Naval Facilities Engineering Systems Command Pacific
JBPHH HI

Final

Bench-Scale JP-5 Evaporation Study Work Plan Red Hill Bulk Fuel Storage Facility

JOINT BASE PEARL HARBOR-HICKAM O‘AHU HI

February 2023

Naval Facilities Engineering Systems Command Pacific
JBPHH HI

Final

Bench-Scale JP-5 Evaporation Study Work Plan
Red Hill Bulk Fuel Storage Facility
JOINT BASE PEARL HARBOR-HICKAM O‘AHU HI

February 2023

Prepared for NAVFAC Pacific by
AECOM Technical Services Inc
1001 Bishop Street Suite 1600
Honolulu HI 96813-3698

N62742-17-D-1800
CTO N6274222F0212

CONTENTS

ACRONYMS AND ABBREVIATIONS

AECOM	AECOM Technical Services, Inc.
HASP	health and safety plan
JP-5	Jet Propellant 5
JSA	job safety analysis
NAPL	nonaqueous phase liquid
SQG	small quantity generator
SVE	soil vapor extraction
SVOC	semivolatile organic compound
QA	quality assurance
QC	quality control
VOC	volatile organic compound

1. JP-5 Evaporation Study

1.1 OBJECTIVES

Air sparging and soil vapor extraction (SVE) pilot testing will be conducted at the Red Hill Fuel Storage Facility to assess the effectiveness and implementability of those remedial technologies for addressing Jet Propellant 5 (JP-5) that was accidently released to the environment. Air sparging and SVE use induced subsurface airflow to volatilize (evaporate) and remove contaminants from the subsurface.

The objectives of the JP-5 evaporation study are to validate that the volatile nature of Jet Propellant 5 (JP-5) will result in a significant decrease in nonaqueous phase liquid (NAPL) mass if exposed to a continuous stream of air and to assess the JP-5 composition change resulting from the induced volatilization. Specifically, the study seeks to answer the following questions:

- What is the mass fraction of JP-5 that evaporates at ambient temperatures?
- How does the composition of the JP-5 change as a function of JP-5 evaporative mass loss?
- How does the density and viscosity of the JP-5 change as a function of JP-5 evaporative mass loss?

JP-5 is a kerosene-like petroleum mixture made up of hundreds of compounds. It is expected that evaporation will preferentially remove more volatile and water-soluble compounds from the JP-5. This expected behavior is a primary remedial mechanism for air sparging and SVE to decrease the toxicity of JP-5. Furthermore, it is expected that evaporation will increase the viscosity and density of the NAPL, which will decrease NAPL mobility.

The results of the JP-5 evaporation bench study will inform the air sparging and SVE field studies, the assessment of remediation technology effectiveness, and the establishment of remedial goals by:

- Determining overall NAPL mass loss that could be achieved under an ideal air sparging/SVE scenario and verifying that the NAPL mass loss is significant.[1]
- Determining the overall change in NAPL composition under an idealized air sparging/SVE scenario and verifying significant reduction in target compounds such as benzene and naphthalene.
- Determining at what point evaporative mass loss results in a significant reduction in target compounds; these data can be used to help establish remedial goals.
- Assessing the change in NAPL mobility due to increased density and viscosity.
- Assessing the degree of JP-5 volatilization that has already occurred under natural conditions by comparing bench trial JP-5 composition data to formation gas extracted during testing.
- Evaluating the changes in NAPL mass as a function of the total sparged air volume.

The results of this study are relevant to understanding the maximum potential effectiveness of both air sparging and SVE for addressing JP-5 in the subsurface. Although in-situ feasibility of air sparging and SVE depends on aquifer characteristics and the distribution of the sparged and vented air in relation to the subsurface NAPL phase (among others), this treatability test will provide information on ideal conditions in which the passage of air is not restricted by soil or groundwater.

[1] It is assumed that mass loss will be significant; if mass loss is insignificant air sparging and SVE will have minimal effectiveness and the remedial program should focus on enhancing in situ petroleum bioremediation.

