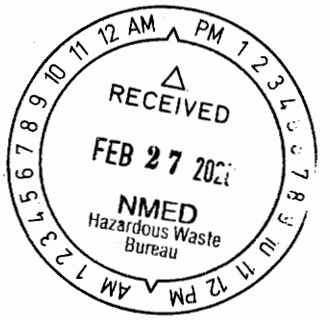
National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
White Sands Test Facility
P.O. Box 20
Las Cruces, NM 88004-0020



February 26, 2020

Reply to Attn of: RE-20-032

Ms. Melanie Sandoval
New Mexico Environment Department
Ground Water Quality Bureau
1190 St. Francis Drive
Santa Fe, NM 87502

Subject: NASA White Sands Test Facility (WSTF) Semi-annual Report for Discharge Permit (DP)-1255 – Second Half of 2019

Enclosed is the NASA WSTF Semi-annual Report for Discharge Permit (DP)-1255 for the second half of 2019. This report provides specific information related to the monitoring of the NASA WSTF Plume Front Treatment System (PFTS) and Mid-plume Interception and Treatment System (MPITS) performed in accordance with DP-1255 during the second half of 2019. The report provides a summary of operational activities, the chemical analytical results of remediation system monitoring, and an evaluation of the health risk of the treated groundwater. This reporting format includes an Executive Summary as Enclosure 1, a paper copy of the report as Enclosure 2, and a PDF version of the report on a CD-ROM as Enclosure 3.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment for knowing violations.

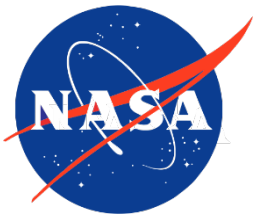
If you have any questions or comments concerning this submittal, please call Antonette Doherty of my staff at 575-524-5497.

Timothy J. Davis
Chief, Environmental Office

3 Enclosures

cc: (with enclosures)
Mr. Kevin Pierard, Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

National Aeronautics and Space Administration



Semi-Annual Report for Discharge Permit (DP)-1255

Second Half of 2019

Report Period: July through December 2019
Report Deadline: March 1, 2020

Executive Summary

The National Aeronautics and Space Administration (NASA) Johnson Space Center White Sands Test Facility (WSTF) is physically located at 12600 NASA Road near Las Cruces, New Mexico. This report provides specific information related to the operation of and activities associated with the NASA WSTF Plume Front Treatment System (PFTS) and Mid-plume Interception and Treatment System (MPITS), presumptive remedy interim corrective actions for groundwater, as they relate to Discharge Plan (DP)-1255 (NMED, 2017). Also included in this report are analytical data from remediation system samples collected between July 1 and December 31, 2019.

The following summarizes events, observations, and/or activities associated with NASA groundwater remediation systems during the second half of 2019 that are relevant to DP-1255:

- All PFTS effluent samples collected during the reporting period met the applicable DP-1255 treatment standards. The carcinogenic risk calculated for individual contaminants of concern (COCs), and the cumulative risk in the effluent, remain below 1.0E-05.
- All MPITS effluent samples collected during the reporting period met the applicable DP-1255 treatment standards. With one exception, the carcinogenic risk calculated for individual COC in the effluent and the cumulative risk remain below 1.0E-05.

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List of Acronyms and Abbreviations

µg/L	Micrograms per liter
607M	Modified EPA Method 607
8260C-LL	Low-level SW-846 Method 8260C
CCV	Continuing Calibration Verification
COC	Contaminant(s) of Concern
DP	Discharge Plan
EPA	Environmental Protection Agency
GC/MS	Gas Chromatography/Mass Spectrometry
gpm	Gallon(s) per minute
HI	Hazard Index
ICV	Initial Calibration Verification
LCS	Laboratory control sample
MDL	Method Detection Limit
Mgal	Million gallons
MPITS	Mid-plume Interception and Treatment System
NASA	National Aeronautics and Space Administration
ND	Not Detected
NDMA	N-nitrosodimethylamine
NDMA-LL	Low-level Analytical Method for NDMA
ng/L	Nanograms per liter
NMED	New Mexico Environment Department
PCE	Tetrachloroethene
PFI	Plume Front Injection
PFTS	Plume Front Treatment System
RAGS	Risk Assessment Guidance for Superfund
RSL	Regional Screening Level
TCE	Trichloroethene
VOC	Volatile Organic Compound
WSTF	NASA Johnson Space Center White Sands Test Facility

1.0 Remediation System Operational Summary

This section briefly discusses activities at the Plume Front Treatment System (PFTS) and Mid-plume Treatment and Interception System (MPITS) as they relate to compliance with Discharge Plan (DP)-1255 (NMED, 2017). More detailed information related to PFTS and MPITS operations, maintenance, and monitoring is provided in the National Aeronautics and Space Administration (NASA) Johnson Space Center White Sands Test Facility (WSTF) Periodic Monitoring Report, which is submitted to the New Mexico Environment Department (NMED) Hazardous Waste Bureau on a quarterly basis under separate cover. PFTS and MPITS operations are summarized in Table 1.1.

2.0 Remediation System Discharge Volumes

DP-1255 requires NASA to meter the volume of treated groundwater discharged to the injection wells and the infiltration basin on a monthly basis and report the volumes in this report (Condition 9; NMED, 2017). The PFTS and MPITS are equipped with totalizing flow meters to monitor the volume of water extracted from the aquifer and discharged following treatment. During the reporting period, NASA recorded flow meter totalizer readings, which were used to calculate monthly discharge volumes to meet DP-1255 and New Mexico Office of the State Engineer requirements.

Table 2.1 provides the volume of treated groundwater discharged to each Plume Front Injection (PFI) well as monitored by totalizing flow meters at each well. Table 2.2 provides the volume of groundwater discharged to grade at each PFI well during routine well maintenance operations. Discharges to grade were below the DP-1255 limit of 10 million gallons (Mgal) per quarter.

Table 2.3 provides the volume of treated groundwater discharged to the Mid-plume infiltration basin as monitored by a totalizing flow meter at the infiltration basin. Discharge to the infiltration basin did not exceed the maximum allowable 288,000 gallons per day specified in DP-1255.

