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BOARD OF LAND AND NATURAL RESOURCES

FOR THE STATE OF HAWAI'I

IN THE MATTER OF A Contested Case Hearing Re Conservation; Use Application (CDUA) HA-3568 For the Thirty Meter Telescope at the Mauna Kea Science Reserve, Ka'ohe Mauka, Hamakua, Hawai'i TMK(3)4-4-015:009	Case No. BLNR-CC-16-002 CINDY FREITAS SEVENTH SUPPLEMENTAL EXHIBIT LIST; CERTIFICATE OF SERVICE

CINDY FREITAS SEVENTH SUPPLEMENTAL EXHIBIT LIST

Ex. No	Description
S-1a	Pre Hearing Statement of Mehana Kihoi (Amended WDT)
S-31d	2000 Master Plan page X1-14 (Amendment Procedures)
S-31e	CDUA page 1-8 (TMT observatory Design)
S-31f	CDUA Page 7-8 (Table 7.5)
S-31g	CDUA page 1-11 (TMT Access Way)
S-31h	Indices of Awards 1929
S-18c	Caterpillar D9L Bulldozer
S-18d	OCCL Letter October 13, 2009
S-18e	Hellman & Associates Safety Meeting Topic
S-18f	Blasting Technology, Inc. "Notice of Blasting"
S-18g	CDUA/TMT Management Plan Appendix D page D-8
S-18h	Hooked on Hydraulics
S-18L	USGS Ground Water n Hawaii
S-18m	Hydraulics Key
S-18n	Image
S-18o	Oil Drum left at Groundbreaking Site
S-18p	Paving Equipment Image
S-28f	The Ascent of Mauna Kea, Hawaii 1892 News Article

Kailua Kona HI. February 12, 2017

Cindy Freitas Petitioner

<u>Pre Hearing Statement of Mehana Kihoi</u>

I am Mehana Kihoi, I am a Native Hawaiian cultural and spiritual practitioner. I am a Native Hawaiian beneficiary as defined by the Hawaiian Homes Commission Act of 1921, and a beneficiary of the Ceded Lands Trust under Section 5(f) of the Admissions Act. I am a descendant of Native Hawaiians who inhabited the Hawaiian Islands prior to 1778 as established through my genealogical lines of Pa'ao and Hewa Hewa Nui. My ancestors and subsequent generations, gathered adze only found on Mauna Kea, to build their voyaging canoes. My ancestors honored Mauna Kea as a place of spiritual worship, where they would offer their deepest prayers to our creators Papa and Wakea.

I have a spiritual, cultural, psychological, physical, close and significant relationship to Mauna Kea that is tied to my identity as a Native Hawaiian. The health and well-being of Mauna Kea are tied directly to my own health and well-being because of my close and significant relationship to the land there. Mauna Kea is my spiritual place where I connect to my ancestors and my creators Papa and Wakea. Mauna Kea is where I achieve my highest level of spirituality. Mauna Kea is a sacred place.

My ancestors were stewards of Mauna Kea and ensured that these sacred lands remained untouched because of its importance to the creation of Native Hawaiians. I empower my own child by teaching her the spiritual practices at Mauna Kea so that one day she may carry these traditions to her children, and future generations. Having a direct ancestral connection to Mauna Kea, I am an active steward of this land to ensure there is no more further desecration of this land because it is tied to my spiritual and cultural identity, health and well-being as a Native Hawaiian.

I am an indigenous native Hawaiian woman, a mother, and a victim of domestic violence. Many years ago, I experienced physical and emotional trauma that left me with 5 broken parts of my face, and deep psychological & emotional pain. Pain that could never have been healed thru pharmaceutical drugs or western therapy. The Mauna is who healed me. The Mauna is where I go to, to ask my ancestors for guidance and strength. The Mauna is who gave me the courage to trust again.

I am Mehana Kihoi, and any further desecration of this sacred site will cause irreparable harm not only to myself but to my child who continues the same cultural practices that were passed on to me. As a victim of trauma, Mauna Kea saved my life and strengthened my identity as a Native Hawaiian because of my spiritual and cultural connection to this sacred place. Mauna Kea is my church and place of worship. Further desecration of this land will cause me an imminent injury because of my strong ancestral and cultural ties to these lands. The existing telescopes on Mauna Kea, and the State of Hawaii and the University of Hawaii's poor management of Mauna Kea have caused me to have an injury because of their failure to honor the customary and traditional practices of this area. My imminent injury is connected to the University of Hawaii's application for a Conservation District Use Permit to request approval to construct a Thirty Meter Telescope that will cause further desecration of Mauna Kea because the proposed construction will forever change the uniqueness and spiritual landscape of this sacred place.

If the permit is granted, the TMT will threaten the continuance of my traditional and customary rights in the respective area. I will suffer a severe cultural, spiritual, psychological and physical injury that will cause irreparable harm to who I am as a Native Hawaiian, my cultural identity and my spirituality as a Native Hawaiian.

ʻO hānau ka Mauna a Wākea,
ʻO puʻu aʻe ka Mauna a Wākea.
ʻO Wākea ke kāne, ʻo Papa, ʻo Walinuʻu ka wahine.

Hānau Hoʻohoku, he wahine,
Hānau Hāloa, he liʻi,
Hānau ka Mauna, he keiki Mauna na Wākea.

University of Hawai'i. The site will be restored to the pre-existing natural site as much as practicable. The Office of Mauna Kea Management will monitor compliance with this condition. The President will receive a report and recommendation from the MKM and the Mauna Kea Management Board before making final decisions on any exemptions to this requirement.

Variances:

Variance requests will be approved or rejected by the President of the University of Hawai'i. Requests for variances from development standards and guidelines may be approved if they are minor in nature and otherwise consistent with the overall goals and objectives of the Master Plan. Variance requests found to be substantially inconsistent with the provisions of this document will not be approved. Variances will be approved after receiving input from the DRC, the Mauna Kea Management Board and UH MKM.

AMENDMENT PROCEDURES

Plan Amendments

The Mauna Kea Master Plan is adopted by the University of Hawai'i Board of Regents and will guide the use and development of the Science Reserve. It is anticipated that there would not be many amendments to the plan during its life. Amendments would be required for large new facilities and major renovations only if they are not anticipated in the Master Plan. Projects identified in the Master Plan would not require plan amendments unless there are significant changes in design or location that have major impacts on the plan itself or the environment. It is proposed that plan amendments be separated into two categories: Class A and Class B amendments.

Class A amendments would be major amendments for proposals that require approval by the Board of Regents. Examples of these include:

- New projects not identified in the Master Plan with site coverage over 2,000 square feet or a building envelop over 24,000 cubic feet (40' x 50' x 12');
- Major expansions of existing facility sites not anticipated in the Master Plan (more than 50% of existing floor area or 2,000 square feet, whichever is greater);
- Improvements identified in the Master Plan which require significant changes in size or location;
- New utility alignments and corridors.

Class B amendments would be administrative. Final approval for Class B amendments would rest with the President of the University of Hawai'i. Class B amendment requirements also apply only to projects that are not anticipated on the Mauna Kea Master Plan. The following are examples of Class B amendments:

1.3.1.2 TMT Observatory Design

Pursuant to the *2000 Master Plan*'s design review process, the TMT Observatory Corporation developed the design in consultation with OMKM with reviews by the Mauna Kea Management Board. It will continue to work closely with OMKM as the Project progresses. Whenever possible, the architects and engineers will incorporate sustainable technologies and energy efficient technologies into facility design and operations, in accordance with CMP Management Action IM-11.[6]

The proposed observatory includes the following:

- The telescope described in Section 1.3.1.1. The center of the surface of the primary mirror will be located approximately 66 feet above the ground surface.
- The instruments mounted around the primary mirror used to image and analyze both the visible part of the spectrum and the infrared spectrum (number 4 in Figure 1.4).
- The TMT adaptive optics (AO) system.[7] The TMT will be the first large optical/infrared observatory to integrate AO into its original design. AO systems correct for the image distortion that is caused by the atmosphere. The AO system will project up to eight laser beams into the atmosphere to create an asterism, or group, of "guide stars" that are used to determine the atmospheric distortion of the visible and infrared light from distant objects and correct for it. The TMT AO system will generate each of these eight beams using a 25-watt laser; the laser light will appear yellow (0.589 microns – the sodium D2 line).
- The dome housing the telescope will be a Calotte[8] type enclosure with the following characteristics (as depicted in Figure 1.5 and Figure 1.6).
  - The total dome height will be 184 feet above the finished grade, with an exterior radius of 108 feet.
  - The dome shutter will be 102.5 feet in diameter and it will retract inside the dome when opened.
  - The dome will rotate on two planes, one horizontal at the base structure 26.5 feet above the finished grade and the other at roughly 25 degrees as the cap structure, enabling the telescope to view from straight up into the sky down to 25 degrees above the horizon.
  - The Calotte dome base, cap, and shutter structures will appear rounded and smooth and have a reflective aluminum-like exterior coating.

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[6] CMP Management Action IM-11 encourages existing facilities and new development to incorporate sustainable technologies, energy efficient technologies, and LEED standards, whenever possible, into facility design and operations.

[7] "Adaptive optics" (AO) is a technology used to improve the performance of optical systems by reducing the effects of rapidly changing optical distortion. AO works by measuring the distortions in the wavefront that occur when it passes through the earth's atmosphere and compensating for them. When used with an AO system, the TMT will provide sharper images than the most capable existing optical/infrared observatories by a factor of three, and greater sensitivity by a factor of ten or more.

[8] A Calotte type dome features a circular shutter and two planes of rotation instead of the rectangular shutter and single plane of rotation characteristic of standard domes. Benefits of a Calotte type dome include (a) overall smaller dome size, (b) improved air flow/lower air turbulence around the dome, (c) simplified mechanical components, and (d) better shedding of snow.

visible in the primary view direction only from the area around Waimea. Of the island's population, 5.5 percent, or 8,100 people reside within the area around Waimea and may be able to see the TMT Observatory.

Table 7.4: Visibility of the TMT Observatory within the Primary View Direction

Location	Hawai'i's Population %	Hawai'i's Population People	Primary View Direction?
Waimea	5.5%	8,100	Yes
Honoka'a	2.8%	4,200	No
Hāwī	2.6%	3,900	No
Waikoloa and Kawaihae	4.3%	6,400	No
Hualālai	0.2%	303	No
Source: Table 3-9, *Final EIS for the Thirty Meter Telescope.*			

Table 7.5 summarizes the results of the silhouette analysis for 13 representative viewpoints where the TMT Observatory may be visible. The purpose of the analysis was to determine whether the view of the facility will be a full or partial silhouette against the sky, or whether it will be seen against the backdrop of Mauna Kea.

Table 7.5: TMT Observatory - Summary of Potential Visual Impacts

View-point	Location	Visual Impact: Is the TMT visible?	Visible in primary view?	Visible in silhouette? No	Partial	Full
1	Hualālai Resort	Yes	No	--	164 feet (50 m)	--
2	Pu'u Waawaa	Yes	N/A[1]	--	58 feet (17 m)	--
3	Big Island Country Club	Yes	N/A[1]	--	82 feet (25 m)	--
4	Waikoloa/Mauna Lani	Yes	No	--	164 feet (50 m)	--
5	Hāpuna Beach	No	No		N/A	
6	Puukohola Heiau	Yes	No	--	164 feet (50 m)	--
7	DHHL Kawaihae at Route 250	Yes	Yes	X	--	--
8	Route 250 Pu'u Overlook	Yes	Yes	X	--	--
9	DHHL Lalamilo	Yes	Yes	--	49 feet (15 m)	--
10	Waimea Park	Yes	Yes	--	89 feet (27 m)	--
11	DHHL Pu'u Kapu	Yes	Yes	--	98 feet (30 m)	--
12	DHHL Waikoloa-Waiąleale	Yes	Yes	--	164 feet (50 m)	--
13	Waipio Valley Lookout	No	N/A		N/A	
14	Honoka'a	Yes	No	--	82 feet (25 m)	--
15	Laupāhoehoe Point	No	N/A		N/A	
16	Mauna Kea Summit	No	N/A		N/A	
17	Lake Waiau	No	N/A		N/A	
18	North ridge of Kūkahau'ula	Yes	N/A	X	--	--
[1] The primary view criterion is not applicable because at these viewpoints the panoramic view is important.						
Source: Table 3-10, *Final EIS for the Thirty Meter Telescope.*						

- An atmospheric turbulence monitor will be mounted on a roughly 30 foot tall tower located on the north side of the graded area, just beyond the guard rail. The monitor is a roughly 8-foot square weather station.

