

University of Minnesota
St. Anthony Falls Hydraulic Laboratory

Addendum to
Project Report No. 311

FIELD FLOW TESTING OF FOUR LARGE
PRIMARY INFLUENT METERS—
TWIN CITIES METRO WASTE TREATMENT PLANT

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I. Introduction

The St. Anthony Falls Hydraulic Laboratory performed field flow measurement tests on two large meters for the Metropolitan Waste Control Commission (MWCC) at the Metro Waste Treatment Plant in August and September 1990. These two 72-inch magnetic flow meters, designated M001A and M001D, were retested by SAFHL in May and June 1991. After the earlier round of testing, the removal of considerable amounts of scum and grit from upstream of the meters necessitated retesting in order to determine if the build-up had affected the accuracy of the meters. The tests were completed as a subcontract to James M. Montgomery Consulting Engineers, Inc., of Wayzata, Minnesota, with whom the MWCC had contracted to conduct an overall evaluation of these and other meters.

The meters were tested using the dye dilution technique for which dye was injected just downstream of gate 454. Continuous monitoring of the effluent and withdrawal of discrete samples was done at the metering tunnel discharge location into the east primary influent channel (See Fig. 1). Throughout the testing process all dye dilution samples were analyzed separately using fluorometers operated by both SAFHL and the research and development staff at the MWCC. Further insight into the dye dilution metering theory, as well as field procedures and complete results of the initial testing, may be found in the St. Anthony Falls Hydraulic Laboratory Project Report No. 311.

II. Test Results

Table 1 gives a summary of the test results obtained for meters M001A and M001D. The table gives the mean fluorometric data obtained from 12 samples for each run as well as data provided by the MWCC computer center and data obtained using a digital Volt-Ohm meter (DVOM) at the point of meter signal transmission. To minimize any effects time would have on the data obtained, testing was done when plant inflow was relatively steady. This also prevented the data from being affected by changes in plant operations due to changes in plant inflow. One extended run of at least three hours duration was performed for each meter as well. These additional runs provided 14 samples for analysis and were useful checks of the methodology used; however, due to plant flow fluctuations, they were not useful for obtaining an accurate flow coefficient and hence were not used in further analysis. Water elevations in the grit chambers were checked periodically (15 minute intervals) during each run in order to verify whether there were changes in effluent storage. Fluctuations of the elevations were minor, with a maximum of 1-1/2 inches over the course of the extended runs.

As seen in Table 1, some variation in the flow coefficient defined as SAFHL DYE Q divided by MWCC DYE Q is apparent from run to run. This variance appears to be related to combinations of various factors involved in the testing which are summarized in a following paragraph regarding testing accuracy.

Using the dye dilution technique, the mean results for M001A and M001D indicated overall flow coefficients, defined as SAFHL DYE Q divided by JMM Q, of 0.831 and 0.873 based on the DVOM readings for the two meters. The data for M001A were randomly scattered about this value while the data for M001D indicated an apparent variation of the coefficient with flow. Further insight into the data may be seen in figures 2 and 3, which compare SAFHL DYE Q vs JMM Q over the range of flows tested. Linear regression of the data provides the following relationships: Meter M-001A, SAFHL DYE Q = 0.859585 (JMM Q) - 4.776; Meter M-001D, SAFHL DYE Q = 1.105310 (JMM Q) - 40.6045; where all values are in millions of gallons per day.

It should be noted that based on the MWCC computer center flow data, M-001D indicated an overall flow coefficient, defined as SAFHL DYE Q divided by MWCC COMPUTER Q, of 0.849. Linear regression provides the equation for M-001D, SAFHL DYE Q = 1.053353 (MWCC COMPUTER Q) - 36.745 as seen in Fig. 4. This is provided because it is significantly different from the DVOM based data; for meter M-001D the DVOM signal consistently gave a reading 3 percent lower than that read in the computer center. This may indicate a time correlation error, but is more likely a computer telemetry or instrumentation problem.

Comparing figures 2, 3, and 4 with Figures 5 and 6 (results from the initial testing) indicates that scum and grit removal had no significant effect on the meter response curves. It should be noted that the slopes of figures 3 and 4 are slightly different from that of Figure 6. During the testing of

meter M001D, the anticipated early morning low flow did not occur; therefore, it was not possible to obtain any low flow data points. In fact, only 30 mgd separated the data for all runs obtained. Therefore, the slope may be somewhat biased and may be greatly influenced by the addition of a low flow point.

Tables 3 through 14 give more detailed data for each test run. As can be seen, most individual data points were in very good agreement with only an occasional point being out of tolerance. For statistical analysis of the data, the points giving the highest and lowest flow coefficient out of the 12 were dropped providing 10 points for the analysis. As seen for these runs, the standard deviation was low for most runs considering the normal variances typically seen in field studies. The data were analyzed using Lotus 1-2-3 software. This required some judgment as the Lotus curve fitting routine did not necessarily initially give good fit. Some data were repeatedly re-analyzed eventually eliminating 1 or 2 of the calibration standards from the analysis. The method of analysis was based on the development of a representative curve with the minimum sum of the squared residuals. As part of the test program, six standards varying in dye dilution ratio from 1×10^6 to 5×10^7 and mixed from effluent obtained immediately prior to testing, were used for each test run. This was done to insure that the test run samples, with dilutions expected to range from approximately 5×10^6 to 1×10^7 , were adequately covered. Therefore the elimination of 1 or 2 standards from calibration curves should not have been detrimental to the calibration curve results provided in all cases that the points eliminated were not representative of grab sample concentrations obtained during that testing run. In the course of testing, standards with dilution ratios from 5×10^6 to 2×10^7 were never eliminated from the calibration. Aside from Runs A, B, and C, no other runs required the elimination of any standards.

Due to a significant variance in the blank sample fluorescence, the calibration standard readings for runs C and E were adjusted by the difference in background fluorescence between the effluent used to mix the standards in the previous run and the effluent actually arriving at the time of the test. Adjustments were not made for any other runs because there was no significant difference between the blank samples.

Fluorometric analysis of all samples was carried out using samples which were filtered through a glass wool filter prior to fluorometric measurement. This was done as the pretesting of controlled samples of unfiltered effluent using both SAFHL's and MWCC's fluorometers indicated a large amount of data scatter. During the pretest, filtering was found to reduce the standard deviation of the sample by a factor of five from that of unfiltered samples. It was also discovered during pretesting that the temperature correction factor, n , should be equal to -0.17 . However, by keeping samples in a constant temperature water bath, we were able to avoid any need to make temperature correction adjustments to the readings.

It should be noted that throughout the study, the fluorometer operated by MWCC personnel indicated a mean flow coefficient 1.02 times greater than the SAFHL fluorometer. As seen in the column, comparing these data on a run by run basis in Table 1, some variation existed between runs; however, the variation was small. This discrepancy may be due to the operating

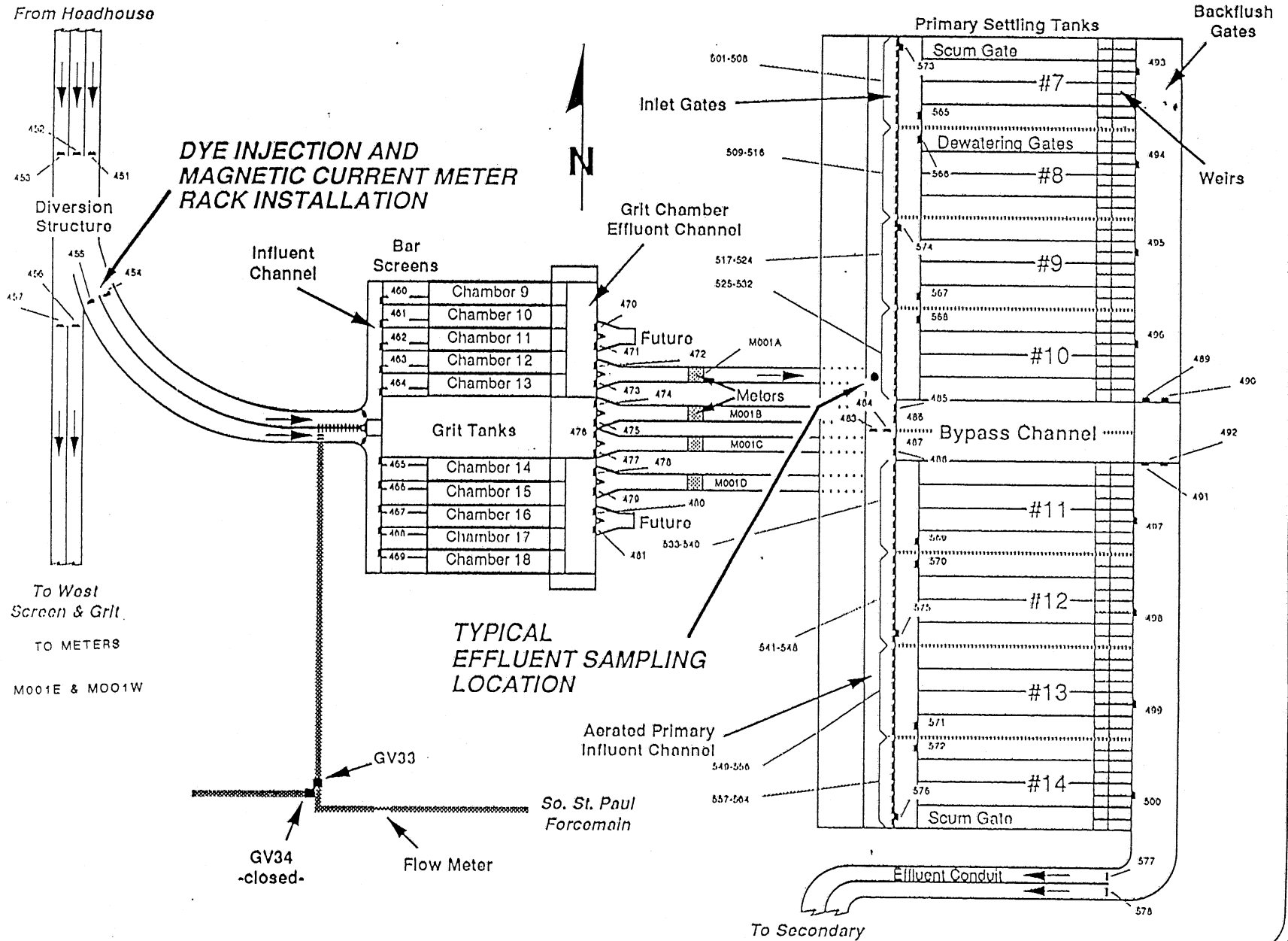
characteristics of the particular fluorometers in use. The variation may also be due to the fluorometer's specific response to the small amount of particulate matter remaining in the sample after filtering. It is not possible to determine if one fluorometer was more accurate than the other. So, as the operation of the SAFHL fluorometer was entirely under control of SAFHL staff members, it was chosen as the basis for all analysis in the study, with data from the MWCC fluorometer provided as supplemental information.

The standard deviation of the data appears to be approximately 3 percent of the mean values obtained for each run. Such a standard deviation appears to be quite good, and further refinement is unwarranted at this time, considering the variability of the many parameters involved in a field study of this nature.

II. Conclusions

The retesting of magmeters M001A and M001D went very smoothly. Methods developed in the pretest and used in the initial testing were continued in the retesting with equally successful results. The flow coefficients obtained during the retest of 0.831 and 0.873 for M001A and M001D respectively, compare favorably with the results of 0.842 and 0.834 from the initial testing. This is especially true if the JMM DVOM values are replaced with the MWCC computer center flow rates giving coefficients of 0.832 and 0.849, respectively. Since the mean of the JMM Q/MWCC COMPUTER Q values from the initial testing was 0.9995, the earlier flow coefficients essentially remain the same and they can be compared directly to these new coefficients. This shows that the removal of the scum and grit build-up apparently had minimal effect on the accuracy of the meters. The same is true for the results of the linear regression analysis of the data as shown in Figures 2 through 6. Data analysis was repeated using several schemes to minimize any potential for misinterpretation. It is believed that the results obtained from this study, in conjunction with the results from the James M. Montgomery, Inc. study, will provide useful information to the Metropolitan Waste Control Commission.

