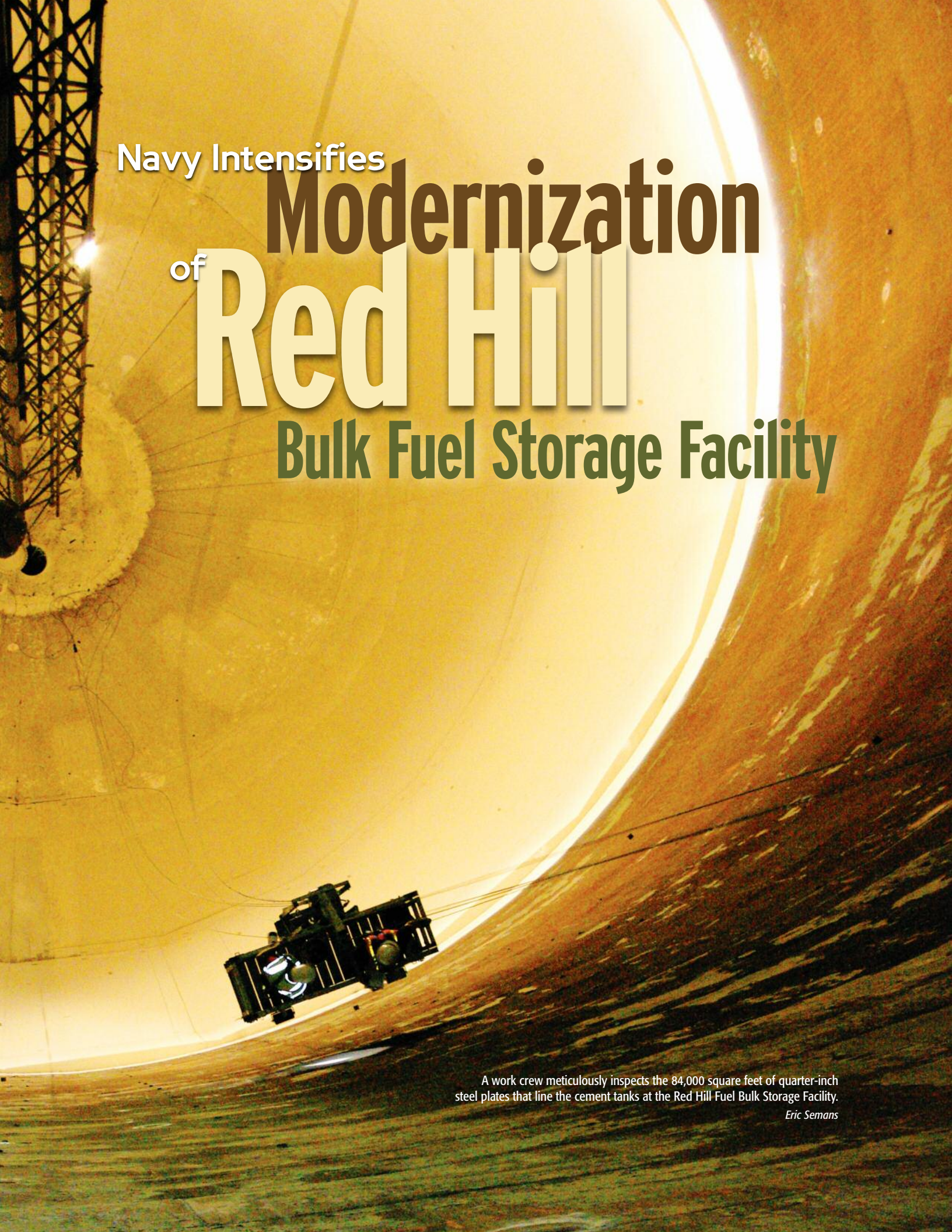
Improvements in Oversight, Technology & Operating Procedures Guard Against Future Releases

In an effort to enhance safety measures and minimize vulnerabilities, the U.S. Navy continues to significantly increase its investment in the one-of-a-kind Red Hill Bulk Fuel Storage Facility. These efforts will improve operation standards and management oversight to ensure Oahu's drinking water remains safe.

