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SUBJECT: Toxicological Assessment of ISS Air and Water Quality: September 29, 2022 – March 28, 2023 (Increment 68) Including NG-18, SpX-26 and SpX-27 Ingress

SUMMARY: Based on these data, air quality was acceptable on ISS for this period, and potable water remains acceptable for crew consumption.

**AIR QUALITY**

Ten archive air samples were successfully collected in mini grab sample containers (mGSCs) on ISS during Increment 68. These consisted of 7 routine samples and 3 ingress samples. A summary of the key air quality indicators from the Increment 68 mGSC samples is provided in Table 1A. An mGSC sample was also collected in SpaceX's Crew-5 Dragon capsule prior to docking to ISS. Additionally, four sets of formaldehyde badges were deployed in the US Lab and the Russian Service Module (SM) during Increment 68. Results from formaldehyde badges deployed on March 8, 2023, are not reported, as these were later understood to be expired by more than a year before they were used. Table 1B includes a summary of the formaldehyde levels measured on the remaining badges.

Data tables containing measured concentrations and corresponding T-values based on appropriate Spacecraft Maximum Allowable Concentrations (SMACs) for compounds present at levels above the laboratory reporting limit are attached to this report. Complete data tables, which include compounds assessed but not detected, are available upon request. Pressure readings for the mGSCs indicate that ten of the eleven reported samples from Increment 68 were acceptable. A sample was collected in the US Lab on March 8, 2023, but the pressure in the sample indicated that no sample was present in the mGSC, so no results are reported for that sample. The mean relative recoveries of the three surrogate standards were all within acceptable limits for all samples.

On-orbit, the Air Quality Monitors (AQMs) automatically collect and analyze samples every 73 hours, which results in 2-3 sampling sessions per unit per week. Monthly average concentrations as well as the Increment average concentrations for compounds measured on the AQMs are presented in Table 2.

**Toxicological Evaluation of ISS Air Quality**

Routine air quality monitoring is performed in-flight using the AQMs. Archive air samples (mGSCs and formaldehyde badges) are collected during each Increment and returned for analysis in the Environmental Chemistry Laboratory. Data from the ground analyses complement the in-flight data and provide a more complete understanding of air quality on the ISS. Analytical results from the routine mGSC samples that returned on SpX-26 and -27 confirmed that air quality was acceptable during this Increment. **T-values calculated using data from all routine archive samples met the 180-d T-value guideline ( $T < 1$ ), indicating no concern for crew health.**

**Table 1A. Analytical summary of ISS air analyses from mGSCs during Increment 68**

Return Flight	Sample Location	Sample Date	Freon 218 (mg/m <sup>3</sup> )	Alcohols <sup>a</sup> (mg/m <sup>3</sup> )	T-Value <sup>b</sup> (units)
Crew-5	Ascent	10/5/2022	<1.5	0.4	0.1 (<0.1)
SpaceX-26	US Lab	10/24/2022	7.9	8.4	0.2
SpaceX-26	JPM	10/24/2022	8	8.5	0.3
SpaceX-26	NG-18 ingress	11/9/2022	3.3	6.2	0.3 (0.2)
SpaceX-26	SpX-26 ingress	11/27/2022	<1.5	2.0	0.1 (0.1)
SpaceX-26	US Lab	12/7/2022	5.0	8.4	0.2
SpaceX-26	Columbus	12/7/2022	4.5	7.8	0.2
SpaceX-27	US Lab	1/20/2023	4.4	7.2	0.2
SpaceX-27	SM	1/20/2023	4.9	8.5	0.2
SpaceX-27	JPM	3/8/2023	11	4.9	0.2
SpaceX-27	SpX-27 ingress	3/16/2023	3.6	2.5	0.1 (0.1)
<i>Guideline</i>			---	<5	<1 <sup>c</sup>

<sup>a</sup> Includes acetone

<sup>b</sup> Sum of the ratios of the measured concentrations and the corresponding 180-day SMAC for each compound; parenthesis indicate value based on 7-day SMACs and applicable to first ingress

<sup>c</sup> T-value <1 used to evaluate routine monthly sampling; <3 used to evaluate first ingress.

**Table 1B: Analytical summary of formaldehyde samples from Increment 68**

Return Flight	Sample Location	Sample Date	Formaldehyde (µg/m <sup>3</sup> )
SpX-26	US Lab	10/24/2022	50
SpX-26	SM	10/24/2022	40
SpX-27	US Lab	12/7/2022	<33
SpX-27	SM	12/7/2022	<33
SpX-27	US Lab	1/20/2023	<33
SpX-27	SM	1/20/2023	<33
<i>Guideline</i>			<120

The average, rounded T-value calculated from the nominal Increment 68 mGSC samples was 0.2 (Figure 1). This value is markedly lower than the T-value from Increment 67 (1.2) and is attributable to the disappearance of acrylonitrile from the ISS atmosphere. The temporary source of acrylonitrile was not determined despite evaluation of several potential sources. T-values based on AQM data and correlated with potential health effects are provided in Figure 2.

**Table 2. Average monthly concentrations (mg/m<sup>3</sup>) of AQM target compounds (Increment 68)**

Compound	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Increment Average
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND
2-Propanol	0.31	0.32	0.16	0.19	0.24	0.2	0.16	0.23
Acetaldehyde	0.2	0.24	0.21	0.16	0.15	0.17	0.23	0.19
Acetone	0.28	0.36	0.27	0.25	0.29	0.26	0.27	0.28
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	MI	MI	MI	MI	MI	MI	MI	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
Dichloromethane	ND	ND	ND	ND	ND	ND	ND	ND
Decamethylcyclopentasiloxane#	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol	5.25	5.41	4.78	4.75	5.49	4.24	3.75	4.81
Ethyl Acetate	0.05	0.16	0.39	0.06	0.09	0.12	0.05	0.13
Hexanal	ND	ND	ND	ND	ND	ND	ND	ND
Hexane	ND	ND	ND	ND	ND	ND	ND	ND
Hexamethylcyclotrisiloxane	ND	ND	ND	ND	ND	ND	ND	ND
Methanol	ND	ND	ND	ND	ND	ND	ND	ND
m, p-Xylenes#	ND	0.05	ND	0.06	ND	ND	ND	ND
n-Butanol	0.04	0.06	0.06	0.04	ND	ND	0.05	0.04
Octamethylcyclotetrasiloxane	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene#	ND	ND	ND	ND	ND	ND	ND	ND
Toluene#	ND	0.03	0.03	0.03	ND	ND	0.03	0.03
Trimethylsilanol	ND	ND	ND	ND	ND	ND	ND	ND

ND: Not detected; &lt;MDL (Minimum Detection Limit)

