Ultra Violet (UV) Monitoring
Summary of Supplement 1 and Additional Information

Red Hill Tank Closure Technical Working Group

Meetings on May 19, May 25, and June 15, 2023

UV Monitoring: Overview of Supplement 1

Concurrent Tank Cleaning and UV Visual Monitoring

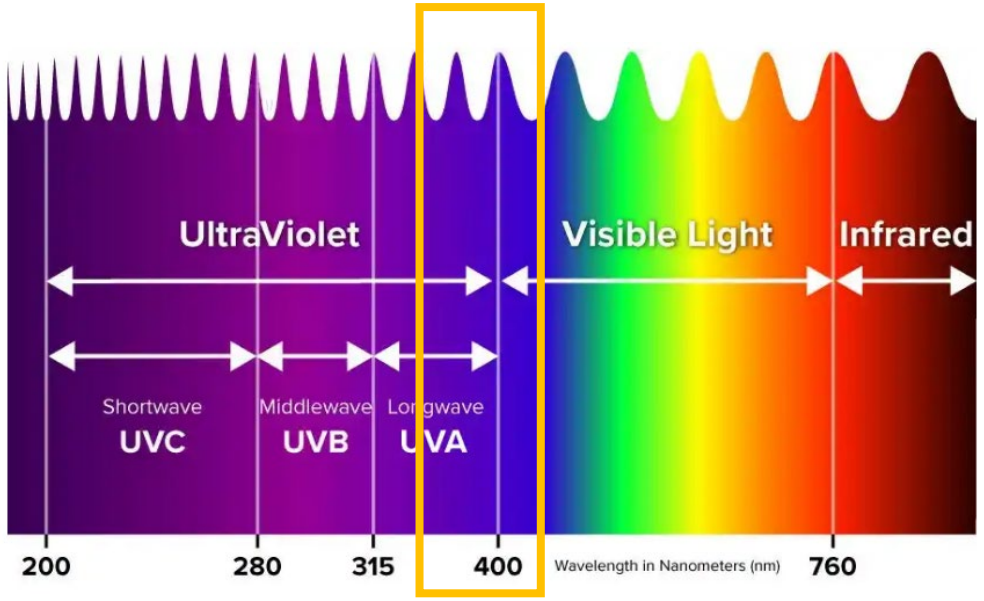
"Presence vs. Absence" UV Verification Method

Follow-on Cleaning of Identified Fluoresced Areas

What is Ultra Violet (UV) Fluorescence?

- The term ultraviolet (UV) refers to light that has a shorter wavelength than visible violet light
- There are 3 categories of UV light:
  - UV-A: Longest wavelength (320nm to 400nm), which is commercially available ("blacklight") and safe for human exposure. Partially within visible light spectrum.
  - UV-B: Middle wavelength (290nm to 320nm), which causes sunburns in humans upon overexposure
  - UV-C: Shortest wavelength (below 280 nm)
- Photoluminescence: Occurs when UV light is absorbed by the fluorophore of certain materials, promoting it to a temporary excited state. As the excited state returns to the ground state, a photon is emitted, producing visible light (VanOrman and Nienhaus, 2020).

