USING MONTHLY MONITORING DATA AS A MANAGEMENT TOOL

Keith M. Brooks and Daniel P. Sheer

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Suite 300
6110 Executive Boulevard
Rockville, Maryland 20852-3903

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as a Management Tool

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ABSTRACT

Much, if not most, of the water quality monitoring done in the Potomac Basin is on a monthly basis. Sampling of selected (usually easily accessible) stations on a periodic basis provides a "baseline" for assessing long term trends in water quality in streams (such as is done in the ICPRB BWQMN reports). It does not, however, provide substantial guidance concerning day to day water quality management, the causes of trends in water quality, or the enforcement of water quality regulations. The use of "routine" monthly monitoring data in these areas is generally limited to simple comparison of the data to water quality standards, and then targeting resources to areas when and where violations are found.

This paper develops methods for making direct use of routine monitoring data in real time water quality management. It explores several statistical methods for identifying field observations which differ significantly from previous water quality observations at a particular station. These include comparing the deviation of the observation from various regressions of water quality on physical parameters with the standard error of the regressions, and simple standardized distance from the mean of previous observations. Values well in excess of standards (e.g. dissolved oxygen (DO) measurements in excess of 6 ppm) may be identified as highly unusual for the specific station and worthy of investigation from the standpoint of possible permit enforcement or early natural or nonpoint source trend identification.

In addition, the paper suggests ways in which field personnel can use real time monitoring data to trigger on site investigations. Because transportation to and from sites represents a very large fraction of monitoring and investigation costs, and because violations of effluent requirements and corresponding water quality effects are generally transient, it would be highly desirable to combine the two functions. Using unusual water quality conditions to trigger investigations of effluent quality should be a logical, efficient, and effective use of scarce resources.

The techniques developed in this paper should help make routine monitoring data much more valuable for managing water quality and enforcing NPDES permit conditions.

I. INTRODUCTION

Managing water quality is a complex undertaking. For each body of water or reach of stream to be managed, appropriate uses must be specified, corresponding water quality standards set, the individual and cumulative impacts of pollutant discharges determined, and appropriate effluent limitations derived and enforced. Finally, the degree to which the streams actually support the specified uses must be constantly reevaluated and used to reconsider the entire management strategy.

With the exception of technology based effluent limitations, all of the determinations listed above are driven by water quality data. Collecting that data is expensive and time consuming. The general method is to obtain and analyze samples from a geographically diverse set of stations on a periodic basis, usually monthly. This represents a compromise between minimizing the cost of the data collection and maximizing the number of water bodies which are monitored. Unfortunately, because of the infrequent nature of the samples and the inherent natural variability of instream water quality, the value of the monitoring information for real time management has been perceived as quite low.

Therefore, little use is made of routine monitoring data in managing water quality. While such data is used to identify areas where water quality standards have been violated in the past, and to identify longer term trends in water quality, it is infrequently used in setting and enforcing effluent standards or in increasing understanding of the impact of particular loads on water bodies.

Taken by itself, a single monthly observation of water quality has limited value. Even though the concentrations of substances in the water are appropriate to support the designated uses, there is no indication of whether or not they will continue to be so. If the concentrations are such as to violate water quality standards, there is no indication as to cause duration or frequency of violations. However, taken in the context of a fairly long series of observations at a single site, a single monthly observation may be quite valuable. Water quality is the function of many factors. The monthly monitoring of specific parameters is useful for tracking long-term trends, however its utility for day to day instream management is limited.

Dissolved oxygen and flow are two parameters commonly monitored and available through STORET (including the daily Flow File from the USGS). Large variances from the expected values could be used as a signal that an unusual occurrence has impacted water quality. These unexpected values could be compared with effluent discharge monitoring reports to attempt a determination of the cause of the degradation.

Violations of water quality standards do not appear under conditions which mask the lowered quality such as high flows, lower temperatures, or when dissolved oxygen is elevated by algal photosynthesis. The use of a model to determine a relationship under all conditions and the variation from the expected would indicate where problems exist under varying conditions. Such information provides a useful tool to the water resources manager who is interested in more than simply water quality violations at a given time.

II. METHODOLOGY

The use of routinely collected water quality data for management purposes was the underlying goal of this project. The monthly water quality data for dissolved oxygen (DO), temperature and the daily flow data was combined to provide the data base for analysis of the statistical water quality model.

Three areas were selected for initial analysis: the North Branch below Cumberland, the South River of the Shenandoah River near Waynesboro and the Monocacy River at Dickerson. In addition a more detailed analysis was done for the Monocacy River at two stations - above and below Frederick, historically, an area with water quality problems. The quantity of data varied among the stations.

STORET provided dissolved oxygen and temperature and was able to calculate the dissolved oxygen saturation percentage. Statistical analyses were performed to find the best fit of the data and to determine the correlation between flow and dissolved oxygen.

For all stations, the relation between flow and dissolved oxygen was weak. The relationships were not linear, nor did they appear to be easily calculated. An approach used by the USGS (Smith, et al., A Study of Trends in Total Phosphorus Measurements at NASQAN Stations, U.S.G.S. Water-Supply Paper 2190) was to identify process trends by developing a time series of flow-adjusted concentrations and test the time series for trend. This technique is referred to as a residual analysis. For each stream, the relationship between discharge and dissolved oxygen is estimated and used to provide conditional expected values of concentration for each flow value. Flow adjusted concentration (FAC) is the actual concentration minus the estimated conditional expected concentration. The relationship between discharge and concentration is expressed in the form of $C = a + b * f(Q)$, where C is the estimated concentration, Q is the instantaneous discharge and f(Q) may have one of the following forms:

functional form	name
$f(Q) = Q$	linear
$f(Q) = \ln Q$	log
$f(Q) = 1/(1 + \beta Q)$	hyperbolic
$f(Q) = 1/Q$	inverse

Using these equations, relationships were developed in order to produce the best correlation. The hyperbolic relationship produces 11 relationships (by changing the positive constant β). Only the best correlation for the hyperbolic function is presented below. The following correlations, standard errors (see), and means (xmean, ymean) were calculated for the Cumberland station.

correlation = .43 (log)
a = 3.09 b = .89 see = 1.20 xmean = 6.59
ymean = 8.95 n = 74

correlation = -.45 (hyperbolic)
a = 11.44 b = -4.38 see = 1.16 xmean = .57
ymean = 8.95 n = 74

correlation = -.37 (inverse)
a = 9.82 b = -413.13 see = 1.28 xmean = 0.00
ymean = 8.95 n = 74

correlation = .29 (linear)
a = 8.51 b = 0.00 see = 1.37 xmean = 1236.93
ymean = 8.95 n = 74

correlation = .44 (log/log)
a = 1.47 b = .10 see = .00 xmean = 6.59
ymean = 2.16 n = 74

The fits of the data did not substantially improve under any of the functions, so a simpler method of identifying unusual observations was used. Standard Normal Residuals were calculated using dissolved oxygen and % saturation without the flow component. Standard deviation and mean were derived for each of the water quality parameters.

III. <u>RESULTS</u>

Flow was shown to be an extremely poor predictor of both percent saturation and dissolved oxygen, even in reaches known to be influenced by waste discharges, and where percent saturation is depressed. The implications of this are discussed later. Because of the extremely poor relationships, analysis of the data focused on standard normal residuals for both the dissolved oxygen and percent saturation data.

It is quite interesting that flow is nearly uniformly a better predictor of dissolved oxygen than it is of percent saturation. The following explanation seems logical. Oxygen solubility is correlated with temperature, and so, dissolved oxygen should also be correlated with temperature, all else being equal. Flow, because of seasonality, is also correlated with temperature. Therefore, flow and dissolved oxygen should correlate with each other. Indeed this seems to be the case.

On the other hand, percent saturation is at least partially corrected for the influence of temperature, and thus, correlation with flow. Again, the data seems to bear this out. By simple inspection of histograms, percent saturation seems to be a much more nearly normally distributed variable than raw dissolved oxygen.

For each of the stations inspected, the mean dissolved oxygen is close to two standard deviations higher than the standard. This makes the probability of noting any irregularities in water quality by comparing monthly observations to the ~~water to the~~ d.o. standard extremely low.

For each of the water quality stations examined, the data are presented in the following manner:

1. Histograms
   a. dissolved oxygen (mg/l)
   b. log of the flow (cfs)
   c. dissolved oxygen saturation (% saturation)
   d. log of the flow for % saturation (cfs)

2. Plots
   a. dissolved oxygen vs. log of the flow
   b. % saturation vs. log of the flow

3. Statistical Analysis (full analysis in Appendix)
   a. regression of dissolved oxygen and log of the flow
   b. standard normal residual for dissolved oxygen
   c. regression of % saturation and log of the flow
   d. standard normal residual for % saturation

The histograms, plots and regression analysis in this report were developed using a general purpose statistical computing system (MINITAB) developed at the Pennsylvania State University.

Regression gives an equation that can be used to predict one variable from another. Any straight line may be written as $y = a + bx$. For any two variables, an infinite number of lines may be drawn between the data points. To choose the best line, first look at the differences of what the line predicts and then what the values actually are. The difference between what is calculated and what is "real" is called the deviation (or residual). The deviations of all values are calculated, then squared and summed. The best line, then, is the line that observed produces the smallest sum of the squared deviations. Terms in the regression analysis:

ANALYSIS OF VARIANCE is a table which contains sum of squares (SS). SS is the total sum of squares corrected for the mean. ST. RES. is the standardized residual.

DEGREES OF FREEDOM may be defined as the number of observations in a sample minus the number of parameters estimated from the sample. The degrees of freedom are the numbers of observations in excess of those necessary to estimate the parameters of the distribution. In most elementary problems, this is one fewer than the number of observations.

R is the correlation and R-squared is the estimated standard deviation about the regression line

R-squared, adjusted for D.F. is adjusted for degrees of freedom. If a variable is added to an equation, R-squared will get larger, even if the added variable is of no real value. This is compensated for by this adjustment.

S is the estimated standard deviation about the regression line.

STANDARD NORMAL RESIDUAL is the value derived from the equation (x - mean)/standard deviation. Dissolved oxygen and % saturation are examined independent of flow to find outliers.

A. NORTH BRANCH NEAR CUMBERLAND, MARYLAND

This station, located west of Mooreshollow Road, has for many years been influenced by upstream waste discharges.

mddo (dissolved oxygen)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
4	1	*
5	3	***
6	4	****
7	10	**********
8	16	****************
9	12	************
10	6	******
11	11	***********
12	8	********
13	3	***

The skew toward the upper end of the distribution may be the result of nutrient enrichment.

logflow (log of flow)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
2.2	8	********
2.4	10	**********
2.6	11	***********
2.8	8	********
3.0	14	**************
3.2	11	***********
3.4	6	******
3.6	4	****
3.8	1	*
4.0	1	*

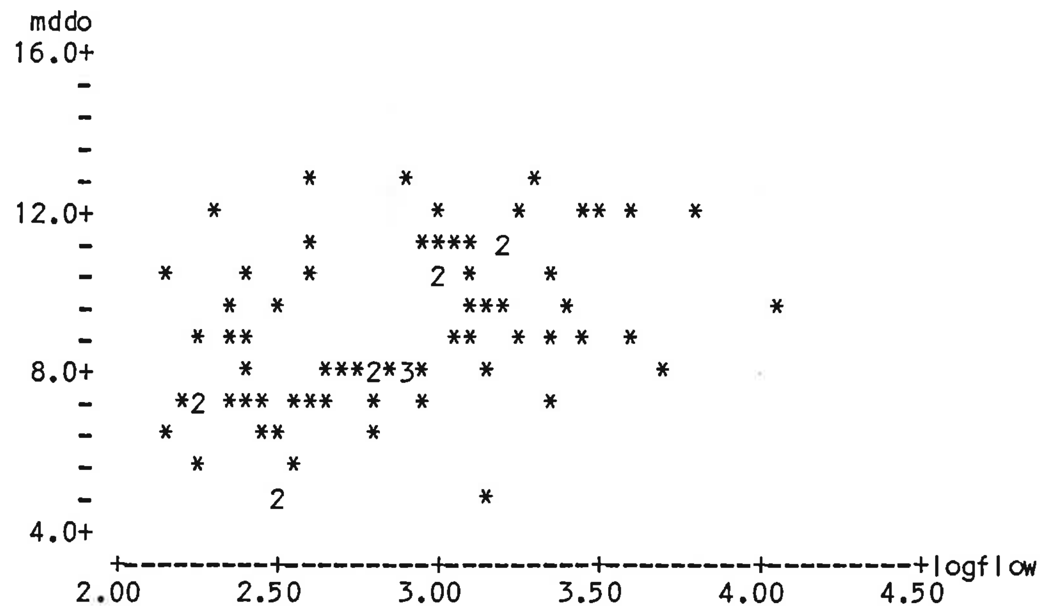
mdsat (% saturation)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
40	1	*
50	2	**
60	2	**
70	12	************
80	18	******************
90	20	********************
100	6	******
110	3	***
120	0	
130	1	*

Note the more nearly normal distribution of percent saturation.

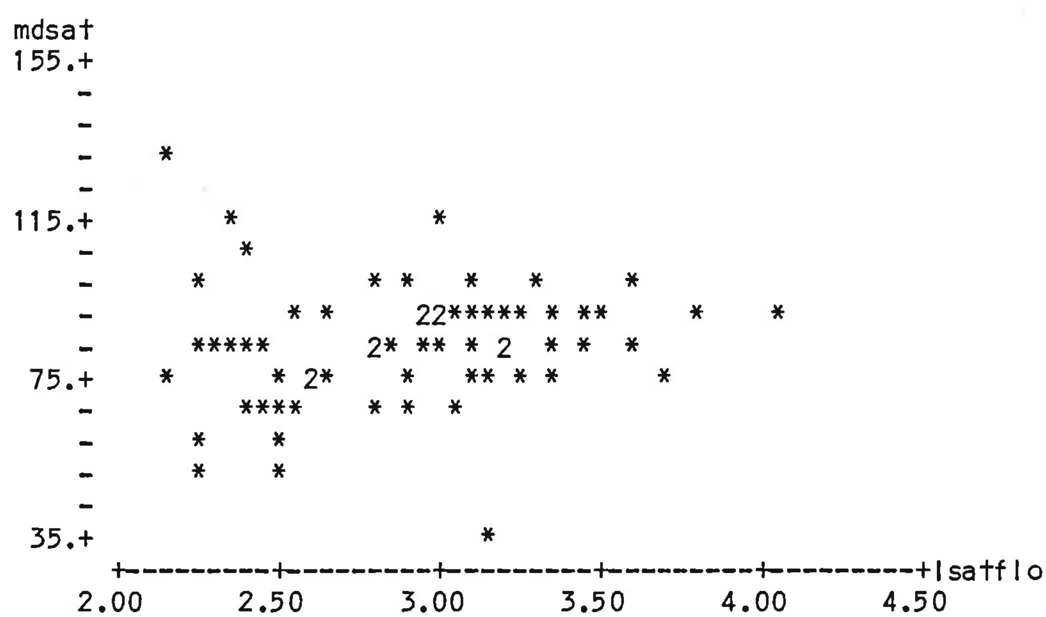
lsatflo (log of flow for saturation data)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
2.2	7	*******
2.4	8	********
2.6	9	*********
2.8	6	******
3.0	13	*************
3.2	11	***********
3.4	5	*****
3.6	4	****
3.8	1	*
4.0	1	*



CORRELATION OF mddo AND logflow = .413

Little correlation exists between dissolved oxygen and flow. At low flows, generally thought to be the most critical condition, the DO ranges from low values near 4 up to values of more than 12. A greater concentration of low DO's at low flows does not occur, contrary to expectation.



CORRELATION OF mdsat AND lsatflo = .125

No correlation exists between the % saturation and flow. % saturation takes into account both temperature and dissolved oxygen. At the lowest flows, there is a wide range of % saturations ranging from supersaturated to extremely depressed conditions.

THE REGRESSION EQUATION IS
mddo = 3.36 + 1.95 logflow

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	3.362	1.468	2.29
logflow	1.9506	0.5065	3.85

S = 1.895

R-SQUARED = 17.1 PERCENT
R-SQUARED = 15.9 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	53.258	53.258
RESIDUAL	72	258.567	3.591
TOTAL	73	311.825	

ROW	logflow	Y mddo	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
6	2.51	4.400	8.262	0.284	-3.862	-2.06R
35	2.62	13.000	8.479	0.252	4.521	2.41R
37	4.06	9.400	11.283	0.645	-1.883	-1.06 X
55	3.14	5.200	9.493	0.262	-4.293	-2.29R
70	2.28	11.900	7.812	0.369	4.088	2.20R

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

STANDARD NORMAL RESIDUAL

dissolved oxygen

N	74
MEAN	8.95
MEDIAN	8.65
TMEAN	8.96
STDEV	2.07
SEMEAN	0.24
MAX	13.20
MIN	4.40
Q3	10.63
Q1	7.55

ROW	DO	ST.RES.
6	4.4	-2.19807
11	13.2	2.05314

The standard of 5 mg/l is 1.9 standard deviations below the mean.

