Red Hill Bulk Fuel Storage Facility
Administrative Order on Consent
Tank Upgrade Alternatives and
Release Detection
Decision Document

September 2019

NAVFAC Hawaii

Executive Summary

Background

The Tank Upgrade Alternatives (TUA) and Release Detection Decision Document records the Unites States (U.S.) Navy and Defense Logistics Agency (DLA) response to the Administrative Order on Consent (AOC). Its purpose is to meet the primary objective of implementing the Best Available Practicable Technology (BAPT) to ensure the drinking water supply in the vicinity of the Red Hill Bulk Fuel Storage Facility (Facility) remains protected, and to ensure the Facility is operated and maintained in an environmentally protective manner. Navy/DLA are working under the oversight of the U.S. Environmental Protection Agency (EPA) and the State of Hawaii Department of Health (DOH) to comply with the AOC.

The AOC directs a process that is working and has led to the implementation of a number of significant improvements to the Facility and its operational procedures since 2015. The process has also resulted in proposed additional improvements by Navy/DLA to allow the Facility to continue to operate in a manner that protects the environment. In accordance with the AOC, Navy/DLA are submitting their TUA Decision.

Decision

Navy/DLA have determined that the BAPT consists of a comprehensive tank restoration and nozzle decommissioning process, combined with coating applications and improved testing, monitoring, modeling, sampling, and analysis throughout the Facility's layers of protection. Since signing the AOC in 2015, the United States Department of Defense (DoD) has spent $162 million to maintain and improve the Facility. DoD anticipates spending an additional $256 million during this programming cycle to facilitate on-going and additional improvements.

Already Completed and On-going Improvements Include:

1. More Frequent Tank Tightness Testing

Navy/DLA test every tank's integrity twice as often as the state requires. Each tank containing petroleum product now undergoes semi-annual tank tightness testing as a best management practice.

2. Increased Inventory of Monitoring Wells

Navy/DLA have installed an additional seven monitoring wells – including Westbay multi-level monitoring systems. Since 2014, Navy/DLA have increased the total number of monitoring wells from eight to 15, as well as one test boring with the capability to measure water levels. Navy/DLA also plan to install eight additional monitoring wells by the end of 2021.

3. Comprehensive Groundwater Modeling

Navy/DLA established the groundwater modeling working group to better collaborate with DOH, EPA, Honolulu Board of Water Supply (BWS), United States Geological Survey (USGS), University of Hawaii (UH), AECOM, and GSI Environmental to develop a new groundwater model.

These experts developed an interim groundwater model using data that greatly improves the understanding of the aquifer. The interim model indicates groundwater generally flows from the Facility towards the Red Hill Shaft.

4. Supplementary Approach to Release Detection via Groundwater Sampling and Soil Vapor Monitoring

Navy/DLA conduct groundwater sampling and analysis from each monitoring well quarterly to confirm fuel constituents from prior releases are being naturally degraded. Additionally, Navy/DLA check the monitoring wells below the tanks monthly for the presence of petroleum. Navy/DLA also conduct monthly soil vapor monitoring in several locations beneath each tank to test for the presence of volatile organic compounds.

5. Inclusive Navy-BWS-USGS Synoptic Water-Level Study

Navy/DLA and the BWS have been working closely with the USGS to evaluate water levels in monitoring wells during pumping or rainfall. The results of this inclusive study further help to understand groundwater flow in the area.

6. Quicker Procedure for Rapidly Draining Tanks

New procedures allow operators to transfer fuel out of a tank within 36 hours.

7. More Accurate Inventory Monitoring and Trend Analysis Using Automated Fuel Handling Equipment (AFHE)

Improved procedures enable operators to identify a potential fuel release (however unlikely) more accurately than in the past by leveraging trend analysis techniques and rigorous oversight. Operators are required to report alarms immediately and the Operations Supervisor reviews the alarm logs to confirm there are no unscheduled fuel movements.

8. Regulator-Approved Clean, Inspect, and Repair Process

Navy/DLA are firmly committed to protecting the environment and drinking water supply through continual improvement of the tank Clean, Inspect, Repair (CIR) program. Navy/DLA have improved those protections through the implementation of EPA/DOH-approved procedures, technological advances, and expanded understanding of key environmental conditions. The current tank CIR program is effective and Non-Destructive Evaluation (NDE) methods assure the full repair of each tank interior.

9. More Effective Identification and Repair of Existing Concrete Tanks with Steel Liners

Steel liner integrity of existing tanks has improved due to the NDE methods used to identify repair locations to bring tanks into compliance with current construction and welding standards.

10. Higher Standard for Tank Inspection, Repair, and Maintenance

The Tank Inspection, Repair, and Maintenance (TIRM) Procedures were approved by EPA and DOH in September 2017. The current standard for inspecting tanks, American Petroleum Institute (API) 653, requires inspecting a percentage of total surface area. Navy/DLA manually inspect the entire interior surface as part of a modified API 653 procedure during each CIR project.

Furthermore, Navy/DLA are investigating and researching new methods to improve TIRM Procedures, including testing robotic scanning technologies, evaluating alternative coatings, and outreach to learn from industry.

11. Theater-wide Fuel Requirements Study

The U.S. Indo-Pacific Command (USINDOPACOM) fuel study will allow modeling of current and future fuel requirements for the U.S. military in the Indo-Pacific. The decision tool will inform, for example, how much bulk fuel storage will be required in Hawaii for peacetime and contingency operations today and in the future. The study will be completed by the end of December 2019.

Additional Improvements – Near-Term

In addition to the above completed and on-going improvements, Navy/DLA propose implementing the following near-term improvements:

1. Enhanced Release Detection

In addition to AFHE which monitors small changes (1/16 of an inch) in fuel level, Navy/DLA plan to install permanent release detection equipment which will detect a release rate of 0.5 gallons per hour (gph) in each tank containing fuel by the end of 2022.

2. Real-Time Continuous Soil Vapor Monitoring Pilot

Navy/DLA will test continuous (vice monthly) soil vapor monitoring to determine if this additional fuel release detection method is viable. This approach will help detect fuel releases in real time.

3. Better Tank Fill Practice and Epoxy Coating

Navy/DLA no longer fill tanks to the maximum level after determining the majority of repairs are required in the upper dome. This new practice further reduces the risk of a fuel release. The lower domes of the tanks are being coated with Polysulfide Modified Novolac Epoxy (PMNE) to reduce corrosion. Navy/DLA are also evaluating coatings that could act as a liner and provide corrosion resistance. Laboratory testing of those coatings will be completed by the end of September 2019.

4. Improved Accuracy of Automatic Tank Gauging Equipment Through Modification of Stilling Wells

Navy/DLA will modify carbon steel automated tank gauging stilling wells with slots during each CIR project to provide more precise automatic tank gauging data and allow for more accurate fuel level monitoring. This improvement will be sequentially completed for each tank during the CIR process.

Additional Improvements – Mid-Term/Long-Term

In addition to the above completed and on-going improvements, Navy/DLA propose implementing the following mid-term/long-term improvements:

1. Reduced Risk by Decommissioning Small Nozzles from Service

Navy/DLA are decommissioning selected nozzles (those too small for a human to inspect from the inside) from service during each CIR project. The Quantitative Risk and Vulnerability Assessment (QRVA) quantified areas that are the most likely source for a fuel release. The study concluded that the nozzles, not the tanks, have the most potential for a fuel release. Navy/DLA are therefore taking action to remove them from service.

2. Addition of Eight More Monitoring Wells

Navy/DLA plan to install eight monitoring wells by the end of 2021. These additional wells will increase the total from 15 to 23 monitoring wells.

3. Experimental Pilot Project to Fully Coat Interior Surface of a Tank

Depending upon the results of the aforementioned laboratory testing of coatings, Navy/DLA will evaluate fully coating the interior surface of one tank to see if that coating can act as an additional liner (as well as providing corrosion resistance).

4. "Double-Wall Equivalency" Secondary Containment or Removal of Fuel in the 2045 Time Frame

Navy/DLA will implement either "double-wall equivalency" secondary containment or remove fuel from Red Hill in approximately the 2045 time frame. Navy/DLA will determine the expected service life of the Facility and evaluate alternate bulk fuel storage options. A plan for placing the empty tanks in a strategic ready reserve status will also be developed for the event of wartime requirements.

5. Water Treatment Plant

Navy/DLA will determine the feasibility for potential construction of a water treatment plant or equivalent engineering controls for the aquifer below the Facility. No later than 2022, Navy/DLA will evaluate the design, logistics, operations, and sustainment requirements for such a facility in order to estimate the cost and construction schedule. Navy/DLA will incorporate into its evaluation how to best attain future DoD military construction funding, as applicable. All proposed improvements are subject to the availability of appropriations.

Implementation

Navy/DLA are confident that the implementation of this comprehensive approach will provide the layers of protection necessary to prevent and mitigate any potential for future fuel release. In the document that follows, Sections I and II and Appendices A through D detail the purpose, objectives, and content of these decisions, and the analytic underpinning that guided Navy/DLA to reach them. Additionally, Section III provides an implementation schedule of on-going and additional improvements that will be made to the Facility. These measures thoroughly demonstrate Navy/DLA commitment to ensuring that safe drinking water from the Red Hill aquifer remains available to our military families and Oahu neighbors today and tomorrow.

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I. Tank Upgrade Alternatives Decision Document

A. Purpose and Objectives

The purpose of the TUA Decision Document is to satisfy the Red Hill AOC requirements and thereby advance the goals of ensuring that groundwater in the vicinity of the Facility is protected, that the Facility is operated and maintained in an environmentally protective manner, and that the Navy is able to sustain its mission in the USINDOPACOM area of responsibility (AOR).

Section 3.5 of the AOC requires Navy/DLA to submit a TUA Decision Document to the regulatory agencies for approval that identifies the BAPT and the manner in which BAPT will be implemented in all in-service tanks used to store fuel at the Facility.

The requirements applicable to the Facility are detailed further in Appendix B: Legal, Statutory and Regulatory Requirements.

The objectives of this document are to:
1. Convey the Navy's recommended BAPT for the Red Hill TUA;
2. Explain the reasons the Navy selected this BAPT for the TUA; and
3. Obtain regulator concurrence with the Navy's choices for BAPT for the TUA.

Key objectives for Navy/DLA are the prevention of future releases of fuel from the tanks at Red Hill, to ensure that the DoD does not expose the public drinking water sources to contaminants, and to ensure the Facility is operated and maintained in a safe and environmentally protective manner, while simultaneously meeting the DoD mission.

Definition of BAPT

The primary objectives of the AOC are to ensure that the drinking water resources in the vicinity of the Facility are protected and to ensure that the Facility is operated and maintained in an environmentally protective manner. The Navy, DLA, DOH and the EPA have agreed that these objectives can best be accomplished by ensuring that the tanks and other infrastructure deploy the BAPT to prevent fuel releases, developing a better understanding of the hydrogeology of the area surrounding the Facility, and by conducting an assessment of the risk to the groundwater resources that may be posed by the Facility.

BAPT is defined as the release prevention methods, equipment, repair, maintenance, new construction and operational procedures, or any combination thereof, that offers the best available protection to the environment, and is feasible and cost-effective.
The selection and approval of BAPT is based on consideration of the following factors:
1. Risks and benefits of the particular technology;
2. Capabilities, feasibility, and requirements of the technology and facilities involved;
3. Anticipated operational life of the technology; and

4. The cost of implementing and maintaining the technology.

The AOC Statement of Work advises that "Reliance on any one of these factors to the exclusion of other factors is inappropriate".

Section I of this document discusses the Navy/DLA proposed Tank Upgrade Alternatives and the supporting analysis with respect to the TUA Decision. Section II discusses the Navy/DLA proposed Release Detection Decision and the respective supporting analysis. Section III discusses the proposed implementation of the recommendations for both decisions. Appendices contain additional information used in determining the proposed recommendations for both the TUA and Release Detection Decisions.

B. Decision

Based on the BAPT, Navy/DLA propose a comprehensive tank restoration and nozzle decommissioning process, combined with coating applications and improved testing, monitoring, modeling, sampling, and analysis throughout the Facility's layers of protection. Navy/DLA will continue to pursue improvements to clean, inspection and repair technologies and procedures.

Navy/DLA have reviewed the TUA Report and have concluded that the most practicable tank upgrade alternative is to retain the reinforced concrete, single-walled steel tank liner configuration, while permanently adopting the significantly upgraded tank CIR program, which was adopted after the 2014 release.

The tank clean, inspect and repair program is the most effective, cost-efficient, and safe means of ensuring and maintaining the integrity of the steel tank liner.

The TUA Report highlighted the technical compromises, construction risks, execution risks, operational impacts and indicative capital funding forecasts and project schedules. Analysis of the TUA report shows that all the other tank upgrade alternatives provide minimal reduction of risk while requiring significant additional cost to taxpayers. The estimated capital costs of the double-walled Tank Upgrade Alternatives are not justified when compared against the costs and benefits of the TUA Decision with the implemented technical and mitigating improvements.

Navy/DLA believe there is adequate evidence to conclude that the current post-2014 CIR program is the best available practicable technology to maintain the integrity of the steel tank liner. This stance is supported by tank tightness testing results, soil vapor monitoring, and groundwater monitoring which continues to provide evidence the drinking water is safe for public consumption.

A brief description of each of the improvements included in the TUA Decision follows.

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Costs Budgeted

Beginning with the signing of the AOC in 2015, DoD has spent $162 million to maintain and improve the Facility. DoD anticipates spending an additional $256 million before October 2024 to continue to maintain and improve the Facility.

C. Analysis of Decision

Navy/DLA arrived at the TUA Decision after careful analysis of the four following criteria: environmental protection; impact to operations; practicality of construction and maintenance; and, fiscal responsibility and cost effectiveness. A detailed evaluation and comparison of the TUA Options is presented in Appendix C.

Assumptions Applied to the TUA Decision

All assumptions in this section are documented to provide background for the recommendations made in this report. New information regarding these assumptions will be reviewed and incorporated into future recommendations for the Facility moving forward.

In finalizing decisions with respect to the TUA Decision, it is assumed that:

1. A comprehensive approach for evaluating Tank Upgrade Alternatives and release-detection alternatives is the appropriate methodology for determining the future operation of the Facility, taking into consideration the environmental performance, operational performance, practicability, cost and effective risk reduction of all options;
2. Prior to 1983, releases were not required to be reported. After 1983, other than the 2014 release, available records indicate there have been no verified releases of fuel from the Facility;
3. The 2014 release was caused by poor workmanship, ineffective quality control and quality assurance, and inadequate response procedures. Updated processes and procedures for inspection, testing, quality control, and quality assurance have already been implemented and will prevent reoccurrence of a similar incident;
4. NDE is a reliable method for detecting corrosion in the tank liner;
5. Since there are no standards directly applicable to large field constructed underground storage tanks, Navy/DLA have adopted principles from the API Standards for above-ground storage tanks for the Facility. It is assumed that the tank integrity management program at the Facility is effective;
6. The potential impact of minor and significant releases to the drinking water is accurate within an order of magnitude and is based on current regulated maximum contaminant levels;
7. The Facility is well protected against kinetic attacks by the significant depth of the volcanic rock above the tanks, which is greater than 100 feet in all areas; and

8. In the unlikely occurrence of a major seismic event or other catastrophic release, all of the Tank Upgrade Alternatives considered would perform in a similar manner.

Environmental Protection

The storage and handling of petroleum is a specialized practice, undertaken throughout the world by a wide variety of industries. The American Petroleum Institute Standards set out the best practice for the design, construction, operation and maintenance of installations for the storage and handling of petroleum products, as well as provide guidance on standard operational practices and emergency management.

As part of the management of a bulk fuel storage facility, the operator is required to identify the credible risk scenarios that apply to the facility, and must have a management system which effectively manages those risks. Risk management generally consists of a combination of preventative and mitigating measures, which are designed to prevent the occurrences of incidents, maximize the probability that incidents will be detected, and minimize the impacts of any incidents that occur.

The preventative and mitigating measures implemented at the Facility are referred to as "Layers of Protection," consisting of a combination of engineering, administrative and procedural controls for the management of risk.

The equipment, processes and procedures work in conjunction with the TUA chosen to prevent, detect and mitigate risks. In addition to the existing controls, Navy/DLA implement additional administrative and engineering controls to further reduce the risk of product being released. Figure 1 and Table 1 consider the scenario of product being released through the steel tank liner, and shows graphically how the preventative controls, release detection systems, and release mitigation processes work together to manage the impact of the two identified risk scenarios: In-Service Corrosion of the Steel Tank Liner and Inadequate Tank Repair. Each of the boxes on the diagram represents procedures, engineering or administrative controls which are designed to prevent or mitigate an incident. As each risk management process independently manages an identified risk, the layers of protection work collectively to prevent, detect and mitigate all the incident scenarios that have been identified as credible, and require risk management.

The TUA Decision implements preventive controls, release detection, and release mitigation. These layers of protection taken together provide new, improved and significant protection to the environment. Figure 1 shows an example of the layers of protection incorporated to keep the drinking water safe for public consumption in the unlikely event of a release through the steel liner.

The concept of layers of protection is illustrated for a hypothetical case of a product release through the steel liner of a tank at the Facility. As the diagram shows, there are multiple layers of protection in place to prevent the occurrence of releases, as well as multiple controls to detect and mitigate the impact of any releases. The TUA Decision to implement these layers of protection is more effective because it is not best practice to solely rely on any one component of the system.

Preventive control measures include internal coating of steel tank liner and the TIRM Procedures. Prevention is the key to unintended release control. To prevent corrosion of the steel liner of the tank, a polyurethane coating has been applied since the 1960s. An additional coating is applied to the lower dome of the tank. This coating reduces the risk of fuel being released through the bottom of the tank. Pending the results of an ongoing experiment, a pilot project taking advantage of new technology will apply the same coating protecting the lower dome to the barrel section and extension ring.

Another preventive control is the TIRM Procedure. During the TIRM Procedure, a tank is completely emptied and then carefully inspected. When any substandard sections are found, they are fixed to current standards. The aim of the TIRM Procedure is to certify the tanks for storing fuel for at least the next 20 years. Currently, it costs approximately [redacted] to inspect and repair each tank. The costs have increased because new technology permits better quality inspections and repairs than was possible in prior years.

Navy/DLA are decommissioning smaller nozzles (those too small for a human to inspect from the inside) to reduce the risk of a release. As each tank moves through the TIRM Procedure, the nozzles that are no longer required will be decommissioned after the fuel in the tank is removed. The TIRM Procedures will result in tanks that are better coated and with fewer nozzles than when originally constructed, thus reducing the risk of a release.

Release-detection measures include semi-annual tank tightness testing, an enhanced release-detection system, automated fuel-handling equipment alarms, soil-vapor monitoring, and groundwater monitoring.

Release-mitigation measures include procedures for tank defueling. In order to quickly stop an unplanned release a tank can be emptied by shifting fuel to other tanks. As soon as the fuel level drops below the location in the tank of the unplanned release, the release stops.

Table 1 describes the Summary of Layers of Protection for "Product Release through Steel Tank Liner" Scenario.

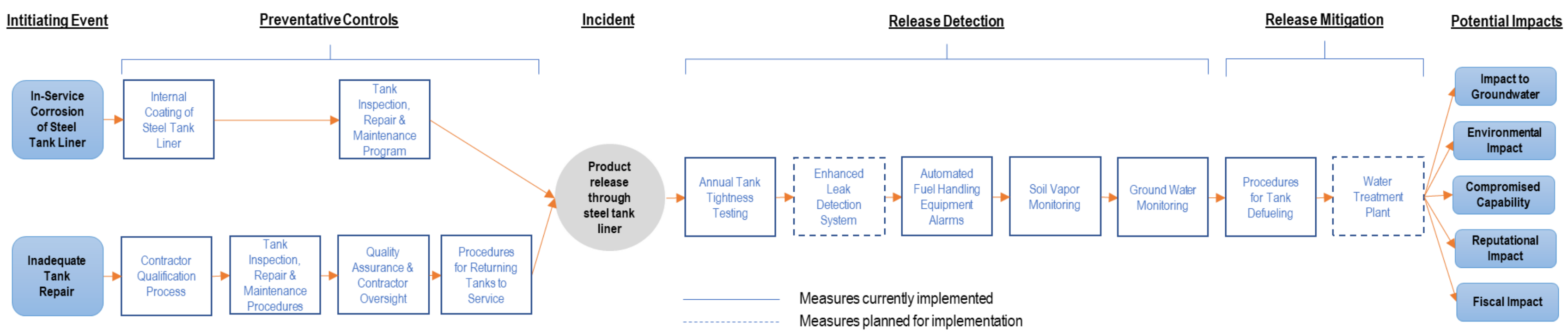

Figure 1: Risk Management Diagram showing "Layers of Protection" as Applied to a "Product Release through Steel Tank Liner" Scenario

Table 1: Summary of Layers of Protection for "Product Release through Steel Tank Liner" Scenario

Risk Control	Type of Barrier	Type of Control	Benefit of Control being in place	Current Status
Internal Coating of Steel Liner	Preventative/ Precautionary	Engineering	Internal surface wall of tank below the maximum fill line is coated to prevent internal corrosion of the steel tank liner.	Implemented
Tank Inspection, Repair and Maintenance Program	Preventative/ Precautionary	Engineering	Tanks are regularly taken out of service and thoroughly inspected and repaired in accordance with TIRM Procedures (updated since 2014 release).	Implemented
Contractor Qualification Process	Preventative/ Precautionary	Procedural	Ensures contractors performing work are appropriately qualified and competent to undertake inspection, repair and maintenance of tanks.	Implemented
TIRM Procedures	Preventative/ Precautionary	Procedural	Ensures consistency of inspection and repairs, embeds lessons learned from previous repairs into future processes.	Implemented
Quality Assurance and Contractor Oversight	Preventative/ Precautionary	Procedural	Dedicated quality assurance and contractor oversight to ensure that inspection and repairs have been executed correctly.	Implemented
Procedures for Returning Tanks to Service	Preventative/ Precautionary/ Response	Procedural	Staged introduction of fuel reduces the potential volume of a release during tank filling.	Implemented
Semi-annual Tank Tightness Testing	Preventative/ Precautionary (Detection)	Engineering & Procedural	Tank tightness performed semi-annually to confirm integrity of steel tank liner.	Implemented
Enhanced Release-Detection System	Preventative/ Precautionary (Detection)	Engineering & Procedural	Permanently installed release-detection system, provides higher level of accuracy, allowing early detection of potential releases.	Planned for implementation
AFHE Alarms & Processes	Preventative/ Precautionary (Detection)	Engineering & Procedural	Automated Fuel Handling Equipment identifies unplanned fuel movements and product discrepancies, provides timely alarms to ensure rapid operational response and investigation.	Implemented
Soil Vapor Monitoring	Preventative/ Precautionary (Detection)	Engineering & Procedural	Allows for detection of product in the surrounding basalt.	Implemented
Groundwater Monitoring	Preventative/ Precautionary (Detection)	Engineering & Procedural	Allows for detection of product in groundwater wells.	Implemented
Procedures for Tank Defueling	Response	Administrative	Procedures for drain-down of tanks in the event of a release, thus minimizing the potential volume of any release.	Implemented
Water Treatment Plant	Response	Engineering	Provides a means of remediating the water supply in the event of a significant release.	Under evaluation

In addition to the measures to minimize the risk of a release from the Facility, the surrounding receptors, fate modeling, and natural biological attenuation of any Minor Releases have been considered. The environmental modeling recognizes that there are multiple aquifers in the immediate vicinity. However, it presently concludes that Minor Releases from the Facility will not impact Oahu's drinking water. All of the environmental studies were considered in determining that the selected alternative meets the criteria for BAPT.

The BAPT for the TUA Decision should not be confused with "Best Available Technology." The term "Practicable" is used in the AOC to recognize that any proposed alternative is expected to be able to be successfully implemented. It also recognizes that public funds must be used appropriately to support the implementation of technology that is cost-effective in the overall reduction of risk. The TUA Decision meets these criteria and as outlined in Section 3 of the AOC. As risk management is a combination of preventative and mitigating risk control measures, it is rarely practical for any risk management system to be entirely preventative, or entirely mitigating. Through the multiple studies initiated in relation to the Facility, Navy/DLA are committed to providing the resources to continue to implement a targeted risk reduction program based on the implementation and strengthening of preventive and mitigating controls for credible incident scenarios.

Tank Inspection, Repair and Maintenance (TIRM)

TIRM Improvements – Implemented Since 2014 & Currently Being Implemented

The following sections detail significant improvements that have been implemented since the 2014 release, and improvements that are currently being implemented. This list is a summary of activities with a significant impact on operational risk reduction.