The entire footprint of the TMT Observatory dome, support building, and parking area will be roughly five acres, including the area of disturbance during construction. A half-acre portion of this area has previously been disturbed by the existing 4-wheel drive road and site testing equipment; the original disturbance occurred during site testing in the 1960s, site testing was also performed in this area for the TMT project in the 2000s.

1.3.2 TMT Access Way

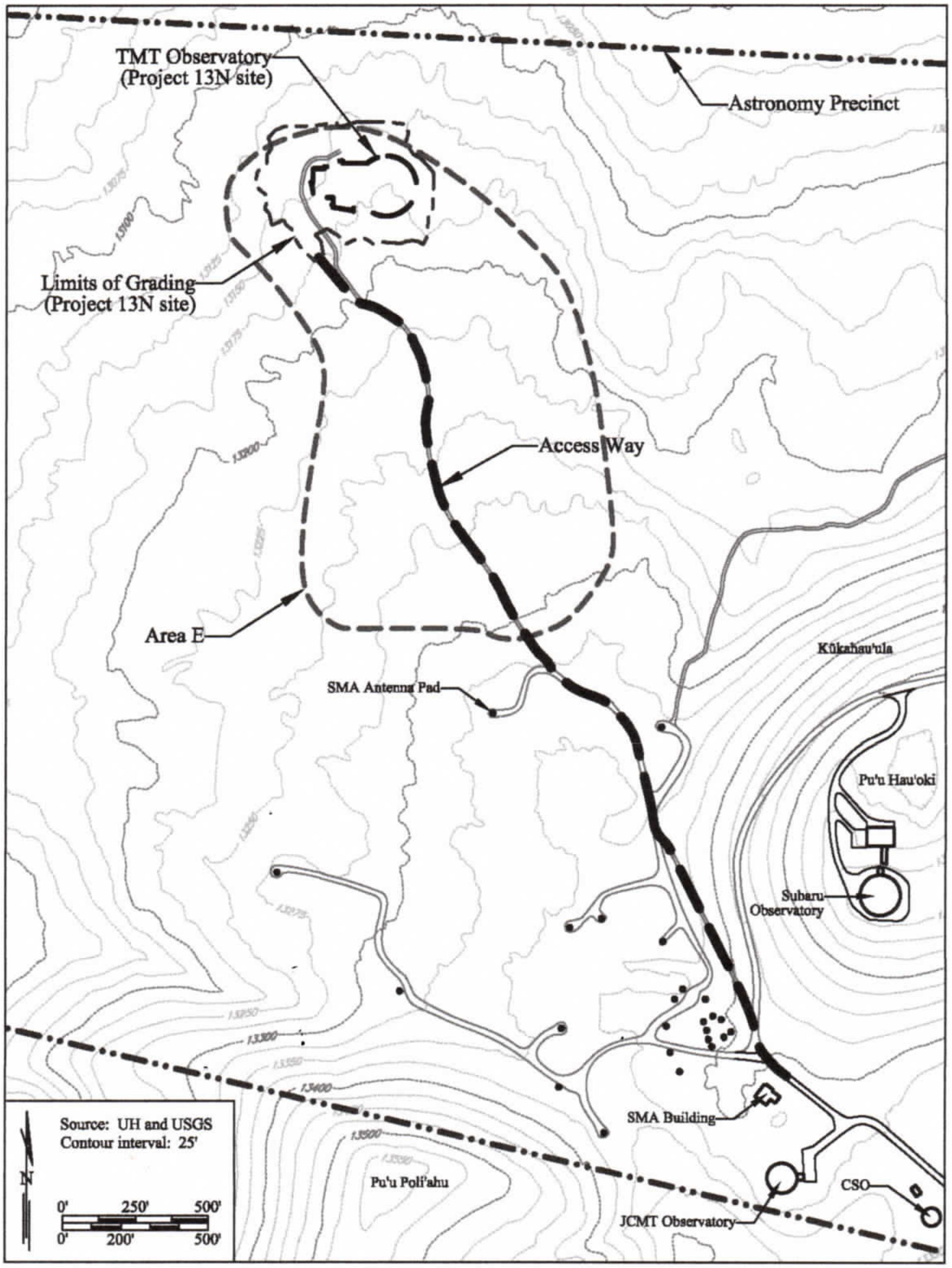
Currently, utility services exist along the Mauna Kea Access Road to a point near the intersection of the Mauna Kea Loop Road and the Submillimeter Array (SMA) roadway.[9] The proposed TMT Access Way will start at that point and extend to the TMT Observatory; for the most part it will follow either existing 4-wheel drive roads or the wider roads that serve the SMA facility. The Access Way that TMT has proposed is limited to a single lane (from a previous design of two lanes) over the southernmost portion of the Access Way (i.e., the portion that crosses Pu‘u Hau‘oki); the remainder is two lanes (see Exhibit B for construction details). The vast majority of the Access Way route follows and goes over an existing single-lane, 4-wheel drive road that was previously developed for access and testing of the 13N site in the 1960s. A portion of the route was graded during construction of the SMA facility as well. Only a 200-foot long section of the 3,400 foot long Access Way does not directly follow an existing road.

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

As with the TMT Observatory design, TMT consulted with the University in developing the Access Way design. Because the proposed Access Way route passes through areas of the SMA project, both parties are working with SMA staff to ensure that the two uses are compatible. The coordination is ongoing, but it has proceeded to the point where only the routing shown in Figure 1.7 is being proposed.

[9] The Submillimeter Array (SMA) is a radio interferometer that operates at frequencies from 180 GHz to 700 GHz using multiple 20-foot diameter dishes that can be arranged in a variety of configurations with baselines as long as 509m. Submillimeter Array is a joint project between the Smithsonian Astrophysical Observatory and the Academia Sinica Institute of Astronomy and Astrophysics and is funded by the Smithsonian Institution and the Academia Sinica.

Figure 1.7. TMT Observatory Access Way



Source: UH and USGS

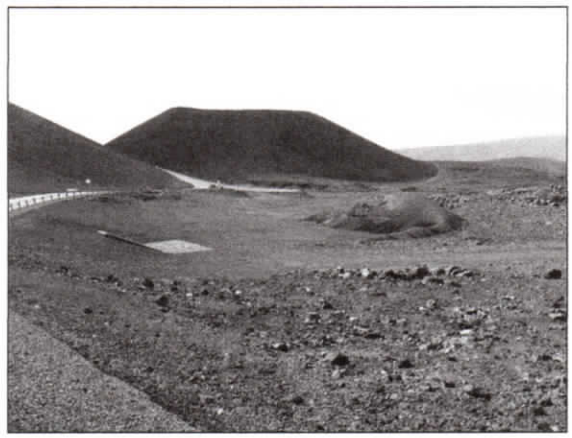
The acreage that will be disturbed by construction of the proposed TMT Access Way is shown in Table 1.2.[10] A portion of the area was previously disturbed by the existing 4-wheel drive and SMA roads as indicated in the table. The University believes that the proposed Access Way is also the best from the viewpoint of minimizing visual and physical impacts.

Table 1.2: Summary of Access Way Disturbances

	Access Way Area in Acres
Total Disturbance	3.6
Portion of Total that has Previously been Disturbed	1.9
Source: TMT provided design drawings by M3.	

1.3.3 Batch Plant Staging Area

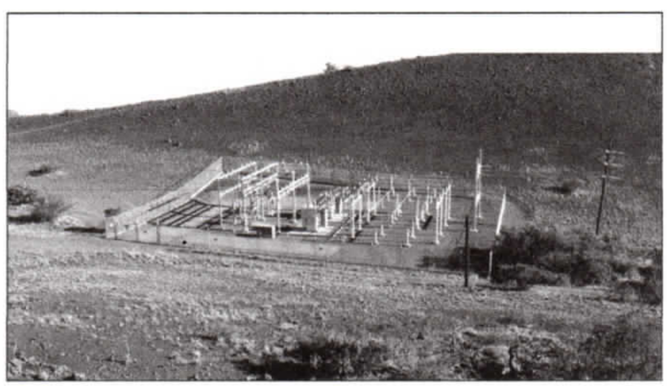
The Batch Plant Staging Area is a roughly 4-acre area northwest of where the Mauna Kea Access Road forks near the summit (see Figure 1.3. This area will be used primarily for storing bulk materials and a concrete Batch Plant, as it has been in the past during construction of other observatories and roads.



Batch Plant Staging Area

1.3.4 Electrical Upgrades

HELCO will upgrade the two transformers within its Hale Pōhaku Substation, which is located approximately 2,000 feet southwest of the main headquarters building at Hale Pōhaku and about 1,000 feet from Mauna Kea Access Road. The new transformers will replace the existing transformers on a one-for-one basis, and the existing fenced compound will not be expanded.



HELCO compound near Hale Pōhaku.
Photo by CSH

[10] The proposed Access Way design is a refinement of one of the routes covered in the *Final EIS.*

INDICES OF AWARDS

MADE BY

THE BOARD OF COMMISSIONERS TO QUIET LAND TITLES

IN THE

HAWAIIAN ISLANDS

COMPILED AND PUBLISHED
BY THE
OFFICE OF THE COMMISSIONER OF PUBLIC LANDS
OF THE
TERRITORY OF HAWAII

TERRITORIAL OFFICE BUILDING
HONOLULU, T. H.

STAR-BULLETIN PRESS
1929

claims, which had their attention, had to be heard, investigated and deliberated on separately, it is surprising that more mistakes were not made. In addition to this there was that other factor contributory to mistakes, haste, for they were aware of the fact that their work required haste, and they labored accordingly, in order to insure completion. There were many exigencies that might have stopped and undone all that had been accomplished, as, for instance, the death of a progressive ruler in entire sympathy with the work of the commission and the succession of one less liberal and helpful. Thus it is seen that any injustice caused by mistakes of the commission was unavoidable under the circumstances, and their mistakes or sins, if they may be called such, were sins of omission rather than of commission, and are being gradually corrected as they come to light.

For the benefit of those interested in land matters in early Hawaii, reference is made to the following ably written papers on this subject, prepared by well-informed men.

"Brief History of Land Titles in the Hawaiian Kingdom," by W. D. Alexander, published as an appendix to the Surveyor General's Report in 1882, and reprinted in Thrum's Annual for 1891.

"Land Matters in Hawaii," by Curtis J. Lyons, published in the Islander in 1875, and reprinted in the Report of the Surveyor of the Territory of Hawaii for 1902.

"A History of the Hawaiian Government Survey, with Notes on Land Matters in Hawaii," by Curtis J. Lyons, published in 1903.

"Land Titles and Surveys in Hawaii," by Arthur C. Alexander, read before the Honolulu Social Science Association, March 1, 1920, and reprinted by the Hawaiian Planters' Record for August, 1920.

Frequent reference to the above document by Arthur C. Alexander has been made in preparing this "Foreword."

A few brief statements follow explaining some of the words appearing in the volumes of the Land Commission pertaining to division of lands.

MOKU The Islands were each divided into districts called "Mokus." These seem to have been geographical subdivisions only, for there were no administrators over these Mokus, as districts.

KALANA The district next smaller than a Moku was called "Kalana."

AHUPUAA Each Moku was divided, for landholding purposes, into smaller divisions called "Ahupuaas," varying in size and shape. The typical form of an Ahupuaa was a strip running from the sea to the mountains and containing a sea fishery and sea beach, a stretch of kula or open cultivatable land and higher up its forest. All Ahupuaas had definite boundaries, usually of natural features, such as gulches, ridges and streams, and each had its specific name. A chief held it, not owned it, for he owed allegiance to a higher chief or the sovereign.

ILI Many of the Ahupuaas were subdivided into smaller lands called "Ilis." Each had its own individual title and was carefully marked as to boundary.

ILI KUPONO There were two kinds of Ilis, one, the "Ili Kupono," known also in abbreviated form as "Ili Ku," being a portion of land, the ownership of which was fixed, for the chief holding an Ili Kupono continued to hold, whatever the change in the Ahupuaa chief. In other words, the transfer of an Ahupuaa to a new chief did not carry with it the transfer of any Ili Kupono contained within its limits.

