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March 1, 2002

Project Number N7538

Ms. Kymberlee Keckler
U.S. Environmental Protection Agency
Federal Facilities Superfund Section
1 Congress Street, Suite 1100
Boston, Massachusetts 02114-2023

Reference: CLEAN Contract No. N62472-90-D-1298
Contract Task Order 0282

Subject: Response to EPA's Comments on the Draft Groundwater Risk Evaluation
Old Fire Fighting Training Area, Naval Station Newport, Newport, Rhode Island
Received in EPA letter to James Shafer of the U.S. Navy January 17, 2002

Dear Ms. Keckler:

This letter provides the Navy's responses to the comments provided by EPA on the draft Groundwater Risk Evaluation for the Old Fire Fighting Training Area site. Within your cover letter additional comments are made on a number of related issues. The Navy has also provided responses to these comments as well in Attachment A (two copies). The responses to EPA's specific comments are provided in Attachment B to this letter (two copies). EPA's comments are presented verbatim in italic type followed by the Navy's response in standard type. The risk evaluation is being revised in accordance with the responses.

Please contact Jim Shafer of the Navy or me if you have any questions about this transmittal or would like to discuss this matter further.

Very truly yours,

James R. Forrelli, P.E.
Project Manager

JRF:rp

Enclosure

c: J. Shafer, NORTHDIV (w/enc. – 3)
M. Griffin, NAV STA Newport (w/enc. – 2)
P. Kulpa, RIDEM (w/enc. – 4)
D. Egan, TAG (w/enc.)
J. Stump, Gannet Fleming (w/enc. – 2)
J. Trepanowski/G. Glenn, TtNUS (w/enc.)
C. Race, TtNUS (w/enc.)
File N7538-8.0 (w/enc.)/File N7538-3.2 (w/o enc. – 2)

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**ATTACHMENT A**
**Responses to General Comments from the**
**U.S. Environmental Protection Agency**
**Draft Groundwater Risk Evaluation**
**Old Fire Fighting Training Area**
**Comments dated January 17, 2002**

No. *Comment*/Response

1. *Comment: According to EPA Region I's Risk Update #3 dated August 1995, EPA accepts the qualitative risk evaluation approach for VOCs inhalation pathway by assuming that the risk from inhalation of VOCs during household use (including showering, bathing, toilets, dishwashers, washing machines and cooking) is equivalent to that from ingestion. The Navy has, however, chosen to run the Foster and Chrostowski's showering model to quantitatively evaluate VOCs inhalation pathway, which is also approved by EPA, instead of the qualitative approach. Since the modeling approach is more complicated than the qualitative approach, it needs to be conducted correctly and all the results need to be provided for verification purposes. The two approaches should provide roughly similar results of non-cancer and cancer risks.*

   Response: Whether cancer and noncancer risks from inhalation during showering are approximately equal to corresponding ingestion risks depends on the model input parameters and on chemical-specific properties used in the shower model calculations. Input parameters that affect the estimated risks include shower duration, water flow rates, air exchange coefficients, room volume, and water temperature. The ratio of inhalation risk to ingestion risk for a chemical is affected by RfDs and slope factors for inhalation versus ingestion and by chemical-specific properties, for example Henry's Law constant (which for benzene is greater than for naphthalene).

2. *Comment: EPA was not able to verify the results of the RME inhalation hazard quotients (HQs) for benzene and naphthalene. EPA Region 1 guidance (EPA, 1995) suggests that inhalation risks and hazard quotients are expected to be roughly equal to ingestion risks and hazard quotients. However, the RME inhalation HQ results (as presented in Table 5-2) are not comparable to the ingestion HQs for each chemical, as would be expected. The ingestion HQ for benzene is (0.3), while the inhalation HQ is an order of magnitude higher at (4.64). The difference between the ingestion and inhalation naphthalene HQ values is even greater with the inhalation HQ (24.5) two orders of magnitude higher than the ingestion HQ (0.2). These inhalation hazard quotients indicate an unacceptable risk from both benzene and naphthalene in the groundwater. Please double check these values to ensure that inhalation risks are not overestimated.*

   Response: In the draft report, inhalation risks were correctly calculated assuming the validity of the Foster and Chrostowski model and the input parameters shown in Table 3.5. The same computer subroutine was used to perform all showering risk calculations.

   For naphthalene and benzene, a look at RfDs reveals one reason why there are differences between noncancer risks from inhalation versus ingestion. As shown in the draft report's toxicity tables, naphthalene's inhalation RfD is much smaller (4.5 %) compared to its ingestion RfD, while benzene's inhalation RfD is larger (176 %) compared to its ingestion RfD. This implies that even if chemical intake rates (mg/kg/day) were to be considered equal for inhalation versus ingestion (which they are not), the relative ratio of inhalation divided by ingestion hazard quotients (HQs) would be 39 times greater for naphthalene relative to benzene.

