Memorandum

May 19, 2010

To: Brooke Asleson, Project Manager, MPCA

From: Melissa Bokman, Sr. Water Resources Planner

Subject: Credit River TMDL Technical Advisory Committee Meeting: May 10, 2010

Cc: Paul Nelson, Scott WMO Administrator

Attendees: Paul Nelson, Scott County; Melissa Bokman, Scott County; Ross Bintner, City of Prior Lake; Judy Sventek, MCES; Hong Wang, MCES; Daryl Jacobsen, BDWMO/City of Burnsville; Sam Lucido, City of Savage; Janell Miersch, DNR; Terry Schwalbe, LMRWD; Ann Messerschmidt, City of Lakeville

Paul started out the meeting going through the data analysis results evidence to show why we feel we have a case for the Credit River to be delisted. Handouts to the attendees included: Memorandum dated April 2, 2010 to Louise Hotka, MPCA; Memorandum dated April 13, 2010 to Brooke Asleson, MPCA; Memorandum dated May 7, 2010 to file regarding the QA/QC field results.

The remainder of the meeting was dedicated to the MCES presentation enclosed and to the development of scenarios summarized in the MCES memo dated May 14, 2010, that information is copied below.

Met Council
This memo outlines the BMP scenarios to run for the SWAT model as part of the Council’s work on the Credit River turbidity TMDL study. Hong and I further discussed the scenarios after the meeting and are proposing a slightly different order. First we would focus on the following 5 scenarios which we are ready to go with. I added in the last two scenarios because I really think that is where we will see improvements so they should be run.

- 2030 land use (We plan to use the Council’s 2030 land use map unless you have a different land use map for us to use.)
- 2030 land use plus current standards (We are working on a proposed methodology to model the standards and will run that by you before we begin).
- 2030 plus channel stabilization
- 2030 plus wetland restoration
• 2030 combination of channel stabilization and wetland restoration

Current standards to include are:
• ½ inch infiltration for all new development
• Rate control (for unincorporated area rate control is for presettlement conditions, for incorporated areas it is for existing conditions).

As we develop our methodology to model for the County’s standards, we will keep in mind the curve numbers below. These numbers are the ones to which rate control ponds are held to at their outlets in the County’s zoning ordinance chapter 6.

<table>
<thead>
<tr>
<th>Soil Group</th>
<th>RCN</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>55</td>
</tr>
<tr>
<td>C</td>
<td>71</td>
</tr>
<tr>
<td>D</td>
<td>77</td>
</tr>
</tbody>
</table>

While we are working on the first 5 scenarios, Melissa will provide us with a 2009 land use data layer. After we run the 2030 scenarios, we can run the 2009 land use, and the 2009 land use plus current standards. We will be running 2009 as a new baseline to capture the effects of development that has occurred between 2002 (current model land use baseline) and what has developed since.

As I mentioned above, Hong is investigating how we would set up the BMP scenarios for requiring ½ inch infiltration and for requiring rate control for incorporated and unincorporated areas. We will discuss methods with you before we run the scenario.
CREDIT RIVER
TURBIDITY TMDL

Technical Advisory Committee
May 10, 2010

Paul Nelson
Ross Bintner
Judy Sventek
Hong Wang
Daryl Jacobsen
Sam Lucido
Sereni Ness
Terry Schwada
Ann Messerschmidt
Melissa Borman

Scott County
City of Prior Lake
MCES
MCES
BDWMO/Burnsville
City of Savage
DNR
LAWA
City of Lakeville
Scott WMO/Scott Co
Credit River Watershed Modeling Using SWAT

Hong Wang and Judy Sventek
Metropolitan Council
Environmental Services
St Paul, MN

Presented at Scott Co TMDL
TAC Meeting, May 10, 2010
Modeling Objectives

• To identify and quantify non-point source pollution loadings and sources
• To study impacts of management practices and land use development on water quality
• To evaluate compliance of water quality with standards and to establish TMDLs
• To assess BMP scenarios for pollution mitigation
SWAT: Soil and Water Assessment Tool

