ANNOUNCEMENT ON WATER AND THE LANDFILL:

Recently, the Townsend Board of Health became aware of a rumor that there are private wells in the area of the Town landfill that are contaminated due to their proximity to the landfill. The Townsend Board of Health contracts with Weston & Sampson to complete the landfill monitoring requirements and those reports are submitted to MassDEP. The Townsend Board of Health requested that Weston & Sampson review the results of their groundwater monitoring and provide a summary, including any concerns about the groundwater in the area. That report has been provided to the Board and has been reviewed.

As you may know, the Townsend Board of Health requires water testing of private wells within three (3) years of the transfer of a property and for any newly constructed well (including irrigation wells). This would include wells on Greenville Rd., Mason Rd., Kristopher Ln., St. James Pl., and Michael Way. Naturally occurring contaminants, such as arsenic and radon have shown up often in the private well samples in this area, but this is typical for most of the Town North of Rt. 119. In all cases where high radon, high arsenic, or other contaminants were found, they were resolved per the requirements of the Townsend Well Regulations. The private well testing completed in this area of Town has not indicated any contamination originating from the landfill and no volatile organic compounds have been found in excess of the maximum contaminant level. Further, the Townsend Board of Health and Nashoba Associated Boards of Health has not been contacted by a resident, or other Agency, claiming that their private well was contaminated because of the proximity to the landfill. There is no evidence that would support the claim of contaminated private wells in the area. Should any resident have concerns related to this, please contact the Townsend Board of Health to discuss.

Weston & Sampson

55 Walkers Brook Drive, Reading, MA 01867 (HQ)
Tel: 978.532.1900

January 11, 2022

Carla Hitzenbuhler
Health Department Administrator
272 Main Street
Townsend, MA 01469

Re: Review of Landfill Groundwater Monitoring Wells, 1,4-Dioxane

Dear Ms. Hitzenbuhler:

Weston & Sampson Engineers, Inc. (Weston & Sampson) has prepared this letter reviewing the analysis of the groundwater data from the Townsend Sanitary Landfill monitoring wells, particularly the detected concentrations of 1,4-dioxane in these wells. Groundwater was sampled on November 2, 2021 during the routine annual monitoring event.

Review of Groundwater Analytical Data, Landfill Wells

Groundwater was collected from seven landfill monitoring wells and analyzed for field parameters, inorganics, dissolved metals, semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). The following differed from comparable standards:

- Groundwater pH was below the Secondary Maximum Contaminant Level (SMCL) lower limit of 6.5 in all wells sampled. This is typical of groundwater pH throughout New England which tends to be naturally acidic.
- Dissolved arsenic was detected above the Massachusetts Maximum Contaminant Level (MMCL) in MW-2S, MW-2D, TW-BD, and DUP-1 at concentrations of 0.024 milligrams per liter (mg/l), 0.036 mg/l, 0.030mg/L, and 0.030 mg/L, respectively. Since Townsend is located within the "arsenic belt" that is present in central Massachusetts, it is likely that this is a background condition not associated with the landfill.
- Dissolved iron was detected above the SMCL in MW-2S, MW-2D, TW-BS, TW-BD, DUP-1, and TW-E at concentrations ranging from 0.70 mg/l to 8.1 mg/l. Dissolved manganese was detected above the SMCL in MW-2S, MW-2D, MW-2BR, TW-BD, and DUP-1 at concentrations ranging from 0.19 mg/l to 0.58 mg/l. Elevated iron and manganese is commonly observed in groundwater throughout New England. It is likely that this is a background condition not associated with the landfill.
- 1,4-Dioxane was above the Office of Research and Standards Guideline (ORSG) and Method 1 GW-1 standard in groundwater monitoring wells MW-2S and MW-2D at concentrations of 0.60 micrograms per liter (µg/L), and 0.90 µg/L, respectively. The guideline is set lower than a concentration that may cause a health effect, but exceedance of this value is an indication that further evaluation is necessary. A human health risk evaluation of the detected concentrations of 1,4-dioxane is conducted below.

