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International Space Station Potable Water Characterization for 2013

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In this post-construction, operational phase of International Space Station (ISS) with an ever-increasing emphasis on its use as a test-bed for future exploration missions, the ISS crews continue to rely on water reclamation systems for the majority of their water needs. The onboard water supplies include U.S. Segment potable water from humidity condensate and urine, Russian Segment potable water from condensate, and ground-supplied potable water, as reserve. In 2013, the cargo returned on the Soyuz 32-35 flights included archival potable water samples collected from Expeditions 34-37. The former Water and Food Analytical Laboratory (now Toxicology and Evironmental Chemistry Laboratory) at the NASA Johnson Space Center continued its long-standing role of performing chemical analyses on ISS return water samples to verify compliance with potable water quality specifications. This paper presents and discusses the analytical results for potable water samples returned from Expeditions 34-37, including a comparison to ISS quality standards. During the summer of 2013, the U.S. Segment potable water experienced a third temporary rise and fall in total organic carbon (TOC) content, as the result of organic contamination breaking through the water system's treatment process. Analytical results for the Expedition 36 archival samples returned on Soyuz 34 confirmed that dimethylsilanediol was once again the responsible contaminant, just as it was for the previous comparable TOC rises in 2010 and 2012. Discussion herein includes the use of the in-flight total organic carbon analyzer (TOCA) as a key monitoring tool for tracking these TOC rises and scheduling appropriate remediation.

Nomenclature

BKO	Russian Multifiltration Beds
CatRx	Catalytic Reactor
CE	Capillary Electrophoresis
CWC	Contingency Water Container
CWC-I	Contingency Water Container - Iodine
DAI	Direct Aqueous Injection
DMSD	Dimethylsilanediol
EPA	Environmental Protection Agency
GC/MS	Gas Chromatography/Mass Spectrometry
IC	Ion Chromatography
ICP/MS	Inductively Coupled Plasma/Mass Spectrometry
ISE	Ion Selective Electrode
ISS	International Space Station
ISS MORD	ISS Medical Operations Requirements Document
IX	Ion Exchange
JSC	Johnson Space Center

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KSC	Kennedy Space Center
LC	Liquid Chromatography
LC/MS	Liquid Chromatography/Mass Spectrometry
LCV	Leuco Crystal Violet
MCL	Maximum Contaminant Level
MF	Multifiltration
N/A	Not Applicable
NA	Not Analyzed
NASA	National Aeronautics and Space Administration
NTU	Nephelometric Turbidity Unit
PFU	Protoflight unit
PWD	Potable-Water Dispenser
RIP	Rack Interface Panel
R&R	Remove and Replace
SM	Service Module
SRV-K	System for Regeneration of Condensate Water
SVO-ZV	System for Water Storage and Dispensing
SWEG	Spacecraft Water Exposure Guideline
TECL	Toxicology and Environmental Chemistry Laboratory
THM	Trihalomethanes
TOCA	Total Organic Carbon Analyzer
U.S.	United States
UV	Ultraviolet
WAFAL	Water and Food Analytical Laboratory
WPA	Water Processor Assembly

I. Introduction

During the 12-month period beginning in late November of 2012 and comprising Expeditions 34-37, the International Space Station (ISS) achieved the 13th year of continuous human operations. With the emphasis now more on research, including the use of station as a test bed for future exploration missions, the crews continued to rely primarily on reclaimed water for consumption. The former Water and Food Analytical Laboratory (WAFAL) now Toxicology and Environmental Chemistry Laboratory (TECL) at the NASA Johnson Space Center continued its long-standing role of performing chemical analyses on ISS return water samples to verify compliance with potable water quality specifications. Analytical data for archival water samples returned during Expeditions 1-33 have been previously reported[1-11]. This paper presents and discusses the analytical results from chemical characterization of the water samples returned during 2013 from Expeditions 34-37, as detailed in Table 1.

Water samples returned on Soyuz 34-37 were unstowed at the landing site and turned over to a NASA representative for transportation home with the U.S. crew members on a NASA jet. Upon arrival at Ellington Field in Houston, Texas the returned samples were received by a TECL representative and delivered directly to the JSC water laboratory for processing and analysis.

Allocation of the ISS return water samples for the various chemical analyses was performed in the TECL based upon sample volume. If the sample volume was sufficient (≥500 mL) then full chemical characterization was performed using the standard and custom analytical methods identified in Table 2. Individual sample volumes of less than 500 mL required elimination of some analyses and/or reductions in allocated volumes, resulting in reduced sensitivity of some analyses performed. Return water samples were shared with the JSC Microbiology Laboratory and their microbial analysis results were separately reported elsewhere.

Russian Segment and U.S. Segment water sample analysis results were evaluated for compliance with the potable-water quality requirements found in the *ISS Medical Operations Requirement Document* (ISS MORD)[12] and the *System Specification for the ISS* document[13], respectively.

Table 1. Summary of Archival Water Samples Returned during Expeditions 34 through 37

Expedition	Flight No.	Samples Received	Sample Type	Sample Collection Date	Sample Receipt Date
34	Soyuz 32	1	PWD Ambient	2/11/2013	3/17/2013
		1	PWD Hot	2/19/2013	
		1	SRV-K Hot	2/19/2013	
		1	SVO-ZV	2/19/2013	
	Total:	**4**			
35	Soyuz 33	1	PWD Ambient	4/8/2013	5/15/2013
	Total:	**1**			
36	Soyuz 34	1	PWD Ambient	7/30/2013	9/12/2013
		1	PWD Hot	8/26/2013	
		1	SRV-K Hot	8/26/2013	
		1	SRV-K Warm	9/6/2013	
		1	WPA RIP	8/19/2013	
	Total:	**5**			
37	Soyuz 35	1	PWD Ambient	10/8/2013	11/12/2013
		1	PWD Hot	11/6/2013	
		1	SRV-K Warm	11/6/2013	
		1	SVO-ZV	11/6/2013	
	Total:	**4**			

Table 2. Water Analytical Methods

Parameter	Method
pH and conductivity	Potentiometric
Total Solids	Gravimetric
Turbidity	Nephelometric
Iodine and iodide	Leuco crystal violet (LCV)
Fluoride	Ion chromatography (IC)
Metals/Minerals	Inductively coupled plasma/mass spectrometry (ICP/MS)
Inorganic anions & cations	Ion chromatography (IC)
Total organic carbon (TOC)	Ultraviolet or heated persulfate oxidation
Alcohols and glycols	Direct injection gas chromatography/mass spectrometry (GC/MS)
Volatile organics	GC/MS with a purge and trap concentrator
Semi-volatile organics	GC/MS after liquid/liquid extraction
Organic acids and amines	Capillary electrophoresis (CE)
Urea/Caprolactam	Liquid chromatography (LC) with UV diode array detector
Formaldehyde	GC/MS after derivatization and extraction
Dimethylsilanediol	LC with refractive index detector

II. Background

During Expeditions 34-37 the onboard water recovery systems provided the majority of the crews' potable water. Available onboard water supplies include U.S. Segment potable water recovered from humidity condensate and urine distillate, Russian Segment potable water regenerated from humidity condensate, and Russian ground-supplied potable water.

U.S. Water Processor Assembly

The U.S. water processor assembly (WPA) located in Node 3 produces potable water by treating a combined wastewater feed containing urine distillate and humidity condensate. This combined wastewater is processed into potable water by a combination of treatment processes (Figure 1). Dissolved inorganic and organic contaminants are removed using multifiltration beds containing a mixture of adsorbents and ion-exchange resins. Further removal of organic contaminants is done using a high-temperature catalytic oxidation reactor. Final treatment is accomplished via a polishing ion-exchange bed that removes reactor by-products and adds residual iodine biocide before storage

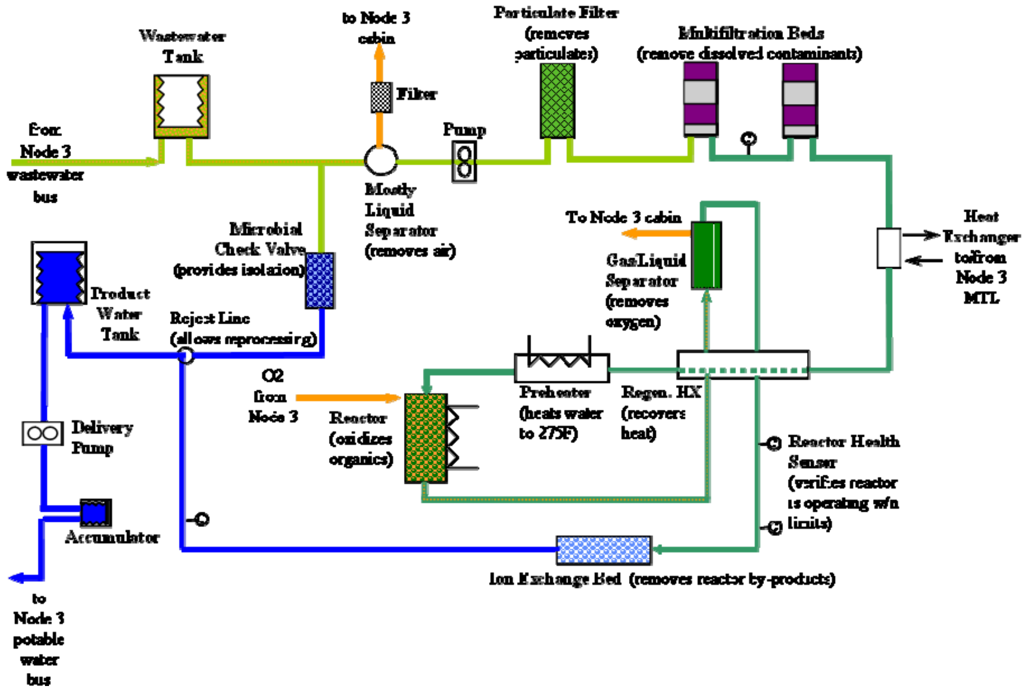

Figure 1. U.S. water processor assembly – WPA

of the product water for delivery to the ISS potable-water bus. The U.S. potable-water dispenser (PWD) delivers water from the potable bus to the crews for consumption as either hot or ambient water, after removing the iodine biocide at the point of use.

The total organic carbon analyzer (TOCA) was delivered along with the WPA to support the ISS 6-person crew operations.[14] The TOCA monitors total organic carbon (TOC) in the WPA product water by providing a measurement of the total amount of organic carbon without identification of specific organic constituents. The TOCA draws water samples from the WPA product tank directly using a dedicated hose on a weekly basis. It is also used monthly to analyze a water sample that the crew collects in a TOCA sample bag from either the PWD hot or ambient ports.

Russian Segment Water Systems

The Russian condensate water recovery system (SRV-K) located in the Service Module of the Russian Segment processes atmospheric humidity condensate recovered directly from cabin air into potable water. U.S. Segment condensate transferred to and stored in a contingency water container (CWC) can also be processed in the SRV-K, as needed. The SRV-K treatment process removes organic and inorganic contaminants using a catalytic filter reactor, phase separator, and multifiltration beds. A conditioning bed adds silver biocide for microbial control and minerals (calcium, magnesium and fluoride) to the product water prior to storage. Product water is available to the crews via the SRV-K galley, where it is pasteurized before being dispensed from either hot or warm ports (Figure 2). The SRV-K system is also designed to accept ground-supplied potable water as makeup, whenever the demand for drinking water exceeds the availability of condensate.

The ISS crews also have available stored potable water from the Russian system for water storage and dispensing (SVO-ZV) that is located in the Service Module. The SVO-ZV system consists of a 22-liter bladder tank in a hard shell (EDV), a manual air pump to pressurize the tank, and a hand-held dispenser (Figure 3). The SVO-ZV tank is typically filled with Russian ground-supplied potable water that is delivered to the ISS in the Progress vehicle's 210-liter Rodnik tanks. This water can be accessed from the SVO-ZV dispenser port at ambient temperature.

Figure 2. SRV-K Galley
Astronaut Donald Pettit collects a SRV-K sample.

Figure 3. SVO-ZV Stored Water Dispenser
Astronaut Donald Pettit collects a SVO-ZV sample.

III. Discussion of Analytical Results

Tabulations of chemical analyses results for ISS return water samples collected during Expeditions 34-37 from the SRV-K (regenerated), SVO-ZV (stored), and WPA water supplies, can be found in Appendices 1, 2, and 3 respectively. Each data table provides the respective ISS potability limits for easy comparison with the analytical results. Results by expedition, including compliance with ISS standards, are discussed below.

EXPEDITION 34

Four archival potable water samples were collected using U.S. water sample hardware during Expedition 34 (PWD ambient, PWD hot, SRV-K hot, and SVO-ZV) as listed in Table 1. All four samples were returned on Soyuz 32 and received in the TECL on March 17, 2013. Due to limited sample volume, solids were not analyzed on any of the samples and turbidity was not analyzed on the SVO-ZV sample. Due to minor leakage from the sample bag during transit, iodine and semi-volatile organics were not analyzed on the SVO-ZV sample.

ISS U.S. Segment:
PWD Potable-Water Samples

All chemical parameters measured for the PWD ambient and hot water samples collected on February 11, 2013 and February 19, 2013, respectively, met the potable-water quality requirements in the *System Specification for the International Space Station*, SSP 41000, document[13]. Nickel levels ranged from 9 to 10 µg/L. Total iodine levels were below the method detection limit of 0.05 mg/L and met the ISS acceptability limit at the point of consumption of <0.2 mg/L (see Figure 4). The plot shows that the WPA has maintained a fairly constant iodine biocide concentration of ~ 2 mg/L in recent years. The total organic carbon (TOC) results ranged from 0.14 to 0.17 mg/L and were well below the U.S. Segment TOC limit of 3.0 mg/L (see Figure 5). Dimethylsilanediol (DMSD), which was the lone compound responsible for previous TOC rises in 2010 and 2012[15-16] (see TOC excursions in Figure 5) was not detected (<0.5 mg/L) in either of the February PWD samples. Methyl sulfone levels ranged from 54 to 96 µg/L (Figure 6). Organic carbon accountability of the 2 samples was 10 to 14%, with <0.2 mg/L TOC unaccounted.

ISS Russian Segment:
SRV-K Potable-Water Sample

All chemical parameters measured for the SRV-K hot water sample collected on February 19, 2013 met the potable-water quality requirements listed in the ISS MORD document[12], except for turbidity (4.4 NTU versus the MORD limit of 1.5 NTU), iron (316 µg/L versus 300 µg/L), manganese (64 µg/L versus 50 µg/L), and nickel (158 µg/L versus 100 µg/L limit). Historical nickel levels for SRV-K samples are presented in Figure 7. Although manganese and nickel levels were above ISS MORD requirements they were both below their respective Spacecraft Water Exposure Guidelines (SWEGs) of 300 µg/L[17]. The ISS MORD requirement for iron was established based on the U.S. EPA secondary drinking water regulation for aesthetics, so the slightly elevated level should not affect crew health. The calcium, magnesium and total inorganic carbon results along with the turbidity, manganese, chloride and sulfate levels suggest that Rodnik water (Russian ground-supplied water) was being used as make-up water when the sample was collected. The total silver level was 42 µg/L, slightly below the desired biocidal range of 100 to 500 µg/L, which can increase the risk of microbial growth. The TOC level of 0.44 mg/L was well below the ISS MORD limit (Figure 8) and no target organic compounds were detected.

SVO-ZV Potable-Water Sample

All chemical parameters measured for the SVO-ZV water sample collected on February 19, 2013 met the potable-water quality requirements listed in the ISS MORD with the exception of manganese. An updated plot of the historical trends for manganese is shown in Figure 9. The manganese concentration of 76 µg/L was slightly above the ISS MORD requirement of 50 µg/L, but well below the SWEG of 300 µg/L. The total silver level was 127 µg/L, and within the acceptable biocidal range. The TOC concentration of 0.48 mg/L in the February sample was well below the ISS MORD limit and no target organic compounds were detected.

EXPEDITION 35

As detailed in Table 1, only one archival potable-water sample was returned from Expedition 35. In total, four potable water samples were collected, two from the U.S. Segment and two from the Russian Segment but three were not loaded on the Soyuz return vehicle. The three non-returning samples were later located onboard but the decision was made to discard them because of low priority for their return on Soyuz. The single returning sample was collected from the PWD ambient port on April 8, 2013, returned on Soyuz 33, and received in the TECL on May 15, 2013. Due to limited sample volume, total solids were not measured on the sample.

