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Final Assessment Report

Prepared for: City of San Diego Public Utilities Department

Project Title: Lake Hodges Reservoir Sediment Oxygen Demand Study

Project No.: 147471

Final Assessment Report

Subject: Lake Hodges Reservoir Oxygen Demand Study

Date: June 11, 2015

To: Goldamer Herbon, Water Resources Specialist
City of San Diego Public Utilities

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Lake Hodges Reservoir Oxygen Demand Study

Dr. Marc Beutel
June 11, 2015

Summary

With the assistance of the City of San Diego Public Utilities Department (Public Utilities) staff (See Figure 1, Attachment B), I implemented a successful field and laboratory effort to assess oxygen demand in Lake Hodges Reservoir (Hodges). Public Utilities staff and I measured sediment oxygen demand (SOD) and water-column oxygen demand (WOD) in experimental incubations using sediment and water collected from three existing sampling stations in the reservoir: Station A near the dam, Station B, and Station C near the boat launch. The incubations assessed SOD under three mixing regimes: quiescent conditions, low water velocity, and high water velocity. SOD showed three key trends:

- SOD decreased as we moved upstream stream in the reservoir from Station A to C.
- SOD increased as water velocity at the sediment-water interface increased.
- SOD under mixed conditions was linearly related to dissolved oxygen (DO) in overlaying water.

SOD levels were some of the highest I have ever measured and ranged from around 0.6-2.3 grams per square meter per day ($g/m^2/d$) depending on location, mixing regime and overlaying DO concentration. WOD was also relatively high compared to other reservoirs and decreased from Station A to C. WOD levels ranged from around 0.2-0.3 milligrams per liter per day (mg/L/d). The high overall oxygen demand at Hodges, as compared to other California reservoirs, likely results from several factors:

- Reservoir age – sediment has accumulated for almost a century.
- Reservoir trophic level – Hodges is hypereutrophic. Heavy organic carbon loads rain down into the hypolimnion and anoxic conditions in bottom water for extended periods result in accumulation of organic matter and reduced species including iron, manganese and sulfides. These compounds exert a high oxygen demand.
- Continued nutrient loading – High productivity in Hodges is maintained via continuing fertilization of reservoir from agricultural and urban runoff, as well as from nutrient cycling within the reservoir which is enhanced by anoxic conditions in bottom water.

Based on experimental data, I developed two models that estimate design hypolimnetic oxygen demand (HOD) as a function of reservoir surface elevation (See Attachment C - Data Appendix). Simply put, HOD was estimated based on SOD multiplied by sediment surface area and WOD multiplied by hypolimnetic volume. I modeled SOD based on presumed mixing regimes and DO concentration. WOD was based on an overall experimental mean of 0.27 mg/L/d.

Both models, as currently programmed, estimate a design HOD of 8,200-8,700 kilograms per day (kg/d), or about 9 tons per day (tpd), at full pool (surface elevation of 315 ft) and 3,400-3,500 kg/d (about 4 tpd) at current surface levels (elevation of 295 ft). At both elevations, SOD makes up close to half of total HOD. Note

that these oxygen demands are higher than preliminary assumptions of oxygen demand used in initial water quality modeling efforts by Water Quality Solutions (Technical Memorandum dated March 18, 2014), an effort that recommended this oxygen demand field study. Oxygen delivery rates used in that study ranged from 3,400-4,400 kg/d (about 4 to 5 tpd). Clearly this experimental study demonstrates that the oxygen demand in hypereutrophic Hodges is significant and any future hypolimnetic oxygenation system (HOS) should be sized to ensure that it has adequate capacity to address all oxygen demands.

Section 1: Sediment Oxygen Demand

1.1 Methods

Public Utilities staff and I collected SOD samples at three established sampling stations at the reservoir: A, B and C (Figure 2, Attachment A). We excluded Station D from the study since the reservoir surface elevation was low and the station was not easily accessible. Station A was deep (~18 m deep) and near the dam. Station B was upstream of Station A (~12 m deep). Station C (~8 m deep) was upstream of B and near the boat ramp area. At each station, we collected sediment and water into specialized SOD chambers using an Ekman dredge. We transported the chambers to the Public Utilities laboratory for testing in an incubator in the dark at 14-15 °C (Fig. 3). SOD was measured in triplicate chambers from each station. SOD testing consisted of three phases. For phase 1, chambers were incubated under quiescent conditions. For phase 2, chambers were installed onto a mixing apparatus and mixed at a mean water velocity of 1.3 centimeters per second (cm/s). For phase 3, chambers were mixed at a mean water velocity of 4 cm/s. These velocities were selected to mimic typical water velocities in the profundal zone of lakes, which tend to range from 0.1-2 cm/s. The 1.3 cm/s was the lowest possible setting on the mixing apparatus. In situ SOD is likely somewhere between results from the quiescent and 1.3 cm/s incubations. SOD at the elevated velocity of 4 cm/s represents anticipated SOD levels near any HOS system where mixing occurs as a result of oxygen addition. During all phases, chamber water overlaying sediment was monitored every 15 minutes with a Hach LDO oxygen/temperature probe and HD40Q data logger. Between phases chambers were reaerated by gently bubbling water with air for 4-5 hours to reestablish fully oxygenated conditions in chamber water prior to the next incubation.

I estimated SOD ($g/m^2/d$) under quiescent conditions as the slope of the linear regression of DO concentration versus time ($g/m^3/d$) multiplied by the chamber water height (m). Under mixed conditions, SOD was a linear function of DO concentration, which I assessed using a linear regression of SOD versus DO for DO concentrations above 1 mg/L. SOD ($g/m^2/d$) at a given DO concentration was estimated as the DO for the time step (i.e., 15 minutes) before minus the DO for the time step after (g/m^3), divided by 30 minutes (0.0208 d), and multiplied by the chamber water height (m).

1.2 Results and Discussion

1.2.1 Magnitude of SOD

The Data Appendix (See Attachment C) presents the complete SOD data set, summarized in Tables 1, 2 and 3 (See Attachment A). Data show a clear spatial pattern with SOD increasing from Station C to A. In addition, higher mixing led to higher SOD. Table 1 summarizes SOD results. Under quiescent conditions, mean SOD ranged from 0.57 $g/m^2/d$ at Station C to 0.91 $g/m^2/d$ at Station A. Under low mixing, and assuming a DO concentration of 5 mg/L in water above sediment, mean SOD ranged from 1.22-1.99 $g/m^2/d$. Under high mixing, mean SOD ranged from 1.18-2.3 $g/m^2/d$. Variability between triplicate chambers was relatively low considering the heterogeneous nature of sediments and the complexity of field sampling and laboratory

monitoring methods. Standard deviations ranged from 0.2-0.3 g/m^2/d. Figure 4 (**Attachment B**) presents data from Table 1 visually. Mixing effects on SOD are initially dramatic, but diminish with increased mixing. The SOD values measured in this study at Stations A and B are some of the highest levels I have measured. Hypereutrophic Lafayette Reservoir near Berkeley, California had an unmixed SOD of ~0.8 g/m^2/d, which is comparable to levels measured in Hodges. SOD levels measured in eutrophic San Vicente Reservoir, San Diego, ranged from ~0.5 g/m^2/d under unmixed conditions to ~1.3 g/m^2/d under highly mixed conditions – comparable to Station C in Hodges. Numerous other mesotrophic reservoirs in California typically have mixed SOD values less than ~0.7 g/m^2/d.

1.2.2 Effects of Mixing of SOD

Under mixed conditions SOD was a linear function of DO concentration in overlaying water. Thus, we can model SOD simply as a slope multiplied by DO concentration plus an intercept. The slope can be interpreted as a first-order oxygen demand for the abiotic reduction of reduced compounds, including sulfide and iron, diffusing upwards from deeper anoxic sediments. The intercept can be interpreted as the approximate baseline rate of microbial organic matter oxidation, which tends to reach a maximum at relatively low oxygen concentrations.

Tables 2 and 3 (**See Attachment A**) summarize slopes and intercepts for low and high mixing conditions. Under both mixing regimes, slopes (intensity of reduced compounds in sediment) tend to increase from Station C to A. Intercepts (intensity of organic matter in sediment) are slightly higher at Station B relative to A, and lower at Station C. This pattern suggests that Stations A and B have elevated levels of reduced compounds and organic matter in sediment, while shallower Station C has lower levels of organic matter and reduced compounds in the sediments. The sediment-water interface at Stations A and B likely experiences longer durations of anoxia than at Station C. Thus, Station A and B sediments have accumulated higher levels of non-biodegraded organic matter and reduced compounds relative to Station C. The higher intercept (intensity of organic matter in sediment) at Station B relative to Station A could be a result of its shallower depth allowing for less time for organic matter to biodegrade in the water column. As a result, a greater portion of settling organic matter at Station B would exert its oxygen demand at the sediment-water interface. It will be interesting to see if the patterns described here correlate with sediment quality analyses, including total organic carbon, that are ongoing by the Public Utilities laboratory. Figure 5 (**Attachment B**) shows data from Tables 2 and 3 visually. The figure re-emphasizes three key observations:

1. SOD increases linearly with DO concentration in overlaying water.
2. SOD is highest at Station A and lowest at Station C.
3. SOD is slightly higher under high mixing relative to low mixing.

1.2.3 Why does mixing and higher DO concentration in overlaying water enhance SOD?

The simplest explication is to conceptualize the DO flux into sediment using Fick's Law:

$$J = \frac{D}{DBL}\Delta DO$$

Where:

J (g/m^2/d) is the flux of oxygen from overlaying water into the sediment – also called SOD,

D (m^2/d) is the diffusion coefficient of dissolved oxygen in water,

DBL (m) is the thickness of the diffusive boundary layer – a very thin layer of stagnant water hugging the sediment, and

Δ*DO* (g/m^3 or mg/L) is the DO concentration gradient – the difference between the bulk DO concentration in the water and the DO concentration right at the sediment-water interface.

Mixing tends to thin or disrupt the *DBL*, thereby increasing *J*. Increasing the DO in the bulk water increases Δ*DO,* thereby increasing *J*.

We expect that the turbulence and higher DO concentrations associated with lake oxygenation will increase SOD in Hodges above natural background levels once the HOS system is in operation. Monitoring of a number of lake and reservoir aeration and oxygenation systems, including Speece cone systems and line diffuser systems, has demonstrated this phenomenon, which is termed induced oxygen demand. The conventional approach to account for induced oxygen demand, and to avoid undersizing a HOS, is to determine the system oxygen demand based on natural DO consumption rates using spring and early summer DO profiles, then multiplying this demand by a factor of 2 to 3. Note this factor is comparable to the increase in Hodges SOD when going from unmixed conditions (~0.6-0.9 g/m^2/d) to mixed conditions (~1.2-2.3 g/m^2/d) (see Table 1, **Attachment A**). Induced oxygen demand should not be thought of as a bad thing or something to be avoided. By inducing demand, oxygen is oxidizing accumulated organic matter and associated reduced compounds. The more organic matter and reduced compounds oxidized, the greater the oxygen penetration into the sediment, and the more overlaying water quality is protected from degradation. The key is providing enough oxygenation capacity to meet, or even exceed, anticipated induced oxygen demand at the sediment-water interface. Hence, oxygen addition tends to stimulate SOD and any HOS needs to be sized to meet this additional demand.

1.3 Recommendation

The recommended approach for the SOD component of the design HOD, the sum of WOD and SOD, for Hodges is to model SOD as a function of DO in overlaying water, splitting the reservoir into sections based on the differing experimental results from Stations A, B and C. I developed the SOD equations based on a conservative incubation temperature of 14-15 °C. SOD, like most biological processes, is temperature sensitive. Higher temperatures lead to higher rates of respiration and higher rates of oxygen uptake. The incubation temperature mimics typical bottom water temperature when the reservoir is at a surface elevation of ~295 ft. But as the reservoir gets deeper, bottom water is likely cooler than this temperature, leading to lower SOD. As a result, experimental SOD is likely a bit higher than anticipated rates when the reservoir is fuller. Thus, this approach is conservative since it may slightly overestimate SOD at higher water elevations. Note that the effect of DO (linear function of DO as presented in this memo) and temperature (using the typical equation for biological reactions as a function of temperature: SOD at temperature T = SOD in this study x $1.065^{(T-14.5)}$) on SOD could be included in any future hydrodynamic/water quality modeling.

I developed two simple spreadsheet models to estimate design HOD. The first model is termed the Bathymetric Based HOD Model. It has three inputs: DO concentration at the sediment-water interface (5 mg/L default value), the WOD (0.27 g/m^3/d recommended, see WOD section below), and the thermocline depth (20 ft default value).

The model then applies the SOD equations for each station based on bathymetry as follows:

- High mixing Station A equation (0.34 x DO + 0.66; see Table 3) for sediments below an elevation of 250 ft;
- Low mixing Station B equation (0.21 x DO + 0.65; see Table 2) for sediments between an elevation of 250-270 ft;
- Low mixing Station C equation (0.17 x DO + 0.37; see Table 2) for sediments between an elevation of 270 ft and the thermocline.

I selected high mixing for Station A since it is the region of sediments closest to oxygen addition, and thus will experience the greatest turbulence as a result of HOS operation.

The second model is termed the Gross Area Based HOD Model. Its inputs are similar as the previous model, but also include an assumed percentage of bottom area assigned to SOD equations (noted above) for Stations A, B and C. Default values are 25%, 25%, and 50%, respectively. The higher value for Station C is based on the fact that much of the sediment area in the hypolimnion is comprised of shallower upstream sediments best represented by SOD results from Station C. Other project stakeholders who have a better quantitative feel for Hodges bathymetry and limnology (i.e., thermocline depth) may adjust bathymetric assumptions and other inputs of both models and evaluate corresponding oxygen demand estimates.

Section 2: Water Column Oxygen Demand

2.1 Methods

The City staff and I collected hypolimnetic water samples in triplicate in glass biochemical oxygen demand (BOD) bottles at 4-5 depths at Stations A, B and C (Fig. 2). To allow for initial reaeration and temperature acclimation, samples were stored overnight with caps off in an incubator in the dark at 14-15 °C. The following day samples were aerated actively by bubbling with air for 2-4 hours. Samples were then capped and DO was monitored in each bottle every 2-4 days. The rate at which oxygen was consumed in each BOD bottle was estimated as a liner fit of the DO concentration with time. This rate is termed the water-column oxygen demand (WOD) and is measured in units of mg/L/d.

2.2 Results and Discussion

2.2.1 Magnitude of WOD

The Data Appendix presents the complete WOD data set, also summarized in Table 4 (See Attachment A). Mean WOD values of triplicate incubations ranged from 0.18-0.34 mg/L/d. WOD showed a decreasing trend moving upstream from Station A to C, though differences were not substantial. Mean WOD at Stations A, B, and C were 0.29 (n = 5), 0.27 (n = 4) and 0.23 (n = 4) mg/L/d, respectively. Pooling triplicate WOD data for all depths and stations yields an overall mean of 0.27 mg/L/d (n = 13). WOD values showed low variability in the triplicate incubations at each station/depth as indicated by the low standard deviations reported in Table 4. Oxygen uptake rates were linear as indicated by the high R^2 values reported in Table 4. Few studies report estimates of WOD separate from overall HOD. I have completed two other studies of WOD and levels in Hodges appear relatively high. WOD in Lake Bard, a mesotrophic reservoir near Ventura, California, ranged from ~0.04-0.06 mg/L/d. WOD levels estimated in eutrophic San Vicente Reservoir, San Diego, ranged from ~0.06-0.14 mg/L/d.

2.2.2 Spatial Patterns of WOD

WOD tended to be lower in the upper hypolimnion relative to the lower hypolimnion. This pattern is interesting since WOD typically decreases with depth as microbes biodegrade falling organic matter. Biodegradation rates tend to decrease with depth as readily biodegradable components of settling organic matter are depleted. This pattern is most apparent in deep systems where settling organic matter remains in the water column for a relatively long time.

