Red Hill Shaft Recovery and Monitoring Plan (RHSRMP)

JBPHH, Oahu, Hawaii

January 2022

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This Red Hill Shaft Recovery and Monitoring Plan was prepared by the Navy, State of Hawaii Department of Health, and the United States Environmental Protection Agency.

Record of Changes

Addendum	Change Summary	Date	Interagency Concurrence (Navy, DOH, EPA)	
1				
2				
3				
4				
5				

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

AOC	Administrative Order on Consent
BOD	biological oxygen demand
CF&T	contaminant fate and transport
COPC	contaminants of potential concern
CWB	Clean Water Branch
CWRM	Commission on Water Resource Management
DLNR	Department of Land and Natural Resources
DMR	Discharge Monitoring Report
DOFAW	Division of Forestry and Wildlife, DLNR
DOH	Department of Health
DOT	Department of Transportation
DQO	Data Quality Objective
eDNA	environmental DNA
EPA	United States Environmental Protection Agency
ERN	Environmental Restoration
ESA	Endangered Species Act
ft	feet
FY	fiscal year
GAC	Granular activated carbon
gpm	gallons per minute
GWF	groundwater flow
HBWS	Honolulu Board of Water Supply
IDWST	Interagency Drinking Water System Team
JBPHH	Joint Base Pearl Harbor-Hickam
LNAPL	Light Non-aqueous Phase Liquid
MGD	million gallons per day
MILCON	military construction
MSL	mean sea level
MTZ	mass transfer zone
NAVFAC	Naval Facilities Engineering Systems Command
Navy	United States Navy
NAP	Natural Attenuation Parameters
NEPA	National Environmental Policy Act
NFH EV	NAVFAC Hawaii Environmental
NITC	Naval Information Technology Center
NMFS	National Marine Fisheries Service
NOI	Notice of Interest
NPDES	National Pollutant Discharge Elimination System
NR	Natural Resources
O&M	Operations and Maintenance
OTU	Operational Taxonomic Units
PHWRMP	Pearl Harbor Water Resources Management Plan
RHMW	Red Hill Monitoring Wells
SDWB	Safe Drinking Water Branch
SOW	Scope of Work
sq	square
TPH-d	Total Petroleum Hydrocarbons-Diesel
TPH-g	Total Petroleum Hydrocarbons-Gasoline
TPH-o	Total Petroleum Hydrocarbons-Oil
TSS	total suspended solids
UH	University of Hawaii
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WTP	Water Treatment Plant

Red Hill Shaft Recovery and Monitoring Plan (RHSRMP)

1 Project Overview

1.1 Project Goal

The overall goal of this plan is to recover and remediate the Red Hill Shaft drinking water quality and quantity for the people of Hawaii while causing no further harm to human or environmental health. The immediate focus towards this project goal is to remove any fuel contamination and create a contaminant capture zone in the vicinity of the Red Hill Shaft through pumping operations at an initial rate of five (5) million gallons per day (MGD). This plan also sets the full context for the larger, longer-term recovery and mitigation activities based on environmental data that is collected and modeled to support solutions protective of the Red Hill Shaft, the aquifer system, and nearby receptors. Adoption of this document by the signatories formalizes the agreements detailed in this plan and obligates signatories to execute this plan in full.

Agreements detailed in this document shall be incorporated into State permits sought by the Navy or its affiliates, and issued by the State of Hawaii at the State's discretion. The Navy and/or its affiliates agree to support the inclusion of the terms or agreements detailed in this plan into regulatory permits associated with the subject facility or activities.

1.2 Introduction

This Red Hill Shaft Recovery and Monitoring Plan (RHSRMP) was developed jointly by representatives of the State of Hawaii, Department of Health (DOH), Department of Land and Natural Resources (DLNR), the United States Environmental Protection Agency (EPA), United States Navy (Navy) and a team of technical and subject matter experts (listed in Section 9 of this document). This plan is designed to capture and remove contamination from water extracted from the Red Hill Shaft and underlying aquifer, and to ensure the aquifer is available for future drinking water use.

The guiding principles inspiring the development of this plan included minimizing any further harm to human or environmental health and protecting human and environmental health into the future. This plan is intended to be used in conjunction with the Joint Base Pearl Harbor-Hickam (JBPHH) Drinking Water Distribution System Recovery Plan, signed on December 17, 2021 and the Drinking Water Sampling Plan, signed on December 20, 2021, and any and all addendums, to make right the impacts from the fuel spill at the Red Hill Bulk Fuel Storage Facility (Red Hill Facility) that contaminated the drinking water aquifer and JBPHH public water system (PWS 360).

1.3 BACKGROUND

On November 20, 2021, there was a release of an unknown quantity of at least several thousand gallons of JP-5 jet fuel in the Adit 3 tunnel of the Red Hill Facility. Upon the first indications that there was a fuel-like odor in drinking water in homes served by the Red Hill Shaft, the well was turned off and the pumps were secured on November 28. Due to releases of fuel from the Red Hill Facility, the groundwater in the area of Red Hill Shaft beneath the facility was contaminated. Immediately following recognition that the Red Hill Shaft was contaminated, the parties to this plan began mobilizing to protect and restore the groundwater and drinking water systems fed by Red Hill Shaft.

On December 5, DOH Safe Drinking Water Branch (SDWB) authorized Navy divers to enter the well and development tunnel to visually inspect for evidence of contamination, and once the operation was safely completed on December 7, the divers confirmed evidence of contamination presence throughout the initial 350-foot section of the tunnel they were able to access. DOH then authorized the Navy divers to deploy a skimming pump and absorbent materials to recover floating contamination off the surface of the well. Those recovery actions are ongoing during preparation for the initiation of a capture zone through pumping to the 5 MGD Granular Activated Carbon (GAC) unit (described below).

1.4 TECHNICAL APPROACH FOR THE IMMEDIATE AND INTERMEDIATE RED HILL SHAFT - RECOVERY AND MONITORING ACTIVITIES

The approach to recovery of the Red Hill Shaft agreed upon by the authors and signatories of this document involves immediate, intermediate, and long-term actions. Immediate actions are already initiated through cooperation of DOH and Navy initially, and subsequently the Interagency Drinking Water System Team (IDWST) including the EPA, Army, US Air Force, and the Navy-Marine Corps Public Health Center. Immediate actions include spill response, release characterization, and contaminant product removal through use of skimming pumps and deployment of fuel-absorbent materials.

The primary intermediate-term action will be preventing contaminant migration through the aquifer environment. The first line of defense against migration of fuel away from the Red Hill Shaft well is to establish a "capture zone" by pumping the well to create a draw-down in the aquifer in the vicinity of the Red Hill Shaft. The current plan includes treating the potentially contaminated pumped water from the Red Hill Shaft with GAC before discharging the treated effluent into South Halawa Stream. *Subject matter experts including contaminant hydrogeology subject matter experts, recognize that there is an imperative to create a capture zone as soon as possible to prevent contamination migration.*

Recognizing this imperative, the Navy's Naval Facilities Engineering Systems Command (NAVFAC) contracted for one (1) 5-MGD treatment system on December 9. The treatment system is designed to provide a level of treatment to the Red Hill Shaft well water to meet discharge limitations set forth in a Clean Water Act National Pollutant Discharge Elimination System (NPDES) permit. Several locations were considered for the site of the treatment system based on available force main connection points as well as a viable discharge point, but ultimately the Red Hill Adit 3 site was selected due to the best ability to isolate the pumping system from the distribution system.

Given the urgency to create a "capture zone" in order to protect public health and the aquifer, the treated effluent from the treatment system will be initially discharged to South Halawa Stream. Options for beneficial reuse/reclamation/recharge may be considered for future development. It is important to realize that use of the treatment media is centered on providing assurance that no contaminants are released to the environment through pumping activities – the treatment system will not be used as a targeted mechanism for product recovery from the well.

Upon eventual change-out of spent treatment media, quantification of any fuel captured by the media will be done to further fuel removal accounting efforts. Ongoing skimming operations and absorbent material will be used to capture any free product on the surface as well as any emulsification layer that may be formed in the well.

The measure of success for the capture zone will be efficacy in recovery of fuel in the Red Hill Shaft, and prevention of migration of fuel and related contaminants away from the well. Efficacy of fuel recovery in the well will be tracked by volume of fuel recovered through episodic skimming of the shaft water surface and/or deployment of absorbent materials. Efficacy of prevention of fuel migration will be determined through a coordinated campaign of monitoring and sampling from the existing groundwater monitoring network, and strategic expansion of the network to delineate any potential plume from the release.

Creation of the capture zone is, again, only an intermediate action to prevent fuel migration. Longer-term remediation solutions will likely need to be implemented to remediate any contamination that is not recovered from the Red Hill Shaft well. This could include recovery/remediation of product remaining in the unsaturated zone where identified, and contamination that has reached the aquifer water table and potentially migrated away from Red Hill. The options and alternatives for longer-term remediation will need to be carefully planned to meet clean-up criteria and standards.

Longer-term actions may include the design, permitting, and construction of a drinking water treatment plant that will allow the Red Hill Shaft well to return to service as a potable water source, changes to pump and treatment methods for aquifer recovery, and the execution of the mitigation measures detailed in this plan.

The notional schedule for all these activities is presented in Section 2, Project Schedule.

1.5 Creation of the Capture Zone

As stated in the technical approach section above, contaminant hydrogeology subject matter experts recognize that there is an imperative to create a capture zone as soon as possible to prevent contamination migration. While subject matter experts do not agree on the specific dynamics of groundwater movement, they agree that it is necessary to prevent contaminants from migrating to other drinking water sources as potential receptors. In the vicinity of the Red Hill Shaft, as noted in Figure 1 below, there are several receptors of concern, particularly Honolulu Board of Water Supply (HBWS) sources in the area of Halawa, Aiea, and Moanalua.

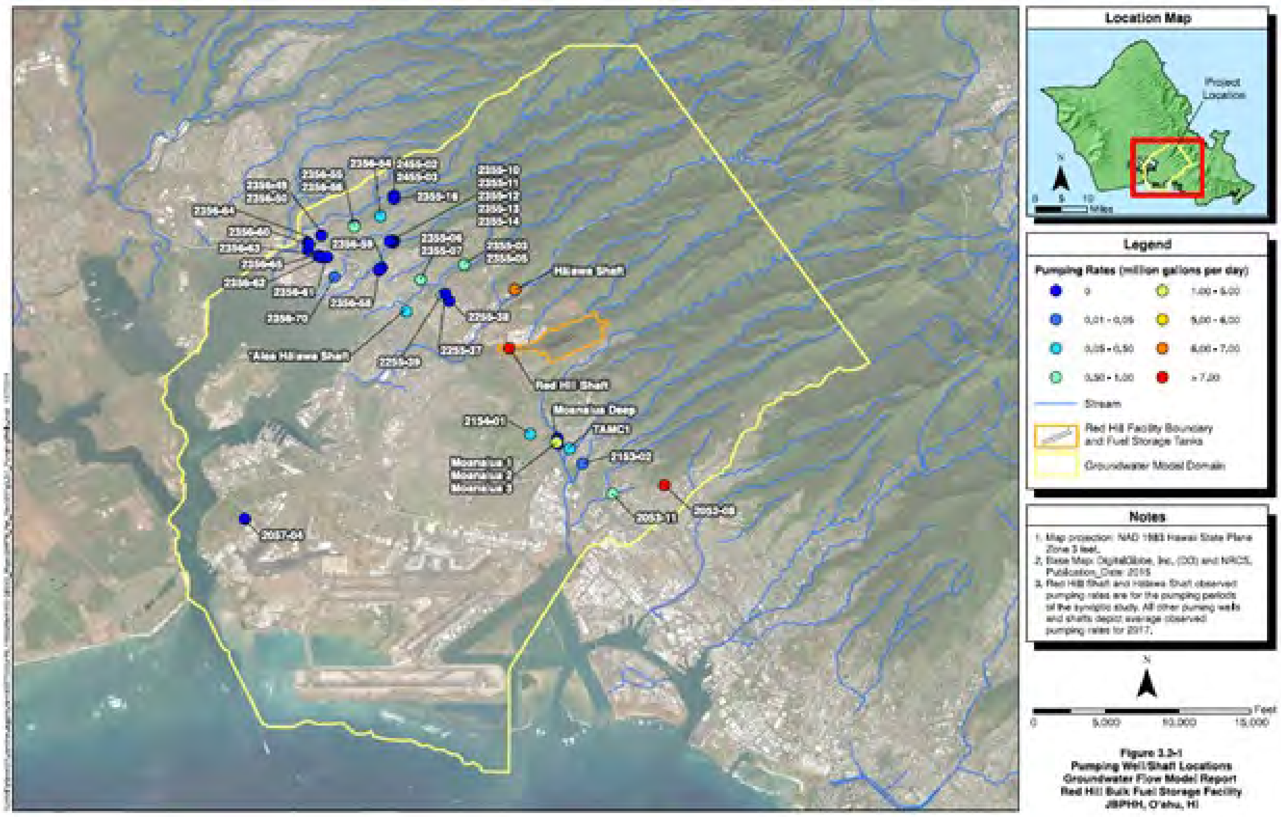


Figure 1. Drinking Water Receptors in the Vicinity of Red Hill

The complexities of geologic formations and the relatively flat water table surface in the Red Hill area makes it difficult to evaluate if there are possible flow paths to the closest drinking water receptors. It is important to note that all of the sources shown in Figure 1 are now turned off, reducing the potential for flow paths from Red Hill to these receptors.

Developing a capture zone through pumping at the Red Hill Shaft will work to impede the development of flow paths to potential receptors. Figure 2 illustrates the general concept of creating a groundwater capture zone in the vicinity of the Red Hill Shaft and its associated development tunnel. The development tunnel, sometimes called an infiltration gallery, is a horizontal void at the aquifer water table surface. The 1,171-foot long development tunnel was excavated in a portion of the rock formation favorable to high water yields for drinking water production. This is especially true in the eastern half of the tunnel where geologic reports note areas of high inflows to the tunnel. For this reason, relatively high pumping flow rates must be maintained to induce a drawdown in the well to create a capture zone. At a pumping rate of 5 MGD, the drawdown is estimated to be on the order of two feet, meaning the water level in the well will be two feet lower than the current non-pumping level. The lower level in the well will cause water near the water table in the adjacent rock formation to seek this lower level and flow toward the development tunnel.

Given the current uncertainty, data collected as part of the efforts associated with this plan will be used for future purposes such as contaminant fate and transport (CF&T) modelling to better inform next steps.

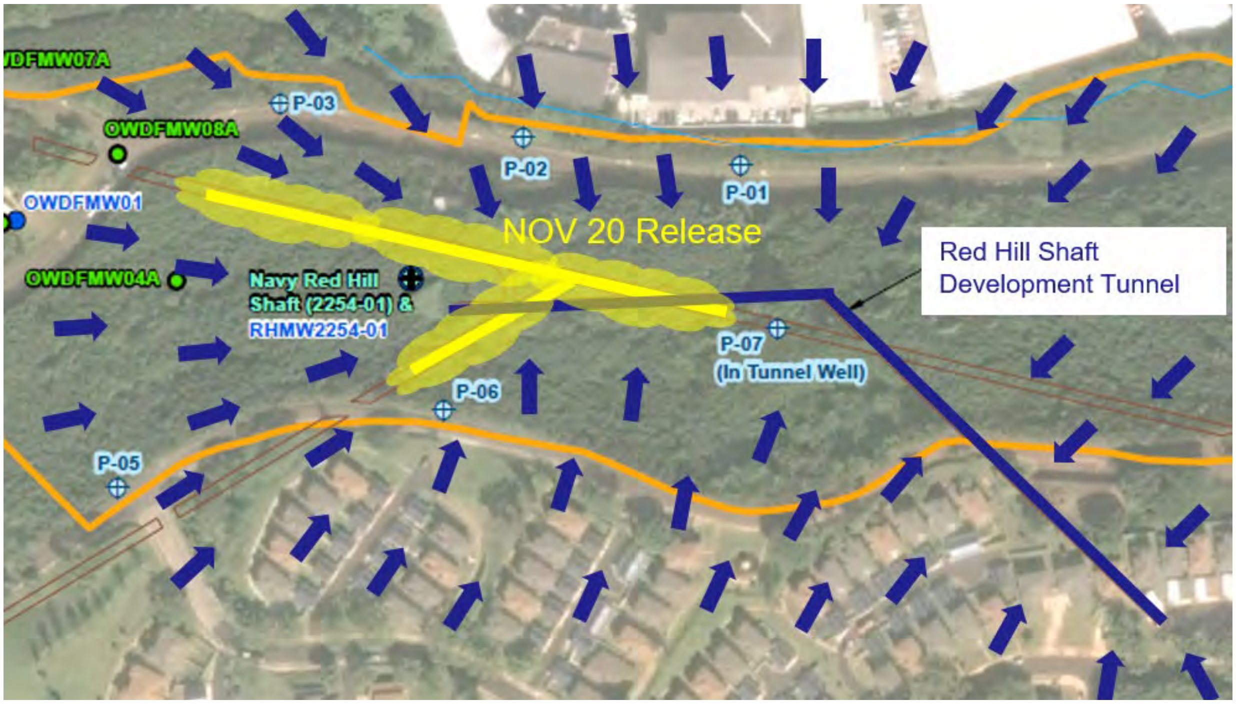


Figure 2 Conceptual representation of a groundwater capture zone in the vicinity of the Red Hill Shaft Development Tunnel under pumping conditions

Figure 2 also shows the presumed extent of the November 20, 2021 fuel spill in the Adit 3 access tunnel as the solid yellow line. Through visual inspections by Navy divers and remote operated vehicles, it has been confirmed that the fuel release reached the water table in the development tunnel. The lighter yellow area surrounding the solid yellow line is a conceptual representation of where the fuel may have made contact with the water table as it traveled approximately 80 feet down from the Adit 3 release area.

The measured water table is relatively flat in the area surrounding the Red Hill Shaft. The geology and hydrogeology of the area is varied and complex. There is considerable uncertainty among experts as to the direction and speed of natural groundwater flow in the area. There is concern that without inducing a groundwater capture zone through pumping, contamination could migrate away from the Red Hill Shaft area, and potentially to other drinking water source receptors. As the time between the release and initiation of pumping increases, that risk increases. Even if the capture zone is not 100% effective, beginning to develop the capture zone expeditiously will limit the quantity of contaminants that may escape the capture zone, and slow the migration of any contamination near the edge of the capture zone, making it easier to locate and remediate in proximity to the release site.

1.6 LIMITS OF THIS PLAN

This plan has been developed cooperatively and in good faith as a response to the contamination of the Red Hill Shaft drinking water system identified in November 2021. None of the agreements, statements, or information in this plan releases parties from legal requirements or constitutes a permit authorizing an activity which is subject to local, State and Federal requirements. Further, this plan does not approve take of any indigenous species or endangered species, per Hawaii Administrative Rules, Chapter 13-124.

Any take of these species may be subject to enforcement or claim for damages by the Hawaii Department of Land and Natural Resources. As stated in Section 1.1 of this document, agreements detailed in this document may be included as requirements in future permits or other enforceable vehicle identified as applicable by State of Hawaii agencies.

1.7 References

This plan references the following documents:

1. Drinking Water Sampling Plan, signed December 16, 2021, amended, January 4, 2022.
2. JBPHH Drinking Water Distribution System Recovery Plan, signed December 17, 2021.

2 Project Schedule

As detailed in the Project Overview Section, the immediate focus of the project is to create a contaminant capture zone in the vicinity of the Red Hill Shaft well through pumping operations at an initial rate of 5 MGD, with the pumped water undergoing GAC treatment as an environmental safeguard before discharge to South Halawa Stream. In support of treatment operations, Figure 3 identifies the major phases of execution. Upon installation, treatment operations are expected to continue for an extended duration, however exact durations are unknown at this time.

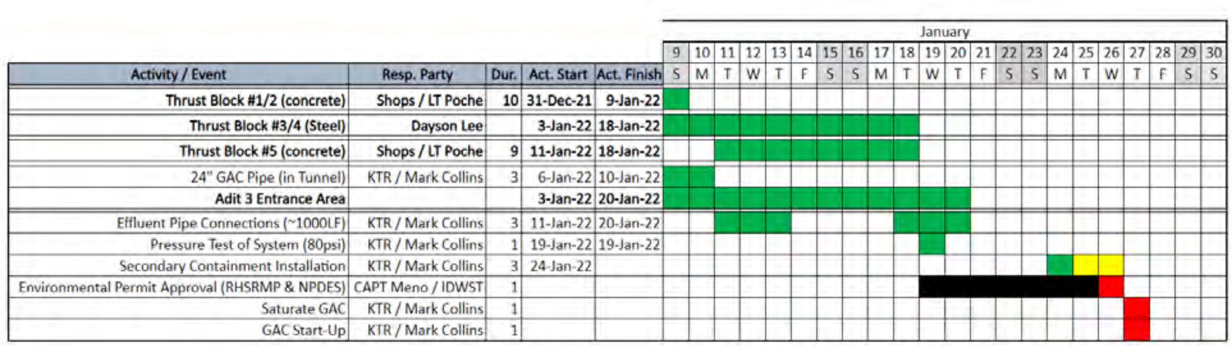


Figure 3. Treatment Operations Schedule and Supporting Activities

The Red Hill Facility site in the vicinity of Adit 3 is currently being prepared as operational area for the Treatment System. NAVFAC Shops personnel are establishing a connection point for the Treatment System while the contracted operator is preparing the Treatment System for system start-up. On the discharge side, some vegetation clearing was done on Navy property to allow for the safe operation, monitoring, and observation of the treated discharge. The Navy or its contractor shall obtain any permits necessary to lawfully prepare the site for installation of the treatment unit.

Treatment operations will continue for an unknown duration once commenced. Groundwater monitoring will be used to determine the course and duration of the treatment operations. Monitoring of groundwater, treated discharge, stream health, and Treatment System efficacy is detailed in Section 5.

While this day-by-day schedule is important to the immediate goals of signing the initial version of this document in support of authorizing the discharge and initiating pumping to create a contaminant capture zone, the larger context of the project is equally important. The total recovery timeframe is uncertain and alternative recovery actions as well as projects and policy updates to increase groundwater recharge and reduce the Navy's use of potable water for non-potable needs will be integrated into the overall solutions set to improve area water security. As such, the schedules seek to align long-term goals beyond the intermediate-term action of the contaminant capture zone.

A notional schedule for Red Hill Shaft recovery and remediation actions is presented in Figure 4. Please note that each of the activities depicted in the schedule are notional, meaning their start dates, durations, and end dates only estimates at this time.

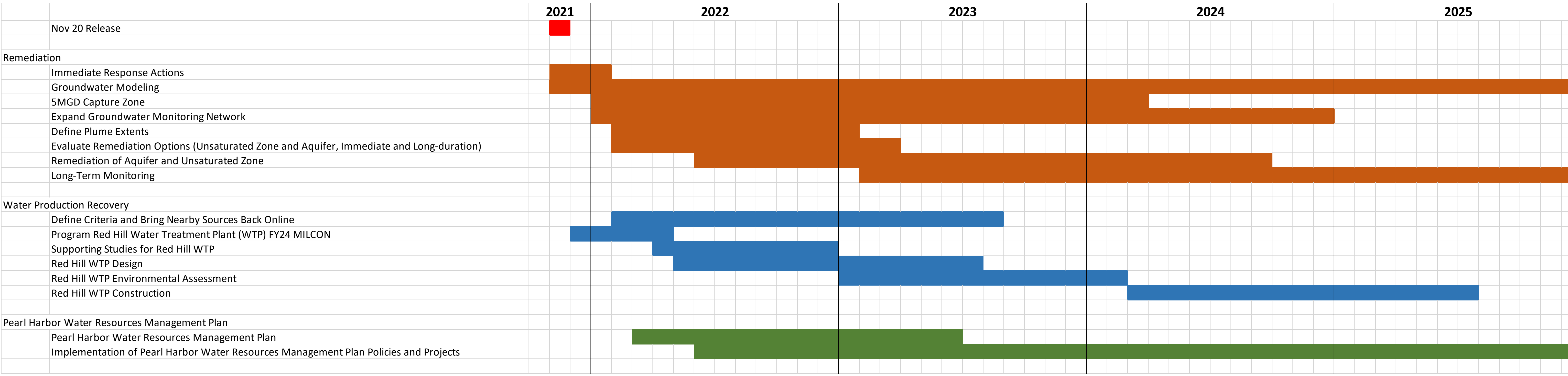


Figure 4. Notional Schedule for Red Hill Shaft Recovery and Remediation

Groundwater modeling has also commenced as a decision-support tool for the IDWST. Under the 2014 Red Hill Administrative Order on Consent (AOC), Navy contractors prepared a Groundwater Flow (GWF) model of the greater Red Hill region of Oahu. Although the GWF model was developed primarily to address a potential scenario of a release to the environment occurring in the area of the large tanks of the Red Hill Bulk Fuel Storage Facility, and has not been formally approved by AOC parties, it was quickly adapted for this undertaking to provide visual approximations of water flow paths with Red Hill Shaft pumps off, and the potential extents of a capture zone from 5 MGD pumping at Red Hill Shaft. These approximations provide a useful visual tool for decision makers to appreciate the imperative to initiate a capture zone before contamination potentially migrates beyond the reach of a Red Hill Shaft capture zone. Groundwater modeling will continue to be a valuable decision support tool throughout the project. A conceptual site model (CSM) is in development to model the release to the environment for eventual incorporation into a contaminant fate and transport (CF&T) groundwater model that will be used to represent how the release may travel through the subsurface system. Seawater intrusion models will also be useful in modeling how redistribution of pumping throughout the aquifer system may affect the freshwater lens.

As mentioned above, the duration of the capture zone as an intermediate recovery and remediation action is unknown at this time. The duration will depend on the efficacy of the capture zone operation. The efficacy of the capture zone will be measured by its effectiveness in removing contamination and preventing the migration of contamination away from the well. Measuring capture zone efficacy will be accomplished through monitoring and data collection efforts. Water level measurements in nearby existing and contemplated groundwater monitoring wells will give an indication of the extent of the capture zone. Monitoring of flow direction in wells could yield similar, complementary information. Water quality monitoring in these wells will give an indication of the extent of any plumes in the Red Hill Shaft vicinity, and monitoring over time will help to determine whether migration of the plume(s) is/are being prevented.

Pumping to create a capture zone and recover contamination may be discontinued if it is determined that all contamination available to be captured has been accomplished to an established threshold or standard. If groundwater monitoring and modeling determine that contaminant removal (either in the vicinity of Red Hill Shaft or elsewhere in the aquifer) can be more effectively accomplished via other methods such as targeted installation of extraction wells, hydraulic barriers, and/or groundwater remediation technologies, etc., then Red Hill Shaft pumping may be discontinued or reduced once these alternate methods are established. However, the longest the Red Hill Shaft capture zone would operate would be until the start-up of a planned permanent water treatment plant at the Red Hill Facility site to resume potable water production.

Concurrent to the capture zone operations will be ongoing assessment of fuel and water chemistry data. The assessment is necessary to track changes suggestive of Light, Non-aqueous Phase Liquid (LNAPL) and dissolved fuel constituent concentrations. In addition to the assessment of fuel and water chemistry data, additional geophysical data review and collection, contaminant fate and transport (CF&T) investigations will be undertaken to build a working understanding of contaminant transport in the unsaturated (vadose) zone where released contaminants may be present from sources in and around the tank farm, and recent releases to the Red Hill Shaft and other water sources. Planning is underway to expand the Red Hill Shaft groundwater monitoring well network with the initial objective of defining the extent of any potential contaminant plume(s). Characterization, where possible, and modeling of the extents and quantities of contamination are the vital primary steps to identify and evaluate feasible remediation options to mitigate existing contamination and reduce likelihood of further adverse impacts to the aquifer and unsaturated zone, on both short-term and long-duration timescales. The efficacy of any remediation will be continually evaluated through long-term monitoring systems. Groundwater monitoring may also be expanded to include “sentinel” wells to provide advanced notice of the possibility of contaminants migrating through the aquifer system in proximity to other drinking water receptors. All data derived from these and other efforts shall be provided to the parties of this plan to guide and coordinate actions to realize the goal of this plan.

Recovery of potable water systems is also a major focus of the overall project. Before the Red Hill Shaft well can be brought back into service, attention will need to be given to other nearby water sources that have been taken offline in an abundance of caution. Criteria will need to be developed to provide assurance that restarting withdrawals from these sources will not threaten the water quality of those sources and will not compromise remediation activities at the Red Hill Shaft. Actions are already being taken to facilitate the construction of a Drinking Water Treatment Plant (WTP) at the Red Hill Facility. This would be a military construction (MILCON) project, and efforts are underway to program the WTP construction as soon as Federal fiscal year (FY) 2024. Prior to a 2024 construction start, studies, design, and National Environmental Policy Act (NEPA) actions will need to be completed. Start-up of the WTP could conceivably occur as soon as 2025.

Parallel to all of these efforts, the Navy is planning to create a Pearl Harbor Water Resources Management Plan, with the intent to create an integrated prioritized list of projects to lessen the Navy’s potable water footprint on Oahu.

3 PROJECT LOGISTICS

3.1 OVERVIEW

As stated in Section 1.4, in order to create a capture zone intend to prevent migration of the contamination from the Red Hill Shaft to other parts of the aquifer, the immediate approach includes removing floating fuel products (free product, emulsion, and/or sheen) within the Red Hill Shaft through a combination of skimming and deploying surface absorbents. In parallel, there is a process for extracting, treating, and discharging the contaminated groundwater pumped from the shaft. These two parallel processes, skimming free product from the surface and extracting contaminated water from the Red Hill Shaft, create two distinct waste streams.

The waste stream created from removing floating fuel products by skimming will be collected in frac tanks where the fuel portion can be quantified volumetrically for fuel release accounting purposes before disposal (see 3.2, below). The waste stream from the extracted water will be sent to a treatment system (see 3.3, below). Any solid waste will be disposed of properly at a permitted solid or hazardous (depending on analysis of the spent media) waste disposal facility.

3.2 FUEL PRODUCT REMOVAL

As detailed above, floating/free fuel products will be skimmed from the surface of the Red Hill Shaft. The pump sump area and boom system (see Section 3.7, Boom Plan) will be monitored regularly to identify free product, the presence of an emulsified layer, and/or sheen. When free product or an emulsification layer has accumulated, pumping of the well will stop and skimming operations and absorbents will be used. Skimming operations will pull free product off the surface of the water and be pumped directly to a frac tank. The contents of these tanks will be properly disposed of through the Navy's hazardous waste contract vehicle or at a Navy fuel oil recovery facility. Absorbents will also be used in applicable locations to remove fuel products. Absorbents will be disposed of properly through the Navy's hazardous waste contract vehicle. This alternating pattern of pumping to create a contaminant capture zone, and then pausing pumping to recover accumulated fuel products, will continue throughout the duration of the treatment operations.

3.3 TREATMENT PROCESS OVERVIEW

Potentially contaminated water extracted from subsurface will pass through a hybrid zeolite-granular activated carbon (GAC) treatment system to remove fuel contaminants and treat the water to levels which meet NPDES permit effluent limits before discharging into South Halawa Stream. Zeolite is an organoclay having a high absorption capacity with a porous surface specifically designed to remove emulsions and hydrocarbon contaminants. Zeolite is designed to absorb 50% of its weight in product in order to remove gross contamination and prolong the life of the granular activated carbon. Granular activated carbon is made from raw organic materials that are high in carbon. Heat, in the absence of oxygen, is used to increase (activate) the surface area of the carbon. The activated carbon removes certain chemicals that are dissolved in water passing through a filter containing GAC by trapping (adsorbing) the chemical in the treatment system.

The GAC Performance Monitoring plan will clearly outline the locations and frequency in which tests will be conducted (see Section 5.1). The installation and operation of the treatment system will occur in at least two phases. The first phase, to run for approximately one month after start-up, will be a largely manual system that requires 24/7 manning and operation to prevent treatment disruptions. At start-up of the treatment system, operators will rely on more frequent inspection and water quality monitoring with field instrumentation to ensure system efficacy.

At present, the Navy and its contractors are working to design and implement a Phase II Treatment System that considers an additional dedicated zeolite chamber or other alternative pre-treatment unit, automation, and real-time water quality instrumentation which will identify fuel contaminants to identify breakthrough levels and predict the timing of zeolite and/or GAC media replacement. In the near term, the effluent leaving the GAC units will discharge into a channelized section of South Halawa Stream.

3.4 Treatment and Disposal Methods Considered

The hybrid zeolite-GAC treatment system was selected as the treatment technology to be used due to its proven capability to remove hydrocarbons from water. The following considerations and design requirements were analyzed to treat and dispose of the contaminated water.

3.4.1 Treatment Method Selected

A hybrid zeolite-GAC system can remove contaminants through a process called adsorption. When water containing contaminants, such as jet fuel, passes through a bed of zeolite or GAC media, the contaminants diffuse into the porous granular particles and attach, or adsorb, themselves onto the walls of the particles' pores.

A 5 MGD hybrid zeolite-GAC system will be erected near the exit of Adit 3. This 5 MGD hybrid zeolite-GAC will be used to treat the contaminated water extracted from the Red Hill Shaft well before discharge or future reuse.

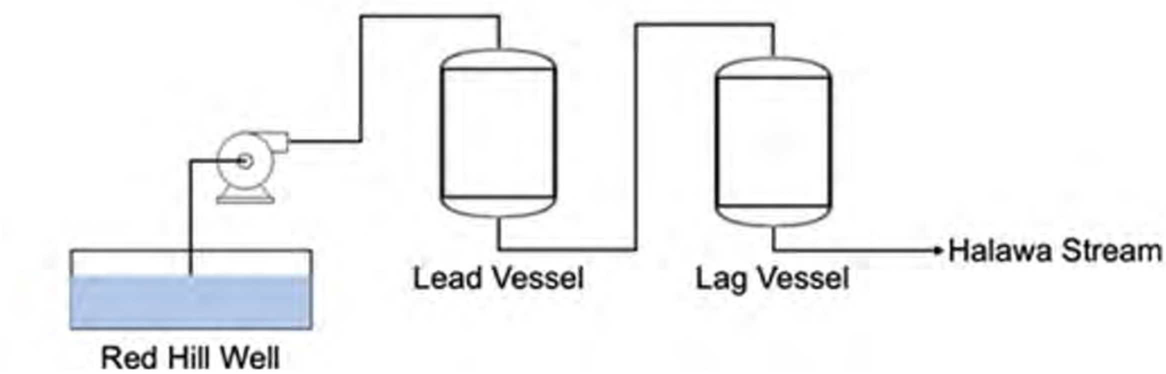


Figure 5. General Tank Configuration

The Phase I hybrid zeolite-GAC treatment system will consist of eight (8) Calgon 20k units. Each individual unit can flow at 1200 gallons per minute (gpm). The eight units will be set up in three treatment trains with one back-up/stand-by treatment train, each in a lead-lag configuration. Sample points are provided on the front side of the lead tank, the back side of the lead tank, and the back side of the lag tank. The units are set up in a down flow configuration allowing water to enter from the top of each unit and discharge out of the bottom. The system pressure will be sufficient for the water to leave the bottom of the lead tank and flow to the top of the lag tank to flow down through the media. Figure 5 identifies general configuration and Figure 6 shows the operational laydown area.

Figure 6. 5 MGD GAC Operation Area

While the hybrid zeolite-GAC treatment system is expected to be effective in contaminant removal through adsorption, the system has a finite adsorption capacity and a process called desorption (or "breakthrough") can also occur if media is not changed or operational parameters are not maintained. Desorption is when contaminants detach themselves from the particles' surface and enter the water again. Proper operation of the hybrid zeolite-GAC treatment system is fundamental to ensuring contaminant removal through adsorption and preventing breakthrough (See Section 4).

Operation and maintenance requirements are described in Exhibit A.

3.4.2 Disposal of Treated Water to Sanitary Sewer Systems

Upon consideration of various disposal methods for the water extracted from the Red Hill Shaft, disposal into the sanitary sewer system was considered but ultimately ruled out. Constructing a temporary sewer line to an existing sanitary sewer to support this recovery and mitigation would require: 1) a relatively near point of connection, 2) a pipe route that can be expeditiously installed (e.g., at grade where possible, with minimal conflicts with existing land use and via temporary easements), and 3) an existing sewer and downstream facilities with sufficient available capacity. Utilizing the Red Hill Shaft's existing water transmission main via the underground tunnel would disrupt water service to Red Hill Housing. Adit 3 is a significant distance – over 1 mile – to the nearest Navy sanitary sewer connection point. Furthermore, adding 5 MGD of dilute water would bring the Navy's 13 MGD Wastewater Treatment Plant (WWTP) to near capacity and possibly result in violation of discharge permit requirements for 85% total suspended solids (TSS) and biological oxygen demand (BOD) removal.

Alternatively, the City and County of Honolulu's sewer network extends to near Adit 3 in the vicinity of the State Animal Quarantine Facility. However, this location in Halawa Valley is in the upper reaches of the Honouliuli WWTP collection system, so the nearest sewer line is relatively small, 15 inches in diameter, and would not accommodate 5 MGD of added baseline flow. In general, the Red Hill ridge line forms a natural geographic boundary between the service areas of the City and County of Honolulu's Sand Island WWTP and Honouliuli WWTP, so the nearest sewers going to either WWTP are relatively small and would not have the capacity for 5 MGD of added flow.

3.4.3 Use of an Oil Water Separator

Separation of water and fuel product via oil water separator followed by discharge of water and disposal of the oily waste was considered but deemed infeasible. This option would require a significant amount of real-estate at a strategic connection point which would not impact the existing distribution system. The Adit 3 connection point, which provides limited real-estate, has been determined to be the only site that eliminates impacts to the distribution system. It should also be noted that this oil water separator option would not provide the large volume draw down required to create the capture zone intended to mitigate migration of the contaminants.

3.5 Site Selection

Several locations were considered for the site of the treatment system based on available force main connection points as well as a viable discharge point, but ultimately the Red Hill Adit 3 site was selected due to the best ability to isolate the pumping system from the distribution system. Previously, two sites were considered at the Navy's Makalapa compound. The sites had the advantages of available parking lot areas to stage the treatment units and adjacent access to Halawa Stream for effluent disposal, but the sites were eliminated from consideration due to the limitations of the distribution piping system to connect safely and reliably to the treatment units at the desired flow rate.

3.6 Treatment System Installation

The hybrid zeolite-GAC treatment system is being directly connected to the Red Hill Shaft pumping apparatus through the installation of temporary piping. The treatment system will be fed by the fixed rate drinking water supply pumps that will be flow restricted to prevent overloading of the units.

Connection Point/Isolations:

The connection point to the piping system, shown in Figure 7, was carefully selected to ensure no service interruption to facilities or residences. The chosen location also allows for blind flange physical separation of all piping at the disconnection point. The 24-inch supply line leading to the 5 MGD treatment system will only feed the hybrid zeolite-GAC units with no other connections.

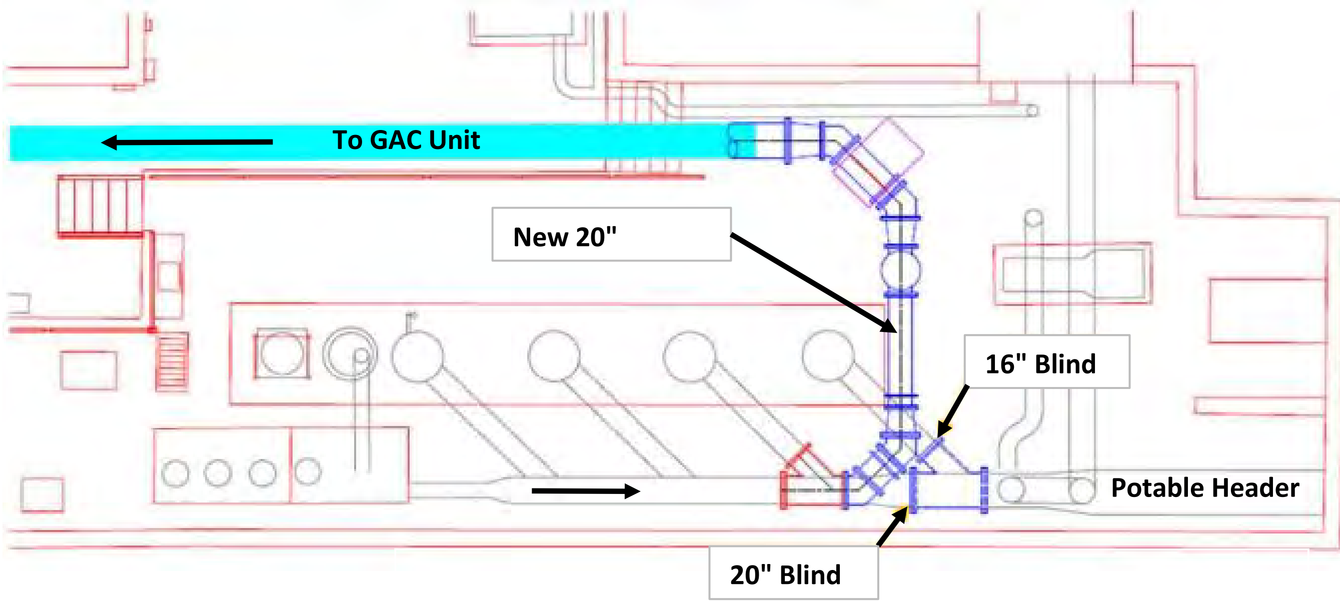


Figure 7. Connection Point Location

3.7 Red Hill Shaft Water Surface Boom Plan

As part of the well recovery activities, the Navy will construct and maintain a series of booms within Red Hill Shaft to address concerns regarding the potential development of a vortex and pulling fuel and emulsion into the pump intake, which could ultimately disrupt the treatment system during operation. This Boom Plan describes the boom components and inspection/maintenance activities that will be conducted throughout pumping and operation of the treatment system.

As stated, an assemblage of boom components will be installed within Red Hill Shaft to keep fuel and emulsion away from the Pump #3 intake during operation, if such conditions exist or develop. The overall staging of the boom components is presented in Figure 8.

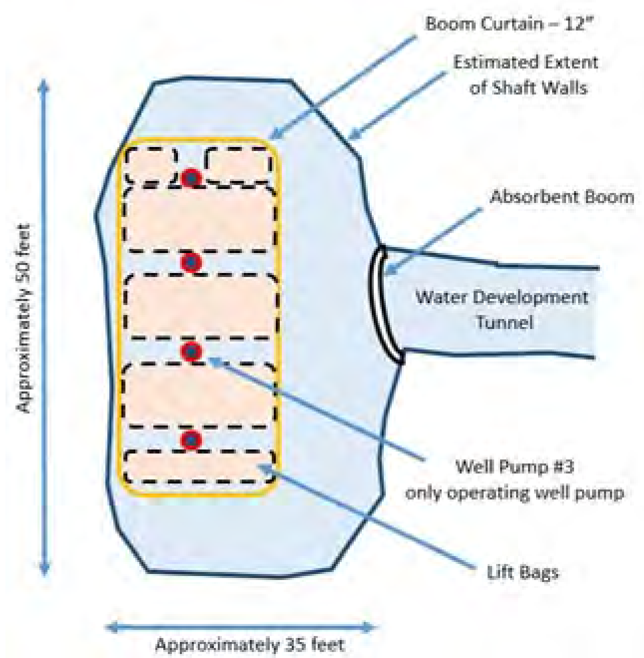


Figure 8. Overall Staging of Boom Components

These boom components and their description/function are provided below:

- **Absorbent Boom:** An absorbent boom will continue to be maintained and/or replaced, on a monthly basis at minimum, at the entrance to the water development tunnel in Red Hill Shaft (see Figures 8 and 9). Based on observations, fuel and emulsion are originating from the water development tunnel. Currently, the absorbent boom is inspected and replaced, as needed, and any fuel or emulsion formation is skimmed via pumping. Thus, the absorbent boom serves as the primary barrier in preventing fuel and emulsion from potentially entering the pump intake and treatment system.

Figure 9. Absorbent Boom in Red Hill Shaft

- **Boom Curtain:** Approximately 100-feet of open water 13-inch containment boom, with 7-inches of freeboard and a 6-inch curtain will be installed within Red Hill Shaft surrounding the four (4) well pump shafts (see Figure 8). Figure 10 provides: 1) a photograph of a boom curtain in open water (upper left); and 2) a profile pictorial of the boom curtain (bottom right). The combination of freeboard and curtain provides a barrier to prevent emulsion and fuel, respectively, from entering the area surrounding the well pump shafts, particularly Well Pump #3 during operation.

Figure 10. Containment Boom

- **Lift Bags:** A series of lift bags, with varying dimensions, will be used to: 1) hold the boom curtain in place around the well pump shafts; and 2) keep the boom curtain upright (see Figure 8). The boom curtain will be attached to the lift bags; therefore, the lift bags and boom curtain will float as one (1) unit, rising and falling with the water surface. The lift bags will encompass the area around the well pump shafts, keeping the boom curtain in place, and due to its height, keeping the boom curtain upright, even if a water current forms within the shaft during operations. Figure 11 provides photographs of example lift bags in use.

Figure 11. Example Lift Bags

- Prior to installing these components in the Red Hill Shaft, the Navy will perform skimming activities within the shaft and water development tunnel to remove any fuel and emulsion. After these components are installed, the absorbent boom, boom curtain, and lift bags will be inspected from the 24-inch manhole on a daily basis as part of the overall inspection of the treatment system. Closer inspections from within the shaft will be conducted on a monthly basis, at a minimum.

Based on daily and monthly inspections, maintenance activities will be conducted immediately and include, but not be limited to, replacing the absorbent boom, adding air to the lift bags, and/or performing skimming activities.

All inspections, observations, and maintenance will be documented in a dedicated field logbook with dates, times, field personnel, and observations.

3.8 Maintaining Vertical Separation between Well Surface Contamination and Pump Intakes, and Vortex Prevention

The bottom elevation of the vertical shaft of the Red Hill Shaft well is –10 ft. mean sea level (MSL; see Figure 12). The bottom elevation of the suction intake for the well pumps are ~0 ft. MSL. The water elevation fluctuates between 18 and 20 ft. MSL. This provides approximately 18 ft. of water above the suction intake of the well pumps, at a minimum. During pumping operations at 5 MGD, measurements demonstrate that the water drawdown is typically 2 ft. This 2 ft. drawdown would bring the water level to within 16 ft. of the suction intake of the well pumps. With these observations/measurements and known physical properties of fuel emulsions, it is conservatively estimated that the extent of the water column with potential to contain fuel concentrations sufficient to create an emulsion would be confined to the top 4 ft. (i.e., 25% of water column during pump operation). When operating at 5 MGD, the potential layer for fuel emulsion (i.e., uppermost 4 ft.) would drawdown, accordingly. The pump is set at 18 ft. below the water level. Therefore, there is approximately 12 ft. (i.e., 18 ft. – [2 ft. + 4 ft.]) within the water column with concentrations below levels that are amenable to emulsification, between: 1) the bottom of the potential layer for fuel emulsion; and 2) suction intake of the well pump. Therefore, although there is physical mixing created by the pump, concentrations at and 12 ft. above the intake are low, creating a "buffer zone." In addition, the pumps are fixed with a suction bell to prevent vortexing and require a minimum of 10 ft. of water above the suction intake to avoid cavitation, which is less than the estimated "buffer zone" of 12 ft. Using float switches within the well shaft the Navy will set an all pumps off level of 12 ft. above the elevation of the suction intake. This will ensure that the pumps will not cavitate and will provide reassurance that water will be drawn from the lower region of the well source and not the surface containing fuel or emulsion.

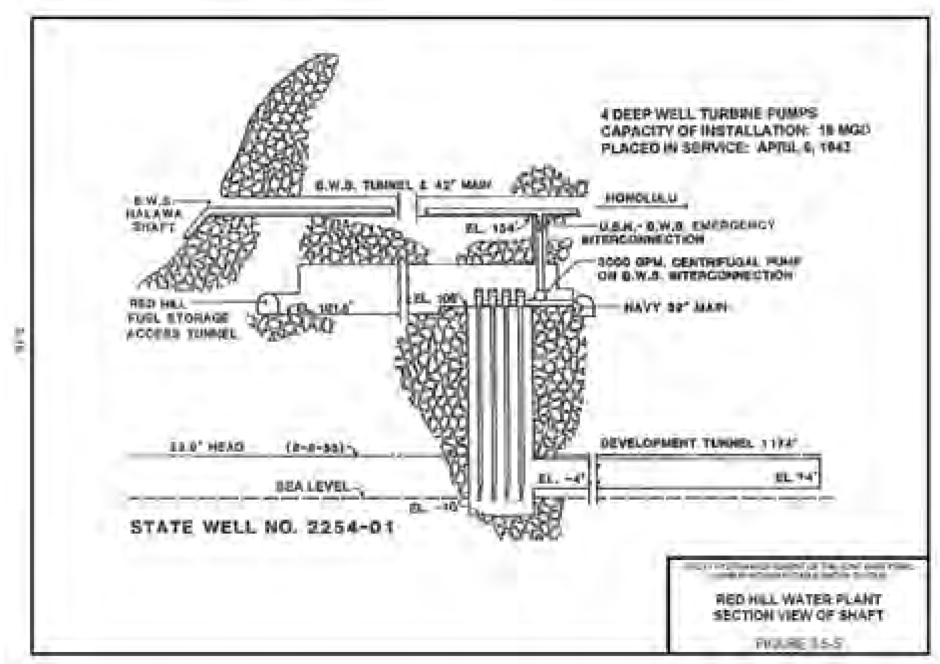
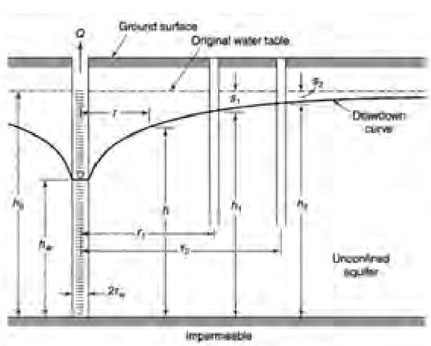


Figure 12. Drawing of the Vertical Shaft at Red Hill Water Plant

The observed fuel emulsion within the Red Hill Shaft is relatively thin (i.e., <0.1 inch) and discontinuous/sporadic (i.e., not a continuous layer). An emulsion can contain up to 30% water, but even with the highest water content, is still less dense than water and floats due to high buoyancy, as observed. If an emulsion does form at depth within the water column, the buoyant nature of the emulsion would likely result in the droplets rising to the top of the water column rather than being captured at the pump intake.

In addition to these measurements, the Thiem Equation was used to calculate the depth and width of drawdown or 'cone of depression' within Red Hill Shaft during pumping operations. To use the Thiem Equation, Red Hill Shaft was assumed as an unconfined aquifer to then model the drawdown and associated radial influence with the pump operating at 5 MGD. Figure 13 presents the radial flow to a well screened within an unconfined aquifer (left) and the Thiem Equation (right).



$$Q = \frac{\pi K (h_2^2 - h_1^2)}{\ln(r_2/r_1)}$$

$$h_2^2 - h_1^2 = \frac{Q}{\pi K} \ln(r_2/r_1)$$

Figure 13. Radial Flow to Well in Unconfined Aquifer (left) and Thiem Equation (right)

Table 1 lists the variables in the Thiem Equation and assumptions made for each variable. To note, the calculation does not account for any centrifugal movement (i.e., circular movement of water around the pump).

Table 1. Thiem Equation Variables and Assumptions

Variable	Assumptions
Q = Flowrate	Assume 5 MGD (668,403 ft^3/day)
K = Hydraulic Conductivity	The largest observed K in subsurface is 10^5 ft./day (Bear, 1972); however, Red Hill Shaft is an open space, so assumed one order of magnitude greater (i.e., 10^6 ft./day).
r_1 = Initial Radius	Assumed a distance immediately at the pump (i.e., 0.0000001 ft.)
r_2 = Distance from Pump	Used values 1 to 1,200 feet to cover the entire length of the water development tunnel.
h_1 = Initial Drawdown at r_1 Distance (initial distance from the pump)	Used Red Hill Pump Station data to calculate the drawdown from no operation to 5 MGD operation (see Figure 13). $h_1 = 23ft^a – (23ft^b – 21ft^c) = 21$ ft. a = current water depth b = static water depth, when pump is not operational c = average water depth when pump is operating at 5 MGD
h_2 = calculated drawdown/ vortex around pump	Calculated across r_2 values. See results in Figure 14.

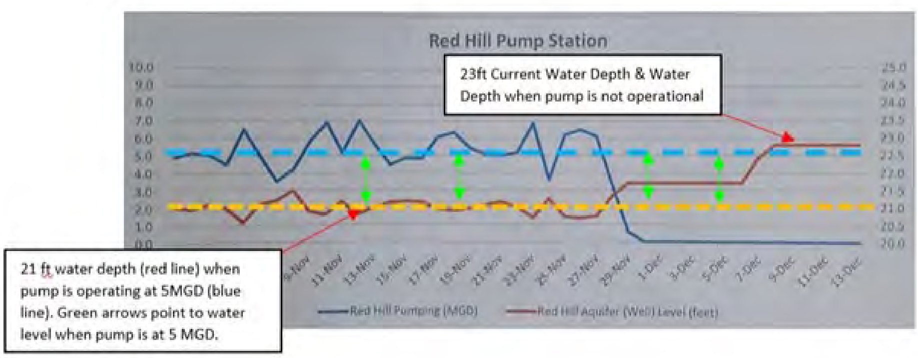


Figure 14. Water Levels within Red Hill Shaft during Pumping Operations

The Thiem Equation is then re-arranged to solve for h_2 to calculate drawdown or radius of influence across the shaft and water development tunnel. Figure 15 presents the anticipated drawdown within the shaft and water development tunnel based on the Thiem Equation and assumptions in Table 1. Figure 16 provides a conceptual model of the drawdown anticipated in the shaft and water development tunnel.

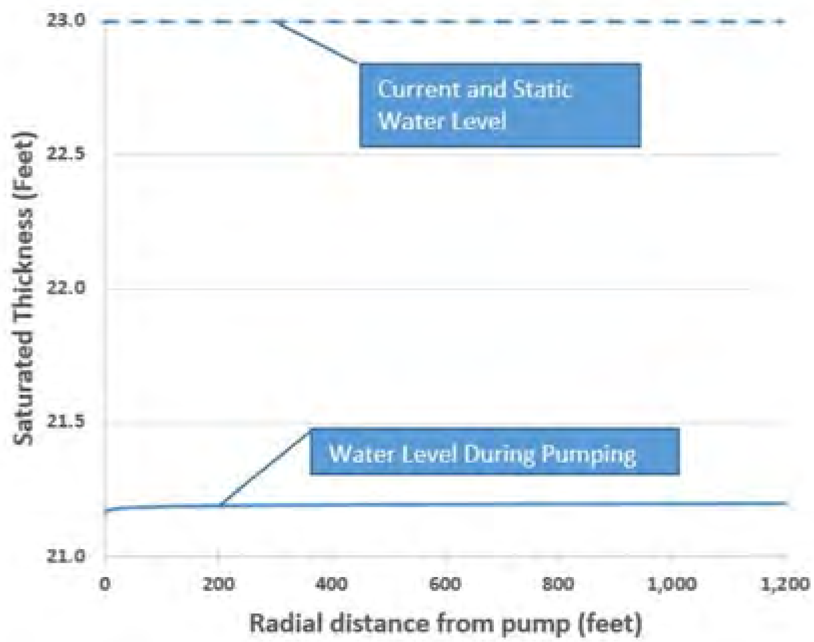


Figure 15. Saturated Thickness in Red Hill Shaft and Water Development Tunnel based on Thiem Equation

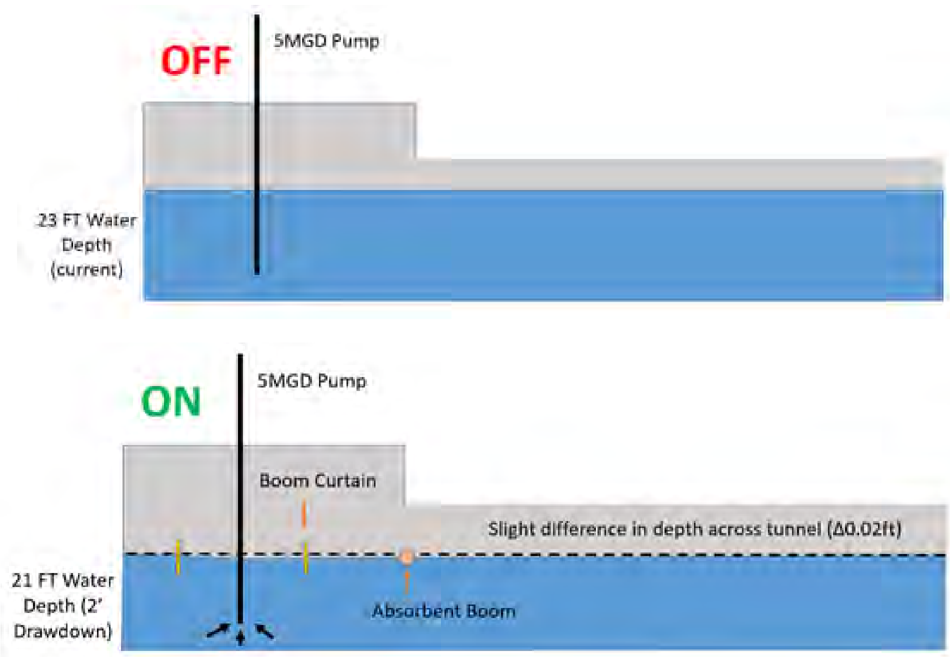


Figure 16. Conceptual model of the water levels in Red Hill Shaft and Water Development Tunnel while the pump is Idle and during operation

Based on the Thiem Equation, once the pump is operating at 5 MGD, the whole water development tunnel should experience a corresponding ~2 ft. drawdown (i.e., from 23 to 21 ft.). The difference in water level calculated between the well pump and the end of the tunnel is 0.02 ft. Therefore, based on these calculations, no vortex or whirlpool effect should occur that would draw in emulsified fuel into the pump and GAC Treatment System. Drawdown will be experienced in equal portion throughout the shaft and tunnel with negligible variance in water level. In the event drawdown is greater than 2 ft., the calculated response is the same – the whole tunnel will exhibit a steady drop in the water level with no significant difference in depth between at the pump and surrounding water.