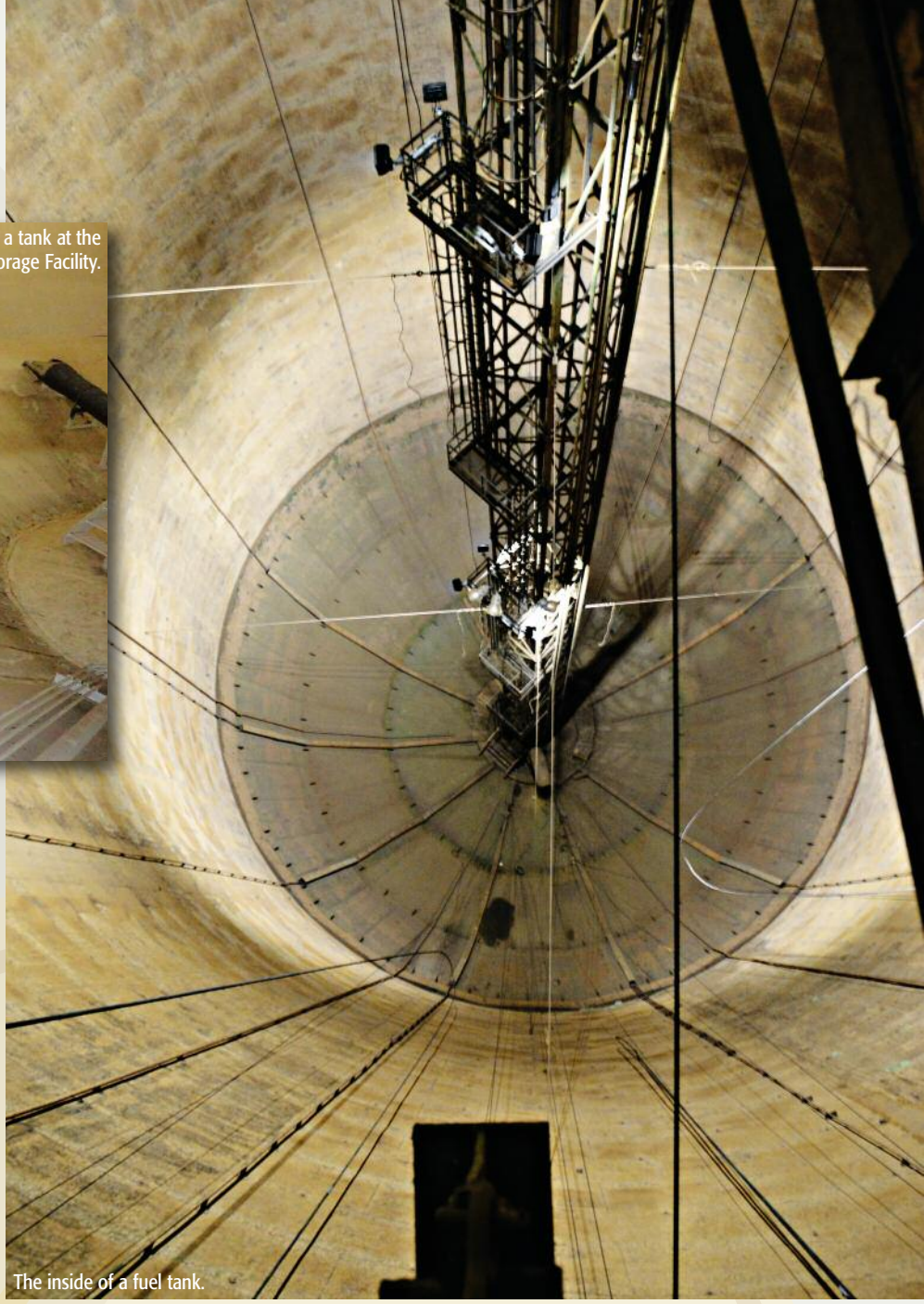
The Red Hill Bulk Fuel Storage Facility at Joint Base Pearl Harbor Hickam is a key component of the Navy's operations in the Pacific and Asia, consisting of 20 tanks, each able to store more than 12.5 million gallons of jet or marine fuel. Red Hill is believed to be the largest underground fuel storage facility of its kind in the world. According to Rear Admiral John Fuller, Commander, Navy Region Hawaii and Naval Surface Group Middle Pacific, the tanks are a strategically critical enabler for forces mobilizing anywhere in the Pacific—from the West Coast and Hawaii to Asia and the Middle East.

