JSC 63414

Spacecraft Water Exposure Guidelines

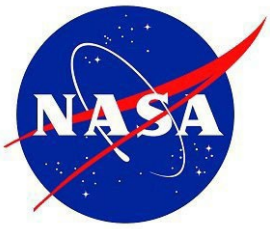
Human Health and Performance Directorate

Biomedical Research and Environmental Sciences Control Board (BRESCB) Controlled

Revision A

November 2023

Internal Publication Notice: This publication does not contain information which falls under the purview of the U.S. Munitions List (USML), as defined in the International Traffic in Arms Regulations (ITAR), 22 CFR 120-130 or the Export Administration Regulations (EAR), 15 CFR 730-744, and is not export controlled.



National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

NASA APPROVAL SHEET

Spacecraft Water Exposure Guidelines
Human Health and Performance Directorate

PREPARED BY:

Shannon Langford (affiliate)
Digitally signed by Shannon Langford (affiliate)
Date: 2023.12.21 13:48:05 -06'00'

12/21/2023

Shannon D. Langford, Ph.D.
Lead, Toxicology Group
Environmental Sciences Branch

DATE

CONCURRED BY:

Daniel Gazda
Digitally signed by Daniel Gazda
Date: 2023.12.21 15:01:10 -06'00'

12/21/2023

Daniel B. Gazda
Chief, Environmental Sciences Branch

DATE

KEVIN MACNEILL
Digitally signed by KEVIN MACNEILL
Date: 2024.01.25 10:57:54 -06'00'

1/25/2024

Kevin Macneill
Chief, Biomedical Research and Environmental Sciences Division

DATE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lyndon B. Johnson Space Center
Houston, Texas

Leanna Hartmann (affiliate)
Digitally signed by Leanna Hartmann (affiliate)
Date: 2024.02.05 10:12:55 -06'00'

CHANGE HISTORY

Revision/PCN	Date	Authorization/ Originator/Phone	Description
Baseline	07/2017	CR# SA-00043 Valerie E. Ryder 281-483-4989	**NOTE: Previous versions of the document were baselined through the STIC Library and not "BASELINED" through a Board. Therefore, the versioning of the document will start at BASELINE for Configuration Management purposes.** SWEGs added: Dimethysilanediol Lead SWEGs updated: Total Organic Carbon (TOC) Chemical nomenclature revised to coincide with published NRC SWEGs, Vol. 2: Barium and Barium Salts Cadmium (Inorganic Salts) Manganese (Inorganic Salts) Zinc and Zinc Salts (Inorganic)
Revision A	11/2023	CR# SA-06682 Shannon D. Langford 281-483-2137	Clarification of Total Organic Carbon values

TABLE OF CONTENTS

1.0 BACKGROUND 5
2.0 PUBLISHED SWEGS 6
3.0 REFERENCES 15

APPENDIX

APPENDIX A ACRONYMS AND ABBREVIATIONS 16

1.0 BACKGROUND

The enclosed table lists official Spacecraft Water Exposure Guidelines (SWEGs), which are guideline values set by the NASA/JSC Toxicology Group in cooperation with the National Research Council Committee on Toxicology (NRCCOT) or through publication in the peer-reviewed scientific literature. Based on documented guidance (NRC, 2000), NASA has established SWEGs for 30 chemical compounds that are particularly relevant to water systems on the International Space Station (ISS) as well as on spacecraft for deep-space exploration. Summaries of these SWEGs are presented in tabular form as part of this publication. Complete documentation is provided in the reference section below.

Acute-exposure SWEGs are set for crew water consumption of 1 and 10 days with the understanding that these limits apply only to contingency conditions. These acute-exposure guidelines allow for a moderate risk that the crew will experience some dissatisfaction with the water, but not to the point where it would result in reduced water consumption. In addition, there is only a slight risk that the compound could cause mild symptoms (e.g., nausea, headache) at acute-exposure limits. Accordingly, these limits are not necessarily fully protective of crew health and should not be used as design criteria.

The second group of SWEGs, for exposure periods of 100 and 1000 days, is set with prolonged consumption of water in mind and allow for no appreciable risk to crew health. This includes considerations for the aesthetic properties of the water. Water that is perceived as smelling or tasing poorly may result in reduced crew consumption, an unacceptable condition for extended spaceflight missions. Longer-term SWEGs are protective against both immediate toxic effects (e.g., gastrointestinal irritation) as well as delayed health impairment (e.g., kidney disease, cancer). Exceedance of a SWEG does not mean that health impairment is certain (there are many other factors that influence ultimate health outcomes), although it does indicate that the crew may be subject to increased risks that must be closely evaluated. Combined effects from multiple chemicals in potable water are not specifically considered when evaluating crewmember exposures, due to the small number of compounds present in potable water and subsequently low risk for cumulative impacts. Cumulative risk may be reevaluated in the future if dictated by changing exposure conditions.