   Because the peer reviewer believes that Q-values were too large, different input parameters for showering were investigated and are proposed below. To document the inhalation risk calculation for naphthalene and benzene, a stepwise example calculation was prepared using revised parameters for shower duration and Q-values (see enclosed attachment).

3. *Comment: The showering model was used to generate the inhalation risk and hazard quotient values, instead of assuming that the inhalation risks and hazard quotients are roughly equal to the ingestion values as recommend by EPA Region 1 guidance. The calculation and use of the "Q" variable in the model may be incorrect. Table 3-5 incorrectly defines "Q" as being "chemical-specific." "Q" is a time constant. When the showering model was run using a typical "Q" value of approximately 2.5, the inhalation HQ result was roughly the same as the ingestion HQ for benzene, as would be expected. Since the showering model was used to generate inhalation risk and hazard quotient values, please verify all results of the showering model conducted for this evaluation. Also, please include the calculated "Q" value in Table 3-5 and present the model results similar to that presented for the lead model.*

Response: The description of Q-values as chemical-specific was an oversight and a revised Table 3.5 will present Q-values explicitly. The example calculation being submitted for benzene and naphthalene applies revised Q-values and provides verification of input values and calculations in a more complete manner than the "black box" output provided by the lead model (IEUBK) referenced by the reviewer, the latter of which is not able to provide any example calculations to enable users to view the intermediate calculations or equations.

Note that the RME Q-value would be lowered to 21.3% of the value utilized in this report if the Table 3.5 CTE parameter values for showering time were used (yielding Q = 2.7897) instead of RME values (Q = 13.0859). The CTE Q-value is much closer than the RME value to the recommended Q-value of 2.5 cited by the reviewer. In the draft report, input parameters for calculating the Q-value were obtained from published survey data summarized in EPA's 1997 Exposure Factors Handbook (EFH):

EFH, Table 15-21, shower duration: 50th percentile = 15 minutes, 91st percentile = 30 minutes
EFH, Table 15-23, time in bathroom after shower: 50th percentile = 5 min., 90th percentile = 20 min.

Calculated inhalation risk is directly proportional to the Q-value used, so using the EFH 50th percentiles times with Q = 2.7897 yields smaller inhalation risks than using Q = 13.0859. TtNUS agrees with EPA that the RME Q- value appears too large because, upon consideration, the 90th percentile values for shower duration seem excessively long and suggest bias in 10 percent of the survey participants' ability to accurately recall the average duration of a shower. Instead, TtNUS proposes using the cited 50th percentile values for both RME and CTE exposures.

One other input factor that should be reconsidered is the water flow rate in liters/minute -- a water flow rate 20 L/min. was used based on recommendations from another EPA region. However, this value may be overly conservative because Table 17-18 of EFH (EPA, 1997) cites a mean flow rate of 3.4 gallons/minute (12.87 L/min.) from non-water conserving showerheads. (Water-conserving showerheads would have even lower flow rates.) Since the 3.4 gal/min. flow rate listed in EFH equates to 64.35% of the RME value shown in Table 3.5, it is recommended that shower flow rate be revised downward.

In summary, using the proposed values for showering times and a modified 12.87 L/min. water flow rate for both RME and CTE exposures would yield a revised showering dose and associated RME cancer or noncancer risks that would be 13.72 % or a factor of 0.64*0.21 compared to the dose and risks presented in the draft OFFTA Groundwater Risk Evaluation report. The revised inhalation HQ for benzene is 0.6 versus the ingestion HQ of 0.3, which yields a ratio of 2.0, roughly equivalent to the ratio of ingestion to inhalation RfDs (1.76). The revised inhalation HQ for naphthalene is 3.4 versus the ingestion HQ of 0.2, which yields a ratio of 16, roughly equivalent to the ratio of ingestion to inhalation RfDs (22).

An example calculation for inhalation risks for naphthalene and benzene risks is attached for the revised parameters given above. After EPA reviews and concurs with the example calculations and revised input parameters, risk tables in the report will be revised accordingly for both RME and CTE showering exposure scenarios.

## RISK ASSESSMENT EXAMPLE CALCULATIONS

The following example calculations are presented in order to verify the approaches taken and calculations used to estimate inhalation risks from exposure to VOCs during showering. The example calculations for risks are all based on RME exposure. Examples are shown for naphthalene and benzene exposures for OFFTA groundwater. CTE risks are not shown here, however, they would be estimated following the same equations using CTE, rather than RME, input parameters from the Table 3.5.