THE REGRESSION EQUATION IS
mdsat = 70.4 + 4.25 lsatflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	70.40	12.49	5.64
lsatflo	4.253	4.267	1.00

S = 15.16

R-SQUARED = 1.6 PERCENT
R-SQUARED = .0 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	228.4	228.4
RESIDUAL	63	14482.5	229.9
TOTAL	64	14710.8	

ROW	lsatflo	Y mdsat	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
6	2.51	50.57	81.08	2.49	-30.51	-2.04R
20	2.35	113.79	80.39	2.99	33.40	2.25R
23	2.14	129.63	79.50	3.72	50.13	3.41R
28	4.06	87.04	87.67	5.33	-0.63	-0.04 X
46	3.14	36.62	83.77	2.16	-47.15	-3.14R

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

STANDARD NORMAL RESIDUAL

% saturation

N	65
MEAN	82.7
MEDIAN	83.8
TMEAN	82.7
STDEV	15.2
SEMEAN	1.9
MAX	129.6
MIN	36.6
Q3	90.8
Q1	74.5

At a saturation DO of 10 mg/l (16 degrees C.), the standard of 5 mg/l (50% saturation) is 2.1 standard deviations below the mean.

ROW	% sat	ST. RES.
6	50.57	-2.11382
20	113.79	2.04540
23	129.63	3.08750
46	36.62	-3.03158

Unlike the other indicators, the Standard Normal Residual for percent saturation picks up observations on both the high and low end of the scale. Particularly, it highlights the wide swings in conditions characteristic of stressed aquatic ecosystems.

B. SOUTH RIVER NEAR WAYNESBORO, VIRGINIA

During the period covered by this analysis, the station was subject to the influence of substantial waste discharges.

srdo (dissolved oxygen)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
4	1	*
5	0	
6	2	**
7	11	***********
8	16	****************
9	27	***************************
10	31	*******************************
11	22	**********************
12	15	***************
13	7	*******
14	3	***
15	3	***

lsrflo (log of flow)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
1.4	6	******
1.6	33	*********************************
1.8	21	*********************
2.0	25	*************************
2.2	27	***************************
2.4	12	************
2.6	8	********
2.8	4	****
3.0	2	**

srsat (% saturation)

```
 MIDDLE OF    NUMBER OF
 INTERVAL     OBSERVATIONS
      50        1     *
      60        2     **
      70        6     ******
      80       13     *************
      90       38     **************************************
     100       40     ****************************************
     110       21     *********************
     120       15     ***************
     130        1     *
     140        1     *
```

Note that again, percent saturation appears to have a more nearly normal distribution than raw DO.

lsrsatfl (log of flow for saturation data)

```
 MIDDLE OF    NUMBER OF
 INTERVAL     OBSERVATIONS
     1.4        6     ******
     1.6       33     *********************************
     1.8       21     *********************
     2.0       25     *************************
     2.2       27     ***************************
     2.4       12     ************
     2.6        8     ********
     2.8        4     ****
     3.0        2     **
```

```
        srdo
       15.0+              *  *          *
           -           *            * *
           -           *       ***3
           -       *  *        *    **2 * 3  3      *
           -       2  **** *   ** ** 2  3  *  *  *2 *
       10.0+      * *4223 2 *  * *3* **3*    *   *     *
           -      **23 2222 2 *2*  2 *  *     *      *
           -         * 2* *3   **** 22
           -         * * * **   **  * **    *
           -                  *          *
        5.0+
           -                        *
           -
           -
           -
         .0+
            +---------+---------+---------+---------+---------+lsrflo
          1.20      1.60      2.00      2.40      2.80 3.20
```

CORRELATION OF   srdo AND lsrflo =   .181

Dissolved oxygen and flow do not appear to be correlated. The lower flows do not exhibit depressed values for dissolved oxygen. Water quality using dissolved oxygen as the indicator appears good, but this stretch of the South River has had degraded water quality in the past, due largely to industrial and municipal discharges.

```
  srsat
  160.+
      -
      -
      -                     *
      -                          *
  120.+          2 ***2      **  * *     *
      -       *2 2232** *    *      3
      -           2 **2  *****2***    *      *
      -       *2*2 33  2*  3* 4**3**  ** 3*   * *
      -         2* 2 * 22  22*** 2 23 *    *  2 * **
   80.+            *         * *****    *
      -          *    ** *      * *
      -                     *      *
      -          *
      -                         *
   40.+
        +---------+---------+---------+---------+---------+lsrsatfl
      1.20      1.60      2.00      2.40      2.80 3.20
```

CORRELATION OF srsat AND lsrsatfl= -.189

The correlation between % saturation and flow is non-existent. There are a significant number of values of low % saturation, indicating some water quality degradation, which are not apparent when dissolved oxygen is used as an indicator.

THE REGRESSION EQUATION IS
srdo = 8.07 + 0.961 lsrflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	8.0654	0.9098	8.87
lsrflo	0.9612	0.4486	2.14

S = 1.893

R-SQUARED = 3.3 PERCENT
R-SQUARED = 2.6 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	16.458	16.458
RESIDUAL	136	487.487	3.584
TOTAL	137	503.945	

ROW	lsrflo	Y srdo	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	2.10	14.000	10.088	0.168	3.912	2.07R
12	2.31	14.600	10.285	0.214	4.315	2.29R
23	2.80	11.600	10.760	0.396	0.840	0.45 X
27	2.18	4.400	10.157	0.180	-5.757	-3.05R
48	2.28	6.200	10.260	0.206	-4.060	-2.16R
78	1.76	15.000	9.753	0.194	5.247	2.79R
97	2.86	8.800	10.818	0.421	-2.018	-1.09 X
120	1.64	14.200	9.645	0.226	4.555	2.42R
129	2.94	10.400	10.889	0.452	-0.489	-0.27 X
130	1.87	14.900	9.862	0.171	5.038	2.67R
133	3.10	11.000	11.042	0.519	-0.042	-0.02 X

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

STANDARD NORMAL RESIDUAL

dissolved oxygen

N	138
MEAN	9.98
MEDIAN	10.00
TMEAN	9.95
STDEV	1.92
SEMEAN	0.16
MAX	15.00
MIN	4.40
Q3	11.20
Q1	8.60

The standard of 5 mg/l is 2.6 standard deviations below the mean.

ROW	DO	ST. RES.
1	14.0	2.09375
12	14.6	2.40625
27	4.4	-2.90625
78	15.0	2.61458
120	14.2	2.19792
130	14.9	2.56250

Note that only one low DO observation is flagged.

THE REGRESSION EQUATION IS
srsat = 113 - 7.72 lsrsatfl

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	112.504	6.992	16.09
lsrsatfl	-7.721	3.447	-2.24

S = 14.55

R-SQUARED = 3.6 PERCENT
R-SQUARED = 2.8 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	1062.1	1062.1
RESIDUAL	136	28790.8	211.7
TOTAL	137	29852.9	

ROW	lsrsatfl	Y srsat	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
22	2.01	64.11	96.99	1.24	-32.88	-2.27R
23	2.80	88.47	90.86	3.05	-2.38	-0.17 X
27	2.18	46.31	95.70	1.39	-49.40	-3.41R
65	2.52	122.90	93.04	2.19	29.86	2.08R
81	1.54	55.79	100.58	1.99	-44.79	-3.11R
87	1.54	68.42	100.58	1.99	-32.16	-2.23R
97	2.86	88.00	90.39	3.24	-2.39	-0.17 X
122	2.21	128.30	95.40	1.45	32.90	2.27R
123	2.00	136.47	97.06	1.24	39.41	2.72R
129	2.94	85.25	89.82	3.47	-4.58	-0.32 X
133	3.10	97.35	88.59	3.99	8.75	0.63 X

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

STANDARD NORMAL RESIDUAL

% saturation

N	138
MEAN	97.1
MEDIAN	96.8
TMEAN	97.4
STDEV	14.8
SEMEAN	1.3
MAX	136.5
MIN	46.3
Q3	107.6
Q1	88.4

ROW	% sat	ST. RES.
22	64.11	-2.22905
27	46.31	-3.43176
48	67.38	-2.00811
81	55.79	-2.79122
122	128.30	2.10811
123	136.47	2.66014

While only one observation violated the DO standard, fully four were more than 2 standard deviations below the mean for % saturation. Further, while analysis of normalized standard residuals for DO highlights supersaturation, examination of percent saturation clearly reveals the influence of the waste discharges.

C. MONOCACY RIVER NEAR DICKERSON, MARYLAND

This station, near the mouth of the Monocacy, has generally good water quality. By this point in the river, the BOD load from Frederick is largely gone. The nutrients added may still be exerting influence, however.

mondo (dissolved oxygen)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
5	1	*
6	8	********
7	22	**********************
8	21	*********************
9	15	***************
10	15	***************
11	9	*********
12	7	*******
13	1	*
14	2	**
15	1	*
16	1	*

lmonflo (log of flow)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
1.6	2	**
1.8	0	
2.0	17	*****************
2.2	17	*****************
2.4	23	***********************
2.6	9	*********
2.8	15	***************
3.0	13	*************
3.2	4	****
3.4	1	*
3.6	1	*
3.8	1	*

mosat (% saturation)

```
MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
    60          1      *
    70          9      *********
    80         25      *************************
    90         38      **************************************
   100         13      *************
   110          6      ******
   120          3      ***
   130          3      ***
   140          1      *
   150          1      *
   160          0
   170          1      *
```

Supersaturation conditions are apparent in this histogram.

lmsatflo (log of flow for saturation data)

```
MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
   1.6          2      **
   1.8          0
   2.0         16      ****************
   2.2         17      *****************
   2.4         23      ***********************
   2.6          8      ********
   2.8         15      ***************
   3.0         13      *************
   3.2          4      ****
   3.4          1      *
   3.6          1      *
   3.8          1      *
```

```
  mondo
  20.0+
      -
      -
      -
      -                     *
  15.0+                             *
      -                            **
      -                           *
      -                * *       * * * *       *
      -                   ** ** *     *2   *
  10.0+               * * ***     ***2 2**   *
      -               4 *  **2    2*   2*
      -              24 **222*** * **              *
      -      *  *     3** 3223* *  ** *
      -               2 2 *   *2
   5.0+                        *
        +---------+---------+---------+---------+---------+lmonflo
      1.20      1.80      2.40      3.00      3.60      4.20
```

CORRELATION OF mondo AND lmonflo = .397

The correlation between flow and dissolved oxygen is poor. Dissolved oxygen was not lowest at the lowest flow on record. The values for dissolved oxygen were extremely high, most likely indicating algae induced supersaturation.

```
   mosat
   200.+
       -
       -
       -                     *
       -
   150.+                  *
       -                *
       -               *   2
       -                    *    * *
       -               2 *   *       2
   100.+               *   ** 3     **  2*  *   *
       -      *       24*3**22*2  234*2*3**
       -         *     2   33332**  * **2     *
       -               3 2 *    *    *              *
       -                        *
    50.+
        +---------+---------+---------+---------+---------+---------+lmsatflo
       1.20      1.80      2.40      3.00      3.60      4.20
```

CORRELATION OF mosat AND lmsatflo= -.063

There is no correlation between flow and % saturation. The range of % saturation was very large showing both depressed conditions, as well as a large number of supersaturated periods.

THE REGRESSION EQUATION IS
mondo = 3.73 + 2.02 lmonflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	3.733	1.182	3.16
lmonflo	2.0228	0.4647	4.35

S = 1.948

R-SQUARED = 15.8 PERCENT
R-SQUARED = 15.0 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	71.907	71.907
RESIDUAL	101	383.266	3.795
TOTAL	102	455.174	

ROW	lmonflo	Y mondo	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
6	1.52	7.100	6.804	0.499	0.296	0.16 X
30	2.39	15.500	8.566	0.200	6.934	3.58R
34	2.88	14.600	9.549	0.257	5.051	2.62R
36	3.76	7.800	11.330	0.610	-3.530	-1.91 X
51	2.56	5.000	8.913	0.193	-3.913	-2.02R
68	2.84	13.600	9.468	0.245	4.132	2.14R
69	3.43	10.400	10.680	0.471	-0.280	-0.15 X
70	3.54	12.000	10.889	0.515	1.111	0.59 X
78	2.85	13.600	9.499	0.249	4.101	2.12R
89	2.09	11.900	7.967	0.272	3.933	2.04R

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

STANDARD NORMAL RESIDUAL

dissolved oxygen

N	103
MEAN	8.81
MEDIAN	8.40
TMEAN	8.69
STDEV	2.11
SEMEAN	0.21
MAX	15.50
MIN	5.00
Q3	10.20
Q1	7.10

The standard of 5 mg/l is 1.8 standard deviations below the mean.

ROW	DO	ST. RES.
30	15.5	3.17062
34	14.6	2.74408
68	13.6	2.27014
78	13.6	2.27014

THE REGRESSION EQUATION IS
mosat = 98.6 - 2.62 lmsatflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	98.56	10.68	9.23
lmsatflo	-2.618	4.192	-0.62

S = 17.45

R-SQUARED = .4 PERCENT
R-SQUARED = .0 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	118.7	118.7
RESIDUAL	99	30130.1	304.3
TOTAL	100	30248.9	

ROW	lmsatflo	Y mosat	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
6	1.52	89.87	94.58	4.52	-4.71	-0.28 X
30	2.39	168.48	92.30	1.81	76.17	4.39R
36	3.76	72.22	88.73	5.49	-16.50	-1.00 X
69	3.54	100.84	89.30	4.63	11.54	0.69 X
82	2.24	153.85	92.70	2.08	61.15	3.53R
86	2.28	129.11	92.59	1.99	36.52	2.11R
88	2.09	140.00	93.08	2.47	46.92	2.72R

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

STANDARD NORMAL RESIDUAL

% saturation

N	101
MEAN	92.0
MEDIAN	89.0
TMEAN	90.4
STDEV	17.4
SEMEAN	1.7
MAX	168.5
MIN	58.8
Q3	98.9
Q1	80.6

ROW	% sat	ST. RES.
20	126.92	2.00690
28	127.06	2.01494
30	168.48	4.39540
82	153.85	3.55460
86	129.11	2.13276
88	140.00	2.75862

In this case, the distribution is skewed toward supersaturated conditions only. This likely indicates large nutrient loadings without accompanying BOD loads, possibly from agricultural runoff or from nutrients originating in the Frederick STP.

D. MONOCACY RIVER ABOVE AND BELOW FREDERICK

Above City of Frederick

a2do (dissolved oxygen)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
6	0	
7	10	**********
8	9	*********
9	9	*********
10	7	*******
11	9	*********
12	8	********
13	2	**
14	2	**
15	1	*

logmona (log of flow)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
2.0	5	*****
2.2	5	*****
2.4	9	*********
2.6	9	*********
2.8	12	************
3.0	6	******
3.2	5	*****
3.4	1	*
3.6	5	*****

a2sat (% saturation)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
70	3	***
80	10	**********
90	21	*********************
100	18	******************
110	3	***
120	1	*
130	0	
140	1	*

The percent saturation data is again more normally distributed than the raw DO data.

logmona (log of flow for saturation data)

```
MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
   2.0         5     *****
   2.2         5     *****
   2.4         9     *********
   2.6         9     *********
   2.8        12     ************
   3.0         6     ******
   3.2         5     *****
   3.4         1     *
   3.6         5     *****
```

```
    a2do
    16.0+
        -                      *
        -                  *
        -                      *
        -                                *    *
    12.0+   2          *  *    *     *            *
        -     **             *    * *  *  *     ***
        -   **                *        *
        - *               *   *
        -        **2*  *   *    *     *
     8.0+           * *  *    **     *
        -       * ***  * *   * * * *               *
        -  *                *
        -
        -
     4.0+
          +---------+---------+---------+---------+---------+---------+logmona
        2.00      2.40      2.80      3.20      3.60      4.00
```

CORRELATION OF   a2do AND logmona = .263

The correlation between dissolved oxygen and flow is poor. The lower flows have dissolved oxygen ranging from 6 to 12 mg/l. At the highest flows, there also are some low DO's. This is despite the location of the station upstream of the water quality impacts of the discharges from the city of Frederick.

```
a2sat
150.+
    -   *
    -
    -
    -
120.+   *
    -    *                 *
    -                     *
    -        *  *     ** * 2          *       *
    - *   *   *    *  **   *    ***2 *    *  *
 90.+   *  *    *    2    * * *  *          * *
    -       * *** *2      ** *                 *
    -          *         *     *
    -  *       *        *
    -
 60.+
      +---------+---------+---------+---------+---------+---------+logmona
    2.00      2.40      2.80      3.20      3.60      4.00
```

CORRELATION OF a2sat AND logmona = -.093

The correlation between % saturation and flow is very poor. No relation may be derived from the regression of % saturation and flow. A wide range of % saturation conditions exist.

THE REGRESSION EQUATION IS
a2do = 6.32 + 1.25 logmona

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	6.322	1.699	3.72
logmona	1.2473	0.6163	2.02

S = 2.030

R-SQUARED = 6.9 PERCENT
R-SQUARED = 5.2 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	16.882	16.882
RESIDUAL	55	226.700	4.122
TOTAL	56	243.582	

ROW	logmona	Y a2do	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
22	2.85	15.000	9.877	0.280	5.123	2.55R
50	2.66	14.200	9.642	0.271	4.558	2.27R

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

STANDARD NORMAL RESIDUAL

dissolved oxygen

N	57
MEAN	9.72
MEDIAN	9.50
TMEAN	9.63
STDEV	2.09
SEMEAN	0.28
MAX	15.00
MIN	6.50
Q3	11.35
Q1	7.85

The standard of 5 mg/l is 2.3 standard deviations below the mean.