Figure 1
Dye Testing Site Plan
Metro East Pretreatment/Primary



M-001A

May - June 1991

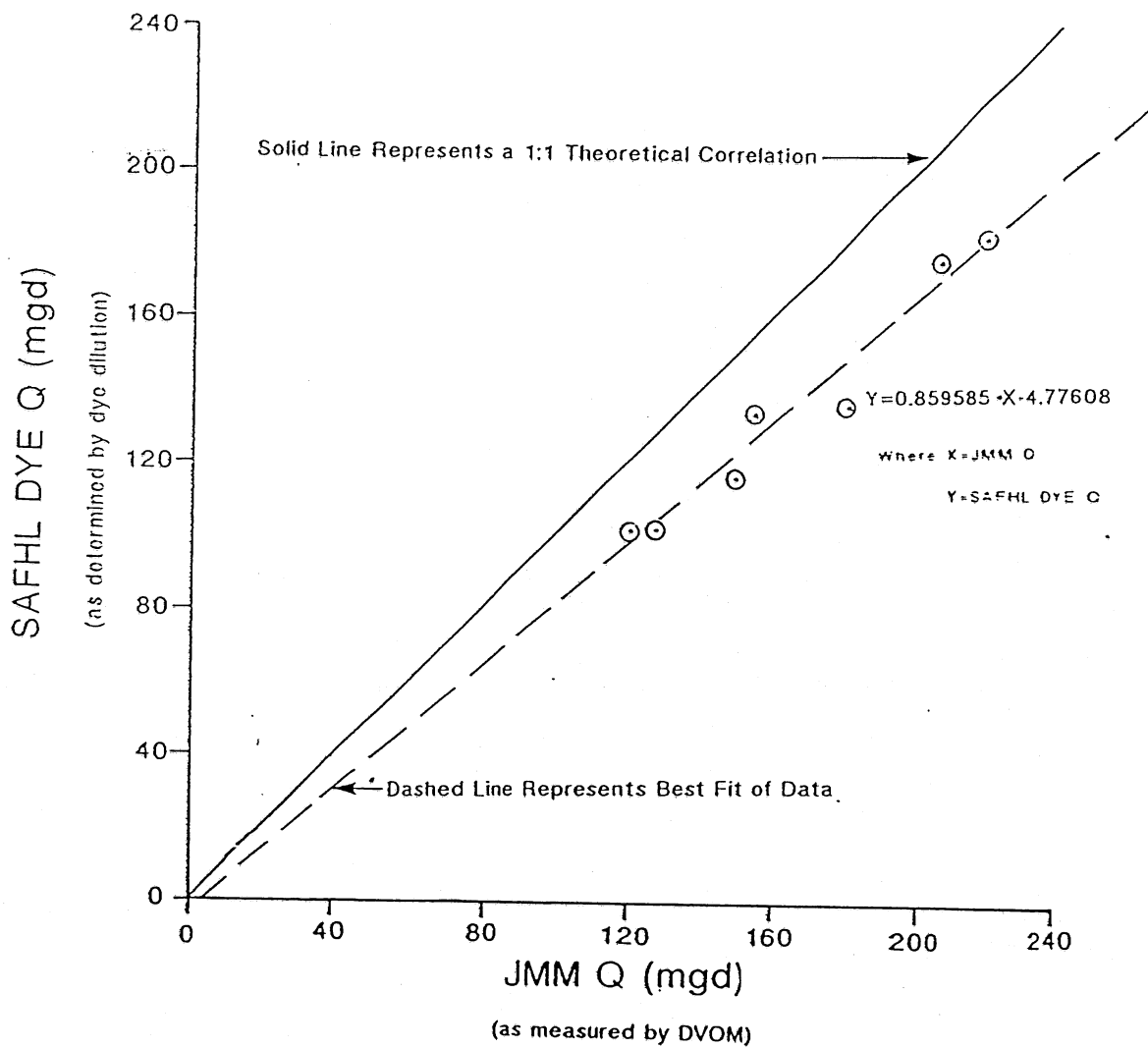


Figure 2

M-001D

May - June 1991

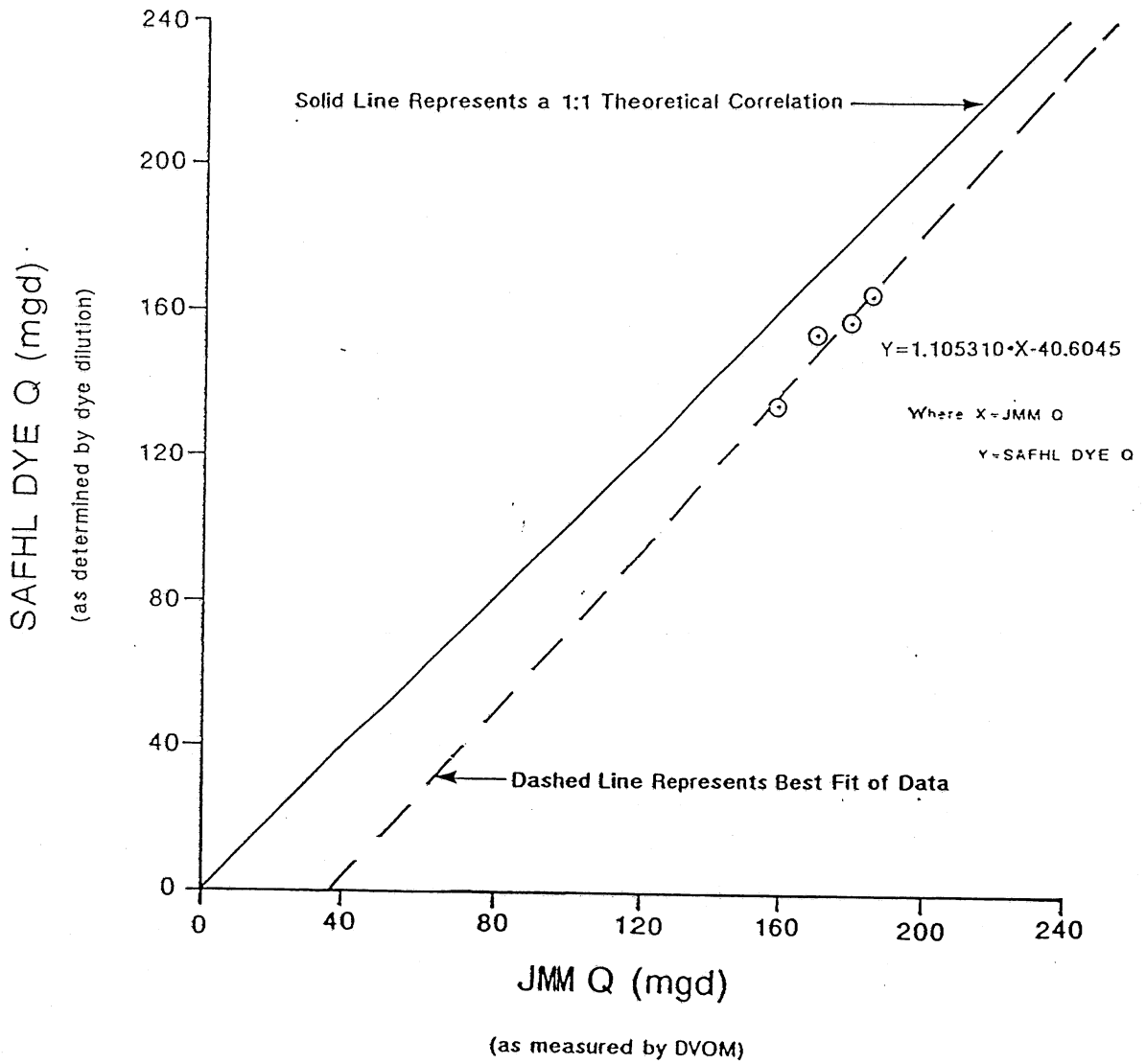


Figure 3

M-001A

August - September 1990

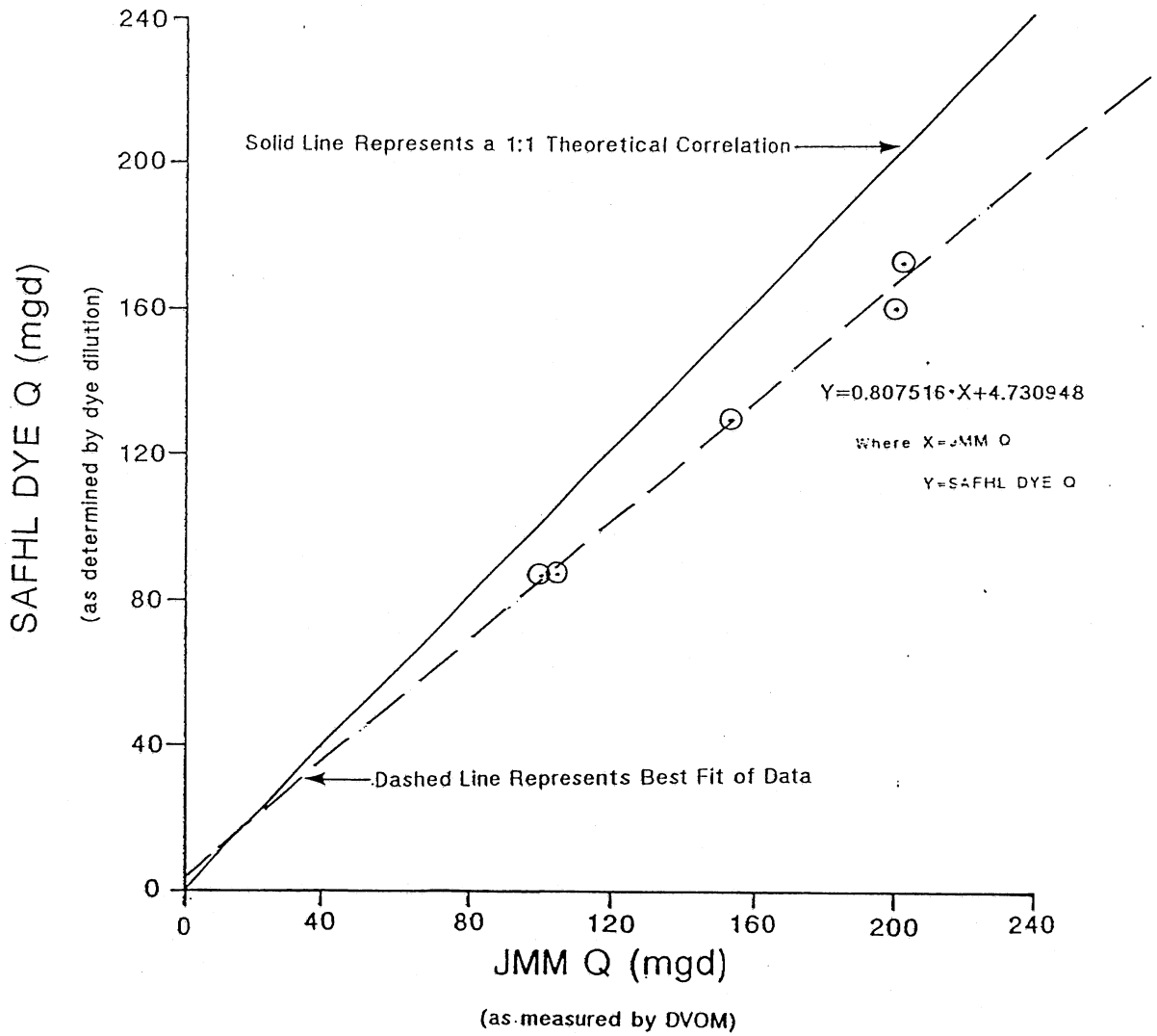


Figure 5

M-001D

August - September 1990

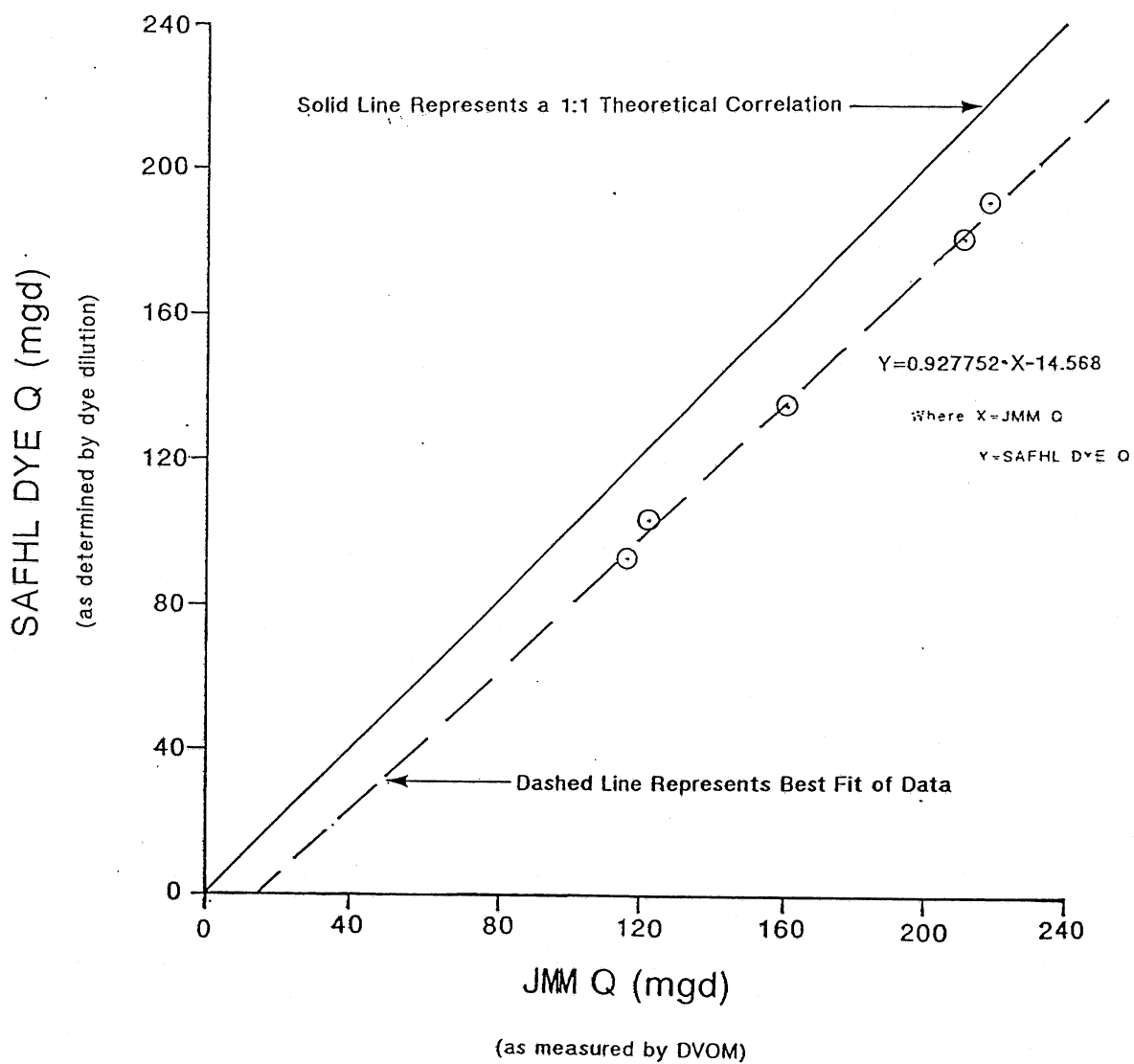


Figure 6

TABLE 1

| Run No. | SAFHL DYE Q | | SAFHL DYE Q/JMM Q | | SAFHL DYE Q/MWCC DYE Q | | MWCC COMPUTER Q/JMM Q | | SAFHL DYE Q/MWCC COMPUTER Q | |
|-----------|-------------|--------|-------------------|----------|------------------------|----------|-----------------------|----------|-----------------------------|----------|
| | Mean | Mean | Mean | St. Dev. | Mean | St. Dev. | Mean | St. Dev. | Mean | St. Dev. |
| 001A-A | 183.48 | 216.86 | 0.849 | 0.037 | 1.040 | 0.013 | 0.999 | 0.015 | 0.849 | 0.037 |
| 001A-B | 102.46 | 126.03 | 0.815 | 0.029 | 1.002 | 0.008 | 1.001 | 0.007 | 0.812 | 0.024 |
| 001A-C | 176.13 | 204.03 | 0.865 | 0.032 | 1.040 | 0.021 | 0.995 | 0.006 | 0.868 | 0.034 |
| 001A-D | 102.28 | 119.13 | 0.860 | 0.024 | 0.994 | 0.010 | 0.999 | 0.006 | 0.861 | 0.024 |
| 001A-E | 133.92 | 152.91 | 0.877 | 0.010 | 1.027 | 0.009 | 0.996 | 0.013 | 0.879 | 0.024 |
| 001D-F | 134.11 | 160.49 | 0.836 | 0.019 | 1.028 | 0.016 | 1.032 | 0.008 | 0.811 | 0.008 |
| 001D-G | 157.13 | 180.30 | 0.873 | 0.021 | 1.019 | 0.006 | 1.030 | 0.012 | 0.847 | 0.014 |
| 001D-H | 154.69 | 171.81 | 0.900 | 0.015 | 1.021 | 0.009 | 1.026 | 0.008 | 0.876 | 0.013 |
| 001D-HEX* | 181.29 | 196.97 | 0.912 | 0.030 | 0.987 | 0.012 | 1.030 | 0.006 | 0.883 | 0.029 |
| 001D-I | 164.43 | 186.55 | 0.884 | 0.033 | 1.007 | 0.019 | 1.028 | 0.009 | 0.861 | 0.028 |
| 001A-J | 116.42 | 148.19 | 0.786 | 0.018 | 1.065 | 0.008 | 0.993 | 0.009 | 0.792 | 0.018 |
| 001A-JEX* | 135.44 | 177.14 | 0.765 | 0.018 | 1.033 | 0.009 | 1.003 | 0.010 | 0.762 | 0.020 |
| 001A-K | 136.30 | 178.08 | 0.766 | 0.007 | 1.030 | 0.007 | 1.000 | 0.010 | 0.765 | 0.005 |

SAFHL DYE Q: Flow determined using SAFHL fluorometer.

JMM Q: Flow determined using 1 minute averages of DVOM signal.

MWCC DYE Q: Flow determined using MWCC fluorometer.

MWCC COMPUTER Q: Flow determined using 1 minute averages of signal transmitted to MWCC metroplamt computer control center.

* - Indicates that this was an extended run of greater than three hours. Due to this, the flow rates had greater variability than runs of shorter duration and these runs were excluded from further statistical analysis.

Mean values of SAFHL DYE Q/JMM Q:
(From May - June 1991)

METER 001A: 0.831 St. Dev.: 0.040
METER 001D: 0.873 St. Dev.: 0.024

Mean values of SAFHL DYE Q/MWCC COMPUTER Q:
(From May - June 1991)

METER 001A: 0.832 St. Dev.: 0.040
METER 001D: 0.849 St. Dev.: 0.024

Mean values of SAFHL DYE Q/JMM Q:
(From August - September 1990)

METER 001A: 0.842 St. Dev.: 0.024
METER 001D: 0.834 St. Dev.: 0.028

SAFHL FLOWMETER CALIBRATION
 May 20, 1991
 Run A - Magmeter M-001A

TABLE 2

Dye injection rate (ml/min): 38.52
 (total dye used: 2234 ml)
 (injection time: 58.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$$Y = 10^{C1} * X^{C2}, \text{ where}$$

Y is the dilution ratio

X is the sample flourometer reading

| | SAFHL | MWCC |
|------------|---------|---------|
| C1 equals | 7.9564 | 8.5712 |
| C2 equals | -1.0092 | -1.0039 |
