COEUR D'ALENE LAKE TOTAL PHOSPHORUS NUTRIENT CALCULATIONS FOR LAKE TRIBUTARIES

July 2017 update for TP

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OLS approaches requested:

1. OLS model with wetland variables in the dataset: Model 1
2. OLS model without wetland variables in the dataset: Models 2 & 3
3. OLS model with wetland variables in the dataset & with stream gradient in the model: Model 1
4. OLS model without wetland variables in the dataset & with stream gradient in the model: Model 3.
5. OLS model with wetland variables in the dataset & with % developed in the model: Model 1
6. OLS model without wetland variables in the dataset & with % developed in the model: Model 4

Model 1 was developed as Model 1 in previous report

Models 2-4 were developed as Models 2-4 (approach 1) in previous report

Approach 2 leads to Model 2

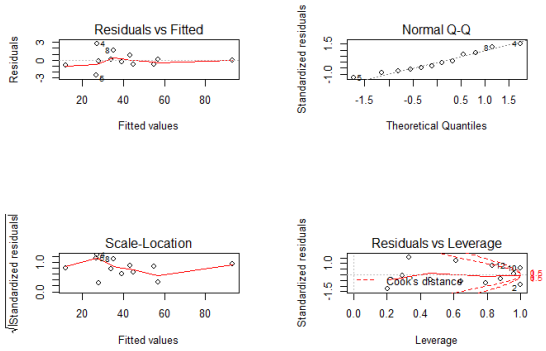
Results 1: OLS Model 1

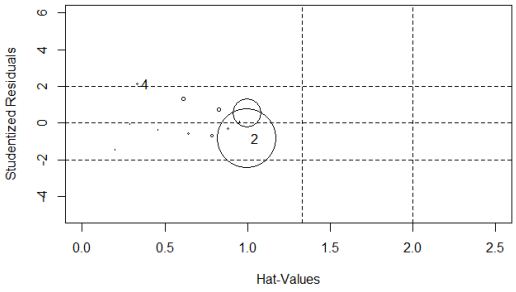
```
Call:
lm(formula = Tp.coeff ~ Road_length200 + Stream_density24k +
    Undeveloped + Wetlands.total + soil_types51_60 + soil_types41_45 +
    Total.crops, data = data)


Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)        97.8624    10.1155    9.67  0.00064 ***
Road_length200     -0.2975     0.0852   -3.49  0.02511 *
Stream_density24k -18.9331     2.5881   -7.32  0.00186 **
Undeveloped       -65.6634    11.0322   -5.95  0.00400 **
Wetlands.total   3212.3176   312.3410   10.28  0.00050 ***
soil_types51_60    12.6323     3.1410    4.02  0.01584 *
soil_types41_45    30.7685     3.3551    9.17  0.00079 ***
Total.crops      1140.7122   102.2428   11.16  0.00037 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.23 on 4 degrees of freedom
Multiple R-squared:  0.996,    Adjusted R-squared:  0.988
F-statistic:  134 on 7 and 4 DF,  p-value: 0.000142
```

RMSE = 1.29
AIC = 58.2
BIC = 62.5





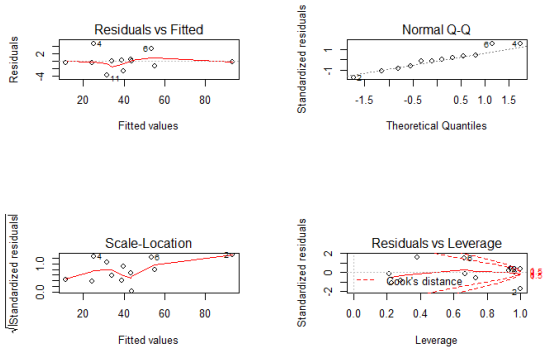
Results 2: OLS Model 2

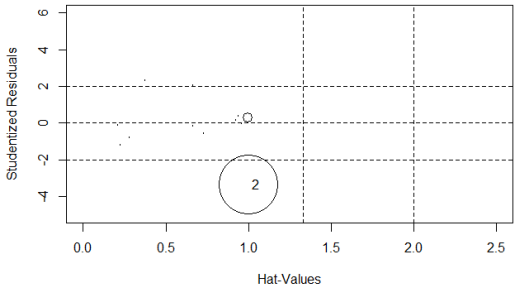
```
Call:
lm(formula = Tp.coeff ~ Road_length200 + Stream_length24k + soil_types51_60 +
    Undeveloped + soil_types41_45 + Total.crops + True.shrub,
    data = data)


Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       119.7131    19.8512    6.03   0.0038 **
Road_length200     -1.2587     0.1680   -7.49   0.0017 **
Stream_length24k    0.3132     0.0486    6.44   0.0030 **
soil_types51_60    19.1408     5.8032    3.30   0.0300 *
Undeveloped      -123.1342    19.9100   -6.18   0.0035 **
soil_types41_45    38.1872     6.1987    6.16   0.0035 **
Total.crops      1341.6041   167.9795    7.99   0.0013 **
True.shrub         43.6118    14.0997    3.09   0.0365 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.77 on 4 degrees of freedom
Multiple R-squared:  0.988,    Adjusted R-squared:  0.967
F-statistic: 46.6 on 7 and 4 DF,  p-value: 0.00113
```

