CHEMICAL UPDATE WORKSHEET

Chemical Name:	**Boron (DD)**
CAS #:	**7440-42-8**
Revised By:	RRD Toxicology Unit
Revision Date:	August 14, 2015

(A) Chemical-Physical Properties

	Part 201 Value	Updated Value	Reference Source	Comments
Molecular Weight (g/mol)	10.811	10.806	CRC	EXP
Physical State at ambient temp	Inorganic	Inorganic	MDEQ	
Melting Point (˚C)	---	2077	CRC	EXP
Boiling Point (˚C)	2550	4000	CRC	EXP
Solubility (ug/L)	NA	NA	NA	NA
Vapor Pressure (mmHg at 25˚C)	NA	NR	NA	NA
HLC (atm-m^3/mol at 25˚C)	NR	NR	NA	NA
Log Kow (log P; octanol-water)	NR	NR	NA	NA
Koc (organic carbon; L/Kg)	NR	NR	NA	NA
Ionizing Koc (L/kg)		NR	NA	NA
Diffusivity in Air (Di; cm^2/s)	NR	NR	NA	NA
Diffusivity in Water (Dw; cm^2/s)	NR	NR	NA	NA
Soil Water Partition Coefficient (Kd; inorganics)	NA	NA	NA	NA

	Part 201 Value	Updated Value	Reference Source	Comments
Flash Point (˚C)	NA	NA	NA	NA
Lower Explosivity Level (LEL; unit less)	NA	NA	NA	NA
Critical Temperature (K)		NR	NA	NA
Enthalpy of Vaporization (cal/mol)		NR	NA	NA
Density (g/mL, g/cm3)		NR	NA	NA
EMSOFT Flux Residential 2 m ($mg/day/cm^2$)	NA	NR	EMSOFT	NA
EMSOFT Flux Residential 5 m ($mg/day/cm^2$)	NA	NR	EMSOFT	NA
EMSOFT Flux Nonresidential 2 m ($mg/day/cm^2$)	NA	NR	EMSOFT	NA
EMSOFT Flux Nonresidential 5 m ($mg/day/cm^2$)	NA	NR	EMSOFT	NA

(B) Toxicity Values/Benchmarks

	Part 201 Value	Updated Value	Source*/Reference /Date	Comments/Notes /Issues
Reference Dose (RfD) (mg/kg/day)	3.2E-1	2.0E-1	IRIS, 2004	
RfD details	Developmental study in rats. Critical effects = depressed fetal body weight and rib abnormalities. NOAEL = 9.6 mg/kg-d. UF = 30: 3 for interspecies effects, 10 for protection of sensitive human subgroups. (Price et al., 1994). Entry date: 7/25/1997 Source: CCD/RRD, 7/25/1997	**Tier 1 Source:** **IRIS:** **Basis:** IRIS is a Tier 1 source and presents the best available RfD. **Critical Studies**: 1) Heindel, JJ; Price, CJ; Field, EA; et al. (1992) Developmental toxicity of boric acid in mice and rats. Fund Appl Toxicol 18:266-277. 2) Price, CJ; Strong, PL; Marr, MC; Myers, CB; Murray, FJ. (1996a.) Developmental toxicity NOAEL and postnatal recovery in rats fed boric acid during gestation. Fund Appl Toxicol 32:179-193. **Methods**: 1) Timed-mated Sprague-Dawley rats (29/group) were administered 0, 0.1, 0.2, or 0.4% boric acid in diet from gestation day (GD) 0 to 20. The estimated diet was 0, 13.6, 28.5 or 57.7 mg B/kg-day. Additional rats (14 rats/group) received boric acid at 0 or 0.8% in the diet (539 mg/kg-day or 94.2 mg B/kg-day) on GD 6-15 only (Heindel, 1992). 2) In a follow-up study in Phase 1, teratogenic part of the study, administered boric acid in the diet to timed-mated CD rats, 60 per group, from GD 0-20 (Price, 1996). **Critical effect**: Decreased fetal weight (developmental) **End point or Point of Departure (POD):** $BMDL_{05}$ = 10.3 mg/kg-day The $BMDL_{05}$ was derived (Allen, 1996) using combined data from Price et al. (1996a) and Heindel et al. (1992). **Uncertainty Factors**: UF = 66 (3.16 each for intraspecies toxicokinetic (TK) and toxicodynamic (TD) adjustment and 3.16 each for interspecies TK and TD) **Source and date:** IRIS, Last Revision — 8/05/2004. An IRIS Toxicological Review is available. **Tier 2 Sources**: **PPRTV:** No PPRTV record available at this time.		Complete

