Phosphorus Loading Trends in Upper Medway Creek

By;
Ankita Hazarika, EIT
Dr. Imtiaz Shah, P.Eng
Date: 19th November, 2019

Western Engineering
Department of Civil and Environmental Engineering

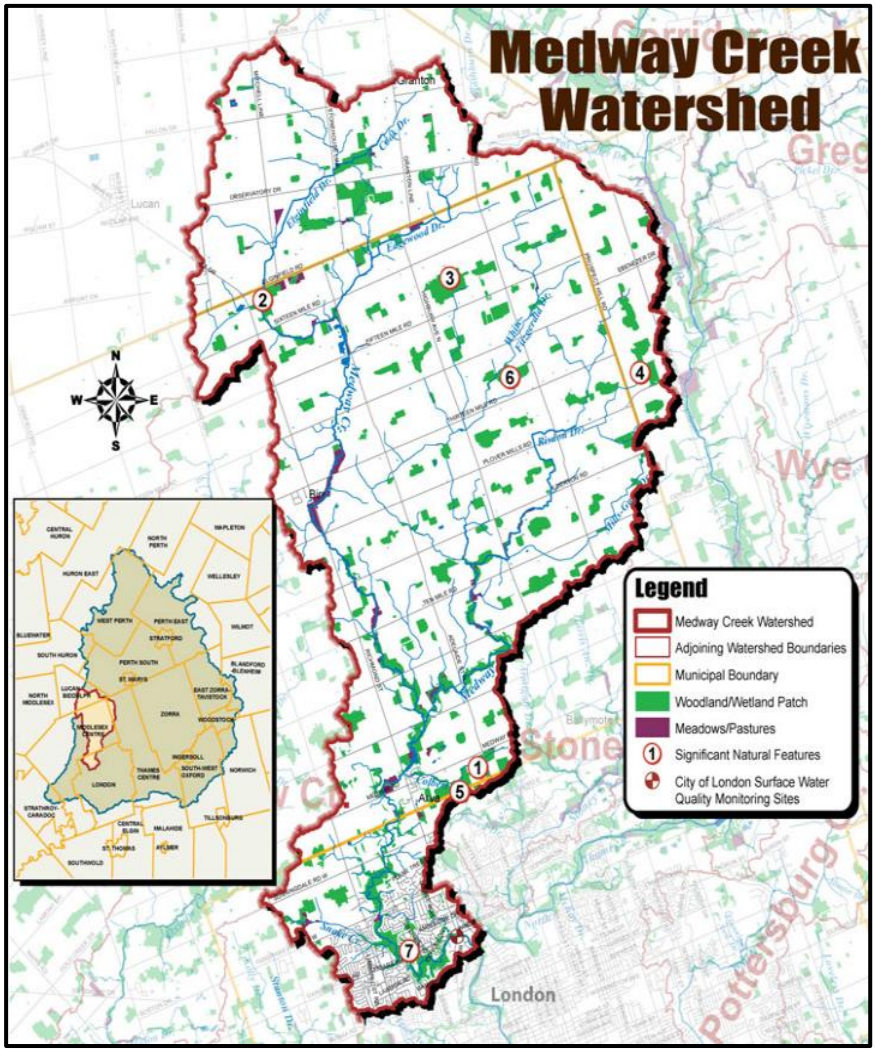
Overview

- Introduction
- Objectives
- Sampling Locations
- Methodology
- Results and
- Conclusions and Recommendations

Introduction

Upper Medway Creek Watershed:

- Location: Township of Lucan- Biddhulph, Middlesex Country, Ontario
- Total Area: 205 Km^2
- Predominant Land use: Agricultural, 82%
- Phosphorus concentration in Medway Creek has exceeded the Provincial Water Quality Objectives.