ISS U.S. Segment:
PWD Potable-Water Sample

All chemical parameters measured for the PWD ambient water sample collected on April 8, 2013 met the U.S. Segment potable-water quality requirements. The nickel level was 7 µg/L. Total iodine (I) was below the method detection limit of <0.05 mg/L in the sample and met the 0.2 mg/L maximum at the point of consumption (Figure 4). The TOC result was 0.13 mg/L, and well below the U.S. Segment limit of 3.0 mg/L (Figure 5). The only organic compound detected was methyl sulfone at 74 µg/L (Figure 6). The organic carbon accountability was 15%, with less than 0.2 mg/L of TOC unaccounted.

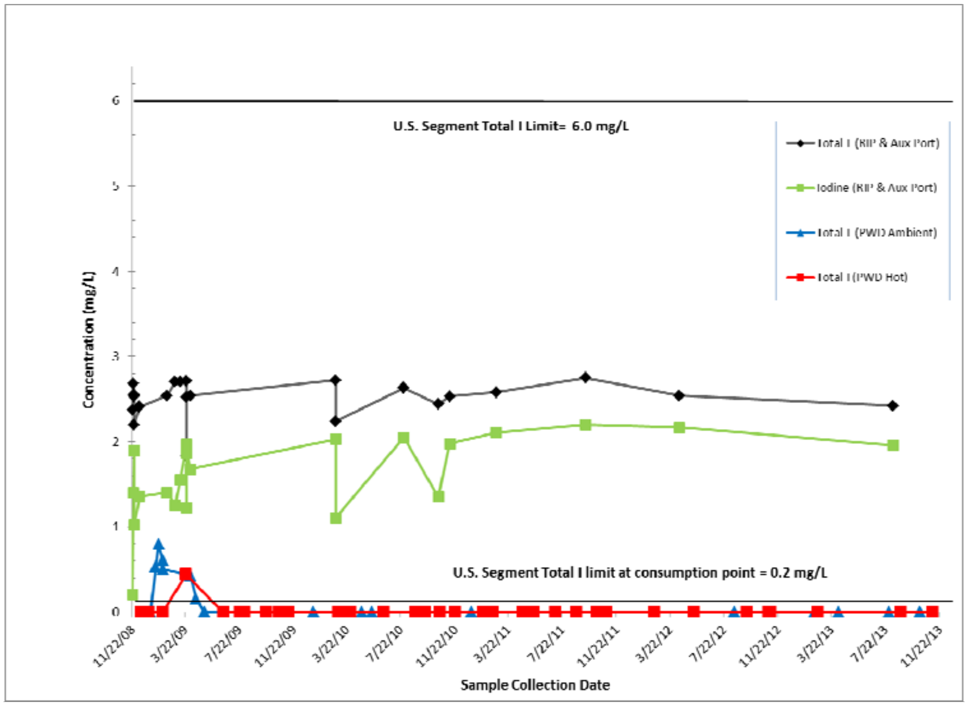

Figure 4. Total I & Iodine Levels in US Potable Water Samples ISS ULF2 to Soyuz 35

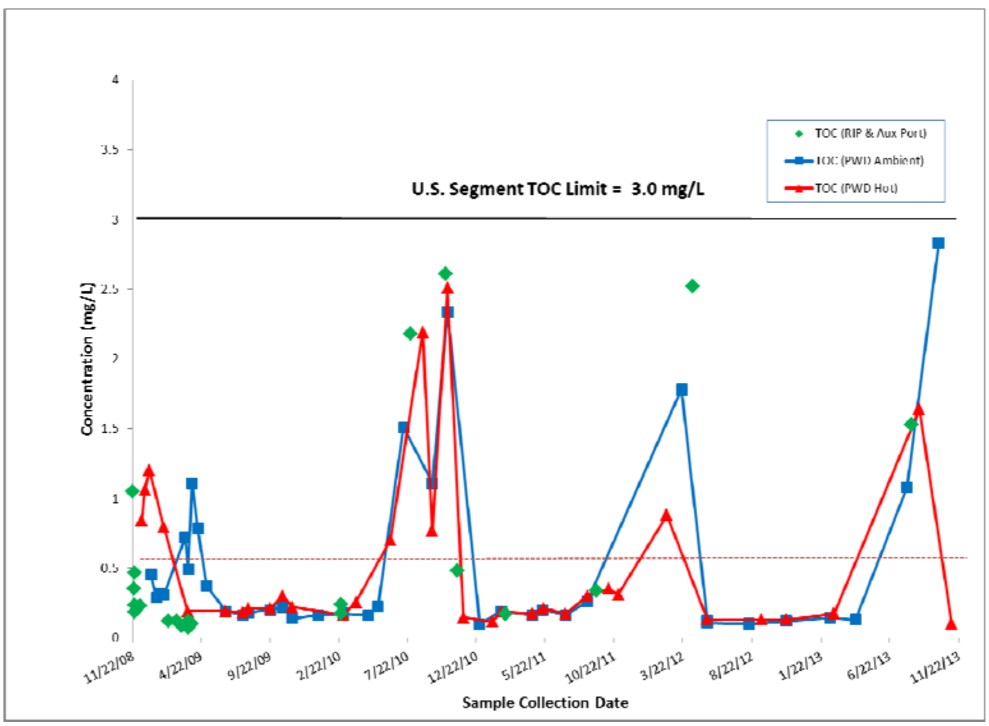

Figure 5. TOC Levels in WPA Archival Water Samples ISS ULF2 to Soyuz 35

-Note the three separate TOC rises in 2010, 2012, and 2013 from DMSD breakthrough

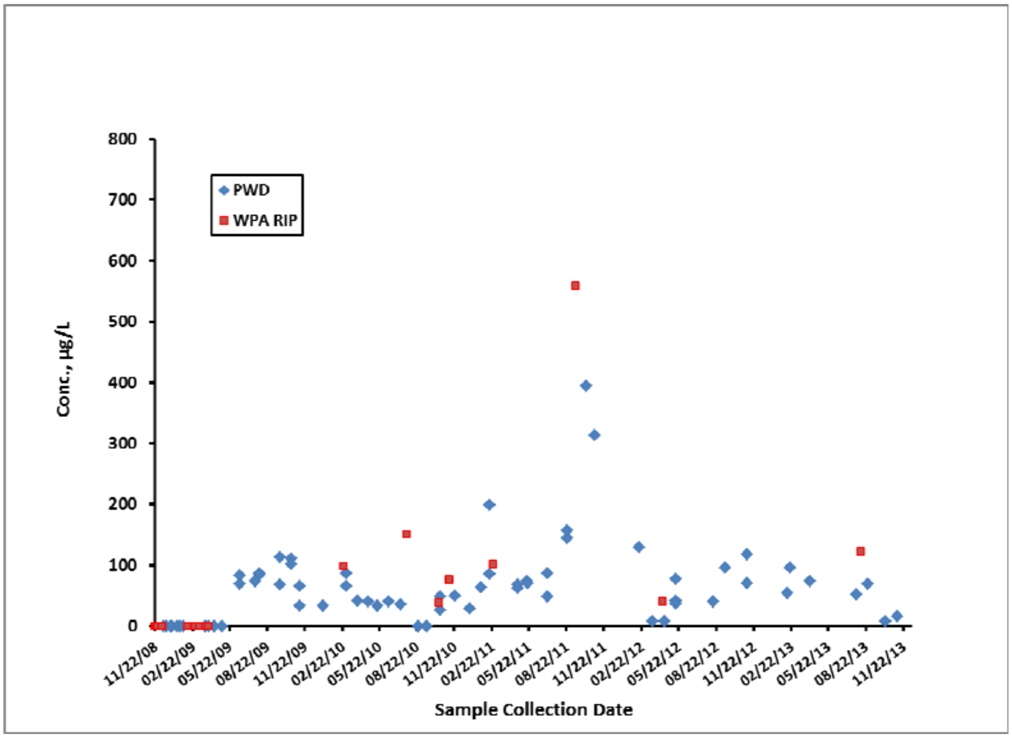

Figure 6 - Methyl Sulfone in US Potable Water Samples ISS ULF2 to Soyuz 35

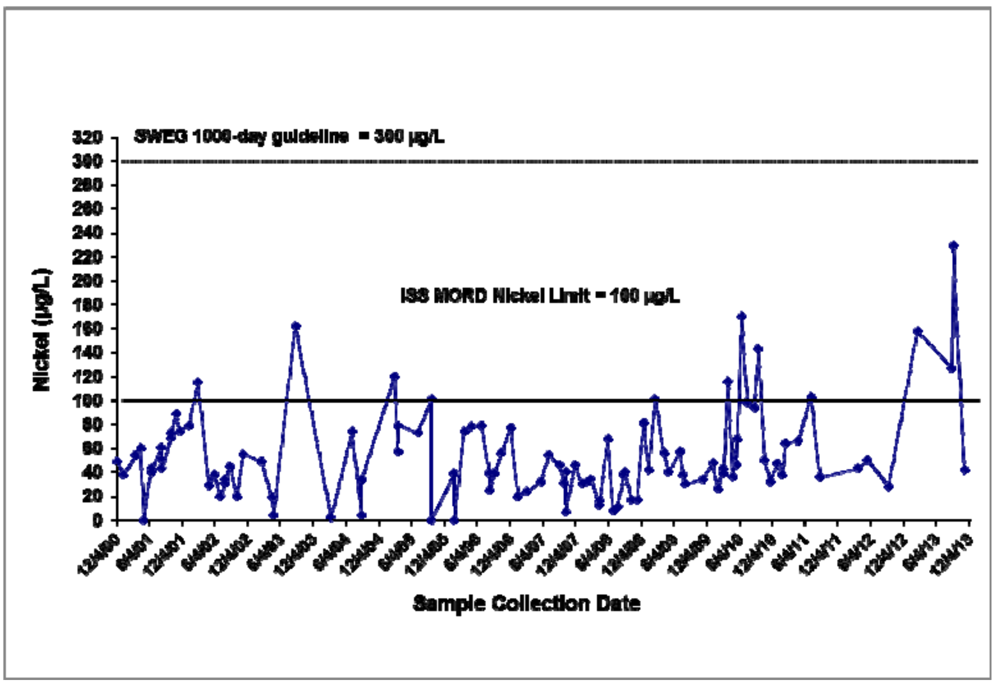

Figure 7. Nickel Levels in SRV-K Water Samples ISS Flights 4A to Soyuz 35

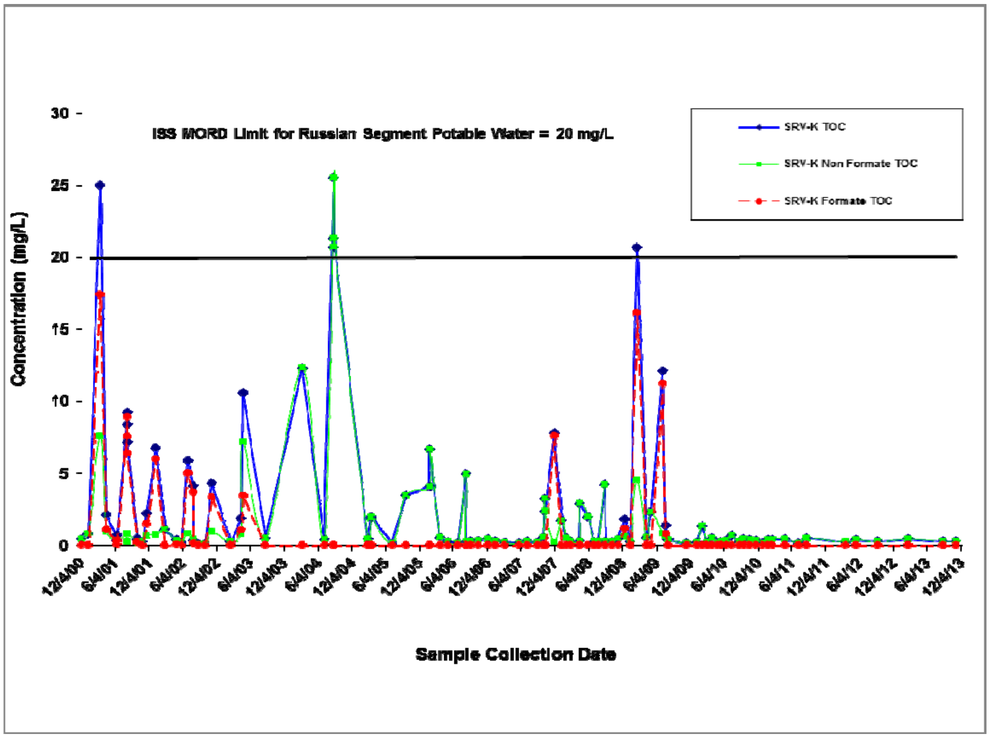

Figure 8. Total, Formate, & Non-formate Organic Carbon in SRV-K Potable Water ISS Flights 4A to Soyuz 35

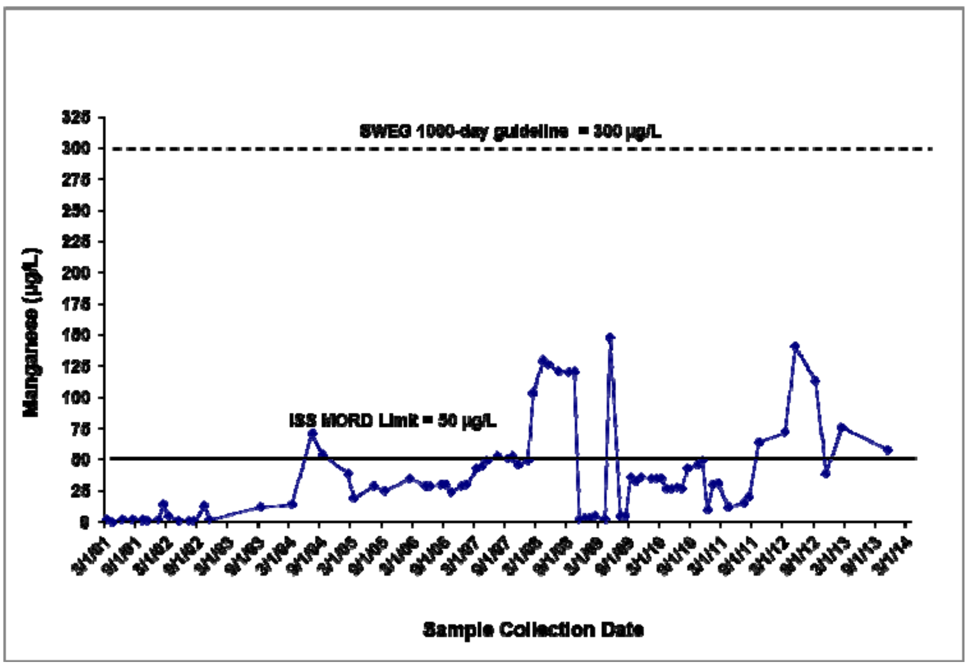

Figure 9. Manganese Levels in SVO-ZV Water Samples ISS Flights 5A to Soyuz 35

EXPEDITION 36

As detailed in Table 1, a total of five archival water samples were collected using U.S. water sample hardware during Expedition 36 (PWD ambient, PWD hot, SRV-K hot, SRV-K warm, and WPA RIP). All of these samples were returned on Soyuz 34 and received in the TECL on September 12, 2013. Due to limited sample volume, turbidity was only measured on the PWD ambient sample and solids were not measured on any of the samples. No chemical analyses were initially planned for the SRV-K Warm sample that was originally collected to confirm the results of an earlier in-flight microbial analysis. Upon inspection after receipt, reddish brown precipitates were observed, so metal and mineral analyses were performed on the sample.

During the summer of 2013, the U.S. Segment potable water experienced an anticipated temporary rise and fall in total organic carbon (TOC) content, as the result of organic contamination breaking through the water system's treatment process. This TOC rise was detected and monitored using the onboard TOCA. Analytical results for the Expedition 36 archival samples returned on Soyuz 34 confirmed the in-flight TOCA results and determined that dimethylsilanediol was once again the sole responsible contaminant, just as it was for comparable TOC rises in 2010 and 2012[15,16].

ISS U.S. Segment:

PWD Potable-Water Samples

The two PWD samples from Expedition 36 were collected on July 30, 2013 (ambient) and August 26, 2013 (hot). All chemical parameters measured for these two samples met the U.S. Segment potable-water quality requirements. The nickel levels ranged from 5 to 6 µg/L. Total iodine (I) in the sample was below the method detection limit of <0.05 mg/L and met the 0.2 mg/L maximum at the point of consumption (Figure 4).

