

SPACECRAFT WATER EXPOSURE GUIDELINES (SWEGs)

Human Health and Performance Directorate

Toxicology Group

Environmental Sciences Branch

Biomedical Research and Environmental Sciences Division

OPEN TO JSC AND JSC CONTRACTOR EMPLOYEES & OTHER
NASA AND NASA CONTRACTOR EMPLOYEES, AS REQUIRED

CCB Controlled (BRES CB)

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Baseline

July 2017



National Aeronautics and Space Administration


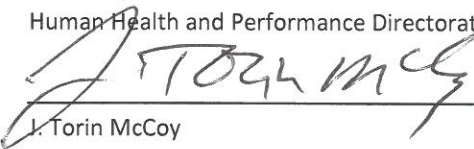
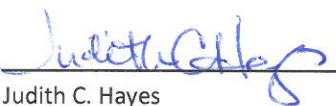
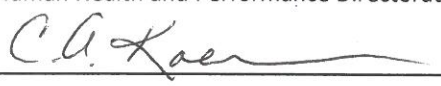
Lyndon B. Johnson Space Center

Houston, Texas

Human Health and Performance Directorate	Title: Spacecraft Water Exposure Guidelines (SWEGs)	
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NASA APPROVAL SHEET

Spacecraft Water Exposure Guidelines (SWEGs)

COMPLIED BY:	 <hr/> Valerie E. Ryder, Ph.D., DABT Toxicologist Human Health and Performance Directorate	<u>7/26/17</u> DATE
CONCURRED BY:	 <hr/> J. Torin McCoy Chief, Environmental Sciences Branch Human Health and Performance Directorate	<u>7/30/17</u> DATE
	 <hr/> Judith C. Hayes Chief, Biomedical Research and Environmental Sciences Division Human Health and Performance Directorate	<u>8-3-17</u> DATE
	 <hr/> Catherine A. Koerner Director, Human Health and Performance Directorate	<u>8/3/17</u> DATE

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

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CHANGE HISTORY

Requested changes shall be submitted on change request (CR) form and approved by the Biomedical Research and Environmental Sciences (BRES) configuration control board (CCB).

Revision/PCN	Date	Authorization/Originator/Phone	Description
Baseline	07/2017	TBD/Valerie E. Ryder/281-483-4989	<p>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/Documentation Management purposes.</p> <p>SWEGs added: Dimethylsilanediol Lead</p> <p>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)</p>

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SPACECRAFT WATER EXPOSURE GUIDELINES (SWEGs)

2017

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 tasting 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, one may think to look to the 76 maximum contaminant levels (MCLs) established by the United States Environmental Protection Agency for municipal water systems (<http://www.epa.gov/safewater/mcl.html>). However, these limits are designed for a different target population and have a tendency to 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.

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SWEGS (Spacecraft Water Exposure Guidelines)

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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	3500 mg/L	150 mg/L	15 mg/L															
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Blood</td> <td>Marrow Hypoplasia</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Blood		Marrow Hypoplasia	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Blood</td> <td>Marrow Hypoplasia</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Blood	Marrow Hypoplasia	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Blood</td> <td>Macrocytic anemia</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Blood	Macrocytic anemia	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Blood</td> <td>Macrocytic anemia</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>
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<u>Organ</u>	<u>Effect</u>																		
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	0.3 mg/L	0.3 mg/L	0.3 mg/L	Documented as C1-C4 Mono-, Di-, and Trialkylamines RWC resulting from unpleasant smell/taste.														
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose		RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>
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<u>Organ</u>	<u>Effect</u>																		
Nose	RWC																		
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	2 mg/L	2 mg/L	2 mg/L	Documented as C1-C4 Mono-, Di-, and Trialkylamines RWC resulting from unpleasant smell/taste.														
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose		RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>
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<u>Organ</u>	<u>Effect</u>																		
Nose	RWC																		
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	0.4 mg/L	0.4 mg/L	0.4 mg/L	Documented as C1-C4 Mono-, Di-, and Trialkylamines RWC resulting from unpleasant smell/taste.														
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose		RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>
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Abbreviations:

CNS: Central Nervous System	CV: Cardiovascular	DCD: Decreased Color Discrimination	DCFF: Decreased Critical Flicker Frequency	GI: Gastrointestinal tract
NRC: National Research Council	N.S.: Not Set	PNS: Peripheral Nervous System	RBC: Red Blood Cells	RespSys: Respiratory System
RWC: Reduced Water Consumption				



SWEGs (Spacecraft Water Exposure Guidelines)