MI: Matrix Interference

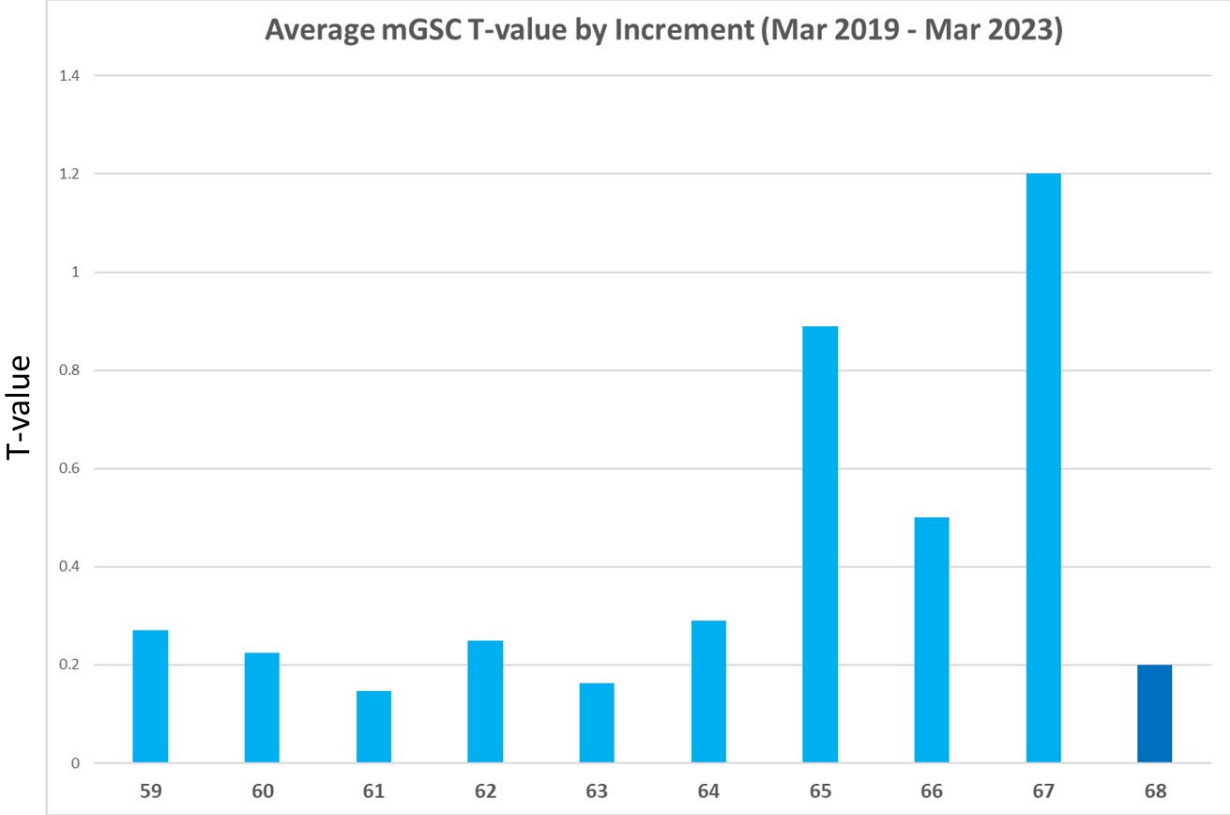


Figure 1. GSC-Derived T-values for Increments 59-68

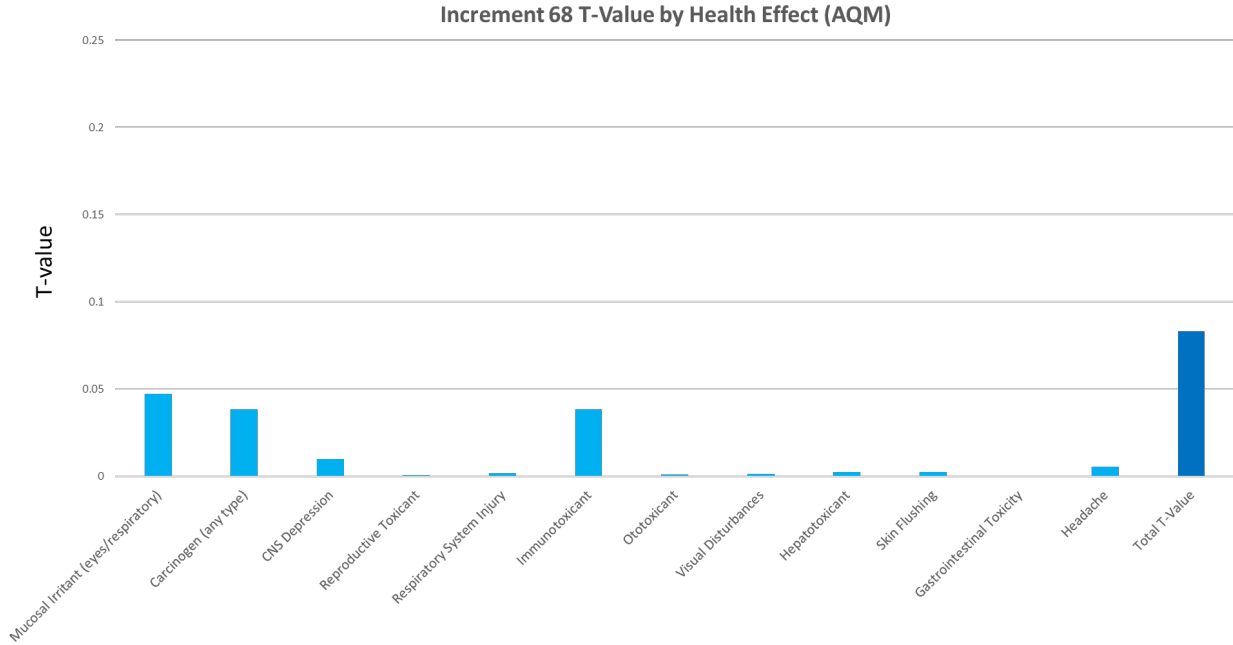
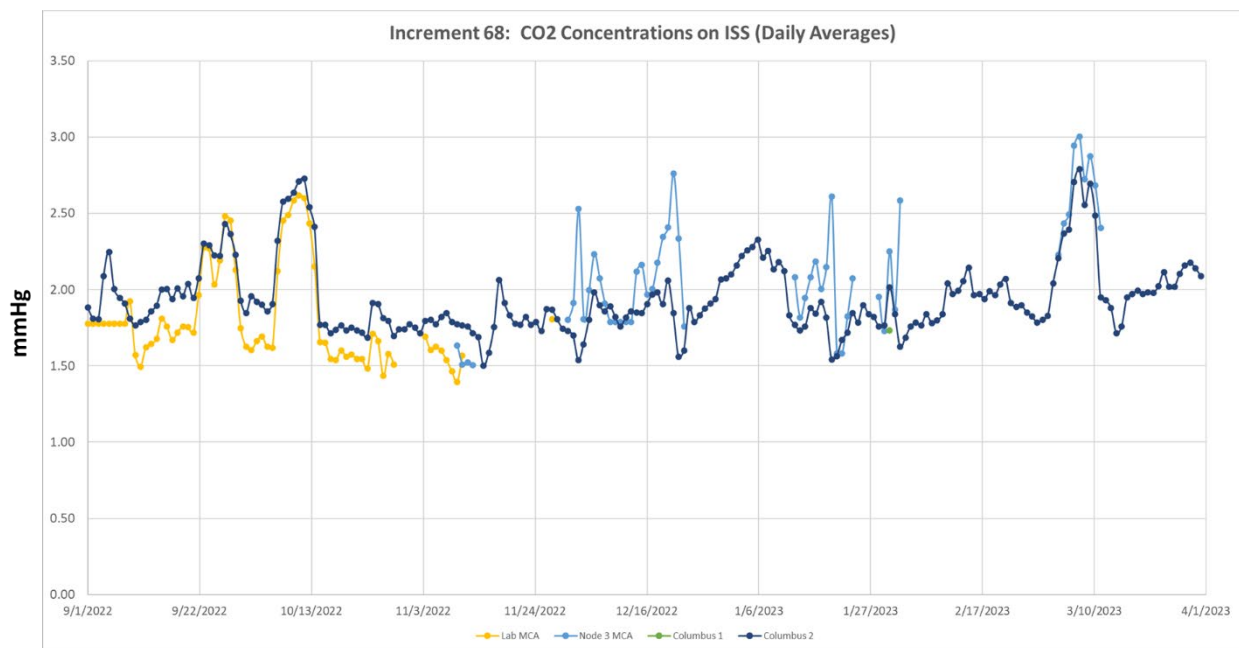