ROW	DO	ST. RES.
22	15.0	2.52632
50	14.2	2.14354

THE REGRESSION EQUATION IS
a2sat = 100 - 2.53 logmona

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	100.16	10.02	10.00
logmona	-2.530	3.633	-0.70

S = 11.97

R-SQUARED = .9 PERCENT
R-SQUARED = .0 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	69.5	69.5
RESIDUAL	55	7876.9	143.2
TOTAL	56	7946.3	

ROW	logmona	Y a2sat	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
10	2.06	121.65	94.94	2.88	26.71	2.30R
27	2.09	143.90	94.86	2.78	49.04	4.21R

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

STANDARD NORMAL RESIDUAL

% saturation

N	57
MEAN	93.3
MEDIAN	93.3
TMEAN	92.4
STDEV	11.9
SEMEAN	1.6
MAX	143.9
MIN	73.8
Q3	98.7
Q1	86.3

ROW	% sat	ST. RES.
10	121.65	2.38235
27	143.90	4.25210

As in the case of the previous station near the mouth of the Monocacy, all the flagged observations are for supersaturated conditions. However, in this case, the standard deviation is much smaller, 11.9 compared with the 17.4 at the mouth of the Monocacy. One likely interpretation is that there is a substantial increase in nutrient loads between the two stations, causing an increase in the potential for algal photosynthesis.

Below City of Frederick

bdo (dissolved oxygen)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
4	5	*****
5	7	*******
6	11	***********
7	8	********
8	13	*************
9	7	*******
10	5	*****
11	7	*******
12	5	*****
13	1	*
14	1	*
15	1	*

logbflo (log of flow)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
2.0	13	*************
2.2	14	**************
2.4	9	*********
2.6	8	********
2.8	9	*********
3.0	8	********
3.2	5	*****
3.4	1	*
3.6	4	****

kbsat (% saturation)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
40	2	**
50	5	*****
60	5	*****
70	10	**********
80	20	********************
90	13	*************
100	15	***************
110	0	
120	1	*

kblogflo (log of flow for saturation data)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
2.0	13	*************
2.2	14	**************
2.4	9	*********
2.6	8	********
2.8	9	*********
3.0	8	********
3.2	5	*****
3.4	1	*
3.6	4	****

```
    bdo
  15.0+                      *
      -                      *
      -                                *
      -                 **         *        *   *
      -              *          ***     *     **
  10.0+     *           *     *      2
      -      *   2   *      2       *
      - *  2   *  * *  * *  ** *   *             *
      -  **    * **        **    *
      - **    232 *    *
   5.0+ 3***                      *
      - 2*     2
      -
      -
      -
    .0+
        +---------+---------+---------+---------+---------+logbflo
      2.00      2.40      2.80      3.20      3.60      4.00
```

CORRELATION OF   bdo AND logbflo = .674

The correlation between dissolved oxygen and flow is high for this station. The data here were distorted by the fact that the samples included some dates with multiple transect collections. Because of the number of samples on one date, the correlation may be better than expected from previous runs. The flows were used as the same with different sampled dissolved oxygen values. The differing dissolved oxygen values on one day were not dependent on the location of the transect, so all points were included. This station has been historically degraded by point sources of pollution.

```
  kbsat
  120.+
      -                      *
      -
      -   *                             *   *
      -    *   *        2   ***  *** * *      **
   90.+     *     *    *    *   *  ***          *
      -  * * * * **  2   2   * *                 *
      - *      2**     *  * *    *
      -       ***** *      *
      - *2    *
   60.+                           *
      - 2 **
      - **     2
      - 2
      -
   30.+
        +---------+---------+---------+---------+---------+kblogflo
      2.00      2.40      2.80      3.20      3.60      4.00
```

CORRELATION OF   kbsat AND kblogflo= .591

The correlation for % saturation and flow was higher in this station than for any of the other stations analyzed. The multiple counting of transect data and the historical nature of degradation account for the better relationship. An averaging of data points for the multiple samples was done with a decrease in correlation, as expected.

THE REGRESSION EQUATION IS
bdo = - 1.89 + 3.84 logbflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	-1.889	1.323	-1.43
logbflo	3.8380	0.5059	7.59

S = 1.945

R-SQUARED = 45.5 PERCENT
R-SQUARED = 44.7 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	217.70	217.70
RESIDUAL	69	260.96	3.78
TOTAL	70	478.66	

ROW	logbflo	Y bdo	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
7	2.84	13.500	8.992	0.265	4.508	2.34R
17	2.85	15.200	9.051	0.269	6.149	3.19R
48	3.03	5.400	9.722	0.324	-4.322	-2.25R
52	2.64	12.100	8.233	0.233	3.867	2.00R
53	3.60	11.600	11.927	0.567	-0.327	-0.18 X
57	3.62	7.800	12.021	0.578	-4.221	-2.27RX

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

STANDARD NORMAL RESIDUAL

dissolved oxygen

N	71
MEAN	8.00
MEDIAN	7.80
TMEAN	7.92
STDEV	2.61
SEMEAN	0.31
MAX	15.20
MIN	3.60
Q3	9.80
Q1	5.90

The standard of 5 mg/l is 1.2 standard deviations below the mean.

ROW	DO	ST. RES.
7	13.5	2.10728
17	15.2	2.75862

THE REGRESSION EQUATION IS
kbsat = 26.1 + 20.9 kblogflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	26.118	8.981	2.91
kblogflo	20.882	3.433	6.08

S = 13.20

R-SQUARED = 34.9 PERCENT
R-SQUARED = 34.0 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	6444.7	6444.7
RESIDUAL	69	12018.2	174.2
TOTAL	70	18462.9	

ROW	kblogflo	Y kbsat	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
17	2.85	116.03	85.65	1.83	30.39	2.32R
24	2.28	46.34	73.70	1.87	-27.36	-2.09R
30	2.09	102.44	69.83	2.28	32.61	2.51R
34	2.01	40.91	68.15	2.49	-27.24	-2.10R
48	3.03	60.00	89.29	2.20	-29.29	-2.25R
53	3.60	88.55	101.29	3.85	-12.74	-1.01 X
57	3.62	84.78	101.80	3.92	-17.02	-1.35 X
59	2.14	98.82	70.74	2.17	28.09	2.16R

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

STANDARD NORMAL RESIDUAL

% saturation

N	71
MEAN	79.9
MEDIAN	81.9
TMEAN	80.6
STDEV	16.2
SEMEAN	1.9
MAX	116.0
MIN	40.9
Q3	93.3
Q1	71.6

ROW	% sat	ST. RES.
17	116.03	2.23025
24	46.34	-2.07160
34	40.91	-2.40679
35	43.18	-2.26667

Using the statistical description of percent saturation as an indicator allows a rather satisfying description of the impact of the STP on the stream. The variance in percent saturation, an inverse indicator of the stability of stream conditions, is up 85% below Frederick. The flagged observations have gone from all supersaturated to 75% depressed. Further, since the increase in variability of percent saturation persists to the mouth of the river, the STP may be influencing a far larger section of stream than the DO data alone indicates.

IV. CONCLUSIONS

The thrust of this paper was to find ways in which monthly monitoring data could be more useful in water quality management. In order to use monthly data effectively, the manager must be able to determine which water quality data points represent exceptional (unusual) conditions, and thus warrant further investigation. To the extent that monthly data can help the manger more effectively allocate his scarce resources, it serves as a good management tool.

The work centered on analysis of dissolved oxygen for several reasons: a large quantity of data is available for several stations, DO is a classic indicator of water quality, and DO is related to several other parameters also routinely available, particularly flow and temperature.

Typically, the analysis of monthly dissolved oxygen data for immediate management use is now limited to comparison of the value with the DO standard, typically 5 mg/l. This limits the information analyzed to that contained in the individual DO data point and the standard itself. Because of the nature of the standard, and the infrequent nature of monthly samples, observed violations of standards should be rare in all but the most polluted of streams. The data used in our analysis bear this out. The DO standard (5 mg/l) is typically two or more standard deviations below the mean.

The techniques examined in this paper all attempt to increase the amount of information used in the analysis, by including (implicitly or explicitly) the values of related parameters typically available when the DO measurement is taken, particularly flow and temperature, and, more importantly, the entire historical record of observations of all three parameters at the sampling station.

Attempts at using flow to improve the utility of the data proved futile. Neither flow nor its log seemed to have any meaningful correlation with either DO or percent saturation. An attempt to improve fits by utilizing functional transforms proposed by the USGS for detrending time series data did little to improve matters. This is disturbing since discharge permits are often written with the assumption that water quality violations occur during times of lowest flow. Critical conditions are generally specified in terms of flow (e.g. seven day - 10 year flows, the 7Q 10). The implications of the lack of relationship between flow and DO have not been explored in this paper, but deserve further analysis.

Data for all stations analyzed in the report were analyzed for seasonality as a check on the lack of correlation with flow. No relationship between season and percent saturation was found. Because of summer supersaturation at most of the stations, even the relationship between season and DO was poor.

Dissolved oxygen and temperature are logically related because of the increasing solubility of oxygen with increasing temperature. This relationship is, however highly non-linear. Percent saturation is a measure which implicitly integrates both DO and temperature data, therefore, the analysis presented in this paper focuses on comparisons of the utility of percent saturation data with that of raw DO data.

The Standardized Normal Residual from the long term mean of percent saturation, in addition to using the information available from both DO and temperature measurements, places the individual data point in the context of the long term trace of measurements at a monitoring station. In all stations examined, it seems (based on inspection of histograms) to be reasonably normally distributed, simplifying the task of statistical analysis. Percent saturation is a more sensitive parameter than DO in an absolute sense.

Because the SNR for percent saturation is normally distributed, it flags both undersaturated and supersaturated conditions as abnormal. This is satisfying, since excessive BOD loads can be masked by daytime algal blooms. However, if the BOD loads are accompanied by large nutrient loads, as may well be the case, large algal blooms may cause sufficient supersaturation to draw attention in any case.

From the standpoint of managing water quality, the use of a parameter like SNR of percent saturation seems to have several advantages:

1) It integrates the information available from DO, temperature and the time series of such observations at the sampling station.

2) Both measurements can be done instantaneously with a probe, allowing immediate identification of exceptional observations, and immediate response.

3) Because the determination as to whether or not the sample warrants investigation can be made in the field, field personnel can do immediate preliminary investigation to find the cause.

4) It affords some opportunity to predetermine the number of observations likely to be identified as unusual. By judiciously setting the cutoff deviation for "flagging" observations, the number of exceptional observations can be estimated in advance. The estimate can be made to correspond with the budget for investigation of the exceptions by varying the cutoff deviation. Such procedure should lead to expenditure of limited funds in a way most likely to produce results.

An implementation program to take advantage of the potential demonstrated by the above analysis should be easily developed. Analysis of historical data can be done directly on STORET (or by other means). The results of the analysis must be given to field personnel, along with general instructions on what to look for when exceptional observations are made. Actions could include contact with the field or central office, who could in turn contact upstream dischargers in an attempt to determine cause. Once the data is entered in a data base, such as STORET, automatic cross referencing of exceptional observations and PCS monitoring data might lead to identification of effects of variations in loadings, and possible enforcement actions.

The analysis performed here clearly shows the SNR of percent saturation is a substantially more sensitive indicator of water quality than simple comparison of ambient DO and a standard. Highly unusual observations frequently did not represent water quality standard violations even if they were caused by undersaturated conditions. The very sensitivity of the measures should allow managers to anticipate, rather than simply react to undesireable changes in water quality. Constant comparisons of current and historical data will serve to highlight water quality trends, and account for them in devising management strategies.

Water quality management has been based upon effluent limitations since 1972 with the passage of the Federal Water Pollution Control Act Amendments. Prior to that time, water quality was based on in-stream water quality standards. The major problem with water quality based effluent limits was the difficulty involved with setting and enforcing the limits, given the variable nature of water quality. The 1972 Amendments mandated the more expensive course of technology based limitations, which have substantially reduced pollutant discharges and improved water quality.

With the focus now shifting toward reduction in costs, a combination of both effluent limitations and ambient water quality standards is necessary. The statistical methods used in this report enables the manager to quantitatively determine how critical the water quality in a stream is by reference to monthly monitoring data. Such information is vital in setting water quality based effluent limitations.

There is no reason that the kind of analysis represented here cannot be applied (with care) to parameters other than DO. Flow is likely to be an important factor with such constituents as nutrients, and should not be ignored because of its lack of relationship to dissolved oxygen.

The authors believe that the use of SNR of percent saturation as a trigger for management actions will improve both the utility of monthly monitoring data and the management of water quality in the Potomac Basin. Further, the extension of the kinds of statistical analysis described in the paper to other parameters should prove equally or more valuable in managing other aspects of water pollution control.

APPENDIX

A. Data Sources

All data for this analysis was retrieved from the U.S. Environmental Protection Agency's STORET (STOrage and RETrieval) water quality data base system and supplemented with more current data from the state of Maryland for its stations, which have no STORET data entered after 1981. The flow data is also from STORET using the flow file which the USGS transfers to EPA twice a year. Flows were available through the end of water year 1983. Data was retrieved for the following stations:

I. North Branch

a. water quality
station number: NBP0103 agency code: 21MD
West of Mooreshollow Road and Md. Rt. 51
period of record: 3/26/74 through 6/2/81

b. flow file
station number: 01603000
North Branch Potomac River near Cumberland, Md.

II. South River

a. water quality
station number: 1BSTH007.80 agency code: 21VASWCB
Rt. 778 Crimora, Va.
period of record: 3/2/70 through 9/8/83

b. flow file
station number: 01626000
South River near Waynesboro

III. Monocacy River

a. water quality

station number: MON0020 agency code: 21MD
Bridge on Rt. 28
period of record: 3/21/66 through 5/5/81

b. flow

station number: 01643000
Monocacy River near Frederick

IV. Monocacy River above and below Frederick

a. water quality
station numbers: MON0269, MON0155 agency code: 21MD
Bridge on Biggs Ford Road, Bridge on Reel's Mill Road
period of record: 4/17/78 through 9/13/83
7/24/78 through 9/13/83

b. flow file
station numbers: 01643000
Monocacy River near Frederick

B. REGRESSION ANALYSIS (full)

This section of the appendix contains the full regression analysis from which the outliers were derived in the text of the report.

I. CUMBERLAND, MD.

THE REGRESSION EQUATION IS
mddo = 3.36 + 1.95 logflow

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	3.362	1.468	2.29
logflow	1.9506	0.5065	3.85

S = 1.895

R-SQUARED = 17.1 PERCENT
R-SQUARED = 15.9 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	53.258	53.258
RESIDUAL	72	258.567	3.591
TOTAL	73	311.825	

ROW	logflow	Y mddo	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	3.03	11.000	9.279	0.236	1.721	0.92
2	3.36	10.000	9.916	0.334	0.084	0.04
3	2.84	8.000	8.894	0.221	-0.894	-0.47
4	3.01	10.600	9.239	0.233	1.361	0.72
5	2.54	7.400	8.315	0.275	-0.915	-0.49
6	2.51	4.400	8.262	0.284	-3.862	-2.06R
7	2.47	6.400	8.186	0.296	-1.786	-0.95
8	2.27	5.400	7.789	0.373	-2.389	-1.29
9	2.38	8.600	8.012	0.328	0.588	0.31
10	3.25	11.800	9.698	0.294	2.102	1.12
11	3.29	13.200	9.784	0.309	3.416	1.83

12	3.60	12.400	10.378	0.431	2.022	1.10
13	3.43	12.000	10.059	0.363	1.941	1.04
14	2.97	11.000	9.146	0.226	1.854	0.99
15	2.81	6.000	8.849	0.222	-2.849	-1.51
16	2.56	5.600	8.349	0.270	-2.749	-1.47
17	2.92	12.600	9.063	0.222	3.537	1.88
18	2.73	8.000	8.688	0.231	-0.688	-0.37
19	2.80	7.800	8.816	0.223	-1.016	-0.54
20	2.65	8.400	8.525	0.246	-0.125	-0.07
21	2.43	7.200	8.111	0.310	-0.911	-0.49
22	2.35	7.600	7.943	0.342	-0.343	-0.18
23	2.35	9.900	7.943	0.342	1.957	1.05
24	2.26	8.600	7.762	0.379	0.838	0.45
25	2.22	7.600	7.693	0.394	-0.093	-0.05
26	3.38	9.800	9.956	0.342	-0.156	-0.08
27	2.71	8.000	8.655	0.233	-0.655	-0.35
28	2.38	10.600	8.012	0.328	2.588	1.39
29	2.41	6.800	8.073	0.317	-1.273	-0.68
30	2.14	10.500	7.537	0.428	2.963	1.61
31	2.24	7.000	7.738	0.384	-0.738	-0.40
32	2.16	6.400	7.567	0.421	-1.167	-0.63
33	2.60	10.800	8.438	0.257	2.362	1.26
34	3.21	10.800	9.623	0.281	1.177	0.63
35	2.62	13.000	8.479	0.252	4.521	2.41R
36	3.52	12.000	10.236	0.400	1.764	0.95
37	4.06	9.400	11.283	0.645	-1.883	-1.06 X
38	2.94	8.300	9.104	0.224	-0.804	-0.43
39	2.48	5.000	8.203	0.294	-3.203	-1.71
40	2.96	7.400	9.144	0.226	-1.744	-0.93
41	2.79	7.200	8.804	0.224	-1.604	-0.85
42	2.50	6.600	8.246	0.286	-1.646	-0.88
43	2.35	8.600	7.947	0.341	0.653	0.35
44	2.98	11.000	9.176	0.228	1.824	0.97
45	3.08	11.000	9.362	0.245	1.638	0.87
46	3.26	9.200	9.712	0.296	-0.512	-0.27
47	3.14	9.400	9.493	0.262	-0.093	-0.05
48	3.36	7.600	9.916	0.334	-2.316	-1.24
49	3.08	9.000	9.369	0.246	-0.369	-0.20
50	2.65	7.000	8.534	0.245	-1.534	-0.82
51	2.88	8.200	8.974	0.220	-0.774	-0.41
52	2.90	8.000	9.024	0.221	-1.024	-0.54
53	3.36	9.000	9.916	0.334	-0.916	-0.49
54	2.90	8.200	9.024	0.221	-0.824	-0.44
55	3.14	5.200	9.493	0.262	-4.293	-2.29R
56	3.06	9.200	9.340	0.242	-0.140	-0.07
57	2.61	10.300	8.449	0.256	1.851	0.99
58	3.78	11.800	10.741	0.515	1.059	0.58
59	3.19	9.400	9.586	0.275	-0.186	-0.10
60	3.11	9.500	9.430	0.253	0.070	0.04
61	3.14	7.800	9.487	0.261	-1.687	-0.90
62	3.58	8.700	10.341	0.423	-1.641	-0.89
63	2.79	8.000	8.811	0.223	-0.811	-0.43
64	2.62	7.100	8.471	0.253	-1.371	-0.73
65	3.70	7.800	10.574	0.476	-2.774	-1.51
66	2.40	7.700	8.040	0.323	-0.340	-0.18

