

Malheur Agricultural Drain Statistical Analysis

Introduction

Since 2003, the Malheur County Soil and Water Conservation District has been monitoring 20 of the largest drains that empty into the Snake and Malheur Rivers. These drains capture irrigation tail water and storm water run-off from urban and rural lands. Their goals were to determine the differences among the drains in their contribution of sediment, nutrients and bacteria. If they determined there were significant differences then the monitoring data would serve to guide the district's priorities in land-owner assistance, and help refine the Hells Canyon – Snake River Total Maximum Daily Load (TMDL) adopted by the EPA in 2004.

The Oregon Department of Agriculture volunteered to help the District statistically analyze the data from the drains. We hope this analysis will help guide the district's efforts.

Methods

District staff have been collecting water samples from 20 drains on a monthly basis since January, 2003. They followed the sampling procedures outlined by Oregon's DEQ and the BOR lab in Boise, Idaho. The BOR lab analyzed the samples for nitrate, total phosphorus, e. coli, and total suspended solids.

The sampling will continue for the foreseeable future. In this report we will analyze the samples taken from January, 2003 to December, 2004. Our statistical analysis was as follows:

1. For each of the four parameters we analyzed the distribution of the data to determine the validity of the assumption of a Gaussian (normal) distribution, which is required by parametric statistical methods. Not surprisingly, none of the distributions were normal as determined by the Shapiro-Wilk W Test. We then transformed the data using a $\log_{10}+1$ procedure and re-tested. These transformations resulted in normal distributions for all parameters except total phosphorus. This phosphorus data was transformed by calculating its square root. The new distribution was examined and we found to be normally distributed.
2. We used Multiple Analysis of Variance (MANOVA) to determine if the parameters varied by drain. We assumed each drain was independent from all others.
3. We tested whether the time of year had an effect by dividing the samples into the categories of Winter, Spring, Summer and Fall.
4. Thus, our analysis was for two independent factors, drain and season and the interaction of those factors drain and season. Our dependent factors were E. coli, nitrate, total-phosphorus and suspended solids.
5. Our null hypothesis is:
 - a. There is no difference in the means of each parameter for each drain and season.

Results

MANOVA uses four tests to accept or reject the null hypothesis. They are: Wilk's Lambda, Pillai's Trace, Hotelling-Lawley, and Roy's Maximum Root. All four tests of the whole model (drain, season and drain *season) provided evidence that the water quality of the drains are statistically different ($p < 0.001$). Tests of the individual factors reveal that the means of the drains ($p=0.02$) and seasons ($p<0.001$) are different but their interaction is not ($p= 0.28$).

Once we established there was evidence to reject our null hypothesis we investigated each parameter separately with analysis of variance (ANOVA) as directed by Zar (1999)¹. We omitted interaction effects because there was no evidence to support this as a significant effect.

These ANOVAs provided evidence that each water quality parameter was significantly different among drains and seasons. Nitrate was the parameter with the largest differences among the drains ($p < 0.001$). We then conducted means comparisons using the Student's t test. This indicated that drains 9 and 20 were significantly higher than the rest and that drain 15 was significantly lower. Please note the attached Box Plots and charts for all the parameters.

There was some inconsistency in parameter means among drains. For example, drain 15 was low for nitrate, but it was the highest for bacteria and was among the highest for the other parameters. Drain 18 had among the highest levels for Total phosphorus, E. coli, and suspended solids but was low in nitrate. See the attached chart for examples of how the drains ranked.

Seasonal differences were significant for all parameters. The summer season had the highest values for all parameters except nitrate where winter had the highest average followed by fall, spring and summer. This is the exact opposite order for all the other parameters. Means comparisons indicated significant differences among all seasons for all parameters except total phosphorus where fall and winter were not significantly different from each other.

Conclusions

Statistical analysis provides strong evidence that many drain's water quality is different. Some possible reasons for this include:

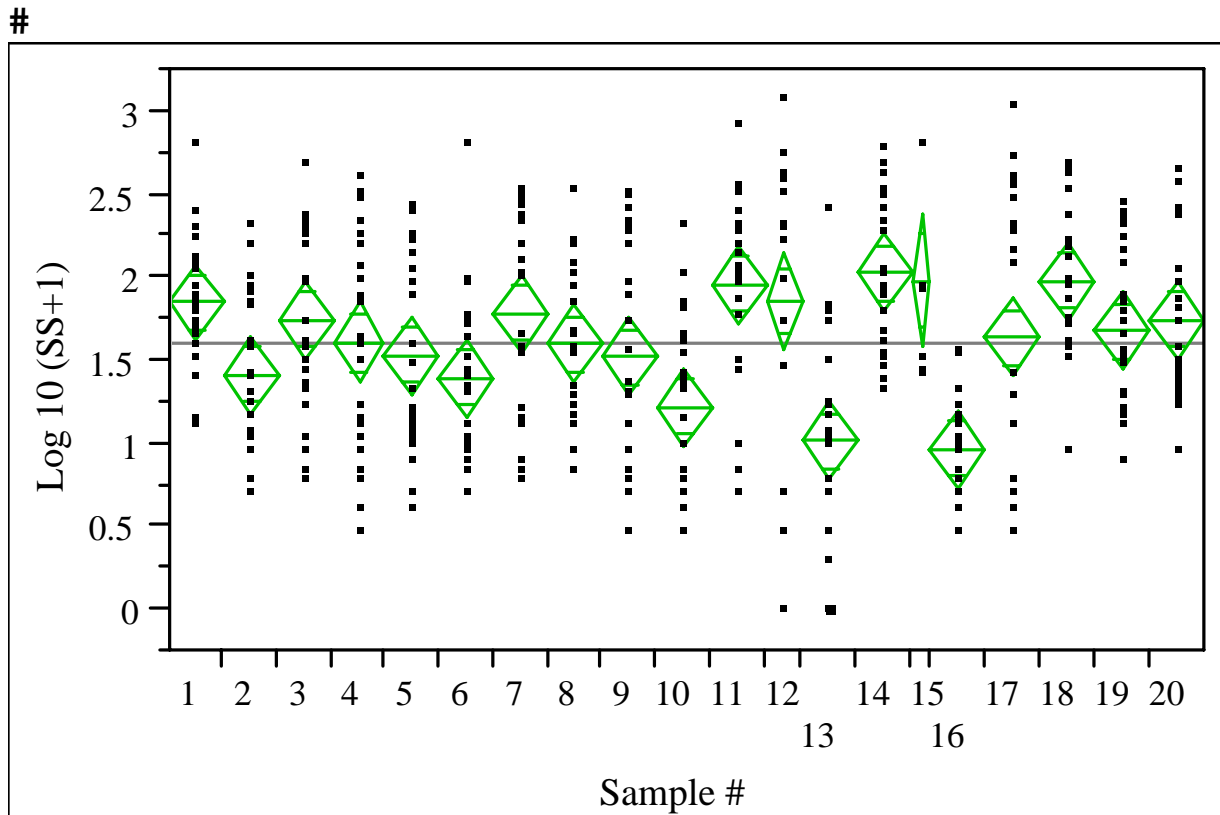
- Different size of the areas being drained,
- Different soil types among the drainage areas,
- Different cropping or other farming practices,
- Influence of urban areas present for some drains and not for others,
- Unknown factors.

