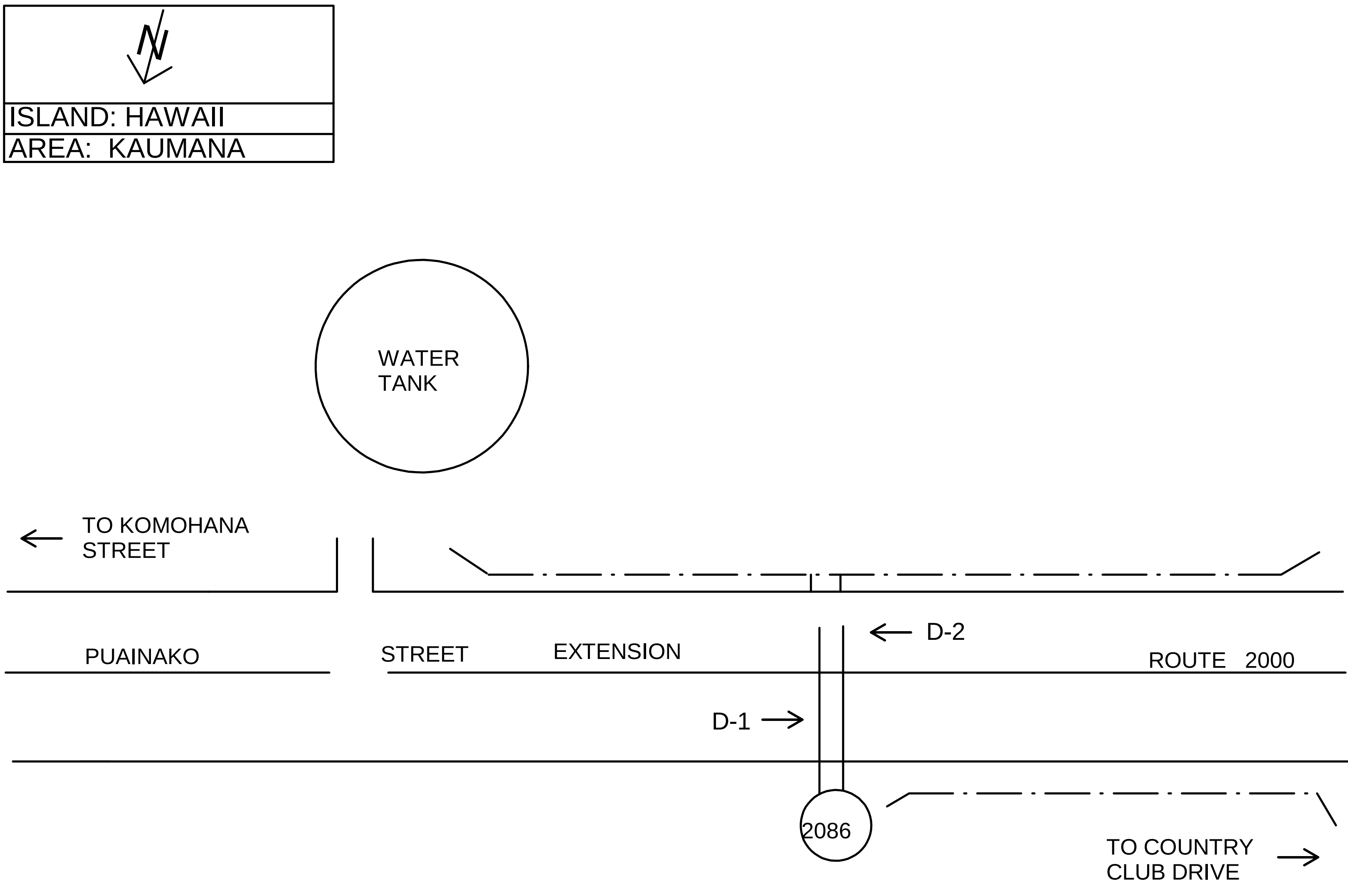
	VOLUME	%	NUMBER OF AXLES
Cycles	169	0.48%	338
PC	24330	69.14%	48660
2A-4T	9496	26.99%	18992
LIGHT VEHICLE TOTALS	33995	96.61%	67990
HEAVY VEHICLES			
Bus	275	0.78%	687
SINGLE UNIT TRUCK			
2A-6T	194	0.55%	388
3A-SU	95	0.27%	285
4A-SU	10	0.03%	40
SINGLE-TRAILER TRUCKS			
4A-ST	67	0.19%	268
5A-ST	434	1.23%	2170
6A-ST	29	0.08%	174
MULTI-TRAILER TRUCKS			
5A-MT	3	0.01%	15
6A-MT	3	0.01%	18
7A-MT	82	0.23%	574
HEAVY VEHICLE TOTALS	1192	3.39%	4619
CLASSIFIED VEHICLES TOTALS	35187 (A)	100.00%	72609 (B)
UNCLASSIFIED VEHICLES TOTALS	0	0.00%	

AXLE CORRECTION FACTOR (A/C) = 0.969

ROADTUBE EQUIVALENT(B/2) = 36305 (C)

PEAK HOUR VOLUME : 1460 2016/04/19 15:00	PEAK HOUR TRUCK VOLUME	% TOTAL PEAK HOUR VOLUME	24 HOUR TRUCK VOLUME	AADT	% OF AADT	HPMS K-FACTOR (PEAK/AADT) (ITEM 66)
SINGLE UNIT TRUCKS (TYPE 4-7)	19	(65A-1) 1.30%	287	17400	(65A-2) 1.65%	8.39%
COMBINATION (TYPE 8-13)	16	(65B-1) 1.10%	309		(65B-2) 1.78%	8.39%

ISLAND: HAWAII
AREA: KAUMANA



Station No:	B71 2000 00222

Station Location:			
Puainako Street Extension between Komohana Street and Kukuau Street			
Station Mileage:	3.22	GPS Coord (Latitude):	19.69374
		GPS Coord (Longitude):	155.09510
Begin Survey (Date/Time):	4-19-16 0000	End Survey (Date/Time):	4-22-16 0000
Survey Method: LOOP **HOSE** OTHER		Survey Type: VOL **CLASS** SPEED OTHER	
Survey Crew:	FIELD CREW	Module No.:	

HPMS DATA					
Segment Description:					
PUAINAKO STREET EXTENSION - PUAINAKO STREET TO KAUMANA DRIVE					
Segment Begin LRS	2.22	Segment End LRS	3.53	Length	1.31

Facility Name	Juris	Func Class	Area Type	Route No.	Route Mile	D-1 = Direction to End of Route / D-2 = Direction to Beginning of Route	
PUAINAKO STREET EXTENSION	S	7	2	2000	3.22	D-1	TO COUNTRY CLUB DRIVE
						D-2	TO RAILROAD AVENUE

Sketch By: RG Date: 3/22/2016 SLD: 2009

Run Date: 2017/07/06

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71200000222 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 6600
Functional Class: TEST NEW URBAN: MINOR COLLECTOR **Count Type:** CLASS **Counter Type:** Tube **Route No:** 2000
Location: Puainako Street Extension: Komohana St to Kukuau St

DATE : 04/20/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	5	5	10	06:00-06:15	55	25	80	12:00-12:15	36	51	87	06:00-06:15	74	39	113
12:15-12:30	6	8	14	06:15-06:30	51	44	95	12:15-12:30	38	32	70	06:15-06:30	40	66	106
12:30-12:45	5	10	15	06:30-06:45	44	55	99	12:30-12:45	51	41	92	06:30-06:45	42	39	81
12:45-01:00	3	2	5	06:45-07:00	53	75	128	12:45-01:00	37	45	82	06:45-07:00	46	58	104
01:00-01:15	1	6	7	07:00-07:15	53	66	119	01:00-01:15	44	41	85	07:00-07:15	45	42	87
01:15-01:30	0	3	3	07:15-07:30	39	84	123	01:15-01:30	50	39	89	07:15-07:30	42	27	69
01:30-01:45	3	1	4	07:30-07:45	47	73	120	01:30-01:45	33	27	60	07:30-07:45	39	27	66
01:45-02:00	2	3	5	07:45-08:00	52	85	137	01:45-02:00	44	52	96	07:45-08:00	38	15	53
02:00-02:15	1	0	1	08:00-08:15	45	57	102	02:00-02:15	44	45	89	08:00-08:15	30	17	47
02:15-02:30	2	1	3	08:15-08:30	42	61	103	02:15-02:30	47	26	73	08:15-08:30	30	23	53
02:30-02:45	2	2	4	08:30-08:45	41	39	80	02:30-02:45	54	54	108	08:30-08:45	19	17	36
02:45-03:00	5	2	7	08:45-09:00	47	48	95	02:45-03:00	50	49	99	08:45-09:00	25	24	49
03:00-03:15	6	4	10	09:00-09:15	52	48	100	03:00-03:15	71	41	112	09:00-09:15	34	12	46
03:15-03:30	4	4	8	09:15-09:30	40	59	99	03:15-03:30	61	50	111	09:15-09:30	25	6	31
03:30-03:45	6	5	11	09:30-09:45	46	48	94	03:30-03:45	63	61	124	09:30-09:45	19	16	35
03:45-04:00	10	3	13	09:45-10:00	42	53	95	03:45-04:00	55	61	116	09:45-10:00	10	22	32
04:00-04:15	2	2	4	10:00-10:15	39	55	94	04:00-04:15	68	62	130	10:00-10:15	18	8	26
04:15-04:30	14	1	15	10:15-10:30	39	50	89	04:15-04:30	61	65	126	10:15-10:30	16	23	39
04:30-04:45	28	8	36	10:30-10:45	50	48	98	04:30-04:45	68	110	178	10:30-10:45	11	15	26
04:45-05:00	35	8	43	10:45-11:00	41	47	88	04:45-05:00	75	63	138	10:45-11:00	5	18	23
05:00-05:15	47	8	55	11:00-11:15	33	37	70	05:00-05:15	56	97	153	11:00-11:15	5	5	10
05:15-05:30	59	7	66	11:15-11:30	46	42	88	05:15-05:30	71	49	120	11:15-11:30	4	9	13
05:30-05:45	54	20	74	11:30-11:45	35	41	76	05:30-05:45	57	67	124	11:30-11:45	8	15	23
05:45-06:00	43	28	71	11:45-12:00	37	28	65	05:45-06:00	64	66	130	11:45-12:00	4	7	11

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:00 AM to 08:00 AM			PM - PEAK HR TIME	04:15 PM to 05:15 PM		
AM - PEAK HR VOLUME	191	308	499	PM - PEAK HR VOLUME	260	335	595
AM - K FACTOR (%)			7.57	PM - K FACTOR (%)			9.03
AM - D (%)	38.28	61.72	100.00	PM - D (%)	43.70	56.30	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	05:15 AM to 06:15 AM	07:00 AM to 08:00 AM		PM - PEAK HR TIME	04:00 PM to 05:00 PM	04:15 PM to 05:15 PM	
AM - PEAK HR VOLUME	211	308		PM - PEAK HR VOLUME	272	335	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:00 AM to 08:00 AM			PM - PEAK HR TIME	04:15 PM to 05:15 PM		
AM - PEAK HR VOLUME	191	308	499	PM - PEAK HR VOLUME	260	335	595
AM - K FACTOR (%)			7.57	PM - K FACTOR (%)			9.03
AM - D (%)	38.28	61.72	100.00	PM - D (%)	43.70	56.30	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	09:00 AM to 10:00 AM		
PEAK HR VOLUME	180	208	388
DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM	09:15 AM to 10:15 AM	
PEAK HR VOLUME	195	215	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	1,069	1,268	2,337
AM 12-HR PERIOD (00:00-12:00)	1,412	1,409	2,821
PM 6-HR PERIOD (12:00-18:00)	1,298	1,294	2,592
PM 12-HR PERIOD (12:00-24:00)	1,927	1,844	3,771
24 HOUR PERIOD	3,339	3,253	6,592
D (%)	50.65	49.35	100.00

Run Date: 2017/07/06

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71200000222 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 6600
Functional Class: TEST NEW URBAN: MINOR COLLECTOR **Count Type:** CLASS **Counter Type:** Tube **Route No:** 2000
Location: Puainako Street Extension: Komohana St to Kukuau St

DATE : 04/21/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	7	13	20	06:00-06:15	38	31	69	12:00-12:15	31	41	72	06:00-06:15	76	52	128
12:15-12:30	2	7	9	06:15-06:30	49	36	85	12:15-12:30	52	30	82	06:15-06:30	78	53	131
12:30-12:45	2	3	5	06:30-06:45	49	56	105	12:30-12:45	45	42	87	06:30-06:45	46	46	92
12:45-01:00	4	8	12	06:45-07:00	41	71	112	12:45-01:00	46	58	104	06:45-07:00	49	47	96
01:00-01:15	4	3	7	07:00-07:15	38	69	107	01:00-01:15	50	88	138	07:00-07:15	42	35	77
01:15-01:30	3	3	6	07:15-07:30	55	65	120	01:15-01:30	37	45	82	07:15-07:30	38	27	65
01:30-01:45	2	1	3	07:30-07:45	42	64	106	01:30-01:45	58	56	114	07:30-07:45	35	20	55
01:45-02:00	3	4	7	07:45-08:00	60	69	129	01:45-02:00	45	45	90	07:45-08:00	41	32	73
02:00-02:15	1	1	2	08:00-08:15	43	58	101	02:00-02:15	44	55	99	08:00-08:15	67	21	88
02:15-02:30	2	1	3	08:15-08:30	65	56	121	02:15-02:30	66	52	118	08:15-08:30	38	21	59
02:30-02:45	2	0	2	08:30-08:45	45	51	96	02:30-02:45	49	48	97	08:30-08:45	38	19	57
02:45-03:00	8	0	8	08:45-09:00	46	51	97	02:45-03:00	49	46	95	08:45-09:00	25	14	39
03:00-03:15	6	1	7	09:00-09:15	53	43	96	03:00-03:15	51	73	124	09:00-09:15	27	18	45
03:15-03:30	5	1	6	09:15-09:30	38	63	101	03:15-03:30	54	44	98	09:15-09:30	27	18	45
03:30-03:45	8	5	13	09:30-09:45	52	63	115	03:30-03:45	68	55	123	09:30-09:45	25	16	41
03:45-04:00	10	2	12	09:45-10:00	33	48	81	03:45-04:00	62	65	127	09:45-10:00	20	17	37
04:00-04:15	6	1	7	10:00-10:15	33	45	78	04:00-04:15	53	82	135	10:00-10:15	15	11	26
04:15-04:30	8	1	9	10:15-10:30	44	53	97	04:15-04:30	74	60	134	10:15-10:30	16	16	32
04:30-04:45	25	9	34	10:30-10:45	40	38	78	04:30-04:45	53	82	135	10:30-10:45	5	13	18
04:45-05:00	33	5	38	10:45-11:00	29	42	71	04:45-05:00	85	79	164	10:45-11:00	10	10	20
05:00-05:15	35	11	46	11:00-11:15	41	57	98	05:00-05:15	60	90	150	11:00-11:15	9	12	21
05:15-05:30	69	13	82	11:15-11:30	32	43	75	05:15-05:30	76	88	164	11:15-11:30	4	10	14
05:30-05:45	46	15	61	11:30-11:45	33	49	82	05:30-05:45	57	71	128	11:30-11:45	7	5	12
05:45-06:00	59	28	87	11:45-12:00	46	54	100	05:45-06:00	56	70	126	11:45-12:00	4	15	19

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:00 AM to 08:00 AM		
AM - PEAK HR VOLUME	195	267	462
AM - K FACTOR (%)			6.71
AM - D (%)	42.21	57.79	100.00
DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:45 AM to 08:45 AM	06:45 AM to 07:45 AM	
AM - PEAK HR VOLUME	213	269	

PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
PM - PEAK HR TIME	04:30 PM to 05:30 PM		
PM - PEAK HR VOLUME	274	339	613
PM - K FACTOR (%)			8.91
PM - D (%)	44.70	55.30	100.00
DIRECTIONAL PEAK			
PM - PEAK HR TIME	04:45 PM to 05:45 PM	04:30 PM to 05:30 PM	
PM - PEAK HR VOLUME	278	339	

AM PERIOD (00:00-12:00)			
TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:00 AM to 08:00 AM		
AM - PEAK HR VOLUME	195	267	462
AM - K FACTOR (%)			6.71
AM - D (%)	42.21	57.79	100.00

PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK			
PM - PEAK HR TIME	04:30 PM to 05:30 PM		
PM - PEAK HR VOLUME	274	339	613
PM - K FACTOR (%)			8.91
PM - D (%)	44.70	55.30	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	12:45 PM to 01:45 PM		
PEAK HR VOLUME	191	247	438
DIRECTIONAL PEAK			
PEAK HR TIME	01:30 PM to 02:30 PM	12:45 PM to 01:45 PM	
PEAK HR VOLUME	213	247	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	1,045	1,275	2,320
AM 12-HR PERIOD (00:00-12:00)	1,395	1,411	2,806
PM 6-HR PERIOD (12:00-18:00)	1,321	1,465	2,786
PM 12-HR PERIOD (12:00-24:00)	2,063	2,013	4,076
24 HOUR PERIOD	3,458	3,424	6,882
D (%)	50.25	49.75	100.00

Run Date: 2017/07/06

Hawaii Department of Transportation
Highways Division
Highways Planning Survey Section

Vehicle Classification Data Summary
2016

Site ID: **B71200000222** **Route No:** **2000** **Date From:** 2016/04/20 0:00

Town: **Hawaii** **Direction:** +MP **Date To:** 2016/04/21 23:45

Location: **Puainako Street Extension: Komohana St to Kukuau St**

Functional Classification: **18 TEST NEW URBAN: MINOR COLLECTOR**

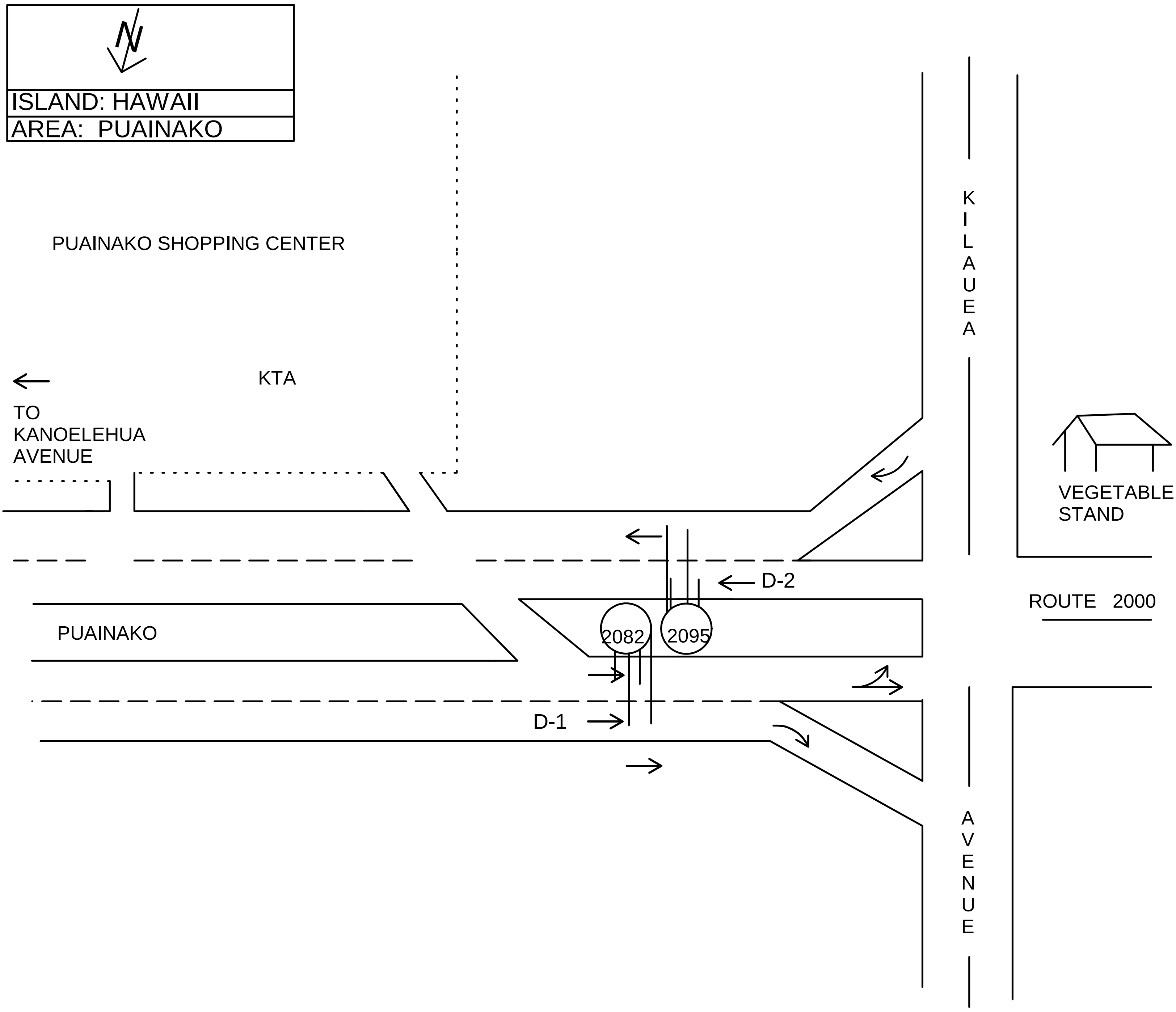
REPORT TOTALS - 48 HOURS RECORDED

	VOLUME	%	NUMBER OF AXLES
Cycles	36	0.27%	73
PC	11993	89.01%	23986
2A-4T	979	7.27%	1958
LIGHT VEHICLE TOTALS	13008	96.54%	26017
HEAVY VEHICLES			
Bus	112	0.83%	280
SINGLE UNIT TRUCK			
2A-6T	182	1.35%	364
3A-SU	33	0.24%	99
4A-SU	0	0.00%	0
SINGLE-TRAILER TRUCKS			
4A-ST	43	0.32%	172
5A-ST	82	0.61%	410
6A-ST	5	0.04%	30
MULTI-TRAILER TRUCKS			
5A-MT	8	0.06%	40
6A-MT	0	0.00%	0
7A-MT	0	0.00%	0
HEAVY VEHICLE TOTALS	465	3.45%	1395
CLASSIFIED VEHICLES TOTALS	13473 (A)	100.00%	27412 (B)
UNCLASSIFIED VEHICLES TOTALS	1	0.00%	

AXLE CORRECTION FACTOR (A/C) = 0.983

ROADTUBE EQUIVALENT(B/2) = 13706 (C)

PEAK HOUR VOLUME : 572 2016/04/20 16:00	**PEAK HOUR TRUCK VOLUME**	**% TOTAL PEAK HOUR VOLUME**	**24 HOUR TRUCK VOLUME**	**AADT**	**% OF AADT**	**HPMS K-FACTOR (PEAK/AADT) (ITEM 66)**
SINGLE UNIT TRUCKS (TYPE 4-7)	**12**	**(65A-1)** **2.10%**	**163**	**6600**	**(65A-2)** **2.47%**	**8.67%**
COMBINATION (TYPE 8-13)	**4**	**(65B-1)** **0.70%**	**69**		**(65B-2)** **1.05%**	**8.67%**



Station No:	B71 2000 00063

Station Location:			
Puainako Street between Kekela Street and Kilauea Avenue			
Station Mileage:	0.68	GPS Coord (Latitude):	19.69490
		GPS Coord (Longitude):	155.06760
Begin Survey (Date/Time):	4-19-16 0000	End Survey (Date/Time):	4-22-16 0000
Survey Method: LOOP **HOSE** OTHER		Survey Type: VOL **CLASS** SPEED OTHER	
Survey Crew:	FIELD CREW	Module No.:	

HPMS DATA

Segment Description:

PUAINAKO STREET - KANOELEHUA AVENUE TO KILAUEA AVENUE

Segment Begin LRS	0.63	Segment End LRS	0.73	Length	0.10

Facility Name	Juris	Func Class	Area Type	Route No.	Route Mile	D-1 = Direction to End of Route / D-2 = Direction to Beginning of Route	
PUAINAKO STREET	S	7	2	2000	0.68	D-1	TO COUNTRY CLUB DRIVE
						D-2	TO RAILROAD AVENUE

Sketch By:	RG	Date:	3/21/2016	SLD:	2003

Run Date: 2017/07/05

Hawaii Department of Transportation

Highways Division — Highways Planning Survey Section

2016 Program Count - Summary

Site ID: B71200000063
Functional Class: URBAN:COLLECTOR
Location: Puainako St - Kekela St to Kilauea Ave
Town: Hawaii
Count Type: CLASS
DIR 1: +MP **DIR 2:** -MP
Counter Type: Tube
Final AADT: 17400
Route No: 2000

DATE : 04/20/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	15	8	23	06:00-06:15	82	69	151	12:00-12:15	154	162	316	06:00-06:15	156	137	293
12:15-12:30	7	10	17	06:15-06:30	106	113	219	12:15-12:30	141	164	305	06:15-06:30	115	103	218
12:30-12:45	3	10	13	06:30-06:45	126	121	247	12:30-12:45	119	173	292	06:30-06:45	130	115	245
12:45-01:00	3	3	6	06:45-07:00	145	180	325	12:45-01:00	146	166	312	06:45-07:00	104	110	214
01:00-01:15	4	5	9	07:00-07:15	186	171	357	01:00-01:15	164	155	319	07:00-07:15	104	117	221
01:15-01:30	2	5	7	07:15-07:30	168	119	287	01:15-01:30	141	134	275	07:15-07:30	89	116	205
01:30-01:45	7	1	8	07:30-07:45	164	130	294	01:30-01:45	131	136	267	07:30-07:45	84	87	171
01:45-02:00	2	6	8	07:45-08:00	160	142	302	01:45-02:00	167	125	292	07:45-08:00	94	77	171
02:00-02:15	6	3	9	08:00-08:15	129	159	288	02:00-02:15	128	164	292	08:00-08:15	96	82	178
02:15-02:30	0	6	6	08:15-08:30	130	133	263	02:15-02:30	129	154	283	08:15-08:30	79	84	163
02:30-02:45	4	3	7	08:30-08:45	132	151	283	02:30-02:45	145	165	310	08:30-08:45	92	73	165
02:45-03:00	5	5	10	08:45-09:00	137	129	266	02:45-03:00	130	205	335	08:45-09:00	82	71	153
03:00-03:15	7	3	10	09:00-09:15	156	136	292	03:00-03:15	153	200	353	09:00-09:15	49	63	112
03:15-03:30	6	9	15	09:15-09:30	132	153	285	03:15-03:30	165	203	368	09:15-09:30	63	39	102
03:30-03:45	8	7	15	09:30-09:45	143	137	280	03:30-03:45	150	191	341	09:30-09:45	41	39	80
03:45-04:00	6	9	15	09:45-10:00	151	178	329	03:45-04:00	146	218	364	09:45-10:00	44	33	77
04:00-04:15	9	5	14	10:00-10:15	116	166	282	04:00-04:15	163	178	341	10:00-10:15	40	32	72
04:15-04:30	16	6	22	10:15-10:30	166	183	349	04:15-04:30	169	137	306	10:15-10:30	26	27	53
04:30-04:45	29	21	50	10:30-10:45	165	150	315	04:30-04:45	164	169	333	10:30-10:45	28	35	63
04:45-05:00	34	21	55	10:45-11:00	140	142	282	04:45-05:00	149	180	329	10:45-11:00	22	30	52
05:00-05:15	42	37	79	11:00-11:15	127	155	282	05:00-05:15	106	194	300	11:00-11:15	13	14	27
05:15-05:30	38	28	66	11:15-11:30	136	161	297	05:15-05:30	149	177	326	11:15-11:30	17	23	40
05:30-05:45	55	45	100	11:30-11:45	124	160	284	05:30-05:45	136	156	292	11:30-11:45	19	25	44
05:45-06:00	66	68	134	11:45-12:00	126	140	266	05:45-06:00	156	148	304	11:45-12:00	11	9	20

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:45 AM to 07:45 AM		
AM - PEAK HR VOLUME	663	600	1263
AM - K FACTOR (%)			6.93
AM - D (%)	52.49	47.51	100.00
DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:00 AM to 08:00 AM	06:45 AM to 07:45 AM	
AM - PEAK HR VOLUME	678	600	

PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
PM - PEAK HR TIME	03:00 PM to 04:00 PM		
PM - PEAK HR VOLUME	614	812	1426
PM - K FACTOR (%)			7.83
PM - D (%)	43.06	56.94	100.00
DIRECTIONAL PEAK			
PM - PEAK HR TIME	04:00 PM to 05:00 PM	03:00 PM to 04:00 PM	
PM - PEAK HR VOLUME	645	812	

AM PERIOD (00:00-12:00)			
TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	09:45 AM to 10:45 AM		
AM - PEAK HR VOLUME	598	677	1275
AM - K FACTOR (%)			7.00
AM - D (%)	46.90	53.10	100.00

PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK			
PM - PEAK HR TIME	03:00 PM to 04:00 PM		
PM - PEAK HR VOLUME	614	812	1426
PM - K FACTOR (%)			7.83
PM - D (%)	43.06	56.94	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	09:45 AM to 10:45 AM		
PEAK HR VOLUME	598	677	1275
DIRECTIONAL PEAK			
PEAK HR TIME	01:00 PM to 02:00 PM	02:00 PM to 03:00 PM	
PEAK HR VOLUME	603	688	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	3,347	3,478	6,825
AM 12-HR PERIOD (00:00-12:00)	3,721	3,802	7,523
PM 6-HR PERIOD (12:00-18:00)	3,501	4,054	7,555
PM 12-HR PERIOD (12:00-24:00)	5,099	5,595	10,694
24 HOUR PERIOD	8,820	9,397	18,217
D (%)	48.42	51.58	100.00

Run Date: 2017/07/05

Hawaii Department of Transportation

Highways Division — Highways Planning Survey Section

2016 Program Count - Summary

Site ID: B71200000063
Functional Class: URBAN:COLLECTOR
Location: Puainako St - Kekela St to Kilauea Ave

Town: Hawaii
Count Type: CLASS

DIR 1: +MP **DIR 2:** -MP
Counter Type: Tube

Final AADT: 17400
Route No: 2000

DATE : 04/21/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	11	12	23	06:00-06:15	82	93	175	12:00-12:15	144	165	309	06:00-06:15	150	138	288
12:15-12:30	9	12	21	06:15-06:30	106	108	214	12:15-12:30	132	157	289	06:15-06:30	132	135	267
12:30-12:45	10	10	20	06:30-06:45	142	117	259	12:30-12:45	139	165	304	06:30-06:45	141	114	255
12:45-01:00	3	3	6	06:45-07:00	150	182	332	12:45-01:00	152	185	337	06:45-07:00	135	138	273
01:00-01:15	6	2	8	07:00-07:15	198	163	361	01:00-01:15	126	142	268	07:00-07:15	116	121	237
01:15-01:30	7	3	10	07:15-07:30	157	136	293	01:15-01:30	141	148	289	07:15-07:30	98	91	189
01:30-01:45	7	5	12	07:30-07:45	155	145	300	01:30-01:45	167	132	299	07:30-07:45	90	92	182
01:45-02:00	2	3	5	07:45-08:00	146	151	297	01:45-02:00	156	151	307	07:45-08:00	101	98	199
02:00-02:15	1	4	5	08:00-08:15	133	170	303	02:00-02:15	147	160	307	08:00-08:15	107	100	207
02:15-02:30	5	2	7	08:15-08:30	141	127	268	02:15-02:30	146	186	332	08:15-08:30	88	80	168
02:30-02:45	6	5	11	08:30-08:45	131	132	263	02:30-02:45	134	166	300	08:30-08:45	90	85	175
02:45-03:00	4	5	9	08:45-09:00	127	124	251	02:45-03:00	166	203	369	08:45-09:00	67	58	125
03:00-03:15	5	6	11	09:00-09:15	133	153	286	03:00-03:15	170	191	361	09:00-09:15	84	60	144
03:15-03:30	11	3	14	09:15-09:30	122	134	256	03:15-03:30	156	175	331	09:15-09:30	71	50	121
03:30-03:45	11	8	19	09:30-09:45	159	163	322	03:30-03:45	161	210	371	09:30-09:45	58	42	100
03:45-04:00	8	13	21	09:45-10:00	130	168	298	03:45-04:00	156	190	346	09:45-10:00	43	47	90
04:00-04:15	14	6	20	10:00-10:15	145	150	295	04:00-04:15	155	186	341	10:00-10:15	39	30	69
04:15-04:30	11	6	17	10:15-10:30	126	145	271	04:15-04:30	161	177	338	10:15-10:30	35	35	70
04:30-04:45	17	13	30	10:30-10:45	143	151	294	04:30-04:45	145	169	314	10:30-10:45	28	31	59
04:45-05:00	25	22	47	10:45-11:00	145	133	278	04:45-05:00	169	201	370	10:45-11:00	30	27	57
05:00-05:15	39	27	66	11:00-11:15	144	149	293	05:00-05:15	142	180	322	11:00-11:15	17	22	39
05:15-05:30	41	26	67	11:15-11:30	147	165	312	05:15-05:30	155	186	341	11:15-11:30	15	23	38
05:30-05:45	47	50	97	11:30-11:45	124	147	271	05:30-05:45	148	165	313	11:30-11:45	19	25	44
05:45-06:00	71	74	145	11:45-12:00	126	165	291	05:45-06:00	156	143	299	11:45-12:00	18	16	34

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:45 AM to 07:45 AM			PM - PEAK HR TIME	03:00 PM to 04:00 PM		
AM - PEAK HR VOLUME	660	626	1286	PM - PEAK HR VOLUME	643	766	1409
AM - K FACTOR (%)			6.89	PM - K FACTOR (%)			7.55
AM - D (%)	51.32	48.68	100.00	PM - D (%)	45.64	54.36	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:45 AM to 07:45 AM	06:45 AM to 07:45 AM		PM - PEAK HR TIME	03:00 PM to 04:00 PM	03:00 PM to 04:00 PM	
AM - PEAK HR VOLUME	660	626		PM - PEAK HR VOLUME	643	766	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:45 AM to 07:45 AM			PM - PEAK HR TIME	02:45 PM to 03:45 PM		
AM - PEAK HR VOLUME	660	626	1286	PM - PEAK HR VOLUME	653	779	1432
AM - K FACTOR (%)			6.89	PM - K FACTOR (%)			7.67
AM - D (%)	51.32	48.68	100.00	PM - D (%)	45.60	54.40	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	593	715	1308
DIRECTIONAL PEAK			
PEAK HR TIME	01:30 PM to 02:30 PM	02:00 PM to 03:00 PM	
PEAK HR VOLUME	616	715	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	3,312	3,471	6,783
AM 12-HR PERIOD (00:00-12:00)	3,683	3,791	7,474
PM 6-HR PERIOD (12:00-18:00)	3,624	4,133	7,757
PM 12-HR PERIOD (12:00-24:00)	5,396	5,791	11,187
24 HOUR PERIOD	9,079	9,582	18,661
D (%)	48.65	51.35	100.00

Run Date: 2017/07/05

Hawaii Department of Transportation
Highways Division
Highways Planning Survey Section

Vehicle Classification Data Summary
2016

Site ID: B71200000063 **Route No:** 2000 **Date From:** 2016/04/20 0:00

Town: Hawaii **Direction:** +MP **Date To:** 2016/04/21 23:45

Location: Puainako St - Kekela St to Kilauea Ave

Functional Classification: 17 URBAN:COLLECTOR

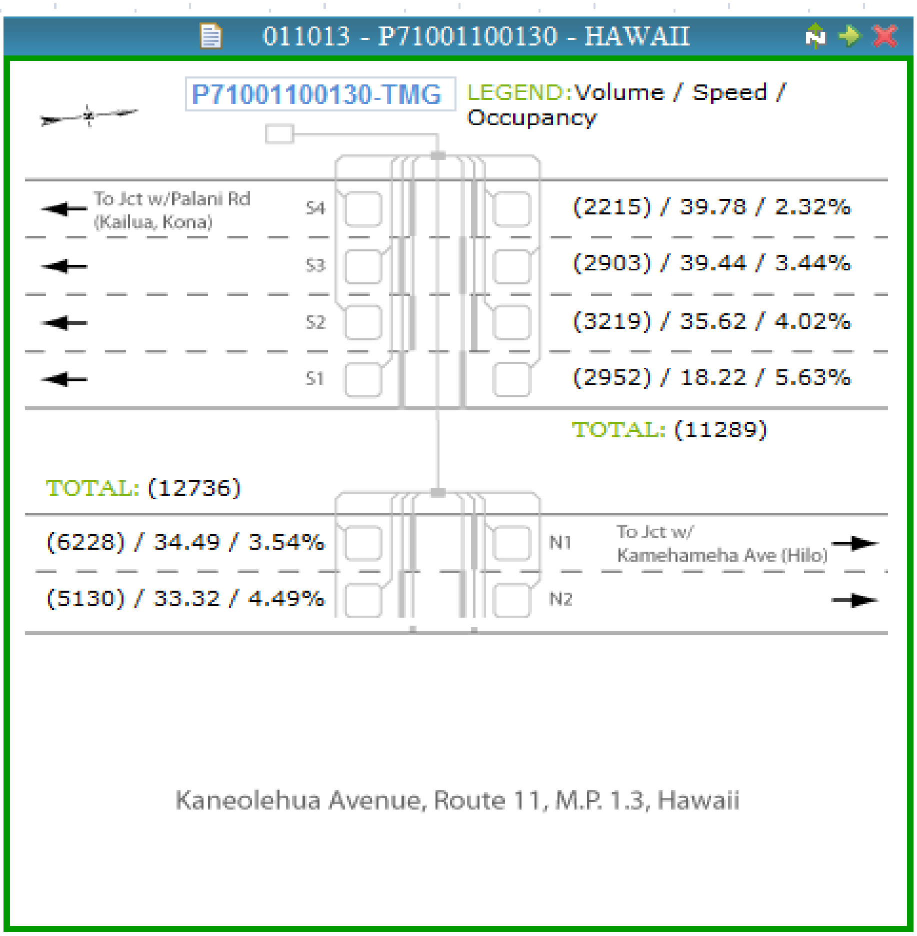
REPORT TOTALS - 48 HOURS RECORDED

	VOLUME	%	NUMBER OF AXLES
Cycles	103	0.28%	207
PC	28412	77.04%	56824
2A-4T	5339	14.48%	10678
LIGHT VEHICLE TOTALS	33854	91.80%	67708
HEAVY VEHICLES			
Bus	1060	2.87%	2650
SINGLE UNIT TRUCK			
2A-6T	665	1.80%	1330
3A-SU	80	0.22%	240
4A-SU	2	0.01%	8
SINGLE-TRAILER TRUCKS			
4A-ST	983	2.67%	3932
5A-ST	179	0.49%	895
6A-ST	6	0.02%	36
MULTI-TRAILER TRUCKS			
5A-MT	40	0.11%	200
6A-MT	1	0.00%	6
7A-MT	8	0.02%	56
HEAVY VEHICLE TOTALS	3024	8.20%	9353
CLASSIFIED VEHICLES TOTALS	36878 (A)	100.00%	77061 (B)
UNCLASSIFIED VEHICLES TOTALS	-0	-0.00%	

