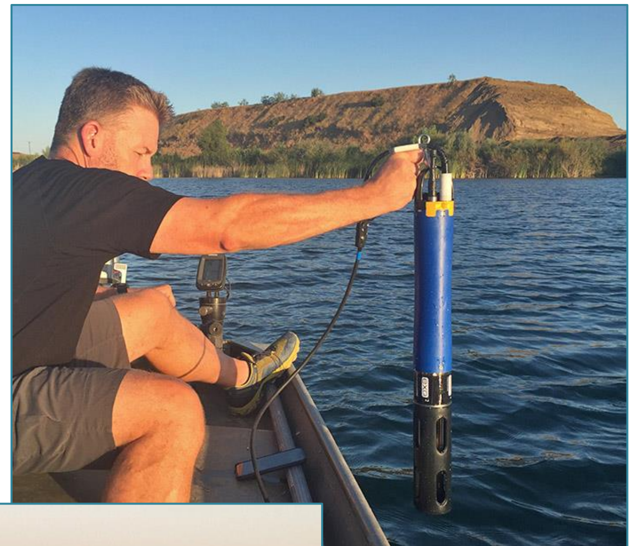
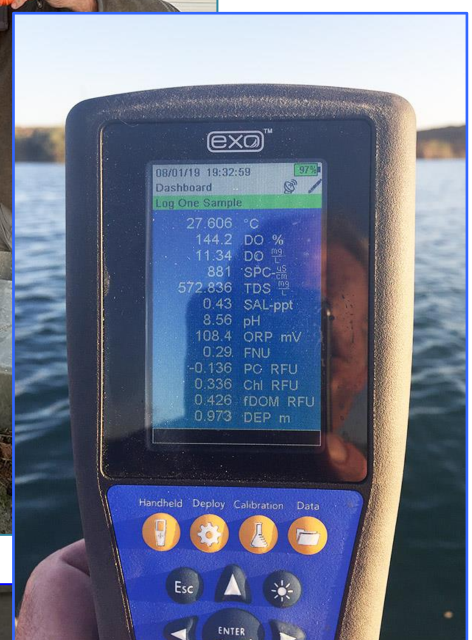
**CACHE CREEK OFF-CHANNEL AGGREGATE MINING PONDS –**



# 2019

# WATER COLUMN PROFILING

**Final Report**
January 2021




*Monitoring and Report by*

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## SUMMARY BULLET POINTS

- Water testing was conducted in 2019 at five Yolo County off-channel, aggregate-mining ponds. These were a subset of the seven ponds currently being monitored for fish mercury, per County Ordinance. Three ponds were identified as significantly elevated in fish mercury in 2 or more years, relative to Cache Creek comparison samples. These were Syar-B1, Teichert-Reiff, and Cemex-Phase 3-4. A fourth pond, Cemex-Phase 1, was also chosen for water testing, as a relatively low-mercury comparison site. Water testing began at these 4 ponds in 2018, to provide supplemental information to better understand why fish mercury is high at some sites and low at others, and to help devise possible mercury management strategies. A fifth pond, Cemex-West, was added to the water profiling in 2019, to test a deeper system.

- A wide range of chemical and physical parameters were measured at each pond, from surface to near bottom, on 5 different dates spanning the warm season between early May and late October. These included bottom depth, water clarity, temperature, dissolved oxygen, conductivity, pH, turbidity, dissolved organic matter, algal chlorophyll (green algae) and phycocyanin (blue-green algae), salinity, dissolved solids (TDS), and oxidation-reduction potential (ORP).

- Several of the monitoring parameters fell within similar ranges at all of the tested ponds. These included pH (basic/non-acidic to very basic), salinity, conductivity, dissolved solids, and redox levels.

- Most of the monitored ponds were too shallow to stratify completely (isolate water layers from each other) in the warm season. Occasional summer winds could stir the water, down to or nearly down to, the bottom.

- Despite occasional mixing of warm, oxygenated water from above, two of the tested shallower ponds – Teichert-Esparto–Reiff and Syar–B1 – maintained enough bottom water separation to lead to the depletion of dissolved oxygen in the bottom waters. This condition is known to accelerate the production of toxic methylmercury and its movement into fish. These two ponds have also been found to contain the highest fish mercury levels of the 7 ponds monitored in the overall mercury program. The new, deeper water profiling site of Syar–West was found to have strong seasonal water separation and bottom anoxia, together with fairly high fish mercury. In contrast, the lowest fish-mercury pond, the control site Cemex–Phase 1, had no oxygen depletion. Seasonal bottom water anoxia (oxygen depletion) was identified as a likely key factor contributing to elevated fish mercury in some of the ponds – and a target for management.

- However, another relatively elevated fish-mercury pond, Cemex-Phase 3-4, had no oxygen depletion, indicating that additional factors must be at play. Methylmercury production and movement into fish can be affected by many processes. Differences in water clarity were identified as likely important. Each of the ponds can have its own character; potential mercury management may need to use different approaches at different sites.

- The **Cemex–Phase 1** Pond, the relative 'control / low fish mercury' pond, was again found to be shallow, turbid (cloudy water) from processing plant slurry discharges, and well-mixed with similar water temperatures top to bottom, no stratification, and no bottom anoxia. Algae and dissolved organic matter levels were low, consistent with the cloudy water conditions lowering photosynthesis.

- The **Cemex–Phase 3-4** Pond, an identified 'elevated fish mercury' pond, was found in 2019 to be of moderate depth and with varied levels of suspended particles (turbidity) in the water as in-pond dredging increased in the eastern part of the pond nearer the index station. Formerly one of the clearest water ponds, visibilities dropped to as low as four feet in conjunction with active mining. Despite being fairly deep (around 35 feet), the Phase 3-4 pond mostly remained well-mixed, likely due to its long east-west dimension allowing wind energy to reach the bottom. The active mining also contributes to water column mixing. Because of the mixing, there was no summer stratification and no bottom anoxia. This particular pond may be challenging for management, as the elevated fish mercury there is not linked to oxygen levels in the water.

- The **Teichert–Reiff** Pond, one of the ponds identified as highly elevated in fish mercury, was found in 2019 to be shallow (17-25 feet) and turbid (cloudy water) from processing plant slurry discharges, as in 2018. Despite the shallow depths and slurry inflows, a light temperature stratification (separation) developed in the water column. Bottom waters became strongly anoxic between May and August, almost certainly increasing methylmercury levels. This seasonal cycle presents a management avenue, through disruption of summer anoxia.

- The **Syar–B1** Pond, one of the ponds identified as highly elevated in fish mercury, was found in 2019 to be of shallow/medium depth, inactive (re mining) and clear, similar to 2018. High surrounding berms give some protection from wind mixing, and a light stratification of the water column was seen as in 2018. Bottom waters, though not going fully anoxic this year, became significantly reduced in oxygen during the early parts of the warm season, likely enhancing methylmercury exposure levels as in other years. This pond, like Teichert–Reiff, may also get management benefits from disruption of summer anoxia.

- The **Syar–West** Pond was monitored to see if this significantly deeper pond would develop a stronger, more permanent thermal stratification in the warm season than the shallower ponds, with the possible depletion of oxygen in the bottom waters. This was found to be the case. The bottom water remained much cooler than the surface layers, isolating it and leading to buildups of some water quality constituents in the bottom water and the consumption of oxygen through normal microbial metabolism – with no replenishment from above, because of the thermal barrier. This 'classic warm season thermal stratification' pattern at Syar–West makes it a straightforward candidate pond for a possible mercury management trial, through warm season aeration of the bottom water by mixing.

## INTRODUCTION

The Water Column Profiling work and this data report are in support of the ongoing Mercury Monitoring program for the Yolo County off-channel aggregate-mining ponds. The primary (fish-based) monitoring is reported separately. This supplemental data report presents information on water quality parameters from a subset of the ponds being monitored for fish mercury. The full set of aggregate ponds being monitored for mercury is shown in Table A and Figure A.

The County Ordinance (Yolo County Code, 2020 – recently updated) specifies the investigation of a suite of water quality parameters that may provide evidence of factors influencing the methylmercury cycle in certain ponds, as follows:

***(f) Expanded Analysis.***

*(1) General.*

*If, during the mining or post-reclamation phase, any pit lake's average fish tissue mercury concentration exceeds the ambient mercury level for any three years, the operator shall undertake expanded analyses. The analysis shall include expanded lake water column profiling (a minimum of five profiles per affected wet pit lake plus one or more nonaffected lakes for control purposes) conducted during the warm season (generally May through October) in an appropriate deep profiling location for each pit lake. The following water quality parameters shall be collected at regular depth intervals, from surface to bottom of each lake, following protocols identified in subsection (a): temperature, dissolved oxygen, conductivity, pH and oxidation-reduction potential (ORP), turbidity or total suspended solids, dissolved organic matter, and algal density by Chlorophyll and/or Phycocyanin.*

'Profiling' refers to taking a set of measurements throughout the water column, from surface to bottom. The May-October timing focuses this monitoring on the warm season of primary biological activity.

Starting in 2018, water column profiling was done at 3 ponds identified as having fish mercury significantly elevated over Cache Creek baseline comparisons. These ponds are Syar-B1, Teichert-Reiff, and Cemex-Phase 3-4. In addition, water testing was done at a fourth pond, Cemex-Phase 1, which was identified as a relatively low-mercury control. The objective of the water column profiling work is to provide supplemental information to better understand why fish mercury may be elevated in some ponds and not in others, and to help in the development of potential mercury management strategies. Toward that end, a fifth pond – Syar–West – was added to the water monitoring in 2019. Fish mercury in that pond has been in the borderline elevated range, but it is of particular interest because it is the only much deeper pond (depths of 50-60 feet) and only example of that type of likely end habitat in the overall aggregate zone eventual restorations. We believe deep ponds may present unique mercury issues, as well as realistic management possibilities.

The chemical and physical constituents measured in the water columns of the ponds are detailed below in Methods.

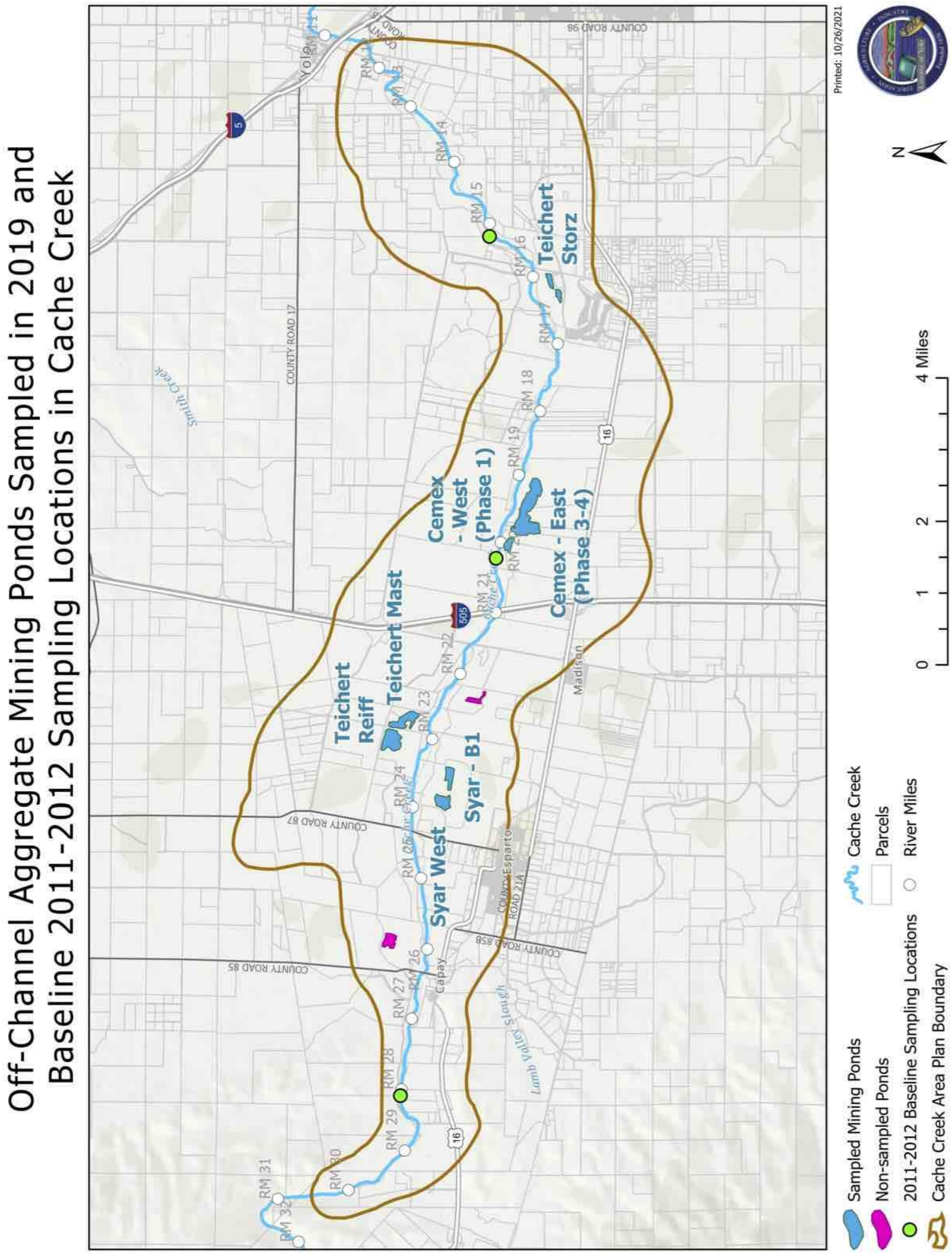
For each of the profiled ponds and each survey date (5 total between May and October), a table of the survey data is presented, together with a figure depicting the water column with several key, foundational parameters including temperature, dissolved oxygen, maximum depth, and Secchi water clarity. Then, for each pond, water column profiles are shown of individual parameters across all 5 surveys in May-October plots.