3.0 Remediation System Sampling

DP-1255 requires NASA to collect samples from the PFTS and MPITS influent and effluent for the analysis of N-nitrosodimethylamine (NDMA), tetrachloroethene (PCE), trichloroethene (TCE), and chloroform to ensure concentrations are below tap water screening levels (NMED, 2019). Chemical analytical data from treatment system influent and effluent samples are presented in this report. Table 3.1 and Table 3.2 provide the analytical results from samples collected at the PFTS influent and effluent and compare them to the DP-1255 discharge standards. Table 3.3 and Table 3.4 provide the analytical results from samples collected at the MPITS influent and effluent and compare them to the DP-1255 discharge standards.

Data that do not meet the requirements of the WSTF groundwater chemical analytical program are qualified as indicated in Table 3.5. These data qualifiers may accompany analytical data provided in Table 3.1 through Table 3.4. There were no significant data exceptions during the reporting period.

4.0 Health Risk Evaluation

NASA calculates the potential health risks posed by influent and effluent results for the PFTS and MPITS on a monthly basis for the four contaminants of concern (COCs) identified in DP-1255. The Environmental Protection Agency (EPA) Risk Assessment Guidance for Superfund (RAGS); Volume1 – Human Health Effects Evaluation Manual, Part A (EPA, 1989), the Regional Screening Level (RSL) Users Guide (EPA, 2019b), and the November 2018 version of the EPA RSL tables (EPA, 2019a) are the regulatory health risk guidance documents referenced for PFTS and MPITS health risk and non-

carcinogenic hazard calculations. Appendix A provides the calculations used to determine carcinogenic risk and non-carcinogenic hazard for the influent and effluent concentrations for each of the four COCs.

Treatment system influent and effluent analytical results for sampling events performed between July 1 and December 31, 2019 were compiled and evaluated for carcinogenic risk and non-carcinogenic hazards. Table 4.1 summarizes the analytical methods and evaluation criteria used for health risk and hazard calculations for COC NDMA, chloroform, PCE, and TCE.

As indicated in Table 4.1, chemical analytical methods used for samples collected at the treatment system influent and effluent include SW-846 Method 8260C and low-level SW-846 Method 8260C (8260C-LL) for volatile organic compounds (VOC), and Modified EPA Method 607 (607M) and a low-level analytical method (NDMA-LL) for NDMA. Analytical results for NDMA by 607M are typically reported uncorrected for extraction efficiency in accordance with the method. However, analytical results from 607M are for extraction efficiency for use in calculating health risk in order to provide a more conservative, and therefore more protective, health risk evaluation. Extraction efficiency is equivalent to the laboratory control sample recovery for the analytical batch (consisting of 20 samples or less) associated with each sample and is not sample specific. Method 607M laboratory extraction efficiencies for NDMA ranged from 37 to 97% in results from this reporting period. At sampling locations where NDMA concentrations are expected to be or have been less than 100 ng/L, NDMA-LL with increased sensitivity is used. The low-level analytical method provides significantly lower method detection limits (MDL) for NDMA, allowing a more conservative determination of health risk. A value equal to one-half the MDL was used to calculate conservative estimates of health risk where COCs were not detected (ND; per RAGS, Volume I, Part A, Section 5.3.3).

4.1 PFTS Health Risk

Table 4.2 provides PFTS influent and effluent cumulative carcinogenic risk and health indices (HI) calculated for DP-1255 COC between July 1 and December 31, 2019. Both the risk calculated for individual COC in the effluent and the cumulative risk remain below 1.0E-05. Effluent HI values for this reporting period were well below the target HI of 1.0.

4.2 MPITS Health Risk

Table 4.3 provides MPITS influent and effluent cumulative carcinogenic risk and HIs calculated for DP-1255 COC between July 1 and December 31, 2019. With one exception, the risk calculated for individual COC in the effluent and the cumulative risk remain below 1.0E-05. Both the individual risk for NDMA and the cumulative risk for the July 2019 effluent exceeded the target risk. Duplicate samples for that event showed elevated NDMA concentrations that resulted in the risk exceedance. NDMA detected in an associated field blank (Table 3.3) may indicate that the samples were contaminated during or following collection. The elevated NDMA levels were not observed in subsequent sampling events. Effluent HI values for this reporting period were well below the target HI of 1.0.

5.0 References

EPA. (1989, December). Risk Assessment Guidance for Superfund (RAGS); Volume1 – Human Health Effects Evaluation Manual, Part A Interim Final. Office of Emergency and Remedial Response, Washington D.C. EPA/540/1-89/002.

EPA. (2019a, November). Regional Screening Levels (RSLs) Generic Tables – Resident Tapwater. Retrieved from https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

EPA. (2019b, November). Regional Screening Levels (RSLs) User's Guide. Retrieved from https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide

NMED Hazardous Waste Bureau and Ground Water Quality Bureau. (2019, June [Rev 2]). Risk Assessment Guidance for Site Investigations and Remediation Volume I Soil Screening Guidance for Human Health Risk Assessments. Santa Fe, NM.

NMED Ground Water Quality Bureau. (2017, July 14). Discharge Permit Renewal and Modification, DP-1255, NASA White Sands Testing Facility. Santa Fe, NM.

Tables

Table 1.1 PFTS and MPITS Operation Summary

Month	Plume Front Treatment System		Mid-plume Treatment System	
	Days Operated	Average Flow Rate (gpm)	Days Operated	Average Flow Rate (gpm)
Jul-19	29 of 31	655	30 of 31	9.3
Aug-19	29 of 31	591	30 of 31	9.3
Sep-19	26 of 30	591	30 of 30	9.6
Oct-19	29 of 31	817	31 of 31	7.6
Nov-19	29 of 30	731	30 of 30	8.2
Dec-19	31 of 31	731	31 of 31	6.0