2.2.3 What explains the high oxygen demand in deeper water samples observed in Hodges?

One explanation is that deep water samples contained reduced compounds that exerted an oxygen demand during the WOD experiments. Field monitoring during sample collection indicated that deep water samples were low and/or void of oxygen, thus these samples likely contained reduced compounds including iron, manganese and sulfide, which we smelled especially at Stations A and B. But samples were allowed to reaerate for an extended period before the WOD incubations to satisfy this short-term demand. The WOD

experiment excluded these demands since they will not be present when an effective oxygenation system is in operation – a primary goal of oxygenation is to suppress the accumulation of these reduced compounds in bottom water. A possible explanation is that extended periods of low DO levels in bottom waters led to the repression of aerobic oxidation of organic matter. Once plentiful oxygen was supplied to deep water samples in the WOD experiment, organic matter could undergo full aerobic biodegradation. Another potential source of oxygen demand in deep water WOD samples was manganese oxidation. Unlike iron and sulfide which can undergo rapid abiotic oxidation in aerated natural waters, manganese undergoes slow abiotic oxidation.

2.3 Recommendation

The recommended approach for the WOD component of the HOD design, the sum of WOD and SOD, for Hodges is to use the overall mean WOD of 0.27 mg/L/d. The overall mean WOD is a conservative value, making it an appropriate design parameter. The mean value is not volume-weighted. Doing so would minimize the impact of WOD in deeper water since on a volume-weighted basis, those WOD values are associated with a relatively small volume of water. As discussed above, deep-water WOD values may include oxygen demand by manganese oxidation, a demand that will not be present once an HOS oxygenates the reservoir. Also, as noted in the SOD sub-section, the incubation temperature of 14-15 °C is higher than is expected at full pool. As a result, experimental WOD is likely a bit higher than anticipated rates when the reservoir is fuller and bottom water is cooler. Thus, design for an HOS using these values would be appropriately conservative.

Section 3: Additional Factors Affecting Oxygen Demand

Oxygen addition in Hodges may result in a decrease in HOD over time. Phytoplankton growth in the reservoir likely is stimulated by internal nutrient loading of phosphate, ammonia and iron released from anoxic sediments. An effective oxygenation system that maintains a well-oxygenated sediment-water interface should repress internal loading, resulting in less phytoplankton growth, less settling organic matter, and lower WOD in hypolimnetic waters during periods of low external nutrient loading. Decreases in WOD could occur in the near-term, on the order of years. SOD, with its historical inventory of previously deposited organic matter, is expected to respond to oxygen addition more slowly. Lake managers should anticipate long-term decreases in SOD after oxygen addition, perhaps on the order of 5 years to a decade.

Another phenomenon to consider is the response of Hodges to future hydrologic conditions that bring the reservoir up to full operating depth. A rapid filling event could lead to a short-term increase in oxygen demand by flooding previously dry sediments rich in organic matter, and by flushing organic matter from the shallow eastern arm into downstream waters where is would sink and decay. The added oxygen demand coupled with a larger hypolimnion as a result of filling could lead to high HOD under flooding conditions. This scenario potentially was observed in Indian Creek Reservoir operated by the South Tahoe PUD. In that reservoir, a 10-foot increase in surface elevation inundated areas that had been dry for a couple of decades, resulting in a relatively high HOD during the following summer.

Finally, some HOS designers include a safety factor that accounts for unanticipated system shutdown during the oxygenation period. In the event of a short-term shut down, oxygen levels would decrease while the system is brought back on line. The system then could be operated at a higher input rate to bring the oxygen inventory back up to levels prior to the system breakdown. For example, assume DO averages 5 mg/L in bottom waters of Hodges during oxygenation. If the system shuts down, and assuming a volume-based HOD of 0.4 mg/L/d, the hypolimnion would go anoxic in 12.5 days. Without excess capacity to add oxygen (i.e., meet demand and add excess DO to bottom water), it will be difficult to reestablish fully oxic conditions in bottom waters once the HOS is turned back on. It is important to emphasize that HOS systems should be thought of as meeting HOD. They are not especially effective at exceeding HOD and building up an inventory

of oxygen in the hypolimnion. This response is why it is important to turn on a HOS before oxygen levels drop substantially in bottom waters in the spring. It is also why it is critical to maintain continuous oxygen input that meets oxygen demand and maintains a steady DO concentration in bottom water. Since Hodges has such a high oxygen demand, lake managers should consider maintaining high DO concentration (7-8 mg/L), and thus a higher total volume of DO in the hypolimnion in bottom water during oxygenation, as a buffer for system shut downs. The higher the bottom water DO, the more time there will be to fix the problem while avoiding the onset of anoxic conditions, which once established, is difficult to overcome. Higher oxygen concentrations in bottom waters also would enhance oxygen penetration into sediment, which would better protect bottom water quality.

Attachment A: Tables

Table 1. Summary of SOD Results						
	Unmixed		Low Mixing		High Mixing	
Station	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
A	0.91	0.37	1.99	0.32	2.34	0.29
B	0.66	0.14	1.72	0.19	2.04	0.27
C	0.57	0.15	1.22	0.26	1.18	0.21

Notes:
1. Units of SOD are g/m²/d
2. Values are mean and standard deviation (Std Dev) of triplicate incubations
3. Mean water velocity is 1.3 cm/s for low mixing and 4 cm/s for high mixing
4. SOD values for low and high mixing assume a DO concentration in overlaying water of 5 mg/L

Table 2. SOD Related Parameters for Low Mixing Conditions														
					SOD (g/m²/d) at given DO concentration									
	Slope		Intercept		3 mg/L			5 mg/L			7 mg/L		
Station	Mean	Std Dev	Mean	Std Dev	Mean		Std Dev	Mean		Std Dev	Mean		Std Dev
A	0.28	0.07	0.57	0.07	1.43	±	0.27	1.99	±	0.40	2.56	±	0.54
B	0.21	0.03	0.65	0.15	1.30	±	0.23	1.72	±	0.28	2.15	±	0.34
C	0.17	0.05	0.37	0.02	0.88	±	0.18	1.23	±	0.29	1.57	±	0.39

Notes:
SOD is calculated as slope x DO + intercept

Table 3. SOD Related Parameters for High Mixing Conditions														
					SOD (g/m²/d) at given DO concentration									
	Slope		Intercept		3 mg/L			5 mg/L			7 mg/L			
Station	Mean	Std Dev	Mean	Std Dev	Mean		Std Dev	Mean		Std Dev	Mean		Std Dev
A	0.34	0.05	0.66	0.08	1.67	±	0.22	2.34	±	0.31	3.02	±	0.40
B	0.26	0.04	0.74	0.10	1.52	±	0.22	2.04	±	0.29	2.56	±	0.37
C	0.17	0.03	0.33	0.10	0.84	±	0.21	1.18	±	0.27	1.52	±	0.34

Notes:
SOD is calculated as slope x DO + intercept

Table 4. Summary of Water-Column Oxygen Demand Results

Station	Depth (m)	WOD (mg/L/d) Mean	Mean R^2	Std Dev	Sample Number
A	6	0.31	0.96	0.01	3
	8	0.27	0.98	0.02	3
	10	0.27	0.88	0.06	3
	12	0.32	0.96	0.01	3
	16	0.31	0.95	0.04	3
Station A mean		*0.29*		*0.03*	*5*
B	6	0.21	0.94	0.05	3
	8	0.21	0.92	0.01	3
	10	0.32	0.97	0.04	3
	12	0.34	0.98	0.04	3
Station B mean		*0.27*		*0.07*	*4*
C	5	0.18	0.86	0.02	3
	6	0.20	0.96	0.02	3
	7	0.20	0.95	0.04	3
	8	0.34	0.98	0.04	3
Station C mean		*0.23*		*0.07*	*4*
Overall Mean		**0.27**		**0.06**	**13**

Attachment B: Figures

Figure 1. Project Study Team with SOD Chamber (From Left to Right): Peter Martin, Marc Beutel, Goldamer Herbon, and Jeffrey Pasek.

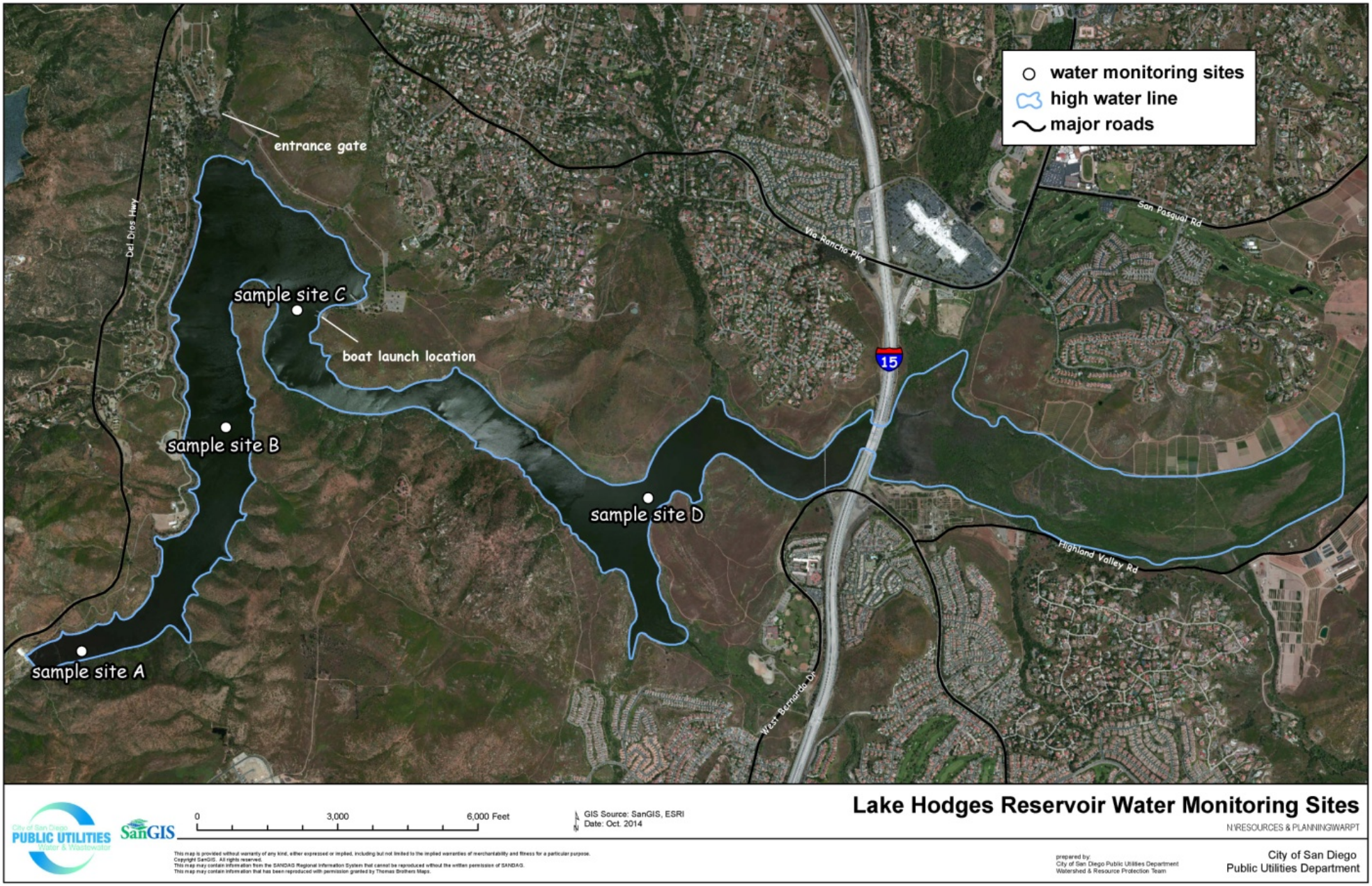


Figure 2. Map of Lake Hodges Reservoir and existing sampling stations A, B, C and D.

Figure 3. Triplicate SOD chambers from Stations A (left) and B (right) being aerated prior to mixing incubation.

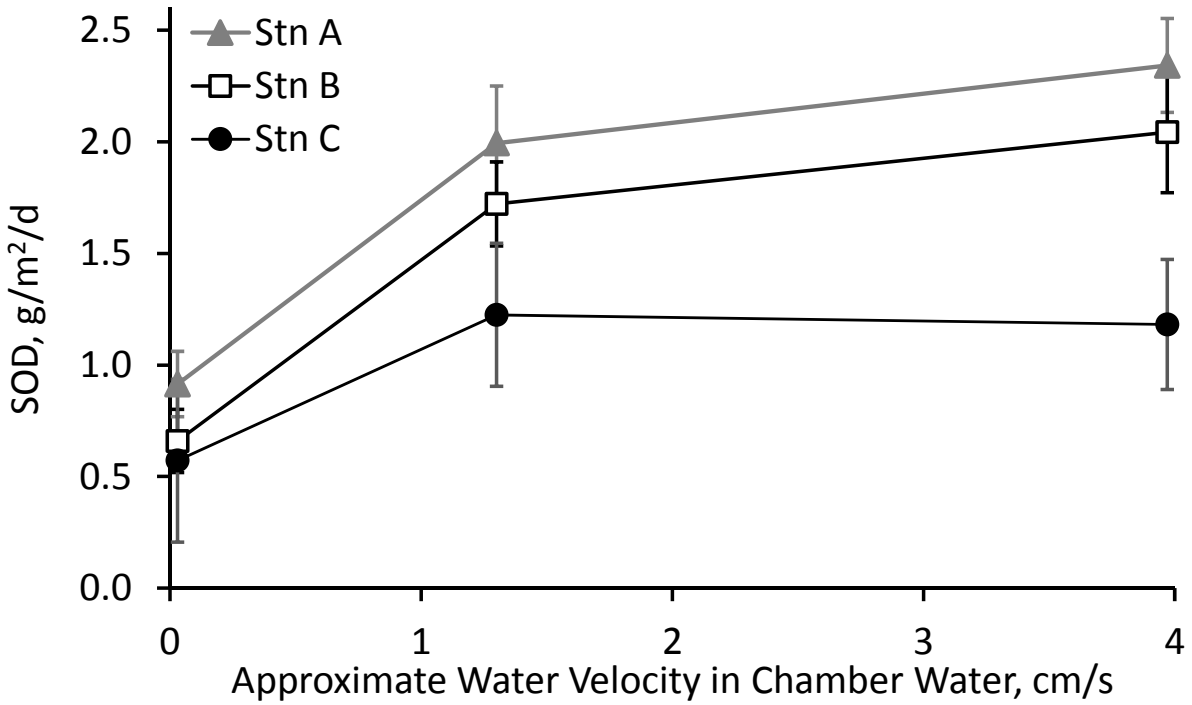


Figure 4. SOD as a function of mixing for sediment from Stations A, B and C. SOD at 1.3 and 4 cm/s is based on a DO concentration of 5 mg/L in overlaying water. The effects of mixing on SOD are initially dramatic, but diminish with increased mixing. This figure also captures the spatial pattern of SOD in the reservoir, with SOD increasing from Station C to A. Error bars are plus/minus one standard deviation; n = 3.