**Table A. Wet Pits Subject to Annual Mercury Monitoring**
*(modified from Yolo County Exhibit C and annual mercury monitoring reports)*

**Blue text**: water profiling conducted – low-mercury control pond
**Red text**: water profiling conducted – identified elevated-mercury ponds
* Syar–West: borderline elevated; added as only deep, heavily stratifying system

| Operator | Site | Pit | Year Mining Crossed Water Table (app) | End Reclamation Plan | Year Fish Mercury Monitoring Began | Year Water Profiling Began |
|---|---|---|---|---|---|---|
| **Cemex** | Madison | **Phase 1** | < 1996 | Lake and habitat | 2015 | 2018 |
| **Cemex** | Madison | **Phase 3-4** | ≤ 2002 | Lake and habitat | 2015 | 2018 |
| **Teichert** | Esparto | **Reiff** | ≤ 2002 | Lake and habitat | 2015 | 2018 |
| **Teichert** | Esparto | **Mast** | 2007-2008 | Lake and habitat | 2017 | – |
| **Teichert** | Woodland | **Storz** | 2010-2011 | Lake and habitat | 2017 | – |
| **Syar** | Madison | **B1** | ≤ 2002 | Lake and habitat | 2015 | 2018 |
| **Syar** | Madison | **West *** | ≤ 2002 | Lake and habitat | 2017 | 2019 |

**Figure A. Site Map**



## METHODS

Water column profiling was conducted from our sampling boat, at the deepest part of each pond. Pond bottom contours and the location of the deepest region were determined by slowly criss-crossing the pond area with a high-resolution depth meter mounted to the boat just below the water surface. General water clarity was measured with a limnological Secchi disk: a 25 cm (10") weighted disk lowered into the water, noting the depth of visual disappearance. Specific water quality constituents were measured by lowering a suite of sensors from the surface to near bottom, pausing at each meter of depth for equilibration and collection of the various readings. A (second) new, custom-designed, multi-parameter unit was purchased for this work (YSI EXO-2). The meter included sensors for measuring:

Temperature
Dissolved Oxygen: mg/L / % Saturation
Conductivity / Salinity / Total Dissolved Solids (TDS)
pH / Oxidation-Reduction Potential (ORP)
Turbidity
Algal Density (Chlorophyll and Phaeophyton)
Dissolved Organic Matter (DOC)

The sensors were carefully calibrated in the laboratory before each survey. They performed well in the field, a major improvement over the AquaRead unit originally used in 2018, which did not provide useful data for the optical parameters (Turbidity, Algae, DOC).

Logged data were transfered to our computers, where they were put into data tables and plotted in water column graphs.

# PRESENTATION OF THE 2019 DATA

## 1. CEMEX–PHASE 1 (West) POND

## 1. Cemex–Phase 1 Pond

The Phase 1 Pond results are first shown for each survey date, one at a time. Numerical data from each of the five 2019 water profiling surveys are presented in Tables 1(a) (May) through 1(e) (October). For each survey date, some of the key, driving parameters are also shown in figure form, Figures 1(a-e).

After the individual survey information, each water quality parameter is plotted across the year of sampling, in Figures 1(f) (Temperature) through 1(m) (Blue-green Algae). In these figures, the different seasonal profiles are shown together, so you can see the full range of values and the changes across the year.

Before the data tables and figures, results are first discussed below, for each of the monitored water parameters and in summary.

Water Depth (Tables and Figs. 1(a-e)): ranged narrowly between 5.8 and 6.4 m (19-21 ft) across the 2019 May-Oct profiling. This pond routinely received plant discharge slurry/water, replacing evaporation losses.

Secchi Water Clarity (Tables and Figs. 1(a-e)): was generally low/turbid, at 1.0-3.3 m (3-11 ft). A function of plant slurry inflows clouding the water.

Temperature (Tables and Figs. 1(a-e), Fig. 1(f)): Overall range 17-27 °C (63-81 °F) between May and October. A slight thermal stratification developed between May and August, with surface waters warming up to 3.5 °C (6 °F) warmer than bottom water. However, the increases in bottom water temperatures during this time (to temperatures near surface levels) indicates ongoing, periodic mixing of the water column, presumably due to wind mixing of this shallow pond, together with the mixing influence of slurry inflows. Without such periodic mixing from above, bottom temperatures would remain essentially unchanged and cool through the summer. The water column remained fairly well mixed (low gradient between surface and bottom temperatures) as overall temperatures dropped in September and October.

Dissolved Oxygen (Tables and Figs. 1(a-e), Fig. 1(g)): remained at or near saturation levels throughout the season, between 8.3 and 9.9 mg/L (ppm). This corresponded to between 96% and 125% of saturation levels. Oxygen above saturation (or super-saturated) is a typical phenomenon in waters containing moderate or greater densities of algae; oxygen is produced during photosynthesis. 'Saturation' levels refer to the equilibrium amount of oxygen that will stay dissolved in water with no ongoing sources or sinks. It is temperature-dependent – cooler water can hold more dissolved oxygen than warm water. A very slight 'D.O. sag' was apparent in June bottom waters when the pond was most thermally stratified. This ended when the pond mixed in succeeding months, as shown by the temperature profiles. Under typical warm season conditions and particularly in deeper systems, a strong thermal stratification often develops in lakes and ponds, with sun-warmed surface waters floating above the winter-cooled bottom water. Because water masses of different temperature are very resistant to mixing (similar to oil and water), this seasonal stratification has the effect of isolating the bottom water from the upper water layers and the air above. If there is a moderate or greater amount of biological activity in the isolated bottom waters during this time, normal metabolism of microbes and other organisms will gradually deplete the dissolved oxygen, which cannot be replaced in the bottom waters until the pond mixes, bringing in new oxygen from above. We are particularly interested in potential seasonal oxygen depletion in this monitoring program, as that is a condition that can greatly accelerate the production and bioavailability of methylmercury. The temperature and oxygen data indicate that this pattern did not develop in the shallow Phase 1 Pond, presumably due to wind mixing and ongoing slurry inflows from the aggregate processing plant. It is notable that this pond was the lowest in fish mercury of the 7 being monitored in the mercury program.

Conductivity (Tables 1(a-e), Fig. 1(h)): ranged between 646 and 770 µS/cm overall. Levels were quite uniform through the water column, but changing together with time. Conductivity increased between May and August (~650-770 µS/cm) and lowered somewhat in September and October, when the water was cooler (~730-740 µS/cm).

Salinity (Tables 1(a-e)): was fairly uniform, at 0.31-0.37 ppt (parts per thousand, g/L) across the sampling season. Typical freshwaters range below 0.50 ppt; seawater averages 35 ppt.

Total Dissolved Solids (TDS) (Tables 1(a-e)): ranged fairly narrowly between 420-501 mg/L (ppm) across the sampling season.

pH (Tables 1(a-e), Fig. 1(i)): was notably very basic (non-acidic; pH > 7.00) in all of the monitored ponds. This is a function of their mining history and the basic nature of local sediments. Water pH in the Phase 1 Pond fell between 8.19 and 8.50 across all depths and dates.

Oxidation/Reduction Potential (ORP) (Tables 1(a-e)): stayed within the range of 55-189 mV (millivolts) across all depths and dates.

Turbidity (Tables 1(a-e), Fig. 1(j)): This is one of two monitored ponds that regularly receives slurry discharge from aggregate processing plants (the other being Teichert-Esparto–Reiff). As a result, it is normally high in suspended solids and turbidity. Turbidity during 2019 samplings ranged between moderately turbid (1-5 FNU; Secchi visibility ~3 m) to very turbid, with Secchi visibilities under 2 m and turbidity readings to over 13 FNU.

Dissolved Organic Matter (FDOM) (Tables 1(a-e), Fig. 1(k)): Measured for the first time in 2019, we will wait a year or two before making any conclusions about this or the other optical parameters. In this shallowest of the monitored ponds, the water column remained fairly well mixed top to bottom, with similar FDOM readings within each date. Overall levels ranged between about 0.6 and 2.3 RFU, gradually rising from May to August and then decreasing from August to October.

Green Algae (Chlorophyll) (Tables 1(a-e), Fig. 1(l)): These first reliable chlorophyll readings, in 2019, showed very low levels throughout the sampling season. This was not surprising, at this typically turbid pond, with corresponding low light penetration and poor conditions for algal growth. At most depths and dates, chlorophyll levels were below 0.50 RFU. A slight increase, to 0.55-0.80 RFU was seen in August in the surface 2 m.

Blue-Green Algae (Phycocyanin) (Tables 1(a-e), Fig. 1(m)): was at similar, low levels throughout the shallow, well mixed water column on each date, with overall levels ranging between 0.05–0.83 RFU. Levels were lowest in May, June, and September (0.05-0.21 RFU) and relatively higher in August and October (0.33-0.83 RFU).

**In summary,** the Cemex–Phase 1 Pond, the relative 'control / low fish mercury' pond, was again found to be shallow, turbid (cloudy water) from processing plant slurry discharges, and well-mixed with similar water temperatures top to bottom, no stratification, and no bottom anoxia. Algae and dissolved organic matter levels were low, consistent with the cloudy water conditions lowering photosynthesis.

**Table 1(a). Cemex – Phase 1 (West) Pond: 2019 Water Column Profiling Data**
**MAY 13:** max. depth 6.4 m (21 ft); Secchi disk water clarity: 1.6 m (5.2 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 23.7 | 9.75 | 115% | 646 | 420 | 0.31 | 8.50 | – |
| **1** | 23.7 | 9.77 | 116% | 646 | 420 | 0.31 | 8.49 | – |
| **2** | 23.0 | 9.82 | 115% | 646 | 420 | 0.31 | 8.46 | – |
| **3** | 22.7 | 9.78 | 114% | 648 | 421 | 0.31 | 8.44 | – |
| **4** | 22.5 | 9.74 | 113% | 648 | 421 | 0.31 | 8.42 | – |
| **5** | 22.4 | 9.62 | 111% | 648 | 421 | 0.31 | 8.40 | – |
| **6** | 22.3 | 9.57 | 110% | 648 | 421 | 0.31 | 8.39 | – |