Figure 2. AQM-Derived T-Values by Health Effect for Increment 68

**Alcohol values for six of the seven routine mGSC samples returned on SpX-26 and -27 exceeded the ECLS guideline of  $<5 \text{ mg/m}^3$ .** The levels are mostly attributable to ethanol, which only fell below  $5 \text{ mg/m}^3$  in the last sample collected in the Increment (JPM, 3/8/2023). Measured levels do not present a risk to crew health but are a potential concern for the water recovery system.

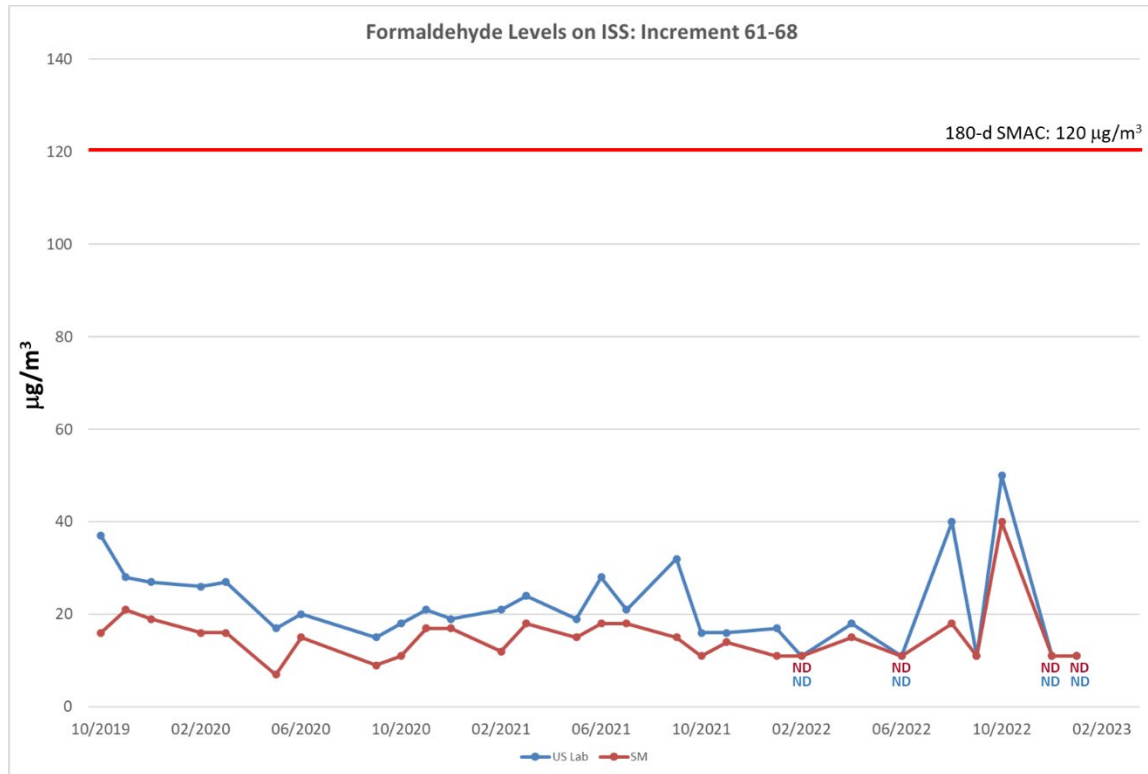
Levels of octafluoropropane (Freon 218) continue to be very low in ISS air compared with historical measurements. NASA's investigation of this change indicates that hardware operating as a technological demonstration for removal of  $\text{CO}_2$  is very efficiently scrubbing octafluoropropane from the ISS atmosphere.

All seven routine mGSC samples collected during Increment 68 contained a  $\text{CO}_2$  concentration below the limit documented in Flight Note F091532D, which requests that the 24-hour average concentration not exceed  $3.0 \text{ mmHg}$  ( $7100 \text{ mg/m}^3$ ,  $4000 \text{ ppm}$ ) on the US segment. While mGSC  $\text{CO}_2$  sampling provides a snapshot of the  $\text{CO}_2$  concentration, real-time  $\text{CO}_2$  data are available from a sensor in the Columbus module, and intermittently from the Major Constituent Analyzers (MCAs) in Node 3 and the US Lab (Figure 3). To preserve the longevity of the instrumentation, MCAs are only activated during EVA activities, crew metabolic characterization, tech demo analysis, anomaly resolution, and when requested by crew surgeons. Overall,  $\text{CO}_2$  concentrations were well-controlled throughout the Increment. The MCA in Node 3 briefly detected  $\text{CO}_2$  levels in excess of  $5 \text{ mmHg}$  on 12/3/2022 (maximum  $5.07 \text{ mmHg}$ ) and 1/20/2023 (max  $5.3 \text{ mmHg}$ ) during EVA activity. These peaks do not appear in Figure 3, as daily averages are presented.



**Figure 3. Environmental  $\text{CO}_2$  Concentrations on ISS During Increment 68 (mmHg)**

Four sets of passive formaldehyde badges were deployed on ISS during Increment 68. The set deployed on March 8, 2023, were found to have been long expired, and thus results from that set are not presented. Results from analysis of the remaining badges indicated that formaldehyde remains at or below the historical range observed on ISS, and concentrations are well below the SMAC of  $120 \text{ } \mu\text{g/m}^3$  (Figure 4). Formaldehyde was detected at  $40\text{-}50 \text{ } \mu\text{g/m}^3$  in October 2022 but was not detected in samples in December 2022, or in January (detection limits were slightly higher for samples from December 2022 and January 2023).



**Figure 4: Formaldehyde Concentrations from October 2019 to March 2023**

#### *Crew-5 Ascent*

An mGSC sample was collected in the Crew-5 capsule during its ascent to ISS on October 5, 2022. As expected, very few trace contaminants were detected in Crew-5 air (T-value <0.1). Isopropanol (2-propanol) was detected at 0.18 mg/m<sup>3</sup> and was likely present due to pre-flight cleaning in the vehicle.