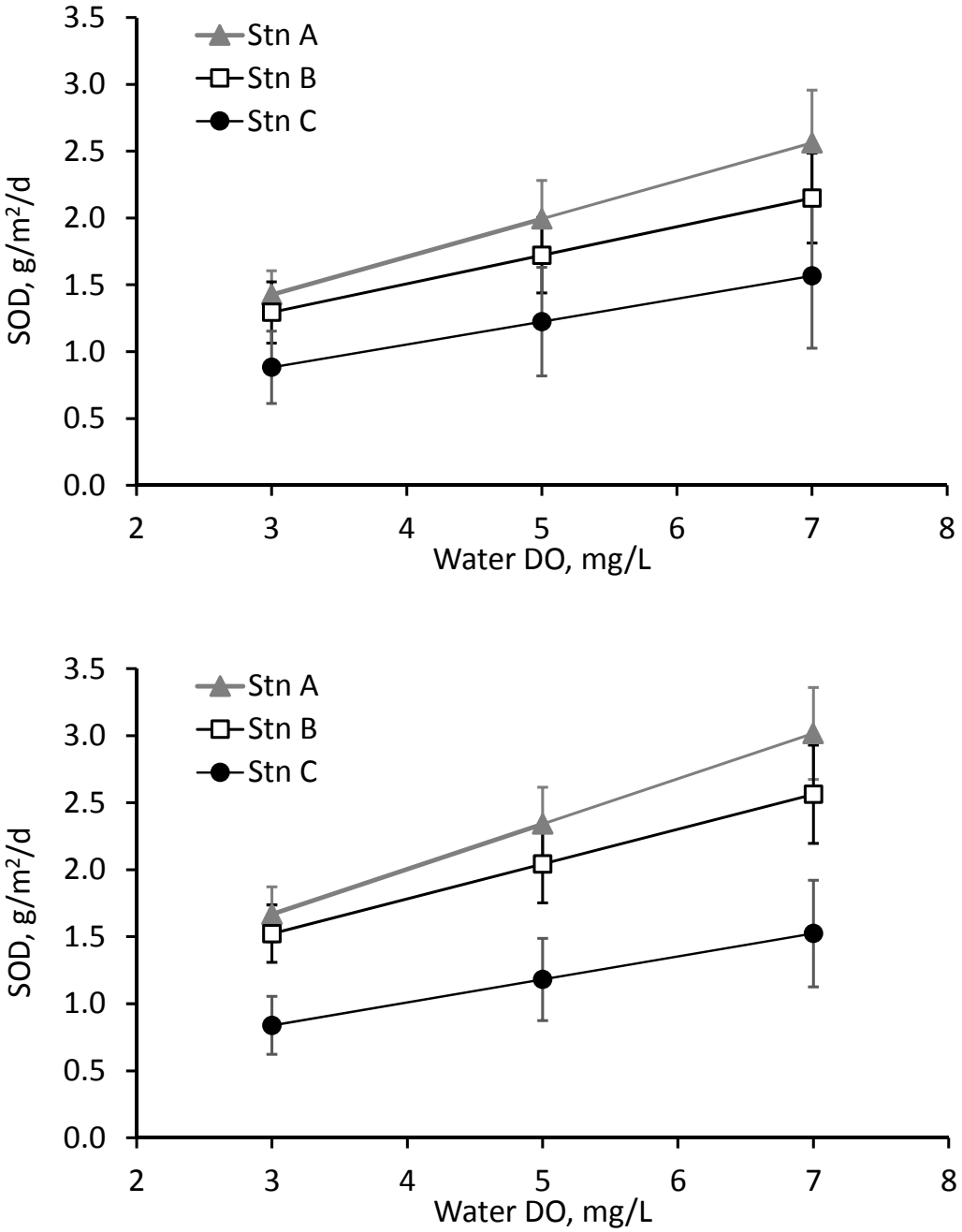


Figure 5. SOD as a function of DO concentration in overlaying water at low mixing (top) and high mixing (bottom) for sediment from Stations A, B and C. The linear models were developed based on results of triplicate SOD chamber incubations from each station. Note: SOD increases linearly with DO concentration. Error bars are plus/minus one standard deviation based on variability observed in triplicate chambers.

Attachment C: Data Appendix

- HOD Model 1
- HOD Model 2
- SOD Data Station A
- SOD Data Station B
- SOD Data Station C
- WOD Data

HOD Model Calculations
Marc Beutel, April 17, 2015

MODEL 1 - BATHYEMETRIC BASED HOD MODEL

Model Inputs

DO	**5.0**	**mg/L**	DO at sediment-water interface controls SOD; acceptable values 1-8 mg/L; SOD is calculated as a function of DO based on experimental results
WOD	**0.27**	**g/m3/d**	Average WOD from Stations A, B and C
Thermocline Depth	**15.0**	**ft**	Conservative estimate based on professional judgement; minimum model value = 15 ft

Model Outputs

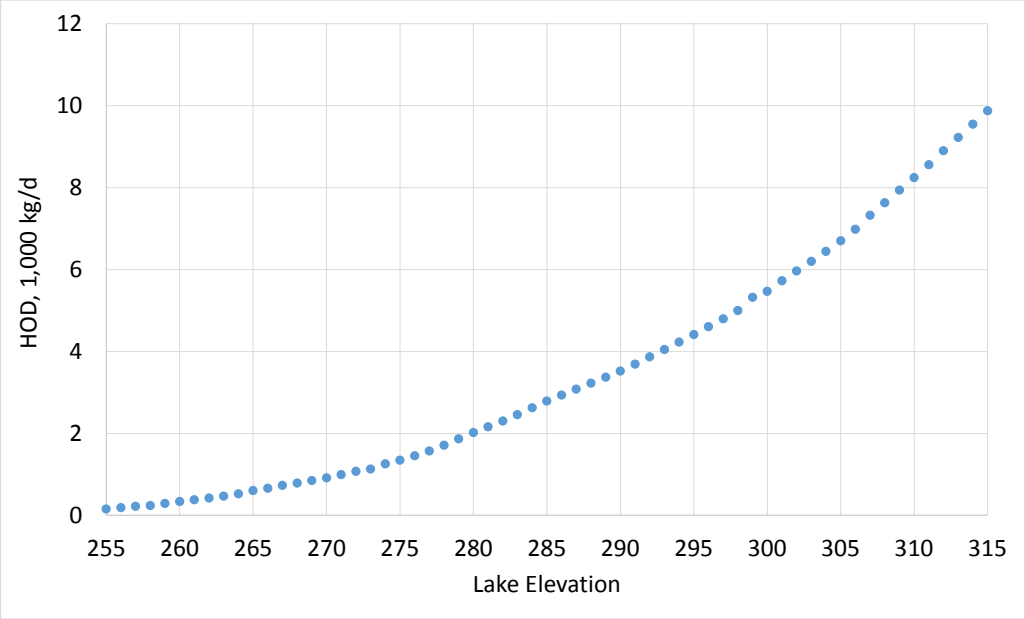
Sediment A SOD	2.36	g/m2/d	SOD based on DO above assuming high mixing since A sediments are near HOS system
Sediment B SOD	1.70	g/m2/d	SOD based on DO above assuming low mixing
Sediment C SOD	1.22	g/m2/d	SOD based on DO above assuming low mixing

Notes by Column
(6) Sediment type based on sampling station; A, B and C are assumed to represent sediments at elevations of 230-250 ft, 250-270 ft, and > 270 ft, respectively
(8) Increment SOD is the SOD for the given elevation (based on sediment type) multiplied by sediment area for given increment of elevation
(9) Total SOD for sediment at given water elevation; calculated as the sum of incremental SODs below the given elevation
(11) Total WOD for volume at given water elevation; calculated as the mean WOD above multiplied by total volume
(12) Total HOD at given water elevation; calculated as total SOD plus total WOD
(13) Surface elevation of reservoir; values change as assumed thermocline depth changes; disregard values above 315 ft, the maximum elevation of the reservoir
(14) Total HOD at given surface elevation based on assumed thermocline depth
(15) SOD:HOD is the fraction of total HOD as SOD; value decrease as elevation decreases since WOD decreases more rapidly than SOD as elevation decreases
(16) Volumetric HOD at given surface elevation; VHOD is the HOD divided by the hypolimnetic volume; typical values are ~0.2 mg/L/d; values are very high in Hodges
(17) Areal HOD at given surface elevation; AHOD is the HOD divided by the surface area of the reservoir; typical eutrophic systems have AHOD above 0.5-0.6 g/m2/d; values are very high in Hodges
(14), (15), (16), (17) Disregard values for elevations above 315 ft, the maximum elevation of the reservoir

BATHEMETRY			SOD CALCULATION						WOD CALCULATION		TOTAL HOD	HOD METRICS				
Elevation (ft)	Surface Area (acres)	Volume (ac-ft)	Surface Area (m2)	Incremental Area (m2)	Sediment Type	Model SOD (g/m2/d)	Increment SOD (kg/d)	Total SOD (1,000 kg/d)	Volume (m3)	Total WOD (1,000 kg/d)	Total HOD (1,000 kg/d)	Lake Surface Elevation (ft)	HOD (1,000 kg/d)	SOD:HOD	Volumetric HOD (mg/L/d)	Areal HOD (g/m2/d)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
315.0	1120.5	30632.6	4,534,545						37,784,707			315	9.87	0.43	0.47	2.18
314.0	1072.8	29538.5	4,341,627						36,435,187			314	9.54	0.44	0.48	2.20
313.0	1049.4	28477.6	4,246,888						35,126,560			313	9.22	0.44	0.48	2.17
312.0	1028.7	27438.7	4,163,145						33,845,068			312	8.90	0.45	0.49	2.14
311.0	1007.8	26420.3	4,078,221						32,588,908			311	8.56	0.45	0.49	2.10
310.0	982.5	25424.7	3,976,025						31,360,852			310	8.24	0.46	0.50	2.07
309.0	961.8	24452.7	3,892,115						30,161,935			309	7.94	0.46	0.50	2.04
308.0	939.0	23502.0	3,800,082						28,989,275			308	7.63	0.47	0.51	2.01
307.0	909.6	22578.1	3,681,051						27,849,587			307	7.33	0.47	0.51	1.99
306.0	886.1	21679.9	3,585,751						26,741,694			306	6.98	0.48	0.51	1.95
305.0	850.4	20811.4	3,441,346						25,670,472			305	6.70	0.48	0.52	1.95
304.0	820.0	19977.5	3,318,513						24,641,829			304	6.44	0.49	0.53	1.94
303.0	796.9	19168.5	3,224,886						23,643,928			303	6.20	0.49	0.53	1.92
302.0	774.0	18383.4	3,132,140						22,675,500			302	5.96	0.50	0.54	1.90
301.0	756.6	17617.8	3,061,917						21,731,215			301	5.72	0.51	0.55	1.87
300.0	739.6	16869.6	2,992,943	70,585	C	1.22	86.1	4.26	20,808,339	5.62	9.87	300	5.47	0.51	0.55	1.83
299.0	722.1	16138.7	2,922,358	70,699	C	1.22	86.3	4.17	19,906,757	5.37	9.54	299	5.32	0.53	0.57	1.82
298.0	704.7	15425.1	2,851,659	74,976	C	1.22	91.5	4.08	19,026,588	5.14	9.22	298	5.00	0.52	0.57	1.75
297.0	686.1	14729.5	2,776,683	93,522	C	1.22	114.1	3.99	18,168,591	4.91	8.90	297	4.80	0.53	0.58	1.73
296.0	663.0	14054.7	2,683,162	79,926	C	1.22	97.5	3.88	17,336,161	4.68	8.56	296	4.60	0.54	0.59	1.72
295.0	643.3	13401.3	2,603,235	79,609	C	1.22	97.1	3.78	16,530,230	4.46	8.24	295	4.41	0.55	0.60	1.70

294.0	623.6	12767.8	2,523,626	83,447	C	1.22	101.8	3.68	15,748,782	4.25	7.94	294	4.23	0.56	0.61	1.68
293.0	603.0	12154.4	2,440,180	87,574	C	1.22	106.8	3.58	14,992,162	4.05	7.63	293	4.05	0.56	0.62	1.66
292.0	581.3	11561.7	2,352,605	128,907	C	1.22	157.3	3.47	14,261,142	3.85	7.33	292	3.87	0.57	0.63	1.64
291.0	549.5	10997.5	2,223,698	81,708	C	1.22	99.7	3.32	13,565,214	3.66	6.98	291	3.69	0.58	0.65	1.66
290.0	529.3	10458.6	2,141,990	69,044	C	1.22	84.2	3.22	12,900,480	3.48	6.70	290	3.52	0.59	0.66	1.64
289.0	512.2	9938.0	2,072,947	64,143	C	1.22	78.3	3.13	12,258,332	3.31	6.44	289	3.37	0.60	0.68	1.63
288.0	496.4	9433.8	2,008,804	58,856	C	1.22	71.8	3.06	11,636,389	3.14	6.20	288	3.23	0.61	0.70	1.61
287.0	481.8	8944.6	1,949,948	65,843	C	1.22	80.3	2.98	11,032,991	2.98	5.96	287	3.08	0.62	0.72	1.58
286.0	465.6	8470.8	1,884,105	85,216	C	1.22	104.0	2.90	10,448,547	2.82	5.72	286	2.94	0.64	0.74	1.56
285.0	444.5	8015.6	1,798,889	0	C	1.22	0.0	2.80	9,887,109	2.67	5.47	285	2.79	0.65	0.76	1.55
284.0	444.5	7577.0	1,798,889	150,070	C	1.22	183.1	2.80	9,346,022	2.52	5.32	284	2.62	0.65	0.78	1.46
283.0	407.4	7156.3	1,648,819	56,233	C	1.22	68.6	2.62	8,827,154	2.38	5.00	283	2.46	0.66	0.79	1.49
282.0	393.5	6755.8	1,592,586	54,288	C	1.22	66.2	2.55	8,333,160	2.25	4.80	282	2.30	0.67	0.81	1.45
281.0	380.1	6369.0	1,538,298	53,912	C	1.22	65.8	2.48	7,856,086	2.12	4.60	281	2.16	0.67	0.83	1.40
280.0	366.8	5995.7	1,484,386	50,227	C	1.22	61.3	2.42	7,395,537	2.00	4.41	280	2.02	0.68	0.85	1.36
279.0	354.4	5635.2	1,434,158	56,208	C	1.22	68.6	2.35	6,950,861	1.88	4.23	279	1.87	0.69	0.86	1.30
278.0	340.5	5287.5	1,377,950	54,604	C	1.22	66.6	2.29	6,522,069	1.76	4.05	278	1.71	0.69	0.87	1.24
277.0	327.0	4953.8	1,323,346	57,781	C	1.22	70.5	2.22	6,110,471	1.65	3.87	277	1.57	0.69	0.88	1.19
276.0	312.7	4633.9	1,265,565	54,776	C	1.22	66.8	2.15	5,715,825	1.54	3.69	276	1.45	0.70	0.90	1.15
275.0	299.2	4328.1	1,210,788	45,397	C	1.22	55.4	2.08	5,338,647	1.44	3.52	275	1.35	0.71	0.92	1.11
274.0	288.0	4034.7	1,165,392	41,856	C	1.22	51.1	2.03	4,976,677	1.34	3.37	274	1.25	0.72	0.95	1.08
273.0	277.6	3751.9	1,123,536	42,362	C	1.22	51.7	1.98	4,627,850	1.25	3.23	273	1.13	0.72	0.95	1.01
272.0	267.2	3479.5	1,081,174	48,437	C	1.22	59.1	1.92	4,291,860	1.16	3.08	272	1.07	0.73	1.00	0.99
271.0	255.2	3218.1	1,032,737	52,911	C	1.22	64.6	1.86	3,969,489	1.07	2.94	271	0.99	0.74	1.03	0.96
270.0	242.1	2972.7	979,826	51,216	B	1.70	87.1	1.80	3,666,807	0.99	2.79	270	0.91	0.75	1.06	0.93
269.0	229.5	2737.1	928,610	56,198	B	1.70	95.5	1.71	3,376,116	0.91	2.62	269	0.85	0.76	1.11	0.91
268.0	215.6	2514.7	872,412	49,477	B	1.70	84.1	1.62	3,101,789	0.84	2.46	268	0.79	0.77	1.17	0.91
267.0	203.4	2308.3	822,934	45,262	B	1.70	76.9	1.53	2,847,189	0.77	2.30	267	0.73	0.78	1.22	0.89
266.0	192.2	2110.7	777,672	45,585	B	1.70	77.5	1.46	2,603,561	0.70	2.16	266	0.66	0.79	1.27	0.85
265.0	180.9	1923.5	732,087	56,154	B	1.70	95.5	1.38	2,372,581	0.64	2.02	265	0.60	0.80	1.32	0.83
264.0	167.0	1749.4	675,933	59,093	B	1.70	100.5	1.28	2,157,812	0.58	1.87	264	0.53	0.79	1.32	0.78
263.0	152.4	1589.5	616,840	54,200	B	1.70	92.1	1.18	1,960,555	0.53	1.71	263	0.47	0.80	1.35	0.76
262.0	139.0	1444.1	562,641	44,511	B	1.70	75.7	1.09	1,781,236	0.48	1.57	262	0.42	0.81	1.40	0.75
261.0	128.0	1310.6	518,130	37,379	B	1.70	63.5	1.02	1,616,634	0.44	1.45	261	0.38	0.81	1.45	0.73
260.0	118.8	1187.5	480,751	31,997	B	1.70	54.4	0.95	1,464,734	0.40	1.35	260	0.34	0.82	1.51	0.70
259.0	110.9	1072.6	448,754	52,160	B	1.70	88.7	0.90	1,323,062	0.36	1.25	259	0.29	0.82	1.54	0.65
258.0	98.0	967.1	396,594	15,867	B	1.70	27.0	0.81	1,192,860	0.32	1.13	258	0.24	0.82	1.50	0.61
257.0	94.1	870.0	380,727	28,831	B	1.70	49.0	0.78	1,073,187	0.29	1.07	257	0.22	0.83	1.61	0.57
256.0	87.0	779.6	351,896	30,117	B	1.70	51.2	0.73	961,634	0.26	0.99	256	0.19	0.83	1.64	0.53
255.0	79.5	696.3	321,780	23,527	B	1.70	40.0	0.68	858,852	0.23	0.91	255	0.16	0.84	1.64	0.49
254.0	73.7	619.8	298,252	20,352	B	1.70	34.6	0.64	764,476	0.21	0.85	254	0.14	0.85	1.78	0.48
253.0	68.7	548.6	277,900	22,282	B	1.70	37.9	0.61	676,715	0.18	0.79	253	0.12	0.85	1.85	0.44
252.0	63.2	484.1	255,618	27,910	B	1.70	47.4	0.57	597,105	0.16	0.73	252	0.11	0.87	2.00	0.41
251.0	56.3	424.4	227,708	23,981	B	1.70	40.8	0.52	523,461	0.14	0.66	251	0.09	0.88	2.20	0.40
250.0	50.3	371.1	203,727	26,747	A	2.36	63.1	0.48	457,684	0.12	0.60	250	0.08	0.89	2.41	0.38
249.0	43.7	323.9	176,980	17,808	A	2.36	42.0	0.42	399,576	0.11	0.53	249	0.07	0.90	2.83	0.38
248.0	39.3	282.6	159,172	14,050	A	2.36	33.2	0.38	348,555	0.09	0.47	248	0.06	0.92	3.29	0.35
247.0	35.9	245.0	145,122	14,738	A	2.36	34.8	0.34	302,253	0.08	0.42	247	0.04	0.93	3.63	0.28
246.0	32.2	211.0	130,384	13,747	A	2.36	32.4	0.31	260,221	0.07	0.38	246	0.03	0.94	4.33	0.23
245.0	28.8	180.4	116,638	14,989	A	2.36	35.4	0.28	222,490	0.06	0.34	245	0.02	0.96	6.47	0.20
244.0	25.1	153.5	101,648	17,993	A	2.36	42.5	0.24	189,339	0.05	0.29					
243.0	20.7	130.4	83,656	6,701	A	2.36	15.8	0.20	160,904	0.04	0.24					
242.0	19.0	110.2	76,955	10,931	A	2.36	25.8	0.18	135,916	0.04	0.22					
241.0	16.3	92.5	66,024	10,558	A	2.36	24.9	0.16	114,109	0.03	0.19					
240.0	13.7	77.5	55,466	4,520	A	2.36	10.7	0.13	95,536	0.03	0.16					