*(additional parameters next page)*

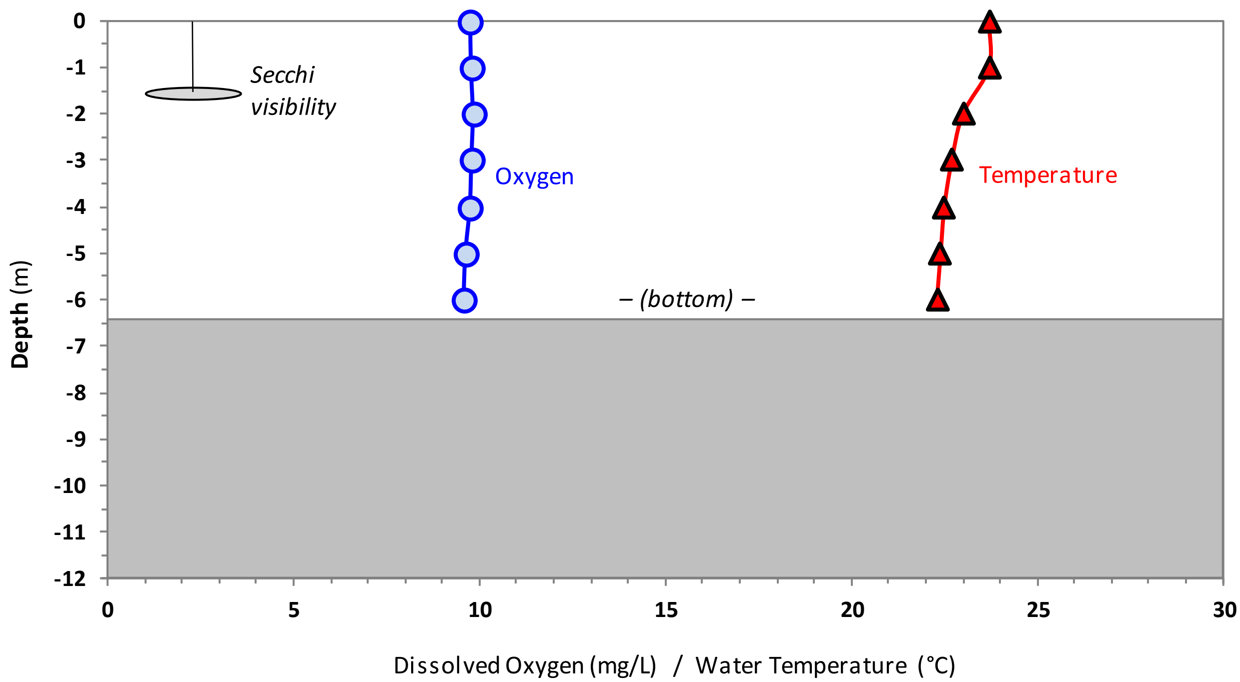



**Figure 1(a). MAY 13, 2019 – Phase 1 Pond framework parameters**

**Table 1(a).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**MAY 13:** max. depth 6.4 m (21 ft); Secchi disk water clarity: 1.6 m (5.2 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae;*
*FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 23.7 | 9.75 | 115% | 3.11 | 0.63 | 0.07 | 0.05 |
| **1** | 23.7 | 9.77 | 116% | 3.53 | 0.63 | 0.03 | 0.07 |
| **2** | 23.0 | 9.82 | 115% | 4.32 | 0.73 | 0.02 | 0.09 |
| **3** | 22.7 | 9.78 | 114% | 12.25 | 0.74 | 0.03 | 0.10 |
| **4** | 22.5 | 9.74 | 113% | 13.73 | 0.74 | 0.09 | 0.08 |
| **5** | 22.4 | 9.62 | 111% | 13.11 | 0.75 | 0.08 | 0.11 |
| **6** | 22.3 | 9.57 | 110% | 12.63 | 0.75 | 0.06 | 0.09 |

**Table 1(b). Cemex – Phase 1 (West) Pond: 2019 Water Column Profiling Data**
**JUN 16**: max. depth 6.2 m (20 ft); Secchi disk water clarity: 3.3 m (10.8 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 26.0 | 9.72 | 120% | 701 | 456 | 0.34 | 8.35 | 178 |
| **1** | 25.9 | 9.69 | 120% | 701 | 456 | 0.34 | 8.35 | 178 |
| **2** | 25.0 | 9.38 | 114% | 702 | 457 | 0.34 | 8.30 | 180 |
| **3** | 24.8 | 9.16 | 111% | 702 | 456 | 0.34 | 8.28 | 182 |
| **4** | 23.4 | 9.69 | 114% | 696 | 453 | 0.34 | 8.21 | 186 |
| **5** | 22.9 | 8.75 | 103% | 696 | 452 | 0.34 | 8.19 | 187 |
| **6** | 22.5 | 8.28 | 96% | 696 | 452 | 0.34 | 8.19 | 189 |

*(additional parameters next page)*

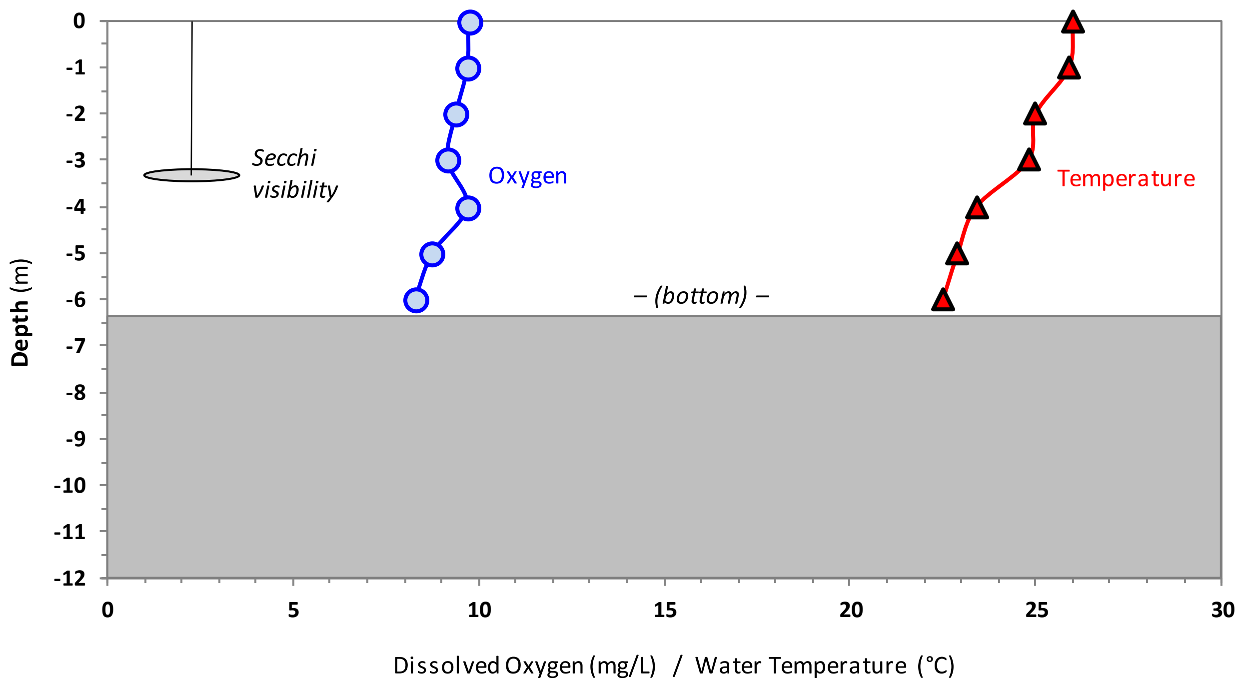



**Figure 1(b). JUN 16, 2019 – Phase 1 Pond framework parameters**

**Table 1(b).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**JUN 16**: max. depth 6.2 m (20 ft); Secchi disk water clarity: 3.3 m (10.8 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 26.0 | 9.72 | 120% | 1.47 | 1.22 | 0.23 | 0.05 |
| **1** | 25.9 | 9.69 | 120% | 1.39 | 1.24 | 0.29 | 0.06 |
| **2** | 25.0 | 9.38 | 114% | 1.09 | 1.55 | 0.23 | 0.10 |
| **3** | 24.8 | 9.16 | 111% | 0.86 | 1.57 | 0.22 | 0.10 |
| **4** | 23.4 | 9.69 | 114% | 1.50 | 1.79 | 0.45 | 0.18 |
| **5** | 22.9 | 8.75 | 103% | 1.86 | 1.68 | 0.35 | 0.19 |
| **6** | 22.5 | 8.28 | 96% | 2.12 | 1.70 | 0.25 | 0.19 |

**Table 1(c). Cemex – Phase 1 (West) Pond: 2019 Water Column Profiling Data**
**AUG 1:** max. depth 5.8 m (19 ft); Secchi disk water clarity: 1.0 m (3.3 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 27.3 | 9.88 | 125% | 764 | 497 | 0.37 | 8.37 | 138 |
| **1** | 27.0 | 9.71 | 122% | 764 | 497 | 0.37 | 8.35 | 140 |
| **2** | 26.3 | 8.82 | 109% | 768 | 500 | 0.37 | 8.28 | 142 |
| **3** | 26.0 | 8.54 | 105% | 767 | 499 | 0.37 | 8.28 | 144 |
| **4** | 25.9 | 8.48 | 105% | 768 | 499 | 0.37 | 8.26 | 146 |
| **5** | 25.8 | 8.50 | 105% | 770 | 501 | 0.37 | 8.23 | 148 |
| **5.4** | 25.8 | 8.42 | 104% | 770 | 500 | 0.37 | 8.23 | 149 |

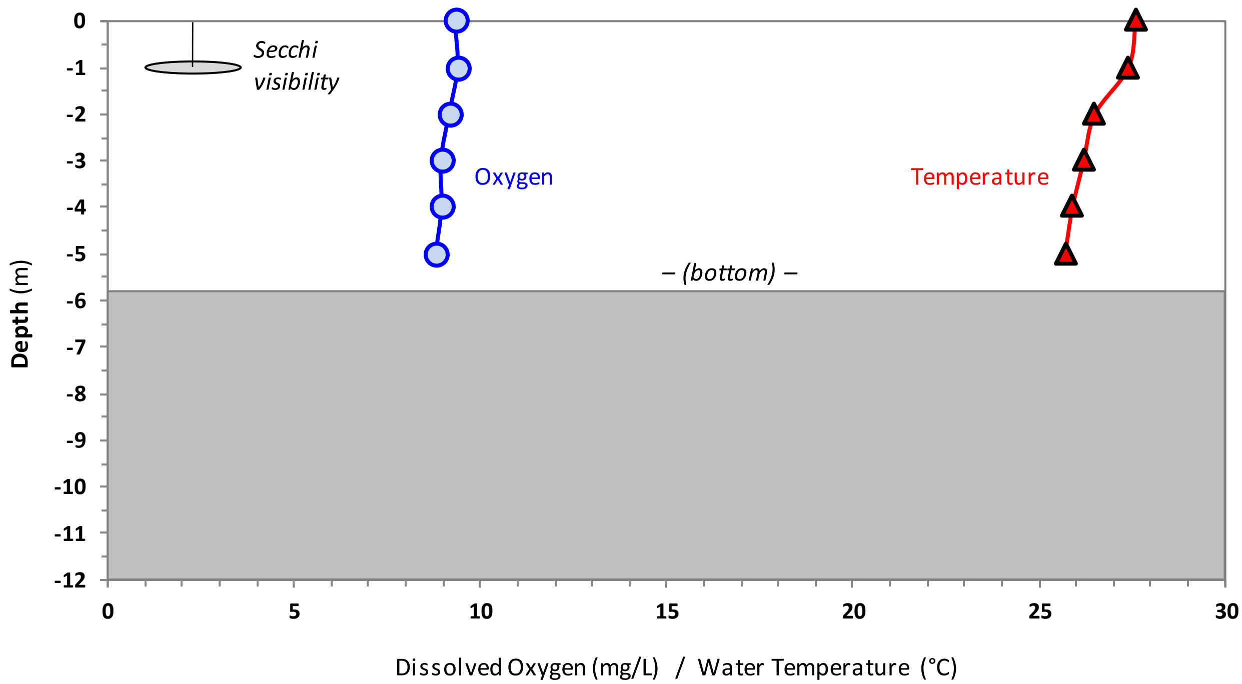



**Figure 1(c). AUG 1, 2019 – Phase 1 Pond framework parameters**

**Table 1(c).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**AUG 1:** max. depth 5.8 m (19 ft); Secchi disk water clarity: 1.0 m (3.3 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 27.3 | 9.88 | 125% | 7.06 | 1.82 | 0.80 | 0.43 |
| **1** | 27.0 | 9.71 | 122% | 5.73 | 1.86 | 0.55 | 0.33 |
| **2** | 26.3 | 8.82 | 109% | 14.35 | 2.11 | 0.43 | 0.35 |
| **3** | 26.0 | 8.54 | 105% | 11.44 | 2.07 | 0.33 | 0.39 |
| **4** | 25.9 | 8.48 | 105% | 15.07 | 2.22 | 0.30 | 0.34 |
| **5** | 25.8 | 8.50 | 105% | 30.07 | 1.99 | 0.28 | 0.34 |
| **5.4** | 25.8 | 8.42 | 104% | 24.30 | 2.26 | 0.22 | 0.35 |

**Table 1(d). Cemex – Phase 1 (West) Pond: 2019 Water Column Profiling Data**
**SEP 14:** max. depth 5.8 m (19 ft); Secchi disk water clarity: 2.8 m (9.2 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 25.0 | 9.81 | 119% | 728 | 473 | 0.35 | 8.45 | 166 |
| **1** | 24.9 | 9.96 | 121% | 727 | 473 | 0.35 | 8.44 | 166 |
| **2** | 24.3 | 9.69 | 116% | 729 | 474 | 0.35 | 8.40 | 167 |
| **3** | 24.1 | 9.64 | 115% | 729 | 474 | 0.35 | 8.39 | 168 |
| **4** | 24.0 | 9.62 | 115% | 731 | 475 | 0.36 | 8.38 | 168 |
| **5** | 23.8 | 9.56 | 113% | 730 | 474 | 0.36 | 8.37 | 169 |