Human Health Risk Evaluation of 1,4-Dioxane

This human health risk evaluation assumed that a residential receptor would be exposed to 1,4-dioxane in potable water. Exposure pathways included ingestion of drinking water, and dermal contact and inhalation of water in a shower scenario (i.e. while bathing). The higher concentration of 1,4-dioxane

detected in landfill monitoring wells, 0.9 ug/L, was used to estimate potential health risks. MassDEP conservative default exposure assumptions were used to estimate potential health risks with the exception of the exposure period. For the exposure period, the more conservative 70-year exposure was used in place of the MassDEP typical 30-year residential exposure. The 70-year exposure assumes the receptor lives in the same house for 70 years and is exposed to 0.9 ug/L 1,4-dioxane via ingestion of drinking water, and dermal contact and inhalation via a shower scenario every day.

Based on this very conservative evaluation, there is a condition of No Significant Risk to human health associated with exposure to this concentration of 1,4-dioxane. The potential health risks were calculated as less than the MassDEP noncancer Hazard Index (HI) of 1 (HI = 0.002) and less than the MassDEP Excess Lifetime Cancer Risk (ELCR) of 1E-5 (ELCR = 4E-6) for a 70-year exposure period.

If you have any questions or comments regarding this letter or need any additional information, please do not hesitate to contact our office at 617-412-4480.

Sincerely,
WESTON & SAMPSON ENGINEERS, INC.

Marie Rudiman
Senior Risk Assessor/Toxicologist

Michael Roether, PE
Project Manager

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Risk Assessment for Resident Exposed to Chemicals in Drinking Water

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Tab	
EPCs	Sheet 1: Select chemicals and enter Exposure Point Concentrations (EPCs). Estimated risks are shown to the right.
C Eq	Sheet 2: Equations to calculate cancer risks.
NC Eq	Sheet 3: Equations to calculate noncancer risks.
DA Eq	Sheet 4: Equations to calculate Absorbed Dermal Dose.
DA	Sheet 5: Dermal Absorbed Dose from Showering
IECs Eq	Sheet 6: Equations to calculate Inhalation Exposure Concentrations in the shower.
IECs	Sheet 7: Inhalation Exposure Concentration in the Shower
Exp	Sheet 8: Definitions and exposure factors.
Chem	Sheet 9: Chemical-specific data.

Questions and Comments may be addressed to:
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Boston, MA 02108 USA
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Drinking Water Risk Assessment
Exposure Point Concentration (EPC) and Risk
Based on Resident Ages 1-71 (Cancer) and 1-8 (Noncancer)

Drinking Water Version 08-2016
Vlookup Version v0315

ELCR (all chemicals) = 3.5E-06
HI (all chemicals) = 2.4E-03

****Do not insert or delete any rows****
Click on empty cell below and select OHM using arrow.

Oil or Hazardous Material (OHM)	EPC (µg/L)	ELCR ingestion	ELCR dermal	ELCR inhalation	$ELCR_{total}$	Chronic HQ_{ing}	Chronic HQ_{derm}	Chronic HQ_{inh}	HQ_{total}
DIOXANE, 1,4-	9.0E-01	3.4E-06	3.3E-09	8.3E-08	3.5E-06	1.8E-03	1.8E-06	6.8E-04	2.4E-03

MassDEP ORS
Contact: Lydia Thompson
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Drinking Water: Sheet 2
Equations to Calculate Cancer Risk for Resident (Age 1-71 years)

Vlookup Version v0315

Cancer Risk from Ingestion

$$ELCR_{ing} = LADD_{ing(1\text{-}71)} * CSF$$

$$LADD_{ing\ (1\text{-}71)} = LADD_{ing\ (1\text{-}8)} + LADD_{ing\ (8\text{-}15)} + LADD_{ing\ (15\text{-}71)}$$

$$LADD_{ing\ (age\ group\ x)} = \frac{EPC * VI_x * RAF_{c\text{-}ing} * EF * ED_{ing} * EP_x * C}{BW_x * AP_{lifetime}}$$