It is critical to note that the TIRM Procedures have been significantly improved since the 2014 release, and as such does not represent maintenance of the "status quo" for tank inspection, repair and maintenance. The current TIRM Procedures were approved by both the EPA and the Department of Health in 2017

1. Specification for Tank Inspection

Detection of corrosion and tank integrity-related defects are important elements in effective TIRM Procedures. Inspection procedures at the Facility have been and are continually being reviewed and improved. The appropriate method to document the process and improvements is through criteria. Navy/DLA developed a Unified Facilities Guide Specification (UFGS) Section in accordance with MIL-STD-3007F, which formalizes criteria for a fuel tank inspection and memorializes process innovations to minimize the probability of releases due to a poor inspection of tanks.

The specification standardizes tank inspections, establishes the basis for future inspections, leveraging lessons learned, and sets minimum performance standards. This specification will have the effect of reducing variability in inspection results, improving data integrity and formalizing the process for proposing inspection personnel for Government quality assurance oversight.

2. Specification for Tank Repair

The Navy's review of available tank records going back to the 1940s reveals that over 47 percent of releases occurred as a result of ineffective repairs and were discovered during the return to service evolutions. To improve the tank repair process and address lessons learned from Tank 5, Navy/DLA have developed a UFGS Section to formalize criteria for a Red Hill tank repair to minimize the probability of releases due to improper repair of tanks.

The specification standardizes multiple aspects of repair, establishing the basis for future repair designs, leveraging lessons learned, and setting minimum performance standards. This specification will have the effect of reducing variability for repairs, establishing minimum certification requirements for key roles, formalizing weld inspection and documentation requirements, and specifying material requirements for repairs.

3. Separation of Management Roles across Separate Individuals

To improve the process used to inspect and repair tanks, Navy/DLA have separated the roles and responsibilities for project management, construction management, and design management. The separation of these roles increases oversight and reduces the probability of a release due to over-reliance on single individuals. The separation of management roles among different personnel spreads workload more evenly, allowing better Quality Assurance, while leveraging the expertise of various Naval Facilities Engineering Command (NAVFAC) communities.

4. Location of Construction Management and Quality Assurance Oversight on Oahu

Navy/DLA's subject matter experts (SMEs) for fuel tanks are located in Port Hueneme, CA and Fort Belvoir, VA. To improve the process to inspect and repair tanks, Navy/DLA have located the construction management role on Oahu to increase construction oversight and reduce the probability of a release due to inadequate Quality Assurance oversight.

The Construction Manager, Contracting Officer's Representative, and Engineering Technician provide primary Navy/DLA oversight of construction. The consistency and efficiency of quality and safety oversight is substantially improved when the individuals performing these roles are required to be located on Oahu.

5. Use of Standard Design-Build Contract Specific to Fuel Work

To improve the process for inspecting and repairing tanks, Navy/DLA awarded a specialty construction contract for fuel systems formalizing the NAVFAC design-build model and deploying specialty engineering and construction expertise. The contract details requirements for products, material, and workmanship, as well as requirements for contractor quality control, safety, and schedule. Potential contractors are evaluated based on their experience and technical expertise in the field of fuel systems, including tank inspections and repair.

6. New Filling and Return to Service Instruction

Fleet Logistics Center Pearl Harbor (FLCPH) treats tanks being returned to service as having an increased potential for releases. All tanks containing petroleum, oil, or lubricant products under formal inspection programs must comply with Naval Supply Systems Command (NAVSUP) Global Logistics Support Instruction 10345.1.

The new instruction standardizes the filling and return-to-service process for a storage tank, including administrative requirements and approval processes, mandates a tank inspector certify that tanks are suitable for return to service, including any caveats, clarifications, or limitations that would affect tank operations after return to service, and requires a Final Inspection Report prior to refilling. The instruction also requires the development of a tank-specific Operations Order; a specific procedure which includes tank filling procedures, physical inspection, gauging, trend analysis, and emergency drain-down plan, and is approved by the FLCPH Commanding Officer (CO) prior to refilling the tank.

7. Update UFGS Section 33 65 00 Cleaning Petroleum Storage Tanks

The specific benefits of this updated specification are to indicate pressure requirements for water used during tank cleaning to provide assurance that the existing coating will not be stripped during the cleaning operations, and requires the contractor to perform quality control on a test patch to ensure that pressure cleaning will not cause well-adhered coating to disbond from the tank shell.

TIRM Improvements – Planned for Implementation

8. Spot Coating of Areas where Coating is Currently Disbonded

Areas more susceptible to internal corrosion are coated with a barrier system which minimizes chance of bimetallic corrosion between new and old steel and in heat-affected zone of fillet welds.

9. Modify ATG Stilling Wells

The existing carbon steel ATG stilling wells will be modified with slots during each CIR project to prevent stratification of the fuel in wells compared to the bulk tank, providing more precise ATG data.

10. Documenting Tank Conditions

Each Red Hill tank has unique conditions and repairs. In order to reduce variability and increase the quality of designs, Navy/DLA are currently documenting the known history, repairs, and conditions of each Red Hill tank into a set of record documents. The record documents would be used by the various engineering firms in performing the tank inspection and repair. The records documents would accompany new inspection and repair specifications.

The benefits of these documentations are:

1. The drawings will be used for future inspection and repair projects;
2. The designs will complement the new inspection and repair specifications;
3. As-built documentation will capture future changes, updates, and improvements to the tanks; and
4. Reduce the variability of documentation between engineering firms by utilizing government provided templates to assure uniformity and accuracy.

Soil Vapor Monitoring

Current Practices

Monthly, discrete testing of soil vapor is currently conducted at soil vapor monitoring points (SVMP) beneath each of the 18 active tanks. Results are reported monthly to DOH as required by the Groundwater Protection Plan, which was approved by the DOH. Each SVMP is monitored at three different depths (shallow, middle and deep, beneath each tank,) for Volatile Organic Compounds (VOCs) using a Photo-Ionization Detector (PID). The soil vapor monitoring results are a means of identifying any changes to the subsurface hydrocarbon profiles, which can be used as an additional trigger for causative research to occur.

If the PID detects over 280,000 parts per billion of VOCs by volume (ppbv) (i.e. half the calculated concentration expected above water with dissolved Jet Propellant (JP) 8 at the solubility limit) for tanks containing jet fuels, or 14,000 ppbv (i.e. half the calculated concentration expected above water with dissolved diesel fuel at the solubility limit) for tanks containing diesel fuel, then actions will be taken to assess the integrity of the associated tank system and mitigate, as needed, for potential fuel releases. If, after an inspection of the tank system, it is uncertain whether a release exists, it is recommended that soil vapor samples be taken for laboratory analysis.

In order to continuously improve the release-detection processes for the Facility, Navy/DLA are considering the available technologies for expansion of the soil vapor monitoring program to a real-time vapor monitoring system. As hydrocarbons are known to occur beneath the tanks from known historical releases, one concern is whether such a system will generate valuable data, and whether the system would generate false alarms.

Refinements to the Evaluation of Monthly Soil Vapor Monitoring Results

The existing soil vapor monitoring program has been evaluated and recommendations have been developed that would enhance the current monthly release-detection program as well as potentially reduce or eliminate the number of false-positive events. Data from the 2014 release indicates that soil vapor monitoring can provide an effective approach for evaluating release detection. The recommendations will not change the current procedures for the monthly PID monitoring, they will only change the data evaluation and response action levels.

New action levels of 50,000 ppbv for tanks with Jet Fuel and 8,000 ppbv for tanks with Marine Diesel are recommended. The threshold (action-level) values are based on an empirical review of the monthly PID monitoring results from 2008 to present, a dataset covering 146 monthly monitoring events. An action level of 50,000 ppbv appears to be an appropriate threshold between background levels and elevated vapor concentrations potentially associated with a tank release.

The existing protocols for evaluation of soil gas monitoring events uses a concentration trend methodology to trigger causative research. Use of this trend-based approach has led to causative research which did not reveal evidence of inventory control problems. In addition, the 2014 release from Tank 5 was detected as part of inventory control reconciliation. The leak would not have been detected for several months using only the trend-based soil gas monitoring. Use of the 50,000 and 8,000 ppb thresholds for jet fuel and diesel fuel, respectively, would have allowed the release to be detected sooner and independent of inventory control measures.

Based on 10 years of monitoring, the concentration trend evaluations do not appear to be useful for identification of possible fuel releases, and therefore will be discontinued.

Response to Action Level Exceedance

If a PID reading above the new action level is recorded for a tank where the inventory reconciliation system (IRS) does not indicate a release, additional sampling will be conducted to distinguish between natural variations in baseline PID readings and a possible new release (thus minimizing/eliminating issues with false positives). Once a PID reading above the Action Level has been identified, an additional sample will be immediately collected (i.e. the same day) from the same location in a Summa canister sample. The supplemental sample will be collected and analysed in accordance with EPA Compendium Method for Toxic Organics (TO-15) using gas chromatography/mass spectrometry.

The determination of fresh versus weathered hydrocarbons will be made based largely on evaluation of the laboratory chromatogram (e.g., the presence of n-alkanes and lighter-end hydrocarbons associated with unweathered petroleum). This additional evaluation of whether an elevated PID reading is attributable to historical releases will further reduce the potential effort required by the Navy/DLA and FLCPH to respond to false positive release indications, and will provide more definitive information of potential new releases to ensure the prevention of contaminants migrating to municipal water supplies.

Considerations for Continuous Soil Vapor Monitoring – Pilot Test

A method for conducting a continuous soil vapor monitoring program is proposed to provide more rapid detection of a new fuel release compared to monthly PID monitoring. However, prior to determining if a facility-wide continuous soil vapor monitoring program is appropriate, a pilot test should be performed.

The goals of the pilot test will be to determine:

1. Whether the equipment used for continuous monitoring is sufficiently reliable, robust, and cost effective; and
2. Whether the continuous monitoring results are of sufficient quality to reliably identify a new fuel release while minimizing false-positive release indications.

The proposed pilot test will consist of a monitoring system for one to three tanks (Tanks 5, 7, and 8). An auto-sampler will be connected to each SVMP at each of the three tanks. A laboratory grade PID (not gas chromatography/mass spectrometry) will be used to analyze the soil vapors, and the data will be stored in a data recorder at the site. Since this is a pilot test, data will be manually accessed periodically for evaluation over six months to one year. The pilot test results will not be used directly for release detection purposes.

The pilot test results will be used to verify that: a) the design and operation of the continuous monitoring system is appropriate; and b) the results are reliable and consistent with monthly monitoring results. In addition, the pilot test data will be used to identify action levels for a full-scale continuous monitoring system, should one be developed, which will help to identify new fuel releases while minimizing false positive results. If this approach is deemed appropriate, data can be reviewed and action levels can be refined on a tank-by-tank basis to further improve release-detection capabilities.

During the pilot test, the monthly PID monitoring conducted by others will continue, and those monthly results will be evaluated using the new recommended criteria.

If a determination is made to conduct continuous soil vapor monitoring across the entire Facility, data will be sent by hard wire telemetry to the control room for real-time evaluation based on tank-specific baseline concentrations developed as part of a start-up program.
The advantages of continuous PID monitoring may include:

1. Real-time release detection, which may significantly reduce the time to determine whether a release is occurring;
2. Significant reduction/elimination of false-positive events;
3. Refined ability to relate release timing to tank/facility operations, allowing for more effective determination of potential release causes; and

4. Ability to determine tank-specific background soil vapor concentrations for development of more robust release-detection capabilities that may further enhance release-detection capabilities.

While there are no industry best practices for development of such a soil vapor monitoring program for release detection, due to the unique nature of the Facility, data demonstrates that soil vapor monitoring beneath the tanks can provide an effective means of secondary release detection at the Facility.

Groundwater Monitoring

Groundwater monitoring utilizes monitoring wells located inside and outside the lower access tunnel (LAT) and sampling point Red Hill Monitoring Well (RHMW) 2254-01, where groundwater samples are collected and analyzed quarterly for petroleum products, with results compared to site-specific risk-based levels for total petroleum hydrocarbons, and to the DOH Environmental Action Levels (EAL) for concentrations of contaminants.

On a monthly basis, oil/water interface measurements are taken at the monitoring wells located in the LAT (RHMW01, RHMW02, RHMW03, and RHMW05) to measure for the presence of light non-aqueous phase liquids (LNAPL). These results are then reported to DOH on a monthly basis.

Groundwater monitoring results are reported to DOH on a quarterly basis. All groundwater samples are analyzed for petroleum constituents. Analytical results are compared to site specific risk based levels (SSRBL) for total petroleum hydrocarbons as diesel fuel (TPH-d) and benzene (TEC, 2008). Analytical results are also compared to DOH EALs for sites where groundwater is a current or potential drinking water source. The locations of existing groundwater monitoring locations are shown in Figure 2.

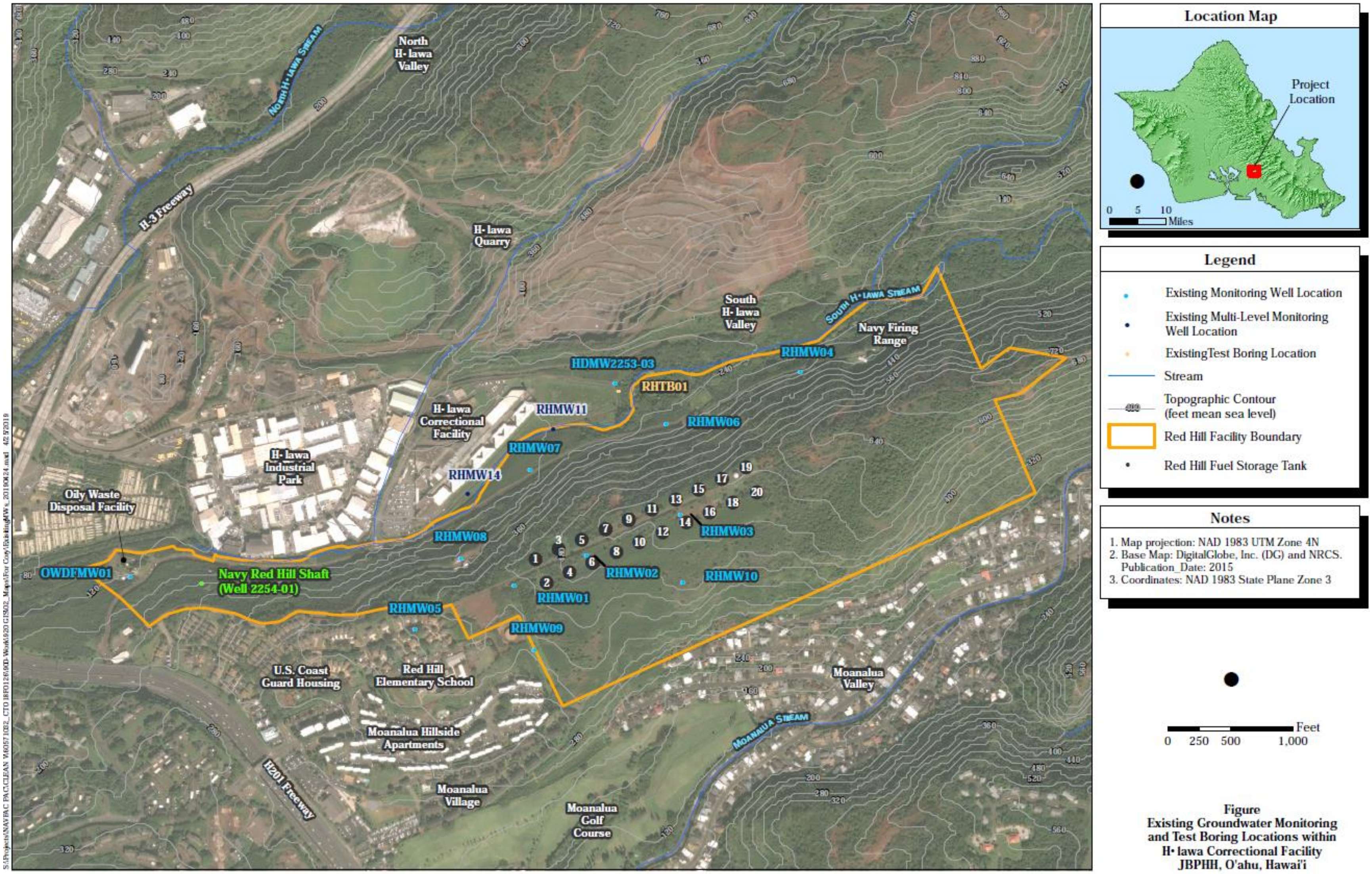

Figure 2: Map showing Existing Groundwater Monitoring Wells

Procedures for Rapid Tank Drain-down

If one of the multiple methods of release detection indicates the possibility of a release, the timeliness of any incident response can have a significant impact to the overall volume of fuel released.

Two key response measures which will mitigate the potential volume of fuel released are:
1. Removal of remaining fuel from any tank identified as releasing fuel; and
2. Prevention of further fuel being added into any tank identified as releasing fuel.

The removal of fuel from a tank that is releasing fuel requires an alternate fuel storage location for the remainder of the fuel, whereas prevention of further fuel being added into the tank is managed through fuel transfer procedures.

The available volume in a tank between the current liquid level and the maximum filling level is known as "ullage." The ullage of a tank is defined as the additional volume of fuel that can be added into the tank safely at that point in time. Where the combined ullage of all other tanks is insufficient to meet the current volume of ullage required, procedures are in place to drain the tanks to tankers if necessary.

Contingency Water Treatment Plant

In the improbable event that all of the control measures fail to effectively prevent or mitigate the release of fuel from the Facility, and observed conditions are not in accordance with the environmental modeling predictions, the protection of the drinking water would require removal of any contaminants from the groundwater prior to it entering the water system.

Navy/DLA will determine the feasibility for potential construction of a water treatment plant or equivalent engineering controls for the aquifer below the Facility. No later than 2022, Navy/DLA will evaluate the design, logistics, operations, and sustainment requirements for such a facility in order to estimate the cost and construction schedule. Navy/DLA will incorporate into its evaluation how to best attain future DoD military construction funding, as applicable. All proposed improvements are subject to the availability of appropriations.

In 2016, a study to Evaluate Treatment Technologies for the Red Hill Drinking Water Well[8] was completed by HDR, Inc. for NAVFAC Hawaii. The primary objective of the study was to identify and recommend a viable treatment system to protect the potable water supplied by the Red Hill Shaft. Currently, this same concept is being considered to develop a capture zone to prevent the migration of contaminants towards municipal water supplies and the surrounding environment. Costs of the proposed system were updated in 2018. The system recommendation was based on the previous site investigations, and reports on the Red Hill Shaft. This study:
1. Developed maximum allowable influent concentration (MAIC) limits for contaminants of concern to ensure compliance with existing regulations;

2. Identified treatment technologies capable of treating contaminants of concern to limits within existing drinking water regulations;
3. Identified three viable treatment system alternatives, conducted a hydraulic analysis of each alternative, and provided a budgetary cost estimate and a life cycle analysis for each alternative;
4. Recommended the optimum alternative as the basis for establishing a conceptual construction budget and programming project to construct the treatment plant if other environmental studies indicate that such a facility will become necessary; and
5. Proposed an action level limit for the treatment plant being implemented.

The EPA has identified granular activated carbon (GAC) as the best available treatment technology for the majority of organic contaminants, and has identified GAC and air stripping as the best available treatment technologies for the removal of volatile organic compounds. The combination of air stripping and GAC treatment has been proven to prolong GAC life expectancy, and is generally considered to be more cost-effective than using GAC alone as a treatment technology. Therefore, the combination process of air-stripping followed by GAC treatment was established as the best available practicable treatment technology for the Red Hill Shaft.

In the unlikely scenario of a Significant Release from the Facility, there is a high probability of the Red Hill Shaft being directly impacted within a short period of time. The environmental modeling predicts that for any Significant Release to be captured and prevented from entering the public drinking water source, the Red Hill Shaft would need to maintain continuous pumping, and thus would require a water treatment plant to ensure the quality of the drinking water being supplied to Joint Base Pearl Harbor-Hickam (JBPHH).

The mitigation of any releases from the Facility would be via the extraction of contaminated water via Red Hill Shaft. As the aquifer is a dynamic system, the rate at which the water is extracted is important to the development of a capture zone. As water level gradients in the vicinity of the site are very flat, this creates challenges for defining flow paths and capture zones. The mathematical representation of the physical configuration of the aquifer system, including preferential groundwater flow aligned with basalt flows, boundary conditions, and hydraulic conductivity contrasts (e.g., saprolite barriers) greatly influences groundwater flow directions and the development of capture zones.

The preliminary analysis from groundwater modeling shows that with Halawa Shaft pumping at 16 mgd (maximum sustainable rate, for an extended period of time), and the Moanalua Wells pumping at 3.7 mgd, particle tracking with the interim groundwater flow model indicates capture of groundwater underlying the Facility with Red Hill Shaft pumping at 5 mgd. The actual range of pumping would be in the order of 5-10 mgd to attempt to account for any simplifying assumptions of the interim groundwater flow model, and would account for known heterogeneity in the groundwater system. Development of a capture zone is highly dependent on what is being captured. For example, a capture zone to contain a small release from Tank 2 is expected to require pumping rates near the low end of the range provided. A capture zone to contain a large release from higher up Red Hill Ridge would require more pumping at higher rates to ensure containment, and thus the high end of the range will be used for the design of any water treatment plant.

The conceptual site model uses "steady-state" conditions. The sink terms in the model (Red Hill and Halawa Shafts and Moanalua Wells) were simulated as continuously pumping at a fixed rate. In reality these sink terms operate or can operate in a "transient" fashion, turning on and off, sometimes on a daily basis. Groundwater flow directions are different between pumping and non-pumping conditions, hence Red Hill Shaft will need to maintain a continuous pumping rate and contingencies, such as backup pumps, need to be considered to ensure that pumping continues as long as is required. The design of a GAC water treatment plant needs to consider both potential flow rates, and potential contaminant properties and mass flux.

Navy/DLA will determine the feasibility for potential construction of a water treatment plant or equivalent engineering controls for the aquifer below the Facility. No later than 2022, Navy/DLA will evaluate the design, logistics, operations, and sustainment requirements for such a facility in order to estimate the cost and construction schedule. Navy/DLA will incorporate into its evaluation how to best attain future DoD military construction funding, as applicable. All proposed improvements are subject to the availability of appropriations.

Impact to Operations

Due to the strategic nature of the Facility, one important consideration in the review of the TUA options is the impact on operations if the alternative is implemented. The tank upgrade alternative needs to consider how the execution of a tank upgrade alternative will affect the ability of the operations team to continue to receive and dispense fuel, to monitor and control the movement of fuel, and to respond to any incidents or events occurring within the area. Operations will be impacted by factors such as construction vehicles and machinery, work permitting requirements, temporary disconnection of services, and delivery/storage of construction materials.

This TUA Decision encompasses current approved practices, with improvements to operational procedures, maintenance practices, release detection, incident investigation processes and emergency response procedures, which have been developed since 2014. This alternative fully supports the operational and capability demand, while providing the required storage capacity.

The Facility is required to maintain a pre-determined quantity of strategically stored fuel at all times to support the DoD mission. The TUA Decision achieves this requirement without a reduction in fuel storage capacity.

Practicality of Construction and Maintenance

Constructability for any TUA must strongly be considered (although not at the risk of keeping the environment safe). This Facility is one of a kind. There are a limited of number of contractors that can effectively complete this work successfully. Historically, the largest challenge tank contractors have faced at the Facility is the difficulty of moving personnel, material, and equipment into the tunnel, and then into the tanks. Current contractors have sufficient experience with personnel and material handling necessary to implement the TUA Decision.

Occupational Safety and Health Administration (OSHA) Section 1910.252 c.2.ii stipulates a minimum ventilation flow rate of 2,000 cubic feet per minute for each welder in a confined space. If this ventilation rate is not achieved, personal airline respirators would be required. OSHA caveats this minimum requirement by stating that adequate ventilation to prevent oxygen deficiency and build-up of toxic materials is required, thus the minimum ventilation rate may not be adequate.

Due to limited welding required for existing repair operations, ventilation during welding has not historically been an issue. The TUA Decision should have sufficient ventilation capability.

Ventilation requirements for coating operations will vary depending on the coating product, ambient temperature, and relative humidity. All personnel applying coating inside the tanks after abrasive blasting will be outfitted with full face respirators with Type C NIOSH approval, thus ventilation will be for coating purposes, not personnel safety. Novolac products require ventilation but do not specify a number of required air changes per hour.

Fiscal Responsibility and Cost Effectiveness

Table 2 summarizes the estimated costs and year of completion necessary to complete construction for each alternative for all 18 tanks that would continue to contain fuel.

