E. coli Effectiveness as a Small System Screen

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Presentation Overview

- EPA's LT2 indicator criteria and guidance to States
- Indicator accuracy and effectiveness for small systems
- Overview of data used in the analysis
- Analysis that informs the effectiveness of the alternative trigger level and other hypothetical trigger levels
- Implications for Round 2 monitoring

LT2 Indicator Criteria

- Small systems (<10k) may monitor for *E. coli* for 12 months and, *if mean E. coli is above a trigger*, they must monitor for *Cryptosporidium* for 24 months
  - Lake Reservoir – 10 cfu/100ml (mean)
  - Flowing Stream – 50 cfu/100ml (mean)
  - Alternative guidance may be specified by State

EPA's Guidance to States

- On Feb 4, 2010, EPA issued guidance to States, based on analysis of LT2 data available at that time
- Advised that alternative trigger levels of 100 *E. coli*/100ml for both lake/reservoir and flowing streams provide more accurate identification of systems requiring *Crypto* monitoring
- States had several options:
  - Retain their current trigger levels,
  - Approve the alternatives, or
  - Propose other alternatives.
- Most but not all approved the alternative trigger levels

Indicator Accuracy and Effectiveness

- Ideally only those plants with high *Cryptosporidium* would be triggered into monitoring
- Falling short of this ideal, the most effective trigger level is that which minimizes the number of plants being triggered into monitoring while maximizing the number of plants with high *Cryptosporidium* that are triggered into monitoring
- Two measures are used to inform the above condition
  - Number of plants triggered into *Cryptosporidium* monitoring based on *E. coli* monitoring results
  - Number of the plants with high *Cryptosporidium* concentrations (> 0.075 oocysts/L) that would be correctly assigned to a treatment bin