Cancer Risk from Dermal Absorption

$$ELCR_{derm} = LADD_{derm(1\text{-}71)} * CSF$$

$$LADD_{derm\ (1\text{-}71)} = LADD_{derm\ (1\text{-}8)} + LADD_{derm\ (8\text{-}15)} + LADD_{derm\ (15\text{-}71)}$$

$$LADD_{derm(age\ group\ x)} = \frac{DA_x * SA_x * EF * ED_{derm} * EP_x}{OAE_c * BW_x * AP_{lifetime}}$$

or, if outside "Effective Predictive Domain", then

$$LADD_{derm(age\ group\ x)} = DM * LADD_{ing(age\ group\ x)}$$

Cancer Risk from Inhalation

$$ELCR_{inh} = LADE_{(1\text{-}71)} * URF$$

$$LADE_{(1\text{-}71)} = LADE_{(1\text{-}8)} + LADE_{(8\text{-}15)} + LADE_{(15\text{-}71)}$$

$$LADE_{(age\ x)} = \frac{IEC_{S\text{-}x} * EF * ED_{inh\text{-}x} * EP_x}{AP_{lifetime}}$$

Parameter	Value	Units
CSF	OHM-specific	$(mg/kg\text{-}day)^{-1}$
URF	OHM-specific	$(\mu g/m^3)^{-1}$
LADD	age/OHM-specific	mg/kg-day
LADE	age/OHM-specific	$\mu g/m^3$
EPC	OHM-specific	µg/L
$VI_{(1\text{-}8)}$	1	L/day
$VI_{(8\text{-}15)}$	2	L/day
$VI_{(15\text{-}71)}$	2	L/day
$RAF_{c\text{-}ing}$	OHM-specific	dimensionless
EF	1.00	event/day
$ED_{ing\ \&\ derm}$	1	day/event
$ED_{inh(1\text{-}8)}$	0.046	day/event
$ED_{inh(8\text{-}15)}$	0.046	day/event
$ED_{inh(15\text{-}71)}$	0.044	day/event
$EP_{(1\text{-}8)}$	7	years
$EP_{(8\text{-}15)}$	7	years
$EP_{(15\text{-}71)}$	56	years
C	0.001	mg/µg
$BW_{(1\text{-}8)}$	17.0	kg
$BW_{(8\text{-}15)}$	39.9	kg
$BW_{(15\text{-}71)}$	58.7	kg
$AP_{(lifetime)}$	70	years
$IEC_{S\text{-}x}$	age/OHM-specific	$\mu g/m^3$
DA_x	age/OHM-specific	$mg/cm^2\text{-}day$
OAE_c	OHM-specific	dimensionless
$SA_{(1\text{-}8)}$	7130	cm^2
$SA_{(8\text{-}15)}$	12800	cm^2
$SA_{(15\text{-}71)}$	16731	cm^2
DM	OHM-specific	dimensionless

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Drinking Water: Sheet 3
Equations to Calculate Noncancer Risk for Resident Child (Age 1-8 years)

Vlookup Version v0315

Noncancer Risk from Ingestion

$$HQ_{ing} = \frac{ADD_{ing}}{RfD}$$

$$ADD_{ing} = \frac{EPC * VI * RAF_{nc\text{-}ing} * EF * ED_{ing} * EP * C}{BW * AP}$$

Noncancer Risk from Dermal Absorption

$$HQ_{derm} = \frac{ADD_{derm}}{RfD}$$

$$ADD_{derm} = \frac{DA * SA * EF * ED_{derm} * EP}{OAE_{nc} * BW * AP}$$

or, if DA is outside the "Effective Predictive Domain" of the dermal model, then

$$ADD_{derm} = DM * ADD_{ing}$$

Noncancer Risk from Inhalation

$$HQ_{inh} = \frac{ADE}{RfC}$$

$$ADE = \frac{IEC_S * EF * ED_{inh} * EP * C}{AP}$$

Parameter	Value	Units
RfD	OHM-specific	mg/kg-day
RfC	OHM-specific	mg/m^3
ADD_{ing}	OHM-specific	mg/kg-day
ADD_{derm}	OHM-specific	mg/kg-day
ADE	OHM-specific	mg/m_3
EPC	OHM-specific	µg/L
VI	1	L/day
$RAF_{nc\text{-}ing}$	OHM-specific	dimensionless
$RAF_{nc\text{-}derm}$	OHM-specific	dimensionless
EF	1.00	event/day
ED_{ing}	1	day/event
ED_{derm}	1	day/event
ED_{inh}	0.046	day/event
EP	7	years
C	0.001	mg/µg
BW	17.0	kg
$AP_{(noncancer)}$	7	years
IEC_S	OHM-specific	$µg/m^3$
DA	OHM-specific	mg/cm^2-day
OAE_{nc}	OHM-specific	dimensionless
SA	7130	cm^2
DM	OHM-specific	dimensionless

