

# **Lower Minnesota River Oxygen Dynamics Assessment**

## **APPENDIX E**

### **SEDIMENT NUTRIENT FLUX PILOT STUDY**



## SEDIMENT NUTRIENT FLUX LOWER MINNESOTA RIVER PILOT STUDY

### BACKGROUND

As part of their comprehensive study of water quality on the lower Minnesota River, MCES contracted with the U.S. Army Engineer Research and Development Center's Eau Galle Aquatic Ecology Laboratory in Spring Valley, Wisconsin, to assess the nutrient flux potential of the sediment bed of the Minnesota River. The Eau Galle laboratory is using a field core/laboratory method to accomplish their objectives, having collected numerous sediment cores throughout the lower Minnesota River study reach. Since HydrO<sub>2</sub>'s *in situ* SOD chamber method incorporates the capability to acquire *in situ* sediment nutrient flux rates, MCES requested that HydrO<sub>2</sub> propose for their consideration the addition of flux measurements during the second optional survey. Because of several environmental, analytical, and logistical factors that affect the potential for success of *in situ* sediment nutrient flux measurements, which will be discussed below, HydrO<sub>2</sub> proposed a cooperative no-cost pilot assessment at one station during the September 2006 study in order to evaluate use of the *in situ* chamber method on the lower Minnesota River. HydrO<sub>2</sub> would conduct the field operations and sampling and MCES would provide the laboratory analysis.

### STUDY APPROACH

Summarily, the measurement of sediment nutrient flux using the *in situ* chamber method parallels that of the *in situ* SOD method described in Appendix G (Study Plan). It involves the deployment of the chambers on the sediment bed, with a diver assuring effective chamber-to-substrate seals, and then extracting water samples (usually initial and final) from each chamber over a time period, followed by laboratory analysis to measure the change in nutrient concentrations between samples from the same chamber. As with SOD measurements, a "blank" chamber, filled with bottom water but isolated from the sediment, is used to adjust the sediment contact chamber rates for water column effects. Based on experience, several environmental, analytical, and logistical factors govern the potential for success of *in situ* sediment nutrient flux measurements. Based on the chamber surface area to volume ratio of HydrO<sub>2</sub>'s *in situ* SOD chambers, if flux rates are slow and low level analytical methods are not used, then considerable incubation time on station may be required in order to be able to detect a measurable change between the initial and final samples from which to calculate nutrient flux. Logistically, remaining on station for several hours in a flowing stream increases the potential for erosion and compromising of the chamber-to-substrate seal thereby aborting the experiment due to intrusion of "new" water into the chamber. Accordingly, monitoring of the DO decay rate over a very long time period (several hours) coupled with diver inspection of chamber seals is required. Measurements initiated under aerobic conditions must be concluded prior to anoxic conditions occurring within the chamber so frequent monitoring of the DO concentration within each chamber is essential. Additionally, incubation of chambers for the entire day, and overnight in some cases, potentially exposes the field crews and equipment to hazards of severe weather and night time barge traffic.

Based on the above factors, MCES and HydrO<sub>2</sub> agreed that for the trial, sediment nutrient flux measurements would be incorporated with SOD measurements at station RM-11.2 in the September 2006 study. Chamber incubation was initiated as early as practical during the morning of September 4, 2006, allowing time for transit to the station and effective 4-point anchoring, and concluded before dark. This approach resulted in approximately seven hours of chamber incubation, recognizing that the success of the trial would have to await laboratory analysis.

## RESULTS

Frequent monitoring of DO concentrations within the *in situ* chambers is a requirement of both SOD and sediment nutrient flux measurements. As stated earlier, nutrient flux sampling initiated under aerobic conditions should conclude under aerobic conditions. During the pilot study at RM-11.2, DO concentrations within the *in situ* sediment chambers ranged from 5.1 mg/L at initial sampling to a low of 3.15 mg/L at final sampling, a result of the sediment oxygen demand within each chamber.

Table E-1 presents the condensed analytical results and computations of sediment nutrient flux for the total (unfiltered) nutrient species of nitrogen (N) and phosphorus (P), while Table E-2 presents the dissolved (filtered) components, all corrected for water column processes. With the exception of nitrite-nitrate nitrogen ( $\text{NO}_2 + \text{NO}_3\text{-N}$ ), which typically exhibits negligible change, the sediment bed of the Minnesota River at RM-11.2 served as a source (positive flux) of nutrients during the September 2006 assessment. Results for total dissolved phosphorus (TDP) are presented with the qualification that data for this parameter are questionable based upon the analytical results associated with the final "blank" sample for TDP, which indicated a substantial (more than an order of magnitude) increase in TDP from initial to final. Based on  $\text{HydrO}_2$  experience with other sediment nutrient flux sampling, such a remarkable change is not typical, and in the case of this study, is highly inconsistent with the results for dissolved orthophosphate (D-Ortho-P) from the same chamber. Accordingly, if the final D-Ortho-P concentration of 0.017 mg/l in the blank chamber is arbitrarily substituted for the highly questionable value, then the flux of TDP would, likewise, be consistent with findings relative to D-Ortho-P, with a positive flux from sediment to the water column (Table E-2).

