Stantec

Memo

To:	Jason Cook	From:	Patrick Vaughan
	Department of Ecology		Portland, OR
File:	Former Bayliner	Date:	August 28, 2019

Reference: Evaluation of PCE Groundwater Trends

Hello Jason;

At your request, Stantec has conducted a statistical evaluation of the concentrations of PCE in groundwater monitoring wells MW-1, MW-4 and MW-8 (the only wells where PCE has been detected during quarterly groundwater monitoring) at the former Bayliner facility in Arlington, WA using the USEPA developed ProUCL version 5.1.

Evaluation of contaminant trends was performed using Mann-Kendall analysis that is provided within the ProUCL software and was performed using a 0.95 confidence coefficient. The results indicate:

- Concentrations of PCE in MW-1 since December 2009, exhibit statistically significant evidence of a decreasing trend;
- There is insufficient statistical evidence of an increasing or decreasing trend of PCE in MW-4 when data is evaluated using a 0.95 confidence coefficient; both the regression slope and Thiel-Sen slope portrayed on the attached graph are less than -0.03. However, a decreasing trend is noted when using a 0.90 confidence coefficient;
- There is insufficient statistical evidence of an increasing or decreasing trend of PCE in MW-8. This results from the relatively stable concentrations of PCE reported since 2011 (mean concentration of 33.23 with a 95UCL concentration of 37 µg/L).

The absence of a significant trend (either up or down) of PCE in wells MW-4 and MW-8 since at least 2011 indicates that any plume associated with these wells can be considered as stable at least at the Ecology-requested confidence coefficient.

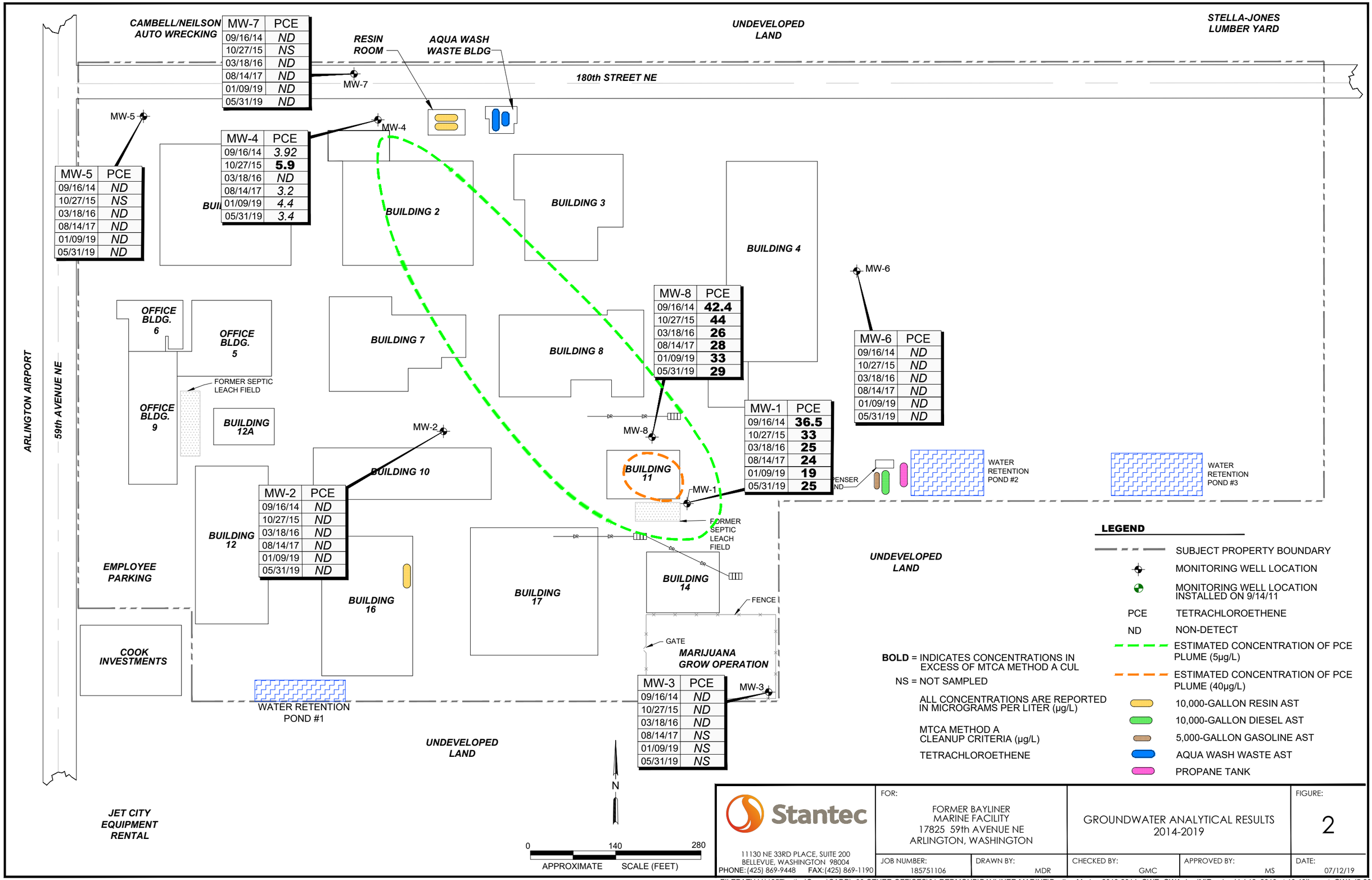
Stantec Consulting Services Inc.

Patrick Vaughan MS, CEM
Principal, Facility Assessment and Indoor Environment

Phone: 971 230 5206
Fax: 503 297 5429
Patrick.Vaughan@stantec.com

Attachment: Attachment

c. C.C.