Table 2.1 Treated Groundwater Discharged to Plume Front Injection Wells

Month	PFI-1		PFI-2		PFI-3		PFI-4		Total Monthly Volume (acre-feet)	Total Monthly Volume (Mgal)
	Volume Injected (acre-feet)	Volume Injected (Mgal)	Volume Injected (acre-feet)	Volume Injected (Mgal)	Volume Injected (acre-feet)	Volume Injected (Mgal)	Volume Injected (acre-feet)	Volume Injected (Mgal)		
Jul-19	16.031	5.224	27.099	8.830	25.578	8.335	22.554	7.349	91.262	29.738
Aug-19	18.089	5.894	29.127	9.491	29.530	9.622	23.395	7.623	100.141	32.631
Sep-19	10.967	3.574	20.824	6.786	20.081	6.543	15.983	5.208	67.855	22.111
Oct-19	11.770	3.835	23.438	7.637	22.817	7.435	19.833	6.463	77.858	25.370
Nov-19	12.833	4.182	32.176	10.485	28.887	9.413	24.600	8.016	98.496	32.095
Dec-19	9.895	3.224	37.245	12.136	34.020	11.085	28.055	9.142	109.215	35.588
Well Total	**79.585**	**25.933**	**169.909**	**55.365**	**160.913**	**52.434**	**134.420**	**43.801**		
Total Volume Injected into PFI Wells in the Second Half of 2019									**544.827**	**177.532**

Table 2.2 Treated Groundwater Discharged to Grade at Plume Front

Month	PFI-1 to grade		PFI-2 to grade		PFI-3 to grade		PFI-4 to grade		Volume Discharged to Grade (acre-feet)	Volume Discharged to Grade (gallons)
	Volume Dis-charged (acre-feet)	Volume Dis-charged (gallons)	Volume Dis-charged (acre-feet)	Volume Dis-charged (gallons)	Volume Dis-charged (acre-feet)	Volume Dis-charged (gallons)	Volume Dis-charged (acre-feet)	Volume Dis-charged (gallons)		
Jul-19	0.359	117,000	0.510	166,200	0.465	151,500	0.216	70,400	1.550	505,100
Aug-19	0.226	73,600	0.235	76,600	0.306	99,700	0.146	47,600	0.913	297,500
Sep-19	0.184	60,000	0.179	58,300	0.206	67,100	0.069	22,500	0.638	207,900
3Q19 Discharge	**0.769**	**250,600**	**0.924**	**301,100**	**0.977**	**318,400**	**0.431**	**140,400**	**3.101**	**1,010,500**
Oct-19	0.570	185,700	0.579	188,700	0.665	216,700	0.220	71,700	2.034	662,800
Nov-19	0.287	93,500	0.287	93,500	0.324	105,600	0.208	67,800	1.106	360,400
Dec-19	0.306	99,700	0.360	117,300	0.447	145,700	0.352	114,700	1.465	477,400
4Q19 Discharge	**1.163**	**379,000**	**1.226**	**399,500**	**1.436**	**467,900**	**0.780**	**254,200**	**4.605**	**1,500,600**
Total Volume Discharged to Grade in the Second Half of 2019									**7.706**	**2,511,100**

Table 2.3 Treated Groundwater Discharged to Mid-plume Infiltration Basin

Month	Volume (gallons)	Volume (acre-feet)
Jul-19	480,000	1.473
Aug-19	402,400	1.235
Sep-19	462,400	1.419
3Q19 Discharge	**1,344,800**	**4.127**
Oct-19	418,100	1.283
Nov-19	332,000	1.019
Dec-19	302,100	0.927
4Q19 Discharge	**1,052,200**	**3.229**
Total Volume Discharged to the Infiltration Basin in the Second Half of 2019	**2,397,000**	**7.356**

Table 3.1 PFTS Influent and Effluent Concentrations – Third Quarter 2019

COC	Discharge Standard[1]	Jul-19		Aug-19		Sep-19	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
NDMA (ng/L)	4.91	75[2]	<0.22	58[3]	<0.22	57[4]	<0.22
PCE (µg/L)	40.3	0.73[5] J	<0.21	0.77[5] J	<0.21	0.43 J	<0.21
TCE (µg/L)	2.59	18[5]	<0.20	19[5]	<0.20	14	<0.20
Chloroform (µg/L)	2.29	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24

[1] The discharge standard is the lower of the cancer or noncancer tap water screening level provided in NMED Risk Assessment Guidance for Investigations and Remediation (NMED, 2019).

[2, 3, 4] Modified EPA Method 607 batch-specific laboratory control sample recovery of NDMA: [2] 76%, [3] 34%, [4] 76%.

[5] The result provided is the average of results from duplicate samples collected during the calendar month. Health risk evaluations in Section 4.1 use the average result.

The presence of "<" indicates that the analyte was not detected above the method detection limit.

Data qualifiers ("flags") are defined in Table 3.5.

Table 3.2 PFTS Influent and Effluent Concentrations – Fourth Quarter 2019

COC	Discharge Standard[1]	Oct-19		Nov-19		Dec-19	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
NDMA (ng/L)	4.91	67[2,5]	<0.22	75[3,5]	<0.22	63[4,5]	<0.22
PCE (µg/L)	40.3	0.69 J	<0.21	0.84[5] J	<0.21	0.84[5] J	<0.21
TCE (µg/L)	2.59	19	<0.20	18[5]	<0.20	21[5]	<0.20
Chloroform (µg/L)	2.29	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24

[1] The discharge standard is the lower of the cancer or noncancer tap water screening level provided in NMED Risk Assessment Guidance for Investigations and Remediation (NMED, 2019).

[2, 3, 4] Modified EPA Method 607 batch-specific laboratory control sample recovery of NDMA: [2] 52%, [3] 35%, [4] 31%.

[5] The results provided are the averages of results from duplicate samples collected during the calendar month. Health risk evaluations in Section 4.1 use these average results.

The presence of "<" indicates that the analyte was not detected above the method detection limit.

Data qualifiers ("flags") are defined in Table 3.5.

Table 3.3 MPITS Influent and Effluent Concentrations – Third Quarter 2019

COC	Discharge Standard[1]	Jul-19		Aug-19		Sep-19	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
NDMA (ng/L)	4.91	1,400[2]	2.9[5] FB QD	2,300[3]	<0.23	1,800[4]	<0.22
PCE (µg/L)	40.3	2.0	<0.21	3.3	<0.21	2.1	<0.21
TCE (µg/L)	2.59	41	<0.20	70	<0.20	48	<0.20
Chloroform (µg/L)	2.29	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24

[1] The discharge standard is the lower of the cancer or noncancer tap water screening level provided in NMED Risk Assessment Guidance for Investigations and Remediation (NMED, 2019).

