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In reply, please refer to:
File: RB 073 2023

November 20, 2023

Agency for Toxic Substances and Disease Registry (ATSDR)
ATTN: Elizabeth Irvin, PhD
Office of Community Health and Hazard Assessment
Agency for Toxic Substances and Disease Registry
(sent via email)

Subject: Response to: *Technical Review - Exposure Assessment: November 2021 Release of JP-5 Jet Fuel into the Joint Base Pearl Harbor Hickam and Connected Drinking Water Systems*

Dear ATSDR Reviewers,

Thank you for your comments and recommended edits to the July 26 and August 14, 2023, editions of the Hawai'i Department of Health (HIDOH) report *Exposure Assessment: November 2021 Release of JP-5 Jet Fuel into the Joint Base Pearl Harbor Hickam and Connected Drinking Water Systems* (ATSDR letter dated November 6, 2023). Earlier, draft comments and discussions held during conference calls were taken into consideration during preparation of the October 2023 update to the document. Final comments provided in the November 6, 2023, letter reflected earlier discussions and do not require additional edits to the document.

A summary of key comments and associated edits to the report is attached. Please contact me at 1-808-586-4249 or roger.brewer@doh.hawaii.gov if you have any further questions.

Sincerely

Roger Brewer, PhD
Senior Environmental Scientist
Hazard Evaluation and Emergency Response (HEER)

Attachment 1: ATSDR comments on HIDOH JBPHH Exposure Assessment
Attachment 2: HIDOH Response to ATSDR comments

Attachment 1: ATSDR Letter Technical Review (November 6, 2023)

Letter Technical Review

Hawaii Department of Health

Technical Review - Exposure Assessment: November 2021 Release of JP-5 Jet Fuel into the Joint Base Pearl Harbor Hickam and Connected Drinking Water Systems

Prepared by the

Agency for Toxic Substances and Disease Registry

November 6, 2023

DEPARTMENT OF HEALTH & HUMAN SERVICES Public Health Service

Centers for Disease Control
and Prevention (CDC)
Atlanta, GA 30341-3724

November 6, 2023

Dr. Roger Brewer
Senior Environmental Scientist
Hazard Evaluation and Emergency Response Office
Hawaii Department of Public Health
2385 Waimano Home Rd #100
Pearl City, Hawaii 96782

Dear Dr. Brewer,

This letter has been prepared by the Agency for Toxic Substances and Disease Registry (ATSDR), Office of Community Health Hazard Assessment, to respond to your June 2023 request for ATSDR's technical review of the Hawaii Department of Health's Red Hill Exposure Assessment. We have reviewed the July 26, 2023 and August 14, 2023 versions of the report, "Exposure Assessment: November 2021 Release of JP-5 Jet Fuel into the Joint Base Pearl Harbor Hickam and Connected Drinking Water Systems," the report attachments, and a video overview available from the "JBPHH November 2021 JP-5 Exposure Assessment" section of the Hawaii Department of Health Red Hill Website (https://health.hawaii.gov/about/red-hill-water-information/).

We appreciate this innovative effort to fill important data and information gaps related to exposures during the Red Hill water contamination incident. We offer several comments and questions below.

Overall Comments

1. The report adds valuable detailed information to the limited body of knowledge related to JP-5 and provides innovative analyses and approaches for consideration. We appreciated the following aspects of the report:
    a. It is helpful to have a clear explanation of the components of the fuel in neat, dissolved phase, and vapor phase. The explanation and estimates for how dissolved and emulsified product could have combined is also helpful.
    b. The experimental methods used to estimate potential exposures, risk assessment and risk characterizations are well presented and supported by the experimental data.
    c. This is a well written document that uses an approach that divides a complex TPH mixture into subfractions with reduced complexity. Then each subfraction can be

assessed using a relevant mixture approach for that particular fraction. Finally, risk of the complex mixture can be estimated by adding individual fraction risks.