Stantec

11130 NE 33RD PLACE, SUITE 200
BELLEVUE, WASHINGTON 98004
PHONE:(425) 869-9448 FAX:(425) 869-1190

FOR:
FORMER BAYLINER MARINE FACILITY
17825 59th AVENUE NE
ARLINGTON, WASHINGTON

GROUNDWATER ANALYTICAL RESULTS 2014-2019

FIGURE: 2

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
185751106	MDR	GMC	MS	07/12/19

FILEPATH:V:\1857\active\Secor\CADD_00 OTHER OFFICES\01-REDMOND\BAYLINER MARINE\BaylinerMarine-2013-2014_GWE_GWA.dwg|MiRamirez|Jul 12, 2019 at 10:40|Layout: GWA (5-2019)

Table 1
Summary of Groundwater Monitoring Results
Former Bayliner Marine Facility - Arlington, Washington

Well ID	Sample Date	Depth of Well (feet)	Top of Casing (ft. MSL)	Screen (ft. bgs)		Screen (ft. MSL)		Depth to GW (feet)	GW Elevation (ft. MSL)	Volatile Organic Compounds[1] (VOCs) (µg/L)		
				Top	Bottom	Top	Bottom			Tetrachloroethene (PCE)	Trichloroethene (TCE)	All Remaining VOCs
MW-1	12/10/2009	29.95	129.42	15	30	114.42	99.42	18.89	110.53	**59**	ND	ND
	2/18/2010	29.95	129.42	15	30	114.42	99.42	16.71	112.71	**48**	ND	ND
	5/26/2010	29.95	129.42	15	30	114.42	99.42	16.51	112.91	**50**	ND	ND
	9/9/2010	29.95	129.42	15	30	114.42	99.42	19.22	110.20	**57**	ND	ND
	12/20/2010	29.95	129.42	15	30	114.42	99.42	17.28	112.14	**43**	ND	ND
	9/22/2011	29.95	129.42	15	30	114.42	99.42	16.53	112.89	**32**	ND	ND
	9/6/2013	29.95	129.42	15	30	114.42	99.42	17.05	112.37	**35**	ND	ND
	11/26/2013	29.95	129.42	15	30	114.42	99.42	18.28	111.14	**35**	ND	ND
	6/5/2014	29.95	129.42	15	30	114.42	99.42	13.72	115.70	**30.6**	ND	ND
	9/16/2014	29.95	129.42	15	30	114.42	99.42	18.10	111.32	**36.5**	ND	ND
	10/27/2015	29.95	129.42	15	30	114.42	99.42	20.92	108.50	**33**	ND	ND
	3/18/2016	29.95	129.42	15	30	114.42	99.42	10.65	118.77	**25**	ND	ND
	8/14/2017	29.95	129.42	15	30	114.42	99.42	16.44	112.98	**24**	ND	ND
	1/9/2019	29.95	129.42	15	30	114.42	99.42	16.19	113.23	**19**	ND	ND
	5/31/2019	29.95	129.42	15	30	114.42	99.42	17.24	112.18	**25**	ND	ND
MW-2	12/10/2009	27.25	129.68	15	30	114.68	99.68	20.02	109.66	ND	ND	ND
	2/18/2010	27.25	129.68	15	30	114.68	99.68	17.64	112.04	ND	ND	ND
	5/26/2010	27.25	129.68	15	30	114.68	99.68	17.41	112.27	ND	ND	ND
	9/9/2010	27.25	129.68	15	30	114.68	99.68	18.48	111.20	ND	ND	ND
	12/20/2010	27.25	129.68	15	30	114.68	99.68	18.49	111.19	ND	ND	ND
	9/22/2011	27.25	129.68	15	30	114.68	99.68	16.80	112.88	ND	ND	ND
	9/6/2013	27.25	129.68	15	30	114.68	99.68	17.40	112.28	ND	ND	ND
	11/26/2013	27.25	129.68	15	30	114.68	99.68	18.92	110.76	ND	ND	ND
	6/5/2014	27.25	129.68	15	30	114.68	99.68	14.63	115.05	ND	ND	ND
	9/16/2014	27.25	129.68	15	30	114.68	99.68	18.67	111.01	ND	ND	ND
	10/27/2015	27.25	129.68	15	30	114.68	99.68	21.47	108.21	ND	ND	ND
	3/18/2016	27.25	129.68	15	30	114.68	99.68	11.81	117.87	ND	ND	ND
	8/14/2017	27.25	129.68	15	30	114.68	99.68	16.88	112.80	ND	ND	ND
	1/9/2019	27.25	129.68	15	30	114.68	99.68	17.55	112.13	ND	ND	ND
	5/31/2019	27.25	129.68	15	30	114.68	99.68	18.17	111.51	ND	ND	ND
MW-3	12/10/2009	24.30	129.90	10	25	119.90	104.90	16.89	113.01	ND	ND	ND
	2/18/2010	24.30	129.90	10	25	119.90	104.90	15.02	114.88	ND	ND	ND
	5/26/2010	24.30	129.90	10	25	119.90	104.90	14.85	115.05	ND	ND	ND
	9/9/2010	24.30	129.90	10	25	119.90	104.90	19.20	110.70	ND	ND	ND
	12/20/2010	24.30	129.90	10	25	119.90	104.90	15.28	114.62	ND	ND	ND
	9/22/2011	24.30	129.90	10	25	119.90	104.90	15.39	114.51	ND	ND	ND
	9/6/2013	24.30	129.90	10	25	119.90	104.90	15.89	114.01	ND	ND	ND
	11/26/2013	24.30	129.90	10	25	119.90	104.90	16.77	113.13	ND	ND	ND
	6/5/2014	24.30	129.90	10	25	119.90	104.90	12.24	117.66	ND	ND	ND
	9/16/2014	24.30	129.90	10	25	119.90	104.90	16.70	113.20	ND	ND	ND
	10/27/2015	24.30	129.90	10	25	119.90	104.90	19.57	110.33	ND	ND	ND
	3/18/2016	24.30	129.90	10	25	119.90	104.90	8.95	120.95	ND	ND	ND
	8/14/2017	24.30	129.90	10	25	119.90	104.90	NM	NM	NS	ND	ND
	1/9/2019	24.30	129.90	10	25	119.90	104.90	NM	NM	NS	ND	ND
	5/31/2019	24.30	129.90	10	25	119.90	104.90	NM	NM	NS	ND	ND
MW-4	12/10/2009	28.40	130.42	15	30	115.42	100.42	21.20	109.22	**13**	**16**	ND
	2/18/2010	28.40	130.42	15	30	115.42	100.42	18.55	111.87	**5.3**	ND	ND
	5/26/2010	28.40	130.42	15	30	115.42	100.42	18.24	112.18	**5**	ND	ND
	9/9/2010	28.40	130.42	15	30	115.42	100.42	19.79	110.63	**5.2**	ND	ND
	12/20/2010	28.40	130.42	15	30	115.42	100.42	19.62	110.80	**7.7**	ND	ND
	9/22/2011	28.40	130.42	15	30	115.42	100.42	17.10	113.32	2.4	ND	ND
	9/6/2013	28.40	130.42	15	30	115.42	100.42	17.74	112.68	ND	ND	ND
	11/26/2013	28.40	130.42	15	30	115.42	100.42	19.61	110.81	3.1	ND	ND
	6/5/2014	28.40	130.42	15	30	115.42	100.42	15.26	115.16	1.73	ND	ND
	9/16/2014	28.40	130.42	15	30	115.42	100.42	19.25	111.17	3.92	ND	ND
	10/27/2015	28.40	130.42	15	30	115.42	100.42	23.16	107.26	**5.9**	ND	ND
	3/18/2016	28.40	130.42	15	30	115.42	100.42	12.47	117.95	ND	ND	ND
	8/14/2017	28.40	130.42	15	30	115.42	100.42	17.22	113.20	3.2	ND	ND
	1/9/2019	28.40	130.42	15	30	115.42	100.42	18.55	111.87	4.4	ND	ND
	5/31/2019	28.40	130.42	15	30	115.42	100.42	18.98	111.44	3.4	ND	ND
MTCA Method A Cleanup Level										5	5	See comments