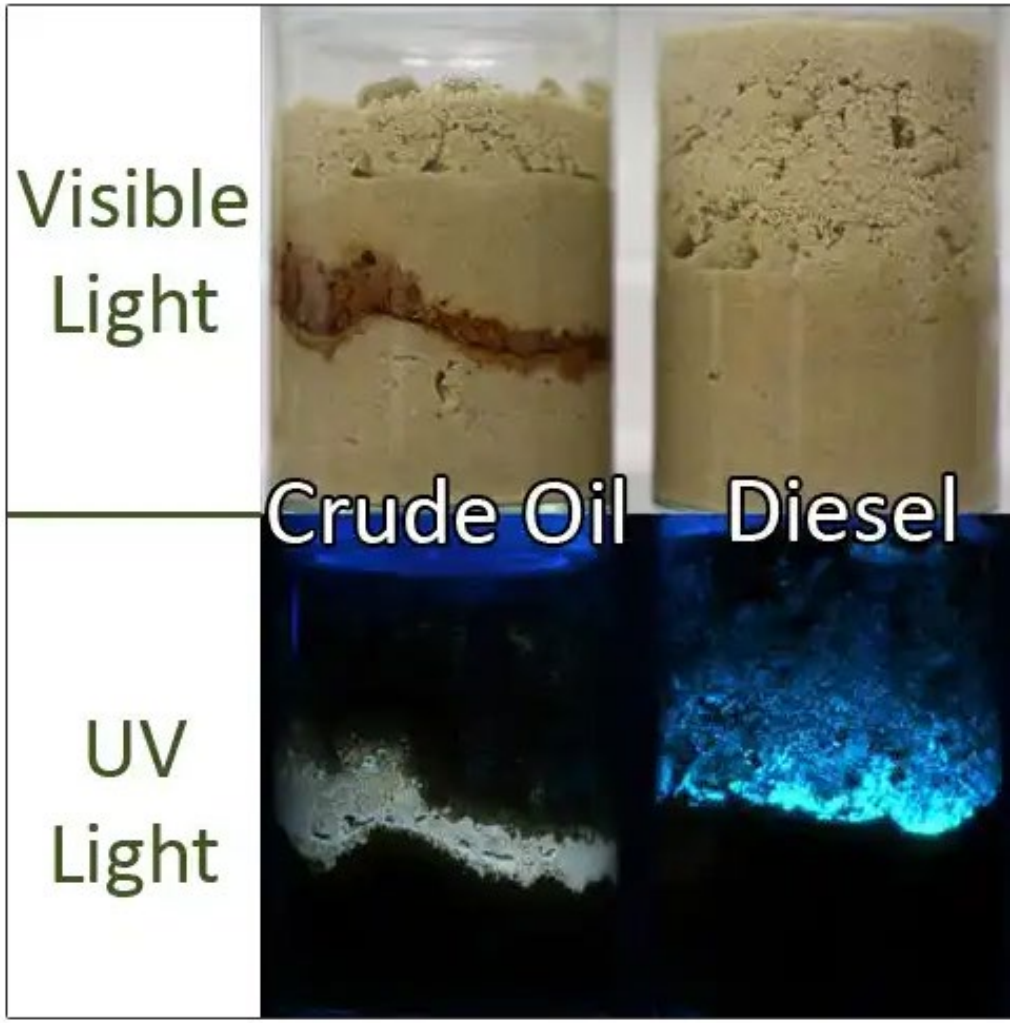
JP-5, F-24, F-76 lie within the same wavelength range.



Graphic: https://www.hepacart.com/blog/far-uv-vs.-near-uv

How does UV Fluorescence Relate to Petroleum?

- Petroleum becomes electronically excited in the presence of UV light, resulting in fluorescence, primarily in the visible region of the spectrum (Brown and Fingas, 2003).
- Under UV light, petroleum products and crude oils exhibit fluorescence which varies in intensity and hue (Riecker, 1962; Bujewski and Rutherford, 1997).
- As a screening tool, fluorescence induced by UV light can discriminate petroleum-based products on most backgrounds (Fingas and Brown, 2014).