| R squared: | 0.999 | 1.000 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUOROMETRY **** | | |
|--------|--------------|----------|------------------------------|----------------------------|-------|----------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 84.50 | 31.62 | >10 | >316 * |
| 2 | 5E-07 | 2E+06 | 46.50 | 31.62 | 7.10 | 224.50 * |
| 3 | 2E-07 | 5E+06 | 17.00 | 10.00 | 7.32 | 73.20 |
| 4 | 1E-07 | 1E+07 | 8.60 | 10.00 | 3.68 | 36.80 |
| 5 | 5E-08 | 2E+07 | 4.60 | 10.00 | 1.84 | 18.40 |
| 6 | 2E-08 | 5E+07 | 2.35 * | 3.16 | 3.30 | 10.43 * |

*- indicates standard was dropped from calibration to improve R squared
 water bath temp: 14.4; water temp: 20.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 May 20, 1991
 Run A - Magmeter M-001A

Table 2 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|---------------|-------------|------------------|----------------|------------------------------|-------|---------|----------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 1 | 01:25 PM | 7.30 | 1.22E+07 | 10 | 3.46 | 34.60 | 1.06E+07 |
| 2 | 01:30 PM | 7.30 | 1.22E+07 | 10 | 3.46 | 34.60 | 1.06E+07 |
| 3 | 01:35 PM | 7.25 | 1.23E+07 | 10 | 3.12 | 31.20 | 1.18E+07 |
| 4 | 01:40 PM | 7.25 | 1.23E+07 | 10 | 3.06 | 30.60 | 1.20E+07 |
| 5 | 01:45:30 | 7.15 | 1.24E+07 | 10 | 3.04 | 30.40 | 1.21E+07 |
| 6 | 01:50 PM | 7.10 | 1.25E+07 | 10 | 3.02 | 30.20 | 1.22E+07 |
| 7 | 01:55:45 | 7.20 | 1.23E+07 | 10 | 3.04 | 30.40 | 1.21E+07 |
| 8 | 02:00 PM | 7.25 | 1.23E+07 | 10 | 3.08 | 30.80 | 1.19E+07 |
| 9 | 02:05 PM | 6.30 | 1.41E+07 | 10 | 2.64 | 26.40 | 1.39E+07 |
| 10 | 02:10 PM | 6.45 | 1.38E+07 | 10 | 2.76 | 27.60 | 1.33E+07 |
| 11 | 02:15 PM | 6.85 | 1.30E+07 | 10 | 2.92 | 29.20 | 1.26E+07 |
| 12 | 02:20 PM | 7.25 | 1.23E+07 | 10 | 3.08 | 30.80 | 1.19E+07 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|---------------|-------------|----------|-----------|---------------|-----------|---------|----------|----------|----------|
| | | DYE FLOW | DIL. FLOW | COMPUTER FLOW | DVOM FLOW | ----- | ----- | ----- | ----- |
| | | | | | | Q(JMM) | Q(MWCC) | Q(COMP) | Q(JMM) |
| 1 | 01:25 PM | 178.29 | 155.62 | 211.72 | 213.13 | 0.993 | 1.146 | 0.842 | 0.837 |
| 2 | 01:30 PM | 178.29 | 155.62 | 219.53 | 220.31 | 0.996 | 1.146 | 0.812 | 0.809 |
| 3 | 01:35 PM | 179.53 | 172.65 | 213.59 | 220.94 | 0.967 | 1.040 | 0.841 | 0.813 |
| 4 | 01:40 PM | 179.53 | 176.05 | 216.17 | 219.38 | 0.985 | 1.020 | 0.831 | 0.818 |
| 5 | 01:45:30 | 182.07 | 177.21 | 214.34 | 215.63 | 0.994 | 1.027 | 0.849 | 0.844 |
| 6 | 01:50 PM | 183.36 | 178.39 | 218.05 | 208.75 | 1.045 | 1.028 | 0.841 | 0.873 |
| 7 | 01:55:45 | 180.79 | 177.21 | 215.64 | 216.09 | 0.998 | 1.020 | 0.838 | 0.837 |
| 8 | 02:00 PM | 179.53 | 174.90 | 216.56 | 222.19 | 0.975 | 1.026 | 0.829 | 0.808 |
| 9 | 02:05 PM | 206.87 | 204.17 | 218.98 | 218.28 | 1.003 | 1.013 | 0.945 | 0.948 |
| 10 | 02:10 PM | 202.02 | 195.26 | 217.73 | 217.50 | 1.001 | 1.035 | 0.928 | 0.929 |
| 11 | 02:15 PM | 190.11 | 184.52 | 218.83 | 215.16 | 1.017 | 1.030 | 0.869 | 0.884 |
| 12 | 02:20 PM | 179.53 | 174.90 | 218.20 | 212.19 | 1.028 | 1.026 | 0.823 | 0.846 |
| MEAN= | | 183.48 | | MEAN = | 216.86 | 0.999 | 1.040 | 0.849 | 0.849 |
| | | | | STD DEV = | | 0.015 | 0.013 | 0.030 | 0.037 |

Note: mean and standard deviation were calculated after the high and low values were eliminated.