Navy Intensifies Modernization of Red Hill Bulk Fuel Storage Facility



A work crew meticulously inspects the 84,000 square feet of quarter-inch steel plates that line the cement tanks at the Red Hill Fuel Bulk Storage Facility.
Eric Semans

An employee inspects a tank at the Red Hill Fuel Bulk Storage Facility.



The inside of a fuel tank.

In January 2014, the facility experienced its first and only extreme fuel release since formal reporting requirements were established in 1988. Since that time all releases must be reported to the State of Hawaii Department of Health (DOH). Due to the absence of regulatory reporting requirements prior to 1988, the Navy's records from the date the Red Hill facility was placed into service (1943) to 1988 do not provide detailed information regarding releases from the tanks. Through enhanced safety measures and oversight, combined with modernization projects already underway, the Navy has taken steps to dramatically minimize the probability of future incidents.

Creating Red Hill

Because of the escalating tension in Europe and Asia early in the last century, the Navy grew concerned about the myriad above-ground fuel tanks at Pearl Harbor and their vulnerability to air attack. Construction began on the Red Hill facility in 1940.

For three straight years as many as 4,000 people (at peak construction) worked non-stop to complete the facility, except for a one-day halt during the Imperial Japanese Navy's attack on Pearl Harbor on December 7, 1941.

Workers began construction of Red Hill by excavating and removing surface soil on the top of the Red Hill

In January 2014, the facility experienced its first and only extreme fuel release since formal reporting requirements were established in 1988.

ridge to expose the underlying geology (i.e., basalt). Engineers and construction crews then created each tank by first excavating a 14-foot-wide vertical shaft that connected an upper and lower access tunnel, then boring a 100-foot-diameter tunnel in between.

Next came the tough part—building each tank from the outside in, first pouring the concrete shell, then installing the steel plates to fortify each structure. At the base of each tank is a large concrete foundation that provides additional support.

More About the Construction of Red Hill

As World War II began to take shape, U.S. military officials became concerned about the vulnerability of the existing fuel storage facility at Pearl Harbor, which consisted of a series of above-ground tanks. Well before the Pearl Harbor attack, it was decided that a new underground facility was needed.

The site chosen would provide unprecedented flow rates due to its elevation. In addition, the site's unique geological characteristics, including basalt rock, could support such large tanks.

The original plan was for four large underground tanks—they would be horizontal, as all underground tanks were at the time. However, midway through the planning process, the project manager and a consultant had a better idea. They decided that building vertical tanks would be faster and easier, because a central shaft would allow construction debris to be excavated through a series of conveyor belts located in the lower access tunnel, which enabled construction and excavation to occur simultaneously. Plans were changed to build two rows of ten vertical tanks.

In addition to the tanks, upper and lower access tunnels would be built, as well as cross-tunnels to connect the center shafts. The tunnels and shafts were built prior to the tanks to allow excavation during tank construction.

Additional access tunnels were also built around the site of each proposed tank. Miners worked in these tunnels to carve out the tank's dome. Building the dome first provided miners with more protection against cave-ins. After the dome on each tank was finished, miners would descend into the central shaft and begin removing the rock between them and the outside edges of the dome. As the rock fell, it would fall into the shaft and onto conveyor belts below. Then, a rock crusher would crush the rock down to 10-inch diameter pieces for disposal. After enough rock was cleared, scaffolding was built around the entire inner circumference of the tank and a platform erected. Miners would lower themselves by rope, insert dynamite into the rock wall, return to the platform then detonate the explosives. They would do this again and again.

After the entire area was hollowed out, gunite (a mixture of cement, sand, and water applied through a pressure hose, producing a dense hard layer of concrete used in building for lining tunnels and structural repairs) was used to line the basalt rock. Workers then began to erect the steel liner and rebar incrementally so that they could pour concrete in stages. Concrete was poured continually and workers had to remove wooden shoring as concrete filled. Grout was injected to fill every void space between When finished, the tanks were testedby slowly filling them with water.