Graphic: https://www.dakotatechnologies.com/learn-more/intro-to-lif/overview

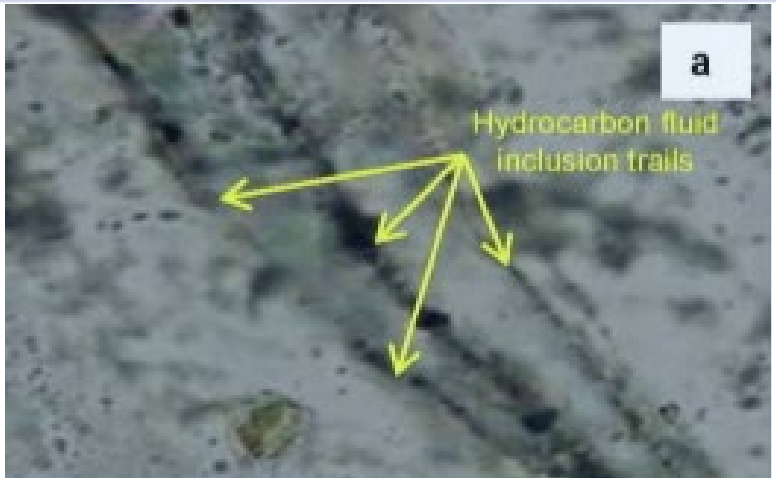
UV Identification of Residual Petroleum

Standard Visual Monitoring

- Limited to observation of residual petroleum in the visible light range.

UV Fluorescence Visual Monitoring

- Positively identifies residual petroleum contamination based on emission of fluorescence.



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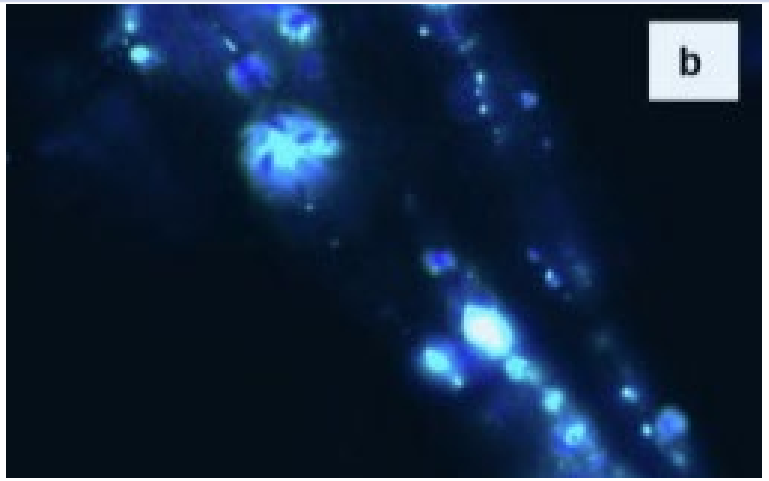
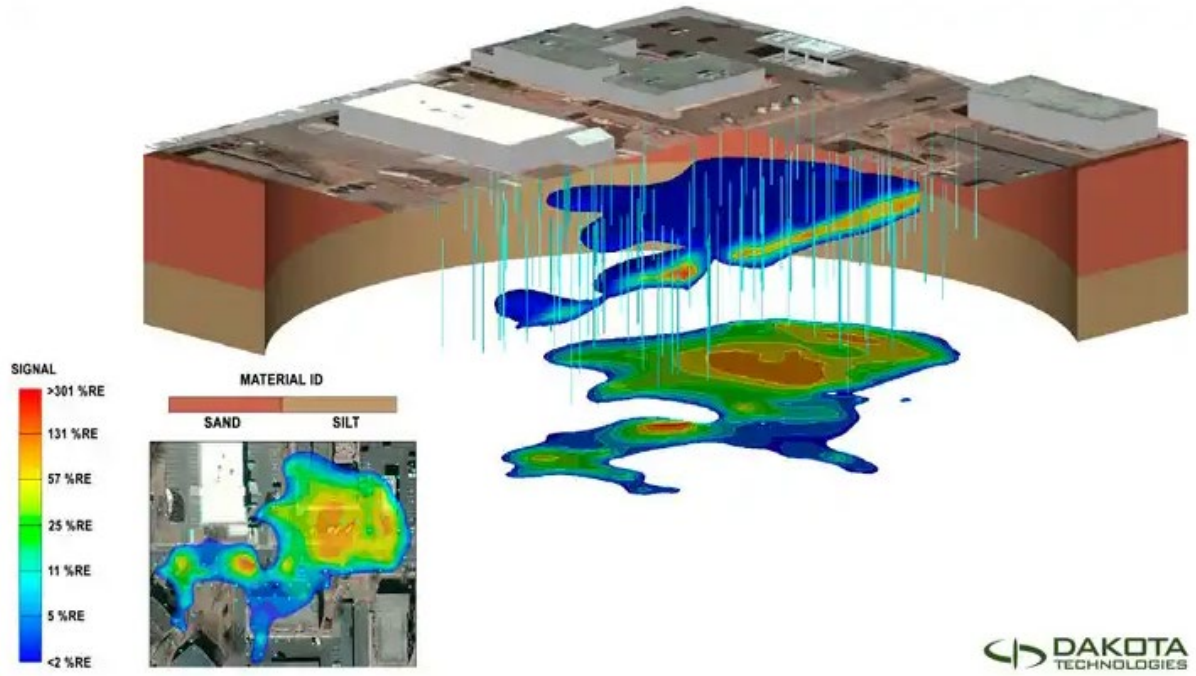