- A thirty-year effort by USDA-ARS and Texas A&M University
- A GIS-based watershed model used to predict impacts of environmental stressors and management practices on hydrology and water quality
- Application to small and large complex watersheds with varying soil, land use and management conditions
SWAT Processes

- Water and pollutant yields in fields

- Movement, behavior and fate of water and pollutants in impoundment and channels
Model Inputs

- 10-meter DEM
- 2002 MCES land use map
- STATSGO soil map
- Weather data at Farmington and Jordan
- Agriculture management practices
- Hydrology and TSS monitoring for TSS source estimation and calibration
Model Setup Highlights

- 70 subbasins delineated according to DEM, streams, impoundments and gages
- No point sources in the watershed
- Drainage tiles assumed for crops with slopes 5% or less
- 1 m filter strips assumed in all agriculture land uses
- Management practices included tillage, fertilization, plantation, rotation, harvesting and kill operations
Delineated Watershed
Calibration and Performance Assessment

- **Calibration**
  - Calibration: 1997 – 2002
  - Validation: 2003 - 2008

- **Performance Assessment**
  - Relative deviation (RD ~ 0)
  - Root mean square deviation (RMSD ~ 0)
  - Coefficient of determination (R² ~ 1)
  - Index of agreement (IA ~ 1)
  - Nash-Sutcliffe coefficient of efficiency (NSCE > 0)
Daily Hydrology
Daily Hydrology
(2005 – 2008)
Monthly Hydrology

Monthly mean flow (m$^3$/s)

Measured  Simulated

Month

10/95 10/96 10/97 10/98 10/99 10/00 9/01 9/02 9/03 9/04 9/05 8/06 8/07 8/08
Annual Hydrology

![Graph showing annual mean flow (m³/s) for measured and simulated data from 1997 to 2008. The x-axis represents the years, and the y-axis represents the annual mean flow in m³/s. The graph compares measured and simulated data points for each year.]
# Hydrology Calibration Statistics

<table>
<thead>
<tr>
<th></th>
<th>OM (m³/s)</th>
<th>RD</th>
<th>RMSD</th>
<th>IA</th>
<th>NSCE</th>
<th>R²</th>
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</thead>
<tbody>
<tr>
<td>Daily</td>
<td>0.53</td>
<td>0.61</td>
<td>0.34</td>
<td>0.48</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>Monthly</td>
<td>0.53</td>
<td>-2.9%</td>
<td>0.34</td>
<td>0.93</td>
<td>0.741</td>
<td>0.64</td>
</tr>
<tr>
<td>Annual</td>
<td>0.08</td>
<td>0.08</td>
<td>0.99</td>
<td>0.80</td>
<td>0.84</td>
<td></td>
</tr>
</tbody>
</table>
TSS and Bank Erosion Calibration Method

**Sources**
- TSS from field erosion (%)
- TSS from non-field erosion (%)

**Routes**
- Buffer removal
- Impoundment settling
- Channel deposition with bank erosion off
- Channel deposition
- Re-suspension

**Discharges**
- Discharge at outlet = Field TSS + Non-field TSS loads

Validation using other erosion studies, if any

Discharge at outlet = Field TSS + Non-field TSS loads
Field and Non-Field Ratio

- Estimation of the ratio based on observed TSS loads
Field and Non-Field Ratio

- Assumptions for estimating field and non-field erosion
  - Upstream NFE is marginal
  - Downstream NFE = (L_{MCES} - L_{154}) - FE_{154}
  - Mixed rural FE is consistent watershed wide
  - Urban FE was assumed equal to that in Shingle Creek

- TSS contributions from field and non-field erosion
  - 14.5% from field erosion
  - 85.5% from non-field erosion
The ratios in other Lower MN River basins using Fingerprint tests:

- Average: 14%
- Carver Creek: 10%
- Bevens Creek: 18%

* Provided by MN Science Museum
St. Croix Watershed Research Station
Monthly TSS Calibration

- Observed Watershed Load
- Simulated Field Erosion
- Simulated Watershed Load

Monthly TSS Load (t) vs. Month
Annual TSS Calibration

Measured vs. Simulated Annual TSS Load (t) from 1997 to 2008.
# TSS Calibration Statistics