	Part 201 Value	Updated Value	Source*/Reference /Date	Comments/Notes /Issues
		MRL: Per ATSDR (11/2010), no oral chronic MRL value at this time. An intermediate oral MRL = 0.2 mg/kg-day was derived based on developmental effect. **Critical Studies**: 1) Heindel, JJ; Price, CJ; Field, EA; et al. (1992) Developmental toxicity of boric acid in mice and rats. Fund Appl Toxicol 18:266-277. 2) Price, CJ; Strong, PL; Marr, MC; Myers, CB; Murray, FJ. (1996a.) Developmental toxicity NOAEL and postnatal recovery in rats fed boric acid during gestation. Fund Appl Toxicol 32:179-193. **Methods**: 1) Groups of 26–28 pregnant Sprague-Dawley rats and Swiss mice were exposed to 0, 0.1, 0.2, or 0.4% boric acid in the diet on gestation days 0–20. Estimated boron doses are 0, 13.6, 28.5, or 57.7 mg boron/kg/day (0, 78, 163, or 330 mg boric acid/kg/day) for rats and 0, 43, 79, or 176 mg boron/kg/day (0, 248, 452, or 1,003 mg boric acid/kg/day) for mice. (Heindel, 1992). 2) Groups of 60 female Sprague-Dawley rats were exposed to 0, 0.025, 0.050, 0.075, 0.100, or 0.200% boric acid in the diet on gestation days 0–20. The study was performed in two phases; offspring were evaluated in both phases. Phase I was terminated on gestation day 20. The calculated average maternal dose of boron was 0, 3.3, 6.3, 10, 13, or 25 mg boron/kg/day (0, 19, 36, 55, 76, or 143 mg boric acid/kg/day). Phase II dams were allowed to litter and rear their pups until postnatal day (pnd) 21. For these dams, the calculated average doses of boron were 0, 0.2, 6.5, 9.7, 12.9, and 25.3 mg/kg/day (0, 19, 37, 56, 74, and 145 mg boric acid/kg/day). (Price, 1996). **Critical effect**: reduced fetal body weight **End point or Point of Departure (POD):** $BMDL_{05}$ = 10.3 mg/kg-day The $BMDL_{05}$ was derived (Allen, 1996) using combined data from Price et al. (1996a) and Heindel et al. (1992). **Adjustment Factors**: AF = 66 (3.16 each for intraspecies toxicodynamic (TK) and human toxicodynamic variability, 3.3 for interspecies, and 2.0 for human toxicokinetic variability. **Source and date:** ATSDR, 11/2010. From 12/2014 MRL list.		

	Part 201 Value	Updated Value	Source*/Reference /Date	Comments/Notes /Issues
		Additional Note: Per ATSDR, the pregnant female is considered to be the sensitive population for boron exposure; the fetal effects in rats are the most sensitive end point for boron toxicity. Since maternal and fetal kinetics should be essentially equal, the maternal boron plasma concentration is an appropriate surrogate for fetal plasma levels. **Tier 3 Source:** **MDEQ:** Per DEQ-CCD/RRD, RfD = 3.2E-1 mg/kg-day. See Part 201 Value RfD details.		
Oral Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$)	--	NA	MDEQ, 2015	
CSF details	NA	**Carcinogen Weight-of-Evidence (WOE) Class**: data are inadequate for an assessment of human carcinogenic potential **IRIS WOE Basis**: No data regarding the existence of an association between cancer and boron exposure in humans are available. Studies in animals were inadequate to ascertain whether boron causes cancer. No inhalation cancer studies were located. Studies of boron compounds for genotoxicity were overwhelmingly negative. **Source and Date**: IRIS, 8/05/2004 **Tier 1 and 2 Sources**: **IRIS:** Per IRIS (8/05/2004), no value at this time. **PPRTV:** No PPRTV record is available at this time. **MRL:** NA; MRLs are for non-cancer effects only. **Tier 3 Source:** **MDEQ:** Per DEQ-CCD/AQD, no value at this time.		Complete
Reference Concentration (RfC) or Initial Threshold Screening Level	--	3.0E+1	ATSDR, 2010	