This list of SWEGs is not meant to define the set of compounds that may be of toxicological concern in evaluating/designing a spacecraft water system. Given the relatively small number of chemicals with established SWEGs, it is likely that chemicals will be encountered in spaceflight design or operations that do not have available SWEGs. In these cases, maximum contaminant levels (MCLs) established by the United States Environmental Protection Agency for municipal water systems (http://www.epa.gov/safewater/mcl.html) may be considered; however, these limits are designed for a different target population and may be overly conservative for direct application to astronauts. Instead, in cases where SWEGs for compounds of interest have not been established, the recommended course of action is to contact the JSC Toxicology Group.

2.0 PUBLISHED SWEGS

SWEGs (Spacecraft Water Exposure Guidelines)

POTENTIAL EXPOSURE DURATION

Chemical	1 day	10 days	100 days	1000 days	Remarks:
Acetone CAS #: 67-64-1 Reference: Garcia, Hector D. (2007), Acetone, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 11-38. The National Academies Press, Washington, DC.	3500 mg/L *Organ* / *Effect* Blood / Marrow Hypoplasia	3500 mg/L *Organ* / *Effect* Blood / Marrow Hypoplasia	150 mg/L *Organ* / *Effect* Blood / Macrocytic anemia	15 mg/L *Organ* / *Effect* Blood / Macrocytic anemia	
Alkylamines (di) CAS #: Variable Reference: Hampton, Jean M. (2007), C1-C4 Mono-, Di-, and Trialkylamines, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 96-153. The National Academies Press, Washington, DC.	0.3 mg/L *Organ* / *Effect* Nose / RWC	0.3 mg/L *Organ* / *Effect* Nose / RWC	0.3 mg/L *Organ* / *Effect* Nose / RWC	0.3 mg/L *Organ* / *Effect* Nose / RWC	Documented as C1-C4 Mono-, Di-, and Trialkylamines RWC resulting from unpleasant smell/taste.
Alkylamines (mono) CAS #: Variable Reference: Hampton, Jean M. (2007), C1-C4 Mono-, Di-, and Trialkylamines, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 96-153. The National Academies Press, Washington, DC.	2 mg/L *Organ* / *Effect* Nose / RWC	2 mg/L *Organ* / *Effect* Nose / RWC	2 mg/L *Organ* / *Effect* Nose / RWC	2 mg/L *Organ* / *Effect* Nose / RWC	Documented as C1-C4 Mono-, Di-, and Trialkylamines RWC resulting from unpleasant smell/taste.
Alkylamines (tri) CAS #: Variable Reference: Hampton, Jean M. (2007), C1-C4 Mono-, Di-, and Trialkylamines, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 96-153. The National Academies Press, Washington, DC.	0.4 mg/L *Organ* / *Effect* Nose / RWC	0.4 mg/L *Organ* / *Effect* Nose / RWC	0.4 mg/L *Organ* / *Effect* Nose / RWC	0.4 mg/L *Organ* / *Effect* Nose / RWC	Documented as C1-C4 Mono-, Di-, and Trialkylamines RWC resulting from unpleasant smell/taste.

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; DCFF: Decreased Critical Flicker Frequency; GI: Gastrointestinal tract; NRC: National Research Council; PNS: Peripheral Nervous System; RBC: Red Blood Cells; RWC: Reduced Water Consumption

SWEGs (Spacecraft Water Exposure Guidelines)