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Drinking Water: Sheet 4
Equations to Calculate Absorbed Dermal Dose from Showering (DA)

Vlookup Version v0315

Model equations obtained from U.S. EPA (2001) Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim (http://www.epa.gov/oswer/riskassessment/ragse/index.htm).

Steady State versus Non-Steady State for Organic Chemicals: The time for an organic chemical to reach steady state is a function of the chemical's molecular weight (MW) and it's ability to traverse skin (expressed as a permeability constant, Kp). If an organic chemical does not reach steady state before the shower is over (i.e., time to reach steady state, t*, is greater than the shower duration, D_s), Equation (1) is used to calculate the dermal dose for this non-steady state. For organic chemicals that have reached a steady state by the end of the shower, Equation (2) is used to calculate dermal dose.

Effective Predictive Domain: The model is not used for organic chemicals that fall outside its effective predictive domain. Strictly, chemicals with very large or very small Kow values are outside of the EPD. Chemicals outside the Effective Predictive Domain are identified with an asterix in Tables B-2 and B-3 in the above citation as well as in Table V4 in the Vlookup (V) workbook.
For these chemicals, the dermal dose is estimated as a function of the oral dose according to MA DEP (1995) Guidance for Disposal Site Risk Characterization and Equation (3) below. Note that the dermal dose in these cases is calculated as an average daily dose (ADD) or life-time average daily dose (LADD) and expressed in mg/kg-bw. Equation (3) is also presented in Tables DW-2 and DW-3.

(1) Organic Chemicals Inside Effective Predictive Domain - *Non-Steady State*
Equation for estimating dermally absorbed dose (DA) for organic chemicals when the shower duration (D_s) is less than or equal to the time to reach steady state (t*).

$$DA = 2 * FA * C * Kp * Cw * [(6*t*D_s)/p)]^{1/2}$$

(2) Organic Chemicals Inside Effective Predictive Domain - *Steady State*
Equation for estimating DA for organic chemicals when D_s is greater than the time to reach t*.

$$DA = FA * C * Kp * Cw * [(D_s/(1+B)) + 2 * t * ((1+3B+3B^2)/(1+B)^2)]$$

(3) Organic Chemicals Outside Effective Predictive Domain

$$(L)ADD_{derm} = DM * (L)ADD_{ing}$$

(4) Inorganic Chemicals
Equation for estimating DA for inorganic chemicals in water.

$$DA = C * Kp * Cw * D_s$$

Where the equations to calculate the input values are:

(a) Equation for predicting strateum corneum permeability constant (Kp) for organic chemicals:

$$Kp = 10^{[-2.8+(0.66*logKow)-(0.0056*MW)]}$$

(b) Equation for calculating ratio of permeability of chemical in strateum corneum to permeability in viable epidermis (B)

$$B = Kp * ((MW)^{1/2}/2.6)$$

(c) Calculations for calculating time to reach steady state (t*):

When B is less than or equal to 0.6

$$t^* = 2.4 * t$$

When B is greater than 0.6

$$t^* = (b - (b^2 - c^2)^{1/2}) * l_{sc}^2/D_{sc}$$

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Drinking Water: Sheet 4
Equations to Calculate Absorbed Dermal Dose from Showering (DA)