<table>
<thead>
<tr>
<th></th>
<th>OM (t)</th>
<th>RD (%)</th>
<th>RMSD</th>
<th>IA</th>
<th>NSCE</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td>108.5</td>
<td>1.0</td>
<td>97.0</td>
<td>0.91</td>
<td>0.60</td>
<td>0.78</td>
</tr>
<tr>
<td>Annually</td>
<td>1041.4</td>
<td></td>
<td>127.6</td>
<td>0.97</td>
<td>0.90</td>
<td>0.80</td>
</tr>
</tbody>
</table>
Visualization of Watershed modeling

Credit River Watershed Simulation by SWAT

Flow (cms) vs Date/Time

TSS Loading (tons) vs Date
Surface Runoff and Water Yield by Land Use

- Surface Runoff
- Total Water Yield

Land Use: Alfalfa, Urban, Corn, Forest, Hay/Oak, Pasture, Soybean, Sand Mining, Wetland
TSS Loading by Area and Reach

- Field erosion contributes marginal TSS load to the river (0.05 - 51.9 t/yr)
- Non-field erosion is major TSS source to the river
  - Significant TSS loads from lower reaches (32.6 t/yr - 143.2 t/yr).
  - No or less non-field erosion from upstream reaches
TSS Balance in Watershed

Field TSS load (83%)
5870 t
93% removal by buffers, wetlands & ponds within subbasins
380 t
50% settled in channels and lakes
190 t
- 14.5% from field
- 85.5% from non-field at MCES gage
1030 t

Non-Field TSS load (17%)
1180 t
29% settled in channels and lakes
840 t

Total:
11770 t
BMP Scenarios

• Potential BMPs for Credit River watershed
  – Conservation tillage
  – Filter Strips
  – Infiltration basins
  – Wetland restoration
  – Land use transfer
  – Bank and non-field erosion control
  – Combinations of field and non-field erosion control BMPs
  – 2030 conditions
Questions

Hong Wang
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Memorandum

To: File

From: Paul Nelson, Scott WMO Administrator; Jaime Rockney, Scott SWCD; Melissa Bokman, Senior Water Resources Planner

Subject: Credit River Turbidity TMDL – QA/QC Field Results

Date: May 7, 2010

This memorandum presents the results of the analysis of portions of the QAQC program for the Credit River Turbidity TMDL. Results are summarized for Precision, Accuracy, Completeness and Representativeness.

Precision

Over the course of the study, field duplicates were collected for the analysis of precision and assessment of whether or not there were systematic problems with the collection of samples. The measurement of precision used was relative percent difference (RPD). Relative percent difference is expressed as a percent and is calculated as:

\[ \text{RDP} = \left( \frac{\text{Sample Value} - \text{Duplicate Value}}{\left( \frac{\text{Sample Value} + \text{Duplicate Value}}{2} \right)} \right) \times 100 \]

The data quality objectives (DQO) for various parameters with respect to RPD are shown in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>RPD Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>10%</td>
</tr>
<tr>
<td>TSS</td>
<td>30%</td>
</tr>
<tr>
<td>VSS</td>
<td>30%</td>
</tr>
<tr>
<td>TP</td>
<td>30%</td>
</tr>
<tr>
<td>TDP</td>
<td>30%</td>
</tr>
<tr>
<td>Chloride</td>
<td>20%</td>
</tr>
<tr>
<td>Chl-a</td>
<td>30%</td>
</tr>
<tr>
<td>Transparency Tube</td>
<td>10%</td>
</tr>
<tr>
<td>Turbidity</td>
<td>30%</td>
</tr>
</tbody>
</table>
Duplicate samples were collected on 6 dates in 2008 and 4 dates in 2009. Duplicate samples collected on these dates were analyzed for the full suite of parameters thereby representing hundreds of duplicate analyses.

Individual analyses from the Scott WMO sites that exceeded the RPD data quality objectives are shown in Table 2. In general, results of the assessment of precision using duplicates were good and no systematic problems attributable to sampling were identified. Individual duplicates occasionally exceeded the data quality objective for specific parameter, but other parameters from the same sample meet RPD objectives. In addition, most of the exceedences of the data quality objective were at low concentrations where resolution of the analysis was the cause of the exceedence. No individual analyses were rejected.