2. ATSDR appreciates the use of multiple lines of evidence and sees value in estimating potential maximum exposures. But there are more lines of evidence that could be considered, including:
    a. Statements about outdoor air exposure from tunnel venting could be strengthened with additional modeling/meteorological data.
    b. Comparing modeled/estimated results with well & drinking water sampling data collected after the release. We recognize those data have gaps and limitations, but we recommend they be integrated into this assessment.
        i. Additional discussion of the sampling (e.g., split Navy/DOH sampling that began in December 2021) and analytical (i.e., 8015B) methods would be helpful.
        ii. Consider a comparison of compound concentrations between samples from 12/7/2021 (https://health.hawaii.gov/about/files/2021/12/J77793-1-UDS-Level-2-Report-Final-Report-RH-Shaft.pdf) and the estimated concentrations from the EA report (Table 2, Attachment 4).
3. The exposure assessment could be more nuanced/specific with additional information about the JBPHH drinking water system – what parts of the system would have been most affected? When? Perhaps a hydrologist could help address how neat/dissolved/emulsified product would have behaved in the shaft/system.
4. ATSDR will consider ways to use the data and/or some of the analyses from this exposure assessment in our public health assessment process. However, the RMEs in this exposure assessment were estimated using a different procedure than ATSDR's typical process for public health assessments.
5. The report and YouTube presentation are written/delivered at a level beyond what a non-technical reader would want to digest. A general audience would likely appreciate simpler, shorter products that explain this technical report.
6. The report needs editorial proofreading for typos, word repetition and other inconsistencies. In addition, references to section numbers that changed in updates to the report should be updated (e.g., there are references to section 3.4.1, which no longer exists).
7. There are multiple table numbers/letters that are repeated (e.g., Table 1 on pgs 32, 52, 78, and 82 and Table C on pages 63 and 68). Suggest revising so each table has a unique number/letter.
8. The math in the tables doesn't always add up, which is likely the result of rounding errors in what is being presented. See Table A, pg 67 where 27% and 73% were rounded differently than what is reflected in the second column (i.e., 3.9/5.4 = 0.722 ~ 72% and 1.5/5.4 = 0.277 ~ 28%). Benzene is rounded down from 1.85% to the displayed 1.8 (0.10/5.4).

Detailed Comments and Questions

9. 1.2, pg 2: When were TPH (as opposed to TOC) samples first collected from the shaft and/or system? If known, suggest noting when TPH sampling began in the report.
10. 2.2, pg 7, Additives. Are you able to elaborate on potential trace amounts of other, proprietary additives?
11. 3.1., pg 10: We are unclear the basis for how DiEGME would be dissolved into groundwater due to miscibility. The degradation of DiEGME with short half-life does not explain it being not detected in groundwater samples. Have you considered the roles of preservation techniques or

the transportation and holding times? Were samples treated with HCl prior to transportation? If so, that could have caused the hydrolysis of the ether bond to give methanol and ethylene glycol.