4 OPERATION AND MAINTENANCE OF THE TREATMENT SYSTEM

The contractor, or trained government operator, will be on site 24/7 during pumping operations. Access will be provided to regulators for observation and opportunity to pull independent samples for testing. The Operations and Maintenance described below reflect the Phase I Treatment System. This document and its associated exhibits will change when the Navy completes design and construction of the Phase II Treatment System.

4.1 TREATMENT SYSTEM OPERATIONS AND MAINTENANCE

Treatment System Operations and Maintenance will be conducted in accordance with the “Red Hill Water Treatment System Operations Plan,” included in this document as Exhibit A.

4.2 CHANGING FLOW RATE TO MAINTAIN CAPTURE ZONE

The flow rate through the treatment system can be modified by adjusting the number of treatment trains or adjusting the final gate valve on each treatment train. During treatment system operation, Well Pump #3 will be pumping, while Well Pumps #1, #2, and #4 will remain idle.

In accordance with State permits, draw from the Red Hill Shaft shall not exceed 5 MGD. If groundwater quality and level results indicate that the capture zone can be maintained at a lower flow rate, reducing flows may be considered. If a larger capture zone is deemed necessary, planning with regulatory agencies will commence and this document will need to be amended.

5 Monitoring and Sampling Plans

The monitoring protocols and sampling plans described in this section and detailed in applicable exhibits were crafted to meet specific data quality objectives (DQOs) stated below. The monitoring programs considered risk to human and environmental health, confidence levels in the efficacy and stability of treatment system, and the level of data required to make sound decisions based on quantifiable metrics.

Monitoring and water quality sampling in the field and in certified third-party laboratories provides data to ensure that the target contaminant is being removed, meets NPDES and other regulatory permit requirements, verifies performance of the GAC units, and quantifies impact on Halawa Stream. Any changes to the monitoring plans associated with this plan require written authorization by the DOH and/or DLNR.

5.1 NPDES Compliance Monitoring Scheme and Sampling Plan

DQO: To determine whether the discharge from the Red Hill Shaft Recovery and Monitoring Plan complies with the applicable NPDES discharge permit and related water quality parameters.

Compliance sampling to meet NPDES permit requirements will be conducted by a Navy contractor at the treatment system effluent sample point on a daily, weekly, or monthly basis for various constituents and parameters as required by the NPDES permit and consistent with the monitoring scheme developed for the JBPHH Drinking Water Distribution System Recovery Plan, Section 3, Compliance Sampling. In no ways does this plan limit the monitoring and reporting requirements set forth in the applicable NPDES permit.

5.1.1 NPDES Compliance Monitoring Plan

The specific NPDES discharge water quality monitoring sampling and analysis plan and details is attached as Exhibit B.

5.2 Treatment System Performance Monitoring Scheme and Sampling Plan

DQO: To determine whether the GAC System is operating as designed.

The contractor shall conduct treatment system performance monitoring as described in Exhibit A. All treatment system performance monitoring is to be designed and conducted to meet the stated DQO above and to ensure that the treatment system operates as designed and within parameters that comply with NPDES permitted discharge limitations. If any performance monitoring identifies situations whereupon the treatment system is not operating in a manner that is safe, secure, and in compliance with permits or specifications detailed in this plan or applicable exhibits, the treatment system shall be shut down until it may be restored to specifications.

5.2.1 Treatment System Performance Monitoring Plan

As stated above, treatment system performance monitoring is detailed in Exhibit A.

The treatment system performance monitoring plan shall be revised upon completed design of the Phase II Treatment System.

5.3 Groundwater Monitoring and Sampling Plan

DQOs:

1. Estimate the current impacts to the vadose zone and the aquifer from fuel releases from the Red Hill Facility, with particular emphasis on the November 20 and May 6 releases.
2. Using a variety of methods, gather evidence of subsurface fuel plume(s) location.
3. Evaluate effectiveness of capture from operation of the Red Hill Shaft.

Given the evidence that the fuel from releases reached the groundwater in the vicinity of the Red Hill Shaft well, the groundwater monitoring scheme must generally be designed to answer two questions: (1) what is the current extent of impact to the groundwater based on transport through the vadose zone; and (2) what is the future impact to the groundwater due to prior releases? To do this, characterization of contaminant fate and transport of any fuel products already in the subsurface must be completed. This characterization will be done through conceptual, analytical, and numerical models informed by data collection efforts. Current data collection efforts include groundwater level and water quality measurements, soil vapor monitoring throughout the tank farm and along the area associated with the November 20, 2021 release, and soil investigations surrounding the leach tank where the Adit 3 sump is presumed to have discharged a fuel and water mixture during the November 20, 2021 release. These data collection efforts will be expanded to guide Red Hill Shaft recovery efforts through such means as geological and geophysical surveys, gravity surveys, geochemical testing and tracer studies to improve the understanding of contaminant transport and degradation processes in the unsaturated zone and the aquifer.

This monitoring plan will address impacts from the November 20 and May 6 releases as well as the collective past fuel releases. Of particular concern is the monitoring and control of the fate and transport of fuel product in the subsurface. The data collected will be used to evaluate impacts to the groundwater and recommend when appropriate mitigative measures should be initiated or discontinued upon successful risk abatement. Groundwater monitoring under this plan will therefore have a practical focus on impacts to groundwater and appropriate corresponding remedial actions due to actual releases that may have occurred, and therefore does not address release detection, release prevention, or nature and extent of past fuel releases (which is being performed under other programs). Table 2 summarizes the data gathering activities recommended to meet the DQO listed above.

Table 2. Summary of Groundwater Data Collection and Requirements

<table>
<tr><td>DQO</td><td>Information Needed</td><td>Data Requirements</td></tr>
<tr><td>1. Estimate the current impacts to the vadose zone and the aquifer from past fuel releases from the Red Hill Facility.</td><td>Field data and laboratory chemistry data</td><td>Field parameters, Contaminants of Potential Concern (COPC) laboratory analyses of monitoring well samples, Natural Attenuation Parameters (NAPs), groundwater chemistry</td></tr>
<tr><td>2. Using a variety of methods, gather evidence of subsurface fuel plume(s) location</td><td rowspan="2">Water level and product-related data, product recovery volumes, COPC concentration trends in extracted groundwater</td><td rowspan="2">Groundwater elevation measurements, free product gauging, headspace PID readings, COPC laboratory analyses of extracted groundwater samples</td></tr>
<tr><td>3. Evaluate effectiveness of capture from operation of the Red Hill Shaft</td></tr>
</table>

Results from field data gathering activities will also provide information on the following:

1. Whether changes in Red Hill Shaft pumping rates are recommended (e.g., determining triggering levels to shut down, reduce, or increase pumping).
2. Changes in the fuel product layer on the water in the Red Hill Shaft to determine when intermittent skimming is needed and subsequent quality of water entering the GAC.
3. Trends or changes in COPCs, NAPs, water levels, recovered product quantity, extracted groundwater quality, and degradation of the subsurface fuel.
4. Progress of remedial actions (to be determined at a later time after receipt and evaluation of initial field data gathering activities) and whether any adjustments are needed or alternative remediation is recommended.

5.3.1 Current Groundwater Monitoring

The following is a summary of current groundwater monitoring requirements that address the DQOs of this section.

- DQO #1: Groundwater sampling and analysis from 21 nearby Red Hill Monitoring Wells (RHMW) and the Adit 3 sump are being performed on a weekly basis as required by the DOH in response to the May 6, 2021 and November 20, 2021 events. Sampling and analysis is being done in accordance with the "May 6th Release and Nov 20th Release Notice of Interests' (NOI) Groundwater Sampling Plan" dated December 13, 2021 (Exhibit C). Results from weekly groundwater monitoring events obtained since the May 6, 2021 event may be used in conjunction with results from samples collected from the 21 RHMWs to evaluate the subsurface fuel plume as well as inform groundwater flow modeling and contaminant fate and transport modeling efforts. Sampling and analysis of recently installed nearby monitoring wells at the former Oily Waste Disposal Facility (NAVFAC Environmental Restoration [ERN] Site) are being used to augment the information obtained from the weekly sampling required by the DOH NOI Groundwater Sampling Plan. As agreed upon between the Navy and the regulators, groundwater sampling and chemical analyses in select wells will be temporarily discontinued in order to allow for the monitoring of groundwater levels in response to changing pumping conditions prior to and after starting the Red Hill Shaft pump and treatment system.
- DQO#2/#3: Multi-agency synoptic water level surveys were conducted on December 23, 2021 and January 18, 2022 between the hours of 0930 and 1200. USGS proposed wells were included in the survey along with the Navy recommendations for three additional basal monitoring wells (OWDFMW04A, OWDFMW05A, and OWDFMW07A from the NAVFAC Former Oily Waste Disposal Facility ERN site and RHMW12A) to provide additional water level data in the area near Adit 3. These synoptic water level surveys were executed to capture water table conditions prior to treatment system start-up. Transducers to be installed in select priority wells will also collect valuable high-frequency water level measurements that will provide information on how the aquifer responds to pumping conditions. Water level data will be used to evaluate groundwater flow patterns, the capture zone created when Red Hill Shaft is pumping and to inform groundwater flow modeling efforts.

Many of the Navy's RHMWs, required to be sampled on a weekly basis by DOH, may also be included in future synoptic water level survey efforts, which the Navy recommends to occur on a recurring basis.Some of the RHMWs currently have dedicated pumps used for sampling deployed in the wells, which therefore must be removed prior to the water level surveys to eliminate potential measurement disruptions.

5.3.2 Additional Groundwater Monitoring

A Groundwater Monitoring Plan (Exhibit D) detailing the current (Exhibit C) and additional groundwater monitoring efforts to meet the DQOs of this section will be developed in collaboration with the Aquifer Recovery Focus Group (ARFG) stakeholders (i.e., DOH, EPA, DLNR, USGS, BWS, etc.). Exhibit C will be superseded when it becomes incorporated into Exhibit D. This Exhibit E monitoring plan will be included as an exhibit to this RHSRMP for approval by DOH and EPA within 60 days of the IDWST approval of this plan. Development and implementation of the Groundwater Monitoring Plan will be iterative with new piezometer and well installation, and associated sampling approach, methods, and frequency will be subject to change based on information obtained from ongoing and future field data gathering activities. Additional methods for ongoing data collection may include, but not be limited to: soil vapor data collection to evaluate vadose zone conditions and impacts; collection of more information on conditions during recent releases; additional site characterization; addition of targeted monitoring wells; monitoring well network expansion and field studies including additional transducers; borescope studies; and analysis of hydrogeologic movement of dissolved contaminants.

Initial groundwater monitoring efforts are anticipated to be significant due to the urgent need to address the fuel that reached Red Hill Shaft from the November 20, 2021 release. The amount and frequency of data gathering activities must be balanced with available resources and subject matter expertise within DOH, EPA, and the Navy to collect, process, understand, evaluate, and draw conclusions from the data in a timely manner in order to make decisions on remedial actions. Capacity of laboratories with required certifications shall be considered. Use of non-certified laboratories and alternative analytical methods (e.g., EPA method 3510 instead of 3520) will also be considered for screening purposes. If internal manpower resources or laboratory capacities are limiting factors, collection of data will be prioritized to a reasonable and realistic amount so as not to create a backlog of work and information. Decision makers should strive to identify and prioritize data needs in order to provide practical solutions in a timely fashion.

It is anticipated that the groundwater monitoring intensity will eventually taper to a long-term monitoring and reporting requirement once effective control and sufficient mitigation is established. Current long-term monitoring occurring on a regular and recurring basis will provide additional information to support the DQOs and may be modified in the future based on the results of the groundwater monitoring efforts in this plan.

5.3.3 Groundwater Monitoring Plan

Parties agree to follow the Groundwater Monitoring Plan attached as Exhibit D of this document. Changes may be made but must be agreed to in writing by the Navy and DOH.

5.4 Halawa Stream Ecosystem Monitoring

DQO: To determine and quantify how the ecology of Halawa Stream and lower estuary area is being impacted by the Red Hill Shaft recovery through active monitoring.

The drainage area of the South Halawa watershed is 3.2 square (sq.) miles and receives a mean annual precipitation of 99.6 inches. The drainage area of the North Halawa watershed is 4.6 sq. miles and receives a mean annual precipitation of 118 inches. At USGS station 16226200 on North Halawa Stream at 160 ft in elevation it is dry at least 50% of the time. At USGS station 16226400 on North Halawa Stream at 60 ft in elevation, above the confluence with South Halawa Stream, it is also dry at least 50% of the time.

NAVFAC Natural Resources (NR) staff conducted a reconnaissance survey of Halawa Stream on December 21, 2021. Halawa Stream follows a concrete channel from above the proposed discharge point. The distance from the discharge point to the end of the concrete channel (i.e. at Salt Lake Boulevard) is approximately 1.67 miles (see Figure 17). During the reconnaissance survey, NR staff did not observe any fish or wildlife species within the concrete channel, but did observe intermittent rain and consistent water flow. Based on visual observation, the NR staff estimated that the water depth in the concrete channel was approximately 0.5 inches and that the stream flow was about 2 feet per second. Furthermore, the water appeared clear, and no vegetation was observed within the channel. Dense stands of kiawe are present on the sides of the concrete channel.

Below the discharge point on South Halawa channel, there are multiple concrete ledges in the stream channel which may restrict upstream movement of aquatic species. The stream flows through two tunnels under the H201 freeway with a combined distance of approximately 600 ft. Downstream of the tunnels, the concrete channel has filled in with sediment, rock, and vegetation, creating pool, riffle, and run habitat that supports native and non-native aquatic species. North Halawa channel is concrete as it traverses under the H201 and H3 freeway overpasses. Just before its confluence with South Halawa, the concrete ends. Halawa Stream below the confluence has a natural channel and supports multiple native and non-native species. Populations of ‘oʻopu naniha (Stenogobius hawaiiensis) and of ‘oʻopu nākea were observed in Halawa Stream below the confluence and in South Halawa below the tunnels. Water sampling for eDNA at multiple elevations within Halawa Stream, North Halawa Stream, and South Halawa Stream will confirm the presence of specific native and non-native aquatic species.

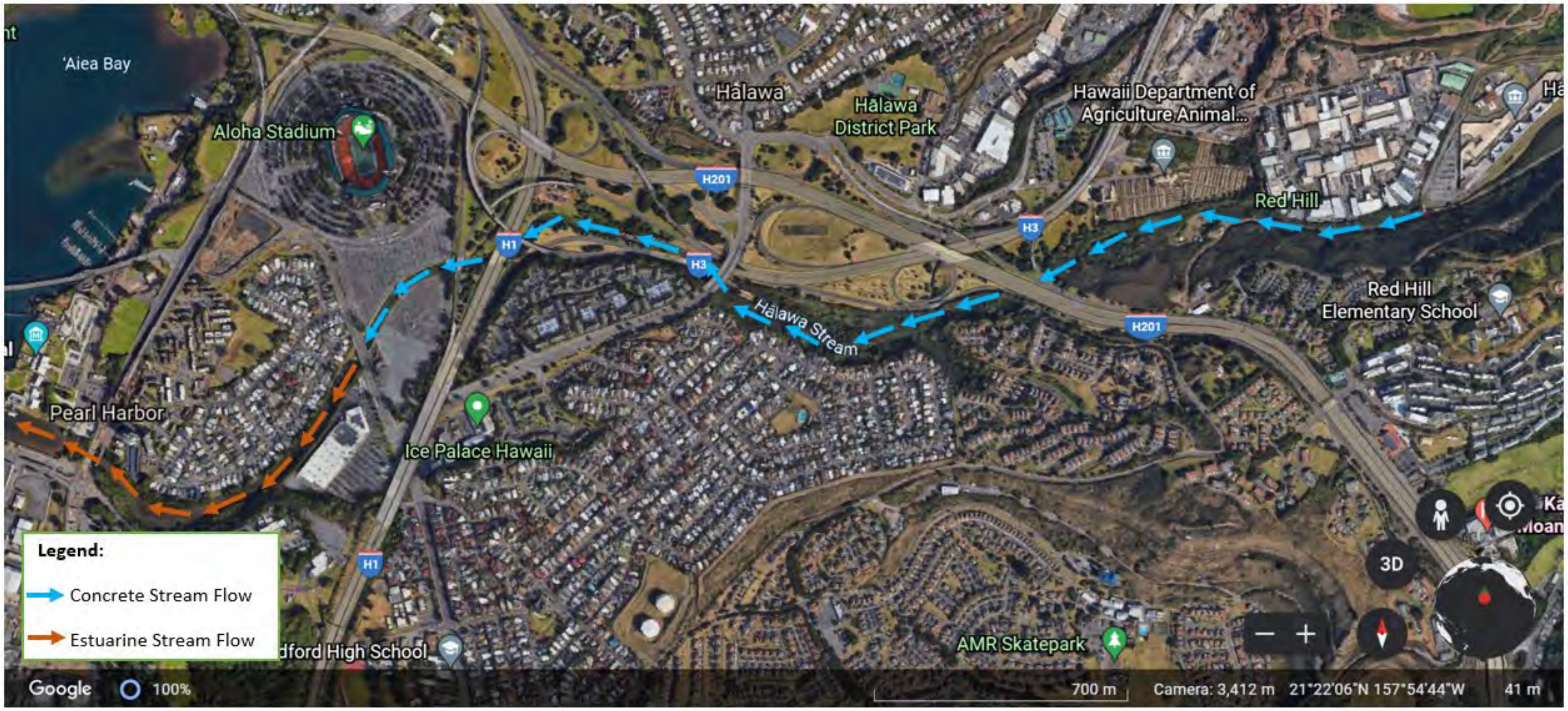


Figure 17. Map depicting the length of the concrete channel of Halawa Stream from the discharge point (blue arrows) to the downstream end point at Salt Lake Boulevard and the length of the estuary from Salt Lake Boulevard to Pearl Harbor (orange arrows)

From Salt Lake Boulevard to the mouth of Halawa Stream is estuarine habitat and is approximately 0.67 miles in length (see Figure 17). During the reconnaissance survey, numerous avian species were observed in this stretch of Halawa Stream, in addition to fish observed in the water. Other notable observations included:

- Five ducks (appeared to be mallards or possibly mallard-Hawaiian duck hybrids) resting and foraging where the concrete channel meets the estuary habitat (downstream site #2).
- A black crowned-night heron was observed foraging in the same area (downstream site #2).
- Other avian non-native species included the cattle egret, myna, northern cardinal, white-rumped shama, and warbling white-eye.
- The water was a greenish brown with a visibility of approximately 3 ft. in depth.
- The banks of the estuarine portion of Halawa Stream are dominated by mangroves.

NAVFAC NR staff engaged with State of Hawaii Department of Land and Natural Resources (DLNR), the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), discussed the proposed discharge to Halawa Stream, and identified potential concerns to protected resources and their habitats, including both terrestrial and aquatic biota, due to the artificial increase in water flow. In addition, all stakeholders discussed methodologies for monitoring these biota as well as monitoring stream flow and water quality as it relates to the proposed discharge.

5.4.1 Terrestrial Biota

USFWS noted that no species protected by the Endangered Species Act (ESA) are known to occur in this stretch of the Halawa Stream, although ESA-listed species potentially in the area include native waterbirds (Hawaiian stilt, Hawaiian moorhen, and Hawaiian coot). This aligned with their database of ESA-listed species locations. Rising water levels and increases in flow rate could possibly be a concern for nesting waterbirds along the affected portion of the stream, though it's noted that this is unlikely given that the 5 MGD discharge rate is far below storm event flow. Given that no ESA-listed species are known to occur in this segment of Halawa Stream, it was determined that there was no effect.

USFWS also noted that if outdoor lighting was utilized during night operations in the treatment system operations area, this could have impacts to ESA-listed seabirds that may pass over this area. This is particularly a concern during the fledging season from September – December. If outdoor night lighting is required, USFWS recommended use of full cut-off or downward facing lights.

Terrestrial In-House Monitoring (NAVFAC NR)

To supplement baseline data, the Navy NR staff initiated an in-house monitoring effort focused on terrestrial species prior to the planned discharge.

Methodology, Data Management, and Reporting

NAVFAC NR staff will conduct monitoring surveys to collect qualitative data changes in stream height, turbidity, and other physical characteristics (e.g., changes in sediment deposits). In addition, monitoring surveys for ESA-listed species will occur. If any ESA-listed species are observed, number of individuals, location, and behavior will be documented.

Monitoring will be conducted at five sites along Halawa Stream two days per week beginning just prior to the start of discharge operations and continuing thereafter. Surveys will be conducted at least 48 hours apart on any given week. The five sites were chosen based on the following criteria:

1. One upstream site
2. Two downstream sites
3. Two estuarine sites
4. Accessibility of the sites
5. Safety of personnel

NAVFAC NR staff will conduct visual inspections of Halawa Stream at each site and record species observed, including ESA-listed species as described above. Monitors will fill out a Halawa Stream monitoring data sheet and a Division of Forestry and Wildlife (DOFAW) waterbird survey data sheet (Exhibit E) at each site regardless of species observations. Notes may be taken in a field notebook, and data sheets may be filled out digitally after the survey is complete to allow for photographs to be included. Data sheets will be saved on a Department of the Navy server. Results from monitoring efforts will be provided to interested agencies within one business day of monitoring. If an ESA-listed species or unusual aggregation is observed or if physical conditions of Halawa Stream change drastically (e.g., habitat is created/destroyed, fish kill is observed), notification will be provided same-day. If a fish-kill is observed by NR staff, the GAC operations would be notified immediately (see contact information in Section 7) and discharge would be stopped until the water quality can be verified as meeting permitted discharge parameters.

Monitoring Site Locations

The monitoring sites are described below (Figure 18). The discharge site is also described but may not be monitored on a regular basis if access or safety concerns do not allow.

1. Upstream Site – before the overpass to the Red Hill Entrance Gate along Moanalua Road in Aiea
2. Discharge Site – near the Red Hill Entrance gate along an unnamed paved road
3. Downstream #1 – Mauka side of the overpass (red arrow) along Salt Lake Boulevard between McDonalds and Aloha Stadium looking towards the canal and mountains
4. Downstream #2 – Makai side of the overpass on Salt Lake Boulevard between McDonalds and Aloha Stadium
5. Estuarine #1 – overpass along Kamehameha Highway between Halawa Drive and Kalaloa Street
6. Estuarine #2 – southern end of Arizona Memorial Place

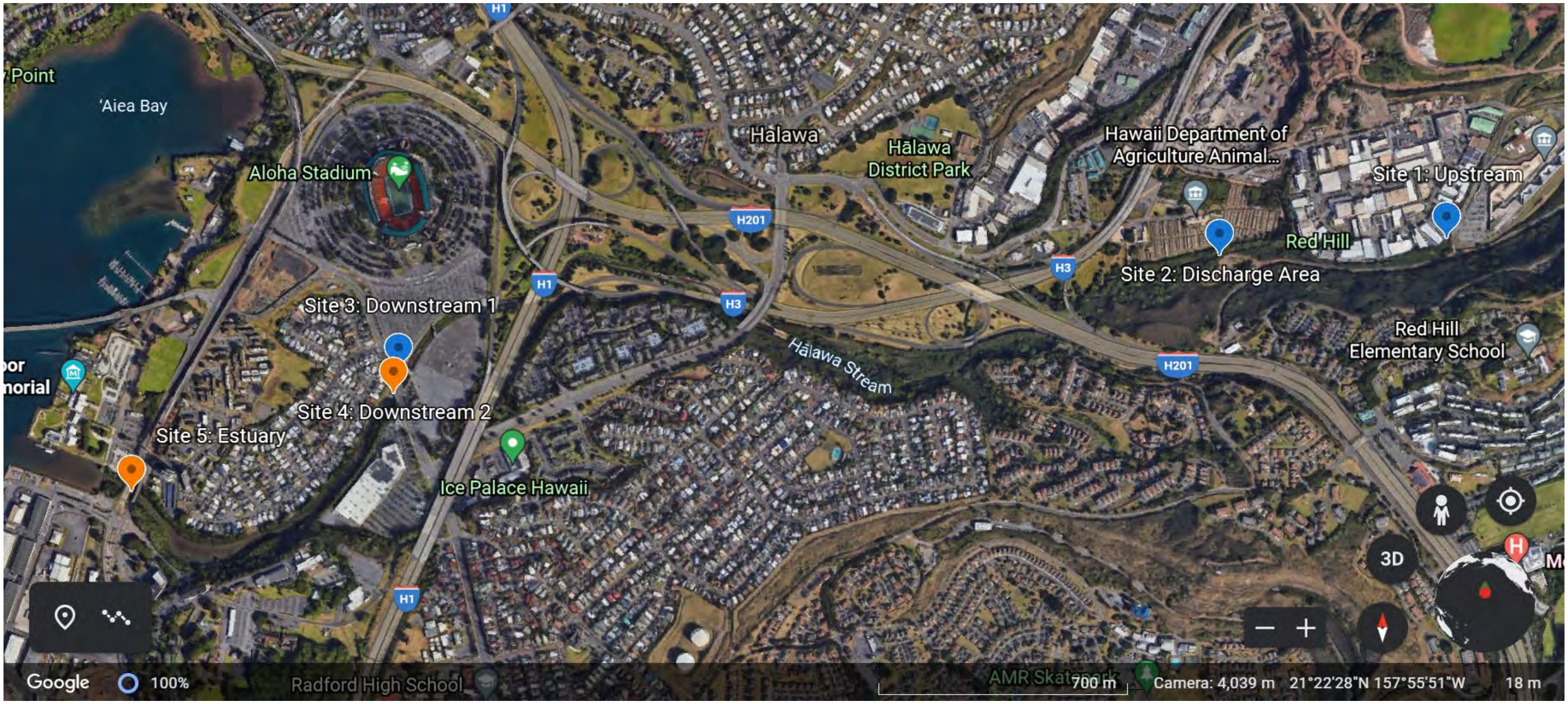


Figure 18. Map of the five terrestrial monitoring site locations along Halawa Stream, with blue markers indicating sites at the concrete channel and orange markers indicating sites in the estuary

5.4.2 Aquatic Biota

A recent Fish Biodiversity study (Oct 2021) documented the aquatic resources present in Halawa Stream at the estuary. The planned discharge of 5 MGD would increase the base flow to South Halawa essentially from zero to 5 MGD. This will likely create artificial recruitment of aquatic biota to South Halawa Stream. Recruitment naturally goes up during the wet season, but adding 5 MGD to a stream may artificially increase the available habitat and thus the population of species attracted to this stream. That biota may become dependent on this increased flow, subject to the duration of the planned discharge event. Large quantities of black-chin tilapia were observed in pools at the freshwater convergence at the downstream site #1 and were unable to migrate upstream and unable to move upstream past the smooth levee where the canal's concrete floor started. Increased stream flow from discharge and freshets may increase movement and spread upstream or downstream of this non-native invasive species. On January 7 and 8, 2022, scientists from UH Manoa, DLNR, and the Navy conducted a rapid biological assessment using visual surveys, eDNA sampling, and water quality sampling at two sites on North Halawa above the confluence (at USGS stations 16226200 at 160 ft in elevation and 16226400 at 60 ft in elevation), three sites on South Halawa Stream (at 180 ft, at USGS station 16226700 at 85 ft, and 60 ft in elevation), and at three sites on Halawa Stream below the confluence (at 50 ft, 10 ft, and at 2 ft). Results will be provided to the IDWST once available.

Aquatic Monitoring (via Cooperative Agreement conducted by the University of Hawaii [UH])

A previous biodiversity study conducted on Halawa Stream (Exhibit F) provides a baseline of the stream conditions for comparative purposes once the water discharge begins. Key elements of this previous study will be repeated as closely as possible. Additional elements are also proposed to provide a robust monitoring effort. Specific methodological details regarding locations and frequencies for this work will be clearly outlined in the Scope of Work (SOW) and in the required project Proposal provided by UH in response to the Navy's project request. These details will be developed in coordination with State and Federal resources partners and embody the intent and details of this section and DQO above. In general terms, the study will include the following:

1. General physical habitats survey (UH)

The water depth, channel width, and types of habitats substrates will be measured and documented at approximately 4-8 sites selected along Halawa Stream. When possible, basic water quality (e.g. temperature, pH, salinity, and specific conductivity) will be measured during the surveys and stream flow estimates will be made. Recommended locations for these are: two sites within the downstream estuary, one site further up the stream but downstream of the water discharge, and one site upstream of the water discharge. It is recommended that these surveys be conducted on a quarterly basis. Using the sampling results, the IDWST will be able to determine if sampling frequency should be adjusted.

2. Biological surveys (UH)

- Insect surveys: Aquatic insect sampling will follow the method described by Polhemus (1995) and Englun et al. (1998) to conduct the survey using aerial sweep nets, aquatic dip nets, seines, and by taking benthic samples. Insect specimens will be stored in 75% ethanol for further identification. It is recommended that these surveys be conducted on a quarterly basis. Using the sampling results, interagency team will be able to determine if sampling frequency should be adjusted.

- Fish Surveys: The previous study conducted on Halawa Stream informs which fish surveying techniques will be used in this monitoring effort. Environmental DNA (eDNA) sampling and deployment of cameras were the two methods that yielded the most data. Other techniques were less successful. Minnow traps and pole fishing proved time consuming and less fruitful for various reasons, including stolen traps left in the field. In addition, seine netting was not possible due to the soft sediment precluding researcher’s ability to walk along the stream bottom.

  - eDNA Sampling: DNA from 500ml surface grab samples will be concentrated onto filters, and the DNA will be extracted in the laboratory. Instead of a species-specific assay, two 'universal' assays will be utilized to amplify DNA across broad taxonomic ranges. One assay will amplify all fish DNA present in the eDNA samples, and a second assay will amplify all insect DNA that has been captured in the eDNA samples. All amplified DNA will then be sequenced on a High Throughput Sequencing platform (i.e., Illumina MiSeq), generating millions of sequences. The output will be run through a bioinformatics pipeline that will cluster sequences by similarity into Operational Taxonomic Units (OTUs). Finally, a representative OTU sequence will be identified to species based on a reference database (i.e., NCBI). eDNA sampling will take place in at least four locations (as noted above in general physical habitats survey section) on a monthly basis. The recipient of this cooperative agreement will propose sampling locations. One recommendation for the estuary is to collect samples across the stream channel width (left bank, center, and right bank) without the need to launch a boat. An eDNA sample from the bank of the estuary site is also advisable, as are collections downstream from the discharge on the mauka side (channelized section) of Salt Lake Boulevard and at the upstream site above the discharge location which would provide information on species upstream and on recruiting 'o'opu (Hawaiian freshwater goby). It is recommended that these surveys be conducted on a quarterly basis. Using the sampling results, interagency team will be able to determine changes in species presence and then determine if sampling frequency should be adjusted.

  - Camera Monitoring: Cameras will be deployed at the same locations that are selected for aquatic monitoring. Cameras are placed in the field and left for 2 hours (battery life) before retrieving. They will provide video for two hours, followed by post-processing to review the video and ID the species filmed. Species presence and number of times filmed in the video within 2 hours will be recorded/documented. This data method has been successful in the past, but is dependent on water clarity in order to see clear images of species and sometimes not possible in stormy/turbid water conditions. It is recommended that these surveys be conducted on a quarterly basis. Using the sampling results, interagency team will be able to determine if sampling frequency should be adjusted.

  - Additional techniques: Additional techniques for fish monitoring will be attempted, including dip netting, cast netting and deployment of minnow traps. The frequency and locations of these techniques will be evaluated as the study progresses and if proven successful can be incorporated into the regular monitoring efforts along with eDNA sampling and use of field cameras. When possible, species will be identified in the field, or specimens will be preserved in 75% ethanol for later identification.

- Species Identification and data analysis: Species identification will be made to the lowest taxonomic level possible and species composition will be determined for each stream site. Data for each site will allow for comparison of any changes on a monthly basis. Newly obtained compositions will be compared with historical survey results.

3. Fish Kill Sampling (UH)

In the event of a fish kill, samples will be collected for toxicology analysis and comparison to any known baseline toxicological levels known to occur in aquatic biota from Halawa Stream and to results taken from the discharge source. Furthermore, in the event of a fish kill, live fish samples will be collected for additional toxicological analysis in coordination with DLNR and UH.

4. Contaminants Analysis (UH)

Water samples will be collected to test for contaminants in the water column from locations along Halawa Stream agreed upon through collaboration with our State and Federal partners. Discharged water will be NPDES-permit approved, drinking water quality, with a variety of safeguards and testing procedures in place to ensure the integrity of the system. That said, documenting an early baseline of normally occurring stream contaminants as early as possible (before discharge or soon thereafter) would be prudent. Thereafter it is recommended that these samples be conducted on a quarterly basis. Using the sampling results, interagency team will be able to determine if sampling frequency should be adjusted.

All maps and related data sets shall be delivered in a Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE) compliant file geodatabase format (Access database file) utilizing the latest version of ArcGIS that has been approved by the Naval Information Technology Center (NITC). Geographic data must be provided in both MXD and PDF file formats and be submitted electronically and on DVD-ROM.

5.4.3 Stream Flow Monitoring (USGS)

USGS will provide all appropriate stream flow monitoring. USGS conducted a seepage runs on sections of Halawa Stream on December 28, 2021 and January 18, 2022. These were done to capture pre-discharge measurements, and repeat seepage runs will be done after the discharge commences. Measurements were conducted both above and below the proposed discharge point. USGS also identified and installed a stream gaging (flow monitoring) station in the stream’s concrete channel approximately 700 feet downstream of the discharge point. Initially, data from the stream gaging station must be collected manually, but it is planned to be upgraded to a real-time stream monitoring station in the future.

5.4.4 Halawa Stream Ecosystem Monitoring Workplan

Within 30 days of the approval of the RHSRMP, the Navy shall submit a draft Halawa Stream Ecosystem Monitoring workplan that clearly details the purpose, scope, specifics, individuals, contact information, monitoring, reporting, and other information relevant for the implementation of the monitoring activities described in Section 5.4 of this plan. The draft workplan shall be reviewed by the DOH and its partners and shall be revised at the direction of the DOH prior to implementation.

5.5 Compliance Reporting

Recordkeeping and reporting are instrumental in tracking performance of the treatment system to remove the contamination in the raw water before discharge to the Halawa Stream, satisfactorily meet NPDES permit conditions, and to predict breakthrough and GAC media replacement.

The Navy's NPDES and GAC treatment system contractors will keep tabular records of all monitored parameters and contaminants; review all field and laboratory results; trend the results, and provide laboratory, field data, and operational reports/logs to NAVFAC Hawaii Environmental (NFH EV) at the frequencies detailed in the following sections. Daily and weekly operational report templates are included in Exhibits A and B, respectively.

Contractor records shall be maintained and made available to NFH EV at all times during the Contract period. Annually and at the end of the Contract period, contractor shall provide all records (electronic [pdf and native] and hardcopy) to NFH EV.

5.5.1 NPDES Compliance Reporting

As described in Section 5.1 and Exhibit B, the NPDES contractor (AECOM) will conduct compliance sampling to meet NPDES permit requirements specified in Hawaii Administrative Rules (HAR), Title 11 Chapter 55, Appendix D, Sections 9(a) and 9(b), and parameters identified in the NPDES Discharge Sampling Protocol. The contractor will keep a tabular record of all monitored parameters and third-party certified laboratory results. The contractor will review the data to ensure the NPDES permit conditions are satisfactorily met. The tabular record, complete third-party laboratory reports, and field data/observation sheets shall be forwarded to NFH EV at least weekly.

If any permit conditions are not satisfactorily met, including noncompliance, unanticipated bypass or upset, the NPDES and/or treatment system contractors shall immediately notify NFH EV via phone and follow-up with a written notification as required by the applicable NPDES permit.

Using the data submitted by the NPDES and/or GAC treatment system contractors, NFH EV will compile and submit a Discharge Monitoring Report (DMR) to DOH Clean Water Branch, Hawaii Department of Transportation (DOT), and EPA on a monthly basis meeting all NPDES reporting requirements. A blank DMR form is provided in Exhibit G but electronic reporting via NetDMR may be used. The report shall be submitted no later than 28 days following the end of the reporting month and satisfy all reporting/recordkeeping requirements in the NPDES permit. NFH EV or its duly authorized representative shall report non-compliance as required by the NPDES permit.

On a quarterly basis, NFH EV will report any planned physical alterations or additions to the permitted facility to DOH. No change anticipated to alter discharge quality shall be made without written authorization by the DOH.

The NPDES permit requires annual reporting by January 28th of each year of chemicals used in ground water treatment and which are discharged. This GAC Treatment System does not propose to use chemicals in the ground water treatment nor discharge such.

The NPDES permit requires submission of a schedule for any maintenance that may result in exceedance of effluent limitations at least 14 days prior to initiating the maintenance activity. It is not anticipated that the maintenance of this GAC Treatment System, including GAC media change out and gasket replacements, will result in exceedance of effluent limitations. However, as described in the following Section 5.5.2, NFH EV will submit monthly reports on GAC Treatment System performance, including estimations of remaining GAC media life and maintenance activities.

NFH EV will maintain records available for inspection by DOH/DOT/EPA for a minimum of five (5) years. All reporting related to NPDES permit compliance shall be conducted in full compliance with the terms and conditions of the applicable NPDES permit.

5.5.2 Treatment System Performance Reporting

As described in Section 5.2 and Exhibit B, the treatment system contractor will conduct onsite monitoring to determine GAC media exhaustion and the effectiveness of contaminant removal from the raw Red Hill Shaft water. The contractor will forward laboratory results, tabular record of all monitored parameters and third-party laboratory results, daily monitoring logs, and operational changes at least weekly to NFH EV via the NAVFAC Contracting Officer's Representative (or per contract terms).

The contractor shall also trend the data for each sample point to track contaminant concentration. The purpose of the trending at each sample point is as follows:

- Raw water from Red Hill Shaft upstream of hybrid GAC treatment – to understand if contamination is decreasing in water pumped from Red Hill Shaft
- Lead contactors – to track/predict contaminant breakthrough and determine when media should be replaced
- Lag contactors and plant effluent – to ensure compliance with NPDES permit conditions

At least weekly, the contractor (Vectrus) will provide an estimation of remaining GAC media life, current operating scheme for each treatment train and contactor (e.g. lead/lag position, operating/out-of-service for media replacement, etc.), identification of performance issues, and maintenance activities to NFH EV via the NAVFAC Contracting Officer's Representative.

Using the data provided by the contractor, NFH EV will compile and submit a report on GAC Treatment System performance to DOH/EPA on a monthly basis and submit the report as an attachment to the monthly Discharge Monitoring Report required under the NPDES Compliance Reporting section (above).

NFH EV to maintain records available for inspection by DOH/EPA for a minimum of five (5) years.

5.5.3 Groundwater Monitoring Reporting

All data will be shared among parties to this plan (DOH, EPA, NAVFAC, etc.) on Mondays and Thursdays each week as agreed upon by DOH, EPA, and NAVFAC on December 23, 2021. Frequency of data sharing may be modified via written approval on a case-by-case basis. Raw data files are to be provided where requested. Should an error or other data require disqualification due to QA failures, parties shall be made aware of the erroneous data.

5.5.4 Ecosystem and Halawa Stream Reporting

All data will be shared among parties to this plan (DOH, EPA, NAVFAC, etc.) within 48 hours of receipt unless otherwise specified in the Environmental Sampling and Analysis Plan or if written approval is given on a case-by-case basis. Raw data files are to be provided where requested. Should an error or other data require disqualification due to QA failures, parties shall be made aware of the erroneous data.

Monthly reports summarizing the changes findings and results from ecosystem and stream monitoring pursuant to this plan shall be submitted to the DLNR contact listed below. All monthly reports shall be submitted by the 28th day of the month following when ecosystem or stream monitoring were conducted (similar to NPDES DMRs).

5.6 Environmental Safeguards

5.6.1 Contingency Operations

As discussed in Section 4.2, the GAC Treatment System will be monitored for performance of the system as well as for compliance with NPDES and City and County of Honolulu Department of Facilities Maintenance municipal separate storm sewer system discharge permitting. The requirements below are in place in case there are unexpected discharges or environmental situations (e.g. weather) that require episodic changes to operations to prevent additional harm to human or environmental health. The requirements are in addition to any specific actions detailed in plans written and implemented pursuant to this document.

5.6.2 Oil Boom at Lower Halawa Stream

The Navy shall install and maintain a floating oil containment boom at a location near the mouth of Halawa Stream at a location designated by the DNLR. The Navy shall obtain all necessary permits and/or regulatory approvals to do so and shall ensure the boom is in good working condition and is removed during storm events to prevent damage or flooding. The purpose of the boom shall be to act as a last chance best management practice to prevent any inadvertent discharges of fuel or other petroleum material from entering into a waterbody where it is unable to be recovered. Another function of the boom is to aggregate potential biota kills and assist with that determination.

5.6.3 Triggers for Immediate Cease of Discharge

Should any of the following criteria be identified either at the point of discharge or in an area impacted by the discharge or other recovery activities:

- Observed fish or bird kills
- Observed impacts to native or endangered species
- Oily sheen or other visible evidence of petroleum contamination
- Petroleum odors
- Exceedances of any NPDES effluent limit or action level referenced in this plan
- Operators identify either preventative or corrective maintenance of the treatment system is required

5.6.4 Spill Kits/Spill Response

For spills or releases where Halawa Stream is threatened, the Navy shall maintain spill kits including absorbent booms, containment booms, and absorbent pads onsite. All onsite operators shall be trained to deploy the booms in Halawa Stream or use materials necessary to reduce impact from spills or releases.

To respond to larger spills and/or structural failure of the treatment units or appurtenances, the Navy shall provide adequate secondary containment. Prior to start-up of the Treatment System, secondary containment shall at a minimum include maintaining adequate materials (e.g. flood barriers, impervious liners, etc.) that can be deployed to contain the spill while a vacuum truck collects and contains any spilled substance. The vacuum truck shall be immediately available to collect and contain any spill to prevent the spilled material from contaminating pervious surfaces or nearby waterbodies. Further, during any spill response, the Navy shall deploy covers for the storm drain inlets located near the treatment system and as such, shall maintain all needed materials onsite.

Within 30 calendar days of the approval of the RHSRMP, the Navy shall construct a semi-permanent secondary containment system engineered to contain 100% of the liquid capacity of the largest single vessel in the treatment system.

Any spill shall not be allowed to flow into Adit 3 of the Red Hill facility.

5.6.5 Spill Notification

In the event of a spill, the treatment system contractor shall immediately notify the Navy On-Scene Coordinator (NOSC) Representative at (808) 864-2463 (24 hours).

Spills or releases shall follow State requirements which can be found on the web at:
https://health.hawaii.gov/heer/how-to-report-a-release-spill/.

The following are spills of reportable quantities:

- On water spill:
  - Any amount that causes a sheen to appear on surface water or any navigable water
- On land spill:
  - Any amount of oil released to the environment greater than 10 gallons
  - Any amount of oil release to the environment which is less than 10 gallons, but which is not contained and remedied within 72 hours
  - Any amount of a hazardous substance that either poses a threat to public health or welfare, could become the focus of an enforcement action, may attract media attention and/or any major release from a system owned, operated, or maintained by NAVFAC
- Any free product that appears on groundwater

Immediately after a reportable release, , the Navy On-Scene Coordinator (NOSC) Representative representing the owner (Navy) of the facility will make the following spill notifications:

- NAVFAC Hawaii Duty Officer – (808) 347-8289
- DOH Hazard Evaluation and Emergency Response (HEER) Office & State Emergency Response Commission (SERC) – (808) 586-4249 (7:45am – 4:30pm Monday to Friday), (808) 236-8200 (after hours which includes weekends, holidays and after 4:30 weekdays); Send written follow-up report within 30 days.
- National Response Center (NRC) for spill to Waters of the U.S. – (808) 424-8802 or (202) 267-2675
- Local Emergency Planning Committee – (808) 723-8960 (leave message), 911 (emergency only)
- Navy Oil or Hazardous Substance Message within 4 hours

5.6.6 Reuse of Effluent or Groundwater Recharge

Once the Treatment System has been operational for a period of time and has demonstrated that the treated effluent is consistently free of contaminants, the Navy will evaluate the utility of treated effluent for non-potable use or groundwater recharge. The Navy will seek regulatory approval prior to reuse or groundwater recharge.

6 WATER RESOURCES IMPACT OFFSETS

Hawaii is an island state, whose resources are both precious and finite. Hawaii's natural resources make it possible for people to continue to live and thrive on islands located in the middle of the Pacific Ocean. As stewards of Hawaii's resources and as people of this community, we are accountable to each other, and to the land and resource itself. The ability to share resources such as the wai (freshwater) that flows through our aquifers and into our streams and coastal waters must be recognized for what it is, a privilege. Relationships with Hawaii's resources must be based on reciprocity and exchange in both intent and action. A one-way relationship in which resources are continually extracted yet never replenished, nor adequately cared for to ensure their continued health, is unsustainable and will lead to the diminishment of the health of Hawaii's environment and Hawaii's communities. Hawaii's resources are not to be "had" or used without a sense of respect and accountability for the health of that resource. They should be cared for and respected as members of our family because we (people, plants and animals) only thrive when the resources are both abundant and healthy. Water security is a priority of the Navy and the protection of the Pearl Harbor Aquifer is essential to the resilience of JBPHH.

The November 20, 2021 release has affected management of Oahu water resources. The most immediate effect was the loss of the Red Hill Shaft well as a potable water source of approximately five (5) MGD when the pumps were secured on November 28. Nearby sources, including the HBWS Halawa Shaft well and the Navy Aiea Halawa Shaft well, ceased operations shortly thereafter out of an abundance of caution. Closure of these nearby resources is necessary in the intermediate-term to prevent spread of contamination across the aquifer water table, and to foster conditions that will best support the Red Hill Shaft capture zone. The cumulative impact of these well closures is that over 16 MGD of aquifer pumping is being temporarily redistributed across Oahu to continue to meet daily potable water demands. While these wells are those immediately impacted, without knowing the extent of water contamination and timeframe required to fully mitigate impacts, the total impact to water resource availability could be as large as 166 MGD considering the sustainable yields of the Pearl Harbor Aquifer.

This creates new stresses on the freshwater lens aquifer system across Oahu and in some cases may increase the risk of seawater intrusion into the aquifer where pumping has increased to meet water demands.

The DLNR Commission on Water Resource Management has established a Permitted Interaction Group (PIG) to identify specific actions for the broader Commission to take. Subsequent studies will be used to help inform the PIG and other watershed best management practices.

In recognition of the above, the Navy shall take the following actions and implement the following project as immediate mitigation associated with the RHSRMP.

Within 30 days of the approval of the RHSRMP, the Navy shall commission a study for the beneficial use of water that is extracted and treated at the Red Hill Shaft.

Within 60 days of the approval of the RHSRMP, the Navy shall commission a "Pearl Harbor Water Resources Management Plan (PHWRMP)." The objective of the PHWRMP will be to rapidly identify policies and projects to decrease the Navy's net potable water footprint across JBPHH, the communities served by Navy drinking water systems, and the broader communities of southern Oahu where Navy water resource management decisions have impacts to water security. The PHWRMP will build on innovative ways that the Department of Defense identified to reduce water use in the April 2019 report to Congress titled, "Improving Water Security and Efficiency on Installations."

The PHWRMP will be developed respecting the intent of the Hawaii Water Plan and the State Water Code, Chapter 174C, Hawaii Revised Statutes, which recognizes the need for a program of comprehensive water resources planning to address the problems of supply and conservation of water. Hawaii's water protection policies, which are reflected in the State's Water Resource Protection Plan and Water Quality Plan, will be taken into account as the PHWRMP is developed.

The overall goal of the PHWRMP will be to find at least 20 MGD in implementable water balance solutions in the areas of conservation, water reuse, enhanced recharge, source protection, and production capacity expansion. The output of the stakeholder-inclusive process will be an integrated priority list of projects in each area, ranked by factors such as beneficial volumetric, environmental, and community impacts; feasibility; implementation timeline; and cost.

Potential projects and policies to be considered as part of the PHWRMP may include:

- **Conservation:** Distribution System Leak Detection Programs, Water Conservation/Shortage/Drought Plans, Artificial Turf, Low-flow Fixtures and Appliances, LEED Green-Building Initiatives and other Design Standards
- **Water Reuse:** Connection to City and County of Honolulu Non-potable Reclamation "Purple Pipe" to Increase Demands, Implementing Wastewater Reclamation Projects at Navy Wastewater Treatment Facilities and/or Collection System Lift Stations (see project #2 below), Facility Graywater Systems
- **Enhanced Recharge:** Low-Impact-Development (LID) Stormwater Management Initiatives, Watershed Protection Initiatives, Ecohydrology Initiatives (replacing "thirsty" invasive species with native species, hydrologic monitoring), Off-stream Recharge Basins in Upper Watersheds (Mauka recharge)
- **Source Protection:** Wellhead Protection Programs, Deep Well Salinity Monitoring, Freshwater Lens Seawater Intrusion Modeling, Groundwater Remediation to Protect Potable Sources
- **Production Capacity Expansion:** Drinking Water Treatment Plants for Potentially Impacted Groundwater Sources, Seawater and/or Brackish Water Desalination for Potable or Non-potable Uses, Development of Additional/Alternate Potable and Non-potable Sources to Increase Water Security and Distribute Pumping Stress across the Aquifer System

The PHWRMP will build on documents that have covered similar topics in the same geographic area, including:

- Central Oahu Watershed Study, May 2007. Prepared by Oceanit, Townscape, and Eugene Dashiell for the Honolulu Board of Water Supply, US Army Corps of Engineers, and the City and County of Honolulu Department of Environmental Services
- An Appraisal of the Statewide Framework for Stormwater Reclamation and Reuse in Hawaii, December 2008. Prepared by the US Department of Interior, Bureau of Reclamation
- Central Oahu Non-Potable Water Master Plan – Phase 2, November 2014. Prepared by Brown and Caldwell for the Hawaii Department of Land and Natural Resources, Commission on Water Resource Management

- Watershed Management Plans for Central Oahu, Ewa, and the Primary Urban Center, in preparation for the Honolulu Board of Water Supply

Similar to the process utilized to create the documents listed above, the PHWRMP will be prepared in cooperation with a broad set of Federal, State, and County partners, as well as non-government organizations and the general public. Planning for new projects and sharing of results will be reported out through several outreach vehicles, including the Navy's continued participation in the Hawaii Community Foundation's "Wai Maoli: Hawaii Freshwater Initiative" per the conservation, reuse, and recharge goals outlines in the initiative's "A Blueprint of Action: Water Security for an Uncertain Future 2016-2030" - https://www.hawaiicommunityfoundation.org/file/2021/Blueprint-for-Action-2016-2030-2.pdf. The goals of this initiative are consistent with the goals of the Department of Defense's Readiness and Environmental Protection Integration (REPI) Program and focus on military installation resilience.

In addition to conducting the study above, the Navy or other Department of Defense entity shall support and complete the following efforts to begin meeting the study goal of producing 20 MGD in implementable water balance solutions.

1. Restoration and increase of future drinking water from the Red Hill Shaft through funding and implementation of "Drinking Water Creation" projects. The Navy agrees to submit REPI program projects specific to addressing water security for the aquifers used to provide water to JBPHH and other installations as deemed appropriate. REPI program project submissions will be on annual basis and documentation of submissions will be provided as described in the last paragraph of this section.

    a. At a minimum, the REPI program project submission in FY23 will include funding to build and/or improve fencing for watershed protection and projects to remove ungulate and invasive species in order to facilitate water recharge in the upper watershed.
    b. The Navy will commit to using all authorities within the REPI program to enhance watershed protection efforts. This not only includes the annual REPI program submission but also REPI challenge project submissions, and other REPI program initiatives that are aligned to water security and installation resiliency.
    c. All projects will be developed in coordination with DLNR and DOH and shall not require State matching funding.
    d. Should targeted REPI funding not be provided, the Navy shall seek alternative mechanisms to fund the Drinking Water Creation projects sought by the State. No provision herein shall be interpreted to require obligation or payment of funds in violation of the Anti-Deficiency Act, 31 U.S.C. § 1341.

2. Drinking Water Conservation and Efficiency efforts to reduce the stress on the Waiawa drinking water source and improve drinking water sustainability for JBPHH. This includes:

    a. Developing, supporting, and submitting for congressional approval a military construction (MILCON) DD-1391 for the upgrade of the NAVFAC Wastewater Treatment Plant and distribution system to produce R-1 water and replace all irrigation and non-potable water uses with treated wastewater. Completion and submission of a budget ready DD-1391 shall be completed no later than fiscal year (FY) 2024. Prior to the start of construction, studies, design, and National Environmental Policy Act (NEPA) actions will need to be completed as part of the project. Upgrade of the WWTP could conceivably begin as soon 2027. The Navy will develop timelines and milestones for the project as part of the DD-1391.

b. The Navy will expand its water meter program to ensure conservation methods are effective. The priority focus will be on high demand users with a goal of having meters on all service connections. The water meter program enhancements will be included in the annual submission described below.

c. Conduct annual American Water Works Association water audits to ensure optimum conservation and efficiency measures for calendar year 2022 and beyond, consistent with the intent of Act 169, Session Laws of Hawaiʻi, 2016. The annual water audit will be provided to DLNR-CWRM no later than March 31st of the following year. As part of the March 31, 2022, annual water audit submissions, the Navy shall:
    i. Submit all delinquent water audit reports for previous years since 2016. If water audits for previous years were not completed, the Navy shall submit a report stating as such and implement corrective actions.

The Navy shall submit current and future year budget estimates that support these efforts to the DOH, DLNR, and DLNR-CWRM on annual basis, as part of progress reports on each effort, no later than November 1, annually. The submission will include all prior year, current year, and planned future year expenditures in the areas above along with the status of any other capital improvements or restoration and modernization of the potable water and wastewater treatment and distribution systems. The Navy will seek to find beneficial use of the water from the Red Hill Shaft until it is deemed potable or a capture zone is no longer required.

7 CONTACT LIST

This section details points of contact for each company or agency. The contractor shall supplement this contact list with points of contact for spare parts, GAC media, and any other equipment or personnel to maintain continuous operation of the GAC Treatment System.

Vectrus

Red Hill Project Manager (253) 439-0768

AECOM

Senior Engineer and Project Manager, (808) 356-5374

Navy

NAVFAC Hawaii Duty Officer (808) 347-8289
NAVSUP FLC Deputy Fuels Director (808) 473-7801
Navy Region Hawaii, On Scene Coordinator (808) 864-2463
Navy Region Hawaii – Regional Dispatch Center (808) 471- 7117

DOH-Clean Water Branch

Report NPDES Permit Noncompliance, Unanticipated Bypass or Upset:
During regular office hours (M-F 0745-1615):
(808) 586-4309

Outside regular office hours:
(808) 247-2191 - Hawaii State Hospital

Submit non-DMR Reports to:
Clean Water Branch
Hawaii Department of Health
Hale Ola Building
2827 Waimano Home Road, Room 225
Pearl City, Hawaii 96782

DOH-Safe Drinking Water Branch

POC to receive monthly reports:

Safe Drinking Water Branch
Hawaii Department of Health
Uluakupu Building 4
2385 Waimano Home Road, Suite 110
Pearl City, Hawaii 96782-1400
Phone: (808) 586-4258
SDWB@doh.hawaii.gov

8 Plan Contributors

This plan was developed through the coordination and collaboration of technical experts, regulatory experts, subject matter experts, and military personnel. The persons and organizations listed below followed core principals of protecting human and environmental health to formulate the actions detailed.