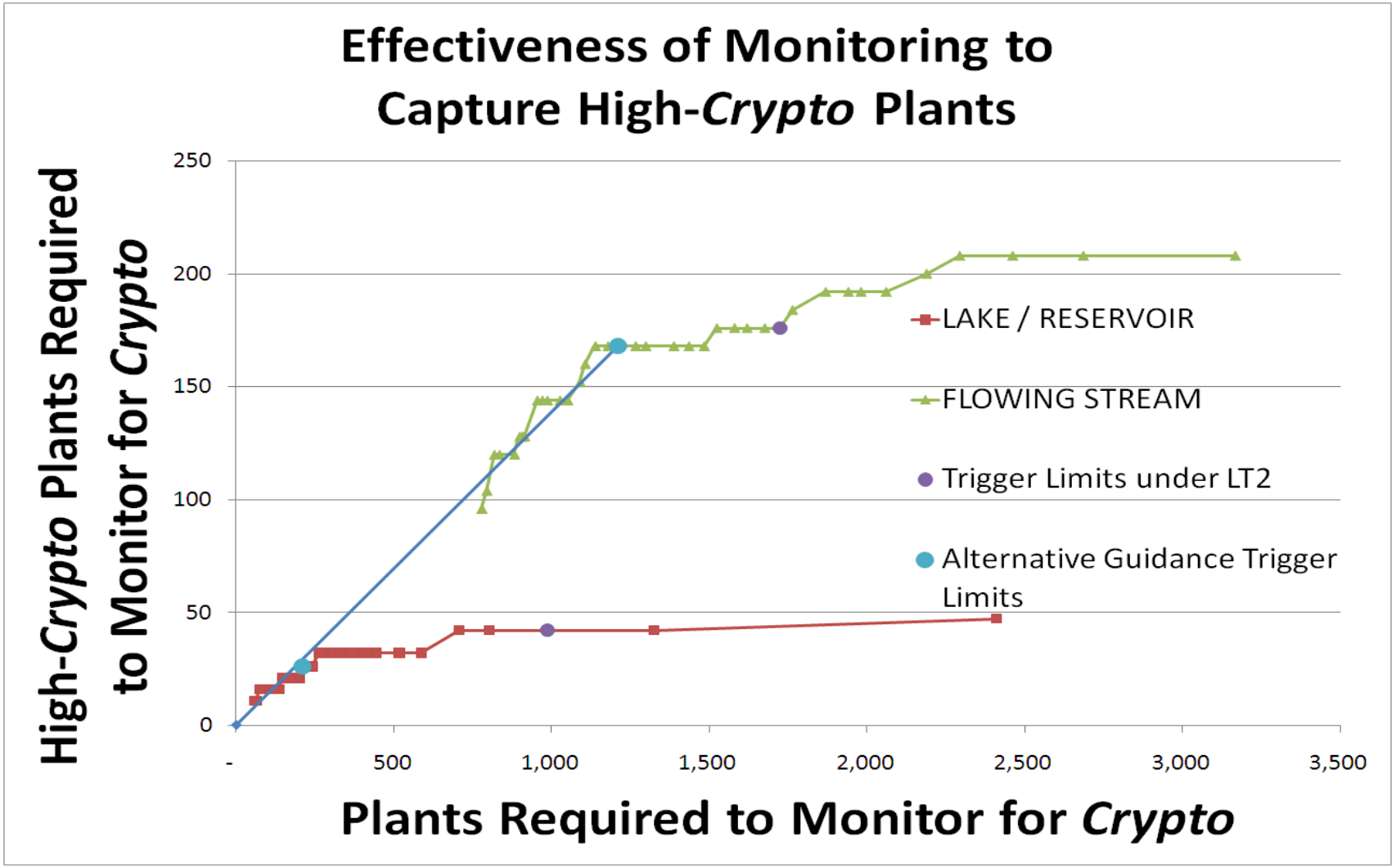


Figure based on data collected to support 2010 Alternative Guidance Trigger

Use of alternative indicator allows for large reduction in plants required to monitor for Crypto with only a small reduction of plants with high Crypto not being required to monitor.

Overview of Data Used in the Analysis

- Crypto and *E. coli* from DCTS data
- *Crypto* and *E. coli* samples collected on the same date from the same plant were paired
- Calculated *E. coli* data
  - Before any further analysis could be conducted, the *E. coli* concentrations needed to be calculated for samples where the lab entered the raw data
- The data cleaning and pairing operation resulted in 29,741 samples representing 1,356 plants.

Data Analysis Preparations

- Performed calculations for *E. coli* and *Crypto* and linked samples together for the analysis.
- Plant averages for *E. coli* are straight averages of all samples taken
- For *Crypto,* the running annual averages for each 12 month period is calculated and the highest average is considered the plant average
  - If at least 48 samples exist, the plant average is the straight average

Summary of Round 1 Monitoring Results

Water Type	Number of Facilities	Mean *E. coli*[2] (CFU/100mL)	Mean Cryptosporidium[2] (oocysts/L)
Lake/Reservoir (LR)	656	34.0	0.008
River/Stream (FS)	565	299.5	0.039
Both (LR & FS)	41	138.9	0.046
GWUDI (LR)	26	383.6	0.022
GWUDI (FS)	68	33.7	0.012
All	1,356	154.4	0.023

[1] Only includes facilities with both *E. coli* and *Cryptosporidium* paired data

[2] Based on average of plant averages

Table 1. Parameters for Reservoirs and Lakes

Levels of Testing Based on Various Trigger Levels						
	E. coli Trigger Level (CFU/100ml)					
Parameter	**10**	**50**	**75**	**100**	**150**	**200**
% Plants with low Crypto that exceeded trigger (F+)	95.51%	92.91%	91.18%	90.28%	90.00%	84.62%
% Plants with high Crypto that did not exceed trigger (F-)	1.56%	1.93%	1.85%	2.08%	2.44%	2.38%
% Plants with high Crypto that would exceed trigger (Sensitivity)	70.00%	45.00%	45.00%	35.00%	20.00%	20.00%
% Plants with low Crypto that would not exceed trigger (Specificity)	55.98%	82.57%	86.26%	90.40%	94.68%	96.75%
% of All Plants Protectively Classified	99.14%	98.42%	98.42%	98.13%	97.70%	97.70%
% of All Plants not Protectively Classified	0.86%	1.58%	1.58%	1.87%	2.30%	2.30%
% of All Plants Correctly Waived from Monitoring	54.38%	80.20%	83.79%	87.80%	91.97%	93.97%
% of All Plants Required to Monitor	**44.76%**	18.22%	14.63%	**10.33%**	5.74%	3.73%

LT2 Rule Trigger

Alternative Guidance Trigger

Table 2. Parameters for Rivers and Streams

Levels of Testing Based on Various Trigger Levels						
	E. coli Trigger Level (CFU/100ml)					
Parameter	**10**	**50**	**75**	**100**	**150**	**200**
% Plants with low Crypto that exceeded trigger (F+)	84.98%	81.13%	79.68%	77.15%	76.55%	72.97%
% Plants with high Crypto that did not exceed trigger (F-)	1.52%	3.04%	3.90%	3.99%	5.61%	5.77%
% Plants with high Crypto that would exceed trigger (Sensitivity)	97.33%	89.33%	84.00%	81.33%	70.67%	66.67%
% Plants with low Crypto that would not exceed trigger (Specificity)	23.94%	46.96%	54.51%	62.06%	68.14%	75.14%
% of All Plants Protectively Classified	99.68%	98.71%	98.06%	97.73%	96.44%	95.95%
% of All Plants not Protectively Classified	0.32%	1.29%	1.94%	2.27%	3.56%	4.05%
% of All Plants Correctly Waived from Monitoring	21.04%	41.26%	47.90%	54.53%	59.87%	66.02%
% of All Plants Required to Monitor	78.64%	**57.44%**	50.16%	**43.20%**	36.57%	29.94%