1.2 METHODS

The JP-5 used for the study will be sourced from the Red Hill supply, which represents the NAPL composition at the time of the JP-5 release. Weathered NAPL present in the subsurface was not considered for testing because there is insufficient available volume to support the bench testing. A continuous stream of air will be injected (sparged) into the NAPL to accelerate the evaporation process. The flow rate for the evaporation lab tests will be 1.0 liter per minute. The change in NAPL composition over time will be determined by collecting samples before, during and after air sparging for analytical laboratory analysis.

The experiments will be set up in glass media bottles under a safety fume hood to prevent lab worker exposure to volatile organic compounds (VOCs). In-house compressed air will be connected to a pressure regulator and a manifold equipped with three digital gas flow meters with controllers (Aalborg), as shown in Photo 1, to set independent flowrates using Viton tubing. Viton is a material that is chemically compatible with JP-5. For each test bottle, a brass muffler will be attached at the end of the tube placed inside the NAPL phase to avoid changes in height and to allow a consistent dispersion of air and bubble size.

Photo 1: Sample Experiment Setup

A pretest will be conducted to record mass loss over time under the study conditions. The intent of the pre-test is to do range finding to understand the expected total evaporation and change in mass over time, which will be used to inform the composition sampling program. Air will be sparged into a single bottle containing 0.5 liters of NAPL. The temperature of the NAPL sample will measured and recorded prior to initiation of testing. Testing will continue until the change in mass in the previous hour is less than 0.1 percent of the initial mass. If that threshold is not achieved during the first day of testing, the test will be paused and resumed on the following day(s).

The evaporation study will use triplicate bottles containing 0.5 liters of NAPL. The temperature of the NAPL sample will measured and recorded prior to initiation of testing. All bottles will be monitored for mass reduction of NAPL, which will be determined gravimetrically using precision laboratory scales.

Weight reduction of the NAPL will be documented at least every 15 minutes for the first hour of testing, every 30 minutes during the next three hours, and hourly thereafter. Testing will continue until the change in mass in the previous hour is less than 0.1 percent of the initial mass. If that threshold is not achieved during the first day of testing, the test will be paused and resumed on the following day(s).

The change in NAPL composition will be evaluated by collecting samples of the NAPL and samples of the sparged air for analysis. NAPL samples will be collected from the stock JP-5 and from the experimental bottles after sparging is concluded. Multiple gas samples will be collected to show the composition change in the sparged air as a function of the mass loss. Gas samples will be collected at the start and end of the test from the sparge air stream after the air has passed through the NAPL to quantify the start and end condition. Additional gas samples will be collected after 10, 20, 50, and 80 percent of the expected mass loss[2] is observed based on the pre-test data. The sampling program is biased towards the early part of the test to assess preferential removal of highly volatile compounds. The air samples will be collected using a summa canister. The analyses and methods are presented in Section 2.

Characterization of post treatment samples will be performed by collecting 80 milliliters of remaining NAPL for analysis of saturated hydrocarbons, VOCs, and semivolatile compounds (SVOCs) to determine the change in NAPL composition and the extent of VOCs and SVOCs removal. In addition to chemical analyses, the density and viscosity of the NAPL will be measured before and after evaporation to evaluate changes in NAPL physical properties. The analytical methods to be used for this test are presented in Section 2. AECOM standard operating protocol for air sparge laboratory testing is presented in Appendix A.