AXLE CORRECTION FACTOR (A/C) = 0.957

ROADTUBE EQUIVALENT(B/2) = 38531 (C)

PEAK HOUR VOLUME : 1426 2016/04/20 15:00	PEAK HOUR TRUCK VOLUME	% TOTAL PEAK HOUR VOLUME	24 HOUR TRUCK VOLUME	AADT	% OF AADT	HPMS K-FACTOR (PEAK/AADT) (ITEM 66)
SINGLE UNIT TRUCKS (TYPE 4-7)	92	(65A-1) 6.45%	903	17400	(65A-2) 5.19%	8.20%
COMBINATION (TYPE 8-13)	67	(65B-1) 4.70%	608		(65B-2) 3.49%	8.20%


011013 - P71001100130 - HAWAII
P71001100130-TMG
LEGEND:Volume / Speed / Occupancy
To Jct w/Palani Rd (Kailua, Kona)
S4
(2215) / 39.78 / 2.32%
S3
(2903) / 39.44 / 3.44%
S2
(3219) / 35.62 / 4.02%
S1
(2952) / 18.22 / 5.63%
TOTAL: (11289)
TOTAL: (12736)
(6228) / 34.49 / 3.54%
N1
To Jct w/ Kamehameha Ave (Hilo)
(5130) / 33.32 / 4.49%
N2
Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii

STATION: 011013
STATION DESCRIPTION: 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii
YEAR: 2016 - 2016
LOC'N Hawaii
DIRECTION 01 (D1): To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 (D2): To Jct w/ Kamehameha Ave (Hilo), MOV 1

MONTH	MON	TUE	WED	THU	FRI	SAT	SUN	WEEKDAY AVERAGE	MONTHLY AVERAGE	AADT MON AVE	AADT AVE WKDY
January	38772	38804	37757	37747	41830	32313	24926	38982	36021	0.99794	0.92215
February	38410	38141	38315	38662	43082	34807	25948	39322	36766	0.97771	0.91417
March	38201	39153	38647	39576	41845	32713	25595	39484	36533	0.98396	0.91041
April	37208	37924	37303	37673	42895	34164	26313	38601	36211	0.99270	0.93126
May	37691	38554	37392	38474	41739	33336	26856	38770	36292	0.99050	0.92719
June	36919	36527	37061	37827	41450	32075	25453	37957	35330	1.01746	0.94705
July	37912	38090	37979	38465	41353	33708	26780	38760	36327	0.98955	0.92743
August	37740	37773	38145	38121	41950	33068	25655	38746	36064	0.99675	0.92777
September	36717	37676	37158	36649	41425	33332	25248	37925	35458	1.01380	0.94784
October	36712	37106	35928	37909	40645	31935	24869	37660	35015	1.02663	0.95452
November	37402	37576	37687	38755	41577	31999	24925	38599	35703	1.00683	0.93128
December	39080	39290	38482	38405	40593	31376	22282	39170	35644	1.00851	0.91772
AVERAGE	37730	38051	37654	38189	41699	32902	25404	AVERAGE 38665	D1+D2 AADT 35947		

K-FACTOR 9.57%
K-FACTOR PERIOD PM
D-FACTOR 62.60%

STATION: 011013
STATION DESCRIPTION: 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii
YEAR: 2016 - 2016
LOC'N

DIRECTION 01 (D1): Hawaii
To Jct w/ Palani Rd (Kailua, Kona),MOV 5

MONTH	MON	TUE	WED	THU	FRI	SAT	SUN	WEEKDAY AVERAGE	MONTHLY AVERAGE	AADT MON AVE	AADT AVE WKDY
January	21040	21012	20448	20404	22727	17311	13266	21126	19458	0.98971	0.91158
February	20945	20644	20913	21075	23456	18723	13744	21406	19928	0.96635	0.89963
March	20653	21170	20891	21428	22611	17552	13632	21351	19705	0.97729	0.90198
April	19960	20394	20023	20204	23018	18146	13992	20720	19391	0.99314	0.92945
May	20259	20579	19969	20597	22313	17758	14209	20743	19383	0.99352	0.92838
June	19601	19454	19743	20178	22122	16972	13363	20220	18776	1.02565	0.95243
July	20129	20308	20267	20392	21969	17852	14084	20613	19286	0.99855	0.93426
August	20182	20147	20434	20322	22364	17604	13480	20690	19219	1.00201	0.93078
September	19608	20183	20005	19681	22212	17770	13471	20338	18990	1.01409	0.94689
October	19650	19871	18955	20274	21706	17100	13204	20091	18680	1.03094	0.95853
November	20097	20175	20235	20758	22269	17082	13217	20707	19119	1.00726	0.93002
December	21203	21195	20678	20629	21791	16764	11841	21099	19157	1.00524	0.91273
AVERAGE	20277	20428	20213	20495	22380	17553	13459	AVERAGE 20759	D1 AADT 19258		

STATION: 011013
STATION DESCRIPTION: 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii
YEAR: 2016 - 2016
LOC'N

DIRECTION 02 (D2): Hawaii
To Jct w/ Kamehameha Ave (Hilo), MOV 1

MONTH	MON	TUE	WED	THU	FRI	SAT	SUN	WEEKDAY AVERAGE	MONTHLY AVERAGE	AADT MON AVE	AADT AVE WKDY
January	17732	17792	17310	17344	19104	15002	11659	17856	16563	1.00761	0.93465
February	17465	17497	17402	17588	19626	16084	12205	17916	16838	0.99116	0.93155
March	17548	17983	17756	18148	19234	15161	11963	18134	16828	0.99178	0.92034
April	17249	17530	17280	17469	19878	16017	12321	17881	16821	0.99220	0.93335
May	17431	17975	17423	17878	19426	15578	12647	18027	16908	0.98705	0.92581
June	17318	17073	17318	17649	19328	15103	12090	17737	16554	1.00816	0.94091
July	17783	17782	17712	18073	19384	15856	12696	18147	17041	0.97936	0.91967
August	17558	17626	17711	17799	19585	15464	12175	18056	16845	0.99074	0.92432
September	17109	17493	17153	16968	19213	15562	11777	17587	16468	1.01345	0.94895
October	17062	17234	16973	17636	18939	14835	11665	17569	16335	1.02170	0.94994
November	17305	17401	17452	17997	19308	14917	11709	17893	16584	1.00635	0.93275
December	17877	18095	17804	17776	18802	14611	10440	18071	16487	1.01229	0.92354
AVERAGE	17453	17623	17441	17694	19319	15349	11946	AVERAGE 17906	D2 AADT 16689		

January, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	D-02	D-01	D-02	1+2	D-01	D-02	1+2	D-01	D-02	D-01	D-02	1+2	D-01	D-02
1/1/2016	Fri	*		52.4	47.6	10751	9762	20513	3391	3304	6695	754	723	7360	6458	13818	790	903
1/2/2016	Sat			53.4	46.6	16273	14201	30474	5453	5609	11062	1486	1234	10820	8592	19412	1539	1187
1/3/2016	Sun			53.1	46.9	13356	11778	25134	4197	4187	8384	1015	946	9159	7591	16750	1061	1024
1/4/2016	Mon			54.3	45.7	21901	18414	40315	7169	8236	15405	1768	1441	14732	10178	24910	2167	1304
1/5/2016	Tue			54.0	46.0	21675	18459	40134	7297	8136	15433	1714	1340	14378	10323	24701	2167	1238
1/6/2016	Wed			54.0	46.0	20121	17107	37228	6657	7806	14463	1475	1259	13464	9301	22765	2035	1154
1/7/2016	Thu			53.7	46.3	20246	17469	37715	6713	8071	14784	1532	1273	13533	9398	22931	1915	1202
1/8/2016	Fri			54.3	45.7	22553	19016	41569	7323	8304	15627	1699	1298	15230	10712	25942	2039	1333
1/9/2016	Sat			53.5	46.5	17578	15270	32848	6064	6379	12443	1472	1291	11514	8891	20405	1516	1267
1/10/2016	Sun			53.5	46.5	13719	11910	25629	4347	4377	8724	1028	957	9372	7533	16905	1140	1040
1/11/2016	Mon			53.9	46.1	20190	17282	37472	6790	8125	14915	1599	1265	13400	9157	22557	1920	1255
1/12/2016	Tue			53.8	46.2	20396	17481	37877	6691	8090	14781	1471	1227	13705	9391	23096	1978	1267
1/13/2016	Wed			53.7	46.3	19841	17095	36936	6367	8030	14397	1344	1224	13474	9065	22539	2049	1102
1/14/2016	Thu			53.9	46.1	20514	17541	38055	6756	8141	14897	1513	1232	13758	9400	23158	1969	1266
1/15/2016	Fri			54.1	45.9	22643	19190	41833	7181	8375	15556	1626	1301	15462	10815	26277	2169	1289
1/16/2016	Sat			52.7	47.3	16467	14764	31231	5655	6066	11721	1378	1240	10812	8698	19510	1348	1265
1/17/2016	Sun			52.8	47.2	12695	11363	24058	4098	4005	8103	969	863	8597	7358	15955	1005	949
1/18/2016	Mon	*		52.6	47.4	16725	15065	31790	5677	6512	12189	1343	1229	11048	8553	19601	1363	1195
1/19/2016	Tue			54.2	45.8	21084	17805	38889	6920	8221	15141	1539	1297	14164	9584	23748	2004	1316
1/20/2016	Wed			54.5	45.5	20946	17467	38413	6774	8156	14930	1448	1272	14172	9311	23483	2040	1200
1/21/2016	Thu			54.2	45.8	20089	17002	37091	6661	7804	14465	1537	1142	13428	9198	22626	2038	1165
1/22/2016	Fri			54.4	45.6	22591	18948	41539	7263	8390	15653	1622	1326	15328	10558	25886	2188	1362
1/23/2016	Sat			53.8	46.2	17625	15108	32733	5930	6402	12332	1422	1286	11695	8706	20401	1537	1231
1/24/2016	Sun			53.4	46.6	13363	11652	25015	4440	4490	8930	984	962	8923	7162	16085	1079	934
1/25/2016	Mon			54.6	45.4	21028	17500	38528	7083	8188	15271	1478	1240	13945	9312	23257	1963	1321
1/26/2016	Tue			54.5	45.5	20891	17423	38314	7079	8253	15332	1558	1282	13812	9170	22982	2047	1214
1/27/2016	Wed			54.3	45.7	20883	17569	38452	6954	8319	15273	1446	1274	13929	9250	23179	1992	1167
1/28/2016	Thu			54.5	45.5	20765	17363	38128	6843	8126	14969	1481	1222	13922	9237	23159	2015	1196
1/29/2016	Fri			54.6	45.4	23119	19260	42379	7470	8510	15980	1683	1401	15649	10750	26399	2098	1373
1/30/2016	Sat			54.3	45.7	18612	15666	34278	6201	6460	12661	1531	1320	12411	9206	21617	1542	1221
1/31/2016	Sun			53.2	46.8	13198	11594	24792	4431	4388	8819	1117	988	8767	7206	15973	1126	996

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

February, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
2/1/2016	Mon			55.0	45.0	21240	17378	38618	7269	8188	15457	1618	1312	13971	9190	23161	1993	1236
2/2/2016	Tue			54.7	45.3	20863	17306	38169	6818	8008	14826	1493	1218	14045	9298	23343	2088	1223
2/3/2016	Wed			54.9	45.1	21433	17624	39057	7164	8319	15483	1527	1315	14269	9305	23574	2040	1092
2/4/2016	Thu			54.6	45.4	21178	17575	38753	6925	8058	14983	1559	1155	14253	9517	23770	2120	1109
2/5/2016	Fri			55.0	45.0	23713	19373	43086	7949	8342	16291	1836	1366	15764	11031	26795	2165	1250
2/6/2016	Sat			54.2	45.8	19002	16082	35084	6502	6423	12925	1606	1257	12500	9659	22159	1530	1311
2/7/2016	Sun			52.9	47.1	11774	10467	22241	5008	4270	9278	1233	945	6766	6197	12963	1104	979
2/8/2016	Mon		1	54.1	45.9	20665	17539	38204	6389	7791	14180	1524	1275	14276	9748	24024	2169	1229
2/9/2016	Tue		1	54.1	45.9	20748	17612	38360	6557	8119	14676	1497	1231	14191	9493	23684	2036	1212
2/10/2016	Wed			54.9	45.1	21435	17578	39013	6861	8129	14990	1562	1220	14574	9449	24023	2117	1154
2/11/2016	Thu			54.9	45.1	22007	18046	40053	7071	8080	15151	1583	1192	14936	9966	24902	2150	1188
2/12/2016	Fri		1	54.5	45.5	23767	19871	43638	7297	8486	15783	1807	1392	16470	11385	27855	2280	1328
2/13/2016	Sat			53.8	46.2	19158	16435	35593	6445	6400	12845	1623	1360	12713	10035	22748	1645	1326
2/14/2016	Sun			52.6	47.4	14967	13463	28430	4864	4719	9583	1162	1088	10103	8744	18847	1212	1162
2/15/2016	Mon	*		53.5	46.5	16967	14744	31711	5784	6130	11914	1414	1275	11183	8614	19797	1390	1222
2/16/2016	Tue			54.8	45.2	21517	17718	39235	7153	8178	15331	1651	1255	14364	9540	23904	2196	1212
2/17/2016	Wed			54.2	45.8	19988	16893	36881	6885	8082	14967	1559	1237	13103	8811	21914	2025	1101
2/18/2016	Thu			54.2	45.8	20874	17605	38479	6801	8081	14882	1441	1233	14073	9524	23597	2053	1101
2/19/2016	Fri			53.9	46.1	23198	19879	43077	7265	8617	15882	1690	1350	15933	11262	27195	2193	1266
2/20/2016	Sat		1	52.6	47.4	17732	15994	33726	5558	6586	12144	1490	1319	12174	9408	21582	1567	1208
2/21/2016	Sun			52.9	47.1	14072	12547	26619	4556	4741	9297	1103	1000	9516	7806	17322	1217	1099
2/22/2016	Mon			54.4	45.6	20521	17211	37732	6995	7978	14973	1532	1199	13526	9233	22759	2118	1169
2/23/2016	Tue			52.8	47.2	19551	17467	37018	6002	8075	14077	1255	1200	13549	9392	22941	1938	1237
2/24/2016	Wed			54.3	45.7	20795	17513	38308	7095	8250	15345	1505	1247	13700	9263	22963	2037	1144
2/25/2016	Thu			54.2	45.8	20239	17125	37364	6744	7991	14735	1495	1240	13495	9134	22629	2046	1154
2/26/2016	Fri		1	54.0	46.0	22493	19167	41660	7427	8462	15889	1605	1397	15066	10705	25771	2017	1320
2/27/2016	Sat			53.4	46.6	18010	15735	33745	6213	6504	12717	1497	1297	11797	9231	21028	1461	1193
2/28/2016	Sun			53.4	46.6	14161	12341	26502	4912	4707	9619	1127	1009	9249	7634	16883	1167	1147
2/29/2016	Mon			54.2	45.8	21074	17807	38881	7068	8299	15367	1584	1304	14006	9508	23514	2153	1251

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

March, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
3/1/2016	Tue			54.3	45.7	21518	18117	39635	7052	8416	15468	1578	1286	14466	9701	24167	2195	1178
3/2/2016	Wed			54.5	45.5	20925	17460	38385	6969	8273	15242	1497	1247	13956	9187	23143	2064	1179
3/3/2016	Thu			54.5	45.5	22049	18435	40484	7362	8517	15879	1712	1368	14687	9918	24605	2123	1229
3/4/2016	Fri			54.3	45.7	23399	19706	43105	7628	8614	16242	1670	1315	15771	11092	26863	2154	1287
3/5/2016	Sat			54.2	45.8	19006	16074	35080	6894	6884	13778	1656	1306	12112	9190	21302	1632	1331
3/6/2016	Sun			53.2	46.8	14352	12634	26986	4807	4847	9654	1172	1004	9545	7787	17332	1281	932
3/7/2016	Mon			54.4	45.6	21359	17891	39250	7240	8284	15524	1607	1303	14119	9607	23726	2177	1305
3/8/2016	Tue			54.2	45.8	21120	17862	38982	7085	8273	15358	1541	1249	14035	9589	23624	2062	1281
3/9/2016	Wed			54.4	45.6	21060	17682	38742	7164	8244	15408	1528	1230	13896	9438	23334	2050	1207
3/10/2016	Thu			54.1	45.9	20816	17671	38487	6886	8086	14972	1483	1280	13930	9585	23515	2040	1255
3/11/2016	Fri			54.2	45.8	22418	18942	41360	7581	8348	15929	1697	1275	14837	10594	25431	2052	1332
3/12/2016	Sat			53.9	46.1	16593	14177	30770	5897	5961	11858	1493	1223	10696	8216	18912	1443	1200
3/13/2016	Sun			53.6	46.4	13150	11370	24520	4470	4228	8698	1149	875	8680	7142	15822	1202	996
3/14/2016	Mon			54.5	45.5	20707	17306	38013	6996	7961	14957	1569	1219	13711	9345	23056	2099	1162
3/15/2016	Tue			54.4	45.6	20999	17630	38629	6877	8149	15026	1535	1287	14122	9481	23603	2076	1238
3/16/2016	Wed			53.8	46.2	20439	17521	37960	6750	8268	15018	1593	1311	13689	9253	22942	2092	1140
3/17/2016	Thu			54.1	45.9	20745	17598	38343	6806	7894	14700	1547	1241	13939	9704	23643	2134	1161
3/18/2016	Fri			53.6	46.4	22017	19053	41070	7302	8475	15777	1735	1416	14715	10578	25293	2043	1278
3/19/2016	Sat			53.2	46.8	17200	15140	32340	6007	6282	12289	1409	1252	11193	8858	20051	1489	1273
3/20/2016	Sun			53.0	47.0	13394	11886	25280	4743	4624	9367	1172	954	8651	7262	15913	1189	949
3/21/2016	Mon			53.4	46.6	20178	17599	37777	6984	8031	15015	1674	1332	13194	9568	22762	2007	1107
3/22/2016	Tue			53.9	46.1	21161	18063	39224	6916	8147	15063	1573	1433	14245	9916	24161	2054	1270
3/23/2016	Wed			53.4	46.6	20314	17699	38013	6621	8046	14667	1502	1364	13693	9653	23346	1890	1147
3/24/2016	Thu			53.6	46.4	20863	18032	38895	6770	8068	14838	1508	1310	14093	9964	24057	2019	1208
3/25/2016	Fri	*		53.2	46.8	19741	17379	37120	6803	7517	14320	1554	1401	12938	9862	22800	1636	1319
3/26/2016	Sat			53.3	46.7	17409	15252	32661	5967	6250	12217	1382	1278	11442	9002	20444	1388	1185
3/27/2016	Sun	*		52.2	47.8	12637	11557	24194	4427	4687	9114	1032	959	8210	6870	15080	981	974
3/28/2016	Mon			53.9	46.1	20368	17396	37764	6793	7869	14662	1562	1306	13575	9527	23102	1995	1168
3/29/2016	Tue			53.6	46.4	21053	18243	39296	6953	8490	15443	1474	1326	14100	9753	23853	2093	1276
3/30/2016	Wed			54.1	45.9	21715	18420	40135	6994	8697	15691	1546	1346	14721	9723	24444	1887	1397
3/31/2016	Thu			54.4	45.6	22668	19004	41672	7136	8889	16025	1534	1301	15532	10115	25647	2217	1286

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

April, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	D-02	D-01	D-02	1+2	D-01	D-02	1+2	D-01	D-02	D-01	D-02	1+2	D-01	D-02
4/1/2016	Fri			54.1	45.9	24944	21156	46100	8010	9498	17508	1776	1499	16934	11658	28592	2235	1391
4/2/2016	Sat			53.3	46.7	18773	16437	35210	5752	7000	12752	1233	1268	13021	9437	22458	1874	1170
4/3/2016	Sun			53.3	46.7	14507	12719	27226	5143	4701	9844	1122	1059	9364	8018	17382	1129	1118
4/4/2016	Mon			53.6	46.4	20703	17936	38639	7021	8399	15420	1575	1352	13682	9537	23219	2040	1173
4/5/2016	Tue			53.7	46.3	21562	18565	40127	7256	8630	15886	1518	1306	14306	9935	24241	2058	1300
4/6/2016	Wed			53.7	46.3	20218	17430	37648	6885	8304	15189	1470	1219	13333	9126	22459	2144	1139
4/7/2016	Thu			53.4	46.6	20153	17611	37764	6736	8049	14785	1454	1252	13417	9562	22979	1920	1264
4/8/2016	Fri			53.5	46.5	22274	19348	41622	7267	8579	15846	1549	1327	15007	10769	25776	2103	1299
4/9/2016	Sat			53.1	46.9	17839	15786	33625	6189	6738	12927	1542	1280	11650	9048	20698	1492	1304
4/10/2016	Sun			53.0	47.0	14102	12512	26614	4539	4858	9397	1113	974	9563	7654	17217	1161	1016
4/11/2016	Mon			54.0	46.0	20038	17095	37133	6976	8098	15074	1447	1193	13062	8997	22059	1995	1186
4/12/2016	Tue			53.7	46.3	20262	17473	37735	6869	8110	14979	1505	1143	13393	9363	22756	1952	1317
4/13/2016	Wed			53.3	46.7	19343	16957	36300	6447	8177	14624	1365	1311	12896	8780	21676	1878	1174
4/14/2016	Thu			53.6	46.4	20225	17491	37716	6652	8117	14769	1452	1205	13573	9374	22947	1898	1237
4/15/2016	Fri			53.6	46.4	22740	19649	42389	7199	8533	15732	1538	1309	15541	11116	26657	2214	1291
4/16/2016	Sat			53.1	46.9	18272	16133	34405	6388	6878	13266	1552	1264	11884	9255	21139	1500	1273
4/17/2016	Sun			53.2	46.8	13748	12073	25821	4491	4559	9050	1030	970	9257	7514	16771	1136	1017
4/18/2016	Mon			53.3	46.7	18621	16310	34931	6622	7812	14434	1376	1187	11999	8498	20497	1875	1086
4/19/2016	Tue			53.8	46.2	19671	16899	36570	6657	8051	14708	1355	1189	13014	8848	21862	1865	1290
4/20/2016	Wed			53.8	46.2	20386	17538	37924	6806	8286	15092	1415	1211	13580	9252	22832	2003	1108
4/21/2016	Thu			53.7	46.3	20430	17594	38024	6727	8124	14851	1410	1161	13703	9470	23173	2002	1181
4/22/2016	Fri			53.4	46.6	22539	19684	42223	7143	8589	15732	1535	1310	15396	11095	26491	2019	1351
4/23/2016	Sat			53.1	46.9	17285	15276	32561	6151	6347	12498	1446	1229	11134	8929	20063	1424	1207
4/24/2016	Sun			53.2	46.8	13610	11981	25591	4733	4496	9229	1054	903	8877	7485	16362	1107	1043
4/25/2016	Mon			53.7	46.3	20476	17654	38130	6933	8193	15126	1498	1236	13543	9461	23004	1966	1329
4/26/2016	Tue			53.9	46.1	20079	17184	37263	6684	8152	14836	1366	1204	13395	9032	22427	1993	1183
4/27/2016	Wed			54.0	46.0	20146	17194	37340	6789	8082	14871	1410	1199	13357	9112	22469	1904	1175
4/28/2016	Thu			53.8	46.2	20007	17179	37186	6638	8022	14660	1382	1179	13369	9157	22526	1854	1304
4/29/2016	Fri			53.6	46.4	22591	19551	42142	7532	8723	16255	1579	1352	15059	10828	25887	2060	1290
4/30/2016	Sat			53.0	47.0	18563	16454	35017	6220	6771	12991	1503	1306	12343	9683	22026	1607	1253

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

May, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
5/1/2016	Sun			53.3	46.7	14315	12545	26860	5051	5044	10095	1079	1086	9264	7501	16765	1134	1114
5/2/2016	Mon			54.0	46.0	20335	17337	37672	6971	8039	15010	1505	1191	13364	9298	22662	1924	1235
5/3/2016	Tue			53.8	46.2	21281	18252	39533	7263	8518	15781	1492	1300	14018	9734	23752	2103	1269
5/4/2016	Wed			53.6	46.4	20204	17480	37684	6740	8297	15037	1452	1224	13464	9183	22647	1938	1148
5/5/2016	Thu			54.0	46.0	21675	18501	40176	7212	8328	15540	1423	1289	14463	10173	24636	2070	1335
5/6/2016	Fri			53.5	46.5	22312	19397	41709	7308	8499	15807	1535	1297	15004	10898	25902	2040	1375
5/7/2016	Sat			53.6	46.4	18636	16165	34801	6567	6912	13479	1555	1372	12069	9253	21322	1552	1241
5/8/2016	Sun			53.3	46.7	14441	12654	27095	5145	5040	10185	1118	1040	9296	7614	16910	1211	1113
5/9/2016	Mon			54.1	45.9	20389	17306	37695	7109	8000	15109	1596	1189	13280	9306	22586	1931	1333
5/10/2016	Tue			53.4	46.6	20337	17761	38098	6969	8400	15369	1497	1260	13368	9361	22729	1903	1271
5/11/2016	Wed			53.2	46.8	19326	16977	36303	6652	8101	14753	1389	1220	12674	8876	21550	1930	1109
5/12/2016	Thu			53.5	46.5	19901	17299	37200	6660	8079	14739	1392	1237	13241	9220	22461	1965	1259
5/13/2016	Fri			53.6	46.4	22716	19702	42418	7534	8654	16188	1778	1281	15182	11048	26230	1939	1372
5/14/2016	Sat			53.3	46.7	17861	15641	33502	6082	6840	12922	1436	1272	11779	8801	20580	1894	1125
5/15/2016	Sun			52.8	47.2	14389	12855	27244	4847	4910	9757	1097	1010	9542	7945	17487	1101	1054
5/16/2016	Mon			53.7	46.3	20121	17381	37502	7028	8177	15205	1531	1240	13093	9204	22297	2036	1173
5/17/2016	Tue			53.3	46.7	20219	17702	37921	6864	8128	14992	1403	1190	13355	9574	22929	1891	1313
5/18/2016	Wed			53.5	46.5	20369	17679	38048	6900	8308	15208	1393	1203	13469	9371	22840	1854	1253
5/19/2016	Thu			53.4	46.6	20126	17553	37679	6921	8088	15009	1461	1224	13205	9465	22670	1889	1268
5/20/2016	Fri			53.6	46.4	23141	20055	43196	7683	8756	16439	1813	1366	15458	11299	26757	2001	1356
5/21/2016	Sat			53.2	46.8	17731	15573	33304	6340	6483	12823	1471	1257	11391	9090	20481	1382	1157
5/22/2016	Sun			52.5	47.5	14147	12808	26955	4654	4873	9527	1104	1011	9493	7935	17428	1124	1052
5/23/2016	Mon			53.3	46.7	20192	17701	37893	6973	8231	15204	1487	1278	13219	9470	22689	1953	1238
5/24/2016	Tue			53.1	46.9	20348	17978	38326	6923	8336	15259	1469	1246	13425	9642	23067	1847	1334
5/25/2016	Wed			53.2	46.8	19975	17557	37532	6806	8220	15026	1486	1333	13169	9337	22506	1796	1263
5/26/2016	Thu			53.3	46.7	20685	18157	38842	7169	8398	15567	1503	1294	13516	9759	23275	1928	1282
5/27/2016	Fri			53.2	46.8	21084	18549	39633	7306	8681	15987	1586	1417	13778	9868	23646	1939	1156
5/28/2016	Sat			52.9	47.1	16804	14932	31736	5820	6165	11985	1341	1212	10984	8767	19751	1378	1174
5/29/2016	Sun			52.6	47.4	13754	12373	26127	4516	5079	9595	1023	981	9238	7294	16532	1070	1029
5/30/2016	Mon	*		52.3	47.7	14514	13223	27737	4733	5549	10282	1105	1166	9781	7674	17455	1136	1058
5/31/2016	Tue			53.2	46.8	20709	18183	38892	7005	8577	15582	1596	1336	13704	9606	23310	1942	1301

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

June, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	D-02	D-01	D-02	1+2	D-01	D-02	1+2	D-01	D-02	D-01	D-02	1+2	D-01	D-02
6/1/2016	Wed			53.4	46.6	19550	17051	36601	6684	8067	14751	1540	1254	12866	8984	21850	1927	1113
6/2/2016	Thu			53.4	46.6	19925	17364	37289	6697	7943	14640	1482	1311	13228	9421	22649	1871	1177
6/3/2016	Fri			53.4	46.6	22644	19788	42432	7566	8882	16448	1728	1426	15078	10906	25984	1907	1383
6/4/2016	Sat			53.1	46.9	17434	15389	32823	6417	6924	13341	1534	1318	11017	8465	19482	1524	1228
6/5/2016	Sun			52.4	47.6	13850	12578	26428	4819	5035	9854	1183	1029	9031	7543	16574	1264	1031
6/6/2016	Mon			53.2	46.8	19830	17422	37252	6784	7911	14695	1525	1267	13046	9511	22557	1996	1199
6/7/2016	Tue			53.3	46.7	19994	17530	37524	6770	7921	14691	1581	1235	13224	9609	22833	1917	1179
6/8/2016	Wed			53.5	46.5	19706	17162	36868	6455	7928	14383	1420	1315	13251	9234	22485	1951	1084
6/9/2016	Thu			53.3	46.7	20200	17674	37874	6657	8032	14689	1383	1295	13543	9642	23185	1877	1209
6/10/2016	Fri	*		52.5	47.5	19123	17272	36395	6610	7365	13975	1516	1343	12513	9907	22420	1573	1297
6/11/2016	Sat			52.8	47.2	16249	14514	30763	5468	6059	11527	1260	1220	10781	8455	19236	1352	1128
6/12/2016	Sun			52.4	47.6	13284	12074	25358	4066	4248	8314	1036	1021	9218	7826	17044	1155	1129
6/13/2016	Mon			53.0	47.0	18868	16718	35586	6511	7900	14411	1500	1307	12357	8818	21175	1836	1098
6/14/2016	Tue			53.0	47.0	18317	16262	34579	6309	7602	13911	1413	1245	12008	8660	20668	1760	1021
6/15/2016	Wed			53.3	46.7	19714	17248	36962	6549	7859	14408	1430	1233	13165	9389	22554	1798	1208
6/16/2016	Thu			53.2	46.8	19919	17491	37410	6269	7543	13812	1438	1185	13650	9948	23598	1915	1241
6/17/2016	Fri			53.4	46.6	21768	18961	40729	7092	8162	15254	1600	1294	14676	10799	25475	2010	1308
6/18/2016	Sat			53.0	47.0	17410	15457	32867	6019	6365	12384	1378	1219	11391	9092	20483	1331	1232
6/19/2016	Sun			52.4	47.6	12927	11731	24658	4394	4447	8841	1125	983	8533	7284	15817	1077	1073
6/20/2016	Mon			53.0	47.0	20179	17881	38060	6633	7965	14598	1439	1274	13546	9916	23462	2033	1259
6/21/2016	Tue			52.9	47.1	19684	17539	37223	6760	8227	14987	1501	1314	12924	9312	22236	2008	1220
6/22/2016	Wed			53.0	47.0	19981	17734	37715	6628	8100	14728	1453	1339	13353	9634	22987	1922	1250
6/23/2016	Thu			53.5	46.5	20490	17780	38270	6648	7983	14631	1417	1328	13842	9797	23639	1904	1184
6/24/2016	Fri			53.3	46.7	21954	19236	41190	7243	8348	15591	1576	1282	14711	10888	25599	2078	1260
6/25/2016	Sat			52.7	47.3	16793	15052	31845	6051	6651	12702	1302	1209	10742	8401	19143	1364	1165
6/26/2016	Sun			52.8	47.2	13391	11977	25368	4557	4516	9073	1070	957	8834	7461	16295	1056	983
6/27/2016	Mon			53.1	46.9	19527	17252	36779	6665	7982	14647	1493	1266	12862	9270	22132	1921	1195
6/28/2016	Tue			53.9	46.1	19822	16961	36783	6512	7632	14144	1472	1218	13310	9329	22639	1920	1184
6/29/2016	Wed			53.2	46.8	19763	17396	37159	6689	7971	14660	1471	1231	13074	9425	22499	1903	1224
6/30/2016	Thu			53.2	46.8	20358	17934	38292	6551	7934	14485	1403	1289	13807	10000	23807	1861	1299

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

July, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii
Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
7/1/2016	Fri			53.1	46.9	22984	20314	43298	7642	8876	16518	1744	1496	15342	11438	26780	1901	1415
7/2/2016	Sat			53.2	46.8	17394	15311	32705	6145	6450	12595	1461	1242	11249	8861	20110	1433	1257
7/3/2016	Sun			52.0	48.0	13791	12706	26497	4493	4692	9185	1130	951	9298	8014	17312	1117	1060
7/4/2016	Mon	*		51.1	48.9	13497	12896	26393	4418	4864	9282	970	1025	9079	8032	17111	1052	1006
7/5/2016	Tue			53.5	46.5	20952	18181	39133	7073	8115	15188	1592	1326	13879	10066	23945	2048	1259
7/6/2016	Wed			53.3	46.7	20024	17514	37538	6654	8034	14688	1548	1331	13370	9480	22850	2027	1162
7/7/2016	Thu			53.1	46.9	20472	18056	38528	6608	8107	14715	1457	1266	13864	9949	23813	1936	1266
7/8/2016	Fri			53.2	46.8	22333	19650	41983	7105	8555	15660	1598	1354	15228	11095	26323	2125	1258
7/9/2016	Sat			52.9	47.1	18508	16460	34968	6107	7387	13494	1483	1365	12401	9073	21474	1598	1287
7/10/2016	Sun			52.7	47.3	14283	12838	27121	4284	4905	9189	1045	976	9999	7933	17932	1492	883
7/11/2016	Mon			53.0	47.0	20238	17933	38171	6764	8289	15053	1489	1378	13474	9644	23118	1876	1248
7/12/2016	Tue			53.1	46.9	20206	17873	38079	6658	8075	14733	1494	1259	13548	9798	23346	1946	1231
7/13/2016	Wed			53.3	46.7	20329	17835	38164	6488	8136	14624	1447	1280	13841	9699	23540	2020	1110
7/14/2016	Thu			52.9	47.1	20399	18143	38542	6646	8293	14939	1459	1360	13753	9850	23603	1872	1297
7/15/2016	Fri			53.3	46.7	21699	18997	40696	6905	8187	15092	1643	1376	14794	10810	25604	1920	1296
7/16/2016	Sat			52.8	47.2	17772	15892	33664	6060	6524	12584	1428	1277	11712	9368	21080	1323	1253
7/17/2016	Sun			53.0	47.0	14255	12661	26916	4635	4673	9308	1050	990	9620	7988	17608	1085	1096
7/18/2016	Mon			53.1	46.9	19903	17602	37505	6860	8058	14918	1688	1294	13043	9544	22587	1820	1163
7/19/2016	Tue			53.1	46.9	20138	17751	37889	6713	7940	14653	1492	1310	13425	9811	23236	2003	1208
7/20/2016	Wed			53.4	46.6	20543	17894	38437	6720	8259	14979	1551	1398	13823	9635	23458	2084	1181
7/21/2016	Thu			53.0	47.0	20259	17992	38251	6444	7891	14335	1459	1271	13815	10101	23916	2013	1254
7/22/2016	Fri			53.0	47.0	20730	18390	39120	7259	8257	15516	1654	1332	13471	10133	23604	1870	1206
7/23/2016	Sat		3	52.6	47.4	9334	8418	17752	3901	3632	7533	835	700	5433	4786	10219	768	641
7/24/2016	Sun		3	52.9	47.1	12596	11214	23810	4156	3764	7920	1050	897	8440	7450	15890	1136	993
7/25/2016	Mon			53.2	46.8	20247	17814	38061	6652	7925	14577	1576	1339	13595	9889	23484	1917	1276
7/26/2016	Tue			53.5	46.5	19934	17324	37258	6537	7813	14350	1455	1279	13397	9511	22908	1932	1242
7/27/2016	Wed			53.4	46.6	20170	17606	37776	6472	7962	14434	1406	1289	13698	9644	23342	1955	1208
7/28/2016	Thu			53.0	47.0	20437	18101	38538	6507	8072	14579	1515	1295	13930	10029	23959	1840	1271
7/29/2016	Fri			53.0	47.0	22099	19570	41669	6902	8326	15228	1574	1335	15197	11244	26441	2075	1366
7/30/2016	Sat			52.9	47.1	17734	15761	33495	5956	6509	12465	1428	1248	11778	9252	21030	1462	1212
7/31/2016	Sun			52.7	47.3	14008	12579	26587	4597	4609	9206	1145	945	9411	7970	17381	1146	1009