Another conclusion is that each parameter varies significantly by season. Not surprisingly the summer months were the highest. This season corresponds with irrigation season. Nitrate levels were the exception. Perhaps this is due to algae consuming the nitrogen. Further testing, for example dissolved oxygen and pH levels, would be required to confirm this hypothesis.

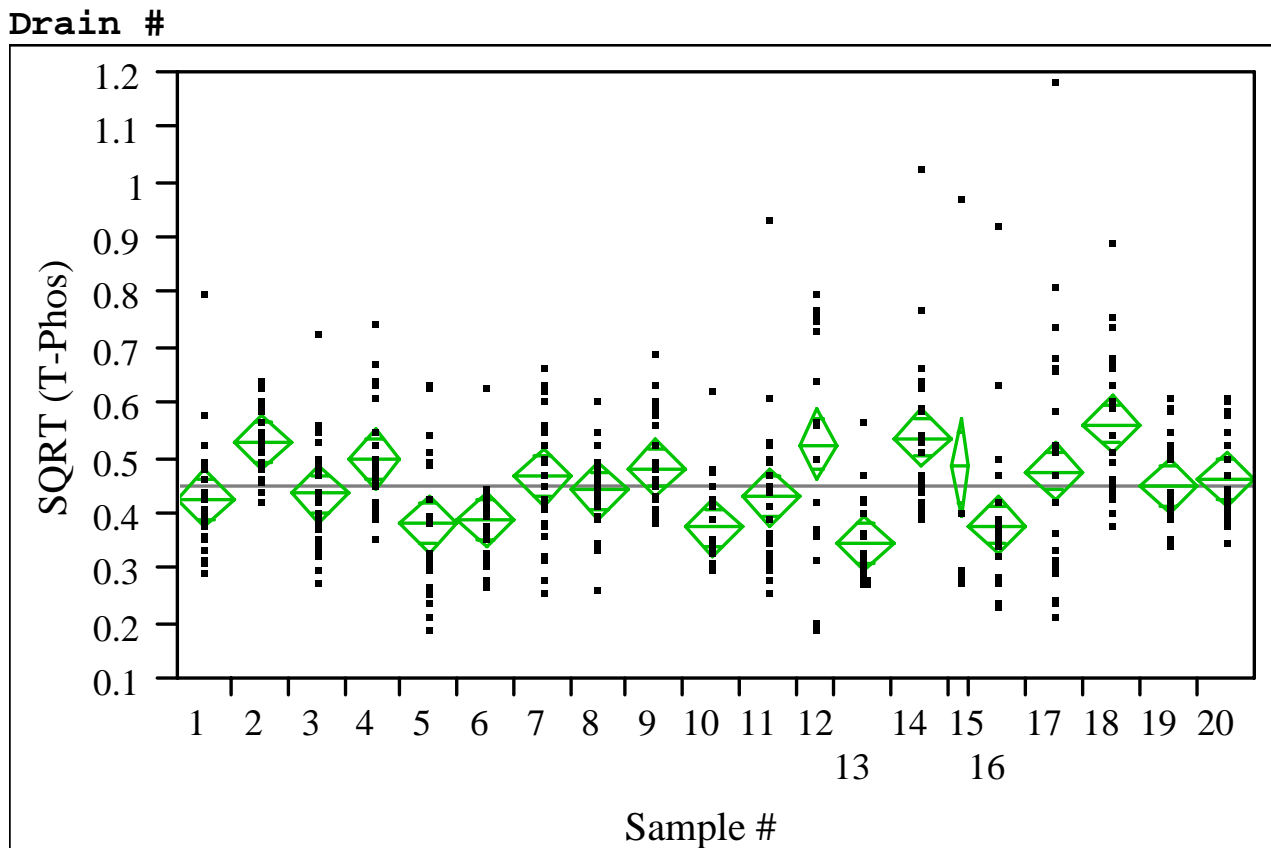
¹ Zar, J.H. 1999. Biostatistical Analysis. 4th Edition. Prentice Hall. Upper Saddle River, New Jersey. 664 pgs.