Analysis of precision of flow measurements through the completion of duplicate flow gauging measurements is presented in a separate memorandum (Credit River Watershed Turbidity TMDL – Flow Value Development). Over the course of the project a number of duplicate flow measurements were completed. All of the duplicate measurements were in close agreement with each other.

### Table 2. Analyses Exceeding Relative Percent Difference (RPD) Data Quality Objectives

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Parameter</th>
<th>RPD %</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>C68</td>
<td>4-22-08</td>
<td>Nitrogen, Total Nitrate_mg/L</td>
<td>28%</td>
<td>0.04</td>
<td>0.03</td>
<td>Accept results; exceedence due to resolution</td>
</tr>
<tr>
<td>C68</td>
<td>4-8-09</td>
<td>Phosphorus, Total_mg/L</td>
<td>43%</td>
<td>.2</td>
<td>.129</td>
<td>Accept results; other analyses meet objectives at the site on that date</td>
</tr>
<tr>
<td>154</td>
<td>5-6-08</td>
<td>Turbidity NTRU</td>
<td>40%</td>
<td>3</td>
<td>2</td>
<td>Accept results; exceedence due to resolution</td>
</tr>
<tr>
<td>154</td>
<td>6-17-08</td>
<td>Turbidity NTRU</td>
<td>40%</td>
<td>6</td>
<td>4</td>
<td>Accept results; exceedence due to resolution</td>
</tr>
<tr>
<td>154</td>
<td>5-5-09</td>
<td>Solids, Volatile Suspended_mg/L</td>
<td>67%</td>
<td>~1</td>
<td>~2</td>
<td>Accept results; exceedence due to resolution</td>
</tr>
<tr>
<td>154</td>
<td>8-11-09</td>
<td>Nitrogen, Total Nitrate_mg/L</td>
<td>18%</td>
<td>.36</td>
<td>.3</td>
<td>Accept results; exceedence due to resolution</td>
</tr>
<tr>
<td>154</td>
<td>8-11-09</td>
<td>Solids, Volatile Suspended_mg/L</td>
<td>40%</td>
<td>3</td>
<td>2</td>
<td>Accept results; exceedence due to resolution</td>
</tr>
<tr>
<td>154</td>
<td>9-9-09</td>
<td>Chlorophyll-a, Trichromatic Uncorrected_ug/L</td>
<td>32%</td>
<td>9.4</td>
<td>6.8</td>
<td>Accept results; close to objective</td>
</tr>
<tr>
<td>154</td>
<td>9-9-09</td>
<td>Solids, Volatile Suspended_mg/L</td>
<td>67%</td>
<td>2</td>
<td>1</td>
<td>Accept results; exceedence due to resolution</td>
</tr>
<tr>
<td>154</td>
<td>9-9-09</td>
<td>Suspended Solids_mg/L</td>
<td>40%</td>
<td>4</td>
<td>6</td>
<td>Accept results;</td>
</tr>
</tbody>
</table>
exceedence due to resolution

**Accuracy**
Accuracy for the field measurements of water quality parameters was controlled by on-going calibrations of various meters used. The Hydrolab MS5 and Quanta multi-parameter sondes used for grab sampling, synoptic and continuous in-situ monitoring were calibrated in the office on a regular basis. The parameters calibrated included dissolved oxygen, pH, specific conductivity and turbidity.

Dissolved oxygen was calibrated using an air-saturated water method and was done every time the sonde is used. Specific conductance was calibrated using a 1413µS standard on a weekly basis, if needed. Turbidity was calibrated using the Hach StablCal <0.1 and 100 NTU standards on a monthly basis. pH was routinely checked and calibrated using a 7 and 10 pH standard weekly, if needed.

A Hach 2100P turbidimeter was used with the Hydrolab Quanta and was calibrated as needed, following the same protocols as mentioned above. However, the Quanta dissolved oxygen was calibrated using the water-saturated air method.

The calibration results were logged and entered into the METC Water Quality Database and the data was flagged accordingly.