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

August, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii
Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
8/1/2016	Mon			53.7	46.3	21246	18333	39579	7115	8230	15345	1580	1364	14131	10103	24234	2058	1216
8/2/2016	Tue			53.2	46.8	20347	17898	38245	6868	8214	15082	1467	1300	13479	9684	23163	1885	1319
8/3/2016	Wed			53.3	46.7	20758	18171	38929	7112	8383	15495	1510	1330	13646	9788	23434	1980	1206
8/4/2016	Thu			53.4	46.6	20225	17642	37867	6814	7976	14790	1500	1152	13411	9666	23077	1782	1285
8/5/2016	Fri			53.4	46.6	23312	20379	43691	7613	8796	16409	1675	1419	15699	11583	27282	2084	1381
8/6/2016	Sat			53.9	46.1	18200	15538	33738	6408	6283	12691	1477	1218	11792	9255	21047	1435	1233
8/7/2016	Sun			52.6	47.4	14003	12595	26598	4694	4824	9518	1135	1048	9309	7771	17080	1171	1095
8/8/2016	Mon			53.5	46.5	20398	17757	38155	6913	8117	15030	1475	1272	13485	9640	23125	1994	1313
8/9/2016	Tue			52.9	47.1	19921	17733	37654	6820	8253	15073	1398	1279	13101	9480	22581	1901	1309
8/10/2016	Wed			53.4	46.6	20411	17798	38209	6926	8285	15211	1416	1268	13485	9513	22998	1905	1245
8/11/2016	Thu			53.0	47.0	20119	17807	37926	6754	8267	15021	1382	1229	13365	9540	22905	1967	1194
8/12/2016	Fri			53.1	46.9	21603	19078	40681	7161	8338	15499	1562	1335	14442	10740	25182	1987	1320
8/13/2016	Sat			52.6	47.4	16223	14602	30825	5604	5974	11578	1345	1210	10619	8628	19247	1318	1203
8/14/2016	Sun			52.6	47.4	13232	11930	25162	4465	4432	8897	1052	1042	8767	7498	16265	1100	991
8/15/2016	Mon			53.0	47.0	19782	17543	37325	6907	8114	15021	1533	1317	12875	9429	22304	1985	1205
8/16/2016	Tue			53.3	46.7	20403	17850	38253	6880	8126	15006	1414	1225	13523	9724	23247	1970	1335
8/17/2016	Wed			53.4	46.6	20629	18032	38661	6978	8367	15345	1466	1282	13651	9665	23316	1883	1272
8/18/2016	Thu			53.6	46.4	20875	18082	38957	7086	8318	15404	1523	1285	13789	9764	23553	1937	1311
8/19/2016	Fri	*		53.2	46.8	20888	18398	39286	7132	7691	14823	1563	1409	13756	10707	24463	1739	1320
8/20/2016	Sat			53.1	46.9	17802	15722	33524	6026	6534	12560	1464	1288	11776	9188	20964	1492	1237
8/21/2016	Sun			52.3	47.7	13840	12644	26484	4538	4654	9192	1140	983	9302	7990	17292	1169	1081
8/22/2016	Mon			53.7	46.3	19418	16712	36130	6803	7859	14662	1501	1148	12615	8853	21468	1807	1241
8/23/2016	Tue			53.7	46.3	18861	16258	35119	6929	7720	14649	1457	1174	11932	8538	20470	1805	1203
8/24/2016	Wed			54.2	45.8	19937	16842	36779	6549	7529	14078	1396	1158	13388	9313	22701	1906	1153
8/25/2016	Thu			53.2	46.8	20069	17666	37735	6631	8180	14811	1352	1232	13438	9486	22924	1975	1251
8/26/2016	Fri			53.5	46.5	22178	19299	41477	7387	8396	15783	1460	1304	14791	10903	25694	1906	1382
8/27/2016	Sat			53.2	46.8	18192	15992	34184	6153	6614	12767	1496	1258	12039	9378	21417	1523	1236
8/28/2016	Sun			52.7	47.3	12845	11529	24374	4543	4402	8945	1099	949	8302	7127	15429	1053	1065
8/29/2016	Mon			53.5	46.5	20067	17445	37512	6776	7903	14679	1450	1201	13291	9542	22833	1866	1289
8/30/2016	Tue			53.6	46.4	21204	18389	39593	7449	8652	16101	1602	1333	13755	9737	23492	1998	1251
8/31/2016	Wed		3	52.3	47.7	10160	9258	19418	5329	5630	10959	1116	908	4831	3628	8459	972	692

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

September, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
9/1/2016	Thu			53.3	46.7	18332	16078	34410	6047	7093	13140	1483	1298	12285	8985	21270	1668	1185
9/2/2016	Fri			53.1	46.9	21499	18958	40457	7187	8430	15617	1581	1350	14312	10528	24840	1946	1353
9/3/2016	Sat			52.9	47.1	16251	14493	30744	6139	6139	12278	1471	1342	10112	8354	18466	1409	1241
9/4/2016	Sun			53.0	47.0	11785	10443	22228	4073	3725	7798	972	728	7712	6718	14430	997	850
9/5/2016	Mon	*		52.4	47.6	15030	13627	28657	4745	5124	9869	1130	1196	10285	8503	18788	1301	1047
9/6/2016	Tue			53.5	46.5	21182	18394	39576	7229	8648	15877	1578	1335	13953	9746	23699	1985	1358
9/7/2016	Wed			53.5	46.5	20513	17845	38358	6877	8202	15079	1528	1172	13636	9643	23279	1986	1236
9/8/2016	Thu			53.3	46.7	20174	17673	37847	6787	8227	15014	1372	1256	13387	9446	22833	1952	1246
9/9/2016	Fri			53.2	46.8	22228	19549	41777	7447	8524	15971	1547	1289	14781	11025	25806	2009	1306
9/10/2016	Sat			52.9	47.1	17287	15407	32694	5982	6670	12652	1489	1248	11305	8737	20042	1369	1285
9/11/2016	Sun			53.0	47.0	13481	11952	25433	4531	4528	9059	1093	925	8950	7424	16374	1081	1034
9/12/2016	Mon			53.2	46.8	19807	17440	37247	6935	8307	15242	1486	1251	12872	9133	22005	1952	1187
9/13/2016	Tue			53.2	46.8	19612	17231	36843	7011	8328	15339	1493	1197	12601	8903	21504	1916	1216
9/14/2016	Wed			54.1	45.9	20062	17017	37079	6762	8285	15047	1363	1212	13300	8732	22032	1954	1189
9/15/2016	Thu			54.2	45.8	19136	16192	35328	6905	7399	14304	1314	1162	12231	8793	21024	1890	1174
9/16/2016	Fri			53.6	46.4	21991	19073	41064	7348	8164	15512	1586	1261	14643	10909	25552	1917	1448
9/17/2016	Sat			53.6	46.4	17371	15060	32431	6240	6377	12617	1466	1254	11131	8683	19814	1504	1260
9/18/2016	Sun			52.6	47.4	13072	11771	24843	4357	4417	8774	1056	943	8715	7354	16069	1108	1069
9/19/2016	Mon			53.4	46.6	19662	17150	36812	6742	7848	14590	1505	1224	12920	9302	22222	1976	1225
9/20/2016	Tue			53.6	46.4	20269	17551	37820	6771	7985	14756	1432	1168	13498	9566	23064	2058	1276
9/21/2016	Wed			53.9	46.1	20222	17306	37528	6751	8020	14771	1390	1185	13471	9286	22757	2058	1195
9/22/2016	Thu			53.8	46.2	20941	18003	38944	6629	8050	14679	1385	1193	14312	9953	24265	2067	1292
9/23/2016	Fri			53.8	46.2	22545	19393	41938	7045	8152	15197	1469	1262	15500	11241	26741	2066	1349
9/24/2016	Sat			53.9	46.1	20171	17286	37457	6157	6360	12517	1404	1254	14014	10926	24940	1515	1303
9/25/2016	Sun			54.6	45.4	15546	12943	28489	4750	4589	9339	1091	1017	10796	8354	19150	1135	1094
9/26/2016	Mon			53.6	46.4	19356	16737	36093	6753	7906	14659	1407	1231	12603	8831	21434	1933	1153
9/27/2016	Tue			53.9	46.1	19670	16795	36465	6967	7892	14859	1522	1159	12703	8903	21606	1805	1160
9/28/2016	Wed			53.9	46.1	19223	16443	35666	6401	7579	13980	1343	1112	12822	8864	21686	1913	1206
9/29/2016	Thu			54.0	46.0	19823	16893	36716	6755	7654	14409	1418	1099	13068	9239	22307	1901	1193
9/30/2016	Fri			54.4	45.6	22797	19093	41890	7505	8174	15679	1613	1291	15292	10919	26211	2025	1308

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

October, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	D-02	D-01	D-02	1+2	D-01	D-02	1+2	D-01	D-02	D-01	D-02	1+2	D-01	D-02
10/1/2016	Sat			54.2	45.8	16384	13834	30218	5965	5665	11630	1408	1125	10419	8169	18588	1397	1090
10/2/2016	Sun			53.1	46.9	12707	11236	23943	4328	4270	8598	1094	819	8379	6966	15345	1195	824
10/3/2016	Mon			53.4	46.6	19671	17185	36856	6909	7997	14906	1537	1309	12762	9188	21950	1796	1250
10/4/2016	Tue			53.6	46.4	19420	16838	36258	6897	8020	14917	1462	1226	12523	8818	21341	1998	1154
10/5/2016	Wed			50.6	49.4	17581	17153	34734	5773	8094	13867	785	1629	11808	9059	20867	1599	1163
10/6/2016	Thu			53.3	46.7	19804	17383	37187	6838	8087	14925	1456	1238	12966	9296	22262	1971	1163
10/7/2016	Fri			53.3	46.7	21443	18788	40231	7137	8224	15361	1533	1251	14306	10564	24870	2115	1247
10/8/2016	Sat			53.8	46.2	17821	15313	33134	6262	6273	12535	1473	1206	11559	9040	20599	1465	1287
10/9/2016	Sun			52.8	47.2	13485	12051	25536	4479	4574	9053	996	978	9006	7477	16483	1140	994
10/10/2016	Mon			53.6	46.4	18991	16462	35453	6428	7376	13804	1433	1245	12563	9086	21649	1753	1156
10/11/2016	Tue			53.4	46.6	20163	17587	37750	6770	8010	14780	1508	1258	13393	9577	22970	1956	1173
10/12/2016	Wed			53.5	46.5	19438	16909	36347	6571	7879	14450	1406	1186	12867	9030	21897	1898	1107
10/13/2016	Thu			53.5	46.5	20650	17939	38589	6718	7951	14669	1486	1269	13932	9988	23920	1926	1225
10/14/2016	Fri			53.4	46.6	22402	19573	41975	7287	8595	15882	1602	1435	15115	10978	26093	2078	1289
10/15/2016	Sat			53.0	47.0	17243	15315	32558	5802	6268	12070	1367	1208	11441	9047	20488	1407	1217
10/16/2016	Sun			53.3	46.7	13841	12133	25974	4582	4740	9322	1043	985	9259	7393	16652	1124	1039
10/17/2016	Mon			53.4	46.6	19501	17003	36504	6814	8027	14841	1516	1217	12687	8976	21663	1923	1206
10/18/2016	Tue			53.5	46.5	19785	17228	37013	6768	8024	14792	1473	1201	13017	9204	22221	1930	1249
10/19/2016	Wed			53.3	46.7	18903	16536	35439	6556	7774	14330	1323	1236	12347	8762	21109	1849	1093
10/20/2016	Thu			53.8	46.2	20474	17552	38026	6845	8029	14874	1435	1208	13629	9523	23152	2002	1234
10/21/2016	Fri			53.5	46.5	22068	19160	41228	7101	8318	15419	1505	1286	14967	10842	25809	2165	1318
10/22/2016	Sat			53.5	46.5	17823	15473	33296	6212	6761	12973	1449	1342	11611	8712	20323	1443	1200
10/23/2016	Sun			53.3	46.7	13478	11805	25283	4452	4438	8890	1074	959	9026	7367	16393	1123	1034
10/24/2016	Mon			53.9	46.1	19914	17055	36969	7063	8012	15075	1516	1212	12851	9043	21894	2057	1185
10/25/2016	Tue			53.8	46.2	20117	17284	37401	6730	7980	14710	1370	1140	13387	9304	22691	1978	1283
10/26/2016	Wed			53.5	46.5	19898	17293	37191	6632	8054	14686	1384	1261	13266	9239	22505	1917	1207
10/27/2016	Thu			53.3	46.7	20166	17669	37835	6842	8216	15058	1476	1257	13324	9453	22777	2003	1296
10/28/2016	Fri			53.4	46.6	20909	18235	39144	6838	7983	14821	1511	1204	14071	10252	24323	1933	1266
10/29/2016	Sat			53.3	46.7	16230	14238	30468	5844	5943	11787	1468	1187	10386	8295	18681	1417	1226
10/30/2016	Sun			53.0	47.0	12509	11102	23611	4140	4340	8480	1007	862	8369	6762	15131	1188	838
10/31/2016	Mon			53.4	46.6	20172	17604	37776	6682	7851	14533	1552	1266	13490	9753	23243	1838	1310

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

November, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii
Hawaii

DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
11/1/2016	Tue			53.4	46.6	19760	17243	37003	6879	8107	14986	1462	1264	12881	9136	22017	1904	1194
11/2/2016	Wed			53.6	46.4	19537	16928	36465	6569	7946	14515	1420	1231	12968	8982	21950	1925	1194
11/3/2016	Thu			53.6	46.4	20898	18089	38987	7157	8423	15580	1536	1259	13741	9666	23407	2029	1252
11/4/2016	Fri			53.3	46.7	22229	19509	41738	7019	8377	15396	1519	1354	15210	11132	26342	2053	1316
11/5/2016	Sat			53.6	46.4	17674	15284	32958	6258	6514	12772	1409	1293	11416	8770	20186	1522	1234
11/6/2016	Sun			53.2	46.8	13848	12204	26052	4646	4703	9349	1113	969	9202	7501	16703	1149	1027
11/7/2016	Mon			53.8	46.2	20677	17757	38434	6993	7983	14976	1556	1244	13684	9774	23458	2047	1231
11/8/2016	Tue	*		53.0	47.0	18326	16277	34603	6414	7340	13754	1424	1253	11912	8937	20849	1670	1137
11/9/2016	Wed			53.4	46.6	19710	17213	36923	6607	8138	14745	1392	1263	13103	9075	22178	2006	1151
11/10/2016	Thu			53.6	46.4	20973	18159	39132	6861	8150	15011	1472	1302	14112	10009	24121	2066	1289
11/11/2016	Fri	*		53.1	46.9	19286	17034	36320	6633	7360	13993	1461	1317	12653	9674	22327	1550	1212
11/12/2016	Sat			53.3	46.7	16567	14490	31057	5881	6230	12111	1484	1260	10686	8260	18946	1365	1276
11/13/2016	Sun			53.1	46.9	13385	11810	25195	4579	4414	8993	1058	926	8806	7396	16202	1093	941
11/14/2016	Mon			53.5	46.5	19593	17045	36638	6930	8063	14993	1549	1162	12663	8982	21645	1950	1176
11/15/2016	Tue			53.8	46.2	20146	17277	37423	6789	7910	14699	1482	1183	13357	9367	22724	1992	1201
11/16/2016	Wed			53.6	46.4	20104	17382	37486	6698	8025	14723	1384	1209	13406	9357	22763	2032	1166
11/17/2016	Thu			53.5	46.5	20403	17743	38146	6746	8190	14936	1445	1224	13657	9553	23210	1960	1161
11/18/2016	Fri			53.9	46.1	22309	19106	41415	7062	8194	15256	1476	1342	15247	10912	26159	2050	1379
11/19/2016	Sat			53.7	46.3	18174	15647	33821	6354	6736	13090	1521	1359	11820	8911	20731	1546	1347
11/20/2016	Sun			52.9	47.1	13283	11842	25125	4429	4468	8897	1098	991	8854	7374	16228	1181	1001
11/21/2016	Mon			53.8	46.2	19388	16636	36024	6635	7520	14155	1396	1146	12753	9116	21869	1984	1197
11/22/2016	Tue			54.0	46.0	21085	17941	39026	7069	8022	15091	1491	1272	14016	9919	23935	2021	1310
11/23/2016	Wed			54.0	46.0	21585	18405	39990	7223	8337	15560	1554	1257	14362	10068	24430	2116	1294
11/24/2016	Thu	*		52.1	47.9	10530	9685	20215	3754	3803	7557	810	684	6776	5882	12658	793	550
11/25/2016	Fri		3	53.1	46.9	19294	17014	36308	6774	7142	13916	1507	1293	12520	9872	22392	1701	1259
11/26/2016	Sat			52.8	47.2	15914	14247	30161	5348	5559	10907	1222	1152	10566	8688	19254	1283	1164
11/27/2016	Sun			52.9	47.1	12351	10978	23329	4249	3991	8240	1029	818	8102	6987	15089	1012	883
11/28/2016	Mon			53.8	46.2	20730	17783	38513	7043	8000	15043	1566	1264	13687	9783	23470	1995	1359
11/29/2016	Tue			53.5	46.5	19710	17143	36853	6711	7924	14635	1437	1195	12999	9219	22218	1895	1314
11/30/2016	Wed			53.9	46.1	20239	17332	37571	6703	7934	14637	1430	1198	13536	9398	22934	2020	1160

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

December, 2016

STATION NO 011013 STATION DESCRIPTION 011013-TMG Kaneolehua Avenue, Route 11, M.P. 1.3, Hawaii
Hawaii

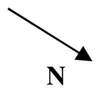
DIRECTION 01 To Jct w/ Palani Rd (Kailua, Kona),MOV 5
DIRECTION 02 To Jct w/ Kamehameha Ave (Hilo), MOV 1

Date	Day of Week	H / WD	Unsuccessful Polling	24-HOUR TOTAL					A.M. TOTAL					P.M. TOTAL				
				%		Volume			00:00 - 12:00			PEAK HOUR		12:00-24:00			PEAK HOUR	
				D-01	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**	**D-01**	**D-02**	**1+2**	**D-01**	**D-02**
12/1/2016	Thu			53.6	46.4	19047	16481	35528	6433	7579	14012	1358	1114	12614	8902	21516	1833	1183
12/2/2016	Fri			52.2	47.8	18356	16796	35152	6375	7457	13832	1297	1161	11981	9339	21320	1521	1143
12/3/2016	Sat			53.8	46.2	16930	14534	31464	5857	5752	11609	1440	1080	11073	8782	19855	1473	1185
12/4/2016	Sun			53.2	46.8	12965	11385	24350	4620	4240	8860	1161	846	8345	7145	15490	1201	929
12/5/2016	Mon			54.4	45.6	21315	17866	39181	7085	7884	14969	1680	1382	14230	9982	24212	2114	1274
12/6/2016	Tue			54.2	45.8	21224	17932	39156	7261	8130	15391	1529	1285	13963	9802	23765	2122	1243
12/7/2016	Wed			54.2	45.8	20653	17447	38100	6776	7920	14696	1442	1211	13877	9527	23404	2050	1168
12/8/2016	Thu			53.9	46.1	20993	17941	38934	7019	8065	15084	1532	1188	13974	9876	23850	2011	1214
12/9/2016	Fri			53.8	46.2	22514	19338	41852	7363	8351	15714	1628	1324	15151	10987	26138	2003	1370
12/10/2016	Sat			53.5	46.5	17918	15543	33461	6302	6200	12502	1545	1225	11616	9343	20959	1600	1270
12/11/2016	Sun			53.3	46.7	13944	12199	26143	4637	4437	9074	1109	939	9307	7762	17069	1171	1056
12/12/2016	Mon			54.2	45.8	20474	17331	37805	7031	7790	14821	1579	1178	13443	9541	22984	2095	1132
12/13/2016	Tue			54.2	45.8	20878	17661	38539	7114	7972	15086	1453	1274	13764	9689	23453	1997	1300
12/14/2016	Wed			53.6	46.4	20777	17980	38757	6950	8228	15178	1495	1274	13827	9752	23579	2094	1236
12/15/2016	Thu			54.0	46.0	21779	18574	40353	7086	8267	15353	1533	1301	14693	10307	25000	2095	1220
12/16/2016	Fri			53.9	46.1	23340	19967	43307	7535	8536	16071	1679	1329	15805	11431	27236	2060	1361
12/17/2016	Sat			53.9	46.1	18455	15816	34271	6478	6411	12889	1548	1284	11977	9405	21382	1601	1286
12/18/2016	Sun			53.5	46.5	12124	10517	22641	4271	3840	8111	1025	864	7853	6677	14530	1004	836
12/19/2016	Mon			54.2	45.8	21819	18435	40254	7147	7838	14985	1627	1365	14672	10597	25269	2169	1204
12/20/2016	Tue			54.1	45.9	22451	19052	41503	7452	8307	15759	1696	1341	14999	10745	25744	2182	1334
12/21/2016	Wed			54.1	45.9	21836	18496	40332	7405	8268	15673	1581	1298	14431	10228	24659	1966	1237
12/22/2016	Thu			54.0	46.0	21753	18550	40303	6821	7850	14671	1644	1352	14932	10700	25632	1988	1236
12/23/2016	Fri			54.4	45.6	23248	19495	42743	7655	8294	15949	1814	1389	15593	11201	26794	1880	1401
12/24/2016	Sat			53.1	46.9	16059	14210	30269	6015	5807	11822	1418	1137	10044	8403	18447	1332	1161
12/25/2016	Sun			52.1	47.9	8332	7660	15992	2781	2709	5490	671	539	5551	4951	10502	668	666
12/26/2016	Mon	*		52.7	47.3	15623	14034	29657	5337	5368	10705	1309	1159	10286	8666	18952	1401	1168
12/27/2016	Tue			53.3	46.7	20228	17734	37962	6793	7733	14526	1592	1358	13435	10001	23436	1974	1129
12/28/2016	Wed			52.9	47.1	19444	17294	36738	6453	7533	13986	1562	1318	12991	9761	22752	1818	1135
12/29/2016	Thu			53.0	47.0	19573	17334	36907	6252	7248	13500	1458	1216	13321	10086	23407	1844	1250
12/30/2016	Fri			53.9	46.1	21497	18415	39912	7014	7755	14769	1625	1398	14483	10660	25143	1946	1267
12/31/2016	Sat			52.7	47.3	14460	12953	27413	5600	5511	11111	1289	1135	8860	7442	16302	1292	1090

1 - INCOMPLETE FILE
2 - DIRECTIONAL SPLIT
3 - USER DEFINED ERROR

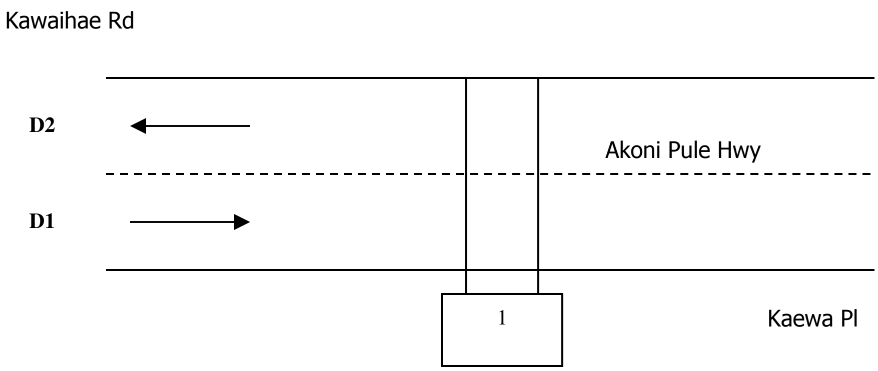
Traffic Data Service

Traffic Station Sketch



Section ID/Station #: B71027000150

Island: Hawaii
Area: Puako



Meter #	File Name	GPS
1. bw72	D0419025_B71027000150 D0419026_B71027000150	20.03979, -155.8304

Station Description:

Akoni Pule Hwy: Kawaihae Rd to Kaewa Pl

Survey Beginning Date/Time: 4/19/16 @ 0000		Survey Ending Date/Time: 4/20/16 @ 2400	
Survey Method:	Road Tube	Data Type:	Class
Survey Crew:	LM		C1B
Sketch Updated:		By:	SR
Remarks:	1367		

FACILITY NAME	JURI	FUNC CLASS	AREA TYPE	ROUTE NO.	ROUTE MILE
Akoni Pule Hwy		16		0270	

D1= Direction to End — D1: Kaewa Pl / Pololu Valley entrance

D2= Direction to Begin — D2: Kawaihae Rd / Queen Kaahumanu Hwy (Rte 19)

Run Date: 2017/07/26

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71027000150 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 5100

Functional Class: RURAL:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 270

Location: Akoni Pule Hwy - Kawaihae Rd to Kaewa Pl

DATE : 04/19/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	1	0	1	06:00-06:15	22	66	88	12:00-12:15	62	41	103	06:00-06:15	55	19	74
12:15-12:30	5	0	5	06:15-06:30	26	82	108	12:15-12:30	47	57	104	06:15-06:30	49	29	78
12:30-12:45	5	1	6	06:30-06:45	31	68	99	12:30-12:45	40	56	96	06:30-06:45	45	18	63
12:45-01:00	2	0	2	06:45-07:00	36	66	102	12:45-01:00	53	45	98	06:45-07:00	38	13	51
01:00-01:15	3	1	4	07:00-07:15	19	80	99	01:00-01:15	50	49	99	07:00-07:15	34	31	65
01:15-01:30	3	2	5	07:15-07:30	13	79	92	01:15-01:30	63	48	111	07:15-07:30	31	18	49
01:30-01:45	2	0	2	07:30-07:45	26	70	96	01:30-01:45	48	57	105	07:30-07:45	28	13	41
01:45-02:00	1	0	1	07:45-08:00	28	50	78	01:45-02:00	53	51	104	07:45-08:00	16	10	26
02:00-02:15	0	2	2	08:00-08:15	38	48	86	02:00-02:15	56	53	109	08:00-08:15	21	12	33
02:15-02:30	1	2	3	08:15-08:30	31	58	89	02:15-02:30	58	56	114	08:15-08:30	33	10	43
02:30-02:45	2	1	3	08:30-08:45	36	50	86	02:30-02:45	64	57	121	08:30-08:45	26	12	38
02:45-03:00	1	1	2	08:45-09:00	34	54	88	02:45-03:00	55	50	105	08:45-09:00	13	5	18
03:00-03:15	0	4	4	09:00-09:15	30	48	78	03:00-03:15	57	41	98	09:00-09:15	15	8	23
03:15-03:30	0	6	6	09:15-09:30	38	47	85	03:15-03:30	56	50	106	09:15-09:30	25	4	29
03:30-03:45	0	5	5	09:30-09:45	42	54	96	03:30-03:45	69	52	121	09:30-09:45	29	5	34
03:45-04:00	4	6	10	09:45-10:00	39	41	80	03:45-04:00	75	51	126	09:45-10:00	33	1	34
04:00-04:15	2	8	10	10:00-10:15	38	44	82	04:00-04:15	83	64	147	10:00-10:15	22	6	28
04:15-04:30	4	25	29	10:15-10:30	43	43	86	04:15-04:30	67	58	125	10:15-10:30	25	2	27
04:30-04:45	1	22	23	10:30-10:45	53	41	94	04:30-04:45	83	53	136	10:30-10:45	16	5	21
04:45-05:00	7	19	26	10:45-11:00	57	38	95	04:45-05:00	81	43	124	10:45-11:00	22	10	32
05:00-05:15	6	27	33	11:00-11:15	43	32	75	05:00-05:15	76	43	119	11:00-11:15	15	1	16
05:15-05:30	4	37	41	11:15-11:30	41	49	90	05:15-05:30	62	29	91	11:15-11:30	13	2	15
05:30-05:45	14	45	59	11:30-11:45	44	43	87	05:30-05:45	62	32	94	11:30-11:45	7	1	8
05:45-06:00	15	61	76	11:45-12:00	56	52	108	05:45-06:00	67	23	90	11:45-12:00	3	3	6

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:15 AM to 07:15 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	112	296	408	PM - PEAK HR VOLUME	308	226	534
AM - K FACTOR (%)			6.77	PM - K FACTOR (%)			8.87
AM - D (%)	27.45	72.55	100.00	PM - D (%)	57.68	42.32	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	08:00 AM to 09:00 AM	06:15 AM to 07:15 AM		PM - PEAK HR TIME	04:00 PM to 05:00 PM	03:45 PM to 04:45 PM	
AM - PEAK HR VOLUME	139	296		PM - PEAK HR VOLUME	314	226	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:15 AM to 07:15 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	112	296	408	PM - PEAK HR VOLUME	308	226	534
AM - K FACTOR (%)			6.77	PM - K FACTOR (%)			8.87
AM - D (%)	27.45	72.55	100.00	PM - D (%)	57.68	42.32	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	233	216	449
DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM	01:30 PM to 02:30 PM	
PEAK HR VOLUME	233	217	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	864	1,303	2,167
AM 12-HR PERIOD (00:00-12:00)	947	1,578	2,525
PM 6-HR PERIOD (12:00-18:00)	1,487	1,159	2,646
PM 12-HR PERIOD (12:00-24:00)	2,101	1,397	3,498
24 HOUR PERIOD	3,048	2,975	6,023
D (%)	50.61	49.39	100.00

Run Date: 2017/07/26

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71027000150 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 5100

Functional Class: RURAL:MINOR ARTERIAL **Count Type:** CLASS **Counter Type:** Tube **Route No:** 270

Location: Akoni Pule Hwy - Kawaihae Rd to Kaewa Pl

DATE : 04/20/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	0	0	0	06:00-06:15	23	67	90	12:00-12:15	46	42	88	06:00-06:15	54	29	83
12:15-12:30	4	1	5	06:15-06:30	23	72	95	12:15-12:30	60	53	113	06:15-06:30	38	21	59
12:30-12:45	3	1	4	06:30-06:45	38	72	110	12:30-12:45	41	41	82	06:30-06:45	47	16	63
12:45-01:00	2	1	3	06:45-07:00	23	64	87	12:45-01:00	38	40	78	06:45-07:00	44	23	67
01:00-01:15	7	2	9	07:00-07:15	26	92	118	01:00-01:15	48	27	75	07:00-07:15	37	17	54
01:15-01:30	1	1	2	07:15-07:30	18	96	114	01:15-01:30	52	46	98	07:15-07:30	23	19	42
01:30-01:45	1	1	2	07:30-07:45	41	72	113	01:30-01:45	50	55	105	07:30-07:45	37	17	54
01:45-02:00	2	0	2	07:45-08:00	33	42	75	01:45-02:00	63	43	106	07:45-08:00	20	19	39
02:00-02:15	1	0	1	08:00-08:15	32	47	79	02:00-02:15	54	51	105	08:00-08:15	27	16	43
02:15-02:30	0	3	3	08:15-08:30	44	55	99	02:15-02:30	68	46	114	08:15-08:30	32	8	40
02:30-02:45	2	1	3	08:30-08:45	34	60	94	02:30-02:45	81	48	129	08:30-08:45	35	14	49
02:45-03:00	4	1	5	08:45-09:00	32	51	83	02:45-03:00	60	48	108	08:45-09:00	17	5	22
03:00-03:15	1	2	3	09:00-09:15	46	55	101	03:00-03:15	55	53	108	09:00-09:15	24	7	31
03:15-03:30	0	2	2	09:15-09:30	43	57	100	03:15-03:30	81	52	133	09:15-09:30	12	8	20
03:30-03:45	4	1	5	09:30-09:45	46	55	101	03:30-03:45	92	57	149	09:30-09:45	23	7	30
03:45-04:00	0	6	6	09:45-10:00	34	62	96	03:45-04:00	88	55	143	09:45-10:00	23	9	32
04:00-04:15	2	11	13	10:00-10:15	42	38	80	04:00-04:15	67	53	120	10:00-10:15	19	7	26
04:15-04:30	0	20	20	10:15-10:30	35	47	82	04:15-04:30	72	52	124	10:15-10:30	23	0	23
04:30-04:45	0	24	24	10:30-10:45	38	38	76	04:30-04:45	65	61	126	10:30-10:45	20	6	26
04:45-05:00	1	20	21	10:45-11:00	29	35	64	04:45-05:00	76	34	110	10:45-11:00	14	3	17
05:00-05:15	1	33	34	11:00-11:15	50	34	84	05:00-05:15	67	31	98	11:00-11:15	11	5	16
05:15-05:30	8	46	54	11:15-11:30	40	49	89	05:15-05:30	66	35	101	11:15-11:30	13	1	14
05:30-05:45	8	40	48	11:30-11:45	63	42	105	05:30-05:45	71	32	103	11:30-11:45	8	2	10
05:45-06:00	21	58	79	11:45-12:00	34	44	78	05:45-06:00	59	21	80	11:45-12:00	14	2	16

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:45 AM to 07:45 AM		
AM - PEAK HR VOLUME	108	324	432
AM - K FACTOR (%)			7.16
AM - D (%)	25.00	75.00	100.00
DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:30 AM to 08:30 AM	06:30 AM to 07:30 AM	
AM - PEAK HR VOLUME	150	324	

PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
PM - PEAK HR TIME	03:15 PM to 04:15 PM		
PM - PEAK HR VOLUME	328	217	545
PM - K FACTOR (%)			9.03
PM - D (%)	60.18	39.82	100.00
DIRECTIONAL PEAK			
PM - PEAK HR TIME	03:15 PM to 04:15 PM	03:45 PM to 04:45 PM	
PM - PEAK HR VOLUME	328	221	

AM PERIOD (00:00-12:00)			
TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	06:45 AM to 07:45 AM		
AM - PEAK HR VOLUME	108	324	432
AM - K FACTOR (%)			7.16
AM - D (%)	25.00	75.00	100.00

PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK			
PM - PEAK HR TIME	03:15 PM to 04:15 PM		
PM - PEAK HR VOLUME	328	217	545
PM - K FACTOR (%)			9.03
PM - D (%)	60.18	39.82	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	02:00 PM to 03:00 PM		
PEAK HR VOLUME	263	193	456
DIRECTIONAL PEAK			
PEAK HR TIME	01:45 PM to 02:45 PM	09:00 AM to 10:00 AM	
PEAK HR VOLUME	266	229	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	867	1,346	2,213
AM 12-HR PERIOD (00:00-12:00)	940	1,621	2,561
PM 6-HR PERIOD (12:00-18:00)	1,520	1,076	2,596
PM 12-HR PERIOD (12:00-24:00)	2,135	1,337	3,472
24 HOUR PERIOD	3,075	2,958	6,033
D (%)	50.97	49.03	100.00

Run Date: 2017/07/26

Hawaii Department of Transportation
Highways Division
Highways Planning Survey Section

Vehicle Classification Data Summary
2016

Site ID: B71027000150 **Route No:** 270 **Date From:** 2016/04/19 0:00

Town: Hawaii **Direction:** +MP **Date To:** 2016/04/20 23:45

Location: Akoni Pule Hwy - Kawaihae Rd to Kaewa Pl

Functional Classification: 6 RURAL:MINOR ARTERIAL

REPORT TOTALS - 48 HOURS RECORDED

	VOLUME	%	NUMBER OF AXLES
Cycles	171	1.42%	342
PC	8367	69.40%	16734
2A-4T	3159	26.20%	6318
LIGHT VEHICLE TOTALS	11697	97.02%	23394
HEAVY VEHICLES			
Bus	45	0.37%	113
SINGLE UNIT TRUCK			
2A-6T	106	0.88%	212
3A-SU	84	0.70%	252
4A-SU	10	0.08%	40
SINGLE-TRAILER TRUCKS			
4A-ST	28	0.23%	112
5A-ST	55	0.46%	275
6A-ST	7	0.06%	42
MULTI-TRAILER TRUCKS			
5A-MT	17	0.14%	85
6A-MT	6	0.05%	36
7A-MT	1	0.01%	7
HEAVY VEHICLE TOTALS	359	2.98%	1174
CLASSIFIED VEHICLES TOTALS	12056 (A)	100.00%	24568 (B)
UNCLASSIFIED VEHICLES TOTALS	-0	-0.00%	

AXLE CORRECTION FACTOR (A/C) = 0.981

ROADTUBE EQUIVALENT(B/2) = 12284 (C)