#### *NG-18 Ingress*

An ingress sample was collected in NG-18 on November 9, 2022, at 18:00 GMT. The hatch was opened at 15:40 GMT, and thus the interior air for NG-18 had likely mixed well with the ISS atmosphere. CO<sub>2</sub> was detected at 3600 mg/m<sup>3</sup> (2000 ppm, 1.5 mmHg), similar to normal levels on ISS. Octafluoropropane and methane were also present at levels indicating a moderate level of mixing with ISS air. As such, the measured contaminant levels do not reflect the vehicle contribution.

#### *SpX-26 Ingress*

An ingress sample was collected in SpX-26 on November 27, 2022, at 14:02 GMT, approximately 2 minutes after hatch opening. The CO<sub>2</sub> levels in this sample were all higher than expected for an uncrewed vehicle (5600 mg/m<sup>3</sup>, 3100 ppm, 2.4 mmHg), but this is likely due to the presence of laboratory animals on the flight. Regardless, **the T-value for SpX-26 ingress was 0.1, well below levels of concern for crew health.**

#### *SpX-27 Ingress*

An ingress sample was collected in SpX-27 on March 16, 2023, at 13:30 GMT, approximately 30 minutes after hatch opening. Concentrations for CO<sub>2</sub> and octafluoropropane were consistent with the ISS atmosphere, while methane was slightly lower. Given that the vehicle atmosphere had mixed with ISS atmosphere, measured contaminant levels are not representative of the contribution of the vehicle.

## WATER QUALITY

In total, four water samples were collected from the US Segment during Increment 68 and returned on SpX-26 and -27. Two of these were ambient potable water samples collected from the US Potable Water Dispenser (PWD), which fall under the ISS Crew Health Care System (CHeCS). The remaining two samples were non-potable water, including a sample collected from the PWD Aux Port and one sample of US condensate (ECLS). Summaries of select analytical results from the Increment 68 samples are provided in Tables 3A and 3B.

**Table 3A. Analytical Summary of ISS Water Analyses for CHeCS Samples (Increment 68)**

Return Mission	Sample Location	Sample Date	TOC (mg/L)	DMSD (mg/L)	Methyl Sulfone (mg/L)	Conductivity (μS/cm)	Total Iodine (mg/L)
SpX-26	WPA PWD Ambient	12/16/2022	0.6	1.1	0.09	<1	<0.05
SpX-27	WPA PWD Ambient	3/21/2023	0.5	1.2	0.08	<1	<0.05

NA: not analyzed

**Table 3B. Analytical Summary of ISS Water Analyses for ECLS Samples (Increment 68)**

Return Mission	Sample Location	Sample Date	TOC (mg/L)	DMSD (mg/L)	Methyl Sulfone (mg/L)	Conductivity (μS/cm)	Total Iodine (mg/L)
SpX-26	WPA PWD Aux Port	1/3/2023	0.5	1.2	0.08	2	2.1
SpX-26	WPA Condensate	1/3/2023	137	19	0.07	240	NA

NA: not analyzed

### Toxicological Evaluation of ISS Water Quality

Routine water quality monitoring is performed in-flight using the total organic carbon analyzer (TOCA). Results from these analyses provide a general indication of overall water quality. Typically, archive water samples are also collected during each Increment and returned for comprehensive analysis in ground laboratories. Data from the ground analyses complement the in-flight data and provide a more complete understanding of water quality on the ISS.

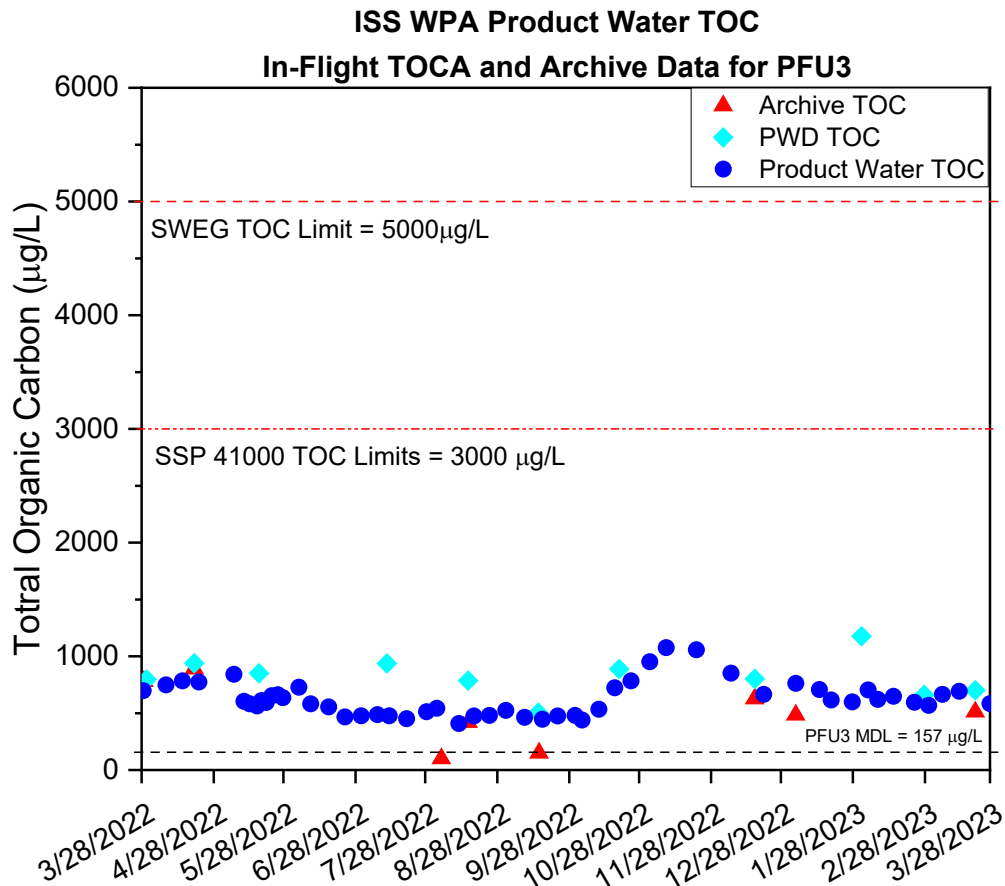
#### Potable Water

**Concentrations of all chemicals detected in the potable water samples met the requirements listed in SSP 41000, System Specification for the International Space Station and JSC 63414, Spacecraft Water Exposure Guidelines (SWEGs).** Total organic carbon (TOC) concentrations from in-flight (PWD TOC and WPA TOC) and ground analyses (Archive TOC) performed between March 2022 and March 2023 are shown in Figure 5. The TOC concentrations in the two potable samples continued to be low and were well below both the specification for the US segment (<3 mg/L) and the 100-day SWEG (5 mg/L).