Vlookup Version v0315

(d) Equations for calculating b and c

$$c = (1 + 3B + 3B^2)/(3 * (1+B)) \qquad b = (2(1+B)^2/p) - c$$

(e) Equation for calculating lag time (t)

$$t = l_{sc}^2/(6*D_{sc})$$

(f) Equation for calculating effective diffusivity (D_{sc})

$$D_{sc} = 10^{-2.8-(0.0056*MW)} * l_{sc}$$

Parameter	Value	Units	Notes
DA_{event} - Absorbed dose per event per area skin exposed	calculated	mg/cm^2-day	see Table RW-4 and RW-5
FA - Fraction absorbed	OHM-specific	dimensionless	see Table RW-5
Kp - Strateum corneum (sc) permeability constant	OHM-specific	cm/hr	see Table RW-9
C - Conversion Factor	0.000001	m^3/cm^3	
C_w - [OHM] in water, Exposure Point Concentration	OHM-specific	mg/m^3	see Table RW-1, expressed as µg/L
t - Lag time	calculated	hrs	Time for chemical to cross strateum corneum (Table RW-5)
D_s - Shower Duration	age-specific	hrs	see Table RW-6
$LogK_{ow}$ - Octanol/water partition coefficient	OHM-specific	dimensionless	see Table RW-9
MW - Molecular Weight	OHM-specific	g/mole	see Table RW-9
t* - Time to reach steady state	calculated	hr	see Table RW-5
b - Empirical variable used to calculate t*	calculated	dimensionless	see Table RW-5
c - Empirical variable used to calculate t*	calculated	dimensionless	see Table RW-5
l_{sc} - Thickness of skin	0.001	cm	MA DEP (1995). Guidance for Disposal Site Risk Characterization. Appendix Table B-9.
D_{sc} - Effective diffusivity for chemical transfer through the skin	calculated	cm^2/hr	see Table RW-5
B - Ratio of permeability of chemical in strateum corneum to permeability of chemical in viable epidermis	calculated	dimensionless	see Table RW-5

Drinking Water: Sheet 5
Dermal Absorded Dose (DA) from Showering

Vlookup Version v0315

Oil or Hazardous Material	Ratio of perm in strateum corneum to viable epidermis B	Lag Time (tau) hours	Effective Diffusivity of Chemical Transfer Through Skin Dsc (cm2/hr)	Time to Reach Steady State t* hours	t* when B>0.6 hours	b	c	Absorbed Dose (1-8) DA (mg/cm2-day)	Absorbed Dose (8-15) DA (mg/cm2-day)	Absorbed Dose (15-71) DA (mg/cm2-day)	Outside Effective Predictive Domain	Fraction Absorbed FA	Absorbed Dose (1-8) w/ FA term DA(1-8) (mg/cm2-day)	Absorbed Dose (8-16) w/ FA term DA(8-16) (mg/cm2-day)	Absorbed Dose (16-71) w/ FA term DA(16-71) (mg/cm2-day)	Dermal Mult DM
DIOXANE, 1,4-	1.13E-03	0.327	5.10E-07	0.78		3.0E-01	3.3E-01	1.26E-10	1.21E-10	1.07E-10		1	1.26E-10	1.21E-10	1.07E-10	

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Drinking Water: Sheet 6
Equations to Calculate Inhalation Exposure Concentration in the Shower (IEC_S)

Vlookup Version v0315

Model equations obtained from Foster, S.A. and Chrostowski, P.C. (1987) Inhalation Exposures to Volatile Organic Contaminants in the Shower. Presentation at the 80th Annual Meeting of APCA. New York, NY. June 21-26, 1987.

(1) Inhalation Exposure Concentration in the Shower.

$$IECs = [(S/R_{ae}) * (D_s + (e^{-Rae*Dt}/R_{ae}) - (e^{Rae(Ds-Dt)}/R_{ae}))] / D_t$$

Where the equations to calculate the input values are:

(a) Indoor Air Generation Rate

$$S = (C_{wd} * FR) / SV$$

(b) Concentration Leaving Water Droplet

$$C_{wd} = C_{w0}(1-e^{((-KaL*ts)/60d)})$$

(c) Adjusted Mass Transfer Coefficient

$$K_{aL} = K_L \cdot ((T_l * u_s)/(T_s * u_l))^{-1/2}$$

(d) Overall Mass Transfer Coefficient

$$K_L = [(1/k_l) + (R * T)/(HLC * k_g)]^{-1}$$

(e) Liquid Film Mass Transfer Coefficient

$$k_l = k_l(CO_2) * ((MW_{CO2})/(MW_{VOC}))^{1/2}$$

(f) Gas Film Mass Transfer Coefficient

$$k_g = k_{g(water)} * (MW_{water}/MW_{VOC})^{1/2}$$

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Drinking Water: Sheet 6
Equations to Calculate Inhalation Exposure Concentration in the Shower (IEC_S)