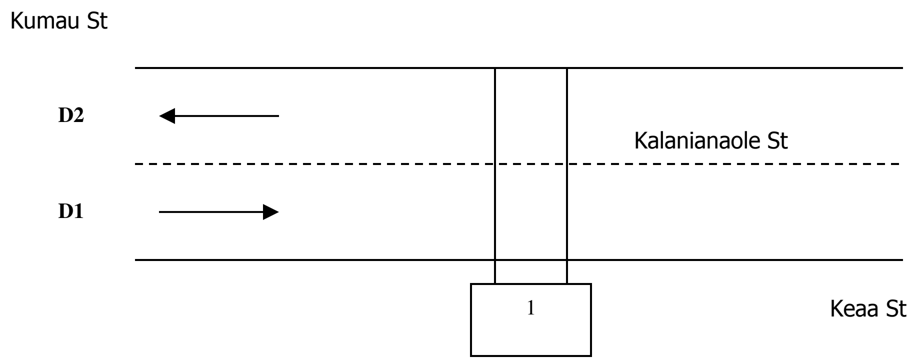
PEAK HOUR VOLUME : 533 2016/04/20 15:00	PEAK HOUR TRUCK VOLUME	% TOTAL PEAK HOUR VOLUME	24 HOUR TRUCK VOLUME	AADT	% OF AADT	HPMS K-FACTOR (PEAK/AADT) (ITEM 66)
SINGLE UNIT TRUCKS (TYPE 4-7)	12	(65A-1) 2.25%	122	5100	(65A-2) 2.39%	10.45%
COMBINATION (TYPE 8-13)	4	(65B-1) 0.75%	57		(65B-2) 1.12%	10.45%

Traffic Data Service

Traffic Station Sketch

Section ID/Station #: B71001900029

Island: Hawaii	
Area: Hilo	



Meter #	File Name	GPS
1. bz51	D0412033_B71001900029 D0412034_B71001900029	19.72576, -155.0581

Station Description:

Kalanianaole St: Kumau St to Keaa St

Survey Beginning Date/Time: 4/12/16 @ 0000			Survey Ending Date/Time: 4/13/16 @ 2400
Survey Method:	Road Tube	Data Type:	Class
Survey Crew:	LM		C1B
Sketch Updated:		By:	SR
Remarks:	1320		

FACILITY NAME	JURI	FUNC CLASS	AREA TYPE	ROUTE NO.	ROUTE MILE
Kalanianaole St		14		0019	

D1= Direction to End — D1: Keaa St / Palani Rd (Rte 190)

D2= Direction to Begin — D2: Kumau St / ent to Kuhio Wharf

Run Date: 2017/07/20

Hawaii Department of Transportation

Highways Division — Highways Planning Survey Section

2016 Program Count - Summary

Site ID: B71001900029 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 14200

Functional Class: URBAN:PRINCIPAL ARTERIAL - OTHER **Count Type:** CLASS **Counter Type:** Tube **Route No:** 19

Location: Kalanianaole St - Kumau St to Keaa St

DATE : 04/12/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	15	8	23	06:00-06:15	53	46	99	12:00-12:15	132	130	262	06:00-06:15	94	136	230
12:15-12:30	8	10	18	06:15-06:30	81	62	143	12:15-12:30	156	119	275	06:15-06:30	77	111	188
12:30-12:45	8	6	14	06:30-06:45	101	69	170	12:30-12:45	151	121	272	06:30-06:45	94	86	180
12:45-01:00	9	9	18	06:45-07:00	119	107	226	12:45-01:00	129	136	265	06:45-07:00	95	83	178
01:00-01:15	5	2	7	07:00-07:15	150	95	245	01:00-01:15	111	118	229	07:00-07:15	65	83	148
01:15-01:30	6	2	8	07:15-07:30	200	125	325	01:15-01:30	137	136	273	07:15-07:30	52	70	122
01:30-01:45	6	4	10	07:30-07:45	187	182	369	01:30-01:45	151	133	284	07:30-07:45	49	66	115
01:45-02:00	8	4	12	07:45-08:00	170	174	344	01:45-02:00	155	139	294	07:45-08:00	47	78	125
02:00-02:15	3	12	15	08:00-08:15	148	138	286	02:00-02:15	170	137	307	08:00-08:15	53	53	106
02:15-02:30	9	6	15	08:15-08:30	112	133	245	02:15-02:30	152	181	333	08:15-08:30	55	48	103
02:30-02:45	3	5	8	08:30-08:45	120	156	276	02:30-02:45	142	172	314	08:30-08:45	29	42	71
02:45-03:00	4	5	9	08:45-09:00	109	127	236	02:45-03:00	143	101	244	08:45-09:00	42	35	77
03:00-03:15	4	9	13	09:00-09:15	97	136	233	03:00-03:15	128	109	237	09:00-09:15	38	27	65
03:15-03:30	4	9	13	09:15-09:30	108	133	241	03:15-03:30	159	171	330	09:15-09:30	35	30	65
03:30-03:45	9	3	12	09:30-09:45	117	154	271	03:30-03:45	137	140	277	09:30-09:45	27	24	51
03:45-04:00	7	9	16	09:45-10:00	125	120	245	03:45-04:00	169	166	335	09:45-10:00	29	23	52
04:00-04:15	11	7	18	10:00-10:15	136	135	271	04:00-04:15	173	151	324	10:00-10:15	22	29	51
04:15-04:30	5	14	19	10:15-10:30	106	118	224	04:15-04:30	180	170	350	10:15-10:30	18	22	40
04:30-04:45	18	13	31	10:30-10:45	122	143	265	04:30-04:45	162	194	356	10:30-10:45	14	14	28
04:45-05:00	20	17	37	10:45-11:00	110	121	231	04:45-05:00	155	150	305	10:45-11:00	10	16	26
05:00-05:15	12	28	40	11:00-11:15	128	132	260	05:00-05:15	138	134	272	11:00-11:15	21	9	30
05:15-05:30	20	35	55	11:15-11:30	118	131	249	05:15-05:30	131	132	263	11:15-11:30	11	12	23
05:30-05:45	29	33	62	11:30-11:45	136	130	266	05:30-05:45	91	169	260	11:30-11:45	11	15	26
05:45-06:00	40	51	91	11:45-12:00	119	129	248	05:45-06:00	111	171	282	11:45-12:00	17	12	29

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	705	619	1324	PM - PEAK HR VOLUME	684	681	1365
AM - K FACTOR (%)			8.49	PM - K FACTOR (%)			8.75
AM - D (%)	53.25	46.75	100.00	PM - D (%)	50.11	49.89	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:00 AM to 08:00 AM	07:30 AM to 08:30 AM		PM - PEAK HR TIME	03:45 PM to 04:45 PM	03:45 PM to 04:45 PM	
AM - PEAK HR VOLUME	707	627		PM - PEAK HR VOLUME	684	681	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM			PM - PEAK HR TIME	03:45 PM to 04:45 PM		
AM - PEAK HR VOLUME	705	619	1324	PM - PEAK HR VOLUME	684	681	1365
AM - K FACTOR (%)			8.49	PM - K FACTOR (%)			8.75
AM - D (%)	53.25	46.75	100.00	PM - D (%)	50.11	49.89	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	01:45 PM to 02:45 PM		
PEAK HR VOLUME	619	629	1248
DIRECTIONAL PEAK			
PEAK HR TIME	01:30 PM to 02:30 PM	01:45 PM to 02:45 PM	
PEAK HR VOLUME	628	629	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	2,972	2,996	5,968
AM 12-HR PERIOD (00:00-12:00)	3,235	3,297	6,532
PM 6-HR PERIOD (12:00-18:00)	3,463	3,480	6,943
PM 12-HR PERIOD (12:00-24:00)	4,468	4,604	9,072
24 HOUR PERIOD	7,703	7,901	15,604
D (%)	49.37	50.63	100.00

Run Date: 2017/07/20

Hawaii Department of Transportation

Highways Division — Highways Planning Survey Section

2016 Program Count - Summary

Site ID: B71001900029
Functional Class: URBAN:PRINCIPAL ARTERIAL - OTHER
Location: Kalanianaole St - Kumau St to Keaa St
Town: Hawaii
Count Type: CLASS
DIR 1: +MP **DIR 2:** -MP
Counter Type: Tube
Final AADT: 14200
Route No: 19

DATE : 04/13/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	15	9	24	06:00-06:15	51	46	97	12:00-12:15	102	125	227	06:00-06:15	101	126	227
12:15-12:30	16	0	16	06:15-06:30	74	74	148	12:15-12:30	112	91	203	06:15-06:30	106	114	220
12:30-12:45	12	8	20	06:30-06:45	106	65	171	12:30-12:45	112	106	218	06:30-06:45	62	90	152
12:45-01:00	5	10	15	06:45-07:00	133	70	203	12:45-01:00	104	99	203	06:45-07:00	75	77	152
01:00-01:15	9	7	16	07:00-07:15	125	109	234	01:00-01:15	129	102	231	07:00-07:15	54	69	123
01:15-01:30	6	2	8	07:15-07:30	167	118	285	01:15-01:30	148	152	300	07:15-07:30	47	63	110
01:30-01:45	8	4	12	07:30-07:45	165	182	347	01:30-01:45	133	114	247	07:30-07:45	54	52	106
01:45-02:00	4	8	12	07:45-08:00	151	160	311	01:45-02:00	126	126	252	07:45-08:00	37	55	92
02:00-02:15	3	7	10	08:00-08:15	128	138	266	02:00-02:15	135	108	243	08:00-08:15	46	59	105
02:15-02:30	2	5	7	08:15-08:30	115	155	270	02:15-02:30	111	153	264	08:15-08:30	47	57	104
02:30-02:45	8	8	16	08:30-08:45	117	98	215	02:30-02:45	103	127	230	08:30-08:45	41	64	105
02:45-03:00	7	3	10	08:45-09:00	86	105	191	02:45-03:00	126	124	250	08:45-09:00	36	45	81
03:00-03:15	7	16	23	09:00-09:15	95	107	202	03:00-03:15	107	129	236	09:00-09:15	35	29	64
03:15-03:30	7	11	18	09:15-09:30	96	102	198	03:15-03:30	137	122	259	09:15-09:30	37	41	78
03:30-03:45	6	10	16	09:30-09:45	93	125	218	03:30-03:45	128	162	290	09:30-09:45	38	27	65
03:45-04:00	6	9	15	09:45-10:00	94	101	195	03:45-04:00	145	120	265	09:45-10:00	28	26	54
04:00-04:15	6	13	19	10:00-10:15	101	105	206	04:00-04:15	117	160	277	10:00-10:15	29	23	52
04:15-04:30	11	6	17	10:15-10:30	105	106	211	04:15-04:30	130	153	283	10:15-10:30	17	17	34
04:30-04:45	14	24	38	10:30-10:45	95	112	207	04:30-04:45	133	121	254	10:30-10:45	12	15	27
04:45-05:00	20	18	38	10:45-11:00	111	113	224	04:45-05:00	135	143	278	10:45-11:00	13	15	28
05:00-05:15	12	22	34	11:00-11:15	104	123	227	05:00-05:15	128	135	263	11:00-11:15	10	11	21
05:15-05:30	22	33	55	11:15-11:30	113	107	220	05:15-05:30	98	110	208	11:15-11:30	19	11	30
05:30-05:45	28	31	59	11:30-11:45	90	116	206	05:30-05:45	98	82	180	11:30-11:45	14	11	25
05:45-06:00	50	42	92	11:45-12:00	117	140	257	05:45-06:00	109	109	218	11:45-12:00	14	7	21

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM			PM - PEAK HR TIME	03:30 PM to 04:30 PM		
AM - PEAK HR VOLUME	611	598	1209	PM - PEAK HR VOLUME	520	595	1115
AM - K FACTOR (%)			8.73	PM - K FACTOR (%)			8.05
AM - D (%)	50.54	49.46	100.00	PM - D (%)	46.64	53.36	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM	07:30 AM to 08:30 AM		PM - PEAK HR TIME	03:15 PM to 04:15 PM	03:30 PM to 04:30 PM	
AM - PEAK HR VOLUME	611	635		PM - PEAK HR VOLUME	527	595	

AM PERIOD (00:00-12:00)	DIR 1	DIR 2		PM PERIOD (12:00-24:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	07:15 AM to 08:15 AM			PM - PEAK HR TIME	03:30 PM to 04:30 PM		
AM - PEAK HR VOLUME	611	598	1209	PM - PEAK HR VOLUME	520	595	1115
AM - K FACTOR (%)			8.73	PM - K FACTOR (%)			8.05
AM - D (%)	50.54	49.46	100.00	PM - D (%)	46.64	53.36	100.00

NON-COMMUTER PERIOD (09:00-15:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
PEAK HR TIME	01:15 PM to 02:15 PM		
PEAK HR VOLUME	542	500	1042
DIRECTIONAL PEAK			
PEAK HR TIME	01:15 PM to 02:15 PM	01:45 PM to 02:45 PM	
PEAK HR VOLUME	542	514	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	2,632	2,677	5,309
AM 12-HR PERIOD (00:00-12:00)	2,916	2,983	5,899
PM 6-HR PERIOD (12:00-18:00)	2,906	2,973	5,879
PM 12-HR PERIOD (12:00-24:00)	3,878	4,077	7,955
24 HOUR PERIOD	6,794	7,060	13,854
D (%)	49.04	50.96	100.00

Run Date: 2017/07/20

Hawaii Department of Transportation
Highways Division
Highways Planning Survey Section

Vehicle Classification Data Summary
2016

Site ID:	**B71001900029**	**Route No:**	**19**	**Date From:**	2016/04/12 0:00
Town:	**Hawaii**	**Direction:**	+MP	**Date To:**	2016/04/13 23:45
Location:	**Kalanianaole St - Kumau St to Keaa St**				

Functional Classification: **14 URBAN:PRINCIPAL ARTERIAL - OTHER**

REPORT TOTALS - 48 HOURS RECORDED

	VOLUME	%	NUMBER OF AXLES
Cycles	336	1.14%	672
PC	18133	61.56%	36266
2A-4T	9129	30.99%	18258
LIGHT VEHICLE TOTALS	27598	93.69%	55196
HEAVY VEHICLES			
Bus	283	0.96%	708
SINGLE UNIT TRUCK			
2A-6T	378	1.28%	756
3A-SU	449	1.52%	1347
4A-SU	38	0.13%	152
SINGLE-TRAILER TRUCKS			
4A-ST	32	0.11%	128
5A-ST	511	1.73%	2555
6A-ST	29	0.10%	174
MULTI-TRAILER TRUCKS			
5A-MT	78	0.26%	390
6A-MT	39	0.13%	234
7A-MT	22	0.07%	154
HEAVY VEHICLE TOTALS	1859	6.31%	6598
CLASSIFIED VEHICLES TOTALS	29457 (A)	100.00%	61793 (B)
UNCLASSIFIED VEHICLES TOTALS	1	0.00%	

AXLE CORRECTION FACTOR (A/C) = 0.953

ROADTUBE EQUIVALENT(B/2) = 30897 (C)

PEAK HOUR VOLUME : 1335 2016/04/12 16:00	PEAK HOUR TRUCK VOLUME	% TOTAL PEAK HOUR VOLUME	24 HOUR TRUCK VOLUME	AADT	% OF AADT	HPMS K-FACTOR (PEAK/AADT) (ITEM 66)
SINGLE UNIT TRUCKS (TYPE 4-7)	38	(65A-1) 2.85%	574	14200	(65A-2) 4.04%	9.40%
COMBINATION (TYPE 8-13)	7	(65B-1) 0.52%	355		(65B-2) 2.50%	9.40%

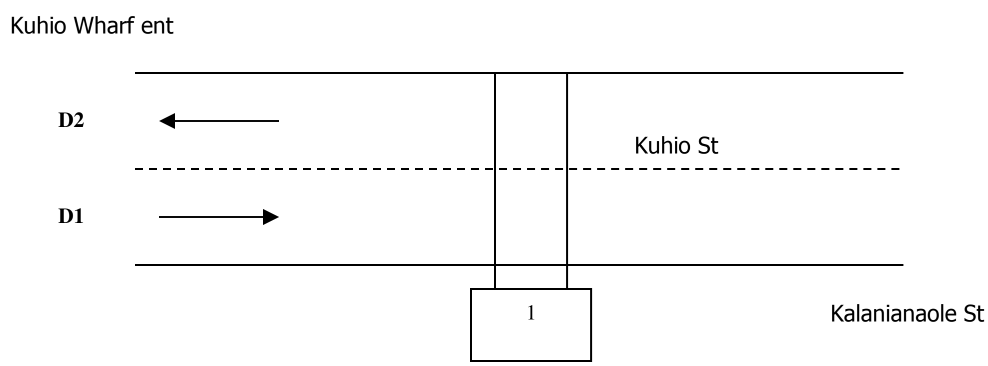
Traffic Data Service

Traffic Station Sketch

N

Island: Hawaii
Area: Hilo

Section ID/Station #: B71001900000



Meter #	File Name	GPS
1. w773	D0418011_B71001900000 D0418012_B71001900000	19.728558, -155.054064

Station Description:

Kuhio St: Kuhio Wharf ent to Kalanianaole St

Survey Beginning Date/Time: 4/18/16 @ 0000		Survey Ending Date/Time: 4/19/16 @ 2400	
Survey Method:	Road Tube	Data Type:	Class
Survey Crew:	LM		C1B
Sketch Updated:		By:	SR
Remarks:	1320		

FACILITY NAME	JURI	FUNC CLASS	AREA TYPE	ROUTE NO.	ROUTE MILE
Kuhio St		14		0019	

D1= Direction to End D1: Kalanianaole St/ Palani Rd (Rte 190)

D2= Direction to Begin D2: Kuhio Wharf ent/ ent to Kuhio Wharf

Run Date: 2017/07/26

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71001900000 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 7900

Functional Class: URBAN:PRINCIPAL ARTERIAL - OTHER **Count Type:** VOLUME **Counter Type:** Tube **Route No:** 19

Location: Kuhio Street: Kuhio Wharf to Kalanianaole St

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
DATE : 04/18/2016															
12:00-12:15	0	0	0	06:00-06:15	5	14	19	12:00-12:15	10	17	27	06:00-06:15	4	3	7
12:15-12:30	0	0	0	06:15-06:30	3	15	18	12:15-12:30	10	13	23	06:15-06:30	8	4	12
12:30-12:45	0	0	0	06:30-06:45	8	34	42	12:30-12:45	6	17	23	06:30-06:45	6	5	11
12:45-01:00	0	0	0	06:45-07:00	13	33	46	12:45-01:00	4	18	22	06:45-07:00	3	1	4
01:00-01:15	0	0	0	07:00-07:15	5	10	15	01:00-01:15	13	20	33	07:00-07:15	0	1	1
01:15-01:30	0	0	0	07:15-07:30	1	17	18	01:15-01:30	11	19	30	07:15-07:30	3	1	4
01:30-01:45	0	1	1	07:30-07:45	15	18	33	01:30-01:45	17	11	28	07:30-07:45	1	0	1
01:45-02:00	3	1	4	07:45-08:00	14	10	24	01:45-02:00	4	13	17	07:45-08:00	5	3	8
02:00-02:15	0	0	0	08:00-08:15	18	15	33	02:00-02:15	10	13	23	08:00-08:15	0	1	1
02:15-02:30	1	0	1	08:15-08:30	20	17	37	02:15-02:30	11	14	25	08:15-08:30	0	1	1
02:30-02:45	0	0	0	08:30-08:45	13	30	43	02:30-02:45	6	15	21	08:30-08:45	0	0	0
02:45-03:00	0	0	0	08:45-09:00	17	24	41	02:45-03:00	5	8	13	08:45-09:00	0	0	0
03:00-03:15	0	1	1	09:00-09:15	18	28	46	03:00-03:15	18	10	28	09:00-09:15	0	3	3
03:15-03:30	0	1	1	09:15-09:30	18	18	36	03:15-03:30	9	6	15	09:15-09:30	1	1	2
03:30-03:45	0	4	4	09:30-09:45	15	17	32	03:30-03:45	23	3	26	09:30-09:45	0	1	1
03:45-04:00	0	0	0	09:45-10:00	17	17	34	03:45-04:00	18	4	22	09:45-10:00	1	3	4
04:00-04:15	1	0	1	10:00-10:15	22	28	50	04:00-04:15	6	8	14	10:00-10:15	5	1	6
04:15-04:30	0	3	3	10:15-10:30	15	11	26	04:15-04:30	4	11	15	10:15-10:30	1	1	2
04:30-04:45	3	6	9	10:30-10:45	13	36	49	04:30-04:45	11	9	20	10:30-10:45	0	3	3
04:45-05:00	0	18	18	10:45-11:00	14	19	33	04:45-05:00	9	8	17	10:45-11:00	0	1	1
05:00-05:15	9	9	18	11:00-11:15	23	15	38	05:00-05:15	9	6	15	11:00-11:15	0	0	0
05:15-05:30	3	6	9	11:15-11:30	17	23	40	05:15-05:30	6	3	9	11:15-11:30	0	1	1
05:30-05:45	1	10	11	11:30-11:45	18	9	27	05:30-05:45	8	3	11	11:30-11:45	0	0	0
05:45-06:00	8	14	22	11:45-12:00	22	14	36	05:45-06:00	3	6	9	11:45-12:00	0	0	0

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2		PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	08:00 AM to 09:00 AM			PM - PEAK HR TIME	03:00 PM to 04:00 PM		
AM - PEAK HR VOLUME	68	86	154	PM - PEAK HR VOLUME	68	23	91
AM - K FACTOR (%)			10.42	PM - K FACTOR (%)			6.16
AM - D (%)	44.16	55.84	100.00	PM - D (%)	74.73	25.27	100.00
DIRECTIONAL PEAK				DIRECTIONAL PEAK			
AM - PEAK HR TIME	08:00 AM to 09:00 AM	06:00 AM to 07:00 AM		PM - PEAK HR TIME	03:00 PM to 04:00 PM	04:00 PM to 05:00 PM	
AM - PEAK HR VOLUME	68	96		PM - PEAK HR VOLUME	68	36	

AM PERIOD (00:00-12:00)				PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK				TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	08:15 AM to 09:15 AM			PM - PEAK HR TIME	12:45 PM to 01:45 PM		
AM - PEAK HR VOLUME	68	99	167	PM - PEAK HR VOLUME	45	68	113
AM - K FACTOR (%)			11.30	PM - K FACTOR (%)			7.65
AM - D (%)	40.72	59.28	100.00	PM - D (%)	39.82	60.18	100.00

NON-COMMUTER PERIOD (09:00-15:00)				6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
TWO DIRECTIONAL PEAK				AM 6-HR PERIOD (06:00-12:00)	344	472	816
PEAK HR TIME	10:30 AM to 11:30 AM			AM 12-HR PERIOD (00:00-12:00)	373	546	919
PEAK HR VOLUME	67	93	160	PM 6-HR PERIOD (12:00-18:00)	231	255	486
DIRECTIONAL PEAK				PM 12-HR PERIOD (12:00-24:00)	269	290	559
PEAK HR TIME	11:00 AM to 12:00 PM	10:00 AM to 11:00 AM		24 HOUR PERIOD	642	836	1,478
PEAK HR VOLUME	80	94		D (%)	43.44	56.56	100.00

Run Date: 2017/07/26

Hawaii Department of Transportation

Highways Division **Highways Planning Survey Section**

2016 Program Count - Summary

Site ID: B71001900000 **Town:** Hawaii **DIR 1:** +MP **DIR 2:** -MP **Final AADT:** 7900

Functional Class: URBAN:PRINCIPAL ARTERIAL - OTHER **Count Type:** VOLUME **Counter Type:** Tube **Route No:** 19

Location: Kuhio Street: Kuhio Wharf to Kalanianaole St

DATE : 04/19/2016

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:00-12:15	0	0	0	06:00-06:15	4	14	18	12:00-12:15	39	17	56	06:00-06:15	18	4	22
12:15-12:30	0	0	0	06:15-06:30	5	15	20	12:15-12:30	27	20	47	06:15-06:30	8	3	11
12:30-12:45	0	0	0	06:30-06:45	6	25	31	12:30-12:45	24	33	57	06:30-06:45	6	5	11
12:45-01:00	0	0	0	06:45-07:00	11	47	58	12:45-01:00	25	33	58	06:45-07:00	3	0	3
01:00-01:15	0	0	0	07:00-07:15	13	17	30	01:00-01:15	23	29	52	07:00-07:15	5	1	6
01:15-01:30	0	0	0	07:15-07:30	8	18	26	01:15-01:30	27	24	51	07:15-07:30	6	10	16
01:30-01:45	0	0	0	07:30-07:45	3	36	39	01:30-01:45	37	19	56	07:30-07:45	1	8	9
01:45-02:00	0	0	0	07:45-08:00	20	23	43	01:45-02:00	17	29	46	07:45-08:00	0	10	10
02:00-02:15	0	0	0	08:00-08:15	18	30	48	02:00-02:15	29	20	49	08:00-08:15	4	0	4
02:15-02:30	0	0	0	08:15-08:30	20	29	49	02:15-02:30	25	18	43	08:15-08:30	5	4	9
02:30-02:45	3	0	3	08:30-08:45	42	32	74	02:30-02:45	17	23	40	08:30-08:45	1	3	4
02:45-03:00	4	0	4	08:45-09:00	25	32	57	02:45-03:00	18	25	43	08:45-09:00	3	6	9
03:00-03:15	0	0	0	09:00-09:15	25	32	57	03:00-03:15	25	24	49	09:00-09:15	0	0	0
03:15-03:30	4	0	4	09:15-09:30	36	37	73	03:15-03:30	43	20	63	09:15-09:30	1	1	2
03:30-03:45	0	0	0	09:30-09:45	46	27	73	03:30-03:45	36	23	59	09:30-09:45	0	0	0
03:45-04:00	1	3	4	09:45-10:00	38	24	62	03:45-04:00	42	18	60	09:45-10:00	0	4	4
04:00-04:15	1	1	2	10:00-10:15	39	28	67	04:00-04:15	14	15	29	10:00-10:15	3	0	3
04:15-04:30	1	6	7	10:15-10:30	42	18	60	04:15-04:30	19	18	37	10:15-10:30	1	3	4
04:30-04:45	8	5	13	10:30-10:45	23	24	47	04:30-04:45	19	17	36	10:30-10:45	5	0	5
04:45-05:00	0	4	4	10:45-11:00	6	25	31	04:45-05:00	18	18	36	10:45-11:00	1	0	1
05:00-05:15	3	4	7	11:00-11:15	27	20	47	05:00-05:15	10	14	24	11:00-11:15	0	0	0
05:15-05:30	1	4	5	11:15-11:30	18	22	40	05:15-05:30	15	6	21	11:15-11:30	0	0	0
05:30-05:45	3	5	8	11:30-11:45	41	20	61	05:30-05:45	23	10	33	11:30-11:45	0	0	0
05:45-06:00	0	10	10	11:45-12:00	38	20	58	05:45-06:00	10	3	13	11:45-12:00	0	0	0

AM COMMUTER PERIOD (05:00-09:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	08:00 AM to 09:00 AM		
AM - PEAK HR VOLUME	105	123	228
AM - K FACTOR (%)			9.38
AM - D (%)	46.05	53.95	100.00
DIRECTIONAL PEAK			
AM - PEAK HR TIME	08:00 AM to 09:00 AM	08:00 AM to 09:00 AM	
AM - PEAK HR VOLUME	105	123	

PM COMMUTER PERIOD (15:00-19:00)	DIR 1	DIR 2	
TWO DIRECTIONAL PEAK			
PM - PEAK HR TIME	03:00 PM to 04:00 PM		
PM - PEAK HR VOLUME	146	85	231
PM - K FACTOR (%)			9.50
PM - D (%)	63.20	36.80	100.00
DIRECTIONAL PEAK			
PM - PEAK HR TIME	03:00 PM to 04:00 PM	03:00 PM to 04:00 PM	
PM - PEAK HR VOLUME	146	85	

AM PERIOD (00:00-12:00)			
TWO DIRECTIONAL PEAK			
AM - PEAK HR TIME	09:15 AM to 10:15 AM		
AM - PEAK HR VOLUME	159	116	275
AM - K FACTOR (%)			11.31
AM - D (%)	57.82	42.18	100.00

PM PERIOD (12:00-24:00)			
TWO DIRECTIONAL PEAK			
PM - PEAK HR TIME	03:00 PM to 04:00 PM		
PM - PEAK HR VOLUME	146	85	231
PM - K FACTOR (%)			9.50
PM - D (%)	63.20	36.80	100.00

NON-COMMUTER PERIOD (09:00-15:00)			
TWO DIRECTIONAL PEAK			
PEAK HR TIME	09:15 AM to 10:15 AM		
PEAK HR VOLUME	159	116	275
DIRECTIONAL PEAK			
PEAK HR TIME	09:30 AM to 10:30 AM	09:00 AM to 10:00 AM	
PEAK HR VOLUME	165	120	

6-HR, 12-HR, 24-HR PERIODS	DIR 1	DIR 2	Total
AM 6-HR PERIOD (06:00-12:00)	554	615	1,169
AM 12-HR PERIOD (00:00-12:00)	583	657	1,240
PM 6-HR PERIOD (12:00-18:00)	582	476	1,058
PM 12-HR PERIOD (12:00-24:00)	653	538	1,191
24 HOUR PERIOD	1,236	1,195	2,431
D (%)	50.84	49.16	100.00

Appendix C: Construction Trip Data

Maximum Construction Vehicles Per Day For Major Construction Activity Phases
(1) trip is one ascend or one descend (round trip = 2 trips)
June 2019

Highest Total - South	(light green)
Highest Total - North	(light yellow)
Highest Staff Trips - South	(green)
Highest Staff Trips - North	(orange)

	Total Trips Per Day																											
	MEP Demo				Partition Demo				Structure Demo				Paving Demo				Underground Removal				Backfill				Finish Work			
	South of HP		North of HP		South of HP		North of HP		South of HP		North of HP		South of HP		North of HP		South of HP		North of HP		South of HP		North of HP		South of HP		North of HP	
Alternative - Complete Removal/Full Restoration																												
Permanent	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8
Subs/Crew	5	10	0	0	5	10	0	0	11	22	0	0	1	2	1	2	7	14	0	0	5	10	0	0	8	16	0	0
Subs/Crew in Vans	0	0	1	2	0	0	1	2	0	0	2	4	0	0	0	0	0	0	2	4	0	0	1	2	0	0	2	4
Flatbed	1	2	1	2	0	0	0	0	2	4	2	4	1	2	1	2	1	2	1	2	1	1	1	1	1	2	1	2
Water Truck	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Dump Truck	2	4	2	4	2	4	2	4	0	0	0	0	4	8	4	8	3	6	3	6	0	0	0	0	0	0	4	48
Dump Truck First Day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0	0
Total		26		18		24		16		36		18		22		22		32		22		21		13		32		64
Alternative - Complete Removal/Moderate Restoration																												
Permanent										8						8									4	8	4	8
Subs										22						2									4	8	0	0
Subs in Vans																									0	0	1	2
Flatbed	← Same as Alternative CR/FR →																								0	0	0	0
Water Truck																									1	2	1	2
Dump Truck																									0	0	0	0
Dump Truck First Day																									0	0	0	0
Total		26		18		24		16		36		18		22		22		32		22		21		13		18		12
Alternative - Complete Removal/Minimal Restoration																												
Permanent										8						8												
Subs										22						2												
Subs in Vans																												
Flatbed	← Same as Alternative CR/MOD →																											
Water Truck																												
Dump Truck																												
Dump Truck First Day																												
Total		26		18		24		16		36		18		22		22		32		22		21		13		18		12
Alternative - Infrastructure Capping/Moderate Restoration																												
Permanent										8			4	8	4	8	4	8	4	8					4	8	4	8
Subs										22			1	2	1	2	6	12	4	8					4	8	0	0
Subs in Vans													0	0	0	0	0	0	0	0	Same as Alternative CR/FR				0	0	1	2
Flatbed	← Same as Alternative CR/FR →												1	2	1	2	1	2	1	2					0	0	0	0
Water Truck													1	2	1	2	1	2	1	2					1	2	1	2
Dump Truck													4	8	4	8	3	6	3	6					0	0	0	0
Dump Truck First Day													0	0	0	0	0	0	0	0					0	0	0	0
Total		26		18		24		16		36		18		22		22		30		26		21		13		18		12
Alternative - Infrastructure Capping /Minimal Restoration																												

	Total Trips Per Day													
	MEP Demo		Partition Demo		Structure Demo		Paving Demo		Underground Removal		Backfill		Finish Work	
	South of HP	North of HP	South of HP	North of HP	South of HP	North of HP	South of HP	North of HP	South of HP	North of HP	South of HP	North of HP	South of HP	North of HP
Permanent					8			8						
Subs					22			2						
Subs in Vans														
Flatbed							Same as Alternative IC/MOD							
Water Truck														
Dump Truck														
Dump Truck First Day														
Total	26	18	24	16	36	18	22	22	30	26	21	13	18	12

Appendix G. Scoping Message and Background Summary

Decommissioning
Caltech Submillimeter Observatory (CSO) on Maunakea

The California Institute of Technology (Caltech) is decommissioning the Caltech Submillimeter Observatory (CSO) from Maunakea. CSO was completed in 1986, and used until scientific operations ended in 2015.

With the CSO, astronomers from all over the world were able to observe light naturally emitted by celestial objects at submillimeter wavelengths. This spectral range, between infrared and radio, allows for studying the molecular gases and small solid dust particles that fill the densest regions of the interstellar medium, where stars form as gas clouds contract and collapse under the pull of gravity.

Caltech Submillimeter Observatory (CSO)

CSO Facility Overview

The CSO facility includes the telescope, dome, foundation, other underground structures, and support structures.

- Situated on a 0.75-acre site at 13,350 ft altitude near the summit of Maunakea
- CSO consists of the following structures and improvements:
  - Radio telescope: 10.4-m (34-feet) diameter with aluminum panel reflector supported by steel truss
  - Co-rotating dome: steel structure clad with aluminum sheets on concrete foundation
  - Dimensions: 60-feet in diameter and 52-feet high
  - Surrounding CSO facilities: Support building, parking area, utilities infrastructure

Caltech Will Follow Sub-Lease Terms, Maunakea Comprehensive Management Plan, and Decommissioning Plan

The process of decommissioning includes preparation of related plans and analysis that consider a range of issues, including the impacts of demolition, waste management, contamination, removal of underground fixtures, habitat restoration, and cost. Caltech will follow the process outlined in the Decommissioning Plan (Plan), including preparation and submittal for review of:

- An Environmental Due Diligence Review,
- A Site Deconstruction and Removal Plan (SDRP), and
- A Site Restoration Plan (SRP)

These documents will be part of an Environmental Assessment (EA) with the typical alternatives and analysis and solicitation of public comment. It is anticipated that the following technical reports would also be part of the EA:

- Archaeological Setting
- Cultural Setting and Consultation
- Biological Setting
- Geological Setting
- Traffic Analysis
- Solid Waste Disposal
- Benefits and Cost Analysis (including social, cultural, economic, etc.)
- Engineering Reports
  - Deconstruction/Removal Plan
  - Restoration Plan; and
  - Environmental Site Assessment (Environmental Due Diligence Review)

A Conservation District Use Permit (CDUP), as well as other County, State and Federal agency reviews and/or permits will be required. Decommissioning involves the removal of the physical structures associated with the observatory facility, and restoration of the site, *to the greatest extent possible*, to its preconstruction condition. The extent of removal and level of restoration must be acceptable to both the University of Hawaiʻi (UH) and Department of Land & Natural Resources. Once CSO is removed and the site restored, the site will not be used for observatory development.

Removal of Physical Structures

The CSO is the first telescope to be removed from Maunakea under the Decommissioning Plan. As stipulated in the Plan, Caltech will prepare an impact analysis of dismantling and removal of CSO structures. The SDRP will outline approaches to decommissioning, including analysis of the cultural, environmental, and financial impacts and benefits, a schedule for implementation, and impacts of two scenarios:

- **Complete removal** – total removal of the above and underground structures
- **Partial removal and infrastructure capping** – removal of the top of the underground structures and burial of the reminder

Site Restoration

The Plan stipulates two primary objectives for site restoration – 1) restore look and feel of the summit prior to observatory construction, and 2) provide habitat for aeolian arthropod fauna. Preparation of an SRP will describe methods for restoring disturbed areas after activities described in the SDRP are completed. While the Plan states "full restoration" be used as the starting point for a sublessee to determine restoration, the Maunakea Comprehensive Management Plan (2009) identifies three levels of restoration:

- **Minimal** – removal of all man-made materials and grading of the site
- **Moderate** – includes the above and enhancing the physical habitat to benefit arthropods
- **Full** – return the site to its original topography, as well as restoring arthropod habitat

The Plan further states "the level of restoration attempted and the potential benefits and impacts of the restoration activities on natural and cultural resources during and post-activity must be carefully evaluated."