239.0	12.6	64.6	50,946	7,081	A	2.36	16.7	0.12	79,698	0.02	0.14
238.0	10.8	53.1	43,865	5,050	A	2.36	11.9	0.10	65,445	0.02	0.12
237.0	9.6	42.8	38,815	4,756	A	2.36	11.2	0.09	52,841	0.01	0.11
236.0	8.4	33.8	34,060	4,669	A	2.36	11.0	0.08	41,746	0.01	0.09
235.0	7.3	26.3	29,390	3,382	A	2.36	8.0	0.07	32,432	0.01	0.08
234.0	6.4	19.4	26,008	4,593	A	2.36	10.8	0.06	23,979	0.01	0.07
233.0	5.3	13.6	21,415	5,661	A	2.36	13.4	0.05	16,723	0.00	0.06
232.0	3.9	9.0	15,754	3,780	A	2.36	8.9	0.04	11,082	0.00	0.04
231.0	3.0	5.6	11,974	2,349	A	2.36	5.5	0.03	6,960	0.00	0.03
230.0	2.4	3.0	9,626	9,626	A	2.36	22.7	0.02	3,662	0.00	0.02



HOD Model Calculations
Marc Beutel, April 17, 2015

MODEL 2 - GROSS AREA BASED HOD MODEL

Model Inputs			
DO	**5.0**	**mg/L**	DO at sediment-water interface controls SOD; acceptable values 1-8 mg/L; SOD is calculated as a function of DO based on experimental results
WOD	**0.27**	**g/m3/d**	Average WOD from Stations A, B and C
Thermocline Depth	**15.0**	**ft**	Conservative estimate based on professional judgement; minimum model value = 15 ft
% Area of A sediment	**25.0**	**%**	
% Area of B sediment	**25.0**	**%**	
% Area of C sediment	**50.0**	**%**	

Model Outputs			
Sediment A SOD	2.36	g/m2/d	SOD based on DO above assuming high mixing since A sediments are near HOS system
Sediment B SOD	1.70	g/m2/d	SOD based on DO above assuming low mixing
Sediment C SOD	1.22	g/m2/d	SOD based on DO above assuming low mixing
Area-Weighted Mean SOD	1.63	g/m2/d	Mean SOD based on % coverage

Notes by Column
(5) Total SOD for sediment at given water elevation; calculated as the area-weighted mean SOD above multiplied by total surface area
(7) Total WOD for volume at given water elevation; calculated as the mean WOD above multiplied by total volume
(8) Total HOD at given water elevation; calculated as total SOD plus total WOD
(9) Surface elevation of reservoir; values change as assumed thermocline depth changes; disregard values above 315 ft, the maximum elevation of the reservoir
(10) Total HOD at given surface elevation based on assumed thermocline depth
(11) SOD:HOD is the fraction of total HOD as SOD; value decrease as elevation decreases since WOD decreases more rapidly than SOD as elevation decreases
(12) Volumetric HOD at given surface elevation; VHOD is the HOD divided by the hypolimnetic volume; typical values are ~0.2 mg/L/d; values are very high in Hodges
(13) Areal HOD at given surface elevation; AHOD is the HOD divided by the surface area of the reservoir; typical eutrophic systems have AHOD above 0.5-0.6 g/m2/d; values are very high in Hodges
(10), (11), (12), (13) Disregard values for elevations above 315 ft, the maximum elevation of the reservoir

BATHEMETRY			SOD CALCULATION		WOD CALCULATION		TOTAL HOD	HOD METRICS				
Elevation (ft)	Surface Area (acres)	Volume (ac-ft)	Surface Area (m2)	Total SOD (1,000 kg/d)	Volume (m3)	Total WOD (1,000 kg/d)	Total HOD (1,000 kg/d)	Lake Surface Elevation (ft)	Total HOD (1,000 kg/d)	SOD:HOD	Volumetric HOD (mg/L/d)	Areal HOD (g/m2/d)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
315.0	1120.5	30632.6	4,534,545		37,784,707			315	10.48	0.46	0.50	2.31
314.0	1072.8	29538.5	4,341,627		36,435,187			314	10.12	0.47	0.51	2.33
313.0	1049.4	28477.6	4,246,888		35,126,560			313	9.77	0.47	0.51	2.30
312.0	1028.7	27438.7	4,163,145		33,845,068			312	9.42	0.48	0.52	2.26
311.0	1007.8	26420.3	4,078,221		32,588,908			311	9.04	0.48	0.52	2.22
310.0	982.5	25424.7	3,976,025		31,360,852			310	8.69	0.49	0.53	2.19
309.0	961.8	24452.7	3,892,115		30,161,935			309	8.35	0.49	0.53	2.15
308.0	939.0	23502.0	3,800,082		28,989,275			308	8.01	0.49	0.53	2.11
307.0	909.6	22578.1	3,681,051		27,849,587			307	7.67	0.50	0.54	2.08
306.0	886.1	21679.9	3,585,751		26,741,694			306	7.28	0.50	0.54	2.03
305.0	850.4	20811.4	3,441,346		25,670,472			305	6.96	0.50	0.54	2.02
304.0	820.0	19977.5	3,318,513		24,641,829			304	6.68	0.50	0.54	2.01

303.0	796.9	19168.5	3,224,886		23,643,928			303	6.41	0.51	0.55	1.99
302.0	774.0	18383.4	3,132,140		22,675,500			302	6.15	0.52	0.56	1.96
301.0	756.6	17617.8	3,061,917		21,731,215			301	5.88	0.52	0.56	1.92
300.0	739.6	16869.6	2,992,943	4.86	20,808,339	5.62	10.48	300	5.59	0.52	0.57	1.87
299.0	722.1	16138.7	2,922,358	4.75	19,906,757	5.37	10.12	299	5.45	0.54	0.58	1.86
298.0	704.7	15425.1	2,851,659	4.63	19,026,588	5.14	9.77	298	5.06	0.53	0.57	1.78
297.0	686.1	14729.5	2,776,683	4.51	18,168,591	4.91	9.42	297	4.84	0.53	0.58	1.74
296.0	663.0	14054.7	2,683,162	4.36	17,336,161	4.68	9.04	296	4.62	0.54	0.59	1.72
295.0	643.3	13401.3	2,603,235	4.23	16,530,230	4.46	8.69	295	4.41	0.55	0.60	1.69
294.0	623.6	12767.8	2,523,626	4.10	15,748,782	4.25	8.35	294	4.21	0.55	0.61	1.67
293.0	603.0	12154.4	2,440,180	3.97	14,992,162	4.05	8.01	293	4.00	0.56	0.61	1.64
292.0	581.3	11561.7	2,352,605	3.82	14,261,142	3.85	7.67	292	3.80	0.57	0.62	1.62
291.0	549.5	10997.5	2,223,698	3.61	13,565,214	3.66	7.28	291	3.60	0.57	0.63	1.62
290.0	529.3	10458.6	2,141,990	3.48	12,900,480	3.48	6.96	290	3.41	0.58	0.64	1.59
289.0	512.2	9938.0	2,072,947	3.37	12,258,332	3.31	6.68	289	3.24	0.58	0.65	1.56
288.0	496.4	9433.8	2,008,804	3.26	11,636,389	3.14	6.41	288	3.08	0.59	0.66	1.53
287.0	481.8	8944.6	1,949,948	3.17	11,032,991	2.98	6.15	287	2.92	0.60	0.68	1.50
286.0	465.6	8470.8	1,884,105	3.06	10,448,547	2.82	5.88	286	2.75	0.61	0.69	1.46
285.0	444.5	8015.6	1,798,889	2.92	9,887,109	2.67	5.59	285	2.58	0.62	0.70	1.44
284.0	444.5	7577.0	1,798,889	2.92	9,346,022	2.52	5.45	284	2.42	0.62	0.72	1.35
283.0	407.4	7156.3	1,648,819	2.68	8,827,154	2.38	5.06	283	2.26	0.63	0.73	1.37
282.0	393.5	6755.8	1,592,586	2.59	8,333,160	2.25	4.84	282	2.11	0.63	0.74	1.32
281.0	380.1	6369.0	1,538,298	2.50	7,856,086	2.12	4.62	281	1.97	0.64	0.76	1.28
280.0	366.8	5995.7	1,484,386	2.41	7,395,537	2.00	4.41	280	1.83	0.65	0.77	1.23
279.0	354.4	5635.2	1,434,158	2.33	6,950,861	1.88	4.21	279	1.68	0.65	0.78	1.17
278.0	340.5	5287.5	1,377,950	2.24	6,522,069	1.76	4.00	278	1.53	0.65	0.78	1.11
277.0	327.0	4953.8	1,323,346	2.15	6,110,471	1.65	3.80	277	1.40	0.66	0.78	1.05
276.0	312.7	4633.9	1,265,565	2.06	5,715,825	1.54	3.60	276	1.28	0.66	0.79	1.01
275.0	299.2	4328.1	1,210,788	1.97	5,338,647	1.44	3.41	275	1.18	0.66	0.80	0.97
274.0	288.0	4034.7	1,165,392	1.89	4,976,677	1.34	3.24	274	1.09	0.67	0.82	0.93
273.0	277.6	3751.9	1,123,536	1.83	4,627,850	1.25	3.08	273	0.97	0.67	0.81	0.86
272.0	267.2	3479.5	1,081,174	1.76	4,291,860	1.16	2.92	272	0.91	0.68	0.85	0.84
271.0	255.2	3218.1	1,032,737	1.68	3,969,489	1.07	2.75	271	0.83	0.69	0.86	0.81
270.0	242.1	2972.7	979,826	1.59	3,666,807	0.99	2.58	270	0.75	0.69	0.88	0.77
269.0	229.5	2737.1	928,610	1.51	3,376,116	0.91	2.42	269	0.69	0.70	0.90	0.74
268.0	215.6	2514.7	872,412	1.42	3,101,789	0.84	2.26	268	0.63	0.71	0.94	0.73
267.0	203.4	2308.3	822,934	1.34	2,847,189	0.77	2.11	267	0.58	0.72	0.97	0.70
266.0	192.2	2110.7	777,672	1.26	2,603,561	0.70	1.97	266	0.51	0.72	0.98	0.66
265.0	180.9	1923.5	732,087	1.19	2,372,581	0.64	1.83	265	0.45	0.73	0.99	0.62
264.0	167.0	1749.4	675,933	1.10	2,157,812	0.58	1.68	264	0.40	0.73	0.99	0.59
263.0	152.4	1589.5	616,840	1.00	1,960,555	0.53	1.53	263	0.35	0.73	1.01	0.57
262.0	139.0	1444.1	562,641	0.91	1,781,236	0.48	1.40	262	0.32	0.74	1.05	0.56
261.0	128.0	1310.6	518,130	0.84	1,616,634	0.44	1.28	261	0.28	0.75	1.08	0.54
260.0	118.8	1187.5	480,751	0.78	1,464,734	0.40	1.18	260	0.25	0.76	1.12	0.52
259.0	110.9	1072.6	448,754	0.73	1,323,062	0.36	1.09	259	0.22	0.76	1.14	0.48
258.0	98.0	967.1	396,594	0.64	1,192,860	0.32	0.97	258	0.18	0.76	1.11	0.45
257.0	94.1	870.0	380,727	0.62	1,073,187	0.29	0.91	257	0.16	0.77	1.19	0.42
256.0	87.0	779.6	351,896	0.57	961,634	0.26	0.83	256	0.14	0.78	1.21	0.39
255.0	79.5	696.3	321,780	0.52	858,852	0.23	0.75	255	0.12	0.78	1.21	0.36
254.0	73.7	619.8	298,252	0.48	764,476	0.21	0.69	254	0.10	0.79	1.31	0.35