Red Hill by the Numbers

1. Each tank is large enough to hold a 20-story building.
2. The facility can hold nearly six million barrels of oil.
3. To create each dome, concrete was poured for 70 straight hours.
4. The tanks contain enough steel to build 12,000 classic cars, enough concrete to build five miles of interstate highway.

Fuel lines leading to the tanks.

Each tank consists of a quarter-inch of steel backed by two-and-a-half to four foot thick reinforced concrete depending on the location within the tank. The tanks are built within the basalt-rock mountain. They each measure 100 feet in diameter and are approximately 23 stories tall with a capacity to hold more than 12.5 million gallons of fuel. A gravity-fed distribution system delivers fuel from the tanks to Pearl Harbor, three-and-a-half miles away, and can operate manually even if cut off from electricity. In fact, the facility can operate completely "off the grid" requiring no connection to the Internet or outside power source.

The tanks at Red Hill are designated as field-constructed Underground Storage Tanks (UST), a category of tank that had until recently been exempt from certain U.S. Environmental Protection Agency's (EPA) UST regulations. Even when the tanks were exempted from EPA requirements, the Navy conducted routine inspections to ensure they held the facility to the highest maintenance and operational standards, meeting or exceeding industry standards. In the early 2000's, the Navy and the U.S. Department of Defense's Defense Logistics Agency (DLA) spent millions of dollars installing a state-of-the-art inventory management system that can measure each tank's total inventory in real-time. Over the last six months, the Navy has been working collaboratively with EPA to establish rigorous inspection criteria for operations, maintenance and safety practices.

The Groundwater Protection Plan

Many entities, including the Navy, University of Hawaii and U.S. Geological Survey (USGS), study the movement of groundwater in and around Red Hill. Of note, not all groundwater makes its way to drinking water sources. Navy modeling to date indicates any fuel constituents in the groundwater are not likely to reach any of Oahu's drinking water sources.

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Between 2005 and 2014, the Navy implemented the following actions:

2005

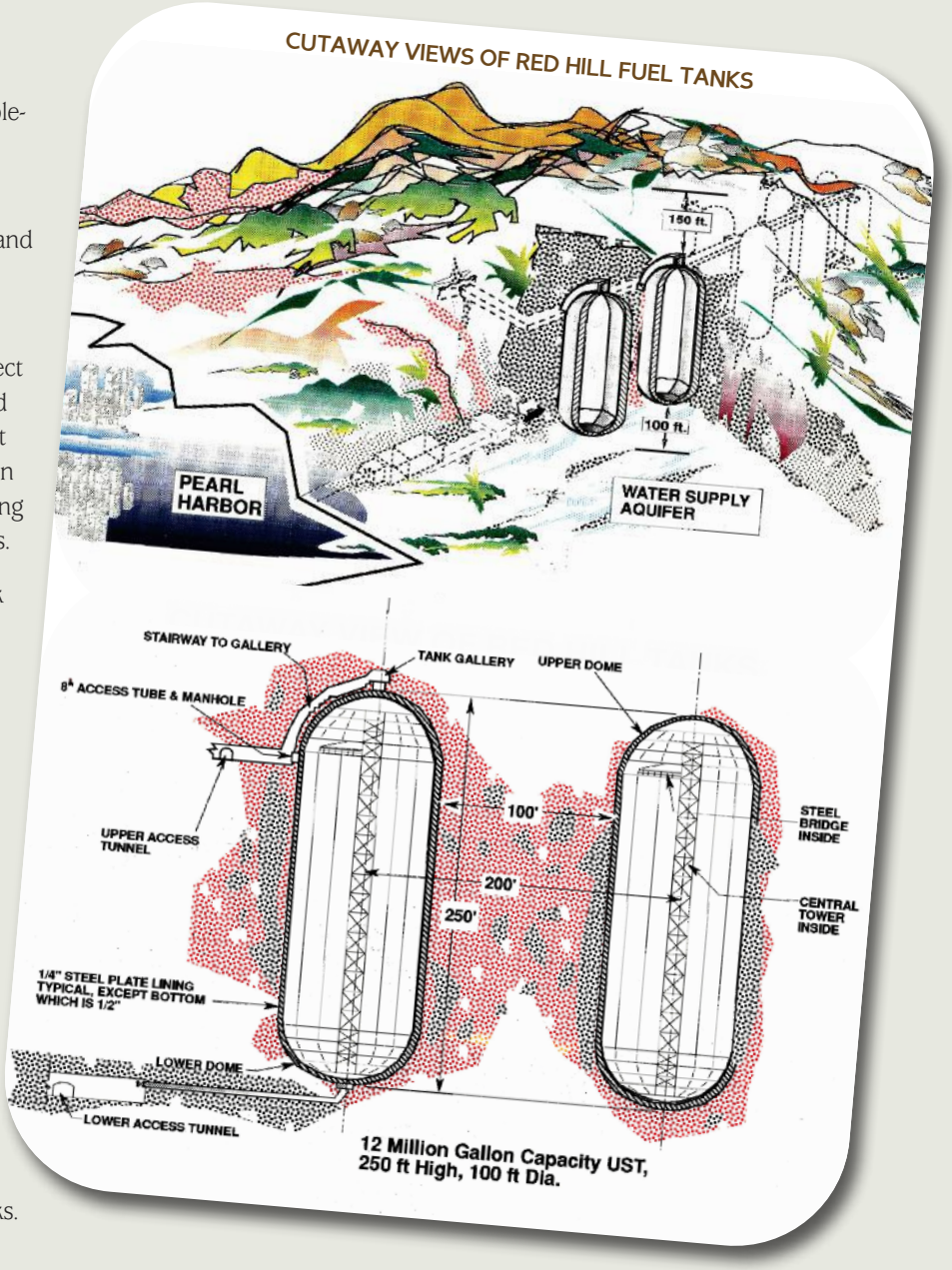
- Quarterly groundwater monitoring and sampling at the Red Hill Facility.

2007

- Environmental investigation to collect additional data for groundwater and contaminant fate (how and where it disperses) and transport modeling in order to provide better understanding and forecasting of potential impacts.
- A more in-depth human health risk assessment to evaluate potential impacts to drinking water.
- A contingency plan to protect the drinking water well located closest to the Red Hill Facility.

2008

- The Groundwater Protection Plan (GWPP) (subsequently updated in 2009 and 2014) to mitigate risk associated with inadvertent fuel releases from the tanks.



The GWPP presents a step-wise strategy to help prevent risks associated with inadvertent fuel releases from the tanks, and focuses on long-term mitigations for those potential risks. These steps include:

- Implement a tank inspection and maintenance program.
- Describe a soil vapor monitoring program to support primary leak detection processes.
- Describe the groundwater sampling program and results of risk assessments.
- Implement a long-term groundwater monitoring program that will provide warning of potential risk to human health.
- Establish responsibilities and response actions that will be performed should groundwater data exceed Hawaii DOH environmental action levels.
- Conduct periodic market surveys to evaluate best available leak detection technologies for large, field-constructed fuel storage facilities.

Tank 5 Release

In December 2013, contractors finished up a three-year, scheduled routine maintenance upgrade on tank 5 at Red Hill. This work included cleaning, inspecting, and repairing any anomalies found in the tank. At the conclusion of the overhaul in January 2014, the Navy initiated a Return to Service (RTS) evolution, refilling the tank with Air Force jet fuel (JP-8). During the RTS, the inventory management alarms sounded. Red Hill operators first assumed the alarm system was malfunctioning because the tank was

The fuel pumps in the underground pump house.

recently overhauled and should not have been leaking. Eventually, the Navy determined the alarms were not false and reported a 27,000-gallon jet fuel loss to Hawaii DOH and the EPA.