8.1 Contributors

<u>State of Hawaii, Department of Health</u>

Kathleen S. Ho, Deputy Director, Environmental Health Administration

Elizabeth (Liz) Galvez, State On-Scene Coordinator, Hazard Evaluation and Emergency Response Office

Gabrielle (Fenix) Grange, Acting Manager, Hazard Evaluation and Emergency Response Office

Joanna L. Seto, Chief, Environmental Management Division

Gaudencio (Dennis) Lopez, Chief, Safe Drinking Water Branch

Michael Miyahira, Supervisor, Safe Drinking Water Branch Engineering Section

Robert (Bob) Whittier, Geologist, Safe Drinking Water Branch, Source Water Protection

Alec Wong, Chief, Clean Water Branch

Matthew Kurano, Supervisor, Clean Water Branch Compliance and Enforcement Section

Anay Shende, Geologist, Solid and Hazardous Waste Branch

Bree Kunishima, Wastewater Branch

<u>State of Hawaii, Department of Land and Natural Resources</u>

Kaleo Manuel, Deputy Director, Commission on Water Resource Management (CWRM)

<u>Commission on Water Resource Management (CWRM)</u>

Dean Uyeno, Hydrologic Program Manager, Stream Protection and Management Branch

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Aquifer Recovery Focus Group

Throughout the development of this document, progress was shared with the Aquifer Recovery Focus Group, comprised of principals and SMEs from the USEPA, USGS, US Navy, US Army and its Corps of Engineers; the State of Hawaii Department of Health, Department of Land and Natural Resources (including staff from the Commission on Water Resource Management, Division of Forestry and Wildlife, and Division of Aquatic Resources), University of Hawaii and its Water Resources Research Center; and the City and County of Honolulu's Board of Water Supply, Department of Environmental Services, and Department of Facility Maintenance. Professionals from these groups shared generously with their guidance, expertise, and time.

9 List of Exhibits

Exhibit A: Red Hill Water Treatment System Operations Plan

Exhibit B: NPDES Compliance Monitoring Plan

Exhibit C: May 6th Release and Nov 20th Release Notice of Interests' Groundwater Sampling Plan

Exhibit D: Groundwater Monitoring Plan (Reserved for amended Groundwater Monitoring Plan)

Exhibit E: Halawa Stream Monitoring and Division of Forestry and Wildlife Waterbird Survey Data Sheets

Exhibit F: Previous Biodiversity Study on Halawa Stream

Exhibit G: Blank Discharge Monitoring Report Form

Exhibit A:

Red Hill Water Treatment System Operations Plan

Red Hill Water Granular Activated Carbon System

Operations Plan

January 25th, 2022

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Table of Contents

1. INTRODUCTION

This manual covers a general description of system design and operating procedures for the Navy Red Hill water well Granular Activated Carbon (GAC) filter treatment system.

2. DESCRIPTION OF TREATMENT SYSTEM

a. Purpose

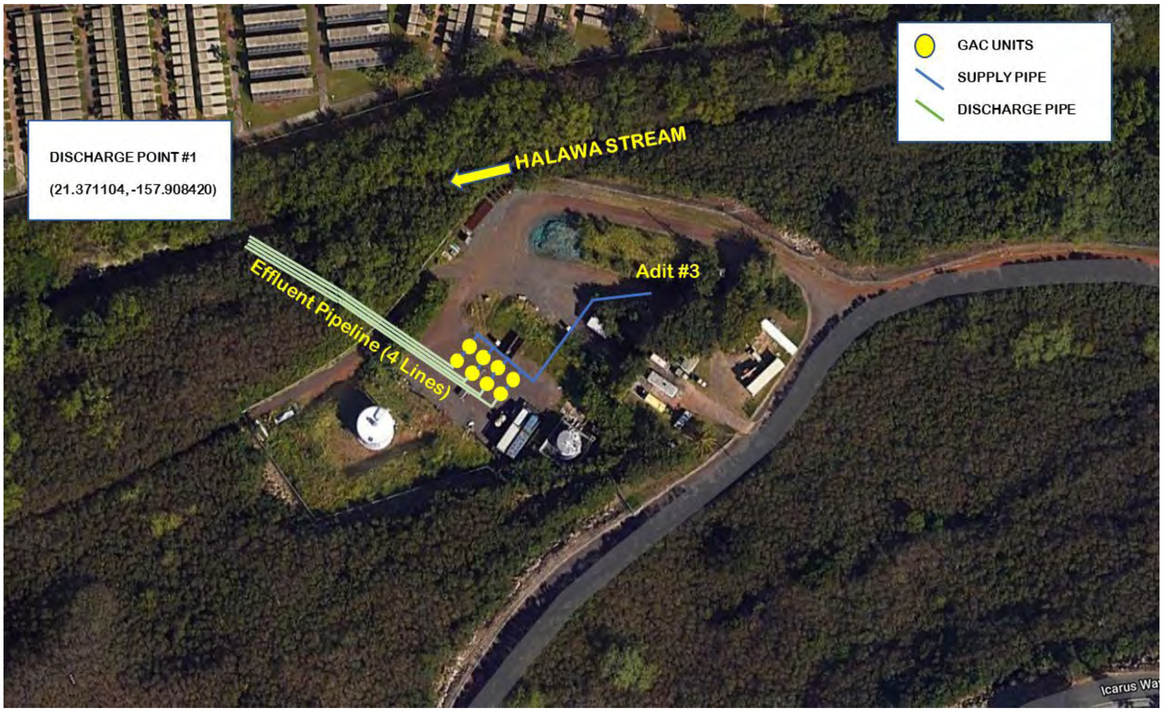
The primary purpose of the GAC Treatment System is to remove residual petroleum constituents from the Red Hill well and discharge the treated effluent to the Halawa Stream in accordance with Hawaii environmental regulations.

This action must be done expeditiously and will be implemented in various phases. Phase I operations are an expedited response design and operation to allow protection and remediation of the aquifer to begin as quickly as safety, environmental regulation, and prudence will allow. Phase II demonstrates system improvements which include additional automation within the system to reduce the risk of human error in operation.

b. Site Location

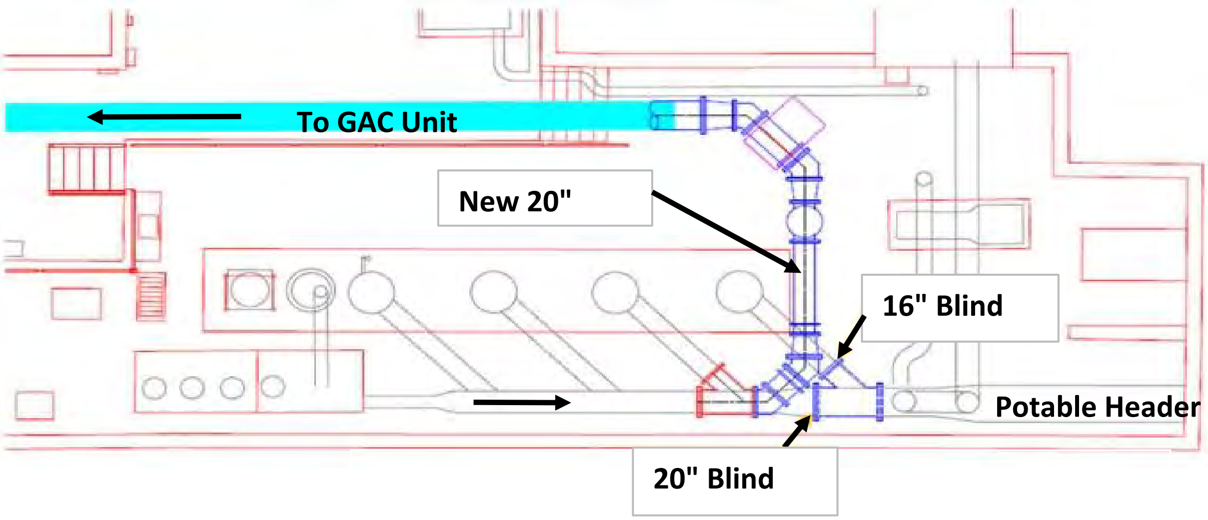
The proposed location of the GAC treatment system is the Red Hill Bulk Fuel Storage Facility, Adit 3. This site was selected by the Naval Facilities Engineering System Command because of its proximity to the Red Hill drinking water well/pump house, the available access to install the interconnection with the well supply pump, and the nearby Halawa Stream that can receive the processed water discharge

GENERAL SITE LAYOUT (not to scale)



The proposed connection point redirects the well pump discharge to the 24-inch high-density polyethylene pipe supplying the GAC units, completely isolating the flow from the existing potable water distribution system.

ADIT 3 CONNECTION (not to scale)



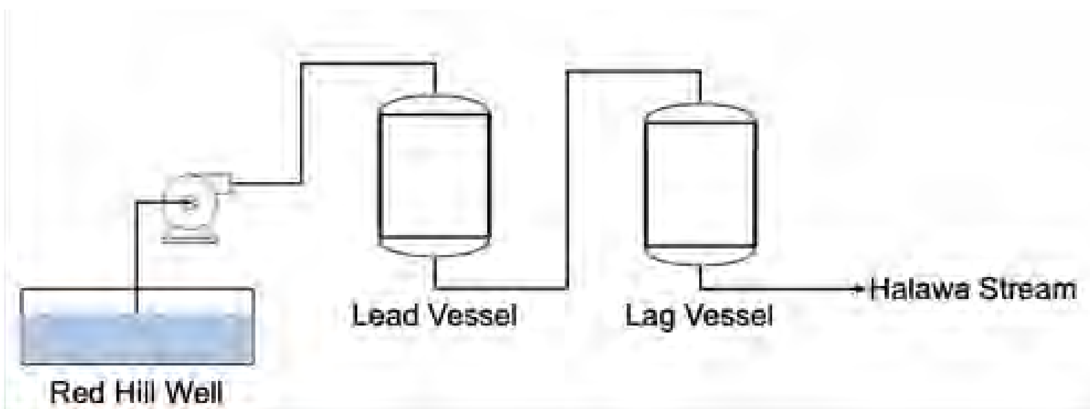
Provided by Naval Facilities Engineering Systems Command, Hawaii (December 2021)

c. General Descriptions of GAC Tank System

The treatment system consists of four (4) parallel systems each comprised of two (2) cylindrical GAC tanks connected in series with isolation valves, inlet and outlet connections, sample ports, pressure gauges, and interconnecting piping and hoses.

The units are arranged to flow with water entering from the top of each GAC tank and discharging out of the bottom, enabling complete water to GAC media contact as it flows through the system.

A general representation of the GAC Tank System is illustrated below.



The more detailed P&ID, and general layout drawings of the treatment system are included as **Attachment 1.**

In addition, each GAC tank is fitted with a containment structure designed to hold incidental discharges from vents, pipe disconnections, media change out, and accidental spills from sampling events. They are designed to ensure safe accessibility of the treatment vessels during required daily inspection, sampling, and routine media changeout. The containment structures will be able to retain water and remove any accumulated processed or uncontaminated rainwater. Uncontrolled releases will be mitigated by 24-hour manned surveillance of the operation, and the operator's ability to immediately cease flow through each or all the operating units, should the need arise.

d. GAC System Size Selection

i. Influent Characteristics

Influent data collected between November 24, 2021 and December 10, 2021 by the Naval Facilities Engineering Systems Command show that the range of petroleum constituents varied greatly. Samples collected from the pre-chlorination spigot and the post-chlorination drinking water compliance point had results for total petroleum hydrocarbon-diesel (C6-C12) of 290 ug/L, however, bailer samples from the well yielded results as high as 130,000 ug/L.

Bailer samples are collected near the surface of the well where most of the petroleum contaminates are expected (floating on the surface or partly emulsified very near the surface) and therefore these samples provide an upper boundary and perhaps are unrepresentative of the existing concentration of contaminants within the flow to the GAC unit from the Red Hill well. The samples collected from the pre-chlorination spigot and the post-chlorination drinking water compliance points are potentially more representative of what is anticipated to be drawn by the Red Hill well pump station and delivered to the GAC unit. The pump curve, the statement indicating the unfavorable conditions for vortex formation and influent sample data is included in **Attachment 2.**

In addition to hydrocarbons, the contaminated water may contain fuel additives for which GAC may have limited adsorption capacity. A sampling and analysis program should be conducted before operation commences to verify that all contaminants present in the groundwater will be satisfactorily removed with GAC.

ii. Process Description

The treatment system consists of four (4) parallel systems each consisting of two (2) cylindrical vessels connected in series. Three (3) systems will be in operation with one on stand-by. The lead vessel of each parallel system will be loaded with 20,000 pounds of zeolite clay media in the top half of the vessel and 10,000 pounds of GAC in the bottom half, with the secondary (lag) vessel filled with 20,000 pounds of GAC. Influent water from the Red Hill well will be distributed through a header to each of the three operating lead tanks. The water will be processed through the first vessel, then flow into the GAC bed of the second vessel. Each GAC vessel is rated for an operational pressure of 100 psi with a design flowrate of up to 1700 gpm. Service pressure on the inlet coming from the Red Hill well is anticipated to be in the 30 – 50 psi range. The vessels will discharge through anti-siphon loops designed to break a vacuum caused by the large volume of water in the sloped discharge header should the inlet flow be interrupted. This will avoid siphoning the water out of the tanks and exposing the GAC to air.

A Badger model TFX-5000 ultrasonic clamp-on flow meter will be fitted on the 24-inch high-density polyethylene (HDPE) pipe leading to the GAC treatment system and on each effluent line exiting the GAC lag units. Initially grab samples will be observed and the meters will be read manually, and flow rates and totals recorded at the prescribed frequencies, on daily logs. A description of these flow measuring devices is included in **Attachment 3.**

Manual flow valves will be installed upstream of each of the four (4) treatment trains to enable each system to be isolated and additionally, to manually balance the flows between the three operating treatment trains. This will ensure the desired 1,157 gpm feeding each unit train is achieved. A flow of 1,250 gpm per train should not be exceeded to ensure adequate water/media contact time.

Note: For the initial period of operation until the first media change out on each of the four units, the fourth unit may be used to introduce a stagger in the unit flows. This is being done to prevent a situation where all three units would experience lead tank breakthrough at the same time. When the medial change out on all four units has occurred and future change-outs are staggered, the fourth unit will become the standby unit.

Anti-Siphon and Vacuum Protection are required since the GAC system is located at a higher elevation than the discharge point. If water is drained from one or more vessels, they must be re-filled in a manner similar to the initial fill, which may cause operational delays. To prevent siphoning an automatic air relief (vacuum breaker) and siphon loop are installed on the discharge side of each lag tank. Once the process flow is stopped, the mass of the water in the long discharge lines may pull a negative pressure and start to suck water out of the tanks. To prevent this a vacuum breaker is installed at the top of siphon loop. The vacuum breaker on the siphon loop will open and admit atmospheric air into the top of the loop, which allows the water in the discharge line to drain into the stream without draining the water from the tanks.

The treated water will be discharged into the Halawa Stream. This stream is often dry or maintains only a minimal flow. During seasonal rains, the stream conveys more water, but the discharge rate of 5 mgd will be a small percentage of the streams normal rain event flow. There will be the option to shut down the well pump and stop processing through the GAC if the stream is approaching or experiencing flooding conditions.

The discharge of the treated well water is subject to the Clean Water Act and is regulated by the Hawaii Department of Health through a National Pollutant Discharge

Elimination System (NPDES) general permit. Compliance monitoring will be conducted by the Naval Facilities Engineering System Command, Hawaii, and the Hawaii Department of Health. The frequency, locations and analytical parameters will be specified in the Notice of General Permit Coverage (NGPC) issued to the Navy. A copy of the NGPC is contained as **Attachment 4.**

iii. Filler Media

Given the potential for a wide range of petroleum contaminates within the Red Hill well, a treatment system consisting of a first (lead) vessel containing a top layer (approximately equal amount by volume) of zeolite clay and a lower layer of Granular Activated Carbon (GAC) followed by a second (lag) vessel containing a full charge of Granular Activated Carbon (GAC) was selected.

- Zeolite Clay: Such as Hydrosil HS-200 (8 X 14 mesh): is a zeolite-based organoclay, having a high absorption capacity with a porous surface specifically designed to remove emulsions and free hydrocarbon contaminates. The zeolite clay is designed to absorb 50% of its weight in product, with the intention of removing potential gross contamination and prolong the life of the granular activated carbon. When breakthrough conditions are first detected in the lead vessel, the two thanks in that unit will be taken off-line and the media changed out in both the lead and lag vessels. As operating experience is gained, there may be the opportunity to change out the lag vessel every two or three changes of the lead vessel.
- The layer of Hydrosil will act to protect the activated carbon beds from any quantities of organic phase or emulsion phase contaminates that might otherwise overwhelm (coat and render ineffective) the Activated Carbon.
- Liquid Phase Reactivated Carbon (8 X 30 mesh): Liquid phase reactivated carbon (also referred to as Granular Activated Carbon, or GAC) is a hard, reactivated carbon manufactured from pooled spent carbon used in a variety of wastewater and process water treatment. This material produces a strong absorption pore structure for a broad range of contaminants and is efficient in removing a wide range of organic compounds.

iv. Empty Bed Contact Time (EBCT)

EBCT is the amount of time in which the influent is in contact with the treatment medium within a contact vessel, assuming all liquid passes through the vessel at the same velocity. EBCT is calculated as the volume of the empty bed divided by the flow rate.

To determining the maximum capacity of the GAC system the following rationale is provided given the recommended EBCT for petroleum is 7.5 minutes **(Attachment 5):**

Maximum Capacity of System

Loading of GAC Lead Tank
= 10,000 lbs. GAC
= 10,000 lbs. / 28 lbs./ft^{C}
= 357.14 cubic feet
+ 20,000 lbs. zeolite clay
= 20,000 lbs. / 58 lbs./ft3
= 344.83 cubic feet
Total = 701.97

Loading of GAC Lag Tank
= 20,000 lbs
= 20,000 lbs. / 28 lbs./ft3
Total = 714.28 cubic feet

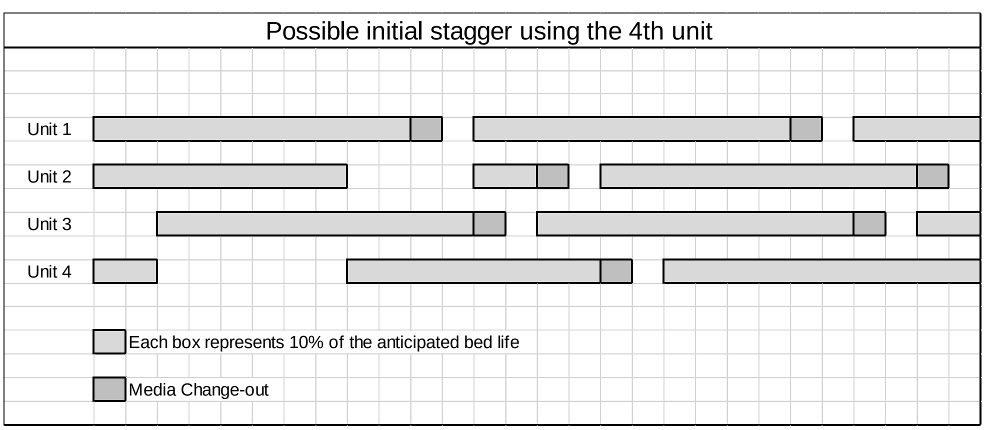
Maximum Capacity Per GAC Treatment Train
= [(701.97 ft3 +714.28 ft3) x 7.48 gal/ft3) / 7.5 min
= 1412 gallons per minute or 6.1 mgd Maximum Capacity

v. Operating Flow Rate

The operating flow criteria for the system is 5.0 million gallons per day (mgd), which equals to 3,473 GPM. Therefore, utilizing three (3) treatment trains, each consisting of two (2) GAC tanks, has sufficient capacity to satisfy a minimum EBCT of 7.5 minutes.

Treatment Capacity = 1157 GPM x 3 = 3,473 GPM

Note: For the initial period of operation up to the first media change out on all four units, the fourth unit may be used to stagger the units to avoid the potential for a simultaneous bed breakthrough in more than one unit.



vi. Projected Bed Life

Looking at the water sample results (Attachment 2c), only the bailer samples collected from the surface had high TPH concentrations. Surface contamination will be isolated from the system pump inlets by booms and the pump inlet being submerged 18' below the surface. Of the other samples provided, all were non-detect, except for one that was at 640ppb for TPH-d and lower for other TPHs. We would expect to see values in this range or lower.

Attachment 5d shows bed life calculations for feed concentrations of 140 ppm, 70 ppm, 14 ppm, 5 ppm, 1ppm, and 500 ppb for the following bed configurations:

20k lbs. Organoclay (in lead tank)

10k lbs. GAC (in lead tank)

20k lbs. Clay + 10k lbs. GAC (composite lead tank)

20k lbs. GAC (lag tank)

The charts show that given an inlet feed concentration of 5 ppm we can expect approximately 75 days before we see the hydrocarbon (hexane in the simulation) in the lead tank (with the clay/ carbon beds) discharge start to rise. At 14 ppm it drops to roughly 40 days and goes out 180 days for a 1 ppm feed. The simulation is run on hexane.

Additional water quality data has been provided and is currently under review. The intent in these simulations is to model the performance based on the actual chemistry—the charts provided are based on hexane, because we don't yet know what is in the water. It was noted that the bulk of the water at the well is TPH-d, but that still covers a broad range of materials (C10-C28), and the model requires inputting the specific parameter for each constituent of concern. So, absent having accurate, specific water quality data, we need to use a surrogate – hexane, and because hexane tends to reach breakthrough sooner, it's a conservative assumption.

The runs at higher concentrations are important for the clay to characterize capacity of the clay to catch slugs. The lower concentrations are important for the GAC, especially in the lag tank to characterize the safety factor that it provides.

It was also confirmed that the HS-200 and the R830 modeled in the simulation are the specific products provided by Clean Harbors for the Red Hill GAC.

vii. Uncertain Conditions

It is uncertain how much, if any, organic phase or emulsified contaminate may be picked up by the well pump and fed to the GAC system. Given the potential variability of the concentration of petroleum contaminates in the feed stream, the system is designed as a dual-stage system consisting of the lead vessel containing an approximate balanced blend (by volume) zeolite clay and GAC filtering media followed by a lag system containing only GAC.

A review of the Navy's current efforts to boom, skim and contain the organic phase and emulsion phase materials at the well away from the pumps includes, the pump suction piping located 18 feet below the water level. Additionally, the vortex resistant design of the inlet to the pump suction line contributes to reducing the potential for the GAC system to encounter large quantities of organic phase or emulsified contaminates.

To address this uncertainty, the system has been designed to handle multiple conditions. If there are minimal amounts of organic phase or emulsified materials, the treatment of the contaminated water should be well within the capabilities of the system and the anticipated times between media change-outs could be considerably extended. The system can also easily handle occasional small amounts of organic phase or emulsified material with the zeolite clay layer protecting the GAC beds.

Only if there are significant levels of organic phase or emulsified materials continually being entrained in the inlet water, could the lead tank media become saturated or blinded and experience a premature indication of a break though. The lag vessel will avoid any effluent excursion for a limited period before the unit would be scheduled for a media changeout. If the amounts of organic or emulsified materials is significantly larger than anticipated the period between required change outs may become unacceptably frequent. In this case, alternate methods such as an oil separator, dedicated zeolite pretreatment tanks or other technology to protect the GAC would be considered. However, the remote likelihood of this becoming a problem excludes the need in Phase I to consider additional steps for a condition that is not likely to be an issue.

viii. Future Improvements

Future installation of more and better instrumentation and controls will improve reliability and efficiency. The P&ID shows many of the proposed instruments in dotted lines. These field mounted instruments could be linked to a central control system and connected to a process historian to collect real-time process data (flow, concentration, etc.) for analysis and forecasting.

Alternatives for a more robust, containment solution with capacity to handle more serious spills or leaks are being considered and incorporated into the future operation. Currently the thinking for phase 1 is to erect temporary curb barriers around the perimeter of the four units and channel the water into a semi-watertight temporary retaining area formed using concrete jersey barriers and plastic sheeting. From here it can be more easily vacuumed for disposal or pumped through the standby GAC unit for treatment.

3. SYSTEM OPERATIONS

a. Operating Conditions

i. Pre-Check Prior to Start-up and Initial Operation

- Perform visual inspection of all tanks, pipes, valves, instruments, and connectors to ensure there are no loose, missing, or defective components that would disrupt operations or threaten structural integrity.
- Confirm tanks are stable and secure.
- Hydrotest all newly fabricated piping to the appropriate pressure with potable water to assure system integrity before acceptance for operation.
- Connect all piping and hoses to vessels, including the sample valves, air valves and carbon dust discharge valves. Verify all connections are tight and secure.

- Once all the piping connections are made, the entire system will be filled with potable water and tested under hydrant pressure to assure there are no leaks.

ii. Load and Prepare Filter Media

Validate media to be used in vessels. Each vessel is filled with the appropriate media utilizing a manlift and forklift or crane. Each supersack of media is intended to be handled using a specific supersack cradle and is lifted above the open upper hatch. The chute at the bottom of the supersack is then opened to allow the media to flow into the vessel. The 10,000 pounds of GAC (bottom half) is first placed followed by 20,000 pounds of zeolite clay media in the lead vessel, and 20,000 pounds GAC in the lag vessel.

- Safety Protocols - appropriate PPE will be worn including hard hat, safety glasses and gloves. The fittings on air lines will be pin-locked and hose whip locks will be attached. Pressure introduced to the system will be monitored at the compressor by the gauge located on the hose connection assembly.
- Presoak – Once the correct media is charged the presoak can be started. Fill operational vessels with water from the temporary hydrant connection and hold for the recommended 12 - 24 hours. Begin by opening the inlet valve on the train to be filled. Open the high point air bleed valves on both tanks, the interconnecting valves between the lead and lag tanks and close the lag tank outlet valve. Start filling the lead tank using the hydrant water. This water will be allowed to flow out of the lead tank and enter and fill the lag tank. Air will continue to escape from the air vent lines as each vessel fills. The high point air bleed valve can be connected to a hose that drops to a safe operating height where it is terminated by a second valve. Air is evacuated from the vessels through these hoses and valves until water is received at the valve. Once fluid begins to exit through the air valves, the vent valves can be closed, and filling will cease. An operator will be overseeing this action to ensure that releases from the air valves will be minimized, controlled, and captured in the containment structure under each tank. During the filling activity, the integrity of the tank and piping will be checked to assure there are no leaks.
- Allow the recommended time for the carbon to soak and purge any excess air. Verify and validate that there are no leaks in the tank and supply and discharge lines.
- Sample, monitor and adjust pH levels as necessary. Activated carbon products can produce an initial alkaline effluent. The potential increase in pH is influenced by several factors such as surface charges on the activated carbon, the ash content of the starting material, total dissolved solids (TDS) of the influent water, the buffering capacity of the influent water, and pH of the influent water. Recent research literature indicates that the primary mechanism for the initial pH rise is due to positively charged sites on the carbon formed during the activation process. These sites appear to exchange anions from the feed water, thus raising the pH. This elevated pH is thought to be temporary and varies in reading levels and flow duration.

- To adjust the pH levels, the following procedures can be implemented.
  - Equipment Inspection - Before beginning the introduction of compressed air, the system will be “walked”, and valve configurations will be checked. Influent and effluent valves will be closed, and the top mounted air bleed-off valve will be opened.
  - Compressed Air Introduction- After valve positions are confirmed an air fitting will be connected to the effluent line at the air valve. This connection assembly will include a 3/4-inch air connection and a pressure gauge. After all connections have been completed, compressed air will be introduced to the GAC tank by connecting a hose from a diesel-powered air compressor to the 3/4-inch air connection fitting. The air bleed-off valve at the top of the tank will be opened. The air valve in the tank discharge line will then be opened allowing compressed air to flow up through the screens in the bottom of the carbon bed. The air flow should be maintained between 3 and 5 cfm.
  - Aeration of the water will continue until pH levels are within the permitted limits. After pH levels are consistently within the acceptable range, the air inlet valve will be closed and the compressor stopped, but the air bleed-off valve will remain open until tank pressure is dissipated. The air bleed- off valve will then be closed. The same procedure will be followed on the second (lag) tank of the system.
  - In situations where the above steps do not bring the pH into an acceptable range, the high pH water can be aerated with CO_2 from a compressed CO_2 cylinder connected into the air injection point to bring the pH into line. The CO_2 flow should be maintained between 3 and 5 cfm at 20 to 30 psi.
  - Once the pH is brought into acceptable limits the units are ready to purge out the activate carbon fines that may have collected at the bottom of the vessels during the soak period.
  - To capture and prevent any carbon fines that may be present in the initial first flush from being discharged into Halawa Stream. We will collect the fine particles (dust) from the GAC media in the water using a 0.5- or 1.0-micron pore filter-bag attached to the 4” branch connection located on each unit discharge.
  - Once the bag is in place, initiate flow from the potable water source and open the 4” valve and let the first few gallons of water exit through the bag for about one minute and collect the carbon fines in the bag. The water will be filtered potable water and can be released or collected and disposed as instructed.
  - Residual carbon fines material will be disposed as solid waste consistent with the Resource Conservation and Recovery Act regulations.

iii. Switching to Normal Operations

- Coordinate with NAVFAC Hawaii utilities to be prepared to start the pump at the Red Hill shaft and open the recycle valve to allow the pump discharge to recycle back to the well for start-up.
- In preparation for start-up, align all GAC unit valves to allow flow through all four units.
- Keep the lag tank discharge valve closed until right before the well pump startup to prevent the tanks from draining.
- Walk the system from incoming water header to the effluent discharge to verify that all valves are properly set, the bleed lines are closed, and the system is ready for operation.

iv. Operations

- **Initial System Start:** Upon operator certification that all initial startup items have been completed, adjust the 24" main line flow control valve to almost closed, confirm the Navy has opened the bypass on the well pump to recycle some of the well water back into the well. Confirm the inlet and outlet flow valves on all 4 GAC units are prepared for the initiation of flow.
- Request the Navy to start the well pump. Once the pressure builds, gradually open the 24" main line flow control valve and the gradually open the lag tank discharge valves to introduce flow through all four GAC units. Once flow is established, gradually open the 24" main valve while monitoring the flow through all four GAC units.
- Increase the flow per train by adjusting the lag tank discharge valves, the lead tank inlet valves and the 24" main line flow control valve. As the system allows adjust to the design flow rate 1157 gpm for all three operating units. Gradually reduce the flow on the 4^{th} unit and place it on standby. The total flow to the 3 operating units should be maintained at 3471 gpm.
- Verify the inline analyzers are measuring the TPH and it is within the acceptable range for discharged into Halawa stream
- Isolate a unit if the TPH is out of range on that unit alone. If the TPH is out of range on multiple units, shut down the GAC System by stopping the well pump. This will reduce the quantity of any out-of-compliance discharge.
- To isolate a single unit, close the inlet valve to the lead vessel and the outlet valve on the lag vessel of the unit that is not working as designed and establish flow through the backup unit.
- Inspect that all units are working properly, and that there are no leaks.
- If there are leaks or if any part of the system is not working as designed, isolate the unit or if broader than one unit, shut down the GAC System by stopping the well pump.

- As the incoming flow is established, bled off any air trapped in the tanks through the air vent lines.
- Verify that all monitoring devices are operating as designed. Check pressure gauges for indications of restricted water flow, and flow meters for valid flow measurement.
- Ensure all sampling ports are operational and secured.
- Troubleshoot problems, isolate, and replace devices not operating correctly. If the tank requires dewatering to address mechanical problems, follow change out procedures in Section 3c and startup procedures in Section 3.a.iv above.
- Visually inspect the systems and effluent lines to ensure no bypass or leaks are detectable. Initially, inspect hourly for the first 4 hours of operation and then 3-4 times per shift thereafter.
- During normal operations, conduct routine inspections for closed air bleed valves, vessel pressure checks and flow readings/balance adjustments should be made.
- System operators shall collect visual samples of the incoming water to check for free hydrocarbon or emulsions present during rounds.
- Additionally, the collection of a visual sample of the effluent shall be completed to check for clarity and other issues. In the event free product or heavy emulsions are detected in the influent, the flow rate may be temporarily reduced by partially closing the inlet valves to the lead tanks and the discharge valves on the lag tanks to insure we get the best possible treatment until that condition clears.
- Daily log and operator notes will be prepared and kept onsite and available for inspection and review. A sample of the Daily Discharge and Monitoring Log are included in **Attachment 6.**

v. Operational Consideration

As the water containing petroleum constituents passes through the vessel column of filtering material, a mass transfer zone develops. This “mass transfer zone” is defined as the media bed depth required to reduce the contaminant concentration from the initial to the final level, at a given flow rate. As the mass transfer zone moves through the media column and reaches its exit boundary, contamination begins to show in the effluent. This condition is classified as “breakthrough” and the amount of material adsorbed is considered the breakthrough capacity. If the bed continues to be exposed to the contaminated water stream, the mass transfer zone will pass completely out of the bed and the effluent contaminant level will equal the influent. At that point, saturation capacity is reached.

The operational plan consists of monitoring for signs of a potential breakthrough of the lead vessel, triggering a media changeout in the lead tank (and initially in both thanks) when effluent concentration begins to rise. Inline analyzers on the incoming line and each of the lag vessel discharges plus the manual sampling (initially hourly for the first 4 hours of operation and three times per shift thereafter), combined with the permit required compliance testing will be used to track individual lead and lag vessel performance. This continuous performance oversight of the units enables the operators to monitor bed capacity, ensuring media replacement is planned, scheduled, and completed in an orderly manner before a breakthrough occurs.

This enhanced oversight ensures that the lag vessel retains the full operational capacity to prevent any discharge containing contaminants that exceed environmental requirements. This program of system oversight is also expected to minimize a situation of having multiple treatment trains being serviced simultaneously. Ultimately the fail-safe system to prevent an uncontrolled discharge is to shut down the flow from the Red Hill pump station.

vi. Treatment System Design Description

As indicated in Section 2.d.v above, the treatment system is designed to treat the required five (5) mgd with three (3) treatment trains. One (1) treatment train will be available on standby to provide operational redundancy and will be utilized to isolate and deactivate an individual system during media replacement. The new replacement material will be presoaked, and the vessel will be staged ready for operation. This process will be repeated as required to ensure that fully functional material is always being used in all treatment vessels.

To avoid biological growth that could blind the zeolite and activated carbon, two methods are being considered:

1. A pool type chlorine chemical (HTH or equal) will be charged into the lead and lag tanks on standby in sufficient quantity to minimize adverse biological activity, or
2. Each day, or some specified frequency, the standby unit will be activated, and flow established for a brief period to flush out the water retained in the two tanks and replace it with fresh inlet water. This way the biological activity will be flushed out of the standby system.

Flow measurement: Flow metering will consist of total influent measurement from the source as it enters the treatment system, and measurement of effluent flow at each individual treatment train discharge. This flow data will be used to control influent volume by a valve at each lead tank and to balance the flow to each treatment train.

Pressure gauges: Liquid filled pressure gauges rated for 0 to 100 psi are positioned at the top of each tank. This way they can measure the pressure drop across the Lead Tank bed. Day to day the pressure drop should remain constant for a give flowrate. However, any significant change up or down in the pressure drop across the Lead Tank bed could indicate an unusual condition in the Lead Tank media bed such as channeling or blinding. If this were to develop, close attention must be paid to the Lead Tank discharge to verify that the contaminate concentration is not increasing. If the contaminate is increasing or the pressure drop becomes so great, that the desired flow of 1157 gpm cannot be maintained, a bed replacement would be needed.

b. System Performance and Monitoring

We plan to collect frequent samples from the inlet to the treatment system and evaluate them for separate-phase and emulsified hydrocarbons. If significant quantities of separate-phase or emulsified hydrocarbons are encountered, this will provide valuable information, for assessing future modifications of the treatment system and require more mitigation measures to reduce the entrainment.

Sampling and analysis will be required to ensure that the GAC system is operating at maximum efficiency and that treatment performance complies with the permit limits for the effluent being discharged.

Initially as described, water samples shall be taken and analyzed by a third-party certified laboratory to determine the removal performance of the treatment system, and to determine compliance with discharge limitations.

Frequency and analytes are to be determined by the government/ regulatory agency as shown in Attachment 4.

In addition to third party compliance monitoring, additional monitoring and testing will be conducted for process control and assess the need for media change out. This process control testing will initially consist of daily monitoring for the following parameters:

- Total Petroleum Hydrocarbon – Inline Analyzers and periodic manual samples per the sampling schedule
- Visual (effluent outfall and mason jar)
- Tank pressure readings

Internal performance process testing will be conducted onsite at the prescribed frequency using a portable hydrocarbon analyzer (see Attachment 3c) and augmented with the MultiSensor 1200, and 1700 Oil in Water Analyzers once they are installed.

Proposed group of samples:

1. Main header from the Well Pump
2. Outlet of the Lead tank on one unit in operation (sample a different unit each hour)
3. Outlet of the Lag tank on one unit in operation (sample a different unit each hour)

Proposed Sample frequency:

1. For complete system start-up - Every hour for the first 4 hours of operation from one of the three units in operation, switching every hour to a different unit so that in three hours there will be a complete sample of the GAC system
2. Every 4 hours thereafter, again switching units at every sample so that by the end of a 12-hour shift there will be a complete sample of the GAC system.
3. Proposed sample schedule

Proposed Sample Schedules

	For initial start-up of all three units - sample every hour during the first 4 hours of operation, rotating between operating units				Single unit start up operation - Sample every hour for the first 4 hours				Subsequent operation - Sample every 4 hours rotating between the operating units			
Time	13:00	14:00	15:00	16:00	20:00	21:00:00	22:00	23:00	20:00	24:00:00	4:00	8:00
System Inlet	X	X	X	X	X	X	X	X	X	X	X	X
Unit 1												
Lead Tank Discharge	X			X	X	X	X	X	X			X
Lag Tank Discharge	X			X	X	X	X	X	X			X
Unit 2												
Lead Tank Discharge		X								X		
Lag Tank Discharge		X								X		
Unit 3												
Lead Tank Discharge			X								X	
Lag Tank Discharge			X								X	

Upon installation of the online analyzers, and as GAC operations generate analytical data and become more predictable, a recommendation for changes in process control testing will be submitted for consideration. Any changes to the testing program will not be executed without written authorization.

Analytical data from the Red Hill well will be used to evaluate filtering media loading rates, and performance efficiency of the treatment system. Lead and lag sampling is used to develop trends, evaluate treatment efficiency, predict contaminant breakthrough, and initiate media replacement. Unit effluent is used to measure treatment efficiency and determine compliance with permit limits.

Based on the analytical data, any change in the pressure differential and visual inspection, an estimate of remaining GAC media life will be made. This decision will be based on criteria established in Section 3.a.v. GAC media life will be a function of operational conditions and influent contaminant concentrations. GAC replacement will be scheduled based on analytical results and operational needs.

For the initial operation, no provision is available to sample the clay layer in the lead vessels. Only by analyzing the lead tank discharge will operators know whether the capacity of the combined clay and carbon is nearing exhaustion. Future additions to the system may include a sample port at the clay carbon interface. However, if samples indicate the clay layer is nearing depletion, the carbon in the bed would still be changed when the clay was changed.

The backup treatment system provides flexibility and redundancy to accommodate GAC media replacement demands.

This assessment, documentation and reporting will be provided in a format identified by the Interagency Drinking Water System Team.

The lead vessel will be isolated from service and its Zeolite and GAC media replaced expeditiously when any monitored contaminant (i.e., TPH-o, TPH-d, or TPH-g) meets or exceeds the targeted limitations at the Lead tank discharge. The turnaround time for a media replacement is 36 – 48 hours. Initially the media in the lag bed will be replaced at the same time for each change out until sufficient operating data is obtained to better calculate the lag tank bed life. A longer bed life may allow the replacement of the lag media every second or third lead tank change-out.

In general, the plan is to isolate and replace the lead bed media at approximately 60 – 70% of the anticipated bed life, well before a breakthrough occurs. Initially, the lag bed will also be changed at the same time until sufficient experience demonstrates that the lag bed life is long enough to go through two or three lead bed changes.

Controlling for potential breakthroughs will require frequent sampling to detect any increase in the TPH levels in the stream exiting the lead tank. The initial sampling schedule is hourly for the first four hours of operation and then three times per shift thereafter. Once some operating experience is gained the frequency of sampling may be adjusted. Upon installation of the inline analyzers, Fuel Oils will be the controlling indicator, with parallel samples tested to confirm the analyzer results.

TPH is proposed because it can be measured in less than an hour and reflects the nature of the fuel contaminate. Once the GAC unit is in operation the initial concentration for TPH exiting the Lead tank shall be established.

The hexane-based breakthrough curve in Attachment 5d3 indicates that there will be some time that very low levels of TPH will be detected exiting the Lead tanks (75 days for a 5 mg/l feed stream). However, once the TPH levels begin to rise there is a short time (15 days for the 5 mg/l inlet stream) before the bed experiences a complete breakthrough and TPH levels climb until they are equal to the incoming stream. Therefore, the trigger for a bed change will be the start of the upswing in TPH exiting the Lead tank. Note: The number of days projected depends on the inlet concentration and different times can be expected as shown on the curve in Attachment 5d3

Downtime for media exchange is reduced by the presence of a fourth set of lead/lag vessels, filled with media and pre-charged with water. This allows the unit approaching breakthrough to be taken out of service for media exchange without reducing the total flow through the treatment system. Under such a configuration, once trigger concentration is detected, the standby train would be put in operation.

Once the standby unit is up to full flow, the unit nearing breakthrough will be taken off-line and isolated. The process to change out the media in both vessels of the unit would be initiated.

c. Change out Procedures

Change Outs – The process is outlined below.

- The vessel(s) to have media changed out are taken offline and isolated by closing the lead tank inlet valve.
- Compressed air is supplied to the air vent valve on the lead tank, and the air will push the liquid water out of the bottom of the lead tank and up to the inlet of the lag tank. The water will then be pushed through the lag tank GAC bed and the exit out the lag tank discharge and flow out to the stream.
- Once the liquid water is removed, the lag tank discharge valve will be closed.
- The media is then removed from the vessel using a vacuum unit. In this case, we plan to use a Hurricane 500 unit we have sourced on the island. **(Attachment 8e)**

- The proposed equipment will allow us to place the media in supersacks or special disposal bins or packs. NOTE: Wet media can weigh up to 50% more than dry media due to the adsorption of water into the media or into its interior porosity. It is not recommended to put 3,000 pounds of wet media into a super-sack designed for 2,000 pounds of the same media dry. Therefore, additional bags, bins, or packs will be needed.
- Prior to transport, all spent GAC, and zeolite will be stacked on pallets and stored in a closed top roll-on roll-off container.
- The sacks will be held in closed top storage for sufficient time to allow all free water to drain, both reducing the final weight and avoiding any unwanted liquid discharge during transport.
- This liquid runoff from the sacks will be collected, tested, and disposed of properly.
- The sacks of spent GAC will be tested and profiled for disposal or regeneration.
- The spent zeolite HS-200 cannot be regenerated and will have to be characterized and disposed.
- Once fully drained and profiled, the media will be ready to ship to the chosen facility or location.
- Once the tanks are empty, conduct an inspection of the tank internals, and collect a comprehensive set of photographs of the interiors of the vessels for the permanent project file.
- Refill the tanks with the correct medium per Section 3.a. ii.

d. Maintaining Flow Rates

The flow rate must be maintained to ensure pumping from the Red Hill Shaft creates and sustains a capture zone in the ground water aquifer. Each unit of lead/lag vessels is fitted with an influent and an effluent valve as well as a flow meter. Splitting and balancing the flows is accomplished through manual manipulation of the inlet and outlet valves on each unit. Flow meter readings will allow operators to balance the flows and ensure the desired flow of 1,157 gpm/ unit is achieved.

e. Spent Media Management

Processing media that will be regenerated (carbon)

1. A composite sample of media to be disposed of must be gathered and analysis performed for constituents of concern.
2. Sample is sent to accredited laboratory for analysis.
3. Upon receipt of analytical result, the client must determine if media is hazardous material, or non-hazardous material.
    a. If the media is deemed non-hazardous, an acceptance letter will need to be prepared for media to be regenerated at regeneration

facility or sent to a municipal landfill disposal.

b. If the media is deemed Hazardous, an appropriate landfill or incineration facility will be identified for disposal of the media.

4. If the media is deemed non-hazardous, the material will be re-containerized into flex bins for transportation to regeneration facility.
   a. A “Hurricane” unit will be utilized to vacuum media out of dewatering boxes or sacks
   b. Spent media will then be placed into flex bins utilizing the bulk loader on the back of the unit.
   c. Spent media flex bins will be staged for shipping to regen facility

5. If deemed Hazardous, the material will be profiled for appropriate disposal method
   a. A “Hurricane” unit will be utilized to vacuum media out of dewateringboxes or sacks
   b. Spent media will then be placed into flex bins utilizing the bulk loader on the back of the unit.
   c. Spent media flex bins will be staged for shipping to disposal facility in a covered roll on roll off trailer or an enclosed trailer similar to the Adler units shown in Attachment 8.
   d. Disposal will be coordinated with NAVFAC Hawaii, Joint Base Pearl Harbor-Hickam for manifesting, tracking, recording keeping and disposal
   e. Media will be shipped in accordance with DOT regulation to an identified/approved disposal facility for disposal

4. ENVIRONMENTAL CONTROLS

a. General / Project Environmental Awareness

All employees working on this project have an environmental awareness oversight/training of the potential impacts of this project. A detailed work breakdown structure (WBS) for each job, and written SOPs, drills (breakthrough, spills etc.) and a visual decision tree that talks to “if this happens then we do this” are being prepared and are currently in final review. All activities will be recorded in the daily log with notes on any non -standard events. Sample results, flow, pressure, and analyzer readings will be recorded on a daily log sheet.

Environmental SMEs are available to assist and provide guidance with any aspect of the project that potentially have an environmental or human health impact. A project specific environmental management plan has been prepared for this project. The primary focus of the plan is awareness, pollution prevention, prompt reporting and documentation. The Environmental Management Plan is included at **Attachment 7.**

b. Spill Containment

The spill response plans include the following for rapid response to a release:

- Four 24-hour-per-day trained operators working on site.

- Mobile phones for the operators to call the Pump Station for shutdown of the well pump. Contact Number for the Pump Station: 808-474-4229
- Emergency Response Spill Kits and stockpiled spill containment sorbent pads, socks, and booms.
- Sufficient Oil sorbent boom material for the stream
- A vacuum truck stationed on site.

As previously described in Section 2c, for initial operation, each vessel will be fitted with a 13' x 13' x 1' spill containment structure on grade consisting of a sixty (60)mil single ply membrane that extends beyond the exterior dimensions of the vessel.

The operations staff will have a suction pump to evacuate uncontaminated, accumulated storm water that collects during a rain event. The containment structures will capture and contain incidental discharges from vents, pipe or hose disconnections, media changeouts, and accidental spills from sampling events. Standard practices include:

- Daily inspection of the containment structures to determine the integrity of the containment walls and retentive membrane. Repairs to be made as needed.
- Inspecting any accumulated water for a visible sheen:
  - If there is a sheen, the liquid will be collected for appropriate disposal.
  - If there is no sheen, accumulated water will be drained or suctioned from the containment.

Alternatives for a more robust, containment solution with capacity to handle more serious spills or leaks are being considered and incorporated into the future operation. As described above, the phase 1 plan would erect a temporary barriers around the perimeter of the four units to channel any spill into a semi-watertight area where it can more easily be vacuumed up or treated through the standby unit.

c. Spill Response Procedures

The Emergency Spill Response would be triggered in the event of a leak that could not be contained and immediately stopped. The steps of the Emergency Response are as follows:

1. A sizable leak is detected, and it cannot be stopped immediately
2. One operator will initiate a call to the Pump Station at 808-474-4229 and request that the pump be shutdown due to an emergency leak
3. Other operators will deploy appropriate elements of the spill response kits, pads, socks, or boom materials to direct the runoff and cause the spilled water to contact the sorbent materials.
4. One operator will contact the appropriate contacts in the Telephone Points of Contact table below to report the spill
5. Once the pump is shut down, all valves in the GAC system should be closed and the systems secured
6. Operators are to take instruction from the On-Scene Coordinator

To allow for this response, the treatment system will be staffed continuously by a trained operator/watch personnel.These individuals are routinely monitoring for leaks/spills, observing and reporting intrusion/vandalism to base security, facilitating sampling, and monitoring pressure gauges.

Additionally, the operator/watch personnel routinely inspect the effluent line to ensure there are no leaks or failures, and visually assessing the quality of the effluent being discharged into Halawa stream. The watch should also evaluate weather conditions, any existing upgradient Halawa stream flow, and inspect the discharge location to ensure that the energy of the effluent discharge is not eroding the Halawa stream bed, bank walls nor creating excessive turbidity.

Accumulated rainwater water in the containment that does not have a visible sheen shall be tested for TPH and if below discharge permit limits, released. If not below the discharge permits, it can be suctioned and discharged to a process sewer or other approved method of disposal. This will ensure the full capacity of the spill containment is available if needed. All inspection information shall be documented in a daily log sheet acceptable to the Navy and/or the Regulatory agency.

Spill kits shall be pre-staged onsite to clean up any spills of contaminated water. Additional quantities of clean-up materials for larger spills will be stationed nearby in drums or covered storage. Larger spills, defined as spills exceeding Navy Standards, will be reported to the NAVFAC Hawaii, Duty Officer, and the Emergency Operations Center for a coordinated response. Response activities will follow the existing Navy Region Hawaii, Oil and Hazardous Substance Contingency Plan. Oil and Hazardous Substances release response actions will be directed by the Navy Region Hawaii, On-Scene Coordinator. All releases of raw or process water shall be reported to the COR and Contracting Officer as soon as practicable.

d. Telephone Points of Contact

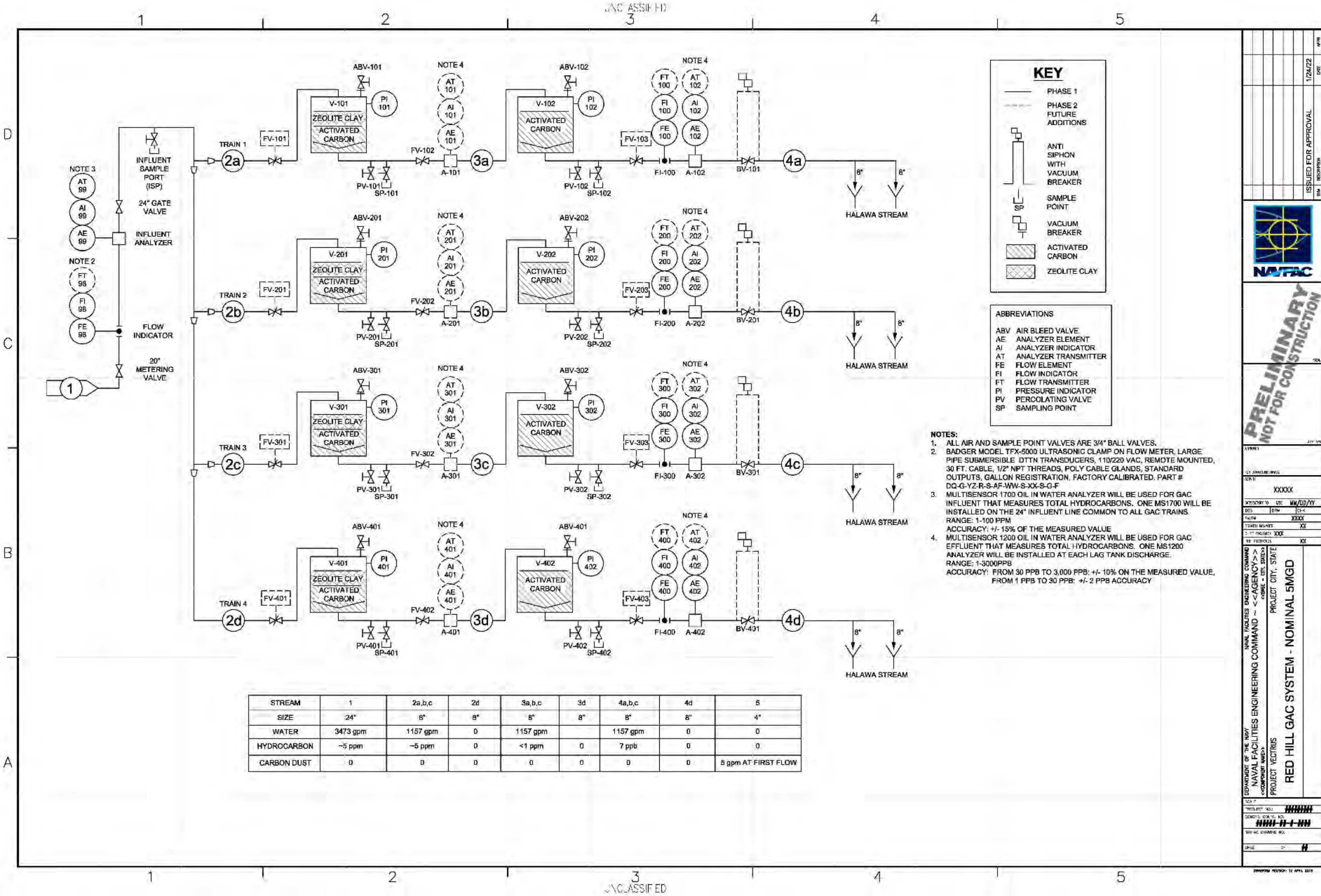
Name	Telephone Number
NAVFAC Hawaii Duty Officer	(808) 347-8289
NAVFAC Hawaii EmergencyOperations Center	
National Response Center Oil Spill to Waters of the US	(800) 424-8802
Navy Region Hawaii, On SceneCoordinator	(808) 864-2463
Navy Region Hawaii – RegionalDispatch Center	(808) 471- 7117

Report incidents to the contacts above and the Navy will make the necessary notifications to other agencies.