[2, 3, 4] Modified EPA Method 607 batch-specific laboratory control sample recovery of NDMA: [2] 76%, [3] 41%, [4] 76%.

[5] The results provided are the averages of results from duplicate samples collected during the calendar month. Health risk evaluations in Section 4.1 use these average results.

The presence of "<" indicates that the analyte was not detected above the method detection limit.

Data qualifiers ("flags") are defined in Table 3.5.

Table 3.4 MPITS Influent and Effluent Concentrations – Fourth Quarter 2019

COC	Discharge Standard[1]	Oct-19		Nov-19		Dec-19	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
NDMA (ng/L)	4.91	2,600[2]	<0.22	1,800[3]	<0.86[5]	2,500[4]	<0.22
PCE (µg/L)	40.3	4.3	<0.21	2.5	<0.21	4.1	<0.21
TCE (µg/L)	2.59	87	<0.20	47	<0.20	87	<0.20
Chloroform (µg/L)	2.29	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24

[1] The discharge standard is the lower of the cancer or noncancer tap water screening level provided in NMED Risk Assessment Guidance for Investigations and Remediation (NMED, 2019).

[2, 3, 4] Modified EPA Method 607 batch-specific laboratory control sample recovery of NDMA: [2] 52%, [3] 35%, [4] 31%.

The presence of "<" indicates that the analyte was not detected above the method detection limit.

[5] The results provided are the averages of results from duplicate samples collected during the calendar month. Health risk evaluations in Section 4.1 use these average results.

Data qualifiers ("flags") are defined in Table 3.5.

Table 3.5 WSTF Data Qualifiers

Qualifier	Definition
*	User-defined flag. See quality assurance narrative.
A	The result of an analyte for a laboratory control sample (LCS), initial calibration verification (ICV) or continuing calibration verification (CCV) was outside standard limits.
AD	The relative percent difference for analyst (laboratory) duplicates was outside standard limits.
D	The reported result is from a dilution.
EB	The analyte was detected in the equipment blank.
FB	The analyte was detected in the field blank.
G	The result is an estimated value greater than the upper calibration limit.
i	The result, quantitation limit, and/or detection limit may have been affected by matrix interference.
J	The result is an estimated value less than the quantitation limit but greater than or equal to the detection limit.
NA	The value/result was either not analyzed or not applicable.
ND	The analyte was not detected above the detection limit.
Q	The result for a blind control was outside standard limits.
QD	The relative percent difference for a field duplicate was outside standard limits.
R	The result is rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.
RB	The analyte was detected in the method blank.
S	The result was determined by the method of standard addition.
SP	The matrix spike recovery and/or the relative percent difference for matrix spike duplicates was outside standard limits.
T	The sample was analyzed outside the specified holding time or temperature.
TB	The analyte was detected in the trip blank.
TIC	The analyte was tentatively identified by a gas chromatography/mass spectrometry (GC/MS) library search and the amount reported is an estimated value.

Table 4.1 Analytical Methods and Evaluation Criteria used for Health Risk Calculations

Analytical Method		COC	Value used for Risk Calculation
Influent	**Effluent**		
8260C	8260C-LL	Chloroform, PCE, TCE	Monthly mean concentration. If ND, ½ MDL for 8260C or 8260C-LL
607M	NDMA-LL	NDMA	Monthly mean concentration. Influent: NDMA concentrations corrected for extraction efficiency. Effluent: If ND, ½ MDL for NDMA-LL

Table 4.2 Individual and Cumulative Risk and Hazard Values for PFTS Influent/Effluent

Month/Year	Sample Location	NDMA	PCE	TCE	Chloroform	Cumulative Risk	Cumulative Hazard Indices
Jul-19	Influent	6.71E-04	6.51E-08	3.81E-05	5.39E-07	7.10E-04	6.78
	Effluent	9.84E-07	9.37E-09	2.12E-07	5.39E-07	1.74E-06	0.04
Aug-19	Influent	5.19E-04	6.87E-08	4.02E-05	5.39E-07	5.60E-04	6.83
	Effluent	9.84E-07	9.37E-09	2.12E-07	5.39E-07	1.74E-06	0.04
Sept-19	Influent	5.10E-04	3.84E-08	2.96E-05	5.39E-07	5.40E-04	5.25
	Effluent	9.84E-07	9.37E-09	2.12E-07	5.39E-07	1.74E-06	0.04
Oct-19	Influent	5.99E-04	6.16E-08	4.02E-05	5.39E-07	6.40E-04	7.0
	Effluent	9.84E-07	9.37E-09	2.12E-07	5.39E-07	1.74E-06	0.04
Nov-19	Influent	6.71E-04	7.50E-08	3.81E-05	5.39E-07	7.10E-04	6.78
	Effluent	9.84E-07	9.37E-09	2.12E-07	5.39E-07	1.74E-06	0.04
Dec-19	Influent	5.63E-04	7.50E-08	4.44E-05	5.39E-07	6.09E-04	7.53
	Effluent	9.84E-07	9.37E-09	2.12E-07	5.39E-07	1.74E-06	0.04

Table 4.3 Individual and Cumulative Risk and Hazard Values for MPITS Influent/Effluent

Month/Year	Sample Location	NDMA	PCE	TCE	Chloroform	Cumulative Risk	Hazard Indices
Jul-19	Influent	1.25E-02	1.78E-07	8.67E-05	5.39E-07	1.26E-02	34.83
	Effluent	2.59E-05	9.37E-09	2.12E-07	5.39E-07	2.67E-05	0.08
Aug-19	Influent	2.06E-02	2.94E-07	1.48E-04	5.39E-07	2.07E-02	58.03
	Effluent	1.03E-06	9.37E-09	2.12E-07	5.39E-07	1.79E-06	0.04
Sept-19	Influent	1.61E-02	1.87E-07	1.02E-04	5.39E-07	1.62E-02	43.30
	Effluent	9.84E-07	9.37E-09	2.12E-07	5.39E-07	1.74E-06	0.04
Oct-19	Influent	2.33E-02	3.84E-07	1.84E-04	5.39E-07	2.34E-02	68.05
	Effluent	9.84E-07	9.37E-09	2.12E-07	5.39E-07	1.74E-06	0.04
Nov-19	Influent	1.61E-02	2.23E-07	9.94E-05	5.39E-07	1.62E-02	43
	Effluent	7.96E-06	9.37E-09	2.12E-07	5.39E-07	8.45E-06	0.05
Dec-19	Influent	2.24E-02	3.66E-07	1.84E-04	5.39E-07	2.25E-02	66.47
	Effluent	9.84E-07	9.37E-09	2.12E-07	5.39E-07	1.74E-06	0.04