RMSE= 2.18
AIC = 70.7
BIC = 75.1





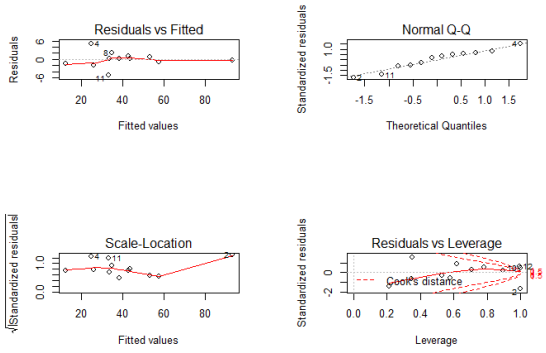
Results 3: OLS Model 3

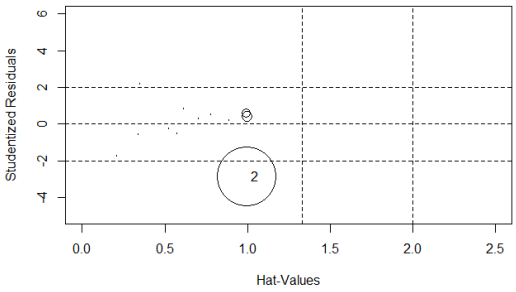
```
Call:
lm(formula = Tp.coeff ~ Road_length200 + Road_length + soil_types51_60 +
    Undeveloped + soil_types41_45 + Stream_gradient + Total.crops,
    data = data)


Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     139.4300    20.1038    6.94   0.0023 **
Road_length200   -1.5013     0.2059   -7.29   0.0019 **
Road_length       0.1461     0.0442    3.31   0.0298 *
soil_types51_60  14.5393     5.9289    2.45   0.0703 .
Undeveloped    -106.1275    21.0561   -5.04   0.0073 **
soil_types41_45  36.5735     6.7342    5.43   0.0056 **
Stream_gradient  -3.0987     1.4325   -2.16   0.0965 .
Total.crops    1250.1381   185.0050    6.76   0.0025 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.13 on 4 degrees of freedom
Multiple R-squared:  0.985,    Adjusted R-squared:  0.96
F-statistic: 38.8 on 7 and 4 DF,  p-value: 0.00162
```

RMSE= 2.38
AIC = 72.9
BIC = 77.3





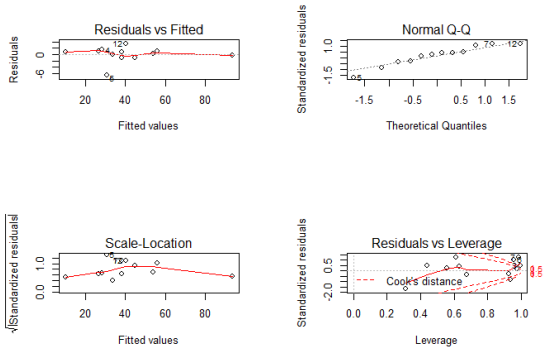
Results 4: OLS Model 4

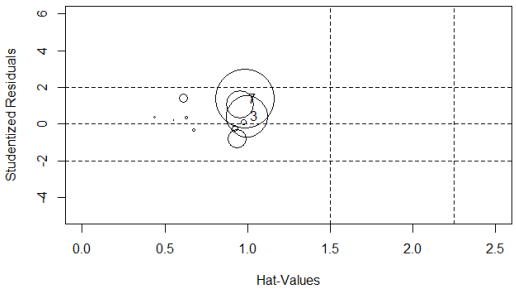
```
Call:
lm(formula = Tp.coeff ~ Road_length200 + Developed.open + soil_types51_60 +
    Undeveloped + soil_types41_45 + Road_density + Stream_gradient +
    Harvest.evergreen, data = data)


Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)        591.255     94.948    6.23   0.0084 **
Road_length200      -1.583      0.205   -7.72   0.0045 **
Developed.open    -586.067    191.331   -3.06   0.0549 .
soil_types51_60     23.596      7.144    3.30   0.0456 *
Undeveloped       -515.819    101.609   -5.08   0.0148 *
soil_types41_45     59.604      9.428    6.32   0.0080 **
Road_density        -8.682      1.511   -5.75   0.0105 *
Stream_gradient     -6.400      1.349   -4.75   0.0177 *
Harvest.evergreen -523.000    147.296   -3.55   0.0381 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.64 on 3 degrees of freedom
Multiple R-squared:  0.986,    Adjusted R-squared:  0.95
F-statistic: 26.9 on 8 and 3 DF,  p-value: 0.0103
```