Graphic: Thankan, S et al, 2023

Has UV Fluorescence been used to identify petroleum contamination?

- UV fluorescence is increasingly used by the petroleum industry as it offers high sensitivity and good diagnostic potential (Steffens et. al., 2010).
- Laser-induced fluorescence (LIF) is used to identify petroleum products in the subsurface.
- LIF is heavily cited by HDOH HEER guidance documents (Technical Guidance Manual (TGM) Section 8; TGM Section 3; HDOH, 2017; and HDOH, 2018).



Graphic: https://asct-1.itrcweb.org/3-4-laser-induced-fluorescence/

KEY POINT

LIF uses UV light in the form of a laser, which is needed to excite petroleum in the subsurface and emit a detectable signal. In the open air setting of a tank, lasers are not needed, and a UV floodlight is sufficient. In each case, the concept of UV fluorescence of petroleum remains the same.

Regulations Supporting UV Light

- The SOP is modeled after “California Code of Regulations Title 23 § 2642 – Visual Monitoring” (Cal. Code Regs. Tit. 23, § 2642), which describes procedures for visual inspection of underground storage tanks for hazardous substances.
- Application of UV light to induce fluorescence and identify petroleum products is based upon approved field screening procedures accepted by State of Hawaii Department of Health’s (HDOH) Hazard Evaluation and Emergency Response (HEER), including the following HDOH HEER documents:
    - Technical Guidance Manual (TGM) Section 8 (Subsection 8.5.4 Other CPT instruments),
    - Section 3 (Subsection 3.4.4 Subsurface Decision Units),
    - LNAPL Guide Companion Document (HDOH 2018), and
    - Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater (HDOH 2017).

Supplement 1: Summary of UV Inspection

- As part of their Quality Control Program (QC), the tank cleaning contractor will perform visual monitoring and verification of successful tank cleaning by ultraviolet (UV) fluorescence.
- The Navy will be responsible for quality assurance (QA) and will use UV fluorescence to verify successful tank cleaning.
- The UV process provides a “presence or absence” indication of residual fuel within the tanks.
    - The absence of fluorescence indicates cleaning is complete
    - The observation of fluorescence indicates presence of residual fuel, and additional cleaning will occur.

Supplement 1: Contractor QC

- Tanks will be cleared by a certified marine chemist or industrial hygienist to ensure tanks are safe for entry.
- UV inspection personnel will receive documented training for the operation of mobility and safety equipment, the UV inspection equipment, and emergency procedures.
- UV inspection personnel will survey the entirety of the internal surface within the tanks using UV.
- Prior to use, UV light instruments will be demonstrated to be capable of producing fluorescence on a fuel contaminated surface from a distance of 25 feet *[As noted in Navy responses to DOH and EPA comments, the Navy will determine the UV light "effective distance," which may be less than 25 feet. All UV inspections will be performed from the effective distance or less. See Slide 13 below.]*
- If inspection personnel observe fluorescence, the tank cleaning contractor will perform additional cleaning. Cleaning will repeated as necessary until fluorescence is not observed.