**Completeness**
Completeness was assessed as the number of samples and/or monitoring events planned versus the number completed. Results are presented in Table 3. In general data collection was completed as planned. The exception was the number of samples which was limited to less than plan by the lack of water, intermittent flow at some sites, and dry conditions over the sampling period.

<table>
<thead>
<tr>
<th>Completeness</th>
<th>Planned</th>
<th>Completed</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synoptics</td>
<td>6</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Sonde Deployments</td>
<td>4</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Samples: 25/site/1st yr; 16/site/2nd year</td>
<td>50</td>
<td>42</td>
<td>32</td>
</tr>
<tr>
<td>Flow measurements: 7-8/site/yr</td>
<td>14-16</td>
<td>14-16</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 3: Environmental Field Measurement Completeness
Representativeness
Representativeness of the samples collected to the flow conditions over the monitored years was evaluated by plotting the sample collection dates on the hydrographs for sites with continuous flow records. These hydrographs are attached. Review of the hydrographs and sample collection dates show that samples collected are representative of the range of flows observed. They are also spread throughout the year and include snow melt samples. With respect to the hydrographs it should be noted that large parts of the 2008 hydrographs are predicted based on a relationship developed between stage at the two sites and the MCES site located near the mouth of the river. For 2009 flows could not be predicted to fill in those parts of the year where stage was not measured at the two sites, because there were problems at the MCES site.
Memorandum

To: Brooke Asleson, MPCA

From: Paul Nelson, Natural Resource Program Manager

Subject: Credit River Turbidity Delisting – TSS Data

Date: April 13, 2010

Per your request I have analyzed the TSS data for the Credit River. This analysis is presented below. Unfortunately the TSS data suffers from some of the same problems as the turbidity data with respect to sampling protocol biasing higher flows.

To complete the analysis I used the Metropolitan Council database. The data you sent me from MPCA previously only had data for two out of the ten most recent years, but I knew that the Metropolitan Council has been monitoring every year.

TSS/Turbidity Relationship
Analysis by the Metropolitan Council (2009) found that a TSS concentration of 139 mg/L was equivalent to 25 NTU turbidity (Metropolitan Council’s Impaired Waters Project: Development of TSS/Turbidity Relationship, July 30, 2009).

Credit River TSS Distribution Analysis
Data was analyzed using the JMP Statistical software package. Source of the data is the Metropolitan Council. Data from 1993 through 2000 is from a station located at river mile 0.6. The monitoring site was moved in 2001 such that data from 2001 through 2009 is from river mile 0.9. The analysis presented below is completed separately for each site. In addition analysis of each site is completed both with and without composite samples included. It is known that inclusion of the composite samples creates a biased result weighted more toward high flows and corresponding high TSS and turbidity, as should be represented for comparison with a percent exceedence based standard. It is also possible that removal of these results could bias the result low since the composite samples represent storms and higher flow periods.

Review of the results shows that TSS is generally lower in the more recent data than the older data. In addition the more recent data shows that TSS exceeds 194 mg/L 10% of the time and thus the 139 mg/L TSS surrogate for turbidity of 25NTU when the composite samples are included. Without the composite samples the 10% exceedence level is 47 mg/L which is well below the 139 mg/L TSS surrogate. As discussed above the data set with composite samples is biased high with respect to representing the actual distribution and central tendency, while the data without the composites may be biased low. The actual distribution and central tendency is probably somewhere in between. The best representation of the distribution of turbidity is the
data from the continuous turbidimeter which as previously analyzed and reported exceeded the 25NTU turbidity standard only 1.2% of the time over 2008 and 2009.