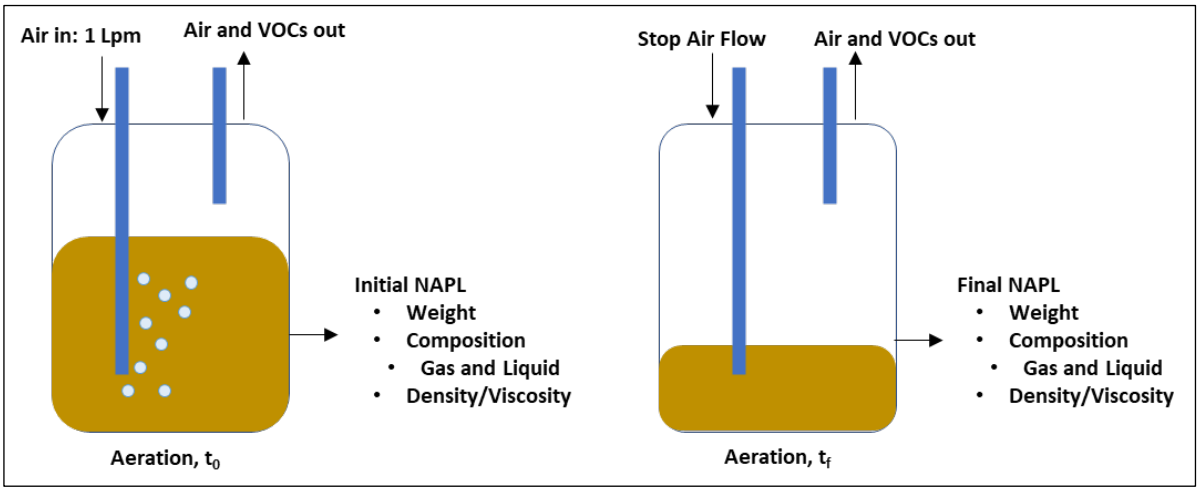


Figure 1: Conceptual Bench Test Configuration

2. Analytical Methods

The analytical program will require the services of multiple laboratories. The AECOM treatability laboratory has in-house testing capabilities, and a portion of the analyses will be performed by AECOM for efficiency to decrease the volume of samples shipped to outside laboratories. The AECOM treatability laboratory follows standard methods for the in-house weight measurements. Standard operating protocols for the AECOM analyses are attached in Appendix A.

[2] If the pre-test determines that 50 percent of the JP-5 mass evaporates under ambient conditions, the 20-percent gas sampling would be collected after 10 percent total mass loss is observed.

A summary of the parameters and matrix that will be analyzed is presented in Table 1.

Table 1: Parameters Summary

Parameter	Matrix	Analytical Method	Frequency	Number of Test Samples	Number of Control Samples	Total Samples
Saturated Hydrocarbons PIANO	NAPL	EPA 8015m EPA 8260	Start, End	3	NA	6
VOCs and SVOCs	Gas	TO-3, TO-15, TO-17	Start, 10%, 20%, 50%, 80%, End	3	1	24
Density	NAPL	ASTM D1429-13, ASTM D3505-18	Start, End	3	NA	6
Viscosity	NAPL	ASTM D7945-21 or ASTM D445-19a	Start, End	3	NA	6

% percent
ASTM ASTM International
EPA Environmental Protection Agency, United States
PIANO paraffins, isoparaffins, aromatics, naphthenes, and olefins
NA not applicable

3. Data Analysis and Reporting

The analytical data will be reviewed to assess the change in NAPL composition due to air sparging. It is likely that volatile constituents will be completely removed by air sparging and mass loss will be observed for semi-volatile constituents. The paraffins, isoparaffins, aromatics, naphthenes, and olefins (PIANO) and soil gas analyses will quantify the mass fraction of individual compounds in the NAPL and sparged air, respectively. The following indicator compounds will be evaluated to assess the change in VOCs and SVOCs in the NAPL and partitioning into sparged air:

- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- 1-Methylnaphthalene
- 2-Methylnaphthalene
- Naphthalene

The saturated hydrocarbon analysis will produce chromatograms that will be used to graphically compare changes in NAPL composition. Additionally, the saturated hydrocarbon analysis will produce quantitative composition data for C_{10} to C_{40} hydrocarbons and isoprenoid compounds which are resistant to biodegradation. These data will be used to determine whether air sparging changes the lower molecular weight petroleum hydrocarbons, i.e., from C_{10} to C_{15}. There will be no material biodegradation during sparging; instead, diagnostic ratios of hydrocarbons and recalcitrant isoprenoids used to evaluate biodegradation will be assessed to look for potential false positive signals resulting from air sparging.

Pre and post-sparging NAPL viscosity and density will be compared to determine the change in physical properties of the NAPL. It is expected that removal of the lighter molecular weight volatile compounds from the NAPL will increase both the viscosity and density of the NAPL.