Navy On-Scene Coordinator will report any releases to DOH within one hour

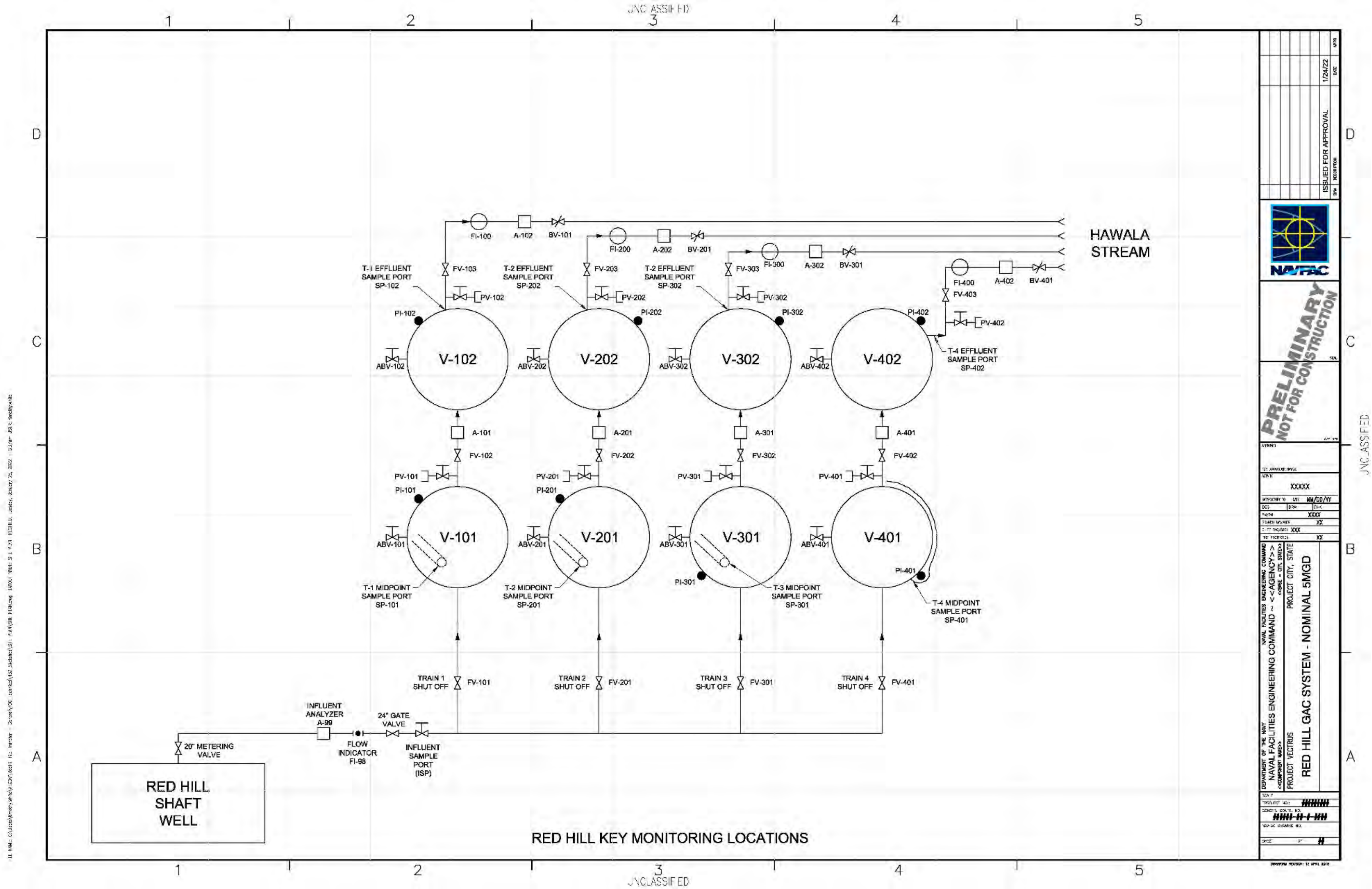
ATTACHMENT 1

a. P&ID

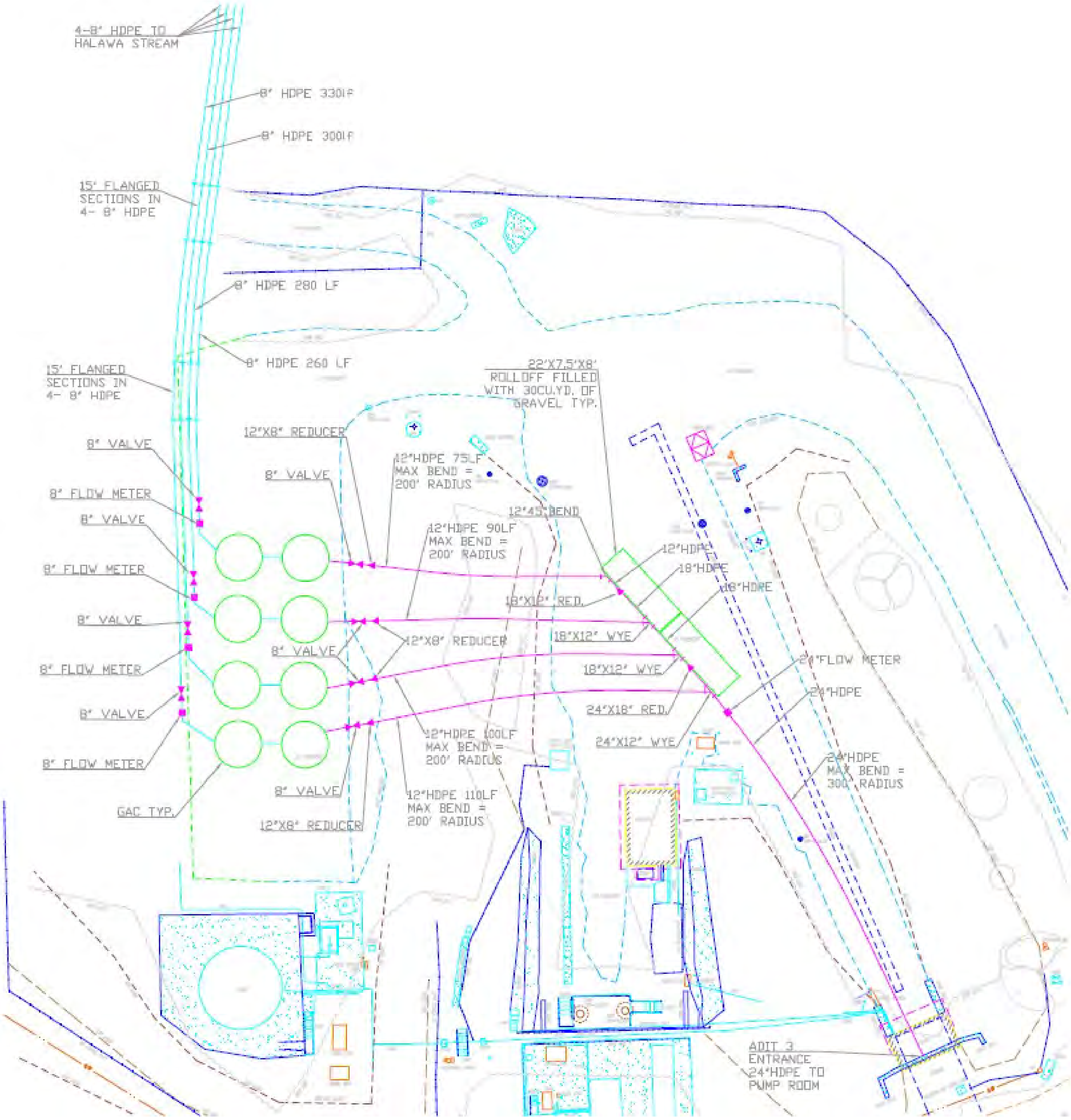


STREAM	1	2a,b,c	2d	3a,b,c	3d	4a,b,c	4d	5
SIZE	24"	8"	8"	8"	8"	8"	8"	4"
WATER	3473 gpm	1157 gpm	0	1157 gpm		1157 gpm	0	0
HYDROCARBON	~5 ppm	~5 ppm	0	<1 ppm	0	7 ppb	0	0
CARBON DUST	0	0	0	0	0	0	0	5 gpm AT FIRST FLOW

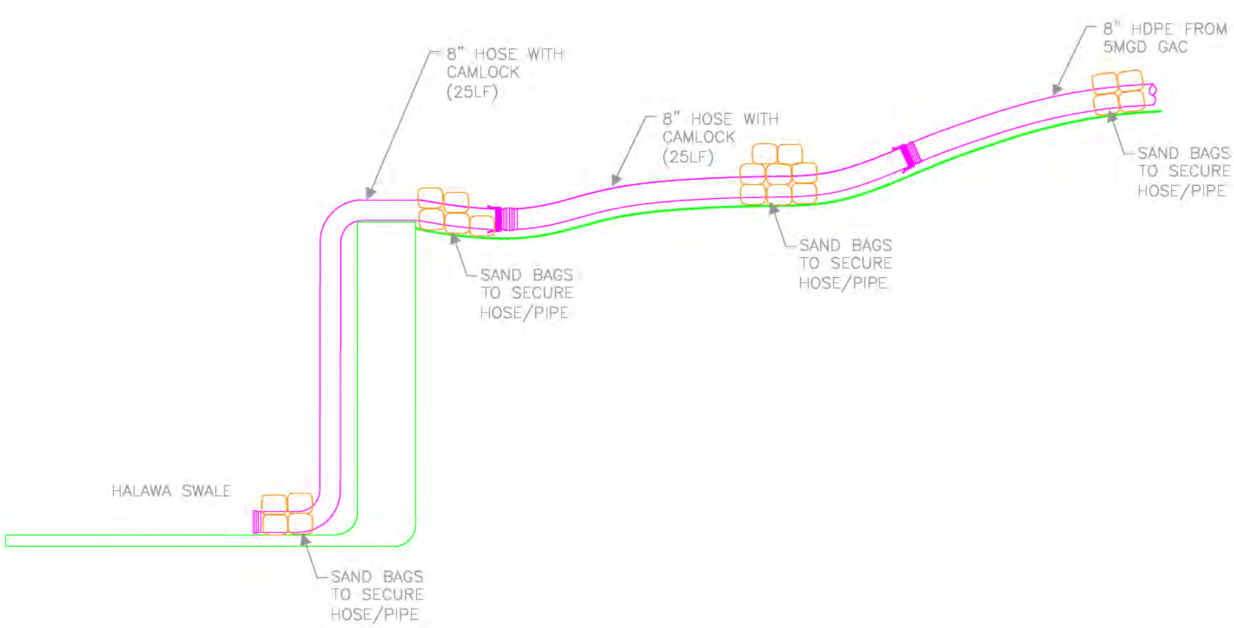
b. Plot Plan


UNCLASSIFIED
HAWALA STREAM
V-102
V-202
V-302
V-402
V-101
V-201
V-301
V-401
T-1 EFFLUENT SAMPLE PORT SP-102
T-2 EFFLUENT SAMPLE PORT SP-202
T-2 EFFLUENT SAMPLE PORT SP-302
T-4 EFFLUENT SAMPLE PORT SP-402
T-1 MIDPOINT SAMPLE PORT SP-101
T-2 MIDPOINT SAMPLE PORT SP-201
T-3 MIDPOINT SAMPLE PORT SP-301
T-4 MIDPOINT SAMPLE PORT SP-401
TRAIN 1 SHUT OFF
TRAIN 2 SHUT OFF
TRAIN 3 SHUT OFF
TRAIN 4 SHUT OFF
INFLUENT ANALYZER A-99
24" GATE VALVE
20" METERING VALVE
FLOW INDICATOR FI-98
INFLUENT SAMPLE PORT (ISP)
RED HILL SHAFT WELL
RED HILL KEY MONITORING LOCATIONS
PRELIMINARY NOT FOR CONSTRUCTION
NAVFAC
ISSUED FOR APPROVAL
1/24/22
RED HILL GAC SYSTEM - NOMINAL 5MGD
NAVAL FACILITIES ENGINEERING COMMAND ~ <<AGENCY>>
PROJECT VECTRUS
UNCLASSIFIED

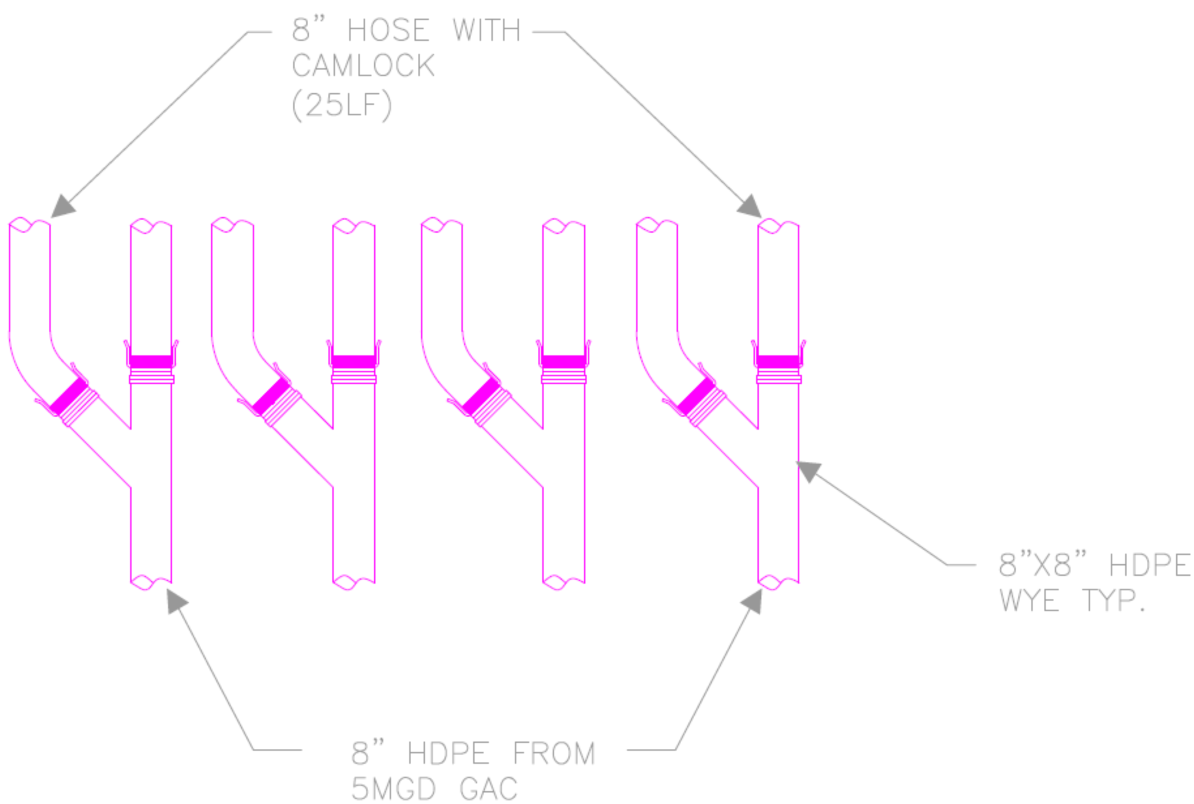
c. ADIT 3 Exterior Site Plan



d. Discharge Pipe dwg

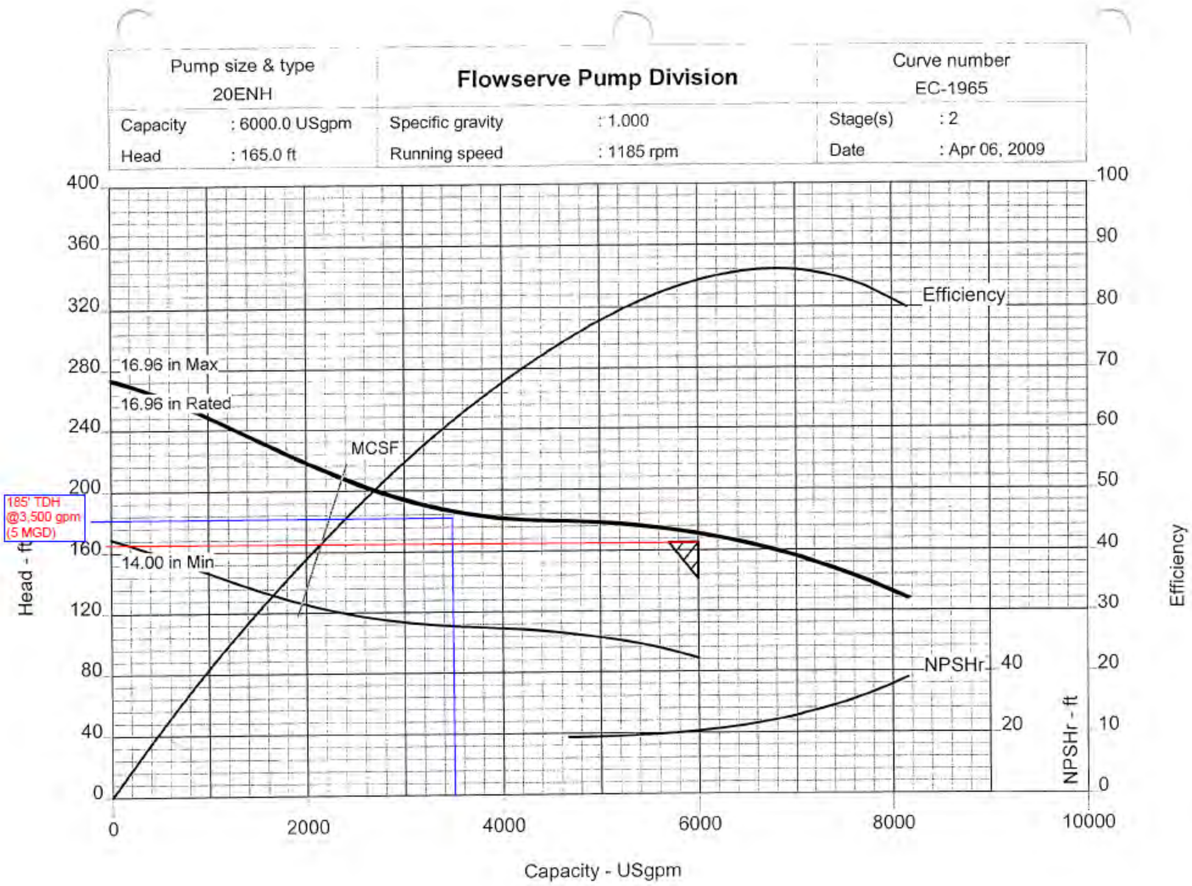


e. Discharge Wyes and Hoses



ATTACHMENT 2 - INCOMING WATER QUALITY

a. Pump Curve



b. Boom and Vortex Plans

Attachment 2a – Red Hill Well and Pump Characteristics - Boom and Vortex Plans

7. BOOM PLAN

In an abundance of caution, the Navy will construct and maintain a series of booms within Red Hill Shaft (RHS) to address concerns regarding the potential development of a vortex and pulling fuel and emulsion into the vortex, pump intake, and ultimately GAC Treatment System during operation. During treatment system operation, Well Pump #3 will be pumping, while Well Pumps #1, #2, and #4 will remain idle. This Boom Plan describes the boom components and inspection/maintenance activities that will be conducted throughout pumping and operation of the GAC Treatment System.

As stated, an assemblage of boom components will be installed within RHS to keep fuel and emulsion from the Pump #3 intake during operation, if such conditions exist or develop. The overall staging of the boom components is presented in Figure 11.

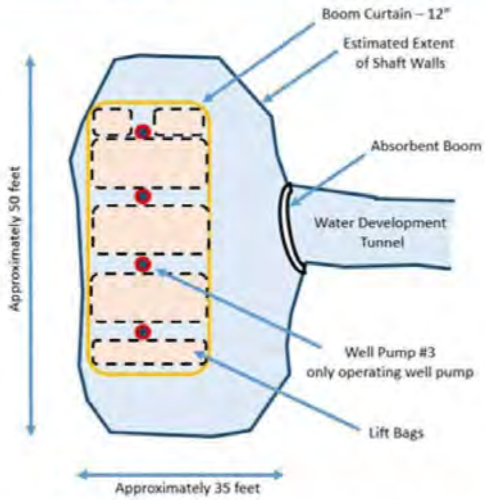


Figure 11. Overall Staging of Boom Components

These boom components and their description/function are provided below:

- **Absorbent Boom:** An absorbent boom will continue to be maintained and/or replaced, on a monthly basis at minimum, at the entrance to the water development tunnel in RHS (see Figures 11 and 12). Based on observations, fuel and emulsion are originating from the water development tunnel. Currently, the absorbent boom is inspected and replaced, as needed, and any fuel or emulsion formation is skimmed via pumping. Thus, the absorbent boom serves as the primary barrier in preventing fuel and emulsion from potentially entering the pump intake and GAC Treatment System.

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1

Attachment 2a – Red Hill Well and Pump Characteristics - Boom and Vortex Plans

Figure 12. Absorbent Boom in Red Hill Shaft

- **Boom Curtain:** Approximately 100-feet of open water 13-inch containment boom, with 7-inches of freeboard and a 6-inch curtain will be installed within RHS surrounding the four well shafts (see Figure 11). Figure 13 provides: 1) a photograph of the boom curtain in open water (upper left) and 2) a profile pictorial of the boom curtain (bottom right). The combination of freeboard and curtain provides a barrier to prevent emulsion and fuel, respectively, from entering the area surrounding the well shafts, particularly Well Pump #3 during operation.

Figure 13. Containment Boom

- **Lift Bags:** A series of lift bags, with varying dimensions, will be used to: 1) hold the boom curtain in place around the well shafts and 2) keep the boom curtain upright (see Figure 11). The boom curtain will be attached to the lift bags; therefore, the lift bags and boom curtain will float as one (1) unit, rising and falling with the water surface. The lift bags will encompass the area around the well shafts, keeping the boom curtain in place, and due to its height, keeping the boom curtain upright, even if a water current forms within the shaft during operations. Figure 14 provides photographs of example lift bags in use.

Figure 14. Example Lift Bags

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2

Attachment 2a – Red Hill Well and Pump Characteristics - Boom and Vortex Plans

Prior to installing these components in RHS, the Navy will perform skimming activities within the shaft and water development tunnel to remove any fuel and emulsion. After these components are installed, the absorbent boom, boom curtain, and lift bags will be inspected from the 24-inch manhole on a daily basis, as part of the overall inspection of the GAC Treatment System. Closer inspections from within the shaft will be conducted on a monthly basis, at a minimum. Based on daily and monthly inspections, maintenance activities will be conducted immediately and include, but not be limited to replacing the absorbent boom; adding air to the lift bags, and/or performing skimming activities. All inspections, observations, and maintenance will be documented in a dedicated field logbook with dates, times, field personnel, and observations.

Page Break

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8. 3.7 MAINTAINING VERTICAL SEPARATION BETWEEN WELL SURFACE CONTAMINATION AND PUMP INTAKES

The bottom elevation of the vertical shaft of the Red Hill well is –10 ft. mean seal level (MSL; see Figure 15). The bottom elevation of the suction intake for the pumps are ~0 ft. MSL. The water elevation fluctuates between 18 and 20 ft. MSL. This provides approximately 18 ft. of water above the suction intake of the pumps, at a minimum. During pumping operations at 5 MGD, measurements demonstrate that the water drawdown is typically 2 ft. This 2 ft. drawdown would bring the water level to within 16 ft. of the suction intake of the pumps. With these observations/measurements and known physical properties of fuel emulsions, it is conservatively estimated that the extent of the water column with potential to contain fuel concentrations sufficient to create an emulsion would be confined to the top 4 ft. (i.e., 25% of water column during pump operation). When operating at 5 MGD, the potential layer for fuel emulsion (i.e., uppermost 4 ft.) would drawdown, accordingly. The pump is set at 18 ft. below the water level. Therefore, there is approximately 12 ft. (i.e., 18 ft. – [2 ft. + 4 ft.]) within the water column with concentrations below levels that are amenable to emulsification, between: 1) the bottom of the potential layer for fuel emulsion and 2) suction intake of the pump. Therefore, although there is physical mixing created by the pump, concentrations at and 12 ft. above the intake are low, creating a "buffer zone." In addition, the pumps require a minimum of 10 ft. of water above the suction intake to avoid cavitation, less than the estimated "buffer zone" of 12 ft. Using float switches within the well shaft the Navy will set an all pumps off level of 12 ft. above the elevation of the suction intake. This will ensure that the pumps will not cavitate and will provide reassurance that water will be drawn from the lower region of the well source and not the surface containing fuel or emulsion.

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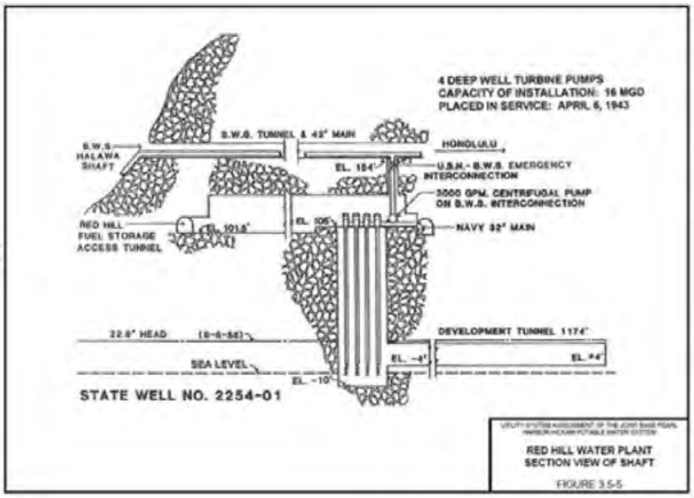
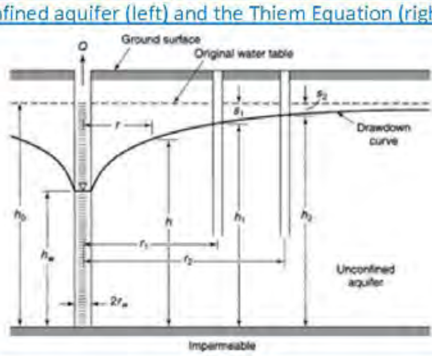
3

Attachment 2a – Red Hill Well and Pump Characteristics - Boom and Vortex Plans



The observed fuel emulsion within the RHS is relatively thin (i.e., <0.1 inch) and discontinuous/sporadic (i.e., not a continuous layer). An emulsion can contain up to 30% water, but even with the highest water content, is still less dense than water and floats due to high buoyancy, as observed. If an emulsion does form at depth within the water column, the buoyant nature of the emulsion would likely result in the droplets rising to the top of the water column rather than being captured at the pump intake.

In addition to these measurements, the Thiem Equation was used to calculate the depth and width of drawdown or 'cone of depression' within RHS during pumping operations. To use the Thiem Equation, RHS was assumed as an unconfined aquifer to then model the drawdown and associated radial influence with the pump operating at 5 MGD. Figure 16 presents the radial flow to a well screened within an unconfined aquifer (left) and the Thiem Equation (right).



$$Q = \frac{\pi K (h_2^2 - h_1^2)}{\ln(r_2/r_1)}$$

$$h_2^2 - h_1^2 = \frac{Q}{\pi K}\ln(r_2/r_1)$$

Figure 16. Radial Flow to Well in Unconfined Aquifer (left) and Thiem Equation (right)

Table XX lists the variables in the Thiem Equation and assumptions made for each variable. To note, the calculation does not account for any centrifugal movement (i.e., circular movement of water around the pump).

Table XX. Thiem Equation Variables and Assumptions

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4

Attachment 2a – Red Hill Well and Pump Characteristics - Boom and Vortex Plans

Variable	Assumptions
Q = Flowrate	Assume 5 MGD (668,403 ft^3/day)
K = Hydraulic Conductivity	The largest observed K in subsurface is 10^5 ft./day (Bear, 1972); however, RHS is an open space, so assumed one order of magnitude greater (i.e., 10^6 ft./day).
r_1 = Initial Radius	Assumed a distance immediately at the pump (i.e., 0.0000001 ft.)
r_2 = Distance from Pump	Used values 1 to 1,200 feet to cover the entire length of the water development tunnel.
h_1 = Initial Drawdown at r_1 Distance (initial distance from the pump)	Used Red Hill Pump Station data to calculate the drawdown from no operation to 5 MGD operation (see Figure 17). h_1 = 23ft^a – (23ft^b – 21ft^c) = 21 ft. a = current water depth b = static water depth, when pump is not operational c = average water depth when pump is operating at 5 MGD
h_2 = calculated drawdown/ vortex around pump	Calculated across r_2 values. See results in Figure 18.

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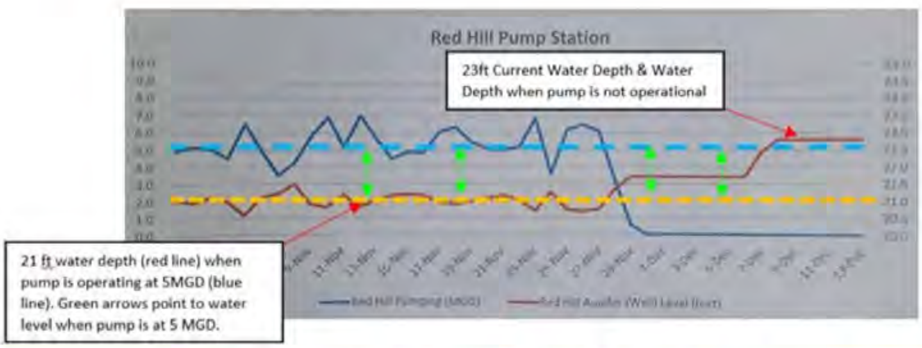

Figure 17. Water Levels within Red Hill Shaft during Pumping Operations

The Thiem Equation is then re-arranged to solve for h_2 to calculate drawdown or radius of influence across the shaft and water development tunnel. Figure 18 presents the anticipated drawdown within the shaft and water development tunnel based on the Thiem Equation and assumptions in Table XX. Figure 19 provides a conceptual model of the drawdown anticipated in the shaft and water development tunnel.

This document provided by US Navy

5

Attachment 2a – Red Hill Well and Pump Characteristics - Boom and Vortex Plans

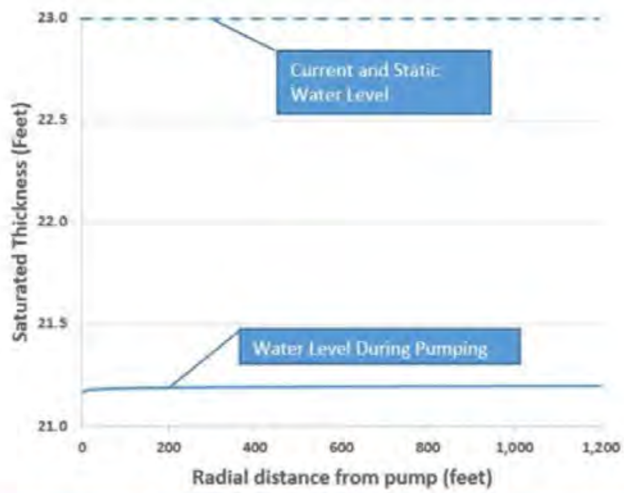

Figure 18. Saturated Thickness in Red Hill Shaft and Water Development Tunnel based on Thiem Equation

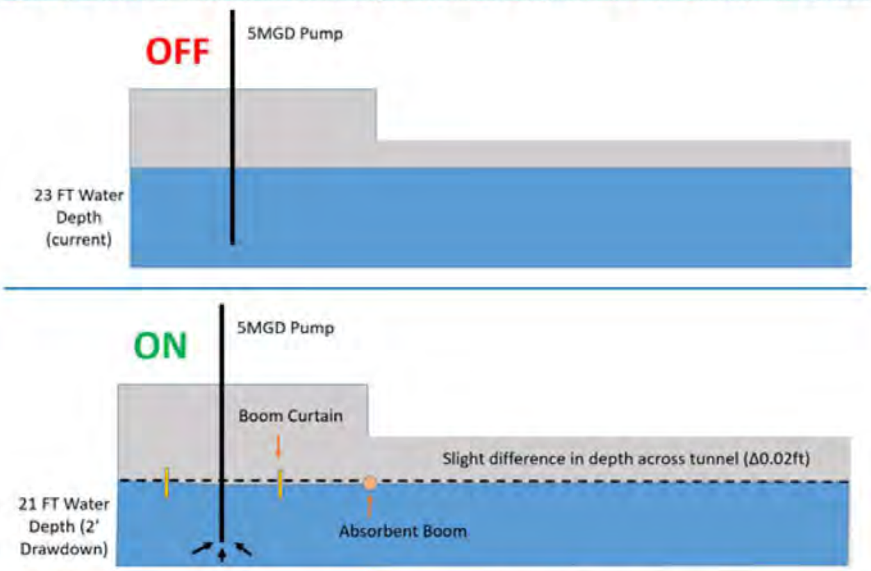

Figure 19. Conceptual Model of the Water Levels in Red Hill Shaft and Water Development Tunnel while the Pump is Idle and during Operation

Based on the Thiem Equation, once the pump is operating at 5 MGD, the whole water development tunnel should experience a corresponding ~2 ft. drawdown (i.e., from 23 to 21 ft.). The difference in water level calculated between the pump and the end of the tunnel is 0.02 ft. Therefore, based on these calculations, no vortex or whirlpool effect should occur that would draw in emulsified fuel into the pump and GAC Treatment System. Drawdown will be experienced in equal portion throughout the shaft

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6

Attachment 2a – Red Hill Well and Pump Characteristics - Boom and Vortex Plans

and tunnel with negligible variance in water level. In the event drawdown is greater than 2ft, the calculated response is the same – the whole tunnel will exhibit a steady drop in the water level with no significant difference in depth between at the pump and surrounding water.

c. Water Sample Results

Joint Base Pearl Harbor Hickam Drinking Water Issue
Eurofins TestAmerica Seattle Laboratory Results - Well Results

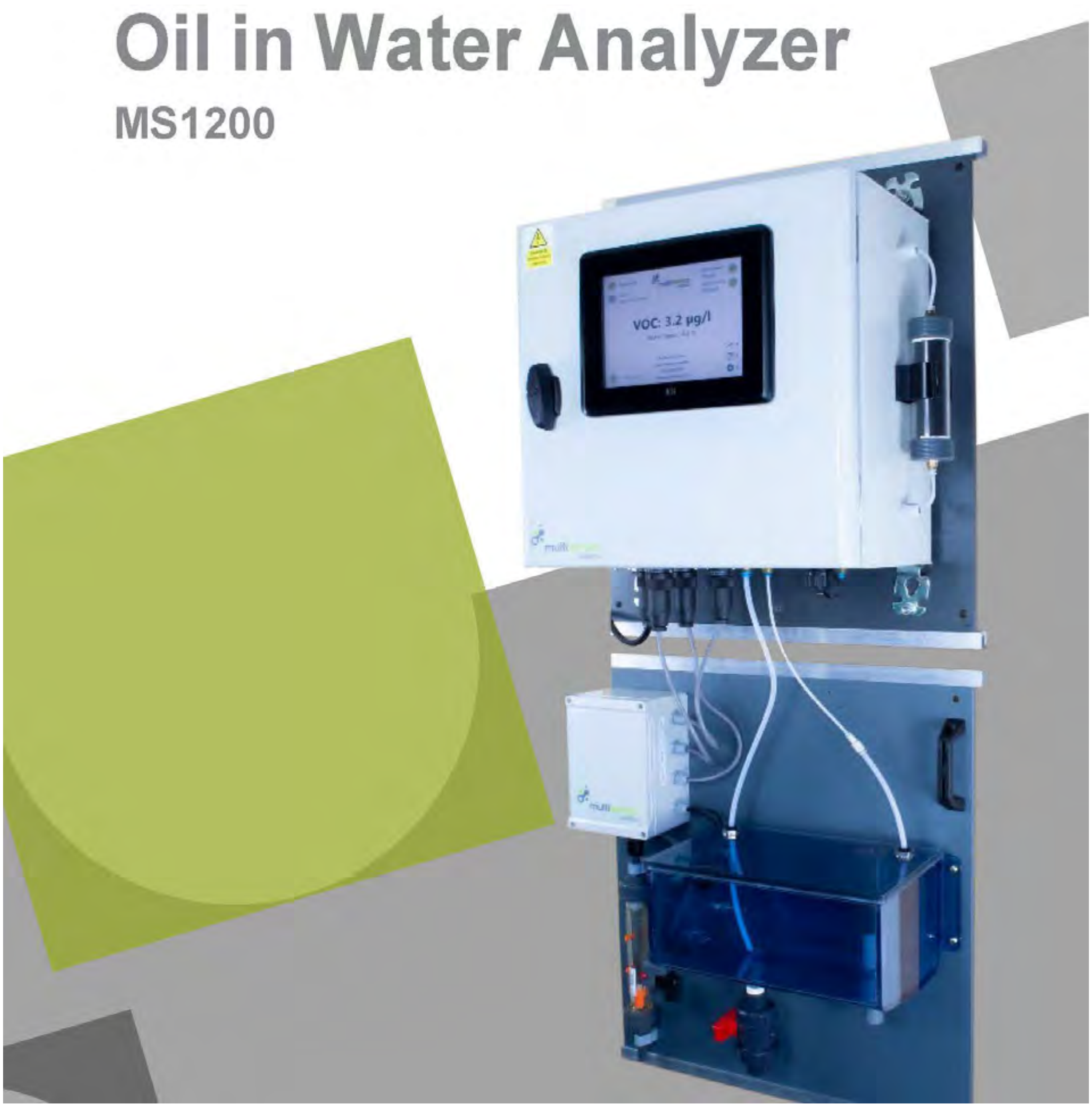
								Analyte	Benzene	Ethylbenzene	Toluene	Xylenes	Naphthalene	TPH-g (C6-C12)	TPH-d (C9-C25) [a]	TPH-d (C9-C25) with Silica Gel Cleanup	TPH-o (C24-C40) [a]	TPH-o (C24-C40) with Silica Gel Cleanup
								CAS No.	71-43-2	100-41-4	108-88-3	1330-20-7	91-20-3	PHCC6C10	PHCC10C24	PHCC10C24SGC	PHCC24C40	PHCC24C40SGC
								Method	8260B	8260B	8260B	8260B	8260B	8260B	8015B_E	8015B_E	8015B_E	8015B_E
								DOH Tier 1 EAL	5	30	40	20	17	300	400	—	500	—
								EPA MCL	5	700	1000	10000	—	—	—	—	—	—
								Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Location (General Location / Building)	Specific Location	Field Observations	Sample ID	Sampling Date	Sampling Time	Associated Trip Blank	Type		Result	Result	Result	Result	Result	Result	Result	Result	Result	Result
Red Hill PS Pre-Chlorination/Aquifer	pre-chlorination spigot	Ambient VOCs in shaft=0.6 ppm; no color or odor or VOCs stronger than ambient conditions noted	ERH1970	11/29/2021	14:05	ERH1985	Normal		0.50 U	0.80 U	0.80 U	1.4 J	8.8	91 J	280 U	64 J	280 U	73 U
Red Hill PS DW Compliance Point	DW Compliance Point (post-chlorination)	Ambient VOC=0.1 ppm, headspace=0.1 ppm, no color or odors noted in samples	ERH1971	11/29/2021	14:40	ERH1985	Normal		0.50 U	0.80 U	0.80 U	0.80 U	2.0 U	80 U	290 U	40 J	290 U	73 U
Red Hill Shaft Well (RHMW2254-01)	[illegible] sample down manhole	Ambient PID: 0.8 ppm, Above Open Manway PID: 11.4 ppm, Downhole PID: 86.1 ppm; distinct pale yellow layer was observed on top of water	ERH2050	12/3/2021	14:30	ERH2049	Normal		0.50 U	1.4	0.80 U	16.2	44 Q	1200	130000 D	140000 DQ	100 J	60 J
Red Hill Shaft Well (RHMW2254-01)	[illegible] sample down manhole	Ambient PID: 0.4 ppm, Ground near sampling area PID: 38.5 ppm, Bailer Headspace PID: 63.4 ppm, Downhole PID: 194.2 ppm; distinct layer was observed on top of water	ERH2130	12/6/2021	13:05	ERH2129	Normal		0.50 U	0.80 U	0.80 U	5.1	11 Q	950	52000 D	59000 DQ	150 U	28 JQ
Red Hill Shaft Well (RHMW2254-01)	product sample [illegible]	Water quality data not collected.	ERH2156	12/10/2021	8:40	ERH2161	Normal							810	58,000	52,000	390	430
Red Hill Shaft Well (RHMW2254-01)	low-flow pump	Strong fuel-like odor, thin layer of ~1mm product (LNAPL), contained suspended droplets of slightly opaque NAPL, continued biomat in suspension	ERH2157	12/10/2021	9:40	ERH2161	Normal							18 U	180 J	300.0 U	180 J	190 J
Red Hill Shaft Well (RHMW2254-01)	low-flow pump	Part of weekly NOI sampling		11/24/2021			Normal								140 U		140 U	
Red Hill Shaft Well (RHMW2254-01)	low-flow pump	Part of weekly NOI sampling		12/1/2021			Normal								640	120 U	580	150 U

ATTACHMENT 3 MEASURING DEVICES

a. Analyzers

i. Oil in Water Analyzer MS1200

multisensor systems
sensing measuring protecting



MS1200
Oil in Water Analyzer

Continuous Water Intake Protection

VOC BTEX FUEL OILS PAH

The **MS1200 Oil in Water and Pollution Analyzer** is designed to protect drinking water treatment plants from pollution events at the raw water intake. These events can result in expensive filter replacement and clean-up operations and may also affect the **quality of drinking water** produced.

In addition, the system can be used for a wide range of surface water, ground water and industrial water applications.

The MS1200 utilizes a contactless measurement technique, sensing headspace gases to provide a measurement system that is **not affected by the turbidity** of the water and has very low maintenance requirements.

The instrument is accurate to low ppb concentrations for a **wide range** of compounds, including fuel oils, PAH, VOCs and BTEX compounds.

Its continuous measurement mode provides immediate information on pollution levels allowing a rapid response to any event.

It is available with a **standard display or touch screen** interface.

√ Monitors for pollution events
√ No sensor contact with water
√ Low maintenance, no sensor cleaning
√ Not affected by turbidity
√ High sensitivity, ideal for boreholes

Applications

- Monitoring of water abstraction points
- Monitoring of **drain and storm water** systems
- Detection of **fuel pollution** in surface water
- Detection of VOC breakthrough in **carbon beds**
- **Reverse Osmosis membrane** protection
- Protection of **desalination plants**

Installation

Installation is a **simple process** and consists of connecting the instrument to power and the water source to be monitored. Setup uses a user friendly app running on a laptop PC or the touchscreen interface.

case study

The Problem

In 2013 a petrochemical plant in the UK caused an oil spill into a river. The local water company extracted water from the river to supply a nearby town and had no water monitoring in place. This meant that the extraction point experienced **high levels of hydrocarbon contamination**.

The Consequences

The hydrocarbon pollution led to **significant disruption** for customers because of the halt in production. The water company also faced high costs for the clean-up. The disruption to supply led to negative PR, on a local and national level, questioning the quality of the water.

The Solution

The water company approached Multisensor Systems looking for a **reliable solution**. After some discussions, the WTP purchased an MS1200 Oil in Water Analyzer.

The MS1200 is now installed in an outbuilding at around 70 m from the extraction point. Water is analyzed for hydrocarbons and VOCS and, if there's an increased level, an **alarm is triggered and appropriate action is taken**.

Since the installation the system has protected the water plant on **several occasions** from significant pollution events.

"...without the MS1200 it is far more likely that we'll be prosecuted and make the national news."

technical specification

PARAMETER	OPERATIONAL REQUIREMENTS		NOTES
	Minimum	*Maximum*	
Supply Voltage	90 V AC	240 V AC	50 Hz or 60 Hz
Power Consumption: Standard Version Touch Screen Version		15 W 45 W	Typical 10 W during operation Typical 20 W during operation
Water Supply	2 l/min / 0.52 US gpm		Clear PVC tank
Water Pressure	4.0 bar / 58 psi		
Working Temp: Ambient	0 ℃ / 32 ℉	40 ℃ / 104 ℉	
Working Temp: Water	1 ℃ / 34 ℉	40 ℃ / 104 ℉	
Sampling Period	Continuous		
Detection Range	1 ppb	3000 ppb	Measured against Toluene standard. For calibration using other compounds contact Multisensor Systems
Repeatability	-2%	+2%	200 ppb sample measured using standard 1.5 l solution (Water plus Toluene dissolved in DMSO) in glass 2.5 l Winchester type bottle using magnetic stirrer at 20 ℃ / 68 ℉
Accuracy	-10%	+10%	
Display Range (Default)	0 ppb	1000 ppb	Configurable on commissioning
Analog Output	4 mA	20 mA	Scalable to range required, max load 900 Ω
Analog Output Isolation	400 V DC		
Relay Voltage		50 V	3x, Alarm 1, Alarm 2 and Fault Relays with NO and NC contacts
Relay Current		5 A	
User Interface	USB-A to PC		Using Multisensor Software provided
Flow Limit Switch	Contacts closed if flow below set point		Option available on request
Instrument Case	IP65 / NEMA 4X		Coated Mild Steel
Sample Tank Material	Clear PVC		Other materials available
Weight	25 kg / 55 lbs		
Dimensions	1170 x 490 x 300 mm 46 x 19.2 x 11.8 inches		Mounted on 2 separate PVC back-boards

Service and consumables

Every 6 Months: Air FiltersEvery 12 Months: Air Pump

Multisensor Systems Limited reserves the right to revise any specifications and data contained within this documentwithout notice.

ii. Oil in Water Analyzer MS1700

multisensor systems
sensing measuring protecting

High Concentration Oil in Water Analyzer

MS1700

MS1700

High Concentration Oil in Water Analyzer

Monitoring industrial water for complete security

VOC BTEX PAH

The MS1700 is a **high concentration oil in water analyzer** designed to monitor the outflows from industrial facilities, water in industrial processes and to detect fuels and other VOCs in drains and waste water networks.

The instrument works by sensing gases or volatiles to provide a non-contact measurement system with very **low maintenance** requirements.

The MS1700 is accurate in concentrations up to 100 ppm in water* and its very **wide dynamic range** allows it to be used in a variety of environments.

A **user programmable** concentration alarm threshold can be set, connecting to a relay output and an indicator on the front panel. This allows connection to other peripheral equipment such as isolation valves, pumps, samplers or audio-visual alarms.

A 4–20 mA output is available for connection to a PLC or SCADA system.

The MS1900 can operate from 90–240 V AC or 12 V DC power supplies.

√ Continuous monitoring
√ Low operating and maintenance costs
√ High reliability
√ No reagents
√ Field proven technology

*Toluene at 20 °C / 68 °F

multisensor systems

Applications

- Monitoring of industrial **drains** and discharges
- Monitoring of process water
- Storm water measurement
- **Oil and Fuel Leak** Detection
- Detection of **VOCs in wastewater systems**

Installation

Installation is a **simple process** and consists of connecting the instrument to power and the water source to be monitored. Setup uses a user friendly app running on a laptop PC.

case study

Industrial Effluent: The Problem

Discharge of VOCs into wastewater is an endemic problem in engineering, chemical processing, food and beverage production and other industrial processes.

Spills can lead to **illegal discharges, pollution, fines and negative PR.**

The Consequences

Following a spill the customer was **prosecuted** by the Environment Agency resulting in financial penalties and negative publicity.

Moreover the **cost of restoration** and remediation of the environment was extremely high for which the company was liable.

The Solution

By installing the **MS1700 High Concentration Oil in Water Analyzer** at the outflow of the plant, the customer is provided data as soon as the contamination starts to increase and is able to take appropriate action, avoiding all the problems associated with an unexpected pollution event.

The MS1700 utilizes a **contactless measurement** technique that means:

√ It does not need reagents
√ Requires little maintenance
√ It is robust and reliable
√ It is cost effective

technical specification

PARAMETER		OPERATIONAL REQUIREMENTS		NOTES
		Minimum	*Maximum*	
Supply Voltage	AC Version	90 V AC	240 V AC	50 Hz or 60 Hz
	DC Version	10 V DC	15 V DC	
Power Consumption			9 W	Typical 7 W during operation
Working Temp: Ambient		0 ℃ / 32 °F	50 ℃ / 122 °F	Higher temperature available
Sampling Period		Continuous measurement		
Instrument Case		IP65 / NEMA 4X		ABS
Detection Range		1 ppm	100 ppm	Measured against Toluene standard. For calibration using other compounds contact Multisensor Systems
Accuracy		-15%	+15%	
Analogue Output		4 mA	20 mA	Scalable to range required, max load 900 Ω
Analogue Output Isolation		400 V DC		
Relay Voltage			50 V	Alarm and Fault Relays with NO and NC contacts
Relay Current			5 A	
User Interface		USB-A to PC		Using Multisensor Software provided
Data Storage		µSD Card		Instrument lifetime data stored
Instrument Weight		5 kg / 11 lbs		
Instrument Dimensions		300 x 200 x 132 mm 11.8 x 7.8 x 5.2 inches		
Sampling System Capacity		3 liters 0.8 US gal		
Sampling Sys. Dimensions		570 x 490 mm 22.4 x 19.2 inches		
Sampling Sys. Weight		12 kg / 26.4 lbs		
Sampling Chamber Material		Stainless Steel		Optional: PVC
Water Flow Rate		2 liters per minute 0.52 US gpm		
Water Temperature		1 °C / 34 °F	40 °C / 104 °F	

Typical Target Substances

Kerosene	Diesel	Acetone	Heptane	Methanol
Ethanol	Toluene	Xylene	Benzene	Mercaptan

Consumables

Every 6 Months: Air Filters
Every 12 Months: Air Pump

multisensor
9
systems

MS1700 Data Sheet, 2021, 1- 000119, V1.0

Multisensor Systems is a developer and supplier of Water and Gas Analyzers specializing in Oil in Water, Hydrocar-bon Analyzers, Oil in Water Detectors, THM Analyzers and Ammonia Analyzers based in the United Kingdom.

sensing measuring protecting

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b. Flow Meters Badger TFX-5000

Transit Time Ultrasonic Flow Meters

TFX-5000 Meter

DESCRIPTION

The TFX-5000 transit time ultrasonic flow meter measures volumetric flow and heating/cooling energy rates in clean liquids as well as those with small amounts of suspended solids or aeration, such as surface water or raw sewage.

TFX-5000 flow and energy meters clamp onto the outside of pipes and do not contact the internal liquid.

BENEFITS

By clamping onto the outside of pipes, the meters have inherent advantages over other flow meter technologies, including:

- Reduced installation time and cost
- Non-invasive, non-contact measurement
- Continued operation during installation—no need to shut down the process
- No pressure head loss
- No moving parts to maintain or replace

FEATURES

- Large, bi-directional flow measuring range
- Data log up to 8 records
- Modbus® RTU or BACnet® MS/TP over EIA-485; Modbus TCP/IP; BACnet/IP; EtherNet/IP; AquaCUE®/BEACON® connectivity
- Configure and troubleshoot over USB with SoloCUE
- Reynolds, ultrasonic speed and temperature compensation
- Large, easy-to-read graphical display
- Rugged, aluminum enclosure for a long service life in harsh environments

APPLICATIONS

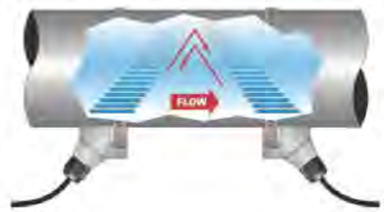
The TFX-5000 meter is available in a variety of configurations that permit the user to select a meter with features suitable to meet particular application requirements.

The TFX-5000 meter is available in two versions:

- A flow meter for water delivery, sewage, cooling water, water-glycol mixtures, alcohols and chemicals
- A heating/cooling energy flow meter used in conjunction with dual clamp-on RTDs for temperature measurement—ideal for hydronic process and HVAC applications

OPERATION

Transit time flow meters measure the time difference between the travel time of an ultrasound wave going *with* the fluid flow and *against* the fluid flow. The time difference is used to calculate the velocity of the fluid traveling in a closed-pipe system. The transducers used in transit time measurements operate alternately as transmitters and receivers. Transit time measurements are bi-directional and are most effective for fluids that have low concentrations of suspended solids and are sonically conductive.



An ultrasonic meter equipped with heat flow capabilities measures the rate and quantity of heat delivered or removed from devices such as heat exchangers. By measuring the volumetric flow rate of the heat exchanger liquid, the temperature at the inlet pipe and the temperature at the outlet pipe, the energy usage can be calculated.

Badger Meter

TTM-DS-02221-EN-09 (June 2021)

Product Data Sheet

Transit Time Ultrasonic Flow Meters, TFX-5000 Meter

SPECIFICATIONS

System

Liquid Types	Most clean liquids or liquids containing small amounts of suspended solids or gas bubbles	
Flow Accuracy	Medium Pipes (UZ, KZ, NZ, RZ, WZ, HZ)	±0.5% ± 0.025 ft/s (0.008 m/s) of reading
	Large Pipes (LZ, YZ)	±0.5% ± 0.049 ft/s (0.015 m/s) of reading
	Small Pipes (CA-CT, UZ)	1 in. (25 mm) and larger = ±1% ± 0.03 ft/s (0.009 m/s) of reading 3/4 in. (20 mm) and smaller = ±1% of full scale
Repeatability	0.2% above 1.5 ft/s	
Velocity	Medium and Large Pipes	Up to 40 ft/s, depending on pipe and fluid
	Small Pipes	Up to 20 ft/s, depending on pipe and fluid
Straight Run Requirements	10 diameters upstream, 5 diameters downstream from single elbow	
Certification and Compliance	**General Safety (all models):** cCSAus, CE, Pollution Degree 2, CE compliance to Low Voltage Directive, 2014/35/EU **U.S./Canada Hazardous Location transmitter and transducers:** **Transmitter and transducers (certification option B):** cCSAus Class I Division 2 Groups ABCD T4 Requires flexible conduit Not available with UZ, HZ or JZ and KZ (Easy Rail) transducers, Auxiliary Dry Contact card or units with AquaCUE/BEACON endpoints **Transmitter (certification option R):** cCSAus Ex ec ic nC IIC T4 Gc; Ex tc IIIB T100° C Dc; Class I, Zone 2, AEx ec ic nC IIC T4 Gc; Zone 22, AEx tc IIIB T100° C Dc; Class II, Division 2, Groups FG; Class III Not available with Auxiliary Dry Contact card or units with AquaCUE/BEACON endpoints **Transducers RZ LZ, NZ, RZ, WZ, YZ (certification option R):** cCSAus Ex ec IIC T6 Gc; Ex tc IIIB T60° C Dc; Class I, Zone 2, AEx ec IIC T6 Gc; Zone 22, AEx tc IIIB T60° C Dc; Class II, Division 2, Groups FG; Class III Requires flexible conduit Not available with CA-CT, UZ, HZ or JZ and KZ (Easy Rail) transducers **ATEX Hazardous Location:** Transmitter (certification option V): II 3 G D Ex ec ic nC IIC T4 Gc, Ex tc IIIB T100° C Dc; Tamb: -25…60° C JZ (DTTJ), KZ (DTTK), LZ (DTTL), NZ (DTTN) and RZ (DTTR) Transducers: II 3 G D Ex ec IIC T6 Gc; Ex tc IIIB T60°C Dc; Tamb: -25…60° C Not available with UZ, CA to CT, or HZ transducers; flexible conduit, Auxiliary Dry Contact card or AquaCUE/BEACON endpoints **IECEx Hazardous Location:** Transmitter (certification option V): Ex ec nC ic IIC T4 Gc; Ex tc IIIC T100° C Dc; Tamb: -25°C…60° C JZ, KZ, LZ, NZ and RZ Transducers: Ex ec IIC T6 Gc; Ex tc IIIB T60° C Dc; Tamb: -25…60° C Not available with UZ, CA to CT, or HZ transducers; flexible conduit, Auxiliary Dry Contact card or AquaCUE/BEACON endpoints	

Transmitter

Power Options	24V DC/AC	9…28V DC @ 8 W max. or 20…26 AC 47…63 Hz @ 0.5 A max., 2 Amp slow-blow fuse, not field replaceable
	Mains AC	85…264V AC 47…63 Hz @ 24VA max. 1 Amp slow-blow fuse, manually field replaceable
		Over-Voltage Rating Category II (CAT II)
Display	Options	Display with keypad or no display/keypad
	Keypad	4-button navigation, keypad with tactile feedback; polyester film
	Display	128 × 64 pixel LED backlit graphical display; adjustable brightness and timeout; polycarbonate window
	Flow rate/total	8-digit
Enclosure	NEMA Type 4X, IP67	
Construction	Aluminum construction; painted; wall, panel or pipe mounting; stainless steel fasteners and mounting hardware; EPDM gasket	
	Conduit Holes	(4) 1/2 in. NPT, M20 × 1.5 or 1/2 BSPP; cable glands available for NPT and M20
Environmental Ratings	Pollution Degree	2
	Altitude Restriction	Up to 2000 m (6561 ft)
	Ambient Temperature Range	-4…140° F (-20…60° C)
	Storage Temperature Range	-40…176° F (-40…80° C)
	Humidity	0…85%, non-condensing
Configuration	Via optional keypad or SoloCUE configuration software; SoloCUE available on DVD or download	
Units (Field-Selectable)	Velocity	feet/second, meters/second
	Volumetric total	US Gallons, Million Gallons, Imperial Gallons, Million Imperial Gallons, Acre-Feet, Liters, Hectoliters, Cubic Meters, Cubic Feet, Oil Barrels (42 gallons), Fluid Barrels (31.5 gallons), Imperial Fluid Barrels (36 imperial gallons), Pounds (Kilograms) and custom units
	Flow rate	Acre Feet/Day, Liters/Second, Liters/Minute, Liters/Hour, Cubic Meters/Second, Cubic Meters/Minute, Cubic Meters/Hour, Cubic Feet/Minute, Cubic Feet/Minute, Cubic Feet/Hour, Gallons/Second, Gallons/Minute, Gallons/Hour, Million Gallons/Day, Imperial Gallons/Second, Imperial Gallons/Minute, Imperial Gallons/Hour, Million Imperial Gallons/Day, Oil Barrels/Day, Fluid Barrels/Day, Imperial Fluid Barrels/Day and custom units
	Energy total (energy meters)	British Thermal Unit (Btu), Thousand Btu, Millions Btu, Kilocalories, Mega calories, Kilowatt-hour, Megawatt hour, Kilojoules, Mega joules, Ton-hour (Refrigeration)
	Heat/cooling rate (energy meters)	Btu/hour, Thousand Btu/hour, Millions Btu/hour, Ton (Refrigeration), Watts, Kilowatts, Megawatts, Kilojoules/hour, Mega joules/hour, Kilocalories/hour, Mega calories/hour
	Temperature (energy meters)	Farenheit, Celcius, Kelvin

		Flow Meter	Energy Meter
Inputs and Outputs	0/4…20 mA output	One 16-bit, isolated, max 800 Ohms, internal or external power	Two 16-bit, isolated, max 800 Ohms, internal or external power
	Digital input	One 5…30V DC, isolated, externally or internally sourced, reset totalizer or alarm output	
	Digital output	Two selectable pulse, alarm, flow direction, sink isolated open collector, 5…30V DC, max. 50 mA externally or internally sourced, leakage current 1uA max.	Three selectable pulse, frequency, alarm, flow direction, isolated open collector, 5…30V DC, externally or internally sourced, leakage current 1uA max.
		Frequency output: 50% duty cycle, 63…10k Hz maximum frequency	
		Pulse (totalizer) output: Open collector, pulse width 1…500 ms programmable	
		Optional: Two dry contact output for alarm or flow direction 30V DC max., 5A max. (Ethernet not available with this option)	
	RTD (energy only)	None	Two 2-wire, 3-wire or 4-wire Pt100/Pt1000 RTD 12-bit inputs; Range of –40…200° C; Clamp-on resistor kits available
Ports	Programming	USB 2.0 mini B connector for connection to a device with SoloCUE configuration software	
	EIA-485	Modbus RTU command set or BACnet MS/TP; Baud rates 9600, 14400,19200, 38400, 57600, 76800, 115k; terminating resistor selectable	
	Ethernet	Optional 10/100 Base T RJ45, communication via Modbus TCP/IP, BACnet/IP or EtherNet/IP	
	AquaCUE/BEACON	Connectivity to AquaCUE/BEACON endpoint (LTE cellular)	
Data Logging	Number of points	Up to 8 parameters per record. Selectable 1 second to 1 day Transfer logs via memory card	
	Real Time Clock	Backed up with a super capacitor, minimum of 32 days of data retention without power; Requires no servicing	
	MicroSD card slot	8 GB card, included with transmitter	
Alarms	Records 150 previous alarms, warnings or errors		
Languages	English, French, German, Italian, Spanish		
Security	Four levels: Read-only, Operator, Service and Admin; 6-digit passcode number; selectable auto logout		

Transducers

Model	Construction	Cable Length Max.	Pipe/Tubing Sizes [1]	Flow Rate Max. GPM (LPM)	Pipe/ Tubing Materials
CA-CT [5] fixed small pipe	CPVC, Ultem®, Nylon cord grip, PVC cable jacket; –40…194° F	100 ft	0.5…2 in.	190	See [2]
UZ adjustable small pipe	CPVC, Ultem, and anodized aluminum track system; Nickel-plated brass connector with Teflon insulation; PVC cable jacket, –40…194° F (–40…90° C)	100 ft (30 m)	0.5…2 in. (12…50 mm)	190 (720)	
NZ (IP67) standard pipe	CPVC, Ultem®, Nylon cord grip, PVC cable jacket; –40…194° F (–40…90° C)	300 ft (90 m)	2.5…12 in. (DN65…DN300)	4000 (15,000)	
RZ (IP54) standard pipe	PBT glass filled, Ultem®, Nylon cord grip; PVC cable jacket;, –40…250° F (–40…121° C)	300 ft (90 m)	2.5…12 in. (DN65…DN300)	4000 (15,000)	
JZ, KZ (IP54) standard pipe, integrated rail	PBT glass filled, Ultem, Nylon cord grip; PVC cable jacket; –40…250° F (–40…121° C)	300 ft (90 m)	2.5…6 in. (DN65…DN150) 2.5…12 in. (DN65…DN300)	4000 (15,000)	
WZ (IP68) [7] standard pipe, submersible	CPVC, Ultem, Nylon cord grip; Polyethylene cable jacket; –40…194° F (–40…90° C)	300 ft (90 m)	2.5…12 in. (DN65…DN300)	4000 (15,000)	
HZ high temperature	PTFE, Vespel, Nickel-plated brass cord grip; FEP cable jacket; –40…350° F (–40…176° C)	300 ft (90 m)	2.5…12 in. (DN65…DN300)	4000 (15,000)	
LZ (IP67) large pipe	CPVC, Ultem, Nylon cord grip PVC cable jacket; –40…194° F (–40…90° C)	300 ft (90 m) [6]	8…48 in. (DN200…DN1200) [3,4]	33,000 (125,000)	
YZ (IP68) [7] large pipe, submersible	CPVC, Ultem, Nylon cord grip; Polyethylene cable jacket; –40…194° F (–40…90° C)	300 ft (90 m) [6]	8…48 in. (DN200…DN1200) [3,4]	33,000 (125,000)	

[1] Recommendations based on unlined, new pipes with water. Recommended pipe or tubing sizes vary with pipe conditions and fluid.
[2] PVC, CPVC, HDPE, PTFE, PDVF, stainless steel, ductile iron, aluminum, brass naval, carbon steel, copper.
[3] Large pipe transducers are recommended for 8…12 in. pipes if normal velocity is expected to be greater than 12 ft/s (3.6 m/s).
[4] Consult factory for larger pipe sizes.
[5] Not for metric pipes.
[6] Cable lengths up to 600 ft are available. Consult factory for lead times.
[7] IP68 tested at 1 meter for 24 hours.