The DMSD concentrations were above the 1 mg/L reporting limit in the PWD ambient samples (1.1 and 1.2 mg/L) from December 2022 and March 2023. Methyl sulfone was detected in both potable water

samples at levels well below the SWEG of 1,500 mg/L. Silicon was also detected in both potable samples (~0.3 mg/L).

Iodine is a biocide used on the US Segment. It is added to the water produced by the WPA but removed prior to crew consumption to avoid potential thyroid dysfunction. The total iodine level in both potable samples collected from the PWD were below the reporting limit (0.05 mg/L), indicating effective removal of iodine in water intended for consumption. For additional information regarding microbial analyses, see the Increment 68 post-flight report generated by the JSC Environmental Microbiology Laboratory.



**Figure 5. Total Organic Carbon (TOC) trending in US Potable Water from Archive Water Samples and On-Orbit TOCA (PFU3) for March 2022 to March 2023**

*WPA Product Water (PWD Aux Port)*

The sample from the PWD Aux Port on 1/3/2023 contained TOC levels of 0.48 mg/L. Methyl sulfone was detected at levels well below the SWEG of 1500 mg/L. The total iodine level of this sample was 2.12 mg/L, but otherwise the chemical results from this sample were consistent with potable water.

*Condensate*

The condensate sample collected on January 3, 2023, contained TOC levels of 137 mg/L, near the historical average of 150 mg/L. Organic compounds detected at or above 1 mg/L are listed in Table 4. Ethanol



continues to be present at levels above historical average concentrations, consistent with the higher-than-historical levels of ethanol in ISS air. Silicon was present at 6.5 mg/L and can mostly be accounted for by the presence of DMSD. Zinc was detected at 8.5 mg/L, much higher than previously observed. This increase is likely the result of rewetting the condensing heat exchanger after an extended dry out. Ammonium was present at 28.2 mg/L, below the historical average of 37 mg/L. All of these compounds were effectively removed by the WRS, as evidenced by the low or undetectable levels of these species in the potable samples.

**Table 4: Organic Compounds Detected >1 mg/L in US Condensate During Increment 68**

Compound	Condensate (mg/L)	Historical average (mg/L)
	January 3, 2023	
Benzoic acid	1.6	1.1
Benzyl alcohol	8.4	13
2-propanol (isopropanol)	1.9	1.4
Acetone	4.6	1.9
Ethanol	90	49
Methanol	9.5	4.8
1,2-ethanediol (ethylene glycol)	1.7	5.7
1,2-propanediol (propylene glycol)	21	27
Dimethylsilanediol (DMSD)	19	36
Acetate	43	40
Formate	4.4	7.6
Propionate	1.6	1.0
Formaldehyde	1.3	1.1

ND: not detected

Expanded summary tables containing organic carbon recoveries and results for all analytes present at concentrations above reporting limits are included as attachments to this report.

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#### Enclosures

- Table S-1: Analytical concentrations of compounds quantified in mGSCs collected in and returned on Crew-5, SpaceX-26, and SpaceX-27

- Table S-2A: T-values corresponding to concentrations for routine mGSC samples returned on Crew-5, SpaceX-26, and SpaceX-27
- Table S-2B: T-values corresponding to concentrations for NG-18, SpaceX-26, and SpaceX-27 ingress air samples, based on 7-day and 180-day SMACs
- Table S-3A: Analytical concentrations of compounds quantified in ambient water samples returned on SpaceX-26 and SpaceX-27
- Table S-3B: Analytical concentrations of compounds quantified in US condensate and WPA PWD Aux Port water samples returned on SpaceX-26