POTENTIAL EXPOSURE DURATION

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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	1 mg/L	1 mg/L	1 mg/L	RWC resulting from unpleasant smell/taste.
	<u>Organ</u> <u>Effect</u> Nose RWC	<u>Organ</u> <u>Effect</u> Nose RWC	<u>Organ</u> <u>Effect</u> Nose RWC	<u>Organ</u> <u>Effect</u> Nose RWC	
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	4 mg/L	4 mg/L	2 mg/L	And soluble salts
	<u>Organ</u> <u>Effect</u> G.I. Emetic	<u>Organ</u> <u>Effect</u> G.I. Emetic	<u>Organ</u> <u>Effect</u> G.I. Emetic	<u>Organ</u> <u>Effect</u> Blood Hematotoxicity	
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	21 mg/L	10 mg/L	10 mg/L	
	<u>Organ</u> <u>Effect</u> Heart Cardiotoxicity	<u>Organ</u> <u>Effect</u> Heart Cardiotoxicity	<u>Organ</u> <u>Effect</u> Nose RWC	<u>Organ</u> <u>Effect</u> 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	2 mg/L	0.7 mg/L	0.07 mg/L	
	<u>Organ</u> <u>Effect</u> Blood Immunotoxicity	<u>Organ</u> <u>Effect</u> Blood Immunotoxicity	<u>Organ</u> <u>Effect</u> Blood Leukemia	<u>Organ</u> <u>Effect</u> Blood Leukemia	

Abbreviations:

CNS: Central Nervous System CV: Cardiovascular DCD: Decreased Color Discrimination DCF: Decreased Critical Flicker Frequency GI: Gastrointestinal tract
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POTENTIAL EXPOSURE DURATION

Chemical	1 day	10 days	100 days	1000 days	Remarks:														
Cadmium (Inorganic Salts) CAS #: Variable Reference: Ramanathan, Raghupathy (2007), Cadmium (Inorganic Salts), Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 154-263. The National Academies Press, Washington, DC.	1.6 mg/L	0.7 mg/L	0.6 mg/L	0.022 mg/L	RWC resulting from unpleasant smell/taste.														
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>G.I.</td> <td>Emetic</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	G.I.		Emetic	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Bone</td> <td>Osteotoxicity</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Bone	Osteotoxicity	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Kidney</td> <td>Nephrotoxicity</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>
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G.I.	Emetic																		
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Bone	Osteotoxicity																		
<u>Organ</u>	<u>Effect</u>																		
Kidney	Nephrotoxicity																		
Caprolactam CAS #: 105-60-2 Reference: Ramanathan, Raghupathy. (2007), Caprolactam, Spacecraft Water Exposure Guidelines for Selected Contaminants, Vol. 2: 264-299. The National Academies Press, Washington, DC.	200 mg/L	100 mg/L	100 mg/L	100 mg/L															
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Kidney	Nephrotoxicity																		
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Kidney	Nephrotoxicity																		
<u>Organ</u>	<u>Effect</u>																		
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	60 mg/L	18 mg/L	6.5 mg/L	RWC resulting from unpleasant smell/taste.														
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Liver	Hepatotoxicity																		
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	175 mg/L	80 mg/L	40 mg/L															
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Human Health and Performance Directorate	Title: Spacecraft Water Exposure Guidelines (SWEGs)	
	Document: JSC 63414	Baseline
	Date: 07/2017	Page: 8



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	1300 mg/L	30 mg/L	20 mg/L																							
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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	40 mg/L	40 mg/L	15 mg/L	RWC resulting from unpleasant smell/taste																						
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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. <i>Aviat Space Environ Med</i> 2012; 83:598-603.	Not Set mg/L	Not Set mg/L	35 mg/L	Not Set mg/L																							
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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	140 mg/L	20 mg/L	4 mg/L																							
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Abbreviations:

CNS: Central Nervous System	CV: Cardiovascular	DCD: Decreased Color Discrimination	DCFF: Decreased Critical Flicker Frequency	GI: Gastrointestinal tract
NRC: National Research Council	N.S.: Not Set	PNS: Peripheral Nervous System	RBC: Red Blood Cells	RespSys: Respiratory System
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SWEGS (Spacecraft Water Exposure Guidelines)

