APPENDIX D

Examples of Trends Analysis for Skagit County Monitoring Program

Introduction

Trends analysis provides tools for helping to determine if water quality parameters are improving, staying the same, or deteriorating. One difficulty in the analysis of water quality data is the seasonally-variable nature of many of the parameters. Temperature, dissolved oxygen, and most other water quality parameters are sensitive to climate and weather patterns, so winter observations may not be directly comparable to those obtained in the summer.

While there are many possible approaches to this kind of analysis, Skagit County is currently focusing on use of the Seasonal Kendall's Test. An example is included below. The Seasonal Kendall's Test is specifically designed to account for seasonal variability and makes it ideal for Skagit County Monitoring Program data. This tool has been used in a wide variety of water quality studies in North America (e.g. Cude 2002, Holdeman et al 2003).

Another possibly useful tool is the analysis of variance incorporating data from one season compared to the same season from a previous year. This tool has been used to compare water quality between years to determine if statistically significant changes have taken place (e.g. Carroll et al 1996, Stewart and Skousen 2000). An example of that approach follows the Seasonal Kendall's Test example.

Seasonal Kendall's Test

The Seasonal Kendall's Test is a method that accounts for seasonal variability in fitting the trend line to the data. Figure D-1 is an example of the test as applied to fecal coliform data from Thomas Creek at Highway 99 (Site 3 in the Skagit County Monitoring Program).

Figure D-1 indicates that there is no statistically significant trend in fecal coliform at this site. The table to the right of the graph indicates that the slope of the line (in blue) is not significantly different from zero at the 80, 90, and 95% confidence level. A zero slope indicates no trend.