SAFHL FLOWMETER CALIBRATION

Table 3

May 21, 1991

Run B - Magmeter M-001A

Dye injection rate (ml/min): 38.79
 (total dye used: 2638 ml)
 (injection time: 68.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$Y = 10^{\wedge}C1 * X^{\wedge}C2$, where
 Y is the dilution ratio
 X is the sample flourometer reading

| | | |
|------------|---------|---------|
| | SAFHL | MWCC |
| C1 equals | 7.9597 | 8.6533 |
| C2 equals | -1.0157 | -1.0421 |
| R squared: | 0.999 | 1.000 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUOROMETRY **** | | |
|--------|--------------|----------|------------------------------|----------------------------|-------|----------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 82.50 | 31.62 | 11.90 | 376.28 * |
| 2 | 5E-07 | 2E+06 | 45.50 | 31.62 | 7.10 | 224.50 * |
| 3 | 2E-07 | 5E+06 | 17.20 | 10.00 | 7.56 | 75.60 |
| 4 | 1E-07 | 1E+07 | 8.40 | 10.00 | 3.80 | 38.00 |
| 5 | 5E-08 | 2E+07 | 4.60 | 10.00 | 2.00 | 20.00 |
| 6 | 2E-08 | 5E+07 | 2.38 * | 3.16 | 3.42 | 10.81 * |

*-indicates standard was dropped from calibration to improve R squared
 water bath temp: 15.3; water temp: 17.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 May 21, 1991
 Run B - Magmeter M-001A

Table 3 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|---------------|-------------|------------------|----------------|------------------------------|-------|---------|----------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 1 | 07:30 AM | 12.25 | 7.15E+06 | 10 | 5.23 | 52.30 | 7.28E+06 |
| 2 | 07:38 AM | 12.60 | 6.95E+06 | 10 | 5.46 | 54.60 | 6.96E+06 |
| 3 | 07:40 AM | 12.60 | 6.95E+06 | 10 | 5.42 | 54.20 | 7.02E+06 |
| 4 | 07:45 AM | 12.60 | 6.95E+06 | 10 | 5.54 | 55.40 | 6.86E+06 |
| 5 | 07:50 AM | 12.40 | 7.07E+06 | 10 | 5.46 | 54.60 | 6.96E+06 |
| 6 | 07:55 AM | 12.50 | 7.01E+06 | 10 | 5.54 | 55.40 | 6.86E+06 |
| 7 | 08:00 AM | 13.20 | 6.63E+06 | 10 | 5.68 | 56.80 | 6.68E+06 |
| 8 | 08:05 AM | 12.80 | 6.84E+06 | 10 | 5.54 | 55.40 | 6.86E+06 |
| 9 | 08:10 AM | 12.60 | 6.95E+06 | 10 | 5.50 | 55.00 | 6.91E+06 |
| 10 | 08:15 AM | 12.30 | 7.12E+06 | 10 | 5.38 | 53.80 | 7.07E+06 |
| 11 | 08:20 AM | 12.60 | 6.95E+06 | 10 | 5.46 | 54.60 | 6.96E+06 |
| 12 | 08:25 AM | 14.40 | 6.07E+06 | 10 | 6.26 | 62.60 | 6.04E+06 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|---------------|-------------|---------------|---------------|---------------|-----------|-----------------|------------------|------------------|-----------------|
| | | DYE DIL. FLOW | DYE DIL. FLOW | COMPUTER FLOW | DVOM FLOW | ----- Q(JMM) | ----- Q(MWCC) | ----- Q(COMP) | ----- Q(JMM) |
| 1 | 07:30 AM | 105.57 | 107.51 | 123.20 | 123.75 | 0.996 | 0.982 | 0.857 | 0.853 |
| 2 | 07:38 AM | 102.59 | 102.79 | 123.13 | 122.97 | 1.001 | 0.998 | 0.833 | 0.834 |
| 3 | 07:40 AM | 102.59 | 103.58 | 123.28 | 122.66 | 1.005 | 0.990 | 0.832 | 0.836 |
| 4 | 07:45 AM | 102.59 | 101.25 | 123.75 | 122.19 | 1.013 | 1.013 | 0.829 | 0.840 |
| 5 | 07:50 AM | 104.27 | 102.79 | 125.31 | 122.50 | 1.023 | 1.014 | 0.832 | 0.851 |
| 6 | 07:55 AM | 103.43 | 101.25 | 127.42 | 126.72 | 1.006 | 1.022 | 0.812 | 0.816 |
| 7 | 08:00 AM | 97.86 | 98.65 | 127.89 | 129.38 | 0.989 | 0.992 | 0.765 | 0.756 |
| 8 | 08:05 AM | 100.97 | 101.25 | 128.75 | 127.66 | 1.009 | 0.997 | 0.784 | 0.791 |
| 9 | 08:10 AM | 102.59 | 102.01 | 125.86 | 127.19 | 0.990 | 1.006 | 0.815 | 0.807 |
| 10 | 08:15 AM | 105.14 | 104.39 | 127.66 | 128.13 | 0.996 | 1.007 | 0.824 | 0.821 |
| 11 | 08:20 AM | 102.59 | 102.79 | 129.38 | 129.38 | 1.000 | 0.998 | 0.793 | 0.793 |
| 12 | 08:25 AM | 89.58 | 89.14 | 129.38 | 130.00 | 0.995 | 1.005 | 0.692 | 0.689 |
| MEAN= | | 102.46 | | MEAN = | 126.03 | 1.001 | 1.002 | 0.812 | 0.815 |
| | | | | STD DEV = | | 0.007 | 0.008 | 0.024 | 0.029 |

Note: mean and standard deviation were calculated after the high and low values were eliminated.

SAFHL FLOWMETER CALIBRATION
 May 21, 1991
 Run C - Magmeter M-001A

Table 4

Dye injection rate (ml/min): 40.47
 (total dye used: 2428 ml)
 (injection time: 60.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$Y = 10^{C1} * X^{C2}$, where
 Y is the dilution ratio
 X is the sample flourometer reading

| | | |
|------------|---------|---------|
| | SAFHL | MWCC |
| C1 equals | 8.0713 | 8.7353 |
| C2 equals | -1.1311 | -1.1233 |
| R squared: | 0.999 | 1.000 |

Fluorometer calibration -

| TEST # | DYE | | SAFHL | **** MWCC FLUOROMETRY **** | | |
|--------|-------|----------|---------------------|----------------------------|-------|----------|
| | CONC. | DILUTION | FLUOROM. READING | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 84.22 * | 31.62 | 10.20 | 322.91 * |
| 2 | 5E-07 | 2E+06 | 43.02 * | 31.62 | 5.34 | 169.24 * |
| 3 | 2E-07 | 5E+06 | 16.47 | 10.00 | 6.54 | 65.79 |
| 4 | 1E-07 | 1E+07 | 8.62 | 10.00 | 3.44 | 34.79 |
| 5 | 5E-08 | 2E+07 | 4.92 | 10.00 | 1.82 | 18.59 |
| 6 | 2E-08 | 5E+07 | 2.12 | 3.16 | 2.56 | 8.48 |

*-indicates standard was dropped from calibration to improve R squared
 water bath temp: 15.9; water temp: 19.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 May 21, 1991
 Run C - Magmeter M-001A

Table 4 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|---------------|-------------|------------------|----------------|------------------------------|-------|---------|----------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 1 | 12:10 PM | 7.80 | 1.15E+07 | 10 | 3.26 | 32.60 | 1.09E+07 |
| 2 | 12:15 PM | 7.80 | 1.15E+07 | 10 | 3.34 | 33.40 | 1.06E+07 |
| 3 | 12:20 PM | 7.97 | 1.13E+07 | 10 | 3.20 | 32.00 | 1.11E+07 |
| 4 | 12:25 PM | 8.00 | 1.12E+07 | 10 | 3.20 | 32.00 | 1.11E+07 |
| 5 | 12:30 PM | 8.00 | 1.12E+07 | 10 | 3.24 | 32.40 | 1.09E+07 |
| 6 | 12:35 PM | 8.00 | 1.12E+07 | 10 | 3.26 | 32.60 | 1.09E+07 |
| 7 | 12:40 PM | 8.00 | 1.12E+07 | 10 | 3.28 | 32.80 | 1.08E+07 |
| 8 | 12:45 PM | 7.95 | 1.13E+07 | 10 | 3.26 | 32.60 | 1.09E+07 |
| 9 | 12:50 PM | 7.68 | 1.17E+07 | 10 | 3.24 | 32.40 | 1.09E+07 |
| 10 | 12:55 PM | 7.43 | 1.22E+07 | 10 | 3.10 | 31.00 | 1.15E+07 |
| 11 | 01:00 PM | 7.82 | 1.15E+07 | 10 | 3.12 | 31.20 | 1.14E+07 |
| 12 | 01:05 PM | 7.61 | 1.19E+07 | 10 | 3.10 | 31.00 | 1.15E+07 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|---------------|-------------|---------------|---------------|---------------|-----------|---------|----------|----------|----------|
| | | DYE DIL. FLOW | DYE DIL. FLOW | COMPUTER FLOW | DVOM FLOW | ----- | ----- | ----- | ----- |
| | | | | | | Q(JMM) | Q(MWCC) | Q(COMP) | Q(JMM) |
| 1 | 12:10 PM | 177.68 | 167.09 | 200.86 | 201.25 | 0.998 | 1.063 | 0.885 | 0.883 |
| 2 | 12:15 PM | 177.68 | 162.61 | 199.69 | 202.50 | 0.986 | 1.093 | 0.890 | 0.877 |
| 3 | 12:20 PM | 173.40 | 170.62 | 202.03 | 202.81 | 0.996 | 1.016 | 0.858 | 0.855 |
| 4 | 12:25 PM | 172.66 | 170.62 | 201.72 | 207.50 | 0.972 | 1.012 | 0.856 | 0.832 |
| 5 | 12:30 PM | 172.66 | 168.25 | 206.48 | 205.31 | 1.006 | 1.026 | 0.836 | 0.841 |
| 6 | 12:35 PM | 172.66 | 167.09 | 210.08 | 203.75 | 1.031 | 1.033 | 0.822 | 0.847 |
| 7 | 12:40 PM | 172.66 | 165.95 | 207.34 | 208.75 | 0.993 | 1.040 | 0.833 | 0.827 |
| 8 | 12:45 PM | 173.89 | 167.09 | 210.31 | 212.50 | 0.990 | 1.041 | 0.827 | 0.818 |
| 9 | 12:50 PM | 180.82 | 168.25 | 200.78 | 201.09 | 0.998 | 1.075 | 0.901 | 0.899 |
| 10 | 12:55 PM | 187.72 | 176.81 | 199.84 | 202.50 | 0.987 | 1.062 | 0.939 | 0.927 |
| 11 | 01:00 PM | 177.16 | 175.54 | 204.14 | 204.84 | 0.997 | 1.009 | 0.868 | 0.865 |
| 12 | 01:05 PM | 182.70 | 176.81 | 196.02 | 195.63 | 1.002 | 1.033 | 0.932 | 0.934 |
| MEAN= | | 176.13 | | MEAN = | 204.03 | 0.995 | 1.040 | 0.868 | 0.865 |
| | | | | STD DEV = | | 0.006 | 0.021 | 0.034 | 0.032 |

Note: mean and standard deviation were calculated after the high and low values were eliminated.

SAFHL FLOWMETER CALIBRATION
 May 22, 1991
 Run D - Magmeter M-001A

Table 5

Dye injection rate (ml/min): 35.54
 (total dye used: 2488 ml)
 (injection time: 70.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$Y = 10^{C1} * X^{C2}$, where
 Y is the dilution ratio
 X is the sample fluourometer reading

| | | |
|------------|---------|---------|
| | SAFHL | MWCC |
| C1 equals | 8.0007 | 8.6462 |
| C2 equals | -1.0424 | -1.0538 |
| R squared: | 0.999 | 0.999 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUOROMETRY **** | | |
|--------|--------------|----------|------------------------------|----------------------------|-------|---------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 83.00 | 31.62 | 10.52 | 332.64 |
| 2 | 5E-07 | 2E+06 | 45.00 | 31.62 | 5.42 | 171.38 |
| 3 | 2E-07 | 5E+06 | 16.90 | 10.00 | 6.70 | 67.00 |
| 4 | 1E-07 | 1E+07 | 8.65 | 10.00 | 3.54 | 35.40 |
| 5 | 5E-08 | 2E+07 | 4.80 | 3.16 | 5.96 | 18.83 |
| 6 | 2E-08 | 5E+07 | 2.00 | 1.00 | 8.24 | 8.24 |

water bath temp: 15.2;

water temp: 18.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 May 22, 1991
 Run D - Magmeter M-001A