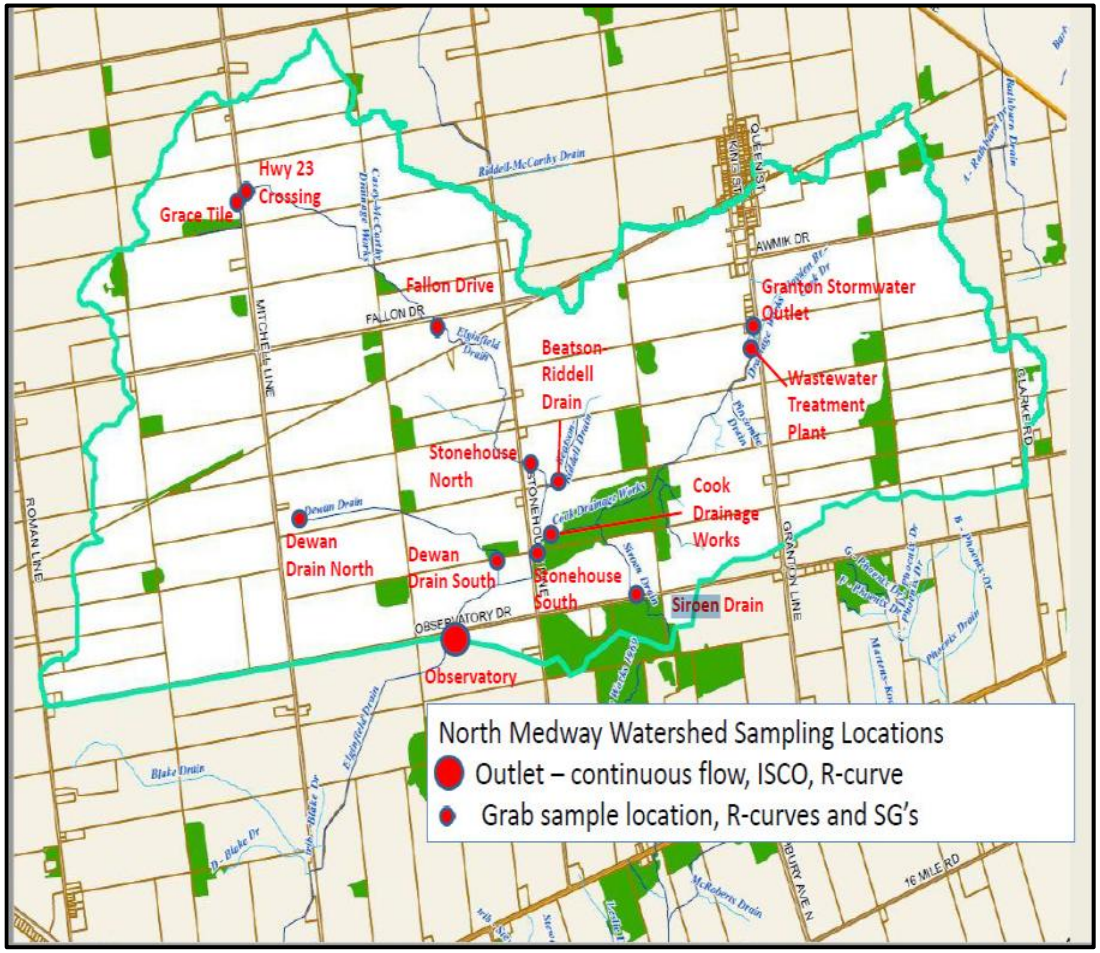


Objectives

- To examine trends of phosphorus loading between ISCO samples and grab samples taken at various locations along the Medway Creek;
- To conduct literature reviews related to the project;
- To analyze the collected data using statistical methods and;
- To investigate phosphorus loading trends between continuous automatic sampling and grab sample monitoring.

Sampling Locations

- Water quality samples were taken at the locations shown in the figure.
- Sampling Methodologies:
  - ISCO programmable water samplers and;
  - Selected Discrete grab samples.



Methodology

Water Quality data from February 2016 to April 2018.