	Part 201 Value	Updated Value	Source*/Reference /Date	Comments/Notes /Issues
(ITSL) (µg/m³)				
RfC/ITSL details	NA	**Tier 2 Source:** **ATSDR:** **Basis:** No Tier 1 available. **ATSDR** acute inhalation MRL = 0.3 mg/m^3. MDEQ applied an additional UF of 10 (to account for acute to chronic exposure extrapolation) to derive a chronic RfC = 3.0E-2 mg/m^3 = 3.0E+1 µg/m^3. No chronic inhalation MRL value is available at this time. **Critical Studies**: 1) Cain WS, Jalowayski AA, Kleinman M, et al. 2004. Sensory and associated reactions to mineral dusts: Sodium borate, calcium oxide, and calcium sulfate. J Occup Environ Hyg 1:222-236. 2) Cain WS, Jalowayski AA, Schmidt R, et al. 2008. Chemesthetic responses to airborne mineral dusts: boric acid compared to alkaline materials. Int Arch Occup Environ Health 81:337-345. **Methods**: 1) Male and female volunteers were trained to recognize the difference in chemesthetic feel (pungency or irritancy) of various levels of CO_2 offered to the eyes, nose, and throat. Exposures of ≥17.7% CO_2 resulted in a "feel" described by the volunteers as irritating. Twelve male volunteers were exposed to 0, 0.8, 1.5, 3.0, 4.5, or 6.0 mg boron/m^3 (0, 5, 10, 20, 30, or 40 mg sodium borate pentahydrate/m^3) for 20 minutes while performing light exercise (Cain et al. 2004). 2) Six male and six female volunteers were exposed to 1.5 mg boron/m^3 (10 mg sodium borate/m^3) or 1.8 mg boron/m3 (10 mg boric acid/m^3) for 47 minutes while exercising. They reported the magnitude of "feel" of boric acid and borate dusts in terms of equivalent CO_2 irritancy. **Critical effect**: increased volume of nasal secretions **End point or Point of Departure (POD):** NOAEL = 0.8 mg/m^3 The $BMDL_{05}$ was derived (Allen, 1996) using combined data from Price et al. (1996a) and Heindel et al. (1992). **Uncertainty Factor**: UF = 3 (for human variability)		Complete

	Part 201 Value	Updated Value	Source*/Reference /Date	Comments/Notes /Issues
		Source and Date: ATSDR, 11/2010. From 12/2014 MRL list. **Tier 1 and 2 Sources**: **IRIS:** Per IRIS (8/05/2004), no value at this time. **PPRTV:** No PPRTV record is available at this time **Tier 3 Source:** **MDEQ:** Per DEQ-CCD, no value at this time.		
Inhalation Unit Risk Factor (IURF) ((µg/m^3)$^{-1}$)	--	NA	MDEQ, 2015	
IURF details	NA	**Carcinogen Weight-of-Evidence (WOE) Class**: data are inadequate for an assessment of human carcinogenic potential **IRIS WOE Basis**: No data regarding the existence of an association between cancer and boron exposure in humans are available. Studies in animals were inadequate to ascertain whether boron causes cancer. No inhalation cancer studies were located. Studies of boron compounds for genotoxicity were overwhelmingly negative **Source and Date**: IRIS, 8/05/2004 **Tier 1 and 2 Sources**: **IRIS:** Per IRIS (8/05/2004), no value at this time. **PPRTV:** No PPRTV record is available at this time. **MRL:** NA; MRLs are for non-cancer effects only. **Tier 3 Source:** **MDEQ:** Per DEQ-CCD/AQD, no value at this time.		Complete
Mutagenic Mode of Action (MMOA)? (Y/N)	--	NO	USEPA, 2015	
MMOA Details	--	NA Not listed as a carcinogen with mutagenic MOA in the USEPA OSWER List.		