Table 5 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|---------------|-------------|------------------|----------------|------------------------------|-------|---------|----------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 1 | 07:38 AM | 12.30 | 7.32E+06 | 10 | 4.90 | 49.00 | 7.33E+06 |
| 2 | 07:45 AM | 12.10 | 7.45E+06 | 10 | 4.80 | 48.00 | 7.49E+06 |
| 3 | 07:52 AM | 12.00 | 7.51E+06 | 10 | 4.60 | 46.00 | 7.83E+06 |
| 4 | 07:55 AM | 11.70 | 7.71E+06 | 10 | 4.70 | 47.00 | 7.66E+06 |
| 5 | 08:00 AM | 12.00 | 7.51E+06 | 10 | 4.68 | 46.80 | 7.69E+06 |
| 6 | 08:05 AM | 11.85 | 7.61E+06 | 10 | 4.78 | 47.80 | 7.52E+06 |
| 7 | 08:12 AM | 12.20 | 7.38E+06 | 10 | 4.88 | 48.80 | 7.36E+06 |
| 8 | 08:15 AM | 12.20 | 7.38E+06 | 10 | 4.82 | 48.20 | 7.46E+06 |
| 9 | 08:20 AM | 11.80 | 7.65E+06 | 10 | 4.62 | 46.20 | 7.80E+06 |
| 10 | 08:25 AM | 11.60 | 7.78E+06 | 10 | 4.60 | 46.00 | 7.83E+06 |
| 11 | 08:30 AM | 11.70 | 7.71E+06 | 10 | 4.62 | 46.20 | 7.80E+06 |
| 12 | 08:35 AM | 11.70 | 7.71E+06 | 10 | 4.68 | 46.80 | 7.69E+06 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|---------------|-------------|---------------|---------------|---------------|-----------|-----------------|------------------|------------------|-----------------|
| | | DYE DIL. FLOW | DYE DIL. FLOW | COMPUTER FLOW | DVOM FLOW | ----- Q(JMM) | ----- Q(MWCC) | ----- Q(COMP) | ----- Q(JMM) |
| 1 | 07:38 AM | 99.01 | 99.11 | 112.11 | 112.03 | 1.001 | 0.999 | 0.883 | 0.884 |
| 2 | 07:45 AM | 100.71 | 101.29 | 114.30 | 115.00 | 0.994 | 0.994 | 0.881 | 0.876 |
| 3 | 07:52 AM | 101.59 | 105.93 | 115.31 | 115.31 | 1.000 | 0.959 | 0.881 | 0.881 |
| 4 | 07:55 AM | 104.30 | 103.56 | 114.30 | 115.31 | 0.991 | 1.007 | 0.913 | 0.905 |
| 5 | 08:00 AM | 101.59 | 104.03 | 115.55 | 115.16 | 1.003 | 0.977 | 0.879 | 0.882 |
| 6 | 08:05 AM | 102.93 | 101.73 | 116.95 | 115.78 | 1.010 | 1.012 | 0.880 | 0.889 |
| 7 | 08:12 AM | 99.85 | 99.54 | 121.41 | 121.41 | 1.000 | 1.003 | 0.822 | 0.822 |
| 8 | 08:15 AM | 99.85 | 100.84 | 122.27 | 122.34 | 0.999 | 0.990 | 0.817 | 0.816 |
| 9 | 08:20 AM | 103.38 | 105.45 | 122.66 | 123.13 | 0.996 | 0.980 | 0.843 | 0.840 |
| 10 | 08:25 AM | 105.24 | 105.93 | 122.58 | 123.75 | 0.991 | 0.993 | 0.859 | 0.850 |
| 11 | 08:30 AM | 104.30 | 105.45 | 123.13 | 124.38 | 0.990 | 0.989 | 0.847 | 0.839 |
| 12 | 08:35 AM | 104.30 | 104.03 | 125.70 | 124.06 | 1.013 | 1.003 | 0.830 | 0.841 |
| MEAN= | | 102.28 | | MEAN = | 119.13 | 0.999 | 0.994 | 0.861 | 0.860 |
| | | | | STD DEV = | | 0.006 | 0.010 | 0.024 | 0.024 |

Note: mean and standard deviation were calculated after the high and low values were eliminated.

SAFHL FLOWMETER CALIBRATION
 May 22, 1991
 Run E - Magmeter M-001A

Table 6

Dye injection rate (ml/min): 35.81
 (total dye used: 2686 ml)
 (injection time: 75.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$$Y = 10^{C1} * X^{C2}, \text{ where}$$

Y is the dilution ratio

X is the sample fluorometer reading

| | | |
|------------|---------|---------|
| | SAFHL | MWCC |
| C1 equals | 7.9631 | 8.6445 |
| C2 equals | -1.0320 | -1.0531 |
| R squared: | 0.999 | 0.999 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUOROMETRY **** | | |
|--------|--------------|----------|------------------------------|----------------------------|-------|---------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 78.93 | 31.62 | 10.52 | 332.62 |
| 2 | 5E-07 | 2E+06 | 42.93 | 31.62 | 5.42 | 171.36 |
| 3 | 2E-07 | 5E+06 | 16.13 | 10.00 | 6.70 | 66.98 |
| 4 | 1E-07 | 1E+07 | 8.30 | 10.00 | 3.54 | 35.38 |
| 5 | 5E-08 | 2E+07 | 4.48 | 3.16 | 5.96 | 18.81 |
| 6 | 2E-08 | 5E+07 | 1.83 | 1.00 | 8.24 | 8.22 |

water bath temp: 17.1;

water temp: 18.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 May 22, 1991
 Run E - Magmeter M-001A

Table 6 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|---------------|-------------|------------------|----------------|------------------------------|-------|---------|----------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 1 | 12:25 PM | 8.85 | 9.68E+06 | 10 | 3.82 | 38.20 | 9.52E+06 |
| 2 | 12:30 PM | 8.75 | 9.79E+06 | 10 | 3.82 | 38.20 | 9.52E+06 |
| 3 | 12:35 PM | 8.90 | 9.62E+06 | 10 | 3.86 | 38.60 | 9.41E+06 |
| 4 | 12:40 PM | 8.85 | 9.68E+06 | 10 | 3.84 | 38.40 | 9.46E+06 |
| 5 | 12:45 PM | 8.65 | 9.91E+06 | 10 | 3.72 | 37.20 | 9.79E+06 |
| 6 | 12:50 PM | 8.70 | 9.85E+06 | 10 | 3.74 | 37.40 | 9.73E+06 |
| 7 | 12:55 PM | 8.70 | 9.85E+06 | 10 | 3.86 | 38.60 | 9.41E+06 |
| 8 | 01:00 PM | 8.65 | 9.91E+06 | 10 | 3.78 | 37.80 | 9.62E+06 |
| 9 | 01:05 PM | 8.65 | 9.91E+06 | 10 | 3.82 | 38.20 | 9.52E+06 |
| 10 | 01:10 PM | 8.70 | 9.85E+06 | 10 | 3.82 | 38.20 | 9.52E+06 |
| 11 | 01:15 PM | 8.70 | 9.85E+06 | 10 | 3.82 | 38.20 | 9.52E+06 |
| 12 | 01:20 PM | 8.55 | 1.00E+07 | 10 | 3.72 | 37.20 | 9.79E+06 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|---------------|-------------|----------|----------|---------------|-----------|---------|----------|----------|----------|
| | | DYE FLOW | DYE FLOW | COMPUTER FLOW | DVOM FLOW | ----- | ----- | ----- | ----- |
| | | | | | | Q(JMM) | Q(MWCC) | Q(COMP) | Q(JMM) |
| 1 | 12:25 PM | 131.88 | 129.67 | 154.38 | 149.38 | 1.034 | 1.017 | 0.854 | 0.883 |
| 2 | 12:30 PM | 133.44 | 129.67 | 152.42 | 154.69 | 0.985 | 1.029 | 0.875 | 0.863 |
| 3 | 12:35 PM | 131.12 | 128.26 | 152.66 | 152.50 | 1.001 | 1.022 | 0.859 | 0.860 |
| 4 | 12:40 PM | 131.88 | 128.96 | 150.70 | 153.13 | 0.984 | 1.023 | 0.875 | 0.861 |
| 5 | 12:45 PM | 135.03 | 133.34 | 150.08 | 152.97 | 0.981 | 1.013 | 0.900 | 0.883 |
| 6 | 12:50 PM | 134.23 | 132.59 | 149.69 | 154.06 | 0.972 | 1.012 | 0.897 | 0.871 |
| 7 | 12:55 PM | 134.23 | 128.26 | 153.59 | 152.19 | 1.009 | 1.047 | 0.874 | 0.882 |
| 8 | 01:00 PM | 135.03 | 131.12 | 149.69 | 152.66 | 0.981 | 1.030 | 0.902 | 0.885 |
| 9 | 01:05 PM | 135.03 | 129.67 | 152.58 | 151.88 | 1.005 | 1.041 | 0.885 | 0.889 |
| 10 | 01:10 PM | 134.23 | 129.67 | 153.13 | 150.94 | 1.015 | 1.035 | 0.877 | 0.889 |
| 11 | 01:15 PM | 134.23 | 129.67 | 155.55 | 154.06 | 1.010 | 1.035 | 0.863 | 0.871 |
| 12 | 01:20 PM | 136.66 | 133.34 | 154.69 | 155.63 | 0.994 | 1.025 | 0.883 | 0.878 |
| MEAN= | | 133.92 | | MEAN = | 152.91 | 0.996 | 1.027 | 0.879 | 0.877 |
| | | | | STD DEV = | | 0.013 | 0.009 | 0.013 | 0.010 |

Note: mean and standard deviation were calculated after the high and low values were eliminated.

SAFHL FLOWMETER CALIBRATION
 May 30, 1991
 Run F - Magmeter M-001D

Table 7

Dye injection rate (ml/min): 36.76
 (total dye used: 1801 ml)
 (injection time: 49.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$$Y = 10^{C1} * X^{C2}, \text{ where}$$

Y is the dilution ratio

X is the sample flourometer reading

| | | |
|------------|---------|---------|
| | SAFHL | MWCC |
| C1 equals | 7.9219 | 8.5870 |
| C2 equals | -1.0054 | -1.0186 |
| R squared: | 0.999 | 1.000 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUDROMETRY **** | | |
|--------|--------------|----------|------------------------------|----------------------------|-------|---------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 78.50 | 31.62 | 10.80 | 341.50 |
| 2 | 5E-07 | 2E+06 | 44.00 | 31.62 | 5.76 | 182.13 |
| 3 | 2E-07 | 5E+06 | 16.10 | 10.00 | 7.04 | 70.40 |
| 4 | 1E-07 | 1E+07 | 7.95 | 10.00 | 3.56 | 35.60 |
| 5 | 5E-08 | 2E+07 | 4.25 | 3.16 | 5.74 | 18.14 |
| 6 | 2E-08 | 5E+07 | 1.67 | 1.00 | 7.56 | 7.56 |

water bath temp: 18.3;

water temp: 21.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 May 30, 1991
 Run G - Magmeter M-001D

Table 8

Dye injection rate (ml/min): 37.11
 (total dye used: 2783 ml)
 (injection time: 75.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$Y = 10^{C1} * X^{C2}$, where
 Y is the dilution ratio
 X is the sample flourometer reading

| | | |
|------------|---------|---------|
| | SAFHL | MWCC |
| C1 equals | 7.9198 | 8.5870 |
| C2 equals | -1.0055 | -1.0186 |
| R squared: | 0.999 | 1.000 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUOROMETRY **** | | |
|--------|--------------|----------|------------------------------|----------------------------|-------|---------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 77.50 | 31.62 | 10.80 | 341.50 |
| 2 | 5E-07 | 2E+06 | 44.00 | 31.62 | 5.76 | 182.13 |
| 3 | 2E-07 | 5E+06 | 16.00 | 10.00 | 7.04 | 70.40 |
| 4 | 1E-07 | 1E+07 | 7.95 | 10.00 | 3.56 | 35.60 |
| 5 | 5E-08 | 2E+07 | 4.25 | 3.16 | 5.74 | 18.14 |
| 6 | 2E-08 | 5E+07 | 1.65 | 1.00 | 7.56 | 7.56 |

water bath temp: 19.1;

water temp: 21.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 May 30, 1991
 Run G - Magmeter M-001D