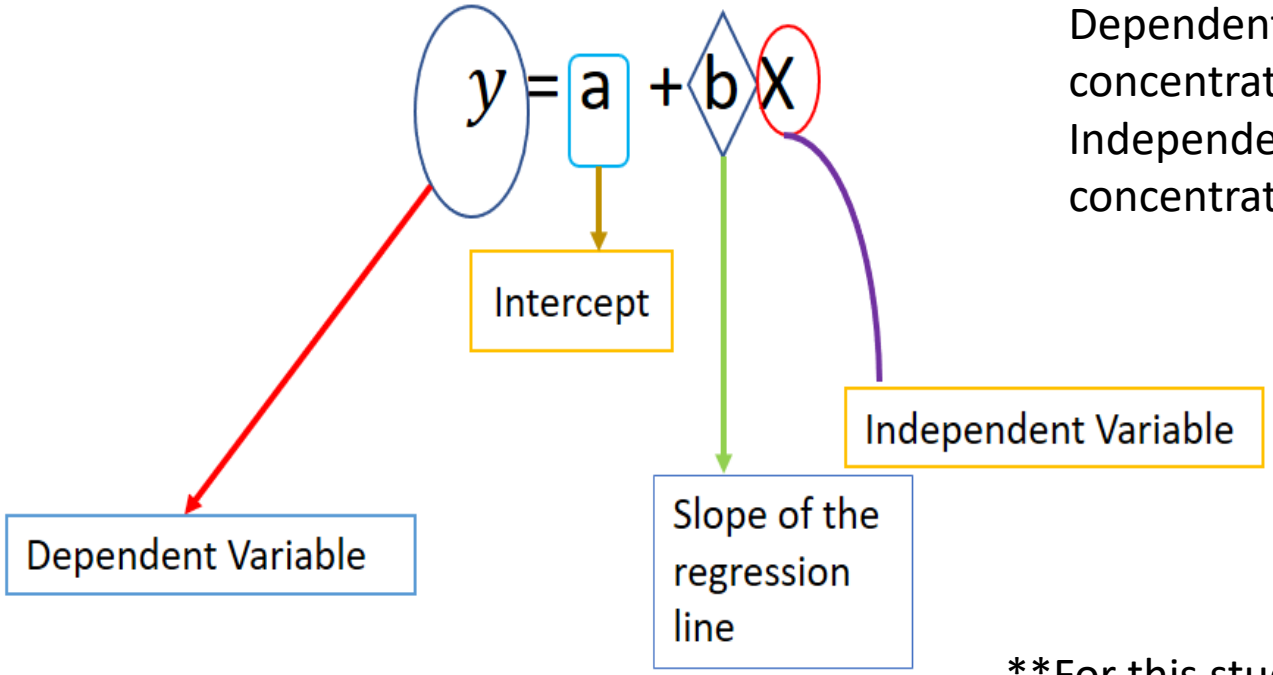
- Time series plots;
- Descriptive statistics;
- Outlier Removal;
- Pearson correlation;
- Test for Normality;
- Data transformation; and
- Linear Regression Analysis.

Software Used:

- MINITAB 18 Statistical Software and,
- Microsoft Office Excel 2016.