12. 3.2.1 pg11: Can a citation be added for the following statement? "Resident reports indicate that impacts to outdoor air were especially strong…"
13. 3.3: For estimating inhalation and dermal exposures, HDOH might be interested in ATSDR's SHOWER model: https://www.neha.org/Images/resources/JEH4.19-Column-Direct-From-ATSDR.pdf
14. 3.3.2, pg 13: Exposure Concentrations – Dissolved-Phase Contaminants
    a. Suggest explaining the rationale for applying a 10 mL layer of JP-5 on 1 liter of water for the lab experiment. Would there be value in using a range of milliliter layers of JP-5 placed in the funnel flasks (e.g., 5-mL, 10-mL, 15-mL) to account for more or less JP-5 volume entering the drinking water system?
    b. What is reason for using sterilized water for five flask experiments vs. using Red Hill shaft water absent of TPHs? Could there be effects of differences in basic water quality parameters (e.g., pH, alkalinity, etc.)?
    c. [From the report: "The relative makeup of hydrocarbon exposure mimics the makeup of the fuel, dominated by >C8-C18 aliphatic compounds (121 mg/L) with a lesser amount of >C8 aromatics (39 mg/L) and a small contribution from BTEXMN compounds (4.3 mg/L)."] Can a comparison be made of the relative percentages of different compounds in the experimental flasks to the relative percentages of different compounds in water samples collected from the Red Hill shaft or taps? In other words, do we expect that the relative percentages of various >C8-C18 aliphatic compounds, >C8 aromatics, and BTEXMN compounds in the experimental flasks to be similar to that in Red Hill supply water?
    d. Suggest adding a discussion of where/how water is drawn out of the Red Hill shaft and when it would have been mixed with other well water in the system.
15. 3.3.3 pg 15: The report notes that concentration of TPH measured in the shaft reflects the last water drawn into the well prior to shut down. But is it possible that additional contamination could have migrated to the shaft in the intervening weeks?
16. 3.3.4, pg 15: Suggest describing where the DiEGME emulsion formed. In groundwater? The shaft? System?
17. 3.3.5, pg 16-17: It is unclear how HDOH attributed resident health affects to inhalation of vapors as opposed to ingestion. Did these residents report how they were using the water?
18. 4.0, pg 18, 3rd paragraph. Health Effects: Suggest noting that most of the health effects associated with DiEGME described in this report are from animal studies. Several reproductive effects have been reported after DiEGME exposure, though at high concentrations in an animal model. In human exposure studies, commercial grade diethylene glycol monoethyl ether (not methylether) (containing 30% ethylene glycol) and an aqueous dilution of pure diethylene glycol monoethyl ether (0.2% ethylene glycol) showed slight faint erythema, as cited in the report (NIH 2023).
19. 5.1, pg 19 Toxicity Factors – Individually Targeted Compounds
    a. Suggest adding a description of what the various screening levels represent (e.g., Reference Dose, Reference Concentration, etc)

b. The report states “Acute toxicity factors are not available for any of the compounds.” However, ATSDR has established acute MRLs that could be incorporated for certain contaminants/exposure routes (e.g., benzene, toluene, naphthalene)

20. 7.2, pg 25: Summary of Exposure Assessment
    a. Suggest noting in the report body that table 6 only addresses ingestion (not inhalation risks)
    b. The following statement may set unrealistic expectations regarding ATSDR’s public health assessment, since ATSDR will not be collecting additional health outcome data: “A better understanding of observed and reported health effects both within the effected [sic] community as a whole and between affected individuals requires a thorough public health assessment of affected base residents.” Consider replacing “a thorough public health assessment” with “additional epidemiological study”
21. Figure 2, pg 33. Conceptual Site Model of exposure of JBPHH residents to JP-5 jet fuel. We suggest adding inhalation as an exposure pathway for cooking, a potential pathway noted in the report section 3.1, pg 10.
22. Table 5, pg 42. Risk-based screening levels for JP-5 jet fuel-related contaminants in tap water and ambient air.
    a. Why is the chronic naphthalene inhalation screening level (3.1 μg/m3) higher than the subchronic (0.6 μg/m3)?
23. Please provide clarification on the reason for adjusting the carbon range data to achieve 100% as noted in the following:
    a. Table 1 (pg 55) Summary of water-fuel laboratory experiment JP-5 neat fuel sample data
    b. Table 3a (pg 76) Modeled effective solubilities and relative makeup of dissolved-phase hydrocarbons in water that is in contact with fresh JP-5 jet fuel.
    c. Table 1, note 1: “Carbon range data normalized at recommendation of Newfields to generate a total concentration (mass) of compounds in the JP-5 fuel of 1,000,000 mg/kg (100%).”
    d. Table 3a, note 1:“JP-5 composition based on analysis of JP-5 collected from Red Hill facility (Newfields 2023a). Carbon range data adjusted to generate a total BTEXNM+Carbon Range concentration of 1,000,000 mg/kg.”
24. In some tables superscripts/notes are not defined or missing.
    e. Table C, pg 68 does not use superscript/note 1, though there is a note 1.
    f. Table 1, pg 84 doesn’t include superscript/note 3 and Table 1, pg 85 doesn’t define superscript/note 3.
25. Table C, pg 63 and Table C, pg 68: It looks like “BTEXN” in the “Total BTEXN” row and the last two columns should be “BTEXNM” since the total includes 1- and 2-methylnaphthalene (e.g., Table C, pg 68: Total BTEXN would be benzene + toluene + ethylbenzene + xylenes + naphthalene = 1.8% + 3.7% + 1.5% + 12% = 21.4%. But, the total listed is 27% because it includes 1-methylnaphthalene and 2-methylnaphthalene, 3.4% and 2.1%, respectively.)
26. Attachment 7: Calculation of Carbon Range-Weighted TPH Toxicity Factors:
    a. Equations 1-3 are based on dose additivity, which is often used for mixtures assessment.
    b. We found the explanation of equation 4 and the USEPA tap water model for TPH (p 75) difficult to follow. We suggest more thoroughly describing the model.