Table 2: Summary of Total Estimated Costs and Year of Completion for Each Alternative

Alternative	Total Estimated Costs	Estimated Year of Completion for BAPT
1A-Reconstruction of Existing Tank using Current CIR Program	[redacted]	2036
1B-Restoration of Existing Tank plus Interior Epoxy Coating (Single Wall)	[redacted]	2046
1D-Remove and Replace Existing Steel Liner with Interior Coating (Single Wall)	[redacted]	2039
2A-Composit Tank Carbo Steel with Interior Coating (Double Wall)	[redacted]	2041
2B-Composite Tank Stainless Steel (Double Wall)	[redacted]	2038
3A-Tank within a Tank, Carbo Steel, Full Interior and Exterior Coating (Double Wall)	[redacted]	2039
Alt-New Tanks (Double Wall) UST	[redacted]	2052

All the costs of improving the Facility will be paid by United States taxpayers. The expense of the improvements is justified by the importance of the Facility to national defense. Navy/DLA have a responsibility to ensure the TUA Decision is fiscally responsible and cost effective. The TUA Decision is a supportable budget decision. The TUA Decision provides equivalent or better safety and mitigation in a shorter time at less cost. The estimated cost of simply executing the CIR program alone described in the TUA Decision is within a range of [redacted]. Preliminary estimates indicate double-walled tank alternatives are roughly ten times more expensive than the TUA Decision. Furthermore, the anticipated project completion for the delivery of the double-walled tank alternatives is much later than the TUA Decision.

Studies Concerning the Future of the Facility

Navy/DLA will implement either "double-wall equivalency" secondary containment or remove fuel from Red Hill in approximately the 2045 time frame. Navy/DLA will determine the expected service life of the Facility and evaluate alternate bulk fuel storage options. A plan for placing the empty tanks in a strategic ready reserve status will also be developed for the event of wartime requirements.

USINDOPACOM is one of six geographic combatant commands defined by the DoD Unified Command Plan (UCP). USINDOPACOM is in charge of using and integrating United States Army, Navy, Air Force and Marine Corps forces within its AOR to achieve U.S. national security objectives while protecting national interests.

A USINDOPACOM fuel study is currently underway, which will determine the strategic fuel storage requirements across the Indo-Pacific Region. For security reasons, the results of this study will be classified. The USINDOPACOM fuel study will develop a model to inform fuel laydown and distribution requirements for the U.S. military in the Indo-Pacific area of responsibility. Once complete, the model can be used to help inform how much bulk fuel storage will be required in Hawaii, allowing DoD to make informed decisions with respect to decommissioning assets and prioritizing funding of military construction projects to meet future needs. The fuel study allows for strategic planning to occur with respect to any decommissioning of assets, new construction projects to be initiated, or changes to the volumes or grades of fuel being stored in each location.

Navy/DLA recognize that at some point, all assets become uneconomical to maintain, regardless of the structural integrity of all of the components that make up the asset. The management of assets is the combination of financial, economic, engineering and other practices applied to physical assets, with the objective of providing the required level of service in the most cost-effective manner. It includes management of the whole life cycle of the physical asset, including design, construction, commissioning, operation, maintenance, repair, modification, replacement and decommissioning. The effective life of an asset is not defined by the original design life; typically, the effective life of an asset is determined through a combination of engineering review and assessments of the ongoing cost effectiveness of continuing to operate and maintain the asset.

Informed by the results of the USINDOPACOM fuel study and asset management considerations, Navy/DLA will evaluate alternative fuel storage options on Oahu in order to meet the DoD fuel requirements. The study will investigate alternative locations for new storage tanks, as well as potential for commercial arrangements with industry partners. The scope of this work includes estimation of the ongoing costs associated with continuing to maintain and operate the Facility, along with recommendations regarding anticipated timeframes for a staged withdrawal of fuel and decommissioning of tanks at the Facility. A plan for placing the empty tanks in a strategic ready reserve status will also be developed toward the event of wartime requirements.

II. Release Detection Decision

A. Purpose and Objectives

The purpose of the Release Detection Alternatives Decision Document is to satisfy the Red Hill AOC requirements and thereby advance the goals of ensuring that groundwater in the vicinity of the Facility is protected, that the Facility is operated and maintained in an environmentally protective manner, and that the Navy is able to sustain its mission in the INDOPACOM AOR.

Section 4.8 of the AOC requires Navy/DLA to submit a Release Detection Alternatives Decision Document, including an implementation plan and schedule, to the regulatory agencies for approval that identifies the BAPT and the manner in which BAPT will be implemented in all in-service tanks used to store fuel at the Facility. Once approved by the regulatory agencies, Navy/DLA shall implement the Release Detection Alternatives Decision Document in accordance with the approved schedule.

The requirements applicable to the Facility are detailed further in Appendix B: Legal, Statutory and Regulatory Requirements.

The objectives of this document are to:
1. Convey the Navy's recommended BAPT for the Facility release detection technology;
2. Explain the reasons Navy/DLA selected this release detection technology; and
3. Obtain EPA and DOH concurrence for implementing the Navy/DLA proposed release detection technology.

Through the AOC, the Navy, DLA, EPA and DOH agreed that these objectives can best be accomplished by:
1. Ensuring that tanks and other infrastructure at the Facility utilize the BAPT to prevent fuel releases;
2. Developing a better understanding of the hydrogeology of the area surrounding the Facility; and
3. Conducting an assessment of the risk to the groundwater resources that may be posed by the Facility.

B. Decision

The proposed release detection at the Facility will include the following items to provide layers of protection to protect the public drinking water supply.

Install permanent enhanced release detection equipment

In addition to the AFHE that can currently monitor changes in level down to 1/16 of an inch, Navy/DLA plan to install permanent release detection equipment capable of Minimum Detectable

Leak Rate (MDLR) of 0.5 gph in each tank actively in use by the end of 2022. Once a permanent system is installed in all active tanks, Navy/DLA will have the ability to run as many tests as desired, which will be at a frequency that exceeds federal and state requirements of one annual test at 0.5 gph MDLR. Navy/DLA will certify the permanent release detection system on an annual basis to verify the integrity of the permanent system installed.

Conduct Semi-annual Tank Tightness Testing

Since 2008 when tank tightness testing began, every tank tested has successfully passed each tank tightness test. All Facility tanks containing petroleum products now undergo semi-annual tank tightness testing as a Best Management Practice (BMP), twice the frequency required by the current Hawaii State standard, which requires tightness testing to be undertaken annually.
Semi-annual tank tightness testing will continue at the Facility until the permanently installed enhanced release detection equipment is installed, at which point a policy decision will be made regarding the appropriate frequency for routine tank tightness testing to occur.

Install Slots in Stilling Wells to Improve ATG Precision

Slotted stilling wells are used to improve the precision of ATG equipment by dampening the effect of fuel movement on level instrumentation. Existing carbon steel stilling wells will be modified with slots for each ATG level probe during the CIR projects to improve the precision of ATG data, and allow for improved level monitoring.

Conduct a Real-time Soil Vapor Monitoring Pilot Project

Navy/DLA plan to conduct a pilot project to test a continuous soil vapor monitoring program to determine if a more-rapid detection method is available to detect high VOC concentrations rather than rely on the monthly sampling currently conducted. If effective, this process will be able to rapidly identify a release using soil vapor monitoring, in the unlikely event that a release occurs.

Install Additional Monitoring Wells

Since the 2014 release, Navy/DLA have installed an additional seven monitoring wells to increase the total of number of monitoring wells from eight to 15 in total. Navy/DLA plan to install eight additional monitoring wells for a total of 23 monitoring wells by the end of 2021.

Additional monitoring wells provide more information, to better confirm the direction of groundwater flow around the Facility, while confirming that groundwater is free from petroleum constituents.

Continue Ongoing Groundwater Sampling and Soil Vapor Monitoring

Groundwater sampling and analysis from each of the monitoring wells is conducted quarterly to confirm the groundwater in the basal aquifer continues to be free from petroleum constituents.

Additionally, every month the water surface of each monitoring well is checked for the presence of petroleum. Navy/DLA conduct soil vapor monitoring monthly in multiple locations beneath each tank to test for the presence of VOCs.

The current program of groundwater sampling and soil vapor monitoring will be expanded to include the additional groundwater monitoring wells and any results from the real-time soil vapor monitoring pilot program.

C. Analysis of Decision

Release Detection Measures in Place Prior to 2014

GSI Multifunction Tank Gauge Automatic Tank Gauging

In 2001, Navy/DLA installed the Multifunction Tank Gauge (MTG) ATG equipment manufactured by Gauging Systems, Inc. (GSI). This equipment was installed on all tanks at the Facility, including underground and above-ground storage tanks. This system, known as the MTG 3000, included a sensor probe and MTG electronics. In 2009, the MTG electronics were updated and the name changed to MTG 3012. The MTG 3012 measures temperature and pressure, and provides liquid level measurement data to the AFHE.

The MTG 3012 is a hybrid tank gauging system, combining traditional and hydrostatic tank gauging qualities, measuring both mass and density. Each tank is fitted with a vertical array of temperature and pressure sensors, which provide data which the software converts to the data used in the tank level module of the AFHE. The MTG 3012 ATG equipment is calibrated semi-annually, and after every fuel movement, to a maximum tolerance of 1/16 inch by manual gauging. The MTG 3012 system provides data to the tank level module of the AFHE system, but does not perform independent release-detection testing.

The procedures used for tank tightness testing at the Facility are defined by Mass Technology Corporation (MTC) Precision Mass Measurement Systems SIM-1000 and CBU-1000 (24-hour) release-detection methods. Determination of a fuel release is based on the criteria established in the Ken Wilcox Associates, Inc. third-party evaluation and as listed in the National Work Group on Leak Detection Evaluations (NWGLDE).

The MTC Precision Mass Measurement System is certified with a capability to detect releases on a tank proportional to the product surface area with a probability of detection of 95 percent and probability of a false alarm of 5 percent.

This tank tightness testing utilizes two test units to perform five 24-hour precision tightness tests per test unit over a five-day period (120 hours total) on all available Bulk Field Constructed Underground Storage Tanks (BFCUST). These five 24-hour tests are then averaged, and compared against the 0.5 gallons per hour (gph) MDLR requirement. The MTC standard test procedure includes ensuring that any isolation valve(s) are properly seated (via closing, reopening, and reclosing) and that the bleed ports of double-block and bleed isolation valves are checked for the presence of product during each test.

Navy/DLA exceed regulatory requirements for annual tank tightness testing. As a BMP to reduce the duration between tank tightness tests, Navy/DLA have implemented semi-annual (twice per year) testing of the tanks at Red Hill.

AFHE Inventory Control

The AFHE is an inventory control system, used to continuously monitor fuel inventories at the Facility. The MTG 3012 ATG equipment contributes to the data collected and processed by the AFHE. The AFHE is not a certified release detection system. However the AFHE does provide an accurate method for inventory control.

AFHE can detect inventory discrepancies during dynamic operations through an "Evolution Trending" function. The Control Room Operator receives an audible and visual "Out of Balance" alarm whenever the total volume of fuel between its source and destination exceed pre-set thresholds during a scheduled evolution. These thresholds are listed below:

1. During operations at Pearl Harbor's truck loading rack, an audible and visual "Out of Balance" alarm will actuate when the total volume difference exceeds 20 barrels (840 gallons);
2. During scheduled transfers of less than 20,000 barrels (840,000 gallons), an audible and visual "Out of Balance" alarm will actuate when the total volume difference exceeds 100 barrels (4,200 gallons); and
3. During scheduled transfers of more than 20,000 barrels (840,000 gallons), an audible and visual "Out of Balance" alarm will actuate when the total volume difference exceeds 0.5 percent of the total scheduled volume to be transferred.

Combined MTG, ATG and AFHE

The previous sections discuss the ATG and AFHE system independently, however their current use as an integrated system is more relevant to release detection. The AFHE collects and processes the ATG data using Maximo, an integrated software system used to detect Unscheduled Fuel Movements (UFM). The AFHE system generates alerts of potential UFMs, whereas Maximo accounts for product movements using flow meters and ATG data, combined with tank strapping charts. Under static conditions, the integrated AFHE system generates a warning alarm for more than ½-inch of product height discrepancy (approximately 2,448 gallons), and a critical alarm for more than ¾-inch of product height discrepancy (approximately 3,672 gallons).

The AFHE can detect bulk inventory discrepancies across the Facility and alert operators to an "Out-of-Balance" alarm, which indicates the volume of product between the source and the destination exceeds pre-set thresholds. The AFHE system also conducts a gross form of static release detection as part of inventory control functions.

Environmental Sampling

Environmental sampling methods currently used at the Facility include soil vapor monitoring, oil/water interface monitoring, and groundwater monitoring. These methods are used to collect data for environmental monitoring programs, in conjunction with monitoring for indications of fuel releases into the surrounding environment.

Soil Vapor Monitoring (SVM) utilizes multiple tubes bored beneath active and accessible tanks. Soil vapor samples are collected from these tubes monthly and analyzed for increased concentrations of VOC using a PID.

Oil/water interface measurements are taken at monitoring wells RHMW01, RHMW02, RHMW03, and RHMW05 which are located in the LAT. The water level at each well is gauged and analyzed for Light Non-Aqueous Phase Liquids (LNAPL) using an interface meter. The interface meter is lowered into the wells to determine the depth of water (to the nearest 0.01 ft.), and the existence of any immiscible layer.

Groundwater samples are collected from sampling point RHMW2254-01, as well as monitoring wells located inside and outside the LAT. All groundwater samples are analyzed for petroleum constituents. Analytical results are compared to SSRBLs for total petroleum hydrocarbons, as well as diesel fuel (TPH-d) and benzene (TEC, 2008). Analytical results are also compared to DOH EALs for sites where groundwater is a current or potential drinking water source.

Improvements Made Under the AOC

The MTC Leak Detection System (LDS) testing undertaken prior to October 2014 included the addition of a safety factor to account for uncertainties due to the unique configuration of the tanks at the Facility. This safety factor included reporting a MDLR of 0.7 gph, higher than had been calculated during the test event. After several years of testing, the safety factor was removed and the revised MDLR of 0.5 gph was incorporated in October 2014.

In late 2014, the frequency of leak detection testing at the Facility was increased from biennial to annual, and in July 2015, revised 40 Code of Federal Regulations (CFR) 280 regulations were published which included specific release detection requirements for field-constructed underground storage tanks. When the revised 40 CFR 280 was published, the tank tightness testing program at the Facility was already compliant with the revised federal requirements.

The current leak detection program at the Facility is a semi-annual point-in-time tank tightness testing, utilizing the MTC LDS equipment with static in-tank measurement (SIM) capable of detecting 0.5-gph MDLR, for a P_D (Probability of Detection) of 95% and a P_{FA} (Probability of False Alarm) of 5%, in accordance with the requirements of 40 CFR 280.252(d)(1)(i).

In response to the 2014 Release from the Facility, Navy/DLA have already implemented the following actions in accordance with the AOC:

1. Semi-annual tank tightness testing: Every tank tested since 2008 when tank tightness testing began has successfully passed the tank tightness test. Each Red Hill tank containing petroleum product now undergoes semi-annual tank tightness testing as a BMP. This BMP is double the current Hawaii State requirement to conduct tank tightness testing annually.
2. Installation of additional monitoring wells: Since the 2014 release, Navy/DLA have installed an additional seven monitoring wells to increase the total of number of monitoring wells from eight to 15. Navy/DLA are planning to install an additional eight monitoring wells for a total of 23 monitoring wells by the end of 2021. Additional monitoring wells provide more information to better confirm the direction of groundwater flow around the Facility and, more importantly, confirm drinking water continues to be safe for human consumption.
3. Ongoing groundwater sampling and soil vapor monitoring to test for presence of fuel contaminants: Groundwater sampling and analysis from each of the monitoring wells is conducted quarterly to confirm the drinking water from the basal aquifer continues to be safe for human consumption. Additionally, every month the water surface of each monitoring well is checked for the presence of petroleum. Navy/DLA conduct soil vapor monitoring monthly in multiple locations beneath each tank to test for the presence of VOCs.
4. Manual trend analysis: Weekly FLCPH Fuels Director and Deputy review data from AFHE to determine if there was anything outside of the normal or any suspected issues that would trigger an additional immediate trend analysis review. The trend analysis provides the ability to spot any issues that might be below the threshold of the alarm system.
5. Ongoing inventory monitoring using AFHE: The inability to identify the release in 2014 contributed significantly to the volume of product released to the environment; it took approximately 35 days to identify the release before starting to drain the tank. The current procedure requires operators to report all unscheduled fuel movement alarms immediately. Additionally, the operations supervisor reviews alarm logs to confirm there are no unscheduled fuel movements. This protocol enables operators to identify a potential release more accurately, reducing the potential volume of product released to the environment, and thus providing better protection of the drinking water.

Criteria for the Release Detection Decision

Prior to 2015, leak detection for BFCUST was not mandated in many states. As a proactive measure, Navy/DLA conducted market research to determine if there were any leak detection systems that could be successfully implemented at the Facility on such large BFCUST. Navy/DLA identified potential vendors, analyzed the published performance claims, performed some Red Hill specific tests, and selected the appropriate method to meet leak detection goals.

The NWGLDE is a national, independent, technical work group comprised of federal and state regulators. The NWGLDE committees review third-party evaluations to determine if tests of the leak detection system and/or equipment were conducted in accordance with EPA test method protocols, and meets regulatory performance standards. The standard industry approach is to utilize publications by the NWGLDE as guidance for selecting appropriate leak detection.

The NWGLDE website (http://nwglde.org/) provides listings of vetted leak detection systems and equipment, allowing operators to find appropriate leak detection solutions for tank storage systems without commissioning individual third-party evaluations. Additionally, it includes a summary of LDS listings, including system and equipment implementation requirements, limitations, and expected results (LDS sensitivity and LDS reliability).

Hawaii Administrative Rules (HAR) §11-280.1, published 15 July 2018, requires annual tank tightness testing to be performed. The Facility exceeds this requirement by testing semi-annually using a tank tightness test which is capable of detecting a 0.5 gph release.

Analysis of Release Detection Alternatives

The Red Hill tanks present unique challenges due to size, geometry, construction, and throughput, all of which must be considered when evaluating and selecting an appropriate LDS. Properties which make these tanks unique include:

1. Each Red Hill tank is approximately 250 feet high by 100 feet diameter, compared with common field-constructed tanks, which range in size from 10 feet high and 42 feet diameter to 25 feet high and 120 feet diameter;
2. The geometry of each Red Hill tank resembles a capsule with dome-shaped top and bottom, compared with common field-constructed tanks that are vertical cylinders with a flat top and bottom;
3. The construction of each Red Hill tank includes a composite concrete structure (concrete, grout, gunite and native basalt rock), with an inner steel tank liner, compared to construction of common field-constructed tanks, which consist of welded steel plates laid upon reinforced concrete foundations, in-contact with engineered backfill;
4. The throughput is infrequent as the Red Hill tanks are operated as reserve storage, whereas the throughput for common field-constructed tanks is more frequent as tanks are utilized for operational storage; and
5. The Red Hill tanks represent a very small percentage of the population of tanks (in commercial or military applications) that the industry supports with leak detection; due to the small demand (20 tanks) the industry has not developed readily available leak detection systems.

Under the AOC, Navy, DLA, DOH and EPA representatives agreed to evaluate potential leak detection systems for the Facility. This evaluation was required to include a comparison of Leak Detection Sensitivity as a MDLR and LDS reliability as the P_D and as the P_{FA} as applied to the underground storage tanks at the Facility. The systems were evaluated against vendor claims and NWGLDE data.

This evaluation was undertaken to allow a comparative analysis of the leak detection results provided by each system, as field tested on the tanks at Red Hill. Once the effectiveness of each system was evaluated, a decision matrix was developed to assist in identifying the most appropriate technology.

This decision matrix was populated with information acquired during the development of this evaluation report and reviewed during the "Decision Matrix Meeting", held at the EPA Region 9 offices in San Francisco, California, on 26 April 2018. During this meeting, the main components of the decision matrix were discussed and agreed upon by the AOC stakeholders.

The decision matrix was used in conjunction with a scoring system, to assist in the selection of a release detection method for use at the Facility. The attributes considered in the selection are defined in Table 3.

Table 3: Release Detection System Attribute Definitions

Attribute	Attribute Definition (Criteria for Evaluation)
1.Release Detection	Release detection system should meet current MDLR (in gph) requirements of 40 CFR 280 for field-constructed USTs (0.5-gph with 95% Probability of Detection and 5% Probability of False Alarm).
2a. Undetected Release: 7-day	This is the quantity (in gallons) of fuel that may be released from the tank undetected by release detection system if one test was conducted every 7-days.
2b. Undetected Release: 30-day	This is the quantity (in gallons) of fuel that may be released from the tank undetected by release detection system if one test was conducted every 30-days.
2c. Undetected Release: 90-day	This is the quantity (in gallons) of fuel that may be released from the tank undetected by release detection system if one test was conducted every 90-days.
2d. Undetected Release: 365-day	This is the quantity (in gallons) of fuel that may be released from the tank undetected by release detection system if one test was conducted every 365-days.
3a. Constructible: Inside Tank	Release detection system requires sensors to be located inside the tank; logistics could include: draining the tank, ventilating, and working inside the tank.
3b. Constructible: Outside Tank	Release detection system requires computer to be located outside the tank and incorporated into secure data network.
3c. Constructible: Schedule	The amount of time to install release detection systems in all operational tanks.
4a. Operable: Data	Release detection system requires that onsite data processing be evaluated by manufacturer technician.
4b. Operable: Static	Release detection testing can be completed while the tank is isolated.
5a. Reliable At Product Level Heights	Reliable at product level heights, as evaluated, range between 125-feet and 190-feet (located within the vertical barrel section of the tank).
6. Serviceable: Inside Tank	Repair / replacement of release detection system components located inside the tank.
7. Other Installations	Release detection system in-use elsewhere.

III. Implementation

Subject to approval of the Tank Upgrade Alternatives and Release Detection Decision document, Navy/DLA propose to complete the proposed improvements according to the following schedule.

Table 4: TUA/Release Detection Implementation Schedule

Improvement	Year of Implementation
Semi-annual tank tightness testing	2019
Ongoing groundwater sampling and soil vapor monitoring	2015
Developed procedures for rapidly draining a Facility tank	2018
USGS Synoptic Water-Level Study	2018
Inventory monitoring and manual trend analysis using AFHE	2018
Groundwater modeling development	2016-2020
USINDOPACOM Fuel Study	2018-2019
Install additional monitoring wells	2015-2021
Conduct real time soil vapor monitoring pilot project	2021
Install enhanced release detection	2020-2022
Pilot project to fully coat the interior surface of a Facility tank below the max fill line	2022
Evaluate ability for funding Water Treatment Plant	TBD-See Note 1
Install slots in stilling wells	2020-2036
Decommission smaller nozzles from service	2019-2036
Evaluate long-term solutions and options for fuel storage	2020-

Note 1: Navy/DLA do not have authority to commit funds for a water treatment plant. Funding requires congressional approval for Military Construction (MILCON) projects. Navy/DLA will determine how to best incorporate funding during the evaluation for the water treatment plant.

Additionally, Navy/DLA proposed the following reporting requirements to ensure compliance with the proposed the proposed BAPT.