	Part 201 Value	Updated Value	Source*/Reference /Date	Comments/Notes /Issues
Developmental or Reproductive Effector? (Y/N)	YES	YES-oral, the RfD is based on a reproductive-developmental effect. Oral Exposure Pathways- Single Exposure No-inhalation, the RfC is not based on a reproductive-developmental effect.	MDEQ, 2015	
Developmental or Reproductive Toxicity Details	Developmental study in rats. Critical effects = depressed fetal body weight and rib abnormalities. NOAEL = 9.6 mg/kg-d. (Price et al., 1994). Reproductive effects (testicular atrophy in rats and dogs and reproductive failure in female rats) have been observed following oral exposure to boron. The NOAEL for testicular atrophy in rats is 17 mg/kg-d. *While the RfD is based on a maternal dose, the*	**Per IRIS 2004;** **Critical effect**: Decreased fetal weight (developmental) **Critical Studies**: 1) Heindel, JJ; Price, CJ; Field, EA; et al. (1992) Developmental toxicity of boric acid in mice and rats. Fund Appl Toxicol 18:266-277. 2) Price, CJ; Strong, PL; Marr, MC; Myers, CB; Murray, FJ. (1996a.) Developmental toxicity NOAEL and postnatal recovery in rats fed boric acid during gestation. Fund Appl Toxicol 32:179-193. **Methods**: 1) Timed-mated Sprague-Dawley rats (29/group) were administered 0, 0.1, 0.2, or 0.4% boric acid in diet from gestation day (GD) 0 to 20. The estimated diet was 0, 13.6, 28.5 or 57.7 mg B/kg-day. Additional rats (14 rats/group) received boric acid at 0 or 0.8% in the diet (539 mg/kg-day or 94.2 mg B/kg-day) on GD 6-15 only (Heindel, 1992). 2) In a follow-up study in Phase 1, teratogenic part of the study, administered boric acid in the diet to timed-mated CD rats, 60 per group, from GD 0-20 (Price, 1996).		

	Part 201 Value	Updated Value	Source*/Reference /Date	Comments/Notes /Issues
	Residential DCV will continue to be calculated based on an age-adjusted intake dose to be protective of reproductive effects in young children.			
State Drinking Water Standard (SDWS) (ug/L)	--	NO	SDWA, 1976	
SDWS details	NA	MI Safe Drinking Water Act (SDWA) 1976 PA 399		
Secondary Maximum Contaminant Level (SMCL) (ug/L)	--	NO	SDWA, 1976 and USEPA SMCL List	
SMCL details	NA	MI Safe Drinking Water Act (SDWA) 1976 PA 399 and USEPA SMCL List, 2015		
Is there an aesthetic value for drinking water? (Y/N)	NO	Not evaluated.	NA	
Aesthetic value (ug/L)	--	NA	NA	
Aesthetic Value details		NA		
Phytotoxicity Value? (Y/N)	Yes	Yes	MDEQ, 1998	
Phytotoxicity Value	**0.5 mg boron/L**	0.5 mg boron/L	MDEQ, 1998	
Phytotoxicity details	The groundwater criterion of 0.5 mg	Boron, although essential for plant growth, can be exceedingly toxic at concentrations only slightly above	MDEQ, 1998	