TABLE S-1: ANALYTICAL RESULTS FOR CREW-5, SPACEX-26, AND SPACEX-27 RETURN SAMPLES

Increment Mission	68										
	Crew-5	SpaceX-26				SpaceX-27			SpaceX-26		SpaceX-27
Sample Location	Dragon Module	JPM	Lab	Lab	Columbus Module	Lab	SM	JPM *	NG	Dragon Module	Dragon Module
Sample Description	Nominal air sample, Ascent, S/N 2102	Nominal air sample, S/N 2010	Nominal air sample, S/N 2011	Nominal air sample, S/N 2014	Nominal air sample, S/N 2013	Nominal air sample, S/N 2018	Nominal air sample, S/N 2048	Nominal air sample, S/N 2025	Ingress air sample NG-18, S/N 2012	Ingress air sample, SpX-26, S/N 2039	Ingress air sample, SpX-27, S/N 2041
Sample Date	10/5/2022	10/24/2022	10/24/2022	12/7/2022	12/7/2022	1/20/2023	1/20/2023	3/8/2023	11/9/2022	11/27/2022	3/16/2023
Sample Time	18:45	08:30	08:30	12:35	12:37	19:42	19:44	15:55	18:00	14:02	13:30
Analysis/Sample ID	AQ230276	AQ230063	AQ230170	AQ230064	AQ230065	AQ230383	AQ230384	AQ230386	AQ230171	AQ230066	AQ230388
<b>Volatiles Targets GCMS (TO-15 mod)</b>											
	mg/m3								mg/m3		
1,1,1,2-Tetrafluoroethane	<0.042	0.077	0.073	0.093	0.094	0.063	0.079	0.064	0.060	0.16	0.20
1-Butanol	<0.018	0.060	0.065	0.060	0.055	0.046	0.056	0.041	0.069	0.021	0.042
1-Propanol	<0.015	0.063	0.061	0.039	0.033	0.038	0.054	0.027	0.060	0.016	0.021
2-Butanone (Methyl ethyl ketone)	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	0.024	<0.018	<0.018
2-Methyl-1-propene	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	0.039	<0.014	<0.014
2-Propanol (Isopropanol)	0.18	0.55	0.65	See GC-FID	See GC-FID	0.54	0.65	0.18	See GC-FID	0.67	0.22
3-Methylhexane	<0.024	<0.024	<0.025	<0.025	<0.024	<0.025	0.026	<0.024	0.033	<0.024	<0.024
Acetaldehyde	0.033	0.19	0.20	0.17	0.16	0.15	0.17	0.11	0.19	0.057	0.091
Acetone	0.11	0.42	0.51	0.31	0.31	0.28	0.36	0.22	0.42	0.11	0.17
Carbon disulfide	<0.019	<0.019	<0.020	<0.020	<0.019	0.022	0.022	<0.019	0.023	<0.019	<0.019
Carbonyl sulfide (Carbon oxide sulfide)	<0.015	<0.015	<0.016	<0.016	<0.015	<0.016	<0.016	<0.015	0.017	<0.015	0.018
Ethanol	0.044	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID
Ethyl acetate	<0.022	0.038	0.039	0.050	0.043	0.038	0.046	0.022	0.27	<0.022	<0.022
Isobutane	0.055	0.091	0.076	0.051	0.062	0.034	0.033	0.068	0.53	<0.014	0.026
Isoprene (2-Methyl-1,3-butadiene)	<0.017	0.065	0.069	0.023	0.021	0.034	0.043	0.030	0.039	<0.017	0.026
Methanol	0.084	See GC-FID	See GC-FID	See GC-FID	See GC-FID	0.36	See GC-FID	0.34	See GC-FID	0.20	0.14
Methyl acetate	<0.018	<0.018	<0.019	<0.019	<0.018	0.020	0.023	<0.018	0.042	<0.018	<0.018
Methylene chloride (Dichloromethane)	<0.020	<0.020	<0.021	<0.021	<0.020	<0.021	<0.021	<0.020	0.051	<0.020	<0.020
n-Heptane	<0.024	<0.024	<0.025	<0.025	<0.024	<0.025	<0.025	<0.024	<0.025	<0.024	<0.024
Nonane	<0.032	<0.032	<0.034	<0.034	<0.032	<0.034	<0.034	<0.032	<0.034	<0.032	<0.032
Octamethylcyclotetrasiloxane (OMCTS)	<0.12	<0.12	<0.13	<0.13	<0.12	<0.13	<0.13	<0.12	<0.13	<0.12	<0.12
Octane	<0.028	<0.028	<0.029	<0.029	<0.028	<0.029	<0.029	<0.028	<0.029	<0.028	<0.028
o-Xylene	<0.026	<0.026	<0.027	<0.027	<0.026	<0.027	0.028	<0.026	<0.027	<0.026	<0.026
Pentanal	<0.022	<0.022	<0.023	<0.023	<0.022	<0.023	<0.023	<0.022	<0.023	<0.022	<0.022
Pentane	<0.018	<0.018	<0.019	<0.019	<0.018	<0.019	<0.019	<0.018	<0.019	<0.018	<0.018
Perfluoro(2-methylpentane)	<0.082	<0.082	1.2	<0.086	<0.082	<0.086	<0.086	<0.082	1.4	0.53	<0.082
Propane	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	<0.011	0.012
Toluene	<0.022	0.028	0.028	0.035	0.040	0.029	0.035	0.025	0.10	<0.022	0.037
Trimethylsilanol	0.042	0.11	0.12	0.080	0.10	0.054	0.058	0.065	0.30	0.031	0.048
<b>Volatiles Non-Targets GCMS (estimated conc.)</b>											
C11-Alkanes	not found	<0.076	<0.080	<0.080	<0.076	not found	not found	not found	0.099	<0.076	not found
Tetradecafluorohexane	not found	4.2	4.0	4.0	3.7	6.7	7.8	1.1	4.2	3.1	2.7
<b>Volatiles Targets GCFID</b>											
2-Propanol (Isopropanol)	NR	NR	NR	0.76	0.76	NR	NR	NR	0.97	NR	NR
Ethanol	NR	7.0	6.7	6.6	6.1	5.9	6.9	4.1	4.3	1.0	1.9
Methanol	NR	0.42	0.37	0.60	0.56	NR	0.52	NR	0.35	NR	NR
Octafluoropropane (Perfluoropropane)	<1.5	8.0	7.9	5.0	4.5	4.4	4.9	11	3.3	<1.5	3.6
<b>Volatiles Targets TGA</b>											
Carbon dioxide	2,100	3,500	4,300	3,800	3,900	3,600	3,700	6,400	3600	5,600	6,200
Carbon monoxide	0.52	0.99	0.72	0.94	0.89	1.0	1.1	1.4	0.75	1.1	1.1
Hydrogen	1.2	5.4	5.6	4.2	4.1	6.3	6.6	6.0	3.0	1.1	2.5
Methane	<2.6	150	150	110	100	120	120	140	86	18	63
	GMT 278	GMT 297	GMT 297	GMT 341	GMT 341	GMT 20	GMT 20	GMT 67	GMT 313	GMT 331	GMT 75

Comments: NR= Not Reported  
Not Found =No unknown peaks above the threshold limit

\* Sample AQ230385, collected in the Lab on 3/8/23, was not analyzed due to low canister pressure.

TABLE S-2A: T-VALUES FOR CREW-5, SPACEX-26 AND SPACEX-27 RETURN

Increment Mission Sample Location Sample Description Sample Date Sample Time Analysis/Sample ID	68								
	Crew-5		SpaceX-26				SpaceX-27		
	T-Value (7-day)	T-Value (180-day)	T-Value (180-day)						
	Dragon Module Nominal air sample, ascent, S/N 2102	Dragon Module Nominal air sample, ascent, S/N 2102	JPM Nominal air sample, S/N 2010	Lab Nominal air sample, S/N 2011	Lab Nominal air sample, S/N 2014	Columbus Module Nominal air sample, S/N 2013	Lab Nominal air sample, S/N 2018	SM Nominal air sample, S/N 2048	JPM * Nominal air sample, S/N 2025
	10/5/2022	10/5/2022	10/24/2022	10/24/2022	12/7/2022	12/7/2022	1/20/2023	1/20/2023	3/8/2023
	18:45	18:45	08:30	08:30	12:35	12:37	19:42	19:44	15:55
	AQ230276	AQ230276	AQ230063	AQ230170	AQ230064	AQ230065	AQ230383	AQ230384	AQ230386
<b>Volatiles Targets GCMS (TO-15 mod)</b>									
1,1,1,2-Tetrafluoroethane	ND	ND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1-Butanol	ND	ND	0.002	0.002	0.002	0.001	0.001	0.001	0.001
1-Propanol	ND	ND	0.001	0.001	0.001	0.000	0.001	0.001	0.000
2-Propanol (Isopropanol)	0.001	0.001	0.004	0.004	See GC-FID	See GC-FID	0.004	0.004	0.001
3-Methylhexane	ND	ND	ND	ND	ND	ND	ND	0.002	ND
Acetaldehyde	0.008	0.008	0.048	0.049	0.042	0.041	0.036	0.042	0.027
Acetone	0.002	0.002	0.008	0.010	0.006	0.006	0.005	0.007	0.004
Carbon disulfide	ND	ND	ND	ND	ND	ND	0.020	0.020	ND
Ethanol	0.000	0.000	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID
Ethyl acetate	ND	ND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Isobutane	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Isoprene (2-Methyl-1,3-butadiene)	ND	ND	0.022	0.023	0.008	0.007	0.011	0.014	0.010
Methanol	0.003	0.003	See GC-FID	See GC-FID	See GC-FID	See GC-FID	0.014	See GC-FID	0.013
Methyl acetate	ND	ND	ND	ND	ND	ND	0.000	0.000	ND
o-Xylene	ND	ND	ND	ND	ND	ND	ND	0.001	ND
Perfluoro(2-methylpentane)	ND	ND	ND	0.000	ND	ND	ND	ND	ND
Toluene	ND	ND	0.002	0.002	0.002	0.003	0.002	0.002	0.002
Trimethylsilanol	0.011	0.011	0.028	0.031	0.020	0.025	0.013	0.014	0.016
<b>Volatiles Non-Targets GCMS (estimated conc.)</b>									
Tetradecafluorohexane	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<b>Volatiles Targets GCFID</b>									
2-Propanol (Isopropanol)	NR	NR	NR	NR	0.005	0.005	NR	NR	NR
Ethanol	NR	NR	0.004	0.003	0.003	0.003	0.003	0.003	0.002
Methanol	NR	NR	0.016	0.014	0.023	0.021	NR	0.020	NR
Octafluoropropane (Perfluoropropane)	ND	ND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<b>Volatiles Targets TGA</b>									
Carbon monoxide	0.008	0.031	0.058	0.042	0.055	0.052	0.060	0.063	0.080
Hydrogen	0.004	0.004	0.016	0.016	0.012	0.012	0.019	0.019	0.018
Methane	ND	ND	0.042	0.044	0.031	0.030	0.034	0.035	0.039
<b>Total T-Value</b>	<b>&lt; 0.1</b>	<b>0.1</b>	<b>0.3</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>

Comments: ND= Value is less than the laboratory reporting limit.  
NR= Not Reported

\* Sample AQ230385, collected in the Lab on 3/8/23, was not analyzed due to low canister pressure.