67	2.23	7.300	7.703	0.392	-0.403	-0.22
68	2.50	9.600	8.246	0.286	1.354	0.72
69	3.00	12.200	9.223	0.231	2.977	1.58
70	2.28	11.900	7.812	0.369	4.088	2.20R
71	3.22	11.500	9.638	0.284	1.862	0.99
72	3.10	10.700	9.417	0.251	1.283	0.68
73	2.99	10.500	9.195	0.229	1.305	0.69
74	3.43	8.800	10.059	0.363	-1.259	-0.68

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

THE REGRESSION EQUATION IS
mdsat = 70.4 + 4.25 lsatflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	70.40	12.49	5.64
lsatflo	4.253	4.267	1.00

S = 15.16

R-SQUARED = 1.6 PERCENT
R-SQUARED = .0 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	228.4	228.4
RESIDUAL	63	14482.5	229.9
TOTAL	64	14710.8	

ROW	lsatflo	Y mdsat	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	3.03	88.00	83.30	1.97	4.70	0.31
2	3.36	90.09	84.69	2.74	5.40	0.36
3	2.84	82.47	82.46	1.90	0.01	0.00
4	3.01	112.77	83.21	1.95	29.55	1.97
5	2.54	87.06	81.20	2.41	5.86	0.39
6	2.51	50.57	81.08	2.49	-30.51	-2.04R
7	2.47	68.09	80.92	2.60	-12.83	-0.86
8	2.27	52.94	80.05	3.26	-27.11	-1.83
9	2.38	67.19	80.54	2.87	-13.35	-0.90
10	3.25	90.08	84.21	2.42	5.86	0.39
11	3.29	95.65	84.40	2.54	11.25	0.75
12	3.60	96.87	85.70	3.54	11.18	0.76
13	3.43	91.60	85.00	2.98	6.60	0.44
14	2.97	94.83	83.01	1.91	11.82	0.79
15	2.81	66.67	82.36	1.91	-15.70	-1.04
16	2.56	65.88	81.27	2.37	-15.39	-1.03
17	2.80	84.78	82.29	1.93	2.49	0.17
18	2.65	91.30	81.66	2.15	9.65	0.64
19	2.43	81.82	80.76	2.71	1.06	0.07
20	2.35	113.79	80.39	2.99	33.40	2.25R
21	2.26	97.73	79.99	3.31	17.73	1.20

22	2.38	109.28	80.54	2.87	28.74	1.93
23	2.14	129.63	79.50	3.72	50.13	3.41R
24	2.24	80.46	79.94	3.35	0.52	0.04
25	2.16	72.73	79.57	3.67	-6.84	-0.46
26	3.21	88.52	84.05	2.32	4.47	0.30
27	3.52	91.60	85.39	3.28	6.22	0.42
28	4.06	87.04	87.67	5.33	-0.63	-0.04 X
29	2.94	94.32	82.92	1.89	11.40	0.76
30	2.48	55.56	80.95	2.57	-25.40	-1.70
31	2.96	82.22	83.01	1.90	-0.78	-0.05
32	2.79	85.71	82.27	1.93	3.45	0.23
33	2.50	75.86	81.05	2.51	-5.19	-0.35
34	2.35	79.63	80.40	2.98	-0.77	-0.05
35	2.98	83.97	83.08	1.92	0.89	0.06
36	3.08	75.34	83.48	2.04	-8.14	-0.54
37	3.26	73.60	84.25	2.44	-10.65	-0.71
38	3.14	78.99	83.77	2.16	-4.78	-0.32
39	3.36	74.51	84.69	2.74	-10.18	-0.68
40	3.08	97.83	83.50	2.04	14.33	0.95
41	2.65	74.47	81.68	2.14	-7.21	-0.48
42	2.88	96.47	82.64	1.88	13.83	0.92
43	2.90	78.43	82.75	1.88	-4.31	-0.29
44	3.36	79.65	84.69	2.74	-5.04	-0.34
45	2.90	65.60	82.75	1.88	-17.15	-1.14
46	3.14	36.62	83.77	2.16	-47.15	-3.14R
47	3.06	66.67	83.43	2.02	-16.77	-1.12
48	2.61	72.54	81.49	2.24	-8.96	-0.60
49	3.78	90.08	86.49	4.24	3.59	0.25
50	3.19	83.19	83.97	2.27	-0.78	-0.05
51	3.11	89.62	83.63	2.10	5.99	0.40
52	3.14	88.64	83.76	2.16	4.88	0.33
53	3.58	82.08	85.62	3.48	-3.54	-0.24
54	2.79	95.24	82.28	1.93	12.96	0.86
55	2.62	77.17	81.54	2.21	-4.37	-0.29
56	3.70	76.47	86.13	3.91	-9.66	-0.66
57	2.40	81.05	80.60	2.83	0.45	0.03
58	2.23	61.34	79.87	3.41	-18.52	-1.25
59	2.50	67.61	81.05	2.51	-13.44	-0.90
60	3.00	90.37	83.18	1.94	7.19	0.48
61	2.28	83.80	80.10	3.22	3.70	0.25
62	3.22	85.19	84.09	2.34	1.10	0.07
63	3.10	85.60	83.60	2.09	2.00	0.13
64	2.99	94.59	83.12	1.93	11.48	0.76
65	3.43	86.27	85.00	2.98	1.27	0.09

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

SOUTH RIVER

THE REGRESSION EQUATION IS
srdo = 8.07 + 0.961 lsrflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	8.0654	0.9098	8.87
lsrflo	0.9612	0.4486	2.14

S = 1.893

R-SQUARED = 3.3 PERCENT
R-SQUARED = 2.6 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	16.458	16.458
RESIDUAL	136	487.487	3.584
TOTAL	137	503.945	

ROW	lsrflo	Y srdo	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	2.10	14.000	10.088	0.168	3.912	2.07R
2	2.28	9.900	10.254	0.204	-0.354	-0.19
3	1.81	6.800	9.808	0.181	-3.008	-1.60
4	1.67	9.600	9.673	0.217	-0.073	-0.04
5	1.49	8.600	9.499	0.278	-0.899	-0.48
6	1.54	10.000	9.550	0.259	0.450	0.24
7	1.45	8.600	9.456	0.294	-0.856	-0.46
8	2.12	9.200	10.107	0.171	-0.907	-0.48
9	2.06	10.800	10.050	0.164	0.750	0.40
10	1.94	13.000	9.934	0.163	3.066	1.63
11	2.53	12.400	10.496	0.288	1.904	1.02
12	2.31	14.600	10.285	0.214	4.315	2.29R
13	2.32	11.200	10.291	0.216	0.909	0.48
14	1.94	8.600	9.934	0.163	-1.334	-0.71
15	2.18	7.600	10.157	0.180	-2.557	-1.36
16	1.78	8.500	9.775	0.189	-1.275	-0.68
17	1.90	6.400	9.889	0.167	-3.489	-1.85
18	1.65	7.400	9.654	0.223	-2.254	-1.20
19	2.19	8.200	10.171	0.183	-1.971	-1.05
20	2.06	10.200	10.046	0.164	0.154	0.08
21	2.29	10.200	10.267	0.208	-0.067	-0.04
22	2.01	8.400	9.996	0.161	-1.596	-0.85
23	2.80	11.600	10.760	0.396	0.840	0.45 X
24	2.21	11.000	10.194	0.189	0.806	0.43
25	2.25	6.800	10.224	0.196	-3.424	-1.82
26	2.22	8.400	10.197	0.189	-1.797	-0.95
27	2.18	4.400	10.157	0.180	-5.757	-3.05R
28	2.16	6.800	10.143	0.177	-3.343	-1.77
29	2.49	7.400	10.461	0.275	-3.061	-1.63
30	1.79	8.400	9.781	0.187	-1.381	-0.73
31	2.13	9.000	10.113	0.172	-1.113	-0.59
32	2.60	9.200	10.560	0.313	-1.360	-0.73
33	2.42	11.800	10.391	0.249	1.409	0.75
34	2.50	11.800	10.472	0.279	1.328	0.71
35	2.41	12.400	10.387	0.248	2.013	1.07
36	2.21	12.000	10.192	0.188	1.808	0.96

37	2.26	7.400	10.238	0.200	-2.838	-1.51
38	2.19	9.400	10.171	0.183	-0.771	-0.41
39	1.84	9.600	9.833	0.176	-0.233	-0.12
40	1.72	7.200	9.715	0.204	-2.515	-1.34
41	1.62	7.800	9.626	0.232	-1.826	-0.97
42	2.05	7.000	10.035	0.163	-3.035	-1.61
43	1.75	8.000	9.746	0.196	-1.746	-0.93
44	1.63	10.400	9.635	0.229	0.765	0.41
45	2.31	11.000	10.281	0.213	0.719	0.38
46	2.26	10.000	10.240	0.201	-0.240	-0.13
47	2.44	11.000	10.407	0.255	0.593	0.32
48	2.28	6.200	10.260	0.206	-4.060	-2.16R
49	1.97	8.200	9.957	0.162	-1.757	-0.93
50	1.66	8.800	9.664	0.220	-0.864	-0.46
51	1.95	8.500	9.944	0.162	-1.444	-0.77
52	2.02	8.400	10.008	0.162	-1.608	-0.85
53	1.60	11.000	9.605	0.239	1.395	0.74
54	1.57	9.200	9.573	0.251	-0.373	-0.20
55	2.38	11.700	10.355	0.237	1.345	0.72
56	2.25	10.300	10.231	0.198	0.069	0.04
57	2.31	10.100	10.281	0.213	-0.181	-0.10
58	2.08	12.800	10.060	0.165	2.740	1.45
59	2.22	10.700	10.197	0.189	0.503	0.27
60	2.13	9.500	10.116	0.173	-0.616	-0.33
61	1.78	9.300	9.775	0.189	-0.475	-0.25
62	1.83	7.200	9.827	0.177	-2.627	-1.39
63	1.82	8.000	9.814	0.180	-1.814	-0.96
64	1.91	8.800	9.900	0.166	-1.100	-0.58
65	2.52	12.300	10.489	0.285	1.811	0.97
66	2.03	12.600	10.012	0.162	2.588	1.37
67	1.95	10.400	9.944	0.162	0.456	0.24
68	2.08	12.800	10.064	0.165	2.736	1.45
69	2.14	11.200	10.119	0.173	1.081	0.57
70	2.20	9.700	10.184	0.186	-0.484	-0.26
71	1.85	9.200	9.839	0.175	-0.639	-0.34
72	1.84	9.200	9.833	0.176	-0.633	-0.34
73	2.17	8.300	10.154	0.180	-1.854	-0.98
74	1.75	10.200	9.746	0.196	0.454	0.24
75	1.57	8.600	9.573	0.251	-0.973	-0.52
76	2.32	9.300	10.295	0.217	-0.995	-0.53
77	2.01	12.900	9.996	0.161	2.904	1.54
78	1.76	15.000	9.753	0.194	5.247	2.79R
79	2.06	13.200	10.050	0.164	3.150	1.67
80	1.67	8.400	9.673	0.217	-1.273	-0.68
81	1.54	7.700	9.550	0.259	-1.850	-0.99
82	1.53	9.000	9.537	0.263	-0.537	-0.29
83	2.00	7.400	9.992	0.161	-2.592	-1.37
84	1.78	10.400	9.775	0.189	0.625	0.33
85	1.65	9.200	9.654	0.223	-0.454	-0.24
86	1.65	9.200	9.654	0.223	-0.454	-0.24
87	1.54	6.500	9.550	0.259	-3.050	-1.63
88	1.52	9.600	9.525	0.268	0.075	0.04
89	1.52	9.000	9.525	0.268	-0.525	-0.28
90	2.73	11.200	10.688	0.366	0.512	0.28
91	2.32	11.000	10.295	0.217	0.705	0.37

92	2.01	9.400	10.000	0.161	-0.600	-0.32
93	2.08	10.000	10.067	0.166	-0.067	-0.04
94	1.72	10.600	9.723	0.202	0.877	0.47
95	1.61	10.200	9.616	0.236	0.584	0.31
96	2.68	9.900	10.638	0.345	-0.738	-0.40
97	2.86	8.800	10.818	0.421	-2.018	-1.09 X
98	2.54	10.500	10.507	0.293	-0.007	-0.00
99	2.15	12.000	10.134	0.176	1.866	0.99
100	2.02	11.100	10.004	0.161	1.096	0.58
101	2.52	10.400	10.489	0.285	-0.089	-0.05
102	2.32	12.200	10.293	0.216	1.907	1.01
103	2.03	10.200	10.020	0.162	0.180	0.10
104	1.71	9.400	9.707	0.207	-0.307	-0.16
105	1.73	8.800	9.731	0.200	-0.931	-0.49
106	1.62	9.600	9.626	0.232	-0.026	-0.01
107	1.56	10.300	9.561	0.255	0.739	0.39
108	1.64	11.400	9.645	0.226	1.755	0.93
109	1.57	10.200	9.573	0.251	0.627	0.33
110	1.49	11.400	9.499	0.278	1.901	1.02
111	1.79	11.300	9.788	0.185	1.512	0.80
112	1.63	13.300	9.635	0.229	3.665	1.95
113	1.66	9.500	9.664	0.220	-0.164	-0.09
114	1.61	10.000	9.616	0.236	0.384	0.20
115	2.09	8.300	10.071	0.166	-1.771	-0.94
116	1.54	9.200	9.550	0.259	-0.350	-0.19
117	1.45	10.000	9.456	0.294	0.544	0.29
118	1.46	11.200	9.471	0.289	1.729	0.92
119	1.49	11.800	9.499	0.278	2.301	1.23
120	1.64	14.200	9.645	0.226	4.555	2.42R
121	2.72	11.200	10.676	0.361	0.524	0.28
122	2.21	13.600	10.194	0.189	3.406	1.81
123	2.00	11.600	9.988	0.161	1.612	0.85
124	1.79	7.800	9.788	0.185	-1.988	-1.06
125	1.67	9.300	9.673	0.217	-0.373	-0.20
126	1.70	10.500	9.698	0.209	0.802	0.43
127	1.96	11.100	9.953	0.162	1.147	0.61
128	1.59	11.600	9.595	0.243	2.005	1.07
129	2.94	10.400	10.889	0.452	-0.489	-0.27 X
130	1.87	14.900	9.862	0.171	5.038	2.67R
131	2.24	12.000	10.217	0.194	1.783	0.95
132	2.68	11.300	10.639	0.346	0.661	0.36
133	3.10	11.000	11.042	0.519	-0.042	-0.02 X
134	2.26	12.200	10.233	0.199	1.967	1.04
135	2.06	9.800	10.046	0.164	-0.246	-0.13
136	1.68	10.000	9.681	0.214	0.319	0.17
137	1.64	8.000	9.645	0.226	-1.645	-0.88
138	1.56	10.100	9.561	0.255	0.539	0.29

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

THE REGRESSION EQUATION IS
srsat = 113 - 7.72 lsrsatfl

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	112.504	6.992	16.09
lsrsatfl	-7.721	3.447	-2.24

S = 14.55

R-SQUARED = 3.6 PERCENT
R-SQUARED = 2.8 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	1062.1	1062.1
RESIDUAL	136	28790.8	211.7
TOTAL	137	29852.9	