RMSE= 2.32
AIC = 74.2
BIC = 79.1





Results 5: Model averaging coefficients

Models 2 to 4 (no wetlands variables):

```
Model-averaged coefficients:
(full average)
                   Estimate Std. Error Adjusted SE z value Pr(>|z|)
(Intercept)        1.25e+02   2.17e+01    2.95e+01    4.23   <2e-16 ***
Road_length200    -1.32e+00   2.07e-01    2.74e-01    4.82   <2e-16 ***
Stream_length24k   2.34e-01   1.42e-01    1.48e-01    1.58    0.114
soil_types51_60    1.80e+01   6.17e+00    8.50e+00    2.11    0.034 *
Undeveloped       -1.19e+02   2.15e+01    2.96e+01    4.02   <2e-16 ***
soil_types41_45    3.78e+01   6.38e+00    9.01e+00    4.20   <2e-16 ***
Total.crops        1.32e+03   1.77e+02    2.47e+02    5.33   <2e-16 ***
True.shrub         3.26e+01   2.25e+01    2.56e+01    1.27    0.203
Road_length        3.68e-02   6.72e-02    7.07e-02    0.52    0.603
Stream_gradient   -7.80e-01   1.52e+00    1.69e+00    0.46    0.644
Developed.open    -4.46e-27   1.70e-12    1.83e-12    0.00    1.000
Road_density      -6.61e-29   2.43e-14    2.49e-14    0.00    1.000
Harvest.evergreen -3.98e-27   1.50e-12    1.59e-12    0.00    1.000

(conditional average)
                   Estimate Std. Error Adjusted SE z value Pr(>|z|)
(Intercept)        124.6753    21.6755     29.4804    4.23   <2e-16 ***
Road_length200      -1.3198     0.2071      0.2736    4.82   <2e-16 ***
Stream_length24k     0.3132     0.0486      0.0689    4.55   <2e-16 ***
soil_types51_60     17.9827     6.1674      8.5037    2.11   0.0345 *
Undeveloped       -118.8541    21.5103     29.5576    4.02   0.0001 ***
soil_types41_45     37.7811     6.3763      9.0051    4.20   <2e-16 ***
Total.crops       1318.5848   176.9327    247.4549    5.33   <2e-16 ***
True.shrub          43.6118    14.0997     19.9734    2.18   0.0290 *
Road_length          0.1461     0.0442      0.0626    2.33   0.0196 *
Stream_gradient     -3.0987     1.4325      2.0292    1.53   0.1268
Developed.open    -586.0673   191.3312    310.6696    1.89   0.0592 .
Road_density        -8.6822     1.5107      2.4530    3.54   0.0004 ***
Harvest.evergreen -522.9995   147.2961    239.1686    2.19   0.0288 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

All models (1 to 4):

```
Model-averaged coefficients:
(full average)
                   Estimate Std. Error Adjusted SE z value Pr(>|z|)
(Intercept)        9.79e+01   1.02e+01    1.45e+01    6.78   <2e-16 ***
Road_length200    -3.00e-01   9.99e-02    1.32e-01    2.28    0.023 *
Stream_density24k -1.89e+01   2.75e+00    3.78e+00    4.99   <2e-16 ***
Undeveloped       -6.58e+01   1.14e+01    1.59e+01    4.14   <2e-16 ***
Wetlands.total     3.20e+03   3.51e+02    4.70e+02    6.81   <2e-16 ***
soil_types51_60    1.26e+01   3.16e+00    4.47e+00    2.83    0.005 **
soil_types41_45    3.08e+01   3.38e+00    4.78e+00    6.44   <2e-16 ***
Total.crops        1.14e+03   1.03e+02    1.45e+02    7.85   <2e-16 ***
Stream_length24k   5.89e-04   1.37e-02    1.39e-02    0.04    0.966
True.shrub         8.21e-02   1.99e+00    2.08e+00    0.04    0.969
Road_length        9.24e-05   3.84e-03    4.00e-03    0.02    0.982
Stream_gradient   -1.96e-03   8.59e-02    9.32e-02    0.02    0.983
Developed.open    -1.12e-29   8.53e-14    9.18e-14    0.00    1.000
Road_density      -1.66e-31   1.22e-15    1.25e-15    0.00    1.000
Harvest.evergreen -1.00e-29   7.52e-14    7.96e-14    0.00    1.000