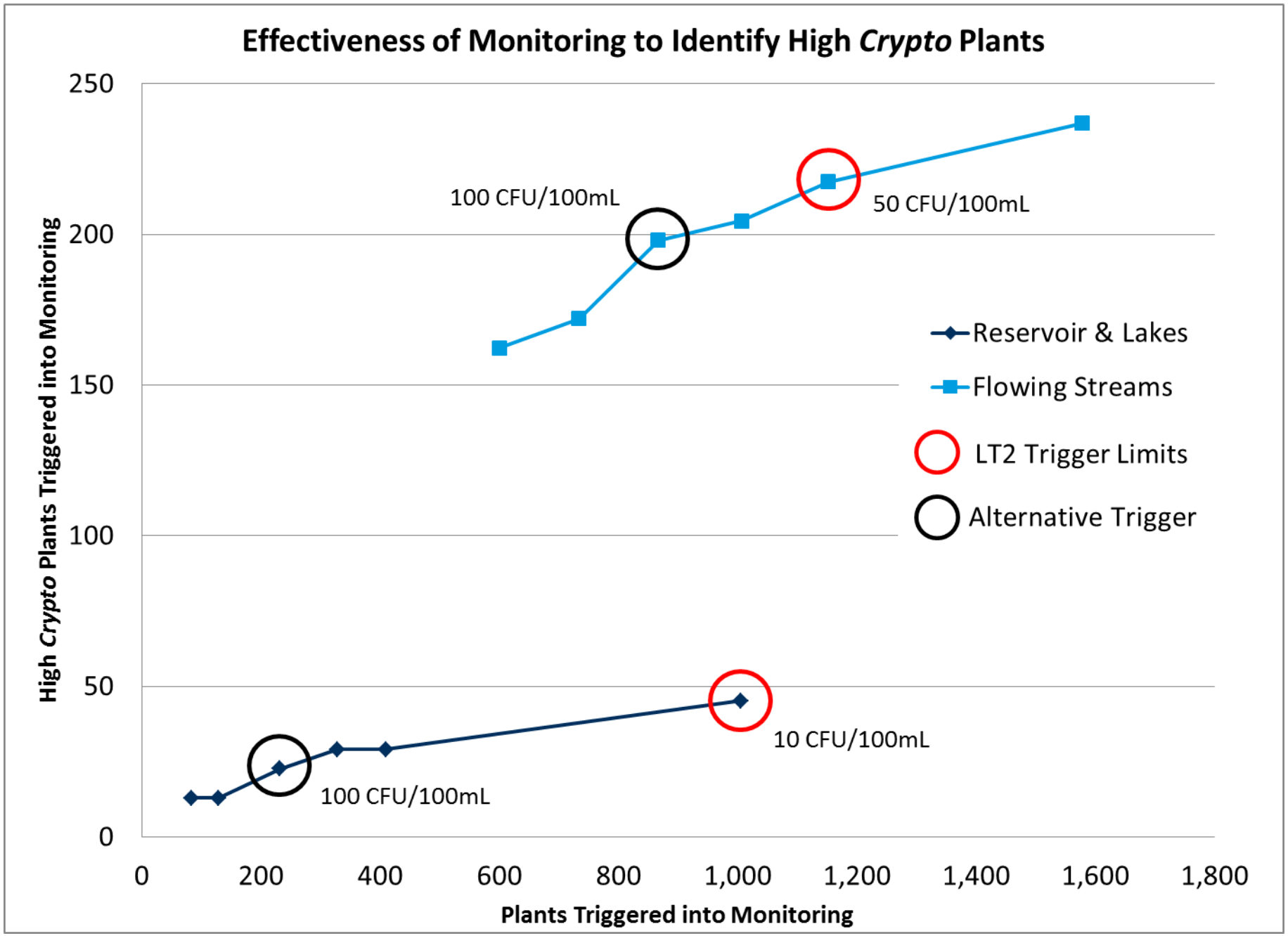
LT2 Rule Trigger

Alternative Guidance Trigger

Table 3. Parameters for All Samples

Levels of Testing Based on Various Trigger Levels						
	E. coli Trigger Level (CFU/100ml)					
Parameter	**10**	**50**	**75**	**100**	**150**	**200**
% Plants with low Crypto that exceeded trigger (F+)	88.92%	83.98%	82.23%	79.48%	78.31%	74.07%
% Plants with high Crypto that did not exceed trigger (F-)	1.50%	2.32%	2.57%	2.77%	3.69%	3.77%
% Plants with high Crypto that would exceed trigger (Sensitivity)	91.92%	79.80%	75.76%	71.72%	59.60%	56.57%
% Plants with low Crypto that would not exceed trigger (Specificity)	41.93%	67.06%	72.39%	78.12%	83.05%	87.27%
% of All Plants Protectively Classified	99.41%	98.53%	98.23%	97.94%	97.05%	96.83%
% of All Plants not Protectively Classified	0.59%	1.47%	1.77%	2.06%	2.95%	3.17%
% of All Plants Correctly Waived from Monitoring	38.86%	62.17%	67.11%	72.42%	76.99%	80.90%
% of All Plants Required to Monitor	60.55%	36.36%	31.12%	**25.52%**	20.06%	15.93%

Alternative Guidance Trigger


Effectiveness of Monitoring to Identify High *Crypto* Plants
High *Crypto* Plants Triggered into Monitoring
250
200
150
100
50
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
Plants Triggered into Monitoring
100 CFU/100mL
50 CFU/100mL
10 CFU/100mL
100 CFU/100mL
Reservoir & Lakes
Flowing Streams
LT2 Trigger Limits
Alternative Trigger

Summary of Analysis

- The number of plants triggered into monitoring increases as the trigger level is decreased
  - As the trigger level drops, the number of high *Cryptosporidium* plants triggered increases.
- While each lower trigger level has a higher number of high *Cryptosporidium* plants triggered, the increase is the greatest between the 100 and 150 cfu/100mL trigger values for both curves.
- The alternative trigger level (100 cfu/100ml) is supported by the data collected during the first round of *Cryptosporidium* monitoring

Implications for Round 2