RTD Kits

Part Number	Description	Installation	RTD Type	Construction	Temperature Range
68996-001	RTD pair; 15 ft (4.5 m) cable	Pipe clamp, surface mount, IP54	Pt 1000, Class A ± (0.15 + 0.002*|t|) with t as temperature °C	Aluminum body, silicone cable jacket	-58…356° F (-50…180° C)
68996-002	RTD pair; 50 ft (15 m) cable				
68996-003	RTD pair; 100 ft (30 m) cable				

SoloCUE Flow Device Manager Software

The flow meter *may* be programmed through the keypad or with SoloCUE software. If the meter is ordered without a display/keypad, the flow meter *must* be programmed with SoloCUE software. The software is used to configure, calibrate and communicate with TFX-5000 meters with English, French, German, Italian and Spanish menus. Additionally, it has numerous troubleshooting tools to make diagnosing and correcting installation problems easier.

SoloCUE	Used to configure, calibrate and troubleshoot flow meters and control valves; Software is compatible with Windows 7, 8, 10	
USB Cable	RC820648	USB 2.0 mini B connector to A connector, shielded

Product Data Sheet

DIMENSIONS

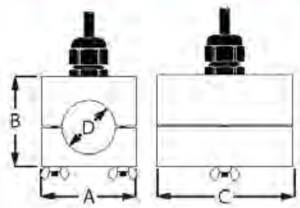
Remote System Enclosure

Panel Mount Enclosure

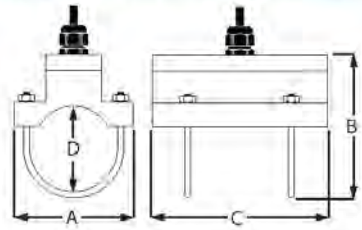
Consult factory for part number selection.

Transducers

Fixed Small Pipe
Pipes and Tubing 1/2 ...2 in. *(Not for metric pipes.)*

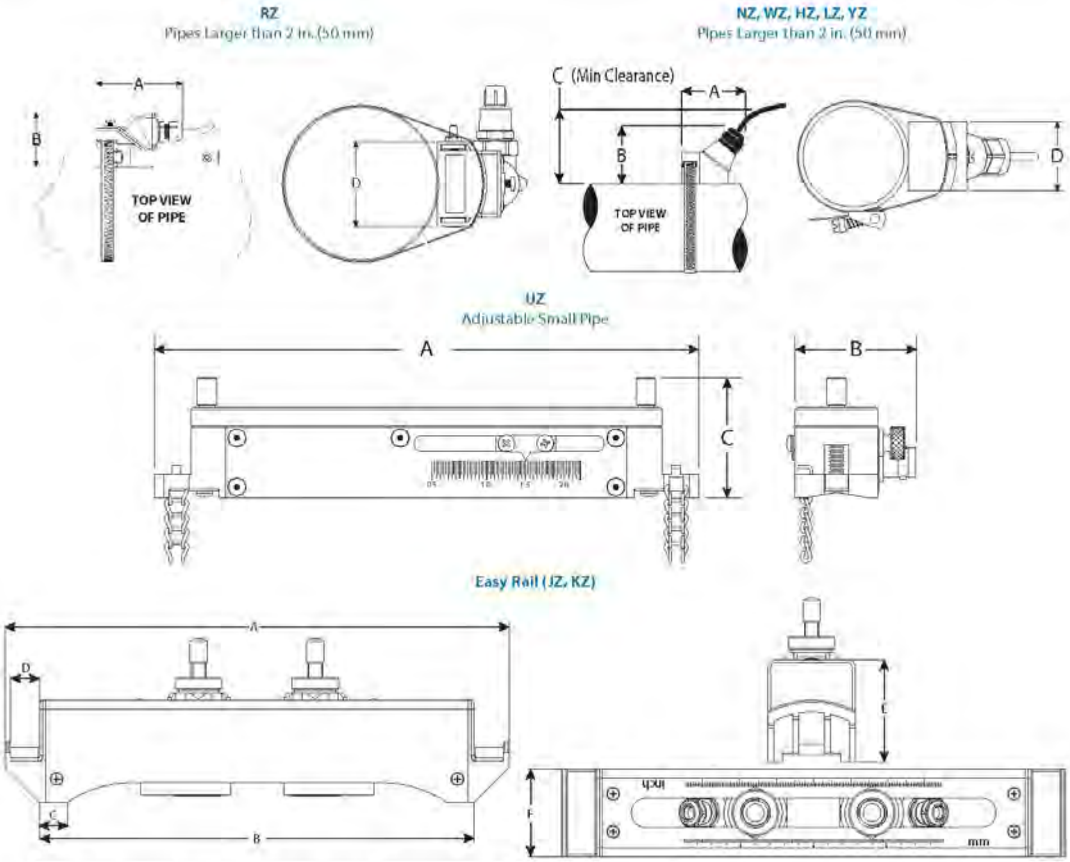


Fixed Small Pipe U-Bolt Connections CF, CL
ANSI/DN and Copper 2 in. Models *(Not for metric pipes.)*



Pipe Size	Pipe Material	A	B	C	D
1/2 in.	ANSI/DN	2.46 in. (62.48 mm)	2.36 in. (59.94 mm)	2.66 in. (67.56 mm)	0.84 in. (21.34 mm)
	Copper	2.46 in. (62.48 mm)	2.36 in. (59.94 mm)	3.33 in. (84.58 mm)	0.63 in. (16.00 mm)
	Tubing	2.46 in. (62.48 mm)	2.28 in. (57.91 mm)	3.72 in. (94.49 mm)	0.50 in. (12.70 mm)
3/4 in.	ANSI/DN	2.46 in. (62.48 mm)	2.57 in. (65.28 mm)	2.66 in. (67.56 mm)	1.05 in. (26.67 mm)
	Copper	2.46 in. (62.48 mm)	2.50 in. (63.50 mm)	3.56 in. (90.42 mm)	0.88 in. (22.35 mm)
	Tubing	2.46 in. (62.48 mm)	2.50 in. (63.50 mm)	3.56 in. (90.42 mm)	0.75 in. (19.05 mm)
1 in.	ANSI/DN	2.46 in. (62.48 mm)	2.92 in. (74.17 mm)	2.86 in. (72.64 mm)	1.32 in. (33.53 mm)
	Copper	2.46 in. (62.48 mm)	2.87 in. (72.90 mm)	3.80 in. (96.52 mm)	1.13 in. (28.70 mm)
	Tubing	2.46 in. (62.48 mm)	2.75 in. (69.85 mm)	3.80 in. (96.52 mm)	1.00 in. (25.40 mm)
1-1/4 in.	ANSI/DN	2.80 in. (71.12 mm)	3.18 in. (80.77 mm)	3.14 in. (79.76 mm)	1.66 in. (42.16 mm)
	Copper	2.46 in. (62.48 mm)	3.00 in. (76.20 mm)	4.04 in. (102.62 mm)	1.38 in. (35.05 mm)
	Tubing	2.46 in. (62.48 mm)	3.00 in. (76.20 mm)	4.04 in. (102.62 mm)	1.25 in. (31.75 mm)
1-1/2 in.	ANSI/DN	3.02 in. (76.71 mm)	3.40 in. (86.36 mm)	3.33 in. (84.58 mm)	1.90 in. (48.26 mm)
	Copper	2.71 in. (68.83 mm)	2.86 in. (72.64 mm)	4.28 in. (108.71 mm)	1.63 in. (41.40 mm)
	Tubing	2.71 in. (68.83 mm)	3.31 in. (84.07 mm)	4.28 in. (108.71 mm)	1.50 in. (38.10 mm)
2 in.	ANSI/DN	3.70 in. (93.98 mm)	3.42 in. (86.87 mm)*	5.50 in. (139.70 mm)	2.38 in. (60.45 mm)*
	Copper	3.70 in. (93.98 mm)	3.38 in. (85.85 mm)*	5.50 in. (139.70 mm)	2.13 in. (54.10 mm)*
	Tubing	3.21 in. (81.53 mm)	3.85 in. (97.79 mm)	4.75 in. (120.65 mm)	2.00 in. (50.80 mm)

*Varies due to U-bolt configuration



	RZ	NZ, WZ	HZ	LZ, YZ	UZ	JZ	KZ
A	3.75 in. (95 mm)	2.95 in. (74.9 mm)	2.95 in. (74.9 mm)	3.40 in. (86.4 mm)	7 in. (178 mm)	13.62 in. (345.95 mm)	19.92 in. (505.97 mm)
B	2.35 in. (60 mm)	2.75 in. (69.8 mm)	2.75 in. (69.8 mm)	2.94 in. (74.7 mm)	1.6 in. (42 mm)	11.73 in. (297.94 mm)	18.03 in. (457.96 mm)
C	—	3.00 in. (76.2 mm)	3.00 in. (76.2 mm)	3.20 in. (81.3 mm)	1.5 in. (39 mm)	0.75 in. (19.05 mm)	0.75 in. (19.05 mm)
D	2.19 in. (56 mm)	1.70 in. (43.2 mm)	1.71 in. (43.4 mm)	2.50 in. (63.5 mm)	—	0.79 in. (20.06 mm)	0.79 in. (20.06 mm)
E	—	—	—	—	—	2.76 in. (70.10 mm)	2.76 in. (70.10 mm)
F	—	—	—	—	—	2.36 in. (59.94 mm)	2.36 in. (59.94 mm)

Transit Time Ultrasonic Flow Meters, TFX-5000 Meter

PART NUMBER CONSTRUCTION

Part Number Construction for TFX-5000 Flow Meters for Pipes 2 in. and Smaller

DQ - G - ☐ - ☐ - ☐ - ☐ - ☐ - ☐ - XX - ☐ - ☐ - ☐

Model	
TFX-5000 Ultrasonic Clamp-On Meter	DQ
Certification	
General Area US/Canada, CE	G
Transducer Type [1]	
1/2 inch ANSI Pipe	CA
3/4 inch ANSI Pipe	CB
1 inch ANSI Pipe	CC
1-1/4 inch ANSI Pipe	CD
1-1/2 inch ANSI Pipe	CE
2 inch ANSI Pipe	CF
1/2 inch Copper Tube	CG
3/4 inch Copper Tube	CH
1 inch Copper Tube	CT
1-1/4 inch Copper Tube	CJ
1-1/2 inch Copper Tube	CK
2 inch Copper Tube	CL
Small pipe, universal, DTTSU (not available with conduit)	UZ
Transmitter Type	
110/220V AC Remote Mounted	R
24V DC/AC Remote Mounted	B
Display	
Display and Keypad	S
No Display/Keypad	W
Remote Cable Length	
15 feet (4.5 m)	AC
30 feet (9 m)	AF
50 feet (15 m)	AK
75 feet (23 m)	AR
100 feet (30 m)	BW
Conduit Type and Length (Conduit length is less than or equal to cable length)	
None	WW
5 feet (1.5 m)	AA
15 feet (4.5 m)	AC
30 feet (9 m)	AF
50 feet (15 m)	AK
75 feet (23 m)	AR
100 feet (30 m)	BW
Hardware	
1/2 in. NPT Threads, Poly cable glands	S
1/2 in. NPT Threads, Nickel Plated Brass cable glands	T
1/2 in. NPT Threads, no cable glands	N
M20 Threads, Poly cable glands	C
M20 Threads, Nickel Plated Brass cable glands	D
M20 Threads, no cable glands	A
Endpoint Wiring Method	
None	XX
Communication/Output	
Standard Output (Modbus RTU or BACnet MS/TP field selectable)	S
Standard Output plus Modbus TCP Ethernet	T
Standard Output plus BACnet/IP Ethernet	V
Standard Output plus EtherNet/IP	U
Standard Output plus Aux Output	9
Units of Measure Totalizer/Flow Rate [2]	
Gallons/gallons per minute	G
Liters/liters per minute	P
Testing & Tagging	
Factory Calibrated	F
Factory Calibrated/Stainless Steel Tag	S

[1] Stainless steel tube 1/2…2 in. options are available.

[2] Field selectable, additional options available.

Page 8 TTM-DS-02221-EN-09 June 2021

Transit Time Ultrasonic Flow Meters, TFX-5000 Meter

Part Number Construction for TFX-5000 Flow Meters for Pipes Larger than 2 in.

DQ - G - □ - □ - □ - □ - □ - □ - XX - □ - □ - □

Model	
TFX-5000 Ultrasonic Clamp-On Meter	DQ
Certification	
General Area US/Canada, CE	G
Transducer Type	
Medium pipe, DTTR, 2.5 in. (65 mm) or larger	RZ
Medium pipe, submersible DTTN, 2.5 in. (65 mm) or larger [1]	WZ
2.5…6 inches (65…150 mm) Easy Rail (not available with condu	JZ
2.5…12 inches (65…300 mm) Easy Rail (not available with cond	KZ
Medium pipe, high temperature (not available with conduit)	HZ
Large pipe, DTTL, 8 in. (200 mm) or larger	LZ
Large pipe, submersible DTTL, 8 in. (200 mm) or larger [1]	YZ
Transmitter Type	
110/220V AC Remote Mounted	R
24V DC/AC Remote Mounted	B
Display	
Display and Keypad	S
No Display/Keypad	W
Remote Cable Length	
15 feet (4.5 m)	AC
30 feet (9 m)	AF
50 feet (15 m)	AK
75 feet (23 m)	AR
100 feet (30 m)	BW
150 feet (46 m)	BK
200 feet (61 m)	DW
250 feet (76 m)	DK
300 feet (90 m)	EW
350 feet (107 m) (DTTL "LZ" and "YZ" only)	EK
400 feet (122 m) (DTTL "LZ" and "YZ" only)	FW
450 feet (137) (DTTL "LZ" and "YZ" only)	FK
500 feet (152 m) (DTTL "LZ" and "YZ" only)	GW
550 feet (168) (DTTL "LZ" and "YZ" only)	GK
600 feet (183 m) (DTTL "LZ" and "YZ" only)	HW
Conduit Type and Length (Conduit length is less than or equal to cable length)	
None	WW
5 feet (1.5 m)	AA
15 feet (4.5 m)	AC
30 feet (9 m)	AF
50 feet (15 m)	AK
75 feet (23 m)	AR
100 feet (30 m)	BW
150 feet (46 m)	BK
200 feet (61 m)	DW
250 feet (76 m)	DK
300 feet (90 m)	EW
Hardware	
1/2 in. NPT Threads, Poly cable glands	S
1/2 in. NPT Threads, Nickel Plated Brass cable glands	T
1/2 in. NPT Threads, no cable glands	N
M20 Threads, Poly cable glands	C
M20 Threads, Nickel Plated Brass cable glands	D
M20 Threads, no cable glands	A
Endpoint Wiring Method	
None	XX
Communication/Output	
Standard Output (Modbus RTU or BACnet MS/TP field selectable)	S
Standard Output plus Modbus TCP Ethernet	T
Standard Output plus BACnet/IP Ethernet	V
Standard Output plus EtherNet/IP	U
Standard Output plus Aux Output	9
Units of Measure Totalizer/Flow Rate [2]	
Gallons/gallons per minute	G
Liters/liters per minute	P
Testing & Tagging	
Factory Calibrated	F
Factory Calibrated/Stainless Steel Tag	S

[1] Submersible transducer cables use two conduit openings.
[2] Field selectable, additional options available.

Page 10 TTM-DS-02221-EN-09 June 2021

c. Portable Hydrocarbon Analyzer

INSTRUMENT SPECIFICATIONS

Weight & Dimensions:	8.1 lbs (3.7 Kg); 12.9" x 10.4" x 8.4" (33 cm x 27 cm x 21 cm)
Power Requirements:	External power supply, Input 100-240V, Output 12V, 0.7A Max
Operating Temperature:	45°F to 95°F; 7°C to 36°C
Principle of Operation:	Ultraviolet fluorescence spectrophotometer (fixed wavelength)
Results Produced:	Performs both quantitative and qualitative measurements
Detector:	Photodiode sensor
Light Source:	Light Emitting Diodes (LEDs): 255 nm and 365 nm
UV Module Optics:	Four modules available each fitted with LED, excitation and emission optical filters sensitive to hydrocarbons of interest
Min. Detection Limits:	Varies depending on module and calibration used; GRO = 0.5 ppm, EDRO = 0.1 ppm, PAHs = 0.05 ppm, TPH-OIL = 0.5 ppm
Display:	Intuitive color touch screen user interface
Readout:	Direct concentration (PPM, PPB, etc.) or raw fluorescence units (RFU) mode
Data Output:	100% ASCII format through a USB port, software available online
Cuvettes:	Uses quartz glass cuvettes. Replacement, spare cuvettes available, sold separately
Calibration:	Can perform and store up to 18 multi-point calibrations. Analyzer is factory calibrated using 5-point calibration curves set up for GRO, EDRO, PAHs and/or TPH OIL.
Blank:	Reads and subtracts blank using methanol or hexane solvents
Response Time:	Measures samples in 6 seconds
Automatic Power Down:	After 20 minutes of inactivity
Other Capabilities:	Turbidity, absorbance and other non-UV applications
Portable Battery Power:	Charger available to power analyzer for days with quick recharge
Warranty:	One-year warranty, parts and labor
Approvals:	CE, UL and C-UL. ISO 9001 manufacturing. Made in USA

PORTABLE HYDROCARBON ANALYZER

CONTAMINANTS

Ideal for gasoline, jet fuel, diesel fuel, heating oils, crude oils, lube oils, creosote, coal tars and many other types of petroleum hydrocarbons.

QUICK RESULTS

Test soil, sediment, water and other samples in just 5 minutes using Sitelab test kits with solvent extraction.

ACCURACY

Correlates well to U.S. EPA and other regulatory lab methods performed by certified laboratories using Sitelab's specially formulated Calibration Kits. Available in methanol or hexane solvent.

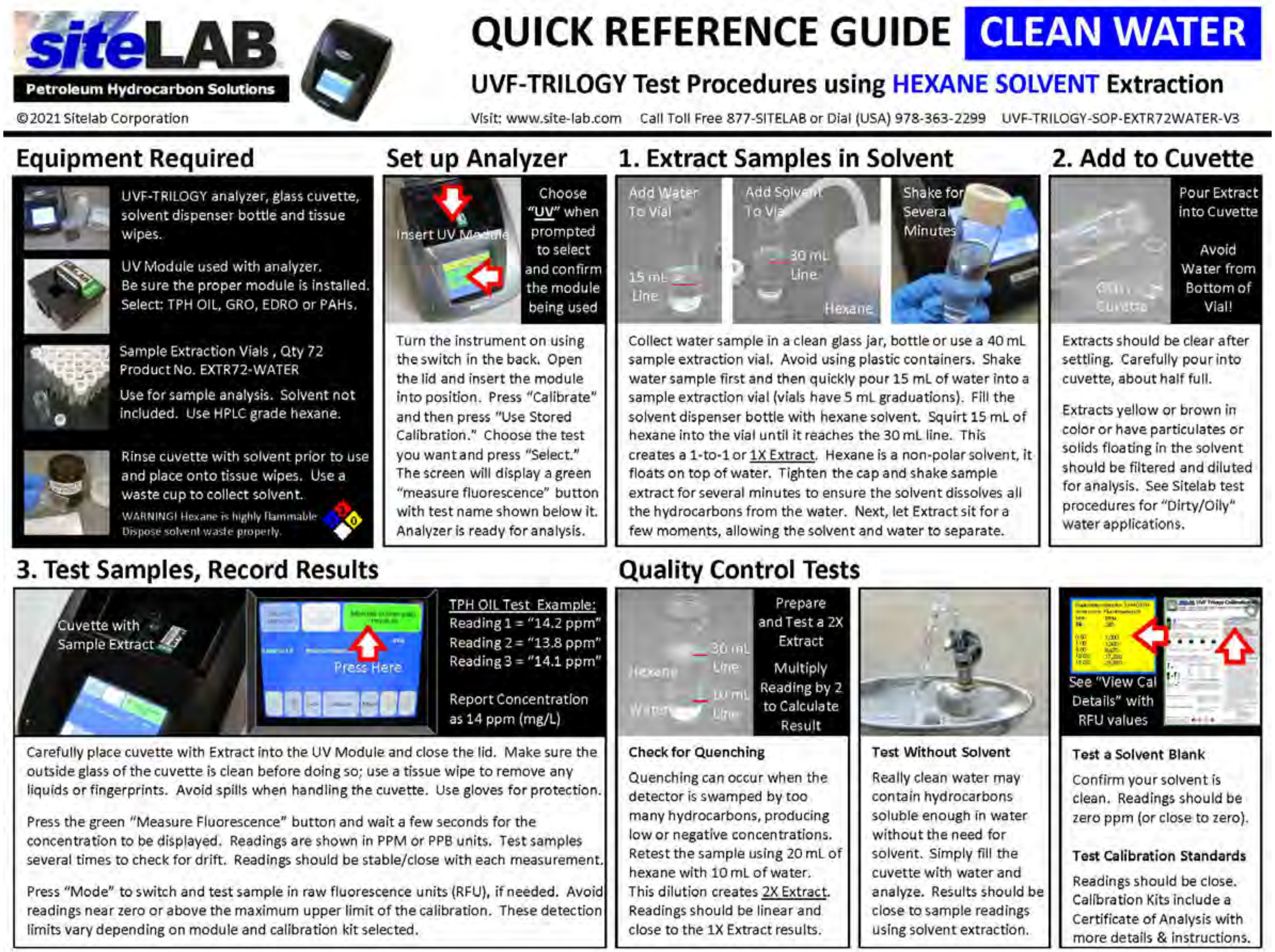
TPH FINGERPRINTING

Forensic analysis can identify the type or age of petroleum on your site in minutes.

UVF-TRILOGY models include all the tools needed to perform tests. Analyzer is factory calibrated and uses snap-in UV modules fitted with LEDs and optical filters sensitive to the following tests:

- Gasoline Range Organics (BTEX)
- Extended Diesel Range Organics
- Polycyclic Aromatic Hydrocarbons
- TPH Oil & Grease

i. Clean Water Analysis



siteLAB Petroleum Hydrocarbon Solutions

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QUICK REFERENCE GUIDE CLEAN WATER

UVF-TRILOGY Test Procedures using HEXANE SOLVENT Extraction

Visit: www.site-lab.com Call Toll Free 877-SITELAB or Dial (USA) 978-363-2299 UVF-TRILOGY-SOP-EXTR72WATER-V3

Equipment Required

UVF-TRILOGY analyzer, glass cuvette, solvent dispenser bottle and tissue wipes.

UV Module used with analyzer. Be sure the proper module is installed. Select: TPH OIL, GRO, EDRO or PAHs.

Sample Extraction Vials , Qty 72 Product No. EXTR72-WATER

Use for sample analysis. Solvent not included. Use HPLC grade hexane.

Rinse cuvette with solvent prior to use and place onto tissue wipes. Use a waste cup to collect solvent.

WARNING! Hexane is highly flammable. Dispose solvent waste properly.

Set up Analyzer

Insert UV Module

Choose "UV" when prompted to select and confirm the module being used

Turn the instrument on using the switch in the back. Open the lid and insert the module into position. Press "Calibrate" and then press "Use Stored Calibration." Choose the test you want and press "Select." The screen will display a green "measure fluorescence" button with test name shown below it. Analyzer is ready for analysis.

1. Extract Samples in Solvent

Add Water To Vial

15 mL Line

Add Solvent To Vial

30 mL Line

Hexane

Shake for Several Minutes

Collect water sample in a clean glass jar, bottle or use a 40 mL sample extraction vial. Avoid using plastic containers. Shake water sample first and then quickly pour 15 mL of water into a sample extraction vial (vials have 5 mL graduations). Fill the solvent dispenser bottle with hexane solvent. Squirt 15 mL of hexane into the vial until it reaches the 30 mL line. This creates a 1-to-1 or 1X Extract. Hexane is a non-polar solvent, it floats on top of water. Tighten the cap and shake sample extract for several minutes to ensure the solvent dissolves all the hydrocarbons from the water. Next, let Extract sit for a few moments, allowing the solvent and water to separate.

2. Add to Cuvette

Pour Extract into Cuvette

Glass Cuvette

Avoid Water from Bottom of Vial!

Extracts should be clear after settling. Carefully pour into cuvette, about half full.

Extracts yellow or brown in color or have particulates or solids floating in the solvent should be filtered and diluted for analysis. See Sitelab test procedures for "Dirty/Oily" water applications.

3. Test Samples, Record Results

Cuvette with Sample Extract

Press Here

TPH OIL Test Example:
Reading 1 = "14.2 ppm"
Reading 2 = "13.8 ppm"
Reading 3 = "14.1 ppm"

Report Concentration as 14 ppm (mg/L)

Carefully place cuvette with Extract into the UV Module and close the lid. Make sure the outside glass of the cuvette is clean before doing so; use a tissue wipe to remove any liquids or fingerprints. Avoid spills when handling the cuvette. Use gloves for protection.

Press the green "Measure Fluorescence" button and wait a few seconds for the concentration to be displayed. Readings are shown in PPM or PPB units. Test samples several times to check for drift. Readings should be stable/close with each measurement.

Press "Mode" to switch and test sample in raw fluorescence units (RFU), if needed. Avoid readings near zero or above the maximum upper limit of the calibration. These detection limits vary depending on module and calibration kit selected.

Quality Control Tests

Hexane

Water

30 mL Line

10 mL Line

Prepare and Test a 2X Extract

Multiply Reading by 2 to Calculate Result

Check for Quenching

Quenching can occur when the detector is swamped by too many hydrocarbons, producing low or negative concentrations. Retest the sample using 20 mL of hexane with 10 mL of water. This dilution creates 2X Extract. Readings should be linear and close to the 1X Extract results.

Test Without Solvent

Really clean water may contain hydrocarbons soluble enough in water without the need for solvent. Simply fill the cuvette with water and analyze. Results should be close to sample readings using solvent extraction.

See "View Cal Details" with RFU values

Test a Solvent Blank

Confirm your solvent is clean. Readings should be zero ppm (or close to zero).

Test Calibration Standards

Readings should be close. Calibration Kits include a Certificate of Analysis with more details & instructions.

ii. Oily Water Analysis

QUICK REFERENCE GUIDE DIRTY/OILY WATER

UVF-TRILOGY Test Procedures using HEXANE SOLVENT Extraction

siteLAB Petroleum Hydrocarbon Solutions

Visit: www.sitelabcorp.com Call Toll Free 877-SITELAB or Dial (USA) 978-363-2299 UVF-TRILOGY-SOP2-V2: EXTR010-20-WATER

Equipment Required

UVF-TRILOGY analyzer, glass cuvette, solvent dispenser bottle, adjustable pipette and tissue wipes.

UV Module used with analyzer. Be sure the proper module is installed. Select: TPH OIL, GRO, EDRO or PAHs.

20 Sample Extraction Kit - Water Product No. EXTR010-20-WATER

Use for sample analysis. Solvent not included. Use HPLC grade hexane.

Rinse cuvette with solvent prior to use and place onto tissue wipes. Use a waste cup to collect solvent.

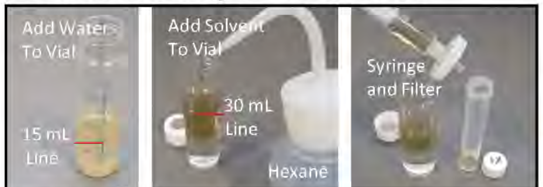
WARNING! Hexane is highly flammable Dispose solvent waste properly.

Set up Analyzer

Choose "UV" when prompted to select and confirm the module being used

Turn the instrument on using the switch in the back. Open the lid and insert the module into position. Press "Calibrate" and then press "Use Stored Calibration." Choose the test you want and press "Select." The screen will display a green "measure fluorescence" button with test name shown below it. Analyzer is ready for analysis.

1. Extract Samples in Solvent



Shake water sample first and then quickly pour 15 mL of water into a sample extraction vial (vials have 5 mL graduations). Fill the solvent dispenser bottle with hexane solvent. Squirt 15 mL of hexane into the vial until it reaches the 30 mL line. This creates a 1-to-1 or 1X Extract. Hexane is a non-polar solvent, it floats on top of water. Tighten the cap and shake Extract for several minutes. Let Extract sit for a few more minutes, allowing the solvent and water to separate. Next, remove the lid and suck up 2 to 4 mL from the surface using a syringe. Attach/screw a filter to the syringe and dispense contents into a test tube. Label Extract tube with sample ID and 1X.

2. Clean Extracts?

Pour Extract into Cuvette

Avoid Water from Bottom of Vial!

Extracts clear in color after settling do not need to be filtered and may not require dilution. Carefully pour into cuvette, about half full, place into analyzer's UV module, close the lid and test sample.

See Sitelab test procedures for "Clean Water" applications for more details.

3. Prepare Dilutions for Analysis

Adjust setting on the micropipette, attach a tip and use a 2nd test tube to prepare a dilution for analysis. Use examples shown below:

Pipette Setting	Extract Used	Add Solvent	Dilution Created
"250" x2	500 uL	into 5 mL	= 10X
"250"	250 uL	into 5 mL	= 20X
"100"	100 uL	into 5 mL	= 50X
"50"	50 uL	into 5 mL	= 100X
"50"	50 uL	into 10 mL	= 200X

Tighten cap and shake test tube for several seconds. Pour dilution into the glass cuvette, about half full. Use a tissue wipe to keep outside glass clean from liquids or fingerprints. Carefully place cuvette into the UV Module and close the lid. Avoid spills!

4. Test Samples, Record Results

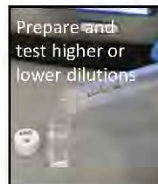
TPH OIL Test Example:
Reading = "6.20 ppm"
x 50X Dilution

Final Concentration = 310 ppm (mg/L)

Press the green "Measure Fluorescence" button and wait a few seconds for the concentration to be displayed. Readings are shown in PPM or PPB units. Press "Mode" to switch and test sample in raw fluorescence units (RFU), if needed. Avoid readings near zero or above the maximum upper limit of the calibration. These detection limits vary depending on module and calibration kit selected.

Multiply reading by dilution tested for final result

Quality Control Tests



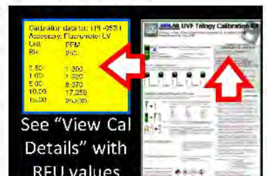
50X Dil = 6.20 ppm

100X Dil = 3.05 ppm

Linear! 310 vs. 305

Check for Quenching

Quenching occurs when the detector is swamped by too many or certain types of hydrocarbons, producing low or negative concentrations. Test the sample at multiple dilutions to confirm results are linear and accurate. Empty test tube and reuse.



See "View Cal Details" with RFU values

Test a Solvent Blank

Confirm your solvent is clean. Readings should be zero ppm (or close to zero).

Test Calibration Standards

Readings should be close. Calibration Kits include a Certificate of Analysis with more details & instructions.

ATTACHMENT 4 - ENVIRONMENTAL

a. NGPC

To be added upon issuance

ATTACHMENT 5 - RECOMMENDED EBCT

a. EBCT Reference

Mike-o-Pedia – Activated Carbon_EBCT

September 20, 2017

Product: Activated Carbon

1. Empty Bed Contact Time (EBCT)

Activated Carbon will reduce or remove many contaminants. Successful removal depends on proper application and equipment sizing.

Empty Bed Contact Time is determined by the contaminant. Some contaminants require longer contact time with carbon to safely reduce or remove these contaminants.

- **To ensure a successful outcome calculate the correct EBCT prior to installation.**
- Some applications such as, PFC's, require multiple tank configurations, known as lead-lag, worker- polisher, or worker-guard.
- A sample point is placed between the tanks for periodic testing of contaminant breakthrough.
- A totalizing water meter is also recommended after critical application carbon tanks to monitor carbon life

Empty Bed Contact Time is equal to the volume of the empty bed divided by the flow rate. It is a measure of the time water is in contact with activated carbon, assuming all water passes through at the same velocity.

$$\text{Empty Bed Contact Time in Minutes} = \frac{\text{Bed Volume (ft}^3\text{)} \times 7.48\ \text{Gallons /ft}^3}{\text{Flow Rate (gpm)}}$$

$$\text{Bed Volume} = \text{Tank Area (sq.ft.)} \times \text{Depth (ft.)}$$

$$\text{Bed Volume} = \frac{\text{Contact Time} \times \text{Flow Rate (gpm)}}{7.48\ \text{gal/ft}^3}$$

Link to EBCT Calculator
Link to EBCT - Fiberglass Tanks 2 Min
Link to EBCT - Fiberglass Tanks 4 Min
Link to EBCT - Fiberglass Tanks 7 Min
Link to EBCT - Fiberglass Tanks 10 Min

Common Activated Carbon Applications and Their Empty Bed Contact Times

1. Chlorine Removal*
All carbon reduces chlorine. Chlorine is not adsorbed – it is a catalytic reduction reaction. The reaction is very fast. The best carbon for Dechlorination is dense (pounds per cubic foot). The most common size is 12x40 mesh.

https://www.cdc.gov/healthywater/drinking/public/chlorine-disinfection.html

Empty Bed Contact Time for Chlorine Removal = 2 Minutes

1

Mike-o-Pedia – Activated Carbon_EBCT

September 20, 2017

2. Chloramine Removal*

Chloramine is chlorine mixed with ammonia and an alternate to disinfection with chlorine. Many municipalities have used chloramine for decades. It is becoming more prevalent however because there are fewer disinfection by products (DBP) associated with its use vs. chlorine. Chloramine can be removed by all types of activated carbon. The rate of the catalytic reduction reaction is much slower. When applying, it requires the use of more GAC and careful monitoring for breakthrough.

We recommend the use of catalytic carbons (Calgon Centaur & Jacobi CX-MCA) which decompose chloramines faster than standard carbon.

CX-MCA

Centaur Spec Sheet

https://www.cdc.gov/healthywater/drinking/public/chloramine-disinfection.html

Empty Bed Contact Time for Chloramine Removal Standard Carbon at least 10 minutes

Empty Bed Contact Time for Chloramine Removal Catalytic Carbon at least 4 minutes

***For Kidney Dialysis applications AAMI standards apply. Advise Urbans Aqua or your water professional when purchasing carbon for Kidney Dialysis.**

3. Disinfection by Products – Trihalomethane, Halogens

Both chlorine and chloramine react with naturally occurring organic matter. This reaction may cause the formation of Trihalomethane (THM). THM is a regulated contaminant. Coconut type carbons are commonly used to reduce trihalomethane.

Empty Bed Contact Time for Disinfection-by-Products Removal Standard Carbon at least 7 minutes

4. Organics **

Organic matter in water comes from decaying plant life and may be referred to as tannins or lignin's. The levels of organics may vary by season. Municipalities use several removal methods including flocculation and powdered activated carbon. For point of entry, households, or point of use, faucets, activated carbon filters can pick up residual municipal water type organics.

Well water which is influenced by surface water often has organics. While activated carbon is a possible solution, it is most often used as post treatment to other treatment methods i.e. hyper-chlorination, anion resin (Tanex), or Ecomix, a specialty media. These alternative treatments are noted elsewhere on this website.

5. PFC – Perfluorinated Compounds: PFOA & PFOS **

An EPA health advisory calls a combined limit of no more than 70 ppt (parts per trillion) of PFOA and PFOS in drinking water. These contaminants are highly resistant to degradation and will accumulate in the body. Testing by Calgon

2

Mike-o-Pedia – Activated Carbon_EBCT

September 20, 2017

Carbon indicated that coal based significantly outperforms coconut and is the best solution for PFC removal. Filtrasorb 600, a 12x40 mesh with enhanced high energy pore structure, is the best choice. A more affordable choice is Filtrasorb 400, also a 12x40 coal based carbon.

Empty Bed Contact Time for PFC's is AT LEAST 10 minutes

Calgon Guide PFC

6. Pesticides

As of 2010 under the Safe Water Act MCL limits have been set for 79 contaminants including 24 pesticides, some of which are no longer in use. Adsorption of pesticides using Activated Carbon is a common removal method. https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/finalization-guidance-incorporation-water-treatment

Empty Bed Contact Time – Caution - Call Urbans Aqua with type and levels of exact pesticide.

7. VOC- Volatile Organic Contaminants **

Volatile Organic Contaminants include a very broad category of chemicals. Some are naturally occurring in the environment, others are man-made. There are 23 regulated compounds with 8 considered carcinogens. Activated Carbon reduces and removes VOC's from water.

It's unlikely you will find high levels of VOC's in your municipally supplied tap water. If you are still concerned use of a carbon filter is recommended.

Ground water should be tested regularly by a certified laboratory. In the event the well is contaminated with VOC's contact Urbans Aqua or a water professional with the analysis to determine the best method of treatment.

Empty Bed Contact Time for VOC's is 7 minutes.

**** Multiple tank configurations known as lead-lag, worker-guard or worker-polisher are recommended. A sample point is placed between the tanks for periodic testing for contaminant breakthrough. A totalizing water meter is highly recommended after critical application carbon tanks to monitor carbon life. It is not necessary to use gravel under bedding in VOC treatment tanks. The gravel will utilize tank space needed for carbon.**

Additional Resources
Table of Regulated Drinking Water Contaminants

https://www.epa.gov/ground-water-and-drinking-water/table-regulated-drinking-water-contaminants

Table of Secondary Standards

https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals

3

Mike-o-Pedia – Activated Carbon_EBCT

September 20, 2017

Contaminant	EBCT	Notes
Chlorine	2 minutes	Any type of GAC works.
Chloramine	10 minutes	Standard GAC
Chloramine	4 minutes	Catalytic
Disinfection-by-Products	7 minutes	Coconut Base
Organics		Post-treatment only
PFC Perfluorinated Compounds PFOA & PFOS	10 minutes	Calgon Filtrasorb F-600
PFC Perfluorinated Compounds PFOA & PFOS	10 minutes	Coal base 12x40 only
Pesticides	Call	
VOC Volatile Organic Contaminants	7 minutes	Coal or coconut shell based

4

b. Zeolite Filtration Media

ACTIVATED CARBON & SERVICES

CH-OC 200 (FILTRATION MEDIA)

LIQUID PHASE ADSORBENT MEDIA

The liquid phase filtration media CH-OC 200 shall be 8x14 mesh zeolite impregnated with no less than 150 millimoles cetyl trimethyl ammonium chloride per kilogram of zeolite.

SPECIFICATIONS	CH-OC 200
Weight moisture content	12-14%
Apparent Density, lb/ft^3	57-59
pH stable range	4-10
U.S. Standard Sieve Size (Mesh Size)	8x14, 14x40
Thermally Stable, °F	33-170
Mohs Scale	4.0
Specific Surface, ft2/g	431

Applications

- Free Standing Mode: Used on its own, CH-OC 200 series can be loaded in drums for use as an efficient stillbed filtration medium. Other applications include tank cleaning, oil spill mitigation, and lining/capping projects.
- Pre-Treatment Mode: CH-OC 200 Series can be used upstream to enhance the performance and extend the useful life of other filtration processes and media such as reverse osmosis, activated carbon and resins.
- Post-Treatment Mode: CH-OC 200 Series utilized downstream of an oil-water separator or coalesce filter, has the ability to act as an effective cleaning and polishing agent.

Standard Packaging

- 2,000 pound polylined supersacks (37 cubic feet)

*This information is offered solely for your consideration and verification. It has been gathered from reference materials and/or test procedures and is believed to be true and accurate. None of this information shall be constituting a warranty or representation, expressed or implied, for which we assume legal responsibility or that the information or goods described is fit for any particular use either alone or in combination with other goods or processes.

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www.cleanharbors.com • www.remediationequipment.com

c. GAC Filtration Media

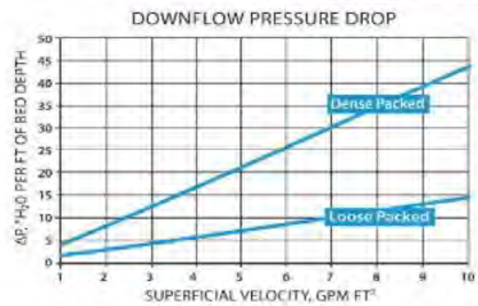
ACTIVATED CARBON & SERVICES

CH-R830 (FILTRATION MEDIA)

LIQUID PHASE REACTIVATED CARBON

CH-R830 (8x 30) is a hard, reactivated carbon manufactured from pooled spent carbon which is recommended for a variety of wastewater and process water treatment. CH-R830 (8 x 30) efficiently removes chlorine, taste and odor compounds, and volatile organics, even with brief contact times.

SPECIFICATIONS	CH-R830	ASTM TEST M
Iodine Number, min	800	-
Bulk Density, min	0.50g/cc	D-2854
Abrasion No., min	75	-
Effective Size, mm	0.8-1.0	-
Moisture as packed	2%	D-2867
U.S. Standard Sieve Size	8 x 30	-
Larger than No. 8, max	15%	
Smaller than No. 30, max	5%	



Applications

- Remediation
- Wastewater Treatment
- Condensate Water Treatment
- Range of Process Water Treatment

Standard Packaging

- 55 lb or 27. 5 lb polylined polypropylene bags
- 200 lb fiber drums
- 1100 lb supersacks

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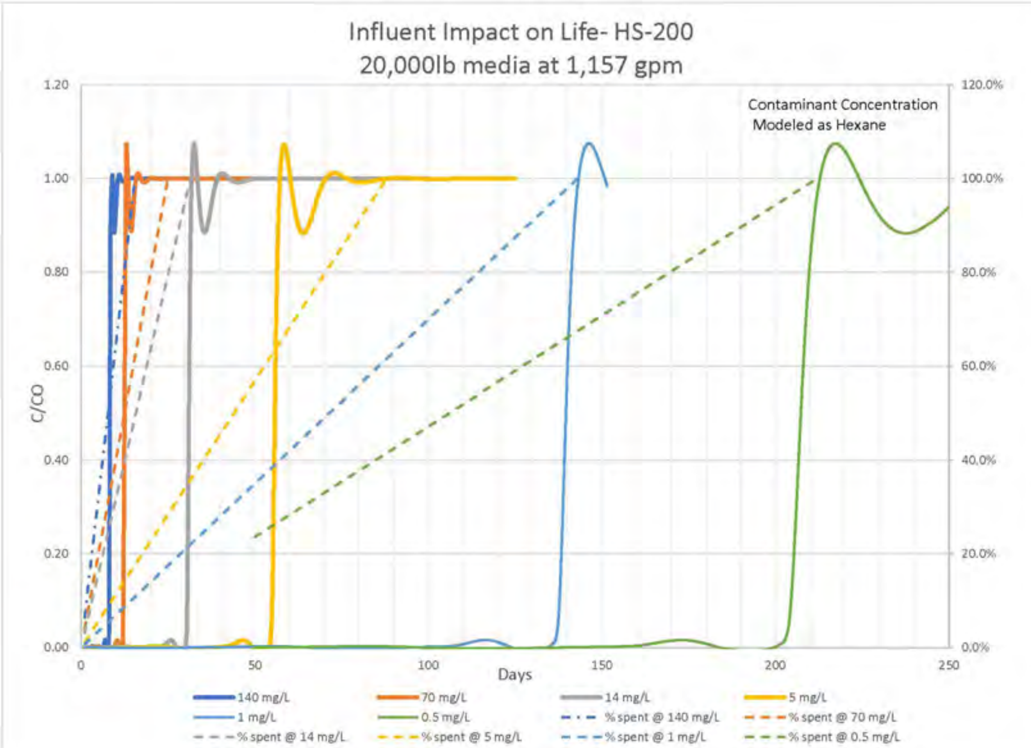
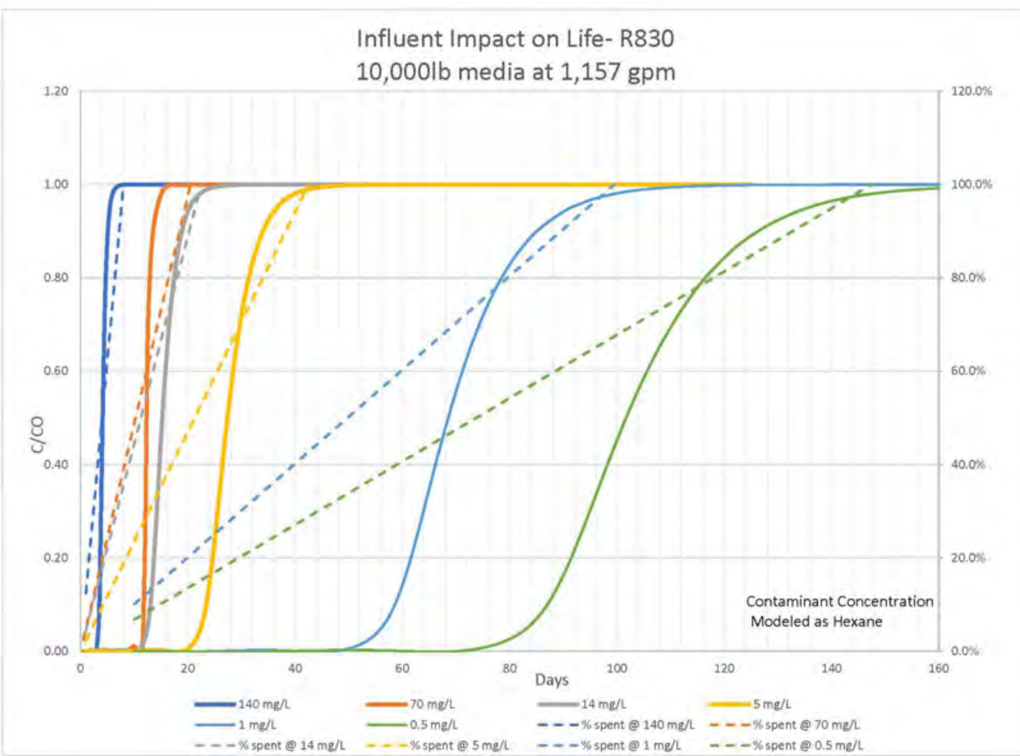
d. Breakthrough Chart

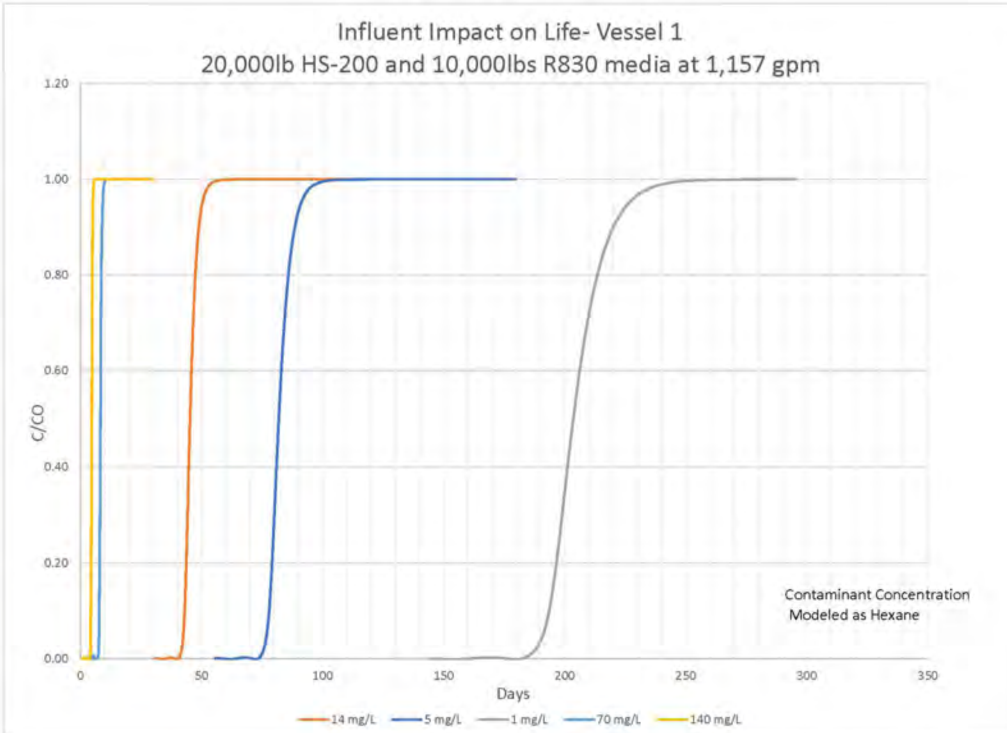
i. Zeolite 20K



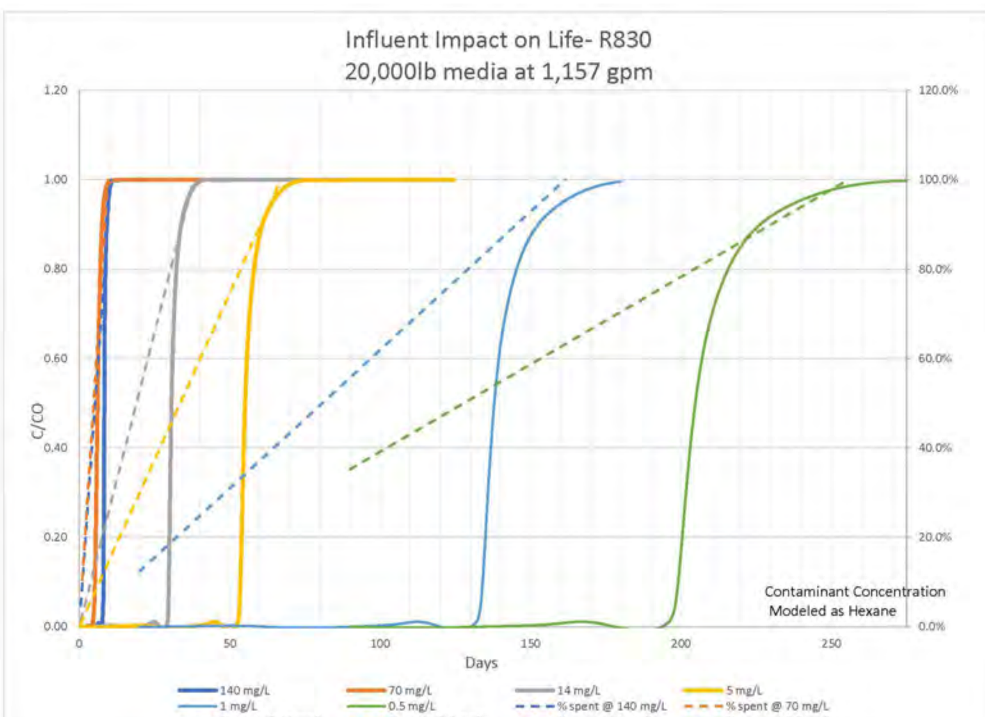
ii. GAC10K



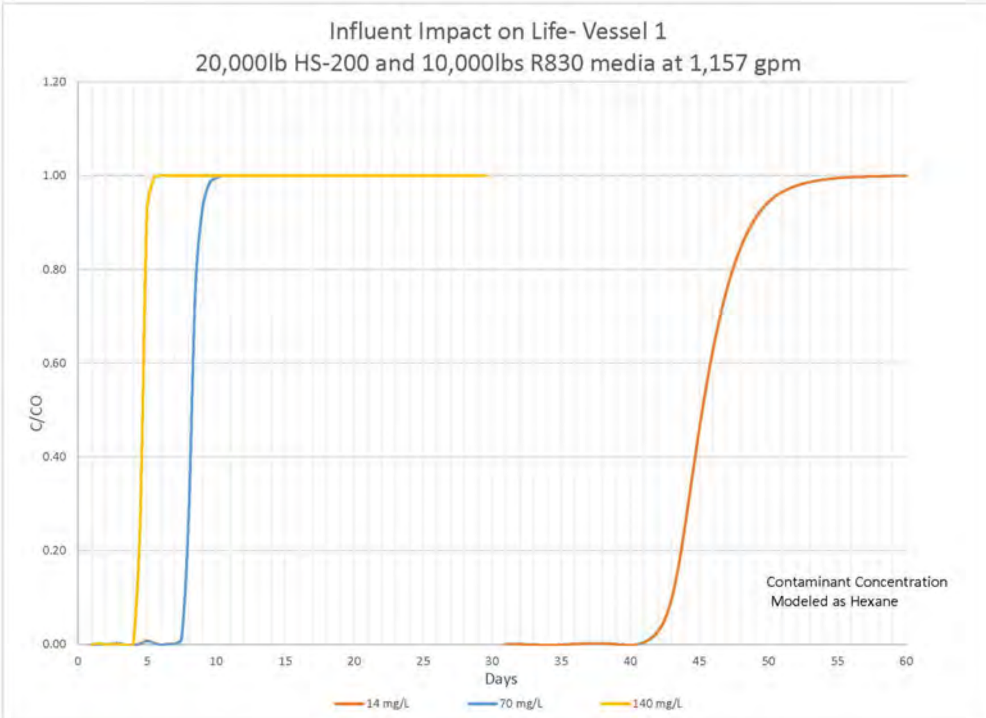
iii. Lead Vessel



iv. GAC20K



v. Lead Vessel Media Life (60 view)



e. Supporting Literature

i. Using Organoclays to Remove Oil from Water

News | October 6, 2000

Using organoclays to remove oil from water

Facility owners and managers can evaluate their entire wastewater treatment system, including meeting discharge permits and the possible recycling of water, and the benefits of an oil/water separator/organoclay/activated carbon treatment system vs. having the water hauled away with potential liabilities and costs. This article discusses various types of oil and how they can be removed from water in a cost-effective manner by using organoclays.