	Part 201 Value	Updated Value	Source*/Reference /Date	Comments/Notes /Issues
	boron/L should present a reasonable amount of protection from boron phytotoxicity for most of the plant species and soil conditions that are expected to be encountered in Michigan. Also see →	optimum. Published tolerance tables indicate the onset of boron toxicity problems among sensitive species of plants grown in Michigan at approximately 0.5 mg/l. Although soil solution boron concentrations may be less than that of irrigation water when first applied, the soil solution concentration may eventually exceed that of the irrigation water as equilibrium conditions are approached. Residential use of groundwater with elevated boron concentrations may present additional concerns due to indiscriminate irrigation practices and irrigation of plants with unknown sensitivity to boron. The groundwater criterion **of 0.5 mg boron/l** should present a reasonable amount of protection from boron phytotoxicity for most of the plant species and soil conditions that are expected to be encountered in Michigan. **Source and date**: MDEQ-RRD. Goeffrey List (2/11/1998). Irrigation Water Limit Justification for Boron		
Others:	--	**Final DWC and DWPC:** The Boron drinking water criteria (DWC) are health-based values and do not protect for adverse impacts to plant life and phytotoxicity from irrigation water. Pursuant to R 299.28, when irrigation water is a reasonable and relevant use of groundwater, the potential for phytotoxicity and injury to the groundwater resource that may impair its use for irrigation require consideration. The department has determined 500 ppb is necessary to address the risks to plant life and groundwater resources not otherwise accounted for with the generic criterion. Boron soil criteria protective of drinking water (GWPC) are based upon adverse impacts to plant life and phytotoxicity from soil conditions. The DWC are followed by an (F) footnote to identify the need to consider use of	MDEQ, 2016	

	Part 201 Value	Updated Value	Source*/Reference /Date	Comments/Notes /Issues
		groundwater for irrigation and the potential for phytotoxicity. The GWPC are followed by an (F) footnote to indicate the use of phytotoxicity-based values in place of the HBVs. (from the Criteria TSD)		

(C) Chemical-specific Absorption Factors

	Part 201 Value	Update	Source/Reference/ Dates	Comments/Notes /Issues
Gastrointestinal absorption efficiency value (ABSgi)	---	1.0	MDEQ, 2015/USEPA RAGS-E, 2004	
ABSgi details		RAGS E (USEPA, 2004) Default Value		
Skin absorption efficiency value (AEd)	---	0.01	MDEQ, 2015	
AEd details				
Ingestion Absorption Efficiency (AEi)		0.5	MDEQ, 2015	
AEi Details				
Relative Source Contribution for Water (RSC_W)		0.2	MDEQ, 2015	
Relative Source Contribution for Soil (RSC_S)		1.0	MDEQ, 2015	
Relative Source Contribution for Air (RSC_A)		1.0	MDEQ, 2015	
Others				

(D) Rule 57 Water Quality Values and GSI Criteria

Current GSI value (µg/L)	7,200 (X)
Updated GSI value (µg/L)	7,200 (X)
Rule 57 Drinking Water Value (µg/L)	4,000

	Rule 57 Value (µg/L)	Verification Date
Human Non-cancer Values- Drinking water source (HNV-drink)	4,000	9/2012
Human Non-Cancer Values- Non-drinking water sources (HNV-Non-drink)	330,000	9/2012
Wildlife Value (WV)	NA	NA
Human Cancer Values for Drinking Water Source (HCV-drink)	NA	NA
Human Cancer values for non-drinking water source (HCV-Non-drink)	NA	NA
Final Chronic Value (FCV)	7,200	12/2011
Aquatic maximum value (AMV)	34,000	12/2011
Final Acute Value (FAV)	69,000	12/2011

Sources:

1. MDEQ Surface Water Assessment Section Rule 57 website
2. MDEQ Rule 57 table

(E) Target Detection Limits (TDL)

	Value	Source
Target Detection Limit – Soil (μg/kg)	8,000	MDEQ, 2015
Target Detection Limit – Water (μg/L)	300	MDEQ, 2015
Target Detection Limit – Air (ppbv)	NA	MDEQ, 2015
Target Detection Limit – Soil Gas (ppbv)	NA	MDEQ, 2015

CHEMICAL UPDATE WORKSHEET ABBREVIATIONS:

CAS # - Chemical Abstract Service Number.