POTENTIAL EXPOSURE DURATION

Chemical	1 day	10 days	100 days	1000 days	Remarks:
Ammonia CAS #: 7664-41-7 Reference: James, John T. (2007), Ammonia, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 39-51. The National Academies Press, Washington, DC.	5 mg/L *Organ* / *Effect* Nose / RWC	1 mg/L *Organ* / *Effect* Nose / RWC	1 mg/L *Organ* / *Effect* Nose / RWC	1 mg/L *Organ* / *Effect* Nose / RWC	RWC resulting from unpleasant smell/taste.
Antimony CAS #: Variable Reference: Ramanathan, Raghupathy. (2008), Antimony, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 3: 13-44. The National Academies Press, Washington, DC.	4 mg/L *Organ* / *Effect* G.I. / Emetic	4 mg/L *Organ* / *Effect* G.I. / Emetic	4 mg/L *Organ* / *Effect* G.I. / Emetic	2 mg/L *Organ* / *Effect* Blood / Hematotoxicity	And soluble salts
Barium and Barium Salts CAS #: Variable Reference: Ramanathan, Raghupathy. (2007), Barium and Barium Salts, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 52-95. The National Academies Press, Washington, DC.	21 mg/L *Organ* / *Effect* Heart / Cardiotoxicity	21 mg/L *Organ* / *Effect* Heart / Cardiotoxicity	10 mg/L *Organ* / *Effect* Nose / RWC	10 mg/L *Organ* / *Effect* Nose / RWC	
Benzene CAS #: 71-43-2 Reference: Khan-Mayberry, Noreen N. & James, John T. (2008), Benzene, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 3: 45-85. The National Academies Press, Washington, DC.	21 mg/L *Organ* / *Effect* Blood / Immunotoxicity	2 mg/L *Organ* / *Effect* Blood / Immunotoxicity	0.7 mg/L *Organ* / *Effect* Blood / Leukemia	0.07 mg/L *Organ* / *Effect* Blood / Leukemia	

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; DCFF: Decreased Critical Flicker Frequency; GI: Gastrointestinal tract; NRC: National Research Council; PNS: Peripheral Nervous System; RBC: Red Blood Cells; RWC: Reduced Water Consumption

SWEGs (Spacecraft Water Exposure Guidelines)

POTENTIAL EXPOSURE DURATION

Chemical	1 day	10 days	100 days	1000 days	Remarks:
Cadmium (Inorganic Salts) CAS #: Variable Reference: Ramanathan, Raghupathy (2007), Cadimium (Inorganic Salts), Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 154-263. The National Academies Press, Washington, DC.	1.6 mg/L *Organ* / *Effect* G.I. / Emetic	0.7 mg/L *Organ* / *Effect* Nose / RWC	0.6 mg/L *Organ* / *Effect* Bone / Osteotoxicity	0.022 mg/L *Organ* / *Effect* Kidney / Nephrotoxicity	RWC resulting from unpleasant smell/taste.
Caprolactam CAS #: 105-60-2 Reference: Ramanathan, Raghupathy. (2007), Caprolactum, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 264-299. The National Academies Press, Washington, DC.	200 mg/L *Organ* / *Effect* Liver / Hepatotoxicity	100 mg/L *Organ* / *Effect* Kidney / Nephrotoxicity	100 mg/L *Organ* / *Effect* Kidney / Nephrotoxicity	100 mg/L *Organ* / *Effect* Kidney / Nephrotoxicity	
Chloroform CAS #: 67-66-3 Reference: Garcia, Hector D. (2004), Chloroform, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 1: 11-56. The National Academies Press, Washington, DC.	60 mg/L *Organ* / *Effect* Nose / RWC	60 mg/L *Organ* / *Effect* Nose / RWC	18 mg/L *Organ* / *Effect* Liver / Hepatotoxicity	6.5 mg/L *Organ* / *Effect* Liver / Hepatotoxicity	RWC resulting from unpleasant smell/taste.
Di-n-butyl phthalate CAS #: 84-74-2 Reference: James, John T. (2004), Di-n-butyl Phthalate, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 1: 88-120. The National Academies Press, Washington, DC.	1200 mg/L *Organ* / *Effect* Testes / Injury	175 mg/L *Organ* / *Effect* Testes / Injury	80 mg/L *Organ* / *Effect* Blood / Hematotoxicity	40 mg/L *Organ* / *Effect* Blood / Hematotoxicity	

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; DCFF: Decreased Critical Flicker Frequency; GI: Gastrointestinal tract; NRC: National Research Council; PNS: Peripheral Nervous System; RBC: Red Blood Cells; RWC: Reduced Water Consumption

SWEGs (Spacecraft Water Exposure Guidelines)