Table 1
Summary of Groundwater Monitoring Results
Former Bayliner Marine Facility - Arlington, Washington

Well ID	Sample Date	Depth of Well (feet)	Top of Casing (ft. MSL)	Screen (ft. bgs)		Screen (ft. MSL)		Depth to GW (feet)	GW Elevation (ft. MSL)	Volatile Organic Compounds[1] (VOCs) (µg/L)		
				Top	Bottom	Top	Bottom			Tetrachloroethene (PCE)	Trichloroethene (TCE)	All Remaining VOCs
MW-5	12/10/2009	33.95	130.39	20	35	110.39	95.39	21.96	108.43	ND	ND	ND
	2/18/2010	33.95	130.39	20	35	110.39	95.39	19.45	110.94	ND	ND	ND
	5/26/2010	33.95	130.39	20	35	110.39	95.39	19.17	111.22	ND	ND	ND
	9/9/2010	33.95	130.39	20	35	110.39	95.39	20.50	109.89	ND	ND	ND
	12/20/2010	33.95	130.39	20	35	110.39	95.39	20.38	110.01	ND	ND	ND
	9/22/2011	33.95	130.39	20	35	110.39	95.39	17.91	112.48	ND	ND	ND
	9/6/2013	33.95	130.39	20	35	110.39	95.39	18.16	112.23	3.1	ND	ND
	11/26/2013	33.95	130.39	20	35	110.39	95.39	20.37	110.02	ND	ND	ND
	6/5/2014	33.95	130.39	20	35	110.39	95.39	16.36	114.03	ND	ND	ND
	9/16/2014	33.95	130.39	20	35	110.39	95.39	20.07	110.32	ND	ND	ND
	3/18/2016	33.95	130.39	20	35	110.39	95.39	13.76	116.63	ND	ND	ND
	8/14/2017	33.95	130.39	20	35	110.39	95.39	18.09	112.30	ND	ND	ND
	1/9/2019	33.95	130.39	20	35	110.39	95.39	19.51	110.88	ND	ND	ND
	5/31/2019	33.95	130.39	20	35	110.39	95.39	19.91	110.48	ND	ND	ND
MW-6	2/19/2010	25.00	130.39	15	25	114.59	104.59	16.68	113.71	ND	ND	ND
	5/26/2010	25.00	130.39	15	25	114.59	104.59	16.51	113.88	ND	ND	ND
	9/9/2010	25.00	130.39	15	25	114.59	104.59	19.21	111.18	ND	ND	ND
	12/20/2010	25.00	130.39	15	25	114.59	104.59	16.40	113.99	ND	ND	ND
	9/22/2011	25.00	130.39	15	25	114.59	104.59	16.42	113.97	ND	ND	ND
	9/6/2013	25.00	130.39	15	25	114.59	104.59	16.99	113.40	ND	ND	ND
	11/26/2013	25.00	130.39	15	25	114.59	104.59	17.85	112.54	ND	ND	ND
	6/5/2014	25.00	130.39	15	25	114.59	104.59	13.51	116.88	ND	ND	ND
	9/16/2014	25.00	130.39	15	25	114.59	104.59	17.92	112.47	ND	ND	ND
	10/27/2015	25.00	130.39	15	25	114.59	104.59	20.99	109.40	ND	ND	ND
	3/18/2016	25.00	130.39	15	25	114.59	104.59	9.76	120.63	ND	ND	ND
	8/14/2017	25.00	130.39	15	25	114.59	104.59	16.62	113.77	ND	ND	ND
	1/9/2019	25.00	130.39	15	25	114.59	104.59	15.93	114.46	ND	ND	ND
	5/31/2019	25.00	130.39	15	25	114.59	104.59	17.55	112.84	ND	ND	ND
MW-7	2/19/2010	30.00	131.27	15	30	116.27	101.27	19.90	111.37	ND	ND	ND
	5/26/2010	30.00	131.27	15	30	116.27	101.27	19.61	111.66	ND	ND	ND
	9/9/2010	30.00	131.27	15	30	116.27	101.27	21.13	110.14	ND	ND	ND
	12/20/2010	30.00	131.27	15	30	116.27	101.27	20.89	110.38	ND	ND	ND
	9/22/2011	30.00	131.27	15	30	116.27	101.27	18.38	112.89	ND	ND	ND
	9/6/2013	30.00	131.27	15	30	116.27	101.27	18.85	112.42	ND	ND	ND
	11/26/2013	30.00	131.27	15	30	116.27	101.27	20.92	110.35	ND	ND	ND
	6/5/2014	30.00	131.27	15	30	116.27	101.27	16.62	114.65	ND	ND	ND
	9/16/2014	30.00	131.27	15	30	116.27	101.27	20.57	110.70	ND	ND	ND
	3/18/2016	30.00	131.27	15	30	116.27	101.27	13.80	117.47	ND	ND	ND
	8/14/2017	30.00	131.27	15	30	116.27	101.27	18.51	112.76	ND	ND	ND
	1/9/2019	30.00	131.27	15	30	116.27	101.27	18.89	112.38	ND	ND	ND
	5/31/2019	30.00	131.27	15	30	116.27	101.27	20.37	110.90	ND	ND	ND
MW-8	9/22/2011	26.70	NM	12	27	NM	NM	16.76	NM	**25**	ND	ND
	9/6/2013	26.70	NM	12	27	NM	NM	17.32	NM	**34**	ND	ND
	11/26/2013	26.70	NM	12	27	NM	NM	18.67	NM	**34**	ND	ND
	6/5/2014	26.70	NM	12	27	NM	NM	NM	NM	**36.9**	ND	ND
	9/16/2014	26.70	NM	12	27	NM	NM	18.42	NM	**42.4**	ND	ND
	10/27/2015	26.70	NM	12	27	NM	NM	21.29	NM	**44**	ND	ND
	3/18/2016	26.70	NM	12	27	NM	NM	10.09	NM	**26**	ND	ND
	8/14/2017	26.70	NM	12	27	NM	NM	16.74	NM	**28**	ND	ND
	1/9/2019	26.70	NM	12	27	NM	NM	17.80	NM	**33**	ND	ND
	5/31/2019	26.70	NM	12	27	NM	NM	17.74	NM	**29**	ND	ND
MTCA Method A Cleanup Level										5	5	See comments