Appendix A
Calculating Carcinogenic Health Risk

Appendix A: Calculating Carcinogenic Health Risk

Calculations and default exposure values for quantifying carcinogenic risk and non-carcinogenic hazard for White Sands Test Facility (WSTF) contaminants of concern (COCs) are based on technical guidance from the Regional Screening Levels (RSLs) User's Guide (updated November 2019) found at https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide.

Calculations included herein include the RSLs (at 1.0E-05 risk) for each exposure route for the individual COC. A risk of 1.0E-05 was back-calculated using the RSL to verify each equation for use on the Plume Front Treatment System (PFTS) and Mid-plume Interception Treatment System (MPITS) influent and effluent COC concentrations.

NDMA Risk Equations verified using RSL (Target Risk [TR] - 1.0E-05) per exposure route. The concentration of water (CW) in each equation is residential adult (RSL) for that exposure route.

Dermal TR

1.0E-05 =

$$\frac{FA(1)\ x\ k_{\rho}\left(\frac{0.000251cm}{hr}\right)\ x\ \left[\frac{ET_{resw-madj-d}\left(\frac{0.6708hr}{event}\right)}{1+B(0.000831)}+2\ x\ r_{event}\left(\frac{0.2733hr}{event}\right)\ x\ \left(\frac{1+3B(0.000831)+3B(0.000831)^2}{\left(1+B(0.000831)\right)^2}\right)\right]\ x\ CW\left(\frac{1.9\mu g}{L}\right)}{\frac{\left(AT_r\left(365\frac{days}{yr}\right)\ x\ LT(70yr)\right)\ x\ \left(\frac{1000\mu g}{mg}\right)}{\left[\frac{CsF_o\left(\frac{51mg}{kg-day}\right)^{-1}}{GIABS(1)}\right]\ x\ DFWM_{res-adj}\left(\frac{8419740\ events-cm^2}{kg}\right)}\ x\ \left(\frac{1000\ cm^3}{L}\right)}$$

Ingestion TR

1.0E-05 =

$$\frac{CsF_o\left(\frac{51mg}{kg-day}\right)^{-1}\ x\ \ IFWM_{res-adj}\left(\frac{1019.9L}{kg}\right)\ x\ CW\left(\frac{0.0049\mu g}{L}\right)}{\left(AT_r\left(365\frac{days}{yr}\right)x\ LT(70yr)\right)\ x\ \left(\frac{1000\mu g}{mg}\right)}$$

Inhalation TR

1.0E-05 =

$$\frac{ET_{r-inh}\left(\frac{24hr}{day}\right)\ x\ \left(\frac{1day}{24hr}\right)\ x\ K\left(\frac{0.5L}{m^3}\right)\ x\ IUR\left(\frac{0.014\ \mu g}{m^3}\right)^{-1}\ x\ \left(ME\ (25{,}200\ days)\right)\ x\ CW\ \left(\frac{0.00145\mu g}{L}\right)}{\left(AT_r\left(365\,\frac{days}{yr}\right)\ x\ LT(70yr)\right)}$$

Calculations used to determine NDMA screening levels (mutagenic) for each exposure route are in the Regional Screening Table Users Guide, Section 4.8.4. The new VOC criteria for the inhalation exposure route are a Henry's Law Constant of 1.0E-05 atm-m3/mole or greater and a vapor pressure greater than 1 mm Hg. The new criteria were established in the November 2019 (revised) edition of the EPA RSL Tapwater Table and User's Guide. Changes are summarized for the November 2019 updated edition here: https://www.epa.gov/risk/regional-screening-levels-rsls-whats-new. NDMA meets the new VOC criteria, thus requiring the calculation of its inhalation risk.

PCE Risk Equations verified using RSL (TR - 1.0E-05) per exposure route. The CW in each equation is RSL (residential adult) for that exposure route.

Dermal TR

1.0E-05=

$$\frac{2\ x\ FA(1)\ x\ k_{\rho}\left(\frac{0.0334cm}{hr}\right)\ x\ \sqrt{\frac{6\ x\ r_{event}\left(\frac{0.8923hr}{event}\right)\ x\ ET_{resw-adj-d}\left(\frac{0.6708hr}{event}\right)}{\pi\ (3.1416)}}\ x\ CW\left(\frac{630\mu g}{L}\right)}{\frac{\left(AT_r\left(\frac{365days}{yr}\right)x\ LT(70yr)\right)x\ \left(\frac{1000\mu g}{mg}\right)}{\left[\frac{CsF_o\left(\frac{0.0021mg-kg}{day}\right)^{-1}}{GIABS(1)}\right]\ x\ DFW_{res-adj}\left(\frac{2721670\ event-cm^2}{kg}\right)}\ x\ \left(\frac{1000\ cm^3}{L}\right)}$$

Ingestion TR

1.0E-05=

$$\frac{CsF_o\left(\frac{0.0021mg-kg}{day}\right)^{-1}\ x\ IFW_{res-adj}\left(\frac{327.95L}{kg}\right)x\ CW\left(\frac{370\mu g}{L}\right)}{AT_r\left(\frac{365days}{yr}\right)\ x\ LT(70yr)\ \ x\ \left(\frac{1000\mu g}{mg}\right)}$$

PCE Risk Equations, continued.

Inhalation TR

1.0E-05 =

$$\frac{EF_r\left(\frac{350days}{yr}\right)\ x\ ED_{resw}\ (26\ yr)\ \ x\ \ ET_{r-inh}\left(\frac{24hr}{day}\right)x\left(\frac{1day}{24\ hr}\right)\ x\ IUR\left(\frac{0.00000026\mu g}{m^3}\right)^{-1}\ x\ K\left(\frac{0.5L}{m^3}\right)x\ CW\left(\frac{220\mu g}{L}\right)}{AT_r\left(\frac{365\ days}{yr}\right)x\ LT(70yr)}$$

Note that $ET_{resw\text{-}adj}$, $DFW_{res\text{-}adj}$, and $IFW_{res\text{-}adj}$ are calculated in the Regional Screening Table Users Guide, Section 4.8.3.