(conditional average)
                   Estimate Std. Error Adjusted SE z value Pr(>|z|)
(Intercept)         97.9299    10.2494     14.4500    6.78   <2e-16 ***
Road_length200      -0.3000     0.0999      0.1317    2.28   0.0227 *
Stream_density24k  -18.9331     2.5881      3.6663    5.16   <2e-16 ***
Undeveloped        -65.7972    11.3870     15.9032    4.14   <2e-16 ***
Wetlands.total    3212.3176   312.3410    442.4559    7.26   <2e-16 ***
soil_types51_60     12.6457     3.1636      4.4723    2.83   0.0047 **
soil_types41_45     30.7861     3.3844      4.7811    6.44   <2e-16 ***
Total.crops       1141.1595   102.8853    145.4572    7.85   <2e-16 ***
Stream_length24k     0.3132     0.0486      0.0689    4.55   <2e-16 ***
True.shrub          43.6118    14.0997     19.9734    2.18   0.0290 *
Road_length          0.1461     0.0442      0.0626    2.33   0.0196 *
Stream_gradient     -3.0987     1.4325      2.0292    1.53   0.1268
Developed.open    -586.0673   191.3312    310.6696    1.89   0.0592 .
Road_density        -8.6822     1.5107      2.4530    3.54   0.0004 ***
Harvest.evergreen -522.9995   147.2961    239.1686    2.19   0.0288 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 1: Observed vs. predicted for OLS models

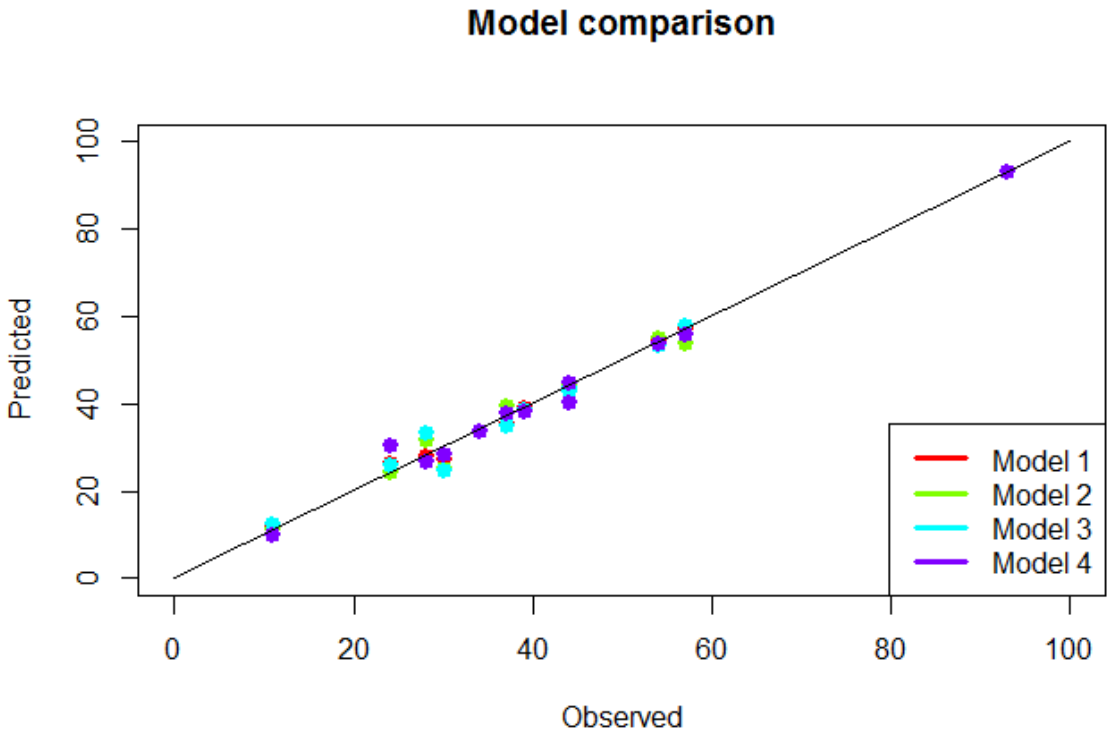


Table 1: Model comparison

	Model 1	Model 2	Model 3	Model 4
adj-R^2	0.988	0.967	0.96	0.95
RMSE	1.29	2.18	2.38	2.32
AIC*	58.2	70.7	72.9	74.2
BIC*	62.5	75.1	77.3	79.1