ROW	lsrsatfl	Y srsat	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	2.10	123.89	96.26	1.29	27.63	1.91
2	2.28	85.34	94.93	1.57	-9.59	-0.66
3	1.81	72.33	98.51	1.39	-26.18	-1.81
4	1.67	110.33	99.59	1.67	10.74	0.74
5	1.49	97.72	100.99	2.14	-3.27	-0.23
6	1.54	121.95	100.58	1.99	21.37	1.48
7	1.45	98.84	101.33	2.26	-2.49	-0.17
8	2.12	79.30	96.10	1.31	-16.80	-1.16
9	2.06	88.44	96.56	1.26	-8.12	-0.56
10	1.94	104.00	97.49	1.25	6.51	0.45
11	2.53	96.80	92.98	2.22	3.82	0.27
12	2.31	116.72	94.67	1.64	22.05	1.53
13	2.32	111.90	94.62	1.66	17.28	1.20
14	1.94	90.52	97.49	1.25	-6.97	-0.48
15	2.18	80.84	95.70	1.39	-14.86	-1.03
16	1.78	101.19	98.77	1.45	2.42	0.17
17	1.90	71.10	97.85	1.28	-26.75	-1.85
18	1.65	80.42	99.74	1.71	-19.31	-1.34
19	2.19	81.99	95.59	1.41	-13.60	-0.94
20	2.06	94.35	96.59	1.26	-2.24	-0.15
21	2.29	87.84	94.82	1.60	-6.98	-0.48
22	2.01	64.11	96.99	1.24	-32.88	-2.27R
23	2.80	88.47	90.86	3.05	-2.38	-0.17 X
24	2.21	99.10	95.40	1.45	3.70	0.26
25	2.25	70.09	95.17	1.51	-25.07	-1.73
26	2.22	88.41	95.38	1.45	-6.97	-0.48
27	2.18	46.31	95.70	1.39	-49.40	-3.41R
28	2.16	71.57	95.81	1.36	-24.25	-1.67
29	2.49	80.42	93.26	2.11	-12.83	-0.89
30	1.79	91.29	98.72	1.44	-7.42	-0.51
31	2.13	90.00	96.05	1.32	-6.05	-0.42
32	2.60	85.18	92.46	2.41	-7.29	-0.51
33	2.42	104.34	93.82	1.92	10.52	0.73
34	2.50	96.64	93.17	2.14	3.47	0.24
35	2.41	94.58	93.86	1.90	0.72	0.05
36	2.21	98.36	95.42	1.45	2.94	0.20

37	2.26	76.28	95.05	1.54	-18.77	-1.30
38	2.19	96.90	95.59	1.41	1.31	0.09
39	1.84	110.33	98.31	1.35	12.03	0.83
40	1.72	84.69	99.25	1.57	-14.56	-1.01
41	1.62	84.77	99.97	1.79	-15.20	-1.05
42	2.05	77.78	96.68	1.25	-18.90	-1.30
43	1.75	75.47	99.01	1.50	-23.53	-1.63
44	1.63	89.57	99.89	1.76	-10.32	-0.71
45	2.31	90.16	94.70	1.63	-4.54	-0.31
46	2.26	92.59	95.03	1.54	-2.44	-0.17
47	2.44	99.10	93.69	1.96	5.41	0.37
48	2.28	67.38	94.87	1.59	-27.49	-1.90
49	1.97	93.17	97.30	1.24	-4.13	-0.29
50	1.66	103.52	99.66	1.69	3.85	0.27
51	1.95	97.70	97.41	1.25	0.29	0.02
52	2.02	88.41	96.90	1.24	-8.49	-0.59
53	1.60	105.77	100.13	1.84	5.64	0.39
54	1.57	96.83	100.39	1.93	-3.56	-0.25
55	2.38	89.24	94.11	1.82	-4.87	-0.34
56	2.25	78.55	95.11	1.52	-16.56	-1.14
57	2.31	84.79	94.70	1.63	-9.91	-0.69
58	2.08	107.48	96.48	1.27	11.00	0.76
59	2.22	104.80	95.38	1.45	9.42	0.65
60	2.13	101.06	96.03	1.33	5.03	0.35
61	1.78	103.32	98.77	1.45	4.55	0.31
62	1.83	84.69	98.35	1.36	-13.66	-0.94
63	1.82	94.12	98.45	1.38	-4.34	-0.30
64	1.91	101.14	97.77	1.27	3.37	0.23
65	2.52	122.90	93.04	2.19	29.86	2.08R
66	2.03	105.80	96.87	1.24	8.93	0.62
67	1.95	85.16	97.41	1.25	-12.25	-0.85
68	2.08	94.74	96.45	1.27	-1.71	-0.12
69	2.14	99.03	96.01	1.33	3.02	0.21
70	2.20	87.38	95.48	1.43	-8.11	-0.56
71	1.85	91.99	98.26	1.34	-6.27	-0.43
72	1.84	96.83	98.31	1.35	-1.47	-0.10
73	2.17	95.39	95.72	1.38	-0.33	-0.02
74	1.75	117.13	99.01	1.50	18.12	1.25
75	1.57	108.85	100.39	1.93	8.45	0.59
76	2.32	89.41	94.59	1.67	-5.18	-0.36
77	2.01	95.48	96.99	1.24	-1.51	-0.10
78	1.76	114.50	98.95	1.49	15.56	1.07
79	2.06	118.83	96.56	1.26	22.27	1.54
80	1.67	99.99	99.59	1.67	0.40	0.03
81	1.54	55.79	100.58	1.99	-44.79	-3.11R
82	1.53	88.24	100.68	2.02	-12.44	-0.86
83	2.00	88.10	97.03	1.24	-8.93	-0.62
84	1.78	118.18	98.77	1.45	19.41	1.34
85	1.65	112.19	99.74	1.71	12.46	0.86
86	1.65	112.19	99.74	1.71	12.46	0.86
87	1.54	68.42	100.58	1.99	-32.16	-2.23R
88	1.52	96.00	100.78	2.06	-4.78	-0.33
89	1.52	88.24	100.78	2.06	-12.54	-0.87
90	2.73	91.80	91.44	2.81	0.37	0.03
91	2.32	113.40	94.59	1.67	18.81	1.30

92	2.01	100.00	96.96	1.24	3.04	0.21
93	2.08	106.38	96.42	1.27	9.96	0.69
94	1.72	121.84	99.19	1.55	22.65	1.57
95	1.61	115.91	100.05	1.81	15.86	1.10
96	2.68	104.21	91.84	2.65	12.37	0.86
97	2.86	88.00	90.39	3.24	-2.39	-0.17 X
98	2.54	92.92	92.89	2.25	0.03	0.00
99	2.15	103.45	95.88	1.35	7.56	0.52
100	2.02	90.98	96.93	1.24	-5.95	-0.41
101	2.52	92.04	93.04	2.19	-1.00	-0.07
102	2.32	115.09	94.60	1.66	20.49	1.42
103	2.03	113.33	96.80	1.25	16.53	1.14
104	1.71	108.05	99.32	1.59	8.73	0.60
105	1.73	103.53	99.13	1.54	4.40	0.30
106	1.62	123.08	99.97	1.79	23.11	1.60
107	1.56	99.04	100.49	1.96	-1.45	-0.10
108	1.64	95.80	99.81	1.74	-4.02	-0.28
109	1.57	91.89	100.39	1.93	-8.50	-0.59
110	1.49	95.80	100.99	2.14	-5.19	-0.36
111	1.79	97.41	98.66	1.42	-1.25	-0.09
112	1.63	109.02	99.89	1.76	9.13	0.63
113	1.66	93.14	99.66	1.69	-6.53	-0.45
114	1.61	103.09	100.05	1.81	3.04	0.21
115	2.09	95.40	96.39	1.28	-0.99	-0.07
116	1.54	109.52	100.58	1.99	8.94	0.62
117	1.45	114.94	101.33	2.26	13.61	0.95
118	1.46	115.46	101.21	2.22	14.25	0.99
119	1.49	113.46	100.99	2.14	12.47	0.87
120	1.64	97.26	99.81	1.74	-2.55	-0.18
121	2.72	87.50	91.53	2.77	-4.03	-0.28
122	2.21	128.30	95.40	1.45	32.90	2.27R
123	2.00	136.47	97.06	1.24	39.41	2.72R
124	1.79	88.64	98.66	1.42	-10.03	-0.69
125	1.67	110.71	99.59	1.67	11.12	0.77
126	1.70	97.22	99.39	1.61	-2.16	-0.15
127	1.96	95.70	97.34	1.24	-1.64	-0.11
128	1.59	113.72	100.22	1.87	13.51	0.94
129	2.94	85.25	89.82	3.47	-4.58	-0.32 X
130	1.87	107.97	98.07	1.31	9.90	0.68
131	2.24	93.75	95.22	1.49	-1.47	-0.10
132	2.68	97.41	91.83	2.66	5.59	0.39
133	3.10	97.35	88.59	3.99	8.75	0.63 X
134	2.26	119.61	95.09	1.53	24.52	1.69
135	2.06	98.00	96.59	1.26	1.41	0.10
136	1.68	117.65	99.52	1.65	18.12	1.25
137	1.64	94.12	99.81	1.74	-5.70	-0.39
138	1.56	118.82	100.49	1.96	18.34	1.27

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

III. MONOCACY RIVER AT DICKERSON, MD.

THE REGRESSION EQUATION IS
mondo = 3.73 + 2.02 lmonflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	3.733	1.182	3.16
lmonflo	2.0228	0.4647	4.35

S = 1.948

R-SQUARED = 15.8 PERCENT
R-SQUARED = 15.0 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	71.907	71.907
RESIDUAL	101	383.266	3.795
TOTAL	102	455.174	

ROW	lmonflo	Y mondo	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	2.48	10.800	8.744	0.193	2.056	1.06
2	2.77	10.200	9.345	0.228	0.855	0.44
3	2.49	7.600	8.772	0.192	-1.172	-0.60
4	2.12	7.000	8.022	0.263	-1.022	-0.53
5	1.68	7.000	7.134	0.430	-0.134	-0.07
6	1.52	7.100	6.804	0.499	0.296	0.16 X
7	2.59	7.600	8.974	0.196	-1.374	-0.71
8	2.40	9.300	8.597	0.198	0.703	0.36
9	2.31	11.200	8.413	0.212	2.787	1.44
10	3.06	12.100	9.916	0.319	2.184	1.14
11	3.06	9.100	9.932	0.322	-0.832	-0.43
12	2.47	6.600	8.720	0.193	-2.120	-1.09
13	2.32	7.500	8.434	0.210	-0.934	-0.48
14	2.02	9.100	7.821	0.297	1.279	0.66
15	1.98	7.600	7.743	0.311	-0.143	-0.07
16	2.33	9.700	8.447	0.209	1.253	0.65
17	2.15	5.600	8.086	0.254	-2.486	-1.29
18	2.15	7.600	8.086	0.254	-0.486	-0.25
19	2.03	6.800	7.830	0.296	-1.030	-0.53
20	2.03	9.900	7.830	0.296	2.070	1.08
21	2.54	6.400	8.864	0.192	-2.464	-1.27
22	2.45	6.900	8.680	0.194	-1.780	-0.92
23	2.45	7.100	8.680	0.194	-1.580	-0.82
24	2.40	7.000	8.590	0.198	-1.590	-0.82
25	2.40	9.600	8.590	0.198	1.010	0.52
26	2.85	10.400	9.499	0.249	0.901	0.47
27	2.76	8.500	9.320	0.225	-0.820	-0.42
28	2.25	10.800	8.285	0.226	2.515	1.30
29	2.17	9.300	8.123	0.248	1.177	0.61
30	2.39	15.500	8.566	0.200	6.934	3.58R
31	2.35	8.500	8.491	0.205	0.009	0.00

32	3.04	10.500	9.885	0.313	0.615	0.32
33	2.71	12.300	9.206	0.213	3.094	1.60
34	2.88	14.600	9.549	0.257	5.051	2.62R
35	2.95	10.200	9.705	0.282	0.495	0.26
36	3.76	7.800	11.330	0.610	-3.530	-1.91 X
37	3.06	9.000	9.924	0.320	-0.924	-0.48
38	2.70	7.500	9.194	0.211	-1.694	-0.87
39	2.80	8.100	9.400	0.235	-1.300	-0.67
40	2.49	8.900	8.764	0.192	0.136	0.07
41	2.19	7.700	8.169	0.242	-0.469	-0.24
42	2.93	9.900	9.652	0.273	0.248	0.13
43	3.05	10.000	9.909	0.317	0.091	0.05
44	2.92	12.400	9.630	0.269	2.770	1.44
45	2.85	12.400	9.490	0.248	2.910	1.51
46	3.13	9.800	10.071	0.348	-0.271	-0.14
47	3.09	9.800	9.976	0.330	-0.176	-0.09
48	2.43	8.000	8.651	0.195	-0.651	-0.34
49	2.56	6.200	8.913	0.193	-2.713	-1.40
50	2.56	6.100	8.913	0.193	-2.813	-1.45
51	2.56	5.000	8.913	0.193	-3.913	-2.02R
52	2.16	6.100	8.099	0.252	-1.999	-1.03
53	2.25	6.700	8.285	0.226	-1.585	-0.82
54	2.25	6.900	8.285	0.226	-1.385	-0.72
55	2.25	7.600	8.285	0.226	-0.685	-0.35
56	2.15	7.300	8.086	0.254	-0.786	-0.41
57	1.98	8.000	7.733	0.313	0.267	0.14
58	2.75	12.600	9.298	0.223	3.302	1.71
59	2.83	10.000	9.455	0.243	0.545	0.28
60	2.85	7.900	9.500	0.249	-1.600	-0.83
61	2.49	7.300	8.772	0.192	-1.472	-0.76
62	2.61	6.500	9.020	0.198	-2.520	-1.30
63	2.36	7.100	8.510	0.204	-1.410	-0.73
64	2.41	6.700	8.604	0.198	-1.904	-0.98
65	2.33	7.200	8.451	0.209	-1.251	-0.65
66	2.06	8.900	7.901	0.283	0.999	0.52
67	2.16	9.900	8.099	0.252	1.801	0.93
68	2.84	13.600	9.468	0.245	4.132	2.14R
69	3.43	10.400	10.680	0.471	-0.280	-0.15 X
70	3.54	12.000	10.889	0.515	1.111	0.59 X
71	2.91	6.800	9.613	0.267	-2.813	-1.46
72	2.84	7.300	9.479	0.246	-2.179	-1.13
73	2.39	7.600	8.562	0.200	-0.962	-0.50
74	2.40	7.700	8.590	0.198	-0.890	-0.46
75	2.79	8.700	9.378	0.232	-0.678	-0.35
76	3.29	11.200	10.379	0.409	0.821	0.43
77	3.04	11.300	9.885	0.313	1.415	0.74
78	2.85	13.600	9.499	0.249	4.101	2.12R
79	3.15	10.000	10.109	0.355	-0.109	-0.06
80	3.14	8.500	10.078	0.349	-1.578	-0.82
81	2.98	7.000	9.768	0.292	-2.768	-1.44
82	2.31	8.000	8.413	0.212	-0.413	-0.21
83	2.24	12.000	8.260	0.230	3.740	1.93
84	2.28	6.100	8.342	0.220	-2.242	-1.16
85	2.28	6.700	8.342	0.220	-1.642	-0.85
86	2.28	8.000	8.342	0.220	-0.342	-0.18

87	2.28	10.200	8.342	0.220	1.858	0.96
88	2.46	8.500	8.717	0.193	-0.217	-0.11
89	2.09	11.900	7.967	0.272	3.933	2.04R
90	2.04	9.100	7.854	0.291	1.246	0.65
91	2.04	8.700	7.854	0.291	0.846	0.44
92	2.01	6.300	7.804	0.300	-1.504	-0.78
93	2.01	6.400	7.804	0.300	-1.404	-0.73
94	2.01	6.500	7.804	0.300	-1.304	-0.68
95	2.01	7.700	7.804	0.300	-0.104	-0.05
96	2.01	7.700	7.804	0.300	-0.104	-0.05
97	2.01	7.700	7.804	0.300	-0.104	-0.05
98	2.01	7.400	7.804	0.300	-0.404	-0.21
99	2.02	8.400	7.813	0.298	0.587	0.30
100	2.51	11.400	8.803	0.192	2.597	1.34
101	2.98	10.600	9.759	0.291	0.841	0.44
102	2.79	9.200	9.367	0.231	-0.167	-0.09
103	2.63	10.700	9.045	0.200	1.655	0.85

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

CORRELATION OF mosat AND lmsatflo= -.063

THE REGRESSION EQUATION IS
mosat = 98.6 - 2.62 lmsatflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	98.56	10.68	9.23
lmsatflo	-2.618	4.192	-0.62

S = 17.45

R-SQUARED = .4 PERCENT
R-SQUARED = .0 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	118.7	118.7
RESIDUAL	99	30130.1	304.3
TOTAL	100	30248.9	

ROW	lmsatflo	Y mosat	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	2.48	95.58	92.07	1.74	3.50	0.20
2	2.77	94.44	91.30	2.05	3.15	0.18
3	2.49	82.61	92.04	1.74	-9.43	-0.54
4	2.12	88.61	93.01	2.39	-4.40	-0.25
5	1.68	77.78	94.16	3.90	-16.38	-0.96
6	1.52	89.87	94.58	4.52	-4.71	-0.28 X
7	2.59	80.00	91.78	1.77	-11.78	-0.68
8	2.40	87.74	92.26	1.79	-4.53	-0.26