Supplement 1: Navy QA

- The DON will be responsible for quality assurance (QA) and will hire a QA contractor or use Navy personnel to verify successful tank cleaning. The QA verification will follow the same UV Standard Operating Procedure (SOP) used during QC. Visual monitoring will be performed within 15 days (or as soon as practicable) following completion of tank cleaning operations.
- If the QA personnel identify fluorescence during UV monitoring, they will note the location and size on the *Red Hill Tank Visual Monitoring Field Form*, with sufficient graphical detail (photo evidence and/or drawings) to aid in follow-on cleaning identified areas. The follow-on cleaning will be verified by the same UV fluorescence procedure, and the cleaning will be repeated until fluorescence is not observed.
- The DON will submit to DOH the final inspection results confirming cleanliness standards have been met prior to closure.

Supplement 1: UV Inspection Documentation

- Inspection personnel will note the location and size of any UV fluorescence on the *Tank Visual Monitoring Field Form* (included in the SOP).
- Contractor inspection personnel will complete and submit to the Navy a *Visual Monitoring Report*, which includes the following:
  - Completion of the *Tank Visual Monitoring Field Form*;
  - Date(s) and duration of monitoring event;
  - The methods and equipment (such as make/model of UV light, type of mobile equipment used), identified by name and model, used for performing the monitoring.
  - The location(s), as identified on a plot plan, where the monitoring was performed;
  - The name(s), title(s), and company of the person(s) who conducted the monitoring and maintained the equipment;
  - Documented findings and any necessary corrective actions

Details and Responses to Comments

Detailed UV Light Process

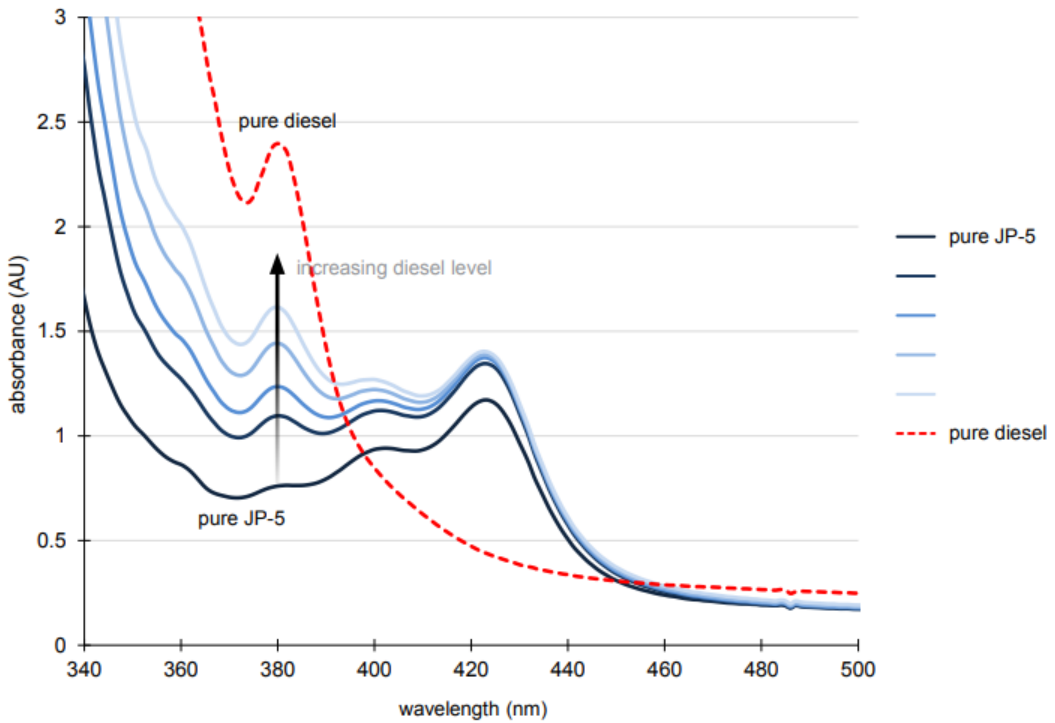
- UV light equipment
  - UVA flood light with ~320nm to ~400nm wavelength
  - Such lights are commercially available and relatively safe for human exposure (compared to UVB or UVC).
- Required effectiveness
  - Must produce fluorescence of a thin layer of fuel (approximately 1 mil [0.001 inch]) for each of the 3 fuels (F-76, F-24, and JP-5)
  - Must work from a distance of 25 feet (conservative, proposed in Supplement 1) or a distance greater than the actual working distance (expected to be 3 to 5 feet). This will be the “effective distance.”
- Standard
  - Visual observation of presence vs. absence of fluorescence
  - Presence means additional cleaning required
  - Absence means cleaning is complete
- Anticipated contractor QC work procedure – entire tank
  - Pressure wash a section of tank wall
  - Shine the UV light from the effective distance (or less)
  - Fluorescence → additional pressure washing
  - No fluorescence → move to next section
- Navy QA procedure – spot checks
  - Same UV light, same effective distance as QC