AECOM will prepare a bench test report once all analytical data are received. The report will present the methods that were used, any deviation from this work plan and the rationale for deviation, the analytical methods used, the results of the analyses, and interpretation of the results.

4. Quality Assurance/Quality Control

Quality assurance (QA) and quality control (QC) activities are needed to assess the quality performance criteria of the data collected. For this study, the use of triplicate experiments will address the aspect of experimental variability throughout all bench-scale tests. In addition, QC samples for analyses performed by the subcontracted laboratories and analyses performed in-house by AECOM will be part of the analytical program. The number of QC samples will be 10 percent of the total samples.

For measurements and analysis generated in-house by AECOM, QA/QC procedures will be performed across all bench-scale tests activities. The following procedures are to be implemented:

- A dedicated laboratory book will be utilized to document all bench-scale test activities. Every new entry should be accompanied by the laboratory technician's initials and the date.
- All reagents and amendments employed in the bench-scale test activities will be documented in the laboratory book, noting the manufacturer/source, the day it was first opened, and the expiration date.
- All internal analytical instruments will be calibrated daily or before every sampling event if not used daily.
- Triplicate air sparging tests will be conducted to provide statistical variances (averages and relative percent standard deviation).
- All spreadsheets containing results data will be initialed by the staff who are responsible for entering the data. All data will be reviewed by staff and signed off with their initials.
- All experimental containers will be properly labeled with at least the following information:
  - Project name
  - Bench-scale test
  - Date of setup
  - Staff initials
- Photologs of experimental samples will be properly labeled/captioned and include the date of creation and the name of the staff involved.
- For samples to be analyzed by a subcontracted commercial laboratory, labels and chain-of-custody forms will be used to properly identify each sample. These labels will contain the name of the project, sample identification, date and time of collection, preservatives, and initials of the sampler.
- All coolers sent for external analyses will have at least two custody seals that are signed and dated.
- 10 percent of all samples shipped to subcontractor for analysis will be allocated for QA/QC purposes.

5. Deviations from Plan

Any deviations from the original work plan, along with the rationale, will be documented. Deviations from the plan may occur for various reasons, such as the availability of reagents/amendments, turn-around times from subcontracted laboratories, unexpected results during data collection, and changes in the original scope.

6. Health and Safety

AECOM has a strong safety culture that guides all work performed by AECOM. To maintain a safe working environment and to perform work safely, a health and safety plan (HASP) is always required for each project. Because the treatability study will take place in a controlled laboratory facility, the facility HASP covers all safety aspects related to the project.

6.1 FACILITY HASP

The AECOM Treatability Laboratory is located within a larger laboratory facility in Austin, Texas. The facility encompasses 15 different laboratories, a shipping and receiving area, a loading dock, print room, machine shop, and office area. A general HASP for the overall facility, referred to as the General Laboratory Safety Plan, covers the following safe-related items:

- Organization and responsibilities
- Overview of the laboratories
- Emergencies (fire, chemical release, etc.)
- Incident and injury management
- Potential hazards
- Mitigations
- Staff training
- Chemical management
- Laboratory safety resources

This General HASP is available in both hard copy and electronic copy to all staff. The plan is updated once a year by the chemical hygiene officer. Any staff person who works in the laboratory must read and sign the document as acknowledgment. The general HASP for the Austin laboratory facilities was last updated in December 2020 and will be available upon request.

6.2 TREATABILITY LABORATORY HASP

In addition to the general HASP for laboratories, each laboratory has its own HASP, which covers the specific tasks performed by that laboratory. The Treatability Laboratory HASP, referred to as the Chemical Hygiene and Health Safety Plan Treatability Laboratory (D-116) covers the following safety-related items:

- Overview of the laboratory
- Organization, roles, and responsibilities
- Access and security
- General practices and procedures for safety operations

- Procedures for handling chemicals and samples
- Disposal of chemicals and samples
- Special disposal procedures
- Procedures for handling compressed gases
- Procedures for handling physical hazards
- Monitoring
- Documentation
- Accidents and emergencies

All staff who participate in the treatability laboratory activities for this study must read and sign the Treatability Laboratory HASP. The document was last updated on February 2022 and is available upon request.