*(additional parameters next page)*

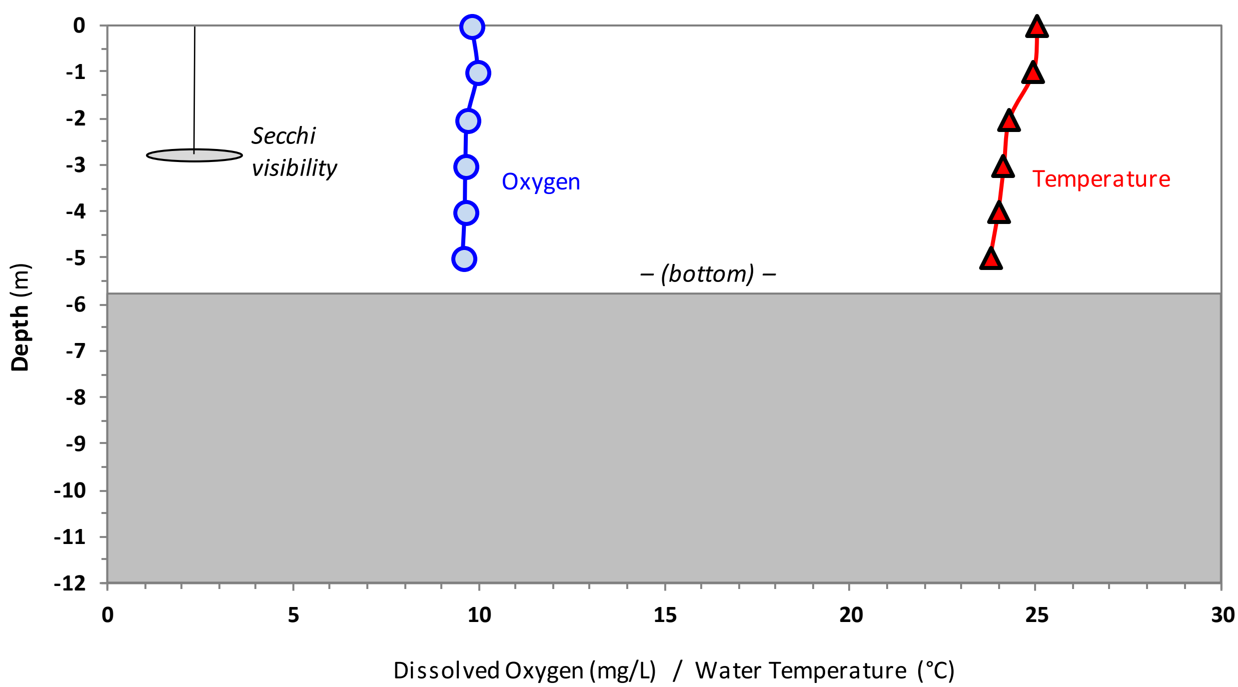



**Figure 1(d). SEP 14, 2019 – Phase 1 Pond framework parameters**

**Table 1(d).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**SEP 14:** max. depth 5.8 m (19 ft); Secchi disk water clarity: 2.8 m (9.2 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 25.0 | 9.81 | 119% | 1.23 | 1.39 | 0.11 | 0.08 |
| **1** | 24.9 | 9.96 | 121% | 1.22 | 1.49 | 0.11 | 0.12 |
| **2** | 24.3 | 9.69 | 116% | 1.32 | 1.83 | 0.11 | 0.08 |
| **3** | 24.1 | 9.64 | 115% | 2.04 | 1.88 | 0.13 | 0.14 |
| **4** | 24.0 | 9.62 | 115% | 5.18 | 1.59 | 0.18 | 0.21 |
| **5** | 23.8 | 9.56 | 113% | 5.14 | 1.77 | 0.14 | 0.15 |

**Table 1(e). Cemex – Phase 1 (West) Pond: 2019 Water Column Profiling Data**
**OCT 27:** max. depth 6.2 m (21 ft); Secchi disk water clarity: 1.5 m (4.9 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 18.0 | 9.77 | 103% | 744 | 483 | 0.37 | 8.27 | 58 |
| **1** | 18.0 | 9.79 | 104% | 744 | 483 | 0.36 | 8.27 | 56 |
| **2** | 17.4 | 9.77 | 102% | 743 | 483 | 0.36 | 8.26 | 56 |
| **3** | 17.1 | 9.66 | 100% | 743 | 483 | 0.37 | 8.24 | 55 |
| **4** | 17.0 | 9.61 | 100% | 743 | 483 | 0.36 | 8.24 | 55 |
| **5** | 17.0 | 9.59 | 99% | 743 | 483 | 0.36 | 8.24 | 55 |
| **6** | 16.9 | 9.56 | 99% | 743 | 483 | 0.36 | 8.24 | 56 |

*(additional parameters next page)*

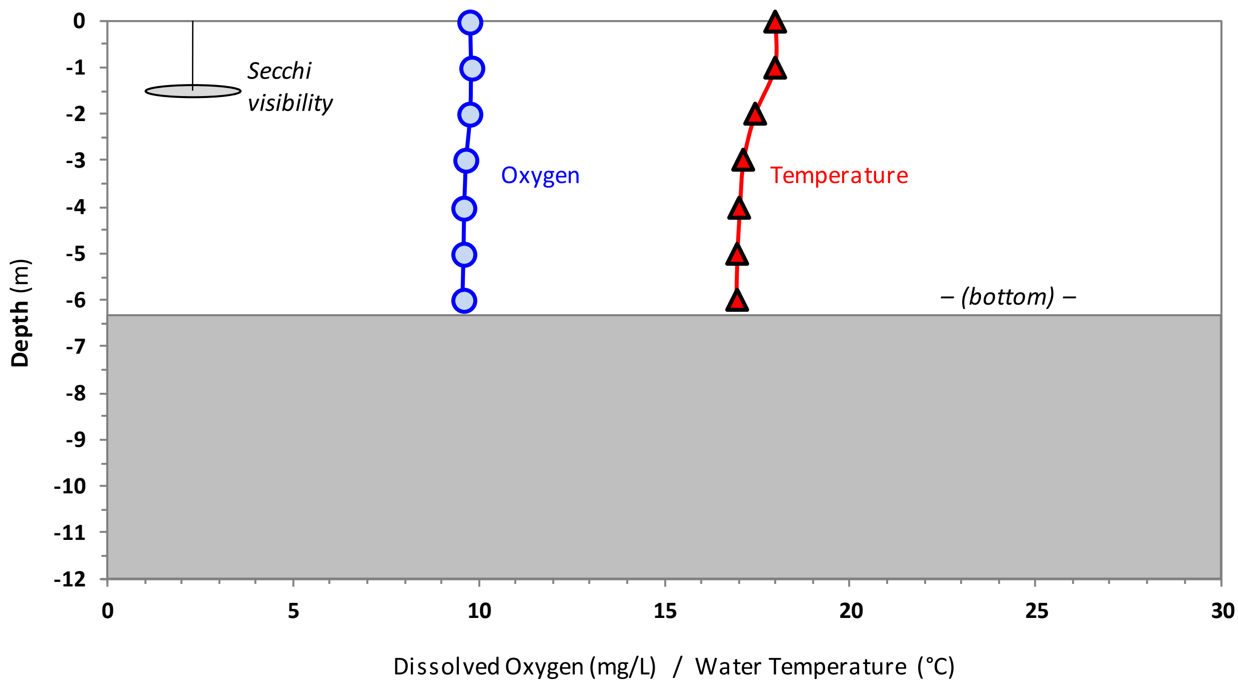



**Figure 1(e). OCT 27, 2019 – Phase 1 Pond framework parameters**

**Table 1(e).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**OCT 27:** max. depth 6.2 m (21 ft); Secchi disk water clarity: 1.5 m (4.9 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 18.0 | 9.77 | 103% | 4.40 | 0.85 | 0.41 | 0.49 |
| **1** | 18.0 | 9.79 | 104% | 4.22 | 0.90 | 0.39 | 0.70 |
| **2** | 17.4 | 9.77 | 102% | 4.79 | 1.08 | 0.30 | 0.69 |
| **3** | 17.1 | 9.66 | 100% | 6.46 | 0.97 | 0.25 | 0.76 |
| **4** | 17.0 | 9.61 | 100% | 6.99 | 1.20 | 0.21 | 0.77 |
| **5** | 17.0 | 9.59 | 99% | 8.62 | 1.18 | 0.19 | 0.83 |
| **6** | 16.9 | 9.56 | 99% | 8.29 | 1.24 | 0.14 | 0.83 |