[1] = VOCs analyzed via United States Environmental Protection Agency Method 8260B
ND = Non Detect at the laboratory's Reported Detection Limit; all reporting limits are below MTCA Method A Cleanup Level
NS = Not Sampled
NM = Not Measured
MTCA - Model Toxics Control Act
ft. bgs = feet below ground surface
ft. MSL = feet above mean sea level
(µg/L) = micrograms per liter

	Mann-Kendall Trend Test Analysis	
User Selected Options		
Date/Time of Computation	ProUCL 5.18/28/2019 11:14:34 AM	
From File	WorkSheet.xls	
Full Precision	OFF	
Confidence Coefficient	0.95	
Level of Significance	0.05	

PCE MW-1

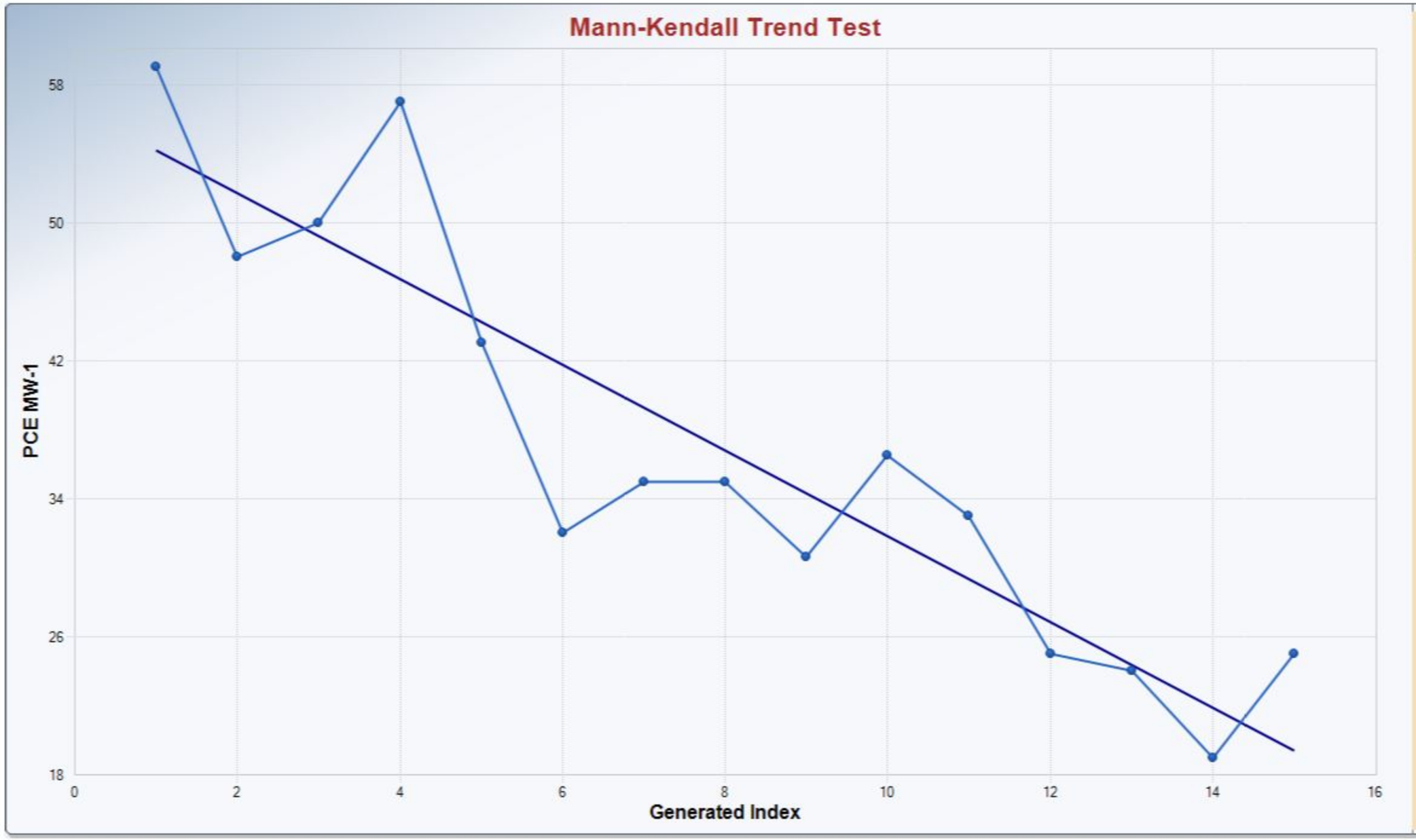
General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	15
Number Values Reported (n)	15
Minimum	19
Maximum	59
Mean	36.81
Geometric Mean	34.97
Median	35
Standard Deviation	12.19
Coefficient of Variation	0.331

Mann-Kendall Test

M-K Test Value (S)	-77
Tabulated p-value	0
Standard Deviation of S	20.16
Standardized Value of S	-3.77
Approximate p-value	8.1536E-5

Statistically significant evidence of a decreasing trend at the specified level of significance.



Mann-Kendall Trend Analysis

n	15
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	20.1577
Standardized Value of S	-3.7703
M-K Test Value (S)	-77
Tabulated p-value	0.0000
Approximate p-value	0.0001

OLS Regression Line (Blue)

OLS Regression Slope	-2.4836
OLS Regression Intercept	56.6752

Statistically significant evidence of a decreasing trend at the specified level of significance.