6.3 JOB SAFETY ANALYSIS

AECOM has standardized safety resources available to ensure that projects are completed safely, which include the job safety analyses (JSAs) for laboratories. The JSAs cover standard and routine laboratory tasks and procedures, provide an in-depth description of the task to perform, and must be read and acknowledged by any staff who will be performing the task. There are two types of JSAs for the treatability facility: the laboratory-specific JSA and the project-specific JSA. Laboratory-specific JSAs for each laboratory is available in both electronic format and hard copy.

Laboratory-specific JSAs: These JSAs are specific to the laboratories and may be used across multiple projects. The project manager can contact the laboratory manager to find out which laboratory JSA(s) applies to the project in question. These JSAs are owned by and created by the laboratory manager (or designee), and approved by the chemical hygiene officer. The JSA(s) must be reviewed and acknowledged by staff prior to commencement of lab work. The JSA may be reviewed and revised if conditions, procedures, or scope of work changes.

Project-specific JSAs: These JSAs are specific to a project or are existing laboratory-specific JSAs that have been modified for special project considerations. These JSAs are generated by the team that will perform the non-routine project task and approved by the project manager. Because all the treatability study activities will be performed in the laboratory, and the laboratory facility already has a list of JSAs that are pertinent to the experimental procedures described in this work plan, the laboratory JSA format will be followed. Additional levels of review can be performed by the chemical hygiene officer or others as deemed necessary. These should be created and reviewed before the start of any hazardous task and be reviewed periodically to assess if conditions have changed and thus require revised controls.

Once the JSA is developed, the laboratory or project manager shall review the JSA with each team member to assess whether they understand the JSA, are familiar with hazards that may be encountered, and know what measures or controls should be implemented to mitigate the hazards. The JSA preparer should develop a list of questions and answers that can be used to assess if a team member read the JSA and comprehended the hazards that will be encountered and the controls that must be used to mitigate the hazard. The laboratory manager (laboratory-specific JSA) or project manager (project-specific JSA) must conduct a review session with each team member performing the task to ensure that the team member understands the risks and controls. A sign-off section in the signature page of the JSA form documents that the review session occurred; this is to be signed by the project manager or laboratory manager for each team member or laboratory personnel.

7. Waste Management

The treatability study will include the laboratory analysis of NAPL, which is considered hazardous. The procedures for laboratory disposal of hazardous waste are as follows:

- The hazardous waste will be stored in a satellite waste container.
- When the container is full, or at the completion of the testing, the laboratory manager will contact the waste disposal specialist to have the waste characterized based on available analytical data.
- The satellite waste will then be transferred into a drum that is in a waste disposal shed until disposal.

The AECOM treatability laboratory in Austin is considered a small quantity generator (SQG) of hazardous waste. SQGs produce between 100 kilograms and 1,000 kilograms of hazardous waste each month. SQGs can accumulate hazardous waste on-site for up to 180 days. Waste derived from the treatability study may be returned to the site generator via ground shipping if existing investigation derived waste containers are expected to be at the site. This the preferred option since the treatability facility has a limit on hazardous waste disposal, as mentioned above. Alternatively, AECOM may perform the waste disposal upon written approval from the client to a Resource Conservation and Recovery Act-compliant disposal facility by a subcontracted waste collector.

Appendix A:
Checking the Calibration of Balances and Pipettes
Standard Operating Procedure

SOP: CHECKING THE CALIBRATION OF BALANCES AND PIPETTES

Task	Checking the calibration of balances and pipettes
Project or Lab Name and Number	Applicable to multiple projects and labs
Additional and Safety Information	The following JSAs must also be read and signed before performing this task: • None
	The following SDSs must be read before performing this task: • None Qualified individuals to teach this task: Lab managers

1. Scope and Applicability

This Standard Operating Procedure describes the procedures and criteria for checking the calibration of pipettes and balances. It applies across all projects and labs unless there are more stringent criteria in place for a particular project.