9	2.31	87.50	92.50	1.93	-5.00	-0.29
10	3.06	89.63	90.56	2.86	-0.93	-0.05
11	3.06	84.26	90.54	2.89	-6.28	-0.36
12	2.47	75.86	92.10	1.75	-16.24	-0.94
13	2.32	75.00	92.47	1.91	-17.47	-1.01
14	2.02	110.98	93.27	2.70	17.71	1.03
15	1.98	87.36	93.37	2.82	-6.01	-0.35
16	2.33	122.79	92.46	1.90	30.33	1.75
17	2.15	66.67	92.92	2.30	-26.26	-1.52
18	2.15	92.68	92.92	2.30	-0.24	-0.01
19	2.03	80.95	93.26	2.68	-12.30	-0.71
20	2.03	126.92	93.26	2.68	33.67	1.95
21	2.54	75.29	91.92	1.74	-16.62	-0.96
22	2.45	79.31	92.16	1.76	-12.85	-0.74
23	2.45	83.53	92.16	1.76	-8.63	-0.50
24	2.40	80.46	92.27	1.80	-11.81	-0.68
25	2.40	114.29	92.27	1.80	22.01	1.27
26	2.85	113.04	91.10	2.24	21.95	1.27
27	2.76	92.39	91.33	2.02	1.06	0.06
28	2.25	127.06	92.67	2.06	34.39	1.99
29	2.17	109.41	92.88	2.25	16.53	0.96
30	2.39	168.48	92.30	1.81	76.17	4.39R
31	2.35	75.22	92.40	1.86	-17.18	-0.99
32	3.04	76.09	90.60	2.81	-14.51	-0.84
33	2.71	91.11	91.47	1.91	-0.36	-0.02
34	2.88	108.15	91.03	2.31	17.12	0.99
35	2.95	81.60	90.83	2.53	-9.23	-0.53
36	3.76	72.22	88.73	5.49	-16.50	-1.00 X
37	3.06	90.00	90.55	2.88	-0.55	-0.03
38	2.70	85.23	91.49	1.90	-6.26	-0.36
39	2.80	90.00	91.22	2.11	-1.22	-0.07
40	2.49	101.36	92.05	1.74	9.31	0.54
41	2.19	85.56	92.82	2.19	-7.26	-0.42
42	2.93	87.61	90.90	2.45	-3.29	-0.19
43	3.05	88.50	90.57	2.85	-2.07	-0.12
44	2.92	94.66	90.93	2.42	3.73	0.22
45	2.85	89.86	91.11	2.23	-1.25	-0.07
46	3.13	101.03	90.36	3.13	10.68	0.62
47	3.09	103.16	90.48	2.96	12.68	0.74
48	2.43	91.95	92.19	1.77	-0.24	-0.01
49	2.56	70.45	91.85	1.75	-21.40	-1.23
50	2.56	58.82	91.85	1.75	-33.03	-1.90
51	2.16	74.39	92.91	2.29	-18.52	-1.07
52	2.25	78.82	92.67	2.06	-13.84	-0.80
53	2.25	84.15	92.67	2.06	-8.52	-0.49
54	2.25	93.83	92.67	2.06	1.16	0.07
55	2.15	89.02	92.92	2.30	-3.90	-0.23
56	1.98	91.95	93.38	2.84	-1.43	-0.08
57	2.75	118.87	91.36	2.00	27.51	1.59
58	2.83	92.59	91.15	2.18	1.44	0.08
59	2.85	89.77	91.09	2.24	-1.32	-0.08
60	2.49	85.88	92.04	1.74	-6.15	-0.35
61	2.61	79.27	91.72	1.79	-12.45	-0.72
62	2.36	87.65	92.38	1.85	-4.72	-0.27
63	2.41	79.76	92.25	1.79	-12.49	-0.72

64	2.33	80.00	92.45	1.89	-12.45	-0.72
65	2.06	91.75	93.16	2.57	-1.41	-0.08
66	2.16	87.61	92.91	2.29	-5.30	-0.31
67	2.84	100.74	91.14	2.20	9.60	0.55
68	3.43	79.39	89.57	4.23	-10.18	-0.60
69	3.54	100.84	89.30	4.63	11.54	0.69 X
70	2.91	73.91	90.95	2.39	-17.04	-0.99
71	2.84	81.11	91.12	2.21	-10.01	-0.58
72	2.39	84.44	92.31	1.81	-7.86	-0.45
73	2.40	85.56	92.27	1.80	-6.72	-0.39
74	2.79	91.58	91.25	2.09	0.33	0.02
75	3.29	99.11	89.96	3.67	9.16	0.54
76	3.04	100.00	90.60	2.81	9.40	0.55
77	2.85	103.82	91.10	2.24	12.72	0.74
78	3.15	92.59	90.31	3.19	2.29	0.13
79	3.14	89.47	90.35	3.14	-0.87	-0.05
80	2.98	76.09	90.75	2.63	-14.66	-0.85
81	2.31	95.24	92.50	1.93	2.74	0.16
82	2.24	153.85	92.70	2.08	61.15	3.53R
83	2.28	74.39	92.59	1.99	-18.20	-1.05
84	2.28	81.71	92.59	1.99	-10.89	-0.63
85	2.28	98.77	92.59	1.99	6.17	0.36
86	2.28	129.11	92.59	1.99	36.52	2.11R
87	2.46	101.19	92.11	1.75	9.08	0.52
88	2.09	140.00	93.08	2.47	46.92	2.72R
89	2.04	110.98	93.22	2.64	17.75	1.03
90	2.04	103.57	93.22	2.64	10.35	0.60
91	2.01	72.41	93.29	2.72	-20.88	-1.21
92	2.01	73.56	93.29	2.72	-19.73	-1.14
93	2.01	74.71	93.29	2.72	-18.58	-1.08
94	2.01	91.67	93.29	2.72	-1.62	-0.09
95	2.01	91.67	93.29	2.72	-1.62	-0.09
96	2.01	88.10	93.29	2.72	-5.19	-0.30
97	2.02	80.77	93.28	2.71	-12.51	-0.73
98	2.51	91.20	92.00	1.74	-0.80	-0.05
99	2.98	86.89	90.76	2.61	-3.87	-0.22
100	2.79	86.79	91.27	2.08	-4.47	-0.26
101	2.63	116.30	91.68	1.80	24.62	1.42

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

IV. MONOCACY ABOVE AND BELOW FREDERICK

A. ABOVE

THE REGRESSION EQUATION IS
a2do = 6.32 + 1.25 logmona

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	6.322	1.699	3.72
logmona	1.2473	0.6163	2.02

S = 2.030

R-SQUARED = 6.9 PERCENT
R-SQUARED = 5.2 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	16.882	16.882
RESIDUAL	55	226.700	4.122
TOTAL	56	243.582	

ROW	logmona	Y a2do	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	2.75	10.800	9.753	0.269	1.047	0.52
2	2.83	12.000	9.850	0.277	2.150	1.07
3	2.85	8.400	9.878	0.280	-1.478	-0.74
4	2.49	8.000	9.429	0.304	-1.429	-0.71
5	2.51	7.300	9.458	0.298	-2.158	-1.07
6	2.36	7.000	9.268	0.349	-2.268	-1.13
7	2.41	6.800	9.326	0.331	-2.526	-1.26
8	2.68	8.800	9.664	0.270	-0.864	-0.43
9	2.33	8.500	9.231	0.361	-0.731	-0.37
10	2.06	11.800	8.892	0.489	2.908	1.48
11	2.16	10.800	9.014	0.440	1.786	0.90
12	2.84	13.500	9.858	0.278	3.642	1.81
13	3.43	12.600	10.606	0.515	1.994	1.02
14	3.17	11.500	10.280	0.387	1.220	0.61
15	2.91	7.500	9.948	0.292	-2.448	-1.22
16	2.84	7.600	9.865	0.279	-2.265	-1.13
17	2.39	7.700	9.300	0.339	-1.600	-0.80
18	2.40	9.200	9.317	0.334	-0.117	-0.06
19	2.79	10.100	9.803	0.272	0.297	0.15
20	3.29	11.400	10.420	0.439	0.980	0.49
21	3.04	11.200	10.115	0.333	1.085	0.54
22	2.85	15.000	9.877	0.280	5.123	2.55R
23	3.15	10.200	10.254	0.377	-0.054	-0.03
24	3.14	9.000	10.234	0.371	-1.234	-0.62
25	2.98	7.400	10.043	0.313	-2.643	-1.32
26	2.31	7.000	9.208	0.368	-2.208	-1.11
27	2.09	11.800	8.933	0.472	2.867	1.45
28	2.02	9.700	8.838	0.511	0.862	0.44
29	2.51	12.000	9.448	0.300	2.552	1.27
30	2.98	11.200	10.038	0.312	1.162	0.58
31	2.79	9.500	9.796	0.272	-0.296	-0.15
32	2.63	9.500	9.598	0.275	-0.098	-0.05
33	2.76	7.200	9.760	0.270	-2.560	-1.27
34	2.62	7.200	9.587	0.277	-2.387	-1.19
35	2.24	7.600	9.116	0.401	-1.516	-0.76
36	2.06	10.200	8.892	0.489	1.308	0.66

37	2.20	11.300	9.061	0.421	2.239	1.13
38	2.64	12.400	9.612	0.274	2.788	1.39
39	3.60	12.000	10.812	0.604	1.188	0.61
40	3.09	11.800	10.180	0.353	1.620	0.81
41	3.62	11.200	10.832	0.613	0.368	0.19
42	2.89	9.200	9.926	0.288	-0.726	-0.36
43	3.62	7.400	10.842	0.617	-3.442	-1.78
44	2.27	8.600	9.150	0.389	-0.550	-0.28
45	2.14	10.000	8.987	0.450	1.013	0.51
46	2.59	8.200	9.558	0.280	-1.358	-0.68
47	2.36	8.900	9.270	0.348	-0.370	-0.18
48	2.38	9.200	9.286	0.343	-0.086	-0.04
49	2.52	8.500	9.466	0.296	-0.966	-0.48
50	2.66	14.200	9.642	0.271	4.558	2.27R
51	3.22	12.500	10.341	0.409	2.159	1.09
52	3.53	10.800	10.723	0.565	0.077	0.04
53	3.56	11.000	10.758	0.580	0.242	0.12
54	3.08	8.400	10.167	0.349	-1.767	-0.88
55	2.78	8.100	9.794	0.272	-1.694	-0.84
56	2.72	6.500	9.716	0.269	-3.216	-1.60
57	2.05	6.700	8.883	0.492	-2.183	-1.11

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

THE REGRESSION EQUATION IS
a2sat = 100 - 2.53 logmona

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	100.16	10.02	10.00
logmona	-2.530	3.633	-0.70

S = 11.97

R-SQUARED = .9 PERCENT
R-SQUARED = .0 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	69.5	69.5
RESIDUAL	55	7876.9	143.2
TOTAL	56	7946.3	

ROW	logmona	Y a2sat	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	2.75	101.89	93.19	1.59	8.69	0.73
2	2.83	100.84	93.00	1.63	7.84	0.66
3	2.85	96.55	92.94	1.65	3.61	0.30
4	2.49	86.97	93.85	1.79	-6.89	-0.58
5	2.51	82.95	93.79	1.76	-10.84	-0.92
6	2.36	86.42	94.18	2.06	-7.76	-0.66

7	2.41	82.93	94.06	1.95	-11.14	-0.94
8	2.68	97.78	93.38	1.59	4.40	0.37
9	2.33	96.59	94.25	2.13	2.34	0.20
10	2.06	121.65	94.94	2.88	26.71	2.30R
11	2.16	95.58	94.69	2.59	0.88	0.08
12	2.84	100.00	92.98	1.64	7.02	0.59
13	3.43	98.44	91.47	3.03	6.97	0.60
14	3.17	94.26	92.13	2.28	2.14	0.18
15	2.91	81.52	92.80	1.72	-11.28	-0.95
16	2.84	86.36	92.97	1.64	-6.60	-0.56
17	2.39	87.50	94.12	2.00	-6.62	-0.56
18	2.40	104.54	94.08	1.97	10.47	0.89
19	2.79	107.45	93.09	1.60	14.35	1.21
20	3.29	100.89	91.84	2.59	9.04	0.77
21	3.04	96.55	92.46	1.96	4.09	0.35
22	2.85	111.11	92.94	1.65	18.17	1.53
23	3.15	94.44	92.18	2.22	2.26	0.19
24	3.14	95.74	92.22	2.19	3.53	0.30
25	2.98	80.43	92.61	1.85	-12.17	-1.03
26	2.31	83.33	94.30	2.17	-10.97	-0.93
27	2.09	143.90	94.86	2.78	49.04	4.21R
28	2.02	95.10	95.05	3.01	0.05	0.00
29	2.51	93.75	93.81	1.77	-0.06	-0.01
30	2.98	91.80	92.62	1.84	-0.82	-0.07
31	2.79	84.07	93.11	1.60	-9.04	-0.76
32	2.63	99.00	93.51	1.62	5.49	0.46
33	2.76	79.30	93.18	1.59	-13.88	-1.17
34	2.62	87.50	93.53	1.63	-6.03	-0.51
35	2.24	86.30	94.49	2.36	-8.19	-0.70
36	2.06	87.50	94.94	2.88	-7.44	-0.64
37	2.20	92.10	94.60	2.48	-2.50	-0.21
38	2.64	98.10	93.48	1.61	4.62	0.39
39	3.60	88.50	91.05	3.56	-2.55	-0.22
40	3.09	94.50	92.33	2.08	2.17	0.18
41	3.62	100.90	91.01	3.61	9.89	0.87
42	2.89	91.00	92.85	1.70	-1.85	-0.16
43	3.62	82.30	90.99	3.64	-8.69	-0.76
44	2.27	103.80	94.42	2.29	9.38	0.80
45	2.14	114.60	94.75	2.65	19.85	1.70
46	2.59	90.30	93.59	1.65	-3.29	-0.28
47	2.36	74.30	94.18	2.05	-19.88	-1.69
48	2.38	76.80	94.14	2.02	-17.34	-1.47
49	2.52	82.00	93.78	1.75	-11.78	-0.99
50	2.66	99.60	93.42	1.60	6.18	0.52
51	3.22	93.30	92.00	2.41	1.30	0.11
52	3.53	89.70	91.23	3.33	-1.53	-0.13
53	3.56	94.10	91.16	3.42	2.94	0.26
54	3.08	88.70	92.36	2.06	-3.66	-0.31
55	2.78	92.80	93.11	1.60	-0.31	-0.03
56	2.72	74.10	93.27	1.59	-19.17	-1.62
57	2.05	73.80	94.96	2.90	-21.16	-1.82

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

B. BELOW

THE REGRESSION EQUATION IS
bdo = - 1.89 + 3.84 logbflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	-1.889	1.323	-1.43
logbflo	3.8380	0.5059	7.59

S = 1.945

R-SQUARED = 45.5 PERCENT
R-SQUARED = 44.7 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	217.70	217.70
RESIDUAL	69	260.96	3.78
TOTAL	70	478.66	

ROW	logbflo	Y bdo	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	2.36	6.600	7.175	0.255	-0.575	-0.30
2	2.41	5.900	7.354	0.246	-1.454	-0.75
3	2.68	7.800	8.394	0.237	-0.594	-0.31
4	2.33	6.300	7.063	0.262	-0.763	-0.40
5	2.11	7.800	6.224	0.328	1.576	0.82
6	2.16	9.800	6.395	0.313	3.405	1.77
7	2.84	13.500	8.992	0.265	4.508	2.34R
8	3.43	12.400	11.293	0.492	1.107	0.59
9	3.17	10.400	10.289	0.380	0.111	0.06
10	2.91	7.500	9.267	0.285	-1.767	-0.92
11	2.84	7.500	9.013	0.267	-1.513	-0.79
12	2.39	7.400	7.274	0.250	0.126	0.07
13	2.40	7.800	7.327	0.247	0.473	0.25
14	2.79	8.300	8.823	0.255	-0.523	-0.27
15	3.29	11.300	10.721	0.427	0.579	0.31
16	3.04	11.200	9.784	0.330	1.416	0.74
17	2.85	15.200	9.051	0.269	6.149	3.19R
18	3.15	10.000	10.209	0.372	-0.209	-0.11
19	3.14	8.600	10.149	0.366	-1.549	-0.81
20	2.98	7.100	9.562	0.310	-2.462	-1.28
21	2.31	6.400	6.991	0.266	-0.591	-0.31
22	2.24	5.700	6.700	0.287	-1.000	-0.52
23	2.28	4.100	6.857	0.275	-2.757	-1.43
24	2.28	3.800	6.857	0.275	-3.057	-1.59
25	2.28	6.100	6.857	0.275	-0.757	-0.39
26	2.28	7.600	6.857	0.275	0.743	0.39
27	2.28	5.500	6.857	0.275	-1.357	-0.70
28	2.28	5.900	6.857	0.275	-0.957	-0.50
29	2.46	8.400	7.567	0.238	0.833	0.43