Section (A) Chemical-Physical Properties

Reference Source(s):

CRC	Chemical Rubber Company Handbook of Chemistry and Physics, 95th edition, 2014-2015
EMSOFT	USEPA Exposure Model for Soil-Organic Fate and Transport (EMSOFT) (EPA, 2002)
EPA2001	USEPA (2001) Fact Sheet, Correcting the Henry's Law Constant for Soil Temperature. Office of Solid Waste and Emergency Response, Washington, D.C.
EPA4	USEPA (2004) User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings. February 22, 2004.
EPI	USEPA's Estimation Programs Interface SUITE 4.1, Copyright 2000-2012
HSDB	Hazardous Substances Data Bank
MDEQ	Michigan Department of Environmental Quality
NPG	National Institute for Occupational Safety and Health Pocket Guide to Chemical Hazards
PC	National Center for Biotechnology Information's PubChem database
PP	Syracuse Research Corporation's PhysProp database
SCDM	USEPA's Superfund Chemical Data Matrix
SSG	USEPA's Soil Screening Guidance: Technical Background Document, Second Edition, 1996
USEPA/EPA	United States environmental protection agency's Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). July, 2004.
W9	USEPA's User Guide for Water9 Software, Version 2.0.0, 2001

Basis/Comments:

EST	estimated
EXP	experimental
EXT	extrapolated
NA	not available or not applicable
NR	not relevant

Section (B) Toxicity Values/Benchmarks

Sources/References:

ATSDR	Agency for Toxic Substances and Disease Registry
CALEPA	California Environmental Protection Agency
CAL DTSC	California Department of Toxic Substances Control
CAL OEHHA	CAEPA Office of Environmental Health Hazard Assessment
CCD	MDEQ Chemical Criteria Database
ECHA	European Chemicals Agency (REACH)
OECD HPV	Organization for Economic Cooperation and Development HPV Database
HEAST	USEPA's Health Effects Assessment Summary Tables
IRIS	USEPA's Integrated Risk Information System
MADEP	Massachusetts Department of Environmental Protection
MDEQ/DEQ	Michigan Department of Environmental Quality
DEQ-CCD/AQD	MDEQ Air Quality Division
DEQ-CCD/RRD	MDEQ Remediation and Redevelopment Division
DEQ-CCD/WRD	MDEQ Water Resources Division
MNDOH	Minnesota Department of Health

NJDEP	New Jersey Department of Environmental Protection
NYDEC	New York State Department of Environmental Conservation
OPP/OPPT	USEPA's Office of Pesticide Programs
PPRTV	USEPA's Provisional Peer Reviewed Toxicity Values
RIVM	The Netherlands National Institute of Public Health and the Environment
TCEQ	Texas Commission on Environmental Quality
USEPA	United States Environmental Protection Agency
USEPA OSWER	USEPA Office of Solid Waste and Emergency Response
USEPA MCL	USEPA Maximum Contaminant Level
WHO	World Health Organization
WHO IPCS	International Programme on Chemical Safety (IPCS/INCHEM)
WHO IARC	International Agency for Research on Cancers
NA	Not Available.
NR	Not Relevant.

Toxicity terms:

BMC	Benchmark concentration
BMCL	Lower bound confidence limit on the BMC
BMD	benchmark dose
BMDL	Lower bound confidence limit on the BMD
CSF	Cancer slope Factor
CNS	Central nervous system
IURF or IUR	Inhalation unit risk factor
LOAEL	Lowest observed adverse effect level
LOEL	Lowest observed effect level
MRL	Minimal risk level (ATSDR)
NOAEL	No observed adverse effect level
NOEL	No observed effect level
RfC	Reference concentration
RfD	Reference dose
p-RfD	Provisional RfD
aRfD	Acute RfD
UF	Uncertainty factor
WOE	Weight of evidence

Section (C) Chemical-specific Absorption Factors

MDEQ	Michigan Department of Environmental Quality
USEPA RAGS-E	United States Environmental Protection Agency's Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). July, 2004.

Section (D) Rule 57 Water Quality Values and GSI Criteria

GSI	Groundwater-surface water interface
NA	A value is not available or not applicable.
ID	Insufficient data to derive value
NLS	No literature search has been conducted