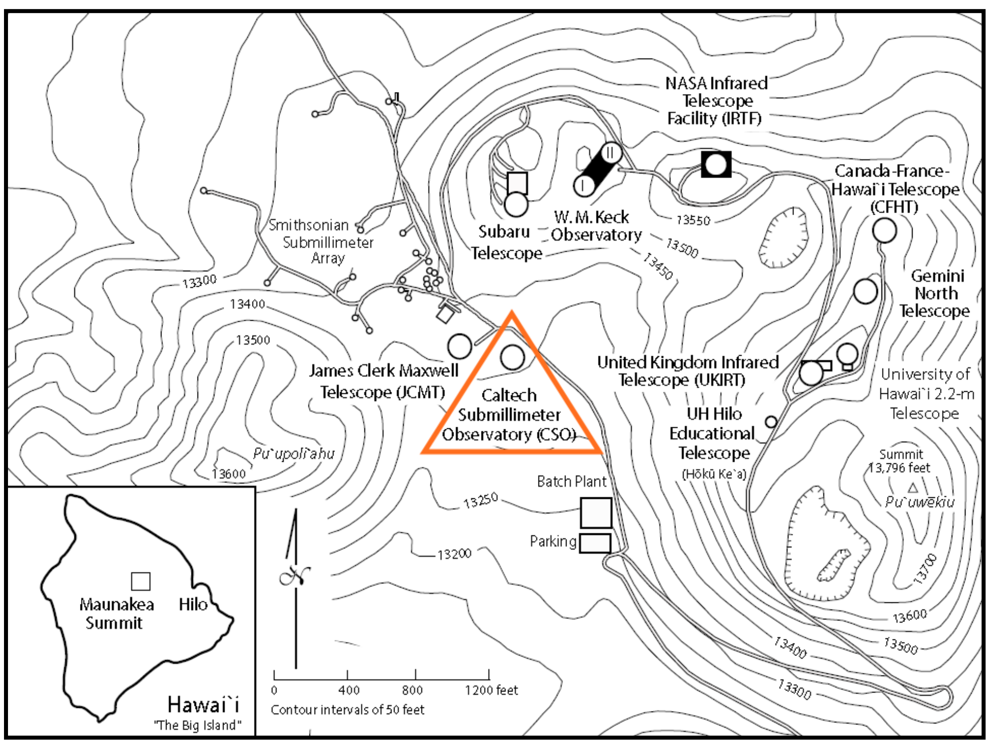
UH has indicated that retaining the existing support building, under its jurisdiction, should also be analyzed as an alternative – for the purposes of addressing visitor and observatory safety needs, as well as continuing long-term environmental monitoring of chlorine monoxide (related to the ozone hole).

Telescope Reuse Plan

As Caltech actively works to fully decommission and restore the CSO site, it is finalizing plans to relocate the CSO telescope - still the world's best 10-m class, THz-capable telescope - to Chile, in order to upgrade the instrumentation in sub-millimeter astronomy, there.

Project Team

Caltech selected M3 Engineering, Hoʻokuleana, and Hastings & Pleadwell: A Communication Company for project planning, permit applications, communication, and community outreach related to CSO decommissioning.



Maunakea Astronomy Precinct – Telescope Locations

Project Status

A public scoping period – the first opportunity for community to comment on removal and site restoration – launched December 4, 2017. The team is meeting with community and business leaders, elected officials, government agencies, and the public-at-large to solicit comment on the decommissioning process.

Periodic updates on the status of decommissioning are at www.cso.caltech.edu.

Appendix H. Site Restoration Effectiveness Monitoring Plan

SITE RESTORATION EFFECTIVENESS MONITORING PLAN FOR THE CALTECH SUBMILLIMETER OBSERVATORY

Personnel and Permitting

A biologist with appropriate experience will be selected by Caltech to perform the monitoring tasks. The individual or firm conducting the monitoring may change from year to year, depending on availability. The selection will be subject to the approval of the Center for Maunakea Stewardship (CMS) Executive Director.

Schedule

All site monitoring will occur in the summer (in June, July, or August).

The first monitoring event will be conducted before the start of CSO deconstruction activities. It is anticipated this will occur in June 2022. This event will provide a baseline against which post-restoration monitoring can be compared.

The first post-restoration monitoring event will occur the summer after site restoration is completed. If site restoration work is completed after May 31, the first monitoring event will occur in June, July, or August of the following year. If site restoration work is completed before May 31, the first monitoring event will occur in June, July, or August of that year.

Post-restoration effectiveness monitoring will be conducted annually for three consecutive years.

Data and reports will be submitted to the CMS Executive Director within three months of completing field monitoring.

Nomenclature

Nomenclature will follow the Hawaiian Terrestrial Arthropod Checklist, Fourth Edition (Nishida 2002), or suitable updates of this checklist. Consistent with previous studies at the CSO Site, the following terms will be used to describe the status of various taxa:

- Endemic – A species native to, or restricted to Hawaiʻi.
- Indigenous – A species native to Hawaiʻi but that naturally occurs outside of Hawaiʻi as well.
- Non-native – An introduced species living outside of its native distributional range. The introduction could be purposeful or accidental.
- Unknown – Used in this report when a genus contains species that are both native and non-native, and the specimen could not be confidently identified to species level. For example, *Bradysia* flies.

Methods

The methods described will be employed across the roughly 1.3 acre CSO Site, which includes the entirety of the 0.75 CSO sublease area (Figure 1).

Floral and Abiotic Features

To assess the abundance and composition of the floral community at the CSO Site, as well as observe any notable features of the abiotic environment and signs of use of the site by non-arthropod animals, transects will be walked parallel to the former CSO sublease boundary line. Transects will be spaced roughly 5 meters apart (16.4 feet). Roughly 17 transects will be walked in order to examine the entire CSO Site (Figure 1).

The position and estimated number of plants, lichens, and other resources observed will be recorded on a map of the area.

Trapping: Native and Non-native Arthropods

The presence of wēkiu bugs (which are not expected to be encountered) and other crawling arthropods, and flying insects will be assessed using traps. Up to four trap types will be installed at each of six locations within the former CSO Site. All trap types and bait will be consistent with those employed by CMS personnel during similar monitoring efforts elsewhere on Maunakea during the subject year.

The six locations will be selected so that they are placed in a diversity of substrate types (e.g., where the ground surface is hard lava vs. where the ground surface consists of gravel, sand and ash; and flat vs. sloped areas)[1], and placed in areas that will be both disturbed and undisturbed during facility deconstruction.

The traps will be retrieved three to four days after being set.

Hand Searching: Arthropods & Vegetation

A visual 5-10 minute hand search for crawling arthropods will be conducted within a 10-m radius of each trap location. Hand searching can be conducted during trap placement or retrieval. Effective hand searching is practiced on the ground level at a slow speed, so that arthropods do not become frightened before they are sighted. Hand searching will differ between substrate types. For example sites with larger rocks can be searched by overturning rocks so that the substrate below the rock, as well as the underside of the rock, can be examined for arthropods. Sites with a higher proportion of cinder and very few large rocks can be searched by brushing your hand over the substrate. Rocks will be replaced immediately following examination. Native vegetation observed during the hand search will be recorded, and invasive plant threats (i.e. fireweeds, telegraph weed) will be recorded and removed.

[1] It may not be possible to install all trap types in certain substrate types, for example, traps that need to partially buried are not possible to install on a bare lava substrate. Only those trap types deemed appropriate to the substrate will be installed.

Reporting

If ants or new arthropod or plant species are discovered during the post-restoration monitoring events, they will be reported to CMS immediately.

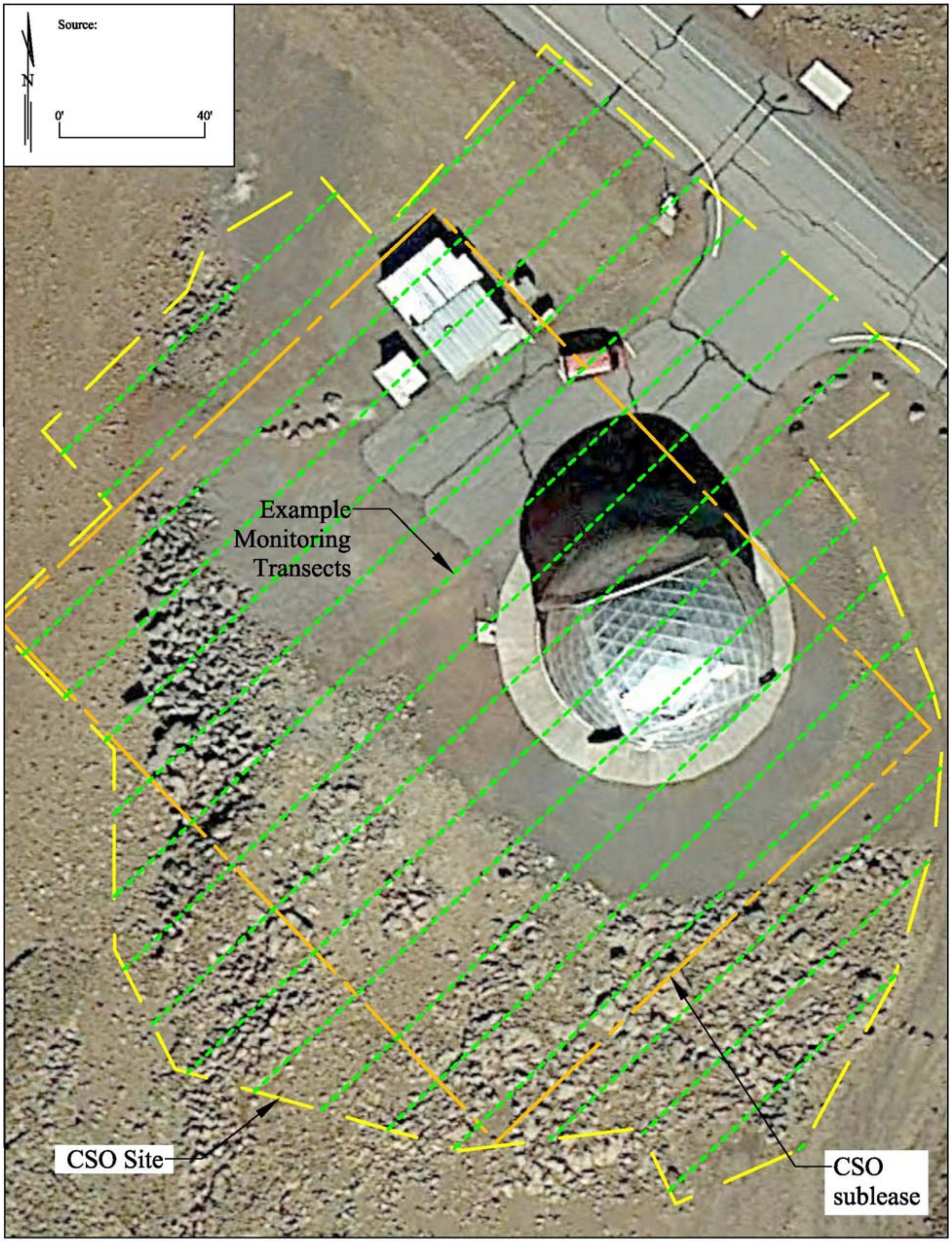
A report summarizing the findings will be prepared by the selected biologist and provided to the CMS Executive Director within three months of completing the field activities outlined in the Methods section. The reports will make comparisons to the monitoring conducted in 2018 during decommissioning planning (SRGII, 2019), prior to the commencement of deconstruction activities, and between the three years of restoration effectiveness monitoring.

The final report will make an assessment of the CSO Site restoration effectiveness and identify lessons learned that could be used to inform future habitat restoration projects within similar areas of Maunakea.

Follow-up Action

If invasive species are encountered and CMS indicates a response is warranted, Caltech and the selected biologist will work with CMS personnel to plan and implement an agreed upon response action.

Figure 1: CSO Site and Transects



Source: PSI

Appendix I. Best Management Practices Plan

DRAFT

BEST MANAGEMENT PRACTICES PLAN FOR THE DECOMMISSIONING OF THE CALTECH SUBMILLIMETER OBSERVATORY

November 2021

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1.0 INTRODUCTION

1.1 INTRODUCTION AND PURPOSE

This *Best Management Practices Plan for the Decommissioning of the Caltech Submillimeter Observatory* (henceforth, the “BMP Plan”) provides the details of various Best Management Practices (BMPs) that the California Institute of Technology (Caltech) has committed to implementing during the decommissioning of the Caltech Submillimeter Observatory (CSO). The commitments are made in the project’s Site Decommissioning Plan (SDP), Environmental Assessment (EA), and Conservation District Use Application (CDUA). The BMPs included in this plan address, and exceed, the applicable Comprehensive Management Plan (CMP) management actions listed below:

- C-1: General requirement – Require an independent decommissioning manager who has oversight and authority to ensure that all aspects of ground-based work comply with protocols and permit requirements.
- C-2: BMP – Require use of *Best Management Practices Plan for Construction Practices*.
- C-3: BMP – Develop, prior to construction, a Rock Movement Plan.
- C-4: BMP – Require contractors to provide information from construction activities to Center for Maunakea Stewardship (CMS) for input into CMS information database.
- C-5: BMP – Require on-site monitors (e.g., archaeological monitor, cultural monitor, and invasive species monitor) during construction, as determined by the appropriate agency.
- C-6: BMP – Conduct required archaeological monitoring during construction projects per State Historic Preservation Division (SHPD)-approved plan.
- C-7: BMP – Education regarding historical and cultural significance.
- C-8: BMP – Education regarding environment, ecology, and natural resources.
- C-9: BMP – Inspection of construction materials.

1.2 SCOPE

The Caltech personnel, contractors, subcontractors, suppliers and other organizations and persons entering and/or working in the UH Management Areas to implement, conduct, or monitor the proposed project must adhere to all measures in this BMP Plan.

1.3 LIST OF PERMITS REQUIRED

- Grading Permit (County of Hawaiʻi, Department of Public Works, Engineering Division Permit Number ____)

- Stockpiling Permit (County of Hawaii, Department of Public Works, Engineering Division Permit Number ____)
- National Pollutant Discharge Elimination System (NPDES) Notice of General Permit Coverage (NGPC) for Construction (Permit Number HI _____)
- Oversize/Overweight Vehicle - Obtained by Contractor from the Hawai‘i Department of Transportation prior to movement of any load that requires this permit.
- Community Noise Permit - Obtained by Contractor.

2.0 Decommissioning Monitoring

The monitoring outlined in this chapter address CMP management actions C-1, C-5, and C-6 (see Section 1.1). As required by those CMP management actions, several specialists will monitor the proposed project and have the authority to: (*i*) monitor ground-based work to verify that it complies with protocols and permit requirements, and (*ii*) stop activities if protocols and permit requirements are not being followed, unknown resources are encountered, or impacts to resources may occur.

All third-party monitors discussed in this chapter will participate, as appropriate, in regularly scheduled meetings lead by the general contractor. The meetings will keep the monitors abreast of the progress of project activities and schedule. The independent monitors will interface with the general contractor to confirm that project activities follow the established protocols. It is also anticipated that each of the monitors will contribute to the project's worker orientation program (Chapter 3.0).

The following sections provide details specific to each of the monitors.

2.1 Independent Decommissioning Manager

In accordance with CMP management action C-1 (see Section 1.1), a fulltime independent decommissioning manager will monitor the proposed project. The decommissioning manager will be independent of the general contractor and will be selected by CMS with the concurrence of the Department of Land and Natural Resources (DLNR). The monitor's time and activities will be supported by Caltech funds.

The independent decommissioning manager will monitor the project's adherence to: (*i*) this BMP Plan; (*ii*) permit conditions, which are anticipated to include the implementation of this plan and other commitments made in the EA and CDUA; and (*iii*) all applicable federal, state, and county statutes, regulations, and standards. The decommissioning manager has the authority to order that any or all activities cease if, in the monitor's judgment: (*i*) there has been a violation of the terms or conditions of the project's permits that warrants cessation of activities; or (*ii*) continued activities will unduly harm natural or cultural resources. Cessation orders shall be for a period not to exceed seventy-two (72) hours for each incident. The monitor shall immediately report cessation orders to the Chairperson of the Board of Land and Natural Resources (BLNR) and the Executive Director of CMS. The BLNR Chairperson may issue a cease-and-desist order to extend the period of time that activity is prohibited or make another order as the Chairperson deems appropriate.

The independent decommissioning manager will:

- Have experience and knowledge of: (*i*) the CMP and Maunakea's resources, (*ii*) Conservation District rules (HAR §13-5), (*iii*) UH Maunakea Lands rules (HAR §20-26), and (*iv*) construction management.

- Have completed the education and training programs related to CMP management action C-7 and C-8 prior to entering the UH Management Areas.
- Be present during activities as they feel appropriate. Activities include the delivery of equipment and materials and any time the Contractor or other project personnel are present in the UH Management Areas.
- Ensure that monitoring requirements are being met and work with other monitors required at varying times during the project. However, it is not the decommissioning manager's job to coordinate or schedule the other monitors; that is the job of the general contractor.
- Review items submitted by the project to CMS.

The independent decommissioning manager may give oral and/or written directives to project personnel to ensure compliance with governing conditions.

2.2 ARCHAEOLOGICAL MONITORING

In accordance with CMP management action C-6 and as recommended in the Archaeological Assessment (AA) prepared for the proposed project (ASM, 2018), an Archaeological Monitoring Plan (AMP) has been prepared in accordance with HAR §13-279 and will be approved by SHPD prior to the start of deconstruction activities. A draft of the AMP is included in Appendix A.

The individual and/or company providing archaeological monitoring services will be selected and funded by Caltech, approved by the CMS Executive Director, and subject to disqualification by SHPD.

In accordance with CMP management action C-5, archaeological monitoring will be performed in compliance with the AMP. Briefly, the AMP stipulates that:

- The archaeological monitor will be present during ground-altering activity (e.g., digging trenches, removal of underground foundations and utilities, and removal of existing fill material) that potentially extends into previously undisturbed ground.
- The archaeological monitor has the authority to halt activities in the vicinity of any find, so that provisions of the AMP can be carried out.
- If a find is made, the archaeological monitor will contact Caltech, SHPD (808-692-8015), CMS, and Kahu Kū Mauna Council.

Should project personnel encounter potential historic material during work activities, they will immediately inform the archaeological monitor.

2.3 CULTURAL MONITORING

In accordance with CMP management action C-5, cultural monitoring will be conducted. As recommended in the Cultural Impact Assessment (CIA) prepared for the proposed project (ASM, 2020), a cultural monitor will be present whenever the archaeological monitor is present. The individual and/or company providing cultural monitoring services will be selected and funded by Caltech and approved by the CMS Executive Director.

Specifics regarding the cultural monitoring effort are included in Chapter 4, the "Cultural Monitoring Methods" section, of the AMP (Appendix A). The cultural monitor shall:

- Have the appropriate background to serve as a cultural monitor and resource specialist within the UH Management Areas.
- Not be affiliated with the firm hired to perform archaeological monitoring.
- Report to Caltech, CMS, and Kahu Kū Mauna Council any findings or concerns on a monthly basis.

Any shrine, find spot,[1] offering, or other evidence of cultural activity encountered by project personnel will be reported to the cultural monitor.

2.4 INVASIVE SPECIES MONITORING PLAN

In accordance with CMP management actions C-5 and C-9 and as recommended in the Biological Setting Analysis (SRGII, 2019), invasive species monitoring will be conducted. The individual and/or company providing invasive species monitoring services will be selected and funded by Caltech, approved by the CMS Executive Director, and subject to disqualification by the DLNR.

The invasive species monitoring protocols shall follow the Maunakea Invasive Species Management Plan (2015) and incorporates its Standard Operating Procedures (SOPs). The project-specific Invasive Species Management Plan (ISMP) is provided in Sections 2.4.1 through 2.4.7. In summary, the project-specific ISMP includes:

- Inspections of equipment, vehicles, and supplies prior to their entering the UH Management Areas to ensure they are not harboring invasive species.
- Monthly monitoring throughout the decommissioning process for invasive species at the CSO Site and staging areas.
- Preparation and implementation of a rapid response plan should a new invasive species be detected.

2.4.1 Overview

Per CMP management action C-8, project personnel will be trained to understand the sensitivity of the UH Management Areas. Part of their project-specific training will be to follow the measures described below, as applicable to their position.

This plan applies to all project activities within the UH Management Areas, including the movement of people, personal supplies, construction materials, earth moving equipment, and vehicles into the UH Management Areas. These movements could

[1] A "find spot" is a cultural remain that is either obviously modern or cannot be confidently classified as a historic site because its age is uncertain, such as a rock pile.

introduce non-indigenous weedy flora or invasive fauna pests to the Maunakea summit region. These alien species can out-compete and displace native species and thereby reduce or eliminate native populations.

This plan and those implementing it will follow OMKM-approved SOPs based on the invasive species monitoring and inspection requirements mandated in the CMP. Monitoring personnel will regularly coordinate with CMS personnel to ensure protocols continue to comply with the CMP and the Maunakea Invasive Species Management Plan (2015).

Should project personnel encounter potential invasive species during work activities within the UH Management Areas, they will immediately inform the invasive species monitor.

2.4.2 CSO Decommissioning Requirements for Invasive Species Prevention

Prior to proceeding beyond Daniel K. Inouye Highway (known locally as “Saddle Road”), in advance of entering UH Management Areas, all construction materials, equipment, crates, and containers carrying materials and equipment will be inspected and certified free of invasive species by the invasive species monitor, who will certify that all materials, equipment, and containers are free of any and all flora and fauna that may potentially have an impact on the alpine stone desert ecosystem.

The proposed project involves the movement of very little material into the UH Management Areas. Nevertheless, inspection and repacking of all shipments will be done prior to proceeding beyond the Saddle Road so that only essential packing material is used for the final transportation. This will help reduce the volume of material potentially harboring invasive species and minimize the waste generated at the project site.

Wooden pallets, if any, must be free of bark to prevent transport of alien species as defined in International Standards for Phytosanitary Measures #15 "Regulation of Wood Packaging Material in International Trade," prepared by the Secretariat of the International Plant Protection Convention.[2]

Items that could serve as a food source for invasive species, such as food, food wrappers, and beverage containers, will be collected separately from other debris and removed from the Maunakea summit region at the end of each day.

Materials and clothing will be washed or otherwise cleaned prior to proceeding above Saddle Road. This will be done at lower elevation locations. In addition, everyone must brush down their clothes and shoes to remove invasive plant seeds and invertebrates prior to traveling above Saddle Road.

Waste containers must be regularly pressure-washed using steam and/or soap to reduce odors that may attract bugs.

[2] Available online at: https://www.fao.org/3/mb160e/mb160e.pdf.

All construction vehicles and equipment must be pressure-washed and inspected in accordance with SOP #01 and SOP #02 to verify the absence of any invasive species before being moved above Saddle Road.[3, 4] In addition, all construction materials, equipment, crates, and containers carrying materials and equipment must be inspected and certified free of invasive species by the invasive species monitor. Inspections are considered a commercial activity and cannot occur along roadsides, at State or County parks, or on Department of Hawaiian Homelands (DHHL) land (e.g., DHHL parking at Puʻuhuluhulu). Generally, inspections need to occur in Hilo, Waimea, or Kona.

The CSO Site and staging areas will be monitored monthly for the presence of invasive species. The monitoring will be performed by the invasive species monitor. The monitoring will be conducted per SOP #10.[5] Invasive species identified during monitoring will be controlled to prevent spread.

2.4.3 Cleaning of Vehicles and Personal Belongings

Complete details and requirements applicable to the project are found in SOP #01, which this section summarizes. The project-specific ISMP applies to project-related (private or commercial) passengers, vehicle operators, immediate personal possessions, and any vehicle or heavy equipment operating in UH Management Areas.

All vehicles are to be cleaned both inside and out by the operator prior to travelling above Saddle Road. The operator of vehicles with less than three axles are to visually inspect the vehicle exterior and interior to ensure it is free of contaminants and other debris that might harbor plant, animal, or earthen materials. If the operator observes a build-up of these contaminants, he/she must clean or arrange for the vehicle to be cleaned prior to proceeding above Saddle Road.

All vehicles are to be cleaned both inside and out by the operator prior to travelling above Saddle Road. Vehicles with three or more axles, and equipment (motor vehicles without a highway license plate), must be inspected by the invasive species monitor to ensure they are free of plant, animal, and earthen materials.

Caltech will require washing of the vehicle undercarriages monthly for vehicles that leave and re-enter UH Management Areas, per SOP #1.

Personal belongings and vehicle safety equipment are to be cleaned and inspected by the operator prior to travelling above Saddle Road.

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[3] SOP #01 is available online at: http://www.malamamaunakea.org/uploads/environment/MKISMP/SOP01_CleaningofVehiclesPersonalBelongings.pdf

[4] SOP #02 is available online at: http://www.malamamaunakea.org/uploads/environment/MKISMP/SOP02_VehicleEquipmentSupplies-Inspection.pdf

[5] SOP #10 is available online at: http://www.malamamaunakea.org/uploads/environment/MKISMP/SOP10_InvasiveInvertFacilitySurveys.pdf

Should an invasive species be found on vehicles or equipment within the UH Management Areas, the operator is to stop, immediately leave the UH Management Areas, and return to a location below Mauna Kea Access Road where the vehicle or equipment must be cleaned before returning.

If plant, animals, or earthen materials are observed at any time, project personnel will contain and securely seal the package or delivery (using garbage bag, plastic wrap, etc.), and contact CMS staff immediately. The contaminated package or delivery is not permitted to proceed into UH Management Areas, until re-inspected and approved by the invasive species monitor. All findings will be recorded and reported to Caltech.

Rangers and staff may conduct vehicle inspections within the UH Management Areas at any time to verify cleanliness; this includes unattended vehicles. Vehicle owners will be notified if any concerns are identified.

2.4.4 Inspection of Construction Equipment and Supplies

Complete details and requirements applicable to the project are found in SOP #02, which this section summarizes. Inspection and cleaning of construction equipment and supplies is required prior to traveling above the Saddle Road. This requirement refers to loads, deliveries, packages, construction materials, and equipment that will be used within the UH Management Areas. This requirement does not refer to items not entering the UH Management Areas, nor does it refer to the cleaning of vehicles with 2 axles or less.

Very little construction equipment and supplies will be brought into the UH Management Areas as part of the proposed project. For instance, no aggregate or other building materials will be imported. Equipment will likely consist of a crane, an office trailer, portable toilets, water tank, a loader, roll-off bins, fencing, and smaller tools.

Preparation

Those shipping or traveling onto Maunakea lands are encouraged to:

- Maintain clean storage, workshop, and shipping locations that are free of invasive plants, insects, and other animals.
- Be aware that an inspection may be required and to include additional time for this activity in planning for shipping and travel.
- Maintain a location for inspections that is free of plant, animal, or earthen material; regularly treated for invasive species; with suitable cleaning supplies (vacuums, running water, etc.) available to take remedial action when concerns are identified during inspections.

Equipment, Materials, Supplies, & Load Guidelines

When shipping supplies and equipment to UH Management Areas, operators are required to:

- Minimize materials and dunnage included to the minimum required for safe and secure delivery. If minimizing materials is not possible, then be prepared to remove packing materials for the invasive species inspection.
- Clean vehicles and deliveries: cleaning includes removal of all plant, animal, and earthen materials on supplies and equipment prior to arrival on Maunakea. See SOP #01 for cleaning details. Once cleaned and inspected, if diverted to another job outside of the UH Management Areas, vehicle and cargo must be re-cleaned and re-inspected prior to returning to UH Management Areas.

All equipment, materials, and supplies are to be cleaned by the operator, prior to proceeding above Saddle Road. All equipment, materials, and supplies entering the UH Management Areas must be inspected by the invasive species monitor to ensure they are free of plant, animal, and earthen materials.

For further details see SOP #02.

2.4.5 Invasive Species Control

The project-specific ISMP will be conducted in consultation with CMS and applicable State agencies. Details of methods and responses are addressed in the ISMP.

In general, should a new invasive species be detected, a rapid response plan would be developed in consultation with CMS and implemented. Components of a rapid response plan that could be implemented immediately by the invasive species monitor include:

- Hand pulling, bagging, and disposal off-site of invasive plant species and other measured included in SOP D.[6]
- Setting traps to assess the size of an invasive arthropod species detected and other measured included in SOP B.[7]

2.4.6 Reporting

If ants or new arthropod or plant species are discovered within the UH Management Areas at any time during the project, the invasive species monitor will report the incident to CMS immediately.

The monitor will provide logs and incident reports to the contractor in a timely manner so that they can be included in the monthly reports (Section 5.2) provided to CMS.

The final report will be prepared that identifies lessons learned related to invasive species that could be used to inform planning for and monitoring during future decommissioning or construction projects in the UH Management Areas.

[6] Available online at: http://www.malamamaunakea.org/uploads/environment/MKISMP/SOP-D_PlantThreatsIDCollectionProcessGuide.pdf
[7] Available online at: http://www.malamamaunakea.org/uploads/environment/MKISMP/SOP-B_Vertebrate_ThreatIDCollectionProcessGuide.pdf

2.4.7 Failure to Comply

Project personnel who fail to comply with these invasive species guidelines will be subject to a penalty. Such penalty may be imposed immediately by the Ranger, or after the report has been reviewed by CMS staff. For example, a vehicle discovered with inappropriate material on the summit on a Tuesday may be directed to leave immediately or entered in the daily Ranger report and directed to leave the following day after the Ranger report is reviewed by CMS staff.

3.0 Training Program

This training program is designed to comply with CMP management actions C-7 and C-8.

3.1 MAUNAKEA USERS ORIENTATION

All project personnel, including Caltech, contractors, suppliers, and vendors, performing work in UH Management Areas will receive the Maunakea Users Orientation prior to entering the UH Management Areas.[8] This is a mandatory annual requirement when working on the project and covers historic, cultural, environmental, ecology, and natural resources related to the UH Management Areas as required in CMP management actions C-7 and C-8.

CMS maintains a list of all persons that have completed an orientation session and issues a card to each person. The card shows the date of completion of the orientation. Numbered stickers for placing on hardhats will also be issued to people that will be working on the project. CMS can require that any person on the CSO Site not having either the card or the sticker immediately leave the UH Management Areas.

All work will be performed in accordance with the principles established in the Maunakea Orientation. Any person not behaving in a manner consistent with the principles established in the Maunakea Orientation will be required to leave the UH Management Areas.

3.2 PROJECT SPECIFIC TRAINING

Project monitors (Chapter 2.0) will provide additional information and training to project personnel during a project kickoff meeting and during weekly meetings (e.g., tailgate safety meetings). The project-specific training will be tailored to the tasks scheduled for the next week and address issues identified during the previous week, if any.

The monitors will cover a wide variety of topics at the kickoff meeting and periodically throughout the implementation of the project. Some of the topics that will be included are:

- If any monitor requests that you cease an activity, you are to immediately cease that activity.
- Invasive species related:
  - Monitor must be informed in advance (a period of time agreed to by the monitor and Contractor) of all equipment and materials being delivered to the site so that inspections can occur and not delay progress.
  - Vehicles and personnel with the UH Management Area are to be clean, as specified in Section 2.4.3.

[8] Available online at: http://www.malamamaunakea.org/about-us/maunakea-orientation

  - All food waste, from plastic wrappers to soda cans to anything else related to food, is to be contained separately (not tossed in roll-off bins) and removed from the UH Management Area daily.
- Archaeology and culture related:
  - There is to be no traffic or movement outside of the designated roads and project areas. This means no driving or other use of the abandon dirt road between the CSO Site and the Batch Plant.
  - Cinder cone areas are particularly sensitive and extra caution is to be used to avoid entering the area on the opposite side of the access road, which is known as Kūkahauʻula.
  - If anything is encountered that could represent an archaeological or cultural resource, stop work and inform the monitors immediately.

4.0 Rock Movement Plan

This plan is designed to comply with CMP management action C-3.

The only rock movement that will occur as part of the CSO Decommissioning Project is the removal of fill from the CSO Site and the stockpiling of that material in a portion of the Batch Plant. As documented in the *Hydrogeological and Geological Evaluation for the Decommissioning of the California Institute of Technology Submillimeter Observatory* report (Intera, 2018), the fill material is consistent with Laupāhoehoe Volcanics and compositionally consistent with the lavas present in the summit region of Maunakea. Much or all of the CSO Site fill is believed to have been sourced from an excavation in a Laupāhoehoe lava flow during widening of the Mauna Kea Summit Access Road and possibly tephra from one of the nearby Laupāhoehoe cinder cones.

4.1 Location, Type, and Volume of Source Material

The location, type, and amount of source material and cut and fill is estimated as the following:

Type of Rock	Existing Location	Finished Location	Amount (cubic yards)
Laupāhoehoe Volcanics (fill placed on CSO Site during development in early 1980s)	CSO Site	Batch Plant	2,830
Fine ash material and small rocks separated from fill placed on CSO Site during development in early 1980s	CSO Site	CSO Site to restore habitat	roughly 5
Note: Quantities are estimates. Source: M3.			

4.2 Rock Extraction Process

All the rock to be moved as part of the CSO Decommissioning Project consists of fill placed on the CSO Site during development in the early 1980s. It is believed that the fill material was extracted from a Laupāhoehoe lava flow during widening of the Mauna Kea Summit Access Road and possibly tephra from one of the nearby Laupāhoehoe cinder cones, moved and managed so it was in a condition appropriate for use during construction in the 1980s, placed on the CSO Site, and compacted.

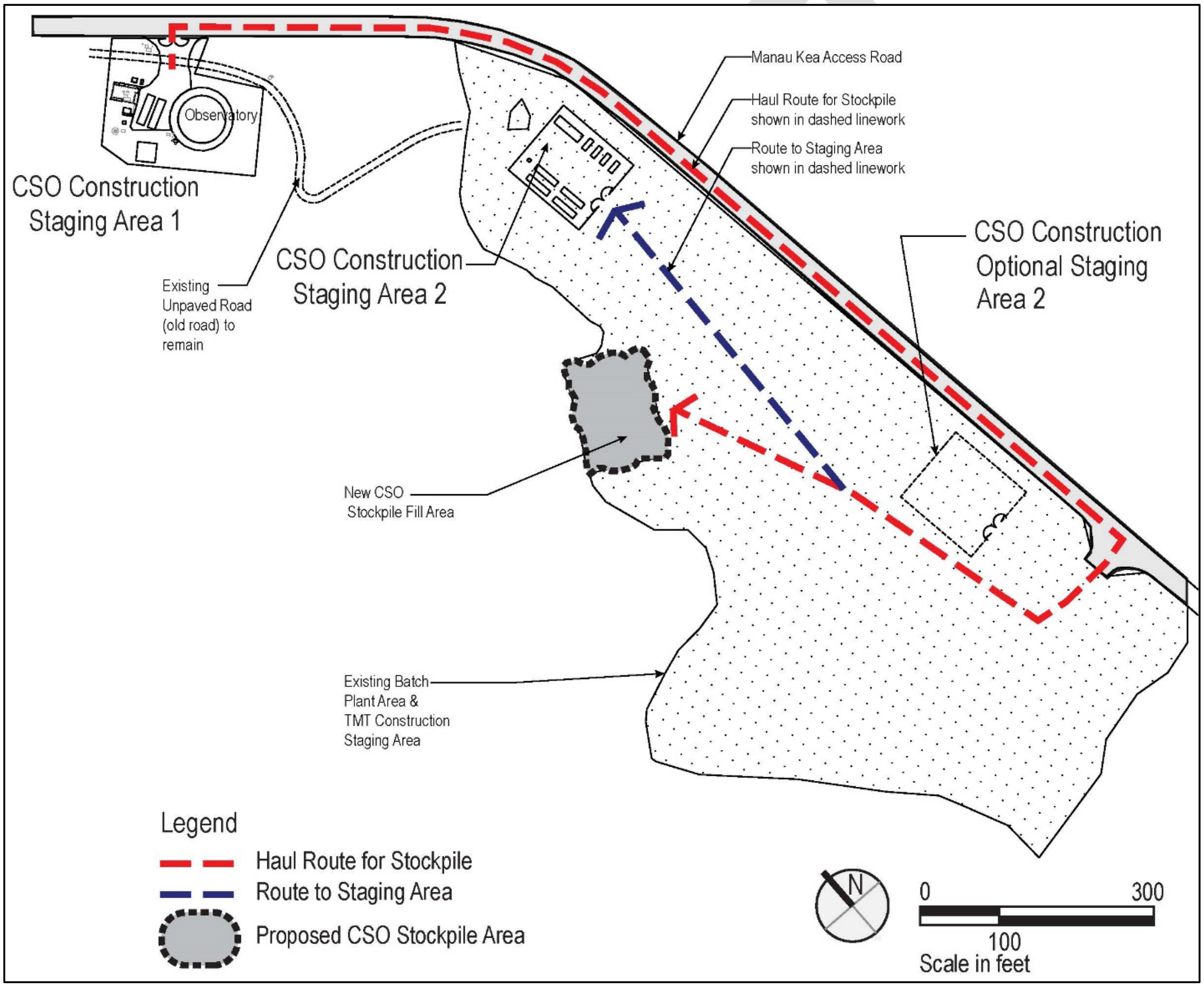
During CSO decommissioning, the fill material will be extracted using heavy, medium, and small equipment and hand tools. As the extraction process approaches the underlying native lava flow substrate, extraction methods will utilize smaller and more precise equipment in order to reduce the disturbance of the underlying native lava flow.

Although the fill material was compacted when placed on the CSO Site in the early 1980s, it is expected and has been confirmed by limited soil boring investigation that standard techniques can be used to extract the fill material from the site. It was found to not include large boulders and could be excavated using hand tools when Intera Inc. conducted their borings.

4.3 Rock Movement Process

As the fill material is extracted from the CSO Site, it will be loaded into dump trucks and transported directly to the Batch Plant using Mauna Kea Access Road. The dump trucks will place the material in a stockpile that will be approximately five feet in height and cover an area of approximately 100' x 135' in the Batch Plant (Figure 4-1) and tightly arrayed in overlapping piles.

Figure 4-1: Conceptual Plan View of Overall Deconstruction Staging



Source: M3 Engineering and Technology (2020)

As the fill is removed, a quantity of roughly five cubic yards of fine ash material and small rocks, consistent with the size and material of the rocks scattered in the nearby undisturbed areas, will be segregated using a screen or similar method and stockpiled on the CSO Site or at the staging area until needed for restoring the arthropod habitat within the CSO Site. If not stored at the CSO Site, the five cubic yards of fine ash material and small rocks will be transported from the staging area back to the CSO Site using a dump truck.