Linear Regression Analysis

A mathematical model used for prediction and forecasting of events



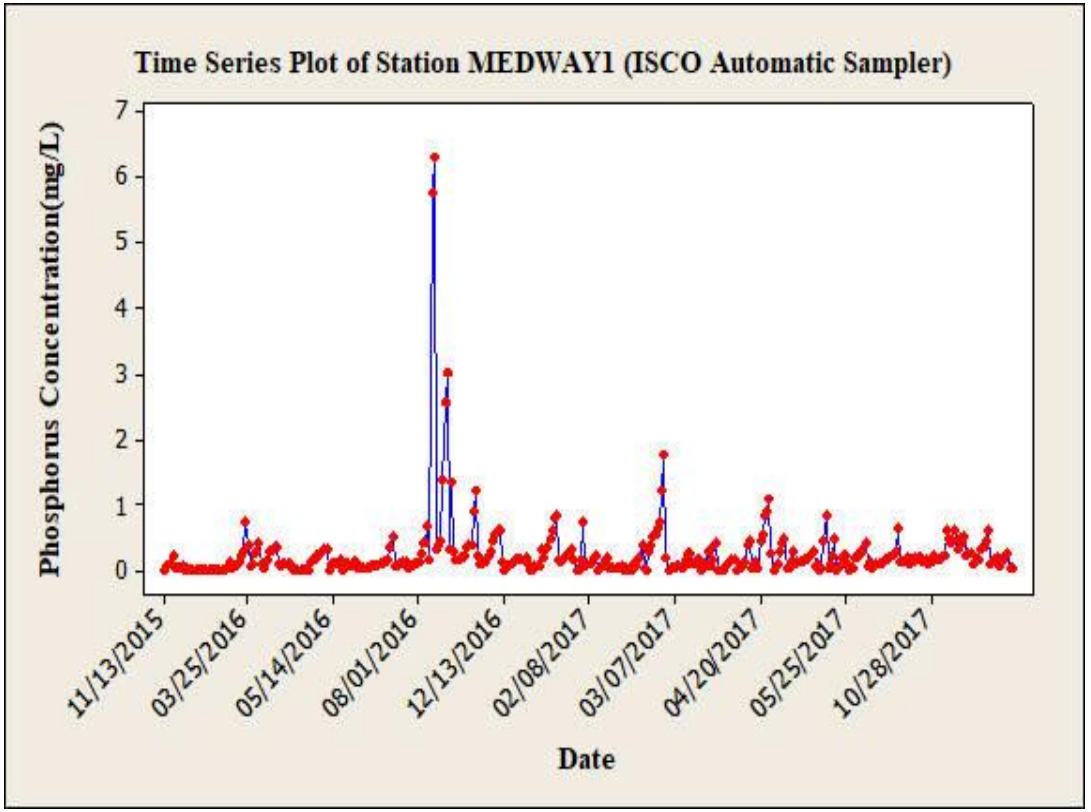
Dependent Variable: Phosphorus concentration of grab stations
Independent variable: Phosphorus concentration of ISCO station