Human Health and Performance Directorate	Title: Spacecraft Water Exposure Guidelines (SWEGS)	
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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	20 mg/L	12 mg/L	12 mg/L																											
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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	2500 mg/L	2500 mg/L	2500 mg/L	Decreased vision: Decreased amplitude of electroretinograms.																										
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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. <i>Aviat Space Environ Med</i> 2014; 85:715-20.	Not Set mg/L	Not Set mg/L	0.009 mg/L	0.009 mg/L	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.																										
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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	5.4 mg/L	1.8 mg/L	0.3 mg/L																											
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POTENTIAL EXPOSURE DURATION

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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	30 mg/L	30 mg/L	30 mg/L																	
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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	40 mg/L	40 mg/L	40 mg/L	Subtle effects on EEG and neurobehavioral tests.																
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CNS	Degeneration																				
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	54 mg/L	54 mg/L	54 mg/L	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																
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose		RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Nose	RWC
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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	1.7 mg/L	1.7 mg/L	0.3 mg/L																	
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Bone Marrow</td> <td>Immuno supression</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Bone Marrow		Immuno supression	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Bone Marrow</td> <td>Immuno supression</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Bone Marrow	Immuno supression	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Bone Marrow</td> <td>Immuno supression</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Bone Marrow	Immuno supression	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;"><u>Organ</u></th> <th style="width: 50%;"><u>Effect</u></th> </tr> <tr> <td>Bone Marrow</td> <td>Immuno supression</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Bone Marrow	Immuno supression
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Abbreviations:

CNS: Central Nervous System	CV: Cardiovascular	DCD: Decreased Color Discrimination	DCFF: Decreased Critical Flicker Frequency	GI: Gastrointestinal tract
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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	8 mg/L	4 mg/L	4 mg/L	RWC resulting from unpleasant smell/taste																						
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>G.I.</td> <td>Irritation</td> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	G.I.		Irritation	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>G.I.</td> <td>Irritation</td> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	G.I.	Irritation	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>G.I.</td> <td>Irritation</td> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	G.I.	Irritation	Nose	RWC	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>G.I.</td> <td>Irritation</td> </tr> <tr> <td>Nose</td> <td>RWC</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	G.I.	Irritation
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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	1600 mg/L	500 mg/L	260 mg/L																							
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>G.I.</td> <td>Toxicity</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	G.I.		Toxicity	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>G.I.</td> <td>Toxicity</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	G.I.	Toxicity	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>Kidney</td> <td>Lesions</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Kidney	Lesions	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>Kidney</td> <td>Lesions</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Kidney	Lesions						
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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	8000 mg/L	8000 mg/L	1700 mg/L	1-, 10-, and 100-d metabolic effects: increased lactic acid, pH and osmolality.																						
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>Blood</td> <td>Metabolic effects</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Blood		Metabolic effects	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>Blood</td> <td>Metabolic effects</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Blood	Metabolic effects	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>Blood</td> <td>Metabolic effects</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Blood	Metabolic effects	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;"><u>Organ</u></th> <th style="text-align: left;"><u>Effect</u></th> </tr> <tr> <td>Blood</td> <td>Hematotoxicity</td> </tr> </table>	<u>Organ</u>	<u>Effect</u>	Blood	Hematotoxicity						
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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	5 mg/L	0.6 mg/L	0.4 mg/L	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																						
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POTENTIAL EXPOSURE DURATION

Chemical	1 day	10 days	100 days	1000 days	Remarks:
<p>Total Organic Carbon</p> <p>CAS #: N/A</p> <p>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.</p>	<p>Not Set mg/L</p> <p><u>Organ</u> <u>Effect</u></p>	<p>Not Set mg/L</p> <p><u>Organ</u> <u>Effect</u></p>	<p>5 mg/L</p> <p><u>Organ</u> <u>Effect</u></p>	<p>Not Set mg/L</p> <p><u>Organ</u> <u>Effect</u></p>	<p>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 day SWEG for formaldehyde (12 mg/L). Previous limit (3 mg/L) was set using the EPA lifetime drinking water exposure limit.</p>
<p>Zinc and Zinc Salts (Inorganic)</p> <p>CAS #: Variable</p> <p>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.</p>	<p>11 mg/L</p> <p><u>Organ</u> <u>Effect</u></p> <p>Blood Immunotoxicity</p>	<p>11 mg/L</p> <p><u>Organ</u> <u>Effect</u></p> <p>Blood Immunotoxicity</p>	<p>2.0 mg/L</p> <p><u>Organ</u> <u>Effect</u></p> <p>Blood Hematotoxicity Blood Immunotoxicity</p>	<p>2.0 mg/L</p> <p><u>Organ</u> <u>Effect</u></p> <p>Blood Hematotoxicity</p>	

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