Vlookup Version v0315

Parameter	Value	Units	Notes
IEC_S - Inhalation Exposure Concentration in shower	calculated	$\mu g/m^3$	see Table RW-7
S - Indoor air generation rate	calculated	$\mu g/m^3$-min	see Table RW-7
R_{ae} - Air Exchange Rate	8.33E-03	1/min	MADEP. 1995. Guidance for Disposal Site Risk Characterization. Appendix Table B-9.
D_s - Shower Duration for age group 1-8	45.7	min	see Table RW-8
	0.762	hour	see Table RW-8
D_t - Total Time in Shower Room for age group 1-8	65.7	min	see Table RW-8
D_s - Shower Duration for age group 8-15	42.1	min	see Table RW-8
	0.702	hr	see Table RW-8
D_t - Total Time in Shower Room for age group 8-15	66.4	min	see Table RW-8
D_s - Shower Duration for age group 15-71	32.8	min	see Table RW-8
	0.547	hr	see Table RW-8
D_t - Total Time in Shower Room for age group 15-71	62.8	min	see Table RW-8
C_{wd} - Concentration leaving water droplet	calculated	µg/l	see Table RW-7
FR - Shower Flow Rate	10	1/min	MADEP. 1995. Guidance for Disposal Site Risk Characterization. Appendix Table B-9.
SV - Shower room air volume	6	m^3	Ibid
C_{w0} - Shower water concentration	OHM-specific	µg/l	EPC. See Table RW-1
K_{aL} - Adjusted mass transfer coefficient	calculated	cm/hr	see Table RW-7
t_s - Shower droplet time	2	seconds	MADEP. 1995. Guidance for Disposal Site Risk Characterization. Appendix Table B-9.
d - Droplet diameter	1	mm	Ibid
60d = Droplet interfacial area	60	cm/hr-seconds	the specific interfacial area, 6/d, for a spherical droplet of diamter d (mm), multiplied by conversion factors, hr/3600 seconds and 100 mm/cm
K_L - Overall mass transfer coefficient	calculated	cm/hr	see Table RW-7
TI = Calibration water temperature of K_L	293	°K	MADEP. 1995. Guidance for Disposal Site Risk Characterizaiton. Appendix Table B-9.
µs - Water viscosity at Ts	0.596	cp	Ibid
T_s - Shower water temperature	318	°K	Ibid
μ_1 - Water viscosity at T_I	1.002	cp	Ibid
k_l - Liquid film mass transfer coefficient	calculated	cm/hr	see Table RW-7
R - Universal Gas Constant	8.20E-05	atm-m^3/mol-°K	MADEP. 1995. Guidance for Disposal Site Risk Characterizaiton. Appendix Table B-9.
T - Absolute temperature	293	°K	Ibid
HLC - Henry's Law Constant	OHM-specific	atm-m^3/mol	see Table RW-7
k_g - Gas-film mass transfer coefficient	calculated	cm/hr	see Table RW-7
$k_l(CO_2)$ - Liquid-film mass transfer coefficient, CO_2	20	cm/hr	MADEP. 1995. Guidance for Disposal Site Risk Characterizaiton. Appendix Table B-9.
MW_{CO2} - Molecular weight of CO_2	44	g/mole	Ibid
MW_{VOC} - Molecular Weight of OHM	OHM-specific	g/mole	Ibid
$k_g(H_2O)$ - Gas-film mass transfer coefficient, water	3000	cm/hr	Ibid
MW_{H2O} - Molecular weight of water	18	g/mole	Ibid

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Drinking Water: Sheet 7
Inhalation Exposure Concentration in the Shower (IEC_S)