**For this study, the confidence level has been kept as 95%. Thus, our α-level is 0.05

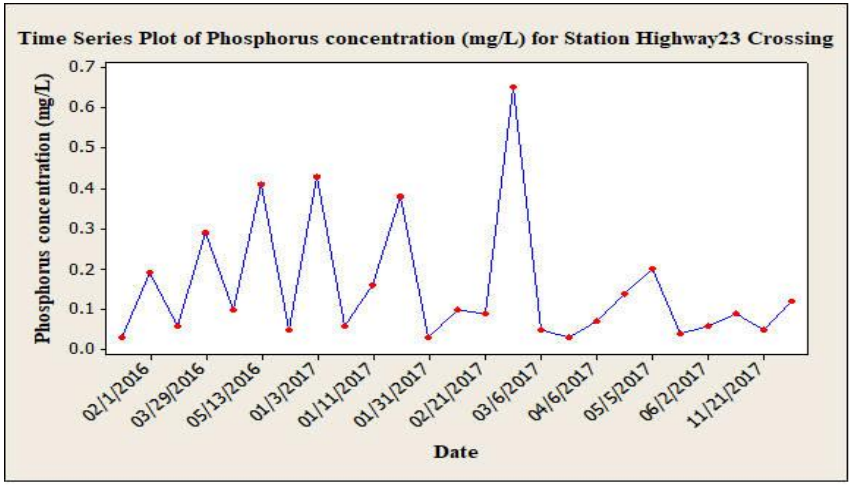
Time Series Plots

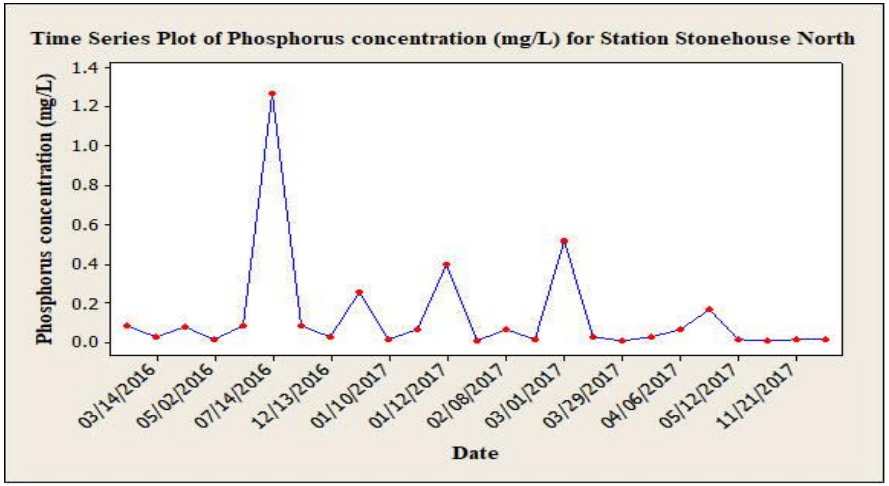
Graphical presentation of relationships between time and observations of variables measured in time

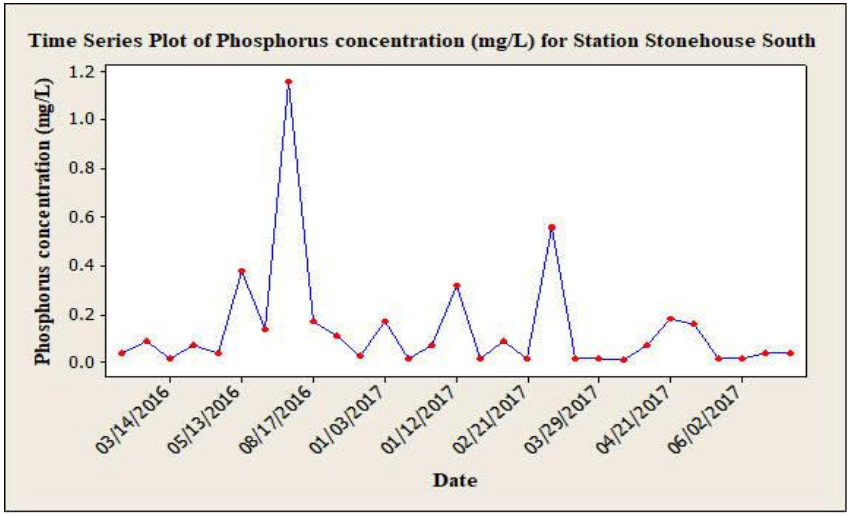
- No Trends and Seasonality were observed
- Presence of outliers were observed