	Mann-Kendall Trend Test Analysis	
User Selected Options		
Date/Time of Computation	ProUCL 5.18/28/2019 11:15:39 AM	
From File	WorkSheet.xls	
Full Precision	OFF	
Confidence Coefficient	0.95	
Level of Significance	0.05	

PCE MW-4

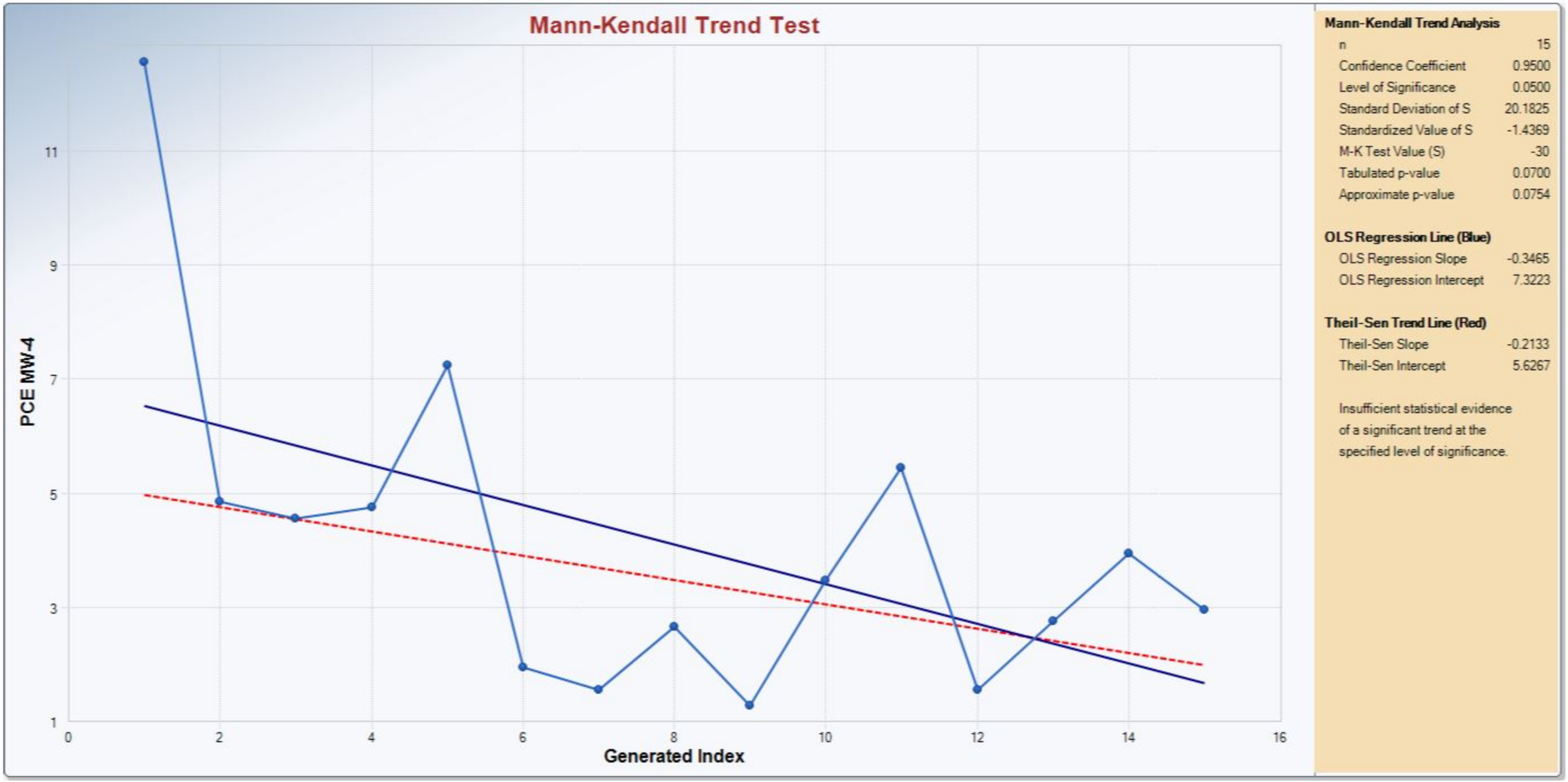
General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	15
Number Values Reported (n)	15
Minimum	1.73
Maximum	13
Mean	4.55
Geometric Mean	3.918
Median	3.92
Standard Deviation	2.873
Coefficient of Variation	0.631

Mann-Kendall Test

M-K Test Value (S)	-30
Tabulated p-value	0.07
Standard Deviation of S	20.18
Standardized Value of S	-1.437
Approximate p-value	0.0754

Insufficient evidence to identify a significant trend at the specified level of significance.



Mann-Kendall Trend Analysis

n	15
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	20.1825
Standardized Value of S	-1.4369
M-K Test Value (S)	-30
Tabulated p-value	0.0700
Approximate p-value	0.0754

OLS Regression Line (Blue)

OLS Regression Slope	-0.3465
OLS Regression Intercept	7.3223

Theil-Sen Trend Line (Red)

Theil-Sen Slope	-0.2133
Theil-Sen Intercept	5.6267

Insufficient statistical evidence of a significant trend at the specified level of significance.

Mann-Kendall Trend Test Analysis		
User Selected Options		
Date/Time of Computation	ProUCL 5.18/28/2019 11:16:10 AM	
From File	WorkSheet.xls	
Full Precision	OFF	
Confidence Coefficient	0.95	
Level of Significance	0.05	