POTENTIAL EXPOSURE DURATION

Chemical	1 day	10 days	100 days	1000 days	Remarks:
Di(2-ethylhexyl) phthalate CAS #: 117-81-7 Reference: James, John T. (2004), Di(2-ethylhexyl) Phthalate, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 1: 121-168. The National Academies Press, Washington, DC.	1800 mg/L *Organ* / *Effect* G.I. / Gastric upset	1300 mg/L *Organ* / *Effect* Testes / Injury	30 mg/L *Organ* / *Effect* Liver / Hematotoxicity Testes / Injury	20 mg/L *Organ* / *Effect* Testes / Injury	
Dichloromethane CAS #: 75-09-02 Reference: Garcia, Hector D. (2004), Dichloromethane, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 1: 57-87. The National Academies Press, Washington, DC.	40 mg/L *Organ* / *Effect* CNS / DCFF Nose / RWC	40 mg/L *Organ* / *Effect* CNS / DCFF Nose / RWC	40 mg/L *Organ* / *Effect* CNS / DCFF Liver / Hepatotoxicity Nose / RWC	15 mg/L *Organ* / *Effect* Liver / Hepatotoxicity	RWC resulting from unpleasant smell/taste
Dimethylsilanediol CAS #: 1066-42-8 Reference: Ramanathan, R., James, J.T., and McCoy, T. Acceptable Levels for Ingestion of Dimethylsilanediol in Water on the International Space Station. *Aviat Space Environ Med* 2012; 83:598-603.	*Organ* / *Effect* - / -	*Organ* / *Effect* - / -	35 mg/L *Organ* / *Effect* G.I. / Diarrhea G.I. / Stomach upset	*Organ* / *Effect* - / -	
Ethylene glycol CAS #: 107-21-1 Reference: James, John T. (2008), Ethylene Glycol, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 3: 86-123. The National Academies Press, Washington, DC.	270 mg/L *Organ* / *Effect* CNS / Depression Kidney / Lesions	140 mg/L *Organ* / *Effect* Kidney / Lesions	20 mg/L *Organ* / *Effect* Kidney / Lesions	4 mg/L *Organ* / *Effect* Kidney / Lesions	

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; DCFF: Decreased Critical Flicker Frequency; GI: Gastrointestinal tract; NRC: National Research Council; PNS: Peripheral Nervous System; RBC: Red Blood Cells; RWC: Reduced Water Consumption

SWEGs (Spacecraft Water Exposure Guidelines)

POTENTIAL EXPOSURE DURATION

Chemical	1 day	10 days	100 days	1000 days	Remarks:
Formaldehyde CAS #: 50-00-0 Reference: McCoy, J. Torin (2007), Formaldehyde, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 300-341. The National Academies Press, Washington, DC.	20 mg/L *Organ* / *Effect* G.I. / Gastric upset	20 mg/L *Organ* / *Effect* G.I. / Gastric upset	12 mg/L *Organ* / *Effect* G.I. / Gastric upset	12 mg/L *Organ* / *Effect* G.I. / Gastric upset	
Formate CAS #: 64-19-7 Reference: Garcia, Hector D. (2007), Formate, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 342-363. The National Academies Press, Washington, DC.	10,000 mg/L *Organ* / *Effect* Eye / Decr. vision	2500 mg/L *Organ* / *Effect* Eye / Decr. vision	2500 mg/L *Organ* / *Effect* Eye / Decr. vision	2500 mg/L *Organ* / *Effect* Eye / Decr. vision	Decreased vision: Decreased amplitude of electroretinograms.
Lead CAS #: 7439-92-1 Reference: Garcia, Hector D., Tsuji, Joyce S., and James, John T. Establishment of Exposure Guidelines for Lead in Spacecraft Drinking Water. *Aviat Space Environ Med* 2014; 85:715-20.	*Organ* / *Effect* - / -	*Organ* / *Effect* - / -	0.009 mg/L *Organ* / *Effect* Blood / Cognition	0.009 mg/L *Organ* / *Effect* Blood / Cognition	Lead SWEGs were set to prevent any increase in blood lead levels due to drinking water consumption combined with lead released from stores in bones.
Manganese (Inorganic Salts) CAS #: variable Reference: Ramanathan, Raghupathy. (2007), Manganese (Inorganic Salts), Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 364-452. The National Academies Press, Washington, DC.	14 mg/L *Organ* / *Effect* CNS / Neurotoxicity G.I. / G.I. discomfort Blood / Clinical chemistry	5.4 mg/L *Organ* / *Effect* CNS / Neurotoxicity Blood / Abnorm clin chem Blood / Hemotology Liver / Abnorm clin chem Liver / Hemotology	1.8 mg/L *Organ* / *Effect* CNS / Neurotoxicity	0.3 mg/L *Organ* / *Effect* CNS / Neurotoxicity	