By George R. Alther, Biomin Inc.

Contents

Oil is found in effluents from a variety of sources including: tanker ballast water (bilge water), oil field produced water, storm water from parking lots, vehicle wash water, process water from factories, landfill leachate, groundwater near storage tanks, tank farms and wood treating sites, boiler feed water, and more. The types of oil found in these waters range from the insoluble hydraulic oils, crude oils, bunker 3 oils, to lubricant oils that contain entire packages of additives, and others that contain detergents and soaps.

These oils can be classified as follows:

1. **Free oil** (FOG, free oil and grease): Oil that rises rapidly to the surface of the water tank under calm conditions. The droplet size is 150 micron. This oil can be removed by an overflow weir in the tank, a skimmer; the traces (100 ppm or less) can be removed by running the water through a filter vessel filled with organically modified clay (organoclay).
2. **Mechanically emulsified oil**: These oil droplets range in size from 20-150 microns. Electrical charges and other forces stabilize mechanically emulsified oil. Such oils mix with water due to an application of high shear, which reduces the size of both oil and water particles and is achieved by the use of pumps, mixers and other means of agitation. Over time these droplets rise to the surface on their own due to the lower specific gravity of oil. In groundwater, oil may be mechanically emulsified due to confining pressure. If time is of the essence, oil/water separators and dissolved air flotation systems can be used, followed by polishing with organoclay and if necessary, activated carbon. Surfactants are only present in very small amounts, if at all. Heat from 150-220° F may have to be applied to cause splitting of the emulsion.

3. **Chemically stabilized emulsions**: Surface active agents (surfactants) provide enhanced stability to the emulsion due to interaction at the oil/water interface. The size of the droplets is less than 20 microns. The color of such contaminated water is usually white, which is an indication of what action is required to split the oil from the water. Such oils contain detergents, soaps and other additives, and the source of the oil is metal working fluids, coolants, lubricants, motor oils and others.
4. **"Dissolved oil"**: These include benzene, phenols, toluene, xylene, which can be removed by activated carbon, distillation or membranes such as reverse osmosis. The molecules are of less than 5 micron in size.
5. **Oil wet solids**: This category includes oil that adheres to sediments and other particulate matter, which is common in wastewater. Such oil is removed with oil/water separators or filter presses, followed by bag filters and absorbers filled with organoclays. Sand filters are used at times, but tend to get fouled (coated) with oil when spikes occur. Polishing of the water is achieved with organoclay (often the sand in the sand filter is replaced with organoclay).

Techniques for splitting oily emulsions

The design of oil/water separators is based on Stoke's law: the lighter oil droplets impact on the slant ribs of the media, coagulate and rise to the surface. Dissolved air flotation (DAF) units use air bubbles for the oil to attach to and coagulate. Chemically emulsified water requires at least heat, which can become expensive (150-220° F), either by means of evaporators, tanks with heating jackets, or heat exchangers. More likely, chemical treatment is required, which is an art based on the technician's experience, as much as a science.

The first step is the addition of an inorganic salt such as aluminum sulfate and/or of a cationic polymer. The purpose is to neutralize the electrical charges on the oil droplets and cause coagulation. If this does not work, the pH is adjusted downward, as low as 3.5 in the case of lubricants, with sulfuric or hydrochloric acid. Then a cationic or anionic flocculant may need to be added to cause flocculation of the coagulated droplets, i.e. a rise to the surface of the tank so they can be skimmed off.

This treatment requires a reaction tank prior to the oil/water separator that allows for a residence time of at least 10 minutes. The acids and polymers can be added to that tank and mixed into the water with mechanical mixers, or injected in-line prior to the tank and the pump, using the pump as a mixer. Polishing of the water is finalized by filtration through a bed of organoclay. The polishing step is becoming more and more a necessity because discharge limits in states such as Wyoming and New Jersey are down to 10 ppm.

The use of the organoclay serves as an insurance for the oil/water separator (they reduce oil to 20-5 ppm), and to allow recycling of the water.

Commercial laundries and truck washes easily spend $2,000 to $5,000 per month for water and sewer discharge permits. Steel mills spend much more. Thus zero discharge with the help of organoclays is an attractive proposition for cutting operations costs.

Synthetic oils are more difficult to remove than mineral oils. They require a higher amount of chemicals to achieve clarity, and below about 100 ppm are not visible to the eye. Organoclays also are used as final polishers, often followed by activated carbon if recycling of the water is the goal.

Bringing the COD/BOD into compliance with discharge regulations is often achieved by removing the oil with organoclay, even though the oil may be in compliance with the permit. COD (chemical oxygen demand) determines the amount of organic compounds present that can be oxidized, which includes oil and grease. Thus, if an operator has a permit for COD for 50 ppm, his COD is 60 ppm, and the oil content is 20 ppm with a limit of 30 ppm, he may not realize that removing the oil with organoclay will bring him into compliance, even though oil by itself is not a problem. This treatise points out that the wastewater engineer should be cognizant of these different methods of splitting oil emulsions, and work with the vendor of the separation equipment and the suppliers of the chemicals to achieve the best results.

The unknown in this equation to achieve recyclable water, in spite of the presence of oil, has hitherto been the organoclay. (Return to Table of Contents)

What is an oganoclay?
Organoclays are manufactured by modifying bentonite with quaternary amines. The nitrogen end of the quaternary amine is ion exchanged onto the clay platelet for sodium or calcium, the most common cations that balance the charges of a montmorillonite clay platelet. Montmorillonite constitutes 90% of the composition of an industrial grade bentonite. The bentonite has a charge of 70-90 meq/gram, of which the quaternary amines use 30-40 meq/gram. The quaternary amines are surfactants, which have a water loving (hydrophilic) and oil loving (lipophilic) end. The lipophilic end partitions into oil droplets and other sparingly soluble chlorinated hydrocarbons.

In this fashion organoclays can remove 50% or more of their dry weight in oil, diesel fuel, PNAH's, PCBs and other chlorinated hydrocarbons. The main function of organoclays has been the prevention of fouling of activated carbon, ion exchange resins and membranes. Organoclays are blended with anthracite to prevent early blinding and add btu value (British Thermal Units) when the media is exhausted with oil. In spite of this blending, the organoclay can remove seven times the amount of oil as activated carbon, and save the operator 50% or more of his filtration costs. A combination of organoclay/activated carbon can easily achieve non-detect levels of most organics. Such a combination is often used to remove such PNA compounds as anthrazene, fluorene, pyrene and others, while the carbon then removes the BTEXs. Antifreeze and aqueous cleaners are filtered through organoclay beds to remove oils and allow for reuse. The absorbers are the same ones as those used for activated carbon, except that they use an air pressure relief valve on top due to its higher bulk density (56 l/ft^3).

Industrial applications for organoclay use include air compressors, cooling water, deburring and metal plating process water, boiler blowdown, boiler feed water, refinery waste water, steel mill waste water, etc. (Return to Table of Contents)

Case studies

1. A manufacturer had 3% oil in its wastewater collection system. He treated the wastewater with conventional coalescing equipment, followed by a bag filter for dirt removal, followed by organoclay and activated carbon as final polish. Instead of having the water hauled to a landfill, he is now reusing it. The system paid for itself in less then two years.
2. In a groundwater cleanup project at an air force base, the oily water contains about 1,000 ppm oil when it enters the settling tank. After letting it settle for several hours, 200 ppm still remain in the water, the remainder that rose to the surface is skimmed off. One pass through a drum with 250 pounds organoclay lowers it to 5 ppm of oil or less, acceptable for discharge. The organoclay was changed out after it removed more than 100 lb of oil.
3. In Kentucky, three fabricators that are not connected to sewer lines have to meet discharge limits for oil and grease of 5 ppm before discharge to surface water is allowed. The source of this oil is wash water from the manufacturing of tubing and cabinets. The water is passed through a 10-micron filter bag, followed by one drum of organoclay, at one quarter gpm. The inflow contains 30-50 ppm of oil and grease, the outflow contains less than 5 ppm, meeting all requirements. The clay is changed twice a year, operating costs are less than $5,000 per year.
4. Air compressor condensate containing automatic transmission fluid (ATF) oil (3%) resisted all emulsion breaking techniques including heating, acidification, and polymers. It had a milky white appearance (chemically emulsified, less than 20 ppm). After settling for 72 hours a faint brown ring of free oil appeared on top of the tank. After passing through the oil/water separator, the oil content was 3,300 mg/l. After the first organoclay/anthracite vessel it retained 200 mg/l, after the second, one less than 5 mg/l.
5. A metal plater in California has to meet discharge limits for zinc (less than one ppm). This is achieved by using a vessel filled with natural zeolite (clinoptilolite). To prevent fouling of the zeolite by oil, an oil/water separator was installed, followed by a vessel with organoclay preceding the zeolite. The operator has had no permit violations since he installed this system three years ago. (Return to Table of Contents)

Conclusions

The owner of a facility needs to evaluate his entire wastewater treatment system, including meeting discharge permits, possible recycling of the water, and the benefits of an oil/water separator/organoclay/activated carbon treatment system vs. having the water hauled away with potential liabilities and costs. Once such a system is installed, costs per 1000 gal are between $0.02-$0.20.The system is usually designed such that the organoclay is changed out once every year (if space for a large filter is available), with a payback period of two months to two years.

For more information on organoclays, see the related articles:

Part I: Organoclays Improve Performance of Pump and Treat Remediation Systems

Part II: Organoclays Improve Performance of Pump and Treat Remediation Systems

About the Author: George Alther is founder of Biomin Inc., which manufactures organoclays used in water filtration media, and has worked in the environmental field for 25 years. He has authored 80 scientific papers, has three patents and four others pending. For more information on this topic, contact Biomin Inc. at: phone 248-544-2552, fax 248-544-3733, or email biomin@aol.com.

Edited by Tracy Fabre
Managing Editor, Water Online

ii. Additional Technical Literature References

Additional Technical Literature References

https://www.researchgate.net/publication/222033421_The_use_of_organo-clays_in_water_treatment

Beall, Gary. (2003). The use of organo-clays in water treatment. Applied Clay Science. 24. 11-20. 10.1016/j.clay.2003.07.006.

Abstract
The use of organo-clays in wastewater treatment has become commonplace in industry today. Organo-clays exhibit a synergistic effect with many commonly utilized water treatment unit processes including granular-activated charcoal, reverse osmosis, and air strippers. Organo-clays have proven to be the technology of choice for treating oily wastewaters. This paper will discuss the physical chemistry of the organo-clays sorption mechanism as well as numerous examples of where the technology has been applied.

Alther, G. *Organoclay cost effectively removes oil from produced water*. United States: N. p., 1997. Web.

Alther, George. "Using Organoclays To Enhance Carbon Filtration". *Waste Management*, vol 22, no. 5, 2002, pp. 507-513. *Elsevier BV*, https://doi.org/10.1016/s0956-053x(01)00045-9.

Waste Management
Volume 22, Issue 5, August 2002, Pages 507-513

Using organoclays to enhance carbon filtration

https://doi.org/10.1016/S0956-053X(01)00045-9

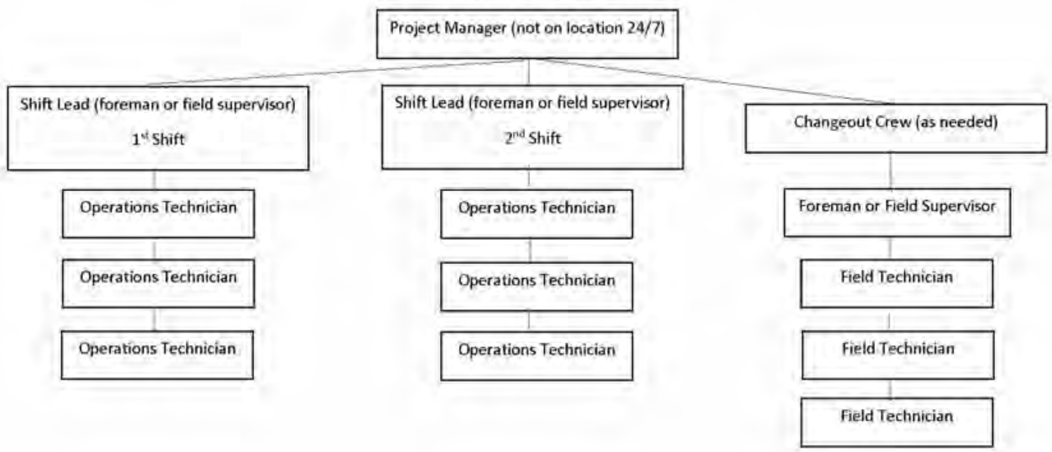
Abstract
Organoclays have found increased acceptance as pre-treatment for activated carbon adsorption systems in both groundwater and wastewater cleanup. The reason is that activated carbon tends to become quickly blinded by large organic molecules of low solubility, particularly oils. However, it is also well established that activated carbon is more efficient at low concentrations of organic contaminants than at higher ones, i.e. at less than 1 ppm. With organoclays it is exactly the opposite, they are better at removing organics at higher concentrations, above 3 ppm. Therefore, it is cost effective in these applications to use two or more vessels in series, the first one filled with organoclay, the remainder with activated carbon. The economics make sense, even though the organoclay is not regenerated, because of the reduction in down time every time a carbon vessel has to be changed out. Use of organoclays increases the volume treated by carbon in many applications seven to nine-fold. In the case of other organic contaminants, as the aqueous solubility increases, the efficiency decreases, except in the case of methylene chloride, which it removes at far higher efficiency then carbon. This article presents the results of a series of tests, including K_d determinations, jar tests, and mini-column tests. These tests determined the adsorption capacity and efficiency of organoclay and activated carbon for the removal of benzene, toluene, xylene and naphtalene from water. These tests were followed by adding the four compounds into one container to see if the combination of organoclay, followed by carbon, would be more efficient then each sorbent alone. The tests also compared the efficiency of organoclay versus carbon for the removal of various oils from water.

ATTACHMENT 6 – OPERATIONS

a. Staffing Organization Chart

Red Hill Staffing Chart

Two 13-hour shifts



Project Manager – responsible for overseeing all operations for the Red Hill Project and Base Hydrant Flushing Project

Shift leads (foreman or field supervisor) = Safety Supervisors – responsible for ensuring all safety protocols are being followed on site, ensuring the system is operating in compliance and leading the operation technicians in their tasks

Operations technician's – responsible for operating the system (controlling valves, tank and pipe maintenance), monitoring discharge water

Changeout crew – responsible for removing the spent granulated carbon from the tank, containerizing for disposal, and loading new granulated carbon

no other tasks to be assigned to these crews

b. Daily Discharge and Monitoring

CleanHarbors

Daily Discharge and Monitoring Report

Operators:
-
-
-
-

Date:

System Location & Designation:
(One Report Per System)

Shift Start Time:	Shift Stop Time:	Run Time:	Weather:
Flow Meter Total Gallons Start of Shift #		Flow Meter Total Gallons End of Shift #	
Total Gallons Discharged Today:		Sample Today Y/N:	
Total Gallons Discharged to Date:			

Time	Flow Meter Readings (GPM/Gallons) Main 24" Instant/Total	Flow Meter Readings (GPM/Gallons) System # Instant/Total	Vessel #1 (PSI) Inlet/Outlet	Vessel #2 (PSI) Inlet/Outlet	Full Equipment Inspection: Leaks, bleed air from vessels, all pressures Confirm (X)	Notes or action taken:
0000	/	/	/	/		
0030	/	/	/	/		
0100	/	/	/	/		
0130	/	/	/	/		
0200	/	/	/	/		
0230	/	/	/	/		
0300	/	/	/	/		
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0900	/	/	/	/		
0930	/	/	/	/		
1000	/	/	/	/		
1030	/	/	/	/		
1100	/	/	/	/		
1130	/	/	/	/		

Operators Signature:

CleanHarbors

1200	/	/	/	/		
1230	/	/	/	/		
1300	/	/	/	/		
1330	/	/	/	/		
1400	/	/	/	/		
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2230	/	/	/	/		
2300	/	/	/	/		
2330	/	/	/	/		
2400	/	/	/	/		

SHIFT NOTES:

Operators Signature:

CleanHarbors

Operators Signature:

ATTACHMENT 7 – ENVIRONMENTAL MANAGEMENT PLAN

Currently under review

	Document Title:		Document Type:
VECTRUS TRUE TO YOUR MISSION	Environmental Protection and Management Plan		Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #	
Approved By		Revision #	00
Publish Date		Page(s)	1 of 15
Contract Reference	N62742-16-D-3552	Deliverable	N/A

REVISION HISTORY		
Revision #	Publish Date	Summary of Changes
00 (Initial)	Dec 2021	Original Issue

PROCESS STAKEHOLDER(S)		
BA or Functional Dept Name: Title of Process Stakeholder *EXAMPLE HR: Director of Recruiting OR Facilities: Warehouse Manager)*		
Operations	-	-

1.0 PURPOSE AND OBJECTIVE

The purpose of this document is to provide the requirements to execute the Global Contingency Services for Red Hill Water Treatment Environmental Protection and Management Plan. This Environmental Protection and Management Plan is the central source of general environmental guidance, procedures, and management practices that seeks to minimize negative impacts to the environment of the proposed water treatment project and enhance positive impacts as a result.

This document delineates responsibilities and provides general procedures for the proper management of environmental aspects and impacts as they pertain to the operations in support of the Red Hill Water Treatment Contract.

This plan intends to establish best management practices for the environmental aspects and impacts of the contract. These aspects were identified using the *4.7.1-7 Environmental Aspects and Impacts Worksheet*. This worksheet allows the identification of environmental aspects based on the scope of the activities and services Vectrus is responsible for, and the environmental impacts associated with them.

The objective of this document is to provide sufficient administrative direction to prevent unnecessary pollution, accidental releases to the environment, and negligent practices.

2.0 APPLICABILITY

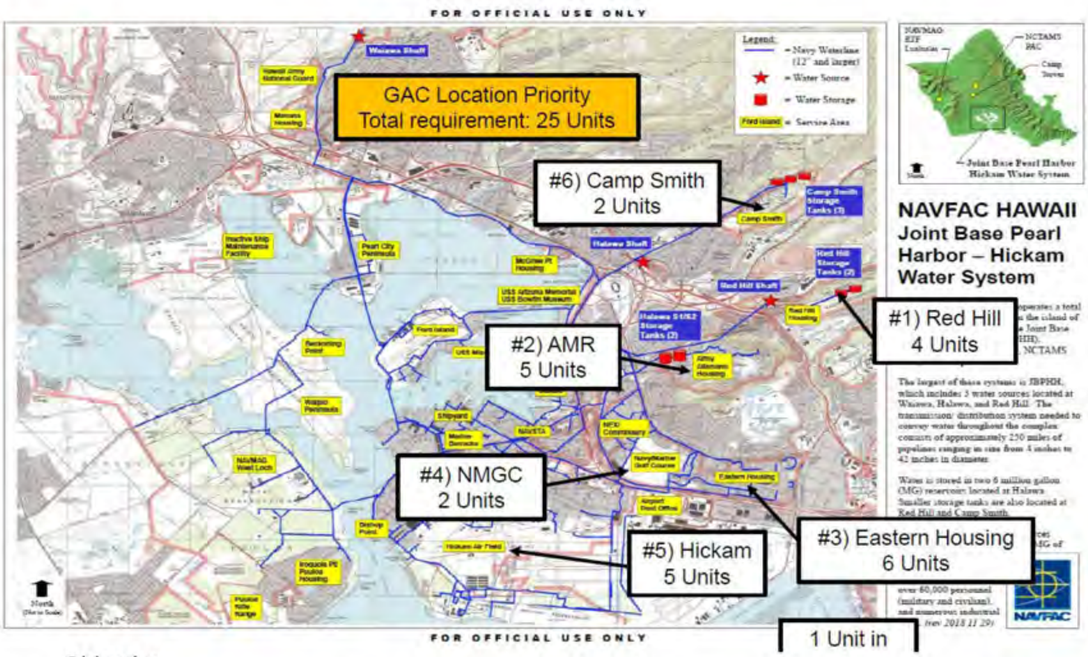
This document applies to all Vectrus employees and supervised contract employees performing any activities in support of the program. Every Vectrus employee and subcontractor has an active part in executing the plan to protect the environment and follow the required procedures in each functional area.

3.0 PROJECT DECRIPTION AND SCOPE

3.1 Area of Operations

3.1.1 The project will be conducted at Joint Base Pearl Harbor – Hickam Water System.

	Document Title:		Document Type:
	Environmental Protection and Management Plan		Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #	
Approved By		Revision #	00
Publish Date		Page(s)	2 of 15
Contract Reference	N62742-16-D-3552	Deliverable	N/A



3.2 Objective

3.2.1 Oil removal by adsorption. Twenty-five (25) mobile granular activated carbon (GAC) units will be used at priority locations to adsorb JP-5 from the water to acceptable levels for safe drinking water. The requested acceptable concentration is below 40 ppb. JP-5 is a kerosene-based jet fuel used as military aircraft fuel. These units must be capable of treating a nominal flow of 500 GPM at an average of 70 psi contaminated water. The treated water with acceptable contaminant levels will be released back into the Halawa stream within the limitis of applicable permits.

3.3 Process Overview

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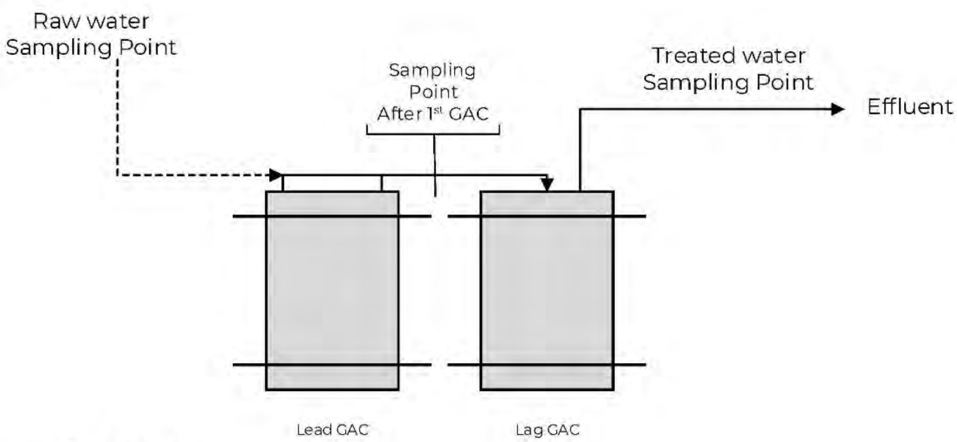
	Document Title:		Document Type:
VECTRUS TRUE TO YOUR MISSION	Environmental Protection and Management Plan		Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #	
Approved By		Revision #	00
Publish Date		Page(s)	3 of 15
Contract Reference	N62742-16-D-3552	Deliverable	N/A



3.4 Equipment

3.4.1 Vessel Specifications and Operating Conditions

- Dual Pressure vessel, 20,000 lbs 8x30 Mesh GAC per Vessel 8" Schedule 40 Pipe, 60F
- Pressure Rating (psig): 125 psig (862 kPa) @ 140°F
- Maximum Range (gpm): 700 gpm per vessel, operated in series

3.5 Monitoring and Sampling

3.5.1 Carbon Changeout

GAC replacement should occur before reaching the maximum contaminant level for target contaminants.

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	Document Title:		Document Type:
VECTRUS	Environmental Protection and Management Plan		Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #	
Approved By		Revision #	00
Publish Date		Page(s)	4 of 15
Contract Reference	N62742-16-D-3552	Deliverable	N/A

The manufacturer should provide a guideline for how often the GAC needs to be replaced.

3.5.2 Startup Sampling

A laboratory analysis from a sample taken at each raw water influent location should be conducted as part of the startup sampling. Sampling will be conducted by AECOM under a different contract.

3.5.3 Contaminants

- Benzene
- Ethylbenzene
- Toluene
- o-Xylenes
- m,p-Xylenes
- Naphtalene
- TPH-o
- TPH-g
- TPH-d
- 2(-2methoxyethoxy)ethanol
- Lead

3.5.4 Routine Monitoring

GAC systems should be monitored routinely to ensure they are operating as intended, the GAC is replaced at the appropriate frequency, and the removal of the target contaminants is being accomplished.

To estimate the time until GAC changeout, it is useful to monitor the progression of the contaminants through the system. Water sampling will be accomplished at four points:

1. Raw water
2. Lead contactor GAC effluent
3. Lag contactor GAC effluent
4. Plant effluent

Where contactors are operated in series, sample tap(s) before and after each contactor for all possible flow configurations through the series.

3.5.5 GAC Water Treatment Facility Sampling Plan

Sample Point	Constituent	Sample Type	Frequency
Raw	TPH-o	Grab	Twice per week for 2 weeks; Weekly thereafter
	TPH-g	Grab	
	TPH-d	Grab	
	2-(2-methoxyethoxy)ethanol	Grab	
	Naphthalene	Grab	
	Benzene	Grab	
	Ethylbenzene	Grab	
	Toluene	Grab	
	o-Xylenes	Grab	

VECTRUS	Document Title:		Document Type:
	Environmental Protection and Management Plan		Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #	
Approved By		Revision #	00
Publish Date		Page(s)	5 of 15
Contract Reference	N62742-16-D-3552	Deliverable	N/A

	m,p-Xylenes	Grab	
	Lead	Grab	
Lead Effluent Contactor	TPH-o	Grab	Twice per week for 2 weeks; Weekly thereafter
	TPH-g	Grab	
	TPH-d	Grab	
Lag Effluent Contactor	TPH-o	Grab	Twice per week for 2 weeks; Weekly thereafter
	TPH-g	Grab	
	TPH-d	Grab	
	TPH-g	Grab	
	TPH-d	Grab	
Plant Effluent	All regulated constituents		Twice per week for 2 weeks; Weekly thereafter

3.5.6 Effluent Sampling

Excerpted from NPDES General Permit application

Parameter	*Constituent*	*CAS #*	*Effluent Limitations*	*Rationale*	*Sample Type*	*Sampling Frequency*
TPH						
8260	TPH-Gasoline (C6-C10)	Gas	300	DOH EALs: Table D-1a (DW, SW<150m)	Grab	Weekly
8015	TPH-Diesel (C10-C24)	Diesel	400	DOH EALs: Table D-1a (DW, SW<150m)	Grab	Weekly
8015	TPH-Oil (C24-C40)	Oil	500	DOH EALs: Table D-1a (DW, SW<150m)	Grab	Weekly
De-icing agent						
8321	*2-(2-methoxyethoxy) ethanol*	*111-77-3*	*80*	EPA Region 9 Screening Level	Grab	Weekly
PAHs						
8270 SIM	1-Methylnaphthalene	90-12-0	10	DOH EALs: Table D-1a (DW, SW<150m)	Grab	Weekly
8270 SIM	2-Methylnapthalene	91-57-6	10	DOH EALs: Table D-1a (DW, SW<150m)	Grab	Weekly
8270 SIM	Naphthalene	91-20-3	17	DOH EALs: Table D-1a (DW, SW<150m)	Grab	Weekly
VOCs						
8260	Benzene	71-43-2	1700	HAR-11-55 Appendix D Table 34.2	Grab	Weekly
8260	Ethylbenzene	100-41-4	140	HAR-11-55 Appendix D Table 34.2	Grab	Weekly
8260	Toluene	108-88-3	2100	HAR-11-55 Appendix D Table 34.2	Grab	Weekly
8260	o-Xylenes	95-47-6	-	DOH EALs: Table D-1a (DW, SW<150m)	Grab	Weekly

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VECTRUS	Document Title:		Document Type:
	Environmental Protection and Management Plan		Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #	
Approved By		Revision #	00
Publish Date		Page(s)	6 of 15
Contract Reference	N62742-16-D-3552	Deliverable	N/A

8260	m,p-Xylenes	1330-20-7	-	DOH EALs: Table D-1a (DW, SW<150m)	Grab	Weekly
Heavy Metals						
6010	Lead	7439-92-1	140	HAR-11-55 Appendix D Table 34.2	Grab	Weekly
Water Quality Parameters						
N/A	Total Nitrogen, N	N/A	300	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly
	Ammonia, N		10	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly
	Nitrate-Nitrite, N		15	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly
	Total Phosphorous, P		60	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly
	Chlorophyll a		2.5	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly
	Whole Effluent Toxicity		Pass	HAR-11-55 Appendix D Table 34.2	Composite	Monthly
Field Measurements						
N/A	Flow (Gallons per Day)	N/A	5 million gallons per day	HAR-11-55 Appendix D Table 34.2	Calculated or Estimate	Daily
	Turbidity (NTUs)		4	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly
	pH		6.8-8.8 and ambient ± 0.5	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly
	Dissolved Oxygen		> 60% Saturation of ambient	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly
	Temperature		ambient ± 1	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly
	Salinity		ambient ± 10%	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly
	Oxidation-Reduction Potential (EH)		> -100 millivolts (in top four inches of sediment)	HAR 11-54-5.2 (d)(2) Pearl Harbor Estuary	Grab	Weekly

3.5.7 Spent Materials

- GAC may be reactivated with heat for reuse or be used as fuel for cement kilns. See Waste Management section below.

	Document Title:			Document Type:
VECTRUS TRUE TO YOUR MISSION	Environmental Protection and Management Plan			Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #		
Approved By		Revision #	00	
Publish Date		Page(s)	7 of 15	
Contract Reference	N62742-16-D-3552	Deliverable	N/A	

4.0 ROLES & RESPONSIBILITIES

- Project Manager
  - Has overall responsibility and provides resources to support the project.
  - Becomes aware of the findings and recommendations following the environmental condition report.
  - Ensures the procedures laid in this document are followed and implemented, and they align with the Project Work Statement (PWS).
  - Supports and emphasizes the practices of waste reduction, loss identification, sustainable use of natural resources, and environmental protection.
  - Makes all necessary training available to support contract activities.
  - Serves as the Point of Contact (POC) for environmental matters for all Vectrus supported site locations.
  - Ensures the prevention of work-related injuries and illnesses as well as the provision of a safe and healthy workplace.
  - Communicates the importance of effective environment, safety, and health management.
  - Promotes the Vector to ZERO philosophy.
  - Ensures compliance with all applicable regulations and standards related to the environmental aspects and impacts of the contract's activities.
  - Assigns, equips, and trains Vectrus personnel to provide the necessary guidance, technical expertise, and assistance to support the implementation of this plan.
  - Coordinates with other installation agencies, such as Fire and Emergency Services Department; and other applicable agencies.
  - Maintains all applicable records and documents generated as a result of the implementation of this document.
  - Ensures required inspections are conducted of all Vectrus-operated equipment and associated activities are inspected in accordance with all applicable requirements.
- Supervisors
  - Monitor site activities to ensure compliance with this plan.
  - Ensure the prevention of work-related injuries and illnesses.
  - Communicate the importance of effective environment, safety, and health management.
  - Promote the Vector to ZERO philosophy.
  - Protect employees and subcontractors from reprisals when reporting incidents, hazards, risks, and opportunities.
  - Provide consultation to employees and subcontractors.
- Project ESH Representative/Officer
  - Acts as a resource and guide for the effective implementation of the environmental management plan.
  - Supports operations and activities to meet or exceed the specific actions listed in the requirements listed below.
  - Maintain records of all incidents that occur onsite during the project, including health and safety incidents, noncompliance incidents, accidental releases involving hazardous materials and petroleum products stored onsite and other indicents as applicable or necessary.
- Employees and Subcontractors
  - Ensure their safety in their respective work areas throughout daily activities.
  - All personnel are responsible for being alert to unsafe workplace acts or conditions and for reporting them to their supervisor for immediate corrective actions and analysis.

VECTRUS	Document Title:		Document Type:
	Environmental Protection and Management Plan		Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #	
Approved By		Revision #	00
Publish Date		Page(s)	8 of 15
Contract Reference	N62742-16-D-3552	Deliverable	N/A

- Follow the stop-work protocol whenever a hazard/unsafe condition/risk is identified, and ensuring the risk is eliminated or controlled appropriately before resuming their duties.
- Commit to the implementation of best practices to protect the environment from unnecessary pollution.

5.0 REFERENCE DOCUMENT(S)

- *ESH SharePoint Library Tools and Resources*
- *4.7.1-6 Safety and Health Hazards and Risks Identification Worksheet*
- *4.7.1-7 Environmental Aspects and Impacts Identification Worksheet*
- *4.7.29 Incident Reporting and Investigation Program*
- *4.7.29-5 Injury and Illness Incident Report Form*
- *6.5.1 Data Retention and Destruction*

6.0 DEFINITIONS

- **Environmental Aspect:** Element of the project's activities or products or services that interacts or can interact with the environment
- **Environmental Impact:** Change to the environment, whether adverse or beneficial, wholly or partially resulting from the Program's environmental aspects.
- **Contactor:** A pressurized container in which granular activated carbon is held and through which water flows for the purpose of contacting the water with the granular activated carbon for contaminant removal.
- **Granular Activated Carbon (GAC):** Granular activated carbon (GAC) is a porous adsorption media with extremely high internal surface area. GACs are manufactured from a variety of raw materials with porous structures.
- **Interested Parties:** person or organization that can affect, be affected by, or perceive itself to be affected by a decision or activity (e.g., Clients, Other Contractors, Government Agencies, Workers, Vectrus Corporate)
- **Internal Issues:** the internal characteristics or conditions of the Program, such as its activities and services, strategic direction, culture, and capabilities (i.e., people, knowledge, processes, systems) that may influence the Program's environmental, safety, and health performance.
- **Life Cycle (environmental):** consecutive and interlinked stages of a product or service system, from raw material acquisition or generation from natural resources to final disposal.
- **National Pollutant Discharge Elimination System (NPDES):** The NPDES permit program, created in 1972 by the *Clean Water Act (CWA)*, helps address water pollution by regulating point sources that discharge pollutants to waters of the United States.
- **Nonconformity:** non-fulfillment of a requirement.
- **Pollutant:** A substance that, when introduced into the environment, adversely affects a resource. Pollutants include a wide range of substances found in solid waste, processes residue, sewage, trash, sludge, chemical waste, biowaste, radioactive material, dirt, agricultural waste, etc.
- **Risk:** the combination of the likelihood of occurrence of a work-related hazardous event or exposure(s) and the severity of injury, illness, or environmental impact that can be caused by the event or exposure(s).
- **Safety Data Sheet (SDS):** A Safety Data Sheet is a document produced in alignment with the UN's Globally Harmonized System of Classification and Labelling of Chemicals (GHS) that the manufacturer, importer, or distributor of a chemical product is required to provide to downstream users. The purpose of an SDS is to ensure that anyone who handles chemicals has the hazard information needed to safely use, handle and store them. A specific 16 section format is used.

Sections 1 through 8 of the SDS contain the more critical information to have during times of emergency, including manufacturer and emergency response contact information, hazard details, chemical composition, safe handling practices, and emergency control measures such as fire-fighting. Sections 9 through 11 and 16 contain other technical information, including physical and chemical properties, stability and reactivity information, and exposure control information. Sections 12 through 15 contain information on environmental impacts, disposal considerations, transport information, and regulatory information.

- **Spill:** The accidental but unpermitted discharge or release of petroleum, oil, or lubricants, or hazardous/regulated substances.

7.0 PROCEDURE

The following areas of environmental management may be under Vectrus' responsibilities. It is important to follow all applicable standards for environmental compliance and best management practices to ensure the protection of the environment in conjunction with the safety of employees, subcontractors, and the customer.

7.1 Environmental Aspects and Impacts Identification

7.1.1 When determining the environmental aspects, the following were considered:

- The environmental impacts from a life cycle perspective considering the extent of control or influence that can be exerted over activities, products, and services;
- Planned developments, new activities, products, and services, as well as abnormal conditions and reasonably foreseeable emergencies.

7.1.2 Operational controls for significant environmental aspects (an aspect that has or can have one or more significant environmental impacts) will include operating criteria to minimize or eliminate environmental impacts.

7.1.3 The identified aspects and impacts resulting from project operations will be addressed throughout this document.

Aspect	*Impact*
Historical and Cultural Resources Preservation/Protection	Disturbance to cultural resources
Natural and Endangered Species Preservation/Protection	Vegetation loss, soil erosion
Environmental Noise	Noise pollution; Human disturbance; Harm to ecosystems
Air Emissions	Air pollution; Human exposure; Harm to ecosystems
Hazardous Materials Storage	Accidental Release; Fire; Human and Environmental exposure and toxicity; Toxic Air emissions; Fines and Violations
Hazardous Materials Handling	Accidental Release; Fire; Human and Environmental exposure and toxicity; Toxic Air emissions; Fines and Violations
Hazardous Materials Transport	Accidental Release; Fire; Human and Environmental exposure and toxicity; Toxic Air emissions; Fines and Violations

Document Title:			Document Type:
	Environmental Protection and Management Plan		Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #	
Approved By		Revision #	00
Publish Date		Page(s)	10 of 15
Contract Reference	N62742-16-D-3552	Deliverable	N/A

Hazardous Materials Disposal	Accidental Release; Fire; Human and Environmental exposure and toxicity; Toxic Air emissions; Fines and Violations
Storage - Hazardous Waste Accumulation Point (HWAP), Hazardous Waste Storage Area (HWSA)	Risk of spills; Fire; Explosion; Reactivity; Human exposure; Harm to ecosystems; Release into water systems
Hazardous Waste Handling	Risk of spills; Fire; Explosion; Reactivity; Human exposure; Harm to ecosystems; Release into water systems
Hazardous Waste Transport	Risk of spills; Fire; Explosion; Reactivity; Human exposure; Harm to ecosystems; Release into water systems
Hazardous Waste Disposal	Risk of spills; Fire; Explosion; Reactivity; Human exposure; Harm to ecosystems; Release into water systems
Solid Waste Separation	Fire; food or harborage for vectors; safety hazard
Recycling of scrap metal and cans, paper, cardboard, plastic, wood, cartridges, electrical scrap and computer quipment	Fire; food or harborage for vectors; safety hazard
Disposal Operations - General waste	Fire; food or harborage for vectors; safety hazard
Water Supply aquifers and surface water sources	Contamination of water sources; human health issues
Water treatment Facilities, Equipment, Operation and Maintenance	Water quality concerns, chemical leaching, hydraulic deterioration
Use, storage and handling of treatment chemicals	Leaks, explosion; human exposure; inuries; fatalities
Discharges of industrial and domestic wastewater into surface waters	Ground/Surface water Pollutionn; Standards Violation; Improper Treatment; Resources degradation; Damage to aquatic ecosystems
Stormwater runoff	Ground/Surface water Contamination; Flooding; Erosion; Property Damage; Sediment clogging; Harm to aquatic animals; Standards Violation
Spills of POL and hazardous substances otherwise not covered	* Releases of Hazardous Substances to Air, Water, or Soil * Human Exposure * Fines * Loss of Business/Reputation
Energy Use	Use of non-renewable energy sources (such as vehicular gasoline) and associated GHG emissions

7.2 Environmental Monitoring

7.2.1 Regular inspections will be conducted during the duration of the project to ensure conformance with this Environmental Plan.

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VECTRUS	Document Title:		Document Type:
	Environmental Protection and Management Plan		Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #	
Approved By		Revision #	00
Publish Date		Page(s)	11 of 15
Contract Reference	N62742-16-D-3552	Deliverable	N/A

7.3 Historic and Cultural Resources

7.3.1 Employees should be aware of the location of any historic and cultural resources and an inventory should be available.

7.3.2 Measures should be implemented to protect and preserve said resources. Any possible adverse effects to these resources should be avoided or mitigated. Before commencing any work activities that could potentially impact the identified resources, a project plan must be prepared to identify their location and any activities that may affect them. Then, an assessment must be conducted to determine the risk of impact, and if this risk is acceptable. Finally, any mitigation measures to ensure the adverse effects are reduced to the minimum extent possible. Mitigation measures may include:

7.3.3 Comprehensive planning and risk assessment;

7.3.4 Limiting the scope of the activities to avoid disturbances;

7.3.5 Ensuring the affected resources can be repaired or restored as necessary, if allowable.

7.3.6 No Vectrus employee shall disturb, damage, or alter any historic or cultural property without the appropriate permission.

7.4 Natural Resources and Endangered Species

7.4.1 Existing plant life shall be preserved. Habitats of endangered species must be protected and maintained to favor the reproduction and survival of indigenous species.

7.4.2 No plant life is to be dug up, cut down, exterminated, or otherwise impacted by any Vectrus employee except at the direction of the PM, with the reason provided.

7.4.3 Wild animals are not to be handled, fed, killed, or captured by Vectrus employees. Animal infestations and other problems such as injured or ill animals are to be reported to the appropriate personnel.

7.4.4 Any Vectrus employee observing the violation of the above provisions should report the violation to their supervisor, ESH representative, or Project Manager.

7.4.5 Any damaged areas will be rehabilitated upon completion of the contract, as soon as possible, to avoid affecting the natural environment.

7.5 Air Emissions

7.5.1 All equipment that generates regulated air pollutants must be operated and maintained in accordance with the manufacturer's specifications, including preventive maintenance inspections, as necessary. Equipment must meet emission limits determined by Hawai'i regulations.

7.5.2 Emission sources that require testing and monitoring should have sampling and testing facilities to determine the nature and quality of the emissions that are discharged as a result of operations. Equipment used for testing and monitoring should be compliant with industry standards.

7.5.3 Records related to compliance with emission standards should be retained in accordance with Vectrus Recordkeeping policies.

7.5.4 Manufacturer specifications, emissions test data, and inspections/maintenance logs should also be retained.

7.5.5 Employees and subcontractors involved in air emissions control should be trained consistently with their responsibilities. Training courses may include Environmental concerns of air emissions, combustion principles, equipment operation, pollution monitoring methods, corrective actions, applicable regulations, etc.

7.6 Asbestos

7.6.1 There is no identified risk of asbestos and ACM exposure or disturbance within the areas of responsibility.

7.7 Lead and Lead-Based Paint

7.7.1 There is no identified risk of lead or lead-based paint exposure or disturbance within the areas of responsibility.

7.8 PCBs

7.8.1 There is no identified risk of lead or lead-based paint exposure or disturbance within the areas of responsibility.

7.9 Water Management

7.9.1 Pollutant discharge systems and NPDES permit
This project will produce effluents to be discharged into waters of the United States that will need a permit to do so.

7.9.2 Records for permitted sources should document all regulated parameters. For monitoring purposes, the following information needs to be maintained: daily volume of effluent discharge, test procedures for the analysis of pollutants, date, location, and time of sampling, name of the individual who performed the sampling, date of analysis, records documenting personnel training and certifications, and any additional records relating to the treatment system. See planned scheduled sampling and regulated parameters in *GAC Water Treatment Facility Sampling Plan*.

7.9.3 Spent Carbon Disposal
Spent carbon produced during the treatment must be disposed of in accordance with the guidance for hazardous waste or solid waste, as applicable. Spent carbon may be reactivated for reuse. Where reactivated GAC is to be used, consider any performance loss resulting from the reactivation process, as well as the time needed to accommodate the reactivation process.

7.9.4 Discharge to Halawa Stream
Applicable monitoring requirements (frequency and regulated parameters, per NPDES to be issued by Hawaii Department of Health) must be followed, with sampling collected before discharging to Halawa Stream.

7.10 Hazardous Materials Management

7.10.1 The following is an inventory of the hazardous materials that will be used during the project:

Chemical Name	Manufacturer	Maximum Quantity	CAS #	SDS on File
Charcoal, Activated Carbon			7440-44-0	Yes

7.10.2 Training

7.10.2.1 All personnel who use, handle, or store hazardous materials must be trained consistently with their responsibilities and potential exposures.

7.10.3 Hazard Communication

7.10.3.1 Information about the identities and hazards of the chemicals must be available and understandable to employees and subcontractors.

7.10.3.2 All sites with hazardous chemicals must have labels and safety data sheets for their exposed personnel, and train them to handle the chemicals appropriately.

7.10.4 Storage and Handling

7.10.4.1 All hazardous materials onsite must have a hazardous material warning label.

7.10.4.2 Hazardous materials must be stored in such a way as to prevent exposure to precipitation, facilitate spill response, and provide appropriate secondary containment. Hazardous material storage/dispensing areas will be properly maintained.

7.10.4.3 Drums/containers must never be leaking.

7.10.4.4 Secondary containment pallets, drip pans/absorbent materials will be used as necessary to collect drips or spills.

7.10.4.5 All containers will be marked with contents.

7.10.4.6 Dispensing areas will be located away from catch basins and storm drains.

7.10.4.7 Containers must be handled with the proper equipment and in a manner that prevents ruptures, leaks, or damage.

7.10.4.8 Unauthorized entry of persons or livestock into hazardous material storage areas will be forbidden.

7.10.4.9 Excess hazardous material, including out-of-specification hazardous materials, will be processed for reuse or disposal.

7.11 Spill Prevention and Response

7.11.1 A spill or accidental release is an unwanted discharge of POL or hazardous material into the environment. Spills create hazards for humans, wildlife, and vegetation. Spill prevention and response plans are required to describe the risk of releases or spills of hazardous substances or regulated materials and specify procedures to prevent and respond to such events. It is Vectrus's policy to prevent spills of these substances, to promptly report any significant spills, and to provide for a quick, coordinated response to contain and clean up spills that might occur. It is important to have a contingency plan to respond to spills and other emergencies. In an emergency, priority will be given to protecting human life and health, and a substantial effort to protect the environment, sensitive areas, and property. Plans must be updated whenever there are changes in operations or whenever significant spills occur. Plans must be revised to ensure compliance with applicable standards, best practices, and be adequate for the site.

7.11.2 <u>Prevention</u>

7.11.2.1 Adequate handling and storage practices of hazardous substances and POL is fundamental to minimizing the risk of a spill or accidental release into the environment.

7.11.2.2 A site-specific accident prevention plan will be available where significant spills could occur. This plan will include an evaluation of all locations that manage hazardous materials for the potential for environmental damage from a release.

7.11.2.3 The plan will include general information on the site, including name, operations conducted, location and address, charts of drainage patterns, designated water protection areas, maps, critical water resources, use of land, and possible migration pathways.

7.11.2.4 The plan will include all areas that have POL or hazardous materials handling and storage, including areas where these substances are more likely to produce a significant spill. In the event of a major failure of the system, information on the total quantity of POL or hazardous substances that might be spilled, and the possible migration pathway must be included.

7.11.2.5 A list of all emergency response equipment (see Response section below), including the description of each item and its capabilities.

7.11.3 <u>Response</u>

7.11.3.1 Response and clean-up equipment/materials will be kept at every hazardous materials/POL storage area. This equipment will be maintained and inspected regularly following the manufacturer's requirements to guarantee a quick response should a spill occur.

7.11.4 Evacuation Plan

7.11.4.1 The response section of the plan will include an evacuation plan for the site. This evacuation plan must be specific and detailed enough to provide the necessary guidance in case of an emergency. It should also include evacuation routes (main and alternate).

7.11.5 Containment

7.11.5.1 When responding to any spill, the priority is always personal and public safety. Should a spill occur, affected individuals onsite will be notified of evacuation procedures, including evacuation routes. Onsite response personnel will only attempt to clean-up or control a spill if they have received the training to do so and are equipped with the appropriate PPE and spill response materials described above. Onsite response personnel will:

- Identify the source and composition of the spilled material by checking containers, warning labels, or markings available;
- Determine the hazard level of the event by consulting the USDOT EMERGENCY RESPONSE GUIDEBOOK or equivalent emergency response guidance for guidelines for responding to the hazardous material spilled;
- Prevent non-emergency personnel from entering the site ensure they are kept at a distance so that they are not injured in case an explosion occurs.
- Immediately notify all trained response personnel;
- Isolate and stop the spill if safely possible;
- Assess the extent of the release;
- Begin clean-up procedures if safely possible, following instructions provided in the site-specific plan, as well as any emergency response measures that need to be considered;
- Materials used for the remediation of spills must be used according to product specifications and guidance for use;
- Initiate evacuation of the area/adjacent areas if necessary;
- After completion of the initial response, any remaining free product and/or contaminated soil will be appropriately characterized, removed, and managed. The affected area will be made safe before allowing non-emergency personnel back into the area.
- In addition to the affected area, equipment and surface that were in contact with the spilled material will be decontaminated too.

7.11.5.2 After spill containment and hazardous waste disposal have been accomplished, the designated person will assess the spill site for evaluation of the damage. Short-term site restoration will include the removal of contaminated soil, decontamination of exposed surfaces, and other immediate actions.

7.11.6 Reporting

7.11.6.1 Any person discovering a spill or release of POL or hazardous substances must immediately report the incident to their supervisor.

7.11.6.2 Records of environmental release reports will be maintained in accordance with the recordkeeping policy.

7.12 Solid Waste Management

7.12.1 Solid wastes must be collected, stored, and recycled in a manner protective of human health and the environment. Uncollected waste may result in serious health and environmental impacts, including pests and diseases, water pollution, and air pollution.

VECTRUS	Document Title:		Document Type:
	Environmental Protection and Management Plan		Procedure (PROC)
BA or Program Name	Environmental, Safety and Health (ESH)	Document #	
Approved By		Revision #	00
Publish Date		Page(s)	15 of 15
Contract Reference	N62742-16-D-3552	Deliverable	N/A

7.12.2 All waste generated as a result of project activities, including spent carbon, must be disposed of appropriately, following the pollution prevention hierarchy.

7.12.3 Waste characterization from the source, including quantities and types of waste, will determine the best plan to manage the waste. The categories of waste chosen for segregation will depend on the project's pollution prevention objectives, and the ability to handle each category. Segregation plans must define materials separated for recycling.

7.12.4 Storage areas should be adequate for the volume of waste generated by the project. These areas should be easily cleaned and maintained and should allow for safe, efficient collection.

7.13 Hazardous Waste Management

7.13.1 Solid waste is hazardous waste if it is specifically listed as a known hazardous waste or meets the characteristics of hazardous waste. Hazardous waste must be managed safely from cradle to grave, that is, from the time it is created, while it is transported, treated, and stored, and until it is disposed of.

7.13.2 Storage

7.13.2.1 Hazardous waste accumulation points (HWAPs) must be located at the point of generation or nearby, and they must be designed and operated to provide appropriate segregation for different waste streams. Warning signs must be placed as required, with the hazardous characteristic of the waste.

7.13.2.2 Project Management must ensure that unauthorized personnel is not allowed in these storage areas.

7.13.2.3 Storage practices must guarantee the safety of personnel and the environment. Ignitable, reactive, or incompatible wastes must be stored so that they do not threaten human health or the environment. Dangers resulting from improper storage of incompatible wastes include the generation of extreme heat, fire, explosion, and generation of toxic gases.

7.13.3 Transportation

7.13.3.1 To be determined.

7.13.4 Disposal

7.13.4.1 Hazardous waste must be disposed of in accordance with Hawaii State Department of Health requirements. Hazardous waste that is destined for land disposal must meet all applicable treatment standards prior to land disposal.

7.14 Nonconformity and Corrective Action

7.14.1 A nonconformity found as a result of an audit, monitoring and measurement process, performance reviews by management, or any other process that indicates that the ESH management processes are not functioning properly or effectively will be documented.

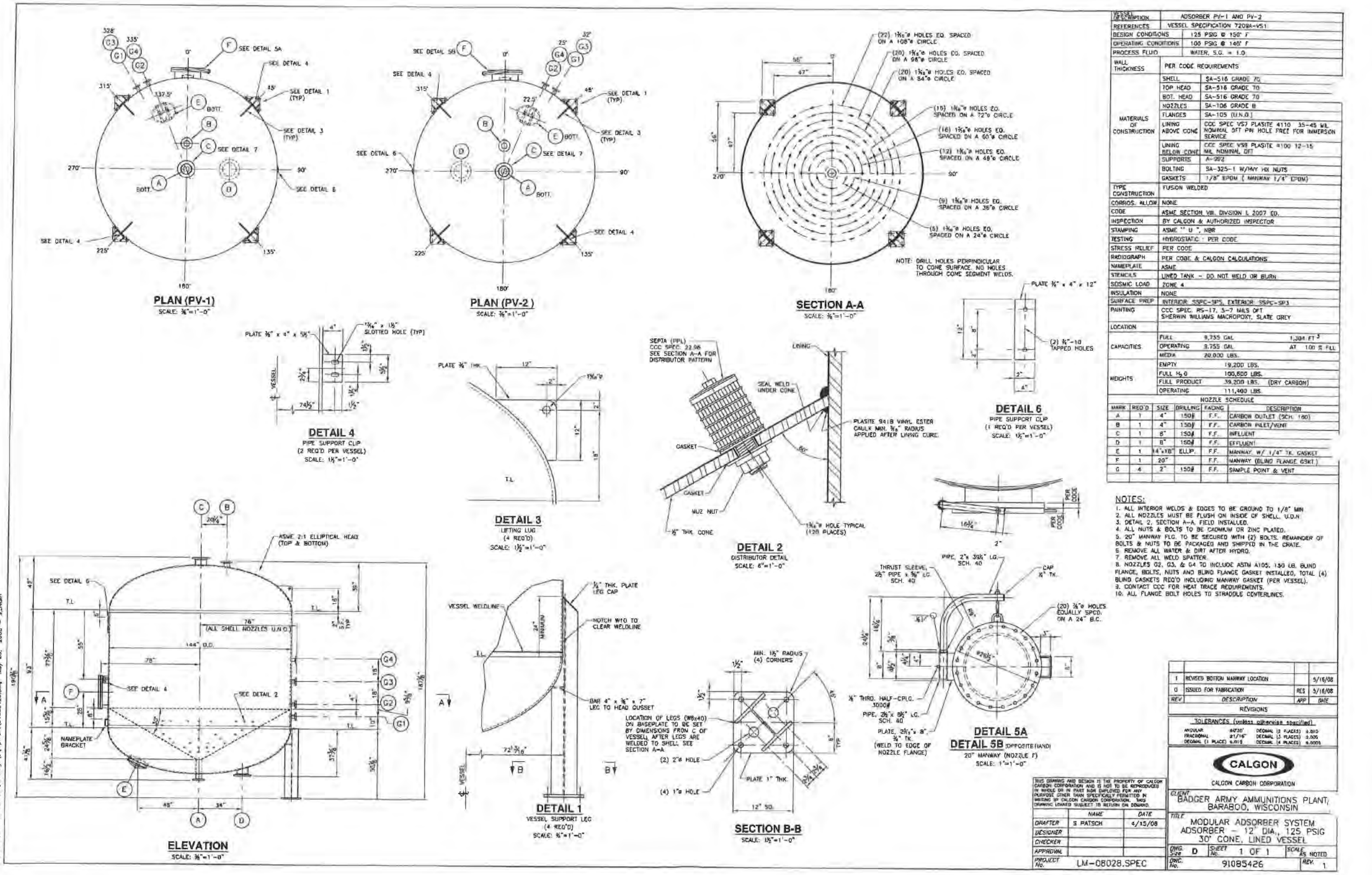
7.14.2 A Corrective Action Tracking system will be used to:

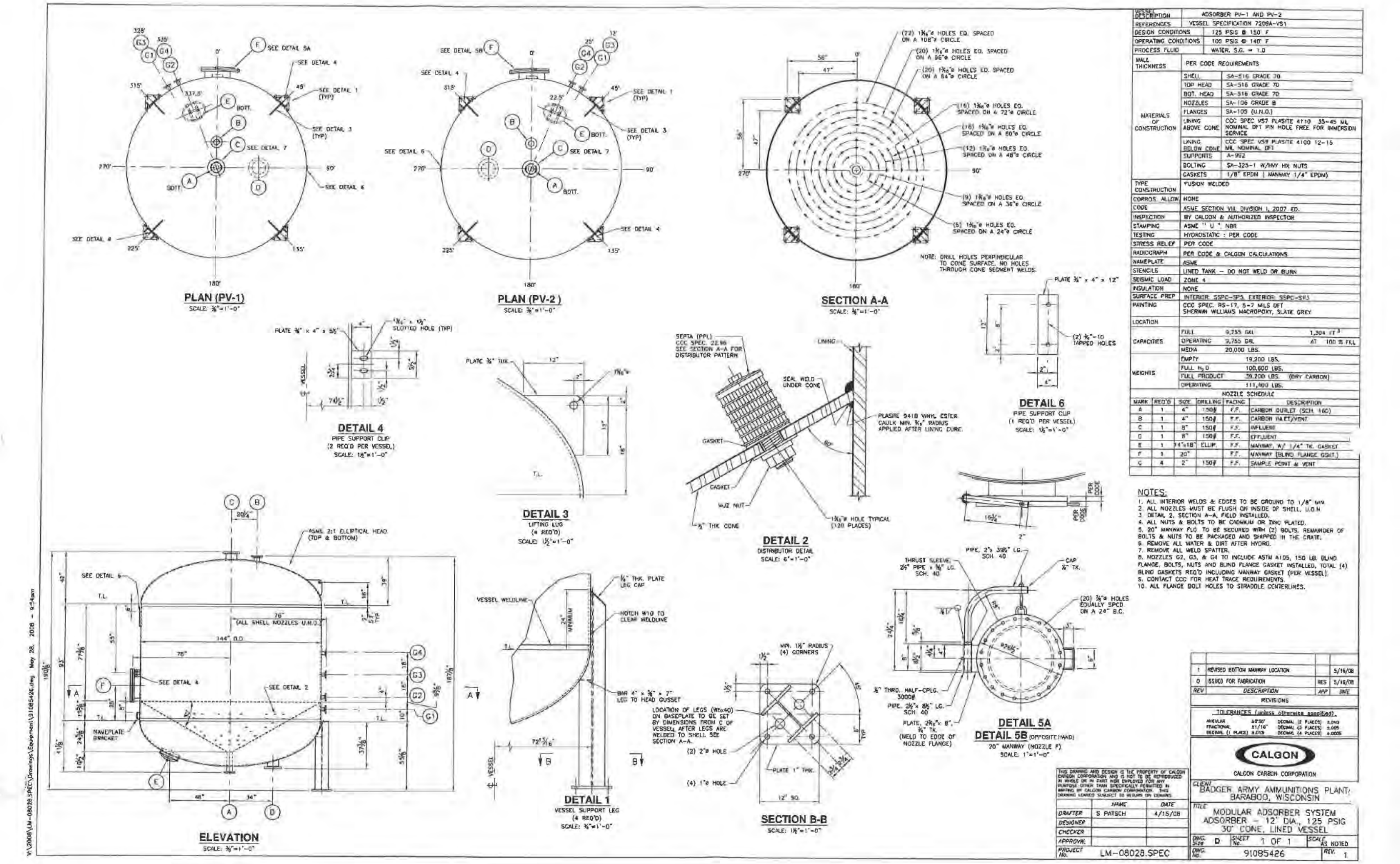
- capture details of the nonconformity;
- identify root causes;
- assign corrective actions;
- define timeframe to close out nonconformity;
- verify action items are completed and effective; and
- close out the nonconformity.