Vlookup Version v0315

Oil or Hazardous Material	Henry's Law Constant HLC atm-m3/mol	Molecular Weight MW g/mole	INTERIM CALCULATIONS: gas-film mass transfer coefficient k_g (cm/hr)	liquid-film mass transfer coefficient k_l (cm/hr)	Overall Mass Transfer Coefficient K_L (cm/hr)	Adjusted Mass Transfer Coefficient K_{wL} (cm/hr)	Concentration Leaving Water Droplet C_{wd} (µg/l)	Indoor Air Generation Rate S (µg/(m3-min))	Inhalation Exposure Concentration $IEC_{S(1-8)}$ (µg/m³)	Inhalation Exposure Concentration $IEC_{S(8-15)}$ (µg/m³)	Inhalation Exposure Concentration $IEC_{S(15-71)}$ (µg/m³)
DIOXANE, 1,4-	4.80E-06	88	1356.80	14.14	0.27	0.36	1.1E-02	1.8E-02	4.41E-01	4.23E-01	3.57E-01

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Drinking Water: Sheet 8
Definitions and Exposure Factors

Note: For consistency with MassDEP MCP Shortforms the 15-71 year old assumptions use 15-31 year old values, which are substantially similar

Vlookup Version v0315

Parameter	Value	Units	Notes
ELCR - Excess Lifetime Cancer Risk	chemical specific	dimensionless	Pathway specific (ing =ingestion, derm=dermal, inh=inhalation)
HI - Hazard Index	chemical specific	dimensionless	Pathway specific (ing =ingestion, derm=dermal, inh=inhalation)
CSF - Cancer Slope Factor	chemical specific	$(mg/kg\text{-}day)^{-1}$	see Table RW-9
URF - Unit Risk Factor	chemical specific	$(\mu g/m^3)^{-1}$	see Table RW-9
RfD - Reference Dose	chemical specific	mg/kg-day	see Table RW-9
RfC - Reference Concentration	chemical specific	$\mu g/m^3$	see Table RW-9
LADD - Lifetime Average Daily Dose	chemical specific	mg/kg-day	Pathway specific. See Table RW-2
LADE - Lifetime Average Daily Exposure	chemical specific	$\mu g/m^3$	see Table RW-2
ADD - Average Daily Dose	chemical specific	mg/kg-day	Pathway specific. See Table RW-3.
ADE - Average Daily Exposure	chemical specific	$\mu g/m^3$	Pathway specific. See Table RW-3.
EPC - Exposure Point Concentration	chemical specific	µg/L	see Table RW-1
$IR_{(1-8)}$ - Volume Ingested for age group 1-8	1	L/day	MADEP. 1995. Guidance for Disposal Site Risk Characterization. Appendix B-9.
$IR_{(8-15)}$ - Volume Ingested for age group 8-15	2	L/day	Ibid
$IR_{(15-71)}$ - Volume Ingested for age group 15-71	2	L/day	Ibid
$RAF_{c/nc}$ - Relative Absorption Factor for Cancer/Noncancer Effects	chemical specific	dimensionless	Pathway specific
EF - Exposure Frequency	1.00	event/day	
$ED_{ing,derm}$ - Exposure Duration for ingestion or dermal exposure	1	day/event	
ED_{inh} - Exposure Duration for inhalation exposure for age group 1-8	0.046	day/event	Calculated: Total time in shower room for a 1 - 8 year old (65.7 min) / day (1440 min).
ED_{inh} - Exposure Duration for inhalation exposure for age group 8-15	0.046	day/event	Calculated: Total time in shower room for a 8 - 15 year old (66.4 min) / day (1440 min)
ED_{inh} - Exposure Duration for inhalation exposure for age group 15-71	0.044	day/event	Calculated: Total time in shower room for a 15 - 31 year old (62.8 min) / day (1440 min)
$EP_{(1-8)}$ - Exposure Period for age group 1-8	7	years	
$EP_{(8-15)}$ - Exposure Period for age group 8-15	7	years	
$EP_{(15-71)}$ - Exposure Period for age group 15-71	56	years	
$BW_{(1-8)}$ - Body Weight for age group 1-8	17.0	kg	U.S. EPA. 1997. Exposure Factors Handbook. Table 7-7, females.