### TSS Distributions Credit River (mg/L)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>90%</td>
<td>242</td>
<td>165</td>
<td>194</td>
<td>47</td>
</tr>
<tr>
<td>75%</td>
<td>114</td>
<td>49</td>
<td>62</td>
<td>18</td>
</tr>
<tr>
<td>50%</td>
<td>42</td>
<td>16</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>25%</td>
<td>14</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>10%</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Credit River
By PAN
4/12/2010
1993-2000

Distributions
TSS

### Quantiles

- 100.0% maximum: 1800.0
- 99.5%: 1788.4
- 97.5%: 645.5
- 90.0%: 242.3
- 75.0% quartile: 114.5
- 50.0% median: 42.5
- 25.0% quartile: 13.8
- 10.0%: 4.0
- 2.5%: 2.0
- 0.5%: 1.0
- 0.0% minimum: 1.0

### Moments

- Mean: 102.00495
- Std Dev: 187.17655
- Std Err Mean: 13.169696
- upper 95% Mean: 127.97344
- lower 95% Mean: 76.036463
- N: 202
Credit River
By PAN
4/12/2010
1993-200
Without Composite Samples

Distributions
TSS

Quantiles
100.0% maximum 730.00
99.5% 730.00
97.5% 398.13
90.0% 165.50
75.0% quartile 48.75
50.0% median 16.00
25.0% quartile 5.00
10.0% 2.50
2.5% 2.00
0.5% 1.00
0.0% minimum 1.00

Moments
Mean 52.432692
Std Dev 105.20786
Std Err Mean 10.31648
upper 95% Mean 72.892997
lower 95% Mean 31.972388
N 104
Credit River
By PAN
4/13/2010
2001-2009

Distributions
TSS

Quantiles

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>100.0%</td>
<td>maximum</td>
<td>1860.0</td>
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<tr>
<td>99.5%</td>
<td></td>
<td>1661.9</td>
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<td>97.5%</td>
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<td>553.0</td>
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<tr>
<td>90.0%</td>
<td></td>
<td>194.0</td>
</tr>
<tr>
<td>75.0%</td>
<td>quartile</td>
<td>62.3</td>
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<td>50.0%</td>
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<td>25.0%</td>
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<tr>
<td>10.0%</td>
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<td>1.0</td>
</tr>
<tr>
<td>2.5%</td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>0.5%</td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>0.0%</td>
<td>minimum</td>
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Moments

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
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<tbody>
<tr>
<td>Mean</td>
<td>66.038462</td>
</tr>
<tr>
<td>Std Dev</td>
<td>162.00528</td>
</tr>
<tr>
<td>Std Err Mean</td>
<td>10.590617</td>
</tr>
<tr>
<td>upper 95% Mean</td>
<td>86.904069</td>
</tr>
<tr>
<td>lower 95% Mean</td>
<td>45.172854</td>
</tr>
<tr>
<td>N</td>
<td>234</td>
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</table>
Credit River
By PAN
4/12/2010
2001-2009
Without Composite Samples

Distributions
TSS

Quantiles

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Value</th>
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Moments

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Memorandum

To: Louise Hotka, Minnesota Pollution Control Agency (MPCA)

From: Paul Nelson, Natural Resource Program Manager; Melissa Bokman, Sr. Water Resources Planner

Subject: Credit River Turbidity Delisting

Date: April 6, 2010

Cc: Brooke Asleson, MPCA

This memorandum provides justification and conveys a request to delist the Credit River for impaired aquatic life due to turbidity. This request was authorized by the Scott County Board on April 5, 2010. Also attached is a CD with the data and analyses presented in this memo. The Credit River was originally included on the 303(d) impaired waters list for turbidity, as described below:

- AUID (Assessment Unit ID#) – 07020012-517
- Reach name / descriptions – Credit River: Headwaters to Minnesota River
- Pollutant / Impairment – Turbidity

Background Information
The data used for the 2002 original listing came from the Metropolitan Council monitoring site of river mile 0.6. Analysis of this data shows that the standard was exceeded about 24% of the time (Figure 1). However, more recent continuous turbidity probe data for a two year period of 2008 and 2009 shows that the turbidity level for which 10% of values exceed the standard is 8.3 NTU after conversion from FNU units to NTU units (Table 1); and further that the percent exceedence of the 25 NTU standard is only 1.2%. It has been hypothesized for this data on the Credit River and for other data (Nine Mile Creek; Greg Wilson, 2009) that differences in the results for continuous probe data and Metropolitan Council laboratory sample data could be due to the following:

1. That the more recent continuous probe readings were taken during a drier period where there were lower flows where lower turbidity results typically occur, and since the continuous data only represents two years, the data may not be as representative of long term conditions as the lab sample data.
2. The analyses using the Metropolitan Council laboratory sample results are biased high since the monitoring program under which the samples were collected was biased toward high flows under which higher turbidity results typically occur.
3. Changes in the watershed characteristics.
Each of these possibilities is evaluated separately below. However, an analysis is first presented showing how the various turbidity units (FNU, NTRU, NTU) were all converted to a common unit, NTU.

