

Supplementary Material

Sanitation Sustainability Index: A Pilot Approach to Develop a Community-Based Indicator for Evaluating Sustainability of Sanitation Systems

Sustainability Evaluation Results for Implementation of Septic Tank and Resource-Oriented Sanitation Systems in South Korea

Including Details of Assumptions and Forecasted Statistical Distributions for All Parameters

Shervin Hashemi

Institute for Environmental Research, Yonsei University College of Medicine,
50-1 Yonsei-ro, Seodaemun-gu, 03722 Seoul, Korea; shervin@yuhs.ac

Oracle Crystal Ball Report

Run Preferences

Number of trials run	1,000,000
Monte Carlo	
Random seed	
Precision control on	
Confidence level	95.00%

Crystal Ball Data

Assumptions	16
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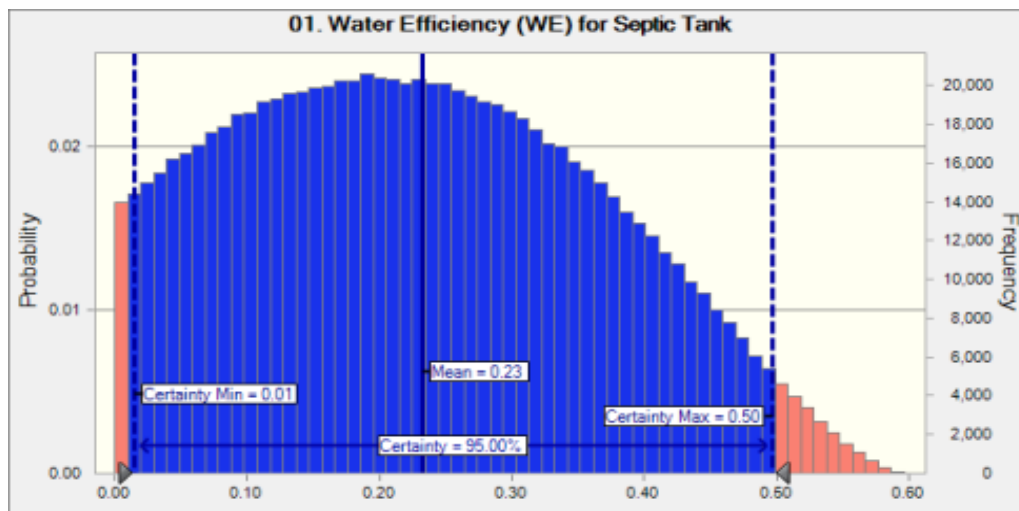
Forecasts

Forecast: 01. Water Efficiency (WE) for Septic Tank

Summary:

Certainty level is 95.0000%
 Certainty range is from 0.01 to 0.50
 Entire range is from 0.00 to 0.60 (filtered)

Base case is 0.20
 After 842,531 trials, the std. error of the mean is 0.00



Statistics:

Trials	842,531
Base Case	0.20
Mean	0.23
Median	0.23
Mode	---
Standard Deviation	0.13
Variance	0.02
Skewness	0.2371
Kurtosis	2.18
Coeff. of Variation	0.5792
Minimum	0.00
Maximum	0.60
Range Width	0.60
Mean Std. Error	0.00
Filtered Values	157469

Forecast values

Percentiles:

5%	0.03
95%	0.47

Forecast values

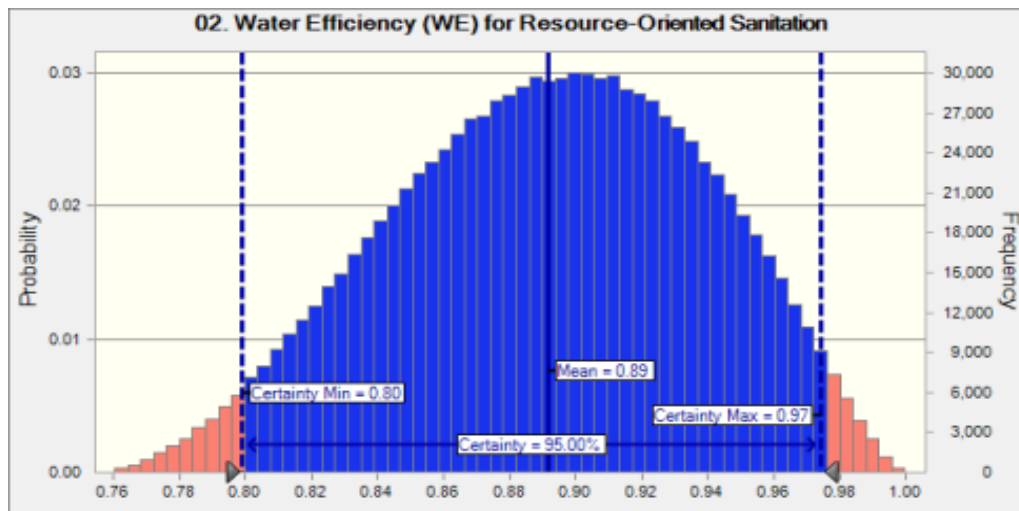
Forecast: 02. Water Efficiency (WE) for Resource-Oriented Sanitation

Summary:

Certainty level is 95.0000%
 Certainty range is from 0.80 to 0.97
 Entire range is from 0.75 to 1.00

Base case is 0.90

After 1,000,000 trials, the std. error of the mean is 0.00



Statistics:

Trials	1,000,000
Base Case	0.90
Mean	0.89
Median	0.89
Mode	---
Standard Deviation	0.05
Variance	0.00
Skewness	-0.1775
Kurtosis	2.38
Coeff. of Variation	0.0525
Minimum	0.75
Maximum	1.00
Range Width	0.25
Mean Std. Error	0.00

Forecast values

Percentiles:

5%	0.81
95%	0.97

Forecast values

Forecast: 03. Energy Efficiency (EE) for Septic Tank

Summary:

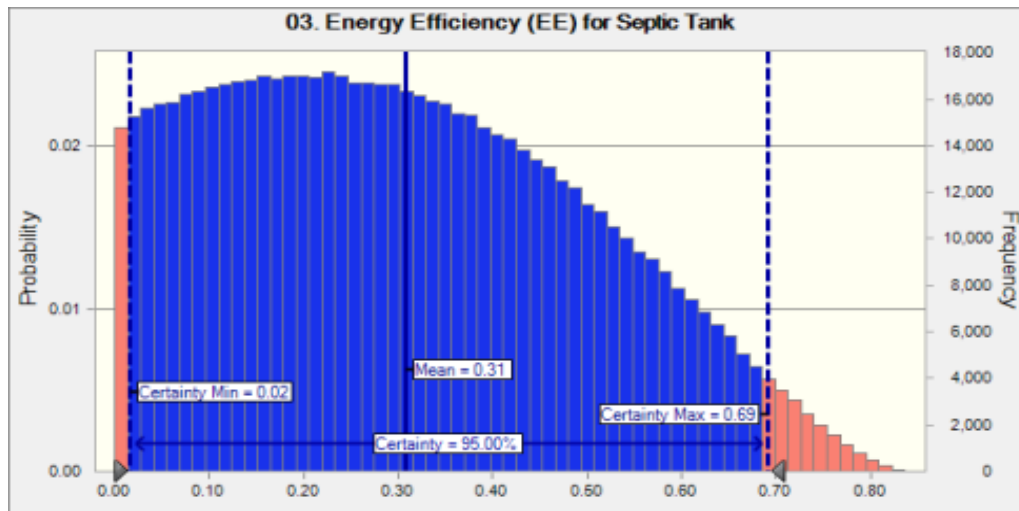
Certainty level is 95.0000%

Certainty range is from 0.02 to 0.69

Entire range is from 0.00 to 0.84 (filtered)

Base case is 0.20

After 699,152 trials, the std. error of the mean is 0.00



Statistics:

Trials
Base Case
Mean
Median
Mode
Standard Deviation
Variance
Skewness
Kurtosis
Coeff. of Variation
Minimum
Maximum
Range Width
Mean Std. Error
Filtered Values