c. USEPA 2004, 2021 and 2023 are cited in footnotes to tables and the text (p80) Suggest including them in the list of references with full citations.
d. ATSDR 2023 is referenced, but there is no ATSDR 2023 document. The appropriate reference is ATSDR 2017 (accessed May 2023).

Minor Editorial Issues:

27. 5.2.1 pg 19, Carbon Ranges: Should "Environment" be "Exposure" in the following sentence? "Confidence in the updated toxicity factors was not reviewed as part of the Environment Assessment but should be included in subsequent Health Assessments that incorporate health effects experienced by JBPHH residents."
28. 6.2 pg 23, Ambient Air: Is this sentence missing a verb (e.g., "are" between "levels" and "below")? "Both screening levels below common background levels of TPH in ambient air of up to and greater than 1,000 µg/L."
29. Table 3, pg 39-40, Toxicity factors for individually targeted contaminants and carbon ranges.
    a. Note 2 – "Acute Minimum Risk Level" should be "Acute Minimal Risk Level" see https://www.atsdr.cdc.gov/mrls/index.html.
    b. Note 4 is unclear – "Sum of acute, subchronic and chronic exposure health effects" – would "Includes" be more accurate than "sum of"? This is the assumption based on the description in the report body.

Please let us know if you have any questions or would like to discuss issues discussed in the technical review.

Sincerely,

Elizabeth Irvin, PhD
Office of Community Health and Hazard Assessment
Agency for Toxic Substances and Disease Registry

Attachment 2: HIDOH Response to ATSDR Comments

Key ATSDR Comments	HIDOH Response
Overall ATSDR Comments	
2a. Statements about outdoor air exposure from tunnel venting could be strengthened withadditional modeling/meteorological data.	Reference to recorded wind patterns on the day of and following the release noted in Section 3.1 of the report and now restated in Section 3.2.1. Modeling of wind dispersion of vapors is beyond the scope of the report and resources of HIDOH.
2bi. Additional discussion of the sampling (e.g., split Navy/DOH sampling that beganin December 2021) and analytical (i.e., 8015B) methods would be helpful.	Refer to edits to Section 3.3.3. Concentrations of BTEXNM in referenced samples from Red Hill Shaft added to the report and discussed in comparison to the JP-5 experiment data.
2bii. Consider a comparison of compound concentrations between and the estimated concentrations from theEA report (Table 2, Attachment 4).	
3. The exposure assessment could be more nuanced/specific with additional information about theJBPHH drinking water system – what parts of the system would have been most affected? When? Perhaps a hydrologist could help address how neat/dissolved/emulsified product would have behaved in the shaft/system.	Agree that this would be useful information. Modeling of the migration of slugs of jet fuel-contaminated water through the JBPHH drinking water system is beyond the scope of the report, however, as well as the resources of HIDOH. Detailed information of the base drinking water system might also be proprietary. Neat/dissolved/emulsified was pulled into the drinking water system by the Red Hill Shaft pump, either from the top of the water table or below the water table via other pathways in the basalt bedrock. Little additional mixing is likely to have occurred on once drawn into the system piping network, although mixing would have occurred in aboveground storage tanks on the bases.
4. ATSDR will consider ways to use the data and/or some of the analyses from this exposure assessment in our public health assessment process. However, the RMEs in this exposure assessment were estimated using a different procedure than ATSDR's typical process for publichealth assessments.	The report provides that best available method for estimation of RMEs. Data from the experiments provides superior information than would have actual sample data from JBPHH taps due to the inclusion of detailed data on the carbon range makeup of both the neat fuel and dissolved-phase hydrocarbons. Standard laboratory methods would have in contrast provided only gross TPH data for GRO, DRO and RRO with no information on the carbon range makeup of either the fuel or dissolved-phase contaminants. Data from the