ILI OF THE AHUPUAA The other Ili was the "Ili of the Ahupuaa." Ilis of the Ahupuaa were subdivisions for the convenience of the chief holding the Ahupuaa.

LELE Another feature of the Ili is that an Ili often consisted of several distinct sections of land, one, for instance, would be on the sea shore, another in dry, open land or kula, another in the regularly terraced and watered taro patch section, and still another in the forest section. These detached pieces were called "Leles."

MOO The arable portions of Ilis were divided into small tracts or fields called "Moos" or "Mooainas." A Moo was the division of land next less than an Ili and was for the purpose of cultivation only. These Moos were named, which were in reality field names.

PAUKU The division of land next less than a Moo was called "Pauku."

KIHAPAI Still smaller than a Pauku was a division called "Kihapai." This was a cultivated patch of ground, a field, a potato patch or garden belonging to and cultivated by the tenants or common people for themselves. These also had their names.

KOELE There were also patches and gardens which were planted by the tenants, or common people, for their landlords. These were called "Koeles." These belonged to the chief but cultivated for him by his people, and these also had their names.

POALIMA These Koeles in later years were worked for the chiefs by the tenants on Fridays only, and they then came to be called "Poalimas," poalima being the Hawaiian word for Friday.

KULEANAS The small areas of an Ahupuaa which the tenants, or common people, had improved or cultivated and used for their own purposes, and to which they substantiated their claims and perfected their rights, securing from the Land Commission an Award of Title in Fee Simple, were known as "Kuleanas." The word itself means "rights"—a right of property which pertains to an individual—and was applied uniformly during the existence of the Land Commission to the Fee Simple holdings awarded by it to the common people.

KONOHIKI

The head man of an Ahupuaa or a person who had charge of a land with others under him was called a "Konohiki." He was an agent who managed a chief's lands. The word Konohiki in time came to be applied to the land under such an agent's care, thus the land held by a chief, an Ahupuaa or Ili, was known as "Konohiki Land."

KONA, HAWAII

Awardee	L. C. A.	Book	Page	R.P.	Book	Page	Location	Area	AP.
Kamaka	7493	7	352	6676	24	725	Kaohe 4	3.86 Acs	2
Kamaka 1	7023	3	549	5306	21	267	Kahauko	3.25 "	2
Kamaka 2	7022	3	555	5538	21	731	Kahauko	1.80 "	1
Kamakahia	9692	5	579	4120	18	193	Keauhou	4.20 "	2
Kamakahiona	8157-C	5	629	5305	21	265	Keekee 2	0.41 "	1
Kamakahue	7368	8	630	8019	34	253	Keopu 3	2.28 "	2
Kamakai	222-B	3	496	6010	23	185	Pahoehoe 1	2.66 "	1
Kamakane	9734	3	506	....	....	....	Pahoehoe 1	2.86 "	2
Kamakauahi	6984	3	530	5234	21	123	Kealia 2	4.33 "	1
Kamalo	5673	7	239	4338	17	673	Kahaluu	3.25 "	1
Kamamalu, V.	7713	10	434	4475	18	405	Keopu (Alip. Ap. 5)	....	1
Kamamalu, V	7713	10	434	6856	25	63	Kahaluu (Alip. Ap. 6)	5443.00 "	1
Kamamalu, V.	7713	10	617	4475	18	405	2 Holualoa (Alip. Ap. 43)	....	1
Kamamalu, V.	7713	10	435	4475	18	405	Honuaino (Alip. Ap. 8)	....	1
Kamamalu, V.	7713	10	617	6865	25	71	Haukalua 2 (Alip. Ap. 44)	184.00 "	1
Kamamalu, V.	7713	10	435	6857	25	65	Honokua (Alip. Ap. 9)	6578.00 "	1
Kamamalu, V.	7713	10	435	4475	18	....	Keauhou (Alip. Ap. 7)	....	1
Kamanawa	4140	9	402	2152	9	269	Puaa 1	2.10 "	2
Kamano	9696	5	571	....	....	....	Keauhou 1	2.00 "	1
Kamanuwai	8566	3	519	6598	24	569	Honomalino	2.72 "	2
Kamaole	7909	7	334	5377	21	409	Kaloko	7.00 "	1
Kamauhili	5683-B	4	565	6811	26	123	Kahaluu	0.20 "	1
Kamaui	5691	7	328	....	....	....	Kahaluu	0.10 "	1
Kamauli	7293-B	8	687	....	....	....	Kalama 3	0.30 "	1
Kamauli	7293-B	9	456	....	....	....	Kalama 2	1.25 "	1
Kamauliole	7807	5	667	4277	17	551	Holualoa 4	1.85 "	2
Kamauoha	1814	4	548	....	....	....	Lanihau	0.83 "	1
Kameeui	5688-B	7	241	....	....	....	Kahaluu	4.40 "	1
Kamehameha L.	7715	10	622	7843	29	179	Kaupulehu (Alip. Ap. 10)	23,545.00 "	1
Kamehameha L.	7715	10	622	7844	29	183	Keauhou 2 (Alip. Ap. 12)	109,600.00 "	1

KONA, HAWAII

CATERPILLAR D9L BULLDOZER

Specifications

Weights:

Opeerating Weigh ….. 106,618.0 lbs.

Dimensions:

Height (FOPS Cab) ….. 150.4 m

Height (ROPSCanopy) ….. 157.5 m

Height (Top of Stack ….. 157.4 m

Length Basic Tractor with Drawbar ….. 204.0 m

Overall Length Basic Tractor ….. 324.0 m
Width over Trunnions ….. 129.9 m
Ground Clearance ….. 23.4 m

CATERPILLAR D9L continued ..

Hydraulic Controls

Pump Type	Piston-type pump geared from flywheel
Pump Output (Steering)	102.0 gal/min
Pump Output (Implement)	60.0 gal/min
Tilt Cylinder Rod End Flow	37.0 gal/min
Tilt Cylinder Head End Flow	50.0 gal/min
Tilt Cylinder Relief Valve Setting	2800.0 psi
Ripper (Lift) Relief Valve Setting	3800.0 psi
Ripper (Pitch) Relief Valve Setting	3800.0 psi
Tank Capacity	23.5 gal
Steering System Pressure	5875.0 psi

Undercarriage

Shoe Type	Extreme Service
Width of Shoe	24.0 in
Shoes/Side	43
Grouser Height	3.3 in
Pitch	9.4 in
Ground Clearance	23.5 in
Track Gauge	88.6 in
Length of Track on Ground	136.6 in
Ground Contact Area	6569.0 in2
Track Rollers/Side	8
Number of Carrier Rollers	1 per side (optional)

CATERPILLAR D9L continued ..

Service Refill Capacities

Fuel Tank	217.0 gal
Cooling System	25.9 gal
Engine Crankcase*	9.7 gal
Power Train	43.3 gal
Final Drives (each)	3.9 gal
Roller Frames (each)	11.9 gal
Pivot Shaft Compartment	7.9 gal
DEF Tank	9.5 gal
Hydraulic Tank Oil (only)	23.5 gal
Note	*With oil filters.

352F L Large Hydraulic Excavator

Machine Weight

Operating Weight 112,200lb
With R3.35 m (11'0") stick, 3.1 m3 (4.1 yd3) bucket, 600 mm (24") DG shoes. *With R3.35 m (11'0") stick, 3.1 m3 (4.1 yd3) bucket, 600 mm (24") DG shoes.

Swing Mechanism
Swing Speed 8.7rpm
Swing Torque 109500 lb f-ft (148.5 kN

Hydraulic System
Main System – Maximum Flow (total) … 203.0 gal/min 770.0 L/min
Swing System – Maximum Flow … 102.0 gal/min 385.0 L/min
Maximum Pressure – Equipment: Normal … 5076.0 psi 35000.0 kPa
Maximum Pressure – Equipment: Heavy Lift ...5512.0 psi 38000.0 kPa
Maximum Pressure – Travel … 5076.0 psi 35000.0 kPa
Maximum Pressure – Swing … 3989.0 psi 27500.0 kPa
Pilot System – Maximum Flow … 7.1 gal/min 27.0 L/min
Pilot System – Maximum Pressure … 598.0 psi 4120.0 kPa

CAT 988K

Hydraulic System – Lift/Tilt

Cylinders, Double Acting: Lift, Bore and Stroke
Lift/Tilt System
Maximum Flow ..... **13.7 gal/min 52.0 L/min**
Maximum Flow at 1,400-1,860 rpm ..... 153.0 gal/min 580.0 L/min
Relief Valve Setting ..... 551.0 psi 3800.0 kPa
Lift/Tilt System – Circuit ..... EH- Positive Flow Control, Flow Sharing EH- Positive Flow Control, Flow Sharing
Relief Valve Setting – Lift/Tilt ..... 4757.0 psi 32800.0 kPa

CAT 988K continued

352F L Large Hydraulic Excavator … continued

Service Refill Capacities

Fuel Tank Capacity … 190.0 gal
Cooling System … 13.2 gal
Swing Drive (each) … 2.6 gal
Final Drive (each) … 4.0 gal
Hydraulic System (including tank) … 150.6 gal
Hydraulic Tank … 107.5 gal
Engine Oil (with filter) … 10.0 gal
DEF Tank Capacity … 11.0 gal

Dimensions:

Heavy-Duty R6.9 m (22'8") Boom; R3.35TB HD 11'0") Stick

Shipping Height … 12.0 ft 3660.0 mm
Shipping Length … 38.92 ft 11870.0 mm
Tail Swing Radius … 12.33 ft 3760.0 mm
Length to Center of Rollers … 14.25 ft 4340.0 mm
Track Length … 17.67 ft 5380.0 mm
Ground Clearance with Shoe Lug Height … 2.33 ft 710.0 mm
Ground Clearance without Shoe Lug Height … 2.42 ft 740.0 mm
Transport Width 600 mm (24") Shoes – Retracted … 11.42 ft 3490.0 mm
Cab Height … 11.08 ft 3370.0 mm
Cab Height with Top Guard … 11.58 ft 3540.0 mm

CATERPILLAR 988 Materials LOADER

Service Refill Capacities

Fuel Tank ..... 188.0 gal 712.0 L
Cooling System ..... 31.7 gal
Crankcase ..... 15.9 gal 60.0 L
Transmission ..... 31.7 gal 120.0 L
Hydraulic System (tank only) ..... 63.4 gal 240.0 L
Differentials and Final Drives – Front ..... 49.1 gal 186.0 L
Differentials and Final Drives – Rear ..... 49.1 gal 186.0 L
Diesel Exhaust Fluid Tank (for Tier 4 Final/Stage IV only) ...8.7 gal 33.0 L
Hydraulic System Factory Fill ....125.5 gal 475.0 L
Coolant (validated by test cell fill quantities) ..... 33.0 gal 125.0 L
Transmission (validated by test cell fill quantities) ..... 9.0 gal 110.0 L

Buckets

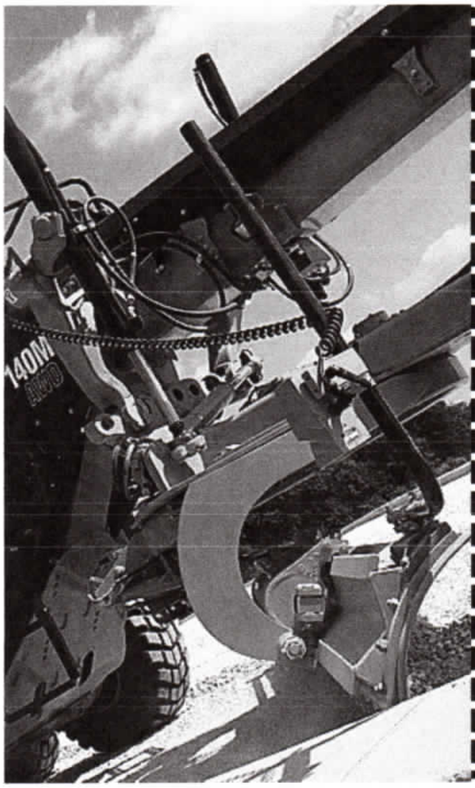
Bucket Capacities 4.7-13 m3 (6.2-17 yd3) 4.7-13 m3 (6.2-17 yd3)

Hydraulic System – Steering

Maximum Flow ..... 71.3 gal/min 270.0 L/min
Dump ..... 2.2 Seconds 2.2 Seconds
Lower Float Down ..... 3.5 Seconds 3.5 Seconds
Rackback ..... 4.5 Seconds 4.5 Seconds
Raise ..... 8.0 Seconds 8.0 Seconds
Total Hydraulic Cycle Time (empty bucket) ..... 18.2 Seconds 18.2 Seconds

CAT 14DM Motorgrader

CAT 14DM MOTORGRADER continued ...