Forecast values

699,152
0.20
0.31
0.29

0.19
0.04
0.3342
2.22
0.6183
0.00
0.84
0.84
0.00
300848

Percentiles:

5%
95%

Forecast values

0.03
0.64

Forecast: 04. Energy Efficiency (EE) for Resource-Oriented Sanitation

Summary:

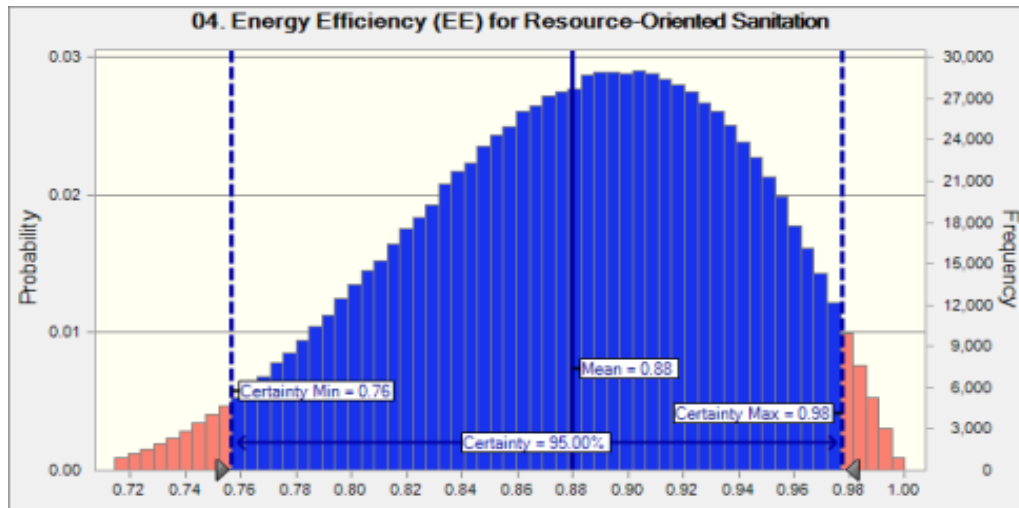
Certainty level is 95.0000%

Certainty range is from 0.76 to 0.98

Entire range is from 0.68 to 1.00

Base case is 0.90

After 1,000,000 trials, the std. error of the mean is 0.00



Statistics:

Trials
Base Case
Mean
Median
Mode
Standard Deviation
Variance
Skewness
Kurtosis
Coeff. of Variation
Minimum
Maximum
Range Width
Mean Std. Error

Forecast values

1,000,000
0.90
0.88
0.88

0.06
0.00
-0.3462
2.50
0.0671
0.68
1.00
0.32
0.00

Percentiles:

5%
95%

Forecast values

0.77
0.97

Forecast: 05. Capital Cost Index (CCI) for Septic Tank

Summary:

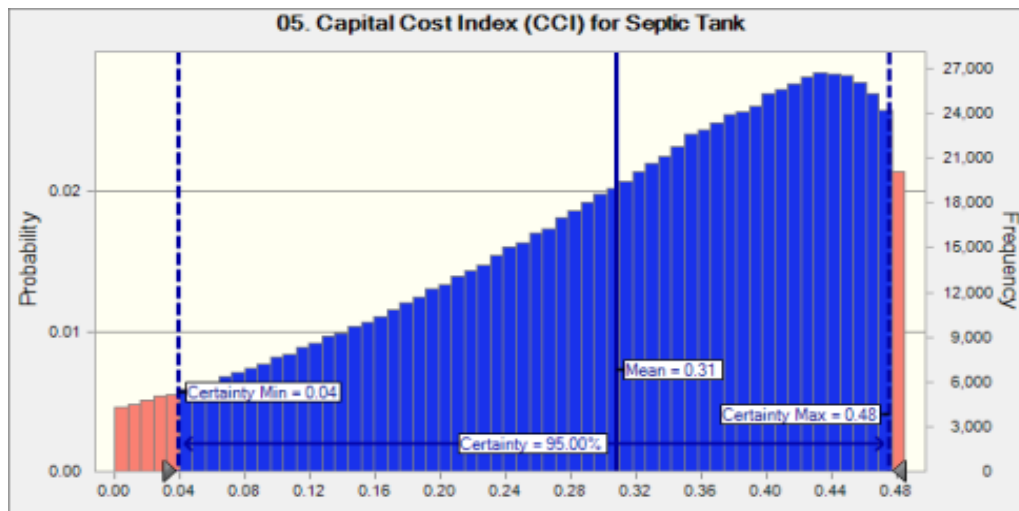
Certainty level is 95.0000%

Certainty range is from 0.04 to 0.48

Entire range is from 0.00 to 0.49 (filtered)

Base case is 0.44

After 938,000 trials, the std. error of the mean is 0.00



Statistics:

Trials	938,000
Base Case	0.44
Mean	0.31
Median	0.33
Mode	---
Standard Deviation	0.12
Variance	0.02
Skewness	-0.5908
Kurtosis	2.40
Coeff. of Variation	0.3996
Minimum	0.00
Maximum	0.49
Range Width	0.49
Mean Std. Error	0.00
Filtered Values	62000

Forecast values

Percentiles:

5%	0.07
95%	0.47

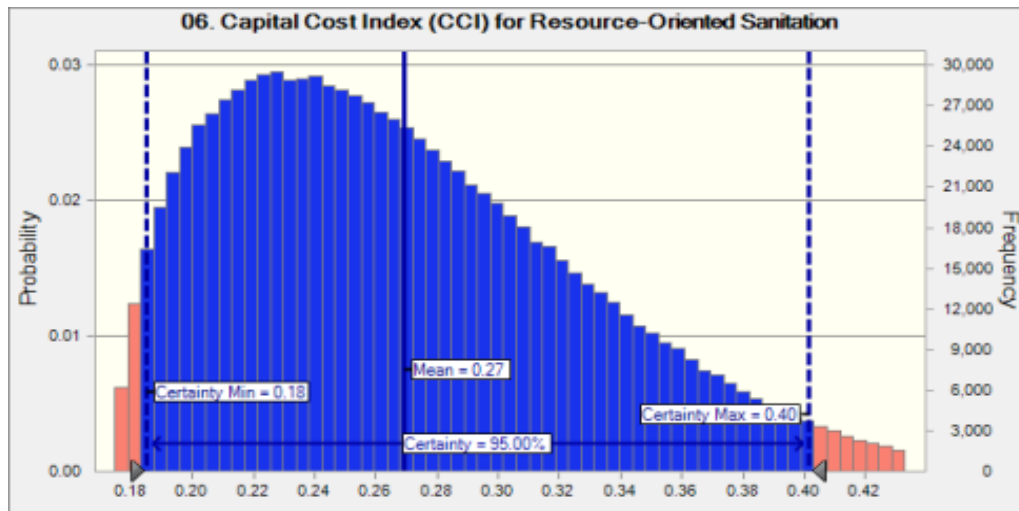
Forecast: 06. Capital Cost Index (CCI) for Resource-Oriented Sanitation

Summary:

Certainty level is 95.0000%
 Certainty range is from 0.18 to 0.40
 Entire range is from 0.17 to 0.51

Base case is 0.23

After 1,000,000 trials, the std. error of the mean is 0.00



Statistics:

Trials	1,000,000
Base Case	0.23
Mean	0.27
Median	0.26
Mode	---
Standard Deviation	0.06
Variance	0.00
Skewness	0.6753
Kurtosis	2.95
Coeff. of Variation	0.2168
Minimum	0.17
Maximum	0.51
Range Width	0.34
Mean Std. Error	0.00

Forecast values

Percentiles:

5%	0.19
95%	0.38

Forecast values

Forecast: 07. Maintenance Cost Index (MCI) for Septic Tank

Summary:

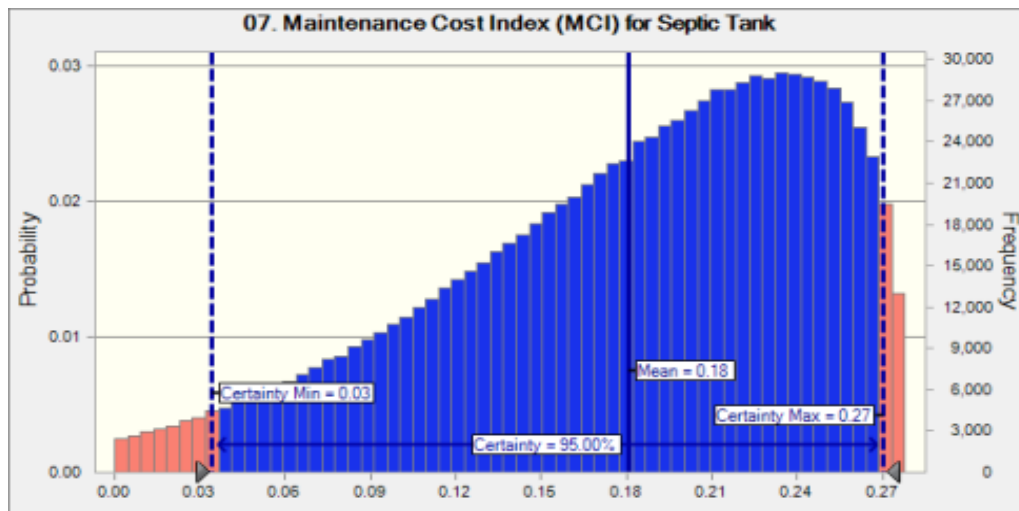
Certainty level is 95.0000%

Certainty range is from 0.03 to 0.27

Entire range is from 0.00 to 0.28 (filtered)

Base case is 0.24

After 982,196 trials, the std. error of the mean is 0.00



Statistics:

Trials
Base Case
Mean
Median
Mode
Standard Deviation
Variance
Skewness
Kurtosis
Coeff. of Variation
Minimum
Maximum
Range Width
Mean Std. Error
Filtered Values

Forecast values

982,196
0.24
0.18
0.19

0.06
0.00
-0.6460
2.64
0.3567
0.00
0.28
0.28
0.00
17804

Percentiles:

5%
95%

Forecast values

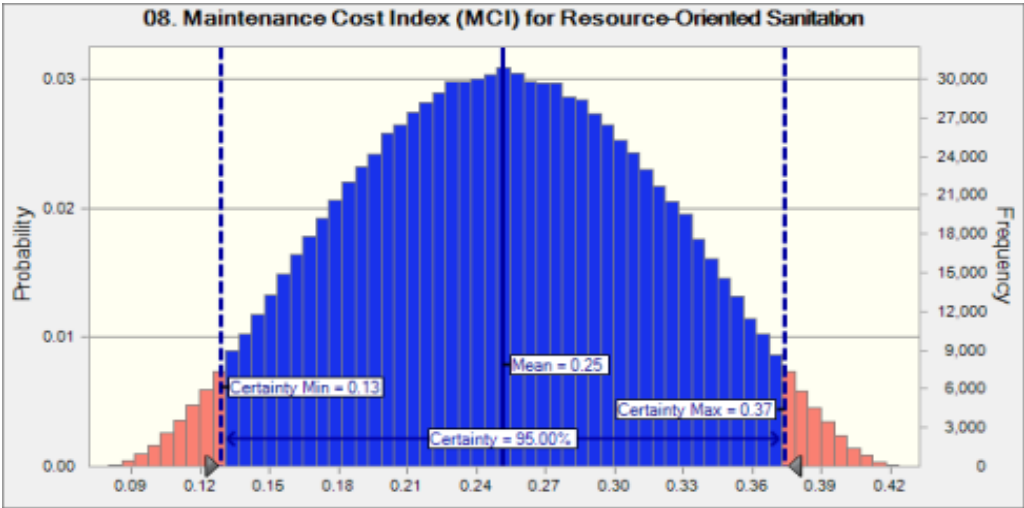
0.06
0.27

Forecast: 08. Maintenance Cost Index (MCI) for Resource-Oriented Sanitation

Summary:

Certainty level is 95.0000%
Certainty range is from 0.13 to 0.37
Entire range is from 0.08 to 0.42

Base case is 0.25
After 1,000,000 trials, the std. error of the mean is 0.00



Statistics:	Forecast values
Trials	1,000,000
Base Case	0.25
Mean	0.25
Median	0.25
Mode	---
Standard Deviation	0.07
Variance	0.00
Skewness	-0.0015
Kurtosis	2.33
Coeff. of Variation	0.2605
Minimum	0.08
Maximum	0.42
Range Width	0.34
Mean Std. Error	0.00

Percentiles:	Forecast values
5%	0.14
95%	0.36

Forecast: 09. Sanitation Sustainability Index for Septic Tank

Summary:

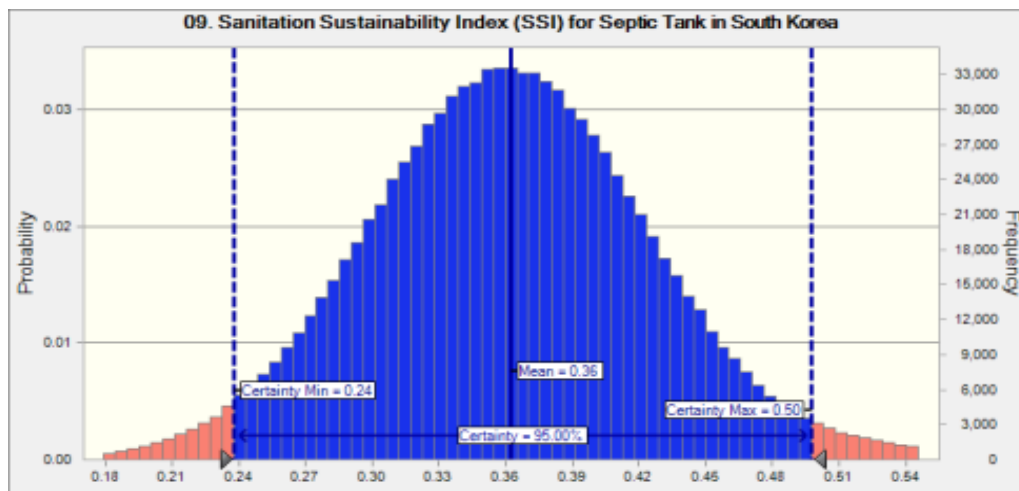
Certainty level is 95.0000%

Certainty range is from 0.24 to 0.50

Entire range is from 0.04 to 0.68

Base case is 0.42

After 1,000,000 trials, the std. error of the mean is 0.00



Statistics:

Trials
Base Case
Mean
Median
Mode
Standard Deviation
Variance
Skewness
Kurtosis
Coeff. of Variation
Minimum
Maximum
Range Width
Mean Std. Error

Forecast values

1,000,000
0.42
0.36
0.36

0.07
0.00
0.1909
3.39
0.1804
0.04
0.68
0.65
0.00

Percentiles:

5%
95%

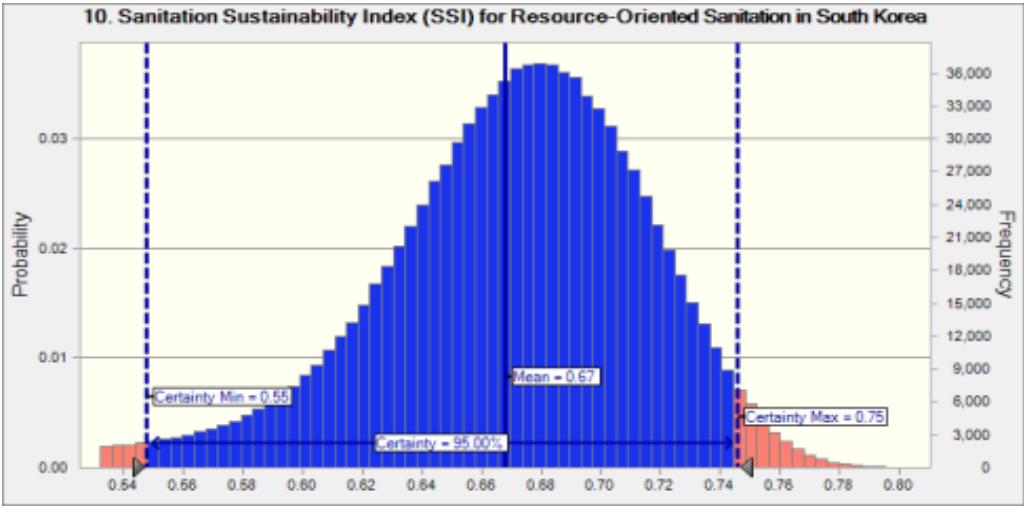
Forecast values

0.26
0.47

Forecast: 10. Sanitation Sustainability Index for Resource-Oriented Sanitation

Summary:

Certainty level is 95.0000%
Certainty range is from 0.55 to 0.75
Entire range is from 0.37 to 0.81
Base case is 0.71
After 1,000,000 trials, the std. error of the mean is 0.00



Statistics:	Forecast values
Trials	1,000,000
Base Case	0.71
Mean	0.67
Median	0.67
Mode	---
Standard Deviation	0.05
Variance	0.00
Skewness	-0.8878
Kurtosis	4.49
Coeff. of Variation	0.0725
Minimum	0.37
Maximum	0.81
Range Width	0.45
Mean Std. Error	0.00

Percentiles:	Forecast values
5%	0.58
95%	0.74

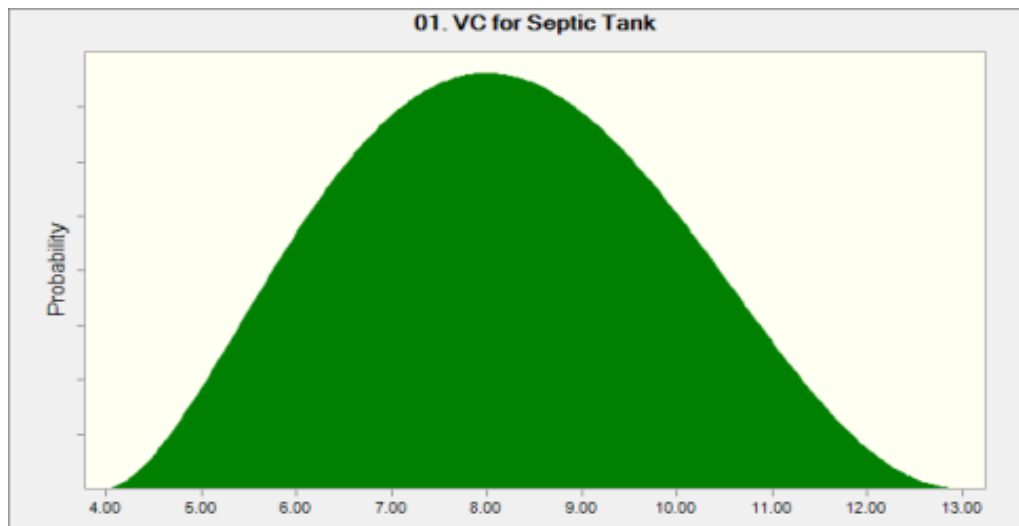
End of Forecasts

Assumptions

Assumption: 01. V_C for Septic Tank

BetaPERT distribution with parameters:

Minimum	4.00
Likeliest	8.00
Maximum	13.00

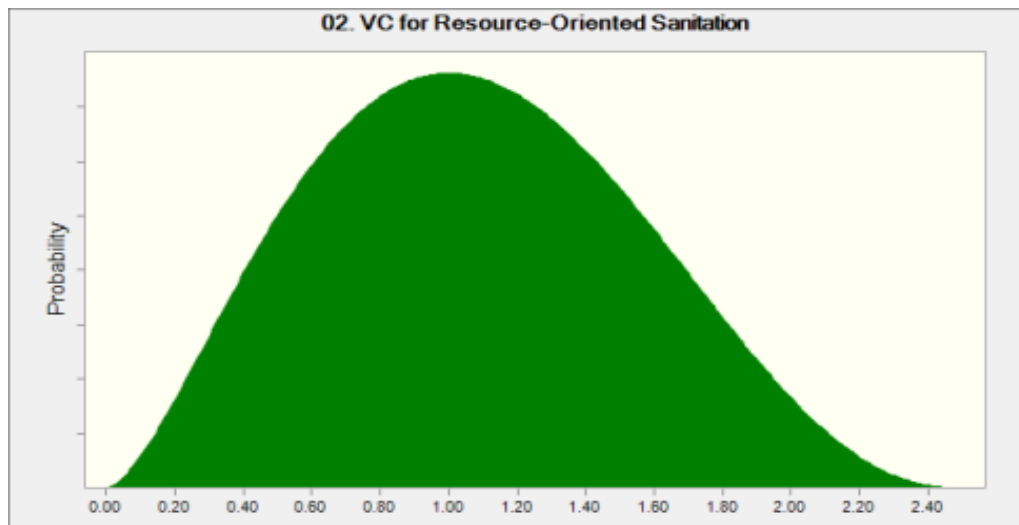


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	8.00	8.00
Mean	8.16	8.17
Median	8.13	8.13
Mode	---	8.00
Standard Deviation	1.70	1.70
Variance	2.88	2.88
Skewness	0.0979	0.0983
Kurtosis	2.34	2.35
Coeff. of Variation	0.2078	0.2077
Minimum	4.03	4.00
Maximum	12.95	13.00
Range Width	8.92	9.00
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	5.44	5.45
95%	11.02	11.02

Assumption: 02. V_C for Resource-Oriented Sanitation

BetaPERT distribution with parameters:

Minimum	0.00
Likeliest	1.00
Maximum	2.50

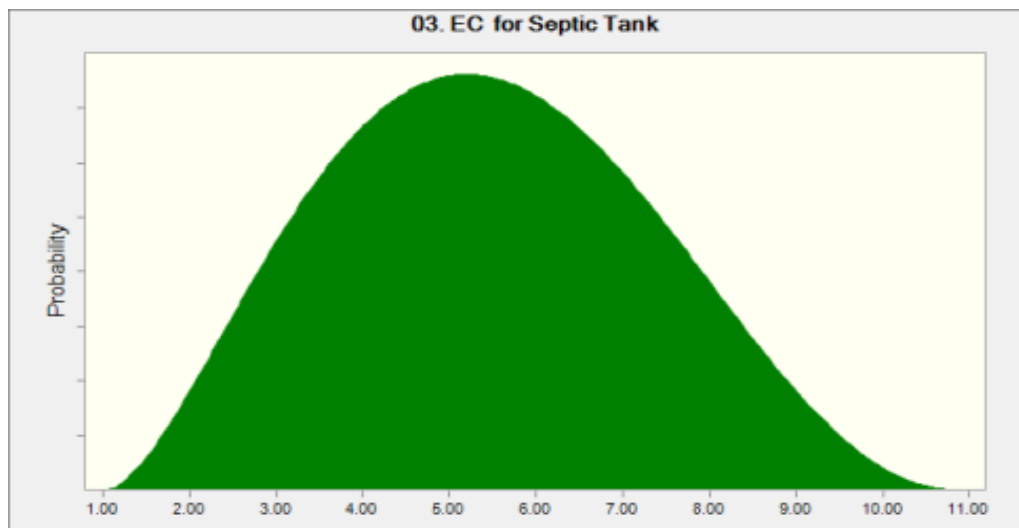


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	1.00	1.00
Mean	1.08	1.08
Median	1.06	1.06
Mode	---	1.00
Standard Deviation	0.47	0.47
Variance	0.22	0.22
Skewness	0.1775	0.1780
Kurtosis	2.38	2.38
Coeff. of Variation	0.4323	0.4322
Minimum	0.01	0.00
Maximum	2.47	2.50
Range Width	2.47	2.50
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	0.35	0.35
95%	1.89	1.89

Assumption: 03. E_C for Septic Tank

BetaPERT distribution with parameters:

Minimum	1.04
Likeliest	5.20
Maximum	10.92

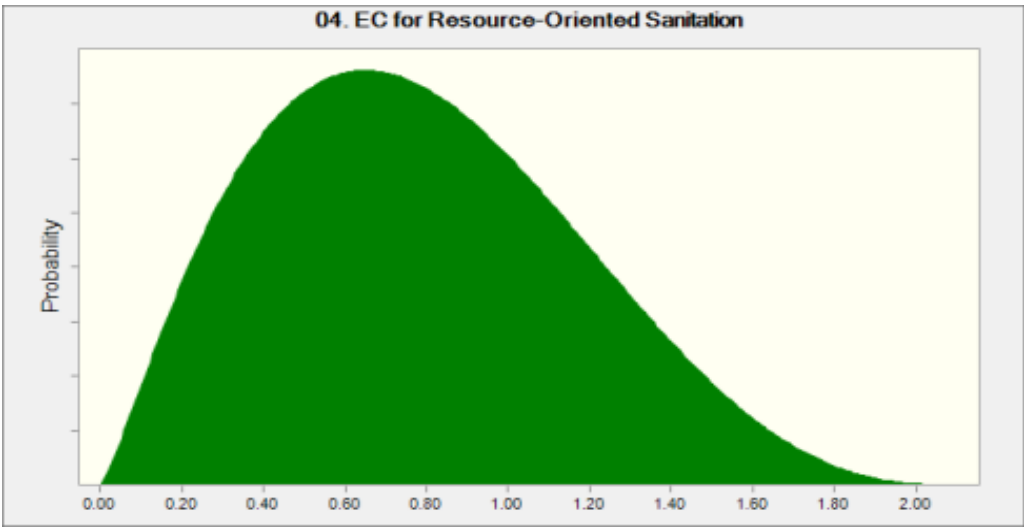


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	5.20	5.20
Mean	5.46	5.46
Median	5.40	5.40
Mode	---	5.20
Standard Deviation	1.86	1.86
Variance	3.45	3.45
Skewness	0.1401	0.1400
Kurtosis	2.36	2.36
Coeff. of Variation	0.3399	0.3401
Minimum	1.07	1.04
Maximum	10.85	10.92
Range Width	9.78	9.88
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	2.52	2.51
95%	8.62	8.62

Assumption: 04. E_C for Resource-Oriented Sanitation

BetaPERT distribution with parameters:

Minimum	0.00
Likeliest	0.65
Maximum	2.10

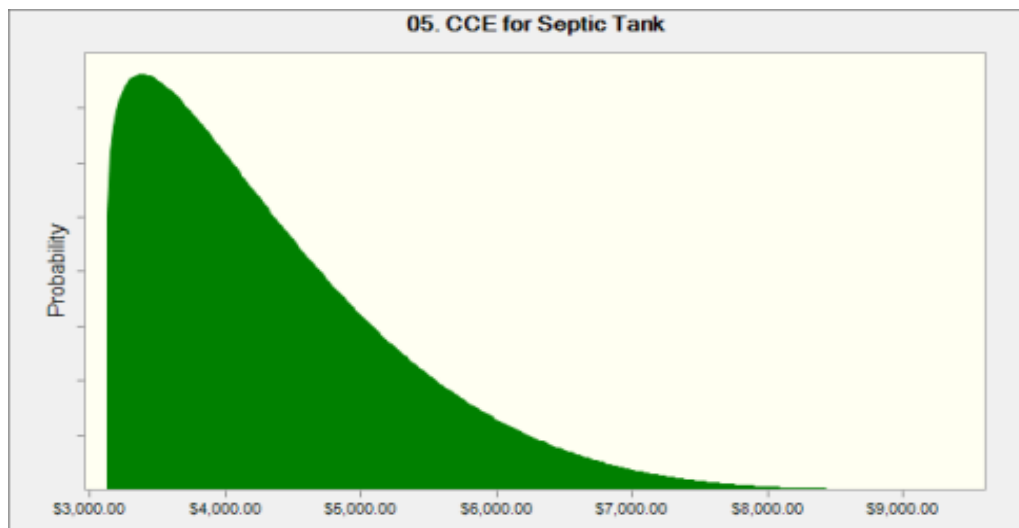


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	0.65	0.65
Mean	0.78	0.78
Median	0.75	0.75
Mode	---	0.65
Standard Deviation	0.38	0.38
Variance	0.15	0.15
Skewness	0.3462	0.3474
Kurtosis	2.50	2.49
Coeff. of Variation	0.4901	0.4900
Minimum	0.00	0.00
Maximum	2.08	2.10
Range Width	2.08	2.10
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	0.21	0.21
95%	1.46	1.47

Assumption: 05. CC_E for Septic Tank

BetaPERT distribution with parameters:

Minimum	\$3,121.00
Likeliest	\$3,380.00
Maximum	\$9,436.00

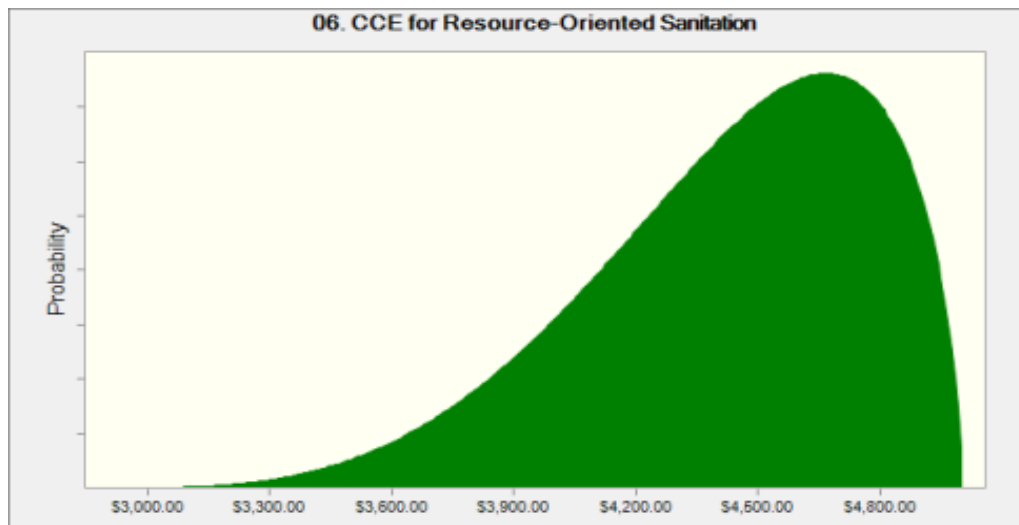


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	\$3,380.00	\$3,380.00
Mean	\$4,344.00	\$4,346.17
Median	\$4,124.27	\$4,127.13
Mode	---	\$3,380.00
Standard Deviation	\$943.30	\$943.84
Variance	\$889,811.03	\$890,842.02
Skewness	1.03	1.02
Kurtosis	3.74	3.73
Coeff. of Variation	0.2171	0.2172
Minimum	\$3,121.00	\$3,121.00
Maximum	\$9,163.29	\$9,436.00
Range Width	\$6,042.29	\$6,315.00
Mean Std. Error	\$0.94	---
Percentiles:	Assumption values	Distribution
5%	\$3,228.47	\$3,228.99
95%	\$6,211.31	\$6,215.29

Assumption: 06. CC_E for Resource-Oriented Sanitation

BetaPERT distribution with parameters:

Minimum	\$2,899.22
Likeliest	\$4,668.18
Maximum	\$5,002.77

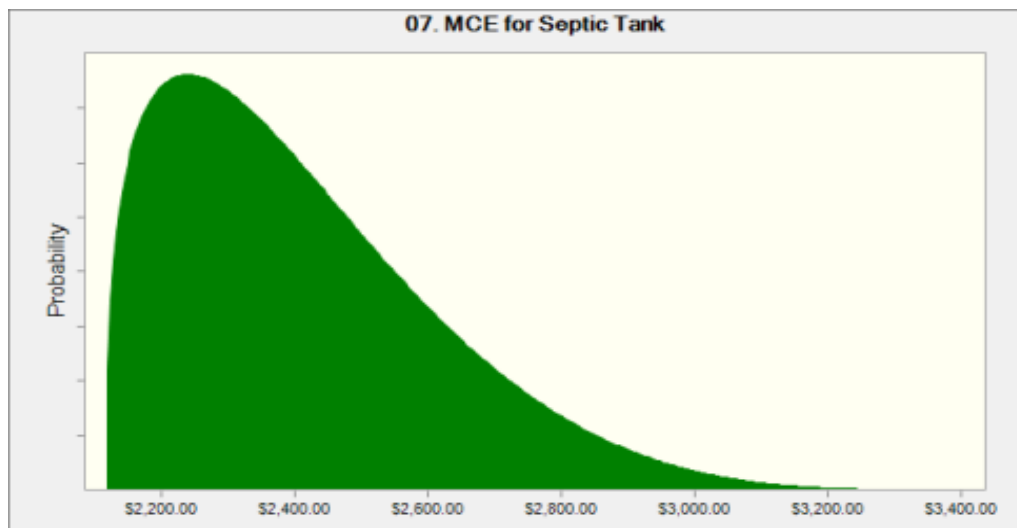


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	\$4,668.18	\$4,668.18
Mean	\$4,429.15	\$4,429.12
Median	\$4,484.36	\$4,484.63
Mode	---	\$4,668.18
Standard Deviation	\$353.85	\$354.08
Variance	\$125,207.84	\$125,375.93
Skewness	-0.6753	-0.6752
Kurtosis	2.95	2.94
Coeff. of Variation	0.0799	0.0799
Minimum	\$2,950.06	\$2,899.22
Maximum	\$5,002.72	\$5,002.77
Range Width	\$2,052.66	\$2,103.55
Mean Std. Error	\$0.35	---
Percentiles:	Assumption values	Distribution
5%	\$3,762.67	\$3,761.55
95%	\$4,905.80	\$4,905.78

Assumption: 07. MC_E for Septic Tank

BetaPERT distribution with parameters:

Minimum	\$2,118.18
Likeliest	\$2,240.16
Maximum	\$3,401.82

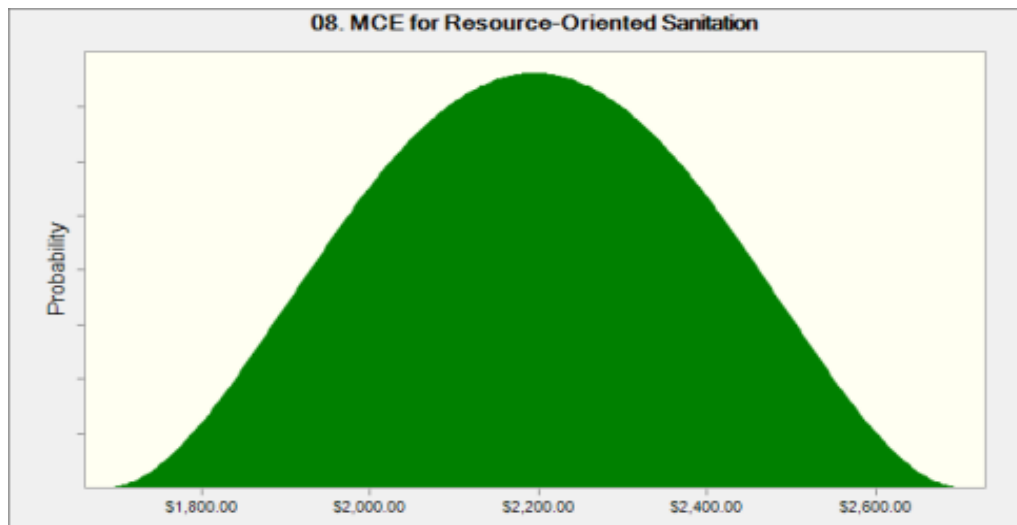


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	\$2,240.16	\$2,240.16
Mean	\$2,413.56	\$2,413.44
Median	\$2,373.76	\$2,373.62
Mode	---	\$2,240.16
Standard Deviation	\$204.17	\$204.18
Variance	\$41,687.04	\$41,689.98
Skewness	0.8456	0.8487
Kurtosis	3.28	3.29
Coeff. of Variation	0.0846	0.0846
Minimum	\$2,118.18	\$2,118.18
Maximum	\$3,334.48	\$3,401.82
Range Width	\$1,216.30	\$1,283.64
Mean Std. Error	\$0.20	---
Percentiles:	Assumption values	Distribution
5%	\$2,155.12	\$2,155.13
95%	\$2,809.00	\$2,808.59

Assumption: 08. MC_E for Resource-Oriented Sanitation

BetaPERT distribution with parameters:

Minimum	\$1,687.58
Likeliest	\$2,195.28
Maximum	\$2,702.92

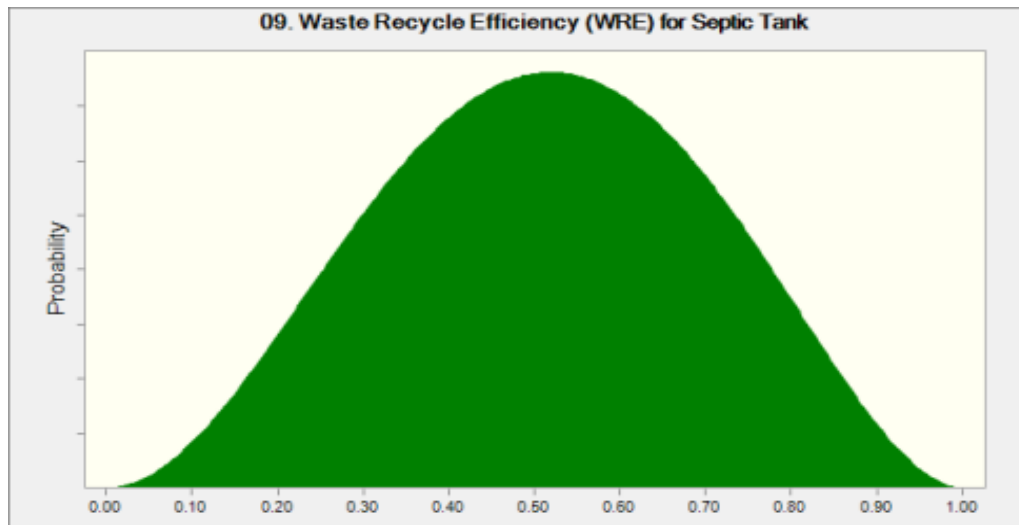


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	\$2,195.28	\$2,195.28
Mean	\$2,195.00	\$2,195.27
Median	\$2,194.91	\$2,195.27
Mode	---	\$2,195.28
Standard Deviation	\$191.92	\$191.88
Variance	\$36,833.30	\$36,818.54
Skewness	0.0015	-5.3695E-05
Kurtosis	2.33	2.33
Coeff. of Variation	0.0874	0.0874
Minimum	\$1,690.61	\$1,687.58
Maximum	\$2,697.21	\$2,702.92
Range Width	\$1,006.60	\$1,015.34
Mean Std. Error	\$0.19	---
Percentiles:	Assumption values	Distribution
5%	\$1,879.36	\$1,879.75
95%	\$2,510.67	\$2,510.78

Assumption: 09. Waste Recycling Efficiency (WRE) for Septic Tank

BetaPERT distribution with parameters:

Minimum	0.00
Likeliest	0.52
Maximum	1.00

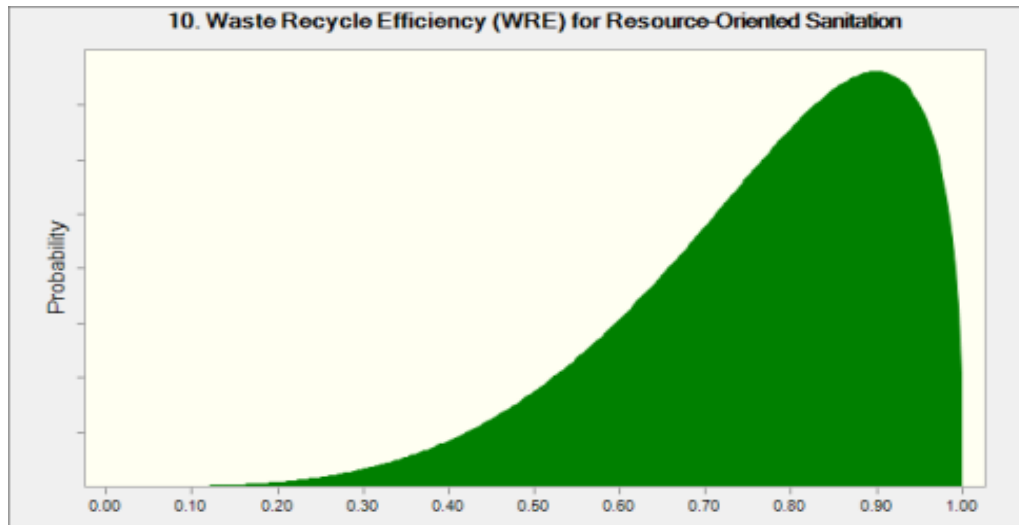


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	0.52	0.52
Mean	0.51	0.51
Median	0.51	0.51
Mode	---	0.52
Standard Deviation	0.19	0.19
Variance	0.04	0.04
Skewness	-0.0341	-0.0335
Kurtosis	2.34	2.33
Coeff. of Variation	0.3688	0.3685
Minimum	0.00	0.00
Maximum	1.00	1.00
Range Width	0.99	1.00
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	0.20	0.20
95%	0.82	0.82

Assumption: 10. Waste Recycling Efficiency (WRE) for Resource-Oriented Sanitation

BetaPERT distribution with parameters:

Minimum	0.00
Likeliest	0.90
Maximum	1.00



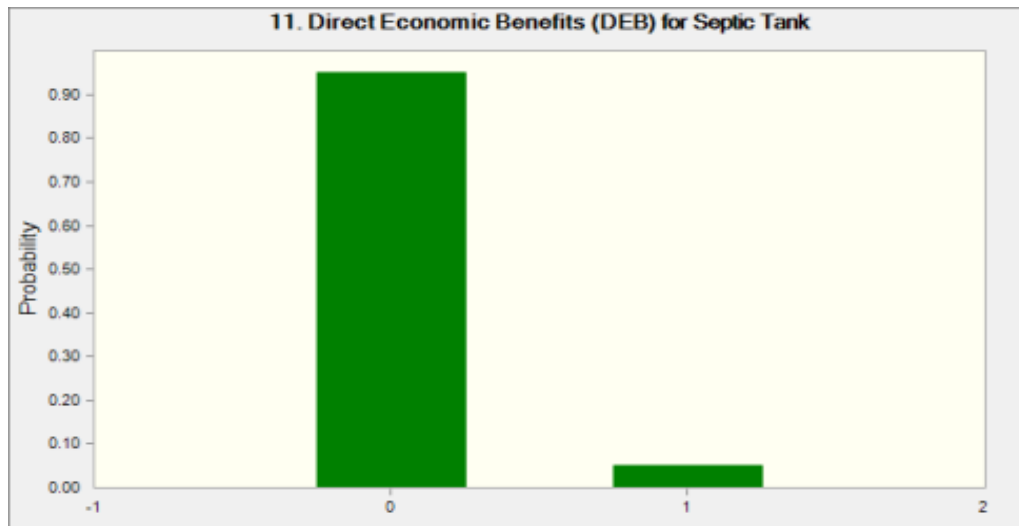
Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	0.90	0.90
Mean	0.77	0.77
Median	0.80	0.80
Mode	---	0.90
Standard Deviation	0.16	0.16
Variance	0.03	0.03
Skewness	-0.8334	-0.8341
Kurtosis	3.25	3.26
Coeff. of Variation	0.2087	0.2085
Minimum	0.03	0.00
Maximum	1.00	1.00
Range Width	0.97	1.00
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	0.46	0.46
95%	0.97	0.97

Assumption: 11. Direct Economic Benefits (DEB) for Septic Tank

Yes-No distribution with parameters:

Probability of Yes(1)

0.05



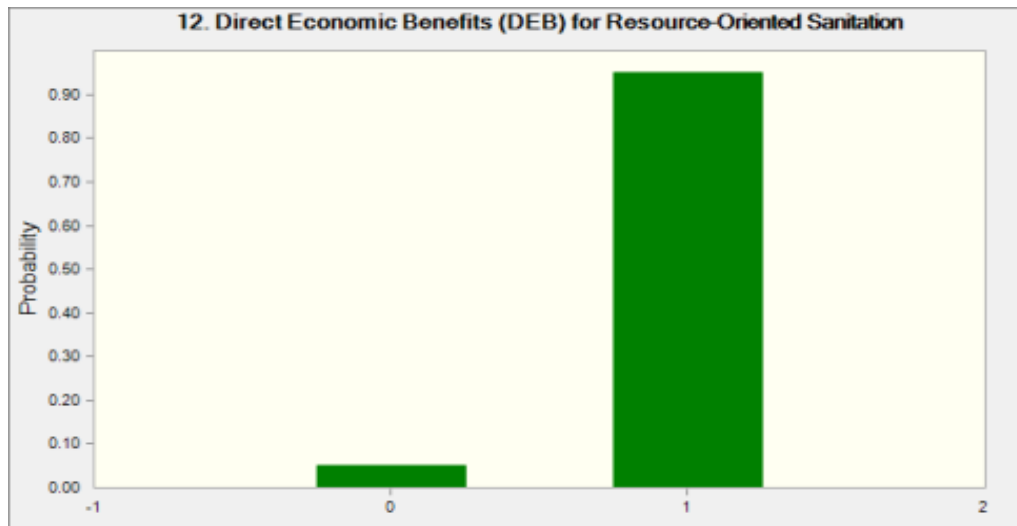
Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	0.00	0.00
Mean	0.05	0.05
Median	0.00	0.00
Mode	0.00	0.00
Standard Deviation	0.22	0.22
Variance	0.05	0.05
Skewness	4.14	4.13
Kurtosis	18.11	18.05
Coeff. of Variation	4.37	4.36
Minimum	0.00	0.00
Maximum	1.00	1.00
Range Width	1.00	1.00
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	0.00	0.00
95%	0.00	0.00

Assumption: 12. Direct Economic Benefits (DEB) for Resource-Oriented Sanitation

Yes-No distribution with parameters:

Probability of Yes(1)

0.95

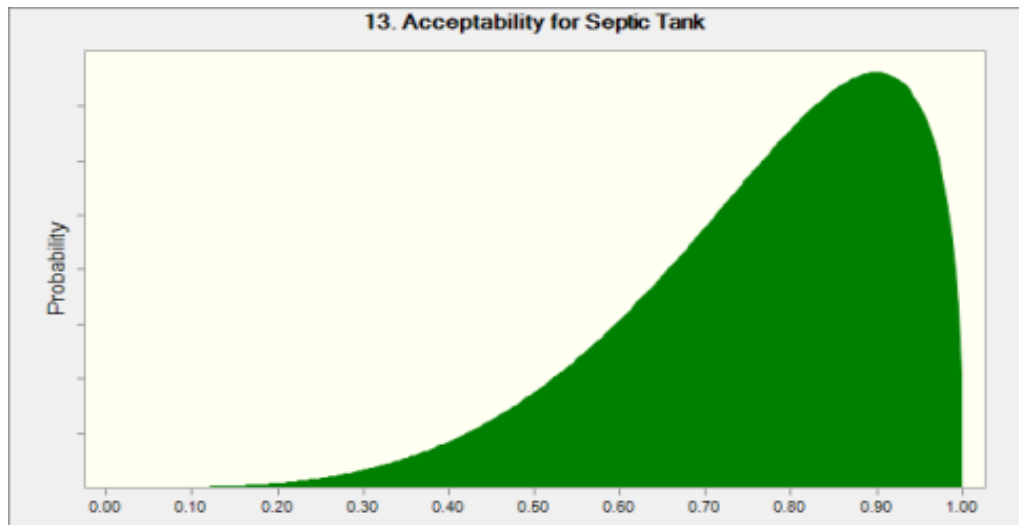


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	1.00	1.00
Mean	0.95	0.95
Median	1.00	1.00
Mode	1.00	1.00
Standard Deviation	0.22	0.22
Variance	0.05	0.05
Skewness	-4.13	-4.13
Kurtosis	18.02	18.05
Coeff. of Variation	0.2296	0.2294
Minimum	0.00	0.00
Maximum	1.00	1.00
Range Width	1.00	1.00
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	0.00	0.00
95%	1.00	1.00