Another confusing item is the turbidity distribution in Table 1 for the more recent reporting cycle (e.g., 10 years) from the MPCA data set. The data in the MPCA data set comes from the Metropolitan Council, yet comparison with almost the same 10 year period using Metropolitan Council data gives different results (Table 1). Comparison of the two data sets showed that the MPCA data set had removed the composite sample results collected by Metropolitan Council – otherwise the data is identical. Granted the composite samples are not discreet measurements, but they are how the Metropolitan Council tries to represent conditions under the highest flows. Removing these could be biasing the data set in the opposite direction. However, values predicted below where the affect of flow is considered are lower than the levels from the “groomed” MPCA data set. To make this a little more confusing, the MPCA data set labels the data received from the Metropolitan Council as having units of NTU, but it is known that since March 2006 Metropolitan Council has a meter that reads in NTRU. Conversion from NTRU to NTU for this data will further lower the levels compared to the standard.

**Turbidity Units**

There is some confusion between the various data sets regarding the turbidity unit. This is due to the meter that was used. Up until March 8, 2006 the Metropolitan Council Laboratory used a meter that provided results in NTU. Starting March 23, 2006, however, the laboratory changed meters to one that presented results as NTRU. The continuous probe uses a slightly different methodology which provides results in units known as FNU. The following provides a description of the conversions used.

- Continuous probe results in FNU were first converted to NTRU, and then to NTU. To convert from FNU to NTRU dates for grab samples evaluated in the lab were matched with same time and date results from the field probe to develop the regression equation in Figure 2. Results in NTRU were then converted to NTU using the equation developed by Johnson (2007).

  \[
  \text{FNU to NTRU equation: } \text{NTRU} = 0.6574 \times \text{FNU} + 0.6703
  \]

- Metropolitan Council laboratory sample results in NTRU were converted to NTU using the equation developed by Johnson (2007).

  \[
  \text{NTRU to NTU equation } \text{NTU} = 10^{(-0.0734+0.926\times \text{LOG(NTRU)})/1.003635}
  \]

**Affects of Flow**

Flow distributions for the long term, a ten year period, and for 2008 are shown in Table 2. Unfortunately reliable flow data was not available from the Metropolitan Council for 2009. Rainfall at Chanhassen was 22.4 inches and 29.8, respectively for 2008 and 2009. Average annual rainfall is about 29 inches. Thus, the two year period with the continuous data represents one dry year and one year close to the average. The flow distributions in Table 2 show that the 10% to 90% range is fairly consistent across the long term, recent 10 years and then 2008. However, the median flow and the extreme high flows are lower in the more recent data sets. Therefore, an analysis was completed using a relationship developed between flow and laboratory turbidity to all the MCES flow records to evaluate whether the standard would have been exceeded if monitoring had been completed on a continuous basis.
The first step of this analysis was to show that there are relationships between flow and turbidity. Figure 3 shows the relationship between continuous data for mean daily flow and mean daily turbidity. Figure 4 shows a similar relationship between lab turbidity sample results (converted to NTU) and flow. Using the equation from Figure 3 gives a turbidity value of 8.6 NTU at the 90% flow value for the 10 year flow record. Using the equations for Figure 4 gives turbidity values of 11 NTU and 18.4 NTU for the 90% flow value of the 10 year record, based on the regression and the upper 95% confidence interval, respectively. This analysis confirms that the 25 NTU standard will be meet 90% of the time with 95% confidence, based on long term flow duration characteristics.