PCE MW-8

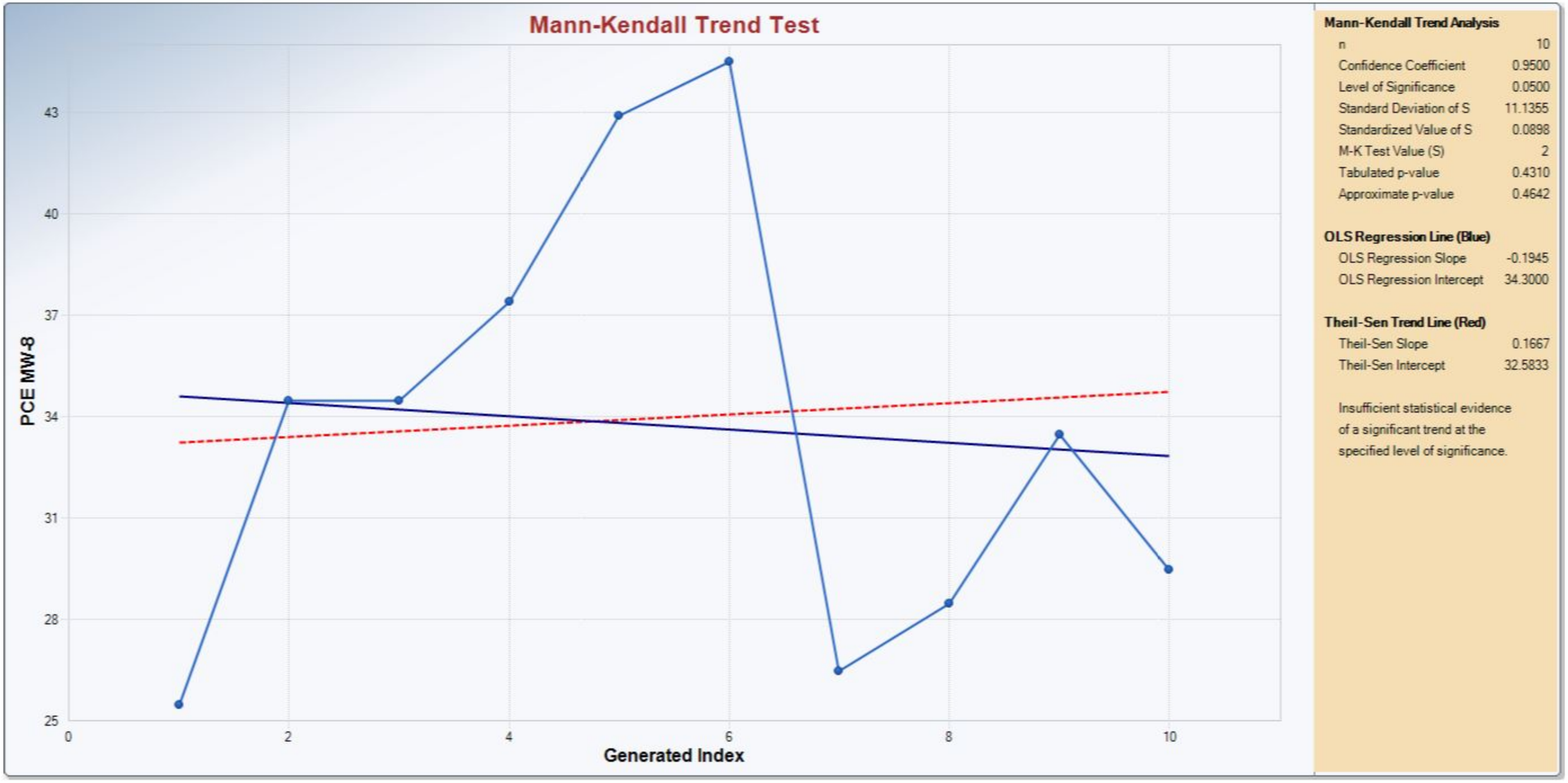
General Statistics

Number or Reported Events Not Used	0
Number of Generated Events	10
Number Values Reported (n)	10
Minimum	25
Maximum	44
Mean	33.23
Geometric Mean	32.67
Median	33.5
Standard Deviation	6.498
Coefficient of Variation	0.196

Mann-Kendall Test

M-K Test Value (S)	2
Tabulated p-value	0.431
Standard Deviation of S	11.14
Standardized Value of S	0.0898
Approximate p-value	0.464

Insufficient evidence to identify a significant trend at the specified level of significance.



Mann-Kendall Trend Analysis

n	10
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	11.1355
Standardized Value of S	0.0898
M-K Test Value (S)	2
Tabulated p-value	0.4310
Approximate p-value	0.4642

OLS Regression Line (Blue)

OLS Regression Slope	-0.1945
OLS Regression Intercept	34.3000

Theil-Sen Trend Line (Red)

Theil-Sen Slope	0.1667
Theil-Sen Intercept	32.5833

Insufficient statistical evidence of a significant trend at the specified level of significance.

1	**UCL Statistics for Data Sets with Non-Detects**	
2		
3	User Selected Options	
4	Date/Time of Computation	ProUCL 5.18/28/2019 11:11:14 AM
5	From File	WorkSheet.xls
6	Full Precision	OFF
7	Confidence Coefficient	95%
8	Number of Bootstrap Operations	2000
9		
10		
11	**PCE MW-1**	
12		
13	**General Statistics**	

14	Total Number of Observations	15	Number of Distinct Observations	13
15			Number of Missing Observations	0
16	Minimum	19	Mean	36.81
17	Maximum	59	Median	35
18	SD	12.19	Std. Error of Mean	3.148
19	Coefficient of Variation	0.331	Skewness	0.53
20				
21	**Normal GOF Test**			
22	Shapiro Wilk Test Statistic	0.94	**Shapiro Wilk GOF Test**	
23	5% Shapiro Wilk Critical Value	0.881	Data appear Normal at 5% Significance Level	
24	Lilliefors Test Statistic	0.177	**Lilliefors GOF Test**	
25	5% Lilliefors Critical Value	0.22	Data appear Normal at 5% Significance Level	
26	**Data appear Normal at 5% Significance Level**			
27				
28	**Assuming Normal Distribution**			
29	**95% Normal UCL**		**95% UCLs (Adjusted for Skewness)**	
30	95% Student's-t UCL	42.35	95% Adjusted-CLT UCL (Chen-1995)	42.44
31			95% Modified-t UCL (Johnson-1978)	42.42
32				
33	**Gamma GOF Test**			
34	A-D Test Statistic	0.27	**Anderson-Darling Gamma GOF Test**	
35	5% A-D Critical Value	0.737	Detected data appear Gamma Distributed at 5% Significance Level	
36	K-S Test Statistic	0.135	**Kolmogorov-Smirnov Gamma GOF Test**	
37	5% K-S Critical Value	0.222	Detected data appear Gamma Distributed at 5% Significance Level	
38	**Detected data appear Gamma Distributed at 5% Significance Level**			
39				
40	**Gamma Statistics**			
41	k hat (MLE)	9.921	k star (bias corrected MLE)	7.981
42	Theta hat (MLE)	3.71	Theta star (bias corrected MLE)	4.612
43	nu hat (MLE)	297.6	nu star (bias corrected)	239.4
44	MLE Mean (bias corrected)	36.81	MLE Sd (bias corrected)	13.03
45			Approximate Chi Square Value (0.05)	204.6
46	Adjusted Level of Significance	0.0324	Adjusted Chi Square Value	200.6
47				
48	**Assuming Gamma Distribution**			
49	95% Approximate Gamma UCL (use when n>=50))	43.07	95% Adjusted Gamma UCL (use when n<50)	43.92
50				
51	**Lognormal GOF Test**			
52	Shapiro Wilk Test Statistic	0.966	**Shapiro Wilk Lognormal GOF Test**	