- *E. coli* appears to be an effective screening tool for reducing *Crypto* monitoring for small systems while remaining protective
- The analysis supports the alternative guidance for Round 2
- If the enhanced method 1623.1 were to be required under Round 2, *E. coli* levels remained the same, and no changes were to be made to the alternative guidance criteria:
  - Similar fractions of systems would likely avoid *Crypto* monitoring
  - But more systems with higher measured *Crypto* would not be captured
- Based on *Crypto* and *E. coli* data captured in Round 2, another alternative guidance could be developed if new data supports

Appendix

Analysis and Results Definition of Terms (1)

- % of False Positives – % plants exceeding *E. coli* trigger with no detected *Crypto* > 0.075 oocysts/L
- % of False Negatives – % plants with *Crypto* > 0.075 oocysts/L detected but below the *E. coli* trigger level
- Sensitivity – % plants that detected *Crypto* > 0.075 oocysts/L and exceeded the *E. coli* trigger level. This is equivalent to the true positives.
- Specificity – % plants that did not have *Crypto* > 0.075 oocysts/L and did not exceed the *E. coli* trigger level.

Analysis and Results Definition of Terms (2)

- % Plants Protectively Classified – *Crypto* < 0.075 oocysts/L or > 0.075 oocysts/L “and” exceeded the *E. coli* trigger
  - Sum of the false positives, the false negatives, and true positives
- % Plants Not Protectively Classified – > 0.075 oocysts/L *Crypto* that did not exceed the *E. coli* trigger and plants with <0.075 oocysts/L *Crypto* that exceeded the *E. coli* trigger
  - Sum of the false negatives and the false positives
- % Plants which were Correctly Identified as not needing *Cryptosporidium* Monitoring – not > 0.075 oocysts/L *Crypto* “and” that did not exceed the *E. coli* trigger
  - Equivalent to the true negatives
- % Plants Required to Monitor – exceeding the *E. coli* trigger
  - Sum of false positives and true positives.