$BW_{(8-15)}$ - Body Weight for age group 8-15	39.9	kg	U.S. EPA. 1997. Exposure Factors Handbook. Table 7-7, females.
$BW_{(15-71)}$ - Body Weight for age group 15-71	58.7	kg	U.S. EPA. 1997. Exposure Factors Handbook. Table 7-7, females.
$AP_{(lifetime)}$ - Averaging Period for lifetime	70	years	
$AP_{(noncancer)}$ - Averaging Period for noncancer	7	years	
IEC_S - Inhalation Exposure Concentration from showering	chemical specific	mg/m^3	Age group specific. See Table RW-7.
DA - Dose Absorbed through skin in shower	chemical specific	mg/cm^2-day	Age group specific. See Table RW-5.
$OAE_{c/nc}$ - Oral Absorption Efficiency for Cancer/Noncancer Effects	chemical specific	dimensionless	
$SA_{(1-8)}$ - Surface Area for age group 1-8	7130	cm^2	50th percentile for females. Appendix Table B-2. MADEP. 1995. Guidance for Disposal Site Risk Characterization.
$SA_{(8-15)}$ - Surface Area for age group 8-15	12800	cm^2	50th percentile for females. Appendix Table B-2. MADEP. 1995. Guidance for Disposal Site Risk Characterization.
$SA_{(15-71)}$ - Surface Area for age group 15-71	16731	cm^2	50th percentile for females. Appendix Table B-2. MADEP. 1995. Guidance for Disposal Site Risk Characterization.
D_s - Shower Duration for age group 1-8	45.7 0.76	min hour	U.S. EPA. 1997. Exposure Factors Handbook. Table 15-21. 95th percentile ages 1-8. Weighted average of 1-8 year age groups: ((4x50)+(3x40))/7= 45.7 minutes
D_t - Total Time in Shower Room for age group 1-8	65.7	min	U.S. EPA. 1997. Exposure Factors Handbook. Tables 15-21,23. Equals the shower duration (Ds) plus the number of minutes spent in the shower room immediately after showering (95th percentile): Ds + ((4*20)+(3*20))/7 = 65.7 minutes
D_s - Shower Duration for age group 8-15	42.1 0.70	min hr	U.S. EPA. 1997. Exposure Factors Handbook. Table 15-21. 95th percentile ages 8-15. Weighted average of 8-15 age groups: ((4x40)+(3x45)/7 = 42.1 minutes
D_t - Total Time in Shower Room for age group 8-15	66.4	min	U.S. EPA. 1997. Exposure Factors Handbook. Tables 15-21,23. Equals the shower duration (Ds) plus the number of minutes spent in the shower room immediately after showering (95th percentile): Ds + ((4*20)+(3*30))/7=66.4 minutes
D_s - Shower Duration for age group 15-71	32.8 0.55	min hr	U.S. EPA. 1997. Exposure Factors Handbook. Table 15-21. 95th percentile ages 15-31. Weighted average of 15-31 year age groups: ((3x45)+(13x30)/16 = 32.8 minutes.
D_t - Total Time in Shower Room for age group 15-71	62.8	min	U.S. EPA. 1997. Exposure Factors Handbook. Tables 15-21,23. Equals the shower duration (Ds) plus the number of minutes spent in the shower room immediately after showering (95th percentile): Ds + ((3*30)+(13*30))/16 = 62.8 minutes
DM - Dermal Multiplier	chemical specific	dimensionless	If Kp < 0.5 cm/hr, then 0.2. Otherwise 1.

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Drinking Water: Sheet 9
Chemical-Specific Data

Vlookup Version v0315

Oil or Hazardous Material	CSF $(mg/kg\text{-}day)^{-1}$	URF $(\mu g/m^3)^{-1}$	$RAF_{c\text{-}ing}$	OAE_c	RfD mg/kg-day	RfC mg/m^3	$RAF_{nc\text{-}ing}$	OAE_{nc}	DM	Molecular Weight g/mole	log K_{ow}	Permeability Coefficient Kp cm/hr	Henry's Law Constant HLC $atm\text{-}m^3/mol$
DIOXANE, 1,4-	1.0E-01	5.0E-06	1	1	3.0E-02	3.0E-02	1	1		88	-0.32	3.13E-04	4.80E-06

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