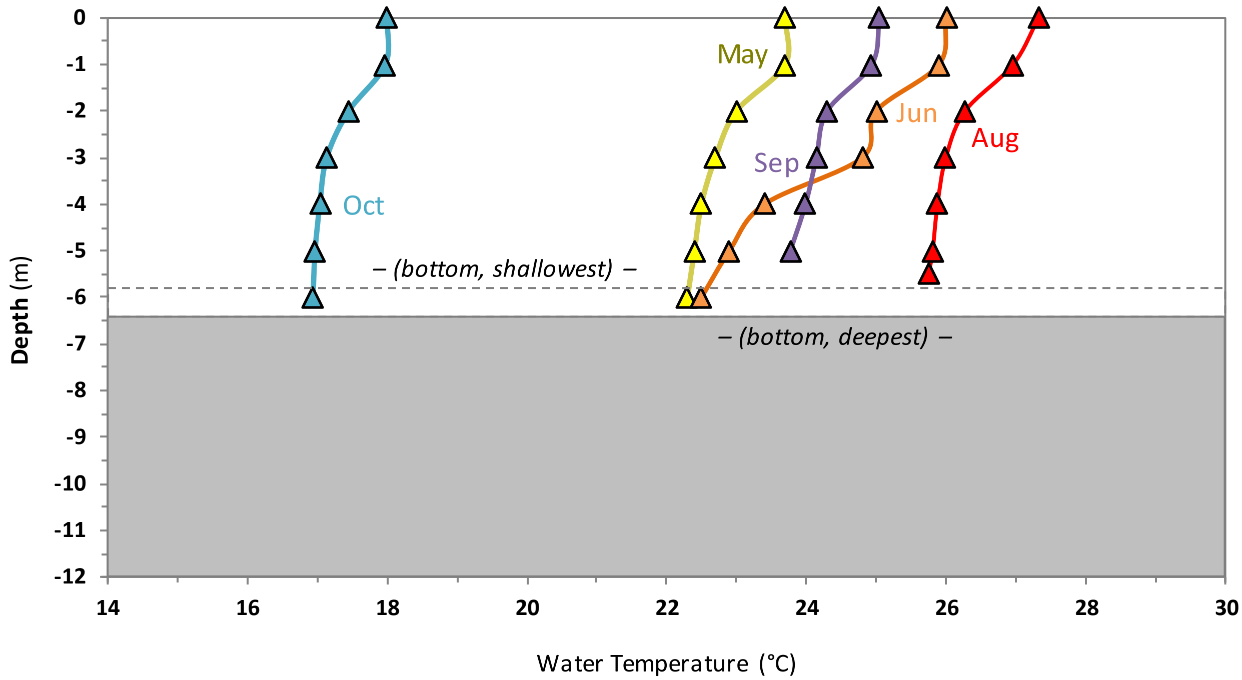



**Figure 1(f). Cemex – Phase 1 (West) Pond: 2019 May-Oct TEMPERATURE**

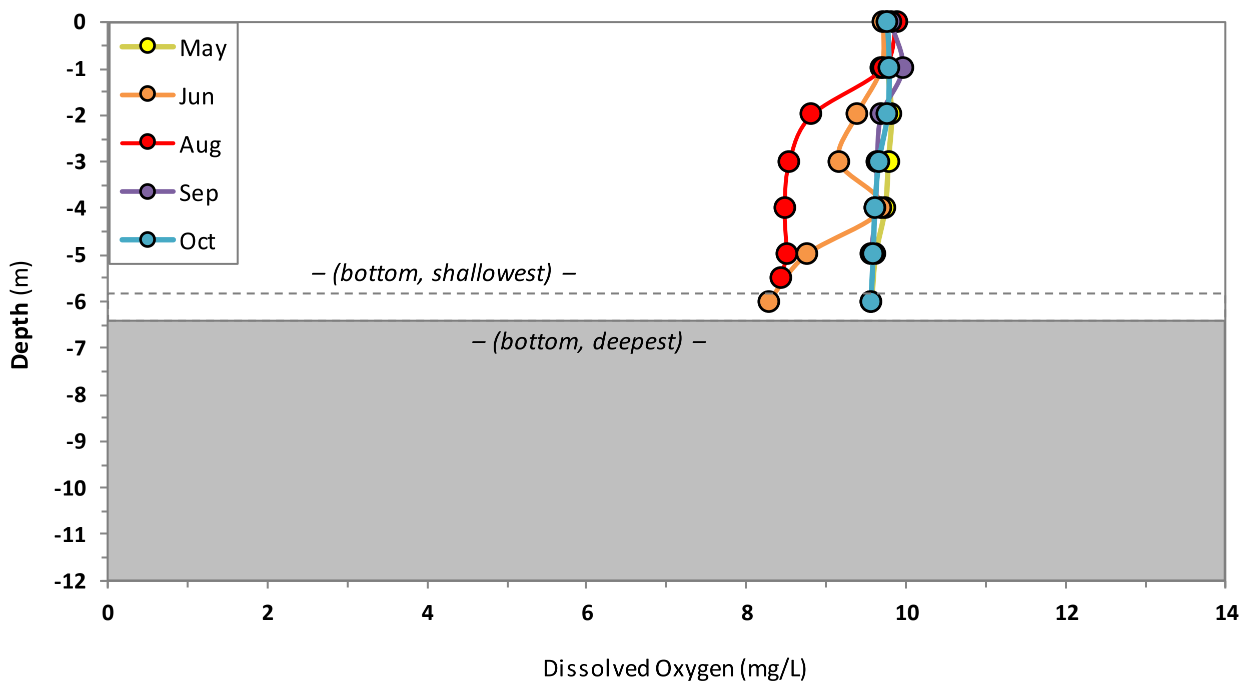



**Figure 1(g). Cemex – Phase 1 (West) Pond: 2019 May-Oct OXYGEN**

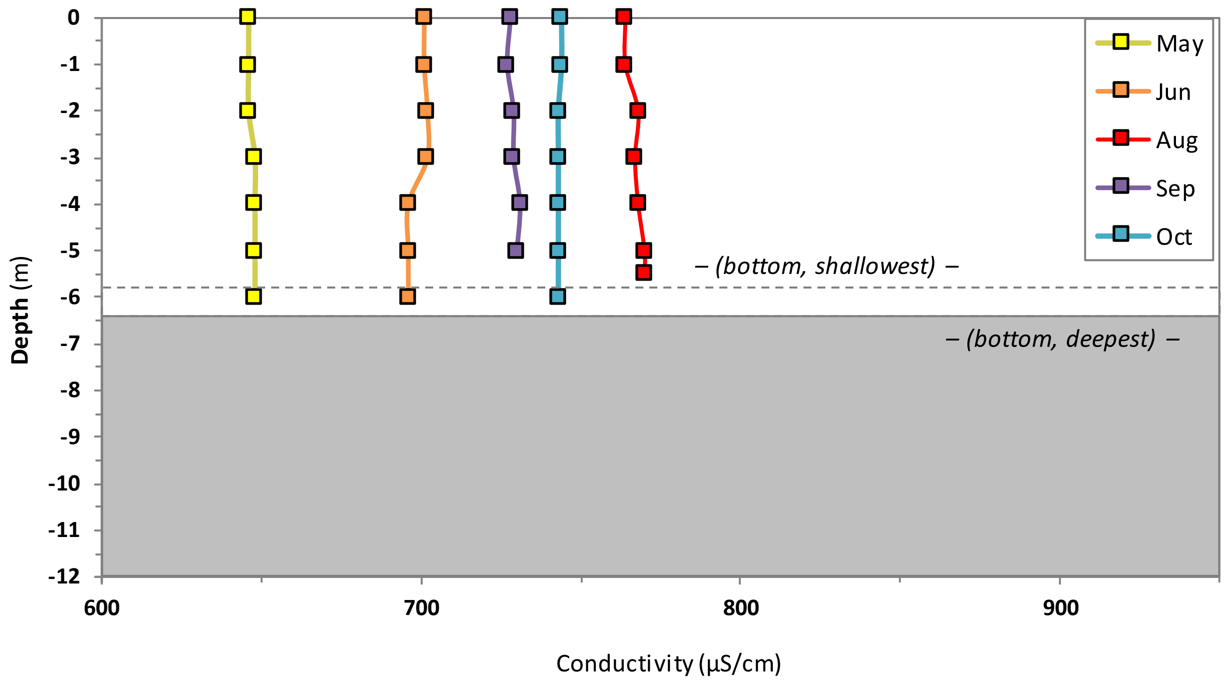



**Figure 1(h). Cemex – Phase 1 (West) Pond: 2019 May-Oct CONDUCTIVITY**

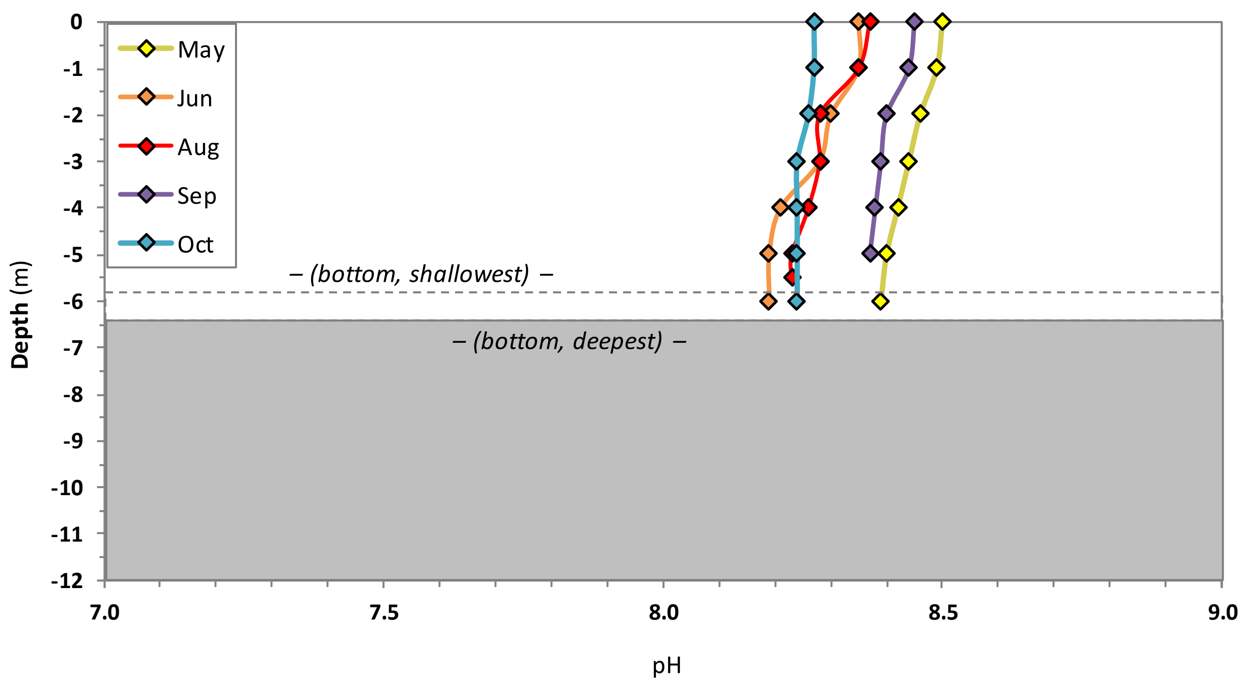



**Figure 1(i). Cemex – Phase 1 (West) Pond: 2019 May-Oct pH**

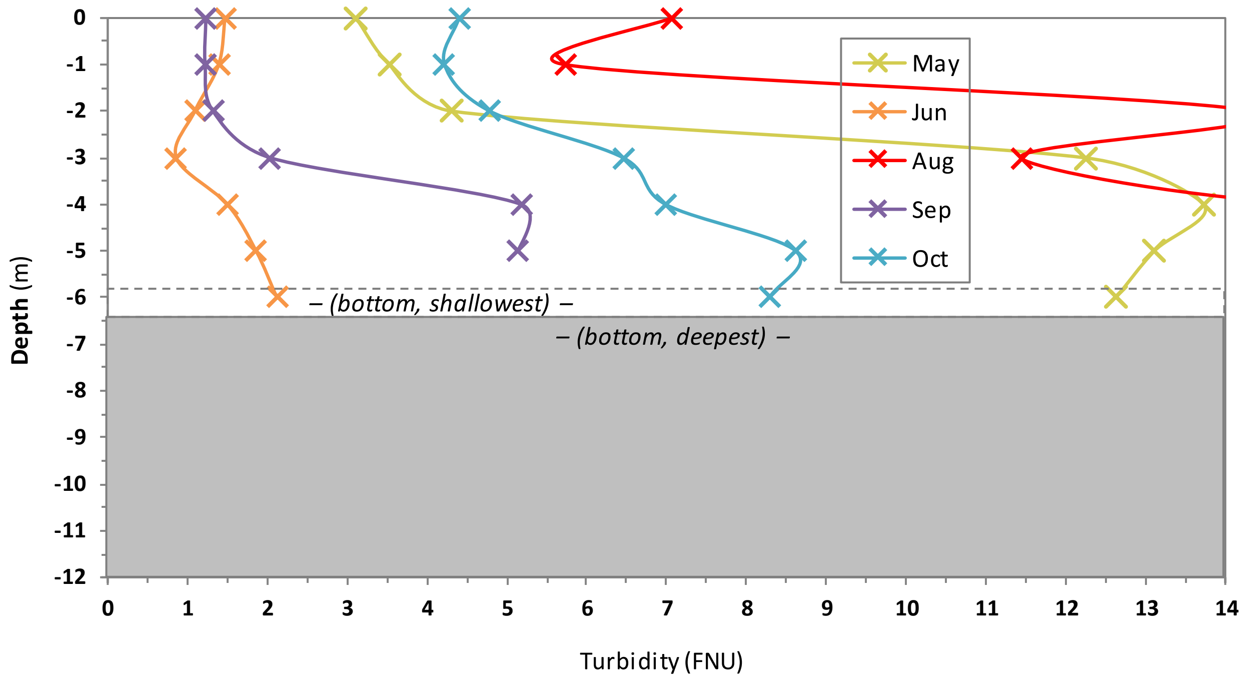



**Figure 1(j). Cemex – Phase 1 (West) Pond: 2019 May-Oct TURBIDITY**

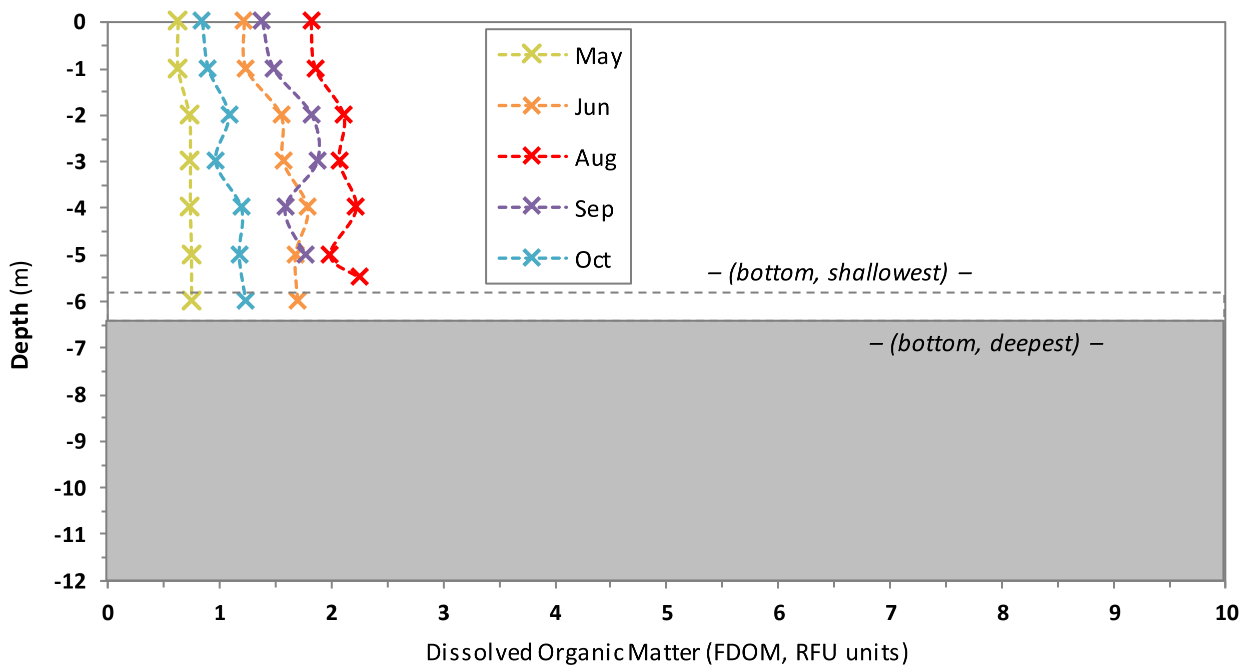



**Figure 1(k). Cemex – Phase 1 Pond: 2019 DISSOLVED ORGANIC MATTER**

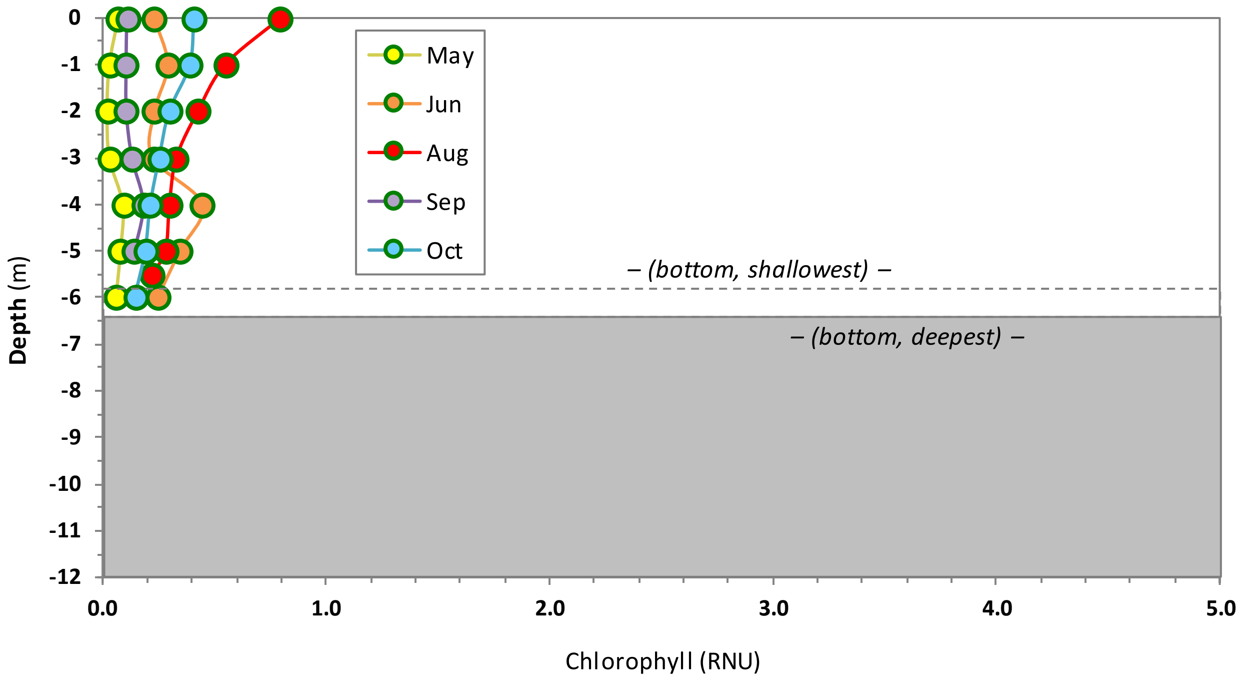



**Figure 1(l). Cemex – Phase 1 (West) Pond: 2019 May-Oct CHLOROPHYLL**

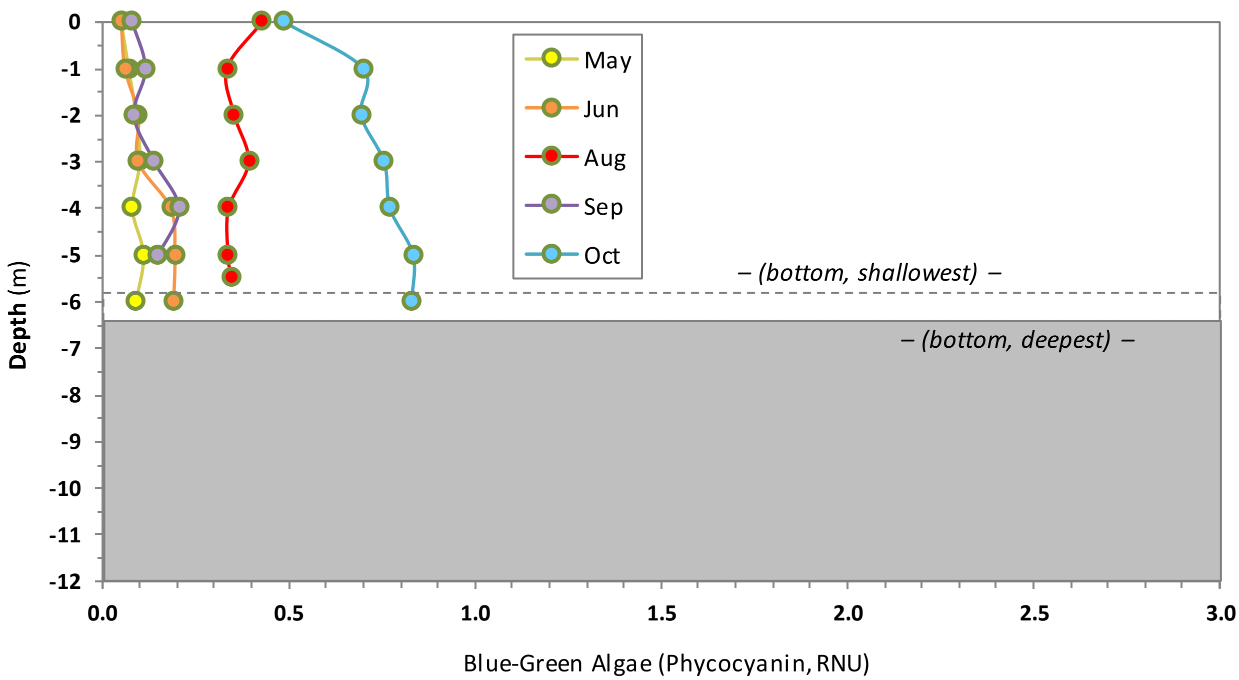



**Figure 1(m). Cemex – Phase 1 Pond: 2019 May-Oct BLUE-GREEN ALGAE**

## 2. CEMEX–PHASE 3-4 (East) POND

## 2. Cemex–Phase 3-4 Pond

The Phase 3-4 Pond results are first shown for each survey date, one at a time. Numerical data from each of the five 2019 water profiling surveys are presented in Tables 2(a) (May) through 2(e) (October). For each survey date, some of the key, driving parameters are also shown in figure form, Figures 2(a-e).

After the individual survey information, each water quality parameter is plotted across the year of sampling, in Figures 2(f) (Temperature) through 2(m) (Blue-green Algae). In these figures, the different seasonal profiles are shown together, so you can see the full range of values and the changes across the year.

Before the data tables and figures, results are first discussed below, for each of the monitored water parameters and in summary.

Water Depth (Tables and Figs. 2(a-e): ranged between 10.1 and 11.6 m (33-38 ft) maximum depth across the 2019 May-Oct profiling.

Secchi Water Clarity (Tables and Figs. 2(a-e): was notably variable this year, ranging from a low of 1.2 m (4 feet) to a high of 7.0 m (23 feet). This was a function of mining activity in the east basin (where the water is profiled) later in the season, as compared to earlier years when mining was confined to the west end.

Temperature (Tables and Figs. 2(a-e), Fig. 2(f)): Overall range 17-28 °C (63-82 °F) between May and October. Despite the greater depth of this pond, as compared to the Phase 1 Pond, the temperature data show a very similar trend. A thermal stratification began to develop in May, with surface waters warming to 3.9 °C (7.0 °F) higher than the bottom water. But this degraded in June and August, with the bottom water temperature increasing to levels close to those at the surface. This indicated frequent mixing of the water column, likely a function of the long east-west dimension letting wind energy reach to the bottom. The whole water column cooled between August and October, continuing to remain well mixed.

Dissolved Oxygen (Tables and Figs. 2(a-e), Fig. 2(g)): in May through August was well above saturation levels ("super-saturated") at all depths, between 10.6 and 24.3 mg/L (ppm), which corresponded to 128-266% of saturation. All of these levels were 'super-saturated', due to algal photosynthesis when the water was relatively clear (Secchi visibility 3.3-7.0 m = 11-23 ft). Oxygen depletion in the bottom waters never developed, as the water column remained fairly well mixed and not stratifying significantly during the warm season. Additionally, the clear water allowed oxygen-generating photosynthesis all the way to the bottom. In fact, in May through June when there was a slight stratification and clear water, the *opposite* of oxygen depletion occurred (Fig. 2(g)) and very high oxygen levels built up toward the bottom. Later in the year and when mining ramped up in the east basin, visibility (and photosynthesis) dropped and so did the oxygen levels, to as low as 6.5 mg/L or 79% of saturation.

Conductivity (Tables 2(a-e), Fig. 2(h)): ranged between 801 and 905 µS/cm overall. Levels were somewhat lower at depth in May and June, and were very uniform throughout the water column in August through October. Conductivity increased gradually across the season (evaporation concentrating dissolved elements), though all the levels were lower than in 2018. Despite being lower than 2018, conductivity was consistently higher at this pond, as compared to all the others monitored, where levels ranged between 614 and 770 µS/cm.