Reporting Requirements

Table 5: Reporting Requirements for Successful Implementation of BAPT

Reports	Frequency	Responsible Command
Continued Prevention of Releases	Annual	NAVSUP
Compliance with BAPT Implementation Schedules	Annual	CNIC
Compliance with Tank Inspection, Repair and Maintenance Schedule	Annual	NAVFAC
Compliance with Tank Inspection Repair and Maintenance Procedures	Periodic	NAVFAC
Compliance with Tank Tightness Testing Program	Semi-annual	NAVSUP
Results of Tank Tightness Testing Program	Semi-annual	NAVSUP
Compliance with Operational Procedures	Quarterly	NAVSUP

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Acronyms, Abbreviations and Initializations

AFHE	Automated Fuel Handling Equipment
AOC	Administrative Order on Consent
AOR	Area of Responsibility
API	American Petroleum Institute
AST	Aboveground Storage Tank
ATG	Automatic Tank Gauge
BAPT	Best Available Practicable Technology
BBL	Barrels
BFCUST	Bulk Field Constructed Underground Storage Tanks
BMP	Best Management Practice
BWS	Honolulu City and County Board of Water Supply
CIR	Clean, Inspect and Repair
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
CMP	Centrally Managed Program
COPC	Chemicals of Potential Concern
COR	Contracting Officer's Representative
CPLO	Community Planning and Liaison Officer
CQC	Contractor Quality Control
CSM	Conceptual Site Model
DFSP	Defense Fuel Support Point
DLA	Defense Logistics Agency
DoD	Department of Defense
DOH	Hawaii State Department of Health
EAL	Environmental Action Levels
EPA	Environmental Protection Agency
ET	Engineering Technician
FAR	Federal Acquisition Regulation
FLC	Fleet Logistics Center
FLCPH	Fleet Logistics Center Pearl Harbor
GAC	Granular Activated Carbon

HAR	Hawaii Administrative Rules
IRR	Investigation and Remediation of Releases
IRS	Inventory Reconciliation System
JBPHH	Joint Base Pearl Harbor Hickam
JP	Jet Propellant
LAT	Lower Access Tunnel
LDS	Leak Detection System
LNAPL	Light non-aqueous-phase liquid
LTM	Long-Term Monitoring
MDLR	Minimum Detectable Leak Rate
MILCON	Military Construction
MTC	Mass Technology Corporation
MTG	Multifunction Tank Gauge
NAVFAC	Naval Facilities Engineering Command
NAVFAC EXWC	NAVFAC Engineering and Expeditionary Warfare Center
NAVSUP	Naval Supply Systems Command
NDE	Non-Destructive Examination
NEPA	National Environmental Policy Act
NSZD	Natural Source-Zone Depletion
NWGLDE	National Work Group on Leak Detection Evaluations
OSHA	Occupational Safety and Health Administration
P_D	Probability of Detection
P_{FA}	Probability of False Alarm
PID	Photo-Ionization Detector
PMNE	Polysulfide Modified Novolac Epoxy
QA	Quality Assurance
QC	Quality Control
QRVA	Quantitative Risk and Vulnerability Analysis
RBDC	Risk based decision criteria
Facility	Red Hill Bulk Fuel Storage Facility
RHMW	Red Hill Monitoring Well
ROM	Rough Order of Magnitude

RTS	Return to Service
SME	Subject Matter Expert
SOP	Standard operating Procedure
SOW	Statement of Work
SSRBL	Site Specific Risk Based Level
SVM	Soil Vapor Monitoring
SVMP	Soil Vapor Monitoring Point
TIRM	Tank Inspection, Repair and Maintenance
TUA	Tank Upgrade Alternatives
UAT	Upper Access Tunnel
UCP	Unified Command Plan
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specification
UFM	Unscheduled Fuel Movement
US	United States
USINDOPACOM	United States Indo-Pacific Command
VOC	Volatile Organic Compound

Appendix A: TUA Decision Background Information

Surrounding Land Uses

The Facility is located on land zoned by the City and County of Honolulu as a mix of F-1 Federal and Military and P-1 Restricted Preservation districts. Preservation land is located east and northeast of the Facility boundary. The closest populated areas are Halawa to the west, and Honolulu to the south and east, which are heavily urbanized and densely populated.
To the southeast are residential single-family homes in Moanalua Valley; a high cliff face with a 100–200 feet elevation difference exists between the Facility and this residential area. Southwest of the tank farm area are the Red Hill Elementary School and Moanalua Hillside Apartments, and further west is US Coast Guard Housing on F-1 Military land. To the North are the South Halawa Valley, light industry in Halawa Industrial Park, and the State-operated Halawa Correctional Facility. To the north of the Correctional Facility is the open-pit Halawa Quarry operated by the Hawaiian Cement Company.

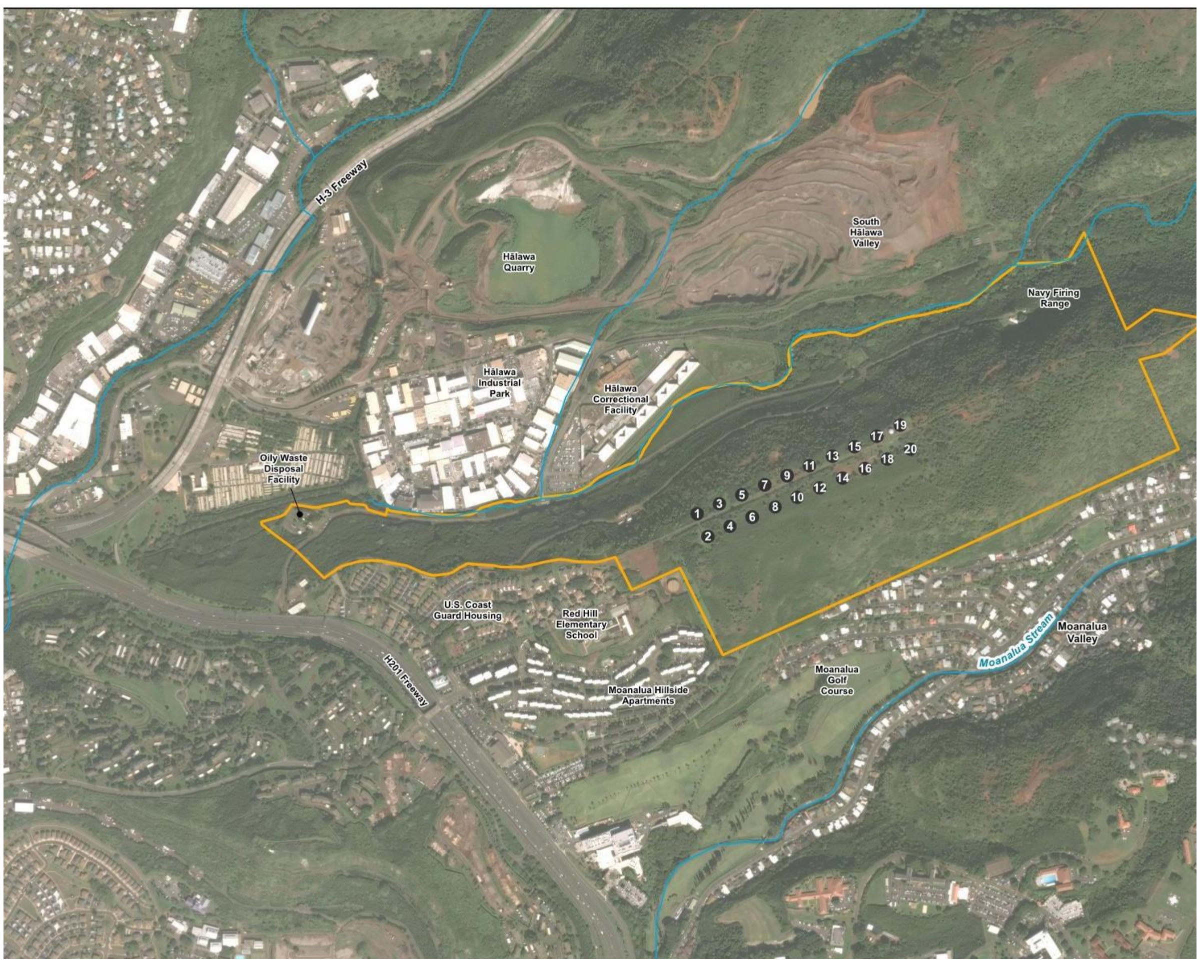

Figure 3: Aerial View of Red Hill Precinct Showing Surrounding Land Uses

Tank Construction

The Facility consists of 20 underground vertical, reinforced concrete, steel-lined fuel storage tanks, connected to an underground pumphouse at Joint Base Pearl Harbor Hickam by three nearly four-mile-long pipelines located inside a tunnel. The Facility was constructed during the early 1940s, and has been in continuous operation since September 1943. Each tank is approximately 250 feet tall and 100 feet in diameter, providing storage capacity of up to 12.5 million gallons per tank. The tanks are arranged in two rows of 10 tanks, spaced 200 feet apart, with 100 feet of lava rock separating each tank. The design and construction is unique, and it is believed to be the only facility of this type anywhere in the world. The Facility was declared a National Civil Engineering Monument in 1995 by the American Society of Civil Engineers.

The tanks were constructed by mining the lava rock formation of Red Hill to create a cavity for each tank which was lined with gunite, grout, steel-reinforced concrete which was pre-stressed with pressure grout, and a ¼ inch thick steel liner. The upper dome was constructed first, then lava rock was mined to create a cavity for the barrel section and lower dome. Steel framing and liner plates were then installed, followed by filling the cavity between the liner plates and lava rock with reinforced concrete which varies in thickness between 2½ feet near the top of the tank and 4 feet near the bottom of the tank. After placement of the pressure grout, the tank envelope was grouted to refusal for consolidation purposes. Each tank is surrounded by more than 15,000 cubic yards, or 1,100 tons of concrete.

Tanks 1 to 4 are 100 feet in diameter, have a 238½ feet overall height, and each has a nominal storage capacity of 285,148 barrels. Tanks 5 to 20 are 100 feet in diameter, with an overall height of 250½ feet, and each has a nominal storage capacity of 301,934 barrels. The top of the upper domes of the tanks are between 110 feet and 175 feet below ground, with the bottoms of the tanks ranging in elevation from 123 feet to 151 feet above sea level.

The tanks are serviced by fuel piping, mechanical and ventilation systems, electrical systems, Upper Access Tunnel (UAT), LAT, access adits and associated fuel system infrastructure. Three pipelines located inside a nearly four-mile long tunnel connect the tanks to an underground pumphouse at JBPHH. The pumphouse allows fuel to be pumped from Pearl Harbor to the Facility. Fuel can be dispensed via gravity to ships from piers at Pearl Harbor, to aircraft at Hickam Field and during emergencies, distributed to Daniel K. Inouye International Airport, Honolulu Harbor, Campbell Industrial Park, and Barbers Point Harbor.

Figure 4 shows an isometric view of the tanks, LAT. UAT and adits. A cross-section of a typical Red Hill Bulk Fuel Storage Tank is shown in Figure 5.

[redacted]

Figure 4: Isometric Diagram of the Tanks, LAT, UAT and Adits at the Facility

Cleaning, inspection and repair of Tank 5 was accomplished between 2010 and 2013 in accordance with the processes in place at that time. Tank 5 was tested for tightness in 2009, and passed this test before being taken out of service in 2010. After completion of the works, certification by the contractor, and handover to operations, the tank was returned to service in accordance with normal operational practices. As part of the repair process, multiple gas test holes were intentionally drilled through the steel tank liner. These holes were required to test for explosive vapors behind the steel liner prior to welding to meet safety requirements.

In January 2014, while refilling Tank 5, Navy/DLA identified an estimated release of 27,000 gallons of jet fuel (JP-8) and reported the release to the DOH. Navy/DLA subsequently drained the tank and collected samples from existing monitoring wells. Results taken around Tank 5 indicated increased levels of hydrocarbons in soil vapor and groundwater, although later analysis of the data obtained from those groundwater samples indicate that fuel released in 2014 did not reach groundwater. The results of drinking water monitoring confirmed continued compliance with federal and state safety standards both before and after the January 2014 release.

An investigation into the 2014 release identified the underlying causes as being:
1. Un-repaired gas test holes; and
2. Defective fillet welds on patch plates which covered the gas test holes.

Contributory factors to the occurrence and response to the release were identified as:
1. Failure by the contractor to report deficiencies in the Tank 5 repair work;
2. Failure of the contractor to perform vacuum box release testing of repair work;
3. Failure of the contractor to perform magnetic particle weld testing of repair work;

4. The contractor's derelict and ineffective quality control program;
5. Incompetent welding and weld inspection of repair work by the contractor;
6. Incompetent liquid penetrant examination of repair work by the contractor;
7. Failure of contractor to perform an API Standard 653 inspection of repairs and failure to certify that Tank 5 was suitable for service;
8. Failure of NAVFAC to perform satisfactory Quality Assurance oversight; and
9. Failure of operators to properly respond to alarms.

In response to the 2014 release, Navy/DLA agreed to an AOC with the EPA and DOH, which was approved by all parties in September 2015. The AOC is a joint administrative action taken by the DOH and EPA (the "regulatory agencies") pursuant to their respective state and federal authorities to regulate underground storage tanks, and to protect drinking water, natural resources, human health, and the environment.

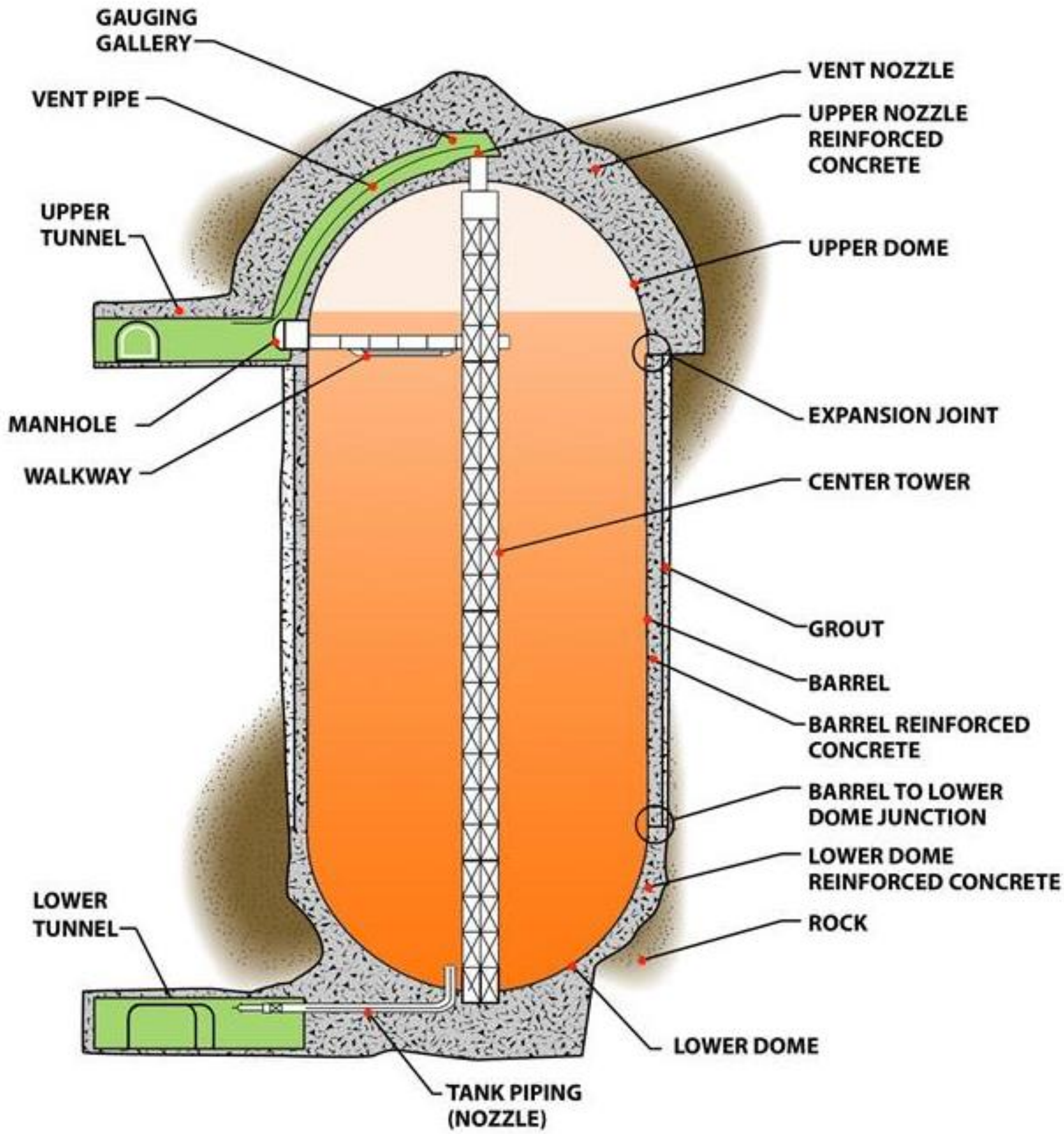

Figure 5: Cross-Section of Typical Red Hill Bulk Fuel Storage Tank

Figure 6: Underground Pumphouse at the Facility

Figure 7: Lower Access Tunnel at the Facility

Presently, Tanks 2-18 and 20 remain in service. Tanks 1 and 19 have been removed from service due to revised fuel storage requirements. Operational and strategic considerations permit the temporary removal of up to three additional tanks from service to allow for scheduled maintenance.

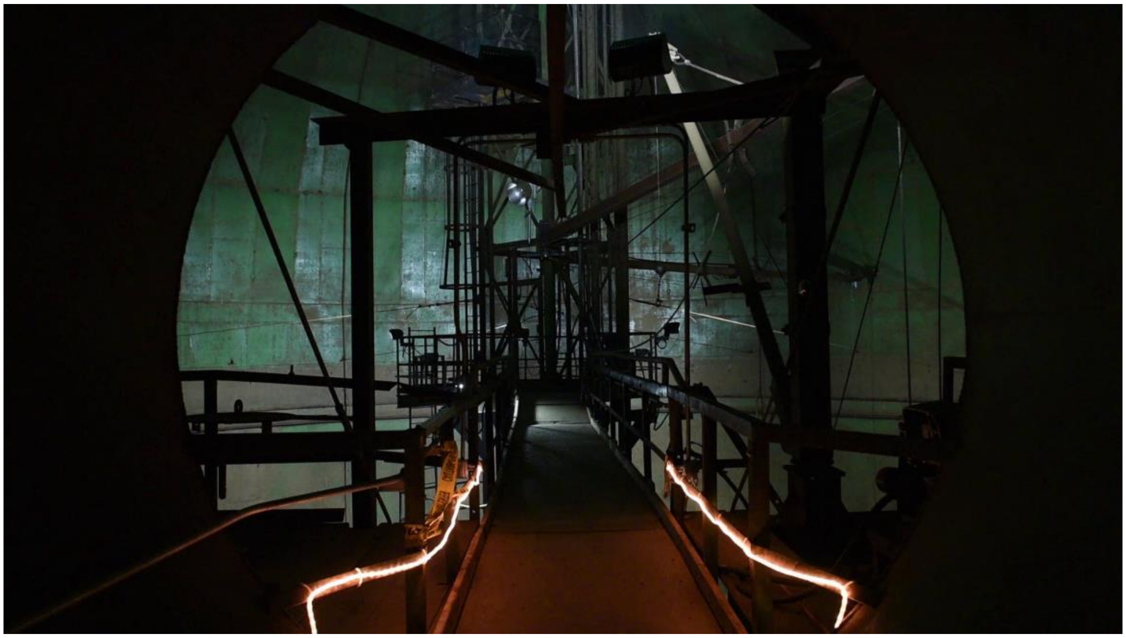

Figure 8: Entrance to Tank 19 (Not in Service) from Upper Access Tunnel at the Facility

Modifications

Over the years that the Facility has been operated, there have been multiple tank maintenance and modification projects. The scopes of these projects are summarized below. Since 2006, DLA has invested over $325 million ($162 million since the AOC was signed in 2015 to maintain and improve the Facility). Currently, Navy/DLA plan to invest another $256 million in improving the Facility from 2020 through 2023.

Conversion Project (1960–1962)

This was the first major tank rehabilitation project at the Facility. The purpose of the project was to isolate Tanks 17 through 20 from the other non-volatile tanks, pipelines, tunnels, ventilation, and slop systems; and convert them to store volatile fuel. Major scope items of work for the tanks included:

1. Cleaning the tanks;
2. Seal welding the 2-inch x ¼-inch backer bars which covered the shell plate joints in the upper dome and the upper 12 feet of the barrel;
3. Replacement of the 1942 vintage telltale systems with heavy-wall piping;
4. Sandblasting and coating the entire interior of the tanks with a polyurethane coating system formulated by the Naval Research Laboratory;
5. The new telltale systems were used to introduce air behind the shell plates to locate additional repair locations. Bad welds were chipped out and re-welded.

Repair Non-Volatile Section Project (1970–1972)

The second major tank rehabilitation project at Red Hill covered Tanks 5, 6, and 12. Major scope items included:

1. Cleaning of the tanks;
2. Inspection and repair of existing welds;
3. Installation of sample piping;
4. Installation of new tank gauging equipment;
5. Replacement of the 1942 vintage telltale systems with heavy-wall piping; and
6. The new telltale system in combination with water in the tank for staging was used to test the shell plates and shell plate welds to locate additional repair locations. Bad welds were chipped out and re-welded.

Modernization Project (1978-1983)

The modernization project at Red Hill consisted of cleaning, inspecting and repairing Tanks 1-16. The project included the following work for each of the tanks:

1. Wash and cleaning of tanks;
2. Repair and modification of center towers;
3. Removal of telltale piping and cover the holes from the removal of the telltale piping in steel tank liner;
4. Inspection, repair and testing of butt welds connecting steel liner plates and patch holes in plates;
5. Removal of steam heating coils and supports;
6. Removal of 4-inch steam lines from 8-inch pipe casing between tank bottom and LAT;
7. Installation of four ¾-inch sample lines from tanks to LAT;
8. Decommissioning of 8-inch slop line nozzles on bottom of tank and installation of patch plates to cover;
9. Conversion of 6-inch steam condensate line to bottom drain slop lines; and
10. Overhaul of 12-inch and 20-inch skin valves on suction and fill lines.

Construction began on the first tank, Tank 7, on October 24, 1978. At the completion of construction, each tank was filled and leak tested using water. Where tanks failed testing, they were drained, repaired, and leak tested again. This process was repeated until all 16 tanks passed leak testing, with the last tank (Tank 6) completed on March 16, 1983. Telltales were removed from Tanks 1-16 as part of this contract. Following this modernization project, no reportable releases occurred until the release in 2014.

Repair Tank 19 Project (1991–1993)

This project consisted of two phases. The scope of the project included:

1. An upgraded tank ventilation system;
2. Upgraded electrical power to support the Phase II tank repairs;
3. Protection of the existing 1961 vintage telltale piping;

4. Installation of two telescoping booms with man-baskets and a platform scaffold beneath the catwalk;
5. Phase II of the project, which was to inspect and repair the tank was never executed, and since 1993, Tank 19 has been out-of-service.

Clean, Inspect, and Recoat Tanks Project, 1994 – 1996

The next major tank rehabilitation project at Red Hill covered Tanks 6, 7, 8, 9, 10, 12, 13, 14, and 16. The Project scope included:

1. Cleaning the tanks;
2. Performing a visual inspection of all areas;
3. Abrasive blasting the 20-foot diameter bottom plate and the first course of sloping plates in the lower dome of Tanks 6, 9, 12, 13, and 14;
4. Inspection in accordance with API Standard 653. Tools used in the API inspection included a pit gauge, ultrasonic thickness tester, soap film, and vacuum boxes of various configurations;
5. Repair of defects identified during the inspection. Repairs to the tank shell included repair of existing welds by chipping and re-welding, and welding patch plates onto the tank shell.
6. Recoating the areas that were previously abrasive blasted.

Repairs for Red Hill Tanks 6, 7, 8, 10, and 16 (1997–1998)

The Project scope included:

1. Inspecting the shell of the tanks' upper dome, barrel, and lower dome in accordance with the applicable requirements of API Standard 653;
2. Visually inspecting all welds;
3. Testing suspect existing welds, repaired welds, and new welds with dye penetrant testing;
4. Inspecting coating visually and using dry film thickness readings; and
5. Repairing the steel tank shell and the coating on the tank shell in accordance with the recommendations in the API Standard 653 inspection reports.

Repair Red Hill Tanks 1 and 15 (2004–2007)

The Scope of this project included:

1. Cleaning Tank 1 and removing it from service;
2. Cleaning Tank 15;
3. Inspecting the shell of Tank 15 upper dome, barrel, and lower dome in accordance with API Standard 653;
4. Testing Tank 15 for leaks by injecting helium gas behind the shell plates and using a helium mass spectrometer to test for helium leaking back into the tank through faulty welds and holes in the shell plates;
5. Testing Tank 15 with Low-Frequency Electro-Magnetic Scanners (LFET) to identify corrosion on the backside of shell plates and piping;
6. Taking ultrasonic thickness measurements to determine the actual metal thickness on detected defects;

7. Inspecting welds with eddy current probes;
8. Conducting shear wave ultrasonic testing to determine remaining thicknesses of welds when indications of weld defects were found; and
9. Inspecting weld flaws using the vacuum box method.

Tank 1 was taken out-of-service in August of 1999. The storage capacity requirements and history of Tank 1 was evaluated, and permanent closure of Tank 1 was recommended for following reasons:
1. Storage capacity requirements did not necessitate ongoing utilization of the tank;
2. Tank 1 was the first tank constructed, and had an unrepaired bulge at the spring line of the lower dome caused by grout pressure during original construction;
3. Historical records indicated corrosion problems in the lower dome;
4. There was no record of damage or repair actions following a fire started by a welder in the tank in the 1970's; and
5. Cost of re-coating the tank internals was not budgeted, and was estimated to increase the budget by 60%.