Table 8 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|---------------|-------------|------------------|----------------|------------------------------|-------|---------|----------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 1 | 12:05 PM | 7.25 | 1.13E+07 | 10 | 3.48 | 34.80 | 1.04E+07 |
| 2 | 12:10 PM | 7.50 | 1.10E+07 | 10 | 3.40 | 34.00 | 1.06E+07 |
| 3 | 12:15 PM | 7.45 | 1.10E+07 | 10 | 3.32 | 33.20 | 1.09E+07 |
| 4 | 12:20 PM | 7.45 | 1.10E+07 | 10 | 3.32 | 33.20 | 1.09E+07 |
| 5 | 12:25 PM | 7.45 | 1.10E+07 | 10 | 3.36 | 33.60 | 1.08E+07 |
| 6 | 12:30 PM | 7.50 | 1.10E+07 | 10 | 3.38 | 33.80 | 1.07E+07 |
| 7 | 12:35 PM | 7.45 | 1.10E+07 | 10 | 3.34 | 33.40 | 1.08E+07 |
| 8 | 12:40 PM | 7.45 | 1.10E+07 | 10 | 3.28 | 32.80 | 1.10E+07 |
| 9 | 12:45 PM | 7.25 | 1.13E+07 | 10 | 3.24 | 32.40 | 1.12E+07 |
| 10 | 12:50 PM | 7.25 | 1.13E+07 | 10 | 3.24 | 32.40 | 1.12E+07 |
| 11 | 12:55 PM | 7.20 | 1.14E+07 | 10 | 3.24 | 32.40 | 1.12E+07 |
| 12 | 01:00 PM | 7.25 | 1.13E+07 | 10 | 3.26 | 32.60 | 1.11E+07 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|---------------|-------------|---------------|---------------|---------------|-----------|---------|----------|----------|----------|
| | | DYE DIL. FLOW | DYE DIL. FLOW | COMPUTER FLOW | DVOM FLOW | ----- | ----- | ----- | ----- |
| | | | | | | Q(JMM) | Q(MWCC) | Q(COMP) | Q(JMM) |
| 1 | 12:05 PM | 160.13 | 146.72 | 186.34 | NA | NA | 1.091 | 0.859 | NA |
| 2 | 12:10 PM | 154.76 | 150.24 | 184.14 | 177.03 | 1.040 | 1.030 | 0.840 | 0.874 |
| 3 | 12:15 PM | 155.81 | 153.93 | 184.38 | 182.34 | 1.011 | 1.012 | 0.845 | 0.854 |
| 4 | 12:20 PM | 155.81 | 153.93 | 184.14 | 178.91 | 1.029 | 1.012 | 0.846 | 0.871 |
| 5 | 12:25 PM | 155.81 | 152.06 | 187.19 | 179.53 | 1.043 | 1.025 | 0.832 | 0.868 |
| 6 | 12:30 PM | 154.76 | 151.15 | 188.36 | 184.38 | 1.022 | 1.024 | 0.822 | 0.839 |
| 7 | 12:35 PM | 155.81 | 152.99 | 187.89 | 180.78 | 1.039 | 1.018 | 0.829 | 0.862 |
| 8 | 12:40 PM | 155.81 | 155.84 | 187.19 | 183.91 | 1.018 | 1.000 | 0.832 | 0.847 |
| 9 | 12:45 PM | 160.13 | 157.80 | 187.19 | 177.97 | 1.052 | 1.015 | 0.855 | 0.900 |
| 10 | 12:50 PM | 160.13 | 157.80 | 182.11 | 178.44 | 1.021 | 1.015 | 0.879 | 0.897 |
| 11 | 12:55 PM | 161.25 | 157.80 | 186.09 | 179.38 | 1.037 | 1.022 | 0.867 | 0.899 |
| 12 | 01:00 PM | 160.13 | 156.82 | 184.53 | 181.41 | 1.017 | 1.021 | 0.868 | 0.883 |
| MEAN= | | 157.13 | | MEAN = | 180.30 | 1.030 | 1.019 | 0.847 | 0.873 |
| | | | | STD DEV = | | 0.012 | 0.006 | 0.014 | 0.021 |

Note: mean and standard deviation were calculated after the high and low values were eliminated.

SAFHL FLOWMETER CALIBRATION

Table 9

June 3, 1991

Run H - Magmeter M-001D

Dye injection rate (ml/min): 38.34
 (total dye used: 2492 ml)
 (injection time: 65.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$$Y = 10^{C1} * X^{C2}, \text{ where}$$

Y is the dilution ratio

X is the sample flourometer reading

| | SAFHL | MWCC |
|------------|---------|---------|
| C1 equals | 7.9906 | 8.6648 |
| C2 equals | -1.0282 | -1.0417 |
| R squared: | 0.999 | 1.000 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUOROMETRY **** | | |
|--------|-----------|----------|------------------------|----------------------------|-------|---------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 83.00 | 31.62 | 11.20 | 354.14 |
| 2 | 5E-07 | 2E+06 | 46.00 | 31.62 | 5.98 | 189.09 |
| 3 | 2E-07 | 5E+06 | 18.00 | 10.00 | 7.68 | 76.80 |
| 4 | 1E-07 | 1E+07 | 9.00 | 10.00 | 4.04 | 40.40 |
| 5 | 5E-08 | 2E+07 | 4.90 | 3.16 | 6.46 | 20.41 |
| 6 | 2E-08 | 5E+07 | 1.87 | 3.16 | 2.64 | 8.34 |

water bath temp: 17.2;

water temp: 23.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 June 3, 1991
 Run H - Magmeter M-001D

Table 9 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|---------------|-------------|------------------|----------------|------------------------------|-------|---------|----------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 1 | 07:42 AM | 9.00 | 1.02E+07 | 10 | 3.92 | 39.20 | 1.01E+07 |
| 2 | 07:45 AM | 8.90 | 1.03E+07 | 10 | 3.94 | 39.40 | 1.01E+07 |
| 3 | 07:48 AM | 8.80 | 1.05E+07 | 10 | 3.86 | 38.60 | 1.03E+07 |
| 4 | 07:51 AM | 8.90 | 1.03E+07 | 10 | 3.98 | 39.80 | 9.96E+06 |
| 5 | 07:54 AM | 8.80 | 1.05E+07 | 10 | 3.90 | 39.00 | 1.02E+07 |
| 6 | 07:57 AM | 8.60 | 1.07E+07 | 10 | 3.82 | 38.20 | 1.04E+07 |
| 7 | 08:00 AM | 8.55 | 1.08E+07 | 10 | 3.78 | 37.80 | 1.05E+07 |
| 8 | 08:05 AM | 8.60 | 1.07E+07 | 10 | 3.84 | 38.40 | 1.03E+07 |
| 9 | 08:10 AM | 8.70 | 1.06E+07 | 10 | 3.80 | 38.00 | 1.05E+07 |
| 10 | 08:15 AM | 8.60 | 1.07E+07 | 10 | 3.74 | 37.40 | 1.06E+07 |
| 11 | 08:20 AM | 8.35 | 1.10E+07 | 10 | 3.66 | 36.60 | 1.09E+07 |
| 12 | 08:25 AM | 8.40 | 1.10E+07 | 10 | 3.66 | 36.60 | 1.09E+07 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|---------------|-------------|---------------|---------------|---------------|-----------|-----------------|------------------|------------------|-----------------|
| | | DYE DIL. FLOW | DYE DIL. FLOW | COMPUTER FLOW | DVOM FLOW | ----- Q(JMM) | ----- Q(MWCC) | ----- Q(COMP) | ----- Q(JMM) |
| 1 | 07:42 AM | 149.08 | 147.57 | 173.13 | 169.53 | 1.021 | 1.010 | 0.861 | 0.879 |
| 2 | 07:45 AM | 150.80 | 146.79 | 175.63 | 170.78 | 1.028 | 1.027 | 0.859 | 0.883 |
| 3 | 07:48 AM | 152.56 | 149.96 | 172.97 | 170.78 | 1.013 | 1.017 | 0.882 | 0.893 |
| 4 | 07:51 AM | 150.80 | 145.25 | 177.34 | 172.19 | 1.030 | 1.038 | 0.850 | 0.876 |
| 5 | 07:54 AM | 152.56 | 148.36 | 176.95 | 171.09 | 1.034 | 1.028 | 0.862 | 0.892 |
| 6 | 07:57 AM | 156.21 | 151.59 | 174.92 | 173.28 | 1.009 | 1.030 | 0.893 | 0.901 |
| 7 | 08:00 AM | 157.15 | 153.27 | 176.88 | 171.56 | 1.031 | 1.025 | 0.888 | 0.916 |
| 8 | 08:05 AM | 156.21 | 150.77 | 173.75 | 171.25 | 1.015 | 1.036 | 0.899 | 0.912 |
| 9 | 08:10 AM | 154.36 | 152.43 | 176.64 | 173.13 | 1.020 | 1.013 | 0.874 | 0.892 |
| 10 | 08:15 AM | 156.21 | 154.97 | 179.30 | 169.38 | 1.059 | 1.008 | 0.871 | 0.922 |
| 11 | 08:20 AM | 161.02 | 158.50 | 180.31 | 174.53 | 1.033 | 1.016 | 0.893 | 0.923 |
| 12 | 08:25 AM | 160.04 | 158.50 | 182.11 | 175.94 | 1.035 | 1.010 | 0.879 | 0.910 |
| MEAN= | | 154.69 | | MEAN = | 171.81 | 1.026 | 1.021 | 0.876 | 0.900 |
| | | | | STD DEV = | | 0.008 | 0.009 | 0.013 | 0.015 |

Note: mean and standard deviation were calculated after the high and low values were eliminated.

SAFHL FLOWMETER CALIBRATION
 June 3, 1991
 Run H EXTENDED - Magmeter M-001D

Table 10

Dye injection rate (ml/min): 37.96 *
 (total dye used: 8542 ml)
 (injection time: 225.00 min)

*-Due to the extended run time, the initial inj. rate was 38.51 ml/min, and as the battery drained, the later rate was 37.64 ml/min. These are the values used in the calculations.

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$Y = 10^{C1} * X^{C2}$, where
 Y is the dilution ratio
 X is the sample flourometer reading

| | | |
|------------|---------|---------|
| | SAFHL | MWCC |
| C1 equals | 7.9906 | 8.6648 |
| C2 equals | -1.0282 | -1.0417 |
| R squared: | 0.999 | 1.000 |

Fluorometer calibration -

| TEST # | DYE | | SAFHL | **** MWCC FLUOROMETRY **** | | |
|--------|-------|----------|------------------|----------------------------|-------|---------|
| | CONC. | DILUTION | FLUOROM. READING | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 83.00 | 31.62 | 11.20 | 354.14 |
| 2 | 5E-07 | 2E+06 | 46.00 | 31.62 | 5.98 | 189.09 |
| 3 | 2E-07 | 5E+06 | 18.00 | 10.00 | 7.68 | 76.80 |
| 4 | 1E-07 | 1E+07 | 9.00 | 10.00 | 4.04 | 40.40 |
| 5 | 5E-08 | 2E+07 | 4.90 | 3.16 | 6.46 | 20.41 |
| 6 | 2E-08 | 5E+07 | 1.87 | 3.16 | 2.64 | 8.34 |

water bath temp: 17.2;

water temp: 23.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 June 3, 1991
 Run H EXTENDED - Magmeter M-001D

Table 10 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|---------------|-------------|------------------|----------------|------------------------------|-------|---------|----------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 13 | 08:30 AM | 8.45 | 1.09E+07 | 10 | 3.60 | 36.00 | 1.11E+07 |
| 14 | 08:45 AM | 8.20 | 1.12E+07 | 10 | 3.50 | 35.00 | 1.14E+07 |
| 15 | 09:00 AM | 7.70 | 1.20E+07 | 10 | 3.36 | 33.60 | 1.19E+07 |
| 16 | 09:15 AM | 7.60 | 1.22E+07 | 10 | 3.26 | 32.60 | 1.23E+07 |
| 17 | 09:30 AM | 7.65 | 1.21E+07 | 10 | 3.26 | 32.60 | 1.23E+07 |
| 18 | 09:45 AM | 7.50 | 1.23E+07 | 10 | 3.22 | 32.20 | 1.24E+07 |
| 19 | 10:00 AM | 7.20 | 1.29E+07 | 10 | 3.02 | 30.20 | 1.33E+07 |
| 20 | 10:15 AM | 6.80 | 1.36E+07 | 10 | 2.80 | 28.00 | 1.44E+07 |
| 21 | 10:30 AM | 6.60 | 1.41E+07 | 10 | 2.76 | 27.60 | 1.46E+07 |
| 22 | 10:45 AM | 6.25 | 1.49E+07 | 10 | 2.70 | 27.00 | 1.49E+07 |
| 23 | 11:00 AM | 6.25 | 1.49E+07 | 10 | 2.68 | 26.80 | 1.50E+07 |
| 24 | 11:15 AM | 7.55 | 1.22E+07 | 10 | 3.30 | 33.00 | 1.21E+07 |
| 25 | 11:30 AM | 8.35 | 1.10E+07 | 10 | 3.58 | 35.80 | 1.11E+07 |
| 26 | 11:45 AM | 7.75 | 1.19E+07 | 10 | 3.28 | 32.80 | 1.22E+07 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|---------------|-------------|---------------|---------------|---------------|-----------|---------|----------|----------|----------|
| | | DYE DIL. FLOW | DYE DIL. FLOW | COMPUTER FLOW | DVOM FLOW | ----- | ----- | ----- | ----- |
| | | | | | | Q(JMM) | Q(MWCC) | Q(COMP) | Q(JMM) |
| 13 | 08:30 AM | 159.76 | 161.96 | 184.06 | 179.84 | 1.023 | 0.986 | 0.868 | 0.888 |
| 14 | 08:45 AM | 164.77 | 166.78 | 190.23 | 184.22 | 1.033 | 0.988 | 0.866 | 0.894 |
| 15 | 09:00 AM | 175.78 | 174.03 | 197.42 | 186.72 | 1.057 | 1.010 | 0.890 | 0.941 |
| 16 | 09:15 AM | 178.16 | 179.59 | 204.22 | 195.78 | 1.043 | 0.992 | 0.872 | 0.910 |
| 17 | 09:30 AM | 176.96 | 179.59 | 207.58 | 200.31 | 1.036 | 0.985 | 0.852 | 0.883 |
| 18 | 09:45 AM | 180.60 | 181.92 | 207.11 | 201.56 | 1.028 | 0.993 | 0.872 | 0.896 |
| 19 | 10:00 AM | 184.08 | 190.09 | 212.11 | 205.78 | 1.031 | 0.968 | 0.868 | 0.895 |
| 20 | 10:15 AM | 195.23 | 205.68 | 234.14 | 228.44 | 1.025 | 0.949 | 0.834 | 0.855 |
| 21 | 10:30 AM | 201.31 | 208.78 | 232.73 | 225.47 | 1.032 | 0.964 | 0.865 | 0.893 |
| 22 | 10:45 AM | 212.91 | 213.62 | 236.25 | 230.16 | 1.026 | 0.997 | 0.901 | 0.925 |
| 23 | 11:00 AM | 212.91 | 215.28 | 199.84 | 196.41 | 1.017 | 0.989 | 1.065 | 1.084 |
| 24 | 11:15 AM | 175.32 | 173.32 | 185.00 | 179.38 | 1.031 | 1.012 | 0.948 | 0.977 |
| 25 | 11:30 AM | 158.07 | 159.22 | 182.34 | 177.03 | 1.030 | 0.993 | 0.867 | 0.893 |
| 26 | 11:45 AM | 170.67 | 174.42 | 183.67 | 179.69 | 1.022 | 0.978 | 0.929 | 0.950 |
| MEAN= | | 181.29 | | MEAN = | 196.97 | 1.030 | 0.987 | 0.883 | 0.912 |
| | | | | STD DEV = | | 0.006 | 0.012 | 0.029 | 0.030 |