The TOC results for the PWD ambient and hot samples were 1.08 and 1.64 mg/L, respectively (Figure 5). Although these levels were well below the 3.0 mg/L limit, they confirmed an upward trend seen in the onboard TOCA results. The TOC concentrations measured in the archive samples were in close agreement with those measured in-flight as shown in Table 3. These data demonstrate excellent accuracy for the TOC concentrations measured with the replacement ISS TOCA unit (PFU2) that became operational in June 4, 2013.

Table 3. Comparison of E36 Archive Samples to Inflight TOCA Results

In-flight TOCA (PFU2)			Expedition 36 (E36) Archive Samples		
Date	**Location**	**TOC (mg/L)**	**Date**	**Location**	**TOC (mg/L)**
7/31/13	PWD ambient	0.99	7/30/13	PWD ambient	1.08
8/19/13	WPA hose	1.20	8/19/13	WPA RIP	1.53
8/26/13	PWD hot	1.69	8/26/13	PWD hot	1.64

DMSD ranged from 3.8 to 5.7 mg/L in the PWD samples which is above nominal levels but below the 35.0 mg/L Spacecraft Water Exposure Guideline (SWEG)[18]. The methyl sulfone level ranged from 52 to 69 µg/L (Figure 6). The organic carbon accountability of the PWD samples ranged from 92 to 93%, with less than 0.2 mg/L of TOC unaccounted, confirming that the rise in TOC levels is due to DMSD.

WPA RIP Product-Water Sample

A WPA product-water sample was collected from the WPA rack interface panel (RIP) on August 19, 2013, two days prior to replacement of the WPA multifiltration (MF) beds. The MF beds were replaced in response to the increasing TOC levels in the WPA product water as measured with the TOCA. The TOC in this sample was 1.53 mg/L (Figure 5). DMSD (5.3 mg/L) and methyl sulfone (0.12 mg/L) were the only organics detected. The organic carbon accountability was 92%, with less than 0.2 mg/L TOC unaccounted. The iodine level was 1.96 mg/L and within the required range of 1.0 to 4.0 mg/L residual iodine. The only metals detected were nickel (29 µg/L) and zinc (1 µg/L).

ISS Russian Segment:

SRV-K Potable-Water Samples

All chemical parameters measured for the SRV-K hot water sample collected on August 26, 2013 met the potable-water quality requirements listed in the ISS MORD document, except for nickel. The nickel level of 127 μg/L exceeded the ISS MORD limit of 100 μg/L but was well below the SWEG of 300 μg/L (Figure 7). The total silver level of 6 μg/L was well below the desired biocidal range of 100 to 500 μg/L, which can increase the risk of microbial growth. The TOC level of 0.31 mg/L was well below the ISS MORD limit, and no target organics (including DMSD) were detected.

As noted above, the SRV-K warm sample collected on September 6, 2013 was originally collected to confirm the results from a previous in-flight microbial analysis. Upon inspection of the sample a reddish brown precipitate was found, so a small volume was allocated for analysis of metals and minerals. Iron (915 μg/L) and nickel (229 μg/L) levels were above the ISS MORD limits of 300 and 100 μg/L, respectively. The sample also contained elevated calcium (56.5 mg/L), magnesium (15.3 mg/L), aluminum (269 μg/L), copper (982 μg/L), lead (41 μg/L), and zinc (121 μg/L) compared to historical levels. Although a new mineralization cartridge was installed in the SRV-K water system several days before this sample was collected, it is unclear that the elevated levels of metals and minerals are associated with installation of the new cartridge. Most likely these levels resulted from the corrosion found in the dispensing unit, which was replaced in late November of 2013.

EXPEDITION 37

Four archival potable water samples were collected using U.S. water sample hardware during Expedition 37 (PWD ambient, PWD hot, SRV-K warm, and SVO-ZV) as summarized in Table 1. All four samples were returned on Soyuz 35 and received in the TECL on November 12, 2013. Due to limited sample volume, solids were not analyzed on any of the samples and turbidity was not measured except on the PWD ambient sample. Due to leakage from the sample bag during transit, iodine and semi-volatile organics were not analyzed on the SVO-ZV sample.

ISS U.S. Segment:

PWD Potable-Water Samples

All chemical parameters measured for the PWD ambient and hot water samples collected on October 8, 2013 and November 6, 2013, respectively, met the U.S. Segment potable-water quality requirements. Nickel levels ranged from 5 to 6 μg/L. Total iodine levels were below the method detection limit of 0.05 mg/L and met the ISS acceptability limit at the point of consumption of <0.2 mg/L (see Figure 4).

The TOC results for the October 8 and November 6 samples were 2.83 and <0.1 mg/L, respectively. The October 8 PWD sample's TOC level represents the peak for the most recent TOC rise which approached but never reached the U.S. Segment limit of 3 mg/L (Figure 5). The subsequent decrease in TOC can be attributed to the change out of the WPA MF beds on August 21, 2013. The lag time between the change out of the beds and the TOC peak (~48 days) is consistent with the previous TOC increases of 2010 and 2012 and represents the time needed to flush DMSD out of the WPA polishing ion-exchange bed. DMSD levels were 12.0 and <0.5 mg/L in the October 8 and November 6 samples, respectively. The October 8 sample's DMSD level remained below the 35.0 mg/L SWEG. The November 6 sample result confirms that the DMSD had been flushed from the WPA at that time. These archive sample results are consistent with the in-flight TOCA data as shown in Table 4.

Table 4. Comparison of E37 Archive Samples to Inflight TOCA Results

In-flight TOCA (PFU2)			Expedition 37 (E37) Archive Samples		
Date	**Location**	**TOC(mg/L)**	**Date**	**Location**	**TOC (mg/L)**
10/8/13	PWD ambient	3.04	10/8/13	PWD ambient	2.83
11/6/13	PWD hot	<0.285	11/6/13	PWD hot	<0.10

Methyl sulfone was below reportable levels in both samples (Figure 6). The organic carbon accountability of the October 8 sample was >100% with an excess TOC concentration of 0.295 mg/L. DMSD was the primary compound responsible for the TOC rise, just as it was for the 2010 and 2012 rises.

ISS Russian Segment:

SRV-K Potable-Water Sample

All chemical parameters measured for the SRV-K warm water sample collected on November 6, 2013 met the potable-water quality requirements listed in the ISS MORD. Levels of iron (41 ug/L), nickel (42 ug/L), aluminum (17 ug/L), copper (4 ug/L), lead (<1 ug/L), and zinc (58 ug/L) were lower than the previous SRV-K warm sample collected on September 6, 2013. The total silver level in the November 6 sample was 21 µg/L. This is below the minimum acceptable biocidal level (100 µg/L) which can increase the risk of microbial growth. The TOC level of 0.31 mg/L was well below the ISS MORD limit (Figure 8) and no target organic compounds were detected.

SVO-ZV Potable-Water Sample

All chemical parameters measured for the SVO-ZV water sample collected on November 6, 2013 met the potable-water quality requirements listed in the ISS MORD with the exception of manganese. The manganese concentration of 58 µg/L was slightly above the ISS MORD requirement of 50 µg/L, but well below the SWEG of 300 µg/L (Figure 9). The total silver level was 134 µg/L, and within the acceptable biocidal range. The TOC concentration of 0.48 mg/L was well below the ISS MORD limit and no target organic compounds were detected.

IV. Conclusions and Recommendations

Chemical analyses results for archive water samples collected in 2013 from the PWD and RIP during Expeditions 34-37 and returned on Soyuz flights 32-35 confirm that the WPA potable water was chemically acceptable for consumption by the ISS crews. During the summer of 2013, the WPA water experienced an anticipated temporary rise and fall in TOC content, as the result of organic contamination breaking through the treatment processes. The TOC levels in the PWD archival samples climbed to a peak of 2.8 mg/L in the October 8 sample but never reached the U.S. Segment limit of 3.0 mg/L, before reversing and quickly falling to nominal levels below the method detection limit (<0.10 mg/L). The subsequent decrease in TOC can be attributed to the change out of the WPA MF beds on August 21. The lag time between the change out of the beds and the TOC peak (~48 days) is consistent with the previous TOC increases of 2010 and 2012 and represents the time needed to flush DMSD out of the WPA polishing ion-exchange bed. Analytical results for Expeditions 36-37 samples returned on Soyuz 34-35 confirmed that DMSD was again responsible for the TOC rise, just as it was for the 2010 and 2012 TOC rises. The levels of DMSD in the PWD archive samples reached a high of 12.0 mg/L before falling back below the detection limit, but never came close to the 35.0 mg/L SWEG limit. Although below levels of health concern, DMSD may still affect the WPA performance by masking the presence of low-levels of other organic compounds that might also breakthrough the system. As mentioned earlier, the 2013 TOC rise was anticipated based upon experience and lessons learned from the previous TOC rises of 2010 and 2012. Although the WPA internal conductivity sensors were again ineffective in signaling DMSD breakthrough, the TOCA once again demonstrated its value and necessity as a key monitoring tool for tracking TOC rises, in particular those associated with DMSD breakthrough, and for scheduling appropriate remediate action (e.g. MF bed R&R). The in-flight TOCA results during the recent TOC rise were consistent with the archive sample results as shown in Tables 3-4, thereby confirming TOCA accuracy for detecting DMSD. Even though the timing of DMSD breakthrough is now fully understood, predictable and being tracked, it is recommended that the ongoing multidisciplinary effort to establish root cause and the environmental source(s) of DMSD in WPA product water should continue.

Due to the ultrapure nature of typical WPA product water, the organic accountability for PWD samples collected outside of the TOC rise period remained low. Current detection limits and sensitivity of the established analytical methods make it difficult to account for about 0.1 mg/L of organic carbon, the average amount of unaccounted carbon in these typical WPA samples from Expeditions 34-37. Nevertheless, efforts are ongoing in the TECL to evaluate current analytical methods to improve sensitivity and/or specificity, to modify or refine current methods to include more target compounds, if feasible, and to develop methods to quantify new compounds, once they are identified.

The chemical analyses results for the Russian Segment archival water samples collected in 2013 from the SRV-K and SVO-ZV during Expeditions 34-37 indicate that the potable water was chemically acceptable for crew consumption. Silver biocide levels in both SVO-ZV samples were within the acceptable range thereby reducing the risk of microbial growth. Manganese exceeded the ISS MORD limit of 50 µg/L in both SVO-ZV samples returned from Expeditions 33-37; however, levels remained well below the 300 µg/L SWEG. It is recommended that manganese continue to be closely monitored in the SVO-ZV water supply even though the system is not widely used by the crews. Nickel in three of four SRV-K water samples returned during Expeditions 34-37 slightly exceeded the ISS MORD limit of 100 µg/L, but were below the SWEG of 300 µg/L. Total silver levels in three of four SRV-K samples were below the desired biocide range of 100 to 500 µg/L, indicating that the primary means of microbial control in the SRV-K galley continues to be heating of the water by the pasteurization unit. Continued monitoring of nickel, biocide level and microbial content in SRV-K water is therefore recommended.

Appendices

Chemical analysis results for archival potable-water samples returned in 2013 from the Russian Segment SRV-K (regenerated water) system during Expeditions 34-37 are presented in Appendix 1. Results of chemical analyses performed on archival potable-water samples returned in 2013 from the Russian Segment SVO-ZV (stored water) system are presented in Appendix 2. Appendix 3 contains the results for U.S. Segment archival water samples that were collected from the PWD and WPA RIP and returned in 2013.

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References

[1]Straub, J.E., Plumlee, D. K., Schultz, J. R., and McCoy, J.T., "Potable-Water Quality for International Space Station Expeditions 30-33", AIAA-2013-3310, *AIAA Proceedings of the 2013 International Conference on Environmental Systems*, 2013.

[2]Straub, J.E., Plumlee, D. K., Schultz, J. R., and McCoy, J.T., "International Space Station Potable Water Quality for Expeditions 26 through 29", AIAA-2012-3413, *AIAA Proceedings of the 2012 International Conference on Environmental Systems*, 2012.

[3]Straub, J. E., Plumlee, D. K., Schultz, J. R., and McCoy, J.T, "Chemical Analysis Results for Potable Water for ISS Expeditions 21-25", AIAA-2011-5152, *AIAA Proceedings of the 2011 International Conference on Environmental Systems*, 2011.

[4]Straub, J. E., Plumlee, D. K., and Schultz, J. R., "ISS Expeditions 16 thru 20: Chemical Analysis Results for Potable Water", AIAA-2010-6042, *AIAA Proceedings of the 2010 International Conference on Environmental Systems*, 2010.

[5]Straub, J. E., Plumlee, D. K., and Schultz, J. R., "Chemical Analysis Results for Potable Water Returned from ISS Expeditions 14 and 15", *SAE International Journal of Aerospace.* 1(1): 556-577, 2008.

[6]Straub, J. E., Plumlee, D. K., and Schultz, J. R., "Sampling and Chemical Analysis of Potable Water for ISS Expeditions 12 and 13", *SAE International Journal of Aerospace*, 2007.

[7]Straub, J. E., Plumlee, D. K., and Schultz, J. R., "ISS Expeditions 10 & 11 Potable Water Sampling and Chemical Analysis Results", *SAE International Journal of Aerospace*, 2006.

[8]Straub, J. E., Plumlee, D. K., and Schultz, J. R., "Chemical Analysis of ISS Potable Water from Expeditions 8 and 9", *SAE International Journal of Aerospace*, 2005.

[9]Straub, J. E., Plumlee, D. K., and Schultz, J. R., "ISS Potable Water Sampling and Chemical Analysis: Expeditions 6 & 7", *SAE International Journal of Aerospace*, 2004.

[10]Plumlee, D. K. and Schultz, J. R., "ISS Potable Water Sampling and Chemical Analysis: Expeditions 4 & 5", *SAE International Journal of Aerospace*, 2003.

[11]Plumlee, D. K. and Schultz, J. R., "Chemical Sampling and Analysis of ISS Potable Water: Expeditions 1-3", *SAE International Journal of Aerospace*, 2002.

[12]*ISS Medical Operations Requirements Document,* SSP 50260, Revision C, NASA Johnson Space Center, February 2006, Section 7.2 and Appendix D, Table D-1.

[13]*System Specification for the International Space Station,* SSP 41000 BY, National Aeronautics and Space Administration, September 21, 2012, Table LXX.

[14]Bentley, N, et al., "Second-Generation International Space Station Total Organic Carbon Analyzer Verification Testing and On-Orbit Performance Results", AIAA-2010-6043, *AIAA Proceedings of the 2010 International Conference on Environmental Systems,* 2010.

[15]Rutz, J. A. et al., “Discovery and Identification of Dimethylsilanediol as a Contaminant in ISS Potable Water”, AIAA-2011-5154, *AIAA Proceedings of the 2011 International Conference on Environmental Systems*, 2011.
[16]McCoy, J. T. et al., “The Story Behind the Numbers: Lessons Learned from the Integration of Monitoring Resources in Addressing an ISS Water Quality Anomaly”, AIAA-2011-5153, *AIAA Proceedings of the 2011 International Conference on Environmental Systems*, 2011.
[17]*Spacecraft Water Exposure Guidelines (SWEGS),* JSC-63414, NASA Johnson Space Center, November 2008.
[18]Ramanathan, R., James, J.T., and McCoy, J.T., “Acceptable levels for ingestion of dimethylsilanediol in water on the International Space Station”, Aviation Space Environmental Medicine, 2012 Jun;83(6);598-603.