4.4 ROCK MOVEMENT MONITORING

As outlined in other plans, a fulltime independent decommissioning manager (Section 2.1) will ensure that BMPs and other commitments are being implemented throughout the decommissioning process. The independent decommissioning manager will work with archaeological (Section 2.2), cultural (Section 2.3), and invasive species (Section 2.4) monitors that will be required at varying times during deconstruction. The specialist monitors will be on-site at the appropriate times relevant to their respective domains and the types of activities taking place.

4.5 AGGREGATE MATERIALS

No fill or aggregate material imported from a non-Maunakea source will be brought to the CSO Site or the staging areas.

5.0 Coordination and Reporting Plans

5.1 COORDINATION PLAN

Caltech will ensure that regular communications with CMS and other parties is conducted throughout implementation of the CSO Decommissioning Project. This will be accomplished using a variety of means, including construction meetings, notices, and, when necessary and appropriate, personal contacts. Caltech believes that doing so will increase the likelihood that the project is successfully completed in a safe, efficient, and environmentally sensitive manner while maintaining normal public access to the mountain. The lines of communication will include: (*i*) the general contractor; (*ii*) the independent decommissioning manager, described in Section 2.1; (*iii*) third-party archaeological, cultural, and invasive species monitors that are described in Sections 2.2, 2.3, and 2.4, respectively; (*iv*) CMS; (*v*) Maunakea Rangers; and (*vi*) representatives of the other MKOs.

To keep CMS, the MKOs, and other parties abreast of the CSO Decommissioning Project's operations, Caltech will conduct weekly meetings (e.g., every Monday morning) at Halepōhaku for observatory staff, CMS personnel, and other interested parties. In addition to these regular briefings, Caltech will:

- Provide weekly summary updates via email (that coincide with the weekly meeting on Mondays) that describe ongoing and upcoming activities and schedules, with emphasis placed on the potential for impacts to other facilities and operations (e.g., timing of truck traffic on Mauna Kea Access Road).
- Attend monthly MKO meetings to provide updates and address questions that may arise over the course of the CSO Decommissioning Project.
- Coordinate with MKOs and CMS at least two weeks prior to field activities which require the use of Global Positioning System (GPS), radio communications, cell phones (Section 6.10), and any other activity that substantially departs from the tasks and methodologies outlined in the SDP, EA, or CDUA.
- Finally, the invasive species monitor will conduct regular coordination with CMS to ensure that protocols continue to comply with the Maunakea CMP and ISMP.

5.2 REPORTING PLAN

This Reporting Plan is designed to comply with CMP management action C-4 and provide timely information to CMS. Caltech will provide reports to CMS during decommissioning, according to the time intervals listed below. The format of the monthly reports will typically consist of a letter containing all the monthly summaries described below, plus copies of logs and other relevant information as attachments. The format of the monthly report may be adjusted from time to time.

Archaeological, cultural, and invasive species monitoring reports will be prepared by the third-party firms performing that perform the monitoring and be in a format consistent with the AMP (Appendix A) and the ISMP (Section 2.4). These reports are submitted directly to CMS with copies to Caltech.

Ongoing record keeping and reporting will include keeping:

- A daily log of weather conditions recorded on the CSO Site.
- A log of all notifications from and to State agencies.
- A log of any data required by a permit.
- A log and any data related to the Materials Storage and Waste Management Plan inspections or issues.
- A log (and copies of manifests) of all materials removed from the UH Management Areas from the CSO Site for recycling and/or disposal.
- A log of all vehicles (contractor, subcontractor, vendor, etc.) with each ingress and egress from the UH Management Area logged (vehicles equipped with radio-frequency identification (RFID) tags, if any, need not be logged).
- A log of work conducted by and incidents and observations made by the invasive species monitor (Section 2.4), including vehicle inspections and site inspections.
- A log of incidents and observations occurring within the CSO Site and staging areas. This would include items such as any stop work orders from monitors, observing ants or other potentially invasive species, spills, etc.
  - Any stop work orders issued by any of the monitors will be reported to CMS directly by the monitor at the time of occurrence.
  - All incidents occurring will be reported to CMS at the time of occurrence.
- A log of incidents and observations occurring outside the CSO Site and staging areas. This would include items such as observing wekiu bugs or other wildlife in the area, observing cultural activities in the area, and observing non-project personnel engaged in inappropriate activities.
  - All such incidents will be reported to CMS within 24 hours.
- A log of emergency situations (i.e., health emergencies, accidents, and fire) and maintain records summarizing response actions, timeliness, and lessons learned.
  - Any emergency situations will be reported to CMS as soon as possible after the situation has been addressed.
  - Reports of investigations of any emergency situations will be provided to CMS upon completion. Caltech will keep CMS apprised of the status while an investigation is underway.
- Documentation of the CSO Site weekly with photographs taken from roughly the four ordinates (e.g., north, south, east, and west).
- Cooperation with CMS in any inspections of the CSO Site and staging areas for compliance with the CDUP.
- Cooperation with CMS on any reports they prepare.

Providing monthly:

- Copies, in electronic format, for the past month of the logs and photographs listed above.
- A short summary of the progress in the past month.
- A short summary of the expected work for the upcoming month.

At completion of the project, providing:

- Copies, in electronic format, of the logs listed above.
- A short summary of the lessons learned.

Report(s) related to monitoring plans, for instance the AMP (Appendix A), will also be produced.

6.0 Environmental Protection Best Management Practices

The plans and policies in this chapter are designed to comply with CMP management action C-2, which requires use of a Best Management Practices Plan for Construction Practices (the “BMP Plan”). This BMP Plan covers a range of topics and incorporates sustainable practices. The plan includes BMPs for:

1. Water use;
2. Vehicle use, ride sharing, and traffic;
3. Material and waste management, including spill prevention;
4. Disturbance of ground surface and dust generation;
5. Erosion and water quality measures;
6. Invasive species prevention and control program;
7. Safety and accident prevention; and
8. Inspection of equipment and materials.

All BMPs will be implemented during both the deconstruction and removal phase and the site restoration phase.

6.1 WATER USE

While stipulated as a topic for BMPs in the CMP (with a goal of minimizing water use), this project does not involve the use of water other than for dust control and the personal use of workers implementing the project. See Section 6.5 for a discussion of water use for dust control purposes.

6.2 WORKER VEHICLE USE, RIDE SHARING, AND PARKING

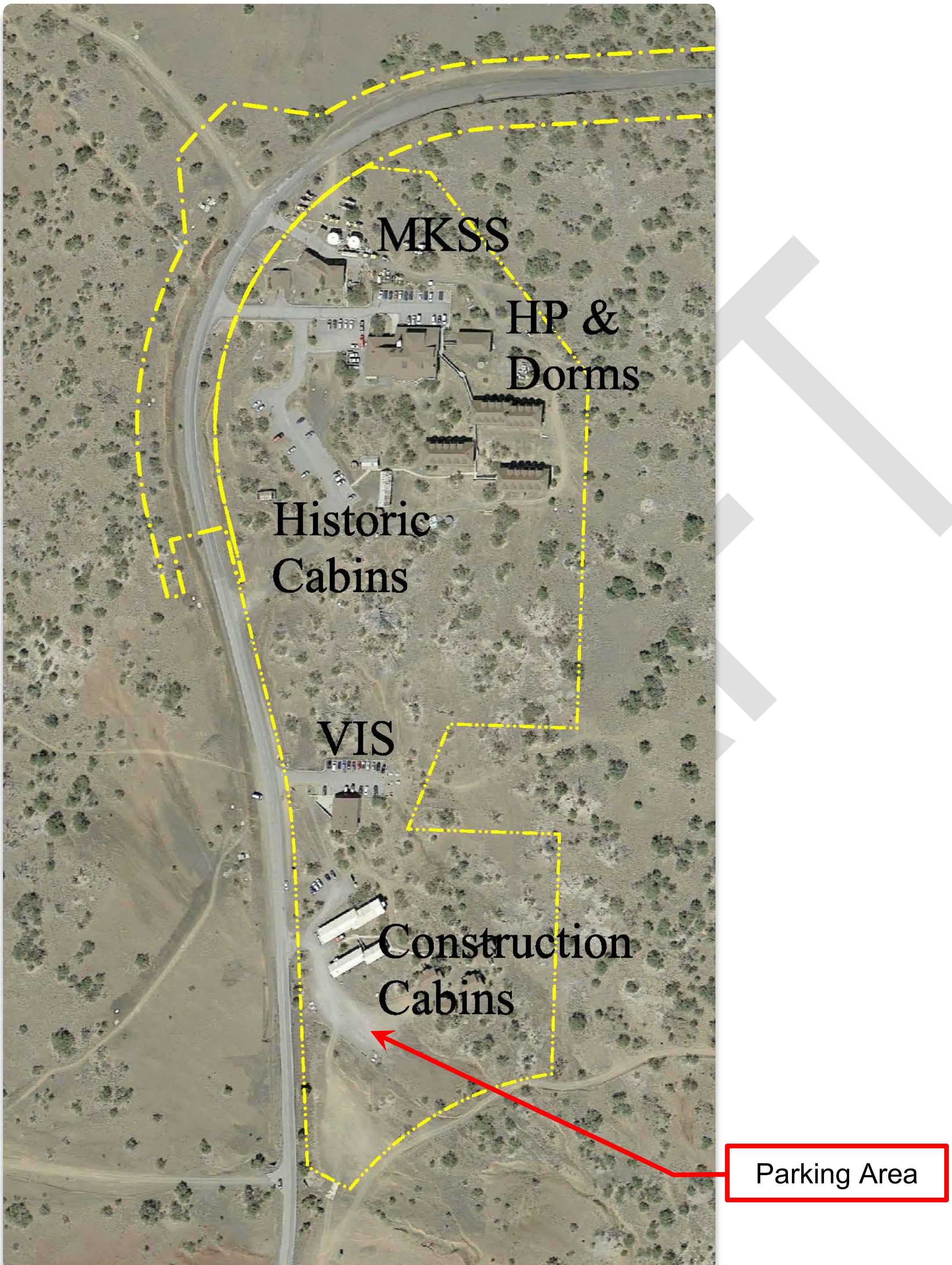
CSO's contractors will participate in a Ride-Sharing Program. Participation will occur whenever desired and is required when the construction crew size that remains in the UH Management Areas throughout the workday (including foremen, but not including third-party monitors) is equal to or greater than 5 individuals. All vehicles, personal or contractor owned, that travel above Halepōhaku must comply with applicable requirements, including that they be four-wheel drive and be cleaned and inspected per the ISMP (Section 2.4). It is anticipated that the construction crew will park their personal vehicles at Halepōhaku and then ride share from Halepōhaku to the CSO Site in appropriate four-wheel drive vehicle(s). Vehicles parked at Halepōhaku, which is also part of the UH Management Area, must also comply with the ISMP. If possible, ride sharing will begin at lower elevations, such as Hilo or Waimea.

This measure is designed to: (*i*) limit traffic on Mauna Kea Access Road, (*ii*) reduce wear and tear on the road, (*iii*) ensure reliable access to the public, (*iv*) limit the potential introduction of invasive species, and (*v*) minimize dust.

Several vehicles (e.g., dump trucks) are considered equipment and not commuting vehicles and, therefore, not subject to the same limitations as commuting vehicles.

There should always by one commuting vehicle available at the CSO Site in case of emergencies. All vehicles that park at Halepōhaku, shall park in the unpaved parking area below the long construction cabin (Figure 6-1); no vehicles shall be parked above the Saddle Road-Mauna Kea Access Road intersection outside of Halepōhaku's boundaries. All vehicles that park in the Science Reserve shall be parked within the CSO Site, within the staging area, or adjacent to the staging area (Figure 4-1).

Figure 6-1: Halepōhaku Parking



Source: Google Earth and Planning Solutions, Inc.

6.3 TRAFFIC MANAGEMENT PLAN

The Traffic Management Plan (TMP) will be developed by the selected contractor and consider several work area strategies to mitigate potential impacts to area traffic flow in the summit region because of the CSO Decommissioning Project. They include employing as appropriate: (*i*) temporary signage; (*ii*) changeable message boards; (*iii*) channelizing devices; (*iv*) flaggers and uniformed traffic control officers; (*v*) barricades; (*vi*) portable barriers; and (*vii*) escort vehicles.

The independent decommissioning manager or designee responsible for discharging the terms of the TMP will monitor all phases of construction work and shall document any problems, issues, or recommendations for remediation and for use by future decommissioning projects.

TMP elements will specifically address the following topics:

- Persons traveling above Halepōhaku should check the weather forecast the same day as the trip. The Maunakea weather forecast can be accessed at the following link: http://mkwc.ifa.hawaii.edu/forecast/mko/. When the road is closed for safety reasons, no project trips above Halepohaku will be made.
- Large trucks, include those delivering large equipment to the project site and those transporting waste materials and recycle materials down the mountain, will be addressed. The contractor, in consultation with CMS, will establish in the TMP appropriate times for these trips on Mauna Kea Access Road and triggers for them being escorted.
- Periods when trucks are making frequent trips between the CSO Site and the Batch Plant (e.g., when roughly 2,800 cubic yards of fill material is being moved from the site to the stockpile). The contractor, in consultation with CMS, will establish in the TMP appropriate periods for these trips on Mauna Kea Access Road and measures such as signage and flaggers. Note, flaggers will not utilize radios (Section 6.10) unless special arrangements are made.

The TMP details cannot be set at this early stage because it is not known what other projects, if any, will be taking place in the summit region when the subject project begins.

6.4 Material Storage, Waste Management, and Spill Prevention Plan

If not properly managed, materials and waste used and stored in construction areas could impact cultural and biological resources, aesthetic and visual characteristics, and water quality in the surrounding area.

To minimize the potential for damage or contamination, contractors will implement a Materials Storage, Waste Management, and Spill Prevention Plan that includes at least the protocols in this section. Materials and wastes will be stored in a manner so as to minimize their impact on the surrounding environment. Measures included in the plan are:

- The contractor will implement measures to minimize storm water pollution in accordance with the Storm Water Pollution Prevention Plan (SWPPP) prepared to support the National Pollutant Discharge Elimination System (NPDES) permit.

- Establish a daily inspection program to ensure satisfactory material and waste storage and disposal, including reporting inspection results (and logs of inspections) as outlined in Section 5.0. All CSO related waste collected outside the CSO Site and staging area (e.g., outside of temporary fenced areas) must be individually identified on the logs and in this reporting. The inspection program shall include, at minimum:
  - Inspection of all materials and wastes prior to start of, and at the end of, each workday to ensure and verify that all lids are and remained closed.
  - Inspection of fenced areas and nearby areas for vagrant CSO-related materials or wastes prior to start of, and at the end of, each workday
- "Roll-off" containers will be equipped with secure tops and lids to ensure no debris can escape, including during high winds (defined as 120mph for engineering standards, unless specified otherwise).
- Outdoor trash receptacles/containers will be secured to the ground with attached/secured lids and plastic liners to assure that the receptacle, its lid, or its contents will not blow away and the contents will not be exposed to storm water.
- "Roll-off" and other trash containers will be pressure washed prior to (within 24 hours prior) every delivery to a CSO Site and delivered empty (free of trash or any detectible residue).
- Construction materials and supplies that are not otherwise protected (e.g., not within a building or bin) will be covered with heavy tarps; steel cables attached to anchors that are driven into the ground may also be used to secure materials. Materials will be secured at the close of each workday, and throughout the day during periods of high winds.
- Waste will be collected and removed from the UH Management Areas on a regular basis before containers become completely full.
- Food waste and food containers will be collected separately and removed daily (i.e., food waste, lunch containers, wrappers, etc. will not be disposed of with regular construction debris).
- Waste containers will be picked up and transported off-site by licensed contractors and disposed of at appropriate facilities. Waste containers will be removed from the site within 24 hours if biological materials are identified (by odor, sight, pest aggregations, etc.).
- The contractor will be required to provide appropriate and adequate hazardous material training that includes proper and safe handling, correct use and environmental protection methods, Material Safety Data Sheets (MSDS), and approved methods for disposal and transport.
- Contractors are required to provide an adequate number of portable toilets for use at their construction sites. The contractors will be responsible to verify that these facilities are properly maintained and serviced by a licensed and permitted contractor.

6.4.1 Components of Materials Storage Management

Generally, all materials will be stored per the manufacturer's recommendations and per all county, state, and federal requirements.

6.4.2 Bulk Erodible Materials

Bulk erodible materials are generally excavated rock/soil and imported aggregate or other fill materials. Refer to the Rock Movement Plan (Section 4.0) when considering the importation, management, and movement of fill or excavated material in the summit region. This includes:

- No bulk material from off-mountain will be imported to the UH Management Areas. The proposed project does not require any bulk materials.

Refer to the project's NPDES permit for protocols regarding the storage of these materials, the only applicable component of the proposed project is the stockpiling of native fill removed from the CSO Site at the Batch Plant. This includes:

- All materials are to be managed per local, state, and federal requirements as well as permit requirements, such as the NPDES permit for the project.
- Soil is to be screened in the field for potential contamination. Potentially contaminated material is to be segregated from clean material to the degree possible.
- Locate stockpiles a minimum of 15.24 meters (50 feet) or as far as practicable from concentrated runoff, storm drain inlets, or outside of any natural buffers, if any. The stockpile location identified on Figure 4-1 complies with this requirement.
- Excavated material/stockpiles will be protected when (a) material will not be added or subtracted to a stockpile for a period greater than twenty-four (24) hours, and (b) when a significant rain event occurs. Protection measures will include placing work area isolation devices, such as gravel bag, fiber roll/sock, and/or silt fence around the stockpile.

6.4.3 Petroleum Products, Other Chemicals, and Hazardous Materials

The policies detailed in the SWPPP govern the management of these materials. The SWPPP states:

Petroleum and hazardous materials required for the work will be stored properly in tightly sealed containers that are clearly labeled. Examples of materials that are likely to be present on the site that fall into this category include, but are not limited to, petroleum products, such as gasoline, diesel, oil, and hydraulic fluid.

It is not anticipated that petroleum products or hazardous materials will be stored at the CSO Site or staging areas during the proposed project. Rather, these materials will only be brought to the site when necessary. Should they be stored at the CSO Site or staging area, then storage areas for petroleum products, other chemicals, and hazardous materials will have the following attributes:

- Be clearly labeled (preferably in original containers), including appropriate warning placards, and tightly sealed when not in use.
- Be covered and elevated at least 6-inches off the ground surface (i.e., on pallets, portable, durable chemical containment).
- Have secondary containment.
- Be placed away from storm water conveyances and drains.
- Have a spill kit, appropriate to the type and volume of products stored.
- Meet all local and state solid-waste management regulations.

Whenever possible, all of a product will be used up before disposing of the container. If the product is a hazardous material, surplus product must be disposed of following manufacturers' or local and State recommended methods for proper disposal container.

The storage of petroleum products or hazardous materials outside of designated areas will not be allowed. These materials are only to be removed from designated storage areas during times of active use and returned promptly when that use is complete. One example of an appropriate storage area would be Conex (a shipping container) specially-designed with secondary containment and containers for lube and hazardous materials.

Additional measures related to petroleum and hazardous materials storage include:

- An accurate and up-to-date inventory of such materials at the site will be maintained. The inventory of such materials on-site will be kept to a minimum, only enough product required to do the job will be stored on-site.
- MSDS for all materials stored in the area will be available to site workers.
- Substances will not be mixed with another unless recommended by the manufacturer.

6.4.4 Spill Prevention and Response Plan

SWPPP prepared as part of the NPDES permit will also govern Spill Prevention and Response. In addition, the Contractor will prepare a Spill Prevention and Response Plan. The following paragraphs describe additional information and measures.

No significant quantities of fuel or combustible material will be present or stored at the CSO Site or staging area. The amount of fuel storage will be minimized to what is required for refueling of heavy equipment on-site. Surface contamination from fuel, combustible materials or excavation operations is not anticipated. The potential for spills will come from the routine need to refuel the heavy equipment that will not be making daily trips to lower elevations, outside of the UH Management Areas, for refueling.

Contractor and its subcontractors who will be doing the refueling have included in their work plans measures to minimize the potential impact of a spill or unintentional release of hazardous materials on the surrounding environment. To prevent overflow due to expansion with changes in elevation, all fuel tanks shall not be more than 3/4 full prior to transport to the summit (unless used as the fuel source for vehicle transport to the summit).

Contractor will provide appropriate spill and response education and training to their personnel. The education and training include standard spill prevention practices and spill response procedures. CSO acknowledges that if a Reportable Quantity is exceeded, the appropriate authorities (including CMS) will be notified. The Contractor will maintain, on-site, the relevant contact information for Federal, State, and/or County agencies and emergency response providers that will be notified in the event of a “reportable quantity” spill. These include the following:

- CMS: 808-933-0734
- Hawaiʻi County Emergency Spill Hotline: 808-656-1111
- Hawaiʻi State Emergency Response Commission (HSERC) and Hazard Evaluation and Emergency Response (HEER) Office: 808-586-4249 during business hours (7:45am-4:30pm Monday to Friday) or 808-236-8200 after hours, weekends, and holidays.
- EPA National Response Center: 800-424-8802

Depending on the nature of the spill, it may be appropriate to contact others, including:

- Local Fire, Police, and Ambulance: 911
- Hawaiʻi County Civil Defense: 808-935-0031 (7:45am-4:30pm) and 808-935-3311 (after hours)
- Poison Control Center: 800-222-1222

Contractor and applicable subcontractors will have appropriate spill response materials and equipment stored and available at the locations where lubricating materials and fuel are stored and used, including equipment transport vehicles and associated support equipment.

A spill kit will be kept with the heavy equipment and work vehicles that travel to the CSO Site and staging area in case of accidents. Clean up response to spills will be done promptly.

When equipment with engines or motors is stored overnight, Contractor will deploy durable barriers or other suitable methods to contain or prevent fuel/oil spills and leaks. Motorized equipment, when stationary, must have a large, durable drain-pan in place suitable for catching fuel or fluid leaks, anchored to ensure it cannot be blown away in high winds.

Storage of fuel and lubricating fluids at the CSO Site and staging area will have provisions for secondary containment to capture any material that accidentally escapes from the primary storage unit.

Storage containers and containment areas will be inspected daily to insure that they are intact and functional. Should a leaking container be identified it will be moved to a ventilated area away from ignition sources. Proper response methods by the container supplier will be followed.

6.5 GROUND DISTURBANCE AND DUST CONTROL

Contractor is to minimize the existing terrain disturbance as much as possible. Extent of disturbance as shown on the drawing is the extent of the terrain disturbance required to complete the decommissioning. The contractor shall not go beyond the edge of disturbance area with any equipment, vehicle, etc. and take all means to minimize the disturbance of the natural terrain. The CSO NPDES permit will outline steps to prevent disturbance of land beyond that which is necessary, which will generally consistent of fencing and other barriers or markers being established prior to the start of first deconstruction, and then restoration, work. Contractors will comply with the CSO Decommissioning Project NPDES permit. Similar measures will also be done at the Batch Plant. These steps will help ensure that all disturbances will remain within approved areas.

During the deconstruction phase, any ground disturbing activity will be monitored by both a cultural monitor and an archeological monitor (Section 2.0).

The generation of excess dust from the CSO Site and staging area is an air quality concern due to the potential impact on cultural, natural, and astronomical resources. Plants, arthropods, and habitat adjacent to unpaved roads and disturbance areas are the most susceptible to impact from dust. Another potential source of dust could be due to storms and the accompanying high winds that can arise quickly in the summit region. Contractors will be required to submit their plan for minimizing generation of dust in the UH Management Areas. The contractor's dust mitigation planning shall include methods to prevent/control the generation of dust during building deconstruction activities, grading operations, dust from roads and material stockpiles, movement of materials by truck, and high winds.

Water will be used to provide dust control during any dust generating activity, including the cutting and breaking of concrete foundations. The removal of the fill material from the CSO Site and the placement of that material at the Batch Plant is expected to have the highest potential for dust development during the work. Water will be used at both locations (the CSO Site and the Batch Plant stockpile) during this operation. Only water from potable sources is permitted for use. Excavation and dumping will not occur without dust control provisions in place.

The most likely dust sources other than the work at the CSO Site will be the occasional driving on the unpaved portions of the Mauna Kea Access Roads. Maintaining a slow speed and ride sharing (Section 6.2) will help minimize the potential of dust issues.

6.6 Erosion and Water Quality

Prior to the start of work, the contractor is required to submit their plans for control of soil erosion and methods they will employ to minimize the potential for pollutants in storm water. Deconstruction activities have the potential to cause erosion and degrade storm water quality due to sediment during heavy rain. In addition, other sources such as water used to control dust and petroleum products could impact storm water if not properly controlled. Erosion control methods that include use of biological material (hay bales, compost, wood shavings, excelsior tubes, etc.) are not permitted. Local rock or cinder not derived from CSO decommissioning activity may not be used for erosion control.

Due to the porosity of the site and the minimal runoff expected, no special provisions will be provided. However, the contractor's plans will comply with the SWPPP prepared when the NPDES permit application is submitted. The SWPPP will be prepared with the following considerations:

- Considerations related to the CSO Site. The SWPPP will call for the installation of limited physical BMPs at the CSO Site because (*i*) the goal is to reduce ground disturbance, especially at the limits of disturbance where BMPs are typically installed; and (*ii*) the ground surface is very permeable and surface flow runoff is rare, and when it happens occurs at a concentration and velocity that would overwhelm BMPs, making the BMPs pollutants. The physical perimeter control BMPs at the CSO Site will be limited to dust and sediment control fabric attached to the temporary construction fence.
- Considerations related to the staging area in the Batch Plant. Because the Batch Plant has been previously disturbed and surface storm water may occur as sheet flow, silt fence will be installed around the perimeter as it is typically done (e.g., the lower portion is buried).
- Considerations related to stockpile area in the Batch Plant. See Section 6.4.2.

All activity will conform to applicable provisions of the water quality and water pollution control standards contained in Hawaii Administrative Rules, Title 11, Chapter 54 - Erosion and Sedimentation Control, of the Hawaii County Code. Appropriate best management practices will be employed at all times during deconstruction.

6.7 Invasive Species Prevention and Control

See Section 2.4 for a detail discussion of invasive species control protocols.

6.8 Safety and Accident Prevention

All CSO staff, contractors, vendors, and other visitors to the CSO Site are reminded that the elevation of the CSO Site is approximately 13,000 feet, and other parts of Maunakea are even higher.

All persons working at the CSO Site and staging area should be aware of the symptoms of altitude sickness and look for these signs in themselves and in others. Any persons showing these symptoms should be taken to a lower elevation. Steps to minimize effects of altitude sickness include the following:

- Stop at Halepōhaku for acclimation.
- Stay hydrated. Have at least 2-3 liters of water per person present in the UH Management Areas.
- Limit presence above Halepōhaku to no more than 12 hours in a calendar day or continuous time period.

A list of the symptoms of altitude sickness, pulmonary edema and cerebral edema are listed in the following link: http://www.malamamaunakea.org/visitor-information/public-safety. Links to additional information can be found at that link.

Personnel are reminded to watch for those symptoms in themselves and others around them. Promptly taking people to a lower elevation usual resolves the symptoms but people should always be taken to medical facilities when fainting and other serious symptoms are present, or when being taken to a lower elevation does not resolve the symptoms. To aid in addressing altitude sickness, first aid equipment and oxygen will be maintained in the office trailer positioned at the staging area in the Batch Plant. The oxygen can be used while the affected individual is being taken to a lower elevation; the use of supplemental oxygen does not replace moving the individual to a lower elevation.

Personnel must wear cold weather gear when necessary when working on the site. If not protected or prepared, severe cold temperatures can cause hypothermia and frostbite. Large snow jackets or parkas, cold weather gloves, hats and waterproof, safety boots are recommended.

Sun exposure is another concern. All persons should wear appropriate clothing, sunscreen, and sunglasses.

Persons traveling above Halepōhaku should check the weather forecast the same day as the trip. The Maunakea weather forecast can be accessed at the following link: http://mkwc.ifa.hawaii.edu/forecast/mko/.

Because of the use of cutting torches and other potentially flammable materials and equipment, Caltech has been in communication with the Hawai‘i County Fire Department (HCFD), the primary agency responsible for fire prevention, fire control, and emergency medical services in the County of Hawai‘i and will continue to coordinate with them throughout implementation of the CSO Decommissioning Project. The HCFD has indicated that during deconstruction, Caltech and its contractors may stage trailers to sort and deposit aluminum, steel, and deconstruction waste on-site. Caltech anticipates using roll-off trailers or similar container, brought to the site, and stationed there during deconstruction. The contractor will be responsible for sorting and depositing deconstruction waste in the appropriate on-site container. HCFD has also stated that:

- Up to four locations may be designated on-site for deconstruction material sorting and collection, and that up to three roll-off trailers may be used, as appropriate, at any time during deconstruction.
- A truck may deliver an empty roll-off container up to a designated open location and haul away the full container while still complying with the total limit of three roll-off containers noted above.
- Recyclable material and deconstruction waste will be properly separated at all times during the deconstruction process.

Caltech and its contractors will also comply with these stipulations along with all applicable standards and procedures of the NFPA's *Uniform Fire Code* (2006) and, specifically, *Code 241 Standards for Safeguarding Construction, Alteration, and Demolition Operations*. Per that guidance, Caltech or its contractors will develop, maintain, and keep on-site a written fire prevention, fire suppression, and emergency evacuation plan.

6.9 Inspection of Equipment and Materials

See Section 2.4 for a detail discussion of inspection of equipment and related protocols.

6.10 Lights, GPS, Radio, and Cell Phone Use

External lighting will not be employed by the contractor within the UH Management Areas during the CSO Decommissioning Project.

GPS, 2-way radios, and cell phones will be turned off and not used within the UH Management Areas, except in the event of an emergency. This is required in order to reduce interference with astronomical observations, which are routinely conducted during daylight hours at the radio and submillimeter facilities.

Should GPS or 2-way radios be required to accurately and safely complete certain project tasks, the contractor will coordinate their use with the MKOs and CMS (Section 5.1) at least two weeks prior to such use. The contractor shall restrict the use of GPS and 2-way radios as much as possible.

Appendix A. Archaeological Monitoring Plan

Will be included when BMP Plan is not an attachment to the Environmental Assessment for the proposed project.

Appendix B. CSO Project Contact List

Will be available upon request after the contractor is selected.

Appendix J. Archaeological Monitoring Plan

Archaeological Monitoring Plan for the Caltech Submillimeter Observatory Decommissioning Project on Mauna Kea

TMK: (3) 4-4-015:009 (por.)

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

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Archaeological Monitoring Report for the Caltech Submillimeter Observatory Decommissioning Project on Mauna Kea

TMK: (3) 4-4-015:009 (por.)

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1. INTRODUCTION

At the request of Planning Solutions, Inc., on behalf of California Institute of Technology (Caltech), ASM Affiliates (ASM) has prepared this Archaeological Monitoring Plan (AMP) for the Caltech Submillimeter Observatory (CSO) Decommissioning Project on Mauna kea. The CSO is located on 0.75 acres subleased from the State of Hawaiʻi within the Mauna Kea Science Reserve on a portion of TMK: (3) 4-4-015:009 in Kaʻohe Ahupuaʻa, Hāmākua District, Island of Hawaiʻi. The CSO is a 10.4-meter (34 ft.) diameter telescope that was engaged in astronomical observations from 1986 until it ceased operation on September 8, 2015. For the purposes of the current archaeological monitoring plan, the current project area (Figures 1, 2, and 3) comprises approximately 9.6 acres and includes the 0.75-acre sublease area and other minor adjacent areas that were disturbed during the original construction or will be disturbed during the decommissioning of the CSO, along with the “Batch Plant” area located southeast of the CSO lease area. Ground disturbing activities associated with the CSO Decommissioning Project will involve the complete removal of improvements within the CSO lease area and the full restoration of the site. Fill material deposited during the construction of the CSO facility will be removed and transported to an approved alternative location in the “Batch Plant” area located southeast of the CSO facility. No ground disturbance is planned within the “Batch Plant” area. Decommissioning of the CSO will be conducted in accordance with the 2010 Board of Land and Natural Resources approved *Mauna Kea Comprehensive Management Plan: UH Management Areas* (CMP) prepared by Hoʻakea (2009), the *Decommissioning Plan for the Mauna Kea Observatories* (Decommissioning Plan) prepared by Sustainable Resources Group Int’l, Inc. (2010), the site specific *Site Decommissioning Plan for the Caltech Submillimeter Observatory* being prepared by Planning Solutions, Inc. (in prep), and the *Cultural Resources Management Plan for the University of Hawaii Management Areas on Mauna Kea* (CRMP) prepared by McCoy et al. (2009). The CSO facility site was included in two Archaeological Inventory Surveys (Barna 2020; McCoy et al. 2010), neither of which identified historic properties within the current project area.

The archaeological monitoring will be conducted as an identification measure in the event that previously unidentified archaeological properties are encountered during the project. The current monitoring plan was prepared in accordance with Hawaiʻi Administrative Rules (HAR) §13-279-4. It provides a project area description, brief culture-historical background, review of relevant prior archaeological studies, followed by a summary of anticipated archaeological remains or historic properties. It then presents a description of the archaeological monitoring effort, including field methods, treatment of recovered remains, reporting, and curation of any recovered items. Provisions for cultural monitoring during the CSO Decommissioning Project are also described in this plan.

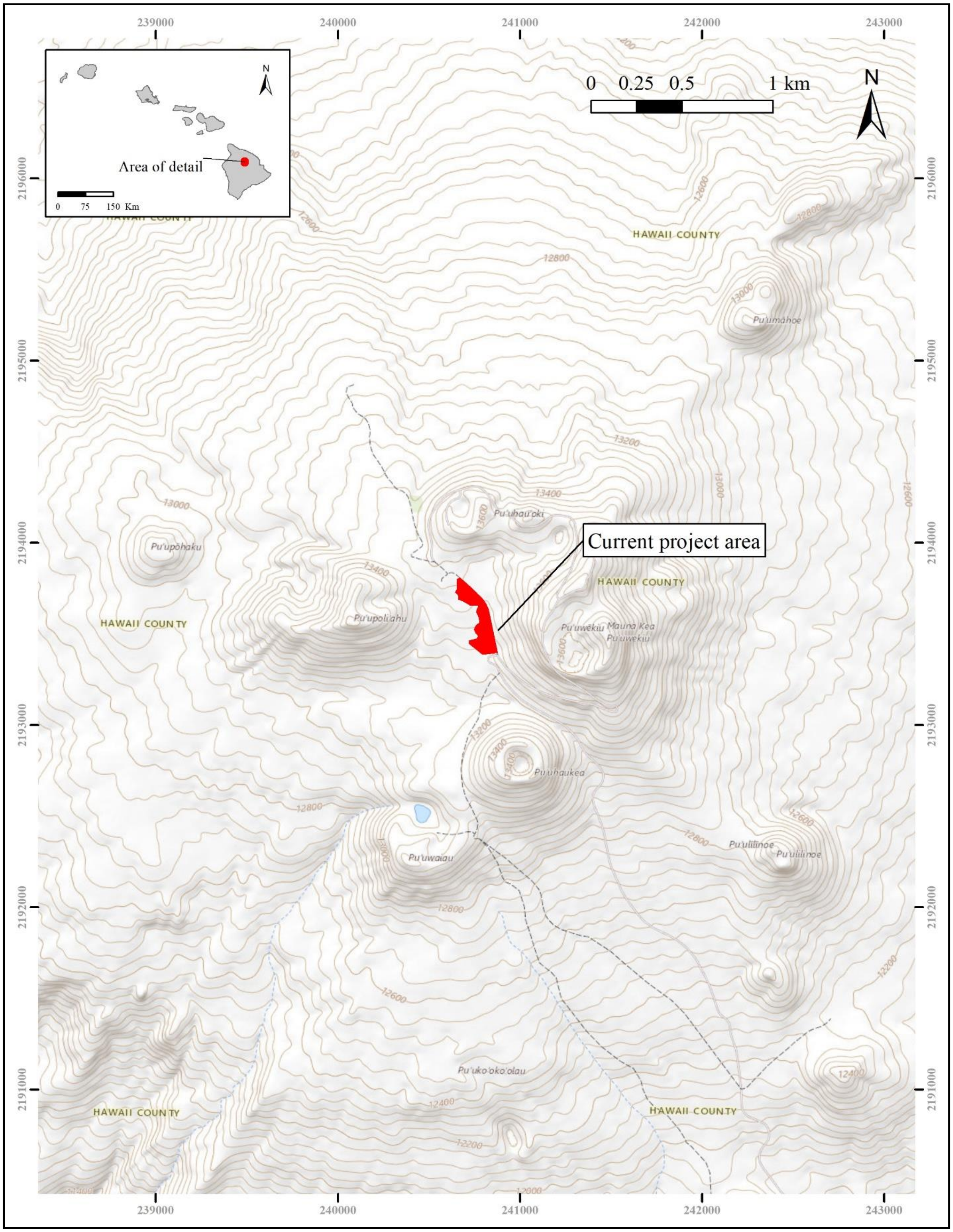

Figure 1. Project area location.