Testing the Water

The Navy's first concern was that fuel might enter the drinking water supply. The nearest drinking water shaft (operated by the Navy) is 3,000 feet away in a different direction, and provides water to 20 percent of the military families on Joint Base Pearl Harbor-Hickam. The next closest water shaft, which is located approximately one mile away, provides drinking water to the city of Honolulu. While all tests results for contamination have come back well within safe drinking water standards, the Navy, EPA, and Hawaii DOH are conducting a study to evaluate groundwater conditions and any potential impacts to groundwater resources in the area. The study will also assess how the presence or absence of natural, geologic barriers may inhibit groundwater and contaminant flow from Red Hill to nearby drinking water sources.

Following the tank 5 release in 2014, the Navy increased the testing frequency for drinking water and groundwater wells. The Navy now sends drinking water samples every quarter to certified independent laboratories that use EPA methods to analyze for contamination.

In May 2016, Admiral Fuller explained to *Hawaii Business* magazine: "There have been detects of trace amounts of fuel constituents near the Navy drinking water shaft." This is in the groundwater, not the drinking water. "We're talking 17 parts per billion, as opposed to zero. The misperception is that there's a spike, but the numbers were small enough that the testing facility had to estimate the amount because the numbers were so low. The 17 parts per billion is below the threshold of something we should be concerned about, which is 100 parts per billion."

"The tanks are not leaking, the water is safe and we're doing everything we can to make sure that continues," summed up Admiral Fuller.

What Went Wrong?

How did a routine scheduled maintenance event go awry? Captain Dean Tufts, former commanding officer of the Navy Facilities Engineering Command Hawaii and lead engineer for Navy Region Hawaii responsible for maintaining Red Hill also spoke to *Hawaii Business* magazine. He described the maintenance process: "We visually inspect all the walls on this huge tank. We x-ray all the walls and look for any anomalies in the steel's thickness. The steel is a quarter-inch thick, backed by

The tanks are not leaking, the water is safe and we're doing everything we can to make sure that continues.
—Rear Admiral John Fuller

2.5 feet to 4 feet of concrete, backed by the basalt rock. If there are any kinds of nicks in the steel, what we're finding is that it's not corrosion. There's no air down there," he explains. The Navy empties and services tanks in this manner every 20 years. For the upgrade of tank 5—the sixth tank to be upgraded, the Navy used a new contractor.

"This contractor goes in, spends three years, does all the welding, does all the cleaning, does all the inspections, and an American Petroleum Institute certified engineer from the contractor signs off on it. It's like driving a new car out of the showroom. Then, we started getting alarms as we filled the tank. It's like when your check-engine light goes on. You think, 'That can't be right; it's brand new; it was just modernized.' And this was our mistake—we just reset the alarm. That happened a couple of times. So, by the time we realized, 'Oh, my gosh, this is really happening,' we had to move all the fuel into another empty tank. And by the time we moved the 12 million plus gallons into another tank, we had lost 27,000 gallons."

Subsequent analyses indicate that the leak was the result of faulty work by the Navy's contractor, compounded by a lack of quality assurance oversight by the Navy, as well as operator error. A subsequent tank 5 inspection revealed pinholes around improper welding repairs. In response to these findings, the Navy improved the oversight process for tank maintenance activities.

The Department of Defense has spent more than $200 million on continual technological modernization and environmental testing at Red Hill since 2006. The facility employs state-of-the-art inventory management and automated control and communication systems to monitor fuel levels in each tank to one sixteenth of an inch and to control the movement of fuel throughout the facility. If a tank level decreases by as little as half an inch, alarms will sound in Red Hill's control room, which is staffed 24/7.

Additionally, the Navy implemented new standard operating procedures to increase contractor scrutiny and provide additional government oversight. These actions further decrease the likelihood of another maintenance failure in the future.

The Administrative Order on Consent

An Administrative Order on Consent (AOC) is a binding legal agreement administered by EPA which mandates the corrective actions to be taken in the wake of an environmental violation. Representatives from the EPA, Hawaii DOH, Navy and DLA signed the AOC for Red Hill in September 2015. It acknowledges the shared responsibility to protect Oahu's drinking water supply and maintain Red Hill as a strategically vital resource.