Inspect and Repair Red Hill Tanks 6, 15 and 16; (2007)

The Scope of this project included:
1. Cleaning Tanks 6, 15, and 16;
2. Inspecting 100% of the tank interior surface area of Tanks 6, 15, and 16 in accordance with a modified API Standard 653 inspection using LFET, ultrasonic inspection, eddy current, and shear wave ultrasonic testing; and
3. Repairing the steel tank shell and the coating on the tank shell in accordance with the recommendations in the API Standard 653 inspection reports.

Clean, Inspect, and Repair Red Hill Tanks 2 and 20 (2008–2010)

The Scope of this project included:
1. Cleaning Tanks 2 and 20;
2. Inspecting Tanks 2 and 20 in accordance with a modified API Standard 653 inspection using LFET, ultrasonic inspection, eddy current, and shear wave ultrasonic testing; and
3. Repairing the steel tank shell and the coating on the tank shell in accordance with the recommendations in the API Standard 653 inspection reports.

Release History

A thorough review of all Facility records was conducted to determine the release history over the lifetime of the Facility. This review considered:
1. Unverified Facility release histories beginning in 1943 and which end in 1983;
2. Emails which repeat much of the unverified Facility release histories, but include some additional information from later years;
3. 2008 Groundwater Protection Plan;

4. Navy Audit Service Report - Department of the Navy Red Hill and Upper Facility Farm Fuel Storage Facilities N2010-0049, 2010;
5. EPA report to the Board of Water Supply, July 20, 2015;
6. Confirmed Release Notifications;
7. Unverified Histories: Releases vs Telltales and Verified Reporting: Since 1988;
8. AFHE Pearl Harbor Facility 0105 Findings; and
9. Individual Facility inspection reports, beginning in 1998 and ending in 2010.

The unverified release histories contain chronological information for each of the tanks. In general, they detail records of fuel releases detected while in operation, the dates of their occurrence, estimated amounts of fuel released in each incident, fuel release rates while the tanks still contained fuel, and the fuel level at the time the release was detected. The dates of successful repair and refilling were also recorded, describing activities undertaken during inspections and repairs.

The Navy Audit report provides inspection records and a record of maintenance intervals, but does not include a summary of the Facility releases.

The EPA report provides a site chronology which includes records of release incidents from the sources noted.

The records contain additional information not available in the unverified histories, such as instances when tanks failed hydrostatic tests using water, which are not included as fuel release events. The comments also contain records of the types and estimated amounts of fuel released. In general, fuel releases can be categorized into three groups:

1. Fuel releases during operation detected by the telltale systems;
2. Fuel releases during operation by changes in liquid level, inventory changes determined from mass balances, or visually due to fuel external to the tank; and
3. Fuel releases detected during tank filling when returning to service from an extended outage.

Key conclusions from the review of the identification of the historical release incidents are:

1. The telltale systems in Tanks 1 through 16 were decommissioned and sealed prior to 1985. The incidents detected by telltale systems prior to this time involved fuel release through the telltale leak detection system to the LAT, which was directed to the fuel drainage system and not to the surrounding rock. After the telltale systems were eliminated, the frequency of the reported fuel release incidents during operation dropped dramatically.
2. Earlier telltale detected releases may be attributed to fuel release via corroded telltale system pipes themselves due to entrained water in the fuel received. Corroded telltale piping would indicate to the operator a release was in progress. However, in reality, the finding was a false positive because the telltale pipe itself was faulty.

Telltale failures do not result in a release of petroleum to the environment. Instead, the fuel is diverted to a fuel drain where it is collected for disposal. According to the available limited historical records, with the exception of the 27,000 gallons released in 2014, all remaining verifiable fuel releases occurred prior to 1988 when release reporting became mandatory. The only verified release after 1988 was the 27,000 gallons during 2014.

Past and Future Environmental Investigations and Modeling

The Conceptual Site Model (CSM), Investigation and Remediation of Releases (IRR) and Groundwater Protection and Evaluation Report[4] summarizes the Navy's interim environmental analysis and an initial analysis of potential environmental risks. Information sources include, but are not limited to, the following:

1. Past investigations conducted in the region and in the vicinity of Red Hill (e.g. geologic, hydrogeological, environmental);
2. Facility information;
3. Fuel types and releases;
4. Groundwater and vapor monitoring data;
5. Geologic and hydrogeological data;
6. Seismic studies data;
7. Hydraulic recharge and water balance;
8. LNAPL and hydrocarbon-based fuel forensic studies;
9. Natural source-zone depletion (NSZD) and natural attenuation studies;
10. Water supply well design and pumping rates;
11. Synoptic water level elevations; and
12. Interim groundwater modeling of migration of groundwater from underneath the Facility and the source water zones for key public supply wells and shafts.

The CSM for the Facility is the primary reference for this document.

The key objectives for the interim environmental analysis were to:

1. Protect public health and environment;
2. Meet DoD operational requirements for the Facility;
3. Comply with the AOC;
4. Comply with existing government regulations; and
5. Meet acceptable environmental performance criteria and risk reduction.

The report presents the interim environmental analysis of current data and an initial framework and analysis of potential environmental risks for the following key areas addressed as part of AOC Sections 6 and 7:

1. LNAPL Properties and Distribution;
2. Dissolved Fuel Constituents in Groundwater and Analytical Considerations;
3. Interim Groundwater Flow Model;
4. Natural Attenuation;
5. Risk-Based Decision Criteria;
6. Mass Flux and Sentry Well Considerations; and
7. Hypothetical Future Release Scenarios.

Data collection and evaluation continue and the key environmental analyses will be updated as appropriate. Results of AOC Sections 6 and 7 activities will be presented in the forthcoming reports required for each section. The conclusions from these studies continue to be refined as more information becomes available.

The work for AOC Sections 6 and 7 has led to a number of key assumptions, which are summarized below:

1. Long-term monitoring (LTM) and associated studies indicate that the 2014 release from Tank 5 has had minimal or no impacts to groundwater at the Facility;
2. Thermal NSZD studies, LTM, and other studies appear to indicate that LNAPL has reached residual saturation primarily within a discrete zone beneath the tanks in the vadose zone above the water table;
3. Dissolved fuel constituents in groundwater are consistent with soluble (aromatic hydrocarbons) components and polar material (likely metabolites) from fuels consistent with biodegraded jet fuel;
4. The geology beneath Red Hill is heterogeneous, resulting in localized hydraulic gradients. Overall flow appears to be highly influenced by clinker zones that provide a preferential pathway to Red Hill Shaft;
5. Seismic studies, coupled with recent drilling activities indicate that extensive saprolite zones exist beneath stream valleys on both sides of Red Hill (including both South Halawa Stream and Moanalua Valley) and that these extend significantly below the water table in some areas, and act as a barrier to the migration of groundwater contaminants. The horizontal and vertical extent of these saprolite zones is being further evaluated;
6. Evaluation of heterogeneity and other geologic features (e.g. probability of the presence of lava tubes) is on-going using a random walk methodology coupled with fractal dimension analysis;
7. Natural attenuation is occurring in both the unsaturated and saturated zones, and acts to degrade fuel-related contaminants in the environment;
8. Data collected as part of recent synoptic water level studies are assisting with the ongoing development of aquifer hydraulic property estimates and groundwater flow conditions in the area of the site;
9. A Transfer Function-Noise (TFN) analysis has been conducted using the synoptic water level study data in order to inform additional groundwater flow modeling; and
10. All interim groundwater flow model runs indicate groundwater flow from beneath the Facility is toward Red Hill Shaft, even when Red Hill Shaft is not pumping. An updated version of the groundwater flow model which incorporates additional geologic features and utilizes information derived from the TFN analysis is being developed.

Appendix B: Legal, Statutory and Regulatory Requirements

Administrative Order on Consent (AOC)

The primary objectives of the AOC are to implement practices to ensure the groundwater resource in the vicinity of the Facility is protected, and to ensure that the Facility is operated and maintained in an environmentally protective manner. The AOC was negotiated in good faith, and all parties agreed that it is fair, reasonable, protective of human health and the environment, and in the public interest.

In accordance with the AOC, Navy/DLA are required to:

1. Improve the CIR process (compared to the standard used in 2014) to ensure that tank infrastructure prevents releases of fuel to the environment to the maximum extent practicable;
2. Undertake a comprehensive study to investigate the feasibility of upgrading the tank structures including, but not limited to, installing secondary containment. After completing the study, a technology or technologies will be approved by the regulatory agencies, and implemented by Navy/DLA. Implementation will occur in phases so that all tanks in operation will employ BAPT within twenty-two years of the effective date of the AOC, or as otherwise provided for in the AOC or Statement of Work (SOW);
3. Conduct tank tightness testing annually, and continue to monitor the inventory of fuel in the tanks. Navy/DLA will also conduct a study to evaluate improvements to the tank tightness and release detection technologies deployed at the Facility and, pending the outcome of the study and approval by the regulatory agencies, implement those improvements;
4. Further develop models to better understand groundwater flow in the areas around the Facility and evaluate the fate and transport of contaminants in the subsurface. As set forth below, based on the modeling effort, as approved by the Regulatory Agencies, Navy/DLA will develop and improve the existing groundwater monitoring network to the extent determined necessary; and
5. Conduct a risk/vulnerability assessment, subject to approval by the regulatory agencies, in an effort to further understand the potential for, and potential impacts of fuel releases on the island's drinking and groundwater supplies and to inform the Parties in development of subsequent BAPT Decisions.

Hawaii Administrative Rules: Ch. 11-280.1

The Hawaii Administrative Rules, Chapter 11-280.1[9], were formally revised on July 15, 2018, stating:

*"**11-280.1-21 Upgrading of UST systems.***

(c) Airport hydrant fuel distribution systems and UST systems with field-constructed tanks: Not later than twenty years after the effective date of these rules, tanks and piping installed before the effective date of these rules must be provided with secondary containment that meets the requirements of section 11-280.1-24 or must utilize a design which the director determines is protective of human health and the environment"

These rules require that operating the Facility will require agreement from the Director of the DOH that the Facility is designed to be protective of human health and the environment if the tanks are to contain fuel beyond July 15, 2038.

Appendix C: Tank Upgrade Alternatives Comparison

Overview

Appendix C includes portions of the of the detailed descriptions of the Tank Upgrades Alternatives from the Tank Upgrades Alternatives Report published on 08 December 2017 and approved by the EPA and DOH on 21 May 2018. Information from the Red Hill Alternative Location Study[7] is also included. The Red Hill Alternative Location Study was submitted on 05 February 2018.
The first step in the TUA selection was the identification of alternatives to be reviewed, based on the input and agreement from key stakeholders, including Navy/DLA, EPA and DOH during a December 2015 scoping meeting. Thirty-three potential alternatives were identified, from which the alternatives shown in Table 5 were chosen for detailed assessment by the stakeholder group.

Table 6: Tank Upgrade Alternatives

TUA No.	Description
1A	Restoration of Existing Tank and Nozzles, including recoating of the lower dome and interior of the tank nozzles.
1B	Restoration of Existing Tank and Nozzles, including recoating of the lower dome, tank barrel, upper dome and interior of the tank nozzles
1D	Removal and Replacement of Existing Steel Liner, including recoating of the lower dome, tank barrel, upper dome and interior of the tank nozzles
2A	Composite Tank (Double-wall) Carbon Steel Tank, including coating of the lower dome, tank barrel and interior of the new double-walled tank nozzles
2B	Composite Tank (Double-wall) with Stainless Steel Tank Liner and double-walled tank nozzles
3A	Tank within a Tank (Carbon Steel), including coating of the lower dome, tank barrel and interior of the new double-walled tank nozzles

These alternatives were evaluated in detail in the TUA Report[3], the results of which are briefly summarized in the following sections. In addition, the construction of new double-walled cut-and-cover tanks at an alternative location is included for completeness.

1A - Restoration of Existing Tank and Nozzles

Alternative 1A is a reinforced concrete, single-walled steel lined tank for the primary containment of fuel. Under this option, the lower dome of the tank and interior of the active product piping to the first valve will be coated with a PMNE coating, which is a DoD-approved tank coating system. The existing steel barrel and upper dome will be recoated as necessary to repair the existing coating system, and to repair the coating along selected patch plate welds. Alternative 1A includes integrity inspection and pressure testing of selected nozzles from inside the tank to the first valve outside tank. Alternative 1A includes decommissioning of nozzles not essential to operations from active fuel service. A typical wall section for Alternative 1A is shown in Figure 9.

Alternative 1A offers much more protection from accidental fuel releases than the pre-2014 system. Alternative 1A implements vastly improved tank integrity inspection and repair protocols along with improvements to the release detection system and operational procedures. In addition, semi-annual tank tightness testing, new monitoring systems, and AFHE and release detection systems will ensure the Red Hill Bulk Fuel Storage Facility is even more protective of human health and the environment.

The upgraded CIR procedures and practices (post-2014) will be used to maintain the single-walled steel tank liner as specified in the current TIRM Procedure Decision Document. Navy/DLA will incorporate lessons learned from on-going tank work to continually improve the CIR Process during the execution of subsequent contracts.

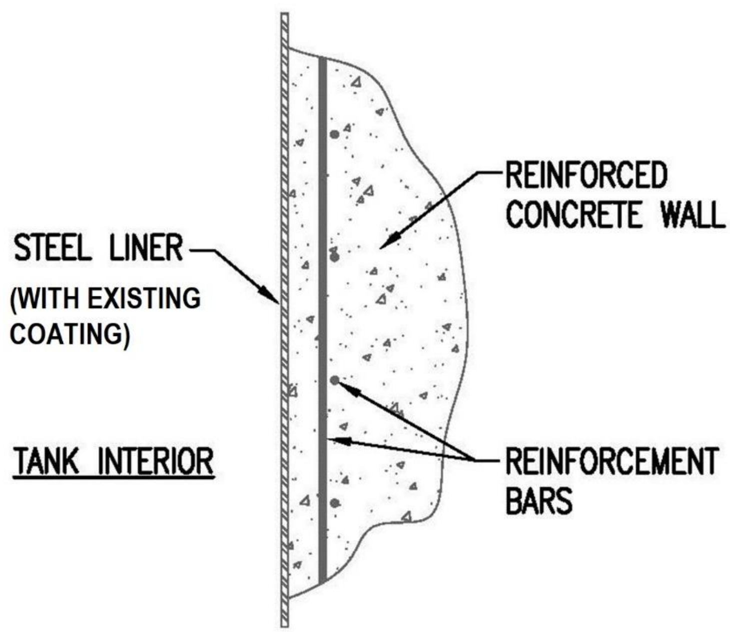

Figure 9: Tank Upgrade Alternative 1A - Typical Wall Section

1B - Restoration of Existing Tank plus Interior Coating

Alternative 1B is essentially the same as Alternative 1A, with the additional coating of all surfaces in contact with fuel (including the barrel section and portions of the upper dome) with PMNE coating. A typical wall section for Alternative 1B is shown in Figure 10.

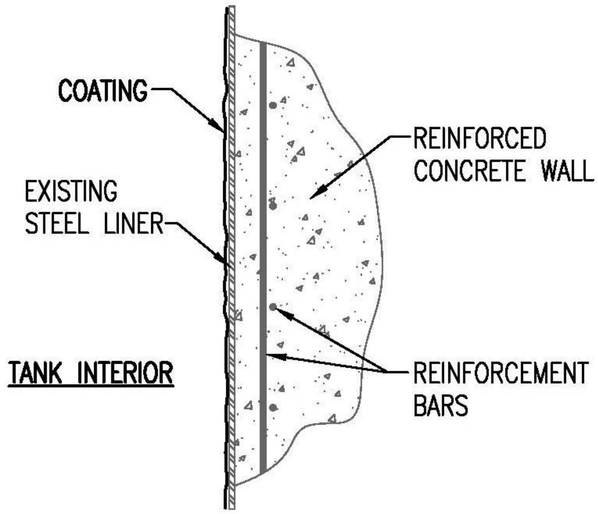

Figure 10: Tank Upgrade Alternative 1B - Typical Wall Section

This alternative includes coating the interior of the active product piping to the first valve with PMNE. As with Alternative 1A, the primary steel tank liner will not be fitted with secondary containment, and therefore relies on semi-annual tank tightness testing for environmental compliance. Alternative 1B includes integrity inspection and pressure testing of the remaining existing nozzle (i.e. the existing single-wall piping from inside the tank to the first valve outside tank). Alternative 1B includes decommissioning from active fuel service nozzles not essential to operations.

The DoD-approved PMNE system is relatively new and is ordinarily used as a protective coating system in service as a barrier to corrosion. However, the system has properties which have the potential to be beneficial for use as a hydraulic barrier. Since the PMNE system has not been tested for use as a hydraulic barrier, Navy/DLA are committed to conducting a pilot study, Alternative 1B Pilot, to determine the effectiveness of the PMNE coating system for use as a hydraulic barrier or tank liner.

1D - Remove existing steel liner and replace with a new steel liner

Alternative 1D removes the existing steel liner on all tank surfaces, assesses the steel support system and installs a new steel liner, welded to the original steel supports in the concrete. A typical wall section for Alternative 1D is shown in Figure 11.
This alternative includes coating the interior of the active product piping to the first valve using the PMNE coating.

As with Alternative 1A and 1B, the tank would not be fitted with secondary containment, and would utilize annual semi-tank tightness testing for environmental compliance. Alternative 1D includes integrity inspection and pressure testing of the nozzles (i.e. the existing single-wall piping from inside the tank to the first valve outside tank). Alternative 1D includes decommissioning from active fuel service nozzles not essential to operations.

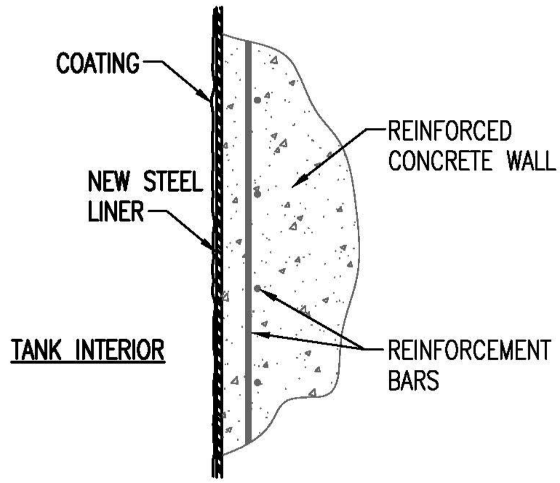

Figure 11: Tank Upgrade Alternative 1D - Typical Wall Section

2A - Composite Tank (Double-wall) Carbon Steel

Alternative 2A installs an additional steel liner within the existing tank, forming a 3 inch concrete or grout filled interstitial space providing for secondary containment and release detection inside the existing tank. The existing steel shell will provide the secondary containment. This effectively removes the ability to repair or renew any part of the existing steel liner upon completion of this upgrade. A typical wall section for TUA 2A is shown in Figure 12, with a tank section shown in Figure 13.

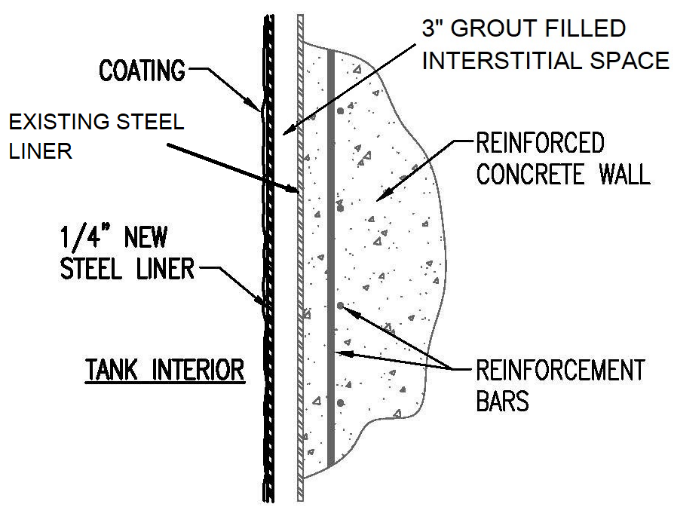

Figure 12: Tank Upgrade Alternative 2A - Typical Wall Section

The new steel liner will undergo inspection, repair and maintenance as per the TIRM Procedures, similar to alternatives relying on the existing liner as primary tank envelope. The new steel liner providing primary containment will be coated with the PMNE coating.

Secondary containment and release detection is provided by the integral interstitial space between the two steel shells, and a network of pipes and channels installed in the interstitial space to convey any liquid released past the new primary containment liner via gravity to sensor racks in the LAT providing continuous release detection with sensors connected to an alarm at a central location.

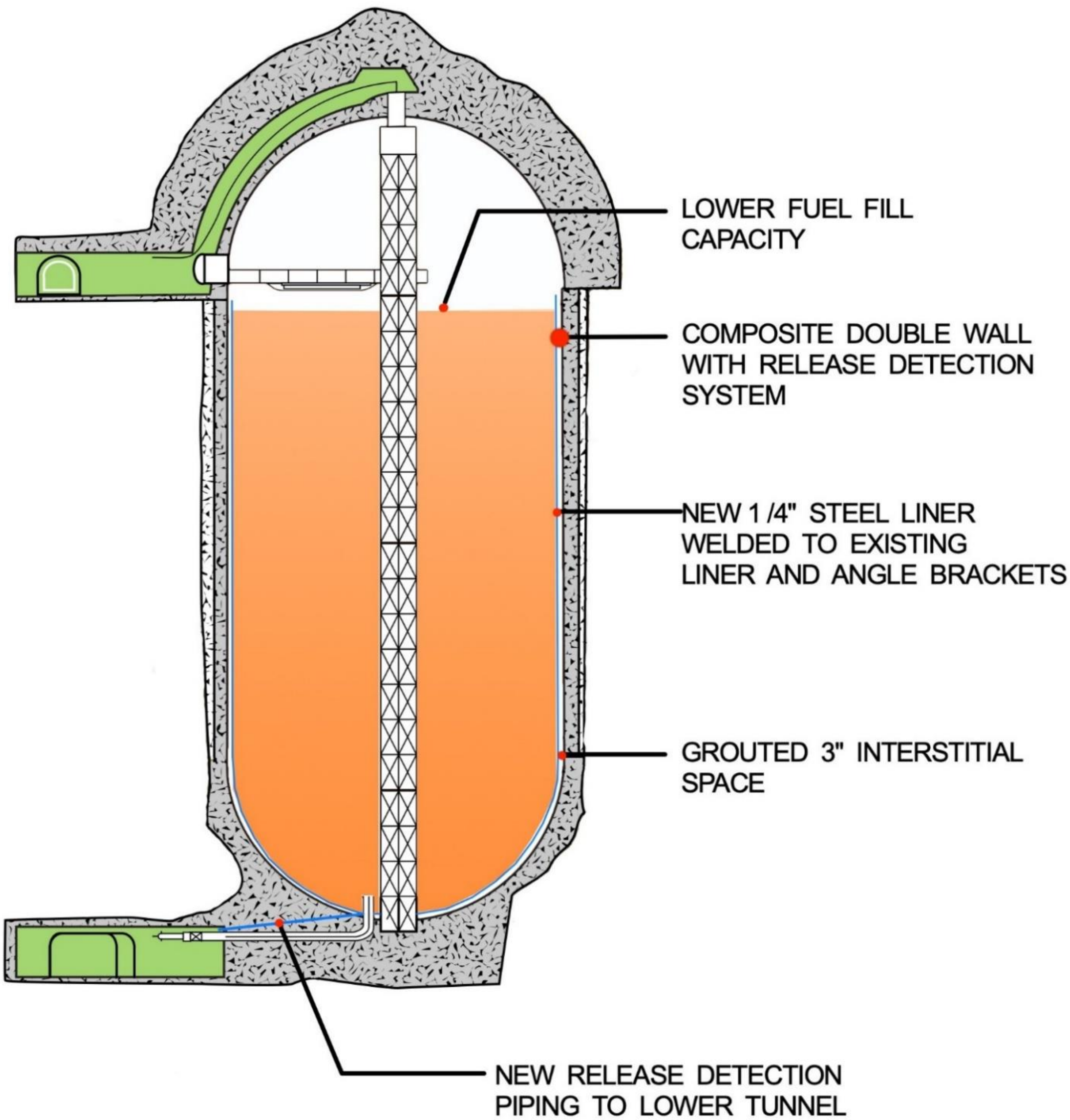

Figure 13: Tank Upgrade Alternative 2A/2B – Typical Tank Section

This alternative includes decommissioning existing concrete-encased nozzles from the tank (i.e. tank nozzles) to the first valve outside tank and replace with double-wall piping. The upper dome will not have a composite liner and would not be used for fuel storage. This alternative results in a reduction in storage capacity.