Appendix 1. ISS SRV-K Potable Water (Regenerated) Summary of Samples Returned During Expeditions 34 through 37

				Expedition 34	Expedition 36		Expedition 37
Mission				Soyuz 32	Soyuz 34		Soyuz 35
Sample Location		Potable Water		SRV-K Hot	SRV-K Hot	SRV-K Warm	SRV-K Warm
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water
Sample Date		Level	Level	2/19/2013	8/26/2013	9/6/2013	11/6/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317003	20130912003	20130912004	20131112004
Physical Characteristics							
pH	pH units	5.5-9.0	MORD	6.1	7.7	NA	8.0
Conductivity	µS/cm			535	250	NA	220
Turbidity	NTU	1.5*	MORD	4.4	NA	NA	NA
Solids	mg/L	100 (1,000#)	MORD	NA	NA	NA	NA
Iodine (LCV)							
Total I	mg/L	0.05	MORD	<0.05	NA	NA	<0.05
Anions (IC/ISE)							
Bromide	mg/L			<0.1	<0.1	NA	<0.1
Chloride	mg/L	250	MORD	3.4	0.8	NA	2.9
Fluoride	mg/L	1.5/4	MCL	0.2	0.8	NA	0.1
Nitrate as Nitrogen (NO3-N)	mg/L	10	MCL	<0.2	3.6	NA	<0.2
Phosphate as P (PO4-P)	mg/L			<0.1	<0.1	NA	<0.1
Sulfate	mg/L	250	MORD	30.6	21.9	NA	18.5
Cations (IC)							
Ammonia as Nitrogen (NH3-N)	mg/L	2/1	MORD/SWEG	<0.12	<0.12	NA	<0.12
Metals (ICP/MS)							
Calcium	mg/L	100	MORD	76.3	32.0	56.5	27.6
Magnesium	mg/L	50	MORD	25.6	8.65	15.3	6.76
Potassium	mg/L			8.12	0.77	0.62	1.60
Sodium	mg/L			4.65	4.92	2.05	2.51
Aluminum	µg/L			195	11	269	17
Antimony	µg/L	2000/6	SWEG/EPA MCL	<2	<2	<4	<2
Arsenic	µg/L	10	MCL	<1	<1	<2	<1
Barium	µg/L	10,000/1,000	SWEG/MORD	59	85	6	18
Beryllium	µg/L	4	EPA MCL	<1	<1	<2	<1
Cadmium	µg/L	22/5	SWEG/MORD	<1	<1	2	<1
Chromium	µg/L	100	MCL	8	3	17	<1
Cobalt	µg/L			<1	<1	12	<1
Copper	µg/L	1,000/1,300	MCL	178	77	982	4
Iron	µg/L	300	MORD	316	12	915	41
Lead	µg/L	50/15	MCL	13	1	41	<1
Manganese	µg/L	300/50	SWEG/MORD	64	3	29	23
Mercury	µg/L	2	MCL	<0.5	<0.5	<1	<0.5
Molybdenum	µg/L			<1	<1	<2	<1
Nickel	µg/L	300/100	SWEG/MORD	158	127	229	42
Selenium	µg/L	10/50	MCL	<1	<1	<2	<1
Silver	µg/L	400/500	SWEG/MORD	42	6	85	21
Silver, Dissolved	µg/L			<2	<2	<2	3
Zinc	µg/L	2,000/5,000	SWEG/MORD	24	26	121	58
Silicon (ICP/MS)							
Silicon (ICP/MS)	µg/L			6420	6740	2950	1690
Total Organic Carbon (Sievers)							
Total Inorganic Carbon	mg/L			68.3	23.6	NA	21.1
Total Organic Carbon	mg/L	20**	MORD	0.44	0.31	NA	0.31
Volatile Organics							
Acetone	µg/L	15,000	SWEG	<5	<50	NA	<5
Acrylonitrile	µg/L			<5	<50	NA	<5
Allyl chloride (3-Chloropropene)	µg/L			<5	<50	NA	<5
Benzene	µg/L	70/5	SWEG/EPA MCL	<5	<50	NA	<5
Bromobenzene	µg/L			<5	<50	NA	<5
Bromochloromethane	µg/L			<5	<50	NA	<5
Bromodichloromethane	µg/L	THM 80	EPA MCL	<5	<50	NA	<5
Bromoform	µg/L	THM 80	EPA MCL	<5	<50	NA	<5
Bromomethane	µg/L			<5	<50	NA	<5
2-Butanone (Methyl ethyl ketone)	µg/L	54,000/4000	SWEG/EPA MCL	<5	<50	NA	<5
n-Butylbenzene	µg/L			<5	<50	NA	<5
sec-Butylbenzene	µg/L			<5	<50	NA	<5
tert-Butylbenzene	µg/L			<5	<50	NA	<5
Carbon disulfide	µg/L			<5	<50	NA	<5
Carbon tetrachloride	µg/L	5	EPA MCL	<5	<50	NA	<5
Chloroacetonitrile	µg/L			<5	<50	NA	<5
Chlorobenzene	µg/L	100	EPA MCL	<5	<50	NA	<5
1-Chlorobutane (Butyl chloride)	µg/L			<5	<50	NA	<5
Chloroethane	µg/L			<5	<50	NA	<5
Chloroform	µg/L	6,500/THM 80	SWEG/EPA MCL	<5	<50	NA	<5
Chloromethane	µg/L			<5	<50	NA	<5
2-Chlorotoluene	µg/L			<5	<50	NA	<5

NA=Not analyzed; MI=Matrix interference
*MORD limit 1.5 mg/L (Russian method)
**limit does not include contribution from formate
#solids allowable limit after mineralization
SWEG - 1000 days (5-2006)

Appendix 1. ISS SRV-K Potable Water (Regenerated) Summary of Samples Returned During Expeditions 34 through 37

				Expedition 34	Expedition 36		Expedition 37
Mission				Soyuz 32	Soyuz 34		Soyuz 35
Sample Location		Potable Water		SRV-K Hot	SRV-K Hot	SRV-K Warm	SRV-K Warm
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water
Sample Date		Level	Level	2/19/2013	8/26/2013	9/6/2013	11/6/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317003	20130912003	20130912004	20131112004
4-Chlorotoluene	µg/L			<5	<50	NA	<5
Dibromochloromethane	µg/L	THM 80	EPA MCL	<5	<50	NA	<5
1,2-Dibromo-3-chloropropane (DBCP)	µg/L	0.2	EPA MCL	<5	<50	NA	<5
1,2-Dibromoethane (EDB)	µg/L	0.05	EPA MCL	<5	<50	NA	<5
Dibromomethane	µg/L			<5	<50	NA	<5
1,2-Dichlorobenzene	µg/L	600	EPA MCL	<5	<50	NA	<5
1,3-Dichlorobenzene	µg/L			<5	<50	NA	<5
1,4-Dichlorobenzene	µg/L	75	EPA MCL	<5	<50	NA	<5
trans-1,4-Dichloro-2-butene	µg/L			<5	<50	NA	<5
Dichlorodifluoromethane	µg/L			<5	<50	NA	<5
1,1-Dichloroethane	µg/L			<5	<50	NA	<5
1,2-Dichloroethane	µg/L	5	EPA MCL	<5	<50	NA	<5
1,1-Dichloroethene	µg/L	7	EPA MCL	<5	<50	NA	<5
cis1,2-Dichloroethene	µg/L	70	EPA MCL	<5	<50	NA	<5
trans-1,2-Dichloroethene	µg/L	100	EPA MCL	<5	<50	NA	<5
1,2-Dichloropropane	µg/L	5	EPA MCL	<5	<50	NA	<5
1,3-Dichloropropane	µg/L			<5	<50	NA	<5
2,2-Dichloropropane	µg/L			<5	<50	NA	<5
1,1-Dichloropropanone	µg/L			<5	<50	NA	<5
1,1-Dichloropropene	µg/L			<5	<50	NA	<5
cis-1,3-Dichloropropene	µg/L			<5	<50	NA	<5
trans-1,3-Dichloropropene	µg/L			<5	<50	NA	<5
Diethyl ether	µg/L			<5	<50	NA	<5
Ethylbenzene	µg/L	700	EPA MCL	<5	<50	NA	<5
Ethyl methacrylate	µg/L			<5	<50	NA	<5
Hexachlorobutadiene	µg/L			<5	<50	NA	<5
Hexachloroethane	µg/L			<5	<50	NA	<5
2-Hexanone	µg/L			<5	<50	NA	<5
Iodomethane	µg/L			<5	<50	NA	<5
Isopropylbenzene (Cumene)	µg/L			<5	<50	NA	<5
4-Isopropyltoluene (Cymene)	µg/L			<5	<50	NA	<5
Methacrylonitrile	µg/L			<5	<50	NA	<5
Methyl acrylate	µg/L			<5	<50	NA	<5
Methyl-t-butylether (MTBE)	µg/L			<5	<50	NA	<5
Methylene chloride (Dichloromethane)	µg/L	15,000/5	SWEG/EPA MCL	<5	<50	NA	<5
Methyl methacrylate	µg/L			<5	<50	NA	<5
4-Methyl-2-pentanone	µg/L			<5	<50	NA	<5
Naphthalene	µg/L			<5	<50	NA	<5
Nitrobenzene	µg/L			<5	<50	NA	<5
2-Nitropropane	µg/L			<5	<50	NA	<5
Pentachloroethane	µg/L			<5	<50	NA	<5
Propionitrile (Ethyl cyanide)	µg/L			<5	<50	NA	<5
n-Propylbenzene	µg/L			<5	<50	NA	<5
Styrene	µg/L	100	EPA MCL	<5	<50	NA	<5
1,1,1,2-Tetrachloroethane	µg/L			<5	<50	NA	<5
1,1,2,2-Tetrachloroethane	µg/L			<5	<50	NA	<5
Tetrachloroethene	µg/L	5	EPA MCL	<5	<50	NA	<5
Tetrahydrofuran	µg/L			<5	<50	NA	<5
Toluene	µg/L	1,000	EPA MCL	<5	<50	NA	<5
1,2,3-Trichlorobenzene	µg/L			<5	<50	NA	<5
1,2,4-Trichlorobenzene	µg/L	70	EPA MCL	<5	<50	NA	<5
1,1,1-Trichloroethane	µg/L	200	EPA MCL	<5	<50	NA	<5
1,1,2-Trichloroethane	µg/L	5	EPA MCL	<5	<50	NA	<5
Trichloroethene	µg/L	5	EPA MCL	<5	<50	NA	<5
Trichlorofluoromethane	µg/L			<5	<50	NA	<5
1,2,3-Trichloropropane	µg/L			<5	<50	NA	<5
1,2,4-Trimethylbenzene	µg/L			<5	<50	NA	<5
1,3,5-Trimethylbenzene	µg/L			<5	<50	NA	<5
Vinyl Acetate	µg/L			<5	<50	NA	<5
Vinyl Chloride	µg/L	2	EPA MCL	<5	<50	NA	<5
m& p-Xylene	µg/L	Total Xylenes 10,000	EPA MCL	<10	<100	NA	<10
o-Xylene	µg/L	Total Xylenes 10,000	EPA MCL	<5	<50	NA	<5
Volatile Organics - Non-Targets (Tentatively Identified Compounds (>/= 80% match quality)							
Acetaldehyde	µg/L			not found	not found	NA	not found
Trimethylsilanol	µg/L			not found	not found	NA	not found
Extractable Organics							
Acetophenone	µg/L			<32	<32	NA	<16
Benzaldehyde	µg/L			<16	<16	NA	<8
Benzoic acid	µg/L			<96	not found	NA	<48
Benzothiazole	µg/L			<16	<16	NA	<8
Benzyl alcohol	µg/L			<16	<16	NA	<8
Benzyl butyl phthlate	µg/L			<16	<16	NA	<8
2-Butoxyethanol	µg/L			<32	<32	NA	<16
2-(2-Butoxyethoxy)ethanol	µg/L			<32	<32	NA	<16

NA=Not analyzed; MI=Matrix interference
*MORD limit 1.5 mg/L (Russian method)
**limit does not include contribution from formate
#solids allowable limit after mineralization
SWEG - 1000 days (5-2006)

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Mission				Soyuz 32	Soyuz 34		Soyuz 35
Sample Location		Potable Water		SRV-K Hot	SRV-K Hot	SRV-K Warm	SRV-K Warm
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water
Sample Date		Level	Level	2/19/2013	8/26/2013	9/6/2013	11/6/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317003	20130912003	20130912004	20131112004
2-(2-Butoxyethoxy)ethyl acetate	µg/L			<16	<16	NA	<8
n-Butylpalmitate	µg/L			<32	<32	NA	<16
Butylated hydroxyanisole (BHA)	µg/L			<16	<16	NA	<8
N-Butylbenzenesulfonamide	µg/L			<16	<16	NA	<8
3-tert-Butylphenol	µg/L			<48	<48	NA	<24
Caffeine	µg/L			<16	<16	NA	<8
tris-2-Chloroethyl phosphate	µg/L			<16	<16	NA	<8
Cholesterol	µg/L			<128	<128	NA	<64
o-Cresol (2-Methylphenol)	µg/L			<16	<16	NA	<8
Cyclododecane	µg/L			<16	<16	NA	<8
Decamethylcyclopentasiloxane	µg/L			<16	<16	NA	<8
Decanoic acid	µg/L			<48	<48	NA	<24
2,6-Di-t-butyl-1,4-benzoquinone	µg/L			<16	<16	NA	<8
2,4-Di-t-butylphenol	µg/L			<16	<16	NA	<8
1,4 Diacetylbenzene	µg/L			<16	<16	NA	<8
N,N-Dibutylformamide	µg/L			<16	<16	NA	<8
Dibutyl phthalate	µg/L	40,000	SWEG	<16	<16	NA	<8
Dibutylamine	µg/L	Dialkylamines 300	SWEG	<16	<16	NA	<8
N,N-Diethyl-m-toluamide	µg/L			<16	<16	NA	<8
Diethylphthalate	µg/L			<16	<16	NA	<8
Diethylene glycol monoethyl ether	µg/L			<16	<16	NA	<8
N,N-Diethylformamide	µg/L			<48	<48	NA	<24
Diiodomethane (Methyl iodide)	µg/L			<16	<16	NA	<8
Diisopropyl adipate	µg/L			<16	<16	NA	<8
Dimethyl phthalate	µg/L			<16	<16	NA	<8
N,N-Dimethyl acetamide	µg/L			<16	<16	NA	<8
N,N-Dimethylbenzylamine	µg/L	Dialkylamines 300	SWEG	<16	<16	NA	<8
N,N-Dimethylformamide	µg/L			<32	<32	NA	<16
Dipropylene glycol methyl ether	µg/L			<16	NA	NA	<8
Dodecamethylcyclohexasiloxane	µg/L			<16	<16	NA	<8
2-Ethoxyethanol	µg/L			<32	<32	NA	<16
2-Ethyl-1-hexanol	µg/L			<16	<16	NA	<8
2-Ethylhexanoic acid	µg/L			<32	<32	NA	<16
bis-2-Ethylhexyl adipate	µg/L	400	EPA MCL	<16	<16	NA	<8
bis-2-Ethylhexyl phthalate (Dioctyl phthlate)	µg/L	20,000/6	SWEG/EPA MCL	<16	<16	NA	<8
4-Ethylmorpholine	µg/L			<16	<16	NA	<8
1-Formylpiperidine	µg/L			<16	<16	NA	<8
Heptanoic acid	µg/L			<48	<48	NA	<24
2-Heptanone	µg/L			<16	<16	NA	<8
gamma-Hexalactone	µg/L			<16	<16	NA	<8
Hexanoic acid	µg/L			<48	<48	NA	<24
2-Hexanol	µg/L			<16	<16	NA	<8
2-Hydroxybenzothiazole	µg/L			<16	<16	NA	<8
Ibuprofen	µg/L			<48	<48	NA	<24
Iodoform	µg/L			<16	<16	NA	<8
Isophorone	µg/L			<16	<16	NA	<8
4-Isopropylphenol	µg/L			<16	<16	NA	<8
Lauramide	µg/L			<16	<16	NA	<8
Lauric acid (Dodecanoic acid)	µg/L			<480	<480	NA	<240
p-Menth-1-en-8-ol (alpha-Terpineol)	µg/L			<16	<16	NA	<8
2-Mercaptobenzothiazole	µg/L	30,000	SWEG	<160	<160	NA	<80
2-Methyl-2,4-pentanediol	µg/L			<16	<16	NA	<8
1-Methyl-2-pyrrolidinone	µg/L			<16	<16	NA	<8
Methyl-4-hydroxybenzoate	µg/L			<16	<16	NA	<8
Methyl sulfone	µg/L			<16	<16	NA	<8
2-Methyl butyric acid	µg/L			<48	<48	NA	<24
2-Methylthiobenzothiazole	µg/L			<16	<16	NA	<8
Monomethyl phthalate	µg/L			<16	<16	NA	<8
Myristic acid	µg/L			<160	<160	NA	<80
(+)-Neomenthol	µg/L			<16	<16	NA	<8
Nicotine	µg/L			<16	<16	NA	<8
Nonadecane	µg/L			<16	<16	NA	<8
Nonanoic acid	µg/L			<200	<200	NA	<100
1-Octadecanol	µg/L			<48	<48	NA	<24
Octamethylcyclotetrasiloxane	µg/L			<16	<16	NA	<8
Octanoic acid	µg/L			<96	<96	NA	<48
4-tert-Octylphenol	µg/L			<16	<16	NA	<8
Oleic acid	µg/L			<280	<280	NA	<140
Oxindole	µg/L			<16	<16	NA	<8
Palmitic acid	µg/L			<480	<480	NA	<240
Pentacosane	µg/L			<16	<16	NA	<8
sec-Phenethyl alcohol	µg/L			<16	<16	NA	<8
Phenol	µg/L	4,000/1,000	SWEG/MORD	<16	<16	NA	<8
2-Phenoxyethanol	µg/L			<16	<16	NA	<8
N-Phenyl-2-naphthylamine	µg/L	260,000	SWEG	<16	<16	NA	<8
2-Phenyl-2-propanol	µg/L			<16	<16	NA	<8