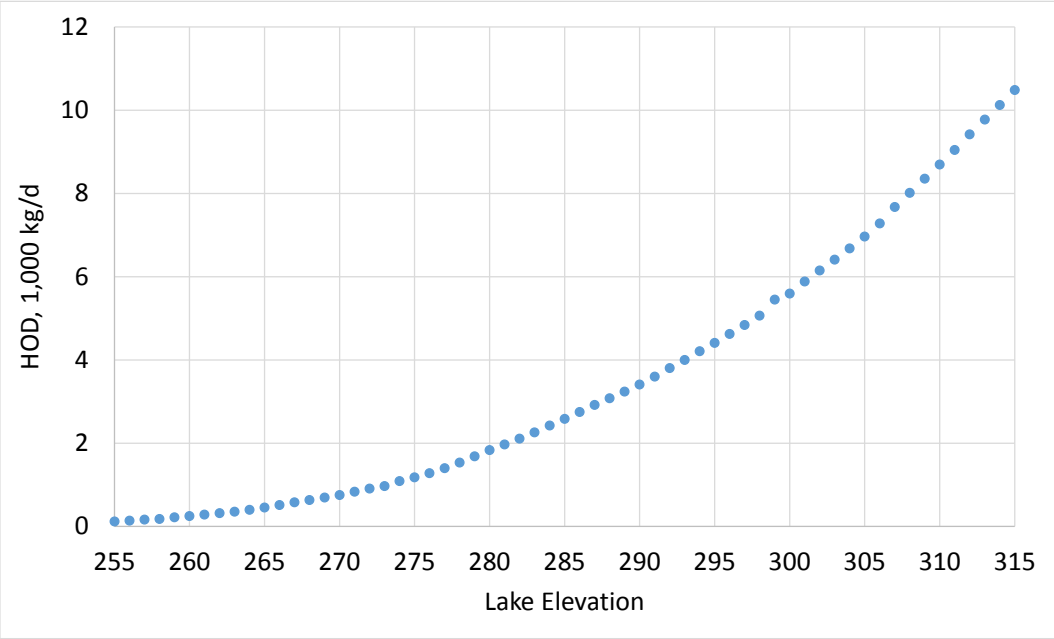
253.0	68.7	548.6
252.0	63.2	484.1
251.0	56.3	424.4
250.0	50.3	371.1
249.0	43.7	323.9
248.0	39.3	282.6
247.0	35.9	245.0
246.0	32.2	211.0
245.0	28.8	180.4
244.0	25.1	153.5
243.0	20.7	130.4
242.0	19.0	110.2
241.0	16.3	92.5
240.0	13.7	77.5
239.0	12.6	64.6
238.0	10.8	53.1
237.0	9.6	42.8
236.0	8.4	33.8
235.0	7.3	26.3
234.0	6.4	19.4
233.0	5.3	13.6
232.0	3.9	9.0
231.0	3.0	5.6
230.0	2.4	3.0

277,900	0.45
255,618	0.42
227,708	0.37
203,727	0.33
176,980	0.29
159,172	0.26
145,122	0.24
130,384	0.21
116,638	0.19
101,648	0.17
83,656	0.14
76,955	0.13
66,024	0.11
55,466	0.09
50,946	0.08
43,865	0.07
38,815	0.06
34,060	0.06
29,390	0.05
26,008	0.04
21,415	0.03
15,754	0.03
11,974	0.02
9,626	0.02

676,715	0.18
597,105	0.16
523,461	0.14
457,684	0.12
399,576	0.11
348,555	0.09
302,253	0.08
260,221	0.07
222,490	0.06
189,339	0.05
160,904	0.04
135,916	0.04
114,109	0.03
95,536	0.03
79,698	0.02
65,445	0.02
52,841	0.01
41,746	0.01
32,432	0.01
23,979	0.01
16,723	0.00
11,082	0.00
6,960	0.00
3,662	0.00

0.63
0.58
0.51
0.45
0.40
0.35
0.32
0.28
0.25
0.22
0.18
0.16
0.14
0.12
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.02

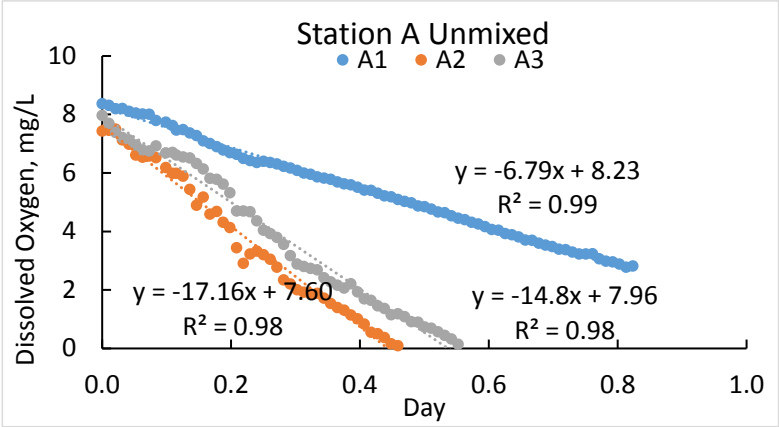
253	0.09	0.80	1.36	0.32
252	0.08	0.82	1.46	0.30
251	0.07	0.83	1.60	0.29
250	0.06	0.85	1.74	0.28
249	0.05	0.87	2.03	0.28
248	0.04	0.89	2.35	0.25
247	0.03	0.90	2.58	0.20
246	0.02	0.91	3.07	0.16
245	0.02	0.94	4.54	0.14



Station A SOD Unmixed

Time, day	DO, mg/L A1	A2	A3
0.00	8.37	7.44	7.97
0.01	8.32	7.46	7.70
0.02	8.20	7.50	7.39
0.03	8.21	7.13	7.22
0.04	8.11	6.99	7.13
0.05	8.05	6.62	6.96
0.06	8.02	6.54	6.79
0.07	8.01	6.58	6.76
0.08	7.80	6.53	6.93
0.10	7.74	6.19	6.69
0.11	7.63	5.99	6.71
0.11	7.47	5.99	6.62
0.13	7.49	5.89	6.55
0.14	7.37	5.44	6.52
0.15	7.28	4.90	6.33
0.16	7.10	5.18	6.14
0.17	7.01	4.60	5.82
0.18	6.90	4.69	5.79
0.19	6.79	4.32	5.62
0.20	6.70	4.14	5.33
0.21	6.64	3.45	4.70
0.22	6.50	2.91	4.70
0.23	6.43	3.23	4.68
0.24	6.36	3.33	4.37
0.25	6.40	3.21	4.05
0.26	6.36	3.05	3.93
0.27	6.31	2.78	3.80
0.28	6.23	2.35	3.56
0.29	6.17	2.21	3.18
0.30	6.09	2.01	2.89
0.31	6.00	1.93	2.81
0.32	5.96	1.87	2.74
0.33	5.87	1.89	2.69
0.34	5.83	1.72	2.42
0.35	5.79	1.54	2.28
0.36	5.70	1.40	2.17
0.38	5.63	1.31	2.07
0.39	5.60	1.15	2.22
0.40	5.52	1.02	1.94
0.41	5.42	0.84	1.70
0.42	5.41	0.56	1.65
0.43	5.31	0.51	1.46
0.44	5.22	0.38	1.37
0.45	5.19	0.16	1.16
0.46	5.10	0.10	1.19
0.47	5.03		1.09
0.48	4.98		0.92
0.49	4.88		0.90
0.50	4.85		0.74
0.51	4.77		0.70
0.52	4.67		0.57
0.53	4.65		0.45
0.54	4.54		0.33
0.55	4.46		0.15
0.56	4.41		
0.57	4.32		
0.58	4.26		
0.59	4.17		

Chamber	A1	A2	A3		
Rate, g/m3/d	6.790	14.800	17.160		
R^2	0.990	0.980	0.980		
Water Ht, m	0.073	0.073	0.068	Mean	Stdev
SOD, g/m2/d	0.496	1.080	1.167	0.914	0.365



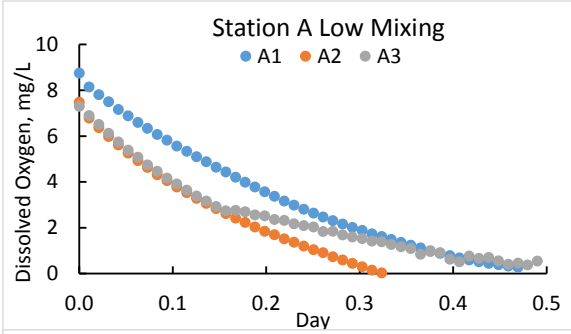
0.60	4.07		
0.61	4.05		
0.63	3.93		
0.64	3.89		
0.65	3.82		
0.66	3.71		
0.67	3.70		
0.68	3.60		
0.69	3.54		
0.70	3.49		
0.71	3.40		
0.72	3.38		
0.73	3.30		
0.74	3.23		
0.75	3.23		
0.76	3.24		
0.77	3.07		
0.78	2.99		
0.79	2.96		
0.80	2.89		
0.81	2.78		
0.82	2.82		

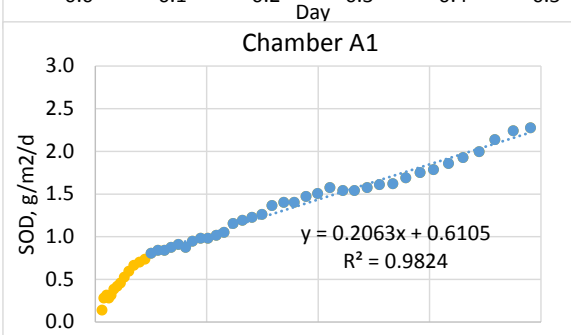
Station A SOD Low Mixed

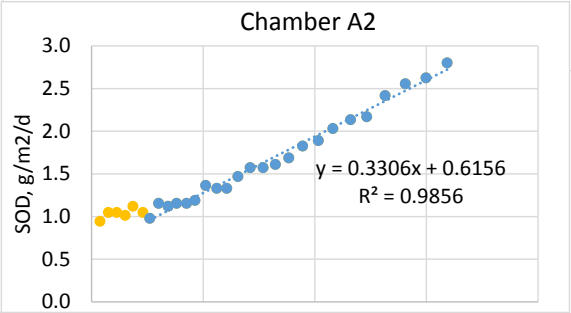
Time,	DO, mg/L			SOD, g/m2/d		
day	A1	A2	A3	A1	A2	A3
0.00	8.75	7.48	7.30			
0.01	8.15	6.79	6.90			2.579
0.02	7.81	6.37	6.51	2.278	2.803	2.546
0.03	7.50	5.99	6.12	2.243	2.628	2.481
0.04	7.17	5.62	5.75	2.137	2.558	2.383
0.05	6.89	5.26	5.39	1.997	2.418	2.187
0.06	6.60	**4.93**	**5.08**	1.927	**2.172**	**2.089**
0.07	6.34	4.64	4.75	1.857	2.137	1.991
0.08	6.07	4.32	4.47	1.787	2.032	1.893
0.09	5.83	4.06	4.17	1.752	1.892	1.828
0.10	5.57	3.78	3.91	1.690	1.828	1.703
0.11	5.34	3.53	3.64	1.621	1.690	1.670
0.13	**5.10**	3.29	3.39	**1.611**	1.611	1.533
0.14	**4.88**	3.07	3.17	**1.575**	1.575	1.500
0.15	4.65	2.84	2.93	1.541	1.576	1.403
0.16	4.44	2.62	2.74	1.542	1.472	0.555
0.17	4.21	2.42	2.76	1.577	1.332	0.131
0.18	3.99	2.24	2.70	1.507	1.332	0.653
0.19	3.78	2.04	2.56	1.472	1.367	0.588
0.20	3.57	1.85	2.52	1.402	1.191	0.653
0.21	3.38	1.70	2.36	1.402	1.156	0.653
0.22	3.17	1.52	2.32	1.367	1.156	0.588
0.23	2.99	1.37	2.18	1.261	1.121	0.718
0.24	2.81	1.20	2.10	1.226	1.156	0.457
0.25	2.64	1.04	2.04	1.191	0.981	0.849
0.26	2.47	0.92	1.84	1.156	1.051	0.620
0.27	2.31	0.74	1.85	1.051	1.121	0.490
0.28	2.17	0.60	1.69	1.016	1.016	0.816
0.29	2.02	0.45	1.60	0.981	1.051	0.522
0.30	1.89	0.30	1.53	0.981	1.051	0.588
0.31	1.74	0.15	1.42	0.946	0.946	0.457
0.32	1.62	0.03	1.39	0.876		0.490
0.33	1.49		1.27	0.911		0.718
0.34	1.36		1.17	0.876		0.588
0.35	1.24		1.09	0.841		1.044
0.36	1.12		0.85	0.841		0.392
0.38	1.00		0.97	0.806		
0.39	0.89		0.92	0.736		1.110
0.40	0.79		0.63	0.701		1.306
0.41	0.69		0.52	0.666		
0.42	0.60		0.77	0.596		
0.43	0.52		0.67	0.526		0.196
0.44	0.45		0.71	0.456		0.359
0.45	0.39		0.56	0.420		0.979
0.46	0.33		0.41	0.385		0.326
0.47	0.28		0.46	0.315		0.098
0.48	0.24		0.38	0.280		
0.49	0.20		0.55	0.315		0.522
0.50	0.15		0.22	0.280		0.685
0.51	0.12		0.34	0.140		
0.52	0.11		0.36			0.131
0.53			0.30			0.326
0.54			0.26			0.555
0.55			0.13			

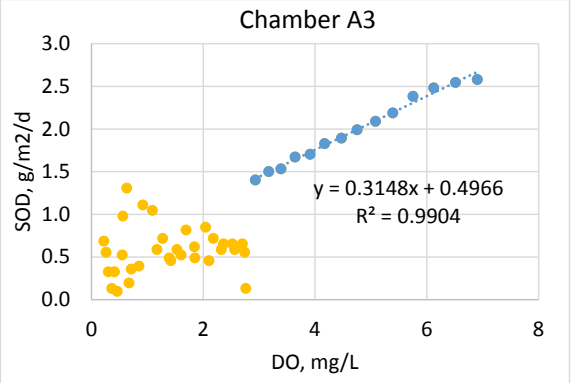
Chamber	A1	A2	A3*		
Water Ht, m	0.073	0.073	0.068		
SOD ~5 mg/L, measured	1.593	2.172	2.089	Mean	Stdev
SOD @ 5 mg/L, model	1.642	2.269	2.071	1.994	0.32
SOD slope	0.206	0.331	0.315	0.284	0.068
SOD int	0.611	0.616	0.497	0.574	0.067