This alternative assumes that Tanks 1 and 19 (currently not in service) can be inspected, repaired, upgraded and returned to service to reduce the loss of the Facility storage volume. Even with two additional tanks being brought into service, Alternative 2A still results in a significant (12%) reduction of facility storage volume when compared to the present storage volume.

2B - Composite Tank (Double-wall) Duplex Stainless Steel

Alternative 2B is essentially the same as Alternative 2A, except that a stainless steel liner is installed instead of a carbon steel liner to serve as the primary containment. A typical wall section for Alternative 2B is shown in Figure14.

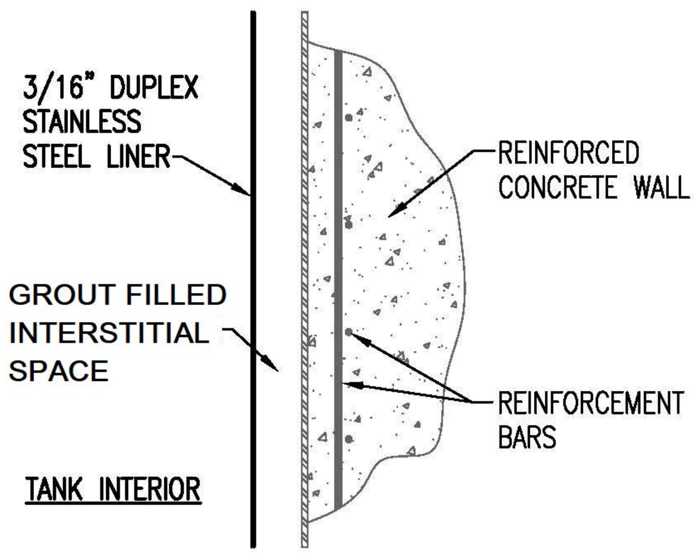

Figure 14: Tank Upgrade Alternative 2B - Typical Wall Section

This alternative assumes that Tanks 1 and 19 (currently not in service) can be inspected, repaired, upgraded and returned to service to reduce the loss of the Facility storage volume. Even with two additional tanks being brought into service, Alternative 2B still results in a significant (12%) reduction of facility storage volume when compared to the present storage volume.

3A - Tank within a Tank (Carbon Steel)

Alternative 3A constructs a new carbon steel tank within the shell of the existing tank and uses the existing steel liner for secondary containment. This design creates a 5 feet wide annular space between the tanks so that both the internal and external steel liners can be inspected and repaired. A typical wall section for Alternative 3A is shown in Figure 15, with a typical tank section shown in Figure 16.

The interior of the new steel tank will be coated with a DoD-approved tank coating system such as PMNE coating. The exterior of the new tank would be coated with a zinc-rich epoxy/epoxy/polyurethane coating. The carbon steel liner on the barrel and upper dome of the existing tank would also be coated with a zinc-rich epoxy/epoxy/polyurethane coating.

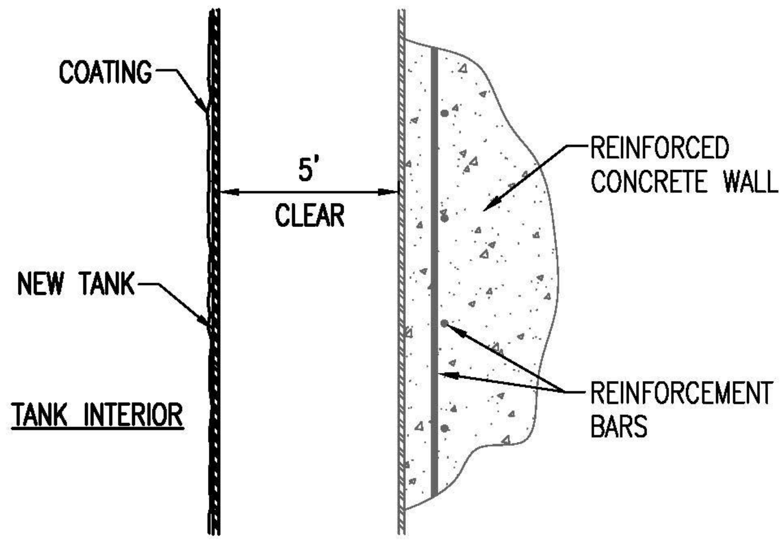

Figure 15: TUA 3A - Typical Wall Section

Alternative 3A allows for fuel storage in the new tank up to the underside of the roof framing at the rim angle. The 5-foot wide annular space between the existing barrel and new tank shell, and the interstitial space between the new tank floor and the existing lower dome, reduces the storage volume of each tank. This alternative assumes that Tanks 1 and 19 (currently not in service) can be inspected, repaired, upgraded and returned to service to reduce the loss of the facility storage volume.

Even with two additional tanks being brought into service, Alternative 3A still results in a significant (20%) reduction of facility storage volume when compared to the present storage volume.

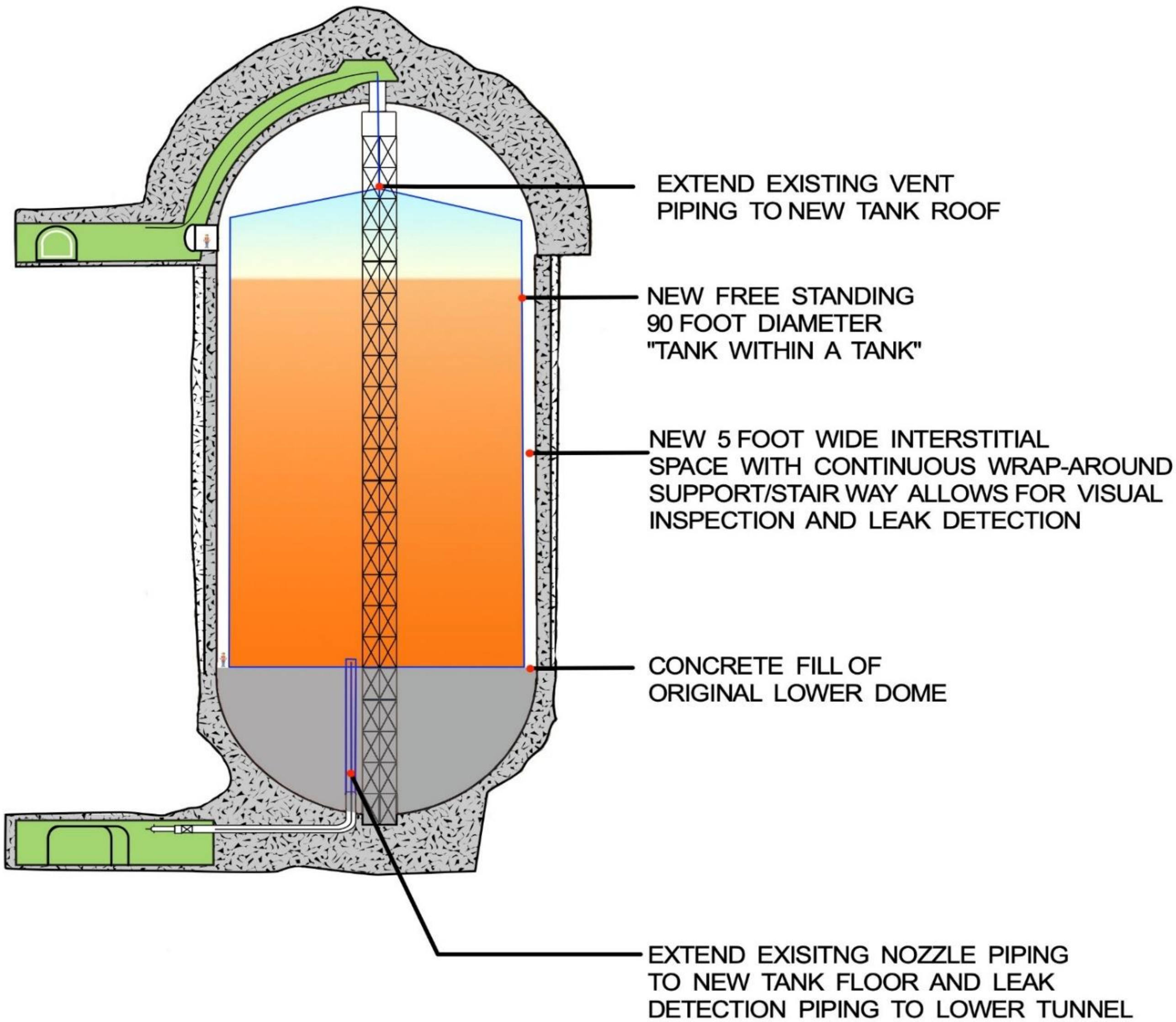

Figure 16: Tank Upgrade Alternative 3A – Typical Tank Section

Install New Cut-and-cover Tank Farm at Alternate Location

This alternative requires the construction of new cylindrical carbon steel tanks, designed in accordance with API Standard 650, within a reinforced concrete tank, which is lined to provide secondary containment. This design creates a 2-inch wide interstitial space between the tank walls. The resulting interstitial space drains to a release detection system. The secondary containment cannot be inspected since it is behind the steel tank, but unlike Alternatives 2A and 2B, the secondary containment is constructed from lined concrete.

New fuel installations for the DoD are generally designed in accordance with the US DoD cut-and-cover tank standards (AW 078-24-33 - Storage Tanks[5]), which are constructed in multiple standard sizes. This DoD standard would be applied to the construction of any new tanks. A typical wall section for new cut-and-cover tanks is shown in Figure 17.

Construction of a new facility to meet the DoD fuel storage requirements would require the identification of an alternate location, extensive environmental impact studies, zoning and permitting approval process, as well as a significant financial commitment. In order for equivalent fuel storage to that currently provided by the Facility, an alternate location would require forty (40) of these 150,000-barrell, cut-and-cover tanks.

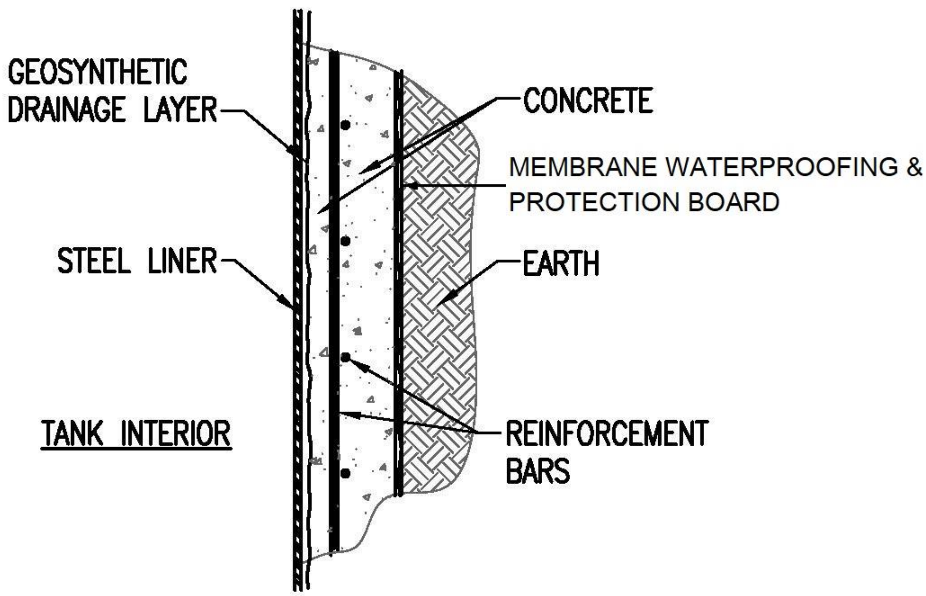

Figure 17: New Cut-and-cover Tanks - Typical Wall Section

TUA Comparison

TUA 1D – Remove Existing Steel Liner and Replace with a New Steel Liner

Environmental Protection

Alternatives 1A, 1B and 1D provide similar levels of environmental protection, given that they are all single-walled alternatives that undergo a rigorous clean, inspect and repair process every 20 years. Alternative 1D has a short-term advantage as the entire liner is replaced. However since the corrosion rates for the new metal are unknown, the first service interval for a 1D tank would be half the current duration.

Impact to Operations

Alternative 1D adds additional risks as it requires the Facility to function as a heavy construction site for an extended duration of between 10 and 25 years. The access tunnels were not designed for modern construction equipment, such as cranes, boom lifts and scaffolding. Due to OSHA safety considerations, there is a risk of cost escalation for this alternative.

The constructability of Alternative 1D represents significant risk to concurrent operations, as any access to the tanks would be through the same tunnels in which power, communications and fuel lines run, and through which operators must travel daily to complete fuel management activities. All of these items add risk to the safety of personnel, security, cost and schedule, and would require mobilization of a highly skilled workforce who are also able to obtain the security clearances required for continued access to a secure facility. Access to the tank interior is limited and would require smaller plates of steel, increasing the number of welds necessary for construction. Additionally, delivery of steel plates to the project site would require the construction of new access roads within the Facility to support the inevitable heavier loads needed.

Practicality of Construction and Maintenance

Alternative 1D is a complex construction project due to the large quantity of materials, equipment and labor that would be required to be transported through the access tunnels. There are also technical and constructability concerns associated with this option which will increase the overall schedule for implementation, further increasing risk to operations. The installation of large pieces of steel required to form the new tank liner would require each piece of steel to be transported through the tunnel, transferred into the tank through the 8-foot diameter manway, and then lifted mechanically into position before being welded into place. While the initial construction of the tanks relied heavily on manual lifting, temporary scaffolds, and manual hoists, this method of construction would not meet current federal or state safety standards.

Historically, the largest challenge Red Hill tank contractors have faced is the difficulty of moving personnel, material, and equipment into the tunnel, and then into the tanks. Multiple contractors have sufficient experience with personnel and material handling. However, no contractor has experience with moving, locating and welding large steel angles, I-beams or plates inside the Red Hill tanks. The largest single repair to date was approximately 15 feet high by 6 feet wide, which is equivalent in size to one of approximately 600 plates that would be required for Alternative 1D. To construct Alternative 1D, the contractor would have to design and install a conveyance system to move steel from Adit 4 to the tank manways. The width of the tunnel and interior doors would limit vehicle movements to one vehicle at a time, as well as creating congestion that impacts on operations. There is significant risk of damage to existing concrete and structural supporting steel behind the liner when removing existing steel liner. This added risk not only increases cost and time of construction, but also increases likelihood of damaging an already functional tank.

A serious consideration when determining the method to move the steel plates is the distances they would need to be moved. The closest tanks, Tanks 1 and 2, are approximately 600 feet from the door at Adit 4, the entrance point to the lower tunnel. The farthest tanks, Tanks 19 and 20, are approximately 2,400 feet away up a steady incline from the Adit to the manway. The materials need to be moved almost a half mile in a tunnel which is 12-feet wide and 12-feet tall. The first 600 feet from Adit 4 to Tank 1 will be a constraint as all materials for multiple projects will enter through here.

OSHA Section 1910.252 c.2.ii stipulates a minimum ventilation flow rate of 2,000 cubic feet per minute (CFM) for each welder in a confined space. If this ventilation rate is not achieved, personal respirators would be required. OSHA caveats this minimum requirement by stating that adequate ventilation to prevent oxygen deficiency and build-up of toxic materials is required, thus the minimum ventilation rate may not be adequate.

Due to limited welding required for existing repair operations, ventilation during welding has not historically been an issue. Alternative 1D would involve considerable amounts of welding. The contractor may need to develop an overall ventilation plan for proposed welding operations, including considering the installation of a ducted vent system.

Ventilation requirements for coating operations will vary depending on the coating product, ambient temperature, and relative humidity. All personnel applying coating inside the tanks after abrasive blasting will be outfitted with full face respirators with Type C NIOSH approval. Ventilation will be for coating purposes, not personnel safety. Novolac products require ventilation, but do not specify a number of required air changes per hour.

Fiscal Responsibility and Cost Effectiveness

Alternative 1D has an estimated cost of approximately [redacted], with an estimated project completion date of 2038 (based on the 2017 TUA Report). Compared to the base case (Alternative 1A), this alternative is approximately five times more expensive, and will take an additional seven years to execute.

As this option provides a similar level of environmental protection to Alternative 1A, it is not perceived as a fiscally responsible use of public funds.

TUA 2A – Composite Tank (Double-wall) Carbon Steel

Environmental Protection

The installation of a carbon steel liner as described in Alternative 2A, would provide an improved level of environmental protection by providing a double-walled underground tank with a 3-inch space between the inner and outer walls for secondary containment and release detection. The disadvantage of this option is that the installation of the new steel tank liner removes the ability to inspect or repair the existing steel liner which becomes the secondary containment. This limits the duration that the secondary containment can be relied upon, as there would be no method to inspect, test or repair the secondary containment to verify its integrity. This option also practically eliminates the ability for any future testing or inspection of the concrete structure.

Alternative 2A, as a double-walled alternative represents improved environmental protection. The design allows any releases to be captured by the secondary containment. Because any Significant Release will be detected by release detection systems and mitigating response actions undertaken prior to large volumes of fuel being released, the double-walled alternatives are most beneficial in ensuring that Minor Releases are captured within the secondary containment, which would otherwise continue without detection.

Impact to Operations

Alternative 2A adds additional risks as it requires the Facility to function as a heavy construction site for an extended duration of between 10 and 25 years. The access tunnels were not designed for modern construction equipment, such as cranes, boom lifts and scaffolding. Due to OSHA safety considerations, there is a risk of cost escalation for all of these alternatives involving a major construction effort.

Alternative 2A does not allow for any future inspection or repair of the existing steel liner which becomes the secondary containment for the system, removing practical opportunities for any future inspection, repair and maintenance of the structural concrete, and do not allow for the integrity of the secondary containment to be reconfirmed. These alternatives cannot be considered as providing long-term secondary containment as there will be no means of confirming the integrity of the secondary containment system after the new steel tank liner is installed.

The Facility is required to maintain a pre-determined quantity of strategically stored fuel at all times to support the DoD mission. Alternative 2A has an associated reduction in fuel storage capacity of 12%. This reduction also assumes that Tanks 1 and 19 will be returned to service, which is not required by any of the single-walled Tank Upgrade Alternatives, and may require additional fuel storage elsewhere.

The constructability of Alternative 2A represents significant risk to concurrent operations, as any access to the tanks would be through the same tunnels in which power, communications and fuel lines run, and through which operators must travel daily to complete fuel management activities. All of these items add risk to the safety of personnel, security, cost and schedule, and would require mobilization of a highly skilled workforce who are also able to obtain the security clearances required for continued access to a secure facility. Access to the tank interior is limited and would require smaller plates of steel, increasing the number of welds necessary for construction. Additionally, delivery of steel plates to the project site would require the construction of new access roads within the Facility to support the inevitable heavier loads.

Practicality of Construction and Maintenance

Alternative 2A would be a complex construction project due to the large quantity of materials, equipment and labor that would be required to be transported through the access tunnels. There are also technical and constructability concerns associated with this option which will increase the overall schedule for implementation, further increasing risk to operations. The installation of large pieces of steel required to form the new tank liner would require each piece of steel to be transported through the tunnel, transferred into the tank through the 8-foot diameter manway, and then lifted mechanically into position before being welded into place. While the initial construction of the tanks relied heavily on manual lifting, temporary scaffolds, and manual hoists, this method of construction would not meet current federal or state safety standards.

Historically, the largest challenge Red Hill tank contractors have faced is the difficulty of moving personnel, material, and equipment into the tunnel, and then into the tanks. Multiple contractors have sufficient experience with personnel and material handling necessary for Alternative 1A. However, no contractor has experience with moving, locating and welding large steel angles, I-beams or plates inside the Red Hill tanks. The largest single repair to date was approximately 15 feet high by 6 feet wide which is equivalent in size to one of approximately 600 plates that would be required for Alternative 2A.

To construct Alternative 2A, the contractor would have to design and install a conveyance system to move steel from Adit 4 to the tank manways. The width of the tunnel and interior doors would limit vehicle movements to one vehicle at a time, as well as create congestion that impacts operations.

A serious consideration when determining the method to move the steel plates is the distances they would need to be moved. The closest tanks, Tanks 1 and 2, are approximately 600 feet from the door at Adit 4, the entrance point to the lower tunnel. The farthest tanks, Tanks 19 and 20, are approximately 2,400 feet away up a steady incline from the Adit to the manway. The materials need to be moved almost a half mile in a tunnel which is 12-feet wide and 12-feet tall. The first 600 feet from Adit 4 to Tank 1 will be a constraint, as all materials for multiple projects will enter through here.

In addition to the movement and installation of steel plates for the construction of Alternative 2A, this design would also require the movement and injection of large quantities of grout to fill the interstitial space between the two steel liners, further adding to the complexity and project risk associated with this alternative.

Alternative 2A has secondary containment provided by the existing liner. Once the new tank liner is installed, the secondary containment (the existing steel liner) can no longer be inspected.

OSHA Section 1910.252 c.2.ii stipulates a minimum ventilation flow rate of 2,000 CFM for each welder in a confined space. If this ventilation rate is not achieved, personal respirators would be required. OSHA caveats this minimum requirement by stating that adequate ventilation to prevent oxygen deficiency and build-up of toxic materials is required, thus the minimum ventilation rate may not be adequate.

Due to limited welding required for existing repair operations, ventilation during welding has not historically been an issue. For Alternative 2A, which will require considerably more welding, the contractor may need to develop an overall ventilation plan for proposed welding operations, including considering the installation of a ducted vent system.

Ventilation requirements for coating operations will vary depending on the coating product, ambient temperature, and relative humidity. All personnel applying coating inside the tanks after abrasive blasting will be outfitted with full face respirators with Type C NIOSH approval. Ventilation will be for coating purposes, not personnel safety. Novolac products require ventilation but do not specify a number of required air changes per hour.

Fiscal Responsibility and Cost Effectiveness

Alternative 2A has an estimated cost of approximately [redacted] with an estimated project completion date of 2039 (based on the 2017 TUA Report). Compared to the base case (Alternative 1A), this alternative is approximately five times more expensive, will take an additional eight years to execute, and will reduce the storage capacity of the Facility by 12%.

This option provides an increased level of environmental protection to Alternative 1A, but the additional cost, duration and reduced storage capacity of this option does not represent a fiscally responsible use of public funds.

TUA 2B – Composite Tank (Double-wall) Duplex Stainless Steel

Environmental Protection

The installation of a stainless steel liner as described in Alternative 2B, would provide an improved level of environmental protection by providing a double-walled underground tank with a 3-inch interstitial space between the inner and outer walls for secondary containment and release detection. The disadvantage of this option is that the installation of the new steel tank liner removes the ability to inspect or repair the existing steel liner which becomes the secondary containment. This limits the duration that the secondary containment can be relied upon, as there would be no method to inspect, test or repair the secondary containment to verify its integrity. This option also practically eliminates the ability for any future testing or inspection of the concrete structure.

Alternative 2B, as a double-walled alternative represents improved environmental protection. The design allows any releases to be captured by the secondary containment. Because any Significant Release will be detected by release-detection systems and mitigating response actions undertaken prior to large volumes of fuel being released, the double-walled alternatives are most beneficial in ensuring that Minor Releases are captured within the secondary containment, which would otherwise continue without detection.

Impact to Operations

Alternative 2B adds additional risks as it requires the Facility to function as a heavy construction site for an extended duration of between 10 and 25 years. The access tunnels were not designed for modern construction equipment, such as cranes, boom lifts and scaffolding. Due to OSHA safety considerations, there is a risk of cost escalation for all of these alternatives involving a major construction effort.

Alternative 2B does not allow for any future inspection or repair of the existing steel liner which becomes the secondary containment for the system, removing practical opportunities for any future inspection, repair and maintenance of the structural concrete, and does not allow for the integrity of the secondary containment to be reconfirmed. These alternatives cannot be considered as providing long-term secondary containment as there will be no means of confirming the integrity of the secondary containment system after the new steel tank liner is installed.

The Facility is required to maintain a pre-determined quantity of strategically stored fuel at all times to support the DoD mission. Alternative 2B has an associated reduction in fuel storage capacity of 12%. This reduction also assumes that Tanks 1 and 19 will be returned to service, which is not required by any of the single-walled Tank Upgrade Alternatives, and may require additional fuel storage elsewhere.

The constructability of Alternative 2B represents significant risk to concurrent operations, as any access to the tanks would be through the same tunnels in which power, communications and fuel lines run, and through which operators must travel daily to complete fuel management activities. All of these items add risk to the safety of personnel, security, cost and schedule, and would require mobilization of a highly skilled workforce who are also able to obtain the security clearances required for continued access to a secure facility. Access to the tank interior is limited and would require smaller plates of steel, increasing the number of welds necessary for construction. Additionally, delivery of steel plates to the project site would require the construction of new access roads within the Facility to support the inevitable heavier loads needed.