--End of Document--

ATTACHMENT 8 - EQUIPMENT DATA

a. Calgon 20K Tank





b. Memo on 700 gpm Flow Question

January 12, 2022

Mark Mod
Vectrus Systems Corporation
2424 Garden of the Gods Rd, Suite 300
Colorado Springs, CO 80919

Dear Mark,

The attached may help to quell some of the concerns raised regarding flow rates through the Model 12 adsorbers. The 700gpm noted on Calgon's website is a maximum treatment flow rate and if one runs the EBCT calc on it, you find that at that rate, one maintains the 7min EBCT minimum in one vessel. In our application, to minimize the footprint, we are using two vessels to meet the necessary EBCT. You can see from the attached that the flow capacity far exceeds the 700gpm noted on the webpage. The backwash rate is 1,700gpm. These vessels are capable of much more than that.
Hope this helps. If any further questions arise, I'll do my best to provide answers.

Sincerely,

Tony Fisher
Vice President
Clean Harbors Remediation Technologies

c. Response 700 gpm Flow Question

Data Sheet

Pure Water. Clean Air. Better World. CalgonCarbon

MODEL 12

Modular Carbon Adsorption System

Description

The Calgon Carbon MODEL 12 is an adsorption system designed for the removal of dissolved organic contaminants from liquids using granular activated carbon. The modular design concept allows the selection of options, additional accessories or alternate materials to best meet the requirements of the site and treatment application.

The MODEL 12 system is delivered as two adsorbers and a separate compact center piping network and interconnecting piping requiring minimal space and field assembly. The preengineered MODEL 12 design assures that adsorption system functions can be performed with the system as provided. The design has the benefit of Calgon Carbon's extensive expertise and has been proven in numerous applications. The engineering package can be provided quickly and the system expedited through Calgon Carbon's production capabilities.

The process piping network for the MODEL 12 accommodates operation of the adsorbers in parallel or series (with either adsorber placed in first stage). The piping can also isolate either adsorber from the flow. This permits carbon exchange or backwash operations to be performed on one adsorber without interrupting treatment. All valves and accessories are located at low elevations for ease of operation and maintenance.

The unique internal cone under-drain design provides for the efficient collection of treated water and the distribution of backwash water. The internal cone also insures efficient and complete discharge of spent carbon from the adsorber.

The MODEL 12 system is designed for use with Calgon Carbon's closed loop carbon exchange service. Using specially designed carbon transport trailers, the spent carbon can be removed from the adsorber via a pressurized carbon-water slurry, and fresh carbon refilled in the same manner. This closed loop transfer is accomplished without exposure of personnel to either spent or fresh carbon. Calgon Carbon can also manage the disposition of the spent carbon. It can be returned to Calgon Carbon for reactivation, avoiding the need for the site to arrange for disposal.

Carbon Adsorbers	MODEL 12
Carbon steel ASME code pressure vessels	
Internal vinyl ester lining (nominal 35-45 mil dft) where GAC contacts steel for potable water and most liquid applications	
Polypropylene slotted nozzles for water collection and backwash distribution	
Standard Adsorption System Piping	
Schedule 40 carbon steel process piping with cast iron fittings	
Cast iron butterfly valves for process piping	
Full bore stainless steel ball valves for GAC fill and discharge	
PPL lined steel pipe for GAC discharge	
Pressure relief using graphite rupture discs	
Pressure gauges to measure pressure drop across system and each adsorber	
Rupture discs open to each vessel for emergency pressure relief	
System External Coating	
High solids epoxy paint system	
Available Options	
System skid, shipped separately, upon which system components can be assembled	
In-bed water sample collection probes	

Safety Message

Wet activated carbon can deplete oxygen from air in enclosed spaces. If use in an enclosed space is required, procedures for work in an oxygen deficient environment should be followed.

1.800.4CARBON calgoncarbon.com

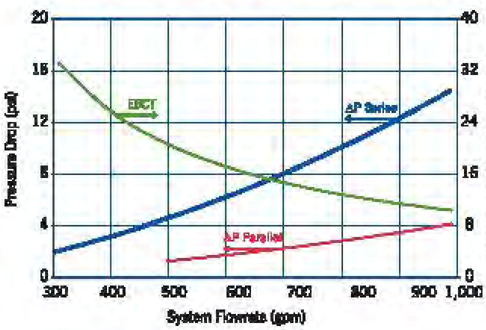
DS-MODEL1215-EIN-E1

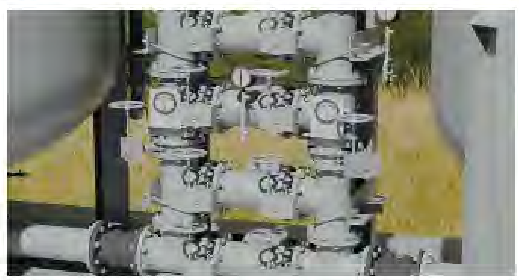
Dimensions and Field Conditions	MODEL 12
Adsorber Vessel Diameter	12' (3,660 mm)
Process and Backwash Pipe	8"
Process Pipe Connection	125# ANSI flange
Utility Water Connection	3/4" hose connection
Utility Air Connection	3/4" hose connection
Carbon Hose Connection	4" Kamlock type
Backwash Connections	8" flange
Drain/Vent Connection	8" flange
Adsorber Maintenance Access	20" round flanged man-way, 14" x 18" man-way below cone
Adsorber Shipping Weight	19,500 lbs. empty (8,850 kg)
System Operating Weight	265,000 lbs. (123,250 kg)

Operating Conditions	MODEL 12
Carbon per Adsorber	20,000 lbs. (9,080 kg)
Pressure Rating	125 psig (862 kPa) @ 140°F
Pressure Relief	Graphite rupture disk (100 psig)
Temperature Rating	140°F maximum (60°C)
Backwash Rate	Typical 1,700 gpm (25% expansion)
Carbon Transfer	Air pressure slurry transfer
Utility Air	100 scfm at 30 psig (reduce to 15 psig for trailer)
Utility Water	100 gpm at 30 psig
Freeze Protection	None provided; enclosure or protection recommended

Model 12 System

20,000 lbs 8x30 Mesh GAC per Vessel 8" Schedule 40 Pipe, 60F





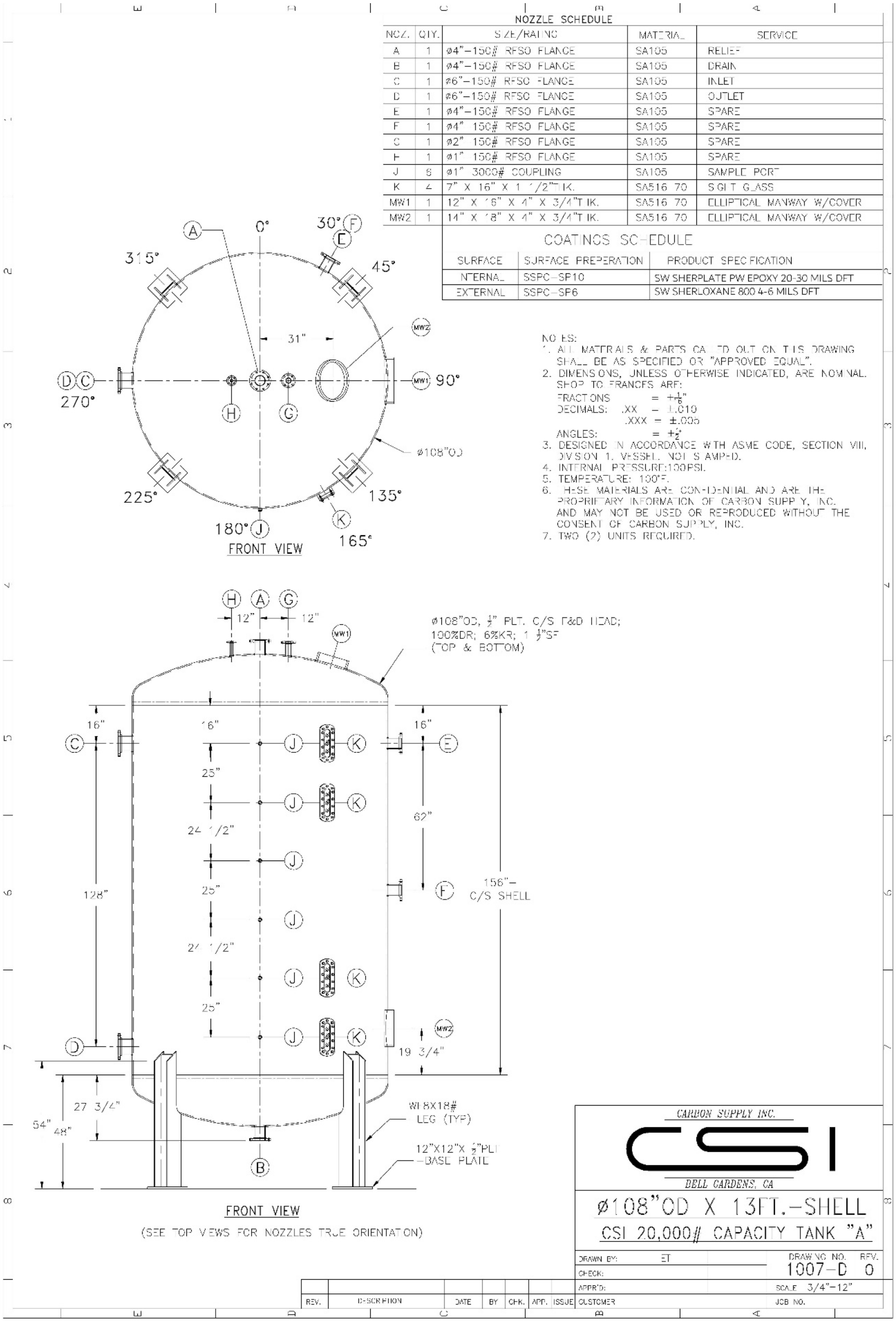
Safety Message

Wet activated carbon can deplete oxygen from air in enclosed spaces. If use in an enclosed space is required, procedures for work in an oxygen deficient environment should be followed.

1.800.4CARBON calgoncarbon.com

DS-MODEL1215-EIN-E1

d. Carbon Supply 20K Tank



e. Hurricane 500 unit

HURRICANE 500

Dimensional drawing on other side

SPECIFICATIONS

- •TRAILER MOUNTED Chassis - tandem 7,000# axles, 4″x 6″ rectangular tube frame, with four 8-lug 235/85/R16 ten ply radials. DOT lighting with electric brakes.
- •POWER SOURCE John Deere Tier 4 turbo-charged diesel engine, 4 cylinder, 4.5 liter, 173 HP @ 2,400 RPM
- •P.T.O. (clutch) Heavy duty NACD 11.5″ clutch
- •VACUUM AIR FLOW (blower) Positive displacement, 2350 CFM capable of 28″ Hg, 5 belt driven with guard. (Roots 616 DVJ or equal)
- •FILTRATION SYSTEM (3-Stage)
  - Stage 1: Cyclonic separation
  - Stage 2: Baghouse/37 Teflon coated, quick change filter bags with air cannon providing reverse pulse filter cleaning
  - Stage 3: Horizontal mounted high efficiency blower safety filter, tool-less filter changeout
- •HYDRAULICS 4.5 GPM, 2200 PSI, direct drive
- •ENCLOSURE Lockable steel shroud over engine
- •INSTRUMENT PANEL (fully enclosed) 12 volt key start, safety system (low oil pressure/high water temperature auto shutdown), oil pressure, water temperature, ammeter, tachometer with hour meter, filter cleaning on/off switch, material vacuum & dump time controls
- •AIR COMPRESSOR Direct drive Bendix twin cylinder; water cooled & oil pressure fed. Haldex air dryer with electronic heater. AMSE certified air tank mounted on vibration isolators (provides air to pneumatic controls and self cleaning filter sytem)

STANDARD EQUIPMENT

- •Paint - one color (custom lettering available)
- •Wet or dry operation
- •Tool box
- •Automatic cone vibrator
- •100 gallon fuel tank
- •Adjustable height pintle hook
- •Emergency stop button pendant
- •10″ inspection door (hopper)
- •Hydraulic lift leg to level trailer
- •Spare tire & carrier
- •Tool-less flip top lid on baghouse

OPTIONS

- •Cold weather package
- •HEPA filtration
- •Slide gate discharge
- •Auxiliary 50 gallon fuel tank
- •16″ manhole on baghouse
- •Asbestos/hazardous waste package
- •Auger in cone
- •Auxiliary air hose 120 PSI
- •Skid mount
- •150 HP electric motor
- •4 point certified lifting cage
- •High reach package

SAFETY FEATURES

- •OSHA approved belt guard
- •Remote pendant emergency stop button
- •Safety struts for baghouse
- •Emergency breakaway chains
- •Wheel chocks
- •Optional HEPA filtration
- •Electric brakes
- •Low oil or high temp engine shutdown

INDUSTRIAL VACUUM

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HURRICANE 500
DIMENSIONS
WIDTH 100"
WEIGHT 10,900 lbs
INDUSTRIAL VACUUM
HURRICANE
Lowered Height 133"
Length when Lowered 214"
*24" High reach option up to 124" discharge height
*Discharge Height 100"
Adjustable hitch range to ground 23"/27"/31"
Length when Raised 293"
Raised Height 220"

ATTACHMENT 9 OPERATIONS MANUAL

Operation Manual

Activated Carbon Treatment System

1-24-22

Telephone Points of Contact:

NAME	NUMBER
NAVFAC Hawaii Duty Officer	(808) 347-8289
Navy Region Hawaii, On Scene Coordinator	(808) 864-2463
Navy Region Hawaii – Regional Dispatch Center	(808) 471- 7117
Red Hill Well Pump Station	(808) 474-4229

Report incidents to the contacts above and the Navy will make the necessary notifications to other agencies.

Navy On-Scene Coordinator will report any releases to DOH within one hour

This manual covers the operation and maintenance (O&M) procedures for the Clean Harbors Environmental Services granular activated carbon treatment system at the Red Hill Remediation Site.

Detailed instructions for operating and maintaining the equipment and instrumentation (if applicable) are contained in the respective manufacturer's literature. This plan will be revised as system upgrades are completed.

I. Description of Filtration System

1. System Components

A. One (1) Vertical Turbine pump will deliver approximately 3,500 gallons per minute of impacted water to the treatment system.
B. 20-inch Metering Valve
C. 20-inch Butterfly Valve
D. Impacted water is pumped to the treatment system through XXX feet of 24-inch HDPE pipe with flow control valves and a flow meter. After the flow meter the flow is split into
E. One (1) 24-inch mag flowmeter
F. One (1) 24-inch mechanical gate valve for flow control.
G. After the gate valve the flow is split to each treatment train with a wye fitting off the main line.
H. Eight (8) 20,000 lb media filters arranged as four parallel trains of lead/lag vessels. The lead vessel in each train is split loaded with 10,000 lbs of 8x30 Reactivated Granular

Activated Carbon (GAC) in the bottom half of the vessel and 20,000 lbs of HS-200 zeolite clay on top of the GAC. The lag vessel is loaded with 20,000 lbs of GAC.

I. 8-inch HDPE pipe conveys water through a flow control valve for each train. Flanged hoses connect the HDPE piping to the inlet of the lead vessel and between the outlet of the lead vessel and inlet of the lag vessel. The outlet of the lag vessel is plumbed with HDPE to a flow control valve and flow meter. Each train has a discharge line to the outfall in Halawa Creek. To reduce energy at the outfall each discharge is split with a wye approximately 20-feet upstream of the outfall.

2. Process Description

The treatment system consists of four (4) parallel systems each consisting of two (2) cylindrical vessels connected in series. Three (3) systems will be in operation with one on stand-by. The lead vessel of each parallel system will be loaded with 20,000 pounds of zeolite clay media in the top half of the vessel and 10,000 pounds of GAC in the bottom half, with the secondary (lag) vessel filled with 20,000 pounds of GAC. Influent water from the Red Hill well will be distributed through a header to each of the three operating lead vessels. The water will be processed through the first vessel, then flow into the GAC bed of the second vessel. Each GAC vessel is rated for an operational pressure of 100 psi with a design flowrate of up to 1700 gpm. Service pressure on the inlet coming from the Red Hill well is anticipated to be in the 30 – 50 psi range. The vessels discharge through anti-siphon loops designed to break a vacuum caused by the large volume of water in the sloped discharge header should the inlet flow be interrupted. This will avoid siphoning the water out of the vessels and exposing the GAC to air.

A Krohne model EnviroMag-2000 electromagnetic flow meter with flanged connection will be fitted into the 24-inch high-density polyethylene (HDPE) pipe leading to the GAC treatment system and on each effluent line exiting the GAC lag trains. Initially grab samples will be collected from installed influent sample port in the pump room, and from mid-point and effluent sample ports on each train. The 24-inch influent flow meter and 8-inch flow meters on each treatment train will be read manually. Flow rates and totals will be recorded at the prescribed frequencies, on daily logs.

Manual flow valves are located upstream of each of the four (4) treatment trains to enable each system to be isolated and additionally, to manually balance the flows between the three operating treatment trains. This will ensure the desired 1,157 gpm feeding each train is achieved. A flow of 1,250 gpm per train should not be exceeded to ensure adequate water/media contact time.

Note: For the initial period of operation until the first media change out on each of the four trains, the fourth train may be used to introduce a stagger in the train flows. This is being done to prevent a situation where all three trains would experience lead tank breakthrough at the same time. When the medial change out on all four trains has occurred and future change-outs are staggered, the fourth train will become the standby train.

Anti-Siphon and Vacuum Protection are required (but not necessary for start-up) since the GAC system is located at a higher elevation than the discharge point and will be installed as all materials are available. If water is drained from one or more vessels, they must be re-filled in a manner similar to the initial fill, which may cause operational delays. To prevent siphoning an automatic air relief (vacuum breaker) and siphon loop are installed on the discharge side of each lag tank. Once the process flow is stopped, the mass of the water in the long discharge lines may pull a negative pressure and start to suck water out of the vessels. To prevent this a vacuum breaker is installed at the top of siphon loop. The vacuum breaker on the siphon loop will open and admit atmospheric air into the top of the loop, which allows the water in the discharge line to drain into the stream without draining the water from the vessels.

The treated water will be discharged into the Halawa Stream. This stream is often dry or maintains only a minimal flow. During seasonal rains, the stream conveys more water, but the discharge rate of 5 mgd will be a small percentage of the streams normal rain event flow. There will be the option to shut down the well pump and stop processing through the GAC if the stream is approaching or experiencing flooding conditions.

The discharge of the treated well water is subject to the Clean Water Act and is regulated by the Hawaii Department of Health through a National Pollutant Discharge Elimination System (NPDES) general permit. Compliance monitoring will be conducted by the Naval Facilities Engineering System Command, Hawaii, and the Hawaii Department of Health. The frequency, locations and analytical parameters will be specified in the Notice of General Permit Coverage (NGPC) issued to the Navy. A copy of the NGPC is contained as Attachment 4 of the Operating Plan.

i. Filter Media

Given the potential for a wide range of petroleum contaminates within the Red Hill well, a treatment system consisting of a first (lead) vessel containing a top layer (approximately equal amount by volume) of zeolite clay and a lower layer of Granular Activated Carbon (GAC) followed by a second (lag) vessel containing a full charge of Granular Activated Carbon (GAC) was selected.

- Zeolite Clay: Such as Hydrosil HS-200 (8 X 14 mesh): is a zeolite-based organoclay, having a high absorption capacity with a porous surface specifically designed to remove emulsions and free hydrocarbon contaminates. The zeolite clay is designed to absorb 50% of its weight in product, with the intention of removing potential gross contamination and prolong the life of the granular activated carbon. When breakthrough conditions are first detected in the lead vessel, the two vessels in that train will be taken off-line and the media changed out in both the lead and lag vessels. As operating experience is gained, there may be the opportunity to change out the lag vessel every two or three changes of the lead vessel.
- The layer of Hydrosil will act to protect the activated carbon beds from any quantities of free product or emulsion phase contaminates that might otherwise overwhelm (coat and render ineffective) the GAC.
- Liquid Phase Reactivated Carbon (8 X 30 mesh): Liquid phase reactivated carbon (also referred to as Granular Activated Carbon, or GAC) is a hard, reactivated carbon manufactured from pooled spent carbon used in a variety of wastewater and process water treatment. This material produces a strong absorption pore structure for a broad range of contaminants and is efficient in removing a wide range of organic compounds.

ii. Empty Bed Contact Time (EBCT)

EBCT is the amount of time in which the influent is in contact with the treatment medium within a contact vessel, assuming all liquid passes through the vessel at the same velocity. EBCT is calculated as the volume of the empty bed divided by the flow rate.

To determining the maximum capacity of the GAC system the following rationale is provided given the recommended EBCT for petroleum is 7.5 minutes (see Attachment 5 of the Operating Plan):

Maximum Capacity of System

Loading of GAC Lead Tank		= 10,000 lbs. GAC
	=	10,000 lbs. / 28 lbs./ft^3
		= 357.14 cubic feet
		+ 20,000 lbs. zeolite clay
		= 20,000 lbs. / 58 lbs./ft^3
		= 344.83 cubic feet
	Total	= 701.97 cubic feet

Loading of GAC Lag Tank = 20,000 lbs.
= 20,000 lbs. / 28 lbs./ft^3
Total = 714.28 cubic feet

Maximum Capacity Per GAC Treatment Train =
[(701.97 ft^3 +714.28 ft^3) x 7.48 gal/ft^3) / 7.5 min] =
1412 gallons per minute or 6.1 mgd Maximum Capacity

iii. Operating Flow Rate

The operating flow criteria for the system is 5.0 million gallons per day (mgd), which equals to 3,473 GPM. Therefore, utilizing three (3) treatment trains, each consisting of two (2) GAC vessels – one lead and one lag – provides sufficient capacity to satisfy a minimum EBCT of 7.5 minutes.

Treatment Capacity = 1157 GPM x 3 = 3,473 GPM

Note: For the initial period of operation up to the first media change out on all four trains, the fourth train may be used to stagger the trains to avoid the potential for a simultaneous bed breakthrough in more than one train.

II. Operating Procedures

1. Preliminary System Checks

Check all equipment, vessels, hoses and connections for leak tightness. If any leaks are found, they are to be repaired or replaced, and the system re-checked.

Ensure all electrical and air connections are complete and secure. Close all sample ports and drain valves on vessels. Open valves for normal system operations.

2. Initial Tank Flooding Sequence – Hydrant Water

The following sequence of steps is for the initial filling of each train in the treatment system, (2) tanks per train:

1. Connect Cam & Groove hose to fire hydrant and to bypass on 24" gate valve.
2. Connect Geo-bags to the two discharge pipes of Train #1 in the concrete basin of the Halawa stream.
3. Close sample ports (SP 101 & 102)

4. Open influent valve (FV101) on Train #1, Tank #1 (V101)
5. Open bypass valve (BV 101) on Train #1 vacuum loop if installed.
6. Close effluent Valves (FV102) on Train #1, Tank #1 (V101) & (FV103) on Tank #2 (V102)
7. Open Hydrant ¼ to ½ turn to begin flow through 12" piping to Train #1
8. As water begins to flow into Tank #1 open air bleed-off valve (ABV101) to allow displaced air to escape. End of blow-off valve shall be placed in a 5gal bucket to capture any water once tank is full.
9. Check for leaks at tank V101 hatches & tank and hose fittings. If leaks are noted stop water flow by turning off hydrant valve. Make repairs if necessary.
10. Once water begins to be discharged from air bleed-off hose of Tank #1, close bleed valve and open Valve (FV102) to begin flow of water to Train #1, Tank #2 (V102).
11. Open air bleed-off valve on Tank #2 (ABV102) to allow displaced air to escape. End of blow-off valve shall be placed in a 5gal bucket to capture any water once tank is full.
12. Once water begins to be discharged from air bleed-off hose of Tank #2, close bleed valve and open Valve (FV103) to begin flow of water to discharge pipe assembly.
13. Check for leaks at tank V102 hatches & tank and hose fittings. If leaks are noted stop water flow by turning off hydrant valve.
14. Verify discharge flow meter is operational.
15. Check discharge point to ensure that water is flowing from the geo-bags.
16. Continue discharging water from Train#1 through geo-bags for approximately ten (10) minutes.
17. After initial flushing is complete BV101(if installed) should be closed to fill vacuum loop assembly.
18. Close hydrant valve
19. Repeat steps 2 through 17 utilizing corresponding valves for Trains #2,3,4.
20. Upon completion of initial fill of all filtration trains, ensure hydrant valve is closed, close bypass on 24" gate valve, disconnect hose from hydrant and gate valve, & close effluent valves on all lag tanks.

The following tables illustrates the valve configurations for the initial tank saturation operations of one filtration train.

Table 1: Initial Fill – Train #1			
Train #1, Lead Tank (V-100)			
Valve	**Label**	**Open**	**Closed**
Influent Valve	FV101	X	
T1 Effluent Valve	FV102		X
T1 Air Bleed Valve	ABV1	X	
T2 Effluent Valve	FV103		X
T2 Air Bleed Valve	ABV2		X
Train #1, Lag Tank (V-101)			
T1 Effluent Valve	FV102	X	

T2 Effluent Valve	FV103		X
T1 Air Bleed Valve	ABV1		X
T2 Air Bleed Valve	ABV2	X	

3. Operating Sequence – Contaminated Water Filtration

1. Verify that 20" metering valve in pump room is set to proper percentage open and that butterfly valve is open.
2. Ensure that recirculation pipe from pump is bypassed to allow partial flow back to aquifer.
3. Open 24" gate valve outside tunnel entrance (inline after flow meter).
4. Check 24" gate valve bypass valves and close if not already.
5. Open influent flow valves FV101, 201, 301, & 401.
6. Check that flow valves FV102, 202, 302, & 402 between lead and lag tanks are in open position.
7. Vacuum loop bypass valves BV 101, 201, 301, & 401 should be closed.
8. Verify all sample ports are closed (SP 101&102, 201&202, 301&302, 401&402)
9. Walk entire pipeline from pump room to discharge point at Halawa Stream looking for evidence of damage to pipe, loose flanges, water leakage, etc.
10. Check discharge points at outfall for obstructions.
11. Stage personnel at the following locations throughout the system:
    A. Pump Room.
    B. Main tunnel adjacent to the 45deg elbow outside of pump room.
    C. Main tunnel near the 45deg offset riser at the stairwell.
    D. Outside the main tunnel at the 24" gate valve.
    E. At each influent valve of trains #1, 2, 3 & 4.
    F. On effluent side of lag tanks.
    G. Along discharge piping between tanks and outfall.
    H. At Halawa Stream overlooking the discharge piping ends.
12. After all prechecks have been completed and personnel have been staged, a Clean Harbors representative will indicate to NAVFAC that the system is ready.
13. Pump initiation will be called in.
14. As water from Pump #2 is sent through the pipeline the personnel will look for leaks and signs of pipe shifting. If no signs of leakage or pipe issues are noted Pump #2 will remain on. If either condition is noted an "all stop" will be called out. System pump will then be shut down and an investigation performed.
15. Proceed to **Routine System Checks**

The following tables illustrates the valve configurations for operations of full filtration system.

Table 2: Operations			
Valve	**Label**	**Open**	**Closed**
24" Butterfly Valve		X	

Train #1 Flow Control	FV101,102,103	X	
Train #1 Air Relief	ABV 101,102		X
Train #1 Vacuum Bypass Valve	BV 101		X
Train #2 Flow Control	FV201,202,203	X	
Train #2 Air Relief	ABV201,202		X
Train #2 Vacuum Bypass Valve	BV201		X
Train #3 Flow Control	FV301,302,303	X	
Train #3 Air Relief	ABV301,302		X
Train #3 Vacuum Bypass Valve	BV301		X
Train #4 Flow Control	FV401,402,403	X	
Train #4 Air Relief	ABV401,402		X
Train #4 Vacuum Bypass Valve	BV401		X

III. Shutdown Sequencing

1. Emergency and Temporary Shutdowns

Follow the Temporary Shutdown procedure given below to secure the system. Take direction of the Navy on site Leadership.

Call the Contact Number for the Pump Station: **808-474-4229** to have the pump turned off then close all flow control valves on operating trains.

In addition, use the emergency shut down buttons on the pump panels adjacent to the pumps in the pump room.

Table 3: Temporary Shutdown			
Valve	**Label**	**Open**	**Closed**
24" Butterfly Valve		X	
Train #1 Flow Control	FV101,102,103		FV-103
Train #1 Air Relief	ABV 101,102		X
Train #1 Vacuum Bypass Valve	BV 101		X
Train #2 Flow Control	FV201,202,203		FV-203
Train #2 Air Relief	ABV201,202		X
Train #2 Vacuum Bypass Valve	BV201		X
Train #3 Flow Control	FV301,302,303		FV-303
Train #3 Air Relief	ABV301,302		X
Train #3 Vacuum Bypass Valve	BV301		X
Train #4 Flow Control	FV401,402,403		FV-403

Train #4 Air Relief	ABV401,402		X
Train #4 Vacuum Bypass Valve	BV401		X

Ensure all electrical and air connections are shutoff and secure. Verify all sample ports and drain valves on vessels are closed.

2. Shutdown for Extended Period or Power Outage

During a longer-term shutdown, it is imperative to drain the system completely. This can be done by evacuating water from the system with compressed air provided by a diesel-powered compressor (185cfm of greater). Compressed air can enter the system through a Chicago fitting on the slurry in line for each lead vessel.

Table 4: Extended Shutdown			
Valve	**Label**	**Open**	**Closed**
24" Butterfly Valve			**X**
Train #1 Flow Control	FV101,102,103	X	FV101
Train #1 Air Relief	ABV 101,102		X
Train #1 Vacuum Bypass Valve	BV 101	X	X
Train #2 Flow Control	FV201,202,203	X	FV201
Train #2 Air Relief	ABV201,202		X
Train #2 Vacuum Bypass Valve	BV201	X	X
Train #3 Flow Control	FV301,302,303	X	FV301
Train #3 Air Relief	ABV301,302		X
Train #3 Vacuum Bypass Valve	BV301	X	X
Train #4 Flow Control	FV401,402,403	X	FV401
Train #4 Air Relief	ABV401,402		X
Train #4 Vacuum Bypass Valve	BV401	X	X

When remediation is complete, and the system is to be shut down and prepared for demobilization; shutdown the system as described above and then drain the system components while ensuring water does not leave the site.

IV. Isolation of a Train for Media Changeout

b. Change out procedures:

Change Outs – The process is outlined below.

- The vessel(s) to have media changed out are taken offline and isolated by closing the lead tank inlet valve labeled FV-101, FV-201, FV-301 or FV-401 depending on the train to be changed.

- Compressed air is supplied to the air vent valve labeled ABV-101, ABV-201, ABV-301 or ABV-401 on the lead tank on the train to be changed, and the air will push the liquid water out of the bottom of the lead tank and up to the inlet of the lag tank. The water will then be pushed through the lag tank GAC bed and the exit out the lag tank discharge and flow to the outfall.
- Once the liquid water is removed, the lag tank discharge valve FV-103, FV-203, FV-303 or FV-403 will be closed.
- The media is then removed from the vessel using a vacuum unit. In this case, we plan to use a Hurricane 500 unit we have sourced on the island.
- The proposed equipment will allow us to place the media in supersacks or special disposal bins or packs. NOTE: Wet media can weigh up to 50% more than dry media due to the adsorption of water into the media or into its interior porosity. It is not recommended to put 3,000 pounds of wet media into a super-sack designed for 2,000 pounds of the same media dry. Therefore, additional bags, bins, or packs will be needed.
- Prior to transport, all spent GAC and zeolite will be stacked on pallets and stored in a closed top roll-on roll-off container (see Attachment 8f of the Operations Plan)
- The sacks will be held in closed top storage for sufficient time to allow all free water to drain, both reducing the final weight and avoiding any unwanted liquid discharge during transport
- This liquid runoff from the sacks will be collected, tested, and disposed of properly.
- The sacks of spent GAC will be tested and profiled for disposal or regeneration.
- The spent zeolite HS-200 cannot be regenerated and will have to be characterized and disposed.
- Once fully drained and profiled, the media will be ready to ship to the chosen facility or location.
- Once the tanks are empty, conduct an inspection of the tank internals, and collect a comprehensive set of photographs of the interiors of the vessels for the permanent project file.

Refill the tanks with the correct medium per Section 3.a. ii of the Operations Plan.

V. Troubleshooting

Refer to manufacturers' manuals for troubleshooting tips.

VI. Routine System Checks

Daily monitoring logs will be completed by each shift of operators and routine intervals as prescribe on the log. An example of the daily log is attached.

1. **Flow Control and Balancing** – The flow rate must be maintained to ensure pumping from the Red Hill Shaft creates and sustains a capture zone in the ground water aquifer. Each train of lead/lag vessels is fitted with an influent and an effluent valve as well as a flow meter. Splitting and balancing the flows is accomplished through manual manipulation of the inlet valves on each train. Flow meter readings will allow operators to balance the flows and ensure the desired flow of 1,157 gpm/ train is achieved.
    a. Balancing flow will be accomplished with one operator manning the flow control valve (FV-101, FV-201, FV-301, and FV-401) ahead of the train and one operator at the flow meter (FI-100, FI-200, FI-300, and FI-400) for the train. The operator at the flow meter will observe the initial meter reading and meter reading after 1-minute. A meter change of 4.39 cubic meters in 1 minute is equal to 1,157 gallon per minute. The flow control valve will be gradually opened or closed until the desired flow rate is established. This may require working back and forth through the three operating trains until all are balanced at the desired flow rate.
    b. Flow rates will be monitored and recorded hourly for each operating train. If adjustments are needed, they will be made as described above.
2. **GAC filters differential pressures** – is a measurement of pressure at the top of each vessel in each train. Increasing pressures over time may indicate fowling of the media bed by sediment or biological growth.
    a. For each train gauges are located as shown on the attached system schematic at labeled PI-101 on the lead vessel and PI-102 on the lag vessel of Train 1. Each additional train is labeled with a PI and corresponding 201, 301 or 401 on the lead vessel and 202, 302 or 402 on the lag vessel.
3. **Influent Sampling** – Frequent samples will be collected from the inlet to the treatment system and evaluated for separate-phase and emulsified hydrocarbons. The influent sample port is located at the 24-inch gate valve as shown on the attached system schematic. If significant quantities of separate-phase or emulsified hydrocarbons are encountered, this will provide valuable information, for assessing future modifications of the treatment system and will guide potential mitigation measures to reduce the free product entrainment. Influent samples will provide data that combined with flow rates establishes a contaminant loading rate on the treatment trains. This data will allow the operators to continually refine the estimated bed life for each train. One influent sample will be collected per day during the first two weeks of operation then weekly thereafter.

4. **Intermediate and Effluent Sampling** – Performance sampling and analysis will be required to ensure that the GAC system is operating at maximum efficiency and that treatment performance complies with the permit limits for the effluent being discharged.

Initially as described, water samples shall be taken and analyzed by a third-party certified laboratory to determine the removal performance of the treatment system, and to determine compliance with discharge limitations.

In addition to third party permit compliance monitoring, additional monitoring and testing will be conducted for process control and assess the need for media change out. Process control testing will initially consist of daily monitoring for the following parameters:

- Total Petroleum Hydrocarbon – Inline Analyzers and periodic manual samples per the sampling schedule
- Visual (effluent outfall and mason jar)
- Tank pressure readings
- Flow readings

Internal performance process testing will be conducted onsite at the prescribed frequency using a portable hydrocarbon analyzer and augmented with the MultiSensor 1200, and 1700 Oil in Water Analyzers once they are installed.

Proposed group of samples:

a. Influent from the well pump (ISP)
b. Outlet of the Lead tank on one train in operation (sample a different train each hour). This sample will be labeled as an intermediate sample and will be collected from the sample ports labeled SP-101, SP-201, SP-301, and SP-401 respectively.
c. Outlet of the Lag tank on one train in operation (sample a different train each hour). This sample will be labeled as an effluent sample and will be collected from the sample ports labeled SP-102, SP-202, SP-302, and SP-402 respectively.

Proposed Sample frequency:

1. For complete system start-up - Every hour for the first 4 hours of operation from one of the three trains in operation, switching every hour to a different train so that in three hours there will be a complete sample set for the GAC system
2. Every 4 hours thereafter switching trains at every sample event so that

by the end of a 12-hour shift there will be a complete sample set for the GAC system.

3. Proposed sample schedule

Proposed Sample Schedules												
	For initial start-up of all three units - sample every hour during the first 4 hours of operation, rotating between operating units				Single unit start up operation - Sample every hour for the first 4 hours				Subsequent operation - Sample every 4 hours rotating between the operating units			
Time	13:00	14:00	15:00	16:00	20:00	21:00:00	22:00	23:00	20:00	24:00:00	4:00	8:00
System Inlet	X	X	X	X	X	X	X	X	X	X	X	X
Unit 1												
Lead Tank Discharge	X			X	X	X	X	X	X			X
Lag Tank Discharge	X			X	X	X	X	X	X			X
Unit 2												
Lead Tank Discharge		X								X		
Lag Tank Discharge		X								X		
Unit 3												
Lead Tank Discharge			X								X	
Lag Tank Discharge			X								X	

5. Inline Analyzers - This section will be updated once the technical package from the analyzer supplier is received and reviewed
6. Piping Inspections – Piping inspections are intended to identify any changes in the system or leaks.
    a. A visual inspection of the entire piping system from the pump room to outfall will be performed every hour. Operators will document any movement of the pipe and look for evidence of leaks at flange connections, fittings and fused pipe joints.
7. Outfall Inspections – A visual inspection of the outfall will be completed and documented every 3-hours during system operation. Items to be observed include estimated depth of flow in the channel, any movement of the outfall piping, and restraint systems are secure.

VII. System Maintenance

See manufacturers' literature for individual component maintenance, Clean Harbors Environmental Services vessels, valving/piping and hose connections should be maintenance free, if maintenance is required, it can be performed on site as needed.

VIII. Illustrations and Attachments

1. Photos of the GAC System
2. Daily Log - Attached
3. P&ID - Attached
4. System Plot Plan - Attached.

Train 1 – flow Control Valve FV-101 on influent side of train.

Train 1 – Vessel 100 and Mid-Point Sample Port SP-101

Train 1 – Vessel 100 and Pressure Indicator PI-101

Train 1 – Vessel V-101, PI-102, Effluent Sample Port SP-102, Flow Valve FV-103, Flow Meter FI-100

Operation Manual
Water Filtration Treatment System
Red Hill Remediation Site, Hawaii

Train 2 – flow Control Valve FV-201 on influent side of train.

19

Train 2 – Vessel 200 and Mid-Point Sample Port SP-201

Train 2– Vessel 200 and Pressure Indicator PI-201

Operation Manual
Water Filtration Treatment System
Red Hill Remediation Site, Hawaii

Train 2 – Vessel V-201, PI-202, Effluent Sample Port SP-202, Flow Valve FV-203, Flow Meter FI-200

Train 3 – flow Control Valve FV-301 on influent side of train. Vessel 300 and Mid-Point Sample Port SP-301

Train 3– Vessel 300 and Pressure Indicator PI-301

Train 3 – Vessel V-301, Effluent Sample Port SP-302, Flow Valve FV-303, Flow Meter FI-300

Train 4 – flow Control Valve FV-401 on influent side of train.

Train 4 – Vessel 400, Mid-Point Sample Port SP-401 and Pressure Indicator PI-401

Train 4 – Vessel V-401, Effluent Sample Port SP-402, Flow Valve FV-403, Pressure Indicator PI-402, Flow Meter FI-400

Operation Manual
Water Filtration Treatment System
Red Hill Remediation Site, Hawaii

RED HILL - DAILY FIELD LOG

Shift Supervisor:						Date:		
Operators:		/				/		
System Start:		System Stop:				Run Time:		
Weather Notes:								
Time/Initials	INF Flow Meter:				Pipeline Check:			
	EFF Meter FI100:							
	EFF Meter FI200:							
	EFF Meter FI300:							
	EFF Meter FI400 End:							
	INF Analyzer (PPB):				Outfall Check:			
	EFF Analyzer A102 (PPB):							
	EFF Analyzer A202 (PPB):							
	EFF Analyzer A302 (PPB):							
	EFF Analyzer A402 (PPB):							
	PI101 PSI	PI102 PSI	PI201 PSI	PI202 PSI	PI301 PSI	PI302 PSI	PI401 PSI	PI402 PSI
Time/Initials	INF Flow Meter:				Pipeline Check:			
	EFF Meter FI100:							
	EFF Meter FI200:							
	EFF Meter FI300:							
	EFF Meter FI400 End:							
	INF Analyzer (PPB):				Outfall Check:			
	EFF Analyzer A102 (PPB):							
	EFF Analyzer A202 (PPB):							
	EFF Analyzer A302 (PPB):							
	EFF Analyzer A402 (PPB):							
	PI101 PSI	PI102 PSI	PI201 PSI	PI202 PSI	PI301 PSI	PI302 PSI	PI401 PSI	PI402 PSI

Page 1 of 2

CleanHarbors
Operation Manual
Water Filtration Treatment System
Red Hill Remediation Site, Hawaii

Time/Initials	INF Flow Meter:	Pipeline Check:
	EFF Meter FI100:	
	EFF Meter FI200:	
	EFF Meter FI300:	
	EFF Meter FI400 End:	
	INF Analyzer (PPB):	Outfall Check:
	EFF Analyzer A102 (PPB):	
	EFF Analyzer A202 (PPB):	
	EFF Analyzer A302 (PPB):	
	EFF Analyzer A402 (PPB):	

	PI101 PSI	PI102 PSI	PI201 PSI	PI202 PSI	PI301 PSI	PI302 PSI	PI401 PSI	PI402 PSI

Additional Notes & Observations:

Page 2 of 2

30

Exhibit B:

NPDES Compliance Monitoring Plan

Red Hill Shaft Recovery Plan NPDES Compliance Sampling Protocol

Red Hill Shaft GAC Water Treatment Unit
Joint Base Pearl Harbor-Hickam, Oahu, HI
January 14, 2022
V.1

This sampling plan has been prepared to document the Department of the Navy's methods and procedures to fulfill anticipated National Pollutant Discharge Elimination System (NPDES) sampling requirements for the Red Hill Shaft Recovery and Monitoring Plan (RHSRMP) (DON 2021). Proposed activities under the RHSRMP include the withdrawal of water from Red Hill Shaft (RHS), treatment in a Granular Activated Carbon (GAC) Water Treatment Unit located near the entrance to Adit 3 within the Red Hill Bulk Fuel Storage facility, and the discharge of treated effluent directly to Halawa Stream, a Class 2 State water. It is the Navy's intent that this sampling protocol be considered in the requested NPDES permit coverage. Proposed changes to this plan, which may be warranted should conditions change, will require the approval of the State of Hawaii Department of Health (DOH) prior to implementation.

This plan was developed to obtain and analyze representative discharges from the GAC. This plan recognizes that field data in conjunction with visual observations at the receiving water location will be critical to make real time determinations whether pumping from Red Hill shaft can continue or must be immediately halted.

Initial compliance samples may be taken under the direct supervision and oversight of DOH Clean Water Branch (CWB) personnel. Split or replicate samples may be ordered by the DOH CWB to verify accurate discharge monitoring results and increase confidence in the compliance monitoring program. GAC operations and NPDES compliance sampling shall be coordinated with the DOH and Incident Command.

The sampling plan includes the following sections:

- Sample frequency
- Sample collection procedures
- Sample chain-of-custody
- Quality assurance/quality control
- Effluent parameters
- Reporting requirements
- Notifications
- Other

Sample Frequency

The RHS GAC unit is expected to operate on a nearly full-time basis for a period of at least several months (the Navy notes that the permit application requested coverage for up to five years), depending on aquifer conditions, to establish hydraulic containment and limit the spread of hydrocarbons, thereby protecting the aquifer. Flow will be continuously monitored using a flow meter on each individual treatment train. The Navy will collect grab water quality samples for analysis of the Hawaii Administrative Rules 11-55 Appendix D Table 34.2 analytes, including total petroleum hydrocarbons (TPH)-diesel range organics (DRO), TPH-gasoline range organics (GRO), benzene, toluene, ethylbenzene, xylenes, lead, and pH. Analyses will also be conducted for TPH-residual range organics (RRO), total TPH (sum of TPH-DRO, -RRO, and -GRO), 1-methylnaphthalene, 2-methylnaphthalene, naphthalene, dissolved oxygen (DO), temperature, conductivity, and turbidity. Grab samples will be collected on a weekly basis.

Composite water quality samples will be collected for whole effluent toxicity (WET) analysis. Composite samples will be collected monthly.

Sample Collection Procedures

Samples of effluent water will be collected from a valve on the discharge hose, but not from the end of the hose. If the GAC system is constructed with non-commingled discharge hoses dedicated to separate treatment trains and if process control monitoring indicates that each treatment train will have equivalent discharge concentrations, then a sample will be collected from only one discharge hose. If process control monitoring suggests that discharge concentrations may not be equivalent between treatment trains, then separate samples will be collected from each treatment train.

A grab sample of the GAC effluent will be collected within 15 minutes of the initial discharge after the unit begins operation and from initial discharge following any 24-hour hour period of non-operation. Subsequent grab samples will be collected according to the frequency specified in the previous section.

At least once per discharge or once daily, if discharge is continuous and duration is longer than one day, the receiving state waters, effluent, and control measures and best management practices, will be visually inspected for turbidity, color, floating oil and grease, floating debris and scum, materials that will settle, substances that will produce taste in the water or detectable off-flavor in fish, and substances that may be toxic or harmful to human or other life (HAR 11-55 Appendix D Part 6[b][2]).

WET samples will be collected as composite samples comprised of at least eight sample aliquots, collected at periodic intervals during the operating hours of the facility over a 24-hour period. The composite shall be flow proportional. WET renewal samples will be collected on day three and day five.

Courier options to deliver WET samples to a mainland laboratory within the 36-hour hold time may not be available. If WET samples are received by the mainland-based analytical laboratory outside of the hold time, then the Navy will consult with the DOH CWB as to whether samples can still be used for WET analysis. To minimize shipping delays, WET sampling will be conducted outside of holiday periods. WET sampling or WET renewal sampling will then resume after the holiday.

All samples will be collected directly into laboratory provided containers (or other containers as directed and approved by the laboratory). Following collection, samples will be immediately cooled on ice and stored in a cooler. Other sample handling procedures in the Navy's Project Procedures Manual (DON 2015) will be followed.

Dissolved oxygen (DO), pH, temperature, conductivity, and turbidity will be measured in the field using handheld or field instrumentation following the collection of samples intended for laboratory analysis. The field measurements will be recorded using a grab sample (not composite). If DO concentrations of less than 4 milligrams per liter (mg/L) are measured, then the Navy will immediately check the receiving water to look for signs of adverse impacts (e.g., fish kills, fish at surface of water column, lethargic movements of fish, etc.).

A sample form will be completed in the field during sample collection. The field forms are provided in Attachment A.

Sample Chain-of-Custody

All samples collected for analysis will be recorded in a field logbook in accordance with Procedure III-D, Logbooks (DON 2015). All samples will be labeled and recorded on chain-of-custody forms in accordance with Procedure III-E, Record Keeping, Sample Labeling, and Chain-of-Custody Procedures (DON 2015).

Each sample will be assigned a chain-of-custody sample identification (ID) number in accordance with the Database Management Plan (DON 2021). All sample ID numbers will be recorded in the field logbook in accordance with Procedure III-D, Logbooks (DON 2015). The chain-of-custody sample ID number (the only ID number submitted to the analytical laboratory) is used to facilitate data tracking and storage and allows all samples to be submitted to the laboratory without providing information on the sample type or source.

Quality Assurance/Quality Control (QA/QC)

QA/QC samples will be collected in accordance with the Navy's Project Procedures Manual, Procedure III-A, Laboratory QC Samples and Procedure III-B, Field QC Samples for Water (DON 2015). It is anticipated that duplicate grab samples will be collected once per month and duplicate WET samples will be collected once per three months.

Effluent Parameters

Table 1 lists the effluent parameters that will be analyzed for and their associated hold times. Effluent parameters, analytical methods, and sampling protocols shall comply with the issued Notice of General Permit Coverage (NGPC). Unless allowed by the type of analysis, all sample vessels will be fully filled such that there is no headspace in the sample container. As practical based on container availability to accommodate at least eight aliquots per 24-hour period for each WET sample and renewal, aliquot bottles used for composite WET samples will be fully filled. The DOH CWB will be notified if container availability or other limitations do not allow for containers to be filled completely.

Reporting Requirements

Field data is to be recorded on the attached Field Sampling datasheet and the Receiving Water Monitoring Observation sheet. Both the Field Sampling datasheets and the Receiving Water Monitoring Observation sheets shall be provided to DOH CWB and appropriate resource agencies weekly, or as otherwise agreed upon between the DOH CWB and the Navy.

Water quality data requiring offsite laboratory analyses shall utilize the Navy's laboratory or laboratories and will report concentrations using standard turnaround times (anticipated to be three weeks).

The Navy will report NPDES required discharge monitoring reports (DMRs) using the standard DMR form (EPA No. 3320-1). Each DMR will only report concentrations for effluent parameters specified in the NGPC. DMRs will be submitted monthly as required by the NPDES standard conditions. Monitoring results obtained during the previous calendar month will be submitted no later than the 28th day of the month following the completed reporting period. Each DMR will be appended with laboratory reports, including any applicable QA/QC data, effluent flow calculations, Field Sampling datasheets, Receiving Water Monitoring Observation sheets, and additional information as necessary.

Notifications

Notification of any noncompliance with NPDES permitting discharge limitations shall be made as required by the issued NGPC. Any exceedances greater than the numeric values included in the RHSRMP shall be reported to the DOH CWB as stated in the RHSRMP. As the GAC treatment and discharge activities are scheduled to continue 24 hours a day, any threat to human or environmental health from the discharges shall be immediately halted and reported to the DOH consistent with the issued NGPC and State Water Pollution laws.

Other

An Initial Investigation Toxicity Reduction Evaluation plan shall be submitted prior to the seventh day after discharge begins.

Table 1: Analytical Parameters and Effluent Limitations

Parameter	Frequency	Method	Units	Effluent Limitations/Screening Levels		Hold Time
				NPDES Limits (freshwater stream)	Surface Water EAL (freshwater) [a]	
Laboratory-Analysis Parameters						
TPH-DRO	Weekly	SW-846 3550/8015	mg/L	Report	0.4	14 days
TPH-RRO	Weekly	SW-846 3550/8015	mg/L	Not required	0.5	7 days
TPH-GRO	Weekly	SW-846 3050/8260 [b]	mg/L	Report	0.3	14 days
Total TPH	Weekly	Sum of TPH-DRO, -RRO, and -GRO	mg/L	Not required	—	—
Benzene	Weekly	SW-846 3050/8260	mg/L	1.8	0.005	14 days
Toluene	Weekly	SW-846 3050/8260	mg/L	5.8	0.04	14 days
Ethylbenzene	Weekly	SW-846 3050/8260	mg/L	11	0.03	14 days
Xylenes	Weekly	SW-846 3050/8260	mg/L	Report	0.02	14 days
Total lead	Weekly	SW-846 6010B	mg/L	0.029	0.015	6 months
Organic lead	Weekly	SW-846 6010B / 939M [c]	mg/L	Report	—	6 months
Whole effluent toxicity [d]	Monthly	EPA 821/R-02-013	—	Pass	—	36 hours
Residual Chlorine [e]	Monthly	4500-CL G-2011 or SM 4500-Cl G	mg/L	Report	—	[e]
Field Parameters						
Flow	Continuous	—	gallons per day	Report	—	—
pH	Weekly	—	Standard units	5.5-8.0	—	Immediate
Dissolved oxygen	Weekly	—	mg/L	Report	—	Immediate
Temperature	Weekly	—	°C	Report	—	Immediate
Conductivity	Weekly	—	µS/cm	Report	—	Immediate
Turbidity	Weekly	—	NTU	Report	—	Immediate

Note: Storm water discharge limitations are the chronic water quality standards established in section 11-54-4, for fresh waters. For pollutants which do not have established chronic water quality standards, the Navy will make best efforts to report concentrations at a detection limit of 0.01 µg/L; however, detection limits are laboratory and method specific and may not be achievable for all analytes (e.g., TPHs).

— not applicable

[a] DOH EALs Fall 2017 Table D (Surface Water Bodies).

[b] TPH-GRO will be analyzed by method 8260. Method 8260 has a lower reporting limit than method 8015 and will allow the Navy more flexibility if comparison to lower screening levels (i.e., environmental action levels) are required.

[c] The Navy recommends analysis of organic lead by both 6010B (per the NGPC) and 939M. The nitric acid preservative in the 6010B container may dissolve both inorganic and organic metal in the water, which may bias the results high. The container for the 939 method is not preserved and allows for differentiation between organic and inorganic lead.
[d] The Navy will utilize the fathead minnow (*Pimephales promelas*) as the test organism. If the fathead minnow is not available, then the daphnid (*Ceriodaphnia dubia*) will be used.
[e] The Navy will consider analysis of residual chlorine and chloride, as appropriate and practical, to supplement the WET analysis. Additional information regarding holding times for residual chlorine laboratory analysis will be determined with the analytical laboratory.