*SOD slope and R2 based on DO > ~2.93 mg/L





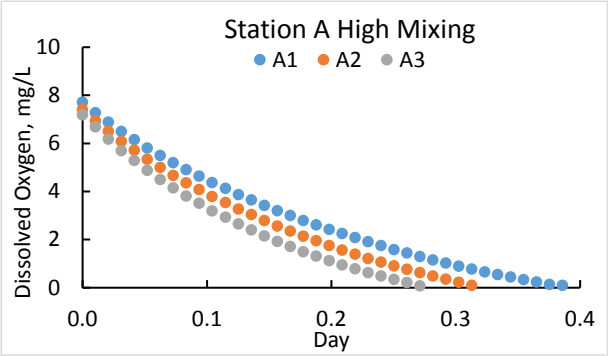


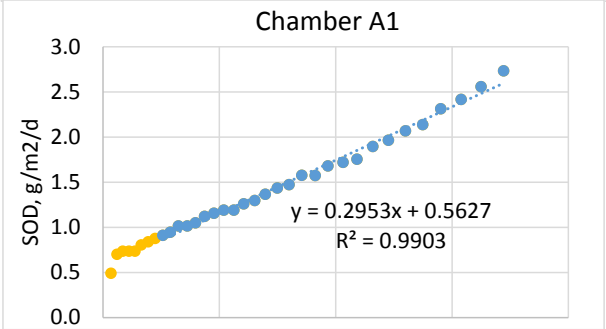


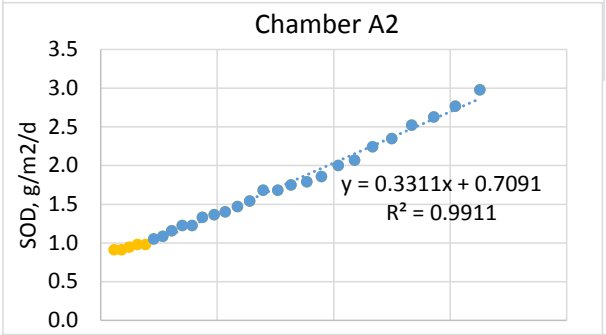
Station A SOD High Mixed

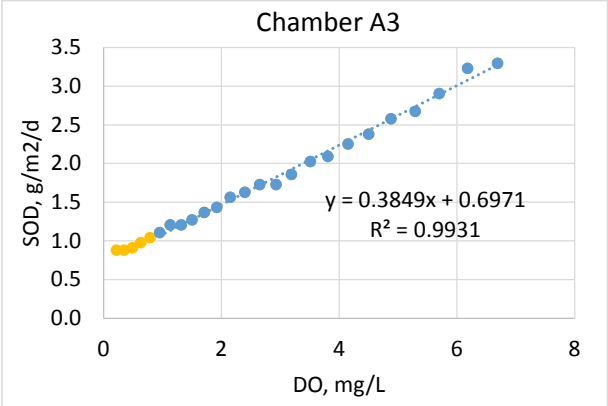
Time,	DO, mg/L			SOD, g/m2/d		
day	A1	A2	A3	A1	A2	A3
0.00	7.72	7.41	7.19			
0.01	7.28	6.94	6.69			3.297
0.02	6.89	6.51	6.18	2.733	2.978	3.231
0.03	6.50	6.09	5.70	2.558	2.768	2.905
0.04	6.16	5.72	5.29	2.418	2.628	2.676
0.05	5.81	5.34	**4.88**	2.313	2.523	**2.579**
0.06	5.50	**5.00**	4.50	2.137	**2.348**	2.383
0.07	5.20	4.67	4.15	2.069	2.244	2.254
0.08	**4.91**	4.36	3.81	**1.965**	2.071	2.092
0.09	4.64	4.08	3.51	1.895	2.000	2.027
0.10	4.37	3.79	3.19	1.756	1.859	1.860
0.11	4.13	3.54	2.93	1.720	1.789	1.731
0.13	3.87	3.27	2.65	1.681	1.751	1.729
0.14	3.65	3.04	2.40	1.575	1.680	1.630
0.15	3.42	2.79	2.15	1.576	1.681	1.566
0.16	3.20	2.56	1.92	1.472	1.542	1.436
0.17	3.00	2.35	1.71	1.437	1.472	1.371
0.18	2.79	2.14	1.50	1.367	1.402	1.273
0.19	2.61	1.95	1.32	1.296	1.367	1.208
0.20	2.42	1.75	1.13	1.261	1.332	1.208
0.21	2.25	1.57	0.95	1.191	1.226	1.110
0.22	2.08	1.40	0.79	1.191	1.226	1.044
0.23	1.91	1.22	0.63	1.156	1.156	0.979
0.24	1.75	1.07	0.49	1.121	1.086	0.914
0.25	1.59	0.91	0.35	1.051	1.051	0.881
0.26	1.45	0.77	0.22	1.016	0.981	0.881
0.27	1.30	0.63	0.08	1.016	0.981	
0.28	1.16	0.49		0.946	0.946	
0.29	1.03	0.36		0.911	0.911	
0.30	0.90	0.23		0.876	0.911	
0.31	0.78	0.10		0.841		
0.32	0.66			0.806		
0.33	0.55			0.736		
0.34	0.45			0.736		
0.35	0.34			0.736		
0.36	0.24			0.701		
0.38	0.14			0.491		
0.39	0.10					

Chamber	A1	A2	A3		
Water Ht, m	0.073	0.073	0.068		
SOD ~5 mg/L, measured	1.965	2.348	2.579	Mean	Stdev
SOD @ 5 mg/L, model	2.039	2.365	2.622	2.342	0.292
SOD slope	0.295	0.331	0.385	0.337	0.045
SOD int	0.563	0.709	0.697	0.656	0.081





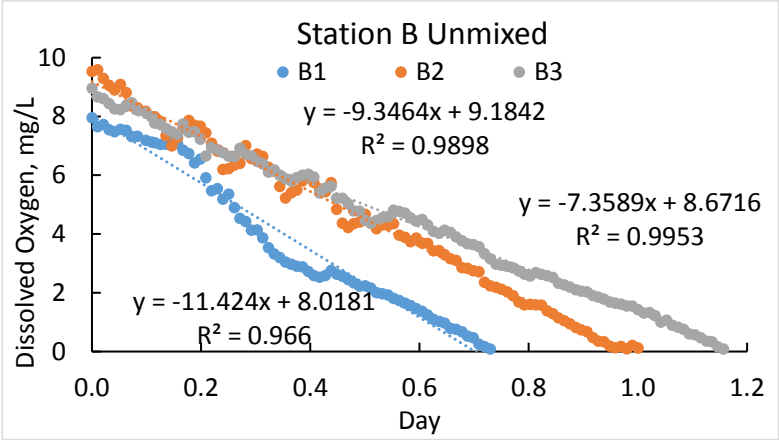




Station B SOD Unmixed

Time, day	DO, mg/L		
	B1	B2	B3
0.00	7.96	9.53	8.96
0.01	7.65	9.59	8.67
0.02	7.73	9.30	8.61
0.03	7.55	9.06	8.44
0.04	7.48	8.90	8.26
0.05	7.56	9.09	8.23
0.06	7.53	8.81	8.38
0.07	7.32	8.36	8.47
0.08	7.33	8.30	8.22
0.10	7.19	8.18	8.13
0.11	7.13	8.00	7.99
0.11	7.11	7.99	7.78
0.13	7.05	7.83	7.73
0.14	7.06	7.35	7.59
0.15	7.15	7.00	7.48
0.16	7.07	7.28	7.39
0.17	6.85	7.62	7.74
0.18	6.74	7.87	7.47
0.19	6.42	7.70	7.48
0.20	6.55	7.67	7.23
0.21	5.91	7.44	6.66
0.22	5.47	7.09	6.95
0.23	5.55	6.82	6.88
0.24	5.19	6.20	6.77
0.25	5.36	6.22	6.65
0.26	4.90	6.35	6.63
0.27	4.53	6.40	6.92
0.28	4.43	7.01	6.71
0.29	4.13	6.57	6.66
0.30	4.14	6.72	6.47
0.31	3.87	6.64	6.39
0.32	3.54	6.27	6.11
0.33	3.32	6.14	6.18
0.34	3.20	5.62	6.00
0.35	3.05	5.23	5.88
0.36	2.97	5.41	5.80
0.38	2.91	5.50	5.92
0.39	2.88	5.81	6.00
0.40	2.73	5.96	6.04
0.41	2.59	5.76	5.94
0.42	2.53	5.54	5.40
0.43	2.59	5.44	5.56
0.44	2.76	5.75	5.63
0.45	2.64	4.84	5.22
0.46	2.56	4.37	5.22
0.47	2.45	4.22	5.02
0.48	2.34	4.35	4.79
0.49	2.23	4.41	4.78
0.50	2.24	4.67	4.47
0.51	2.16	4.38	4.37
0.52	2.01	4.18	4.46
0.53	1.97	4.31	4.56
0.54	1.93	4.30	4.59
0.55	1.81	4.35	4.81
0.56	1.74	3.96	4.77
0.57	1.65	3.89	4.71
0.58	1.57	3.74	4.55
0.59	1.46	3.86	4.44

Chamber	B1	B2	B3		
Rate, g/m3/d	11.424	9.346	7.359		
R^2	0.970	0.990	0.995		
Water Ht, m	0.070	0.071	0.070	Mean	Stdev
SOD, g/m2/d	0.800	0.664	0.515	0.659	0.142

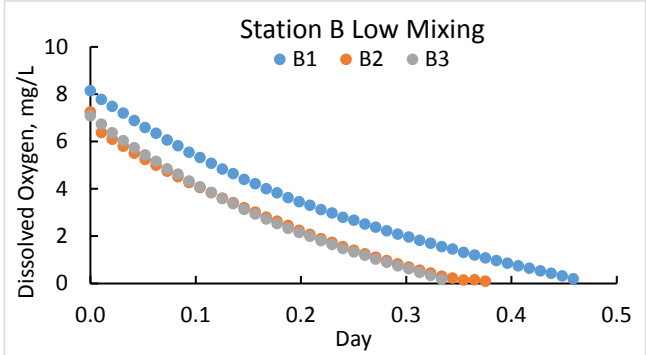


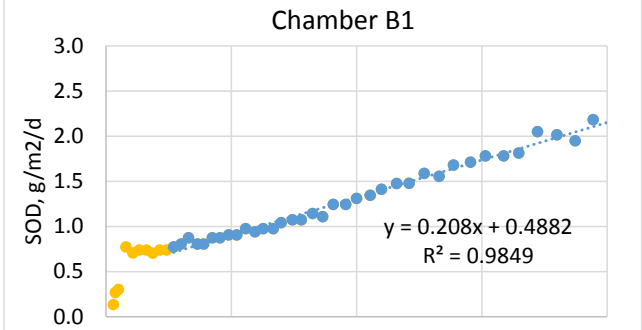
0.6045	1.37	3.69	4.50
0.6149	1.25	3.68	4.31
0.6254	1.10	3.43	4.09
0.6358	1.03	3.44	4.03
0.6462	0.97	3.30	4.13
0.6566	0.79	3.16	4.06
0.667	0.76	3.10	3.90
0.6774	0.68	2.86	3.77
0.6879	0.53	2.83	3.67
0.6983	0.47	2.75	3.64
0.7087	0.25	2.72	3.57
0.7191	0.17	2.36	3.33
0.7295	0.09	2.24	3.16
0.7399		2.19	2.97
0.7504		2.12	2.94
0.7608		2.03	2.90
0.7712		1.90	2.85
0.7816		1.69	2.74
0.792		1.59	2.64
0.8024		1.61	2.57
0.8129		1.59	2.69
0.8233		1.58	2.63
0.8337		1.39	2.58
0.8441		1.29	2.52
0.8545		1.15	2.33
0.8649		1.05	2.27
0.8754		0.95	2.20
0.8858		0.82	2.11
0.8962		0.74	2.06
0.9066		0.68	2.03
0.917		0.48	1.91
0.9274		0.36	1.85
0.9379		0.33	1.79
0.9483		0.19	1.69
0.9587		0.13	1.65
0.9691		0.18	1.62
0.9795		0.10	1.55
0.99		0.21	1.55
1.0004		0.12	1.43
1.0108			1.31
1.0212			1.33
1.0316			1.22
1.042			1.00
1.0525			1.07
1.0629			0.90
1.0733			0.83
1.0837			0.76
1.0941			0.60
1.1045			0.57
1.115			0.47
1.1254			0.36
1.1358			0.33
1.1462			0.16
1.1566			0.09

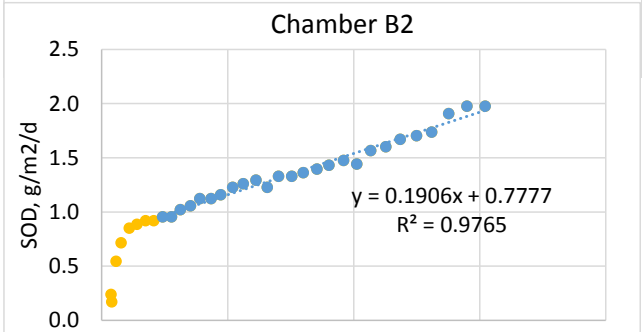
Station B SOD Low Mixed

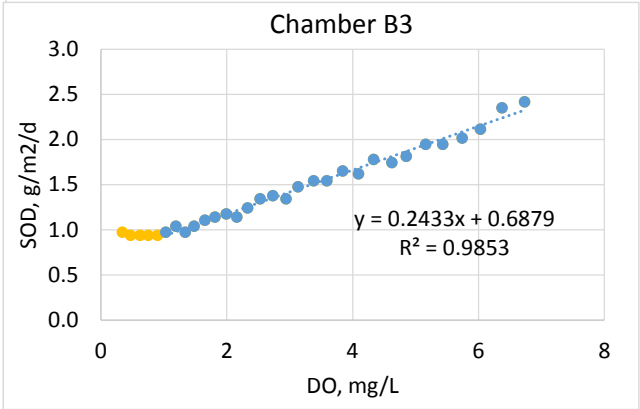
Time,	DO, mg/L			SOD, g/m2/d		
day	B1	B2	B3	B1	B2	B3
0.00	8.14	7.25	7.09			
0.01	7.78	6.38	6.73	2.184		2.419
0.02	7.49	6.09	6.37	1.949	1.977	2.352
0.03	7.20	5.80	6.03	2.016	1.977	2.117
0.04	6.89	5.51	5.74	2.050	1.908	2.016
0.05	6.59	5.24	5.43	1.814	1.738	1.949
0.06	6.35	**5.00**	**5.16**	1.781	**1.704**	**1.949**
0.07	6.06	4.74	**4.85**	1.781	1.670	**1.814**
0.08	5.82	4.51	4.62	1.714	1.602	1.747
0.09	5.55	4.27	4.33	1.680	1.568	1.781
0.10	5.32	4.05	4.09	1.554	1.442	1.620
0.11	**5.08**	3.84	3.84	**1.587**	1.476	1.653
0.13	4.84	3.61	3.59	1.478	1.431	1.545
0.14	4.64	3.42	3.38	1.477	1.396	1.544
0.15	4.40	3.20	3.13	1.410	1.362	1.478
0.16	4.22	3.02	2.94	1.344	1.329	1.344
0.17	4.00	2.81	2.73	1.310	1.329	1.378
0.18	3.83	2.63	2.53	1.243	1.227	1.344
0.19	3.63	2.45	2.33	1.243	1.295	1.243
0.20	3.46	2.25	2.16	1.109	1.261	1.142
0.21	3.30	2.08	1.99	1.142	1.227	1.176
0.22	3.12	1.89	1.81	1.075	1.159	1.142
0.23	2.98	1.74	1.65	1.075	1.125	1.109
0.24	2.80	1.56	1.48	1.042	1.125	1.042
0.25	2.67	1.41	1.34	0.974	1.056	0.974
0.26	2.51	1.25	1.19	0.974	1.022	1.042
0.27	2.38	1.11	1.03	0.941	0.954	0.974
0.28	2.23	0.97	0.90	0.974	0.954	0.941
0.29	2.09	0.83	0.75	0.907	0.920	0.941
0.30	1.96	0.70	0.62	0.907	0.920	0.941
0.31	1.82	0.56	0.47	0.874	0.886	0.941
0.32	1.70	0.44	0.34	0.874	0.852	0.974
0.33	1.56	0.31	0.18	0.806	0.716	
0.34	1.46	0.23		0.806	0.545	
0.35	1.32	0.15		0.874	0.239	
0.36	1.20	0.16		0.806	0.170	
0.38	1.08	0.10		0.773		
0.39	0.97			0.739		
0.40	0.86			0.739		
0.41	0.75			0.706		
0.42	0.65			0.739		
0.43	0.53			0.740		
0.44	0.43			0.706		
0.45	0.32			0.773		
0.46	0.20					
0.47						
0.48	0.24					
0.49	0.20			0.302		
0.50	0.15			0.269		
0.51	0.12			0.134		
0.52	0.11					
0.53						
0.54						
0.55						

Chamber	B1	B2	B3		
Water Ht, m	0.070	0.071	0.070		
SOD ~5 mg/L, measured	1.587	1.704	1.882	Mean	Stdev
SOD @ 5 mg/L, model	1.528	1.731	1.904	1.721	0.1883
SOD slope	0.208	0.191	0.243	0.214	0.0269
SOD int	0.488	0.778	0.688	0.651	0.1482