Salinity (Tables 2(a-e): was very uniform at 0.39-0.45 ppt (parts per thousand, g/L) across all depths and sampling dates. This was down slightly from 2018 levels (0.48-0.51 ppt), indicating some dilution from winter rains. Salinity rose slightly across the season due to normal evaporation concentrating the salts. Typical freshwaters range below 0.50 ppt; seawater averages 35 ppt.

Total Dissolved Solids (TDS) (Tables 2(a-e): ranged between 521 and 575 mg/L (ppm), also lower than in 2018 (618-649 mg/L). As with Conductivity and Salinity, this was likely a function of dilution from winter rains.

pH (Tables 2(a-e), Fig. 2(i)): as at the other monitored ponds, was notably very basic (non-acidic; pH > 7.00). This is a function of their mining history and the basic nature of local sediments. Water pH in the Phase 3-4 Pond was between 8.32 and 8.67 across all depths and dates, similar to 2018. The water became slightly less basic in September and October (8.32-8.41)

Oxidation/Reduction Potential (ORP) (Tables 2(a-e): between May and September ranged from 98-196 mV (millivolts) across all depths. This compared to a narrower range of 99-143 mV in 2018. In October, levels were much lower, at 35-42 mV. This may have been related to low visibility, active mining conditions.

Turbidity (Tables 2(a-e), Fig. 2(j)): The Phase 3-4 Pond was one of the very clearest of the monitored ponds in previous years, at the index station in the larger, eastern basin. Secchi visibilities could reach 10 m (33 feet) or more, away from active mining that occurred in the western basin. In 2019, the dredging equipment was moved into the east basin; turbidity levels in September and October jumped to over 2.0 FNU and as high as 12.4 FNU. Corresponding Secchi visibility dropped to 1.2-2.4 m (4-8 feet).

Dissolved Organic Matter (FDOM) (Tables 2(a-e), Fig. 2(k)): Measured for the first time in 2019, we will wait a year or two before making any conclusions about this or the other optical parameters. Levels were low, between 0.4 and 1.1 RFU in the top 6 m on all dates, and all the way to the 10+ m bottom between early August and late October. In early May through late June, the bottom several meters showed accumulations in the 1.2-3.1 RFU range, indicating a small buildup there of decaying algal cells and other organic material.

Green Algae (Chlorophyll) (Tables 2(a-e), Fig. 2(l)): was uniformly low (0.05-0.76) and was generally consistent from top to bottom on each date. Overall levels were a bit higher in October. In June, there was a slight increase between the surface 5 m (0.16-0.23 RFU) and the deepest reading at 10 m (0.67 RFU).

Blue-Green Algae (Phycocyanin) (Tables 2(a-e), Fig. 2(m)): was uniformly low from top to bottom, between early May and mid September (0.03-0.20 RFU). Late October Phycocyanin was a bit higher, at 0.19-0.39 RFU.

**In summary,** the Cemex–Phase 3-4 Pond, an identified 'elevated fish mercury' pond, was found in 2019 to be of moderate depth and with varied levels of suspended particles (turbidity) in the water as in-pond dredging increased in the eastern part of the pond nearer the index station where the water was profiled. Formerly one of the clearest water ponds in that larger eastern basin, visibilities dropped to as low as four feet in conjunction with nearby mining. Despite being fairly deep (around 35 feet), the Phase 3-4 pond mostly remained well-mixed, likely due to its long east-west dimension allowing wind energy to reach the bottom. The active mining also contributes to water column mixing. Because of the mixing, there was no summer stratification and no bottom anoxia, as in previous years. This particular pond may be challenging for mercury management, as the elevated fish mercury here is not linked to oxygen levels in the water. Management to try to lower methylmercury production and uptake may involve identifying and addressing another factor(s) in this pond's mercury cycle.