Responses to Comments *(1)*

- Is UV inspection effective for the specific fuels at Red Hill?
  - Scientific literature demonstrates that the fuels within Red Hill (JP-5, F-24, F-76) will fluoresce in the presence of 340-420nm light, which is in the UVA and visual spectrum (see Slide 3). Polyaromatic hydrocarbons (PAHs) within these fuels fluoresce at these wavelengths.
  - The cleaning contractor will field verify the UV equipment for JP-5, F-24, F-76
- We were unable to find any examples online of UV fluorescence being used to verify that jet fuel tanks are clean.
  - Since tank regulations do not require UV light confirmation, the Navy is also unaware of any examples where it has been used to verify jet fuel tanks are clean. Nevertheless, UV light has been used successfully in other applications (see Slide 15 below and references in Supplement 1).

Absorbance Curves of Jet Fuel with Diesel Contamination

The spectra below demonstrate how the OMA visualizes the pure jet fuel (JP-5) absorbance curve as well as the structural effects of increasing diesel concentration:



Graphic: Applied Analytics AN-017: Measuring Diesel in Jet Fuel

Responses to Comments *(2)*

- The Navy does not provide a backup method, should UV inspection prove ineffective.
  - The proposed approach is simple and has a proven track record in other settings. If a backup method is needed, Navy would work with DOH and EPA to determine the approach.
- The DOH Technical Guidance Manual (TGM) only describes using UV to identify petroleum in soil and groundwater, not on tank surfaces for cleaning. Please explain how this technology will be used for tank surfaces.
  - A laser is needed to excite petroleum in the subsurface, but a UV floodlight will work in the open air setting of a tank. Thus, the UV approach is simpler for tank surfaces than for soil and groundwater, but the concept of UV fluorescence of petroleum remains the same in each case (see Slide 6).
- Provide examples of this technology being used for similar applications
  - UV fluorescence is widely used in the food and drug industry to verify the cleanliness of processing tanks
  - As noted above, UV fluorescence is to identify petroleum in soil and groundwater.

Responses to Comments *(3)*

- How will Navy ensure inspectors are sufficiently trained and able to perform consistently?
  - Contract documents will require the contractor to provide consistent training to inspectors.
- Where within the tanks will inspection be performed? The entire surface area? A selection of inspection points?
  - For contractor QC, the UV inspections will involve the entire area of the tanks.
  - For QA, UV inspections will involve spot checks
  - If the early results show few or no areas of fluorescence, the Navy may propose a reduction in the inspection areas for DOH and EPA consideration.