Practicality of Construction and Maintenance

Alternative 2B would be a complex construction project due to the large quantity of materials, equipment and labor that would be required to be transported through the access tunnels. There are also technical and constructability concerns associated with this option which will increase the overall schedule for implementation, further increasing risk to operations. The installation of large pieces of steel required to form the new tank liner would require each piece of steel to be transported through the tunnel, transferred into the tank through the 8-foot diameter manway, and then lifted mechanically into position before being welded into place. While the initial construction of the tanks relied heavily on manual lifting, temporary scaffolds, and manual hoists, this method of construction would not meet current federal or state safety standards. Welding stainless steel to carbon steel is a highly specialized skill set which will further limit the number of welders qualified to work at the Facility.

Historically, the largest challenge Red Hill tank contractors have faced is the difficulty of moving personnel, material, and equipment into the tunnel, and then into the tanks. Multiple contractors have sufficient experience with personnel and material handling necessary for Alternative 1A. However, no contractor has experience with moving, locating and welding large steel angles, I-beams or plates inside the Red Hill tanks. The largest single repair to date was approximately 15 feet high by 6 feet wide which is equivalent in size to one of approximately 600 plates that would be required for Alternative 2B.

To construct Alternative 2B, the contractor would have to design and install a conveyance system to move steel from Adit 4 to the tank manways. The width of the tunnel and interior doors would limit vehicle movements to one vehicle at a time, as well as create congestion that impacts operations.

A serious consideration when determining the method to move the steel plates is the distances they would need to be moved. The closest tanks, Tanks 1 and 2, are approximately 600 feet from the door at Adit 4, the entrance point to the lower tunnel. The farthest tanks, Tanks 19 and 20, are approximately 2,400 feet away up a steady incline from the Adit to the manway. The materials need to be moved almost a half mile in a tunnel which is 12-feet wide and 12-feet tall. The first 600 feet from Adit 4 to Tank 1 will be a constraint as all materials for multiple projects will enter through here.

In addition to the movement and installation of steel plates for the construction of Alternative 2B, this design would also require the movement and injection of large quantities of grout to fill the interstitial space between the two steel liners, further adding to the complexity and project risk associated with this alternative.

Alternative 2B has secondary containment provided by the existing liner. Once the new tank liner is installed, the secondary containment (the existing steel liner) can no longer be inspected.
OSHA Section 1910.252 c.2.ii stipulates a minimum ventilation flow rate of 2,000 CFM for each welder in a confined space. If this ventilation rate is not achieved, personal respirators would be required. OSHA caveats this minimum requirement by stating that adequate ventilation to prevent oxygen deficiency and build-up of toxic materials is required, thus the minimum ventilation rate may not be adequate.

Due to limited welding required for existing repair operations, ventilation during welding has not historically been an issue. For Alternative 2B, which will require considerably more welding, the contractor may need to develop an overall ventilation plan for proposed welding operations, including considering the installation of a ducted vent system.

Ventilation requirements for coating operations will vary depending on the coating product, ambient temperature, and relative humidity. All personnel applying coating inside the tanks after abrasive blasting will be outfitted with full face respirators with Type C NIOSH approval. Ventilation will be for coating purposes, not personnel safety. Novolac products require ventilation but do not specify a number of required air changes per hour.

Fiscal Responsibility and Cost Effectiveness

Alternative 2B has an estimated cost of approximately [redacted], with an estimated project completion date of 2037. Compared to the base case (Alternative 1A), this alternative is approximately five times more expensive, will take an additional 6 years to execute, and will reduce the storage capacity of the Facility by 12%.

This option provides an increased level of environmental protection to Alternative 1A, but the additional cost, increased duration and reduced storage capacity of this option does not represent a fiscally responsible use of public funds.

TUA 3A – Tank within a Tank (Carbon Steel)

Environmental Protection

Alternative 3A constructs a new carbon steel tank within the shell of the existing tank and uses the existing steel liner for secondary containment. This design creates a 5 feet wide annular space between the tanks so that both the internal and external steel liners can be inspected and repaired. Alternative 3A, would provide an improved level of environmental protection by providing a double-walled underground tank with a 5-foot space between the inner and outer walls for secondary containment and release detection.

Alternative 3A, as a double-walled alternative, represents improved environmental protection. The design allows any releases to be captured by the secondary containment. Because any Significant Release will be detected by release-detection systems and mitigating response actions undertaken prior to large volumes of fuel being released, the double-walled alternatives are most beneficial in ensuring that Minor Releases are captured within the secondary containment, which would otherwise continue without detection.

Impact to Operations

Alternative 3A adds additional risks as it requires the Facility to function as a heavy construction site for an extended duration of between 10 and 25 years. The access tunnels were not designed for modern construction equipment, such as cranes, boom lifts and scaffolding. Due to OSHA safety considerations, there is a risk of cost escalation for all of these alternatives involving a major construction effort.

The Facility is required to maintain a pre-determined quantity of strategically stored fuel at all times to support the DoD mission. Alternative 3A has an associated reduction in fuel storage capacity of 20%. This reduction also assumes that Tanks 1 and 19 will be returned to service, which is not required by any of the single-walled Tank Upgrade Alternatives, and may require additional fuel storage elsewhere.

Practicality of Construction and Maintenance

The constructability of these alternatives also represents significant risk to concurrent operations, as any access to the tanks would be through the same tunnels in which power, communications and fuel lines run, and through which operators must travel daily to complete fuel management activities. All of these items add risk to the safety of personnel, security, cost and schedule, and would require mobilization of a highly skilled workforce who are also able to obtain the security clearances required for continued access to a secure facility. Access to the tank interior is limited and would require smaller plates of steel, increasing the number of welds necessary for construction. Additionally, delivery of steel plates to the project site would require the construction of new access roads within the Facility to support the inevitable heavier loads needed.

Alternative 3A affords the ability to monitor the space between the inner and outer walls, but creates extremely difficult conditions to inspect and repair primary and secondary containment. In order for this secondary containment (the existing steel liner) to remain tight, existing TIRM Procedures would need to continue. While this option provides an increased level of environmental protection over the single-wall options, it also creates significant challenges due to the complexity associated with the inspection and repair of two steel liners, one of which is contained within a confined space which is 150 feet high and 5 feet wide.

Alternative 3A is the most complex construction project of all the options evaluated due to the large quantity of materials, equipment and labor that would be required to be transported through the access tunnels. There are also technical and constructability concerns associated with this option which will increase the overall schedule for implementation, further increasing risk to operations. The installation of large pieces of steel required to form the new tank liner would require each piece of steel to be transported through the tunnel, transferred into the tank through the 8-foot diameter manway, and then lifted mechanically into position before being welded into place. While the initial construction of the tanks relied heavily on manual lifting, temporary scaffolds, and manual hoists, this method of construction would not meet current federal or state safety standards.

Historically, the largest challenge Red Hill tank contractors have faced is the difficulty of moving personnel, material, and equipment into the tunnel, and then into the tanks. Multiple contractors have sufficient experience with personnel and material handling necessary for Alternatives 1A and 1B. However, no contractor has experience with moving, locating and welding large steel angles, I-beams or plates inside the Red Hill tanks. The largest single repair to date was approximately 15 feet high by 6 feet wide which is equivalent in size to one of approximately 600 plates that would be required for Alternative 3A.

To construct Alternative 3A, the contractor would have to design and install a conveyance system to move steel from Adit 4 to the tank manways. The width of the tunnel and interior doors would limit vehicle movements to one vehicle at a time, as well as create congestion that impacts operations.

A serious consideration when determining the method to move the steel plates is the distances they would need to be moved. The closest tanks, Tanks 1 and 2, are approximately 600 feet from the door at Adit 4, the entrance point to the lower tunnel. The farthest tanks, Tanks 19 and 20, are approximately 2,400 feet away up a steady incline from the Adit to the manway. The materials need to be moved almost a half mile in a tunnel which is 12-feet wide and 12-feet tall. The first 600 feet from Adit 4 to Tank 1 will be a constraint as all materials for multiple projects will enter through here.

In addition to the movement and installation of steel plates for the construction of Alternative 3A, this design would also require the movement of large quantities of concrete to install a new floor in the lower dome of each tank, further adding to the complexity and project risk associated with this alternative.

Alternative 3A also presents additional challenges during regular inspection and scheduled maintenance within the annular containment space. The tank inspection and repair process will effectively increase the time a tank has to be out of service to fully inspect almost triple the surface area for each tank (inner tank wall, outer tank, and secondary tank liner).

Alternative 3A has secondary containment provided by the existing liner. In order for this secondary container (the existing steel liner) to be confirmed as tight, existing TIRM Procedures would need to continue. This may not be practical, given the unresolved challenges of inspecting and repairing a steel liner within a 150 feet high and 5 feet wide annular space.

OSHA Section 1910.252 c.2.ii stipulates a minimum ventilation flow rate of 2,000 CFM for each welder in a confined space. If this ventilation rate is not achieved, personal respirators would be required. OSHA caveats this minimum requirement by stating that adequate ventilation to prevent oxygen deficiency and build-up of toxic materials is required. The minimum ventilation rate may not be adequate.

Due to limited welding required for existing repair operations, ventilation during welding has not historically been an issue. Alternative 3A would involve considerably more welding; the contractor may need to develop an overall ventilation plan for proposed welding operations, including considering the installation of a ducted vent system.

Ventilation requirements for coating operations will vary depending on the coating product, ambient temperature, and relative humidity. All personnel applying coating inside the tanks after abrasive blasting will be outfitted with full face respirators with Type C NIOSH approval. Ventilation will be for coating purposes, not personnel safety. Novolac products require ventilation but do not specify a number of required air changes per hour.

Fiscal Responsibility and Cost Effectiveness

Alternative 3A has an estimated cost of approximately [redacted], with an estimated project completion date of 2038 (based on the 2017 TUA Report). Compared to the base case (Alternative 1A), this alternative is approximately six times more expensive, will take an additional seven years to execute, and will reduce the storage capacity of the Facility by 20%.

This option provides an increased level of environmental protection to Alternative 1A, but the additional cost, increased duration and reduced storage capacity of this option does not represent a fiscally responsible use of public funds.

New Cut-and-Cover Tank Farm

Environmental Protection

The installation of new cut-and-cover tanks in accordance with the DoD standard design would provide similar level of environmental protection as Alternatives 2A, 2B and 3A. The tanks would have a lined concrete secondary containment, in addition to the primary containment provided by the steel tank. The interstitial spaces on these tanks would be monitored for release detection, providing definitive evidence of any release from the steel primary tank. This style of tank has an advantage over the other double-walled alternatives as the secondary containment is non-corrodible, reducing the concern about not being able to inspect it.

Impact to Operations

The installation of a new cut-and-cover tank farm would have minimal impact to the existing operations at the Facility; it has been assumed that any site for a new tank farm would be separated from the existing Facility and would be managed like any other construction site. Further assessments of alternative locations would encompass the entire USINDOPACOM Area of Responsibility (AOR) and would not be limited to only the Island of Oahu.

Practicality of Construction and Maintenance

The secondary containment of the DoD standard cut-and-cover tanks cannot be readily inspected after the primary containment vessel is installed. However, the secondary containment on the cut-and-cover tanks is provided by a lined concrete tank, which is not susceptible to corrosion. The interior of the steel tank (primary containment) is coated with a DoD -approved tank coating system such as PMNE coating, and the exterior is coated with a zinc-rich epoxy/epoxy/polyurethane coating.

Fiscal Responsibility and Cost Effectiveness

New cut-and-cover tanks have been estimated to have a cost of [redacted] (ROM), with an estimated project completion date of 2051 (based on the 2018 Alternate Location Study). Compared to the base case (Alternative 1A), this alternative is approximately ten times more expensive and will take an additional 20 years to execute.

This option provides an increased level of environmental protection to Alternative 1A, but will take the longest duration to implement and as such has not been selected. This alternative will be reconsidered when long-term storage requirement studies are completed.

Appendix D: AOC Information Used to Support Decisions

Tank Tightness Testing

Background

When the 1988 underground storage regulations were implemented, BFCUST were considered deferred requiring no regulatory action. Since 2008, Navy/DLA have been conducting tank tightness testing under DLA's centrally managed program (CMP) on all available tanks on a biennial basis with a MDLR of 0.7 gph. This work was conducted as a BMP.

In 2014, Navy/DLA began testing the Red Hill tanks at a 0.5 gph MDLR well ahead of the revised underground storage tank regulations. In 2015, the testing frequency for all Red Hill tanks was increased from every two years to an annual test cycle. In 2019, Navy/DLA began tank tightness testing semi-annually in response to regulatory agency requirements to conduct tank tightness testing annually.

On July 15th, 2015, EPA published the revised underground storage tank regulations which no longer deferred BFCUST and requires methods to prevent releases. This regulation was required to be implemented on October 13, 2018, requiring all BFCUST with a capacity of 50,000 gallons and greater to meet the release detection requirements in 40 CFR 280 Subpart D, or one of the following alternative methods:

1. Conduct an annual tank tightness test that can detect a 0.5 gallon per hour leak rate;
2. Use an automatic tank gauging system to perform release detection at least every 30 days that can detect a leak rate less than or equal to one gallon per hour. This method must be combined with a tank tightness test that can detect a 0.2 gallon per hour leak rate performed at least every three years;
3. Use an automatic tank gauging system to perform release detection at least every 30 days that can detect a leak rate less than or equal to two gallons per hour. This method must be combined with a tank tightness test that can detect a 0.2 gallon per hour leak rate performed at least every two years;
4. Perform vapor monitoring using a tracer compound placed in the tank system capable of detecting a 0.1 gallon per hour leak rate performed at least every two years;
5. Combine inventory control performed at least every 30 days that can detect a leak equal to or less than 0.50 percent of flow-through combined with one of the following:
    a. A tank tightness test that can detect a 0.5 gallon per hour leak rate performed at least every two years; or
    b. Vapor monitoring or groundwater monitoring performed at least every 30 days; or
    c. Use another method approved by the implementing agency if the owner and operator can demonstrate that the method can detect a release as effectively as any of the alternative methods listed above.

Since the DLA CMP was already conducting annual tank tightness testing at 0.5 MDLR, the implementation of the new regulation did not require additional testing.

Testing Process

The testing procedures used for tank tightness testing at the Facility were those defined as the MTC Precision Mass Measurement Systems SIM-1000 and CBU-1000 (24-hour) leak detection method. Determination of leakage is based on the criteria established in the Ken Wilcox Associates, Inc. third-party evaluation and as listed in the NWGLDE. The MTC Precision Mass Measurement System is certified with a capability to detect releases on a tank proportional to the product surface area with a probability of detection of 95 percent and probability of a false alarm of 5 percent.

This tank tightness testing at the Facility utilized two test units to perform five (5) 24-hour precision tightness tests per test unit over a 5-day period (120 hours total) on all available BFCUST. These five 24-hour tests were then averaged, and compared against the 0.5 gallons per hour (gph) MDLR requirement. The MTC standard test procedure includes ensuring that any isolation valve(s) are properly seated (via closing, reopening, and reclosing). The bleed ports of double-block and bleed isolation valves are then checked for the presence of product during each test.

2008
Two of the tanks in service (Tanks 9 and 15) underwent MTC tank tightness testing. Testing was completed on 11 March 2008, with no detectable leaks above the test method's MDLR of 0.7 gph. These two tanks passed their tests.

2009
Fifteen of the tanks in service underwent MTC tank tightness testing. Testing was completed on 24 June 2009, with no detectable leaks above the test method's MDLR of 0.7 gph. All tanks including Tank 5 passed their tests. At this time, three tanks (Tanks 1, 19 and 20) were not in service during the test event, and two tanks (Tanks 9 and 15) were not tested as they had been tested in the previous year.

2010/2011
Sixteen of the tanks in service underwent MTC tank tightness testing. Testing was completed on 25 March 2011, with no detectable leaks above the test method's MDLR of 0.7 gph. All tanks passed their tests. At this time, two tanks (Tanks 5 and 17) were out of service for inspection during the test event, and two tanks had been removed from service (Tanks 1 and 19).

2012/2013
Fifteen of the tanks in service underwent MTC tank tightness testing. Testing was completed on 5 April 2013, with no detectable leaks above the test method's MDLR of 0.7 gph. All tanks passed their tests. At this time, three tanks (Tanks 5, 14 and 17) were out of service for inspection during the test event, and two tanks had been removed from service (Tanks 1 and 19).

2014/2015
Eleven of the tanks in service underwent MTC tank tightness testing. Testing was completed on 13 Feb 2016, with no detectable leaks above the test method's MDLR of 0.5 gph. All tanks passed

their tests. At this time, three tanks (Tanks 5, 14 and 17) were out of service during the test event for internal inspection. Four tanks (13, 15, 16 and 18) were in service but were not available for testing. This was in addition to the two tanks (Tanks 1 and 19) that had been removed from service.

2016

Fourteen of the tanks in service underwent MTC tank tightness testing. Testing was completed on 27 January 2017, with no detectable leaks above the test method's MDLR of 0.5 gph. All tanks passed their tests. At this time, four tanks (Tanks 5, 13, 14 and 17) were out of service during the test event for internal inspection, and two tanks had been removed from service (Tanks 1 and 19).

2017

Fourteen of the tanks in service underwent MTC leak detection tests. Testing was completed on 19 November 2017, with no detectable leaks above the test MDLR of 0.5 gph. All tanks passed their tests. At this time, four tanks (Tanks 5, 13, 14 and 17) were out of service during the test event for internal inspection, and two tanks had been removed from service (Tanks 1 and 19).

2018

Fourteen of the tanks in service underwent MTC leak detection tests. Testing was completed on 27 November 2018, with no detectable leaks above the test method's MDLR of 0.5 gph. All tanks passed their tests. At this time, 4 tanks (Tanks 5, 13, 14 and 17) were out of service during the test event for internal inspection, and 2 tanks had been removed from service (Tanks 1 and 19).

2019

Fourteen of the tanks in service underwent MTC leak detection tests. Testing was completed on 2 June 2019, with no detectable leaks above the test method's MDLR of 0.5 gph. All tanks passed their tests. At this time, 4 tanks (Tanks 5, 13, 14 and 17) were out of service during the test event for internal inspection, and 2 tanks had been removed from service (Tanks 1 and 19).

Summary

In the period since 2008 when MTC tank tightness testing was conducted, every tank containing fuel has been tested and passed its test and has been certified as "tight." This evidence supports Navy/DLA assertion that the CIR program is effective in ensuring the integrity of the steel tank liner during in-service periods.

Destructive Analysis of Tank 14 Coupons

To ensure tank integrity, the Navy has contractors perform NDE on the operational tanks at periodic intervals. NDE processes include identifying locations of back-side thinning and pitting, weld defects, while documenting the thickness of each section of the tank walls.

In 2018, ten 12-inch x 12-inch (approx.) "coupons" of steel liner were removed from Tank 14, so that an in-depth chemical and physical analysis of the coupons could be undertaken, with the primary aim of validating NDE results. Poly bags of concrete powder samples, taken from exposed concrete at the site of each removed coupon, and corrosion product were also submitted with the coupons.

The coupons and bagged samples were evaluated using a combination of laboratory techniques. Thickness measurements of the coupons were compared against the original nominal wall thickness of 250 mils.

An initial evaluation was performed on the coupons in the as-received condition, which included visual inspection and computerized tomography scans. This work was followed by a step-wise process of excising corrosion product for analysis, CO2 blast cleaning, and determining microstructural, chemical and mechanical properties. The work was performed over a 4-month period, from August to November 2018 by an accredited laboratory.

The analysis of the destructive testing data showed a strong correlation between the NDE processes and the laboratory analyses, and provided valuable insight into the original materials of construction for the Facility. The minimum thicknesses identified by the Metallography indicated to be within the expected ranges, and generally correlated with the anticipated results from the NDE, and were within the Navy's acceptable limits.

Coupon 1 was found to have significantly less metal loss than what was identified by the NDE. Coupons 2, 5, 7, 8, 10, A1 and A2 all had measured thicknesses consistent to what was found with the NDE. Coupon 3 destructive testing showed actionable metal loss whereas the NDE did not identify any in this exact location. An actionable indication was found adjacent to where Coupon 3 was cut out. During the follow on repair process, however, the metal loss at the Coupon 3 location would have been detected. Coupon 6 showed more metal loss than was predicted by the NDE and was just below the repair threshold. The destructive testing identified this to be a very small volume pit. The NDE method used (LFET) does not always detect very small volume metal loss. However, due to the fact there was still 64 percent wall thickness remaining, there is an extremely low probability that even if the corrosion continued there would be any tank wall perforation before the next inspection.

Given the destructive testing results, the Navy is investigating alternatives to improve scanning. The report contains additional recommendations which will be considered by Navy's experts in the continual improvement of TIRM Procedures, including:

1. Analysis of the corrosion rate calculation procedures and recommendations for improvement;
2. Evaluation of results against current corrosion mitigation practices;
3. Recommendations for modifications or improvements to TIRM Procedures; and
4. Recommendations for additional destructive testing.

Environmental Investigations and Modeling

The following Table 7 summarizes the environmental studies completed in association with the Facility. Studies are ongoing. All studies are funded by Navy/DLA.

Table 7: Summary of Environmental Studies

Document	Citation(s)	Content
PLANNING DOCUMENTS		
Work Plan / Scope of Work Rev. 02 [a]	(DON 2017b)	Describes the process, tasks, and deliverables planned for investigation and remediation of petroleum product releases and protection and evaluation of groundwater at the Facility
DERIVATIVE DELIVERABLES		
Monitoring Well Installation Work Plan, Addendum 01, 02	(DON 2016b, 2017a, and 2017j)	Presents the site background and documents the monitoring well installation design rationale, as well as the methods and procedures proposed to advance borings, collect rock cores, sample deep subsurface unconsolidated material (if encountered in the borings), and install and develop monitoring wells for groundwater sampling at the Facility
Sampling and Analysis Plan Rev.01, Addendum 01, 03	(DON 2017g, 2017m, 2018h)	Describes the field, analytical, and quality control (QC) procedures for activities planned for investigation and remediation of petroleum product releases and protection and evaluation of groundwater at the Facility
Conceptual Site Model Development and Update Plan	(DON 2017l)	Outlines how the existing CSM will be iteratively updated and refined for inclusion in the AOC Statement of Work Section 6 *Investigation and Remediation of Releases Report*
Attenuation Evaluation Plan	(DON 2017k)	Presents the plan for collecting and analyzing data to evaluate and bound the rate of fuel attenuation in the subsurface from the range of fuel releases that could occur at the Facility
Groundwater Model Evaluation Plan	(DON 2017n)	Describes development of the groundwater flow and contaminant fate and transport (CF&T) models for the Investigation and Remediation of Releases and Groundwater Protection and Evaluation at the Facility
Sentinel Well Network Development Plan	(DON 2017q)	Presents the plan for evaluating and establishing a sentinel monitoring well network (groundwater monitoring wells and potentially soil vapor wells or vapor monitoring using remote sensing techniques [e.g., thermal imaging, multi-spectral imaging]) for protecting existing water production wells for drinking water ingestion and domestic use, as well as other potential receptors in the study area of the Investigation and Remediation of Releases and Groundwater Protection and Evaluation project at the Facility
Risk-Based Decision Criteria Development Plan	(DON 2017p)	Presents a plan to develop risk-based decision criteria to support the investigation and remediation of releases at the Facility
OTHER		
Technical Memorandum, Second Order, Class I Topographic Survey at Groundwater Monitoring Well Locations	(DON 2017e)	Presents the general approach for conducting a Second Order, Class I topographic survey of the top-of-casing elevations and associated survey reference points for all groundwater monitoring well locations at the Facility
Final Synoptic Water Level Study Work Plan, Hālawa Area	(USGS 2017)	Presents a plan to conduct continuous water level monitoring in 23 wells over a 3-month period to document spatial and temporal variations in groundwater levels under typical and controlled withdrawal conditions
REPORTS		
DERIVATIVE DELIVERABLES		
Existing Data Summary and Evaluation Report	(DON 2017d)	Presents currently compiled existing data and other relevant information pertaining to the groundwater flow modeling area for the Investigation and Remediation of Petroleum Product Releases and Groundwater Protection and Evaluation project at the Facility

Document	Citation(s)	Content
Data Gap Analysis Report	(DON 2017h)	Presents the rationale for data requirements, evaluates the suitability of existing data, and identifies data gaps in order to develop Red Hill's CSM, groundwater flow model, and CF&T model
OTHER		
Quarterly Groundwater Monitoring Reports	(DON 2005) – present	Presents analytical results of periodic groundwater monitoring in the Red Hill network since 2005
Groundwater Flow Model Progress Reports [a]	(DON 2017f, 2017i, 2017o, 2018e, 2018k)	Provides current status reports on the groundwater flow modeling effort, every 4 months following Regulator approval of the project WP/SOW (DON 2017b)
Well Elevation Survey Reports	(DON 2018b, 2018g)	Compiles the results of a high-accuracy leveling survey of monitoring well elevations at the Facility
Testing and Verification of Packer Integrity at RHMW11	(DON 2018c)	Presents the results of testing and verification of packer integrity at monitoring well RHMW11 for the Investigation and Remediation of Releases and Groundwater Protection and Evaluation project at the Red Hill Bulk Fuel Storage Facility
Seismic Profiling to Map Hydrostratigraphy in the Red Hill Area	(DON 2018d)	Presents the results from seismic profiles acquired in the Red Hill area of Oahu, Hawaii to map stratigraphy and hydrogeological boundaries beneath North Halawa Valley, South Halawa Valley, and Moanalua Valley
Gyroscopic Survey Results and Calculated Correction Factors for Groundwater Monitoring Network Wells	(DON 2018f)	Presents the results of gyroscopic surveys, three-dimensional modeling of gyroscopic data, and the resulting corrections for manual depth to water measurements at 12 monitoring wells at the Facility
Conceptual Site Model	(DON 2018i)	Provides a basis for evaluating contaminant transport pathways and the potential for exposure of human receptors to potentially impacted drinking water at the Facility
Groundwater Protection and Evaluation Considerations for the Red Hill Bulk Fuel Storage Facility	(DON 2018j)	Provides an interim environmental analysis of current data, and presents an initial framework and analysis of potential environmental risks in preparation for the AOC Statement of Work Section 6.3 deliverable, *Investigation and Remediation of Releases Report*, and the AOC Statement of Work Section 7.1 deliverable, *Groundwater Flow Model Report*

[a] AOC required deliverable.