TCE Risk Equations verified using RSL (TR -1.0E-05) per exposure route. The CW in each equation is RSL (residential adult) for that exposure route.

Dermal TR

1.0E-05 =

$$\frac{2\ x\ FA(1)\ x\ \ k_{\rho}\left(\frac{0.0116cm}{hr}\right)\ x\ \sqrt{\frac{6\ x\ r_{event}\left(\frac{0.5723hr}{event}\right)\ x\ ET_{resw-madj-d}\ \left(\frac{0.6708hr}{event}\right)}{\pi\ (3.1416)}}\ x\ CW\left(\frac{72\mu g}{L}\right)}{\left(AT_{r}\left(\frac{365days}{yr}\right)x\ LT\ (70yr)\right)\ x\ \left(\frac{1000\mu g}{mg}\right)} \ x\ \left(\frac{1000\ cm^{3}}{L}\right)$$
$$\left[\frac{CsF_{o}\ \left(\frac{0.046mg-kg}{day}\right)^{-1}}{GIABS(1)}\right]\ x\ \left(\left(CAF_{o}(0.804)\ x\ DFW_{res-adj}\left(\frac{2721670events-cm^{2}}{kg}\right)\right)+\left(MAF_{o}(0.202)x\ DFWM_{res-adj}\left(\frac{8419740\ events-cm^{2}}{kg}\right)\right)\right)$$

Ingestion TR

1.0E-05=

$$\frac{CsF_{o}\ \left(\frac{0.046mg}{kg-day}\right)^{-1}\ x\ \left(\left(CAF_{o}\ (0.804)\right)\ x\ IFW_{res-adj}\ \left(\frac{327.95L}{kg}\right)\right)+\left(MAF_{o}\ (0.202)\ x\ IFWM_{res-adj}\ \left(\frac{1019.9L}{kg}\right)\right)\ x\ CW\left(\frac{12\mu g}{L}\right)}{\left(AT_{r}\left(365\frac{days}{yr}\right)\ x\ \ LT(70yr)\right)\ x\ \left(\frac{1000\mu g}{mg}\right)}$$

TCE Risk Equations, continued.

Inhalation TR

1.0E-05=

$$\frac{ET_{r-inh}\left(\frac{24hr}{day}\right)\ x\ \left(\frac{1day}{24hr}\right)\ x\ K\left(\frac{0.5L}{m^3}\right)\ x\ IUR\left(\frac{0.0000041\ \mu g}{m^3}\right)^{-1}\ x\ \left(CE\ (6880\ days)+ME\ (6149\ days)\right)\ x\ CW\ \left(\frac{9.6\mu g}{L}\right)}{\left(AT_r\left(365\,\frac{days}{yr}\right)\ x\ LT(70yr)\right)}$$

Calculation of Carcinogenic Exposure (CE) and Mutagenic Exposure (ME) =

$$\left(\left(EF_r\left(\frac{350days}{yr}\right)\ x\ ED_{resw}\ (26years)\ x\ CAF_i\ (0.756)\right)\right.$$
$$+\left(\left(\left(ED_{0-2}(2years)x\ EF_{0-2}\left(\frac{350days}{yr}\right)\ x\ \ MAF_i(0.244)\ x\ 10\right)\right.\right.$$
$$+\left(ED_{2-6}(4years)x\ EF_{2-6}\left(\frac{350days}{yr}\right)\ x\ \ MAF_i(0.244)\ x\ 3\right)$$
$$+\left(ED_{6-16}(10years)\ x\ EF_{6-16}\left(\frac{350days}{yr}\right)\ x\ MAF_i(0.244)\ x\ 3\right)$$
$$\left.\left.+\left(ED_{16-26}(10years)\ x\ EF_{16-26}\left(\frac{350days}{yr}\right)\ x\ MAF_i(0.244)\ x\ 1\right)\right)\right)\right)$$

Note that $ET_{resw\text{-}adj}$, $DFW_{res\text{-}adj}$, $DFWM_{res\text{-}adj}$, $IFW_{res\text{-}adj}$, and $IFWM_{res\text{-}adj}$ are calculated in the Regional Screening Table Users Guide, Section 4.8.6; the Carcinogenic Adjustment Factor – oral (CAF_o), Mutagenic Adjustment Factor – oral (MAF_o), Carcinogenic Adjustment Factor – inhalation (CAF_i), and Mutagenic Adjustment Factor – inhalation (MAF_i) are calculated in the Regional Screening Table Users Guide, Section 5.18.

Chloroform carcinogenic risk equations verified using RSL (TR = 1.0E-05) per exposure route. The CW in each equation is RSL (residential adult) for that exposure route.

Dermal TR

1.0E-05 =

$$\frac{2\ x\ FA(1) x\ k_{\rho}\left(\frac{0.00683cm}{hr}\right) x\ \sqrt{\frac{6\ x\ r_{event}\left(\frac{0.4902hr}{event}\right) x\ ET_{resw-adj-d}\left(\frac{0.6708hr}{event}\right)}{\pi\ (3.1416)}}\ x\ CW\left(\frac{280\mu g}{L}\right)}{\frac{\left(AT_r\left(\frac{365days}{yr}\right) x\ LT(70yr)\right)\ x\ \left(\frac{1000\mu g}{mg}\right)}{\left[\frac{CsF_o\left(\frac{0.031mg-kg}{day}\right)^{-1}}{GIABS(1)}\right] x\ DFW_{res-adj}\left(\frac{2721670\ event-cm^2}{kg}\right)}\ x\ \left(\frac{1000cm^3}{L}\right)}$$

Ingestion TR

1.0E-05 =

$$\frac{CsF_o\left(\frac{0.031mg}{kg-day}\right)^{-1}\ x\ IFW_{res-adj}\left(\frac{327.95L}{kg}\right) x\ CW\ \left(\frac{25\mu g}{L}\right)}{AT_r\left(\frac{365days}{yr}\right)\ x\ LT(70yr)\ x\ \left(\frac{1000\mu g}{mg}\right)}$$

Chloroform carcinogenic risk equations, continued.