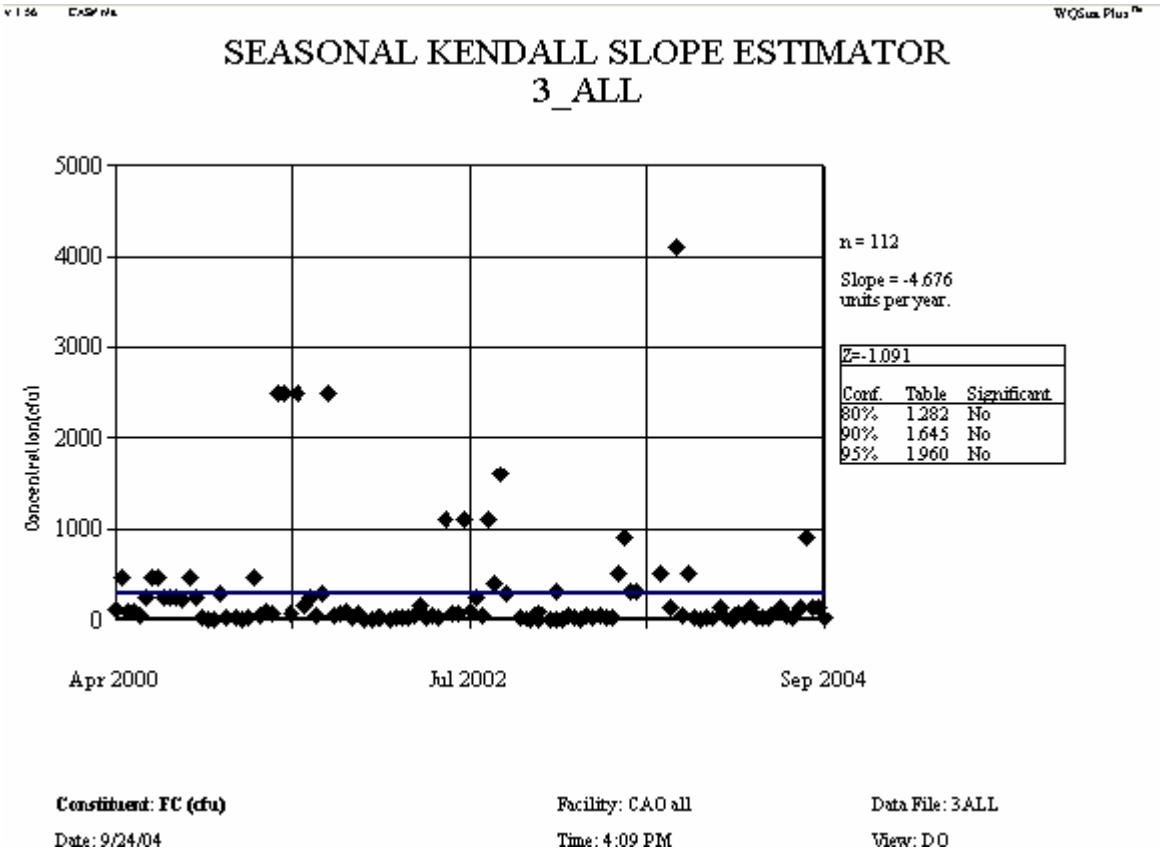

Figure D-1. Seasonal Kendall's Test results for fecal coliform from Site 3, Thomas Creek at Highway 99.

Analysis of Variance

Table D-1 shows the fecal coliform data collected at Site 3 for summer months only. The analysis of variance (ANOVA) is not designed to account for seasonal differences, thus we test only one season at a time.

ANOVAs are based on a number of assumptions about the underlying structure of the data. One of those assumptions is that the data are normally distributed, a common assumption in parametric statistics. Because the data in Table D-1 are not normally distributed (as demonstrated by the Shapiro-Wilks test), we must either transform the data to adjust the distribution or use the non-parametric equivalent test. In this example, we conducted the Kruskal-Wallis non-parametric test. Results of the Kruskal-Wallis test are summarized as a footnote to Table D-1. No significant differences were found between years for fecal coliform at Site 3. This would suggest that there are no significant trends in summer fecal coliform at Site 3 for the past five years.

Results from the ANOVA or its non-parametric equivalents for comparisons between years need to be treated with caution. These techniques were not specifically designed for seasonally-variable data, and even within one season (in this case, summer), there is a

large amount of variability which may or may not be related to seasonal factors. The variability decreases the ability of the test to detect differences between years. Skagit County currently believes that the Seasonal Kendall's Test, which incorporates all data collected while accounting for seasonal differences, gives a better indication of trends in water quality data. In this case, the Kruskal-Wallis test for the summer data agreed with the Kendall's Test results for all data, but that may not always be the case.

Table D-1. Summer fecal coliform data (colony-forming units/100 ml) from Site 3, Thomas Creek at Highway 99

Year	**2000**	**2001**	**2002**	**2003**	**2004**
	240	240	100	300	23
	460	43	240	300	130
	460	290	43	500	900
	240	2500	1100		130
	240	43	390		130
	240	64	1600		13
	210				
Mean	299	530	579	367	221
St. dev.	111	971	629	115	337

Kruskal-Wallis test results: KW Statistic = 5.56, p = 0.2342

Interpretation of Trends

Evidence of a statistically significant trend needs to be carefully evaluated for the factors that may contribute to such a trend. These factors include climate, upstream land use changes, and overall trends in other watercourses. Skagit County will compare trends detected in water quality in agricultural areas with trends seen in the non-agricultural study streams, as well as consider differences in climate and land use patterns that may influence the trends found at any individual watercourse.

References

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Cude, Curtis. 2002. McKenzie Watershed Water Quality Report: Water Years 1992-2001. Oregon Department of Environmental Quality, Portland, OR.

Holdeman, Mark A., Gibson, Sammy C, and Carl Christensen. 2003. Trend Analysis of Fixed Station Water Quality Monitoring Data in the Upper Wabash River Basin 1998. Indiana Department of Environmental Management, Office of Water Quality, Assessment Branch, Surveys Section, Indianapolis, Indiana. IDEM 032/02/023/2003.

Stewart, Jason and Jeff Skousen. 2000. Water Quality Changes in an Acid Mine Drainage Stream Over a 25-Year Period. West Virginia University Extension Service, Morgantown, VA.