Motorgraders are used on roadways to set the grades,to allow for natural runoff of rainwater and even to cut swales at edges making a path to direct runoff to specific outlets.

Motorgraders have a turn table for the blade that is controlled hydraulically. The blade can be turned within that circle to move material, and angled, raised and lowered to attain specific grades. All of this is achieved through the hydraulic pump motor and its extensive system of pipes and hoses.

Motorgraders also have a set of rippers at the rear of the machine. These (up to 5) rippers are inserted in a bar that is also controlled hydraulically and can be positioned up or down as well as curve out or tuck under.

**** above text ptovided by Susan Rosier**

Responsive Hydraulics

A proven load-sensing system and advanced electro-hydraulics give you superior implement control and responsive hydraulic performance that helps make your operator's job easier. Continuously matching hydraulic flow/pressure to power demands creates less heat and reduces power consumption.

- Consistent, Predictable Movement - Proportional Priority Pressure-Compensating (PPP-C) valves have different flow rates for the head and rod ends of the cylinder, so you can count on consistent, predictable implement response.
- Balanced Flow - Hydraulic flow is proportioned to give you confidence that all implements will operate simultaneously without slowing the engine or speed of some implements.

Blade Float

Allows the blade to move freely under its own weight. By floating both cylinders, the blade can follow the contours of the ground. Floating only one cylinder permits the toe of the blade to follow a hard surface while the operator controls the slope with the other lift cylinder.

Independent Oil Supply

Large, separate hydraulic oil supplies prevent cross-contamination and provide proper oil cooling, which reduces heat build-up and extends component life. Cat XT™ hose allows high pressures for maximum power and reduced downtime.

Specifications:

Hydraulic System

Circuit Type ….. Parallel
Pump Type ….. Variable Piston
Pump Output ….. **55.7 gal/min** 210.0 L/min
Maximum System Pressure ….. **3500.0 psi**
Reservoir Tank Capacity …... 16.9 gal 64.0 L
Standby Pressure ….. 885.0 psi

Service Refill

Fuel Capacity ….. 104.0 gal
Cooling System ….. **15.0 gal**
Hydraulic System – Total ….. **26.4 gal**
Hydraulic System – Tank ….. 16.9 gal
Diesel Exhaust Fluid ….. 5.8 gal
Trans./Diff./Final Drives ….. 18.5 gal
Engine Oil ….. 7.9 gal
Tandem Housing (each) ….. 20.0 gal

Operating Weight - Typically Equipped ….. 45917.0 lb

Dimensions

Height - Top of Cab ….. 130.0 in
Length - Counterweight to Ripper ….. 399.0 in
Width - Outside Front Tires ….. 98.9 in
Length - Front Axle to Mid Tandem ….. 241.0 in
Length - Front Tire to Rear of Machine ….. 351.0 in
Length - Between Tandem Axles ….. 60.0 in
Width - Outside Rear Tires ….. 98.9 in
Width - Tire Center Lines ….. 84.3 in
Height to Exhaust Stack ….. 128.0 in
Height to Top of Cylinders ….. 120.0 in
Ground Clearance at Rear Axle ….. 13.3 in

LINDA LINGLE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

OFFICE OF CONSERVATION AND COASTAL LANDS
POST OFFICE BOX 621
HONOLULU, HAWAII 96809

REF:OCCL:TM

ENF: HA 09-53

OCT 13 2009

Richard Chamberlain, Manager
Caltech Submillimeter Observatory (CSO)
111 Nowelo Street
Hilo, HI 96720

Dear Mr. Chamberlain:

SUBJECT: Hydraulic Fluid Release at the Caltech Submillimeter Observatory (CSO) Located at Mauna Kea, island of Hawaii, TMK: (3)

The Office of Conservation and Coastal Lands (OCCL) has reviewed your information regarding the response to a hydraulic fluid release that occurred on or about May 17, 2009. What is believed to be 22.7 gallons of Chevron Rykon Oil AE hydraulic fluid, spilled onto the concrete floor inside the observatory. The majority of the fluid was recovered as it was contained on the concrete floor of the facility. However, approximately (≈) 7gallons ± 5 gallons may have been released to backfill beneath the observatory through a 6" drain hole in the concrete floor used to drain seasonal snowmelt.

This fluid release was reported to the Office of Mauna Kea Management (OMKM) and the Coast Guard's National Response Center (NRC). Myounghee Noh & Associates, LLC (MNA), an environmental consulting firm, was contracted by CSO to assist with the required notifications, assessment, cleanup and mitigation of the released hydraulic fluid. Consultant MNA, carried out the required notifications to the State Department of Health (DoH) Office of Hazard Evaluation and Emergency Response (HEER), the Hawaii County Fire Department and the County's Local Emergency Planning Committee. HEER had received the NRC Incident Report and the release was assigned case # 20090527-1500. In addition, the OCCL is in receipt of MNA's Report and Response to this incident.

The concrete floor slab in the area of the drain was ≈ 12" thick. MNA hand excavated into the drain hole ≈ 24" and removed visibly contaminated material and collected soil samples. The sample was handled and tracked in accordance with the HEER Office and transported to Curtis and Tompkins analytical laboratory in Berkeley, Ca. for analysis of Total Petroleum Hydrocarbons (TPH) as diesel (TPH-D), motor oil (TPH-O), and hydraulic fluid (TPH-HF) by the U.S. Environmental Protection Agency Method 8015M.

Based upon the initial findings, additional backfill was removed from under the concrete slab floor. The total excavation extents were between 55"-57" inches in depth from the top of the floor slab and ≈ 4' in width and length. The potentially contaminated backfill was removed and a licensed waste transporter, Pacific Commercial Services transported 3,500 lbs. of the backfill and 1,000 lbs. of spent absorbent material from the CSO to the West Hawaii landfill.

Incidental to the mitigation efforts, MNA found a shallow 2-inch contaminated backfill just below the slab of unknown lateral extent. It was concluded that this was a previous incident possibly during the construction phase before the slab was poured more than 20 years ago. It has been recommended that the cleanup of this material be deferred until the decommissioning of the CSO facility in 2016.

The DoH has concluded that the completion of the removal actions for the hydraulic spill has been completed. A "No Further Action" is pending upon completion of additional investigation and/or cleanup actions that will be undertaken when the CSO is decommissioned.

The faulty hydraulic line was replaced with a higher psi-rated line. The excavated drain hole in the slab was temporarily sealed with a metal plate and inspection and preventative maintenance procedures were improved to prevent fluid releases. With concurrence from DoH and DLNR, the CSO proposes to backfill the excavation with clean fill material sourced from an OMKM source and repair the opening in the observatory floor with concrete. No drain hole will be present.

Based upon the appropriate actions taken by the CSO, the OCCL believes that this matter has been resolved as CSO has taken measures to comply with all applicable statutes, ordinances, rules and regulations of the Federal, State and County governments and applicable Public Health regulations as specified in Conservation District Use Permit (CDUP) HA-1492. The OCCL concurs that the subject area may be backfilled with clean fill material sourced by the OMKM to repair the floor opening. As a decommissioning plan is part of the Mauna Kea Comprehensive Management Plan, please share your plans for the 2016 decommissioning of the CSO facility with the OMKM.

Should you have any questions regarding this matter, contact Tiger Mills of our Office at (808) 587-0382.

Sincerely,

Samuel J. Lemmo, Administrator
Office of Conservation and Coastal Lands

C: Chairperson
HDLO
OMKM

Hellman & ASSOCIATES
BUILDING PARTNERSHIPS FOR A SAFER WORKPLACE

SAFETY MEETING TOPIC: Hydraulic Hoses and Leakage

You may find it hard to believe, but hydraulic hose assemblies are not designed to leak--though they do. And when they do, something is wrong. Leaks from high-pressure hydraulic lines are not just messy, they are dangerous. Leaks create slip and fall hazards, fire danger, and they contaminate the environment. Leaks can cause skin burns and, under high pressure, can penetrate the skin. The most common causes of leaking hoses are abrasions and improper assembly. If you work with hydraulic hoses, you should become skilled at anticipating problems, preventing them and fixing them.

Preventing Problems: Prevent abrasion by using hoses of the correct length and diameter. Run the hose in the manner specified by the machine manufacturer, making sure it is supported and restrained by all provided hangers and/or brackets. If chaffing guards were originally installed but missing, they must be replaced. Do not ignore a damaged outer jacket. This allows moisture to attack the exposed hose reinforcement, leading to rust. Corrosion could lead to hose failure.

Common Operator Error ---↓

The Wrong Way to Find and Fix Leaks: What do you do when you find a leaking fitting? Find a wrench and give the fitting another turn? That extra turn could cause a greater leak or cause the fitting to fail entirely. Do not use your hand to find the leak. Use a piece of cardboard or wood instead. Hydraulic fluid is hot and can burn the skin. A pinhole leak, under pressure, could actually inject fluid under your skin, causing poisoning, infection, and threaten life and limb. It can and has happened.

Test for Tightness: But before doing this, shut the machine off and bleed hydraulic pressure from the line. If the fitting threads were to strip or a connection were to fail under pressure, injury or fire could result from the sudden release of hot oil. The usual cause of a leak at a fitting is improper assembly or damage. Make sure that:

(1) Both ends are clean inside and out, and that no physical damage has occurred;

(2) New seals are used and they have been cleaned and lubricated before installation;

(3) Fittings are not over-tightened--which can distort seals and ferrules, causing metal fatigue or cracking flared ends;

(4) Fittings are compatible. There are many different thread ends, and some may almost go together properly, but not quite.

Proper Assembly Of Hose Ends Is Important. Hoses that come apart under pressure can whip back with great force and release a lot of hot oil. If the failure occurs at a fitting, the usual reason is improper crimping, an incorrectly cut hose, or a stem that was not inserted into the hose all the way. If you assemble your own hoses, check your crimping dies for wear. On some types of crimping machines, if the dies become worn, the crimp is looser than it should be. Screw type hose clamps are not to be used on pressurized hydraulic hoses.

People who work with any type of fluid piping system know it takes clean, careful workmanship to prevent dangerous leaks. If you see a leak, report it.

Signature of Employees in Attendance: Date: ______________

____________	____________	____________
____________	____________	____________
____________	____________	____________

Provided by: Hellman & Associates, Inc., www.ehscompliance.com, 303-384-9828

S-18f

BLASTING TECHNOLOGY, INC.

P.O. Box 1101, Kihei, Hawaii 96753
(808) 874-5554 Fax (808) 874-5696 Lic. #C14525A

NOTICE OF BLASTING

OVERVIEW

Starting approximately in early April 2013 and continuing until completion, we will conduct drilling and blasting in order to facilitate rock excavation on the Lalamilo Housing Phase 2A project site which is near your property. Prior to blasting, the blast area will be blocked by guards and the site will be secured. Warning signals will be given, the blast will be fired. After an inspection of the blast site, the all clear signal will be given. Your safety and the safety of all the surrounding property as well as the safety of everyone on the project site is our utmost concern.

WHAT TO EXPECT DURING A BLAST

When a blast is fired there is a ground vibration and air displacement known as "air overpressure". You will able to feel vibration and air overpressure during the blast. On this project the blasts will last for a second or two. Blasting will take place between 2:00 and 5:30 PM.

SEISMIC MONITORING, CONSULTANT

We have worked with an independent consultant to assist in determining the impact of blasting in this area. To remove speculation about the amount of vibration generated by the blasts we will use seismic monitoring devices to measure and record the vibration level of each blast.

SEISMIC MONITORING ON YOUR PROPERTY

As we progress from one area of the project site to another, seismic monitoring locations will change to monitor the structures nearest to the blast. We may request permission to come onto your property to place a small monitoring device approximately 6" x 3" into the ground. The device will be removed daily after blasting is completed. If you prefer that we do not come onto your property please contact us at the phone number listed below.

QUESTIONS, CONCERNS

If you have any questions or concerns about the blasting please contact us at the Blasting Technology, Inc. office: 808-874-5554.

BLAST WARNING SIGNALS

Here are the blast warning signals we will use on this project. Please familiarize yourself with these signals so you will know what they mean when you hear them.