53				5% Shapiro Wilk Critical Value		0.881	Data appear Lognormal at 5% Significance Level					
54				Lilliefors Test Statistic		0.115	**Lilliefors Lognormal GOF Test**					
55				5% Lilliefors Critical Value		0.22	Data appear Lognormal at 5% Significance Level					
56	**Data appear Lognormal at 5% Significance Level**											
57												
58	**Lognormal Statistics**											
59				Minimum of Logged Data		2.944	Mean of logged Data					3.554
60				Maximum of Logged Data		4.078	SD of logged Data					0.333
61												
62	**Assuming Lognormal Distribution**											
63				95% H-UCL		43.81	90% Chebyshev (MVUE) UCL					46.45
64				95% Chebyshev (MVUE) UCL		50.82	97.5% Chebyshev (MVUE) UCL					56.87
65				99% Chebyshev (MVUE) UCL		68.77						
66												
67	**Nonparametric Distribution Free UCL Statistics**											
68	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
69												
70	**Nonparametric Distribution Free UCLs**											
71				95% CLT UCL		41.98	95% Jackknife UCL					42.35
72				95% Standard Bootstrap UCL		41.78	95% Bootstrap-t UCL					43.53
73				95% Hall's Bootstrap UCL		42.36	95% Percentile Bootstrap UCL					41.65
74				95% BCA Bootstrap UCL		42.17						
75				90% Chebyshev(Mean, Sd) UCL		46.25	95% Chebyshev(Mean, Sd) UCL					50.53
76				97.5% Chebyshev(Mean, Sd) UCL		56.46	99% Chebyshev(Mean, Sd) UCL					68.13
77												
78	**Suggested UCL to Use**											
79				95% Student's-t UCL		42.35						
80												
81	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
82	Recommendations are based upon data size, data distribution, and skewness.											
83	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
84	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
85												
86	**PCE MW-4**											
87												
88	**General Statistics**											
89				Total Number of Observations		15	Number of Distinct Observations					14
90				Number of Detects		13	Number of Non-Detects					2
91				Number of Distinct Detects		13	Number of Distinct Non-Detects					1
92				Minimum Detect		1.73	Minimum Non-Detect					2
93				Maximum Detect		13	Maximum Non-Detect					2
94				Variance Detects		8.381	Percent Non-Detects					13.33%
95				Mean Detects		4.942	SD Detects					2.895
96				Median Detects		4.4	CV Detects					0.586
97				Skewness Detects		1.944	Kurtosis Detects					4.807
98				Mean of Logged Detects		1.469	SD of Logged Detects					0.516
99												
100	**Normal GOF Test on Detects Only**											
101				Shapiro Wilk Test Statistic		0.822	**Shapiro Wilk GOF Test**					
102				5% Shapiro Wilk Critical Value		0.866	Detected Data Not Normal at 5% Significance Level					
103				Lilliefors Test Statistic		0.22	**Lilliefors GOF Test**					
104				5% Lilliefors Critical Value		0.234	Detected Data appear Normal at 5% Significance Level					

105	**Detected Data appear Approximate Normal at 5% Significance Level**											
106												
107	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
108					KM Mean	4.514				KM Standard Error of Mean	0.755	
109					KM SD	2.81				95% KM (BCA) UCL	5.98	
110					95% KM (t) UCL	5.844				95% KM (Percentile Bootstrap) UCL	5.796	
111					95% KM (z) UCL	5.756				95% KM Bootstrap t UCL	6.691	
112					90% KM Chebyshev UCL	6.78				95% KM Chebyshev UCL	7.806	
113					97.5% KM Chebyshev UCL	9.23				99% KM Chebyshev UCL	12.03	
114												
115	**Gamma GOF Tests on Detected Observations Only**											
116					A-D Test Statistic	0.297				**Anderson-Darling GOF Test**		
117					5% A-D Critical Value	0.737				Detected data appear Gamma Distributed at 5% Significance Level		
118					K-S Test Statistic	0.148				**Kolmogorov-Smirnov GOF**		
119					5% K-S Critical Value	0.238				Detected data appear Gamma Distributed at 5% Significance Level		
120	**Detected data appear Gamma Distributed at 5% Significance Level**											
121												
122	**Gamma Statistics on Detected Data Only**											
123					k hat (MLE)	4.039				k star (bias corrected MLE)	3.158	
124					Theta hat (MLE)	1.224				Theta star (bias corrected MLE)	1.565	
125					nu hat (MLE)	105				nu star (bias corrected)	82.12	
126					Mean (detects)	4.942						
127												
128	**Gamma ROS Statistics using Imputed Non-Detects**											
129	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
130	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)											
131	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
132	This is especially true when the sample size is small.											
133	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
134					Minimum	0.321				Mean	4.376	
135					Maximum	13				Median	3.92	
136					SD	3.072				CV	0.702	
137					k hat (MLE)	1.971				k star (bias corrected MLE)	1.621	
138					Theta hat (MLE)	2.22				Theta star (bias corrected MLE)	2.699	
139					nu hat (MLE)	59.12				nu star (bias corrected)	48.63	
140					Adjusted Level of Significance (β)	0.0324						
141					Approximate Chi Square Value (48.63, α)	33.62				Adjusted Chi Square Value (48.63, β)	32.09	
142					95% Gamma Approximate UCL (use when n>=50)	6.329				95% Gamma Adjusted UCL (use when n<50)	6.631	
143												
144	**Estimates of Gamma Parameters using KM Estimates**											
145					Mean (KM)	4.514				SD (KM)	2.81	
146					Variance (KM)	7.897				SE of Mean (KM)	0.755	
147					k hat (KM)	2.58				k star (KM)	2.109	
148					nu hat (KM)	77.4				nu star (KM)	63.26	
149					theta hat (KM)	1.75				theta star (KM)	2.141	
150					80% gamma percentile (KM)	6.716				90% gamma percentile (KM)	8.671	
151					95% gamma percentile (KM)	10.53				99% gamma percentile (KM)	14.64	
152												
153	**Gamma Kaplan-Meier (KM) Statistics**											
154					Approximate Chi Square Value (63.26, α)	45.96				Adjusted Chi Square Value (63.26, β)	44.15	
155					95% Gamma Approximate KM-UCL (use when n>=50)	6.213				95% Gamma Adjusted KM-UCL (use when n<50)	6.468	
156												