**Inhalation of Benzene Vapors (During Showering):**

$$Cwd = Co \times \left(1 - e^{-KaL \times ts \times \left(6/d\right) \times CF1 \times CF2}\right)$$

| | | |
|---|---|---|
| Cwd | = 15.71 ug/L | = Concentration leaving water droplet after time ts |
| Co | = 33 ug/L | = Concentration of benzene in water |
| KaL | = 19.39 cm/hr | = Adjusted overall mass transfer coefficient |
| ts | = 2 sec | = Shower droplet time |
| d | = 1 mm | = Shower droplet diameter |
| CF1 | = 1/3600 hr/sec | = Conversion Factor |
| CF2 | = 10 mm/cm | = Conversion Factor |

$$KaL = \frac{KL}{\sqrt{\frac{T_1 \times \mu_s}{T_s \times \mu_1}}}$$

| | | |
|---|---|---|
| KaL | = 19.39 cm/hr | = Adjusted overall mass transfer coefficient |
| KL | = 14.36 cm/hr | = Mass transfer coefficient |
| $T_1$ | = 293 °K | = Calibration water temperature of KL |
| $T_s$ | = 318 °K | = Shower water temperature |
| $\mu_1$ | = 1.002 centipoise | = Water viscosity at $T_1$ |
| $\mu_S$ | = 0.596 centipoise | = Water viscosity at $T_s$ |

$$KL = \frac{1}{\left(\frac{1}{kl}\right) + \left(\frac{R \times T}{H \times kg}\right)}$$

| | | |
|---|---|---|
| KL | = 14.36 cm/hr | = Mass transfer coefficient |
| R | = 8.21E-5 atm $m^3$/mol/°K | = Ideal gas law constant |
| T | = 293 °K | = Absolute temperature |
| H | = 0.0055 atm $m^3$/mole | = Henry's Law constant for benzene |
| kg | = 1440.05 cm/hr | = Gas-film mass transfer coefficient |
| kl | = 15.01 cm/hr | = Liquid-film mass transfer coefficient |

$$kg = kH \times \sqrt{\frac{MWH}{MW}}$$

$$kl = kC \times \sqrt{\frac{MWC}{MW}}$$

| | | |
|---|---|---|
| kg | = 1440.05 cm/hr | = Gas-film mass transfer coefficient |
| kl | = 15.01 cm/hr | = Liquid-film mass transfer coefficient |
| kH | = 3000 cm/hr | = kg for water |
| kC | = 20 cm/hr | = kl for carbon dioxide |
| MWH | = 18 g/mole | = Molecular Weight of water |
| MWC | = 44 g/mole | = Molecular Weight of carbon dioxide |
| MW | = 78.12 g/mole | = Molecular Weight of benzene |

Inhalation of benzene (vapor phase during showering) in OFFTA groundwater for a future adult resident under an RME scenario was evaluated using the following equations (EPA, 1989a; Foster and Chrostowski, 1987):

$$InhalationDose(mg/kg \cdot day) = \frac{D \times EF \times ED}{AT}$$

$$D = \left( \frac{IR_{air} \times S}{BW \times Ra \times CF1} \right) \times Q$$

$$Q = Ds + \left[ \frac{e^{-Ra \times Dt}}{Ra} \right] - \left[ \frac{e^{Ra \times (Ds - Dt)}}{Ra} \right]$$

$$S = \frac{Cwd \times Fr}{Sv}$$

Where:

Noncarc-Inhalation Dose = 1.08E-3 = Noncarcinogenic Inhalation Exposure Dose (mg/kg-day)

| | | |
|---|---|---|
| D | = 1.128E-3 mg/kg/shower | = Dose absorbed per kg body weight per shower |
| EF | = 350 days/yr | = Exposure Frequency |
| ED | = 24 yrs | = Exposure Duration |
| ATN | = 8760 days | = Averaging Time for Noncarcinogens (365 d/yr x 24 yrs) |
| $IR_{air}$ | = 14 L/min | = Inhalation Rate |
| S | = 33.698 ug/$m^3$/min | = Indoor VOC generation rate |
| BW | = 70 kg | = Body Weight |
| Ra | = 1.667E-2 $min^{-1}$ | = Rate of air exchange |
| CF1 | = $10^6$ ug L/mg $m^3$ | = Conversion Factor |
| Q | = 2.7897 min | = Function of air exchange rate & time in shower/room |
| Ds | = 15 min | = Duration of shower |
| Dt | = 20 min | = Total time in shower room |
| Cwd | = 15.71 ug/L | = Concentration leaving water droplet after time ts |
| Fr | = 12.87 L/min | = Shower flow rate |
| Sv | = 6 $m^3$ | = Shower room air volume |