Appendix A

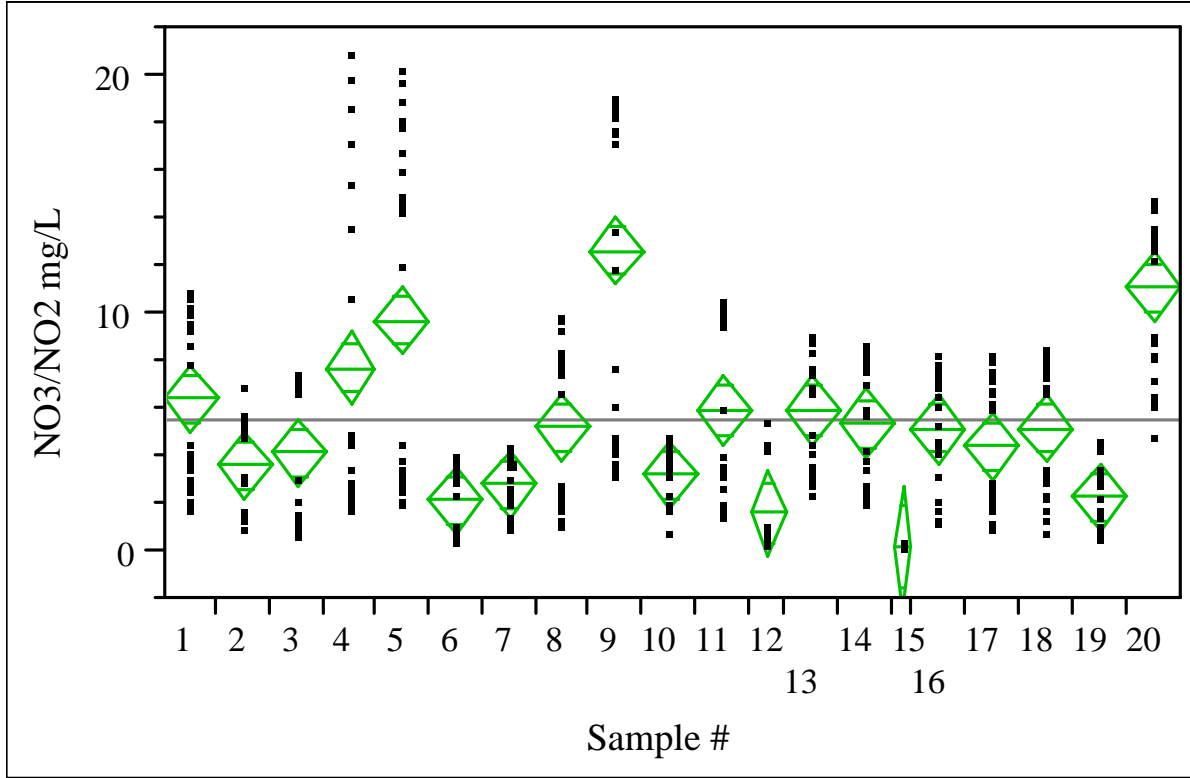
Box Plots of Log 10 (SS+1) By Drain



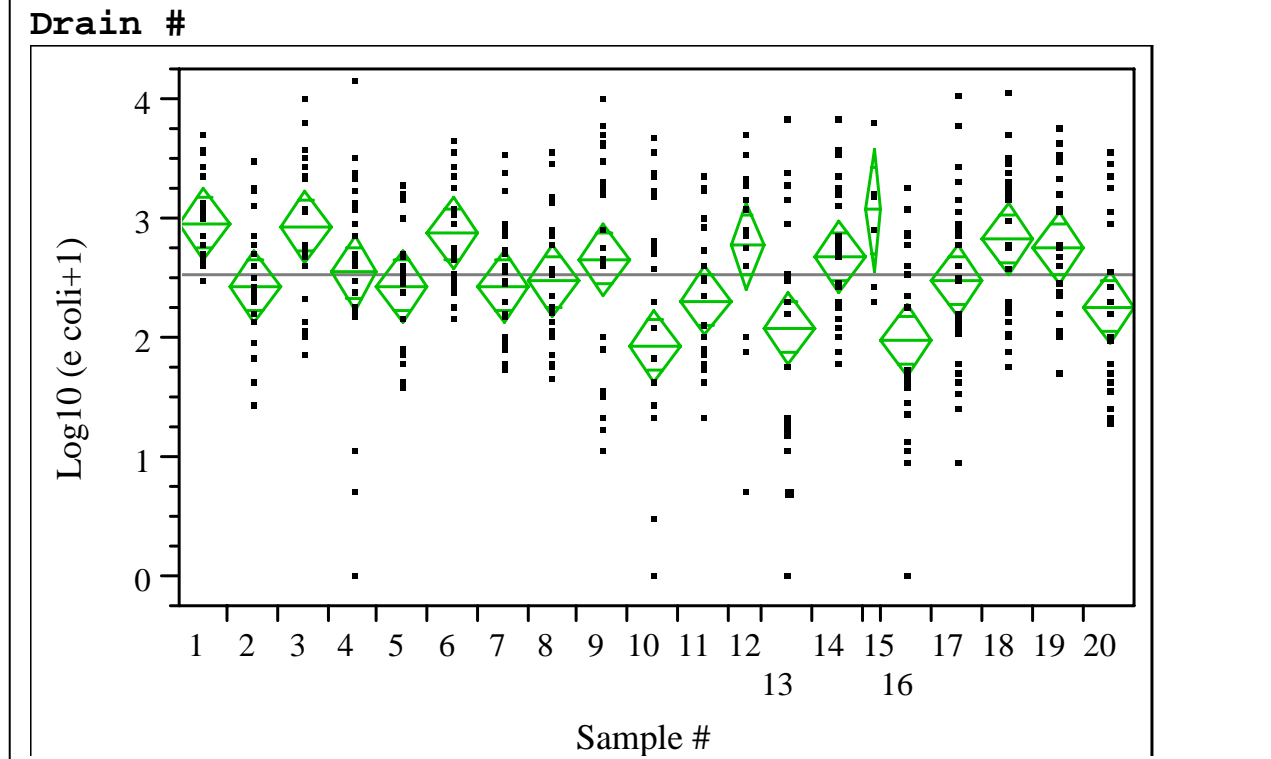
Box Plots of SQRT (T-Phos) By Drain