157	**Lognormal GOF Test on Detected Observations Only**											
158					Shapiro Wilk Test Statistic	0.981	**Shapiro Wilk GOF Test**					
159					5% Shapiro Wilk Critical Value	0.866	Detected Data appear Lognormal at 5% Significance Level					
160					Lilliefors Test Statistic	0.123	**Lilliefors GOF Test**					
161					5% Lilliefors Critical Value	0.234	Detected Data appear Lognormal at 5% Significance Level					
162	**Detected Data appear Lognormal at 5% Significance Level**											
163												
164	**Lognormal ROS Statistics Using Imputed Non-Detects**											
165					Mean in Original Scale	4.503	Mean in Log Scale	1.339				
166					SD in Original Scale	2.921	SD in Log Scale	0.59				
167					95% t UCL (assumes normality of ROS data)	5.832	95% Percentile Bootstrap UCL	5.806				
168					95% BCA Bootstrap UCL	6.219	95% Bootstrap t UCL	6.49				
169					95% H-UCL (Log ROS)	6.393						
170												
171	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
172					KM Mean (logged)	1.346	KM Geo Mean	3.843				
173					KM SD (logged)	0.558	95% Critical H Value (KM-Log)	2.131				
174					KM Standard Error of Mean (logged)	0.15	95% H-UCL (KM -Log)	6.167				
175					KM SD (logged)	0.558	95% Critical H Value (KM-Log)	2.131				
176					KM Standard Error of Mean (logged)	0.15						
177												
178	**DL/2 Statistics**											
179	**DL/2 Normal**						**DL/2 Log-Transformed**					
180					Mean in Original Scale	4.417	Mean in Log Scale	1.273				
181					SD in Original Scale	3.018	SD in Log Scale	0.704				
182					95% t UCL (Assumes normality)	5.789	95% H-Stat UCL	7.066				
183	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
184												
185	**Nonparametric Distribution Free UCL Statistics**											
186	**Detected Data appear Approximate Normal Distributed at 5% Significance Level**											
187												
188	**Suggested UCL to Use**											
189					95% KM (t) UCL	5.844						
190												
191	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
192	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
193												
194	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
195	Recommendations are based upon data size, data distribution, and skewness.											
196	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
197	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
198												
199												
200	**PCE MW-8**											
201												
202	**General Statistics**											
203					Total Number of Observations	10	Number of Distinct Observations	9				
204							Number of Missing Observations	0				
205					Minimum	25	Mean	33.23				
206					Maximum	44	Median	33.5				
207					SD	6.498	Std. Error of Mean	2.055				
208					Coefficient of Variation	0.196	Skewness	0.464				

209												
210	**Normal GOF Test**											
211					Shapiro Wilk Test Statistic	0.936	**Shapiro Wilk GOF Test**					
212					5% Shapiro Wilk Critical Value	0.842	Data appear Normal at 5% Significance Level					
213					Lilliefors Test Statistic	0.153	**Lilliefors GOF Test**					
214					5% Lilliefors Critical Value	0.262	Data appear Normal at 5% Significance Level					
215	**Data appear Normal at 5% Significance Level**											
216												
217	**Assuming Normal Distribution**											
218	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
219					95% Student's-t UCL	37	95% Adjusted-CLT UCL (Chen-1995)	36.93				
220							95% Modified-t UCL (Johnson-1978)	37.05				
221												
222	**Gamma GOF Test**											
223					A-D Test Statistic	0.271	**Anderson-Darling Gamma GOF Test**					
224					5% A-D Critical Value	0.724	Detected data appear Gamma Distributed at 5% Significance Level					
225					K-S Test Statistic	0.147	**Kolmogorov-Smirnov Gamma GOF Test**					
226					5% K-S Critical Value	0.266	Detected data appear Gamma Distributed at 5% Significance Level					
227	**Detected data appear Gamma Distributed at 5% Significance Level**											
228												
229	**Gamma Statistics**											
230					k hat (MLE)	29.7	k star (bias corrected MLE)	20.86				
231					Theta hat (MLE)	1.119	Theta star (bias corrected MLE)	1.593				
232					nu hat (MLE)	594.1	nu star (bias corrected)	417.2				
233					MLE Mean (bias corrected)	33.23	MLE Sd (bias corrected)	7.276				
234							Approximate Chi Square Value (0.05)	370.8				
235					Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	363.2				
236												
237	**Assuming Gamma Distribution**											
238					95% Approximate Gamma UCL (use when n>=50))	37.38	95% Adjusted Gamma UCL (use when n<50)	38.17				
239												
240	**Lognormal GOF Test**											
241					Shapiro Wilk Test Statistic	0.949	**Shapiro Wilk Lognormal GOF Test**					
242					5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level					
243					Lilliefors Test Statistic	0.131	**Lilliefors Lognormal GOF Test**					
244					5% Lilliefors Critical Value	0.262	Data appear Lognormal at 5% Significance Level					
245	**Data appear Lognormal at 5% Significance Level**											
246												
247	**Lognormal Statistics**											
248					Minimum of Logged Data	3.219	Mean of logged Data	3.487				
249					Maximum of Logged Data	3.784	SD of logged Data	0.193				
250												
251	**Assuming Lognormal Distribution**											
252					95% H-UCL	37.57	90% Chebyshev (MVUE) UCL	39.34				
253					95% Chebyshev (MVUE) UCL	42.11	97.5% Chebyshev (MVUE) UCL	45.95				
254					99% Chebyshev (MVUE) UCL	53.5						
255												
256	**Nonparametric Distribution Free UCL Statistics**											
257	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
258												
259	**Nonparametric Distribution Free UCLs**											
260					95% CLT UCL	36.61	95% Jackknife UCL	37				

	A	B	C	D	E	F	G	H	I	J	K	L
261	95% Standard Bootstrap UCL					36.38	95% Bootstrap-t UCL					37.4
262	95% Hall's Bootstrap UCL					37.8	95% Percentile Bootstrap UCL					36.52
263	95% BCA Bootstrap UCL					36.62						
264	90% Chebyshev(Mean, Sd) UCL					39.39	95% Chebyshev(Mean, Sd) UCL					42.19
265	97.5% Chebyshev(Mean, Sd) UCL					46.06	99% Chebyshev(Mean, Sd) UCL					53.68
266												
267	**Suggested UCL to Use**											
268	95% Student's-t UCL					37						
269												
270	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
271	Recommendations are based upon data size, data distribution, and skewness.											
272	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
273	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
274												