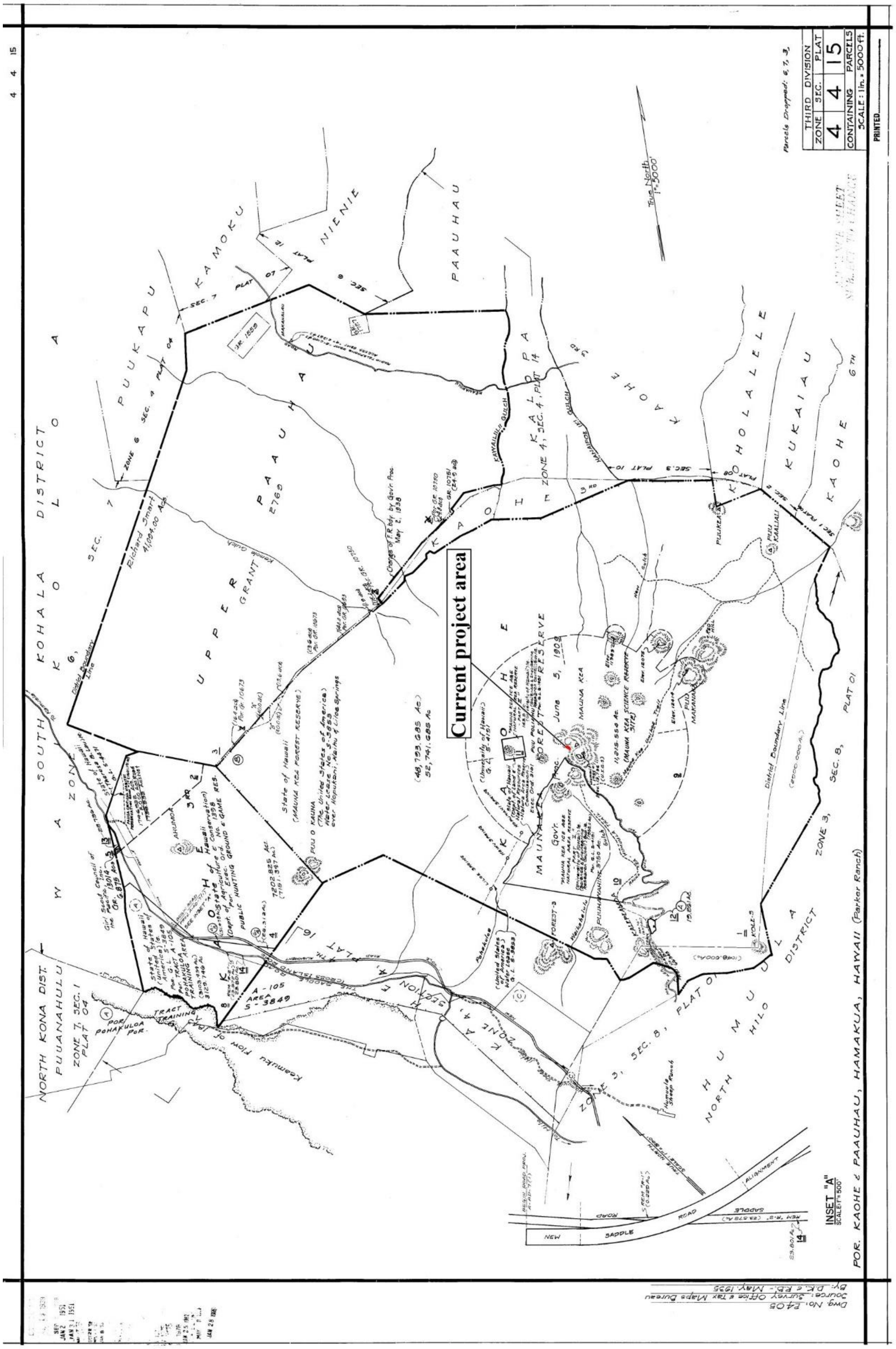

Figure 2. Tax Map Key (3) 4-4-015 showing location of current project area..

Figure 3. Google Earth™ satellite image showing the current project area (outlined in red).

PROJECT AREA DESCRIPTION

The current project area (Figures 4 and 5) comprises 1.3 acres where ground disturbance and/or the operation of mechanical equipment will occur during the decommissioning process (see Figure 3). This area is located at 13,350 feet altitude near the summit of Mauna Kea on a plateau surrounded by Puʻupoliʻahu, Pūʻuhauʻoki, and Pūʻuwēkiu (see Figure 1). It includes the 0.75-acre CSO facility, a 460 meter portion of Mauna Kea Access Road, and the batch plant located downhill (southeast) of the telescope site, which will used as a baseyard/staging area. The CSO facility (see Figure 4) is located within the Mauna Kea Science Reserve (TMK: (3) 4-4-015:009).

Geology in the study area (Figure 6) consists of Laupahoehoe Volcanics comprising a hawaiitic *ʻaʻā* flow which vented, probably from one of the summit cones, and flowed primarily northwest with one lobe extending to the south (Group 70 1982). McCoy (1982a) reported evidence of glaciation in the form of striations, polish, and boulder erratics in the then-proposed CSO site, and these kinds of features are visible outside the current study area. The occurrence of lava tubes in such *ʻaʻā* flows are reported to be rare. Natural soils in this portion of the summit region are extremely limited and are mapped as Lava flows-Cinder land (labeled 8 in Figure 7), which derives from *ʻaʻā* weathering in place. The natural ground surface slopes generally toward the south; however, grading for the construction of the CSO has created a level, cinder-covered ground surface around the telescope and its outbuildings. As originally constructed, the CSO facilities were primarily built on or in fill obtained from other locations on Mauna Kea. Surveys indicates that approximately 2,830 cubic yards of fill were emplaced on the CSO site during construction of the CSO facility in the 1980s. The maximum depth of the fill currently on the site is approximately 10 feet on the downslope, southeast side of the CSO site.

Hydrologically, the *ʻaʻā* underlying the CSO is highly permeable. The nearest surface water is at Lake Waiʻau, located 4,000 feet to the southeast of the CSO facility. Average daytime maximum temperature is 50.1°F and average minimum temperature is 24.8°F. Precipitation averages 8.07 inches per year (Giambelluca et al. 2013) in the form of freezing fog or snow. Above 12,800 feet elevation on Mauna Kea, the ecosystem is classified as Alpine Stone Desert (Gerrish 2013). Vascular plants are very widely scattered and include two native grasses, *Trisetum glomeratum* (*pili uka*) and *Agrostis sandwicensis* (Hawaii bentgrass); and the endemic fern *Asplenium adiantum-nigrum (ʻiwa ʻiwa*).

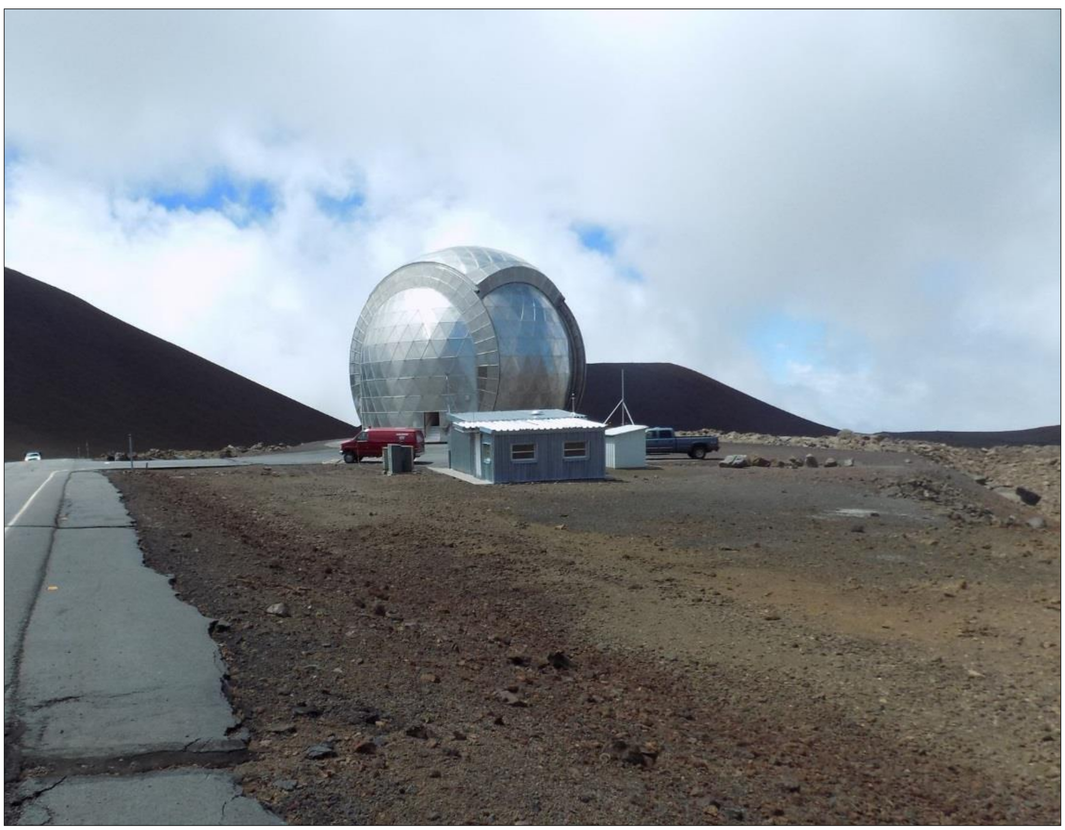

Figure 4. Caltech Submillimeter Observatory facility, view to the southeast.

Figure 5. Portion of project area south of Caltech Submillimeter Observatory facility, view to the southeast.

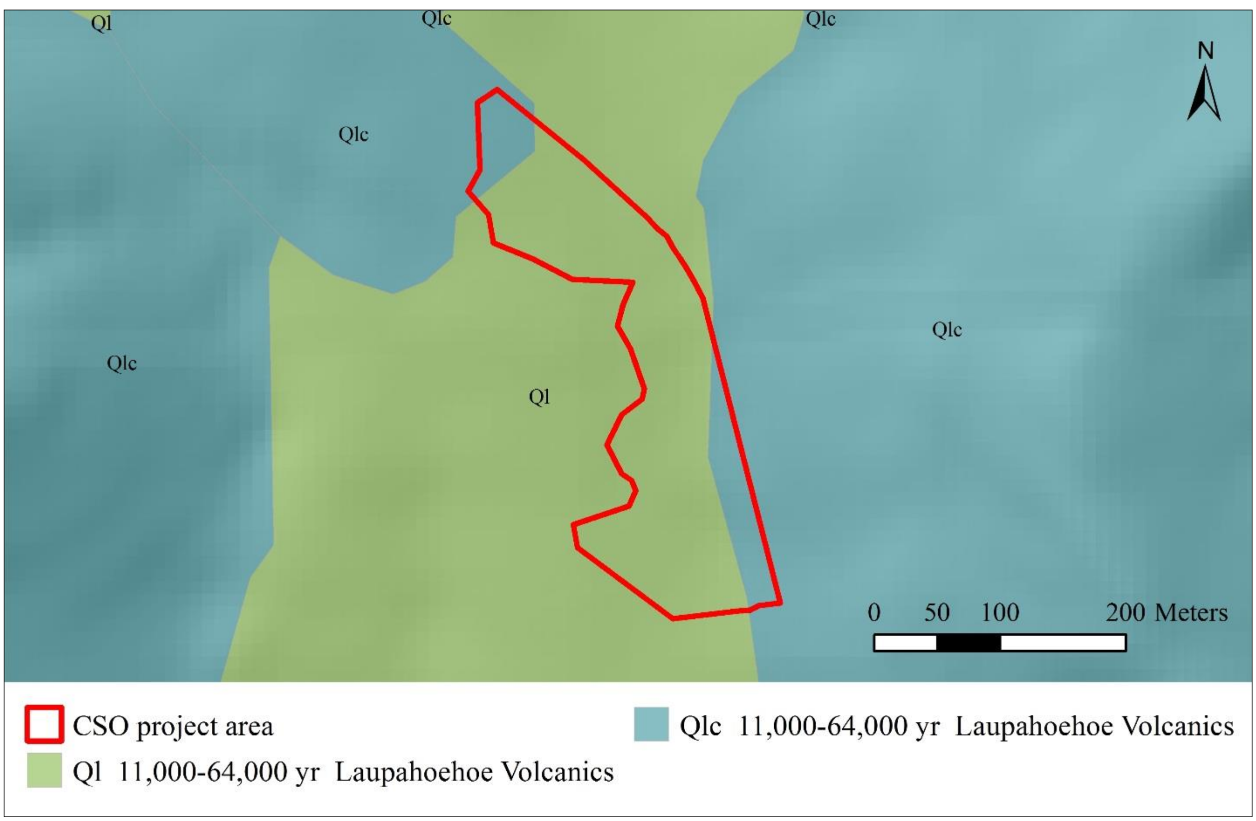

Figure 6. Geology in the direct effects study area.

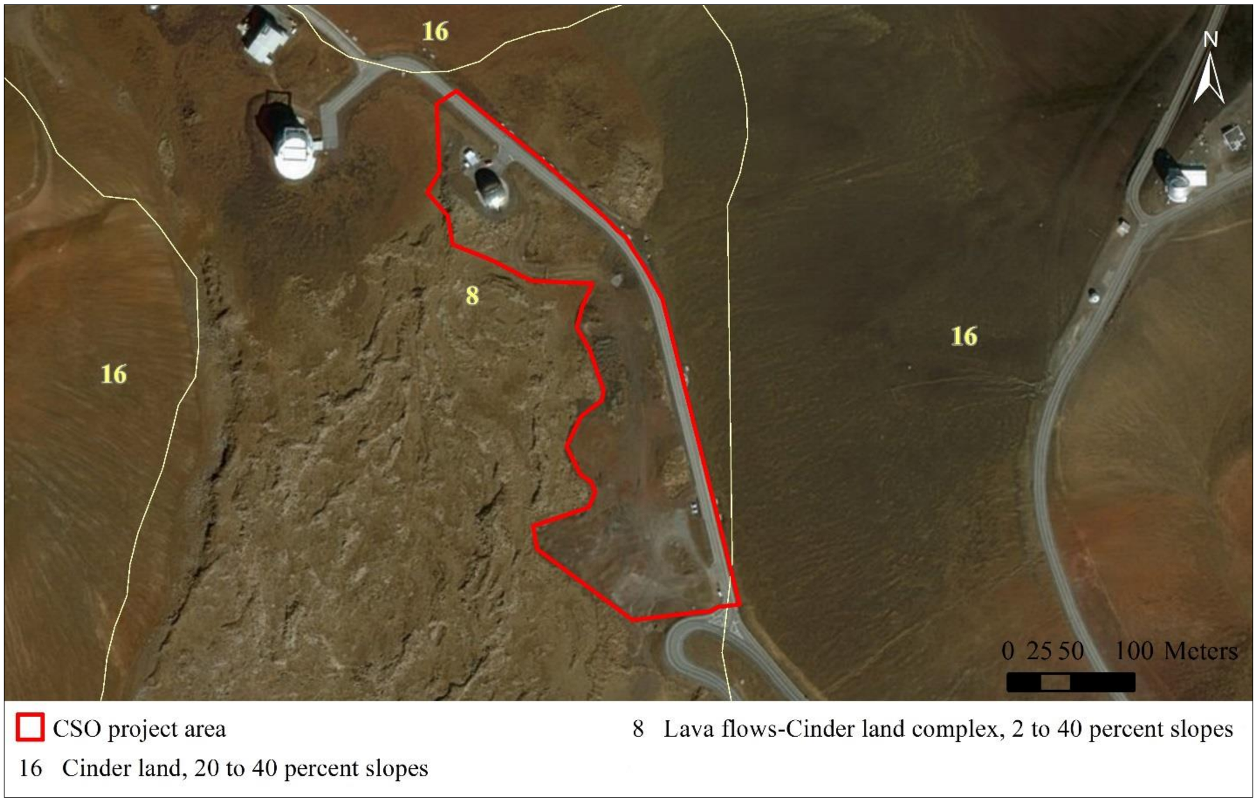

Figure 7. Soils in the direct effects study area.

2. BRIEF CULTURE-HISTORICAL BACKGROUND

An extensive body of culture-historical information concerning Mauna Kea and the summit region has been developed over the past three decades through research and consultation. A detailed culture-history of Mauna Kea and the summit region was prepared by Kumu Pono Associates (Maly and Maly 2005, 2006) using native traditions, historical accounts, and oral history interviews. That study built on prior research (Langlas 1999; Langlas et al 1999, Maly 1998, 1999; McEldowney 1982) and documented a wide range of traditional knowledge and practices associated with the summit region as a traditional realm of Hawaiian *akua* (gods), as a place sacred to contemporary cultural practitioners, and as the setting for western uses of the mountain for scientific inquiry. The information from these prior studies were incorporated into the CRMP (McCoy et al. 2009) to guide the management of cultural resources on Mauna Kea, including requirements for the decommissioning process. The abbreviated culture-historical context presented below summarizes these prior culture-historical studies, focusing on human uses of the summit region with potential to leave archaeological evidence. A more comprehensive discussion of the cultural significance of the Mauna Kea summit region and the mountain as whole in relation to the current project area can be found in a Cultural Impact Assessment (CIA) prepared for the current project (Rechtman 2021). The following abbreviated culture-historical context borrows extensively from the CRMP (McCoy et al 2009) and follows the model presented in the Mauna Kea Comprehensive Management Plan (Hoʻakea 2009), which describes the history of Mauna Kea in terms of a Precontact Period (prior to 1778), a Postcontact Period (1778 to the beginning of the 20th Century), and a Modern Period (post-dating the 20th Century).

Although little direct information on the use of the Mauna Kea summit region is available for the Precontact Period, it is currently thought that access to the summit was limited due to its extreme sacredness. As Maly and Maly (2005) note, the *ʻāina mauna* (mountain lands) of Mauna Kea were frequented by individuals who traveled there to worship, gather stone, bury family members, or deposit *piko* (umbilical cords of newborn children) in sacred and safe areas. Other uses of the upper elevations of Mauna Kea included travel across the island, bird-catching, and collecting material for canoe manufacture (Hoʻakea 2009). The summit was accessed by trails leading from every district except Puna (Maly and Maly 2005). Archaeological evidence for ceremonial use of the summit area include *ʻahu* (stone piles or altars) and *kūahu* (a type of shrine), but as McCoy et al. (2009:2–21) state, the nature of those ceremonies are not well understood:

> Although the archaeologically-documented presence of *ahu* and *kūahu* within the summit region of Mauna Kea indicates religious observances of various kinds in the Hawaiian past, no knowledge regarding the traditional practices and beliefs associated with these structures exists today, or if it does the information has not been shared with anthropologists and archaeologists.

During the Postcontact Period, traditional uses of the summit area were undoubtedly affected by Hawaiians' interactions with and reactions to newly-introduced Western ideas and practices. While use of the summit region had apparently been restricted to certain ritual and craft specialists, Europeans were motivated to venture to the summit by science and a spirit of exploration. The first European known to have ascended Mauna Kea was Reverend Joseph Goodrich, in 1832 (Goodrich 1833). During that same year, Dr. Abraham Blatchley and Mr. Samuel Ruggles, also went to the top (Skinner 1934). Other early visitors included botanists James Macrae in 1825 and David Douglas in 1834, and members of the United States Exploring Expedition in 1841 (Wentworth 1935). Maly and Maly (2005) detail other early visits to Mauna Kea, including expeditions to the summit by astronomers, geologists, surveyors, and other scientists. Several of these early scientific expeditions reported the presence of what are today considered historic properties and archaeological sites, including the adze quarries and traditional burials at Puʻu Līlīnoe.

Not all of the visits to the summit region during this period were led by foreign scientists or explorers. Citing accounts by several different authors, Kamakau (2001) and others, de Silva and de Silva (2006) note that several *aliʻi* ascended Mauna Kea for ceremonial reasons. Kamehameha I went to Waiau to pray and leave an offering of *ʻawa* (Desha 2000), and Kaʻahumanu made the same journey in 1828 in an unsuccessful attempt to retrieve the *iwi* of her ancestress Līlīnoe (Kamakau 2001). Waiau was also visited by Kauikeaouli in 1830, Alexander Liloliho in 1849, and Peter Young Kaʻeo in 1854 (de Silva and de Silva 2006:5). In October of 1882, Queen Emma Kaleleonalani and her royal party ascended Mauna Kea "to demonstrate her lineage and godly connections, and to perform a ceremonial cleansing in the most sacred of the waters of Kāne in Lake Waiau" (Maly and Maly 2005:155). Her journey to the summit was commemorated in several *mele* (songs) and in the names of descendants of its participants, but also physically on the mountain in the form of a pillar of stones observed ten years later by members of a scientific expedition led by W. D. Alexander and E.D. Preston (Maly and Maly 2005).

During the Modern Period, land use on Mauna Kea changed markedly. As the 20th century began, large flocks of feral sheep were devastating the forests on the flanks of the mountain, and governmental response to the damage led to increased access to the summit. To combat the erosion caused by feral grazing, the Civilian Conservation Corps (CCC) undertook a large fencing project during the 1930s (Hoʻakea 2009). At about the same time, the CCC worked to improve roads and build facilities for visitors (Bryan 1939). They constructed a road leading to the summit from Kālaiʻeha that probably followed the ancient Mauna Kea–Humuʻula Trail. Two cabins (Sites 50-10-23-9074 and 9075) were also built by the CCC in 1936 and 1938, respectively, and the name of the facility, Hale Pōhaku, derives from these stone houses (PCSI 2010). A comfort station (SIHP Site 50-10-23-9076), also built of local stone, was constructed in 1950.

Even during the 1950s, the human impacts on the Mauna Kea summit were relatively small. The current project area (Figure 8) was still only accessible by foot. After the development of a weather station on Mauna Loa and the Solar Observatory on Haleakalā on Maui in the late 1950s, however, Mauna Kea attracted the attention of the international astronomy community (Maly and Maly 2005). A test observatory facility was developed on the summit in 1964, which began with the bulldozing of the Mauna Kea Summit Access Road in May of that year followed by the construction of the Lunar and Planetary Station on the summit of Puʻupoliʻahu (Maly and Maly 2005). The success of this project led to the construction of the University of Hawaiʻi 88-inch telescope from 1967 to 1970, and also the establishment of the Mauna Kea Science reserve. The summit road was improved in 1970, allowing easier access to the summit for private and commercial users, and helped to spur additional telescope facility construction.

Construction of the CSO facility began in 1983, and was completed in 1987 (Steiger 2009). As designed, ground-level improvements at the CSO facility (Figures 9 and 10) included, in addition to the concrete foundation and telescope dome, a 6,000 square foot paved parking area with truck access and turnaround, and a 14 by 30 foot paved driveway. Below-ground improvements included utility trenches for conduits, auxiliary generator room and fuel tank, a large underground water tank outside the dome, a sewage holding tank under the dome**,** and an external cesspool (Steiger 2009). The foundation of the telescope dome (Figure 11) was installed on a graded pad located along an existing unpaved road that led to Puʻupoliʻahu and to the James Clerk Maxwell Telescope site (Figure 12). Most of the unpaved road has since been incorporated into the Mauna Kea Summit Access Road (see Figure 3), although a 150-meter long portion of the unpaved road remains immediately southeast of the CSO site.

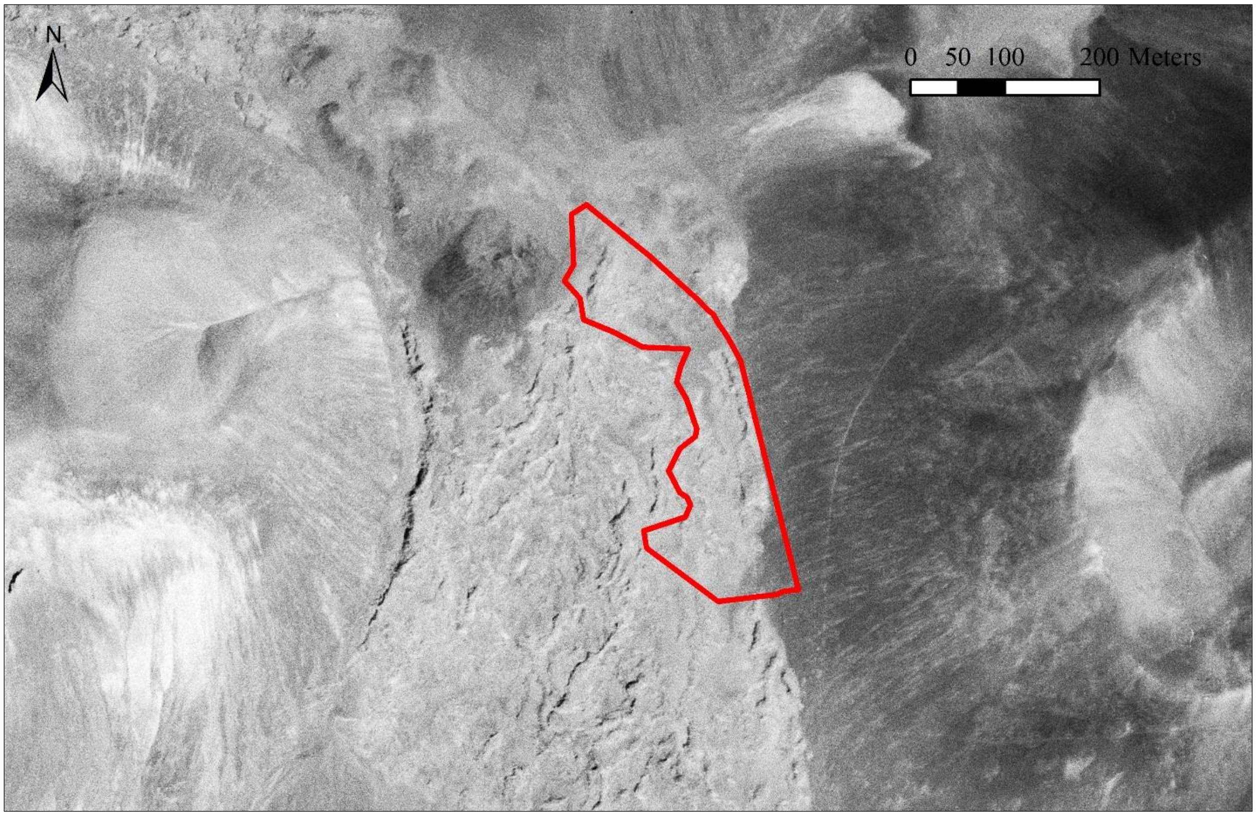

Figure 8. 1954 aerial photograph of the current project area (outlined in red) (USGS 1954).

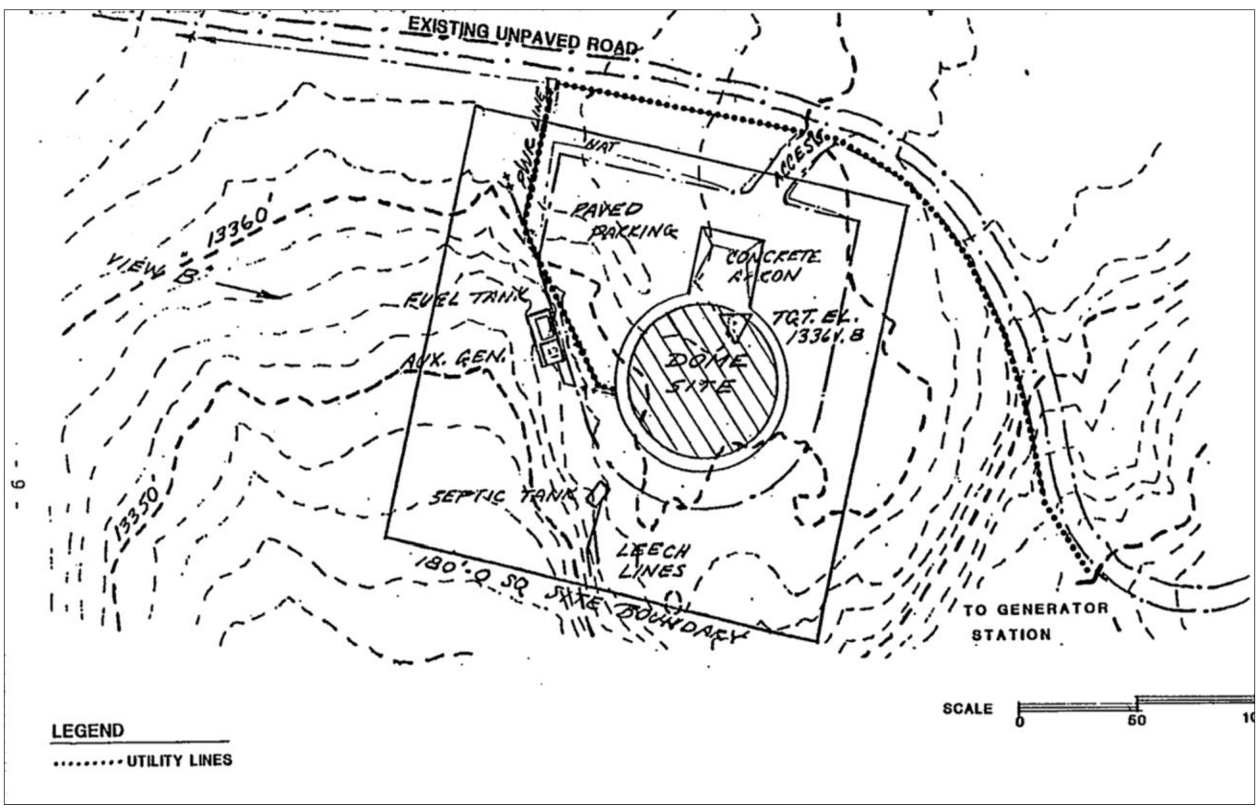

Figure 9. Preliminary plan of CSO facilities (Group 70 1982).

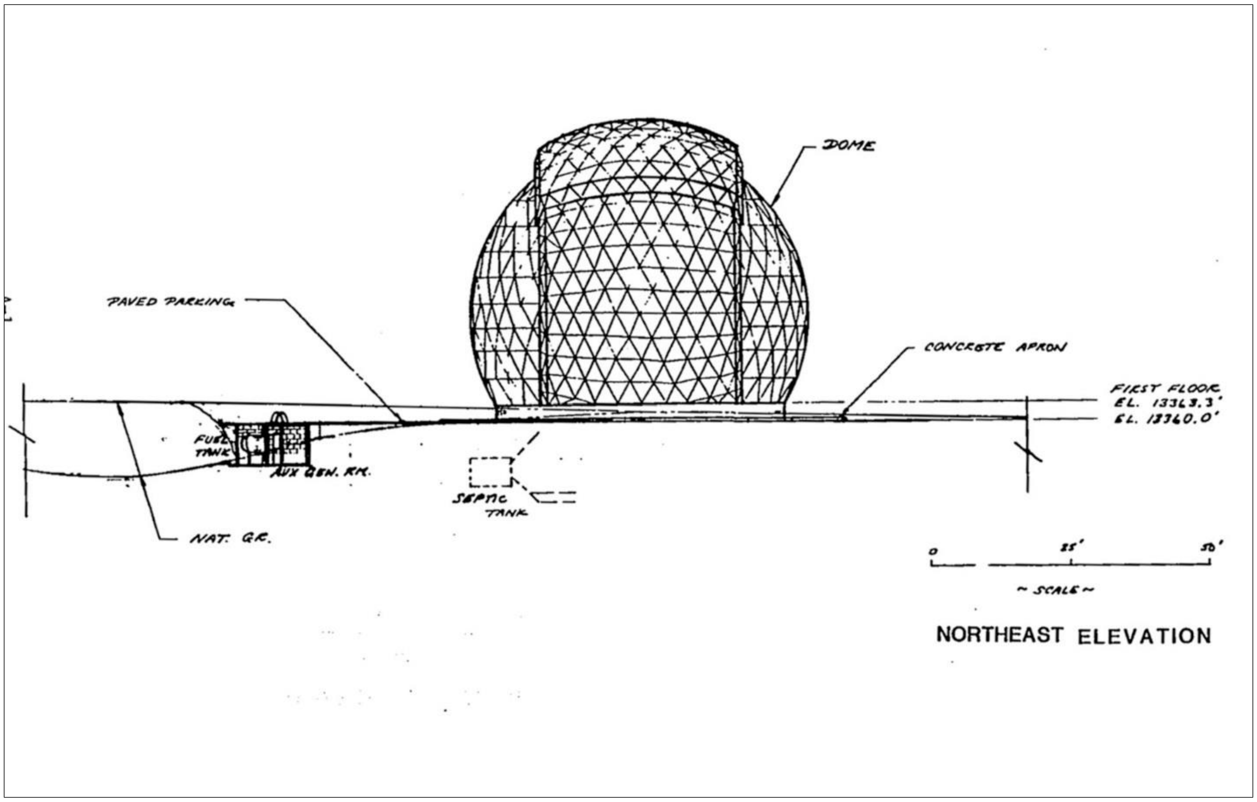

Figure 10. Preliminary elevation of CSO facilities (Group 70 1982).

Figure 11. Observatory and outbuilding foundations in 1985, view to the southwest (Steiger 2009).

Figure 12. CSO under construction, view to the northwest (Steiger 2009).

PREVIOUS ARCHAEOLOGICAL AND CULTURAL STUDIES

The entire summit region of Mauna Kea was subject to archaeological inventory surveys between 2005 and 2009. Results of these surveys and summaries of prior archaeological studies were presented in four AIS reports (Table 1). One of these reports (McCoy et al. 2010) presented results of fieldwork conducted within the Astronomy Precinct, where the CSO facility is located. Another report (McCoy and Nees 2010) included results from the entire Science Reserve (which contains the portion of the current study area outside of the Astronomy Precinct). Two other areas in the summit region were also subject to inventory-level surveys: the Mauna Kea Ice Age Natural Area Reserve (McCoy and Nees 2013), which is located to the south and west of the CSO facility, and Lake Waiau (McCoy and Nees 2009), located to the south of the CSO facility. In addition to these studies, portions of the summit region were included in earlier archaeological reconnaissance surveys, academic research projects, and cultural resource management studies associated with the construction of observatories in the Astronomy Precinct. Results of these smaller-scale studies were incorporated in the four AIS reports described above. One of these earlier reconnaissance studies (McCoy 1982a) included the location of the CSO facility, and two others (McCoy 1982b, 1993) were conducted in areas adjacent to the facility. The summary of previous archaeological work presented below is adapted in part from the Science Reserve AIS (McCoy and Nees 2010) and Natural Area Reserve AIS (McCoy and Nees 2013) and documents archived in the SHPD correspondence files. It includes the negative findings of the Barna (2020) AIS for the current project and focuses primarily on sites that are either near the CSO facility or within the viewshed of the CSO facility.

Table 1. Archaeological Inventory Survey reports for the Mauna Kea Summit Region.

Year	*Author(s)*	*Scope*	*Number of historic properties*
2009	McCoy and Nees	Lake Waiau	41 sites, 1 TCP
2010	McCoy et al.	Astronomy Precinct	6 sites, 1 TCP
2010	McCoy and Nees	Mauna Kea Science Reserve	263 sites, 2 TCP*
2013	McCoy and Nees	Mauna Kea Ice Age Natural Area Reserve	109 sites, 1 TCP**
2020	Barna	CSO Decommissioning Project Area	None in the current project area

* Includes McCoy et al. (2010) findings. ** Includes McCoy and Nees (2009) findings.

The CSO facility site itself was subject to an archaeological survey by the B. P. Bishop Museum (McCoy 1982a) in support of the observatory's environmental impact statement. No archaeological sites were observed within the planned CSO project area; however, two shrines (Sites 50-10-23-16164 and 16165) located 188 meters and 250 meters, respectively, to the south-southwest of the CSO project area were briefly described in that report. In a later report produced for a larger archaeological reconnaissance of the summit region McCoy (1982b) provided more detailed descriptions and analyses of these two sites. As part of the Section 106 process for the construction of the Smithsonian Institution Astrophysical Observatory, McCoy (1993) revisited Sites 16164 and 16165 and found them to be located outside the Astronomy Precinct, recommending that they be flagged during construction of the Smithsonian Institution Astrophysical Observatory as a precautionary measure. These two sites are the closest historic properties to the CSO facility.

The 2005-2009 archaeological surveys (McCoy et al. 2010; McCoy and Nees 2009, 2010, 2013) conducted in the summit region recorded 263 historic properties in the Science Reserve (Figure 13), 109 historic properties in the Mauna Kea Ice Age Natural Area Reserve (Figure 14), 41 sites at Lake Waiau, and 6 sites within the Astronomy Precinct (see Table 1). Combined, these sites include 3 SHPD-designated Traditional Cultural Properties (TCPs, as defined by Parker and King 1998), 151 shrines, the Mauna Kea Adze Quarry Complex (which has been designated a National Historic Landmark), 5 burial features and 56 possible burial features, 23 stone markers or memorials, 4 Historic campsites, 3 temporary shelters, 3 trails, 1 Historic dump, 1 Historic transportation route, 1 petroglyph, and 3 sites of unknown function. The TCPs comprise three *pu'u* (Kūkahau'ula, Site 21438; Pu'u Waiau, Site 21440; and Pu'u Līlīnoe, Site 21439) that were determined to be eligible for inclusion in the National Register of Historic Places based on consultation begun by Langlas (1999) with knowledgeable *kūpuna* (elders). The Mauna Kea Adze Quarry Complex is located near Pōhakuloa Gulch south of the Astronomy Precinct, within the Natural Area Reserve. This complex includes the quarry proper, workshop locations used for manufacturing and/or ritual activities, and one habitation rockshelter located outside of the quarry proper. Of the previously recorded historic properties located in the summit region, none are located within the current project area (see Figures 13 and 14).