False Positives

- *[EPA comment]* The Contaminated Sites Clean-Up Information website states that "…deicing agents, antifreeze additives, and some detergent products…" may also fluoresce. Explain how Navy will avoid a false-positive result.
  - The Navy will treat any fluorescence as an indication of petroleum residual because we do not expect to be able to distinguish fluorescence of petroleum from the other listed constituents. The Navy will accept the effort associated with re-cleaning any false positive areas.
  - If a false positive is caused by material that will not wash off (such as tank coatings), then Navy will propose a method to demonstrate petroleum residual is not present.
  - Most importantly – in advance of cleaning, the tank cleaning contractor will test the 3 fuel types, the tank coatings, and the cleaning solution for false positives.

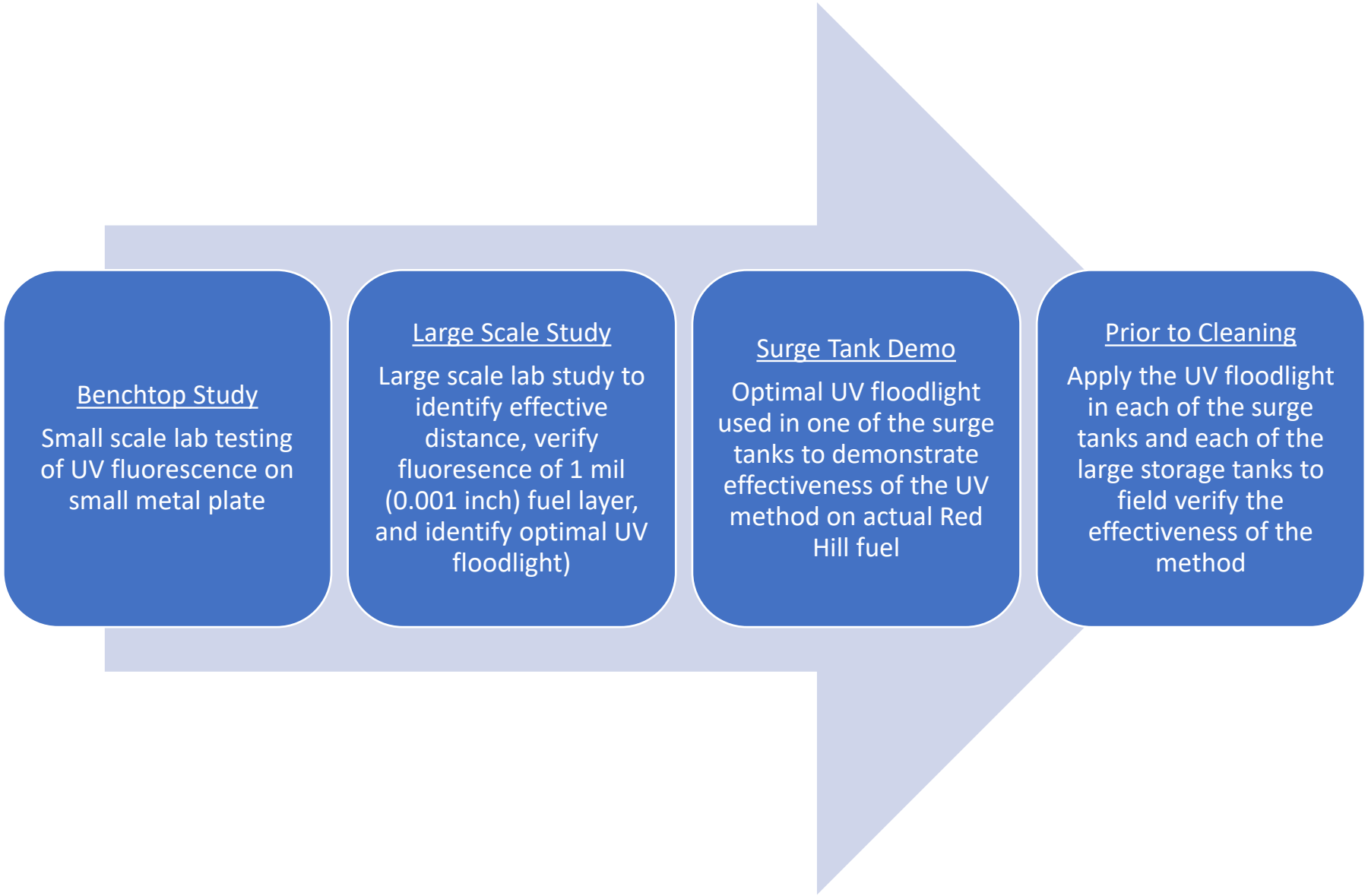
False Negatives

- Expectation of no false negatives
  - Age of Red Hill fuels – variable, perhaps up to 30 years
  - Petroleum fluoresces due to PAHs, which are relatively stable compounds that are very slow to evaporate or biodegrade. PAHs would still be present in the Red Hill fuels after 30 years or more.
- Prior to the start of cleaning, cleaning contractor will test the UV light on the fuels in each tank
  - This evaluation will directly test for false negatives
  - Based on the properties of PAHs, the expectation is that false negatives will not occur

Laboratory and Field Evaluations

- The following evaluations will occur:
  - Navy will conduct a benchtop laboratory study for two of the three Red Hill fuel types (F-76 and JP-5) on small steel plates using UV equipment producing UVA light in wavelengths ranging from ~320nm to ~400nm.
  - The Navy will conduct a large scale study of two Red Hill fuel types (F-76 and JP-5) to identify the distance from which the UV light can produce fluorescence on a thin layer of fuel (approximately 1 mil [0.001 inch]) on large steel plates. This distance will be the "effective distance" of the light. Depending on the results, more than one type of UV light may be tested in order to determine the optimal UV floodlight.