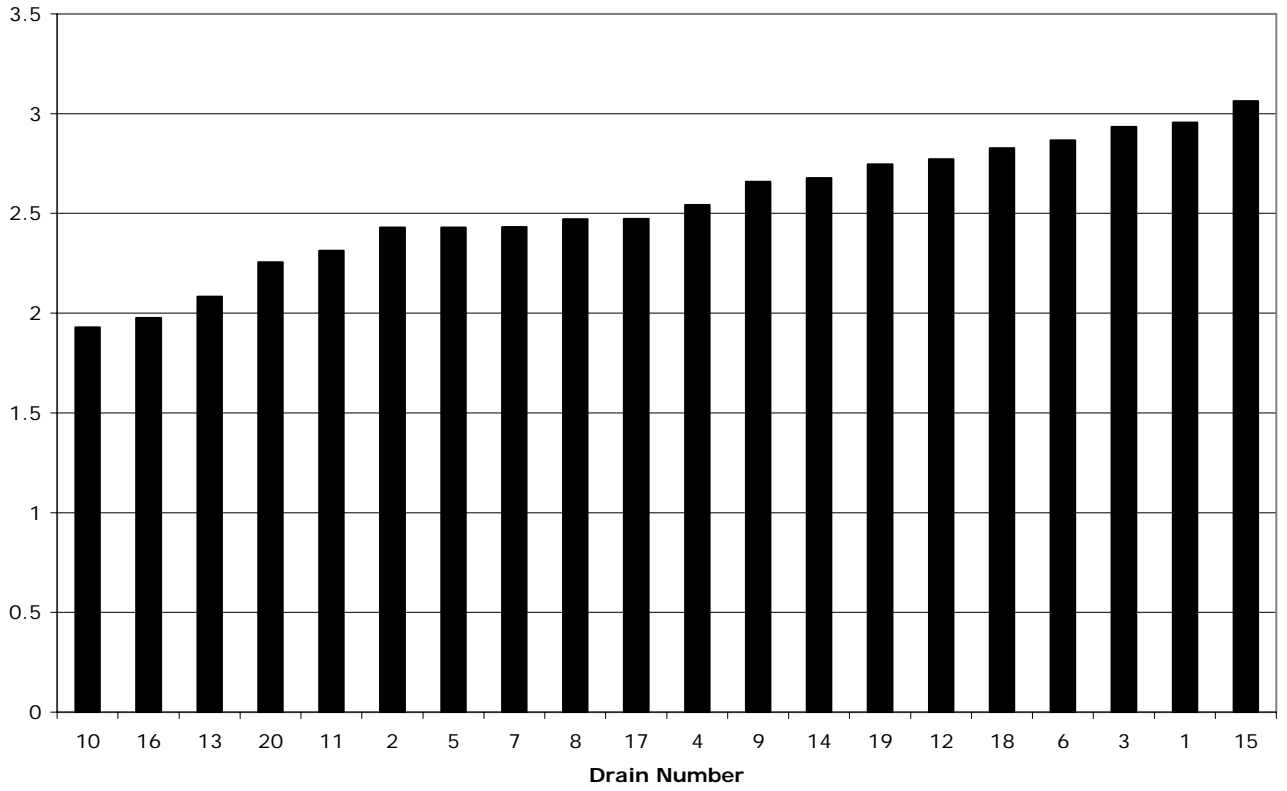
Box Plots of NO3/NO2 mg/L By Drain #



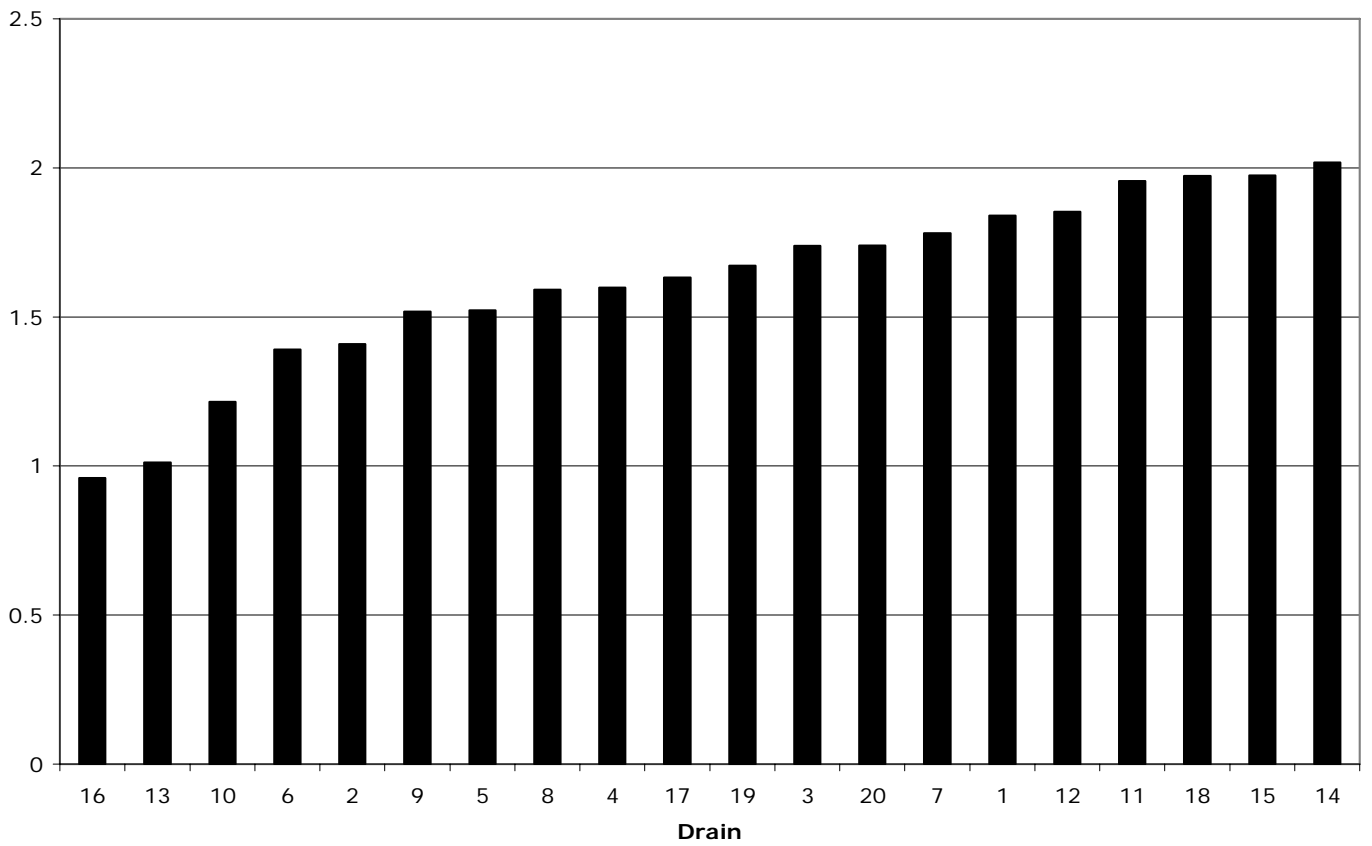
Box Plots of Log10 (e coli+1) By Drain #