The AOC Players

The following parties signed the AOC:

1. **EPA Region 9**
   EPA is the U.S. government agency that writes environmental regulations authorized by Congress. EPA has 10 regional offices, each of which is responsible for several states and territories. These offices carry out more specific tasks, including the particulars of UST cleanups. The offices of EPA Region 9 (Pacific Southwest) are located in San Francisco.
2. **The Hawaii Department of Health**
   The mission of the Hawaii DOH is to protect and improve the health and environment for all Hawaii residents. The regional EPA office has given authority to the DOH to regulate USTs. The Hawaii State DOH offices are located in Honolulu.
3. **Commander, Navy Region Hawaii**
   CNRH is the command responsible for providing, maintaining, and improving shore infrastructure, service, support, and training to enable Fleet operations. CNRH oversees all Navy supporting commands involved in the operation and maintenance of Red Hill. CNRH headquarters is located at Joint Base Pearl Harbor-Hickam.
4. **Defense Logistics Agency**
   DLA is a combat logistics support agency of the United States Department of Defense (DoD) providing the military services with the full spectrum of logistics, acquisition, and technical services. As the DoD executive agent for bulk petroleum, DLA executes the integrated materiel management responsibility for bulk petroleum owned by the DoD. DLA's Pacific headquarters are located at Joint Base Pearl Harbor-Hickam.

An employee monitors the control systems.
MC1 Nardel Gervacio

Lt. Cmdr. Andrew Lovgren, Fuels Director, Naval Supply Systems Command Fleet Logistics Center Pearl Harbor, explains the monitoring systems.
MC1 Nardel Gervacio

The document includes a Statement of Work (SOW) prescribing actions the Navy must take, along with deadlines for completing each task. The SOW has eight areas:

1. Providing overall project management guidance.
2. Improving tank inspection, repair and maintenance.
3. Reviewing potential upgrades to the tanks.
4. Improving the facility's ability to detect leaks and test tank tightness.
5. Addressing current and future corrosion and metal-fatigue practices.
6. Investigating and remediating past releases.
7. Developing better approaches to protect and evaluate groundwater.
8. Thoroughly assessing the risks and vulnerabilities of the Red Hill facility.

Shortly after signing the AOC, Navy and DLA stakeholders met with representatives from EPA, Hawaii DOH and DLA, along with invited subject matter experts. During this meeting, attendees paid particular attention to groundwater monitoring. At that time, there were ten sampling locations. The team determined that four additional ground water monitoring wells were necessary to develop a more precise and useful modeling tool to study groundwater movement. This model will help the Navy better understand how groundwater and fuel would move together if there was a release and improve the ability to assess and predict the potential migration of subsurface fuel constituents.

The Navy also issued reports in April 2016 outlining the state of current release detection measures and tank tightness testing, as well as ongoing efforts with corrosion and metal fatigue testing.

Hawaii DOH hosted a second meeting to address the SOW in May 2016. Participants included DLA, DOH and EPA as well as subject matter experts from the University of Hawaii, the Honolulu Board of Water Supply (BWS) and their consultants, State Department of Land and Natural Resources, and USGS. All participants went on record to say that all aspects of the Red Hill facility—to include infrastructure, security measures and operations practices—currently meet or exceed industry standards.

The newest groundwater monitoring well was installed in early August 2016. Admiral Fuller noted, "Public records confirm that all drinking water remains safe," adding, "this well is more tangible evidence that we are committed to keeping the drinking water safe."

Due to the complex geology surrounding Red Hill, there is no easy answer regarding what happened to this fuel.

Drilling equipment arrives at the first of four new groundwater monitoring well locations for the Red Hill Bulk Fuel Storage Facility.
Denise Emsley

Drilling equipment arrives at the first of four new groundwater monitoring well locations.
Denise Emsley