	experiment also provided information on the weighted toxicity of mixtures of degraded hydrocarbon mixtures in the tapwater that would again have been unavailable by standard laboratory methods.
5. The report and YouTube presentation are written/delivered at a level beyond what a non-technical reader would want to digest. A general audience would likely appreciate simpler, shorter products that explain this technical report.	The Executive Summary added to the October 2023 update of the report is intended to serve this purpose. Less technical summaries will be prepared based on additional requests from stakeholders.
Detailed Comments and Questions	
9. Section 1.2, pg 2. When were TPH (as opposed to TOC) samples first collected from the shaft and/orsystem? If known, suggest noting when TPH sampling began in the report.	Refer to updates to Section 1.2 and Section 1.3 of the EA report. Detailed testing of tapwater for TPH and BTEXNM began in early January 2021. Sample data were intended to assess the adequacy of flushing of individual zones of the JBPHH drinking water system. The data are not representative of tapwater contamination immediately following the November 2021 release of JP-5 into the system.
10. Section 2.2, pg 7, Additives. Are you able to elaborate on potential trace amounts of other, proprietaryadditives?	Additional elaboration on additives is not possible beyond that noted in the text of the report. As discussed in the report, however, additives other than DiGME were apparently present at only trace concentrations. Based on available information, acute health effects experienced by residents were most likely caused by fuel-related hydrocarbons in some cases augmented by DiEGME.
11. Section3.1., pg 10: We are unclear the basis for how DiEGME would be dissolved into groundwater dueto miscibility... Have you considered the roles of preservation techniques or the transportation and holding times? Were samples treated with HCl prior to transportation? Ifso, that could have caused the hydrolysis of the ether bond to give methanol and ethylene glycol.	Water samples were tested for DiEGME using USEPA Method 8270D. This method only calls for chilling of the samples, without the addition of HCL or other preservatives. Entrapment of DiEGME in the gel-like material noted in tapwater is concluded in the report to explain the general absence of dissolved-phase DiEGME in water samples.
12. Section 3.2.1 pg11: Can a citation be added for the following statement? “Resident reports indicate that impacts to outdoor air were especially strong…”	Clarified to state: “Residents reported to the author of this EA report that jet fuel odors in outdoor air were especially strong in the Red Hill and Aliamanu Military Reservation (AMR) areas

	in the days and weeks following the initial release of jet fuel." A further note was added: "The author of this EA report also identified periodic, strong fuel vapors in outdoor air while traveling in the area between Red Hill and AMR during this time period." The Navy's 2022 report referenced in the EA notes that Red Hill workers could smell jet fuel vapors as far away as the H3 highway on the day of the release. This is already noted in the EA report.
13. Section 3.3: For estimating inhalation and dermal exposures, HDOH might be interested in ATSDR's SHOWER model: JEH4.19-Column-Direct-From-ATSDR.pdf (neha.org)	The ATSDR shower model was reviewed. Use of the model to estimate concentrations of hydrocarbons in indoor air during use and flushing of showers could be included in later reviews of the incidence but was determined to be beyond the scope of the subject report.
14a. Section 3.3.2, pg 13: Suggest explaining the rationale for applying a 10 mL layer of JP-5 on 1 liter of water forthe lab experiment. Would there be value in using a range of milliliter layers of JP-5 placed in the funnel flasks (e.g., 5-mL, 10-mL, 15-mL) to account for more or less JP-5 volume entering the drinking water system?	Subject paragraph revised as follows: "The experiments were conducted by carefully placing a 10-milliliter layer of JP-5 jet fuel onto one-liter of sterilized water in funnel flask (1:100 ratio of water to fuel) and allowing the fuel and water to equilibrate over 20 days (refer to figures in Attachment 4; after Bobra 1992). Selection of a 1:100 ratio of fuel to water was based on previous trial experiments. Use of a 1:1,000 ratio of fuel to water as done in the Bobra (1992) experiments resulted in concentrations of dissolved-phase hydrocarbons below laboratory detection limits."
14b. Section 3.3.2, pg 13. What is reason for using sterilized water for five flask experiments vs. using Red Hill shaft water absent of TPHs? Could there be effects of differences in basic water qualityparameters (e.g., pH, alkalinity, etc.)?	Added to Section 3.3.2: "Sterilized water was used to prevent degradation of dissolved-phase hydrocarbons during the course of the experiment. This allowed for a more detailed assessment of the weighted toxicity of dissolved-phase compounds to be evaluated, including aliphatic and aromatic carbon ranges. Separate laboratory experiments to evaluate degradation of JP-5 in groundwater collected from the Red Hill area have been discussed by University of Hawaii researchers but to date such experiments has not been undertaken to the EA author's knowledge."