5 minute warning:	**several long duration bursts of a horn or siren**
1 minute warning:	**several short duration bursts of a horn or siren**
All clear signal:	**one very long duration burst of a horn or siren**

Sincerely,

Ted Fritzen
General Manager

Explosives Engineering & Consulting

- Keep air inlet filters clean. Replace particulate and lubricant removal elements when pressure drop exceeds 2-3 psid. Minimize system leaks. Verify all pressure relief valves are functioning properly. All air-consuming devices inspected on a regular basis for leakage. Leakage will typically occur in: worn, cracked, or frayed hoses, sticking air valves and cylinder packing.
- Tighten motor belts tight. Check belt tension and alignment for proper settings.
- Complete overall visual inspection to be sure all equipment is operating and that safety systems are in place.
- Make sure proper compressor ventilation is available for compressor and inlet. Verify operating temperature is per manufacturer's specification.
- Lubricate motor bearings to manufacturer's specification.

As you can see in this exerpt from the CDUA/TMT Project Management Plan
Appendix D - Maintenance Plan,
TMT is well aware that leakage does occur!

CALCULATIONS

Useful formulas

Pressure:

$P = F/A$

Where P is pressure, psi

F is force, lb

A is area, in.^{2}

Velocity through pipe, hose or tube:

$v = 0.320833 \times Q/A$

Where v is the linear velocity of fluid, ft/sec

Q is flow of fluid, gpm

A is the internal area of the conduit, in.^{2}

Recommended maximum linear velocities through hydraulic lines:

Suction lines: 2 to 4 ft/sec

Return lines: 10 to 15 ft/sec

Pressure lines to 3,000 psig: 15 to 20 ft/sec

Pressure lines greater than 3,000 psig: 25 to 30 ft/sec

Tube burst (Barlow formula):

$P_B = 2 \times S \times T/D$

Where P_B is burst pressure, psi

S is ultimate strength of the tube material, psi

T is nominal wall thickness of tube, in.

d is nominal OD of tube, in.

Boyle's law:

$P_1 \times V_1 = P_2 \times V_2$

Where P_1 is initial absolute pressure of gas

V_1 is initial volume of gas

P_2 is final absolute pressure of gas

V_2 is final volume of gas

Charles' law:

$T_1 \times V_2 = T_2 \times V_1$

Where T_1 is absolute temperature of gas at initial volume

V_2 is final volume of gas

T_2 is absolute temperature of gas at final volume

V_1 is initial volume of gas

General gas law:

$P_1 \times V_1/T_1 = P_2 \times V_2/T_2$

Where P1 is initial absolute pressure of gas

V_1 is initial volume of gas

T_1 is initial absolute temperature of gas

P_2 is final absolute pressure

V_2 is final volume of gas

T_2 is final absolute temperature of gas

Specific gravity:

$G_S = W_f/W_{H20}$

Where G_S is the fluid's specific gravity (nominally, 0.88 for oil)

W_f is weight of a volume of fluid

W_{H20} is weight of the same volume of water

Flow through an orifice:

$\Delta P = (Q \times G_S)^2/(29.81 \times d^2 \times \Delta P)$

Where ΔP is the pressure drop across orifice, psi

PRESSURE DROP THROUGH SHARP-EDGED ORIFICES

	Orifice diameter, in.																
Flow, gpm	3/64	1/16	5/64	3/32	7/64	1/8	9/64	5/32	11/64	3/16	13/64	7/32	15/64	1/4	5/16	3/8	7/16	1/2
3	5,440	1,730	710	333	184	108	68	44	30	21	16	12	9	7	3	1	—	—
5	—	4,800	1,970	925	512	300	188	123	84	59	43	32	24	19	8	4	2	1
10	—	—	—	3,700	2,050	1,200	750	490	336	238	172	128	97	75	31	15	8	5
15	—	—	—	—	4,600	2,700	1,690	1,100	757	534	388	288	219	169	69	33	18	11
20	—	—	—	—	—	4,800	3,000	1,968	1,345	950	690	513	390	300	123	59	32	19
30	—	—	—	—	—		6,750	4,430	3,025	2,135	1,550	1,155	875	675	275	135	72	42
40	—	—	—	—	—	—	—	—	5,380	3,800	2,760	2,050	1,555	1,205	495	235	128	75
50	—	—	—	—	—	—	—	—	—	—	4,310	3,205	2,430	1,880	770	370	200	118
60	—	—	—	—	—	—	—	—	—	—	—	4,615	3,500	2,705	1,110	535	288	170
70	—	—	—	—	—	—	—	—	—	—	—	—	4,765	3,685	1,510	725	390	230
80	—	—	—	—	—	—	—	—	—	—	—	—	—	4,810	1,970	950	510	300
100	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3,080	1,480	800	470

Hydraulic fluid flow through orifices

The table shows approximate pressure drops that may be expected at various flows rates through sharp-edged orifices for petroleum-based hydraulic fluid. Values from the table may be used for sizing flow-limiting orifices in hydraulic systems. Values in the table are approximate because factors such as specific gravity, orifice efficiency, and flow dynamics upstream and downstream of the orifice may cause variations from the values shown.

A knife-edge orifice is used because it is relatively insensitive to changes in fluid temperature and viscosity. This makes flow and pressure drop for a given fluid fairly constant over a reasonable range of oil temperatures. On the other hand, specific gravity of the fluid significantly affects the pressure drop through a given orifice. The pressure drop increases approximately as the square of the increase in specific gravity.

The table was derived using a fluid with a specific gravity of 0.90, a close approximation for hydraulic oils. Apply a multiplying factor to values in the table for a fluid with a higher specific gravity. For example, to find the pressure drop of water (which has a specific gravity of 1.00):

$1.00^2/0.90^2 = 1.00/0.81 = 1.23$

This means all values in the table should be multiplied by 1.23 if the fluid is water.

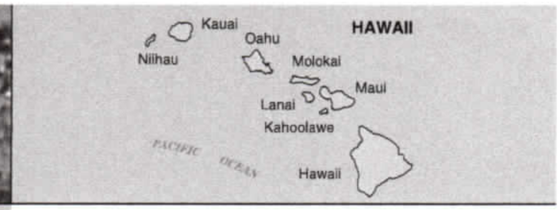
The table was developed using a constant of 23.5 for average orifices. For values that are not shown in the chart, use this equation for petroleum-based hydraulic oil:

$\Delta P = Q/(23.5 \times A)^2$

Where ΔP is pressure drop, psi

Q is flow, gpm

A is orifice area, in.^{2}



USGS
science for a changing world

Ground Water in Hawaii

Ground water is one of Hawaii's most important natural resources. It is used for drinking water, irrigation, and domestic, commercial, and industrial needs. Ground water provides about 99 percent of Hawaii's domestic water and about 50 percent of all freshwater used in the State. Total ground water pumped in Hawaii was about 500 million gallons per day during 1995, which is less than 3 percent of the average total rainfall (about 21 billion gallons per day) in Hawaii. From this perspective, the ground-water resource appears ample; however, much of the rainfall runs off to the ocean in streams or returns to the atmosphere by evapotranspiration. Furthermore, ground-water resources can be limited because of water-quality, environmental, or economic concerns.

Water beneath the ground surface occurs in two principal zones: the unsaturated zone and the saturated zone. In the unsaturated zone, the pore spaces in rocks contain both air and water, whereas in the saturated zone, the pore spaces are filled with water. The upper surface of the saturated zone is referred to as the water table. Water below the water table is referred to as ground water. Ground-water salinity can range from freshwater to that of seawater. Freshwater is commonly considered to be water with a chloride concentration less than 250 mg/L, and this concentration represents about 1.3 percent of the chloride concentration of seawater (19,500 mg/L). Brackish water has a chloride concentration between that of freshwater (250 mg/L) and saltwater (19,500 mg/L).

GROUND-WATER RECHARGE

The amount of recharge available to enter the aquifers is the volume of rainfall, fog drip, and irrigation water that is not lost to runoff or evapotranspiration or stored in the soil. Rainfall is spatially variable because of the islands' topography and the persistent northeasterly tradewinds. In dry areas, annual rainfall is less than 10 inches; in wet areas, annual rainfall is greater than 400 inches. In general, southwestern, leeward sides of the islands are driest and northeastern, windward sides are wettest. Fog drip, which is cloud vapor that is intercepted by vegetation and subsequently drips to the ground, commonly occurs between altitudes of 2,000 and 6,000 ft.

Recharge is typically about 10 to 50 percent of the rainfall, fog drip, and irrigation water. Runoff is directly related to factors including rainfall, topography, soil type, and land use. Runoff is typically about 10 to 40 percent of rainfall, but is higher where rainfall is high and slopes are steep and where rain falls on poorly permeable land surfaces. Evapotranspiration is the loss of water to the atmosphere by the combination of transpiration of plants and direct evaporation from land and water surfaces and can exceed 50 percent of rainfall. Water stored in the soil is available for plants or can eventually flow downward to recharge the aquifer.

Large-scale development of ground water in Hawaii began after the first successful well was drilled in 1879 in southern Oahu. The well shown, drilled in 1909 near Pearl Harbor, derives its water from a volcanic-rock aquifer that is confined by overlying sedimentary deposits. This well is an artesian well because it taps a confined aquifer, and is free flowing because the pressure in the aquifer is sufficient to raise the water above the land surface.

U.S. Department of the Interior
U.S. Geological Survey

S-18L

HYDROGEOLOGY

The most extensive and productive aquifers in the Hawaiian islands are formed by volcanic rocks that erupted during the principal building stage of each volcano. Lava from this stage, called the shield stage, consists of basalts that characteristically form thin flows ranging in thickness from a few feet to a few tens of feet. The shield stage is the most voluminous phase of eruptive activity during which 95 to 98 percent of the volcano is formed. Thousands of lava flows erupt from the central caldera of the volcano and from two or three rift zones that radiate out from the caldera. Intrusive dikes fed by rising magma extend down the rift zones and may erupt if they reach the surface. Some volcanoes have a postshield-stage during which lava flows over the shield-stage basalt. The post-shield stage lava flows are marked by a change in lava chemistry and character that commonly leads to the formation of massive lava flows that can be many tens of feet thick. After a period of volcanic inactivity, lava might issue from isolated vents on the volcano during a final, rejuvenated stage.

The permeability of volcanic rocks is variable and depends on the mode of emplacement, amount of weathering, and thickness of the rocks. (Permeability describes the ease with which fluid can move through rock.) The three main groups of volcanic rocks (lava flows, intrusive dikes, and pyroclastic deposits) are formed by different modes of emplacement. Weathering reduces the permeability of all types of volcanic rocks. The thickness of a lava flow can depend on the lava chemistry and the topography over which it cooled. Thicker flows generally are less permeable and form from highly viscous lava on flat topography.

Lava flows are mainly pahoehoe, which has a smooth, undulating surface with a ropy appearance and aa, which has a surface of coarse rubble (clinker) and an interior of massive rock. A typical sequence of lava flows contains both aa and pahoehoe flows. The interconnected void spaces in a sequence of pahoehoe flows may lead to high permeability. The layers of clinker at the top and bottom of aa flows also impart high permeability (similar to that of coarse-grained gravel) to volcanic-rock aquifers. However, the lava in the core of an aa flow typically cools as a massive body of rock with much lower permeability. The most productive and most widespread aquifers consist of thick sequences of numerous thin lava flows.