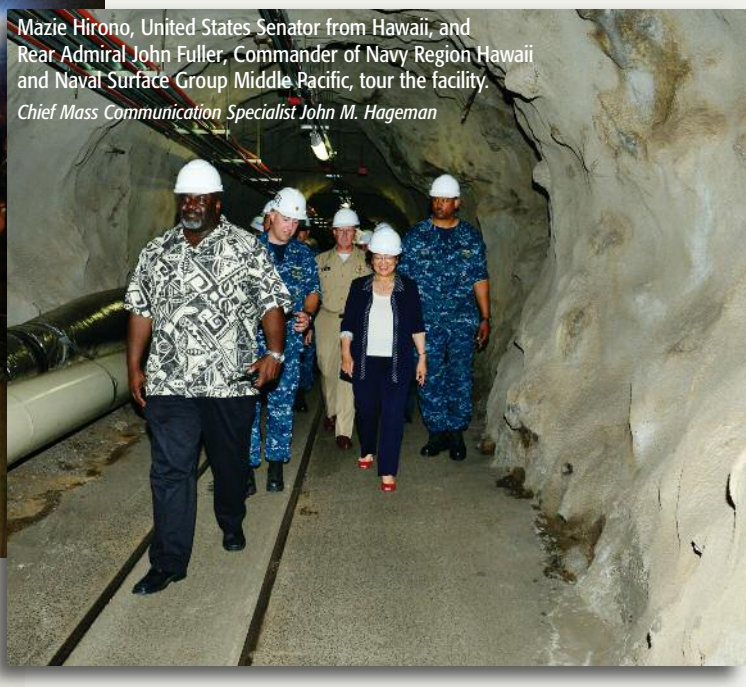
Drilling equipment specialists operate a drilling rig.
Denise Emsley

During the rock coring phase, core samples are carefully removed from the borehole and quickly handed off to geologists at 5-foot intervals. Geologists then observe and catalog the cores in order to develop a better understanding of the subsurface geology of the borehole.
Denise Emsley

Moving Forward

The Navy is also evaluating a number of potential remediation methods for the fuel accidentally released in January 2014. The AOC mandates that these methods be evaluated based on the feasibility of implementation, suitability for use in complex geology, and effectiveness in reducing contamination. Due to the complex geology surrounding Red Hill, there is no easy answer regarding what happened to this fuel, and how quickly natural biological processes may break down the fuel over time.

Captain Ken Epps, left, commander of Naval Supply Systems Command Fleet Logistics Center Pearl Harbor, briefs members of the Honolulu BWS, Moanalua Valley Community Association, and Pearl City Neighborhood Board No. 21 during a visit to one of the fuel tanks at the Red Hill Facility.



Mazie Hirono, United States Senator from Hawaii, and Rear Admiral John Fuller, Commander of Navy Region Hawaii and Naval Surface Group Middle Pacific, tour the facility.
Chief Mass Communication Specialist John M. Hageman

Today, the Navy and DLA continue Red Hill Facility inspections and modernization upgrades, to include the recently upgraded facility fire suppression, ventilation, and oil-tight door systems. Tank 5 repairs are ongoing and management plans to put the tank back into service only after the Navy, through careful and independent assessments, deems it suitable for operations.

The Navy prepared documents that EPA recently posted to their website at www.epa.gov/red-hill. This website contains a summary of meeting discussions, outlines, and reports the Navy and DLA prepared for the EPA and Hawaii DOH.

The Navy uses independent DOH-certified laboratories and EPA methods to test the water near Red Hill. Test results continue to verify that the drinking water near Red Hill is safe and remains within Federal and State standards. Water quality reports for Navy drinking water are available at http://go.usa.gov/3E9MR.

The Navy is committed to building trust with community leaders, elected officials and its neighbors by keeping regulators, stakeholders and the community informed. Over the last year, the Navy provided site tours to more than 500 community leaders and civic stakeholders so they could get a first-hand look at the Red Hill facility and its operation. This past summer, Navy Region Hawaii provided briefings and tours for dozens of state senators and representatives and their staff members. The U.S. congressional delegation from Hawaii, many other members of Congress and dozens of local community leaders have toured Red Hill, and in the fall, the facility welcomed Dr. Janine Davidson, Under Secretary of the Navy, and Mr. Dennis McGinn, Assistant Secretary of the Navy for Energy, Installations & Environment.

"The Navy is on the leading edge of embracing new sources of energy and moving away from fossil fuels," states Admiral Fuller. "At some point in the distant future we will no longer need Red Hill, but for now we must continue to rely on conventional power to protect our national security." ⚓

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