14c. Section 3.3.2, pg 13: Can a comparison be made of the relative percentages of different compoundsin the experimental flasks to the relative percentages of different compounds in water samples collected from the Red Hill shaft or taps? In other words, do we expect that therelative percentages of various >C8-C18 aliphatic compounds, >C8 aromatics, and BTEXMN compounds in the experimental flasks to be similar to that in Red Hill supply water?	Text added to Section 3.3.3 that compares the concentration of dissolved-phase BTEXNM reported for the experiments to dissolved-phase BTEXNM for the sample of groundwater collected in the Red Hill Shaft on 12/8/23. No data are available for concentrations of dissolved-phase hydrocarbons in tapwater at the height of contamination following the November 2021 release.
14d. Section 3.3.2, pg 13: Suggest adding a discussion of where/how water is drawn out of the Red Hill shaft andwhen it would have been mixed with other well water in the system.	Refer to text added to Section 1.2.
15. Section 3.3.3 pg 15: Is it possible that additional contamination could have migrated to the shaft in the intervening weeks?	Added to Section 3.3.3: “Significant migration of contamination into the portion of the Red Hill Shaft where the pump is located and where samples were collected after the pump was turned off is unlikely. The rate of natural groundwater flow in the area is very low. Fuel was also not observed to be directly leaking into the shafter area by Navy inspectors.”
16. Section 3.3.4, pg 15: Suggest describing where the DiEGME emulsion have formed. In groundwater? The shaft? System?	Added to Section 3.1: “Formation of the gel is expected to have taken place relatively quickly after contact of the fuel with groundwater within the Red Hill tunnel.”
17. Section 3.3.5, pg 16-17: It is unclear how HDOH attributed resident health affects to inhalation of vapors as opposed to ingestion. Did these residents report how they were using the water?	Reference to Troeschel et al. 2022 added (Self-Reported Health Symptoms Following Petroleum Contamination of a Drinking Water System — Oahu, Hawaii, November 2021–February 2022). Refer also to referenced Vice News interview of residents.
18. Section 4.0, pg 18, 3rd paragraph. Health Effects: Suggest noting that most of the health effects associated with DiEGME described in this report are from animal studies.	Added to text.
19a. Section 5.1, pg 19 Toxicity Factors – Individually Targeted Compounds. Suggest adding a description of what the various screening levels represent (e.g., Reference Dose, Reference Concentration, etc).	Discussion added to text.

19b. Section 5.1, pg 19 Toxicity Factors – Individually Targeted Compounds. The report states "Acute toxicity factors are not available for any of the compounds." However, ATSDR has established acute MRLs that could be incorporated for certain contaminants/exposure routes (e.g., benzene, toluene, naphthalene).	Text revised to state: "Acute toxicity factors pertinent to potential expression of adverse health effects within an exposure duration up to 14 days are only available for BTEX and naphthalene ("Minimal Risk Levels;" ATSDR 2023). The lack of acute toxicity factors for aromatic and aliphatic carbon range compounds precludes the development of a comprehensive set of correlative screening levels and detailed assessment of acute toxicity risk."
20a. Section .2, pg 25: Summary of Exposure Assessment. Suggest noting in the report body that table 6 only addresses ingestion (not inhalation risks)	The RMEs presented in Table 6 are intended to collectively address ingestion, dermal absorption and inhalation exposure routes (refer to toxicity factors presented in Tables 3 and 4). A note clarifying this was added to the text.