Inhalation TR

1.0E-05 =

$$\frac{EF_r\left(\frac{350 days}{yr}\right)\ x\ ED_{resw}(26\ yr)\ x\ ET_{r-inh}\ \left(\frac{24 hr}{day}\right)\ x\ \left(\frac{1 day}{24\ hr}\right)\ x\ IUR\left(\frac{0.000023 \mu g}{m^3}\right)^{-1}\ x\ K\left(\frac{0.5 L}{m^3}\right) x\ CW\left(\frac{2.4 \mu g}{L}\right)}{AT_r\left(\frac{365\ days}{yr}\right) x\ LT(70 yr)}$$

Note that $ET_{resw\text{-}adj}$, $DFW_{res\text{-}adj}$, and $IFW_{res\text{-}adj}$ are calculated in the Regional Screening Table Users Guide, Section 4.8.3.

NDMA hazard equations verified using RSL (Target Hazard Quotient [THQ] = 1) per exposure route. The CW in each equation is RSL (residential adult) for that exposure route.

Dermal THQ

$$1 = \frac{FA(1)\ x\ k_{\rho}\left(\frac{0.000251cm}{hr}\right)\ x\ \left[\frac{ET_{reswa-d}\left(\frac{0.71hr}{event}\right)}{1+B(0.000831)} + 2\ x\ r_{event}\left(\frac{0.2733hr}{event}\right)\ x\ \left(\frac{1+3B(0.000831)+3B(0.000831)^2}{\left(1+B(0.000831)\right)^2}\right)\right]\ x\ CW\left(\frac{101\mu g}{L}\right)}{\left(AT_r\left(\frac{365days}{yr}\right)x\ ED_{resw}(26yr)\right)\ x\ \left(\frac{1000\mu g}{mg}\right)\ x\ BW_{reswa}(80kg)} \ x\ \left(\frac{1000\ cm^3}{L}\right)$$
$$\left[\frac{1}{RfD_o}\left(\frac{1}{\left(\frac{0.000008mg-day}{kg}\right)x\ GIABS(1)}\right)\right]\ x\ EV_{reswa}\left(\frac{1\ event}{day}\right)\ x\ ED_{resw}(26yr)\ \ x\ EF_r\left(350\frac{day}{yr}\right)\ x\ SA(20900cm^2)$$

Ingestion THQ

$$1 = \frac{EF_r\left(350\frac{day}{yr}\right)\ x\ ED_{resw}(26yr)\ x\ \frac{1}{RfD_o}\left(\frac{1}{0.000008\ ^{mg}/_{kg-day}}\right)\ x\ IRW_{reswa}\left(\frac{2.5L}{day}\right)\ x\ CW\left(\frac{0.267\mu g}{L}\right)}{AT_r\left(\frac{365days}{yr}\right)\ x\ ED_{resw}(26yr)\ \ x\ BW_{reswa}\ (80kg)\ x\ \left(\frac{1000\mu g}{mg}\right)}$$

NDMA hazard equations, continued.

Inhalation THQ

1 =

$$\frac{EF_r\left(\frac{350days}{yr}\right)\ x\ ED_{resw}(26\ yr)\ \ x\ ET_{r-inh}\left(\frac{24hr}{day}\right)\ x\ \left(\frac{1day}{24\ hr}\right)\ x\ \frac{1}{RfC_i}\left(\frac{1}{0.00004mg/m^3}\right)x\ K\left(\frac{0.5L}{m^3}\right)x\ CW\left(\frac{0.0834\mu g}{L}\right)}{AT_r\left(\frac{365days}{yr}\right)\ x\ ED_{resw}(26yr)\ x\ \left(\frac{1000\mu g}{mg}\right)}$$

The new VOC criteria for the inhalation exposure route are a Henry's Law Constant of 1.0E-05 atm-m3/mole or greater and a vapor pressure greater than 1 mm Hg. The new criteria were established in the November 2019 (revised) edition of the EPA RSL Tapwater Table and User's Guide. Changes for the November 2019 update are summarized for each edition here: https://www.epa.gov/risk/regional-screening-levels-rsls-whats-new. NDMA meets the new VOC criteria, thus requiring the calculation of its inhalation HQ.

PCE non-carcinogenic hazard equations verified using RSL (THQ = 1) per exposure route. The CW in each equation is RSL (residential adult) for that exposure route.

Dermal THQ

$$1 = \frac{2\ x\ FA(1)\ x\ k_{\rho}\left(\frac{0.0334cm}{hr}\right)\ x\ \sqrt{\frac{6\ x\ r_{event}\left(\frac{0.8923hr}{event}\right)\ x\ ET_{reswa-d}\left(\frac{0.71hr}{day}\right)}{\pi\ (3.1416)}}\ x\ CW\left(\frac{326\mu g}{L}\right)}{\left(AT_r\left(\frac{365days}{yr}\right)\ x\ ED_r(26yr)\right)\ x\ \left(\frac{1000\mu g}{mg}\right)\ x\ BW_{reswa}(80kg)} \ x\ \left(\frac{1000cm^3}{L}\right)$$
$$\left[\frac{1}{RfD_o}\left(\frac{1}{\left(\frac{0.006mg-day}{kg}\right)\ x\ GIABS(1)}\right)\right]\ x\ EV_{reswa}\left(\frac{1\ event}{day}\right)\ x\ ED_{resw}(26yr)\ x\ EF_r\left(350\frac{day}{yr}\right)\ x\ SA(20900cm^2)$$

Ingestion THQ

$$1 = \frac{EF_r\left(350\frac{day}{yr}\right)\ x\ ED_{resw}(26y)\ x\ \frac{1}{RfD_o}\left(\frac{1}{0.006\ {}^{mg}/_{kg-day}}\right)\ x\ IRW_a\left(\frac{2.5L}{day}\right)\ x\ CW(\frac{200\mu g}{L})}{AT_r\left(\frac{365days}{yr}\right)\ x\ ED_{resw}(26yr)\ x\ BW_{reswa}\ (80kg)\ x\ \left(\frac{1000\mu g}{mg}\right)}$$

PCE non-carcinogenic hazard equations, continued.