**Table 2(a). Cemex – Phase 3-4 (East) Pond: 2019 Water Column Profiling Data**
**MAY 13:** max. depth 11.6 m (38 ft); Secchi disk water clarity: 3.3 m (11 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 23.1 | 11.11 | 130% | 850 | 553 | 0.42 | 8.61 | – |
| **1** | 23.1 | 11.11 | 130% | 850 | 553 | 0.42 | 8.59 | – |
| **2** | 23.0 | 11.16 | 130% | 850 | 553 | 0.42 | 8.58 | – |
| **3** | 22.8 | 11.20 | 130% | 850 | 553 | 0.42 | 8.58 | – |
| **4** | 21.7 | 11.74 | 134% | 844 | 548 | 0.41 | 8.60 | – |
| **5** | 21.6 | 11.73 | 134% | 843 | 548 | 0.41 | 8.58 | – |
| **6** | 21.5 | 12.00 | 136% | 841 | 547 | 0.41 | 8.58 | – |
| **7** | 21.2 | 15.41 | 172% | 831 | 540 | 0.41 | 8.59 | – |
| **8** | 20.8 | 19.76 | 222% | 816 | 531 | 0.40 | 8.61 | – |
| **9** | 19.9 | 22.90 | 253% | 808 | 525 | 0.40 | 8.64 | – |
| **10** | 19.2 | 24.30 | 266% | 801 | 521 | 0.39 | 8.67 | – |

*(additional parameters next page)*

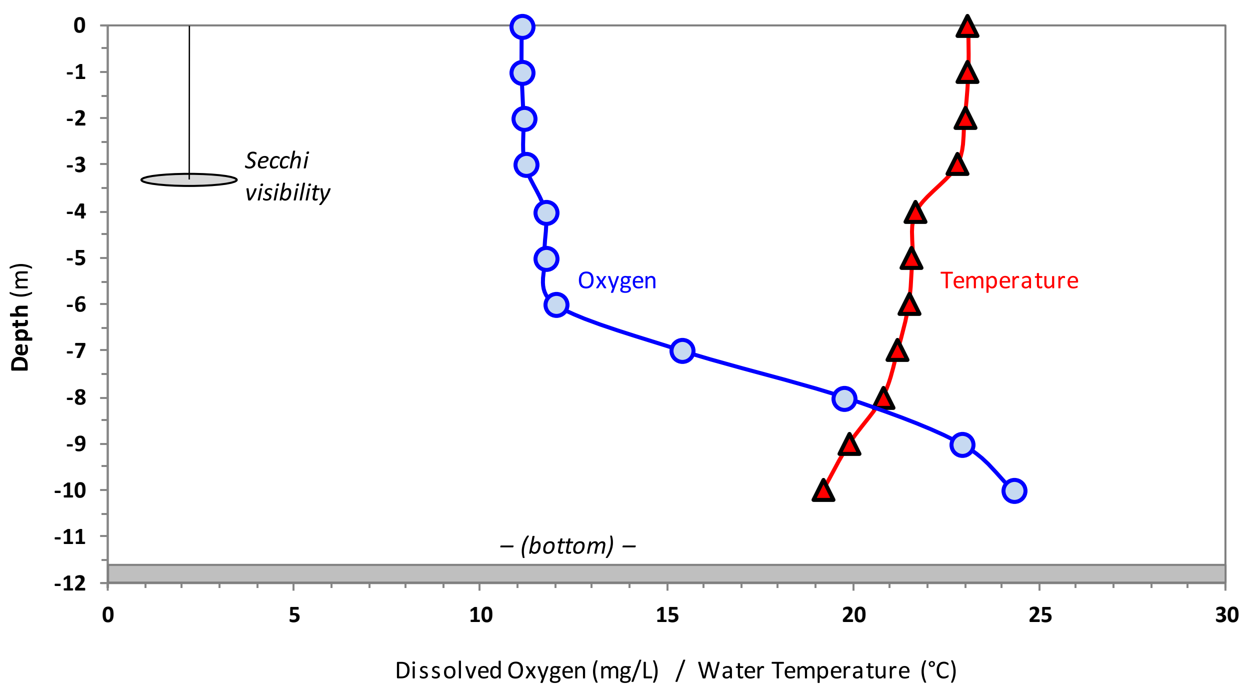



**Figure 2(a). MAY 13, 2019 – Phase 3-4 Pond framework parameters**

**Table 2(a).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**MAY 13:** max. depth 11.6 m (38 ft); Secchi disk water clarity: 3.3 m (11 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 23.1 | 11.11 | 130% | 1.42 | 0.75 | 0.08 | 0.08 |
| **1** | 23.1 | 11.11 | 130% | 1.37 | 0.75 | 0.07 | 0.07 |
| **2** | 23.0 | 11.16 | 130% | 1.20 | 0.76 | 0.09 | 0.05 |
| **3** | 22.8 | 11.20 | 130% | 1.20 | 0.77 | 0.06 | 0.08 |
| **4** | 21.7 | 11.74 | 134% | 0.52 | 0.86 | 0.06 | 0.06 |
| **5** | 21.6 | 11.73 | 134% | 0.48 | 0.91 | 0.07 | 0.07 |
| **6** | 21.5 | 12.00 | 136% | 0.47 | 1.00 | 0.05 | 0.06 |
| **7** | 21.2 | 15.41 | 172% | 0.47 | 1.28 | 0.07 | 0.06 |
| **8** | 20.8 | 19.76 | 222% | 0.43 | 1.82 | 0.06 | 0.07 |
| **9** | 19.9 | 22.90 | 253% | 0.49 | 2.68 | 0.05 | 0.06 |
| **10** | 19.2 | 24.30 | 266% | 0.54 | 3.10 | 0.05 | 0.07 |

**Table 2(b). Cemex – Phase 3-4 (East) Pond: 2019 Water Column Profiling Data**
**JUN 16:** max. depth 11.3 m (37 ft); Secchi disk water clarity: 7.0 m (23 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 24.8 | 10.60 | 128% | 850 | 552 | 0.42 | 8.49 | 140 |
| **1** | 24.6 | 10.60 | 128% | 850 | 552 | 0.42 | 8.49 | 144 |
| **2** | 24.4 | 10.70 | 128% | 849 | 552 | 0.42 | 8.49 | 147 |
| **3** | 24.0 | 11.40 | 136% | 847 | 551 | 0.41 | 8.49 | 151 |
| **4** | 23.6 | 13.40 | 158% | 841 | 547 | 0.41 | 8.48 | 155 |
| **5** | 23.3 | 16.00 | 188% | 837 | 544 | 0.41 | 8.47 | 160 |
| **6** | 23.1 | 17.00 | 199% | 836 | 543 | 0.41 | 8.46 | 165 |
| **7** | 23.0 | 16.90 | 198% | 837 | 544 | 0.41 | 8.45 | 170 |
| **8** | 22.9 | 16.20 | 189% | 838 | 545 | 0.41 | 8.44 | 174 |
| **9** | 22.7 | 16.20 | 188% | 837 | 544 | 0.41 | 8.44 | 177 |
| **10** | 22.5 | 15.40 | 179% | 838 | 544 | 0.41 | 8.44 | 179 |

*(additional parameters next page)*

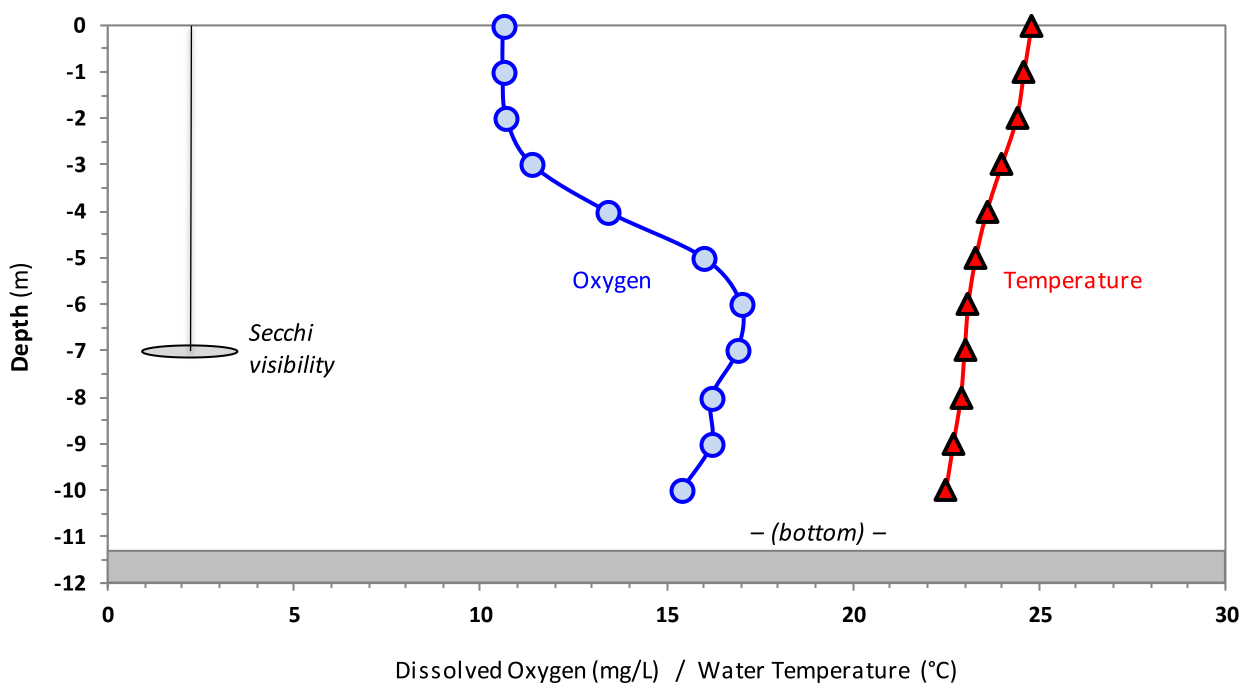



**Figure 2(b). JUN 16, 2019 – Phase 3-4 Pond framework parameters**

**Table 2(b).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**JUN 16:** max. depth 11.3 m (37 ft); Secchi disk water clarity: 7.0 m (23 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 24.8 | 10.60 | 128% | 0.57 | 0.65 | 0.16 | 0.06 |
| **1** | 24.6 | 10.60 | 128% | 0.55 | 0.60 | 0.19 | 0.03 |
| **2** | 24.4 | 10.70 | 128% | 0.44 | 0.63 | 0.18 | 0.06 |
| **3** | 24.0 | 11.40 | 136% | 0.33 | 0.70 | 0.23 | 0.06 |
| **4** | 23.6 | 13.40 | 158% | 0.33 | 0.87 | 0.20 | 0.09 |
| **5** | 23.3 | 16.00 | 188% | 0.34 | 0.95 | 0.23 | 0.12 |
| **6** | 23.1 | 17.00 | 199% | 0.35 | 1.04 | 0.34 | 0.13 |
| **7** | 23.0 | 16.90 | 198% | 0.44 | 1.16 | 0.34 | 0.13 |
| **8** | 22.9 | 16.20 | 189% | 0.39 | 1.54 | 0.34 | 0.16 |
| **9** | 22.7 | 16.20 | 188% | 0.39 | 2.16 | 0.55 | 0.19 |
| **10** | 22.5 | 15.40 | 179% | 0.43 | 2.45 | 0.67 | 0.20 |

**Table 2(c). Cemex – Phase 3-4 (East) Pond: 2019 Water Column Profiling Data**
**AUG 1:** max. depth 10.1 m (33 ft); Secchi disk water clarity: 6.7 m (22 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 27.6 | 11.42 | 145% | 881 | 572 | 0.43 | 8.56 | 98 |
| **1** | 27.6 | 11.35 | 144% | 881 | 573 | 0.43 | 8.56 | 109 |
| **2** | 27.6 | 11.38 | 145% | 881 | 573 | 0.43 | 8.56 | 112 |
| **3** | 27.6 | 11.39 | 145% | 882 | 573 | 0.43 | 8.56 | 114 |
| **4** | 27.6 | 11.55 | 147% | 884 | 574 | 0.43 | 8.55 | 116 |
| **5** | 27.5 | 11.30 | 144% | 882 | 574 | 0.43 | 8.55 | 118 |
| **6** | 27.5 | 11.40 | 145% | 881 | 573 | 0.43 | 8.55 | 120 |
| **7** | 27.4 | 11.24 | 142% | 884 | 575 | 0.43 | 8.53 | 122 |
| **8** | 27.4 | 11.19 | 142% | 884 | 575 | 0.43 | 8.52 | 124 |
| **9** | 27.4 | 11.23 | 142% | 884 | 575 | 0.43 | 8.52 | 126 |