NA=Not analyzed; MI=Matrix interference
*MORD limit 1.5 mg/L (Russian method)
**limit does not include contribution from formate
#solids allowable limit after mineralization
SWEG - 1000 days (5-2006)

Appendix 1. ISS SRV-K Potable Water (Regenerated) Summary of Samples Returned During Expeditions 34 through 37

				Expedition 34	Expedition 36		Expedition 37
Mission				Soyuz 32	Soyuz 34		Soyuz 35
Sample Location		Potable Water		SRV-K Hot	SRV-K Hot	SRV-K Warm	SRV-K Warm
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water
Sample Date		Level	Level	2/19/2013	8/26/2013	9/6/2013	11/6/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317003	20130912003	20130912004	20131112004
2-Phenylacetic acid	µg/L			<64	<64	NA	<32
Phenethyl alcohol	µg/L			<16	<16	NA	<8
2-Phenylphenol	µg/L			<16	<16	NA	<8
Salicyclic Acid	µg/L			<128	<128	NA	<64
trans-Squalene	µg/L			<32	<32	NA	<16
1-Tetradecanol	µg/L			<16	<16	NA	<8
Tetramethylsuccinonitrile	µg/L			<16	<16	NA	<8
Tetramethyl thiourea	µg/L			<16	<16	NA	<8
Tetramethylurea	µg/L			<16	<16	NA	<8
Thymol	µg/L			<16	<16	NA	<8
1,3,5-Triallyl-1,3,5-triazine-2,4,6(1H,3H,5H)-trione	µg/L			<16	<16	NA	<8
Tributylamine	µg/L	Trialkylamines 400	SWEG	<16	<16	NA	<8
Tributyl phosphate	µg/L			<16	<16	NA	<8
Triethyl phosphate	µg/L			<32	<32	NA	<16
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	µg/L			<32	<32	NA	<16
Tripropylene glycol monomethyl ether	µg/L			<16	<16	NA	<8
Undecanoic acid	µg/L			<96	<96	NA	<48
2-Undecanone	µg/L			<16	<16	NA	<8
Valeric acid (Pentanoic acid)	µg/L			<96	<96	NA	<48
Vanillin	µg/L			<32	<32	NA	<16
Alcohols (DAI/GC/MS)							
1-Butanol	µg/L			<200	<200	NA	<200
2-Butanol	µg/L			<200	<200	NA	<200
Ethanol	µg/L			<200	<200	NA	<200
Methanol	µg/L	40,000	SWEG	<200	<200	NA	<200
2-Methyl-1-butanol	µg/L			<200	<200	NA	<200
2-Methyl-2-butanol	µg/L			<200	<200	NA	<200
3-Methyl-1-butanol (Isopentanol)	µg/L			<300	<300	NA	<300
2-Methyl-1-propanol	µg/L			<200	<200	NA	<200
2-Methyl-2-propanol	µg/L			<200	<200	NA	<200
1-Pentanol (Amyl alcohol)	µg/L			<200	<200	NA	<200
2-Pentanol (sec-Amyl alcohol)	µg/L			<200	<200	NA	<200
3-Pentanol	µg/L			<200	<200	NA	<200
1-Propanol	µg/L			<200	<200	NA	<200
2-Propanol (Isopropanol)	µg/L			<200	<200	NA	<200
Glycols (DAI/GC/MS)							
1,2-Ethanediol (Ethylene glycol)	µg/L	4,000/12000	SWEG/MORD	<1000	<1000	NA	<1000
1,2-Propanediol (Propylene glycol)	µg/L	1,700,000	SWEG	<1000	<1000	NA	<1000
Silanols (LC/MS/MS) (R & D Method -NIST traceable standard not available)							
Dimethylsilanediol (DMSD)	µg/L	25,000	SWEG	<500	<500	NA	<500
Carboxylates (CE)							
Acetate	µg/L			<625	<625	NA	<625
Formate	µg/L	2,500,000	SWEG	<625	<625	NA	<625
Glycolate	µg/L			<625	<625	NA	<625
Glyoxylate	µg/L			<625	<625	NA	<625
Lactate	µg/L			<625	<625	NA	<625
Oxalate	µg/L			<1250	<1250	NA	<1250
Propionate	µg/L			<1250	MI	NA	<625
Aldehydes							
Formaldehyde	µg/L	12,000	SWEG	<10	<10	NA	<10
Amines (CE)							
Ethylamine	µg/L	Monoalkylamines 2000	SWEG	<250	<250	NA	<250
Methylamine	µg/L	Monoalkylamines 2000	SWEG	<250	<250	NA	<250
n-Propylamine	µg/L	Monoalkylamines 2000	SWEG	<500	<500	NA	<500
Trimethylamine	µg/L	Trialkylamines 400	SWEG	<500	<500	NA	<500
Non-volatiles (LC/UV-VIS)							
Urea	µg/L			<800	<800	NA	<800
Caprolactam	µg/L	100,000	SWEG	<32	<32	NA	<16
Organic Carbon Recovery	percent			0.00	0.00	NA	0.00
Unaccounted Organic Carbon	mg/L			0.44	0.31	NA	0.00

NA=Not analyzed; MI=Matrix interference
*MORD limit 1.5 mg/L (Russian method)
**limit does not include contribution from formate
#solids allowable limit after mineralization
SWEG - 1000 days (5-2006)

Appendix 2. ISS SVO-ZV Potable Water Summary of Samples Returned During Expeditions 34 through 37

				Expedition 34	Expedition 37
Mission				Soyuz 32	Soyuz 35
Sample Location		Potable Water		SVO-ZV	SVO-ZV
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water
Sample Date		Level	Level	2/19/2013	11/6/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317002	20131112003
Physical Characteristics					
pH	pH units	5.5-9.0	MORD	8.3	8.1
Conductivity	µS/cm			600	490
Turbidity	NTU	1.5*	MORD	NA	NA
Solids	mg/L	100 (1,000#)	MORD	NA	NA
Iodine (LCV)					
Total I	mg/L	0.05	MORD	NA	<0.05
Anions (IC/ISE)					
Bromide	mg/L			<0.1	<0.1
Chloride	mg/L	250	MORD	2.7	8.0
Fluoride	mg/L	1.5/4	MORD/EPA MCL	0.2	0.3
Nitrate as Nitrogen (NO3-N)	mg/L	10	MORD/EPA MCL	<0.2	0.3
Phosphate as P (PO4-P)	mg/L			<0.1	<0.1
Sulfate	mg/L	250	MORD	34.4	38.2
Cations (IC)					
Ammonia as Nitrogen (NH3-N)	mg/L	2/1	MORD/SWEG	<0.12	<0.12
Metals (ICP/MS)					
Calcium	mg/L	100	MORD	87.6	63.0
Magnesium	mg/L	50	MORD	30.6	17.5
Potassium	mg/L			9.38	4.83
Sodium	mg/L			4.56	7.50
Aluminum	µg/L			52	195
Antimony	µg/L	2000/6	SWEG/EPA MCL	<2	<2
Arsenic	µg/L	10	MORD/EPA MCL	1	<1
Barium	µg/L	10,000/1,000	SWEG/MORD	72	51
Beryllium	µg/L	4	EPA MCL	<1	<1
Cadmium	µg/L	22/5	SWEG/MORD	<1	1
Chromium	µg/L	100	MORD/EPA MCL	4	<1
Cobalt	µg/L			<1	<1
Copper	µg/L	1,000/1,300	MORD/EPA MCL	3	2
Iron	µg/L	300	MORD	25	75
Lead	µg/L	50/15	MORD/EPA MCL	<1	<1
Manganese	µg/L	300/50	SWEG/MORD	76	58
Mercury	µg/L	2	MORD/EPA MCL	<0.5	<0.5
Molybdenum	µg/L			<1	<1
Nickel	µg/L	300/100	SWEG/MORD	3	3
Selenium	µg/L	10/50	MORD/EPA MCL	<1	<1
Silver	µg/L	400/500	SWEG/MORD	127	134
Silver, Dissolved	µg/L			<5	54
Zinc	µg/L	2,000/5,000	SWEG/MORD	23	30
Silicon (ICP/MS)					
Silicon (ICP/MS)	µg/L			7790	5000
Total Organic Carbon (Sievers)					
Total Inorganic Carbon	mg/L			65.7	52.1
Total Organic Carbon	mg/L	20**	MORD	0.48	0.48
Volatile Organics					
Acetone	µg/L	15,000	SWEG	<20	<5
Acryloniltrile	µg/L			<20	<5
Allyl chloride (3-Chloropropene)	µg/L			<20	<5
Benzene	µg/L	70/5	SWEG/EPA MCL	<20	<5
Bromobenzene	µg/L			<20	<5
Bromochloromethane	µg/L			<20	<5
Bromodichloromethane	µg/L	THM 80	EPA MCL	<20	<5
Bromoform	µg/L	THM 80	EPA MCL	<20	<5
Bromomethane	µg/L			<20	<5
2-Butanone (Methyl ethyl ketone)	µg/L	54,000/4000	SWEG/EPA MCL	<20	<5
n-Butylbenzene	µg/L			<20	<5
sec-Butylbenzene	µg/L			<20	<5
tert-Butylbenzene	µg/L			<20	<5
Carbon disulfide	µg/L			<20	<5
Carbon tetrachloride	µg/L	5	EPA MCL	<20	<5
Chloroacetonitrile	µg/L			<20	<5
Chlorobenzene	µg/L	100	EPA MCL	<20	<5
1-Chlorobutane (Butyl chloride)	µg/L			<20	<5
Chloroethane	µg/L			<20	<5
Chloroform	µg/L	6,500/THM 80	SWEG/EPA MCL	<20	<5
Chloromethane	µg/L			<20	<5
2-Chlorotoluene	µg/L			<20	<5
4-Chlorotoluene	µg/L			<20	<5
Dibromochloromethane	µg/L	THM 80	EPA MCL	<20	<5
1,2-Dibromo-3-chloropropane (DBCP)	µg/L	0.2	EPA MCL	<20	<5
1,2-Dibromoethane (EDB)	µg/L	0.05	EPA MCL	<20	<5

NA=Not analyzed; MI=Matrix interference
*MORD limit 1.5 mg/L (Russian method)
**limit does not include contribution from formate
#solids allowable limit after mineralization
SWEG - 1000 days (5-2006)

Appendix 2. ISS SVO-ZV Potable Water Summary of Samples Returned During Expeditions 34 through 37

				Expedition 34	Expedition 37
Mission				Soyuz 32	Soyuz 35
Sample Location		Potable Water		SVO-ZV	SVO-ZV
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water
Sample Date		Level	Level	2/19/2013	11/6/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317002	20131112003
Dibromomethane	µg/L			<20	<5
1,2-Dichlorobenzene	µg/L	600	EPA MCL	<20	<5
1,3-Dichlorobenzene	µg/L			<20	<5
1,4-Dichlorobenzene	µg/L	75	EPA MCL	<20	<5
trans-1,4-Dichloro-2-butene	µg/L			<20	<5
Dichlorodifluoromethane	µg/L			<20	<5
1,1-Dichloroethane	µg/L			<20	<5
1,2-Dichloroethane	µg/L	5	EPA MCL	<20	<5
1,1-Dichloroethene	µg/L	7	EPA MCL	<20	<5
cis1,2-Dichloroethene	µg/L	70	EPA MCL	<20	<5
trans-1,2-Dichloroethene	µg/L	100	EPA MCL	<20	<5
1,2-Dichloropropane	µg/L	5	EPA MCL	<20	<5
1,3-Dichloropropane	µg/L			<20	<5
2,2-Dichloropropane	µg/L			<20	<5
1,1-Dichloropropanone	µg/L			<20	<5
1,1-Dichloropropene	µg/L			<20	<5
cis-1,3-Dichloropropene	µg/L			<20	<5
trans-1,3-Dichloropropene	µg/L			<20	<5
Diethyl ether	µg/L			<20	<5
Ethylbenzene	µg/L	700	EPA MCL	<20	<5
Ethyl methacrylate	µg/L			<20	<5
Hexachlorobutadiene	µg/L			<20	<5
Hexachloroethane	µg/L			<20	<5
2-Hexanone	µg/L			<20	<5
Iodomethane	µg/L			<20	<5
Isopropylbenzene (Cumene)	µg/L			<20	<5
4-Isopropyltoluene (Cymene)	µg/L			<20	<5
Methacrylonitrile	µg/L			<20	<5
Methyl acrylate	µg/L			<20	<5
Methyl-t-butylether (MTBE)	µg/L			<20	<5
Methylene chloride (Dichloromethane)	µg/L	15,000/5	SWEG/EPA MCL	<20	<5
Methyl methacrylate	µg/L			<20	<5
4-Methyl-2-pentanone	µg/L			<20	<5
Naphthalene	µg/L			<20	<5
Nitrobenzene	µg/L			<20	<5
2-Nitropropane	µg/L			<20	<5
Pentachloroethane	µg/L			<20	<5
Propionitrile (Ethyl cyanide)	µg/L			<20	<5
n-Propylbenzene	µg/L			<20	<5
Styrene	µg/L	100	EPA MCL	<20	<5
1,1,1,2-Tetrachloroethane	µg/L			<20	<5
1,1,2,2-Tetrachloroethane	µg/L			<20	<5
Tetrachloroethene	µg/L	5	EPA MCL	<20	<5
Tetrahydrofuran	µg/L			<20	<5
Toluene	µg/L	1,000	EPA MCL	<20	<5
1,2,3-Trichlorobenzene	µg/L			<20	<5
1,2,4-Trichlorobenzene	µg/L	70	EPA MCL	<20	<5
1,1,1-Trichloroethane	µg/L	200	EPA MCL	<20	<5
1,1,2-Trichloroethane	µg/L	5	EPA MCL	<20	<5
Trichloroethene	µg/L	5	EPA MCL	<20	<5
Trichlorofluoromethane	µg/L			<20	<5
1,2,3-Trichloropropane	µg/L			<20	<5
1,2,4-Trimethylbenzene	µg/L			<20	<5
1,3,5-Trimethylbenzene	µg/L			<20	<5
Vinyl Acetate	µg/L			<20	<5
Vinyl Chloride	µg/L	2	EPA MCL	<20	<5
m& p-Xylene	µg/L	Total Xylenes 10,000	EPA MCL	<40	<10
o-Xylene	µg/L	Total Xylenes 10,000	EPA MCL	<20	<5
Volatile Organics - Non-Targets (Tentatively Identified Compounds (>/= 80% match quality)					
Acetaldehyde	µg/L			not found	not found
Trimethylsilanol	µg/L			not found	not found
Extractable Organics					
Acetophenone	µg/L			NA	<16
Benzaldehyde	µg/L			NA	<8
Benzoic acid	µg/L			NA	<48
Benzothiazole	µg/L			NA	<8
Benzyl alcohol	µg/L			NA	<8
Benzyl butyl phthlate	µg/L			NA	<8
2-Butoxyethanol	µg/L			NA	<16
2-(2-Butoxyethoxy)ethanol	µg/L			NA	<16
2-(2-Butoxyethoxy)ethyl acetate	µg/L			NA	<8
n-Butylpalmitate	µg/L			NA	<16
Butylated hydroxyanisole (BHA)	µg/L			NA	<8
N-Butylbenzenesulfonamide	µg/L			NA	<8
3-tert-Butylphenol	µg/L			NA	<24
Caffeine	µg/L			NA	<8
tris-2-Chloroethyl phosphate	µg/L			NA	<8
Cholesterol	µg/L			NA	<64

NA=Not analyzed; MI=Matrix interference
*MORD limit 1.5 mg/L (Russian method)
**limit does not include contribution from formate
#solids allowable limit after mineralization
SWEG - 1000 days (5-2006)

Appendix 2. ISS SVO-ZV Potable Water Summary of Samples Returned During Expeditions 34 through 37