TABLE S-2B: T-VALUES FOR SPACEX-26 AND SPACEX-27 RETURN INGRESS SAMPLES

Increment Mission  Sample Location Sample Description Sample Date Sample Time Analysis/Sample ID	68					
	Space X-26				SpaceX-27	
	T-Value (7-Day)	T-Value (180-day)	T-Value (7-day)	T-Value (180-day)	T-Value (7-Day)	T-Value (180-day)
	NG	NG	Dragon Module	Dragon Module	Dragon Module	Dragon Module
	Ingress air sample, NG-18, S/N 2012	Ingress air sample, NG-18, S/N 2012	Ingress air sample, SpX-26, S/N 2039	Ingress air sample, SpX-26, S/N 2039	Ingress air sample, SpX- 27, S/N 2041	Ingress air sample, SpX- 27, S/N 2041
	11/9/2022	11/9/2022	11/27/2022	11/27/2022	3/16/2023	3/16/2023
	18:00	18:00	14:02	14:02	13:30	13:30
	AQ230171	AQ230171	AQ230066	AQ230066	AQ230388	AQ230388
<b>Volatiles Targets GCMS (TO-15 mod)</b>						
1,1,1,2-Tetrafluoroethane	0.000	0.000	0.000	0.000	0.000	0.000
1-Butanol	0.001	0.002	0.000	0.001	0.001	0.001
1-Propanol	0.001	0.001	0.000	0.000	0.000	0.000
2-Butanone (Methyl ethyl ketone)	0.001	0.001	ND	ND	ND	ND
2-Methyl-1-propene	0.000	0.000	ND	ND	ND	ND
2-Propanol (Isopropanol)	See GC-FID	See GC-FID	0.004	0.004	0.001	0.001
3-Methylhexane	0.000	0.003	ND	ND	ND	ND
Acetaldehyde	0.048	0.048	0.014	0.014	0.023	0.023
Acetone	0.008	0.008	0.002	0.002	0.003	0.003
Carbon disulfide	0.021	0.021	ND	ND	ND	ND
Carbonyl sulfide (Carbon oxide sulfide)	0.000	0.001	ND	ND	0.000	0.001
Ethyl acetate	0.001	0.001	ND	ND	ND	ND
Isobutane	0.003	0.003	ND	ND	0.000	0.000
Isoprene (2-Methyl-1,3-butadiene)	0.006	0.013	ND	ND	0.004	0.009
Methanol	See GC-FID	See GC-FID	0.008	0.008	0.005	0.005
Methyl acetate	0.000	0.000	ND	ND	ND	ND
Methylene chloride (Dichloromethane)	0.001	0.005	ND	ND	ND	ND
Perfluoro(2-methylpentane)	0.000	0.000	0.000	0.000	ND	ND
Propane	ND	ND	ND	ND	0.000	0.000
Toluene	0.007	0.007	ND	ND	0.002	0.002
Trimethylsilanol	0.076	0.076	0.008	0.008	0.012	0.012
<b>Volatiles Non-Targets GCMS (estimated conc.)</b>						
C11-Alkanes	0.002	0.002	ND	ND	ND	ND
Tetradecafluorohexane	0.000	0.000	0.000	0.000	0.000	0.000
<b>Volatiles Targets GCFID</b>						
2-Propanol (Isopropanol)	0.006	0.006	NR	NR	NR	NR
Ethanol	0.002	0.002	0.001	0.001	0.001	0.001
Methanol	0.013	0.013	NR	NR	NR	NR
Octafluoropropane (Perfluoropropane)	0.000	0.000	ND	ND	0.000	0.000
<b>Volatiles Targets TGA</b>						
Carbon monoxide	0.012	0.044	0.018	0.066	0.017	0.063
Hydrogen	0.009	0.009	0.003	0.003	0.007	0.007
Methane	0.025	0.025	0.005	0.005	0.018	0.018
<b>Total T-Value</b>	<b>0.2</b>	<b>0.3</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>

**TABLE S-3A: ANALYTICAL CONCENTRATIONS OF COMPOUNDS QUANTIFIED IN POTABLE AMBIENT WATER  
RETURNED ON SPACEX-26 AND SPACEX-27**

Increment Mission	Sample Location	Sample Description	Sample Date Analysis/Sample ID	Units	Test Conducted by	Potable Water Maximum Contaminant Level (MCL)	Maximum Contaminant Level Source	68	
								SpaceX-26	SpaceX-27
								WPA PWD Ambient	WPA PWD Ambient
								Potable Water 12/16/2022 WQ230041	Potable Water 3/21/2023 WQ230126
<b>Physical Characteristics</b>									
	pH			pH units	U.S.	4.5-8.5	41000	5.61	5.61
<b>Minerals ICPMS</b>									
	Calcium			mg/L	U.S.	30	41000	< 0.01	0.01
<b>Trace Metals ICPMS</b>									
	Aluminum			µg/L	U.S.			< 1	5
	Boron			µg/L	U.S.			< 1	1
	Copper			µg/L	U.S.	1,000	41000	< 1	2
	Nickel			µg/L	U.S.	300	SWEG&41000	2	13
	Zinc			µg/L	U.S.	2,000	SWEG&41000	< 1	2
<b>Silicon ICPMS</b>									
	Silicon			µg/L	U.S.			320	334
<b>Total Organic Carbon-Sievers</b>									
	Total Inorganic Carbon (TIC)			mg/L	U.S.			0.439	0.642
	Total Organic Carbon (TOC)			mg/L	U.S.	5 / 3	SWEG / 41000	0.627	0.511
<b>Semi-volatile Organics-Targets</b>									
	Methyl sulfone			µg/L	U.S.	1,500,000	interim SWEG (06-2017)	89	79
<b>Silanol LCRI (Semi-Quantitative-NIST traceable standard not available)</b>									
	Dimethylsilanediol (DMSD)			µg/L	U.S.	35,000	SWEG	1,100	1200
	<b>Organic Carbon Recovery</b>			percent	U.S.			49.28	65.17
	<b>Unaccounted Organic Carbon</b>			mg/L	U.S.			0.32	0.18

NA=Not analyzed  
MI=Matrix Interference  
N/A=Not applicable  
#previously identified as bis(2-Chloroisopropyl) ether