Note: mean and standard deviation were

SAFHL FLOWMETER CALIBRATION
 June 3, 1991
 Run I - Magmeter M-001D

Table 11

Dye injection rate (ml/min): 37.60
 (total dye used: 2820 ml)
 (injection time: 75.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$Y = 10^{C1} * X^{C2}$, where
 Y is the dilution ratio
 X is the sample flourometer reading

| | SAFHL | MWCC |
|------------|---------|---------|
| C1 equals | 7.9855 | 8.6648 |
| C2 equals | -1.0288 | -1.0417 |
| R squared: | 0.999 | 1.000 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUOROMETRY **** | | |
|--------|-----------|----------|------------------------|----------------------------|-------|---------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 82.00 | 31.62 | 11.20 | 354.14 |
| 2 | 5E-07 | 2E+06 | 45.50 | 31.62 | 5.98 | 189.09 |
| 3 | 2E-07 | 5E+06 | 17.60 | 10.00 | 7.68 | 76.80 |
| 4 | 1E-07 | 1E+07 | 8.90 | 10.00 | 4.04 | 40.40 |
| 5 | 5E-08 | 2E+07 | 4.85 | 3.16 | 6.46 | 20.41 |
| 6 | 2E-08 | 5E+07 | 1.85 | 3.16 | 2.64 | 8.34 |

water bath temp: 17.5;

water temp: 23.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 June 3, 1991
 Run I - Magmeter M-001D

Table 11 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|---------------|-------------|------------------|----------------|------------------------------|-------|---------|----------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 1 | 12:00 PM | 8.20 | 1.11E+07 | 10 | 3.58 | 35.80 | 1.11E+07 |
| 2 | 12:05 PM | 7.85 | 1.16E+07 | 10 | 3.40 | 34.00 | 1.17E+07 |
| 3 | 12:10 PM | 7.55 | 1.21E+07 | 10 | 3.28 | 32.80 | 1.22E+07 |
| 4 | 12:15 PM | 7.45 | 1.23E+07 | 10 | 3.24 | 32.40 | 1.23E+07 |
| 5 | 12:20 PM | 7.70 | 1.18E+07 | 10 | 3.42 | 34.20 | 1.17E+07 |
| 6 | 12:25 PM | 7.85 | 1.16E+07 | 10 | 3.40 | 34.00 | 1.17E+07 |
| 7 | 12:30 PM | 7.95 | 1.15E+07 | 10 | 3.62 | 36.20 | 1.10E+07 |
| 8 | 12:35 PM | 8.20 | 1.11E+07 | 10 | 3.70 | 37.00 | 1.07E+07 |
| 9 | 12:40 PM | 9.10 | 9.97E+06 | 10 | 4.16 | 41.60 | 9.51E+06 |
| 10 | 12:45 PM | 8.10 | 1.12E+07 | 10 | 3.56 | 35.60 | 1.12E+07 |
| * 11 | 12:50 PM | 17.20 | 5.18E+06 | 10 | 7.54 | 75.40 | 5.12E+06 |
| 12 | 12:55 PM | 8.00 | 1.14E+07 | 10 | 3.46 | 34.60 | 1.15E+07 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|---------------|-------------|---------------|---------------|---------------|---------------|---------|----------|----------|----------|
| | | DYE DIL. FLOW | DYE DIL. FLOW | COMPUTER FLOW | JMM DVOM FLOW | ----- | ----- | ----- | ----- |
| | | | | | | Q(JMM) | Q(MWCC) | Q(COMP) | Q(JMM) |
| 1 | 12:00 PM | 158.81 | 159.07 | 185.47 | 177.34 | 1.046 | 0.998 | 0.856 | 0.896 |
| 2 | 12:05 PM | 166.10 | 167.85 | 186.72 | 179.69 | 1.039 | 0.990 | 0.890 | 0.924 |
| 3 | 12:10 PM | 172.90 | 174.26 | 189.77 | 182.66 | 1.039 | 0.992 | 0.911 | 0.947 |
| 4 | 12:15 PM | 175.28 | 176.50 | 190.94 | 187.97 | 1.016 | 0.993 | 0.918 | 0.933 |
| 5 | 12:20 PM | 169.43 | 166.83 | 192.34 | 186.41 | 1.032 | 1.016 | 0.881 | 0.909 |
| 6 | 12:25 PM | 166.10 | 167.85 | 194.77 | 189.06 | 1.030 | 0.990 | 0.853 | 0.879 |
| 7 | 12:30 PM | 163.95 | 157.24 | 192.50 | 189.06 | 1.018 | 1.043 | 0.852 | 0.867 |
| 8 | 12:35 PM | 158.81 | 153.70 | 193.36 | 188.13 | 1.028 | 1.033 | 0.821 | 0.844 |
| 9 | 12:40 PM | 142.68 | 136.04 | 193.36 | 187.50 | 1.031 | 1.049 | 0.738 | 0.761 |
| 10 | 12:45 PM | 160.83 | 160.00 | 191.56 | 188.44 | 1.017 | 1.005 | 0.840 | 0.853 |
| * 11 | 12:50 PM | 74.11 | 73.22 | 193.91 | 187.97 | 1.032 | 1.012 | 0.382 | 0.394 |
| 12 | 12:55 PM | 162.90 | 164.82 | 193.59 | 191.72 | 1.010 | 0.988 | 0.841 | 0.850 |
| MEAN= | | 164.43 | | MEAN = | 186.55 | 1.028 | 1.007 | 0.861 | 0.884 |
| | | | | STD DEV = | | 0.009 | 0.019 | 0.028 | 0.033 |

*- Sample apparently contaminated by excess dye. Sample omitted from statistical analysis.

Note: mean and standard deviation were calculated after the high and low values were eliminated.

SAFHL FLOWMETER CALIBRATION
 June 5, 1991
 Run J - Magmeter M-001A

Table 12

Dye injection rate (ml/min): 26.61
 (total dye used: 1996 ml)
 (injection time: 75.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$$Y = 10^{C1} * X^{C2}, \text{ where}$$

Y is the dilution ratio

X is the sample fluourometer reading

| | | |
|------------|---------|---------|
| | SAFHL | MWCC |
| C1 equals | 7.9050 | 8.5362 |
| C2 equals | -0.9953 | -1.0021 |
| R squared: | 1.000 | 1.000 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUOROMETRY **** | | |
|--------|--------------|----------|------------------------------|----------------------------|-------|---------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 79.50 | 31.62 | 10.66 | 337.07 |
| 2 | 5E-07 | 2E+06 | 42.50 | 31.62 | 5.36 | 169.48 |
| 3 | 2E-07 | 5E+06 | 16.30 | 10.00 | 6.88 | 68.80 |
| 4 | 1E-07 | 1E+07 | 7.90 | 10.00 | 3.44 | 34.40 |
| 5 | 5E-08 | 2E+07 | 4.20 | 3.16 | 5.44 | 17.19 |
| 6 | 2E-08 | 5E+07 | 1.58 | 3.16 | 2.14 | 6.76 |

water bath temp: 17.1;

water temp: 20.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 June 5, 1991
 Run J - Magmeter M-001A

Table 12 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|------------------|----------------|---------------------|-------------------|------------------------------|-------|---------|-------------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 1 | 07:45 AM | 7.50 | 1.08E+07 | 10 | 3.34 | 33.40 | 1.02E+07 |
| 2 | 07:50 AM | 7.45 | 1.09E+07 | 10 | 3.36 | 33.60 | 1.02E+07 |
| 3 | 07:55 AM | 7.00 | 1.16E+07 | 10 | 3.18 | 31.80 | 1.07E+07 |
| 4 | 08:00 AM | 7.30 | 1.11E+07 | 10 | 3.24 | 32.40 | 1.05E+07 |
| 5 | 08:05 AM | 7.15 | 1.13E+07 | 10 | 3.22 | 32.20 | 1.06E+07 |
| 6 | 08:10 AM | 7.10 | 1.14E+07 | 10 | 3.20 | 32.00 | 1.07E+07 |
| 7 | 08:15 AM | 7.05 | 1.15E+07 | 10 | 3.18 | 31.80 | 1.07E+07 |
| 8 | 08:22 AM | 7.15 | 1.13E+07 | 10 | 3.20 | 32.00 | 1.07E+07 |
| 9 | 08:25 AM | 7.05 | 1.15E+07 | 10 | 3.12 | 31.20 | 1.09E+07 |
| 10 | 08:30 AM | 6.95 | 1.17E+07 | 10 | 3.04 | 30.40 | 1.12E+07 |
| 11 | 08:35 AM | 6.75 | 1.20E+07 | 10 | 3.04 | 30.40 | 1.12E+07 |
| 12 | 08:40 AM | 6.60 | 1.23E+07 | 10 | 2.96 | 29.60 | 1.15E+07 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|------------------|----------------|------------------|------------------|------------------|--------------|-----------------|------------------|------------------|-----------------|
| | | DYE DIL. FLOW | DYE DIL. FLOW | COMPUTER FLOW | DVOM FLOW | ----- Q(JMM) | ----- Q(MWCC) | ----- Q(COMP) | ----- Q(JMM) |
| 1 | 07:45 AM | 109.51 | 103.45 | NA | NA | NA | 1.059 | NA | NA |
| 2 | 07:50 AM | 110.24 | 102.84 | 143.36 | 145.63 | 0.984 | 1.072 | 0.769 | 0.757 |
| 3 | 07:55 AM | 117.29 | 108.67 | 143.52 | 142.50 | 1.007 | 1.079 | 0.817 | 0.823 |
| 4 | 08:00 AM | 112.50 | 106.65 | 144.30 | 146.72 | 0.984 | 1.055 | 0.780 | 0.767 |
| 5 | 08:05 AM | 114.85 | 107.32 | 141.80 | 145.31 | 0.976 | 1.070 | 0.810 | 0.790 |
| 6 | 08:10 AM | 115.65 | 107.99 | 145.23 | 145.16 | 1.001 | 1.071 | 0.796 | 0.797 |
| 7 | 08:15 AM | 116.47 | 108.67 | 145.31 | 146.25 | 0.994 | 1.072 | 0.802 | 0.796 |
| 8 | 08:22 AM | 114.85 | 107.99 | 148.98 | 149.06 | 0.999 | 1.063 | 0.771 | 0.770 |
| 9 | 08:25 AM | 116.47 | 110.76 | 150.23 | 149.84 | 1.003 | 1.051 | 0.775 | 0.777 |
| 10 | 08:30 AM | 118.13 | 113.68 | 151.41 | 152.66 | 0.992 | 1.039 | 0.780 | 0.774 |
| 11 | 08:35 AM | 121.62 | 113.68 | 152.11 | 153.13 | 0.993 | 1.070 | 0.800 | 0.794 |
| 12 | 08:40 AM | 124.37 | 116.76 | 151.09 | 153.13 | 0.987 | 1.065 | 0.823 | 0.812 |
| MEAN= | | 116.42 | | MEAN = | 148.19 | 0.993 | 1.065 | 0.792 | 0.786 |
| | | | | STD DEV = | | 0.009 | 0.008 | 0.018 | 0.018 |

Note: mean and standard deviation were calculated after the high and low values were eliminated.