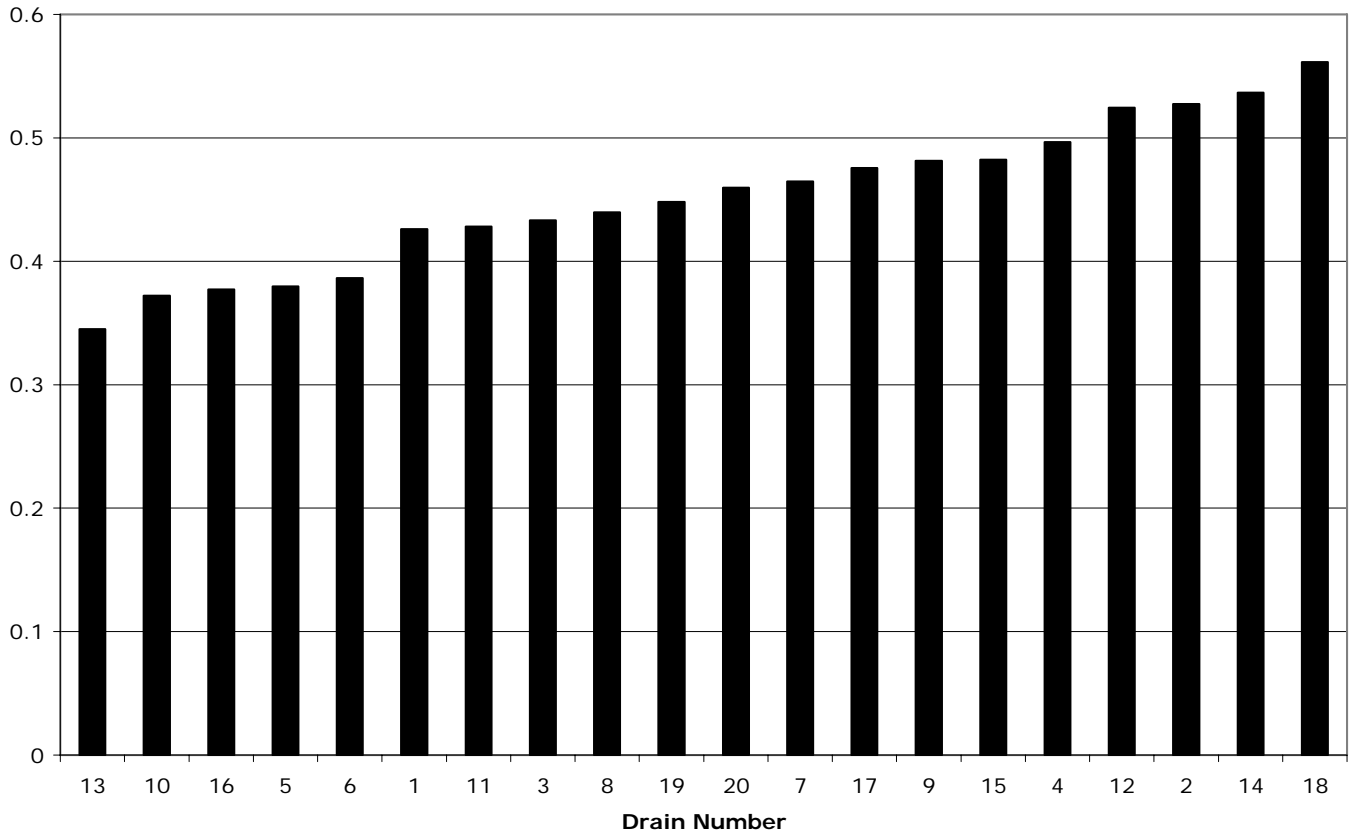
Mean E. coli by Drain Number



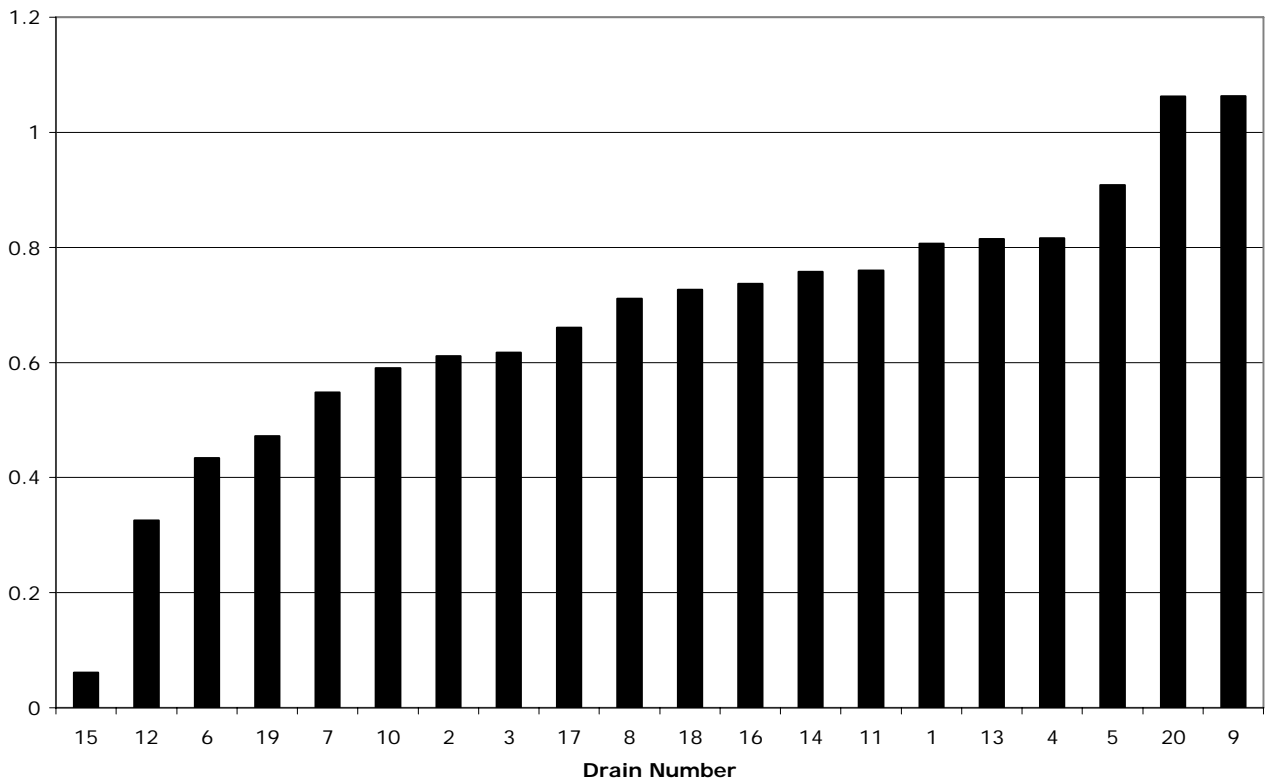