*A typical sequence of lava flows contains aa clinker zones (**A**) of relatively high permeability that occur above and below the massive central cores of aa flows (**B**), and many thin pahoehoe flows (**C**). The sequence shown is about 50 feet thick. (photo by Scot K. Izuka, USGS).*

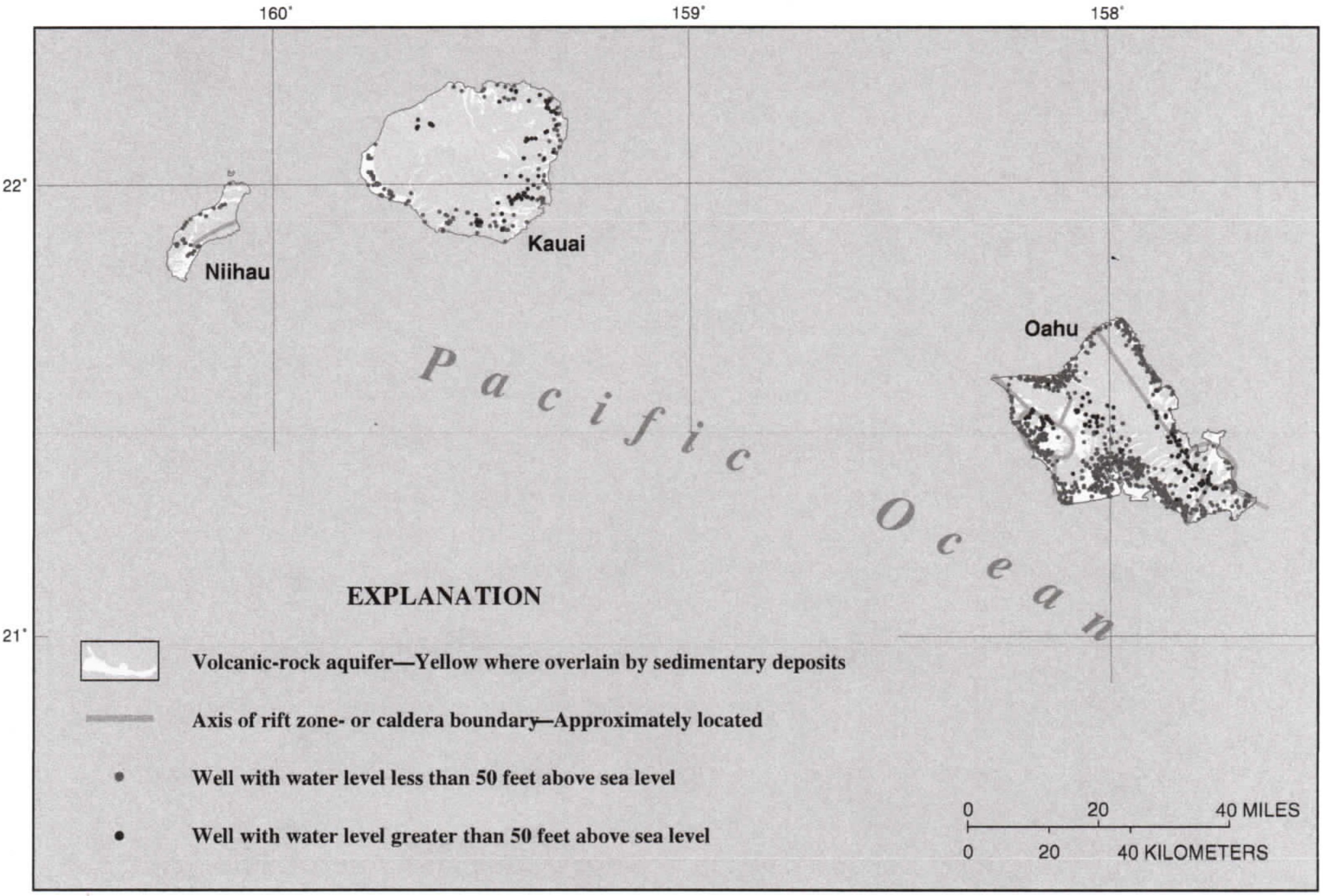
Dikes are thin, near-vertical sheets of massive, low-permeability rock that intrude existing rocks, commonly permeable lava flows. Dikes can extend vertically and laterally for long distances and impede the flow of ground water. Dikes can intersect at various angles and compartmentalize the more permeable rock in which ground water can be impounded. The dikes lower overall rock porosity and permeability.

Pyroclastic rocks include ash, cinder, spatter, and large blocks. Compaction and weathering can reduce the permeability; weathered ash beds commonly act as thin confining units within lava sequences.

Volcanic-rock aquifers are found throughout the eight major islands and are locally overlain by sedimentary deposits. Sedimentary deposits of alluvium, coralline limestone, and cemented beach or dune sand that typically are considered to be productive aquifers in much of the conterminous United States are relatively poor aquifers in the Hawaiian islands. Limestone deposits are highly permeable in many places and usually yield brackish water or saltwater because of good hydraulic connection between the ocean and the limestone and because of low recharge to the limestone.

In some places, weathered volcanic rocks or sedimentary deposits form a low-permeability confining unit overlying high-permeability volcanic rocks. In coastal areas, confining units of weathered volcanic rocks and sedimentary deposits are called caprock, which impedes the discharge of freshwater to the ocean. Confining units are also found in non-coastal areas, separating the volcanic rocks of two different volcanoes. Valley-filling sedimentary deposits generally are also of low permeability and can impede the seaward and lateral movement of ground water.

Hawaii District web site – http://hi.water.usgs.gov



WHAT ARE THE GROUND-WATER SETTINGS IN HAWAII?

In Hawaii, the major fresh ground-water systems are below the lowest water table, and are either freshwater-lens or dike-impounded systems. Where freshwater-lens and dike-impounded systems are adjacent, they form a single, hydrologically connected ground-water flow system. Minor perched systems can exist above the lowest water table.

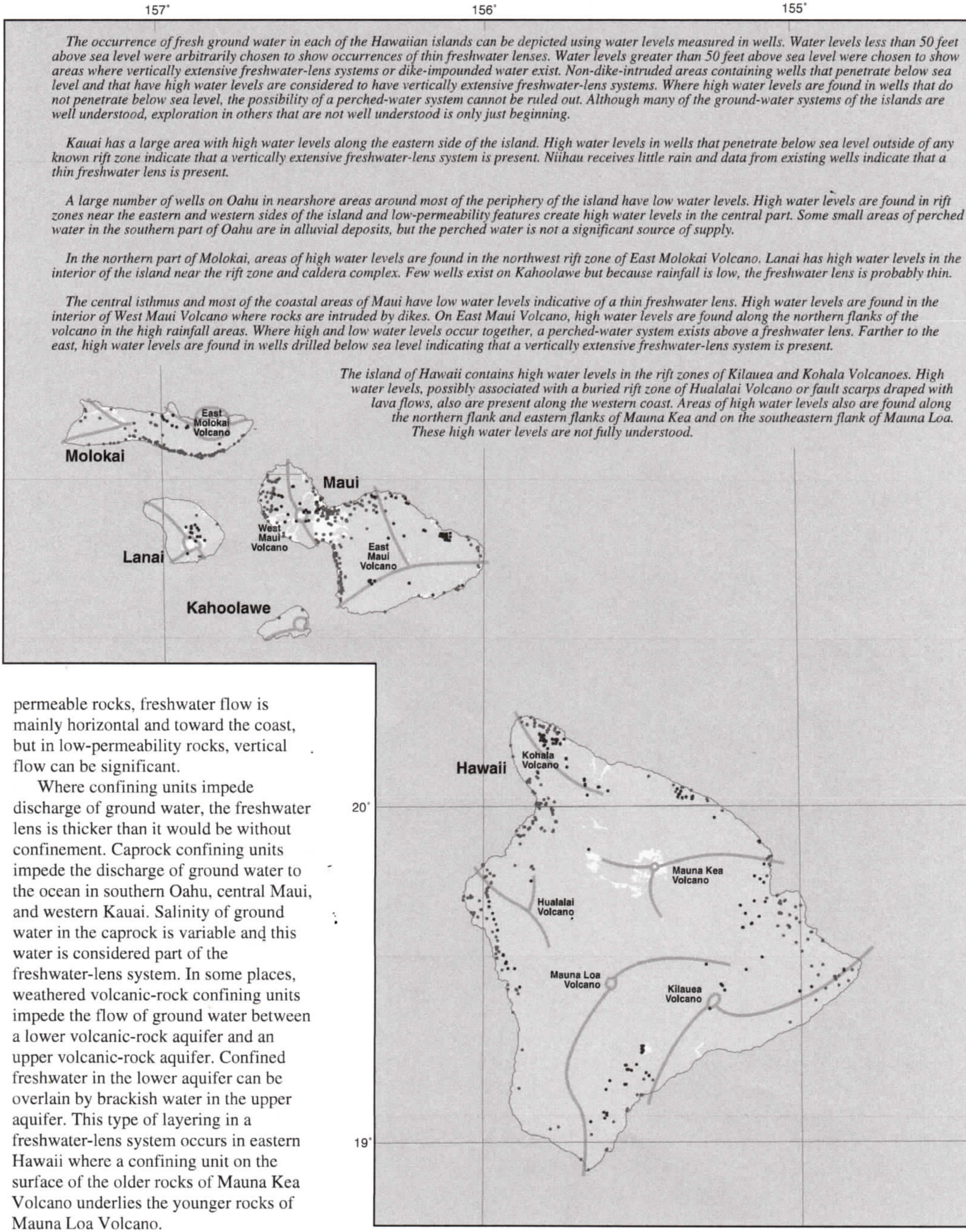
Freshwater-Lens System

A freshwater-lens system includes a lens-shaped freshwater body, an intermediate transition zone of brackish water, and underlying saltwater. The transition zone can be quite thick (several tens to hundreds of feet) depending on the extent of mixing between freshwater and saltwater. Freshwater-lens systems are found in dike-free volcanic rocks and sedimentary deposits under confined or unconfined conditions. The most important sources of ground water in Hawaii are from the freshwater parts of these systems in volcanic rocks.

In general, for a given aquifer permeability, low recharge results in low water levels and a thin freshwater lens. For a given recharge rate, low aquifer permeability results in high water levels and a thick freshwater lens. In the most permeable volcanic rocks, the water table is no more than a few feet above sea level, and the slope of the water table is nearly flat. In some low-permeability volcanic-rock aquifers, such as in eastern Kauai and northeastern Maui, a vertically extensive freshwater-lens system has freshwater extending from below sea level to the water table that is several hundreds or even thousands of feet above sea level. Dikes may intrude the low-permeability rocks, but a vertically extensive freshwater-lens system can exist in areas that are dike free.

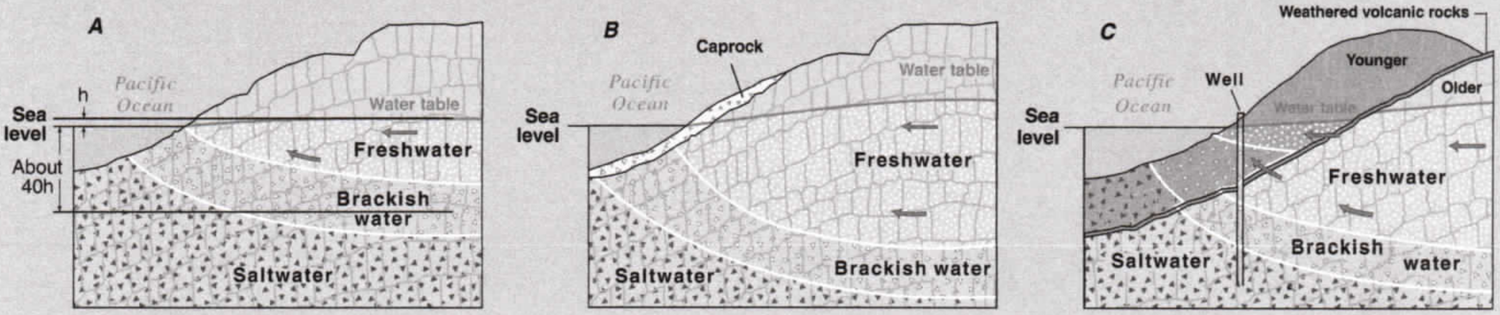
Meinzer (1930) defined water below the lowest water table as basal ground water to distinguish it from perched water. According to this broad definition, ground water in freshwater-lens and in dike-impounded systems both can be considered basal ground water. Descriptions of ground water in Hawaii have generally limited the use of the term "basal" to occurrences of ground water with a water table near sea level in high-permeability rocks, although Meinzer's definition of basal ground water was not so restrictive. Ground water in vertically extensive freshwater-lens systems can also be considered basal ground water using Meinzer's definition.