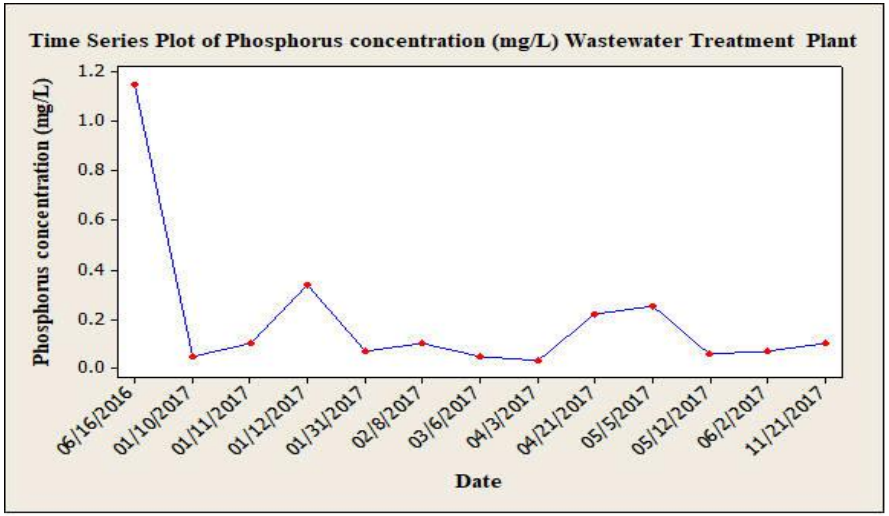


Time Series Plots









Descriptive Statistics

Variable (Phosphorus Concentration, mg/L)	N	N*	Mean	St. Deviation	Variance	Minimum	Q1	Median	Q3	Maximum
Medway1	388	0	0.26	0.52	0.26	0.01	0.07	0.14	0.28	6.32
Cook Drainage Works	22	0	0.26	0.42	0.18	0.02	0.03	0.08	0.29	1.51
Dewan Drain North	20	0	0.1	0.11	0.01	0.01	0.02	0.07	0.17	0.33
Dewan Drain South	22	0	0.09	0.11	0.01	0.01	0.02	0.07	0.13	0.39
Fallon Drive	29	0	0.09	0.13	0.02	0	0.02	0.03	0.1	0.58
Highway 23 Crossing	25	0	0.15	0.16	0.02	0.03	0.05	0.09	0.19	0.65
Stone House North	25	0	0.13	0.27	0.07	0.01	0.02	0.03	0.09	1.27
Stone House South	29	0	0.14	0.24	0.05	0.01	0.02	0.08	0.17	1.16
Wastewater Treatment plant	13	0	0.19	0.3	0.09	0.03	0.06	0.1	0.24	1.15

Outlier Removal

- Outliers are considered as the extreme values in a dataset that lies in abnormal distant from other observations

- 1.5 interquartile range rule is used in this study to identify the outliers present in the datasets.

- Data's above Q3 (Third Quartile) +1.5 IQR and below Q1 (First Quartile) + 1.5 IQR are being considered as outliers as they lie too far distance from other observations.(Interquartile Ranges (IQRs) Outliers,2018)

Pearson Correlation

-Measure of the strength and direction of the association between two variables

- Correlation coefficient lies between −1 and +1
Negative value: Inversely related
Positive value: Directly related

Variable	Pearson Correlation Coefficient, r	P-Value
Cook Drainage Works and Medway1	0.824	0.000
Dewan Drain North and Medway1	0.518	0.019
Dewan Drain South and Medway1	0.572	0.005
Fallon Drive and Medway1	0.77	0.000
Highway 23 Crossing and Medway1	0.877	0.000
Stone House North and Medway 1	0.843	0.000
Stone House South and Medway 1	0.93	0.000
Waste Water treatment plant and Medway 1	0.954	0.000

Test For Normality

- The normality of the data sets was checked before conducting regression analysis.
- Anderson Darling test is used to test if a dataset follows a specific distribution
- The confidence level has been kept as 95% for this study with α=0.005
- Anderson-Darling statistic(AD): Lower AD values indicate a better fit
- P- Value: P value lower than 0.05 indicates that the data do not follow a normal distribution

The hypothesis are:
H_0: The data follows a normal distribution
H_1: The data do not follow a normal distribution
If P value <= α: The decision is to reject the null hypothesis that means that data do not follow a normal distribution.
If P value > α:
The decision is to fail to reject the null hypothesis that means that data do not follow a normal distribution

Transformation of Data

- Box- Cox transformation has been used in this study to make the data follow a normal distribution.

$$T(Y)=(Y\lambda-1)/\lambda$$

Where:

λ = is the transform parameter, and

Y = is the response variable.