Inhalation THQ

1 =

$$\frac{EF_r\left(\frac{350days}{yr}\right)\ x\ ED_{resw}(26\ yr)\ \ x\ ET_{r-inh}\left(\frac{24hr}{day}\right)\ x\ \left(\frac{1day}{24\ hr}\right)\ x\ \frac{1}{RfC_i}\left(\frac{1}{0.04mg/m^3}\right)x\ K\left(\frac{0.5L}{m^3}\right)x\ CW\left(\frac{83.4\mu g}{L}\right)}{AT_r\left(\frac{365days}{yr}\right)\ x\ ED_{resw}(26yr)\ x\ \left(\frac{1000\mu g}{mg}\right)}$$

TCE non-carcinogenic hazard equations verified using RSL (THQ = 1) per exposure route. The CW in each equation is RSL (residential adult) for that exposure route.

Dermal THQ

$$1 = \frac{2\ x\ FA(1)\ x\ k_{\rho}\left(\frac{0.0116cm}{hr}\right) x \sqrt{\frac{6\ x\ r_{event}\left(\frac{0.5723hr}{event}\right) x\ ET_{reswa-d}\left(\frac{0.71hr}{day}\right)}{\pi\ (3.1416)}}\ x\ CW\left(\frac{97.7\mu g}{L}\right)}{\left[\frac{1}{RfD_o}\left(\frac{1}{\left(\frac{0.0005mg-kg}{day}\right) x\ GIABS(1)}\right)\right] x\ EV_{reswa}\left(\frac{1\ event}{day}\right)\ x\ ED_{resw}(26yr)\ x\ EF_r\left(350\,\frac{day}{yr}\right)\ x\ SA(20900cm^2)} \Bigg/ \frac{\left(AT_r\left(\frac{365days}{yr}\right) x\ ED_{resw}(26yr)\right)\ x\ \left(\frac{1000\mu g}{mg}\right)\ x\ BW_{reswa}(80kg)}{x\ \left(\frac{1000cm^3}{L}\right)}$$

Ingestion THQ

$$1 = \frac{EF_r\left(350\,\frac{day}{yr}\right)\ x\ ED_{resw}(26y)\ x\ \frac{1}{RfD_o}\left(\frac{1}{0.0005\ {}^{mg}/_{kg-day}}\right) x\ IRW_{reswa}\left(\frac{2.5L}{day}\right)\ x\ CW(\frac{16.7\mu g}{L})}{AT_r\left(\frac{365days}{yr}\right)\ x\ ED_{resw}\ (26yr)\ x\ BW_{reswa}(80kg)\ x\left(\frac{1000\mu g}{mg}\right)}$$

TCE non-carcinogenic hazard equations, continued.

Inhalation THQ

1 =

$$\frac{EF_r\left(\frac{350 days}{yr}\right)\ x\ ED_{resw}(26\ yr)\ \ x\ ET_{r-inh}\left(\frac{24hr}{day}\right)x\left(\frac{1day}{24\ hr}\right)\ x\ \frac{1}{RfC_i}\left(\frac{1}{0.002mg/m^3}\right)\ x\ K\left(\frac{0.5L}{m^3}\right)\ x\ CW\left(\frac{4.17\mu g}{L}\right)}{AT_r\left(\frac{365\ days}{yr}\right)\ x\ ED_{resw}(26yr)\ x\ \left(\frac{1000\mu g}{mg}\right)}$$

Chloroform non-carcinogenic hazard equations verified using RSL (THQ = 1) per exposure route. The CW in each equation is RSL (residential adult) for that exposure route.

Dermal THQ

$$1 = \frac{2\ x\ FA(1)\ x\ k_{\rho}\left(\frac{0.00683cm}{hr}\right)\ x\ \sqrt{\frac{6\ x\ r_{event}\left(\frac{0.4902hr}{event}\right)\ x\ ET_{reswa-d}\left(\frac{0.71hr}{day}\right)}{\pi\ (3.1416)}}\ x\ CW\left(\frac{3580\mu g}{L}\right)}{\left(AT_r\left(\frac{365days}{yr}\right)\ x\ ED_{resw}(26yr)\right)\ x\ \left(\frac{1000\mu g}{mg}\right)\ x\ BW_{reswa}(80kg)} \ x\ \left(\frac{1000cm^3}{L}\right)$$
$$\left[\frac{1}{RfD_o}\frac{1}{\left(\frac{0.01mg-kg}{day}\right)\ x\ GIABS(1)}\right]\ x\ EV_{reswa}\left(\frac{1\ event}{day}\right)\ x\ ED_{resw}(26yr)\ \ x\ EF_r\left(350\ \frac{day}{yr}\right)\ x\ SA(20900cm^2)$$

Ingestion THQ

$$1 = \frac{EF_r\left(350\ \frac{day}{yr}\right)\ x\ ED_{resw}(26y)\ x\ \frac{1}{RfD_o}\left(\frac{1}{0.01\ {}^{mg}/_{kg-day}}\right)\ x\ \ IRW_{reswa}\left(\frac{2.5L}{day}\right)\ x\ CW(\frac{334\mu g}{L})}{AT_r\left(\frac{365days}{yr}\right)\ x\ ED_{resw}(26yr)\ x\ BW_{reswa}(80kg)\ x\left(\frac{1000\mu g}{mg}\right)}$$

Chloroform non-carcinogenic hazard equations, continued.

Inhalation THQ

1 =

$$\frac{EF_r\left(\frac{350days}{yr}\right) x\ ED_{resw}(26\ yr)\ x\ ET_{r-inh}\left(\frac{24hr}{day}\right)\ x\ \left(\frac{1day}{24hr}\right)\ x\ \frac{1}{RfC_i}\left(\frac{1}{0.0977mg/m^3}\right)\ x\ K\left(\frac{0.5L}{m^3}\right)\ x\ CW\left(\frac{204\mu g}{L}\right)}{AT_r\left(\frac{365days}{yr}\right)\ x\ ED_{resw}(26yr)\ x\ \left(\frac{1000\mu g}{mg}\right)}$$