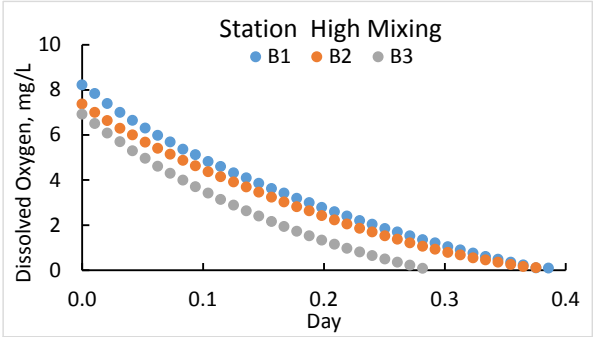


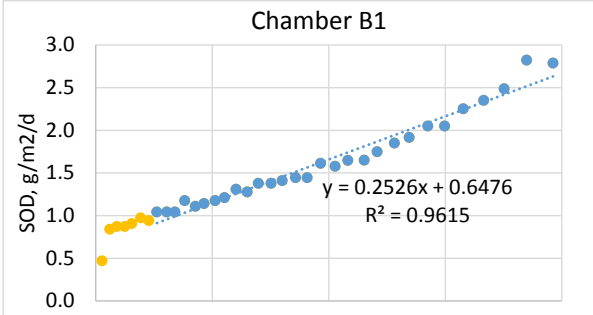


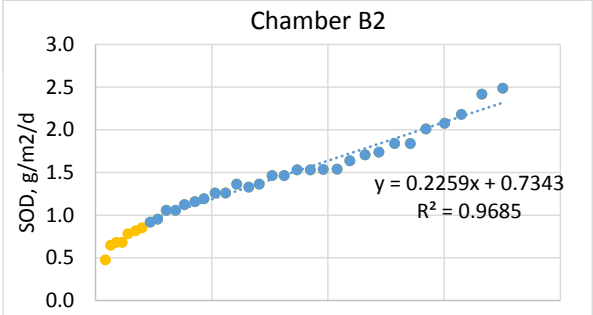
Station B SOD High Mixed

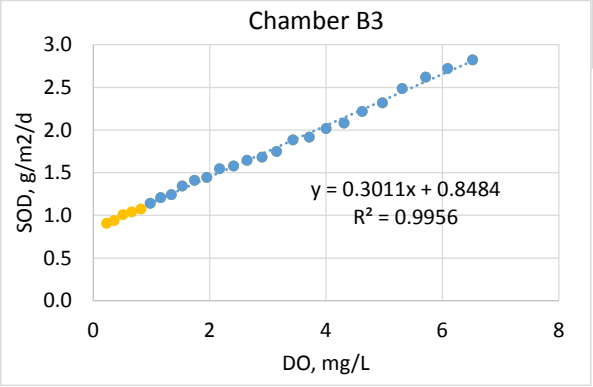
Time,	DO, mg/L			SOD, g/m2/d		
day	B1	B2	B3	B1	B2	B3
0.00	8.23	7.38	6.93			
0.01	7.85	7.01	6.52	2.789	2.488	2.822
0.02	7.40	6.65	6.09	2.822	2.420	2.722
0.03	7.01	6.30	5.71	2.486	2.181	2.621
0.04	6.66	6.01	5.31	2.352	2.079	2.486
0.05	6.31	5.69	**4.97**	2.251	2.011	**2.318**
0.06	5.99	5.42	4.62	2.050	1.840	2.218
0.07	5.70	**5.15**	4.31	2.050	**1.840**	2.083
0.08	5.38	**4.88**	4.00	1.917	**1.739**	2.018
0.09	**5.13**	4.64	3.71	**1.851**	1.707	1.918
0.10	**4.83**	4.38	3.43	**1.750**	1.638	1.885
0.11	4.61	4.16	3.15	1.651	1.540	1.750
0.13	4.33	3.92	2.90	1.649	1.538	1.682
0.14	4.11	3.70	2.64	1.577	1.532	1.645
0.15	3.86	3.47	2.41	1.612	1.533	1.578
0.16	3.63	3.25	2.17	1.445	1.465	1.546
0.17	3.43	3.04	1.95	1.445	1.465	1.445
0.18	3.20	2.82	1.74	1.411	1.363	1.411
0.19	3.01	2.64	1.53	1.378	1.329	1.344
0.20	2.79	2.43	1.34	1.378	1.363	1.243
0.21	2.60	2.24	1.16	1.277	1.261	1.210
0.22	2.41	2.06	0.98	1.310	1.261	1.142
0.23	2.21	1.87	0.82	1.210	1.193	1.075
0.24	2.05	1.71	0.66	1.176	1.159	1.042
0.25	1.86	1.53	0.51	1.142	1.125	1.008
0.26	1.71	1.38	0.36	1.109	1.056	0.941
0.27	1.53	1.22	0.23	1.176	1.056	0.907
0.28	1.36	1.07	0.09	1.042	0.954	
0.29	1.22	0.94		1.042	0.920	
0.30	1.05	0.80		1.042	0.852	
0.31	0.91	0.69		0.941	0.818	
0.32	0.77	0.56		0.974	0.784	
0.33	0.62	0.46		0.907	0.682	
0.34	0.50	0.36		0.874	0.682	
0.35	0.36	0.26		0.874	0.648	
0.36	0.24	0.17		0.840	0.477	
0.38	0.11	0.12		0.470		
0.39	0.10					

Chamber	B1	B2	B3		
Water Ht, m	0.070	0.071	0.070		
SOD ~5 mg/L, measured	1.800	1.790	2.318	Mean	Stdev
SOD @ 5 mg/L, model	1.911	1.864	2.354	2.043	0.27
SOD slope	0.253	0.226	0.301	0.260	0.038
SOD int	0.648	0.734	0.848	0.743	0.101





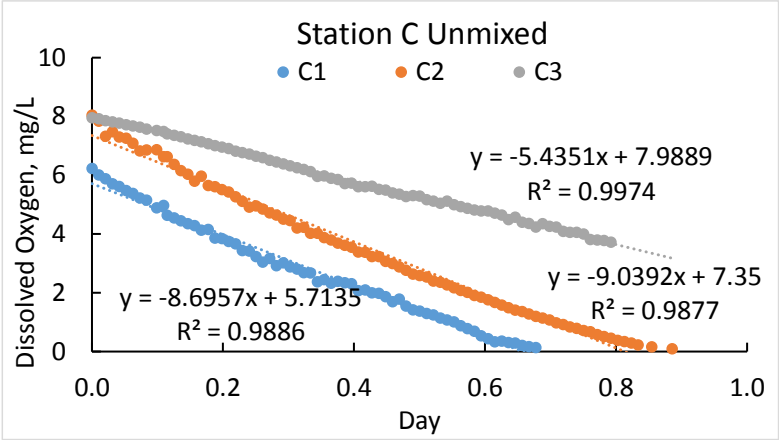




Station C SOD Unmixed

Time, day	DO, mg/L		
	C1	C2	C3
0.00	6.23	8.05	7.96
0.01	6.01	7.84	7.92
0.02	5.88	7.33	7.86
0.03	5.71	7.48	7.82
0.04	5.62	7.30	7.78
0.05	5.48	7.26	7.72
0.06	5.38	7.09	7.68
0.07	5.23	6.83	7.64
0.08	5.15	6.86	7.57
0.10	4.89	6.87	7.52
0.11	4.97	6.63	7.49
0.11	4.64	6.63	7.41
0.13	4.55	6.37	7.36
0.14	4.45	6.16	7.31
0.15	4.35	6.04	7.24
0.16	4.29	5.80	7.19
0.17	4.13	5.97	7.14
0.18	4.16	5.65	7.07
0.19	3.86	5.61	7.01
0.20	3.85	5.51	6.96
0.21	3.75	5.43	6.91
0.22	3.67	5.27	6.82
0.23	3.44	5.11	6.77
0.24	3.42	4.92	6.72
0.25	3.23	4.96	6.65
0.26	3.05	4.85	6.60
0.27	3.17	4.72	6.51
0.28	2.92	4.65	6.45
0.29	3.02	4.51	6.39
0.30	2.88	4.46	6.32
0.31	2.81	4.21	6.26
0.32	2.69	4.23	6.20
0.33	2.68	4.03	6.13
0.34	2.38	4.03	5.96
0.35	2.45	3.88	5.98
0.36	2.33	3.80	5.90
0.38	2.39	3.69	5.86
0.39	2.34	3.62	5.72
0.40	2.31	3.55	5.73
0.41	2.07	3.39	5.61
0.42	2.10	3.38	5.61
0.43	2.00	3.23	5.63
0.44	1.98	3.23	5.52
0.45	1.87	3.07	5.50
0.46	1.70	3.00	5.40
0.47	1.79	2.88	5.36
0.48	1.55	2.77	5.28
0.49	1.42	2.64	5.31
0.50	1.38	2.59	5.29
0.51	1.30	2.54	5.17
0.52	1.25	2.40	5.12
0.53	1.14	2.36	5.05
0.54	1.08	2.27	5.12
0.55	1.01	2.17	5.00
0.56	0.88	2.08	4.93
0.57	0.78	2.02	4.88
0.58	0.69	1.91	4.82
0.59	0.54	1.85	4.79

Chamber	C1	C2	C3		
Rate, g/m3/d	8.696	9.039	5.435		
R^2	0.989	0.988	0.997		
Water Ht, m	0.076	0.072	0.074	Mean	Stdev
SOD, g/m2/d	0.661	0.651	0.402	0.571	0.147

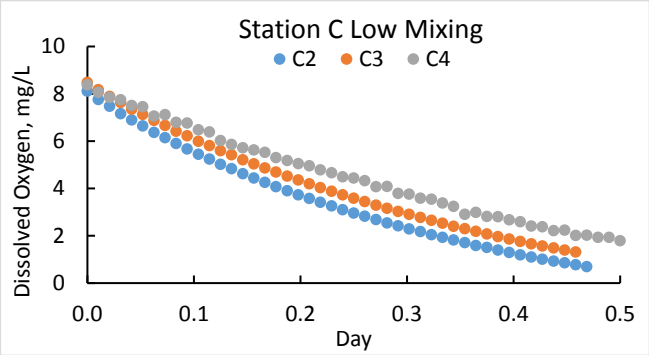


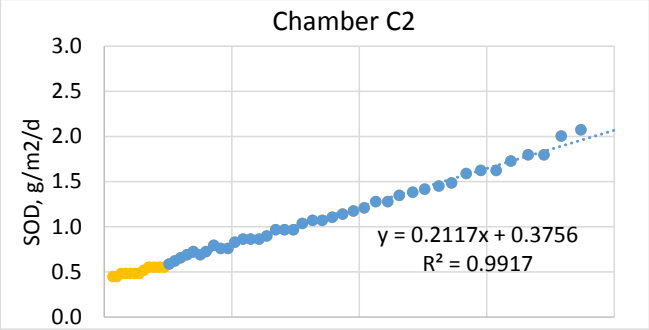
0.60	0.44	1.76	4.79
0.61	0.33	1.67	4.71
0.63	0.36	1.58	4.65
0.64	0.31	1.49	4.49
0.65	0.29	1.41	4.57
0.66	0.21	1.36	4.40
0.67	0.17	1.28	4.36
0.68	0.14	1.20	4.24
0.69		1.14	4.35
0.70		1.08	4.26
0.71		0.98	4.24
0.72		0.92	4.09
0.73		0.84	4.06
0.74		0.79	4.06
0.75		0.72	4.00
0.76		0.68	3.81
0.77		0.58	3.80
0.78		0.51	3.78
0.79		0.46	3.72
0.80		0.38	
0.81		0.34	
0.82		0.29	
0.83		0.23	
0.85		0.16	
0.89		0.10	

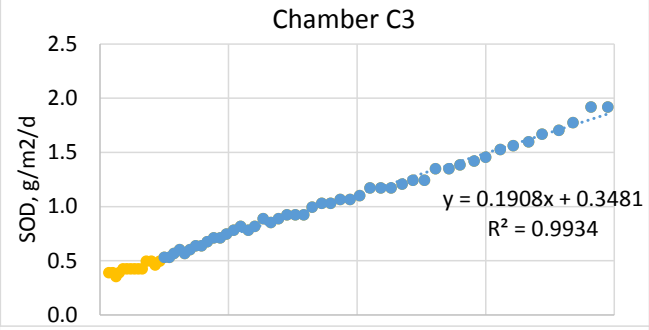
Station C SOD Low Mixed

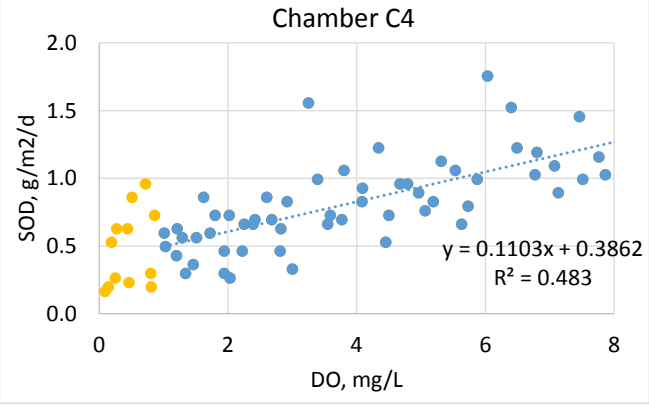
Time,	DO, mg/L			SOD, g/m2/d		
day	C2	C3	C4	C2	C3	C4
0.00	8.12	8.49	8.38			
0.01	7.77	8.18	8.07			
0.02	7.48	7.90	7.86	2.074	1.918	1.027
0.03	7.17	7.64	7.76	2.004	1.918	1.159
0.04	6.90	7.36	7.51	1.797	1.776	0.994
0.05	6.65	7.14	7.46	1.797	1.705	1.457
0.06	6.38	6.88	7.07	1.728	1.669	1.093
0.07	6.15	6.67	7.13	1.624	1.598	0.894
0.08	5.91	6.43	6.80	1.624	1.563	1.192
0.09	5.68	6.23	6.77	1.590	1.527	1.027
0.10	5.45	6.00	6.49	1.486	1.456	1.225
0.11	5.25	5.82	6.40	1.452	1.421	1.524
0.13	**5.03**	5.60	6.03	**1.417**	1.385	1.755
0.14	4.84	5.43	5.87	1.382	1.350	0.994
0.15	4.63	5.22	5.73	1.348	1.350	0.795
0.16	4.45	**5.05**	5.63	1.279	**1.243**	0.662
0.17	4.26	4.87	5.53	1.279	1.243	1.060
0.18	4.08	4.70	5.31	1.210	1.208	1.126
0.19	3.91	4.53	5.19	1.175	1.172	0.828
0.20	3.74	4.37	**5.06**	1.140	1.172	**0.762**
0.21	3.58	4.20	**4.96**	1.106	1.172	**0.894**
0.22	3.42	4.04	4.79	1.071	1.101	0.960
0.23	3.27	3.89	4.67	1.071	1.066	0.960
0.24	3.11	3.74	4.50	1.037	1.066	0.729
0.25	2.97	3.59	4.45	0.968	1.030	0.530
0.26	2.83	3.45	4.34	0.968	1.030	1.225
0.27	2.69	3.30	4.08	0.968	0.995	0.828
0.28	2.55	3.17	4.09	0.899	0.924	0.927
0.29	2.43	3.04	3.80	0.864	0.924	1.060
0.30	2.30	2.91	3.77	0.864	0.924	0.696
0.31	2.18	2.78	3.59	0.864	0.888	0.729
0.32	2.05	2.66	3.55	0.829	0.852	0.662
0.33	1.94	2.54	3.39	0.760	0.888	0.994
0.34	1.83	2.41	3.25	0.760	0.817	1.557
0.35	1.72	2.31	2.92	0.795	0.781	0.828
0.36	1.60	2.19	3.00	0.726	0.817	0.331
0.38	1.51	2.08	2.82	0.691	0.781	0.629
0.39	1.40	1.97	2.81	0.726	0.746	0.464
0.40	1.30	1.87	2.68	0.691	0.710	0.696
0.41	1.20	1.77	2.60	0.657	0.710	0.861
0.42	1.11	1.67	2.42	0.622	0.675	0.696
0.43	1.02	1.58	2.39	0.588	0.639	0.662
0.44	0.94	1.49	2.22	0.553	0.639	0.464
0.45	0.86	1.40	2.25	0.553	0.604	0.662
0.46	0.78	1.32	2.02	0.553	0.568	0.729
0.47	0.70	1.24	2.03	0.553	0.604	0.265
0.48	0.62	1.15	1.94	0.518	0.568	0.298
0.49	0.55	1.08	1.94	0.484	0.533	0.464
0.50	0.48	1.00	1.80	0.484	0.533	0.729
0.51	0.41	0.93	1.72	0.484	0.497	0.596
0.52	0.34	0.86	1.62	0.484	0.462	0.861
0.53	0.27	0.80	1.46	0.484	0.497	0.364
0.54	0.20	0.72	1.51	0.449	0.497	0.563
0.55	0.14	0.66	1.29	0.449	0.426	0.563
0.56	0.07	0.60	1.34		0.426	0.298
0.57		0.54	1.20		0.426	0.431
0.58		0.48	1.21		0.426	0.629
0.59		0.42	1.01		0.426	0.596