30	2.09	5.400	6.145	0.336	-0.745	-0.39
31	2.04	5.500	5.930	0.357	-0.430	-0.23
32	2.04	6.800	5.930	0.357	0.870	0.45
33	2.04	3.600	5.930	0.357	-2.330	-1.22
34	2.01	3.800	5.836	0.367	-2.036	-1.07
35	2.01	4.200	5.836	0.367	-1.636	-0.86
36	2.01	4.800	5.836	0.367	-1.036	-0.54
37	2.01	4.800	5.836	0.367	-1.036	-0.54
38	2.01	4.900	5.836	0.367	-0.936	-0.49
39	2.01	5.800	5.836	0.367	-0.036	-0.02
40	2.02	7.900	5.852	0.365	2.048	1.07
41	2.51	10.800	7.731	0.233	3.069	1.59
42	2.98	11.000	9.544	0.308	1.456	0.76
43	2.79	9.100	8.801	0.254	0.299	0.16
44	2.63	9.500	8.191	0.232	1.309	0.68
45	2.76	6.700	8.691	0.248	-1.991	-1.03
46	2.62	6.400	8.159	0.232	-1.759	-0.91
47	2.12	4.600	6.249	0.326	-1.649	-0.86
48	3.03	5.400	9.722	0.324	-4.322	-2.25R
49	2.24	5.600	6.710	0.286	-1.110	-0.58
50	2.06	6.600	6.020	0.348	0.580	0.30
51	2.20	9.400	6.539	0.300	2.861	1.49
52	2.64	12.100	8.233	0.233	3.867	2.00R
53	3.60	11.600	11.927	0.567	-0.327	-0.18 X
54	3.09	11.600	9.983	0.349	1.617	0.85
55	3.00	11.000	9.625	0.315	1.375	0.72
56	2.89	9.800	9.200	0.280	0.600	0.31
57	3.62	7.800	12.021	0.578	-4.221	-2.27RX
58	2.27	6.900	6.812	0.279	0.088	0.05
59	2.14	8.400	6.311	0.320	2.089	1.09
60	2.59	8.200	8.068	0.231	0.132	0.07
61	2.36	9.100	7.182	0.255	1.918	0.99
62	2.38	9.000	7.232	0.252	1.768	0.92
63	2.52	8.700	7.787	0.232	0.913	0.47
64	2.66	11.600	8.327	0.235	3.273	1.70
65	3.22	12.500	10.479	0.400	2.021	1.06
66	3.53	11.100	11.655	0.534	-0.555	-0.30
67	3.56	11.000	11.760	0.547	-0.760	-0.41
68	3.08	8.300	9.942	0.345	-1.642	-0.86
69	2.78	8.800	8.795	0.254	0.005	0.00
70	2.72	7.000	8.554	0.242	-1.554	-0.81
71	2.05	4.800	5.990	0.351	-1.190	-0.62

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

THE REGRESSION EQUATION IS
kbsat = 26.1 + 20.9 logbflo

COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	26.118	8.981	2.91
logbflo	20.882	3.433	6.08

S = 13.20

R-SQUARED = 34.9 PERCENT
R-SQUARED = 34.0 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	6444.7	6444.7
RESIDUAL	69	12018.2	174.2
TOTAL	70	18462.9	

ROW	logbflo	Y kbsat	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	2.36	81.88	75.44	1.73	6.45	0.49
2	2.41	71.95	76.41	1.67	-4.46	-0.34
3	2.68	86.67	82.07	1.61	4.60	0.35
4	2.33	71.59	74.82	1.78	-3.23	-0.25
5	2.11	82.11	70.26	2.23	11.84	0.91
6	2.16	88.29	71.19	2.12	17.10	1.31
7	2.84	97.83	85.32	1.80	12.51	0.96
8	3.43	99.20	97.84	3.34	1.36	0.11
9	3.17	87.39	92.38	2.58	-4.99	-0.39
10	2.91	81.52	86.82	1.93	-5.30	-0.41
11	2.84	83.33	85.44	1.81	-2.10	-0.16
12	2.39	85.06	75.97	1.69	9.09	0.69
13	2.40	88.64	76.26	1.68	12.37	0.95
14	2.79	88.30	84.40	1.73	3.90	0.30
15	3.29	100.00	94.73	2.90	5.27	0.41
16	3.04	96.55	89.63	2.24	6.92	0.53
17	2.85	116.03	85.65	1.83	30.39	2.32R
18	3.15	94.34	91.94	2.52	2.40	0.18
19	3.14	91.49	91.62	2.48	-0.13	-0.01
20	2.98	77.17	88.42	2.10	-11.25	-0.86
21	2.31	76.19	74.44	1.81	1.75	0.13
22	2.24	72.15	72.85	1.95	-0.70	-0.05
23	2.28	50.00	73.70	1.87	-23.70	-1.81
24	2.28	46.34	73.70	1.87	-27.36	-2.09R
25	2.28	76.54	73.70	1.87	2.84	0.22
26	2.28	77.22	73.70	1.87	3.51	0.27
27	2.28	96.20	73.70	1.87	22.50	1.72
28	2.28	69.62	73.70	1.87	-4.08	-0.31
29	2.46	70.24	77.57	1.61	-7.33	-0.56
30	2.09	102.44	69.83	2.28	32.61	2.51R
31	2.04	65.85	68.66	2.42	-2.81	-0.22
32	2.04	65.48	68.66	2.42	-3.19	-0.25
33	2.04	82.93	68.66	2.42	14.26	1.10
34	2.01	40.91	68.15	2.49	-27.24	-2.10R
35	2.01	43.18	68.15	2.49	-24.97	-1.93
36	2.01	47.73	68.15	2.49	-20.42	-1.58

37	2.01	55.17	68.15	2.49	-12.98	-1.00
38	2.01	56.32	68.15	2.49	-11.83	-0.91
39	2.01	66.67	68.15	2.49	-1.48	-0.11
40	2.02	79.00	68.24	2.48	10.76	0.83
41	2.51	84.38	78.46	1.58	5.92	0.45
42	2.98	90.16	88.33	2.09	1.84	0.14
43	2.79	78.45	84.28	1.72	-5.83	-0.45
44	2.63	97.94	80.96	1.58	16.98	1.30
45	2.76	72.83	83.68	1.68	-10.86	-0.83
46	2.62	78.05	80.79	1.57	-2.74	-0.21
47	2.12	51.11	70.40	2.21	-19.29	-1.48
48	3.03	60.00	89.29	2.20	-29.29	-2.25R
49	2.24	63.64	72.91	1.94	-9.27	-0.71
50	2.06	56.90	69.15	2.36	-12.25	-0.94
51	2.20	81.03	71.97	2.04	9.06	0.69
52	2.64	96.80	81.19	1.58	15.61	1.19
53	3.60	88.55	101.29	3.85	-12.74	-1.01 X
54	3.09	95.08	90.71	2.37	4.37	0.34
55	3.00	97.35	88.76	2.14	8.58	0.66
56	2.89	96.08	86.45	1.90	9.63	0.74
57	3.62	84.78	101.80	3.92	-17.02	-1.35 X
58	2.27	81.12	73.46	1.89	7.66	0.59
59	2.14	98.82	70.74	2.17	28.09	2.16R
60	2.59	89.13	80.29	1.57	8.84	0.67
61	2.36	80.53	75.47	1.73	5.06	0.39
62	2.38	73.77	75.75	1.71	-1.98	-0.15
63	2.52	83.65	78.76	1.58	4.89	0.37
64	2.66	81.69	81.70	1.59	-0.01	-0.00
65	3.22	95.42	93.41	2.72	2.01	0.16
66	3.53	93.28	99.81	3.63	-6.53	-0.51
67	3.56	97.35	100.38	3.71	-3.04	-0.24
68	3.08	88.30	90.49	2.34	-2.19	-0.17
69	2.78	97.78	84.25	1.72	13.53	1.03
70	2.72	79.54	82.94	1.64	-3.39	-0.26
71	2.05	50.53	68.99	2.38	-18.46	-1.42

R DENOTES AN OBS. WITH A LARGE ST. RES.
X DENOTES AN OBS. WHOSE X VALUE GIVES IT LARGE INFLUENCE.

C. STANDARD NORMAL RESIDUAL

Cumberland, Md
Dissolved oxygen

N	74
MEAN	8.95
MEDIAN	8.65
TMEAN	8.96
STDEV	2.07
SEMEAN	0.24
MAX	13.20
MIN	4.40
Q3	10.63
Q1	7.55

ROW	DO	ST.RES.
1	11.0	0.99034
2	10.0	0.50725
3	8.0	-0.45894
4	10.6	0.79710
5	7.4	-0.74879
6	4.4	-2.19807
7	6.4	-1.23188
8	5.4	-1.71498
9	8.6	-0.16908
10	11.8	1.37681
11	13.2	2.05314
12	12.4	1.66667
13	12.0	1.47343
14	11.0	0.99034
15	6.0	-1.42512
16	5.6	-1.61836
17	12.6	1.76329
18	8.0	-0.45894
19	7.8	-0.55556
20	8.4	-0.26570
21	7.2	-0.84541
22	7.6	-0.65217
23	9.9	0.45894
24	8.6	-0.16908
25	7.6	-0.65217
26	9.8	0.41063
27	8.0	-0.45894
28	10.6	0.79710
29	6.8	-1.03865
30	10.5	0.74879
31	7.0	-0.94203
32	6.4	-1.23188
33	10.8	0.89372
34	10.8	0.89372
35	13.0	1.95652
36	12.0	1.47343
37	9.4	0.21739
38	8.3	-0.31401
39	5.0	-1.90821
40	7.4	-0.74879
41	7.2	-0.84541
42	6.6	-1.13527
43	8.6	-0.16908
44	11.0	0.99034
45	11.0	0.99034
46	9.2	0.12077
47	9.4	0.21739
48	7.6	-0.65217
49	9.0	0.02415
50	7.0	-0.94203
51	8.2	-0.36232

52	8.0	-0.45894
53	9.0	0.02415
54	8.2	-0.36232
55	5.2	-1.81159
56	9.2	0.12077
57	10.3	0.65217
58	11.8	1.37681
59	9.4	0.21739
60	9.5	0.26570
61	7.8	-0.55556
62	8.7	-0.12077
63	8.0	-0.45894
64	7.1	-0.89372
65	7.8	-0.55556
66	7.7	-0.60386
67	7.3	-0.79710
68	9.6	0.31401
69	12.2	1.57005
70	11.9	1.42512
71	11.5	1.23188
72	10.7	0.84541
73	10.5	0.74879
74	8.8	-0.07246

% saturation

N	65
MEAN	82.7
MEDIAN	83.8
TMEAN	82.7
STDEV	15.2
SEMEAN	1.9
MAX	129.6
MIN	36.6
Q3	90.8
Q1	74.5

ROW	% sat	ST. RES.
1	88.00	0.34868
2	90.09	0.48618
3	82.47	-0.01513
4	112.77	1.97829
5	87.06	0.28684
6	50.57	-2.11382
7	68.09	-0.96118
8	52.94	-1.95789
9	67.19	-1.02039
10	90.08	0.48553
11	95.65	0.85197
12	96.87	0.93224
13	91.60	0.58553
14	94.83	0.79803

15	66.67	-1.05461
16	65.88	-1.10658
17	84.78	0.13684
18	91.30	0.56579
19	81.82	-0.05789
20	113.79	2.04540
21	97.73	0.98882
22	109.28	1.74868
23	129.63	3.08750
24	80.46	-0.14737
25	72.73	-0.65592
26	88.52	0.38289
27	91.60	0.58553
28	87.04	0.28553
29	94.32	0.76447
30	55.56	-1.78553
31	82.22	-0.03158
32	85.71	0.19803
33	75.86	-0.45000
34	79.63	-0.20197
35	83.97	0.08355
36	75.34	-0.48421
37	73.60	-0.59868
38	78.99	-0.24408
39	74.51	-0.53882
40	97.83	0.99540
41	74.47	-0.54145
42	96.47	0.90592
43	78.43	-0.28092
44	79.65	-0.20066
45	65.60	-1.12500
46	36.62	-3.03158
47	66.67	-1.05461
48	72.54	-0.66842
49	90.08	0.48553
50	83.19	0.03224
51	89.62	0.45526
52	88.64	0.39079
53	82.08	-0.04079
54	95.24	0.82500
55	77.17	-0.36382
56	76.47	-0.40987
57	81.05	-0.10855
58	61.34	-1.40526
59	67.61	-0.99276
60	90.37	0.50461
61	83.80	0.07237
62	85.19	0.16382
63	85.60	0.19079
64	94.59	0.78224
65	86.27	0.23487

South River

Dissolved Oxygen

N	138
MEAN	9.98
MEDIAN	10.00
TMEAN	9.95
STDEV	1.92
SEMEAN	0.16
MAX	15.00
MIN	4.40
Q3	11.20
Q1	8.60

ROW	DO	ST. RES.
1	14.0	2.09375
2	9.9	-0.04167
3	6.8	-1.65625
4	9.6	-0.19792
5	8.6	-0.71875
6	10.0	0.01042
7	8.6	-0.71875
8	9.2	-0.40625
9	10.8	0.42708
10	13.0	1.57292
11	12.4	1.26042
12	14.6	2.40625
13	11.2	0.63542
14	8.6	-0.71875
15	7.6	-1.23958
16	8.5	-0.77083
17	6.4	-1.86458
18	7.4	-1.34375
19	8.2	-0.92708
20	10.2	0.11458
21	10.2	0.11458
22	8.4	-0.82292
23	11.6	0.84375
24	11.0	0.53125
25	6.8	-1.65625
26	8.4	-0.82292
27	4.4	-2.90625
28	6.8	-1.65625
29	7.4	-1.34375
30	8.4	-0.82292
31	9.0	-0.51042
32	9.2	-0.40625
33	11.8	0.94792
34	11.8	0.94792
35	12.4	1.26042
36	12.0	1.05208
37	7.4	-1.34375
38	9.4	-0.30208

39	9.6	-0.19792
40	7.2	-1.44792
41	7.8	-1.13542
42	7.0	-1.55208
43	8.0	-1.03125
44	10.4	0.21875
45	11.0	0.53125
46	10.0	0.01042
47	11.0	0.53125
48	6.2	-1.96875
49	8.2	-0.92708
50	8.8	-0.61458
51	8.5	-0.77083
52	8.4	-0.82292
53	11.0	0.53125
54	9.2	-0.40625
55	11.7	0.89583
56	10.3	0.16667
57	10.1	0.06250
58	12.8	1.46875
59	10.7	0.37500
60	9.5	-0.25000
61	9.3	-0.35417
62	7.2	-1.44792
63	8.0	-1.03125
64	8.8	-0.61458
65	12.3	1.20833
66	12.6	1.36458
67	10.4	0.21875
68	12.8	1.46875
69	11.2	0.63542
70	9.7	-0.14583
71	9.2	-0.40625
72	9.2	-0.40625
73	8.3	-0.87500
74	10.2	0.11458
75	8.6	-0.71875
76	9.3	-0.35417
77	12.9	1.52083
78	15.0	2.61458
79	13.2	1.67708
80	8.4	-0.82292
81	7.7	-1.18750
82	9.0	-0.51042
83	7.4	-1.34375
84	10.4	0.21875
85	9.2	-0.40625
86	9.2	-0.40625
87	6.5	-1.81250
88	9.6	-0.19792
89	9.0	-0.51042
90	11.2	0.63542
91	11.0	0.53125
92	9.4	-0.30208
93	10.0	0.01042

94	10.6	0.32292
95	10.2	0.11458
96	9.9	-0.04167
97	8.8	-0.61458
98	10.5	0.27083
99	12.0	1.05208
100	11.1	0.58333
101	10.4	0.21875
102	12.2	1.15625
103	10.2	0.11458
104	9.4	-0.30208
105	8.8	-0.61458
106	9.6	-0.19792
107	10.3	0.16667
108	11.4	0.73958
109	10.2	0.11458
110	11.4	0.73958
111	11.3	0.68750
112	13.3	1.72917
113	9.5	-0.25000
114	10.0	0.01042
115	8.3	-0.87500
116	9.2	-0.40625
117	10.0	0.01042
118	11.2	0.63542
119	11.8	0.94792
120	14.2	2.19792
121	11.2	0.63542
122	13.6	1.88542
123	11.6	0.84375
124	7.8	-1.13542
125	9.3	-0.35417
126	10.5	0.27083
127	11.1	0.58333
128	11.6	0.84375
129	10.4	0.21875
130	14.9	2.56250
131	12.0	1.05208
132	11.3	0.68750
133	11.0	0.53125
134	12.2	1.15625
135	9.8	-0.09375
136	10.0	0.01042
137	8.0	-1.03125
138	10.1	0.06250

% saturation

N	138
MEAN	97.1
MEDIAN	96.8
TMEAN	97.4
STDEV	14.8
SEMEAN	1.3
MAX	136.5
MIN	46.3
Q3	107.6
Q1	88.4

ROW	% sat	ST. RES.
1	123.89	1.81014
2	85.34	-0.79459
3	72.33	-1.67365
4	110.33	0.89392
5	97.72	0.04189
6	121.95	1.67905
7	98.84	0.11757
8	79.30	-1.20270
9	88.44	-0.58513
10	104.00	0.46622
11	96.80	-0.02027
12	116.72	1.32568
13	111.90	1.00000
14	90.52	-0.44459
15	80.84	-1.09865
16	101.19	0.27635
17	71.10	-1.75676
18	80.42	-1.12703
19	81.99	-1.02095
20	94.35	-0.18581
21	87.84	-0.62568
22	64.11	-2.22905
23	88.47	-0.58311
24	99.10	0.13514
25	70.09	-1.82500
26	88.41	-0.58716
27	46.31	-3.43176
28	71.57	-1.72500
29	80.42	-1.12703
30	91.29	-0.39257
31	90.00	-0.47973
32	85.18	-0.80541
33	104.34	0.48919
34	96.64	-0.03108
35	94.58	-0.17027
36	98.36	0.08514
37	76.28	-1.40676
38	96.90	-0.01351
39	110.33	0.89392