Attachment A:
Field Forms

NPDES GAC Discharge Field Sampling Data Sheet

Observer Name(s): ________________________ Company: _______ Date: _________ Time: _______

GAC Unit: ___________ Coordinates (latitude and longitude): _________________________________

Associated Flushing Report ID: ___________________________

WEATHER CONDITIONS

NOW	Past 24 Hours	Has there been a heavy rain in the past 7 days?
☐ storm (heavy rain)	☐ storm (heavy rain)	☐ yes ☐ no
☐ rain (steady rain)	☐ rain (steady rain)	Ambient Air Temperature (°F)
☐ showers (intermittent)	☐ showers (intermittent)	
____% cloud cover	____% cloud cover	Humidity (%):
☐ clear/sunny	☐ sunny	Wind (mph):

WATER QUALITY:
Equipment (Make, Model S/N): ____

____

DO (mg/L): _______ (if <4 notify observer, if present for location, to visually monitor receiving body for adverse impacts)

pH (S.U.): ________ (effluent limits = freshwater stream 5.5-8.0)

Conductivity (mS/cm): ________ Temperature (°C): _______

Turbidity (NTUs): ________ Flow (gpm): ________

Lab Analysis Parameters: ____

____

GAC Serial #/ID: ____

GAC Start Time: _____________________ Sample Collection Time: ____________________

Grab Sample ID: ____

Composite/WET Sample ID: ____

Water Odors	Water Surface Oils	Water Appearance
☐ Normal/none	☐ None	☐ Clear
☐ Petroleum	☐ Slick	☐ Opaque
☐ Fishy	☐ Sheen	☐ Slightly Cloudy
☐ Sewage	☐ Globs	☐ Cloudy
☐ Chemical	☐ Flecks	☐ Other
☐ Other	☐ Other	Color:

Adapted from USEPA. Rapid Bioassessment Protocols and NPS Pacific Island Network Inventory & Monitoring Protocols

Notes:____
____
____
____
____

Observer 1 Signature: ____ Date: _________________

Observer 2 Signature: ____ Date: _________________

Daily Receiving Water Monitoring Observation Sheet

Observer Name(s): ___________________________ Company: ________ Date: __________ Time: ________

Coordinates (latitude and longitude): _____________________________________

Associated Flushing Report ID: ______________________________

WEATHER CONDITIONS

NOW	Past 24 Hours	Has there been a heavy rain in the past 7 days?
☐ storm (heavy rain)	☐ storm (heavy rain)	☐ yes ☐ no
☐ rain (steady rain)	☐ rain (steady rain)	Ambient Air Temperature (°F)
☐ showers (intermittent)	☐ showers (intermittent)	
_____% cloud cover	_____% cloud cover	
☐ clear/sunny	☐	

WATER QUALITY:

Water Odors	Water Surface Oils	Water Appearance
☐ Normal/none	☐ None	☐ Clear
☐ Petroleum	☐ Slick	☐ Opaque
☐ Fishy	☐ Sheen	☐ Slightly Cloudy
☐ Sewage	☐ Globs	☐ Cloudy
☐ Chemical	☐ Flecks	☐ Other
☐ Other	☐ Other	Color:

PLANT & ANIMAL MONITORING:

% Stream Covered in Plants	Is there any whitening or other discoloration of aquatic botanical species (algae and other water plants)	Observation of Stress on Animal or Aquatic Life
	☐ None ☐ Yes	Fish Breathing Distress/Gulping? ☐ None ☐ Yes
Fish Kill? ☐ yes ☐ no	# Fish Dead	Abnormal Animal Behavior Near Discharge? ☐ None ☐ Yes
Dead Invertebrates? ☐ yes ☐ no	# Invertebrates Dead	Invertebrates collected? ☐ None ☐ Yes
Other Dead Animals? ☐ yes ☐ no	# Dead	Notes (describe any yes):

Observer Signature:____ Date: ____________________

Adapted from USEPA. Rapid Bioassessment Protocols and NPS Pacific Island Network Inventory & Monitoring Protocols

Exhibit C:

May 6th Release and Nov 20th Release Notice of Interests' Groundwater Sampling Plan

Appendix E Groundwater Sampling Plan
Revised December 27, 2021

The objective of the following Groundwater Sampling Plan is to obtain an assessment of groundwater impacts from the May 6 and November 20, 2021 release events, as well as evidence of recent mobilization of earlier fuel spills remaining in the vadose zone. Based on data obtained and additional work to identify nature and extent of the fuel releases on the environment, the scope and frequency of data collection may change. In addition, the groundwater sampling program may eventually be utilized to evaluate the effectiveness of contaminant containment or as a possible indicator of potential impact on Red Hill Shaft during pumping. Effective the week (December 13-17, 2021), the Navy's groundwater sampling plan shall at a minimum consist of:

1. Collect the samples noted on Tables 1, 2 and 3. HDOH or an HDOH contractor shall be afforded an opportunity to be present to observe, and elect on a well by well basis to obtain, handle, and ship the split sample to the HDOH contracted laboratory for analysis;
2. Provide the results in an extractable laboratory database format with an updated cumulative groundwater results spreadsheet in excel format;
3. Have the laboratories provide EDD files and all chromatograms in electronic format of the ASCII files (including a PDF format copy). This includes results from the May 6th release, long term monitoring data, and the Nov 20th release incidents;
4. Provide all the field logs in excel spreadsheet of the Groundwater (GW) monitoring at mentioned wells, since the May 6th release incidence through present and beyond (e.g., Redox Parameters, pH, Total Dissolved Solids (TDS), Oxidation Reduction Potential (ORP), etc.);
5. Provide all the field logs in excel spreadsheet of the Soil Vapor monitoring activities, since the My 6th release incidence through present and beyond;
6. In addition to groundwater samples, provide free product gauging using a bailer and headspace measurements using a photo-ionization detector (PID) for all locations; and
7. Provide fuel fingerprinting for:
   a. Fuel from the Nov 20th release and a sample collected from RHMW2254-01 on December 2, 2021.
   b. The three (3) different fuel types used at Red Hill obtained in response to the Hotel Pier release.
   c. The Fuel Analysis of Free Product mentioned in Table 2 will be analyzed only once.

Please see *Table 1* for the for the Groundwater Sampling Plan, *Table 2* for the Groundwater Parameters and *Table 3* for the Soil Vapor Monitoring and Summa Cannister Sampling.

Appendix E Groundwater Sampling Plan
Revised December 27, 2021

Table 1. Groundwater Sampling Plan

Sample type	Incidence date	Locations	Collection Method	Frequency of sampling	Duration of sampling	Analytes	Reporting Turn Around Time (TAT)
Ground-water	Nov 20th (14 GW wells with 1 Sump and 1 AFFF tank)	RHMW05 RHMW08 RHMW06 RHMW09 RHMW12 RHMW12-A RHMW17 *(when complete)* RHMW16 OWDFMW01	Bailer: RHMW04 RHMW05 RHMW06 RHMW08 RHMW09 RHMW19 Low Flow pump: RHMW12-A RHMW17 (*when complete*) RHMW16 OWDFMW01 Additional four OWDFMW wells*	Weekly	2 months	See Table 2	7 days
		RHMW2254-01 *(2 samples)*	Bailer & Low flow dedicated pump (both)	Weekly	2 months		
		RHMW11 (Zone 5) RHMW13 (Zone 5) RHMW 14 (Zone 3) RHMW15 (Zone 5)	Low flow (Westbay sampling method) Headspace/FP check will be taken after every sample collection)	Weekly	2 months		

	One time groundwater analysis of water portion from the:	**Infiltration Groundwater Sump****	**If additional water enters the sump, sampling to restart and continue weekly instead of a one-time sample**				
		Waste in AFFF tank	**One time**				
	May 6th	**RHMW01R, RHMW02, RHMW03**	**Bailer**	**Weekly**	**2 months**		

*Navy request to include 4 new wells at the OWDF to the GW sampling is approved. DOH reserves right to adjust specific wells selected within two weeks of receiving the monitoring well installation records and field notes.

**The Infiltration Groundwater Sump was sampled by the Navy on November 24, 2021, and these results, once received, will meet the one-time requirement of the sampling plan. If additional water enters the sump, we are asking for weekly sampling instead of a one-time sample.

Table 2: Groundwater Parameters (Analytes): Analyze all the analytes mentioned in the "Table 1. Tier 1 Screening Levels for Groundwater" mentioned in Hawaii Administrative Rules, Section 11-280.1 Subchapter 6: Release Response Action. (§11-280.1-65.3 Site cleanup criteria). In addition, add the following analytes:

Parameters	Analytical method	Analytes	HDOH-EALs (ug/L)	Lab Limits
Total Petroleum Hydrocarbons (TPH) -gasoline range organics (g), diesel range organics (d), or oil range organics (o)	**EPA 8260**	**TPH-g**	**300**	**Requests for the Lab:** 1. Please provide appropriate Limit of Quantitation (LOQ), Limit of Detection (LOD), Method Detection Limit (MDL) for each method. 2. Please ensure MDLs will detect for chemicals with
	EPA 8015	**TPH-d**	**400**	
		TPH-g	**300**	
		TPH-o	**500**	
TPH with Silicon Gel Cleanup (SGC) (TPH-d and TPH-o with SGC would only be analyzed in samples with positive detections of TPH-d and TPH-o without SGC).	**EPA 3630 / 8015**	**TPH-d**		
		TPH-o		
VOC (Full suite) against appropriate HDOH-EALs Including BTEX	**EPA 8260 (full suite)**			

Parameters	Analytical method	Analytes	HDOH-EALs (ug/L)	Lab Limits
				low level EALs (e.g. Benzo-a-Pyrene).
SVOC (Full suite) against appropriate HDOH-EALs Including naphthalene, 1-methylnaphthalene, 2-methylnaphthalene	**EPA 8270 SIM (full suite)**			
One time Fuel Analysis of Free Product from the: **(1) RHMW2254-01** **(2) Waste in the AFFF tank** **(3) Infiltration Groundwater Sump where fuel was collected***	**EPA 8015 B**			**Sample the waste in the AFFF tank if the waste is still representative of what was pumped from the Nov 20th release.**
Total Organic Carbon	**EPA 9060A**			
Methane	**RSK 175 M**			
PFAS	**EPA 537.1 or** **EPA 1633 (draft) ** **			**from RHMW2254 -01. Only one time analysis is requested.**
Lead Scavengers (1—dibromomethane and 1-2 dichloroethane)	**EPA 8011 and EPA 8260**			

** Run EPA draft method 1633 for matrices other than drinking water on the groundwater sample from RHMW2254-01. HDOH acknowledges that laboratories are likely not accredited for this new method.

Table 3. Soil Vapor Monitoring and Summa Canister Sampling

SAMPLE TYPE	METHOD	LOCATIONS	FREQUENCY/DURATION
Soil Vapor Concentrations	Photo-ionization Detector (PID)	All SV probe locations including new probes installed since 11/20/21. Include background reading at each tank	Once per week for 2 months Field note images delivered to DOH within 12 hours of collection and data tables listing ongoing results displayed within 7 days.
Summa Canister Samples	TO-15 & TO-3 w/ C5-C12	SVMP with highest PID readings (e.g., SV15S, SV17S, SV18S, SV20M) and most outer bound probe under the same tanks (SV15D, SV17D, SV18D, SV20D)	Once per month for 6 months.
	TO-15 & TO-3 w/ C5-C12	Collect one round of SVMP samples in the lower tunnel near station 400 and other SVMPs to fingerprint fuel signature	Consider future SVMP summa samples to evaluate migration of other older releases.

Exhibit D:

Groundwater Monitoring Plan

(Reserved for amended Groundwater Monitoring Plan)

Exhibit E:

Halawa Stream Monitoring and Division of Forestry and Wildlife Waterbird Survey Data Sheets

WATERBIRD SURVEY DATASHEET

WETLAND CONDTION CODES		WEATHER CODES	
Water Level (WL)	**Human Impact (HI)**	**Rainfall (RF)**	**Wind**
0 = dry	0 = indirect (little garbage, few people)	0 = no rain	0 = no wind, < 1 mph
1 = lower than normal	1 = moderate	1 = mist or fog	1 = smoke drifts, 1-3 mph
2= normal	2 = heavy (many people present;	2 = drizzle	2 = wind felt on face, 4-7 mph
3 = higher than normal	e.g., wading, boating, fishing, etc)	3 = light rain	3 = leaves and twigs rustle, 8-12 mph
Vegetation Cover (VC)	**Shoreline Condition of Tidal Wetlands (SC)**	4 = heavy rain	4 = dust raises, branches stir, 13-18 mph
0 = open water (<25% veg)	0 = water at high tide mark N/A=not applicable	5 = snow or hail	5 = small trees sway, >19 mph
1 = 26-50% veg cover	1 = water 25 ft from high tide mark	**Cloud Cover (CC)** = Estimate to the n**earest 10%**	
2 = 51-75% veg cover	2 = water 50 ft from high tide mark		
3 = >75% cover	3 = water >50 ft from high tide mark		

REMINDERS: If site it not accessible, include wetland name and write 'no access'
If no birds observed, fill out top portion and write 'no birds'
KEEP A COPY FOR YOUR RECORDS
Subadult includes juveniles and chicks

Observers ______________________

Date ______________________

Island ______________________

Wetland Name																
Condition	WL	VC	HI	SC	WL	VC	HI	SC	WL	VC	HI	SC	WL	VC	HI	SC
Weather	CC	RF	Wind		CC	RF	Wind		CC	RF	Wind		CC	RF	Wind	
Time	Start		Stop		Start		Stop		Start		Stop		Start		Stop	
COOT adult																
subadult																
GALLINULE/MOORHEN adult																
subadult																
STILT adult																
subadult																
KOLOA adult																
subadult																
Koloa/Mallard Hybrid																
Mallard (domestic/feral)																
Other Domestic Duck																
Black-cr. Night Heron																
Cattle Egret																
Pacific Golden Plover																
Ruddy Turnstone																
Sanderling																
Wandering Tattler																
Northern Pintail																
Mallard (migratory)																
Lesser scaup																
Comments																

Rev. Aug 2017

Exhibit F:

Previous Biodiversity Study on Halawa Stream

<u>Halawa Stream Findings from the Biodiversity of Fish in Five Pearl Harbor Streams (Oct 2021)</u>

Halawa Stream Site Description:

Hālawa is the most southeastern stream of the Puʻuloa drainage system (Englund et. al., 2000). It makes up the Hālawa ahupuaʻa and a sub-watershed of the Central Oʻahu Watershed (Oceanit et. al., 2007). The headwaters of the stream begin from two tributaries at nearly 2500 ft at the top of the Koʻolau Mountains near the Tetsuo Harano Tunnel and H-3 Freeway (Google Maps, accessed May 2021). Kamananui (North Hālawa) Stream follows the H-3 Freeway to the Moanalua Freeway junction. Kamanaiki (South Hālawa) Stream runs from the Koʻolau Mountains on the north side of the Moanalua Ahupuaʻa ridgeline and south of Red Hill. The tributaries are un-channelized until their convergence in the Puʻuloa central basin at the junction of the H-3 and Moanalua freeways. The main stream channel is then heavily channelized in sections under the H-1, H-3, and H201 freeways and through Aloha Stadium up to Salt Lake Boulevard. Fluvial wetland habitat appears to be within and between these channelized sections of stream under the freeways and are described in more detail in the Pearl Harbor Wetland Inventory of 2007 (Wil Chee Planning Inc., AECOS, Inc., 2007).

Below the construction of the Salt Lake Boulevard bridge there is a levee within the canal that prevents marine tidal influence further inland. Here the stream's freshwater from the canal system merges with the lower sitting brackish water of Pearl Harbor. The stream then opens to a 1.1 km (0.7 miles) long riparian corridor which facilitates aquatic environments such as pools, rock strewn mud flats, stream runs, and mud banks lined with Red Mangrove. The corridor passes under the Kamehameha Highway and Pearl Harbor gas pipeline. The stream then immediately enters East Loch, confined within concrete bulkheads that run along the property lines of the Pearl Harbor National Memorial Visitors Center and JBPH-H's Hālawa Gate entrance. The stream mouth is located within the highly operated seaport of JBPH-H's Main Shipping Channel.

Hālawa Stream

Upstream Transect: Latitude: 21°22'3.14"N Longitude: 157°55'48.96"W
Downstream Transect: Latitude: 21°21'56.12"N Longitude: 157°56'17.03"W

The lower reaches of Hālawa stream can be described in two sections. A freshwater section above the Salt Lake Boulevard bridge and an estuary section below the Salt Lake Boulevard bridge. Directly under and upstream of the Salt Lake Boulevard bridge, the freshwater of Hālawa stream shallowly riffled over the concrete floor of the canal system and hit pockets of sand, pebbles, and non-native grass on either side of the canal's walls. Aʻeo and ducks were occasionally seen here along the concrete. Divots in the concrete floor created pooling areas for small fish passage upstream. Dozens of snails were found along the shallow, fast moving riffles of water on the concrete floor. The stream was completely freshwater continuing upstream from the Salt Lake Boulevard bridge. The stream did not experience any marine influence due to the construction of a smooth levee within the canal system.

A brackish riparian corridor emerges downstream of Salt Lake Boulevard bridge to the stream mouth entering East Loch. Freshwater from upstream exited a canal levee along the left and the right wall and quickly pooled at the convergence with the lower setting brackish waters of the estuary. Mudflat point bars were exposed between the meander of the stream to the stream mouth. Schooling Mullet (Mugilidae) and small numbers of Flagtails (Kuhliidae) were found swimming in the pebble comprised stream bed along the perimeter of mudflats and mangrove in the riparian corridor. From the upstream transect site located below the canal levee to Kamehameha Highway millions of Gold Spot Sardine were observed in the 1.8 m (6 ft) deep sections of the channel's thalweg on multiple survey events. Towards the mouth of the stream, the stream was shaded by the bridge footings of Kamehameha Highway were resident fishermen often occupied the area.

Hālawa Upstream:

The upstream transect was located 0.9 km (0.6 miles) upstream from the stream mouth outlet where the freshwater and brackish water of Hālawa Stream merged at the start of a canal system levee. This confluence was accessed from the south east side of the Salt Lake Boulevard bridge by scaling the concrete walls of the concrete canal located behind McDonald's. Tilapia were found in large quantities in the pools created from the convergence of freshwater. They were unable to move upstream past the smooth levee where the canal's concrete floor started.

Surveying took place in an area between the left and right bank pool directly below the concrete levee. The transect ran across the natural stream bed in a continuous section of stream. It was X m wide and 2.3-m (7.5 ft) deep. Water chemistry patterns observed between surface, center, and benthic sampling depths reflected water circulation and mixing patterns of fresh and tidal dominated waters at a pool. For instance, benthic water was on average completely fresh with a salinity value of 0.60 ppt while surface waters had an average salinity value of 15.3 ppt (Appendix H). Standard deviation values were relatively high for salinity, DO, and temperature recordings and indicate fluctuations and turbulence at the convergence of fresh and marine water (Appendix H). The stream floor at the transect consisted of land-based sand, pebbles, and river rock. Mullet (Mugilidae) were frequently observed in the area along the shallower mudflat areas near the mangrove lined stream banks.

Hālawa Downstream: The downstream sampling transect divided the entrance to the deep bay of East Loch and the mudflats habitats that were available just upstream of the downstream transect line. The downstream transect was positioned just below and parallel to the Pearl Harbor gas pipeline just before the concrete bulk heads at the stream mouth ran along the left and right bank. Here, the stream was X wide. Fish were surveyed by boat on the downstream side of the gas pipeline. On the right bank of the transect, there was a shallow mud flat that was 0.9-m deep (Table 8). Mangrove seemed to be the primary entity retaining sediment. The stream channel thalweg and left bank were deeper at 2.3 and 1.9-m deep, respectively (Table 8). The shoreline on the left bank was comprised of reef and concrete rubble mixed with dark course sediments. Sponge resembling *Haliclona caerulea* was occasionally found along the shoreline of the left bank. Water between surface, center, and benthic water columns were completely marine with salinity values of 30.5 ppt, 33.9 ppt, and 34.0 ppt, respectively (Appendix I). There was an indication of freshwater streamflow given a sd. of 6.4 ppt for surface water salinity and a stream flow value of 0.06 ft/s. Conductivity at the center water columns was the highest between surface and benthic depths at 35353.0 µS/cm.

Hālawa Fish Detections: Hālawa Stream showed the least species richness ofthe Pearl Harbor streams with a total of 92 different fish species. The Shannon index value for the stream was 4.12. Although Hālawa was the least specious, detection values for CHCRT, PHCRT, and of interest estuarine fish was comparable to Waikele Stream and outnumbered Kalauao Stream (Figure 16 C). There were also more BMUS fish at Hālawa than Kalauao Stream (Figure 16 C). Hālawa Stream had the fewest number of unique species to contribute to the inventory of fish in Pearl Harbor. Three species were found at Hawala and nowhere else. This includes the Bay Cardinal Fish *Foa brachygramma*, the Whitetip Reef Shark, and the non-native Brushtail Tang (Table 10). Unlike Waikele, Waiawa, and Kalauao, but similar to Eʻo, there were more detections for estuarine fish at Hālawa than any other habitation range for species (Figure 16 A). There were 9 fish species that were only found upstream and not found at the downstream transect. Downstream, there was a total of 37 fish species that were not detected upstream (Table 9).

The topmost detected fish species were Gold-spot Sardine, Blackchin Tilapia, HawaiianAnchovy, Kanda Mullet, Western Mosquitofish, ʻoʻopu ʻakupa, and Stiped Mullet (Appendix J). Detections for these fished ranged between 15-18 detections (Appendix J). Hālawa Stream had more native and endemic species found than non-native (Figure 15 B). The endemic Hawaiian Flagtail was captured more at Hālawa than Eo, Waiawa, and Kalauao Stream. Leatherback Lai*,* Bluefin Trevally and Giant Trevally were also among the top native species occurring at the stream site. They were commonly captured downstream via angling during dry survey events when water was less turbid (Appendix J). The Title Trevally *C. tille* was detected once.

Two culturally important shark species, the Whitetip Reef Shark and the Scalloped Hammerhead Shark, were both found at Hālawa Stream (Appendix K). Hammerhead detections were made at both upstream and downstream transect. In addition, detections of Hawaiian Anchovy and Gold-spot Sardine was particularly interesting in comparison to the other streams. There were more Gold-spot Sardine at Hālawa than any other stream. Hawaiian Anchovy was detected just as often in Hālawa as in Waikele Stream. Both species were observed independent of each other in large schools swimming upstream of the stream mouth transect site.

Hālawa stream notably had both reef and estuarine dwelling fish species. Notable reef species for the site include Seahorse species such as the Smooth Seahorse *Hippocampus kuda* and a visual observation of the Fisher's Seahorse *Hippocampus fisheri*. Yellow Tang *Zebrasoma flavescens* was detected just as frequently in Hālawa as in Eo. The Sripped Belly Pufferfish was detected more in Hālawa than any other stream (Appendix K). Other nearshore and estuarine fish that were associated with the stream site include Barracuda *Sphyraena barracuda*, and Hawaiian Lizardfish *Synodus* ulae. The Clouded Lizardfish *Saurida nebulosa* was detected more at Hālawa than anywhere else. Shortjaw Bonefish was occasionally caught via angling. *A. glossodonta* was detected 9 times (Appendix J-K).

Each of the five endemic Hawaiian Goby species were detected at the stream site. Detections for endemic ʻoʻopu were comparable to that of the other streams with more detections for ʻoʻopu naniha and ʻoʻopu nakea than at Eʻo Stream (Appendix J).

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A

B

C.

Figure 17: Hālawa upstream surveying transect: (A) The canal levee and convergence of upstream freshwater with downstream marine water. Freshwater merges with marine water on the left and right wall of the canal creating a pool on each side; (B) sampling at the transect; (C) Zooming in to the right bank to show the sudden drop of the stream bottom.

Methods:

An upstream and downstream transect site for Waikele, Eʻo, Waiawa, Kalauao, and Hālawa Stream were surveyed for fish eight times between August 2018-July 2020…. The majority of sampling occurred at the stream mouth of each stream and referred to in this report as the downstream transect (Figure 1 and Figure 2). This transect was positioned where streambanks widen to the ocean as indicated in Figure 2 A. Fish were surveyed at downstream transects using four traditional sampling methods and collecting a total of 2.5-L of environmental DNA (eDNA) water samples (Figure 3 and Figure 4). The same eDNA sampling method was then repeated approximately 515-980 meters upstream for each stream's respective upstream transect site as indicated in Figure 1 and Figure 2. Upstream and downstream eDNA surveying for a stream was performed within a two-day window of one another within a sampling event. Underwater cameras, cast netting, angling, minnow trapping as well as eDNA sampling for each downstream transect was performed within the same 24-hour period.

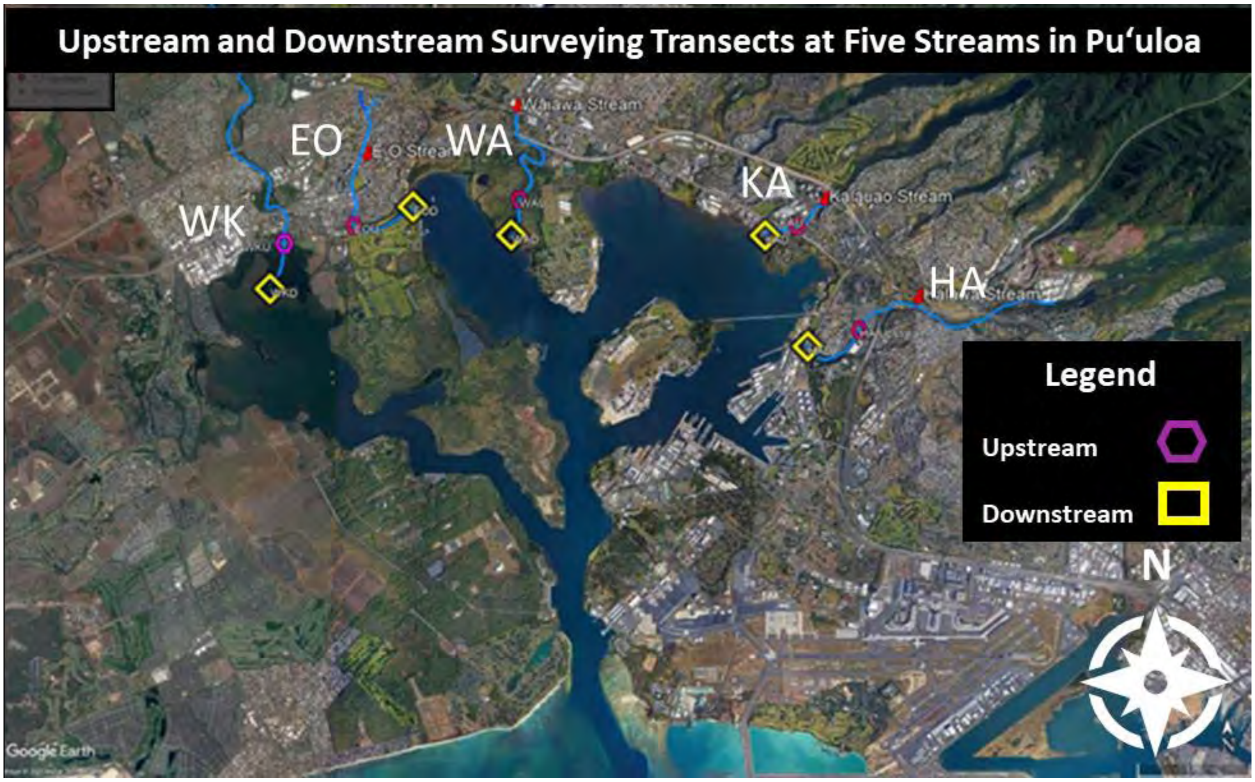


Figure 1: Map of Pearl Harbor upstream and downstream transect sites located on the south shore of O'ahu, Hawai'i. Five streams are represented in blue line, marked with with a red thimble and labeled from west to east: Waikele (WK), E'o (EO), Waiawa (WA), Kalauao (KA) and Hālawa (HA) Stream. Yellow squares indicate downstream surveying locations for each stream. Purple hexagons represent upstream surveying locations.

RESULTS:

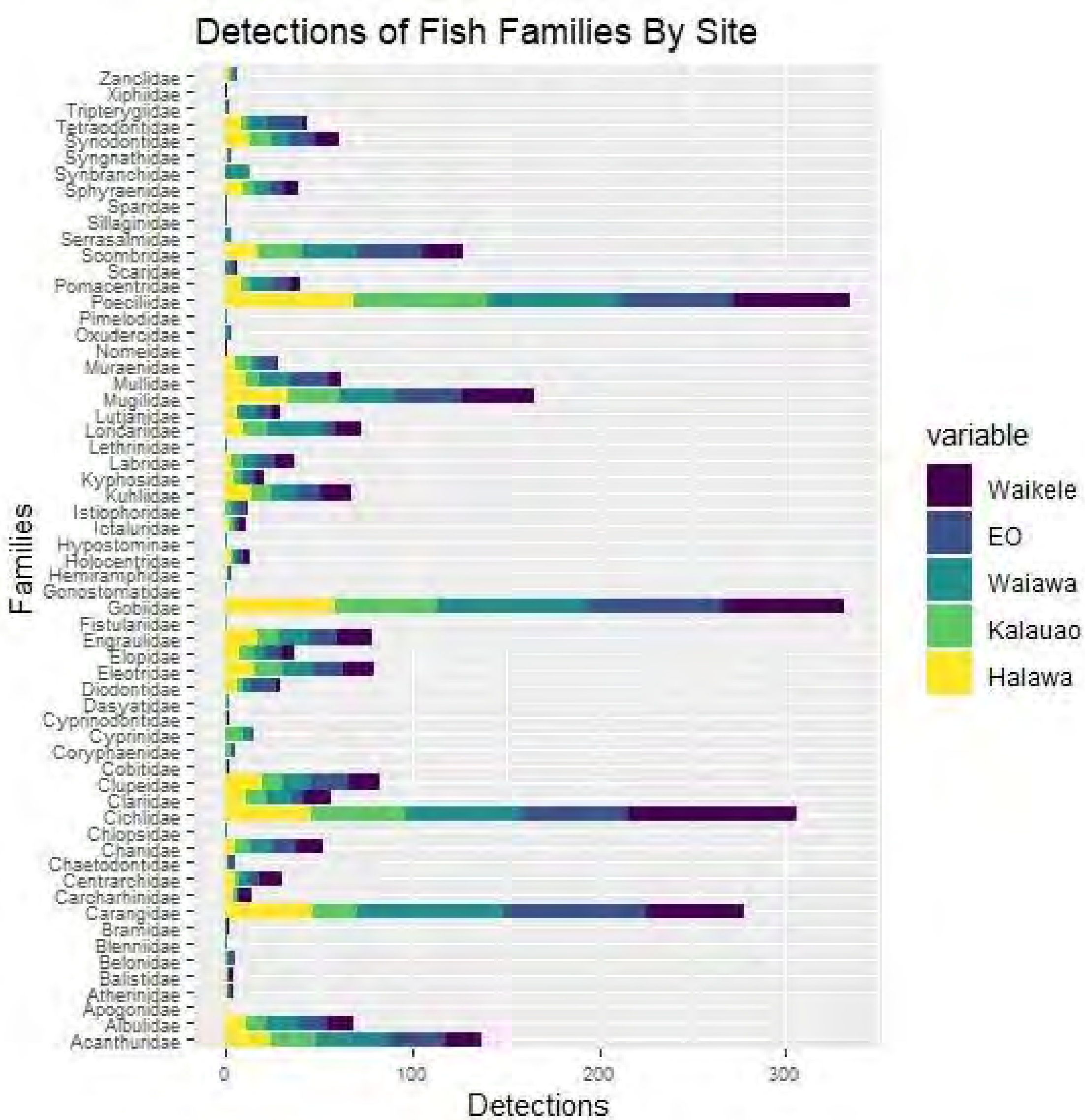
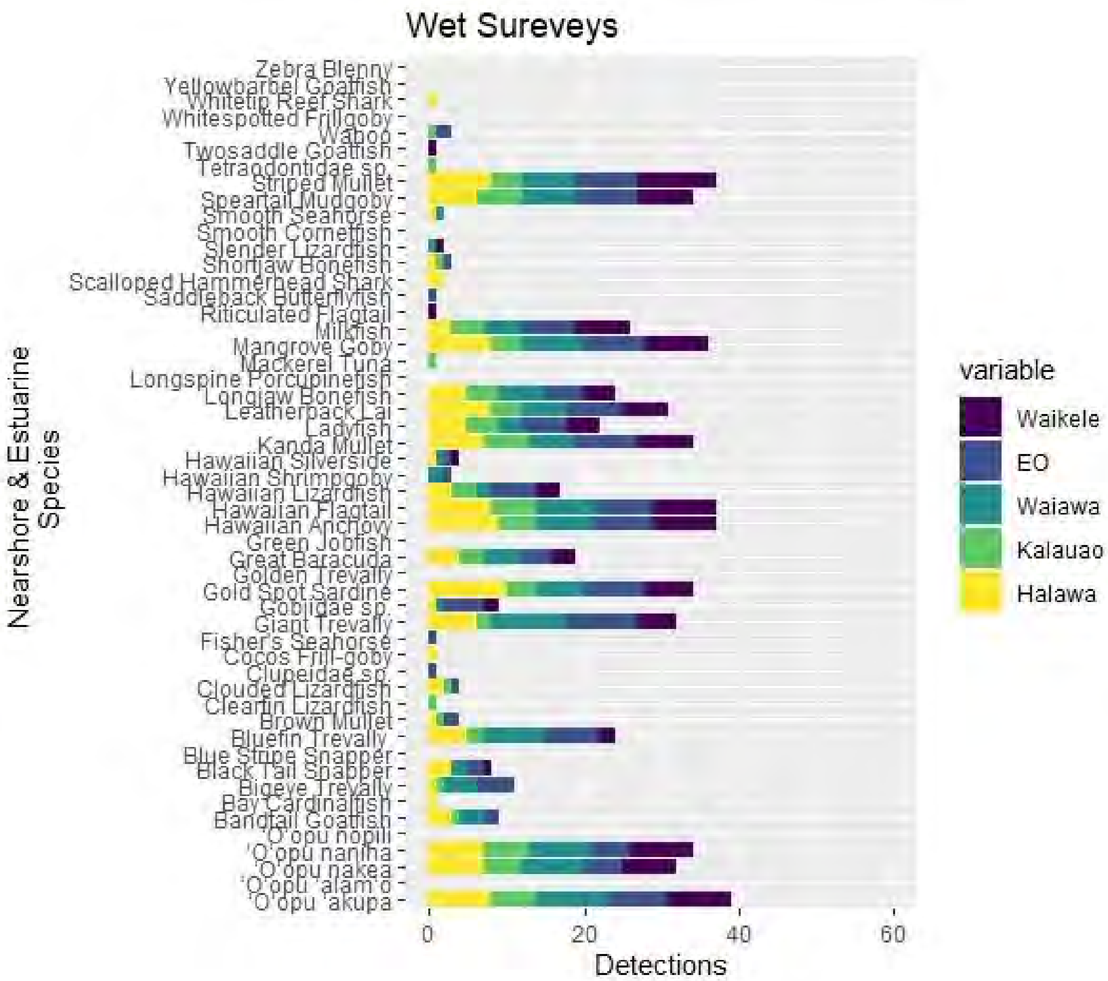


Figure 10: Total number of detections of fish within their respective families between Waikele, E‘o, Waiawa, Kalauao, and Hālawa Stream in the Pearl Harbor estuary.



Wet Sureveys
Zebra Blenny
Yellowbarbel Goatfish
Whitetip Reef Shark
Whitespotted Frillgoby
Wahoo
Twosaddle Goatfish
Tetraodontidae sp.
Striped Mullet
Speartail Mudgoby
Smooth Seahorse
Smooth Cornetfish
Slender Lizardfish
Shortjaw Bonefish
Scalloped Hammerhead Shark
Saddleback Butterflyfish
Riticulated Flagtail
Milkfish
Mangrove Goby
Mackerel Tuna
Longspine Porcupinefish
Longjaw Bonefish
Leatherback Lai
Ladyfish
Kanda Mullet
Hawaiian Silverside
Hawaiian Shrimpgoby
Hawaiian Lizardfish
Hawaiian Flagtail
Hawaiian Anchovy
Green Jobfish
Great Baracuda
Golden Trevally
Gold Spot Sardine
Gobiidae sp.
Giant Trevally
Fisher's Seahorse
Cocos Frill-goby
Clupeidae sp.
Clouded Lizardfish
Clearfin Lizardfish
Brown Mullet
Bluefin Trevally
Blue Stripe Snapper
Black Tail Snapper
Bigeye Trevally
Bay Cardinalfish
Bandtail Goatfish
'O'opu nopili
'O'opu naniha
'O'opu nakea
'O'opu 'alam'o
'O'opu 'akupa
Nearshore & Estuarine Species
0
20
40
60
Detections
variable
Waikele
EO
Waiawa
Kalauao
Halawa

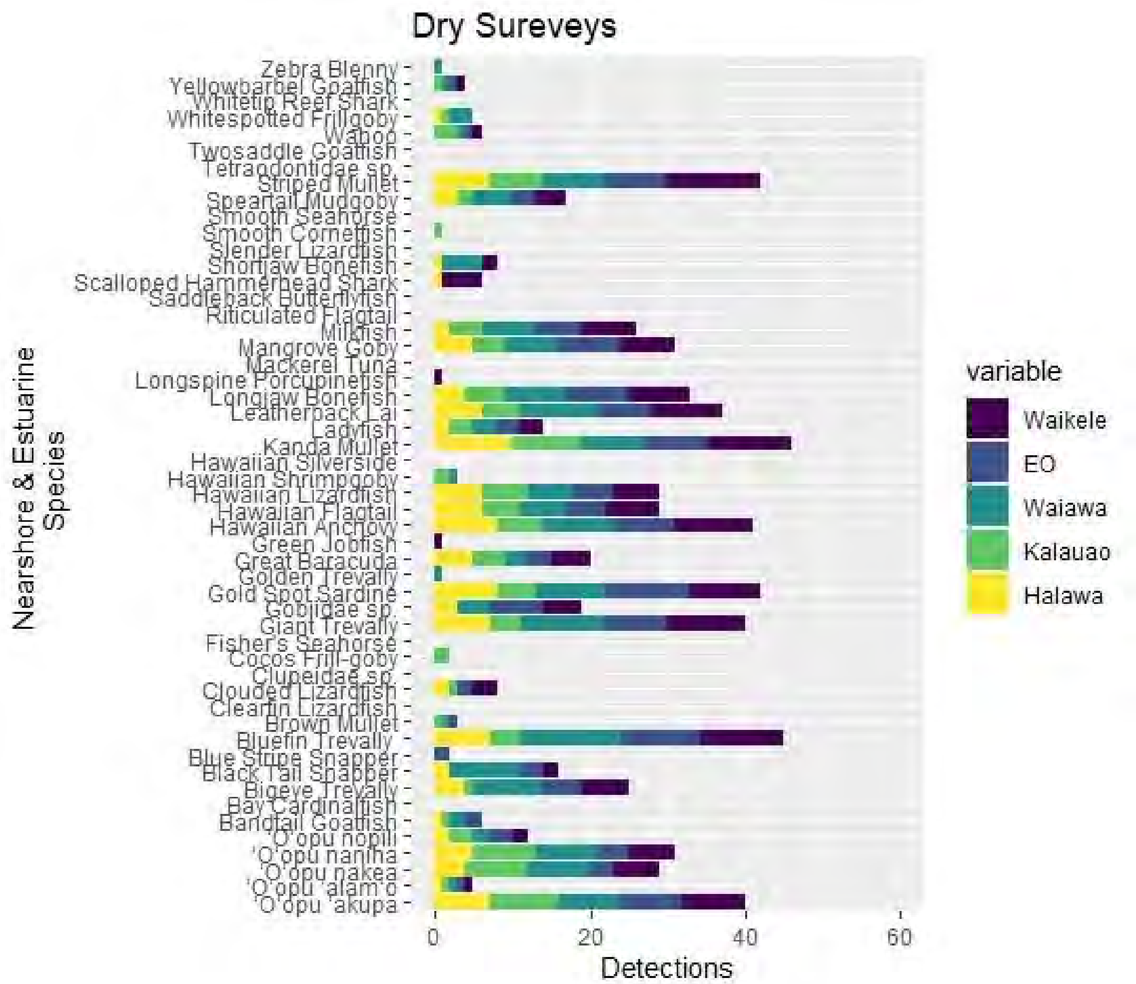


Figure 14 (Wet and Dry Detections): Detections of estuarine and nearshore fish species between wet and dry surveying events for five Pearl Harbor streams.

Highlighted Detections in the Text

- Mixed schools of Kanda and Striped Mullet were in large numbers in Waikele, Kalauao, and Hālawa stream, where structured mudflat area was available.
- The Smooth Seahorse *Hippocampus kuda* was observed at Waiawa and Hālawa stream and may withstand more nutrient rich waters during higher drainage periods
- The Bay Cardinalfish Foa brachygramma and the Whitetip Reef Shark were detected at Hālawa Stream. The Whitetip Reef Shark being detected in January 2020.
- In the eight observations of Sphyrna lewini, six were during the dry surveys of May 2019, June 2020, and July 2020 in Waikele and Hālawa Stream. Detections of the Scalloped Hammerhead Shark in Waikele and Hālawa in the dry season occurred in both upstream and downstream eDNA surveys, alluding to possible mobility of the species upstream.
- The Fivelined Snapper *Lutjanus quinquelineatus* was observed in Eʻo and Hālawa stream.

- Other goby species such as the Whitespotted Frillgoby *Bathygobius coalitus* was detected five times in the study exclusively amongst various dry surveys. At Hālawa stream in survey 4 (May 2019), Waiawa and Kalauao stream in survey 7 (June 2020), and twice in Waiawa in survey 8 (July 8).

STREAM OBSERVATIONS:

Table 8: Average measures of stream depth, water temperature, salinity, dissolved oxygen, and conductivity for downstream sampling sites. Depth measurements were taken on the left, middle, and right sections of sampling transect for five streams, Waikele (WKD), EO (EOD), Waiawa (WAD), Kalauao (KAD) and Hālawa (HAD). Depths for each location were averaged across all eight survey events. Water chemistry data was obtained by season from surface water (30.5 cm depth) sampling locations with an YSI DSS Pro. Values were averaged by season across three wet surveys (10/2018,2/2019,1/2020) and four dry surveys (5/2019,7/2019,6/2020,7/2020)

	Average stream depth (m)			Average Water Chemistry				
Site ID	**Left**	**Middle**	**Right**	**Season**	**Temp (C)**	**Salinity (ppt)**	**DO%**	**C (us/-cm)**
WKD	2.01168	1.92024	1.3716	Wet	21.6	7.19	76.6	11440.1
				Dry	28.3	24.5	85.2	41526.0
EOD	1.79832	2.34696	1.64592	Wet	25.2	27.4	82.6	43030.6
				Dry	28.8	30.5	81.7	50657.5
WAD	1.95072	2.92608	2.80416	Wet	23.3	12.8	84.8	21149.3
				Dry	27.8	27.0	66.9	44675.0
KAD	1.58496	1.55448	1.18872	Wet	22.9	18.5	84.1	29718.5
				Dry	28.0	26.0	66.1	36317.3
HAD	1.95072	2.37744	0.9144	Wet	24.9	23.45	76.5	35040.0
				Dry	28.0	33.3	65.6	53716.2

- Waikele, Eʻo , Waiawa, Kalauao, and Hālawa streams were found to be box shaped with a mean (±SD) width of 3.0 m ± 0.53 m, depth of 2.20 ± 0.92 m, and width depth ratio of 1.64 m, similar to the width-depth ratio metric used to categorize stream type categories based on Rosgen stream classification (Rosgen,1994). Streams in Pearl Harbor were on average more marine in character throughout the year but did experience salinity gradients between surface, center, and benthic sampling depths (Appendix H).
- Eʻo and Hālawa Stream on average were more saline than any other stream (Appendix H).
- Salinity as well as the presence of mudflat areas at streams seemed to support similar communities of fish at each stream site. Eʻo and Waiawa Stream both lacked exposed

mudflat areas and were found to have similar diversity of fish observed. Waikele, Hālawa, and Kalauao Streams had exposed mudflat areas and had more estuarine species in common. Stripped Mullet, Hawaiian Flagtail, and Hawaiian Anchovy (nehu) were seen more in these streams than Eʻo and Waiawa. In comparison, more reef fish were observed at Eʻo and Waiawa Stream.

- Hālawa Stream was the least diverse in fish biota with a Shannon index value of 4.121061. It had 92 different fish species observed at the site with 3 rare and 3 unique species observed at the site (Table 9).
- The fewest number of marine species were found at Hālawa Stream (Figure 15 A).
- Although Hālawa Stream was the least diverse stream, it had more detections of fish than Kalauao with nearly 500 detections (Figure 16). Hālawa Stream also had a greater number of native fish species than Kalauao Stream (Figure 16 B).
- The number of detections for endemic fish species at Eʻo, Hālawa, and Kalauao was 82, 82, and 80, respectively
- Streams with the greatest number of detections for native fish counts to the fewest detections of fish counts were found to be Eʻo (324 detections), Waiawa (286 detections), Waikele (207 detections), Hālawa (206 detections), and Kalauao (174 detections) Stream (Figure 16 B).
- Detections of the Giant Trevally occurred from the greatest number of detections to the least at Waiawa Stream (21 detections), Eʻo (17 detections), Waikele (15 detections), Hālawa (13 detections) and Kalauao (6 detections).

Table 9: Diversity characteristics and unique species observed for Waikele, Eʻo , Waiawa, Kalauao, and Hālawa Stream. The table includes current Shannon diversity index values (Shannon Diversity; Shannon and Weaver 1949), the total number of species found per stream (Species Richness), the number of species that were detected once per stream (Singletons by Site), the number of species that were detected once per stream and were also the only detection of the species in Pearl Harbor (Singletons in PH), the number of species exclusively found at streams (Unique by Site), the number of species found at respective upstream transects but not at downstream transects (Unique to Upstream), the number of species found at respective downstream transects but not upstream transects (Unique to Downstream).

	Waikele	Eʻo	Waiawa	Kalauao	Hālawa
Shannon Diversity	4.16	4.32	4.32	4.20	4.12
Species Richness	109	122	122	106	92
Singletons by Site	49	48	45	41	28
Singletons in PH	12	15	16	13	3
Unique by Site	13	18	21	15	3
Unique to Upstream	23	23	16	26	9
Unique to Downstream	35	38	40	36	37

Table 10: List of fish species exclusively found at Waikele, E'o , Waiawa, Kalauao, and Hālawa Stream.

Waikele	E'o	Waiawa	Kalauao	Hālawa
HawaiianSergeant	Saddleback Butterflyfish	Blue-line Surgoenfish	Whitespotted Surgeonfish	Bay Cardinalfish
Gray Jobfish	Raccoon Butterflyfish	Caranx sp.	Ocellaris Goby	Whitetip Reef **Shark**
Bullethead Parrotfish	Pacific Bullethead Parrotfish	Thredfin Butterflyfish	Atlantic Menhaden	Brushtail Tang
Longfin Cigarfish	Clupeidae sp.	Agile Chromis	Slender Bristlemouth	
Longspine Porcupinefish	Mackerel Scad	Broad Stingray	Snowflake Moray Eel	
Tiger Shark	Whitetipped Mackerel Scad	Golden Trevally	**Ladyfish**	
Channel Catfish	Lutke's Halfbeak	Gobiidae sp.	Mackerel Tuna	
Riticulated Flagtail	Fisher's Seahorse	Suckermouth Catfish	Smooth Cornetfish	
Twosaddle Goatfish	Blue Stripe Snapper	Suckermouth Catfish	Yellowmargin Moray	
Tailspot Squirrelfish	Yellowfin Soldierfish	Atlantic White Marlin	Peppered Moray	
HawaiianSquirrelf ish	Red Seabream	HawaiianCleaner Wrasse	Red Stingray	
Belted Wrasse	Manybar Goatfish	Pumpkinseed	Black Tongue Unicornfish	
Swardfish	Sailfin Molly	Zebra Blenny	Three Spotted Tilapia	
	Japanese Amberjack	Asian Swamp Eel	Clearfin Lizardfish	
	Northern Whiting	Bigeye Emperor	Tetraodontidae sp.	
	Shortbill Spearfish	Rockmover Wrasse		
	Chilean Jack Mackerel	Red-bellied Pacu		
	Whitetongue Jack	Amazon Sailfin Catfish		
		Leka Keppe		
		Long-wiskered Duckbill Catfish		
		Fryer's False Moray		

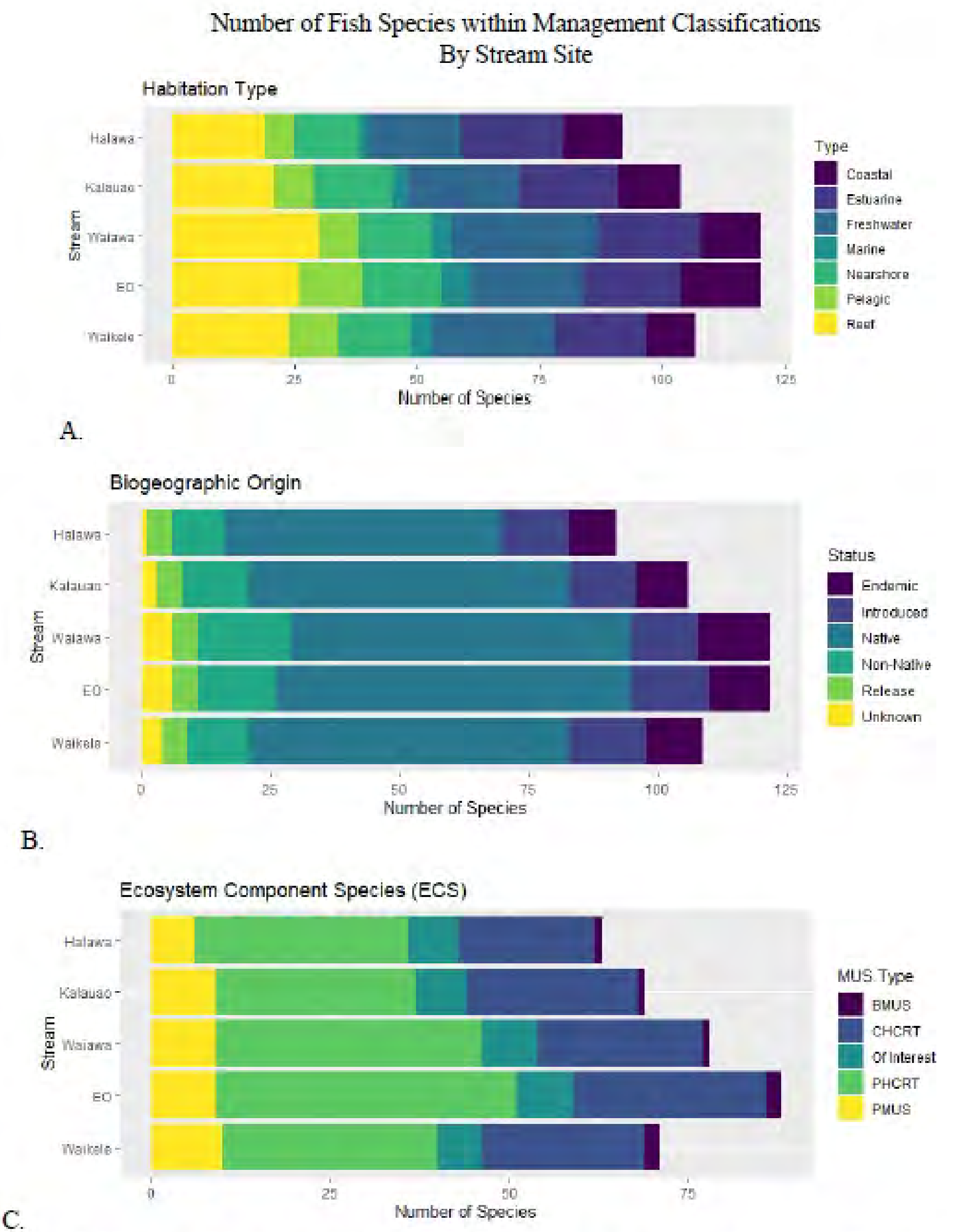
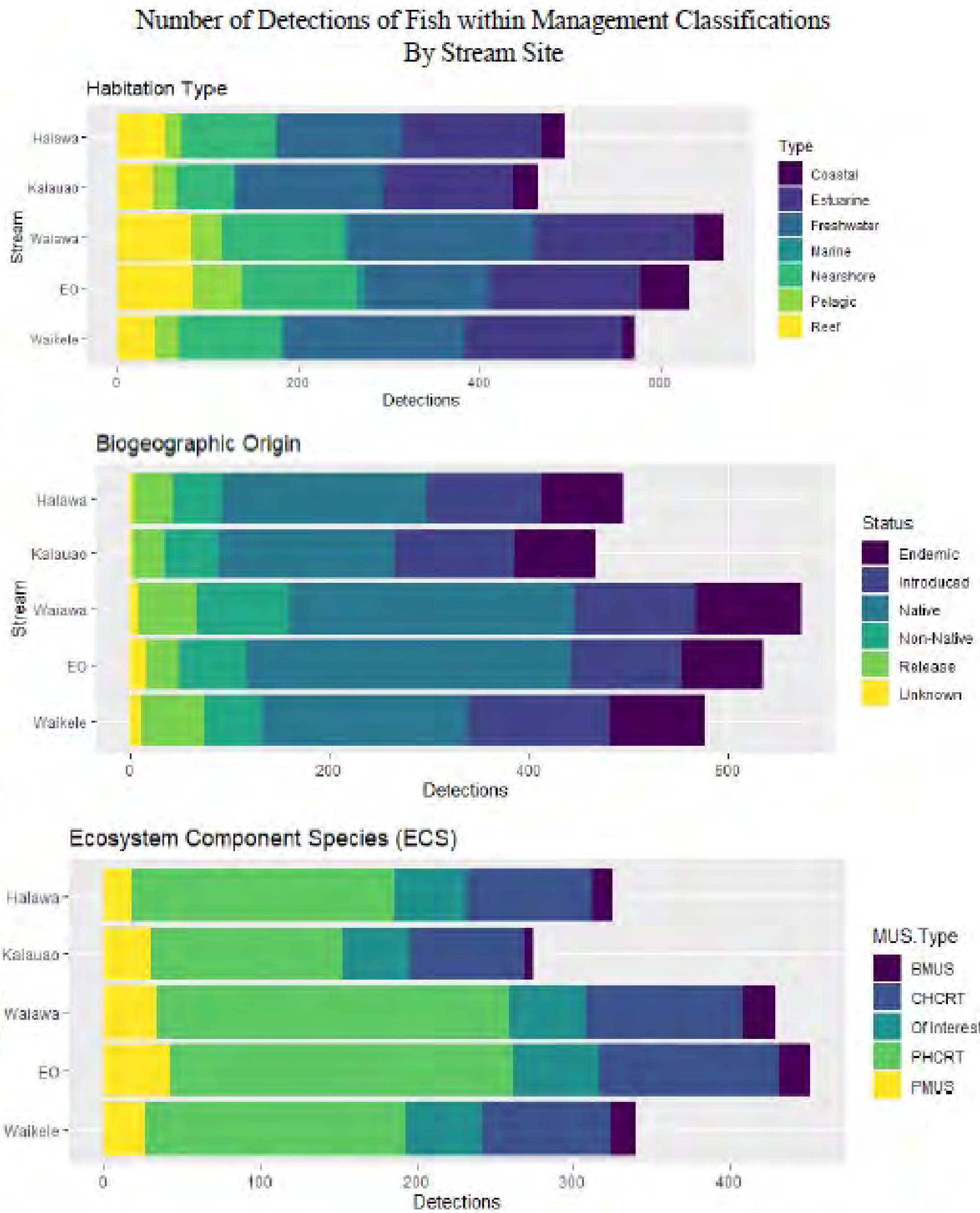


Figure 15: Number of fish species detected according to their designated Habitation Type (A), Biogeographic Origin (B), and federal protections status as an Ecosystem Component Species (ECS) (C) at Waikele, Eʻo, Waiawa, Kalauao, and Hālawa Stream.



A.

B.

C.

Figure 16: Total counts of fish species detected (Detections) according to their designated Habitation Type (A), Source of Origin (B), and Protection Status (C) at Waikele, Eʻo, Waiawa, Kalauao, and Hālawa Stream.

Exhibit G:

Blank Discharge Monitoring Report Form

PERMITTEE NAME/ADDRESS (Include Facility Name/Location if Different)
NAME

ADDRESS

FACILITY
LOCATION

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

Form Approved.
OMB No. 2040-0004

PERMIT NUMBER	DISCHARGE NUMBER

	MONITORING PERIOD						
	YEAR	MO	DAY		YEAR	MO	DAY
FROM				TO			

☐ Check here if No Discharge

NOTE: Read Instructions before completing this form

PARAMETER		QUANTITY OR LOADING			QUALITY OR CONCENTRATION				NO. EX	FREQUENCY OF ANALYSIS	SAMPLE TYPE
		VALUE	VALUE	UNITS	VALUE	VALUE	VALUE	UNITS			
	SAMPLE MEASUREMENT										
	PERMIT REQUIREMENT										
	SAMPLE MEASUREMENT										
	PERMIT REQUIREMENT										
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	PERMIT REQUIREMENT										

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER	I CERTIFY UNDER PENALTY OF LAW THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHER AND EVALUATE THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM, OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS.		TELEPHONE		DATE		
TYPED OR PRINTED		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	AREA CODE	NUMBER	YEAR	MO	DAY

COMMENTS AND EXPLANATION OF ANY VIOLATIONS (Reference all attachments here)