Mean Suspended Solids for each Drain



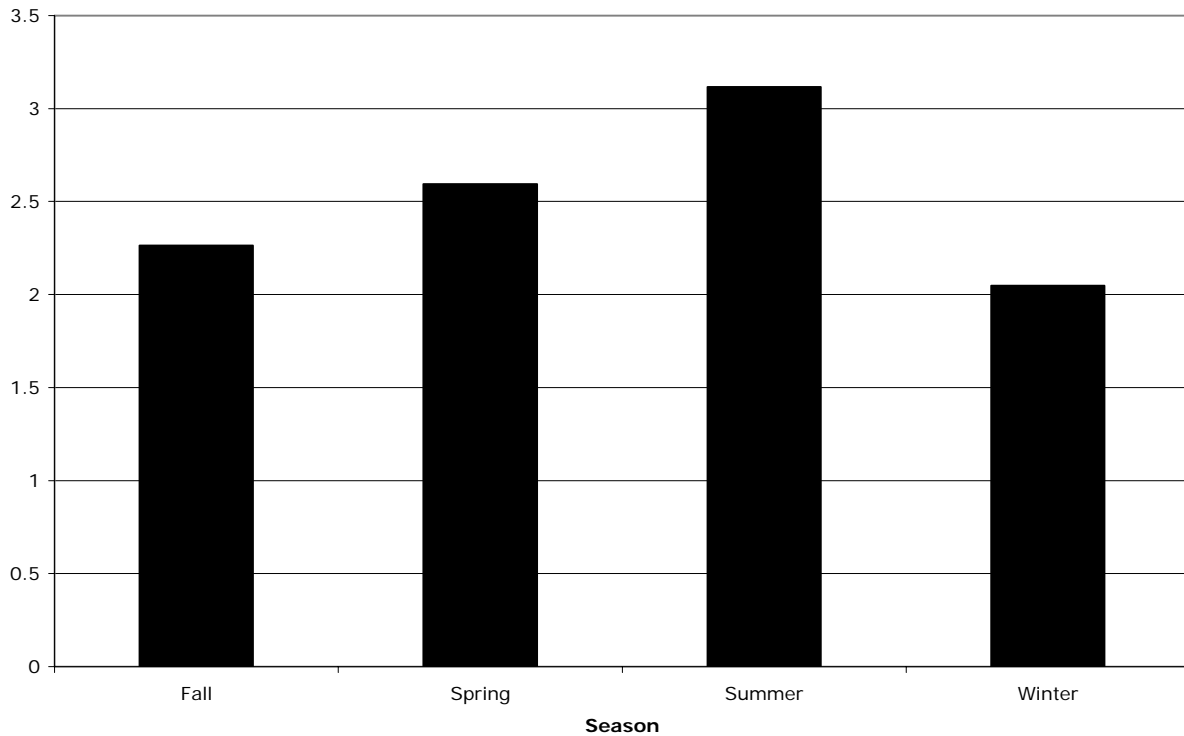
Mean Total Phosphorus Levels For Each Drain