				Expedition 34	Expedition 37
Mission				Soyuz 32	Soyuz 35
Sample Location		Potable Water		SVO-ZV	SVO-ZV
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water
Sample Date		Level	Level	2/19/2013	11/6/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317002	20131112003
o-Cresol (2-Methylphenol)	µg/L			NA	<8
Cyclododecane	µg/L			NA	<8
Decamethylcyclopentasiloxane	µg/L			NA	<8
Decanoic acid	µg/L			NA	<24
2,6-Di-t-butyl-1,4-benzoquinone	µg/L			NA	<8
2,4-Di-t-butylphenol	µg/L			NA	<8
1,4 Diacetylbenzene	µg/L			NA	<8
N,N-Dibutylformamide	µg/L			NA	<8
Dibutyl phthalate	µg/L	40,000	SWEG	NA	<8
Dibutylamine	µg/L	Dialkylamines 300	SWEG	NA	<8
N,N-Diethyl-m-toluamide	µg/L			NA	<8
Diethylphthalate	µg/L			NA	<8
Diethylene glycol monoethyl ether	µg/L			NA	<8
N,N-Diethylformamide	µg/L			NA	<24
Diiodomethane (Methyl iodide)	µg/L			NA	<8
Diisopropyl adipate	µg/L			NA	<8
Dimethyl phthalate	µg/L			NA	<8
N,N-Dimethyl acetamide	µg/L			NA	<8
N,N-Dimethylbenzylamine	µg/L	Dialkylamines 300	SWEG	NA	<8
N,N-Dimethylformamide	µg/L			NA	<16
Dipropylene glycol methyl ether	µg/L			NA	<8
Dodecamethylcyclohexasiloxane	µg/L			NA	<8
2-Ethoxyethanol	µg/L			NA	<16
2-Ethyl-1-hexanol	µg/L			NA	<8
2-Ethylhexanoic acid	µg/L			NA	<16
bis-2-Ethylhexyl adipate	µg/L	400	EPA MCL	NA	<8
bis-2-Ethylhexyl phthalate (Dioctyl phthlate)	µg/L	20,000/6	SWEG/EPA MCL	NA	<8
4-Ethylmorpholine	µg/L			NA	<8
1-Formylpiperidine	µg/L			NA	<8
Heptanoic acid	µg/L			NA	<24
2-Heptanone	µg/L			NA	<8
gamma-Hexalactone	µg/L			NA	<8
Hexanoic acid	µg/L			NA	<24
2-Hexanol	µg/L			NA	<8
2-Hydroxybenzothiazole	µg/L			NA	<8
Ibuprofen	µg/L			NA	<24
Iodoform	µg/L			NA	<8
Isophorone	µg/L			NA	<8
4-Isopropylphenol	µg/L			NA	<8
Lauramide	µg/L			NA	<8
Lauric acid (Dodecanoic acid)	µg/L			NA	<240
p-Menth-1-en-8-ol (alpha-Terpineol)	µg/L			NA	<8
2-Mercaptobenzothiazole	µg/L	30,000	SWEG	NA	<80
2-Methyl-2,4-pentanediol	µg/L			NA	<8
1-Methyl-2-pyrrolidinone	µg/L			NA	<8
Methyl-4-hydroxybenzoate	µg/L			NA	<8
Methyl sulfone	µg/L			NA	<8
2-Methyl butyric acid	µg/L			NA	<24
2-Methylthiobenzothiazole	µg/L			NA	<8
Monomethyl phthalate	µg/L			NA	<8
Myristic acid	µg/L			NA	<80
(+)-Neomenthol	µg/L			NA	<8
Nicotine	µg/L			NA	<8
Nonadecane	µg/L			NA	<8
Nonanoic acid	µg/L			NA	<100
1-Octadecanol	µg/L			NA	<24
Octamethylcyclotetrasiloxane	µg/L			NA	<8
Octanoic acid	µg/L			NA	<48
4-tert-Octylphenol	µg/L			NA	<8
Oleic acid	µg/L			NA	<140
Oxindole	µg/L			NA	<8
Palmitic acid	µg/L			NA	<240
Pentacosane	µg/L			NA	<8
sec-Phenethyl alcohol	µg/L			NA	<8
Phenol	µg/L	4,000/1,000	SWEG/MORD	NA	<8
2-Phenoxyethanol	µg/L			NA	<8
N-Phenyl-2-naphthylamine	µg/L	260,000	SWEG	NA	<8
2-Phenyl-2-propanol	µg/L			NA	<8
2-Phenylacetic acid	µg/L			NA	<32
Phenethyl alcohol	µg/L			NA	<8
2-Phenylphenol	µg/L			NA	<8
Salicyclic Acid	µg/L			NA	<64
trans-Squalene	µg/L			NA	<16
1-Tetradecanol	µg/L			NA	<8
Tetramethylsuccinonitrile	µg/L			NA	<8
Tetramethyl thiourea	µg/L			NA	<8
Tetramethylurea	µg/L			NA	<8
Thymol	µg/L			NA	<8
1,3,5-Triallyl-1,3,5-triazine-2,4,6(1H,3H,5H)-trione	µg/L			NA	<8
Tributylamine	µg/L	Trialkylamines 400	SWEG	NA	<8

NA=Not analyzed; MI=Matrix interference
*MORD limit 1.5 mg/L (Russian method)
**limit does not include contribution from formate
#solids allowable limit after mineralization
SWEG - 1000 days (5-2006)

Appendix 2. ISS SVO-ZV Potable Water Summary of Samples Returned During Expeditions 34 through 37

				Expedition 34	Expedition 37
Mission				Soyuz 32	Soyuz 35
Sample Location		**Potable Water**		SVO-ZV	SVO-ZV
Sample Description		**Maximum Contaminant**	**Maximum Contaminant**	Potable Water	Potable Water
Sample Date		**Level**	**Level**	2/19/2013	11/6/2013
Analysis/Sample ID	**Units**	**(MCL)**	**Source**	**20130317002**	**20131112003**
Tributyl phosphate	µg/L			NA	<8
Triethyl phosphate	µg/L			NA	<16
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	µg/L			NA	<16
Tripropylene glycol monomethyl ether	µg/L			NA	<8
Undecanoic acid	µg/L			NA	<48
2-Undecanone	µg/L			NA	<8
Valeric acid (Pentanoic acid)	µg/L			NA	<48
Vanillin	µg/L			NA	<16
Alcohols (DAI/GC/MS)					
1-Butanol	µg/L			<200	<200
2-Butanol	µg/L			<200	<200
Ethanol	µg/L			<200	<200
Methanol	µg/L	40,000	SWEG	<200	<200
2-Methyl-1-butanol	µg/L			<200	<200
2-Methyl-2-butanol	µg/L			<200	<200
3-Methyl-1-butanol (Isopentanol)	µg/L			<300	<300
2-Methyl-1-propanol	µg/L			<200	<200
2-Methyl-2-propanol	µg/L			<200	<200
1-Pentanol (Amyl alcohol)	µg/L			<200	<200
2-Pentanol (sec-Amyl alcohol)	µg/L			<200	<200
3-Pentanol	µg/L			<200	<200
1-Propanol	µg/L			<200	<200
2-Propanol (Isopropanol)	µg/L			<200	<200
Glycols (DAI/GC/MS)					
1,2-Ethanediol (Ethylene glycol)	µg/L	4,000/1,2000	SWEG/MORD	<1000	<1000
1,2-Propanediol (Propylene glycol)	µg/L	1,700,000	SWEG	<1000	<1000
Silanols (LC/MS/MS) (R& D Method - NIST traceable standard not available)					
Dimethylsilanediol (DMSD)	µg/L	25,000	SWEG	<500	<500
Carboxylates (CE)					
Acetate	µg/L			<625	<625
Formate	µg/L	2,500,000	SWEG	<625	<625
Glycolate	µg/L			<625	<625
Glyoxylate	µg/L			<625	<625
Lactate	µg/L			<625	<625
Oxalate	µg/L			<1250	<1250
Propionate	µg/L			<1250	<625
Aldehydes					
Formaldehyde	µg/L	12,000	SWEG	<20	<10
Amines (CE)					
Ethylamine	µg/L	Monoalkylamines 2000	SWEG	<250	<250
Methylamine	µg/L	Monoalkylamines 2000	SWEG	<250	<250
n-Propylamine	µg/L	Monoalkylamines 2000	SWEG	<500	<500
Trimethylamine	µg/L	Trialkylamines 400	SWEG	<500	<500
Non-volatiles (LC/UV-VIS)					
Urea	µg/L			<800	<800
Caprolactam	µg/L	100,000	SWEG	<500	<16
Organic Carbon Recovery	percent			0.00	0.00
Unaccounted Organic Carbon	mg/L			0.48	0.00

NA=Not analyzed; MI=Matrix interference
*MORD limit 1.5 mg/L (Russian method)
**limit does not include contribution from formate
#solids allowable limit after mineralization
SWEG - 1000 days (5-2006)

Appendix 3. ISS WPA PWD and RIP Summary of Samples Returned During Expeditions 34 through 37

				Expedition 34		Expedition 35	Expedition 36		Expedition 37		Expedition 36
Mission				Soyuz 32		Soyuz 33	Soyuz 34		Soyuz 35		Soyuz 34
Sample Location		Potable Water		WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Hot	WPA RIP
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Product Water (prior to MF bed R&R)
Sample Date		Level	Level	2/11/2103	2/19/2013	4/8/2013	7/30/2013	8/26/2013	10/8/2013	11/6/2013	8/19/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317001	20130317004	20130515001	20130912001	20130912002	20131112001	20131112002	20130912005
Physical Characteristics											
pH	pH units	4.5-8.5	41000	5.2	6.9	4.9	6.4	6.2	5.3	4.8	6.0
Conductivity	µS/cm			2	1	2	1	2	5	4	2
Turbidity	NTU	1	41000	<0.4	<0.4	<0.4	<0.4	NA	<0.4	NA	NA
Total Solids	mg/L	100	41000	NA	NA	NA	NA	NA	NA	NA	NA
Iodine (LCV)											
Total I	mg/L	6/0.2	41000 (tl I max/tl I at pt of consumption)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	2.42
Iodine	mg/L			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.96
Iodide	mg/L			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.46
Anions (IC/ISE)											
Bromide	mg/L			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chloride	mg/L			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fluoride	mg/L			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate as Nitrogen (NO3-N)	mg/L	10	41000	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Phosphate as P (PO4-P)	mg/L			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfate	mg/L	250	41000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cations (IC)											
Ammonia as Nitrogen (NH3-N)	mg/L	1	SWEG& 41000	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.125
Metals (ICP/MS)											
Calcium	mg/L	30	41000	0.01	<0.01	0.01	0.02	0.04	0.05	<0.01	0.02
Magnesium	mg/L	50	41000	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Potassium	mg/L	340	41000	<0.01	<0.01	0.02	<0.01	<0.01	0.05	<0.01	<0.01
Sodium	mg/L			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Aluminum	µg/L			1	1	2	<1	<1	1	3	<1
Antimony	µg/L	2,000	SWEG	<2	<2	<2	<2	<2	<2	<2	<2
Arsenic	µg/L	10	41000	<1	<1	<1	<1	<1	<1	<1	<1
Barium	µg/L	10,000	SWEG& 41000	<1	<1	<1	1	<1	<1	<1	<1
Beryllium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1
Cadmium	µg/L	22	SWEG& 41000	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	µg/L	230	41000	<1	<1	<1	<1	<1	<1	<1	<1
Cobalt	µg/L			<1	<1	<1	<1	<1	<1	<1	<1
Copper	µg/L	1,000	41000	<1	<1	<1	<1	<1	<1	<1	<1
Iron	µg/L	300	41000	<3	<3	<3	<3	<3	<3	<3	<3
Lead	µg/L	50	41000	<1	<1	<1	<1	<1	<1	<1	<1
Manganese	µg/L	300	SWEG& 41000	<1	<1	<1	<1	<1	<1	<1	<1
Mercury	µg/L	2	41000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Molybdenum	µg/L			<1	<1	<1	<1	<1	<1	<1	<1
Nickel	µg/L	300	SWEG& 41000	10	9	7	5	6	5	6	29
Selenium	µg/L	10	41000	1	<1	<1	<1	<1	<1	<1	<1
Silver	µg/L	400	SWEG& 41000	<1	<1	<1	<1	<1	<1	<1	<1
Zinc	µg/L	2,000	SWEG& 41000	2	4	<1	<1	<1	2	<1	1
Silicon (ICP/MS)											
Silicon (ICP/MS)	µg/L			180	105	31	993	1620	3180	64	1420
Total Organic Carbon (Sievers)											
Total Inorganic Carbon	mg/L			0.90	0.83	1.07	1.11	1.03	0.94	0.83	1.07
Total Organic Carbon	mg/L	3	41000	0.14	0.17	0.13	1.08	1.64	2.83	<0.1	1.53

NA=Not analyzed;
MI=Matrix interference
SWEG - 1000 days (11-2008)

Appendix 3. ISS WPA PWD and RIP Summary of Samples Returned During Expeditions 34 through 37

Mission				Expedition 34		Expedition 35	Expedition 36		Expedition 37		Expedition 36
				Soyuz 32		Soyuz 33	Soyuz 34		Soyuz 35		Soyuz 34
Sample Location		Potable Water		WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Hot	WPA RIP
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Product Water (prior to MF bed R&R)
Sample Date		Level	Level	2/11/2103	2/19/2013	4/8/2013	7/30/2013	8/26/2013	10/8/2013	11/6/2013	8/19/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317001	20130317004	20130515001	20130912001	20130912002	20131112001	20131112002	20130912005
Volatile Organics											
Acetone	µg/L	15,000	SWEG	<5	<5	<5	<5	<5	<5	<5	<5
Acryloniltrile	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Allyl chloride (3-Chloropropene)	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Benzene	µg/L	70/5	SWEG/EPA	<5	<5	<5	<5	<5	<5	<5	<5
Bromobenzene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Bromochloromethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Bromodichloromethane	µg/L	THM 80	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Bromoform	µg/L	THM 80	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Bromomethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
2-Butanone (Methyl ethyl ketone)	µg/L	54,000/4000	SWEG/EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
n-Butylbenzene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
sec-Butylbenzene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
tert-Butylbenzene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Carbon disulfide	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Carbon tetrachloride	µg/L	5	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Chloroacetonitrile	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Chlorobenzene	µg/L	100	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1-Chlorobutane (Butyl chloride)	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Chloroethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Chloroform	µg/L	6,500/THM 80	SWEG/EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Chloromethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
2-Chlorotoluene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
4-Chlorotoluene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Dibromochloromethane	µg/L	THM 80	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dibromo-3-chloropropane (DBCP)	µg/L	0.2	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dibromoethane (EDB)	µg/L	0.05	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Dibromomethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichlorobenzene	µg/L	600	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1,3-Dichlorobenzene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,4-Dichlorobenzene	µg/L	75	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
trans-1,4-Dichloro-2-butene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Dichlorodifluoromethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloroethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloroethane	µg/L	5	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloroethene	µg/L	7	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
cis1,2-Dichloroethene	µg/L	70	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
trans-1,2-Dichloroethene	µg/L	100	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloropropane	µg/L	5	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1,3-Dichloropropane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
2,2-Dichloropropane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloropropanone	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloropropene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
cis-1,3-Dichloropropene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
trans-1,3-Dichloropropene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Diethyl ether	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene	µg/L	700	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Ethyl methacrylate	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Hexachlorobutadiene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Hexachloroethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
2-Hexanone	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Iodomethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Isopropylbenzene (Cumene)	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
4-Isopropyltoluene (Cymene)	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Methacrylonitrile	µg/L			<5	<5	<5	<5	<5	<5	<5	<5

NA=Not analyzed;
MI=Matrix interference
SWEG - 1000 days (11-2008)

Appendix 3. ISS WPA PWD and RIP Summary of Samples Returned During Expeditions 34 through 37

