SALT CREEK / DUPAGE RIVER WORK GROUP

# STREAM DISSOLVED OXYGEN IMPROVEMENT FEASIBILITY STUDY FOR SALT CREEK AND EAST BRANCH OF THE DUPAGE RIVER

## DATA REPORT

## 2007 SOD MEASUREMENT SURVEY SALT CREEK

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# TABLE OF CONTENTS



# LIST OF TABLES



# LIST OF FIGURES

## 1.0 Objective

The purpose of this field survey was to supplement the sediment oxygen demand (SOD) data collected in 2006 which provided independent estimates of the SOD that were being modeled for dissolved oxygen in the Salt Creek as part of the Stream Dissolved Oxygen Improvement Feasibility Study for Salt Creek and East Branch of the DuPage River. It was substantiated, during the modeling analysis of Salt Creek stream DO improvement alternatives, that more SOD data in the vicinity of dams were needed to better understand the effects of dam removals. The survey was conducted spanning from July 24 to August 1, 2007 at SOD stations upstream and downstream of each of three dams in Salt Creek: Oak Meadows Golf Course Dam, Old Oak Brook Dam and Graue Mill (Fullersburg) Dam. The field surveys were performed concurrently with the continuous DO monitoring coordinated by the Conservation Foundation. As water temperature affects SOD, the SOD survey period was selected during high water temperatures to be consistent with the 2006 SOD survey and the modeling evaluations of the TMDL study of Salt Creek (approximately 76 $^{o}$F or 24.4 $^{o}$C).

## 2.0 Method

The in-situ method, which by name means the measurements are made in the native location rather than in a laboratory, was employed (Murphy and Hicks 1986, refer to Attachment 1 of this report). SOD measurement chambers designed by EPA Region 4 were used in conjunction with circulating water pumps and DO probes as described in Murphy and Hicks 1986. See Figure 1 for a diagram of In-Situ SOD Measurement Chamber. Two SOD chambers were placed in contact with the bottom sediments to measure the total DO depletion rate. A "blank" chamber that is enclosed at the bottom was used to measure the DO depletion attributable to the water processes, which are the biochemical oxygen demand (BOD) exertion and biotic respiration. In general, the chambers, which are opaque, were not placed within the photic zone where photosynthesis occurred. Light and dark BOD bottles were also deployed as a backup to the "blank" chamber and to measure photosynthetic effects, if any. The SOD rate is then calculated using the following equation:

$$SOD = (V/A) * (b_1 - b_2) / 1000$$

where SOD = sediment oxygen demand rate (g/m$^2$/day)
$b_1$ = rate of change of DO concentration in the SOD chamber (mg/L/d)
$b_2$ = rate of change of DO concentration in the "blank" chamber (mg/L/d)
V = volume of chamber (L)
A = area of chamber (m$^2$)

The three chambers were transported by boat (see Figure 2) to the designated SOD station for deployment by the sampling crew. Water depth recorded at the stations varied between 0.9 ft and 2.5 ft. While the chamber was being lowered to the bottom, water and trapped air was vented from the open ports on the top of the chambers. Ambient bottom water was ultimately enclosed in the chambers for the SOD measurements. The enclosed chambers were left for a minimum of

15 minutes while any resuspended sediment settled to the bottom before the DO measurements began. DO and temperature in each of the three chambers were measured every ten minutes for duration of at least 1.5 hours. The DO meter/probes used with the SOD chambers were YSI models 550 and Hach HQ40D with LDO.

### 2.1 Quality Control

DO probes utilized in the two test chambers were of a newer design than those used in 2006, called luminescence dissolved oxygen (LDO). These probes use an entirely different method of measuring DO than the membrane type probes, are very stable, and require calibration approximately once a year. The probes were initially calibrated using an air saturated water sample. In the field, a sample of air saturated DI water was measured with the LDO probe and the YSI meter was calibrated against this reading. DO readings on the three DO meters/probes at each sampling station were checked by the field crew for agreement within 0.5 mg/L. The determination of SOD is derived from the relative changes in DO and not the absolute value, nonetheless, the accuracy of the LDO probes was consistent with saturated values read from a table.

DO meters/probes were calibrated using the normal air calibration procedure. DO readings on the three DO meters/probes at each sampling station were checked by the field crew for agreement within 0.5 mg/L. In addition, a comparative calibration was generated using Winkler titration and DO probe readings of a de-ionized water sample. The initial and final DO in the light and dark bottles were measured by the YSI DO probe (referred to as Probe 3) as the Hach probes have a large diameter that would not fit in the BOD bottle.