40	84.69	-0.83851
41	84.77	-0.83311
42	77.78	-1.30541
43	75.47	-1.46149
44	89.57	-0.50878
45	90.16	-0.46892
46	92.59	-0.30473
47	99.10	0.13514
48	67.38	-2.00811
49	93.17	-0.26554
50	103.52	0.43378
51	97.70	0.04054
52	88.41	-0.58716
53	105.77	0.58581
54	96.83	-0.01824
55	89.24	-0.53108
56	78.55	-1.25338
57	84.79	-0.83176
58	107.48	0.70135
59	104.80	0.52027
60	101.06	0.26757
61	103.32	0.42027
62	84.69	-0.83851
63	94.12	-0.20135
64	101.14	0.27297
65	122.90	1.74324
66	105.80	0.58784
67	85.16	-0.80676
68	94.74	-0.15946
69	99.03	0.13041
70	87.38	-0.65676
71	91.99	-0.34527
72	96.83	-0.01824
73	95.39	-0.11554
74	117.13	1.35338
75	108.85	0.79392
76	89.41	-0.51959
77	95.48	-0.10946
78	114.50	1.17568
79	118.83	1.46824
80	99.99	0.19527
81	55.79	-2.79122
82	88.24	-0.59865
83	88.10	-0.60811
84	118.18	1.42432
85	112.19	1.01959
86	112.19	1.01959
87	68.42	-1.93784
88	96.00	-0.07432
89	88.24	-0.59865
90	91.80	-0.35811
91	113.40	1.10135
92	100.00	0.19595
93	106.38	0.62703
94	121.84	1.67162

95	115.91	1.27095
96	104.21	0.48041
97	88.00	-0.61486
98	92.92	-0.28243
99	103.45	0.42905
100	90.98	-0.41351
101	92.04	-0.34189
102	115.09	1.21554
103	113.33	1.09662
104	108.05	0.73987
105	103.53	0.43446
106	123.08	1.75541
107	99.04	0.13108
108	95.80	-0.08784
109	91.89	-0.35203
110	95.80	-0.08784
111	97.41	0.02095
112	109.02	0.80541
113	93.14	-0.26757
114	103.09	0.40473
115	95.40	-0.11486
116	109.52	0.83919
117	114.94	1.20541
118	115.46	1.24054
119	113.46	1.10541
120	97.26	0.01081
121	87.50	-0.64865
122	128.30	2.10811
123	136.47	2.66014
124	88.64	-0.57162
125	110.71	0.91959
126	97.22	0.00811
127	95.70	-0.09459
128	113.72	1.12297
129	85.25	-0.80068
130	107.97	0.73446
131	93.75	-0.22635
132	97.41	0.02095
133	97.35	0.01689
134	119.61	1.52095
135	98.00	0.06081
136	117.65	1.38851
137	94.12	-0.20135
138	118.82	1.46757

MONOCACY RIVER AT DICKERSON, MD.

dissolved oxygen

N	103
MEAN	8.81
MEDIAN	8.40
TMEAN	8.69
STDEV	2.11
SEMEAN	0.21
MAX	15.50
MIN	5.00
Q3	10.20
Q1	7.10

ROW	DO	ST. RES.
1	10.8	0.94313
2	10.2	0.65877
3	7.6	-0.57346
4	7.0	-0.85782
5	7.0	-0.85782
6	7.1	-0.81043
7	7.6	-0.57346
8	9.3	0.23223
9	11.2	1.13270
10	12.1	1.55924
11	9.1	0.13744
12	6.6	-1.04739
13	7.5	-0.62085
14	9.1	0.13744
15	7.6	-0.57346
16	9.7	0.42180
17	5.6	-1.52133
18	7.6	-0.57346
19	6.8	-0.95261
20	9.9	0.51659
21	6.4	-1.14218
22	6.9	-0.90521
23	7.1	-0.81043
24	7.0	-0.85782
25	9.6	0.37441
26	10.4	0.75355
27	8.5	-0.14692
28	10.8	0.94313
29	9.3	0.23223
30	15.5	3.17062
31	8.5	-0.14692
32	10.5	0.80095
33	12.3	1.65403
34	14.6	2.74408
35	10.2	0.65877
36	7.8	-0.47867
37	9.0	0.09005

38	7.5	-0.62085
39	8.1	-0.33649
40	8.9	0.04265
41	7.7	-0.52607
42	9.9	0.51659
43	10.0	0.56398
44	12.4	1.70142
45	12.4	1.70142
46	9.8	0.46919
47	9.8	0.46919
48	8.0	-0.38389
49	6.2	-1.23697
50	6.1	-1.28436
51	5.0	-1.80569
52	6.1	-1.28436
53	6.7	-1.00000
54	6.9	-0.90521
55	7.6	-0.57346
56	7.3	-0.71564
57	8.0	-0.38389
58	12.6	1.79621
59	10.0	0.56398
60	7.9	-0.43128
61	7.3	-0.71564
62	6.5	-1.09479
63	7.1	-0.81043
64	6.7	-1.00000
65	7.2	-0.76303
66	8.9	0.04265
67	9.9	0.51659
68	13.6	2.27014
69	10.4	0.75355
70	12.0	1.51185
71	6.8	-0.95261
72	7.3	-0.71564
73	7.6	-0.57346
74	7.7	-0.52607
75	8.7	-0.05213
76	11.2	1.13270
77	11.3	1.18009
78	13.6	2.27014
79	10.0	0.56398
80	8.5	-0.14692
81	7.0	-0.85782
82	8.0	-0.38389
83	12.0	1.51185
84	6.1	-1.28436
85	6.7	-1.00000
86	8.0	-0.38389
87	10.2	0.65877
88	8.5	-0.14692
89	11.9	1.46445
90	9.1	0.13744
91	8.7	-0.05213
92	6.3	-1.18957

93	6.4	-1.14218
94	6.5	-1.09479
95	7.7	-0.52607
96	7.7	-0.52607
97	7.7	-0.52607
98	7.4	-0.66825
99	8.4	-0.19431
100	11.4	1.22749
101	10.6	0.84834
102	9.2	0.18483
103	10.7	0.89573

% saturation

N	101
MEAN	92.0
MEDIAN	89.0
TMEAN	90.4
STDEV	17.4
SEMEAN	1.7
MAX	168.5
MIN	58.8
Q3	98.9
Q1	80.6

ROW	% sat	ST. RES.
1	95.58	0.20575
2	94.44	0.14023
3	82.61	-0.53966
4	88.61	-0.19483
5	77.78	-0.81724
6	89.87	-0.12241
7	80.00	-0.68966
8	87.74	-0.24483
9	87.50	-0.25862
10	89.63	-0.13621
11	84.26	-0.44483
12	75.86	-0.92759
13	75.00	-0.97701
14	110.98	1.09080
15	87.36	-0.26667
16	122.79	1.76954
17	66.67	-1.45575
18	92.68	0.03908
19	80.95	-0.63506
20	126.92	2.00690
21	75.29	-0.96034
22	79.31	-0.72931
23	83.53	-0.48678
24	80.46	-0.66322
25	114.29	1.28103
26	113.04	1.20920
27	92.39	0.02241

28	127.06	2.01494
29	109.41	1.00057
30	168.48	4.39540
31	75.22	-0.96437
32	76.09	-0.91437
33	91.11	-0.05115
34	108.15	0.92816
35	81.60	-0.59770
36	72.22	-1.13678
37	90.00	-0.11494
38	85.23	-0.38908
39	90.00	-0.11494
40	101.36	0.53793
41	85.56	-0.37012
42	87.61	-0.25230
43	88.50	-0.20115
44	94.66	0.15287
45	89.86	-0.12299
46	101.03	0.51897
47	103.16	0.64138
48	91.95	-0.00287
49	70.45	-1.23851
50	58.82	-1.90690
51	74.39	-1.01207
52	78.82	-0.75747
53	84.15	-0.45115
54	93.83	0.10517
55	89.02	-0.17126
56	91.95	-0.00287
57	118.87	1.54425
58	92.59	0.03391
59	89.77	-0.12816
60	85.88	-0.35172
61	79.27	-0.73161
62	87.65	-0.25000
63	79.76	-0.70345
64	80.00	-0.68966
65	91.75	-0.01437
66	87.61	-0.25230
67	100.74	0.50230
68	79.39	-0.72471
69	100.84	0.50805
70	73.91	-1.03965
71	81.11	-0.62586
72	84.44	-0.43448
73	85.56	-0.37012
74	91.58	-0.02414
75	99.11	0.40862
76	100.00	0.45977
77	103.82	0.67931
78	92.59	0.03391
79	89.47	-0.14540
80	76.09	-0.91437
81	95.24	0.18621
82	153.85	3.55460

83	74.39	-1.01207
84	81.71	-0.59138
85	98.77	0.38908
86	129.11	2.13276
87	101.19	0.52816
88	140.00	2.75862
89	110.98	1.09080
90	103.57	0.66494
91	72.41	-1.12586
92	73.56	-1.05977
93	74.71	-0.99368
94	91.67	-0.01897
95	91.67	-0.01897
96	88.10	-0.22414
97	80.77	-0.64540
98	91.20	-0.04598
99	86.89	-0.29368
100	86.79	-0.29943
101	116.30	1.39655

MONOCACY RIVER ABOVE FREDERICK

N	57
MEAN	9.72
MEDIAN	9.50
TMEAN	9.63
STDEV	2.09
SEMEAN	0.28
MAX	15.00
MIN	6.50
Q3	11.35
Q1	7.85

ROW	DO	ST. RES.
1	10.8	0.51675
2	12.0	1.09091
3	8.4	-0.63158
4	8.0	-0.82297
5	7.3	-1.15789
6	7.0	-1.30144
7	6.8	-1.39713
8	8.8	-0.44019
9	8.5	-0.58373
10	11.8	0.99522
11	10.8	0.51675
12	13.5	1.80861
13	12.6	1.37799
14	11.5	0.85167
15	7.5	-1.06220
16	7.6	-1.01435
17	7.7	-0.96651
18	9.2	-0.24880
19	10.1	0.18182
20	11.4	0.80383

21	11.2	0.70813
22	15.0	2.52632
23	10.2	0.22966
24	9.0	-0.34450
25	7.4	-1.11005
26	7.0	-1.30144
27	11.8	0.99522
28	9.7	-0.00957
29	12.0	1.09091
30	11.2	0.70813
31	9.5	-0.10526
32	9.5	-0.10526
33	7.2	-1.20574
34	7.2	-1.20574
35	7.6	-1.01435
36	10.2	0.22966
37	11.3	0.75598
38	12.4	1.28230
39	12.0	1.09091
40	11.8	0.99522
41	11.2	0.70813
42	9.2	-0.24880
43	7.4	-1.11005
44	8.6	-0.53589
45	10.0	0.13397
46	8.2	-0.72727
47	8.9	-0.39234
48	9.2	-0.24880
49	8.5	-0.58373
50	14.2	2.14354
51	12.5	1.33014
52	10.8	0.51675
53	11.0	0.61244
54	8.4	-0.63158
55	8.1	-0.77512
56	6.5	-1.54067
57	6.7	-1.44498

% saturation

N	57
MEAN	93.3
MEDIAN	93.3
TMEAN	92.4
STDEV	11.9
SEMEAN	1.6
MAX	143.9
MIN	73.8
Q3	98.7
Q1	86.3

ROW	% sat	ST. RES.
1	101.89	0.72185
2	100.84	0.63361
3	96.55	0.27311
4	86.97	-0.53193
5	82.95	-0.86975
6	86.42	-0.57815
7	82.93	-0.87143
8	97.78	0.37647
9	96.59	0.27647
10	121.65	2.38235
11	95.58	0.19160
12	100.00	0.56302
13	98.44	0.43193
14	94.26	0.08067
15	81.52	-0.98992
16	86.36	-0.58319
17	87.50	-0.48740
18	104.54	0.94454
19	107.45	1.18908
20	100.89	0.63781
21	96.55	0.27311
22	111.11	1.49664
23	94.44	0.09580
24	95.74	0.20504
25	80.43	-1.08151
26	83.33	-0.83782
27	143.90	4.25210
28	95.10	0.15126
29	93.75	0.03781
30	91.80	-0.12605
31	84.07	-0.77563
32	99.00	0.47899
33	79.30	-1.17647
34	87.50	-0.48740
35	86.30	-0.58824
36	87.50	-0.48740
37	92.10	-0.10084
38	98.10	0.40336
39	88.50	-0.40336
40	94.50	0.10084
41	100.90	0.63866
42	91.00	-0.19328
43	82.30	-0.92437
44	103.80	0.88235
45	114.60	1.78992
46	90.30	-0.25210
47	74.30	-1.59664
48	76.80	-1.38655
49	82.00	-0.94958
50	99.60	0.52941
51	93.30	0.00000
52	89.70	-0.30252
53	94.10	0.06723

54	88.70	-0.38656
55	92.80	-0.04202
56	74.10	-1.61345
57	73.80	-1.63866

MONOCACY RIVER BELOW FREDERICK

dissolved oxygen

	C35
N	71
MEAN	8.00
MEDIAN	7.80
TMEAN	7.92
STDEV	2.61
SEMEAN	0.31
MAX	15.20
MIN	3.60
Q3	9.80
Q1	5.90

ROW	DO	ST. RES.
1	6.6	-0.53640
2	5.9	-0.80460
3	7.8	-0.07663
4	6.3	-0.65134
5	7.8	-0.07663
6	9.8	0.68966
7	13.5	2.10728
8	12.4	1.68582
9	10.4	0.91954
10	7.5	-0.19157
11	7.5	-0.19157
12	7.4	-0.22989
13	7.8	-0.07663
14	8.3	0.11494
15	11.3	1.26437
16	11.2	1.22605
17	15.2	2.75862
18	10.0	0.76628
19	8.6	0.22989
20	7.1	-0.34483
21	6.4	-0.61303
22	5.7	-0.88123
23	4.1	-1.49425
24	3.8	-1.60920
25	6.1	-0.72797
26	7.6	-0.15326
27	5.5	-0.95785
28	5.9	-0.80460
29	8.4	0.15326
30	5.4	-0.99617

31	5.5	-0.95785
32	6.8	-0.45977
33	3.6	-1.68582
34	3.8	-1.60920
35	4.2	-1.45594
36	4.8	-1.22605
37	4.8	-1.22605
38	4.9	-1.18774
39	5.8	-0.84291
40	7.9	-0.03831
41	10.8	1.07280
42	11.0	1.14943
43	9.1	0.42146
44	9.5	0.57471
45	6.7	-0.49808
46	6.4	-0.61303
47	4.6	-1.30268
48	5.4	-0.99617
49	5.6	-0.91954
50	6.6	-0.53640
51	9.4	0.53640
52	12.1	1.57088
53	11.6	1.37931
54	11.6	1.37931
55	11.0	1.14943
56	9.8	0.68966
57	7.8	-0.07663
58	6.9	-0.42146
59	8.4	0.15326
60	8.2	0.07663
61	9.1	0.42146
62	9.0	0.38314
63	8.7	0.26820
64	11.6	1.37931
65	12.5	1.72414
66	11.1	1.18774
67	11.0	1.14943
68	8.3	0.11494
69	8.8	0.30651
70	7.0	-0.38314
71	4.8	-1.22605

% saturation

N	71
MEAN	79.9
MEDIAN	81.9
TMEAN	80.6
STDEV	16.2
SEMEAN	1.9
MAX	116.0
MIN	40.9
Q3	93.3
Q1	71.6

ROW	% sat	ST. RES.
1	81.88	0.12222
2	71.95	-0.49074
3	86.67	0.41790
4	71.59	-0.51296
5	82.11	0.13642
6	88.29	0.51790
7	97.83	1.10679
8	99.20	1.19136
9	87.39	0.46235
10	81.52	0.10000
11	83.33	0.21173
12	85.06	0.31852
13	88.64	0.53951
14	88.30	0.51852
15	100.00	1.24074
16	96.55	1.02778
17	116.03	2.23025
18	94.34	0.89136
19	91.49	0.71543
20	77.17	-0.16852
21	76.19	-0.22901
22	72.15	-0.47840
23	50.00	-1.84568
24	46.34	-2.07160
25	76.54	-0.20741
26	77.22	-0.16543
27	96.20	1.00617
28	69.62	-0.63457
29	70.24	-0.59630
30	102.44	1.39136
31	65.85	-0.86728
32	65.48	-0.89012
33	82.93	0.18704
34	40.91	-2.40679
35	43.18	-2.26667
36	47.73	-1.98580
37	55.17	-1.52654
38	56.32	-1.45556
39	66.67	-0.81667
40	79.00	-0.05556
41	84.38	0.27654
42	90.16	0.63333
43	78.45	-0.08951
44	97.94	1.11358
45	72.83	-0.43642
46	78.05	-0.11420
47	51.11	-1.77716
48	60.00	-1.22840
49	63.64	-1.00370
50	56.90	-1.41975
51	81.03	0.06975
52	96.80	1.04321
53	88.55	0.53395

54	95.08	0.93704
55	97.35	1.07716
56	96.08	0.99877
57	84.78	0.30123
58	81.12	0.07531
59	98.82	1.16790
60	89.13	0.56975
61	80.53	0.03889
62	73.77	-0.37840
63	83.65	0.23148
64	81.69	0.11049
65	95.42	0.95802
66	93.28	0.82593
67	97.35	1.07716
68	88.30	0.51852
69	97.78	1.10370
70	79.54	-0.02222
71	50.53	-1.81296