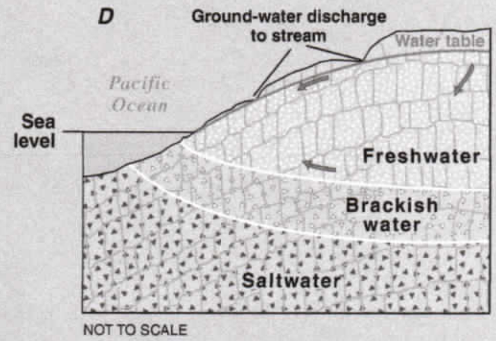
Freshwater-lens systems are recharged by direct infiltration of precipitation and irrigation water, and by inflow from upgradient ground-water systems. Discharge from freshwater-lens systems in highly permeable rocks is by diffuse seepage near the coast and to subaerial and submarine coastal springs. In a vertically extensive freshwater-lens system, much of the fresh ground water discharges directly to stream valleys above sea level where the ground surface intersects the water table. In highly



permeable rocks, freshwater flow is mainly horizontal and toward the coast, but in low-permeability rocks, vertical flow can be significant.

Where confining units impede discharge of ground water, the freshwater lens is thicker than it would be without confinement. Caprock confining units impede the discharge of ground water to the ocean in southern Oahu, central Maui, and western Kauai. Salinity of ground water in the caprock is variable and this water is considered part of the freshwater-lens system. In some places, weathered volcanic-rock confining units impede the flow of ground water between a lower volcanic-rock aquifer and an upper volcanic-rock aquifer. Confined freshwater in the lower aquifer can be overlain by brackish water in the upper aquifer. This type of layering in a freshwater-lens system occurs in eastern Hawaii where a confining unit on the surface of the older rocks of Mauna Kea Volcano underlies the younger rocks of Mauna Loa Volcano.

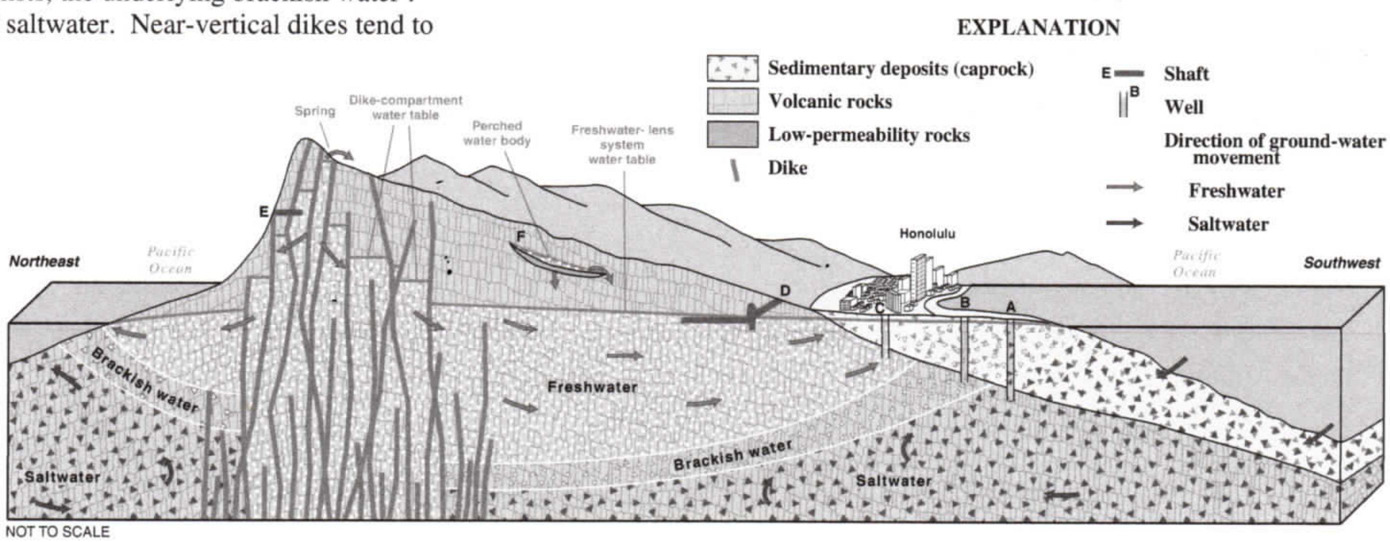




*On oceanic islands, such as the Hawaiian islands, freshwater commonly occurs as a body of water called a freshwater lens that floats on saltwater and is separated from the saltwater by a transition zone of brackish water. (**A**) The Ghyben-Herzberg principle is commonly used in Hawaii to estimate the depth where the brackish water in the transition zone has a salinity about 50 percent that of seawater. The Ghyben-Herzberg principle is named after two scientists who independently described a freshwater-saltwater relation for conditions in which the two fluids do not mix (no transition zone) and the freshwater flow is predominantly horizontal. For these conditions, the freshwater-lens thickness below sea level is directly proportional to the height of the top of freshwater above sea level. In principle, at a place where the water table stands 1 foot above sea level, for example, 40 feet of freshwater will be below sea level, and the freshwater lens will thus be 41 feet thick. This relation exists because seawater is about one-fortieth more dense than freshwater. In a real freshwater-lens system, mixing creates a transition zone and reduces the amount of freshwater above the transition zone. In some places where freshwater is extensively mixed with saltwater, brackish water may exist immediately below the water table. (**B**) Where low-permeability caprock acts as a confining unit near the coast, a thicker freshwater lens develops because ground water cannot discharge as readily to the ocean. The Ghyben-Herzberg principle applies where flow is predominantly horizontal. (**C**) Weathered volcanic rocks on the surface of an older volcano form a confining unit between the lower and upper aquifers. The well penetrates freshwater underlain by brackish water. Beneath the confining unit, the well penetrates deeper freshwater underlain by brackish water and saltwater. Fresh ground water flows from the deeper volcanic-rock aquifer through the confining unit into the upper volcanic-rock aquifer. (**D**) In systems where low-permeability rocks cause significant vertical hydraulic-head gradients, the Ghyben-Herzberg principle does not accurately predict the depth where the brackish water in the transition zone has a salinity about 50 percent of seawater. Although the depth to saltwater has not been measured in wells in these systems, where flow is downward, the freshwater lens is likely thinner than predicted by the Ghyben-Herzberg principle.*

Dike-Impounded System

A dike-impounded system is found in the rift zones and caldera of a volcano where low-permeability dikes have intruded other rocks. The flow system includes the freshwater body, and where it exists, the underlying brackish water . and saltwater. Near-vertical dikes tend to compartmentalize areas of permeable volcanic rocks. Dikes impound water to heights as much as 3,300 feet above sea level on the islands of Maui and Hawaii and as much as 1,600 feet above sea level on Oahu. The depth to which freshwater extends below sea level within a dike-impounded system is not known in places with high water tables. Where few dikes intrude permeable volcanic rocks, the water table may be only a few feet to a few tens of feet above sea level and saltwater has been found below the freshwater.



Fresh ground water generally moves from topographically high areas towards the ocean. Fresh ground-water flow is generally downward in the inland areas, upward in the coastal areas, and horizontal in between. A saltwater circulation system exists beneath the freshwater lens. Saltwater flows landward in the deeper parts of the aquifer, rises, then mixes with fresher water and discharges to the ocean.

*A freshwater-lens system underlies much of southern Oahu. Well **A** produces saltwater from below the transition zone, well **B** produces brackish water from the transition zone, and well **C** produces freshwater.*

*Horizontal shaft **D** (sometimes called a Maui shaft) produces large volumes of freshwater by skimming water from near the top of the freshwater lens. Shaft **E** (sometimes called a Lanai shaft) is dug horizontally into one or more of the dike-bounded compartments. Location **F** indicates a perched water body containing minor amounts of water.*

Where erosion has exposed dike compartments in stream valleys such as in windward Oahu, ground water can discharge directly to the streams. In other areas, fresh ground water in dike-impounded systems can discharge to downgradient ground-water systems or directly to the ocean.

Perched System

Perched water is found in areas where low-permeability rocks impede the downward movement of ground water sufficiently to allow a perched water body to develop within otherwise unsaturated rocks. These low-permeability rocks include massive, thick-bedded lava flows, extensive soil and weathered ash layers, and sedimentary deposits. The areal extent and distribution of these rocks is highly variable. The height of the water table above sea level depends on the altitude of the low-permeability rocks and the rate and duration of recharge, and the extent of the perched system depends on the areal extent of the low-permeability rocks. Discharge from a perched system can be to springs, streams, the ocean, downward to a lower water table, or to the atmosphere by evaporation.

WHAT LIMITS GROUND-WATER AVAILABILITY?

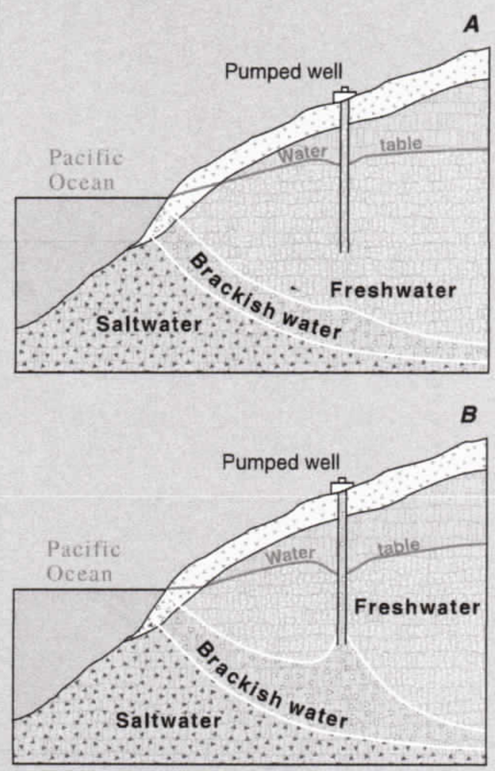
The main factors limiting ground-water availability in the State of Hawaii are saltwater intrusion, the reduction of discharge to streams and the ocean, and lowering of water levels.

When water is withdrawn from a freshwater lens, the freshwater lens shrinks and saltwater or brackish water will intrude upward and landward into parts of the aquifer that formerly contained freshwater. The degree of saltwater intrusion depends on several factors, which include the hydraulic properties of the rocks, recharge rate, pumping rate, and well location. The effect of intrusion on a particular well depends on the vertical and lateral distance between the well and the transition zone. Wells completed in the freshwater lens near the coast are particularly likely to induce brackish water or saltwater movement into the well as pumping continues. Saltwater-intrusion problems can be minimized by appropriately locating wells and by controlling withdrawal rates.

In the Honolulu area of Oahu, some wells that originally produced fresh ground water were later abandoned because of increased salinity due to saltwater intrusion. Pumping from a well can cause the freshwater-saltwater transition zone to rise into the pumped well. Many wells in Hawaii that are pumped at high rates or drilled too deeply are affected by this process, resulting in increased sodium and chloride concentrations in pumped water.

Ground-water withdrawal ultimately reduces the amount of discharge to springs, streams, or the ocean by the amount that is withdrawn. Reduction of springflow and streamflow is a concern for several reasons, including loss of habitat for native aquatic species, reduced water supply for agricultural diversions, aesthetics, and recreational use. Reduced flow to the ocean may affect marine habitat and aquaculture practices in coastal fishponds.

Ground-water withdrawal also lowers water levels around the pumped well. Nearby wetlands and ponds may shrink or dry up causing loss of habitat for aquatic species. Discharge from nearby flowing wells may decrease or stop if water levels are lowered sufficiently.