Value of lambda (λ) varies from -5 to 5

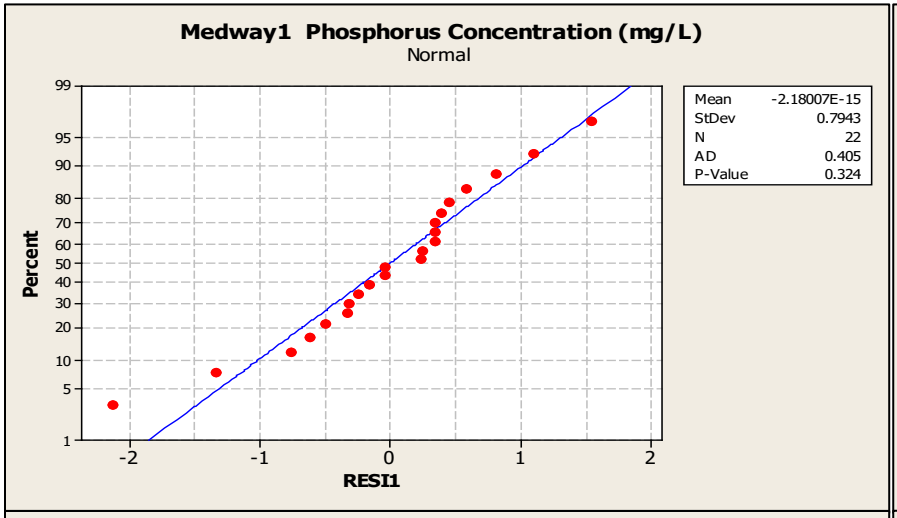
Common Box-Cox Transformations

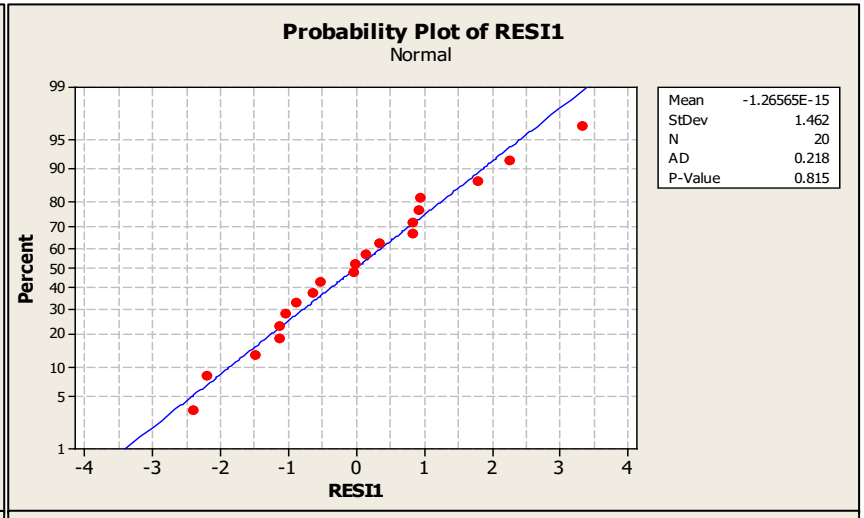
Lambda value (λ)	Transformed data (Y')
-3	$Y^{-3} = 1/Y^3$
-2	$Y^{-2} = 1/Y^2$
-1	$Y^{-1} = 1/Y^1$
-0.5	$Y^{-0.5} = 1/(\sqrt{(Y)})$
0	log(Y)
0.5	$Y^{0.5} = \sqrt{(Y)}$
1	$Y^1 = Y$
2	Y^2
3	Y^3