2. Equipment and Apparatus

- Balances
- Pipettes
- Certified weights

3. Reagents and Standards

- Room temperature water

4. Safety

Do not place water near or spill water on electrical equipment (balance). Wear proper lab attire; at a minimum don gloves and safety glasses.

5. Contamination Control

For balances: Wear specialized gloves (nitrile or provided white cotton) when working with weights to avoid transfer of oil from your hands. If the weight is below 0.5 grams, use the tweezers provided to you to transfer the weight.

For pipettes: Ensure that the container holding water is clean and free of particles (dust, plastic, etc.), which could lead to biased results. Keep water at room temperature.

6. Interferences

Air conditioning drafts and humidity (greater than 50 percent) can cause inaccuracies during measurement of weights. Ensure that balances are not located near air vents and/or use a draft chamber.

7. Procedure

Laboratory equipment used for measuring various parameters must be calibrated periodically and that calibration must be checked routinely. The following procedures will be used in all PTO laboratories and by all PTO staff in field environments, except when there are more stringent criteria set by a particular project.

7.1 EQUIPMENT THAT REQUIRES PERIODIC RE-CALIBRATION

Balances and pipettes are initially calibrated by the vendor, but these items are sensitive to changes over time and, therefore, must be re-calibrated periodically by a certified vendor. Pipettes are only sent for re-calibration when a problem is identified via routine calibration checks. Regardless, balances are re-calibrated by a certified vendor once a year.

To ensure accurate measurements are made with balances and pipettes, the calibrations for these instruments must be checked routinely. When in use, the balances and pipettes must be checked at least once a week and documented in a laboratory notebook.

7.1.1 Checking the Calibration of a Balance

1. Ensure that the balance is on a level surface; check level indicator and adjust feet as necessary.
2. Obtain certified weights from D-128 and record balance and weight information in the designated laboratory notebook.
3. Use a balance brush to sweep away any debris on the weighing surface.
4. Tare the balance.
5. Select two weights that bracket the weights of all samples and standards to be measured.
6. With gloved hands (white glove provided with weights) and/or using the supplied tweezers, place the first weight on the balance and record the weight.
7. Repeat taring and weighing the weights until three consecutive measurements have been made for each of the two weights.
8. For analytical balances, typical weights used are 10 grams (g), 1 g, and 200 milligrams (mg); however, if you plan on weighing items greater than 10 g or less than 200 mg, the 100 g and 10 mg weights may also be used. For top-loading balances, typical weights used are 100 g and 10 g.
9. Balance readings should not be outside the stated tolerance of +/- 1 percent for trace-level analyses or +/- 2 percent for non-trace-level analyses.
10. If balance is outside stated tolerance do not use the balance.

7.1.2 Checking the Calibration of a Pipette

1. Fill a sealable container with deionized water and allow to come to room temperature.
2. Place a disposable beaker on the balance and tare the balance.
3. Record the pipette serial number and calibration volumes.
4. Set the pipette to the first calibration volume.
5. Following proper pipetting technique and transfer an aliquot of water to the disposable beaker.
6. Record the weight of water.
7. Repeat the same volume transfers two more times for a total of three measurements.
8. Repeat the procedure for one additional, different volume ensuring that the two volumes selected bracket the volume of the samples and standards you will be measuring.
9. Assume the density of water is 1 gram per milliliter.

10. Pipette readings should not be outside the stated tolerance of +/- 1 percent for trace-level analyses or +/- 2 percent for non-trace-level analyses.
11. If a pipette is outside the stated tolerances do not use the pipette.

8. Calculations

N/A.

9. Quality Control

9.1 Calibration Certificates

The weights and the balances must be certified once a year. Certification documents should be obtained from the vendor. Pipettes are certified by the vendor before purchase and a certification document should be received with each new pipette. If a pipette must be returned to the vendor to be re-calibrated, a new certification is needed.

10. Troubleshooting

10.1 Balances

Ensure that the balance is level, doors are closed, no drafts are present, and humidity is not greater than 50 percent. Contact the lab manager if balance fails the stated tolerance limits.