Watershed Changes
Much has occurred in the watershed since the original listing in that used data from 2000 and earlier. This portion of Scott County was one of the fastest growth areas in the Country during that period, and into the early part of the 2000s. In addition, communities were just learning how to implement construction erosion control programs. More recent data could reflect lower amount of construction erosion because: 1) the City of Savage, the Credit River Township, and Scott County now all have robust construction erosion control programs; 2) a decrease in construction activity; and 3) the large lot development that has occurred in Credit River Township has come at the expense of agriculture. A reduction in construction activity is demonstrated by the fact that in 1998 and 1999 the City of Savage and Credit River Township combined had over 1,000 new construction building permits. Over the course of 2008 and 2009 this number has dropped to 151. The net result of the third item is that there has been a significant reduction in the amount of agricultural land in the watershed and an increase in permanent vegetation on the large lots.

The City of Savage, Scott SWCD, and Scott WMO have also completed a number of projects in the watershed in recent years. Some of these listed below and are shown on Figure 5. Some these are rather significant as shown in Figures 6, 7, and 8.

- Grassed Waterway (1999)
- City of Savage Stream Channel Stabilization (1999)
- City of Prior lake Raingardens (2008 & 2009)
- City of Savage Stream Channel Stabilization (2007)
- Deb Atchison Cedar Tree Revetment (2008)
- Deb Atchison Cedar Tree Revetment (2008)
- Scott Allison Cedar Tree Revetment (2008)
- City of Savage Environmental Learning Center (2008)
- City of Savage Grade Stabilization (2010)
- City of Savage Hidden Valley Park Raingardens (2008)

Conclusions

1. The original decision to list was based on a set of data collected using a sampling protocol that was designed for a different purpose, and that this data set when used for the purposes of making a decision on regarding listing is biased toward higher turbidity results.

2. Correcting the biases in the original data, and more recent data, confirms that the 25 NTU standard will be meet 90% of the time with 95% confidence.
3. More recent continuously collected turbidity data from 2008 and 2009 shows that 25 NTU standard is being met more than 98.8% of the time.
4. Changes have occurred in the watershed since the original listing that should have reduced erosion and sediment transport, and thus turbidity.
5. The macroinvertebrate community (organisms that do not have a backbone) in the river appears to be healthy.

References
Figure 1: Credit River Turbidity Distribution Using MPCA Data for 2000 Reporting Cycle

Quantiles

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Moments

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Figure 2: Regression between field and laboratory turbidity for the Credit River 0.9 Site (2008 and 2009)

![Credit '08-'09 METC Turbidity](image)

Figure 3: Regression between continuous mean daily turbidity readings and flow for the Credit River

![Credit River 2008 Mean Daily DTS-12 Turbidity vs. Flow](image)
Figure 4: Regression between laboratory turbidity sample analyses and flow from the Credit River

Credit River @ 0.6/0.9 Lab Turbidity vs. Flow, 1993-2008

Note equation for upper 95% CI based on log 10 transformed data. Thus, need to use antilog with the equation.
Figure 5: Recent Watershed Projects
Figure 6: City of Savage Grade Stabilization (2010)

City of Savage Grade Stabilization

<table>
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<th>During Construction</th>
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</table>

Figure 7: City of Savage Stream Channel Stabilization (2007)

City of Savage Stream Channel Stabilization

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<th>Before Construction</th>
<th>During Construction</th>
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Figure 7:
City of Savage Stream Channel Stabilization (1999)
### Table 1: Credit River Turbidity Distributions For Various Data Sets and Time Periods

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<td>FNU(1)</td>
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(1) 2008 and 2009 data from MCES  
(2) Converted from FNU using y = 0.6574x + 0.6703 to get to NTRU and then equation by Johnson (2008) & converting NRTU to NTU  
(3) 1999 through 2009 NTRU converted to NTU using equation by Johnson (2007)  
(4) NTRU converted to NTU using equation by Johnson (2007)  
(5) Labeled as 2000 Assessment reporting cycle  
(6) Most recent 10 years 1999 through 2008  
(7) Unit as presented in the MCPA data set, however, since this data was originally collected by MCES the unit is actually NTRU for data since March 2006.

### Table 2: Credit River Flow Distributions

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(1) 1989 through 2008  
(2) 1999 through 2008