## 3.0 Sampling Stations

The bottom substrate composed of fine grained sediments (clay, silt and sand) are conducive to measuring SOD; coarse materials (gravel, cobbles and boulders) are not because it is difficult to seal the bottom of the chamber. High SOD rate is associated generally with a high organic content of the sediment. Slow moving reaches of the river are areas where fine-grained, organic sediments are likely to be found. The impoundments and pools formed by dams and other obstructions (e.g., debris) were identified by the reconnaissance survey (Task 1) and the helicopter fly-over DVD. The total of 12 sampling stations was designated in the vicinity of three dams in Salt Creek for in-situ SOD measurement. A set of two stations in the upstream impoundment and two stations downstream of each dam were selected as shown in Figure 3. The second station downstream of the Old Oak Brook dam (Station H) is actually located in the impoundment of the Graue Mill (Fullersberg) dam; hence there are three stations in this impoundment. Table 1 lists sampling locations (A to L stations), descriptions and river miles in Salt Creek. When the field crews arrived at each station, the river bottom was viewed or probed to estimate the percent bottom coverage of fine-grained sediment. The width and depth of the river were also measured and recorded. The fine-grained sediment area was identified as a suitable location for deployment of SOD measurement chambers.

## 4.0 Field Measurements

As stated previously, elevated water temperature was preferred for these measurements to reduce the modeling uncertainty associated with applying a temperature adjustment coefficient based on the literature. Field measurements were performed on five days during a period of July 24 to August 1, 2007, when there was no precipitation on that day, and the preceding day. On each day of the field survey, SOD was measured at two to three stations. Water temperature from all 12 stations range from 23.3 $^{o}$C to 28.8 $^{o}$C with an average of 25.1 $^{o}$C. Tables 2 through 13 present raw data taken by the field crew during the 2007 SOD surveys. Water temperature from 8 stations in Salt Creek during 2006 SOD surveys ranged from 21.5 $^{o}$C to 27.0 $^{o}$C with an average of 23.9 $^{o}$C.

## 5.0 Data Analysis

All data recorded in the field were key-entered into Excel for analysis (See Tables 2 through 13) and graphical presentation. The field data sheets are included as Attachment 2 to this report. DO in each of the two replicate chambers and one blank chamber were plotted against time and the data were analyzed by regression analysis to determine the "best-fit" linear equation. The measured data and the slopes are presented graphically for each set of measurements in Figures 4 through 15. Table 14 presents a summary of the calculated SOD of all 12 survey stations in Salt Creek.

In general, the time series of DO data follow linear trends and the regression analyses resulted in highly correlated sets of data with r-squared[1] values greater than 0.90. The DO readings for the blank probe at Station J (Figure 13), which showed some initial fluctuation in DO between 2:54 PM and 3:44 PM due to malfunction of the SOD chamber set-up. Therefore, the data collected prior to 3:44 PM at this station were eliminated in the analyses of the DO uptake rate.

The measurements of DO change in the dark bottles are generally consistent with the DO change in the blank SOD chamber. This is expected because the same biochemical processes are occurring in both containers; however, the surface area to volume ratios are different and this may account for the observed differences.

Differences between the two SOD measurements at a given station varied. Large differences may indicate that the sediment composition varies spatially at that station, whereas small differences indicate a relatively uniform sediment composition. An average of the two SOD measurements is reported in Table 14.

The conventional way of reporting SOD data is at a base water temperature of 20 $^{o}$C. The Arhenius temperature adjustment equation was used to convert SOD rates from the ambient temperature to 20 $^{o}$C.

$$SOD(t) = SOD(20) * \Theta^{(T-20)}$$

[1] r is defined statistically as the correlation coefficient; r-squared is simply $r^2$.

$$=> SOD(20) = SOD(t) / \Theta^{(T-20)}$$

where SOD(t) = SOD at temperature T
SOD(20) = SOD at 20 $^{o}$C
$\Theta$ = temperature correction coefficient

A typical $\Theta$ value for SOD is 1.08, which means there is an 8% change in SOD for a 1 $^{o}$C change in temperature. Similarly, a 10 $^{o}$C lower temperature (than 20 $^{o}$C) yields an SOD rate that is 46% that of the base (20 $^{o}$C) rate. Temperature adjusted to 20 $^{o}$C for all stations are also found in Table 14. The average SOD upstream of each dam is higher than the average SOD downstream of the dam, or the single measurement in the case of the Old Oak Brook dam where there is a single downstream measurement (See Table 15).

## 6.0 Conclusions

The SOD measured at ambient temperature in Salt Creek (SC) ranged from a minimum of 0.28 g/m$^2$/day to a maximum of 4.10 g/m$^2$/day. The highest SOD was observed in the impoundment upstream of Graue Mill (Fullersburg) Dam. Station-averaged 20 $^{o}$C-temperature adjusted SOD was in the range of 0.19 to 2.70 g/m$^2$/day. Figure 16 presents comparisons of the SOD results during the 2006 and 2007 surveys. The 2007 SOD rates are similar to the 2006 SOD rates in the impoundments of the Old Oak Brook and Graue Mill dams. The SOD rates adjusted to the model predicted temperature by the QUAL2K model of Salt Creek during the calibration period (8/13/06 to 8/17/06) are shown along with the 2006 and 2007 data in Figure 17. The 2007 SOD rates are lower than the model SOD data in the impoundment of the Oak Meadow golf course dam, where there were no SOD measurements taken in 2006. The model parameters for this reach will be adjusted based on the results of this field study.

The results of the 2007 SOD survey will be used to supplement the 2006 data and refine the current SOD parameters in the model.