*Saltwater intrusion is a potential problem near the coast. (**A**) Diagram of a well completed in a volcanic-rock aquifer in which withdrawal is small. Only limited saltwater intrusion has taken place. (**B**) Diagram of the same well under conditions of large ground-water withdrawal. Pumping has lowered the water table and caused the freshwater lens to thin. Brackish water has reached the well.*

Additional Reading:

This fact sheet is based on the publication Oki, D.S., Gingerich, S.B., and Whitehead, R.L., 1999, Hawaii *in* Ground Water Atlas of the United States, Segment 13, Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands: U.S. Geological Survey Hydrologic Investigations Atlas 730-N, p. N12–N22, N36.
http://sr6capp.er.usgs.gov//gwa/gwa.html

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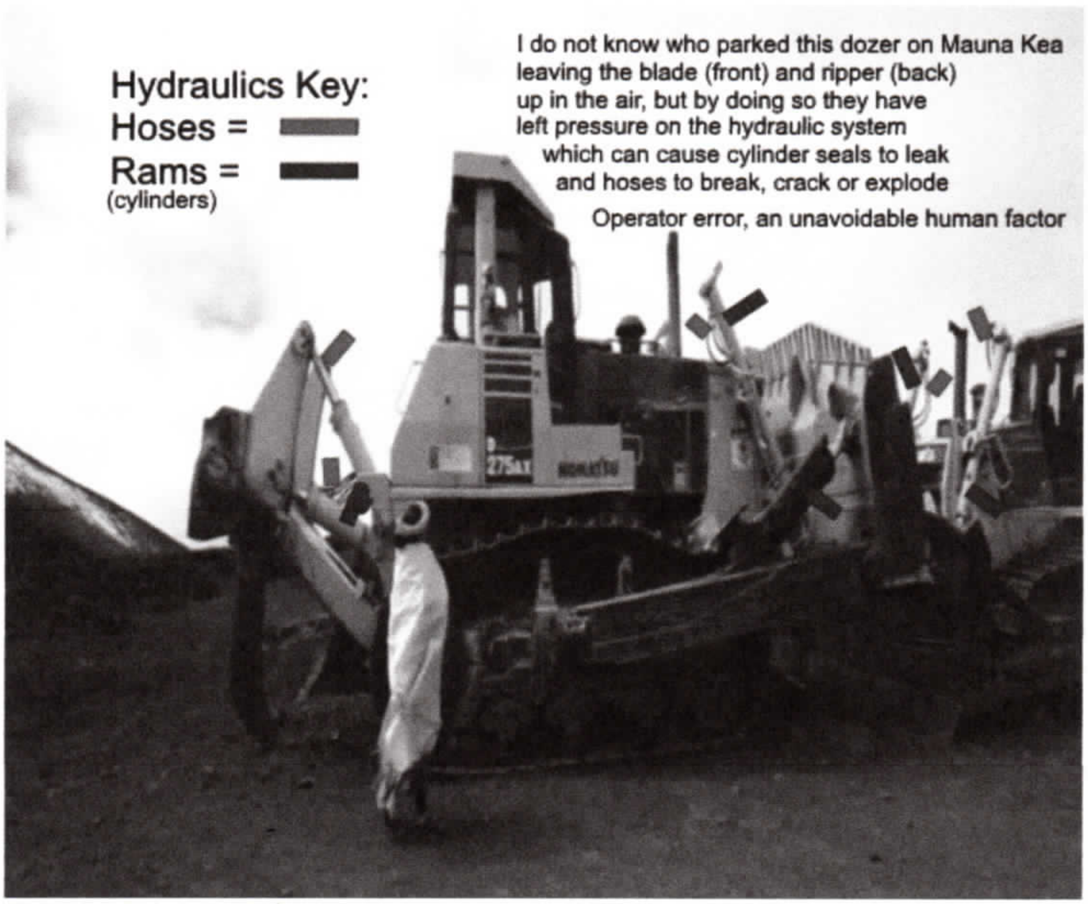
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which can cause cylinder seals to leak
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Operator error, an unavoidable human factor
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Heavy construction equipment used for groundwork, excavation, and grading during geotechnical bóring in August-October 2013 at the proposed TMT site on Mauna Kea.

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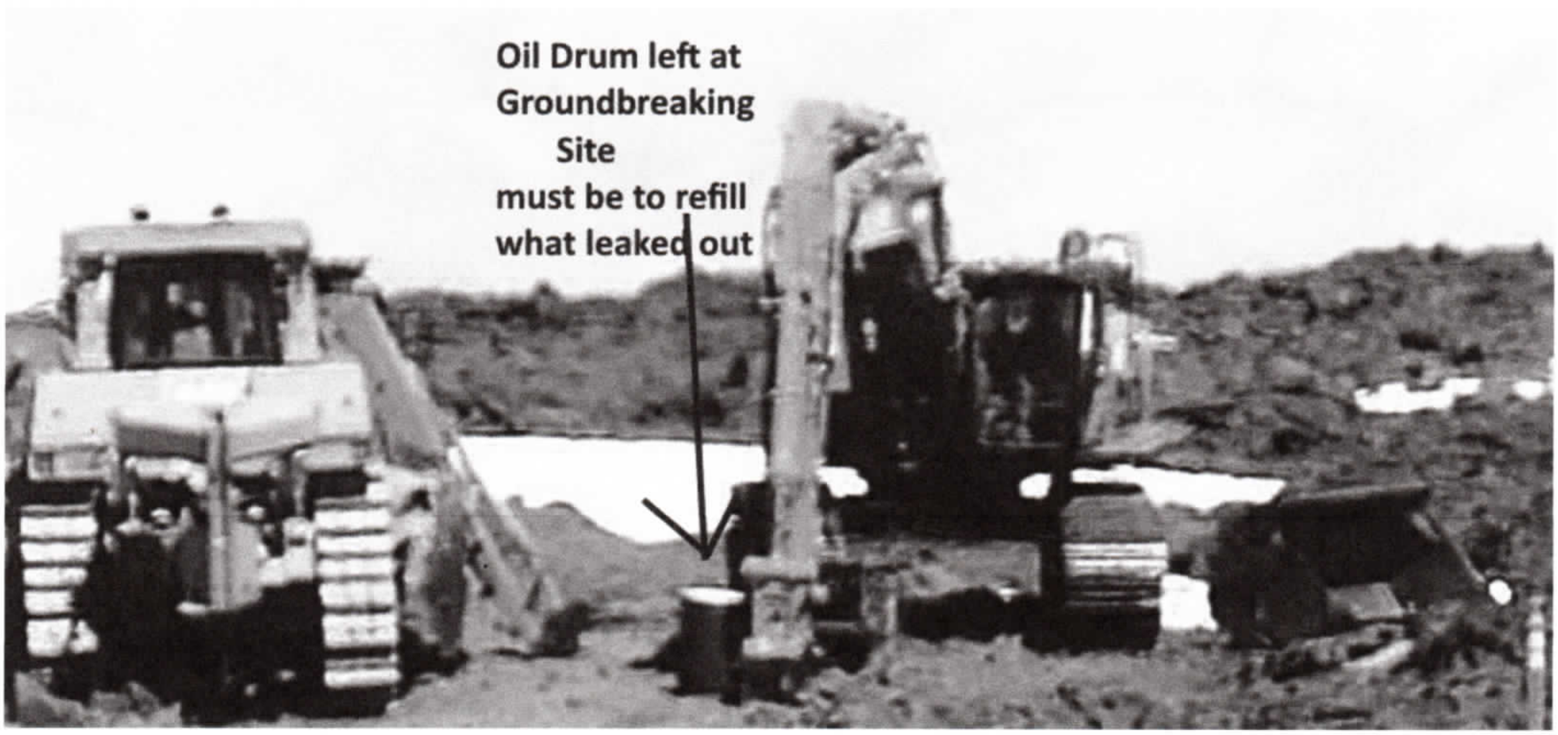
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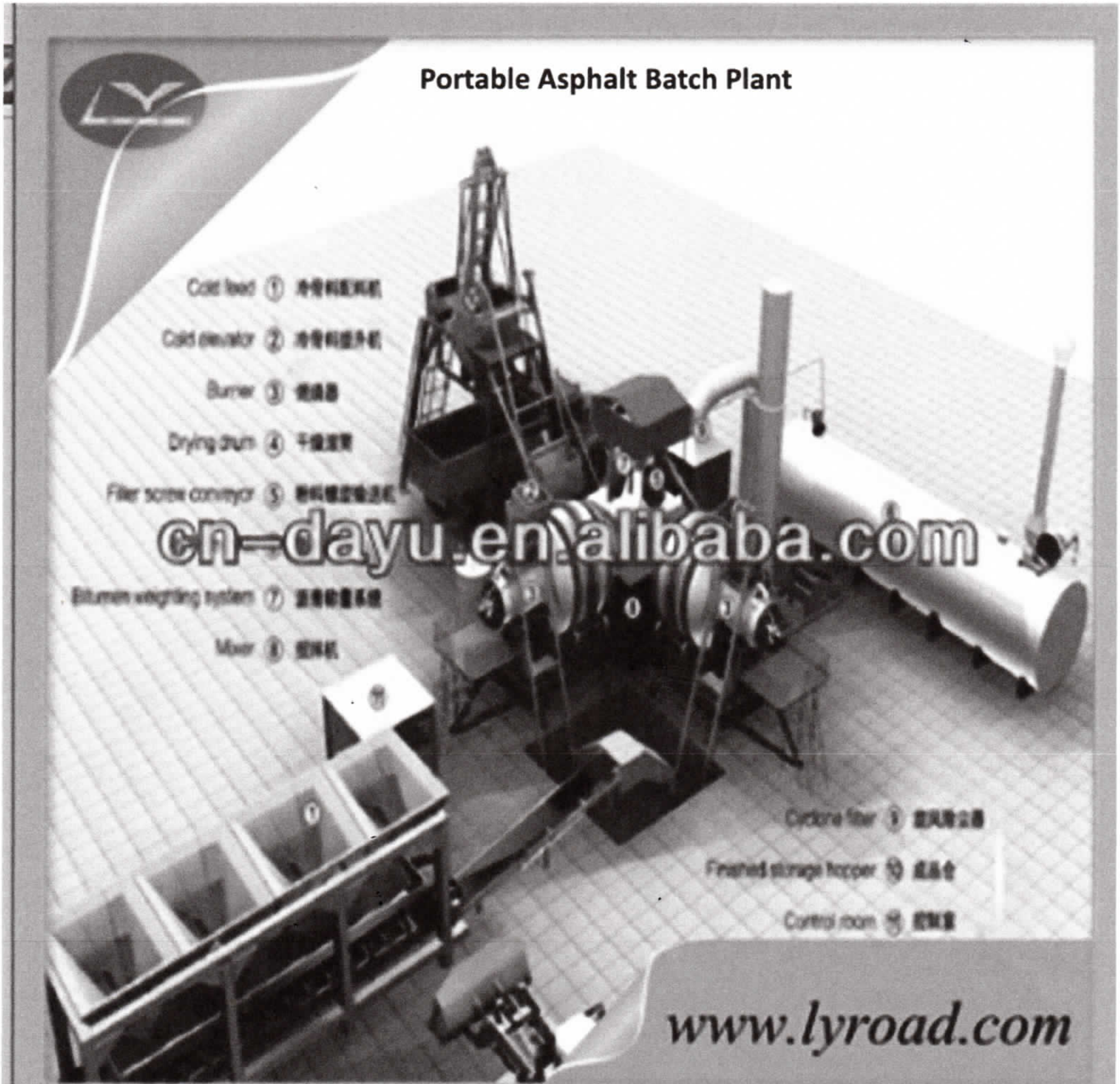
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BOARD OF LAND AND NATURAL RESOURCES

FOR THE STATE OF HAWAI'I

IN THE MATTER OF A Contested Case Hearing Re Conservation; Use Application (CDUA) HA-3568 For the Thirty Meter Telescope at the Mauna Kea Science Reserve, Ka'ohe Mauka, Hamakua, Hawai'i TMK(3)4-4-015:009	Case No. BLNR-CC-16-002 **CINDY FREITAS SEVENTH SUPPLEMENTAL EXHIBIT LIST;** **Certificate of Service**

CINDY FREITAS SEVENTH SUPPLEMENTAL EXHIBIT LIST

The files for submittals S-18b 1 and S-18b 2 are too large to be emailed. The electronic copies are being submitted on a jump drive to the DLNR – Custodian of Records for this contested case hearing in order to be posted online in the Evidentiary Hearing Submittals site. Copies of Submittals S-18b 1 and S-18b 2 are located online and can be directly downloaded from the following website as followed:

S-18b 1: Geology and Ground-Water Resources of the Island of Hawaii

https://pubs.usgs.gov/misc/stearns/Hawaii.pdf

S-18b 2: The Geology and Petrology of Mauna Kea Volcano, Hawaii
A Study of Postshield Volcanism... U.S. Geological Survey Professional Paper 1557

https://pubs.usgs.gov/pp/1557/report.pdf

Kailua Kona HI February 12, 2017

TDC

Cindy Freitas Petitioner

BOARD OF LAND AND NATURAL RESOURCES

STATE OF HAWAI'I

Contested Case Hearing Re Conservation District Use Application (CDUA) HA-3568 for the Thirty Meter Telescope at the Mauna Kea Science Reserve, Ka'ohe Mauka, Hamakua, Hawai'i, TMK (3) 4-4-015:009	BLNR Contested Case HA-16-02 Document title:

CERTIFICATE OF SERVICE

The undersigned hereby certifies that the above referenced document was served upon the following parties by the means indicated on October 10, 2016.

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Date: 2/12/17