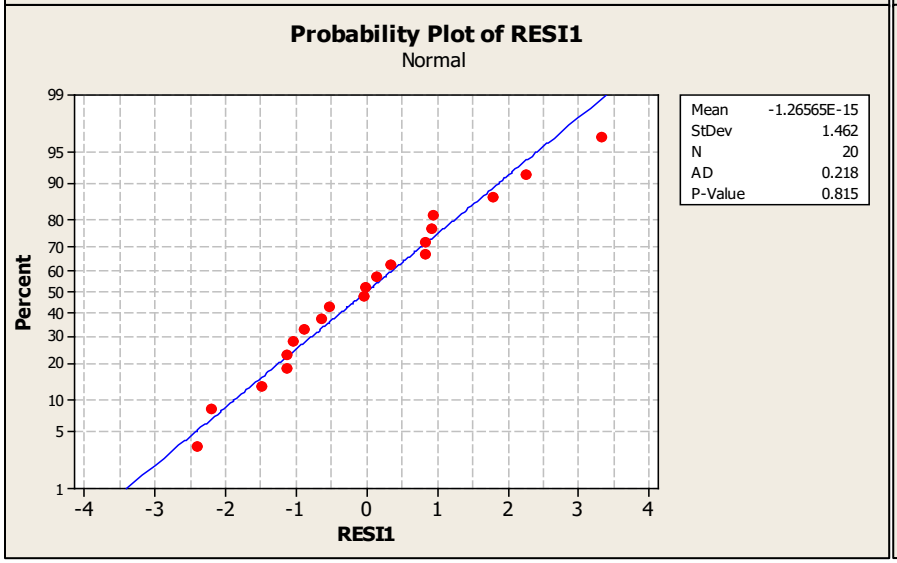
Deduction from the Regression Model

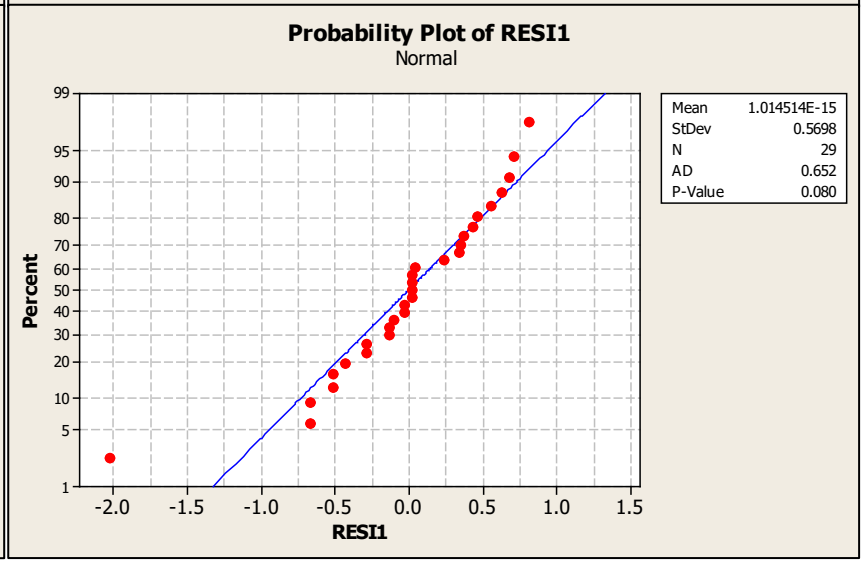
Variable	S	R- Sq	R- Sq(adj)
Cook Drainage Works and Medway1	0.81	81.60%	80.70%
Dewan Drain North and Medway1	1.5	61.90%	59.80%
Dewan Drain South and Medway1	0.61	73.60%	72.30%
Fallon Drive and Medway1	0.58	74.20%	73.30%
Highway 23 Crossing and Medway1	0.89	60.60%	58.90%
Stone House North and Medway 1	0.59	72.70%	71.50%
Stone House South and Medway 1	0.36	88.80%	88.30%
Waste Water treatment plant and Medway 1	0.32	80.50%	78.70%

Residuals


Medway1 Phosphorus Concentration (mg/L)
Normal
Mean -2.18007E-15
StDev 0.7943
N 22
AD 0.405
P-Value 0.324
Percent
RESI1


Probability Plot of RESI1
Normal
Mean -1.26565E-15
StDev 1.462
N 20
AD 0.218
P-Value 0.815
Percent
RESI1


Probability Plot of RESI1
Normal
Mean -1.26565E-15
StDev 1.462
N 20
AD 0.218
P-Value 0.815
Percent
RESI1


Probability Plot of RESI1
Normal
Mean 1.014514E-15
StDev 0.5698
N 29
AD 0.652
P-Value 0.080
Percent
RESI1

Conclusions and Recommendations

Conclusions:

- The adjusted coefficients of determination (R^2) values for loads of total phosphorus for the eight studied sites ranged from 58.9 % to 88.3% respectively.
- Stone House South and Cook Drainage Works stations showed a significant relationship with ISCO station (Medway 1) by having an adjusted R^2 of 88.3% and 80.7% respectively.

Recommendations:

- The frequency of data collection should be more consistent.
- The number of grab samples gathered should be increased
- More predictive variables like dissolved oxygen, PH, total ammonia can be included in the regression models.

Western
UNIVERSITY · CANADA

Thank You!