Problem 8: Minimum detectable change analysis

Appropriate sampling frequency and duration for a NPS monitoring program can be estimated by performing a minimum detectable change (MDC) analysis using existing data from the watershed. The MDC is the minimum change in a pollutant concentration (or load) over a given period of time required to be considered statistically significant (see section 3.4.2 and Tech Notes 7 for details). In other words, MDC is the amount of change you can detect given the sample variability and number of samples collected.

Using Dataset 3 in Sampledata.xlsx, estimate the MDC for fecal coliform bacteria (FC). This dataset represents a typical situation in that available data are limited to grab samples from four, nonconsecutive years. As a general guideline, we would prefer to examine sites with 20 or more observations taken over at least two years. The sites and monitoring data should be representative of either a pre-BMP or baseline condition and similar to the monitoring strategy envisioned for post-BMP implementation.

Perform 36 MDC calculations for a single monitoring station using the following options:

- Sample size for pre-BMP period = 13
- Sampling frequency and duration for post-BMP period
  - 3x/yr for 5 years
  - 6x/yr for 5 years
  - 12x/yr for 5 years
- One-sided *t* values for 95%, 90%, and 80% confidence levels (α=.05, .10, and .20, respectively)
- Two power levels: 0.5 (50 percent) and 0.8 (80 percent)
- Two values of ρ (0 and 0.2) to estimate the impact of autocorrelation
- Assume variance pre- and post-BMP variance is equal

Report the MDC output as a percentage. For log-transformed data, MDC as a percent decrease in the geometric mean concentration relative to the initial geometric mean concentration is calculated as:

$$\text{MDC\%} = (1 - 10^{-\text{MDC}'}) \times 100$$

where MDC[1] is the MDC on the log scale and MDC% is a percentage of the initial geometric mean expressed on an untransformed scale.

Results:

Minitab was used for exploratory data analysis in this example, while Tetra Tech's *MDC Step Trend Analysis Tool v1* was used for the MDC analysis.

All raw data were plotted (Figure 1), and three tests were applied (Anderson-Darling, Ryan-Joiner, and Kolmogorov-Smirnov) to determine if the data met the normality requirement for MDC analysis. All three tests indicated that data were not normal, with p<0.005, p<0.010, and p<0.010, respectively. The Box-Cox transformation confirmed the need for log transformation of the data (Figure 2). The rounded value of λ=0.0 suggests that logarithmic transformation is a good option. Values of 0.5 and 1.0 would indicate square root and no transformation, respectively.

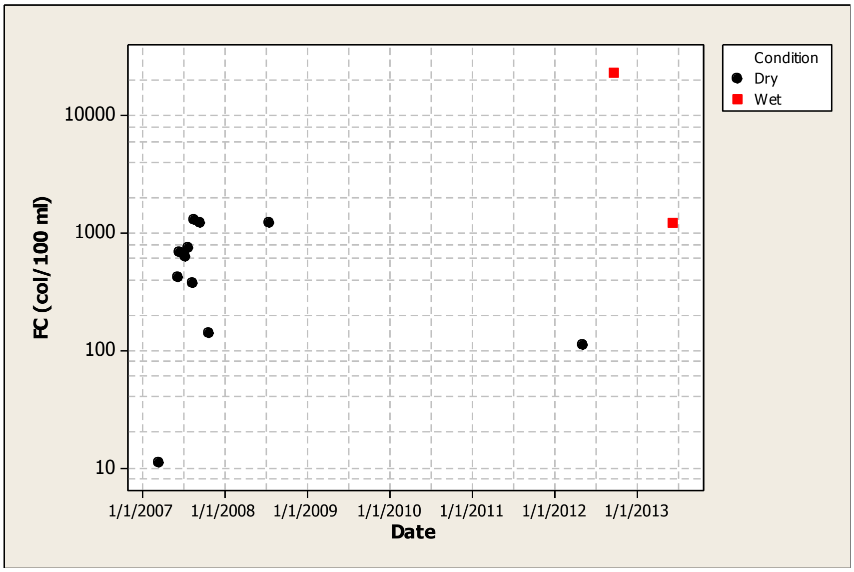

Figure 1. Fecal coliform (col/100ml) time series.

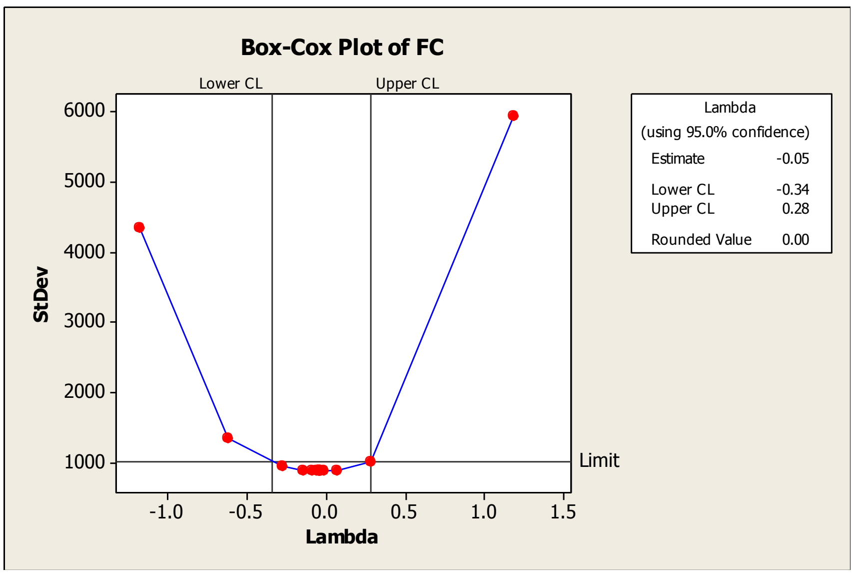

Figure 2. Box-Cox transformation.

The data are not evenly spaced so the autocorrelation test could not be performed. We therefore performed the MDC analysis assuming two levels of autocorrelation (ρ=0 and 0.2).

Summary statistics for the raw and log-transformed data are shown in Table 1.

Descriptive Statistics: FC, Log10FC

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Variable   N  N*   Mean  SE Mean  StDev  Variance  CoefVar  Minimum     Q1  Median     Q3  Maximum
FC        13   0   2385     1722   6210  38566681   260.34       11    255     690   1200    23000
Log10FC   13   0  2.742    0.211  0.759     0.576    27.69    1.041  2.357   2.839  3.079    4.362
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Table 1. Summary statistics for data used in MDC analysis.

Table 2 shows the results of 36 MDC calculations presented as the percent reduction in geometric mean concentration.

Table 1. MDC Analysis Results.

Power	Baseline	Post- BMP	MDC as % (ρ=0)			MDC as % (ρ=0.2)		
	n	n[1]	95% CL	90% CL	80% CL	95% CL	90% CL	80% CL
0.5	13	15	68	58	43	75	66	50
	13	30	62	53	39	70	60	45
	13	60	59	50	36	66	57	43
0.8	13	15	82	76	68	87	83	75
	13	30	77	71	63	83	78	70
	13	60	74	68	60	81	75	67

[1]15 is 3x/yr for 5 yr, 30 is 6x/yr for 5 yr, and 60 is 12x/yr for 5 yr