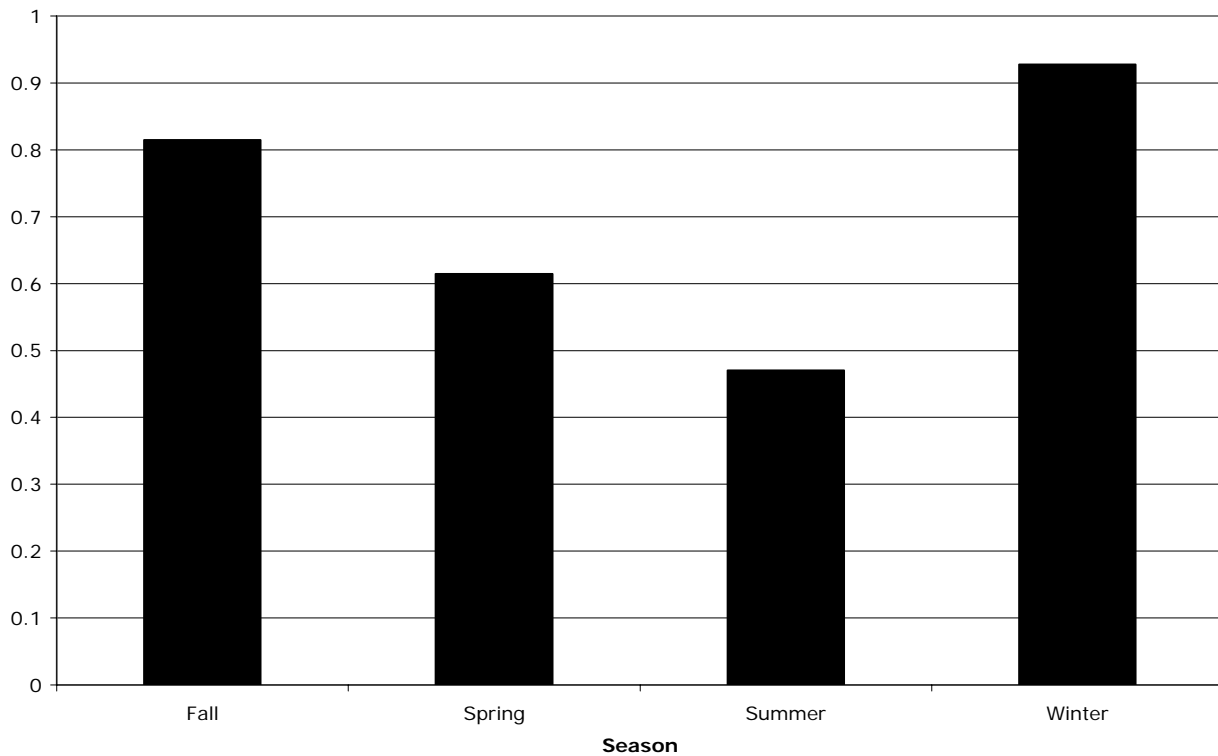
Mean Nitrate Levels for Drains



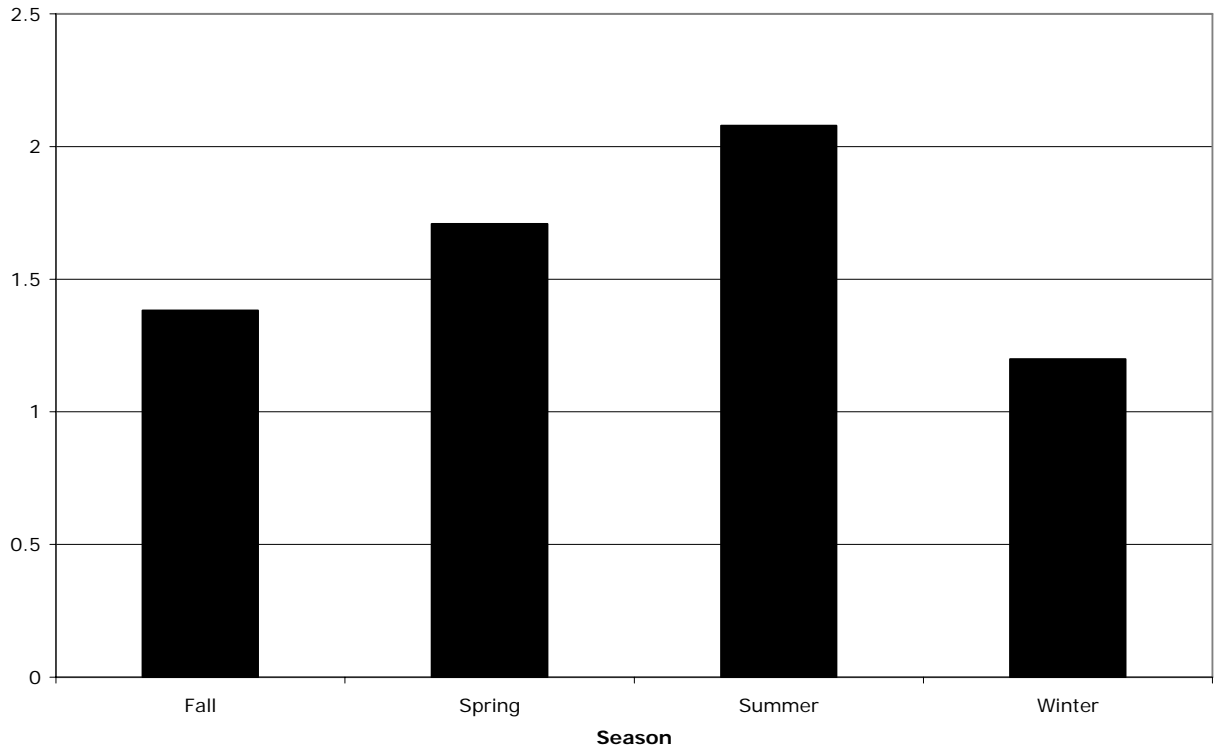
Mean E. coli by Season



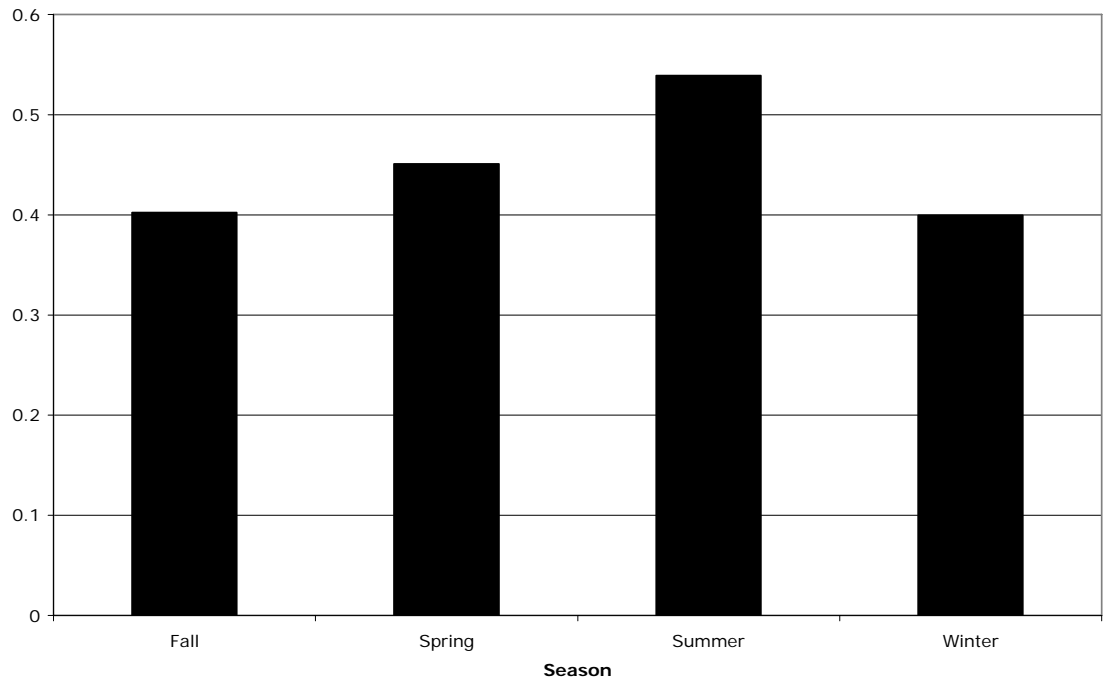
Mean NO3 for Season



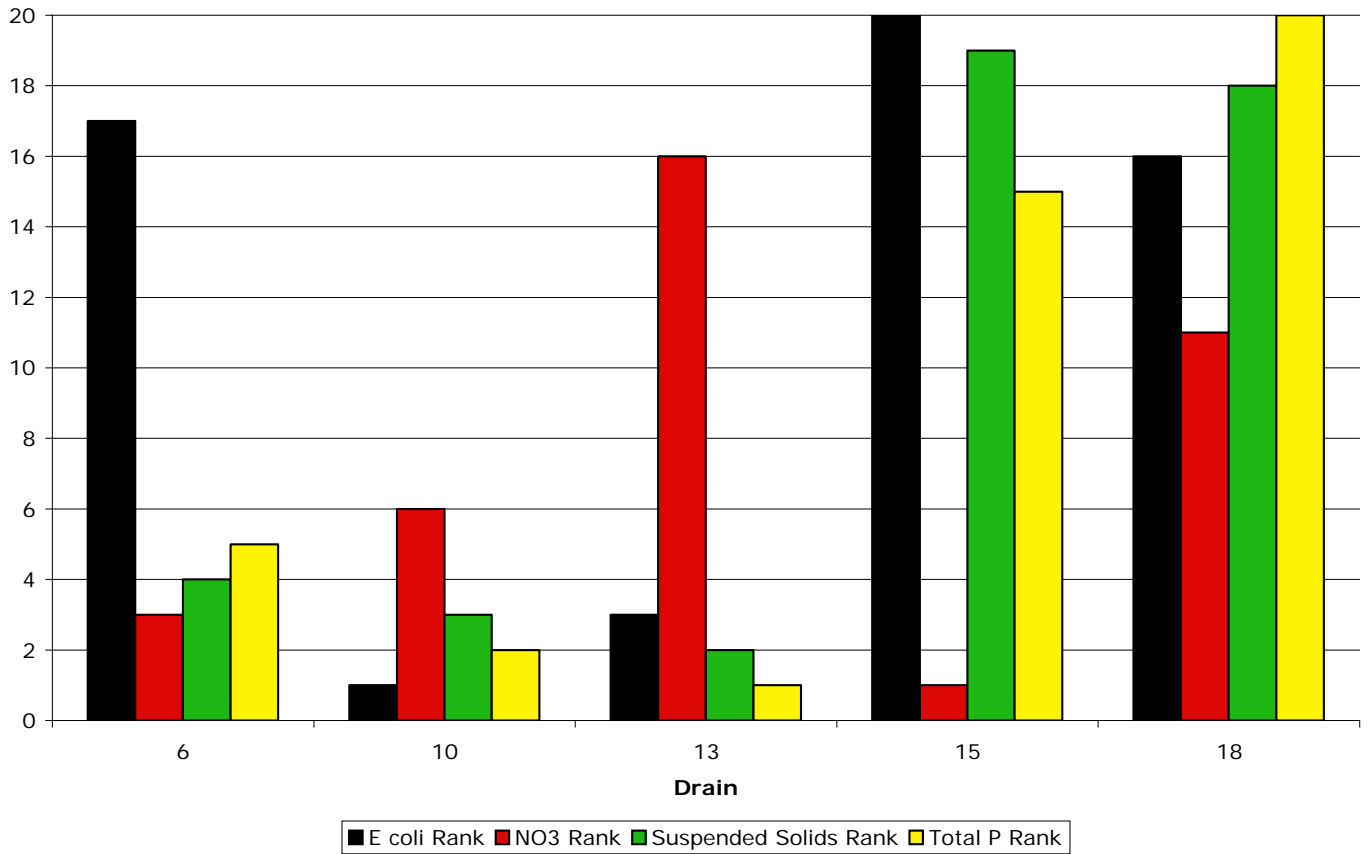
Mean Suspended Solids By Season



Mean Total Phosphorus by Season



Ranks of each Parameter for Selected Drains



We arranged the means for each parameter for each drain from lowest to largest and assigned a ranking (1= lowest and 20 = largest). These five drains appeared to have the most consistent patterns.