The Mauna Kea Summit Region Historic District (SIHP Site 50-10-23-26869) encompasses the extent of the glacial moraines and crest of the relatively pronounced change in slope that creates the impression of a summit plateau (Figure 15). The historic district was designated by SHPD during the preparation of a draft historic preservation plan (HPP) for the Science Reserve. While the draft preservation plan was never finalized, elements of the plan were incorporated into the Mauna Kea Science Reserve Master Plan (Master Plan) prepared by Group 70 International (2000) as appendices. The district was initially proposed in the cultural impact assessment for the Mauna Kea Science Reserve Master Plan (PHRI 1999) and was later discussed in a SHPD review of the Draft Environmental Assessment for the Keck Outrigger Telescope project (Log No.: 23155, Doc No.: 9903PM07; Attachment 1) and the Final Environmental Impact Statement for the Keck Outrigger Telescope project (NASA 2005). All of the historic properties located within the district's boundaries are considered to be contributing elements. As a result of the archaeological inventory surveys conducted between 2005 and 2009 (see Table 1), the district was evaluated to be eligible for listing in the National Register of Historic Places under Criteria A, B, C, and D, and was also determined to be historically significant under Criteria a, b, c, d, and e of HAR 13§13-275-6 as a result of the McCoy et al. (2010) AIS. No contributing elements of the Historic District are located within the current project area. Eleven contributing elements (Table 2) of the Mauna Kea Summit Region Historic District (Site 26869) are visible from CSO facility. These include two shrines (Sites 16164 and 19165) located to the south of the current study area; one USGS survey marker (Site 27579) located at the peak of Pu'upoli'ahu; the TCPs Kūkahau'ula (Site 21438) and Waiau (Site 21440); four sites (Sites 26132, 26133, 26134, and 26142) located on the rim of Pu'u Waiau that include possible burials, a possible shrine, a cairn, mounds, rock piles, and a lithic workshop; a lithic workshop (Site 27585) located almost three kilometers to the southeast of the CSO facility; and four possible burials (Site 28623) located on Pu'uhaukea.

In addition to archaeological sites and other historic properties, archaeological surveys conducted on the summit since 1997 have been recording "find spots" (called "locations" in early reports), that is, anthropogenic features that are either obviously modern (e.g., camp sites with tin cans, pieces of glass and other modern material culture items), or features that cannot be classified with any level of confidence as historic sites because of their uncertain age and function (e.g., a pile of stones on a boulder) (McCoy 1999). During the Science Reserve AIS (McCoy and Nees 2010), 339 find spots were recorded, and approximately 313 find spots were recorded during the Natural Area Reserve AIS (McCoy and Nees 2013). The placement of objects and features classified as "find spots" by cultural practitioners and other visitors to the summit is understood to be ongoing, and management policies regarding construction of new Hawaiian cultural features and constructions considered to be "find spots" is governed by the CMP (Ho'akea 2009).

In 2020, ASM Affiliates conducted an AIS (Barna 2020) for the CSO Decommissioning Project, which encompassed the current project area. As a result of that fieldwork, no archaeological resources of any kind, and no find spots, were identified within the current project area.

Table 2. Contributing elements of the Mauna Kea Summit Region Historic District (Site 26869) visible from the CSO.

Site no.	***Type(s)***	***Features***	***Type of features***	***Location***
16164	Shrine	2	5, possibly 6, uprights	188 meters SSE
16165	Shrine	1	2 uprights	250 meters SSE
21438	Kūkahau‘ula	1	Mauna Kea Summit (as Traditional Cultural Property)	149 meters E
21440	Pu‘u Waiau	1	Pu‘u (as Traditional Cultural Property)	1,280 meters S
26132	Possible burial	2	Alignments	1,550 meters SSE
26133	Cairn	1	Cairn	1,545 meters SSE
26134	Possible burials, Possible shrine, Marker/memorial, Unknown function	17	1 terrace, 1 mound/terrace, 4 pavements, 9 mounds, 2 rock piles	1,530 meters S
26142	Workshop	1	Lithic scatter	1,510 meters S
27579	USGS Marker	1	1 USGS marker	630 meters W
27585	Workshop	1	4 adze manufacturing workshops; flakes, hammerstones, cores	2,530 meters SW
28623	Possible burial	4	4 mounds	930 meters SE

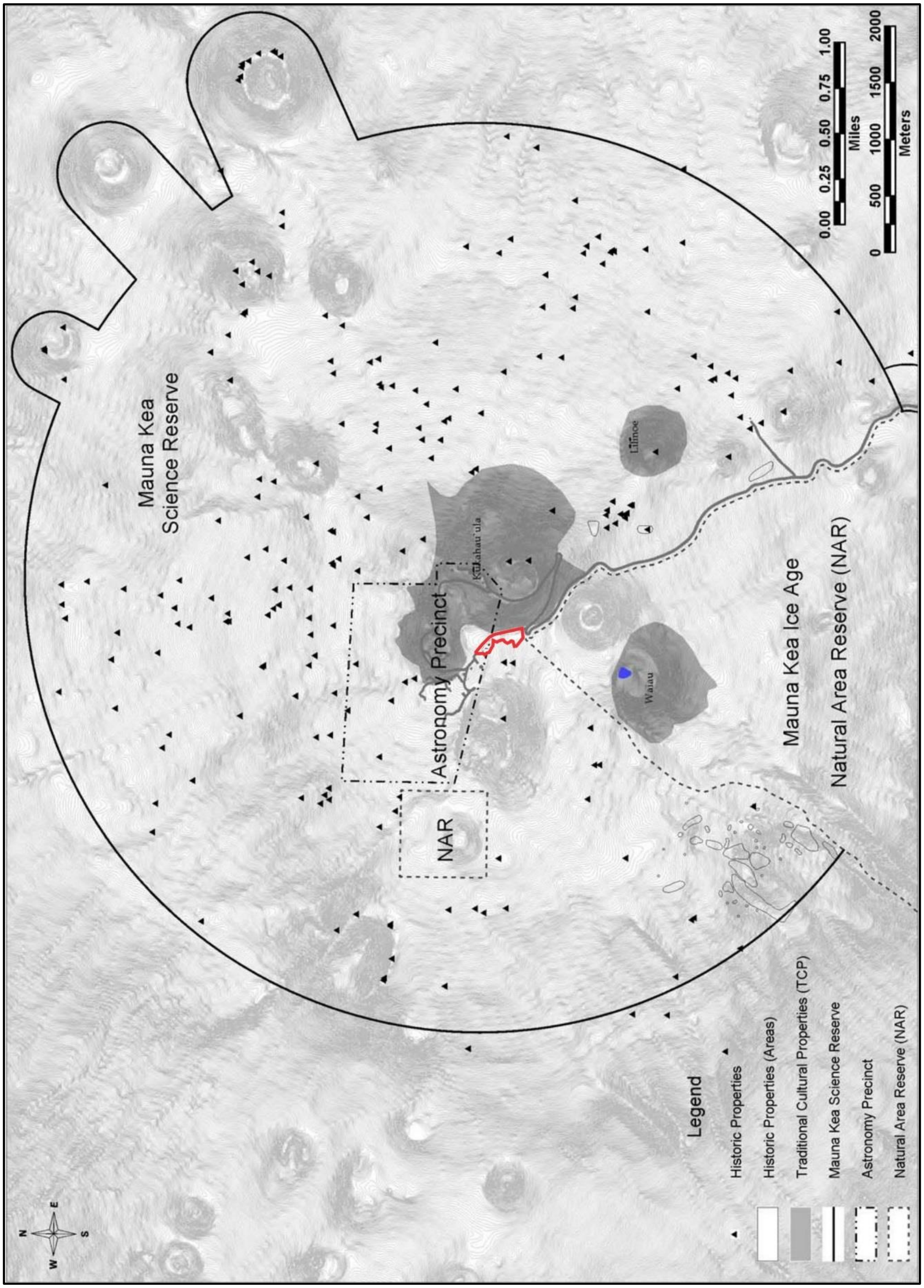

Figure 13. Locations of historic properties in the Mauna Kea Science Reserve, current project area outlined in red (after McCoy and Nees 2010).

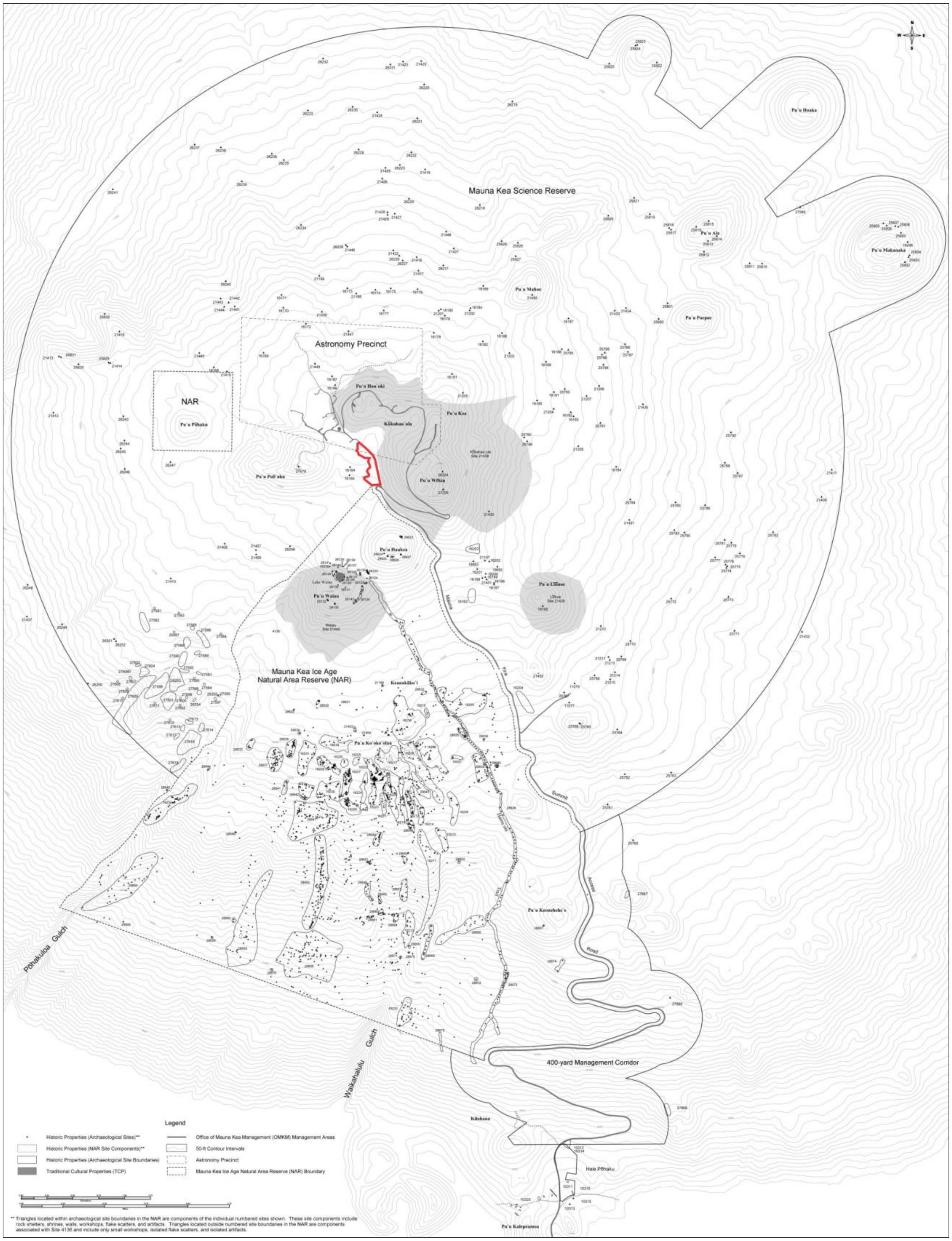

Figure 14. Locations of historic properties in the Mauna Kea Ice Age Natural Reserve Area, current project area outlined in red (after McCoy and Nees 2013).

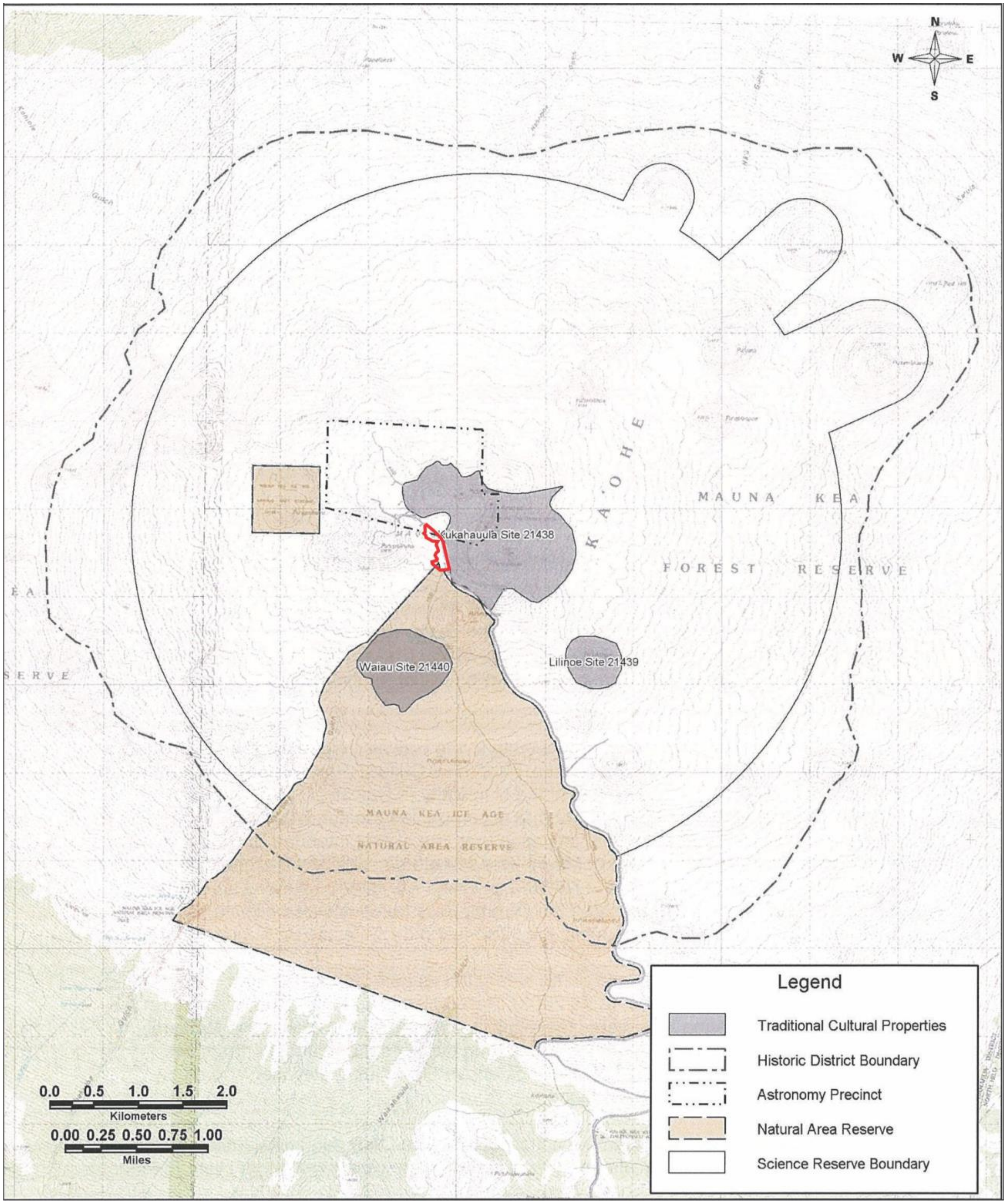

Figure 15. Mauna Kea Summit Region Historic District (Site 26869) boundaries (after McCoy et al. 2009), current project area outlined in red.

3. ANTICIPATED REMAINS

Given these negative findings of the Barna (2020) AIS (Figure 16) and the known quantity of fill material used during the construction of the CSO facility, the likelihood of encountering previously undocumented subsurface archaeological resources is considered to be very low. Cultural concerns are also to be considered during the project implementation. Information that has been generated for Mauna Kea as a result of numerous prior studies (see discussion in Rechtman 2021) clearly demonstrates the sanctity of Mauna Kea and its summit region. The compiled oral-historical information provides further specific details about the cultural importance of the summit's view planes (see Figure 16), the traditional significance of individual *pu'u*, and the importance of proper cultural protocol. It is also clear from the oral-historical information that current-day Hawaiian cultural activities on Mauna Kea are perceived by the practitioners of those activities to be an exercise in, and an extension of, traditional and customary practices.

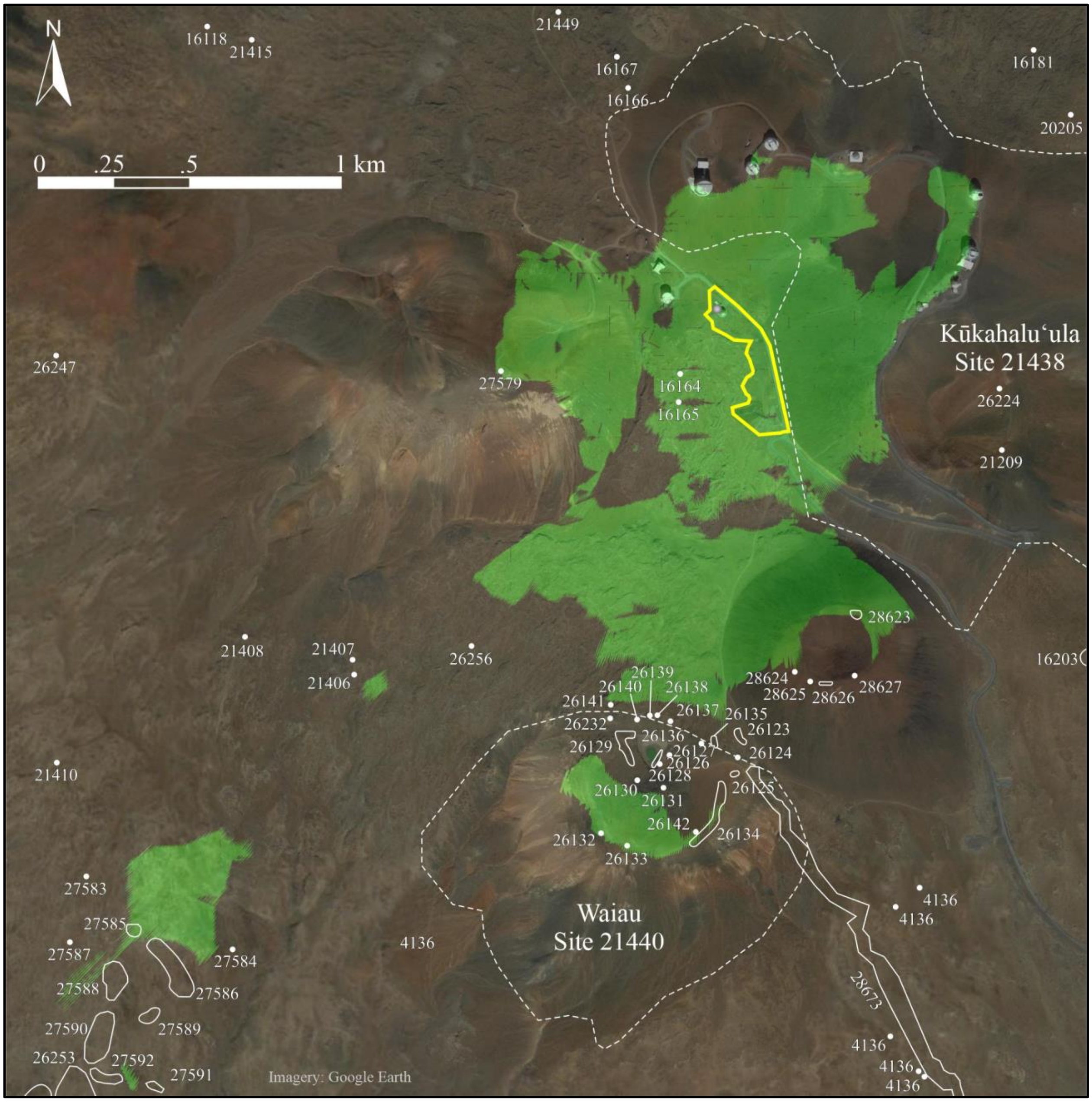

Figure 16. Location of historic and cultural resources relative to the current project area (outlined in yellow) and the CSO facility viewshed (shaded green).

4. THE MONITORING EFFORT

Prior to the start of any proposed subsurface development activities, a meeting will be held among the construction contractor, the project proponent, the project's Principal Archaeologist, primary archaeological monitor, and primary cultural monitor to discuss the procedures for monitoring. At the meeting, it will be explained that the monitoring archaeologist(s) and cultural monitor have the authority to halt ground-disturbing activities in the event that archaeological or other cultural resources are encountered. If archaeological or other cultural resources identified during monitoring are deemed significant, DLNR-SHPD will be notified and consultation will be coordinated as appropriate with any groups or organizations. Additionally, DLNR-SHPD will be notified upon the onset and completion of the monitoring activities. Any change in status of the monitoring (i.e., a shift from on-site to on-call) will occur only with prior written approval from DLNR-SHPD.

ARCHAEOLOGICAL FIELD METHODS

A qualified archaeological monitor(s) will be present on-site to observe all subsurface ground-disturbing activities. When on site, monitors will keep a daily log of activities performed and any discoveries made. Monitors will inspect all exposed soil and sediments, and the stratigraphic profiles of any deep cuts will be examined. A sampling of stratigraphic profiles of excavated areas without archaeological resources will be documented using scaled profile drawings and photographs in order to provide useful information regarding the absence of cultural materials in a given area. At least one 2-meter-long profile will be included in the Archaeological Monitoring Report for reference. This practice will be followed in an effort to identify previously undiscovered and undisturbed cultural deposits, features, artifacts, and human skeletal material. If any such resources are encountered the following procedures will be initiated:

Cultural Deposits

The monitor will notify DLNR-SHPD if non-burial historic properties are identified. All cultural deposits and sequences (including representative natural sequences) identified during the monitoring effort will be mapped, representative scaled profile drawings and plan views will be prepared, photographs will be taken, and the stratigraphic deposits will be described in detail using standard USDA soil descriptions and Munsell colors. If intact cultural deposits are discovered during monitoring, an assessment will be made as to their integrity and significance using the criteria enumerated in HAR 13§13-275-6(b). If the deposit is deemed significant and is likely to be further impacted by demolition activities, work in the affected area will be curtailed, and an appropriate mitigation strategy will be developed in consultation with DLNR-SHPD.

Cultural Features

Subsurface cultural features observed will be fully described, drawn, and photographed. Provenience information will also be recorded and related to an established project datum ensuring accurate horizontal and vertical placement. The limits of the feature will be defined, if possible without further excavation, and any natural or cultural associations (including surrounding soil) will be noted. Where appropriate, samples (e.g., soil, charcoal, etc.) for further analyses will be recovered and processed.

Artifacts

Artifacts observed in the removed soil will be recovered and their general provenience recorded. All traditional Precontact Hawaiian artifacts and diagnostic post-Contact artifacts will be recovered for laboratory analysis. The precise locations of any items found *in situ* will be recorded and the items photographed and recovered for subsequent laboratory analysis. Any observed associations will also be documented, and the surrounding soil will be fully described using standard USDA soil descriptions and Munsell colors.

Human Skeletal Remains

If human skeletal remains are encountered during the monitoring effort, the on-site monitor will halt all ground-disturbing activity in the immediate area of the discovery, stabilize the remains, and contact the appropriate authorities. DLNR-SHPD staff from the Archaeology Branch and from the History and Culture Branch will be notified immediately, and the monitor will notify the appropriate on-site construction personnel, the Police, and Medical Examiner, as appropriate. If the skeletal material is determined to be Historic or Precontact (as opposed to recent), the monitoring archaeologist will direct the applicant to seek DLNR-SHPD guidance on how to proceed with the discovery, and the human skeletal remains will be handled in compliance with HRS Chapter 43.6, HAR §13-300, and DLNR-SHPD directives. If the remains are determined to be recent, the Honolulu Police Department will be contacted.

TREATMENT OF RECOVERED REMAINS

All recovered material will be temporarily stored within a secure location. The recovered items will be recorded in a field catalog, and upon completion of the monitoring fieldwork the disposition of the items will be as follows:

Cultural Material

Artifacts from intact contexts will be analyzed; those recovered from fill will simply be cataloged. Analyzed items will be cleaned, weighed, measured, photographed, and illustrated (if appropriate). Analysis will include formal description and functional interpretation. The identification of artifacts, vertebrate faunal remains, and invertebrate faunal remains will include comparison with reference collections and materials, as needed.

Recovered Samples

All recovered samples (soil, charcoal, etc.) will be initially processed by the qualified archaeological monitor before being dispersed to the appropriate institutions for detailed analysis.

Human Skeletal Remains

If DLNR-SHPD determines that the removal of buried human remains is an appropriate course of action, then a treatment/reburial plan will be developed in consultation with DLNR-SHPD and other consulted parties, as appropriate in accordance with Hawaii State law as outlined in HAR 13§13-300.

REPORTING

On a monthly basis, a log of archaeological monitoring activities and a list of stop work orders, if any, will be prepared and submitted to the Contractor and CMS. Following completion of archaeological monitoring, a draft monitoring report will be prepared and submitted to DLNR-SHPD for review and acceptance. This report will follow the specifications contained in HAR 13§13-279-5. If any human skeletal remains are recovered as part of the monitoring project they will be summarized in the final monitoring report following procedures contained in HAR §13-300.

CURATION OF RECOVERED ITEMS

Any material recovered during the project will be temporarily stored for a period of no more than one year following submission of the final monitoring report, during which time arrangements will be made for permanent curation in consultation with the respective landowner and DLNR-SHPD. It will be the respective landowner’s responsibility to secure permanent curation in an acceptable facility; included in this responsibility are the costs associated with long-term curation.

CULTURAL MONITORING METHODS

In compliance with the CMP (Hoʻakea 2009) and with the commitments described in the CIA prepared for the CSO Decommissioning (Rechtman 2021), Caltech will retain the services of a cultural monitor during the decommissioning project. The on-site cultural monitor will provide an appropriate cultural orientation to individuals conducting on-site work and will provide guidance on cultural protocols during the decommissioning process. Currently, there are no statutory or regulatory mandates for cultural monitors, nor are there any recognized policies or guidelines that set out standards for cultural monitoring. However, consultations with Kahu Kū Mauna for other projects have led to the following basic recommendations for the cultural monitoring:

- A cultural monitor will be present on-site during all ground-disturbing activities and as appropriate during other activities associated with the removal of improvements on the CSO site and the restoration of the site.
- Individuals selected to be cultural monitors will have the appropriate background in order to serve as a cultural monitor and as a cultural resource specialist for cultural matters. The cultural monitor should also be capable of facilitating discussions between the project and the various stakeholders.
- Cultural monitors will not be affiliated with the archaeological firm that is hired to provide archaeological monitoring support.
- Cultural monitors will participate in any pre-construction briefings with the archaeological monitors. In addition, cultural monitors will maintain regular records of attendance and activity on the job site.
- Cultural monitors will provide the Kahu Kū Mauna and the Center for Maunakea Stewardship a report of activities and findings, if any, on a monthly basis.

REFERENCES CITED

Barna, B.
2020 An Archaeological Assessment for the Caltech Submillimeter Observatory Decommissioning Project on Maunakea, TMK: (3) 4-4-015:009 (por.), Kaʻohe Ahupuaʻa, Hāmākua District, Island of Hawaiʻi. ASM Affiliates Project Number 30040.00. Prepared for California Institute of Technology, Pasadena, CA.

Bryan, L.
1939 Lake Waiau of Hawaii. *Paradise of the Pacific* 51(2): 10–11.

Desha, S.
2000 *Kamehameha and his warrior Kekūhaupiʻo*. Translator Frances N. Frazier. Kamehameha Schools Press, Honolulu.

Gerrish, G.
2013 Botanical Baseline Survey (2011) of the University of Hawaii's Managed Lands on Mauna Kea. Biology Department, University of Hawaii at Hilo. Prepared for Office of Mauna Kea Management.

Giambelluca, T. W., Q. Chen, A. G. Frazier, J. P. Price, Y.-L. Chen, P.-S. Chu, J. K. Eischeid, and D. M. Delparte
2013 Online Rainfall Atlas of Hawaiʻi. *Bulletin of the American Meteorological Society* 94(3): 313–316.

Goodrich, J.
1833 Notices of some of the volcanos and volcanic phenomena of Hawaii, (Owyhee,) and other islands in that group, in a letter from Mr. Joseph Goodrich, missionary, dated Nov. 17, 1832. *American Journal of Science and Arts* 25: 199–203.

Group 70
1982 A 10-Meter Telescope for Millimeter and Submillimeter Astronomy at Mauna Kea, Hamakua, Hawaii. Final Environmental Impact Statement. Prepared for California Institute of Technology.

Group 70 International
2000 Mauna Kea Science Reserve Master Plan. Prepared for University of Hawaiʻi, Honolulu, Hawaii. Honolulu, Hawaii.

Hoʻakea (Hoʻakea, LLC dba Kuʻiwalu)
2009 Mauna Kea Comprehensive Management Plan: UH Management Areas. Prepared for University of Hawaiʻi.

Kamakau, S.
2001 *Ke Aupuni Mōʻī: Ka Moʻolelo Hawaiʻi no Kauikeaouli keiki hoʻoilina a Kamehameha a me ke aupuni āna i noho mōʻī ai*. Kamehameha Schools Press, Honolulu.

Langlas, C.
1999 Supplement to Archaeological, Historical and Traditional Cultural Property Assessment for the Hawaiʻi Defense Access Road A-AD-6(1) and Saddle Road (SR200) Project. In *The Saddle Road Corridor: An Archaeological Inventory Survey and Traditional Cultural Property Study for the Hawaiʻi Defense Access Road A-AD-6(1) and Saddle Road (SR200) Project, Districts of South Kōhala, Hāmākua, North Hilo, and South Hilo, Island of Hawaiʻi. Paul H. Rosendahl, Ph. D., Inc. Report 1939-043099*. Prepared for Okahara & Associates, Kailua-Kona.

Langlas, C., T. Wolforth, and J. Head
1999 The Saddle Road Corridor: An Archaeological Inventory Survey and Traditional Cultural Property Study for the Hawaiʻi Defense Access Road A-AD-6(1) and Saddle Road (SR200) Project, Districts of South Kōhala, Hāmākua, North Hilo, and South Hilo, Island of Hawaiʻi. Paul H. Rosendahl, Ph. D., Inc. Report 1939-043099. Prepared for Okahara & Associates, Inc. Kailua-Kona.

Maly, K.
1998 "Mauna Kea - Kuahiwi Ku Ha'o Malie." A Report on Archival and Historical Documentary Research, Ahupua'a of Humu'ula and Ka'ohe, Districts of Hilo and Hamakua, Island of Hawai'i. Kumu Pono Associates, LLC.

1999 Mauna Kea Science Reserve and Hale Pōhaku Complex Development Plan Update: Oral History and Consultation Study, and Archival Literature Research, Ahupua'a of Ka'ohe (Hāmākua District) and Humu'ula (Hilo District), Island of Hawai'i. In *Mauna Kea Science Reserve Master Plan*. Prepared for University of Hawai'i, Honolulu, HI.

Maly, K., and O. Maly
2005 Mauna Kea- Ka Piko Kaulana O Ka 'Āina/Mauna Kea-The Famous Summit of the Land. Kumu Pono Associates Study HIMK67-OMKM (033005b). Prepared for The Office of Mauna Kea Management (University of Hawai'i Hilo), Hilo, HI.

2006 Appendix A: Mauna Kea-"Ka Piko Kaulana o ka "Āina." A Collection of Oral History Interviews Documenting Historical Accounts and Recollections of Mauna Kea and the Mountain Lands of Hāmākua, Hilo and South Kohala, on the Island of Hawai'i." Kumu Pono Associates Study HIMK67-OMKM (033005b). Prepared for The Office of Mauna Kea Management (University of Hawai'i Hilo), Hilo, HI.

McCoy, P.
1982a Archaeological Survey of the Proposed Site of the Caltech 10-Meter Telescope on Mauna Kea, Hawaii. Department of Anthropology, B.P. Bishop Museum Ms. 080682. Prepared for Group 70 Inc., Honolulu, Hawaii.

1982b Archaeological Reconnaissance Survey. In *Cultural Resources Reconnaissance of the Mauna Kea Summit Region*. Department of Anthropology, B. P. Bishop Museum, Honolulu.

1993 Letter Report on the Inspection of Two Sites Located in the Vicinity of the Smithsonian Submillimeter Array. Mountain Archaeology Research Corp. Submitted to the Smithsonian Institution Astrophysical Observatory.

1999 Mauna Kea Science Reserve Archaeological Site Inventory: Formal, Functional, and Spatial Attributes. In *Mauna Kea Science Reserve Master Plan,* p. Appendix K. Prepared for the University of Hawaii, Honolulu.

McCoy, P., S. Collins, S. Clark, and V. Park
2009 A Cultural Resources Management Plan for the University of Hawaii Management Areas on Mauna Kea, Ka'ohe Ahupua'a, Hamakua Districts Hawaii Island, State of Hawaii. TMK: (3) 4-4-015: 09, 12. A Sub-Plan for the Mauna Kea Comprehensive Management Plan. Pacific Consulting Services, Inc. Prepared for Office of Mauna Kea Management, Hilo. Hilo.

McCoy, P., and R. Nees
2009 Archaeological Inventory Survey of Lake Waiau, Mauna Kea Ice Age Natural Area Reserve, Ka'ohe, Hamakua, Island of Hawai`i. Pacific Consulting Services, Inc. report. Prepared for Division of Forestry and Wildlife, Natural Area Reserves System, Department of Land and Natural Resources.

2010 Archaeological Inventory Survey of the Mauna Kea Science Reserve, Ka'ohe Ahupua'a, Hāmākua District, Island of Hawai`i TMK: (3) 4-4-015:09 (por.). Pacific Consulting Services, Inc. report. Prepared for Office of Mauna Kea Management.

2013 Archaeological Inventory Survey of the Mauna Kea Ice Age Natural Area Reserve Ka'ohe Ahupua'a, Hāmākua District, Island of Hawai'i TMK: (3) 4-4-015:10, 11. Pacific Consulting Services, Inc. report. Prepared for Division of Forestry and Wildlife, Natural Area Reserves System, Department of Land and Natural Resources.

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

2010 Archaeological Inventory Survey of the Astronomy Precinct in the Mauna Kea Science Reserve, Ka‘ohe Ahupua‘a, Hāmākua District, Island of Hawai‘i, TMK: (3) 4-4-015:09. Pacific Consulting Services, Inc. report. Prepared for Office of Mauna Kea Management, Hilo.

McEldowney, H.

1982 Ethnographic Background of the Mauna Kea Summit Region. In *Cultural Resources Reconnaissance of the Mauna Kea Summit Region*. Department of Anthropology, B. P. Bishop Museum, Honolulu.

NASA (National Aeronautics and Space Administration)

2005 Final Environmental Impact Statement for the Outrigger Telescopes Project. National Aeronautics and Space Administration, Washington, D.C.

Pacific Consulting Services, Inc. (PCSI)

2010 Architectural Inventory Survey of Hale Pohaku Rest Houses 1 and 2 and Comfort Station, Ka‘ohe Ahupua‘a, Hāmākua District, Hawai‘i Island, Hawai‘i TMK: (3) 4-4-015: 12 (por.). Pacific Consulting Services, Inc. report. Prepared for Office of Mauna Kea Management, Hilo.

Parker, P., and T. King

1998 Guidelines for Evaluating and Documenting Traditional Cultural Properties. *National Register Bulletin 38*. Revised. U.S. Department of the Interior, National Park Service, Cultural Resources.

Paul H. Rosendahl, Ph. D., Inc. (PHRI)

1999 Cultural Impact Assessment Study: Native Hawaiian Cultural Practices, Features, and Beliefs Associated with the University of Hawai‘i Mauna Kea Science Reserve Master Plan Project Area. In Mauna Kea Science Reserve Master Plan, Appendix N. Prepared for the University of Hawaii Institute for Astronomy, Honolulu.

Planning Solutions, Inc.

In prep Site Decommissioning Plan for the Caltech Submillimeter Observatory. Prepared for the California Institute of Technology. Pasadena, CA.

Rechtman, R.

2021 Cultural Impact Assessment for the Caltech Submillimeter Observatory Decommissioning Project on Mauna Kea, TMK: (3) 4-4-015:009 (por.), Ka‘ohe Ahupua‘a, Hāmākua District, Island of Hawai‘i. ASM Affiliates Project Number 30040.00. Prepared for California Institute of Technology, Pasadena, CA.

de Silva, K., and M. de Silva

2006 E Ho‘i ka Nani i Mānā. *Kalenamanu*. http://apps.ksbe.edu/kaiwakiloumoku/kaleinamanu/he-aloha-moku-o-keawe/hoi_ka_nani, accessed June 11, 2018.

Skinner, J.

1934 Mauna Kea. *Paradise of the Pacific* 46(12):9.

Steiger, W.

2009 A Brief History of the Caltech Submillimeter Observatory. *Caltech Submillimeter Observatory*. http://www.cso.caltech.edu/cso_history/CSO_History, accessed May 22, 2018.

Sustainable Resources Group Int’l, Inc.

2010 Decommissioning Plan for the Mauna Kea Observatories: A Sub-Plan of the Mauna Kea Comprehensive Management Plan. Prepared for Office of Mauna Kea Management, Hilo.

USGS (United States Geological Survey)

1954 *Aerial Photograph 1HAI000050016*. Aerial Photograph. United States Department of Geology. https://earthexplorer.usgs.gov/, accessed December 20, 2017.

Wentworth, C.

1935 Mauna Kea, the White Mountain of Hawaii. *Mid Pacific Magazine*.