Chamber	C2	C3	C4		
Water Ht, m	0.072	0.074	0.069		
SOD ~5 mg/L, measured	1.417	1.243	0.828	Mean	Stdev
SOD @ 5 mg/L, model	1.434	1.302	0.938	1.225	0.257
SOD slope	0.212	0.191	0.110	0.171	0.054
SOD int	0.376	0.348	0.386	0.370	0.020







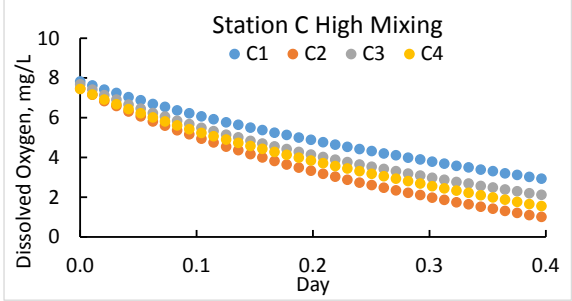


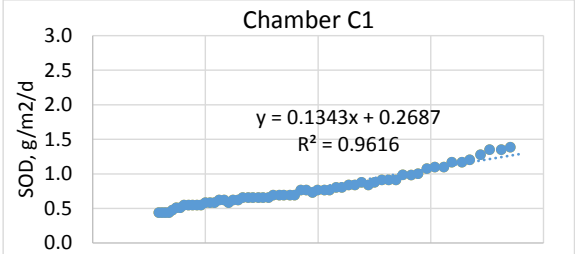
0.60		0.36	1.03		0.426	0.497
0.61		0.30	0.86		0.391	0.729
0.63		0.25	0.81		0.355	0.199
0.64		0.20	0.80		0.391	0.298
0.65		0.14	0.72		0.391	0.960
0.66		0.09	0.51			0.861
0.67			0.46			0.232
0.68			0.44			0.629
0.69			0.27			0.629
0.70			0.25			0.265
0.71			0.19			0.530
0.72			0.09			0.166
0.73			0.14			0.199
0.74			0.03			

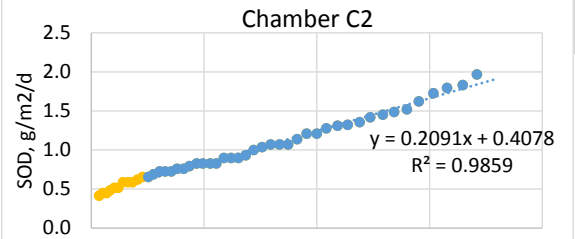
Station C SOD High Mixed

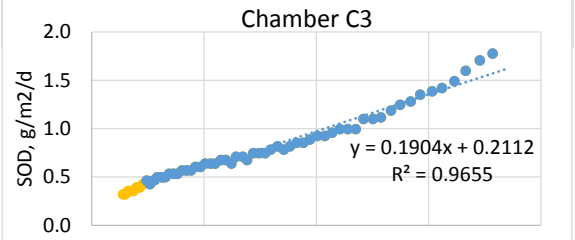
Time,	DO, mg/L				SOD, g/m2/d			
day	C1	C2	C3	C4	C1	C2	C3	C4
0.00	7.83	7.47	7.68	7.45				
0.01	7.63	7.16	7.41	7.17				
0.02	7.41	6.84	7.14	6.91	1.386	1.970	1.776	1.623
0.03	7.25	6.59	6.91	6.68	1.350	1.832	1.705	1.557
0.04	7.04	6.31	6.66	6.44	1.350	1.797	1.598	1.490
0.05	6.88	6.07	6.46	6.23	1.277	1.728	1.492	1.424
0.06	6.69	5.81	6.24	6.01	1.204	1.624	1.421	1.391
0.07	6.55	5.60	6.06	5.81	1.167	1.521	1.385	1.325
0.08	6.37	5.37	5.85	5.61	1.168	1.487	1.351	1.260
0.09	6.23	5.17	5.68	5.43	1.096	1.454	1.281	1.227
0.10	6.07	**4.95**	5.49	5.24	1.096	**1.419**	1.245	1.194
0.11	5.93	4.76	5.33	**5.07**	1.075	1.358	1.187	**1.106**
0.13	5.77	4.55	5.15	**4.90**	1.002	1.323	1.115	**1.073**
0.14	5.65	4.37	**5.01**	4.74	0.984	1.312	**1.100**	1.059
0.15	5.50	4.17	4.84	4.58	0.984	1.278	1.101	1.026
0.16	5.38	4.00	4.70	4.43	0.912	1.210	0.995	0.994
0.17	5.25	3.82	4.56	4.28	0.912	1.210	0.995	0.994
0.18	5.13	3.65	4.42	4.13	0.912	1.140	0.995	0.960
0.19	**5.00**	3.49	4.28	3.99	**0.876**	1.071	0.959	0.927
0.20	4.89	3.34	4.15	3.85	0.839	1.071	0.924	0.927
0.21	4.77	3.18	4.02	3.71	0.876	1.071	0.924	0.927
0.22	4.65	3.03	3.89	3.57	0.839	1.037	0.888	0.861
0.23	4.54	2.88	3.77	3.45	0.839	1.002	0.852	0.861
0.24	4.42	2.74	3.65	3.31	0.803	0.933	0.852	0.894
0.25	4.32	2.61	3.53	3.18	0.803	0.899	0.817	0.828
0.26	4.20	2.48	3.42	3.06	0.766	0.899	0.781	0.828
0.27	4.11	2.35	3.31	2.93	0.766	0.899	0.817	0.828
0.28	3.99	2.22	3.19	2.81	0.766	0.829	0.781	0.795
0.29	3.90	2.11	3.09	2.69	0.730	0.829	0.746	0.828
0.30	3.79	1.98	2.98	2.56	0.766	0.829	0.746	0.795
0.31	3.69	1.87	2.88	2.45	0.766	0.829	0.746	0.762
0.32	3.58	1.74	2.77	2.33	0.693	0.795	0.675	0.762
0.33	3.50	1.64	2.69	2.22	0.693	0.760	0.710	0.762
0.34	3.39	1.52	2.57	2.10	0.693	0.760	0.710	0.762
0.35	3.31	1.42	2.49	1.99	0.693	0.726	0.639	0.729
0.36	3.20	1.31	2.39	1.88	0.693	0.726	0.675	0.729
0.38	3.12	1.21	2.30	1.77	0.657	0.726	0.675	0.729
0.39	3.02	1.10	2.20	1.66	0.657	0.691	0.639	0.696
0.40	2.94	1.01	2.12	1.56	0.657	0.657	0.639	0.696
0.41	2.84	0.91	2.02	1.45	0.657	0.657	0.639	0.696
0.42	2.76	0.82	1.94	1.35	0.657	0.622	0.604	0.662
0.43	2.66	0.73	1.85	1.25	0.657	0.588	0.604	0.663
0.44	2.58	0.65	1.77	1.15	0.621	0.588	0.569	0.630
0.45	2.49	0.56	1.69	1.06	0.620	0.588	0.568	0.596
0.46	2.41	0.48	1.61	0.97	0.584	0.518	0.568	0.596
0.47	2.33	0.41	1.53	0.88	0.620	0.518	0.533	0.596
0.48	2.24	0.33	1.46	0.79	0.620	0.484	0.533	0.563
0.49	2.16	0.27	1.38	0.71	0.584	0.449	0.533	0.563
0.50	2.08	0.20	1.31	0.62	0.584	0.449	0.497	0.530
0.51	2.00	0.14	1.24	0.55	0.584	0.415	0.497	0.497
0.52	1.92	0.08	1.17	0.47	0.547		0.497	0.497
0.53	1.85		1.10	0.40	0.547		0.462	0.464
0.54	1.77		1.04	0.33	0.547		0.426	0.431
0.55	1.70		0.98	0.27	0.547		0.462	0.431
0.56	1.62		0.91	0.20	0.547		0.426	0.431
0.57	1.55		0.86	0.14	0.511		0.391	0.397
0.58	1.48		0.80	0.08	0.511		0.391	
0.59	1.41		0.75		0.474		0.355	
0.60	1.35		0.70		0.438		0.355	
0.61	1.29		0.65		0.438		0.355	
0.63	1.23		0.60		0.438		0.320	
0.64	1.17		0.56		0.438		0.320	
0.65	1.11		0.51					

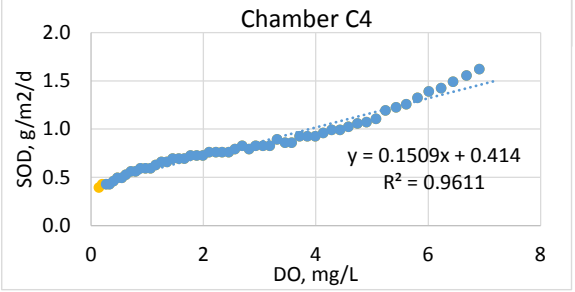
Chamber	C1	C2	C3	C4		
Water Ht, m	0.076	0.072	0.074	0.069		
SOD ~5 mg/L, measured	0.876	1.419	1.100	1.089	Mean	Stdev
SOD @ 5 mg/L, model	0.940	1.453	1.163	1.169	1.181	0.210
SOD slope	0.134	0.209	0.190	0.151	0.171	0.035
SOD int	0.269	0.408	0.211	0.414	0.325	0.101











Summary of Lake Hodges WOD Data

Date (2015)		3/12 1:00 PM	3/14 2:15 PM	3/16 2:45 PM	3/18 12:30 PM	3/20 2:30 PM	3/22 12:40 PM	3/24 6:30 PM				
Day		0.0	2.1	4.1	6.0	8.1	10.0	12.2				
Station A												
Depth	Rep								Slope	R2	Mean	Stdev
6 m	1	6.61	5.57	5.17	4.51	3.95	3.53	2.56	-0.31	0.99	-0.31	0.01
	2	6.19	5.35	4.43	4.61	3.58	2.78	2.29	-0.31	0.97		
	3	6.41	5.48	4.89	4.04	3.60	3.99	2.21	-0.30	0.92		
8 m	1	5.96	5.29	5.07	4.43	3.68	3.84	2.87	-0.24	0.96	-0.27	0.02
	2	5.73	4.91	4.52	4.25	3.42	2.94	2.08	-0.28	0.99		
	3	5.77	5.14	4.49	3.99	3.51	3.17	2.15	-0.28	0.99		
10 m	1	5.39	4.48	3.01	3.69	2.51	3.39	2.48	-0.20	0.69	-0.27	0.06
	2	5.37	4.63	3.76	3.41	2.53	2.19	1.77	-0.30	0.98		
	3	5.17	4.21	3.86	2.94	2.26	1.90	1.62	-0.30	0.97		
12 m	1	7.21	6.21	5.92	5.30	3.75	3.64	3.34	-0.33	0.95	-0.32	0.01
	2	7.53	6.86	6.05	5.70	4.33	4.22	3.92	-0.31	0.96		
	3	8.06	6.71	6.30	5.82	4.82	4.59	3.90	-0.32	0.97		
16 m	1	7.06	5.95	4.98	4.66	4.09	3.38	2.94	-0.33	0.97	-0.31	0.04
	2	7.66	6.50	5.94	5.38	4.77	4.77	4.20	-0.27	0.94		
	3	7.96	6.89	5.63	5.04	5.04	4.12	3.83	-0.33	0.93		
								overall avg		**0.94**	**-0.29**	
Station B												
Depth	Rep								Slope	R2	Mean	Stdev
6 m	1	5.95	5.11	4.83	4.13	3.64	3.13	2.65	-0.27	0.99	-0.21	0.05
	2	6.56	5.66	5.37	5.26	5.07	4.72	4.32	-0.16	0.92		
	3	6.85	6.13	5.92	5.72	4.68	5.16	4.18	-0.20	0.91		
8 m	1	6.00	5.40	5.02	4.21	4.36	3.66	3.56	-0.20	0.94	-0.21	0.01
	2	5.27	4.74	3.71	3.37	2.98	3.11	2.48	-0.22	0.91		
	3	5.36	4.96	3.94	3.58	3.43	3.29	2.76	-0.21	0.92		
10 m	1	5.91	4.87	4.19	3.43	2.57	2.49	1.55	-0.34	0.98	-0.32	0.04
	2	7.11	6.48	5.51	5.41	4.61	3.94	3.92	-0.27	0.96		
	3	8.00	6.84	6.34	5.66	4.54	4.09	3.93	-0.34	0.97		
12 m	1	5.40	4.67	3.41	2.84	2.30	1.51	1.10	-0.36	0.98	-0.34	0.04
	2	6.32	5.50	4.94	4.62	3.68	3.34	2.71	-0.29	0.99		
	3	5.59	4.82	4.50	3.55	2.63	1.64	1.45	-0.36	0.98		
								overall avg		**0.95**	**-0.27**	
Station C												
Depth	Rep								Slope	R2	Mean	Stdev
5 m	1	6.81	6.28	5.77	5.24	4.73	4.59	5.27	-0.16	0.73	-0.18	0.02
	2	7.56	6.92	6.38	6.62	5.79	5.45	5.36	-0.18	0.93		
	3	6.77	6.36	5.66	5.27	5.40	5.00	4.14	-0.19	0.93		
6 m	1	6.49	6.08	5.76	5.26	5.13	4.48	3.96	-0.20	0.98	-0.20	0.02
	2	5.57	5.40	4.92	4.50	4.40	3.89	3.38	-0.18	0.98		
	3	5.55	4.97	4.64	4.84	4.06	3.16	2.95	-0.21	0.92		
7 m	1	6.90	6.45	5.86	5.64	4.75	5.11	4.34	-0.20	0.94	-0.20	0.04
	2	6.35	6.22	5.31	4.90	4.05	4.08	3.81	-0.23	0.94		
	3	5.58	5.20	4.78	4.43	4.17	3.74	3.71	-0.16	0.97		
8 m	1	5.40	4.67	3.41	2.84	2.30	1.51	1.10	-0.36	0.98	-0.34	0.04
	2	6.32	5.50	4.94	4.62	3.68	3.34	2.71	-0.29	0.99		
	3	5.59	4.82	4.50	3.55	2.63	1.64	1.45	-0.36	0.98		
								overall avg		**0.94**	**-0.23**	
								3 site avg			**-0.26**	