  - The tank cleaning contractor will use the optimal UV floodlight in one of the Red Hill surge tanks to demonstrate effectiveness of the UV method on actual Red Hill fuel. *[This effort depends on the timing of surge tank defueling and the contractor having access to a surge tank. If a surge tank is not available, then this evaluation will not occur.]*
  - The tank cleaning contractor will apply the UV floodlight in each of the surge tanks and each of the large storage tanks to field verify the effectiveness of the method prior to beginning cleaning of each tank.

Laboratory and Field Evaluations Summary



Backup Plan

- What is the backup method, should UV inspection prove ineffective?
  - The proposed UV approach is simple and has a proven track record in other settings. If the initial testing (described in Slide 19) indicates that a backup method is needed, the Navy will propose a method to DOH and EPA.
- Summary of prior discussions among DOH, EPA, and Navy
  - Tank closure regulations do not provide guidance on methods or standards to show tanks are clean
  - Past tank closure efforts in HI and elsewhere do not provide examples of viable approaches
  - Thus, there are no ready alternatives to the proposed UV light method
- Navy perspective
  - Work within the UST regulations
  - Avoid a situation where tank cleaning cannot meet the standard
  - If a backup approach is needed, use a method that has been done before (for example, something based on the Marine Chemist approach for demonstrating tanks are safe for human occupancy)
  - Defer discussion of a backup approach until the need arises.

DOH and EPA Approval

- The Navy requests DOH and EPA approval of the UV light method.
  - Approval is needed so the Navy can modify the tank cleaning contract to include UV light verification as described in Supplement 1, responses to DOH and EPA comments, and this presentation
  - DOH and EPA will have the opportunity to review and comment on the contractor work plan

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Questions