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; DCFF: Decreased Critical Flicker Frequency; GI: Gastrointestinal tract; NRC: National Research Council; PNS: Peripheral Nervous System; RBC: Red Blood Cells; RWC: Reduced Water Consumption

SWEGs (Spacecraft Water Exposure Guidelines)

POTENTIAL EXPOSURE DURATION

Chemical	1 day	10 days	100 days	1000 days	Remarks:
2- Mercaptobenzothiazole CAS #: 149-30-4 Reference: Garcia, Hector D. (2004), 2-Mercaptobenzothiazole, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 1: 169-202. The National Academies Press, Washington, DC.	200 mg/L *Organ* / *Effect* CNS / Depression	30 mg/L *Organ* / *Effect* Kidney / Nephrotoxicity	30 mg/L *Organ* / *Effect* Kidney / Nephrotoxicity	30 mg/L *Organ* / *Effect* Kidney / Nephrotoxicity Kidney / Cancer	
Methanol CAS #: 67-56-1 Reference: Garcia, Hector D. (2008), Methanol, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 3: 126-146. The National Academies Press, Washington, DC.	40 mg/L *Organ* / *Effect* CNS / Degeneration	40 mg/L *Organ* / *Effect* CNS / Degeneration	40 mg/L *Organ* / *Effect* CNS / Degeneration	40 mg/L *Organ* / *Effect* CNS / Degeneration	Subtle effects on EEG and neurobehavioral tests.
Methyl ethyl ketone CAS #: 78-93-3 Reference: Garcia, Hector D. (2008), Methyl Ethyl Ketone, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 3: 147-164. The National Academies Press, Washington, DC.	540 mg/L *Organ* / *Effect* Nose / RWC	54 mg/L *Organ* / *Effect* Nose / RWC	54 mg/L *Organ* / *Effect* Nose / RWC	54 mg/L *Organ* / *Effect* Nose / RWC	10-, 100-, and 1000-d SWEGs are set below the odor detection limit to avoid crew dehydration due to odor avoidance. RWC resulting from unpleasant smell/taste
Nickel CAS #: 7440-02-0 Reference: Ramanathan, Raghupathy. (2004), Nickel, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 1: 203-247. The National Academies Press, Washington, DC.	1.7 mg/L *Organ* / *Effect* Bone Marrow / Immuno supression	1.7 mg/L *Organ* / *Effect* Bone Marrow / Immuno supression	1.7 mg/L *Organ* / *Effect* Bone Marrow / Immuno supression	0.3 mg/L *Organ* / *Effect* Bone Marrow / Immuno supression	

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; DCFF: Decreased Critical Flicker Frequency; GI: Gastrointestinal tract; NRC: National Research Council; PNS: Peripheral Nervous System; RBC: Red Blood Cells; RWC: Reduced Water Consumption

SWEGs (Spacecraft Water Exposure Guidelines)

POTENTIAL EXPOSURE DURATION

Chemical	1 day	10 days	100 days	1000 days	Remarks:
Phenol CAS #: 108-95-2 Reference: Lam, Chiu-Wing. (2004), Phenol, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 1: 248 -289. The National Academies Press, Washington, DC.	80 mg/L *Organ* / *Effect* G.I. / Irritation Nose / RWC	8 mg/L *Organ* / *Effect* G.I. / Irritation Nose / RWC	4 mg/L *Organ* / *Effect* G.I. / Irritation Nose / RWC	4 mg/L *Organ* / *Effect* G.I. / Irritation Nose / RWC	RWC resulting from unpleasant smell/taste
N- Phenyl-beta-naphthylamine CAS #: 135-88-6 Reference: Hampton, Jean M. (2004), N-Phenyl-beta-naphthylamine, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 1: 290-323. The National Academies Press, Washington, DC.	1600 mg/L *Organ* / *Effect* G.I. / Toxicity	1600 mg/L *Organ* / *Effect* G.I. / Toxicity	500 mg/L *Organ* / *Effect* Kidney / Lesions	260 mg/L *Organ* / *Effect* Kidney / Lesions	
Propylene glycol CAS #: 57-55-6 Reference: Ramanathan, Raghupathy. (2008), Propylene Glycol, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 3: 165-188. The National Academies Press, Washington, DC.	25,000 mg/L *Organ* / *Effect* Blood / Metabolic effects	8000 mg/L *Organ* / *Effect* Blood / Metabolic effects	8000 mg/L *Organ* / *Effect* Blood / Metabolic effects	1700 mg/L *Organ* / *Effect* Blood / Hematotoxicity	1-, 10-, and 100-d metabolic effects: increased lactic acid, pH and osmolality.
Silver CAS #: 7440-22-4 Reference: Ramanathan, Raghupathy. (2004), Silver, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 1: 324-354.The National Academies Press, Washington, DC.	5 mg/L *Organ* / *Effect* Nose / RWC	5 mg/L *Organ* / *Effect* Nose / RWC	0.6 mg/L *Organ* / *Effect* CNS / Hypoactivity	0.4 mg/L *Organ* / *Effect* Skin / Argyria	Argyria is not considered an adverse toxic effect. The 1000-d value is similar to levels suggested by WHO (1984) for lifetime exposure. RWC resulting from unpleasant smell/taste