The role that sediment nutrient flux potentially plays in nutrient loadings to the Minnesota River is illustrated by extrapolating chamber area results to an arbitrarily assumed river width of 100 meters for a distance of one kilometer (100,000 square meters), resulting in loadings of 4813 gm/day for Total Ammonia-nitrogen and 762 gm/day for Total Phosphorus. Obviously, extrapolations in this manner are highly presumptive and speculative based on the limited extent of the pilot study and are therefore presented only for speculative thought.

**TABLE E-1**  
**SEDIMENT NUTRIENT FLUX DATA AND RATES**  
**STATION RM-11.2, LOWER MINNESOTA RIVER**  
**September 4, 2006**

**LAB/FIELD DATA**

Chamber	Collection Time	NH3	TKN	NO2-NO3	T-P	T-Ortho P
Rep		mg/l	mg/l	mg/l	mg/l	mg/l
O Initial	951	0.13	1.2	0.64	0.133	0.024
O Final	1640	0.15	1.1	0.65	0.1	0.017
1 Initial	1002	0.15	1.2	0.64	0.141	0.022
1 Final	1645	0.17	1.1	0.58	0.121	0.02
2 Initial	1010	0.14	1.2	0.64	0.144	0.023
2 Final	1655	0.22	1.3	0.58	0.118	0.024
3 Initial	1016	0.15	1.3	0.65	0.138	0.021
3 Final	1700	0.28	1.2	0.56	0.112	0.02

**FLUX (mg/l)**

Chamber	Incubation Period	NH3	TKN	NO2-NO3	T-P	T-Ortho P
O	409	0.02	-0.1	0.01	-0.033	-0.007
1	407	0.02	-0.1	-0.06	-0.02	-0.002
2	405	0.08	0.1	-0.06	-0.026	0.001
3	404	0.13	-0.1	-0.09	-0.026	-0.001

**NET SEDIMENT FLUX (GM/M2/DAY)**

Chamber		NH3	TKN	NO2-NO3	T-P	T-Ortho P
1		2.34E-17	0	-0.05907	0.01097	0.004219
2		0.05088	0.1696	-0.05936	0.005936	0.006784
3		0.093511	-1.9E-16	-0.08501	0.005951	0.005101
	<b>Average &gt;&gt;&gt;</b>	<b>0.04813</b>	<b>0.056533</b>	<b>-0.06781</b>	<b>0.007619</b>	<b>0.005368</b>

**NOTE: Positive Nutrient Flux rate is From Sediments To The Water Column**

For a stream bed width of 100m, bed area for a reach of one km = 100,000sqm

Nutrient Release to Water Column for this one kilometer reach is;

**4813 gm/day of Total NH3**

**762 gm/day of Total P**

**TABLE E-2**  
**SEDIMENT NUTRIENT FLUX RATES**  
**DISSOLVED NUTRIENT FRACTIONS**  
**STATION RM-11.2, MINNESOTA RIVER**  
**September 4, 2006**

**LAB/FIELD DATA**

Chamber	Collection Time	D-TKN	D-P	D-Ortho P
Rep		mg/l	mg/l	mg/l
O Initial	951	1.4	0.023	0.024
O Final	1640	1.3	<b>0.017</b>	0.017
1 Initial	1002	1.1	0.021	0.022
1 Final	1645	1.1	0.025	0.02
2 Initial	1010	1.4	0.022	0.023
2 Final	1655	1.3	0.026	0.024
3 Initial	1016	1.4	0.049	0.021
3 Final	1700	1.7	0.082	0.02

**FLUX (mg/l)**

Chamber	Incubation Period	D-TKN	D-P	D-Ortho P
O	409	-0.1	-0.006	-0.007
1	407	0	0.004	-0.002
2	405	-0.1	0.004	0.001
3	404	0.3	0.033	-0.001

**NET SEDIMENT FLUX (GM/M2/DAY)**

Chamber		D-TKN	D-P	D-Ortho P
1		0.084383	0.008438	0.004219
2		0	0.00848	0.006784
3		0.34004	0.033154	0.005101
	<b>Average &gt;&gt;&gt;</b>	<b>0.141474</b>	<b>0.016691</b>	<b>0.005368</b>

**NOTE: Positive Nutrient Flux rate is From Sediments To The Water Column**

**NOTE: Reported value for D-P in RepO final was 0.126, an assumed value of 0.017 was used in these calculations**