				Expedition 34		Expedition 35	Expedition 36		Expedition 37		Expedition 36
Mission				Soyuz 32		Soyuz 33	Soyuz 34		Soyuz 35		Soyuz 34
Sample Location		Potable Water		WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Hot	WPA RIP
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Product Water (prior to MF bed R&R)
Sample Date		Level	Level	2/11/2103	2/19/2013	4/8/2013	7/30/2013	8/26/2013	10/8/2013	11/6/2013	8/19/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317001	20130317004	20130515001	20130912001	20130912002	20131112001	20131112002	20130912005
Methyl acrylate	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Methyl-t-butylether (MTBE)	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Methylene chloride (Dichloromethane)	µg/L	15,000/5	SWEG/EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Methyl methacrylate	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
4-Methyl-2-pentanone	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Naphthalene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Nitrobenzene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
2-Nitropropane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Pentachloroethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Propionitrile (Ethyl cyanide)	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
n-Propylbenzene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Styrene	µg/L	100	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1,1,1,2-Tetrachloroethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,1,2,2-Tetrachloroethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene	µg/L	5	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Tetrahydrofuran	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Toluene	µg/L	1,000	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1,2,3-Trichlorobenzene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,2,4-Trichlorobenzene	µg/L	70	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1,1,1-Trichloroethane	µg/L	200	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
1,1,2-Trichloroethane	µg/L	5	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	µg/L	5	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Trichlorofluoromethane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,2,3-Trichloropropane	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,2,4-Trimethylbenzene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
1,3,5-Trimethylbenzene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Vinyl Acetate	µg/L			<5	<5	<5	<5	<5	<5	<5	<5
Vinyl Chloride	µg/L	2	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
m& p-Xylene	µg/L	Total Xylenes 10,000	EPA MCL	<10	<10	<10	<10	<10	<10	<10	<10
o-Xylene	µg/L	Total Xylenes 10,000	EPA MCL	<5	<5	<5	<5	<5	<5	<5	<5
Volatile Organics - Non-Targets (Tentatively Identified Compounds (>/= 80% match quality)											
Acetaldehyde	µg/L			not found	not found	not found	not found	not found	not found	not found	not found
Trimethylsilanol	µg/L			not found	not found	not found	not found	not found	not found	not found	not found
Extractable Organics											
Acetophenone	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
Benzaldehyde	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Benzoic acid	µg/L			<48	<96	<48	not found	not found	<48	<96	not found
Benzothiazole	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Benzyl alcohol	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Benzyl butyl phthlate	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
2-Butoxyethanol	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
2-(2-Butoxyethoxy)ethanol	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
2-(2-Butoxyethoxy)ethyl acetate	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
n-Butylpalmitate	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
Butylated hydroxyanisole (BHA)	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
N-Butylbenzenesulfonamide	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
3-tert-Butylphenol	µg/L			<24	<48	<24	<24	<24	<24	<48	<48
Caffeine	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
tris-2-Chloroethyl phosphate	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Cholesterol	µg/L			<64	<128	<64	<64	<64	<64	<128	<128
o-Cresol (2-Methylphenol)	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Cyclododecane	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Decamethylcyclopentasiloxane	µg/L			<8	<16	<8	<8	<16	<8	<16	<16

NA=Not analyzed;
MI=Matrix interference
SWEG - 1000 days (11-2008)

Appendix 3. ISS WPA PWD and RIP Summary of Samples Returned During Expeditions 34 through 37

Mission				Expedition 34		Expedition 35	Expedition 36		Expedition 37		Expedition 36
				Soyuz 32		Soyuz 33	Soyuz 34		Soyuz 35		Soyuz 34
Sample Location		Potable Water		WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Hot	WPA RIP
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Product Water (prior to MF bed R&R)
Sample Date		Level	Level	2/11/2103	2/19/2013	4/8/2013	7/30/2013	8/26/2013	10/8/2013	11/6/2013	8/19/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317001	20130317004	20130515001	20130912001	20130912002	20131112001	20131112002	20130912005
Decanoic acid	µg/L			<24	<48	<24	<24	<48	<24	<48	<48
2,6-Di-t-butyl-1,4-benzoquinone	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
2,4-Di-t-butylphenol	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
1,4 Diacetylbenzene	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
N,N-Dibutylformamide	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Dibutyl phthalate	µg/L	40,000	SWEG	<8	<16	<8	<8	<16	<8	<16	<16
Dibutylamine	µg/L	Dialkylamines 300	SWEG	<8	<16	<8	<8	<16	<8	<16	<16
N,N-Diethyl-m-toluamide	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Diethylphthalate	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Diethylene glycol monoethyl ether	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
N,N-Diethylformamide	µg/L			<24	<48	<24	<24	<48	<24	<48	<48
Diiodomethane (Methyl iodide)	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Diisopropyl adipate	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Dimethyl phthalate	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
N,N-Dimethyl acetamide	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
N,N-Dimethylbenzylamine	µg/L	Dialkylamines 300	SWEG	<8	<16	<8	<8	<16	<8	<16	<16
N,N-Dimethylformamide	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
Dipropylene glycol methyl ether	µg/L			<8	<16	<8	NA	NA	<8	<16	NA
Dodecamethylcyclohexasiloxane	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
2-Ethoxyethanol	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
2-Ethyl-1-hexanol	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
2-Ethylhexanoic acid	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
bis-2-Ethylhexyl adipate	µg/L	400	EPA MCL	<8	<16	<8	<8	<16	<8	<16	<16
bis-2-Ethylhexyl phthalate (Dioctyl phthlate)	µg/L	20,000/6	SWEG/EPA MCL	<8	<16	<8	<8	<16	<8	<16	<16
4-Ethylmorpholine	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
1-Formylpiperidine	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Heptanoic acid	µg/L			<24	<48	<24	<24	<48	<24	<48	<48
2-Heptanone	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
gamma-Hexalactone	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Hexanoic acid	µg/L			<24	<48	<24	<24	<48	<24	<48	<48
2-Hexanol	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
2-Hydroxybenzothiazole	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Ibuprofen	µg/L			<24	<48	<24	<24	<48	<24	<48	<48
Iodoform	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Isophorone	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
4-Isopropylphenol	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Lauramide	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Lauric acid (Dodecanoic acid)	µg/L			<240	<480	<240	<240	<480	<240	<480	<480
p-Menth-1-en-8-ol (alpha-Terpineol)	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
2-Mercaptobenzothiazole	µg/L	30,000	SWEG	<80	<160	<80	<80	<160	<80	<160	<160
2-Methyl-2,4-pentanediol	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
1-Methyl-2-pyrrolidinone	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Methyl-4-hydroxybenzoate	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Methyl sulfone	µg/L			54	96	74	52	69	<8	<16	123
2-Methyl butyric acid	µg/L			<24	<48	<24	<24	<48	<24	<48	<48
2-Methylthiobenzothiazole	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Monomethyl phthalate	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Myristic acid	µg/L			<80	<160	<80	<80	<160	<80	<160	<160
(+)-Neomenthol	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Nicotine	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Nonadecane	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Nonanoic acid	µg/L			<100	<200	<100	<100	<200	<100	<200	<200
1-Octadecanol	µg/L			<24	<48	<24	<24	<48	<24	<48	<48
Octamethylcyclotetrasiloxane	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Octanoic acid	µg/L			<48	<96	<48	<48	<96	<48	<96	<96

NA=Not analyzed;
MI=Matrix interference
SWEG - 1000 days (11-2008)

Appendix 3. ISS WPA PWD and RIP Summary of Samples Returned During Expeditions 34 through 37

				Expedition 34		Expedition 35	Expedition 36		Expedition 37		Expedition 36
Mission				Soyuz 32		Soyuz 33	Soyuz 34		Soyuz 35		Soyuz 34
Sample Location		Potable Water		WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Hot	WPA RIP
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Product Water (prior to MF bed R&R)
Sample Date		Level	Level	2/11/2103	2/19/2013	4/8/2013	7/30/2013	8/26/2013	10/8/2013	11/6/2013	8/19/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317001	20130317004	20130515001	20130912001	20130912002	20131112001	20131112002	20130912005
4-tert-Octylphenol	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Oleic acid	μg/L			<140	<280	<140	<140	<280	<140	<280	<280
Oxindole	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Palmitic acid	μg/L			<240	<480	<240	<240	<480	<240	<480	<480
Pentacosane	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
sec-Phenethyl alcohol	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Phenol	μg/L	4,000	SWEG	<8	<16	<8	<8	<16	<8	<16	<16
2-Phenoxyethanol	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
N-Phenyl-2-naphthylamine	μg/L	260,000	SWEG	<8	<16	<8	<8	<16	<8	<16	<16
2-Phenyl-2-propanol	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
2-Phenylacetic acid	μg/L			<32	<64	<32	<32	<64	<32	<64	<64
Phenethyl alcohol	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
2-Phenylphenol	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Salicylic Acid	μg/L			<64	<128	<64	<64	<128	<64	<128	<128
trans-Squalene	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
1-Tetradecanol	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Tetramethylsuccinonitrile	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Tetramethyl thiourea	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Tetramethylurea	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Thymol	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
1,3,5-Triallyl-1,3,5-triazine-2,4,6(1H,3H,5H)-trione	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Tributylamine	μg/L	Trialkylamines 400	SWEG	<8	<16	<8	<8	<16	<8	<16	<16
Tributyl phosphate	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Triethyl phosphate	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
Tripropylene glycol monomethyl ether	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Undecanoic acid	μg/L			<48	<96	<48	<48	<96	<48	<96	<96
2-Undecanone	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Valeric acid (Pentanoic acid)	μg/L			<48	<48	<48	<48	<96	<48	<96	<96
Vanillin	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
Acid Extractables-EPA 625 List											
4-Chloro-3-methylphenol	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
2-Chlorophenol	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
2,4-Dichlorophenol	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
2,4-Dimethylphenol	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
2,4-Dinitrophenol	μg/L			<16	<32	<16	NA	NA	<16	<32	NA
2-Methyl-4,6-dinitrophenol	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
2-Nitrophenol	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
4-Nitrophenol	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
Pentachlorophenol	μg/L	1	EPA MCL	<16	<32	<16	<16	<32	<16	<32	<32
Phenol	μg/L	4,000	SWEG	<8	<16	<8	<8	<16	<8	<16	<16
2,4,5-Trichlorophenol	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
2,4,6-Trichlorophenol	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
4-Methylphenol	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Base/Neutral Extractables - EPA 625 List											
Benzidine	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
3,3-Dichlorobenzidine	μg/L			<16	<32	<16	<16	<32	<16	<32	<32
bis-(2-Ethylhexyl)phthalate	μg/L	20,000/6	SWEG/EPA MCL	<8	<16	<8	<8	<16	<8	<16	<16
Benzyl butyl phthalate	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Dibutylphthalate	μg/L	40,000	SWEG	<8	<16	<8	<8	<16	<8	<16	<16
Diethylphthalate	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Dimethylphthalate	μg/L			<8	<16	<8	<8	<16	<8	<16	<16
Di-n-octyl phthalate	μg/L			<16	<32	<16	<16	<32	<16	<32	<32

NA=Not analyzed;
MI=Matrix interference
SWEG - 1000 days (11-2008)

Appendix 3. ISS WPA PWD and RIP Summary of Samples Returned During Expeditions 34 through 37

Mission				Expedition 34		Expedition 35	Expedition 36		Expedition 37		Expedition 36
				Soyuz 32		Soyuz 33	Soyuz 34		Soyuz 35		Soyuz 34
Sample Location		Potable Water		WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Hot	WPA RIP
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Product Water (prior to MF bed R&R)
Sample Date		Level	Level	2/11/2103	2/19/2013	4/8/2013	7/30/2013	8/26/2013	10/8/2013	11/6/2013	8/19/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317001	20130317004	20130515001	20130912001	20130912002	20131112001	20131112002	20130912005
N-Nitrosodimethylamine	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
N-Nitrosodiphenylamine	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
N-Nitrosodi-n-propylamine	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
2,4-Dinitrotoluene	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
2,6-Dinitrotoluene	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
Isophorone	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Nitrobenzene	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
Acenaphthene	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
Acenaphthylene	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
Anthracene	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
Benzo(a)anthracene	µg/L			<16	<32	<16	<16	<32	NA	NA	<32
Benzo(a)pyrene	µg/L	0.2	EPA MCL	<10	<20	<10	<10	<20	<10	<20	<20
Benzo(b)fluoranthene	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Benzo(ghi)perylene	µg/L			<10	<20	<10	<10	<20	<10	<20	<20
Benzo(k)fluoroanthene	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Chrysene	µg/L			<20	<40	<20	<20	<40	<20	<40	<40
Dibenzo(a,h)anthracene	µg/L			<10	<20	<10	<10	<20	<10	<20	<20
Fluoranthene	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Fluorene	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
Indeno(1,2,3-cd)pyrene	µg/L			<10	<20	<10	<10	<20	<10	<20	<20
Naphthalene	µg/L			<40	<80	<40	<40	<80	<40	<80	<80
Phenanthrene	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
Pyrene	µg/L			<8	<16	<8	<8	<16	<8	<16	<16
bis(2-Chloroethyl) ether	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
bis(2-Chloroethoxy) methane	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
bis(2-Chloroisopropyl) ether	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
4-Bromophenyl phenyl ether	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
4-Chlorophenyl phenyl ether	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
2-Chloronaphthalene	µg/L			<16	<32	<16	<16	<32	<16	<32	<32
1,2-Dichlorobenzene	µg/L	600	EPA MCL	<16	<32	<16	<16	<32	<16	<32	<32
1,3-Dichlorobenzene	µg/L	600	EPA MCL	<16	<32	<16	<16	<32	<16	<32	<32
1,4-Dichlorobenzene	µg/L	75	EPA MCL	<16	<32	<16	<16	<32	<16	<32	<32
Hexachlorobenzene	µg/L	30		<16	<32	<16	<16	<32	<16	<32	<32
Hexachlorobutadiene	µg/L	1		<16	<32	<16	<16	<32	<16	<32	<32
Hexachlorocyclopentadiene	µg/L	50	EPA MCL	<16	<32	<16	<16	<32	<16	<32	<32
Hexachloroethane	µg/L	1		<16	<32	<16	<16	<32	<16	<32	<32
1,2,4-Trichlorobenzene	µg/L	70	EPA MCL	<16	<32	<16	<16	<32	<16	<32	<32
Alcohols (DAI/GC/MS)											
1-Butanol	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
2-Butanol	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
Ethanol	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
Methanol	µg/L	40,000	SWEG	<200	<200	<200	<200	<200	<200	<200	<200
2-Methyl-1-butanol	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
2-Methyl-2-butanol	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
3-Methyl-1-butanol (Isopentanol)	µg/L			<300	<300	<300	<300	<300	<300	<300	<300
2-Methyl-1-propanol	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
2-Methyl-2-propanol	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
1-Pentanol (Amyl alcohol)	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
2-Pentanol (sec-Amyl alcohol)	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
3-Pentanol	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
1-Propanol	µg/L			<200	<200	<200	<200	<200	<200	<200	<200
2-Propanol (Isopropanol)	µg/L			<200	<200	<200	<200	<200	<200	<200	<200

NA=Not analyzed;
MI=Matrix interference
SWEG - 1000 days (11-2008)

Appendix 3. ISS WPA PWD and RIP Summary of Samples Returned During Expeditions 34 through 37

Mission				Expedition 34		Expedition 35	Expedition 36		Expedition 37		Expedition 36
				Soyuz 32		Soyuz 33	Soyuz 34		Soyuz 35		Soyuz 34
Sample Location		Potable Water		WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Ambient	WPA PWD Hot	WPA PWD Ambient	WPA PWD Hot	WPA RIP
Sample Description		Maximum Contaminant	Maximum Contaminant	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Potable Water	Product Water (prior to MF bed R&R)
Sample Date		Level	Level	2/11/2103	2/19/2013	4/8/2013	7/30/2013	8/26/2013	10/8/2013	11/6/2013	8/19/2013
Analysis/Sample ID	Units	(MCL)	Source	20130317001	20130317004	20130515001	20130912001	20130912002	20131112001	20131112002	20130912005
Glycols (DAI/GC/MS)											
1,2-Ethanediol (Ethylene glycol)	µg/L	4000	SWEG	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000
1,2-Propanediol (Propylene glycol)	µg/L	1,700,000	SWEG	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000
Silanols (GC/MS & LC/MS/MS) (R&D Method - NIST traceable standard not available)											
Dimethylsilanediol (DMSD)	µg/L	25,000	SWEG	<500	<500	<500	3800	5700	12000	<500	5300
Carboxylates (CE)											
Acetate	µg/L			<625	<625	<625	<625	<625	<625	<625	<625
Formate	µg/L	2,500,000	SWEG	<625	<625	<625	<625	<625	<625	<625	<625
Glycolate	µg/L			<625	<625	<625	<625	<625	<625	<625	<625
Glyoxylate	µg/L			<625	<625	<625	<625	<625	<625	<625	<625
Lactate	µg/L			<625	<625	<625	<625	<625	<625	<625	<625
Oxalate	µg/L			<1250	<1250	<1250	<1250	<1250	<1250	<1250	<1250
Propionate	µg/L			<1250	<1250	<625	<625	<625	<625	<625	MI
Aldehydes											
Formaldehyde	µg/L	12,000/1,000	SWEG/EPA HA	<10	<10	<10	<10	<10	<10	<10	<10
Amines (CE)											
Ethylamine	µg/L	Monoalkylamines 2000	SWEG	<250	<250	<250	<250	<250	<250	<250	<250
Methylamine	µg/L	Monoalkylamines 2000	SWEG	<250	<250	<250	<250	<250	<250	<250	<250
n-Propylamine	µg/L	Monoalkylamines 2000	SWEG	<500	<500	<500	<500	<500	<500	<500	<500
Trimethylamine	µg/L	Trialkylamines 400	SWEG	<500	<500	<500	<500	<500	<500	<500	<500
Non-volatiles (LC/UV-VIS)											
Urea	µg/L			<800	<800	<800	<800	<800	<800	<800	<800
Caprolactam	µg/L	100,000	SWEG	<16	<32	<16	<16	<32	<16	<32	<32
Organic Carbon Recovery	percent			9.64	14.08	14.58	92.85	91.57	110.42	N/A	92.26
Unaccounted Organic Carbon	mg/L			0.13	0.15	0.11	0.08	0.14	0.00	0.00	0.12