10.2 Pipettes

Ensure proper pipetting techniques are being used, tips are fitted securely on the pipette, water is at room temperature, and water is free of debris. Contact the lab manager if the pipette fails the stated tolerance limits.

11. Documentation

All measurements and related information should be kept in a lab notebook in each lab.

12. References and Supporting Documents

12.1 Balances

https://www.troemner.com/media/downloadablepdfs/tolerance/weight_tolerances.pdf.

12.2 Pipettes

https://www.eppendorf.com/product-media/doc/en/116572_Userguide/Eppendorf_Liquid-Handling_Userguide_025_Pipettes_Calibration-adjustment.pdf.

13. Attachments

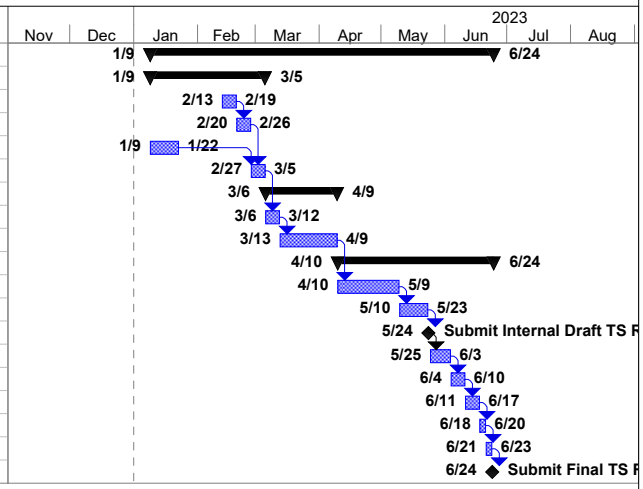
N/A.

Appendix B:
Proposed Schedule

Bench-Scale JP-5 Evaporation Study (dates are subject to change)

Last Updated: Thu 2/16/23

ID	Task Name	Dur	Start	Finish	Predecessors
1	**Bench-Scale JP-5 Evaporation Study**	**167 days**	**Mon 1/9/23**	**Sat 6/24/23**	
2	**Planning**	**56 days**	**Mon 1/9/23**	**Sun 3/5/23**	
3	Request quotes for outside analytical	7 days	Mon 2/13/23	Sun 2/19/23	
4	Setup PO's	7 days	Mon 2/20/23	Sun 2/26/23	3
5	Order supplies for study	14 days	Mon 1/9/23	Sun 1/22/23	
6	Setup AS system	7 days	Mon 2/27/23	Sun 3/5/23	4,5
7	**Treatability Study**	**35 days**	**Mon 3/6/23**	**Sun 4/9/23**	
8	Perform bench-scale TS and ship out samples	7 days	Mon 3/6/23	Sun 3/12/23	6
9	Lab analysis	28 days	Mon 3/13/23	Sun 4/9/23	8
10	**Report**	**76 days**	**Mon 4/10/23**	**Sat 6/24/23**	
11	Prepare Internal Draft	30 days	Mon 4/10/23	Tue 5/9/23	9
12	Peer Review/Tech Edit	14 days	Wed 5/10/23	Tue 5/23/23	11
13	Submit Internal Draft TS Report	1 day	Wed 5/24/23	Wed 5/24/23	12
14	Navy Review	10 days	Thu 5/25/23	Sat 6/3/23	13
15	Prepare/Submit RTCs	7 days	Sun 6/4/23	Sat 6/10/23	14
16	Navy Concurrence of RTCs	7 days	Sun 6/11/23	Sat 6/17/23	15
17	Prepare Draft TS Report	3 days	Sun 6/18/23	Tue 6/20/23	16
18	Peer Review/Tech Edit	3 days	Wed 6/21/23	Fri 6/23/23	17
19	Submit Final TS Report	1 day	Sat 6/24/23	Sat 6/24/23	18



Project: Schedule.mpp

Task | Summary | Project Summary

Milestone | Summary Progress | Progress

Run Date: Thu 2/16/23