Definition of Parameters

	Cryptosporidium concentration < 0.075 oocysts/L	Cryptosporidium concentration ≥ 0.075 oocysts/L
E. coli concentration ≥ trigger value	B	D
E. coli concentration < trigger value	A	C

Based on the definition of variables in the table the eight parameters calculated can be defined as:

- False positives = B/(B+D)
- False negatives = C/(A+C)
- Sensitivity = D/(C+D)
- Specificity = A/(A+B)
- Plants Protectively Classified = (A+B+D)/(A+B+C+D)
- Plants Incorrectly Classified = C/(A+B+C+D)
- Plants Correctly Saved from Monitoring = A/(A+B+C+D)
- Plants Required to Monitor = (B+D)/(A+B+C+D)

Table A.2. Variable Values for an *E. coli* trigger value of 10 CFU/100 mL for Reservoir/Lake Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 10	298	14
	42.75%	2.01%
Plants with avg *E. coli* concentration < 10	379	6
	54.38%	0.86%

Table A.3. Variable Values for an *E. coli* trigger value of 50 CFU/100 mL for Reservoir/Lake Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 50	118	9
	16.93%	1.29%
Plants with avg *E. coli* concentration < 50	559	11
	80.20%	1.58%

Table A.4. Variable Values for an *E. coli* trigger value of 75 CFU/100 mL for Reservoir/Lake Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 75	93	9
	13.34%	1.29%
Plants with avg *E. coli* concentration < 75	584	11
	83.79%	1.58%

Table A.5. Variable Values for an *E. coli* trigger value of 100 CFU/100 mL for Reservoir/Lake Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 100	65	7
	9.33%	1.00%
Plants with avg *E. coli* concentration < 100	612	13
	87.80%	1.87%

Table A.6. Variable Values for an *E. coli* trigger value of 150 CFU/100 mL for Reservoir/Lake Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 150	36	4
	5.16%	0.57%
Plants with avg *E. coli* concentration < 150	641	16
	91.97%	2.30%

Table A.7. Variable Values for an *E. coli* trigger value of 200 CFU/100 mL for Reservoir/Lake Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 200	22	4
	3.16%	0.57%
Plants with avg *E. coli* concentration < 200	655	16
	93.97%	2.30%

Table A.8. Variable Values for an *E. coli* trigger value of 10 CFU/100 mL for Flowing Stream Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 10	413	73
	66.83%	11.81%
Plants with avg *E. coli* concentration < 10	130	2
	21.04%	0.32%

Table A.9. Variable Values for an *E. coli* trigger value of 50 CFU/100 mL for Flowing Stream Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 50	288	67
	46.60%	10.84%
Plants with avg *E. coli* concentration < 50	255	8
	41.26%	1.29%

Table A.10. Variable Values for an *E. coli* trigger value of 75 CFU/100 mL for Flowing Stream Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 75	247	63
	39.97%	10.19%
Plants with avg *E. coli* concentration < 75	296	12
	47.90%	1.94%

Table A.11. Variable Values for an *E. coli* trigger value of 100 CFU/100 mL for Flowing Stream Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 100	206	61
	33.33%	9.87%
Plants with avg *E. coli* concentration < 100	337	14
	54.53%	2.27%

Table A.12. Variable Values for an *E. coli* trigger value of 150 CFU/100 mL for Flowing Stream Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 150	173	53
	27.99%	8.58%
Plants with avg *E. coli* concentration < 150	370	22
	59.87%	3.56%

Table A.13. Variable Values for an *E. coli* trigger value of 200 CFU/100 mL for Flowing Stream Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 200	135	50
	21.84%	8.09%
Plants with avg *E. coli* concentration < 200	408	25
	66.02%	4.05%

Table A.14. Variable Values for an *E. coli* trigger value of 10 CFU/100 mL for All Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 10	730	91
	53.83%	6.71%
Plants with avg *E. coli* concentration < 10	527	8
	38.86%	0.59%

Table A.15. Variable Values for an *E. coli* trigger value of 50 CFU/100 mL for All Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 50	414	79
	30.53%	5.83%
Plants with avg *E. coli* concentration < 50	843	20
	62.17%	1.47%

Table A.16. Variable Values for an *E. coli* trigger value of 75 CFU/100 mL for All Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 75	347	75
	25.59%	5.53%
Plants with avg *E. coli* concentration < 75	910	24
	67.11%	1.77%

Table A.17. Variable Values for an *E. coli* trigger value of 100 CFU/100 mL for All Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 100	275	71
	20.28%	5.24%
Plants with avg *E. coli* concentration < 100	982	28
	72.42%	2.06%

Table A.18. Variable Values for an *E. coli* trigger value of 150 CFU/100 mL for All Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 150	213	59
	15.71%	4.35%
Plants with avg *E. coli* concentration < 150	1044	40
	76.99%	2.95%

Table A.19. Variable Values for an *E. coli* trigger value of 200 CFU/100 mL for All Plants Using the Original Cleaning Procedures.

	Plants with avg Crypto concentration < 0.075 oocysts/L	Plants with avg Crypto concentration >= 0.075 oocysts/L
Plants with avg *E. coli* concentration >= 200	160	56
	11.80%	4.13%
Plants with avg *E. coli* concentration < 200	1097	43
	80.90%	3.17%