NA=Not analyzed;
MI=Matrix interference
SWEG - 1000 days (11-2008)

Updated Kalman Filter to Provide Best Estimated Trajectory of Morpheus

Jake Sullivan

ASEN 6080 – Spring 2014

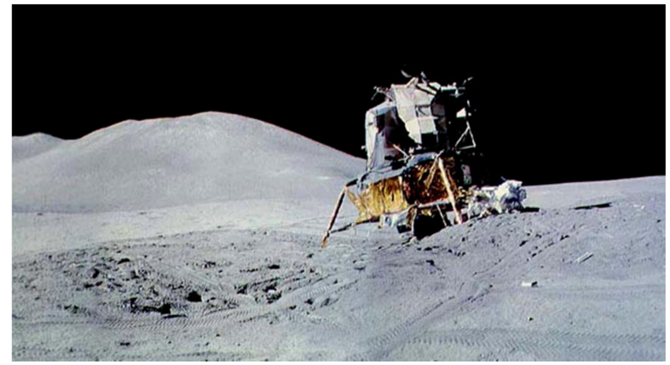
May 6, 2014

Background - Morpheus

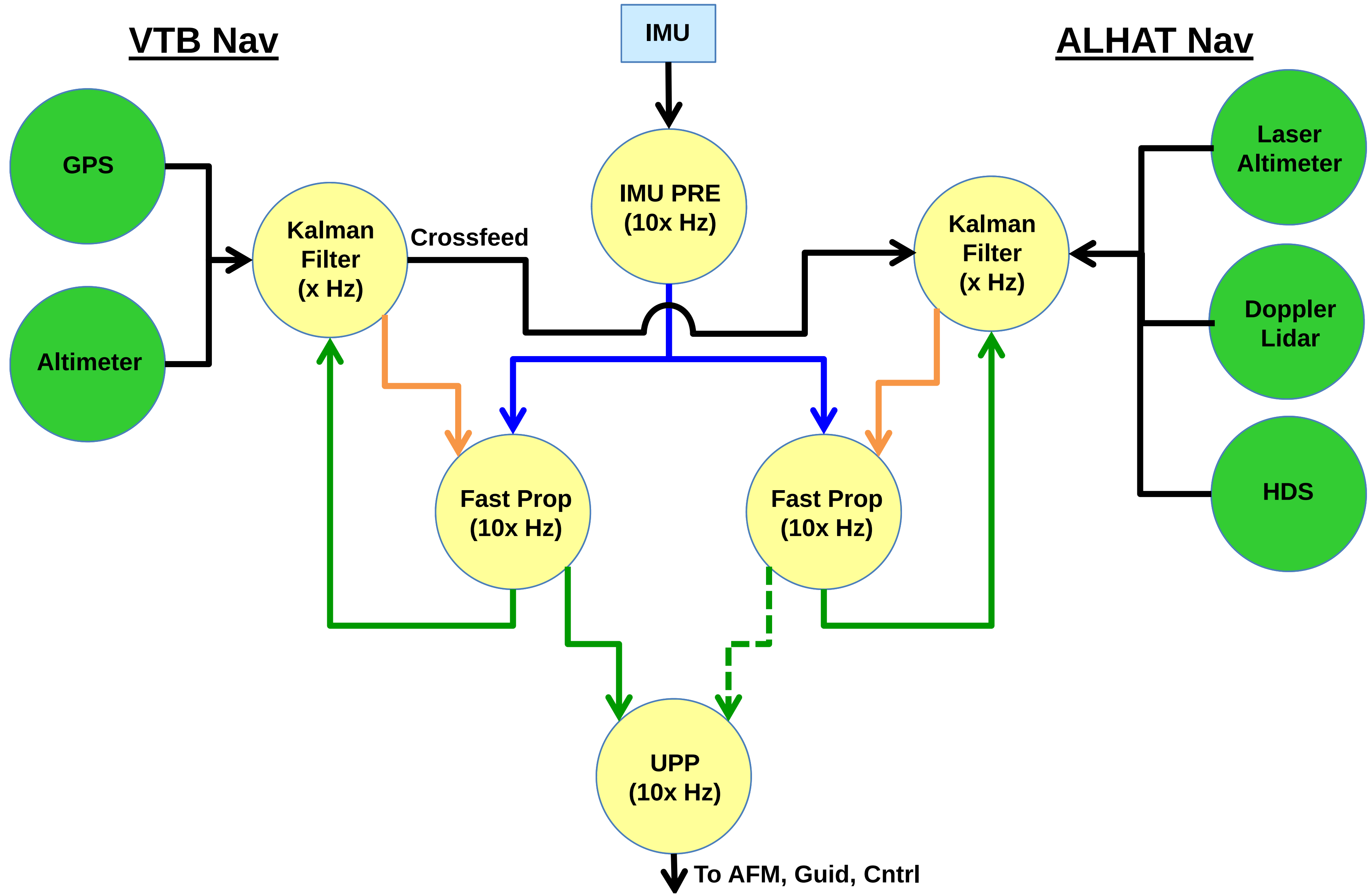
- Vertical Test Bed (VTB) for spacecraft technologies
- 46 test flights since 2011
  - Johnson Space Center (Tether)
  - Kennedy Space Center Shuttle Landing Facility (Tether/Freeflight)
- Provides testing platform for:
  - LOx/Methane Engine/RCS ("green" propellant)
  - Lean Development Practices
  - GN&C Algorithms/Sensors
  - Autonomous Landing and Hazard Avoidance Technology (ALHAT)
    - Primary payload

Background - ALHAT

- Apollo 15 landed ~1 m from crater
  - Surface conditions difficult to judge
- Desire ability to land vehicle precisely
  - Any feasible surface condition
  - Any lighting condition
  - Autonomously
- ALHAT uses three sensors to accompish this:
  - Laser Altimeter (altimetry)
  - Doppler LIDAR (altimetry/velocimetry)
  - Gimballed Flash LIDAR
    - Scans surface
    - Produces Digital Elevation Map (DEM)
    - Provides Hazard Relative Navigation (HRN)
- Testing Objective: TRL-6



Morpheus Navigation Architecture



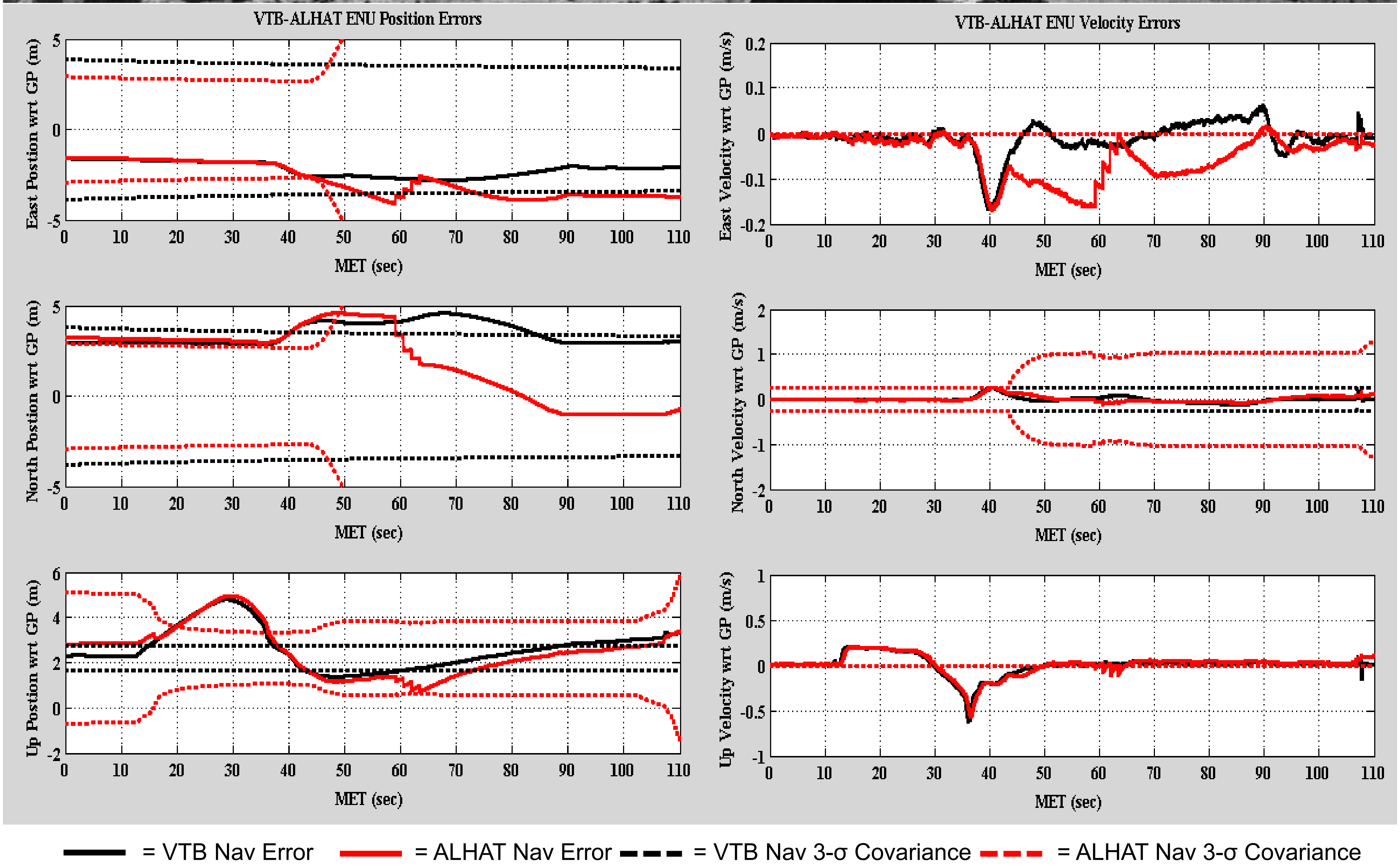
Project Description

- Best Estimated Trajectory (BET) always came from VTB Nav
  - No external measurements, onboard nav state is best estimate
- ALHAT sensors integrated on vehicle in late March
- Project Statement: Modify the Kalman Filter in Morpheus Flight Software to process measurements from ALL the sensors
  - Additional information improves knowledge of the true trajectory
- Test solution from new Kalman Filter against existing solutions from VTB and ALHAT filter in simulation

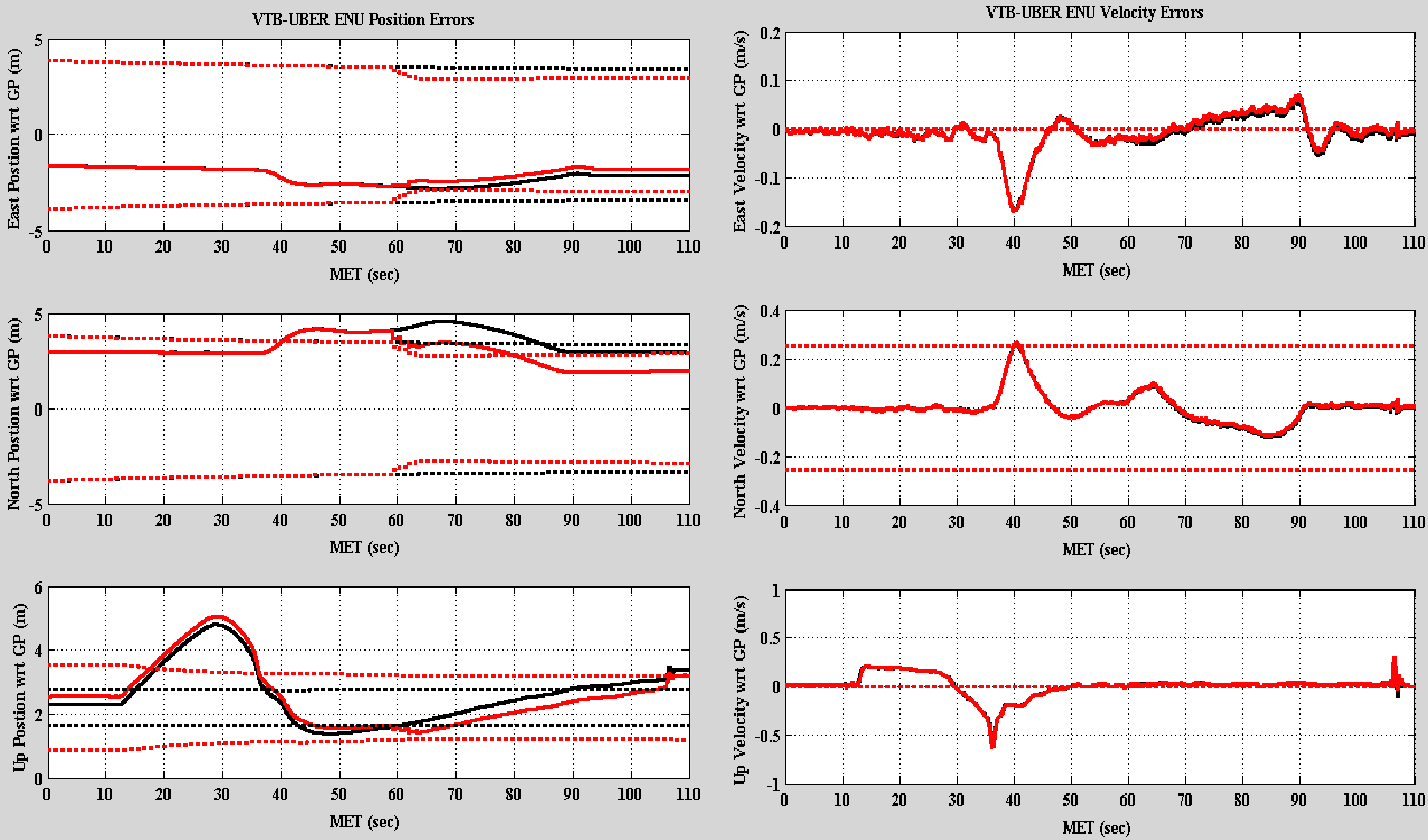
Project Methodology

- Existing Kalman Filter estimates 28 states
  - 3 Inertial position
  - 3 Inertial velocity
  - 3 Attitude
  - 6 IMU bias (gyro and accel)
  - 13 sensor bias (Exponentially Correlated Random Variables)
- Modify the Kalman Filter to handle additional 10 states
  - Reorganize the state vector to insert VTB sensor biases before ALHAT sensor biases, update the pointers so measurement update corrects proper states, regression test
    - Enables new Kalman Filter to run in place of VTB/ALHAT nav
  - Update VTB/ALHAT nav to handle changes (common code)
  - Run trajectory in 6-DOF simulation and compare results

VTB vs. ALHAT ENU Nav Error w/ 3-σ Covariances



VTB vs. UBER ENU Nav Error w/ 3-σ Covariances



= VTB Nav Error = UBER Nav Error = VTB Nav 3-σ Covariance = UBER Nav 3-σ Covariance

Future Work/Video

- Playback utility for flight data in development
  - Run actual data through new filter
- Apply smoother to filtered data to improve estimate
  - Rauch-Tung-Striebel Fixed Interval Smoother (Gelb)
- Freeflight 12 (4/30/2014) Video (2 min - time permitting):
  - http://youtu.be/tmkPJUHYdRA
  - ALHAT HDS correctly identified safe site 1.4 meters east of surveyed landing pad, provided landing site coordinates to Guidance
  - Next flight scheduled for 5/22/2014
- To follow along:
  - http://morpheuslander.jsc.nasa.gov
  - https://twitter.com/morpheuslander