Assumption: 13. Acceptability for Septic Tank

BetaPERT distribution with parameters:

Minimum	0.00
Likeliest	0.90
Maximum	1.00

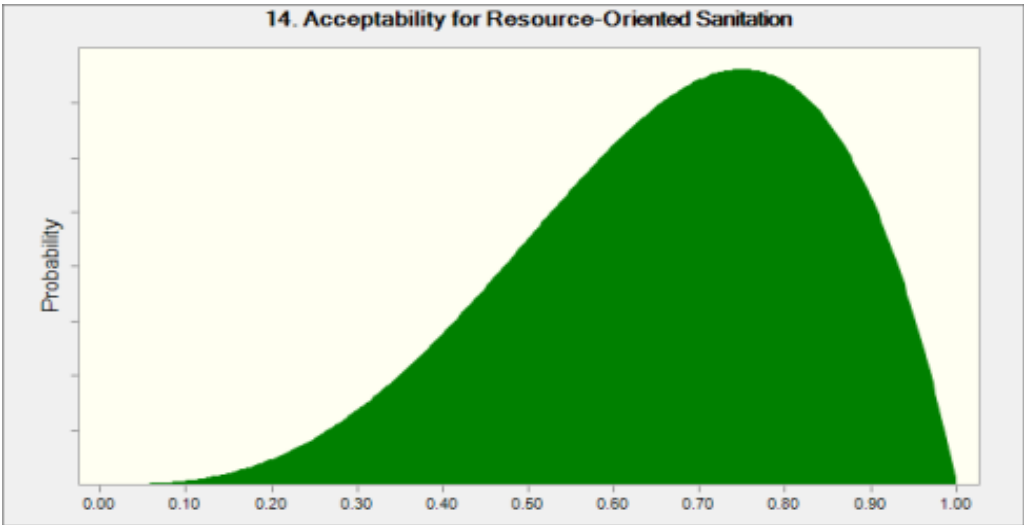


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	0.90	0.90
Mean	0.77	0.77
Median	0.80	0.80
Mode	---	0.90
Standard Deviation	0.16	0.16
Variance	0.03	0.03
Skewness	-0.8342	-0.8341
Kurtosis	3.26	3.26
Coeff. of Variation	0.2085	0.2085
Minimum	0.03	0.00
Maximum	1.00	1.00
Range Width	0.97	1.00
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	0.46	0.46
95%	0.97	0.97

Assumption: 14. Acceptability for Resource-Oriented Sanitation

BetaPERT distribution with parameters:

Minimum	0.00
Likeliest	0.75
Maximum	1.00

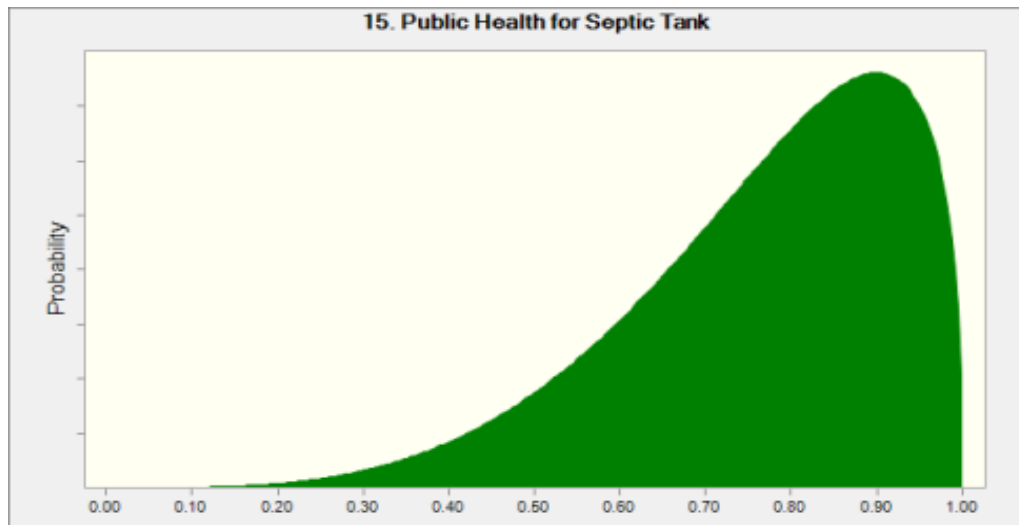


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	0.75	0.75
Mean	0.67	0.67
Median	0.69	0.69
Mode	---	0.75
Standard Deviation	0.18	0.18
Variance	0.03	0.03
Skewness	-0.4669	-0.4677
Kurtosis	2.63	2.63
Coeff. of Variation	0.2674	0.2673
Minimum	0.02	0.00
Maximum	1.00	1.00
Range Width	0.98	1.00
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	0.34	0.34
95%	0.92	0.92

Assumption: 15. Public Health for Septic Tank

BetaPERT distribution with parameters:

Minimum	0.00
Likeliest	0.90
Maximum	1.00

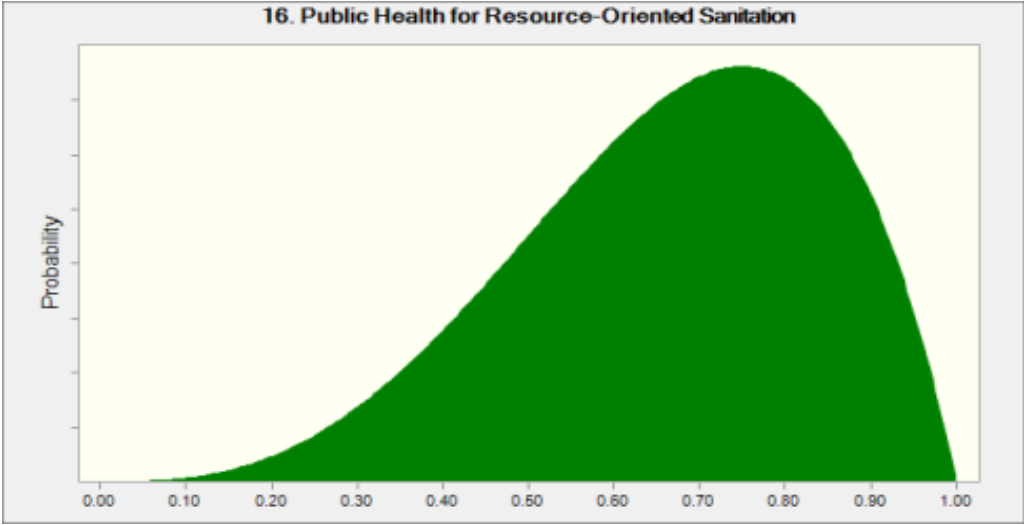


Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	0.90	0.90
Mean	0.77	0.77
Median	0.80	0.80
Mode	---	0.90
Standard Deviation	0.16	0.16
Variance	0.03	0.03
Skewness	-0.8329	-0.8341
Kurtosis	3.26	3.26
Coeff. of Variation	0.2083	0.2085
Minimum	0.04	0.00
Maximum	1.00	1.00
Range Width	0.96	1.00
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	0.46	0.46
95%	0.97	0.97

Assumption: 16. Public Health for Resource-Oriented Sanitation

BetaPERT distribution with parameters:

Minimum	0.00
Likeliest	0.75
Maximum	1.00



Statistics:	Assumption values	Distribution
Trials	1,000,000	---
Base Case	0.75	0.75
Mean	0.67	0.67
Median	0.69	0.69
Mode	---	0.75
Standard Deviation	0.18	0.18
Variance	0.03	0.03
Skewness	-0.4661	-0.4677
Kurtosis	2.62	2.63
Coeff. of Variation	0.2672	0.2673
Minimum	0.02	0.00
Maximum	1.00	1.00
Range Width	0.98	1.00
Mean Std. Error	0.00	---
Percentiles:	Assumption values	Distribution
5%	0.34	0.34
95%	0.92	0.92

End of Assumptions