The CSM, IRR and Groundwater Protection and Evaluation Report[4] summarizes the Navy's interim environmental analysis and an initial analysis of potential environmental risks. The CSM for the Facility is the primary reference for this document. The key objectives for the interim environmental analysis were to:

1. Protect public health and environment;
2. Meet DoD operational requirements for the Facility;
3. Comply with the AOC;
4. Comply with existing government regulations; and
5. Meet acceptable environmental performance criteria and risk reduction.

The CSM presents the interim environmental analysis of current data and an initial framework and analysis of potential environmental risks for the areas addressed as part of AOC Sections 6 and 7. The work for AOC Sections 6 and 7 has led to a number of key findings, which are summarized in the various documents.

Quantitative Risk and Vulnerability Assessment Summary

Overview

The criteria for selection of the BAPT is an analysis of the various Tank Upgrade Alternatives vs. three primary categories of risk evaluated over the short, medium, and long-term:

1. Minor Releases;
2. Significant Releases; and
3. Major Releases.

Protection of the environment is based on an analysis of product release scenarios and risk. These risks are described in the following sections.

Risk and Vulnerability Assessment

In accordance with the AOC, Navy/DLA initiated a QRVA study to provide a comprehensive risk analysis of the Facility. This report will enable the Navy to establish a starting point to identify potential risks and ways to reduce risks as it continues evaluating and implementing the best available practices to ensure our drinking water sources in the vicinity are protected.

A comprehensive QRVA of a facility of this size and complexity generally takes five to seven years to complete. To meet the AOC delivery requirement of 18 months, the QRVA was divided into four phases:

1. Phase 1: Internal events without fire or flood;
2. Phase 2: Internal and External Fire and flood events;
3. Phase 3: Seismic events; and
4. Phase 4: Additional external events.

The Phase 1 report was intended to satisfy the AOC Section 8.3 delivery deadline. The remaining phases would then be used to inform the 5-year review cycle of the BAPT following the Navy/DLA initial Tank Upgrade Alternative Decision.

The Navy’s Consultant and Baseline Assessment

The Navy contracted an environmental engineering consultant to perform the risk and vulnerability assessment. The consulting team included Element Environmental LLC, HDR Engineering, Inc., and ABS Consulting. ABS specializes in risk and vulnerability assessments, with experience derived from standards used in the nuclear power industry. Working with the regulatory agencies, the Navy and its consultants agreed to a SOW to perform a quantitative risk and vulnerability assessment. The consultants’ approach was to produce an independent and objective assessment that met industry standards and could be legally defensible. As such, while Navy/DLA provided requested information and facilitated review and comments from internal and external stakeholder SMEs, Navy/DLA was not significantly involved in the development of the model used to computationally simulate event sequences.

The QRVA Phase 1 Report is meant to be a baseline. Sensitivity case studies would be required to modify certain parameters of the baseline model to evaluate the impacts to the baseline results. This report is an assessment of risk and is presented as potential frequency and potential release volume. After review of the roughly 1,600-page report and attached reference files, the Navy has determined that the baseline model would require sensitivity case studies to improve the accuracy of the reported risks, as well as evaluate risk improvements from the approved CIR Process and updated operational procedures and training.

The following is a list of the Navy/DLA concerns with the baseline QRVA Phase 1 model and results:

1. The report cited the possible frequency of an initiating event resulting in a fuel release between 1,000 and 30,000 gallons is 27.6 percent. This is an assessment of the probability of an event happening, and not that the event will actually happen. It also does not reflect the historical record, which shows that, since 1983, the Navy has not identified a verified release other than the 27,000 gallons from Tank 5 that was reported in 2014, which represents one event in 35 years. This assessment suggests that the methodology or input parameters may need to be re-examined to improve the accuracy of the baseline model.
2. The assessment included a design freeze date of July 27, 2017. A sensitivity case study would be required to evaluate the impact of decommissioning the smaller nozzles in accordance with TIRM Procedures, which was approved by the Regulatory Agencies, but yet to be executed on current tank repairs. The nozzles were identified as important to risk.
3. The liner release rate through a 0.5-inch diameter equivalent hole is likely overestimated using an open orifice calculation. The consultants do not ‘credit’ the concrete for containment properties, but several feet of concrete will provide significant flow resistance at any sized hole. This rate will overstate the release consequence, given a specific reaction time. A sensitivity case study would need to be performed to provide more realistic performance of the concrete/grout structure supporting the steel liner.
4. It appears that the historic API 653 inspection reports, which identify numbers of through holes developing as well as the recorded size, was used to inform frequency and potential consequence throughout the tank. However, it is unclear if the model differentiates between the frequency and size of holes developing in the upper dome (above the maximum fuel level in the tank) or those found in the barrel (below the maximum fuel level in the tank and typically submerged). Corrosion through holes are expected to be more prominent in the vapor zones than on the wetted surfaces. More investigation would be needed by the Navy to understand and validate the methodology used by the Navy’s consultant in the computational model.
5. While the Navy’s consultant acknowledges the higher risk of release during a return to service after the TIRM Procedures, it is unclear if the historic data has been segregated by this criteria, and used as input parameters to the model. The highest release rate events considered by the Navy’s consultant appear to be caused by the TIRM Procedures where the tank was not releasing fuel before being taken out of service. It may be more appropriate that these initiating events be segregated from initiating events that develop during normal operations because there are different mitigating actions available. Further investigation and/or sensitivity case studies would need to be performed to provide more realistic event sequences associated with relevant source data.

6. Chronic releases appear to be distributed near the threshold for detection. The Navy's consultants also state in the report that "it is important to recognize that these postulated fuel release rates involve a number of conservative assumptions, which make the estimates likely to be overstated." With advanced release detection technology being considered by the Navy, however, it would follow that the estimate will drop to reflect the revised threshold of detection. It would still likely be overstated. A sensitivity case study would be needed to estimate the impact of implementing advanced release detection.
7. Chronic release simulations appear to consider 18 tanks in service during the year. This does not account for the expected three tanks that are expected to be out of service during the TIRM Procedure at any given time. This may cause the chronic release estimate to further be overstated. More investigation is needed by the Navy to understand and validate the methodology used by the Navy's consultant in the computational model. A sensitivity case study would be needed to estimate the impact of implementing advanced release detection.
8. The tank tightness testing results appear to be used to postulate chronic release. The assumptions documented were missing results for Tank 5 and Tank 17 before being taken out of service. These documents do exist and can be provided to the Navy's consultant. It is unclear how this may affect the chronic release estimate. More investigation would be needed by the Navy to understand and validate the methodology used by the Navy's consultant in the computational model.
9. Groundwater Flow and Contaminant Fate and Transport modelling is ongoing, with oversight and review by the regulatory agencies and their SMEs. The initial volume used in this assessment to determine the frequency of an event leading to a release of fuel that would likely affect the aquifer is preliminary. Based on the concerns outlined above, it's possible that the frequency is overstated because the rate of release used may not be accurate. Further investigation and/or sensitivity case studies would need to be performed to better assess the probability of a single event affecting the aquifer.
10. While the above concerns may or may not have an impact on the absolute values presented in the Phase 1 Report, individual risks can still be compared on a relative basis. Figure 18 shows that based on frequency, initiating events related to the steel tank liner account for 98 percent of sequences resulting in a release (84 percent Liner Releases + 14 percent Overfill).

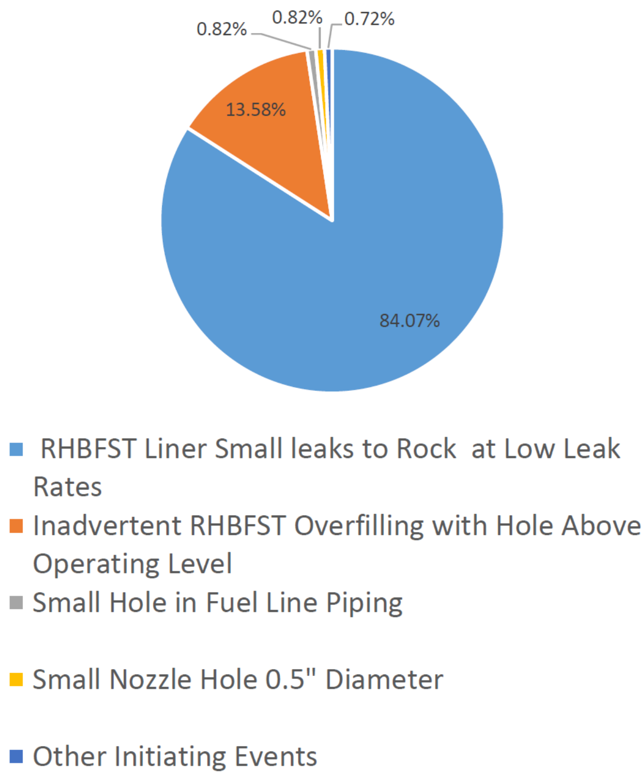

Figure 18: Initiating Event Category Contributors to the Frequency of All Acute Sequences

However, based on a significant release volume of 120,000 gallons or more, Figure 19 shows the initiating events related to the nozzle are approximately five times that of the steel liner.

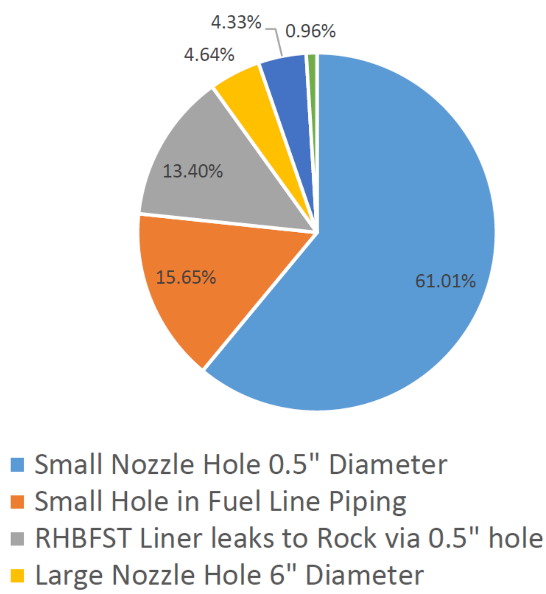

Figure 19: Initiating Event Category Contribution to the Frequency of Acute Sequences Releasing More than 120,000 Gallons

According to the baseline model, nozzle releases contribute about twice the potential release volume per year than small liner releases (<1.5gpm). The baseline model projected that a small nozzle hole results in an acute release of between eight and 33 times the volume of small liner release. The model projected that a large nozzle hole results in an acute release of between 33 and 166 times the volume of a small liner release.

The following items, in order of importance, were identified as key contributors to risk:

1. Availability of tank ullage to accommodate emergency movement of fuel from a releasing tank to a safe storage location;
2. Availability and quality of potential fuel release emergency procedures and associated operator training;
3. The capability and reliability of tank fuel inventory (fuel level) instrumentation and control systems;
4. In response to potential fuel release scenarios, operator actions are generally more important than equipment failures to overall risk;
5. Following tank inspections and maintenance, quality control during tank return-to-service processes;
6. Strategies for responding to fuel releases inside the LAT;
7. Potential fuel releases from the tank nozzles;
8. The capability and reliability of fuel piping isolation in response to fuel release incidents in the LAT;
9. Safety management and control of specific maintenance actions at the Facility; and
10. The design and proximity of the LAT to the Red Hill water shaft.

The Navy's Actions to Mitigate Risk

While the vulnerabilities identified were already known, the risk assessment provided a ranking of relative importance of each. This is a useful tool in planning risk mitigations to address the vulnerabilities effectively with the available resources. The following is a brief discussion on the Navy's approach to controlling the risks.

1. Availability of tank ullage to accommodate emergency movement of fuel from a tank that is releasing fuel to a safe storage location is important to risk.

Tank ullage is identified as having the most influence on risk. If a release is detected, the ability of the Navy to transfer the fuel from the suspect tank is critical to minimizing the potential release of fuel from the Facility. Addressing this vulnerability is not straight forward. Federal Regulations currently prohibit maintaining an asset that is not operationally used – i.e., an empty tank. Further, an empty tank is much more difficult and costly to maintain because, unlike a full tank where the fuel serves as a corrosion inhibitor, an empty tank is far more subject to internal corrosion. Currently, the Navy fuel operations director for Joint Base Pearl Harbor-Hickam is responsible for having situational awareness of inventory and potential spare ullage available at any given time. There are three types of fuel stored at Red Hill, each with their own options for alternate storage locations. Given the large volume of a Red Hill tank, there is a concern that available ullage is not readily available for the entire contents. The USINDOPACOM Fuel Study will provide a model to inform fuel laydown and distribution requirements for the DoD in the Indo-Pacific AOR. Once complete, the model can be used to help inform how much bulk fuel storage will be required in Hawaii, allowing DoD to make informed plans and prioritize funding of military construction projects to meet specific and tailored fuel storage requirements on Oahu. Until an engineered control is available, administrative controls will be implemented via situational awareness to limit risk.

2. **Availability and quality of potential fuel release emergency procedures and associated operator training is important to risk.**

The Tank 5 event reported in 2014 involved human errors made by the Navy's operators. Since then, an updated, comprehensive Operations Manual was developed for the Facility and the operator training program has been revised, and includes procedures to handle fuel releases. The Navy will continue to provide and improve administrative controls to limit risks of human reliability related to fuel release response.

3. **The capability and reliability of tank fuel inventory (fuel level) instrumentation and control systems is important to risk.**

An engineered control to this risk has been implemented with the recent upgrade to the AFHE system.

Another engineered control includes planning to install advanced release-detection equipment for Tank Tightness Testing. This equipment is independent of the AFHE, but can possibly be developed to provide supplemental monitoring and active release detection. Further development and improvements of the AFHE and release-detection systems will allow for early detection and initiation of release confirmation and response procedures.

4. **In response to potential fuel release scenarios, operator actions are generally more important than equipment failures to overall risk.**

The new procedures outlined in the Operating Manual document the lines of communication and responsibilities of an operator in the event of a release. The revised training program will reinforce the procedures on a regular basis. The Navy will continue to provide and improve administrative controls to limit risks of human reliability related to fuel release response.

5. **Following tank inspections and maintenance, quality control during tank return-to-service processes is important to risk.**

The historic data, and specifically, the event at Tank 5 that was reported in 2014, shows that human reliability during the tank CIR Process, (a.k.a. TIRM Procedure) is critical to release prevention.

Several administrative controls to reduce this risk have been planned and implemented, including:

1. Independent scanning and proof up quality control by the contractor;
2. Third party Government quality assurance of the inspection and repair contractor;
3. Tank tightness testing and documentation prior to taking a tank out of service for inspection, repair, and maintenance;
4. Incremental fill procedures to monitor integrity of the tank at discrete fuel levels; and
5. Tank tightness testing and documentation after a tank is filled.

These administrative controls will facilitate release prevention and detection.

6. Strategies for responding to fuel releases inside the LAT are important to risk.

Several engineered controls have been implemented to address the risks in the LAT.

Hydraulically/remote operated oil tight doors provide bulkhead separation of the tunnel into five independent zones. Each zone is equipped with a sump and pump system. The doors are automatic but can be manually activated. Monitoring wells and the water wells are protected by oil tight caps to prevent direct migration to the aquifer.

Other engineered and administrative controls are being reviewed by the Navy to further reduce the risk to the aquifer.

7. Potential fuel releases from the tank nozzles are important to risk.

The Navy understands that tank nozzles present risk because that section of piping cannot be isolated. In other words, if there was a hole at this location, a release could not be controlled because the tank contents cannot be isolated from the nozzle piping. However, the piping is protected from external hazards from outside equipment and tools in the lower access tunnel. It is also substantially encased within the concrete superstructure of the tank, embedding it within the mountain, providing a significant level of seismic protection.

The Navy has implemented engineering and administrative controls to protect the nozzles from corrosion. The two smaller nozzles from each tank will be decommissioned during the CIR Process, which was approved by the regulatory agencies. This leaves the largest of the nozzles for each tank, which, due to its size, can be fully inspected, repaired, and coated to prevent corrosion through holes. The focus of these controls is to reduce risk.

8. The capability and reliability of fuel piping isolation in response to fuel release incidents in the LAT are important to risk.

The pipeline currently undergoes visual inspection daily and is subject to internal and external inspection in accordance with API 570. These are identified industry practices sufficient to mitigate the risk of a release due to corrosion, erosion, or other deteriorating causal agents. The current Facility has fuel piping isolation valves installed in the LAT. While fuel isolation in the pipe is of concern, a more primary concern is to better understand the vulnerability of the pipeline to external initiating events such as seismic activity. Seismic vulnerabilities are being evaluated in follow on phases of the risk and vulnerability assessment. This follow on assessment includes identifying the modifications necessary to reduce risk of a release from the pipeline.

9. Safety management and control of specific maintenance actions at the Facility are important to risk.

Safety management, plant oversight, and maintenance actions are a part of standard operations of the Facility, outlined in the revised Operations Manual and fortified with the updated training program. This administrative control is designed to identify and reduce risks.

10. The design and proximity of the LAT to the Red Hill water shaft is important to risk.

Since the original construction, the access cover to the Red Hill water shaft infiltration gallery has been replaced with a water-tight cover. In the event of a release into the Red Hill water shaft, this prevents contamination of the infiltration gallery. Based on current efforts, there is little more that can be accomplished using additional engineering controls to isolate the Red Hill water shaft from the LAT. Some consideration is being taken for administrative controls to reduce impacts of a catastrophic release of fuel into the lower tunnel, but these are in the initial development stages.

For now, the administrative and engineering controls provided for the nozzles and piping in the LAT as described above represent the preventative and corrective risk controls in place.

Otherwise, the proximity of the lower tunnel to the Red Hill water shaft is an accepted risk.

Levels of Environmental Protection

Overview

The Facility's layers of protection provide redundant elements of detection and capture, equivalent to typical provisions of a "double wall" solution. Enhanced leak detection, tank tightness testing, groundwater monitoring, soil vapor monitoring, trend analysis, and AFHE all work together to allow Navy/DLA to quickly identify a release with complimentary systems. This network of systems extends beyond the area of detection afforded by a simple interstitial space sensor. The Facility and its surrounding environment is complex and dynamic. Due to these conditions, the use of a static capture device, such as a "double wall' may not be the most protective, especially in the unlikely event of a Major (Catastrophic) Release. According to the most recent groundwater model, the use of a WTP to create a "capture zone" around the facility would prevent the spread of contamination to drinking water sources in the unlikely event of a release. Minor or Significant (Gradual) Releases have not impacted the drinking water supply based on past historical releases and drinking water sampling results. The use of a WTP would not only reduce risk of impact to the drinking water supply in the unlikely event of a Minor or Significant (Gradual) Release but also would aid in protecting the drinking water supply in the event of a Major (Catastrophic) Release. Furthermore, the Facility's layers of protection include an emphasis on release prevention using the approved TIRM Procedures. Prevention of the release is more protective than relying solely on detection and capture.

1. Minor (Gradual) Releases (Below Threshold of Detection)

Minor (Gradual) Releases are slow releases occurring at rates below the limits prescribed by federal and state regulations for release-detection systems, which is 0.5 gph. These types of releases may not be detected by primary methods such as tank gauging systems, tank tightness testing or statistical inventory reconciliation processes. These types of releases may be so small they are contained within the reinforced concrete, dissipated before being detected, and may be identified through inventory trend analysis, visual inspection of pipework or secondary methods such as routine inspections of groundwater monitoring wells and soil vapor monitoring systems.
Minor (Gradual) Releases could be caused by minor corrosion, weld defects following tank maintenance, and minor operational releases and spills.

The impact of a Minor (Gradual) Release is generally limited to localized ground contamination with minimal impact beyond the Facility boundary. However, this is dependent on the nature of the surrounding geological conditions, constrained product movement through reinforced concrete and gunite, the duration of any undetected release, and proximity to sensitive receptors.

2. Significant (Gradual) Releases (Above Threshold of Detection)

Significant (Gradual) Releases occur at rates above the limits prescribed by federal and state regulations for release-detection systems, which is 0.5 gph. These types of releases are detected by primary methods such as tank gauging systems, tank tightness testing or inventory reconciliation processes and they will be identified in a timely manner.

Significant (Gradual) Releases could be caused by corrosion, weld defects following tank maintenance, and operational spills.

The impact of a Significant (Gradual) Release depends on the rate of product release and the timeliness of the response and investigation. They will be highly dependent on the nature of the surrounding geotechnical conditions and proximity to sensitive receptors. Significant (Gradual) Releases allowed to continue without intervention have the potential to impact groundwater. The early detection and mitigation of a Significant (Gradual) Release is critical for minimizing the overall volume and subsequent impact of any release. Currently, groundwater modeling suggests any Significant (Gradual) Release could eventually be treated at a Red Hill Shaft water treatment plant without posing risk to the public drinking water source.

3. Major (Catastrophic) Releases (High Rate Product Releases)

Major (Catastrophic) Releases occur at rates well above the threshold of release-detection systems (0.5 gph). As these types of releases will be readily detected by primary methods such as automated tank gauging systems, manual tank gauging procedures, visual observation, or inventory reconciliation processes, they will generally be identified immediately.

Initiating events for Major (Catastrophic) Releases could include kinetic attacks, industrial or construction incidents, nozzle failures, or major seismic events resulting in displacement of piping upstream of the first cut-off valve on a tank.

The impact of Major (Catastrophic) Releases is likely to be high, with the timeliness of any incident response and investigation critical to mitigating the impact of a Major (Catastrophic) Release. The AFHE will quickly detect Major (Catastrophic) Releases as an UFM, rapidly alerting operators so emergency response procedures could be implemented. Major (Catastrophic) Releases have a greater potential to impact groundwater. Currently, groundwater modeling suggests any Major (Catastrophic) Releases could eventually be treated at a Red Hill Shaft water treatment plant without posing risk to the public drinking water source.

The Facility is well protected against kinetic attacks (missile and projectiles) by the significant depth of the volcanic rock above the tanks (greater than 100 feet in all areas).
The EPA commissioned PEMY Consulting LLC to evaluate the potential for a catastrophic release of liquid petroleum from the Facility[6].

"The Red Hill tanks have very low potential for a catastrophic release. The tanks are embedded in bedrock 100 to 200 feet deep that makes them well protected from geologic and natural hazards. There are <u>no credible mechanisms</u> that could rapidly cause a large breach in a tank wall and allow a damaging release of stored liquids." - PEMY Consulting LLC, consultant to EPA.

Therefore, an earthquake causing a breach in the tank is not deemed to be a credible initiating event for a major release of fuel.

Navy/DLA estimate that each of the alternatives offer equivalent levels of environmental protection in the case of a Major (Catastrophic) Release.