Table 13

SAFHL FLOWMETER CALIBRATION

June 5, 1991

Run J EXTENDED - Magmeter M-001A

Dye injection rate (ml/min): 26.37 *
 (total dye used: 5143 ml)
 (injection time: 195.00 min)

*-Due to the extended run time, the initial inj. rate was 26.58 ml/min, and as the battery drained, the later rate was 26.23 ml/min. These are the values used in the calculations.

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$Y = 10^{C1} * X^{C2}$, where
 Y is the dilution ratio
 X is the sample flourometer reading

| | SAFHL | MWCC |
|------------|---------|---------|
| C1 equals | 7.8974 | 8.5362 |
| C2 equals | -0.9840 | -1.0021 |
| R squared: | 1.000 | 1.000 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUOROMETRY **** | | |
|--------|-----------|----------|------------------------|----------------------------|-------|---------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 79.50 | 31.62 | 10.66 | 337.07 |
| 2 | 5E-07 | 2E+06 | 42.50 | 31.62 | 5.36 | 169.48 |
| 3 | 2E-07 | 5E+06 | 16.30 | 10.00 | 6.88 | 68.80 |
| 4 | 1E-07 | 1E+07 | 7.90 | 10.00 | 3.44 | 34.40 |
| 5 | 5E-08 | 2E+07 | 4.20 | 3.16 | 5.44 | 17.19 |
| 6 | 2E-08 | 5E+07 | 1.58 | 3.16 | 2.14 | 6.76 |

water bath temp: 16.8;

water temp: 20.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 June 5, 1991
 Run J EXTENDED - Magmeter M-001A

Table 13 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|------------------|----------------|---------------------|-------------------|------------------------------|-------|---------|-------------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 13 | 08:45 AM | 6.80 | 1.20E+07 | 10 | 2.98 | 29.80 | 1.15E+07 |
| 14 | 09:00 AM | 6.55 | 1.24E+07 | 10 | 2.88 | 28.80 | 1.19E+07 |
| 15 | 09:15 AM | 6.65 | 1.22E+07 | 10 | 2.90 | 29.00 | 1.18E+07 |
| 16 | 09:30 AM | 6.40 | 1.27E+07 | 10 | 2.80 | 28.00 | 1.22E+07 |
| 17 | 09:45 AM | 6.25 | 1.30E+07 | 10 | 2.70 | 27.00 | 1.26E+07 |
| 18 | 10:04 AM | 6.00 | 1.35E+07 | 10 | 2.58 | 25.80 | 1.32E+07 |
| 19 | 10:15 AM | 6.00 | 1.35E+07 | 10 | 2.58 | 25.80 | 1.32E+07 |
| 20 | 10:30 AM | 5.40 | 1.50E+07 | 10 | 2.32 | 23.20 | 1.47E+07 |
| 21 | 10:45 AM | 5.75 | 1.41E+07 | 10 | 2.48 | 24.80 | 1.38E+07 |
| 22 | 11:00 AM | 5.40 | 1.50E+07 | 10 | 2.36 | 23.60 | 1.45E+07 |
| 23 | 11:15 AM | 5.40 | 1.50E+07 | 10 | 2.26 | 22.60 | 1.51E+07 |
| 24 | 11:30 AM | 6.00 | 1.35E+07 | 10 | 2.62 | 26.20 | 1.30E+07 |
| 25 | 11:45 AM | 6.05 | 1.34E+07 | 10 | 2.62 | 26.20 | 1.30E+07 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|------------------|----------------|------------------|------------------|------------------|--------------|-----------------|------------------|------------------|-----------------|
| | | DYE DIL. FLOW | DYE DIL. FLOW | COMPUTER FLOW | DVOM FLOW | ----- Q(JMM) | ----- Q(MWCC) | ----- Q(COMP) | ----- Q(JMM) |
| 13 | 08:45 AM | 121.06 | 115.81 | 151.80 | 154.53 | 0.982 | 1.045 | 0.798 | 0.783 |
| 14 | 09:00 AM | 125.61 | 119.84 | 158.67 | 156.88 | 1.011 | 1.048 | 0.792 | 0.801 |
| 15 | 09:15 AM | 123.75 | 119.01 | 165.08 | 162.66 | 1.015 | 1.040 | 0.750 | 0.761 |
| 16 | 09:30 AM | 128.50 | 123.27 | 168.13 | 167.34 | 1.005 | 1.042 | 0.764 | 0.768 |
| 17 | 09:45 AM | 131.54 | 127.85 | 177.97 | 175.78 | 1.012 | 1.029 | 0.739 | 0.748 |
| 18 | 10:04 AM | 135.18 | 132.09 | 176.56 | 177.81 | 0.993 | 1.023 | 0.766 | 0.760 |
| 19 | 10:15 AM | 135.18 | 132.09 | 182.58 | 182.50 | 1.000 | 1.023 | 0.740 | 0.741 |
| 20 | 10:30 AM | 149.94 | 146.93 | 199.84 | 197.34 | 1.013 | 1.021 | 0.750 | 0.760 |
| 21 | 10:45 AM | 140.96 | 137.43 | 204.61 | 203.91 | 1.003 | 1.026 | 0.689 | 0.691 |
| 22 | 11:00 AM | 149.94 | 144.43 | 201.17 | 200.94 | 1.001 | 1.038 | 0.745 | 0.746 |
| 23 | 11:15 AM | 149.94 | 150.84 | 175.94 | 180.00 | 0.977 | 0.994 | 0.852 | 0.833 |
| 24 | 11:30 AM | 135.18 | 130.07 | 174.69 | 176.25 | 0.991 | 1.039 | 0.774 | 0.767 |
| 25 | 11:45 AM | 134.08 | 130.07 | 174.77 | 171.09 | 1.021 | 1.031 | 0.767 | 0.784 |
| MEAN= | | 135.44 | | MEAN = | 177.14 | 1.003 | 1.033 | 0.762 | 0.765 |
| | | | | STD DEV = | | 0.010 | 0.009 | 0.020 | 0.018 |

Note: mean and standard deviation were

SAFHL FLOWMETER CALIBRATION

Table 14

June 5, 1991

Run K - Magmeter M-001A

Dye injection rate (ml/min): 26.35
 (total dye used: 2108 ml)
 (injection time: 80.00 min)

Equations used:

$$\text{Flow (Q, in MGD)} = (\text{dilution ratio} * 0.0002642 * \text{dye injection rate} * 24 * 60) / 1000000$$

Fluorometer calibration; regression curve fitting:

$Y = 10^{C1} * X^{C2}$, where
 Y is the dilution ratio
 X is the sample fluourometer reading

| | | |
|------------|---------|---------|
| | SAFHL | MWCC |
| C1 equals | 7.9050 | 8.5362 |
| C2 equals | -0.9953 | -1.0021 |
| R squared: | 1.000 | 1.000 |

Fluorometer calibration -

| TEST # | DYE CONC. | DILUTION | SAFHL FLUOROM. READING | **** MWCC FLUOROMETRY **** | | |
|--------|--------------|----------|------------------------------|----------------------------|-------|---------|
| | | | | RANGE | VALUE | READING |
| 1 | 1E-06 | 1E+06 | 79.50 | 31.62 | 10.66 | 337.07 |
| 2 | 5E-07 | 2E+06 | 42.50 | 31.62 | 5.36 | 169.48 |
| 3 | 2E-07 | 5E+06 | 16.30 | 10.00 | 6.88 | 68.80 |
| 4 | 1E-07 | 1E+07 | 7.90 | 10.00 | 3.44 | 34.40 |
| 5 | 5E-08 | 2E+07 | 4.20 | 3.16 | 5.44 | 17.19 |
| 6 | 2E-08 | 5E+07 | 1.58 | 3.16 | 2.14 | 6.76 |

water bath temp: 17.1;

water temp: 20.0;

(All temperatures in degrees Celsius)

SAFHL FLOWMETER CALIBRATION
 June 5, 1991
 Run K - Magmeter M-001A

Table 14 (Continued)

Fluorometric grab sampling data -

| SAMPLE NUMBER | SAMPLE TIME | **** SAFHL **** | | ***** MWCC FLUOROMETRY ***** | | | |
|---------------|-------------|------------------|----------------|------------------------------|-------|---------|----------------|
| | | FLUOROM. READING | CALC. DILUTION | SCALE | VALUE | READING | CALC. DILUTION |
| 1 | 12:00 PM | 6.10 | 1.33E+07 | 10 | 2.66 | 26.60 | 1.28E+07 |
| 2 | 12:05 PM | 6.00 | 1.35E+07 | 10 | 2.58 | 25.80 | 1.32E+07 |
| 3 | 12:10 PM | 5.95 | 1.36E+07 | 10 | 2.60 | 26.00 | 1.31E+07 |
| 4 | 12:22 PM | 6.00 | 1.35E+07 | 10 | 2.62 | 26.20 | 1.30E+07 |
| 5 | 12:25 PM | 5.95 | 1.36E+07 | 10 | 2.62 | 26.20 | 1.30E+07 |
| 6 | 12:30 PM | 5.95 | 1.36E+07 | 10 | 2.56 | 25.60 | 1.33E+07 |
| 7 | 12:35 PM | 5.95 | 1.36E+07 | 10 | 2.60 | 26.00 | 1.31E+07 |
| 8 | 12:40 PM | 5.95 | 1.36E+07 | 10 | 2.60 | 26.00 | 1.31E+07 |
| 9 | 12:45 PM | 6.00 | 1.35E+07 | 10 | 2.60 | 26.00 | 1.31E+07 |
| 10 | 12:50 PM | 6.00 | 1.35E+07 | 10 | 2.60 | 26.00 | 1.31E+07 |
| 11 | 12:55 PM | 5.85 | 1.39E+07 | 10 | 2.52 | 25.20 | 1.36E+07 |
| 12 | 01:00 PM | 5.85 | 1.39E+07 | 10 | 2.52 | 25.20 | 1.36E+07 |

Flow rates (all values in MGD) -

| SAMPLE NUMBER | SAMPLE TIME | SAFHL | MWCC | MWCC | JMM | Q(COMP) | Q(SAFHL) | Q(SAFHL) | Q(SAFHL) |
|---------------|-------------|---------------|---------------|---------------|---------------|---------|----------|----------|----------|
| | | DYE DIL. FLOW | DYE DIL. FLOW | COMPUTER FLOW | JMM DVOM FLOW | ----- | ----- | ----- | ----- |
| | | | | | | Q(JMM) | Q(MWCC) | Q(COMP) | Q(JMM) |
| 1 | 12:00 PM | 133.18 | 128.67 | 173.83 | 173.75 | 1.000 | 1.035 | 0.766 | 0.767 |
| 2 | 12:05 PM | 135.39 | 132.67 | 175.31 | 173.44 | 1.011 | 1.020 | 0.772 | 0.781 |
| 3 | 12:10 PM | 136.52 | 131.65 | 174.69 | 174.69 | 1.000 | 1.037 | 0.782 | 0.782 |
| 4 | 12:22 PM | 135.39 | 130.64 | 176.88 | 177.50 | 0.997 | 1.036 | 0.765 | 0.763 |
| 5 | 12:25 PM | 136.52 | 130.64 | 179.45 | 177.34 | 1.012 | 1.045 | 0.761 | 0.770 |
| 6 | 12:30 PM | 136.52 | 133.71 | 177.11 | 178.44 | 0.993 | 1.021 | 0.771 | 0.765 |
| 7 | 12:35 PM | 136.52 | 131.65 | 178.59 | 180.47 | 0.990 | 1.037 | 0.764 | 0.756 |
| 8 | 12:40 PM | 136.52 | 131.65 | 181.17 | 178.13 | 1.017 | 1.037 | 0.754 | 0.766 |
| 9 | 12:45 PM | 135.39 | 131.65 | 177.73 | 181.09 | 0.981 | 1.028 | 0.762 | 0.748 |
| 10 | 12:50 PM | 135.39 | 131.65 | 176.88 | 179.06 | 0.988 | 1.028 | 0.765 | 0.756 |
| 11 | 12:55 PM | 138.84 | 135.84 | 181.48 | 181.88 | 0.998 | 1.022 | 0.765 | 0.763 |
| 12 | 01:00 PM | 138.84 | 135.84 | 183.91 | 180.31 | 1.020 | 1.022 | 0.755 | 0.770 |
| MEAN= | | 136.30 | | MEAN = | 178.08 | 1.000 | 1.030 | 0.765 | 0.766 |
| | | | | STD DEV = | | 0.010 | 0.007 | 0.005 | 0.007 |

Note: mean and standard deviation were calculated after the high and low values were eliminated.