TABLE S-3B: ANALYTICAL CONCENTRATIONS OF COMPOUNDS QUANTIFIED IN WASTEWATER AND US CONDENSATE WATER SAMPLES RETURNED ON SPACEX-26

Increment Mission	Sample Location	Sample Description	Sample Date Analysis/Sample ID	Units	Test Conducted by	Potable Water Maximum Contaminant Level (MCL)	Maximum Contaminant Level Source	68	
								SpaceX-26	
								WPA PWD Aux Port	WPA Condensate Sample Port
								WPA Product Water 1/3/2023 WQ230020	US Condensate 1/3/2023 WQ230021
<b>Physical Characteristics</b>									
Conductivity				µS/cm	U.S.			2	240
pH				pH units	U.S.	4.5-8.5	41000	5.48	7.27
<b>Iodine ICPMS</b>									
Total I				mg/L	U.S.			NA	0.004
<b>Iodine LCV</b>									
Iodide				mg/L	U.S.			0.12	NA
Iodine				mg/L	U.S.	1.0-4.0	41000 (residual iodine in product water)	2.00	NA
Total I				mg/L	U.S.	6/0.2	41000 (if I max in product water/1 l at pt of consumption)	2.12	NA
<b>Cations IC</b>									
Ammonium (as N)				mg/L	U.S.	1	SWEG&41000	< 0.25	28.2
<b>Minerals ICPMS</b>									
Calcium				mg/L	U.S.	30	41000	< 0.01	0.05
Phosphate (as P)				mg/L	U.S.			< 0.01	0.02
Potassium				mg/L	U.S.	340	41000	< 0.01	0.01
<b>Trace Metals ICPMS</b>									
Aluminum				µg/L	U.S.			2	6
Boron				µg/L	U.S.			< 1	24
Chromium				µg/L	U.S.	230	41000	< 1	2
Copper				µg/L	U.S.	1,000	41000	< 1	4
Manganese				µg/L	U.S.	300	SWEG&41000	< 1	2
Nickel				µg/L	U.S.	300	SWEG&41000	26	152
Silver				µg/L	U.S.	400	SWEG&41000	< 1	43
Zinc				µg/L	U.S.	2,000	SWEG&41000	< 1	8,500
<b>Silicon ICPMS</b>									
Silicon				µg/L	U.S.			320	6,490
<b>Total Organic Carbon-Sievers</b>									
Total Inorganic Carbon (TIC)				mg/L	U.S.			0.952	18.0
Total Organic Carbon (TOC)				mg/L	U.S.	5 / 3	SWEG / 41000	0.484	137
<b>Volatile Organics-Targets</b>									
Acetone				µg/L	U.S.	15,000	SWEG	< 5	See Alcohols
<b>Volatile Organics-Special Interest Compounds (Semi-quantitative)</b>									
Acetaldehyde				µg/L	U.S.			not found	300
Trimethylsilanol				µg/L	U.S.			not found	230
<b>Semi-volatile Organics-Targets</b>									
Benzothiazole				µg/L	U.S.			< 20	28
Decamethylcyclopentasiloxane (DMCPS)				µg/L	U.S.			< 20	21
Dodecamethylcyclohexasiloxane				µg/L	U.S.			< 20	25
Methyl sulfone				µg/L	U.S.	1,500,000	interim SWEG (06-2017)	84	73
<b>Acid Extractables-EPA 625 List GCMS</b>									
4-Methylphenol (p-Cresol)				µg/L	U.S.			< 20	22
Benzoic acid				µg/L	U.S.			< 100	1,550
Phenol				µg/L	U.S.	4,000	SWEG	< 20	138
<b>Base and Neutral Extractables-EPA 625 List GCMS</b>									
Benzyl alcohol				µg/L	U.S.			< 20	8,350
Diethylphthalate				µg/L	U.S.			< 20	432
<b>Semi-volatile Organics-Special Interest Compounds (Semi-quantitative)</b>									
1,3,5-Triallyl-1,3,5-triazine-2,4,6(1H,3H,5H)-trione				µg/L	U.S.			not found	23
1-Methyl-2-pyrrolidinone				µg/L	U.S.			not found	150
2-(2-Butoxyethoxy)ethanol				µg/L	U.S.			not found	270
2-Butoxyethanol				µg/L	U.S.			not found	130
2-Ethoxyethanol				µg/L	U.S.			not found	200
2-Ethyl-1-hexanol				µg/L	U.S.			not found	74
2-Ethylhexanoic acid				µg/L	U.S.			not found	140
2-Phenoxyethanol				µg/L	U.S.			not found	840
2-Phenyl-2-propanol				µg/L	U.S.			not found	48
Benzaldehyde				µg/L	U.S.			not found	61
Heptanoic acid				µg/L	U.S.			not found	120
Hexanoic acid (Caprolate)				µg/L	U.S.			not found	310
N,N-Diethylformamide				µg/L	U.S.			not found	45
N,N-Dimethyl acetamide				µg/L	U.S.			not found	220
N,N-Dimethylformamide				µg/L	U.S.			not found	280
Nonanoic acid				µg/L	U.S.			not found	280
Palmitic acid				µg/L	U.S.			not found	530
Phenethyl alcohol				µg/L	U.S.			not found	22
<b>Alcohols &amp; Acetone GCMS</b>									
1-Butanol				µg/L	U.S.			< 400	603
2-Propanol (Isopropanol)				µg/L	U.S.			< 400	1,860
Acetone				µg/L	U.S.	15,000	SWEG	See Volatiles	4,550
Ethanol				µg/L	U.S.			< 400	89,900
Methanol				µg/L	U.S.	40,000	SWEG	< 400	9,460
<b>Glycols GCMS</b>									
1,2-Ethanediol (Ethylene glycol)				µg/L	U.S.	4000	SWEG	< 1000	1,670
1,2-Propanediol (Propylene glycol)				µg/L	U.S.	1,700,000	SWEG	< 1000	20,900
<b>Silanol LCRI (Semi-Quantitative-NIST traceable standard not available)</b>									
Dimethylsilanediol (DMSD)				µg/L	U.S.	35,000	SWEG	1,200	19,000
Monomethylsilanetriol (MMST)				µg/L	U.S.	110,000	SWEG	< 1000	MI
<b>Carboxylates IC</b>									
Acetate				µg/L	U.S.			< 500	42,900
Butyrate				µg/L	U.S.			< 500	707
Formate				µg/L	U.S.	2,500,000	SWEG	< 500	4,400
Lactate				µg/L	U.S.			< 500	966
Propionate				µg/L	U.S.			< 500	1,580
<b>Aldehydes GCMS</b>									
Formaldehyde (Methanal)				µg/L	U.S.	12,000	SWEG	< 10	1,330
<b>Non-volatile Organics LC</b>									
Caprolactam				µg/L	U.S.	100,000	SWEG	< 500	729
<b>Organic Carbon Recovery</b>									
Unaccounted Organic Carbon				percent	U.S.			69.01	74.56
				mg/L	U.S.			0.15	34.83

NA=Not analyzed  
MI=Matrix Interference  
N/A=Not applicable  
#previously identified as bis(2-Chloroisopropyl) ether