The RME noncarcinogenic risk for a future adult resident from inhalation of benzene vapors in OFFTA groundwater during showering is estimated as follows:

NC = Inhalation Dose/RfD

| | | |
|---|---|---|
| NC | = 6.36E-1 | = Noncarcinogenic Risk |
| RfD | = 1.70E-3 (mg/kg-day) | = Inhalation Reference Dose |

Noncarc-Inhalation Dose = 1.08E-3 = Noncarcinogenic Inhalation Exposure Dose (mg/kg-day)

The volatile chemical generation rate was estimated using the Foster and Chrostowski mass transfer model, which is based on two-phase film theory. The model employs contaminant-specific mass transfer coefficients, Henry's Law constants, droplet drop time, viscosity, temperature, etc. Specific details regarding the application of the mass transfer model can be found in the source documents (Foster and Chrostowski, 1987).

**Inhalation of Naphthalene Vapors (During Showering):**

$$Cwd = Co \times \left(1 - e^{-KaL \times ts \times \left(6/d\right) \times CF1 \times CF2}\right)$$

| | | |
|---|---|---|
| Cwd | = 43.93 ug/L | = Concentration leaving water droplet after time ts |
| Co | = 150 ug/L | = Concentration of naphthalene in water |
| KaL | = 10.397 cm/hr | = Adjusted overall mass transfer coefficient |
| ts | = 2 sec | = Shower droplet time |
| d | = 1 mm | = Shower droplet diameter |
| CF1 | = 1/3600 hr/sec | = Conversion Factor |
| CF2 | = 10 mm/cm | = Conversion Factor |

$$KaL = \frac{KL}{\sqrt{\dfrac{T_1 \times \mu_s}{T_s \times \mu_1}}}$$

| | | |
|---|---|---|
| KaL | = 10.397 cm/hr | = Adjusted overall mass transfer coefficient |
| KL | = 7.697 cm/hr | = Mass transfer coefficient |
| $T_1$ | = 293 °K | = Calibration water temperature of KL |
| $T_s$ | = 318 °K | = Shower water temperature |
| $\mu_1$ | = 1.002 centipoise | = Water viscosity at $T_1$ |
| $\mu_s$ | = 0.596 centipoise | = Water viscosity at $T_s$ |

$$KL = \frac{1}{\left(\dfrac{1}{kl}\right) + \left(\dfrac{R \times T}{H \times kg}\right)}$$

| | | |
|---|---|---|
| KL | = 7.697 cm/hr | = Mass transfer coefficient |
| R | = 8.21E-5 atm $m^3$/mol/°K | = Ideal gas law constant |
| T | = 293 °K | = Absolute temperature |
| H | = 0.00048 atm $m^3$/mole | = Henry's Law constant for naphthalene |
| kg | = 1124.17 cm/hr | = Gas-film mass transfer coefficient |
| kl | = 11.717 cm/hr | = Liquid-film mass transfer coefficient |

$$kg = kH \times \sqrt{\frac{MWH}{MW}}$$

$$kl = kC \times \sqrt{\frac{MWC}{MW}}$$

| | | |
|---|---|---|
| kg | = 1124.17 cm/hr | = Gas-film mass transfer coefficient |
| kl | = 11.717 cm/hr | = Liquid-film mass transfer coefficient |
| kH | = 3000 cm/hr | = kg for water |
| kC | = 20 cm/hr | = kl for carbon dioxide |
| MWH | = 18 g/mole | = Molecular Weight of water |
| MWC | = 44 g/mole | = Molecular Weight of carbon dioxide |
| MW | = 128.19 g/mole | = Molecular Weight of naphthalene |

Inhalation of naphthalene (vapor phase during showering) in OFFTA groundwater for a future adult resident under an RME scenario was evaluated using the following equations (EPA, 1989a; Foster and Chrostowski, 1987):

$$InhalationDose(mg/kg \cdot day) = \frac{D \times EF \times ED}{AT}$$

$$D = \left( \frac{IR_{air} \times S}{BW \times Ra \times CF1} \right) \times Q$$

$$Q = Ds + \left[ \frac{e^{-Ra \times Dt}}{Ra} \right] - \left[ \frac{e^{Ra \times (Ds - Dt)}}{Ra} \right]$$

$$S = \frac{Cwd \times Fr}{Sv}$$

Where:

Noncarc-Inhalation Dose = 3.02E-3 = Noncarcinogenic Inhalation Exposure Dose (mg/kg-day)

| | | |
|---|---|---|
| D | = 3.154E-3 mg/kg/shower | = Dose absorbed per kg body weight per shower |
| EF | = 350 days/yr | = Exposure Frequency |
| ED | = 24 yrs | = Exposure Duration |
| ATN | = 8760 days | = Averaging Time for Noncarcinogens (365 d/yr x 24 yrs) |
| $IR_{air}$ | = 14 L/min | = Inhalation Rate |
| S | = 94.236 ug/m$^3$/min | = Indoor VOC generation rate |
| BW | = 70 kg | = Body Weight |
| Ra | = 1.667E-2 min$^{-1}$ | = Rate of air exchange |
| CF1 | = 10$^6$ ug L/mg m$^3$ | = Conversion Factor |

| | | |
|---|---|---|
| Q | = 2.7897 min | = Function of air exchange rate & time in shower/room |
| Ds | = 15 min | = Duration of shower |
| Dt | = 20 min | = Total time in shower room |
| Cwd | = 43.93 ug/L | = Concentration leaving water droplet after time ts |
| Fr | = 12.87 L/min | = Shower flow rate |
| Sv | = 6 $m^3$ | = Shower room air volume |

The RME noncarcinogenic risk for a future adult resident from inhalation of naphthalene vapors in OFFTA groundwater during showering is estimated as follows:

NC = Inhalation Dose/RfD

| | | |
|---|---|---|
| NC | = 3.36 | = Noncarcinogenic Risk |
| RfD | = 9E-4 (mg/kg-day) | = Inhalation Reference Dose |
| Noncarc-Inhalation Dose | = 3.02E-3 | = Noncarcinogenic Inhalation Exposure Dose (mg/kg-day) |

**ATTACHMENT B**
**Responses to Specific Comments from the**
**U.S. Environmental Protection Agency**
**Draft Groundwater Risk Evaluation**
**Old Fire Fighting Training Area**
**Comments dated January 17, 2002**

No. *Comment*/Response

1. p. 2-3, §2.5.1 *Comment: The second paragraph in this section indicates that the CTE EPCs were selected as the "minimum variance unbiased estimate of the population's arithmetic mean" for lognormal distributions (assuming this value is less than the maximum detected value). Please clarify how these estimates of the population's arithmetic mean were calculated.*

Response: The minimum variance unbiased estimate of the population's arithmetic mean for a lognormal distribution estimates the arithmetic mean for an infinite number of observations taken from a lognormal population, when data are only available for a finite number of observations. It involves a correction factor applied to the arithmetic mean.

The equations below are taken from Gilbert, 1987:

Mean-T = $\exp\{u_L\}Psi_n(s_y^2/2)$

Where: $u_L$ = arithmetic mean of log-transformed data

$s_y$ = standard deviation of log-transformed data

$Psi_n(t)$, with $t = s_y^2/2$, is the infinite series:

$$Psi_n(t) = 1 + (n-1)t/n + (n-1)^3t^2/(2!n^2(n+1)) + (n-)^5t^3/(3!n^3(n+1)(n+3)) + (n-1)^7t^4/(4!n^4(n+1)(n+3)(n+5)) + \ldots$$

2. Table 2-2 *Comment: One of the columns in this table may be incorrectly labeled as "Arithmetic Mean or Mean of Logs." The values shown in this column are too large to represent the mean of the log transformed concentrations. Should the correct title for this column should be "Arithmetic Mean or Geometric Mean?"*

Response: The correct title should be "Arithmetic Mean or Antilog of Mean of Logs"

## REFERENCES

USEPA, 1997. Exposure Factors Handbook. Update to Exposure Factors Handbook. EPA/600/8-89/043 - May 1989. Office of Research and Development.

USEPA, 2001. Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment, Interim Guidance.), Office of Emergency and Remedial Response. Washington, DC.

Gilbert, Richard. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold. NY, NY. P. 165.

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Ms. Kymberlee Keckler
U.S. Environmental Protection Agency
Federal Facilities Superfund Section
1 Congress Street, Suite 1100
Boston, Massachusetts 02114-2023

Reference: CLEAN Contract No. N62472-90-D-1298
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Please contact Jim Shafer of the Navy or me if you have any questions about this transmittal or would like to discuss this matter further.

Very truly yours,

James R. Forrelli, P.E.
Project Manager

JRF:rp

Enclosure

c: J. Shafer, NORTHDIV (w/enc. – 3)
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File N7538-8.0 (w/enc.)/File N7538-3.2 (w/o enc.)

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