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; DCFF: Decreased Critical Flicker Frequency; GI: Gastrointestinal tract; NRC: National Research Council; PNS: Peripheral Nervous System; RBC: Red Blood Cells; RWC: Reduced Water Consumption

SWEGs (Spacecraft Water Exposure Guidelines)

POTENTIAL EXPOSURE DURATION

Chemical	1 day	10 days	100 days	1000 days	Remarks:
Total Organic Carbon CAS #: N/A Reference: James, John T. (2007), Total Organic Carbon, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 453-464. The National Academies Press, Washington, DC.			5 mg/L *Organ* / *Effect* G.I. / Gastric upset	5 mg/L *Organ* / *Effect* G.I. / Gastric upset	TOC limit is based on reasonable worst-case assumption that formaldehyde is the compound responsible for the measured TOC. Limit is the calculated TOC equivalent of the 100-d and 1000-d SWEG for formaldehyde (12 mg/L). Previous limit (3 mg/L) was set using the EPA lifetime drinking water exposure limit (DWEL).
Zinc and Zinc Salts (Inorganic) CAS #: Variable Reference: Ramanathan, Raghupathy. (2007), Zinc and Zinc Salts (Inorganic), Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 465-513. The National Academies Press, Washington, DC.	11 mg/L *Organ* / *Effect* Blood / Immunotoxicity	11 mg/L *Organ* / *Effect* Blood / Immunotoxicity	2.0 mg/L *Organ* / *Effect* Blood / Hematotoxicity Blood / Immunotoxicity	2.0 mg/L *Organ* / *Effect* Blood / Hematotoxicity	

Abbreviations: CNS: Central Nervous System; CV: Cardiovascular; DCD: Decreased Color Discrimination; DCFF: Decreased Critical Flicker Frequency; GI: Gastrointestinal tract; NRC: National Research Council; PNS: Peripheral Nervous System; RBC: Red Blood Cells; RWC: Reduced Water Consumption

3.0 REFERENCES

NRC (2000) Methods for Developing Spacecraft Water Exposure Guidelines, National Academy Press, Washington, D.C.

NRC (2004) Spacecraft Water Exposure Guidelines for Selected Contaminants, Volume 1, National Academy Press, Washington, D.C.

NRC (2006) Spacecraft Water Exposure Guidelines for Selected Contaminants, Volume 2, National Academy Press, Washington, D.C.

NRC (2008) Spacecraft Water Exposure Guidelines for Selected Contaminants, Volume 3, National Academy Press, Washington, D.C.

Ramanathan R, James JT, McCoy T. (2012) Acceptable levels for ingestion of dimethylsilanediol in water on the International Space Station. Aviat Space Environ Med. 83(6):598-603.

Garcia, HD, Tsuji, JS, James, JT. (2014) Establishment of exposure guidelines for lead in spacecraft drinking water. Aviat Space Environ Med. 85:715-20.

APPENDIX A ACRONYMS AND ABBREVIATIONS

CAS	Chemical Abstract Service
C_n	Specific Concentration
CNS	Central Nervous System
CV	Cardiovascular
DCD	Decreased Color Discrimination
DCV	Decreased Conduction Velocity
GI	Gastrointestinal
HA	Headache
ISS	International Space Station
JSC	Johnson Space Center
NASA	National Aeronautics and Space Administration
NRC	National Research Council
NRCCOT	National Research Council Committee on Toxicology
PNS	Peripheral Nervous System
ppm	Parts Per Million
RespSys	Respiratory System
SMACs	Spacecraft Maximum Allowable Concentrations

T_{grp}	Toxicity Index
U.Blad	Urinary Bladder