*(additional parameters next page)*

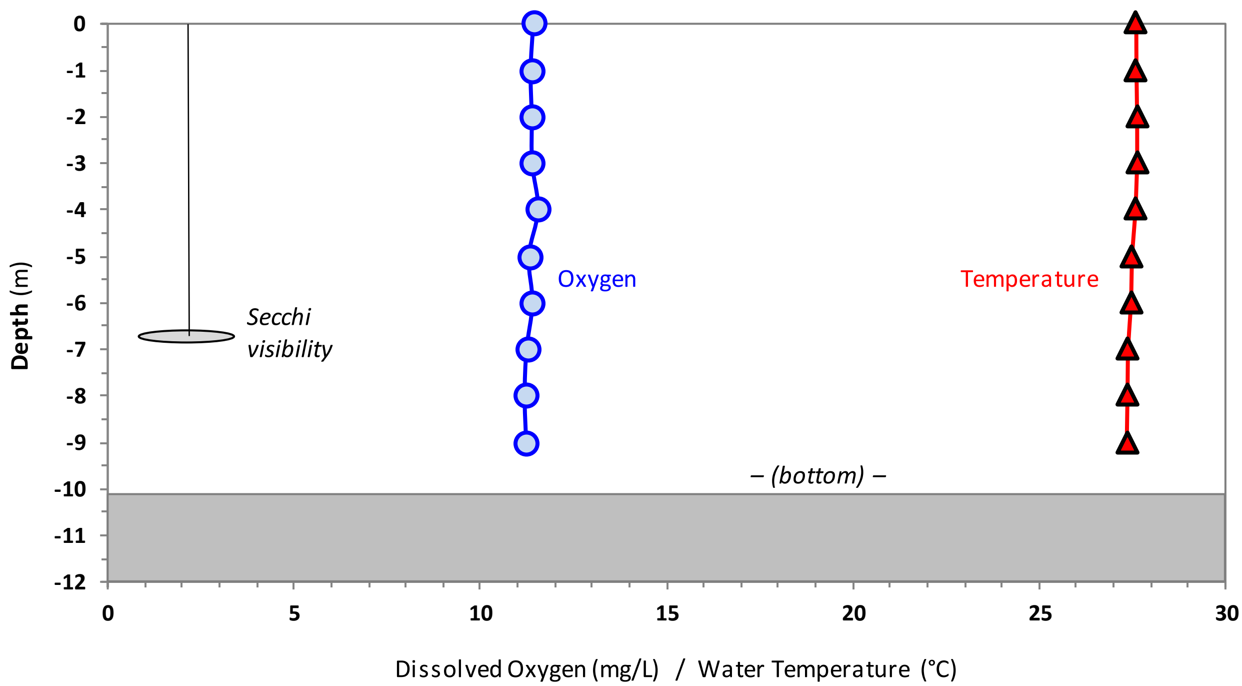



**Figure 2(c). AUG 1, 2019 – Phase 3-4 Pond framework parameters**

**Table 2(c).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**AUG 1:** max. depth 10.1 m (33 ft); Secchi disk water clarity: 6.7 m (22 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 27.6 | 11.42 | 145% | 0.28 | 0.40 | 0.33 | 0.10 |
| **1** | 27.6 | 11.35 | 144% | 0.30 | 0.41 | 0.38 | 0.09 |
| **2** | 27.6 | 11.38 | 145% | 0.30 | 0.43 | 0.34 | 0.10 |
| **3** | 27.6 | 11.39 | 145% | 0.31 | 0.55 | 0.38 | 0.14 |
| **4** | 27.6 | 11.55 | 147% | 0.36 | 0.63 | 0.39 | 0.11 |
| **5** | 27.5 | 11.30 | 144% | 0.27 | 0.51 | 0.32 | 0.11 |
| **6** | 27.5 | 11.40 | 145% | 0.29 | 0.59 | 0.40 | 0.09 |
| **7** | 27.4 | 11.24 | 142% | 0.42 | 0.56 | 0.34 | 0.12 |
| **8** | 27.4 | 11.19 | 142% | 0.36 | 0.60 | 0.37 | 0.13 |
| **9** | 27.4 | 11.23 | 142% | 0.35 | 0.58 | 0.39 | 0.13 |

**Table 2(d). Cemex – Phase 3-4 (East) Pond: 2019 Water Column Profiling Data**
**SEP 14:** max. depth 10.1 m (33 ft); Secchi disk water clarity: 1.2 m (4 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 25.5 | 7.83 | 96% | 873 | 567 | 0.43 | 8.41 | 196 |
| **1** | 25.4 | 7.82 | 96% | 873 | 567 | 0.43 | 8.41 | 193 |
| **2** | 25.4 | 7.61 | 93% | 874 | 568 | 0.43 | 8.40 | 191 |
| **3** | 25.3 | 7.51 | 92% | 875 | 569 | 0.43 | 8.39 | 190 |
| **4** | 25.3 | 7.41 | 90% | 875 | 569 | 0.43 | 8.39 | 189 |
| **5** | 25.3 | 7.17 | 87% | 874 | 568 | 0.43 | 8.38 | 188 |
| **6** | 25.3 | 7.12 | 87% | 874 | 568 | 0.43 | 8.38 | 187 |
| **7** | 25.2 | 6.74 | 82% | 873 | 568 | 0.43 | 8.36 | 185 |
| **8** | 25.2 | 6.76 | 82% | 874 | 568 | 0.43 | 8.36 | 184 |
| **9** | 25.2 | 6.49 | 79% | 874 | 568 | 0.43 | 8.35 | 183 |

*(additional parameters next page)*

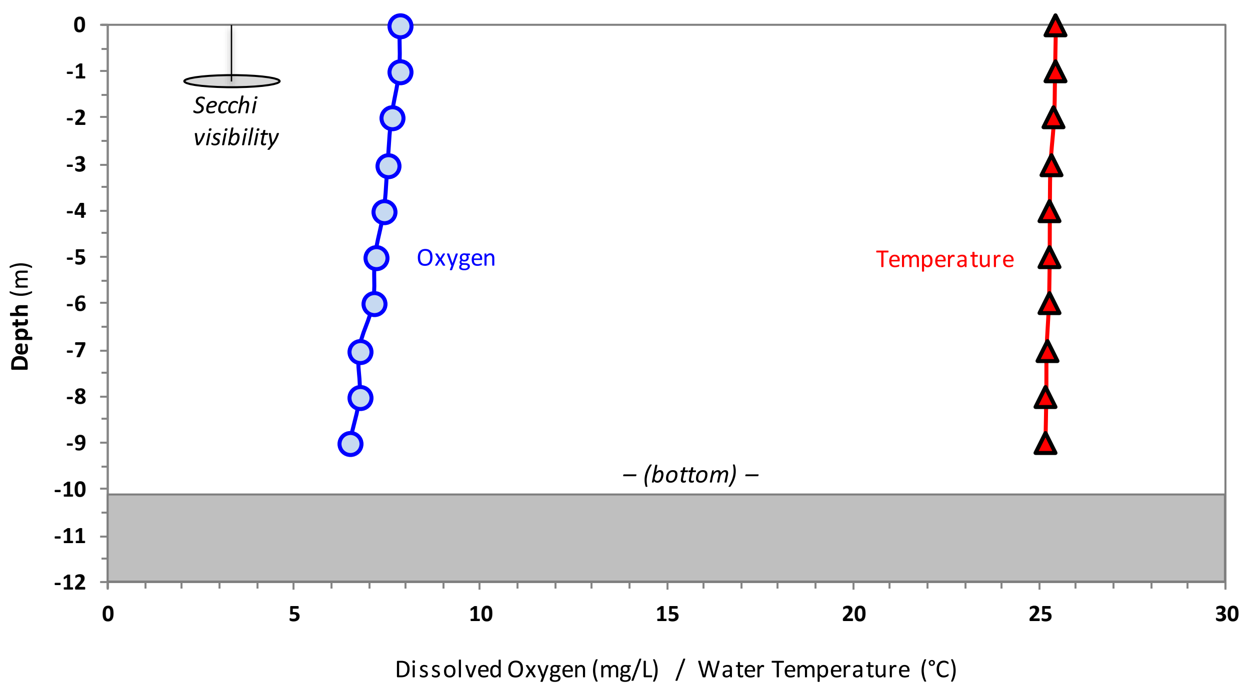



**Figure 2(d). SEP 14, 2019 – Phase 3-4 Pond framework parameters**

**Table 2(d).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**SEP 14:** max. depth 10.1 m (33 ft); Secchi disk water clarity: 1.2 m (4 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae;*
*FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 25.5 | 7.83 | 96% | 5.60 | 0.85 | 0.32 | 0.10 |
| **1** | 25.4 | 7.82 | 96% | 5.06 | 0.74 | 0.35 | 0.11 |
| **2** | 25.4 | 7.61 | 93% | 8.33 | 0.91 | 0.32 | 0.13 |
| **3** | 25.3 | 7.51 | 92% | 10.97 | 0.73 | 0.32 | 0.11 |
| **4** | 25.3 | 7.41 | 90% | 10.64 | 0.72 | 0.32 | 0.15 |
| **5** | 25.3 | 7.17 | 87% | 12.44 | 0.94 | 0.35 | 0.13 |
| **6** | 25.3 | 7.12 | 87% | 11.44 | 0.85 | 0.34 | 0.14 |
| **7** | 25.2 | 6.74 | 82% | 5.12 | 0.82 | 0.45 | 0.10 |
| **8** | 25.2 | 6.76 | 82% | 6.56 | 0.99 | 0.30 | 0.13 |
| **9** | 25.2 | 6.49 | 79% | 6.32 | 0.88 | 0.28 | 0.10 |

**Table 2(e). Cemex – Phase 3-4 (East) Pond: 2019 Water Column Profiling Data**
**OCT 27:** max. depth 10.7 m (35 ft); Secchi disk water clarity: 2.4 m (8 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 18.2 | 9.81 | 104% | 904 | 588 | 0.45 | 8.34 | 35 |
| **1** | 18.1 | 9.71 | 103% | 904 | 588 | 0.45 | 8.33 | 35 |
| **2** | 18.1 | 9.69 | 103% | 904 | 588 | 0.45 | 8.33 | 35 |
| **3** | 17.8 | 9.65 | 102% | 905 | 589 | 0.45 | 8.33 | 36 |
| **4** | 17.5 | 9.50 | 100% | 903 | 587 | 0.45 | 8.33 | 37 |
| **5** | 17.4 | 9.41 | 98% | 903 | 587 | 0.45 | 8.33 | 38 |
| **6** | 17.4 | 9.38 | 98% | 903 | 587 | 0.45 | 8.32 | 39 |
| **7** | 17.4 | 9.37 | 98% | 903 | 587 | 0.45 | 8.33 | 40 |
| **8** | 17.4 | 9.34 | 98% | 904 | 587 | 0.45 | 8.32 | 40 |
| **9** | 17.4 | 9.31 | 97% | 904 | 587 | 0.45 | 8.33 | 41 |
| **10** | 17.4 | 9.27 | 97% | 904 | 587 | 0.45 | 8.32 | 42 |

*(additional parameters next page)*

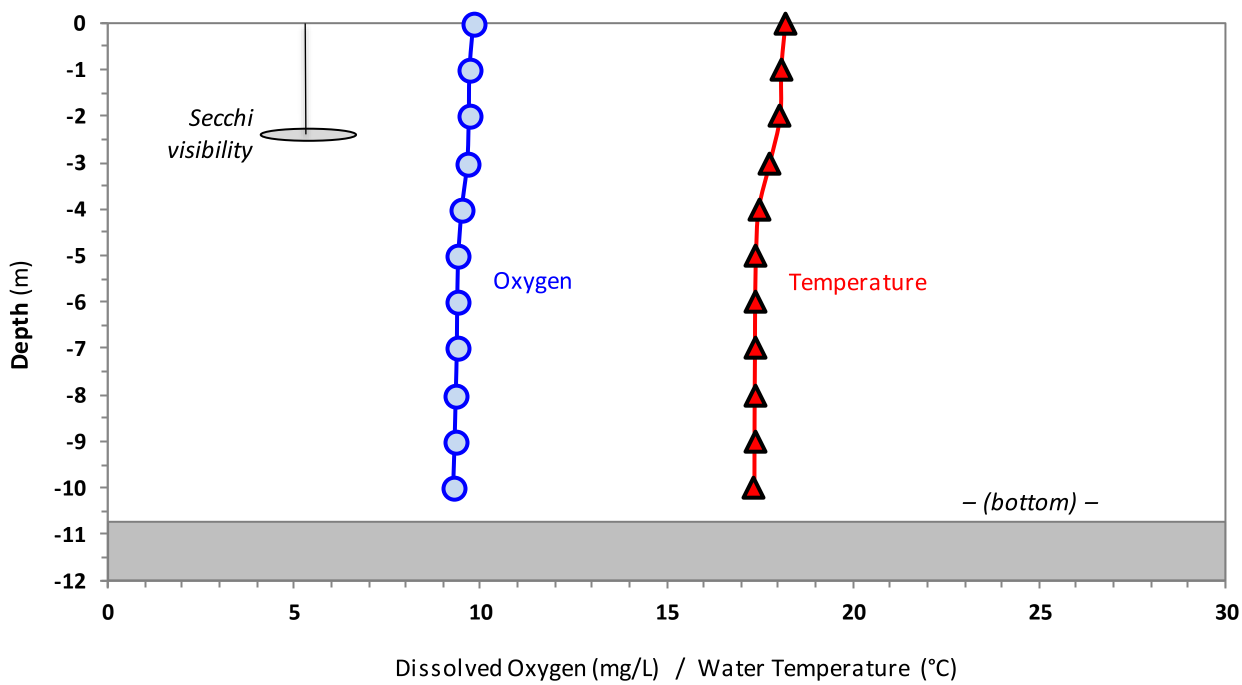



**Figure 2(e). OCT 27, 2019 – Phase 3-4 Pond framework parameters**

**Table 2(e).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**OCT 27:** max. depth 10.7 m (35 ft); Secchi disk water clarity: 2.4 m (8 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae;*
*FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 18.2 | 9.81 | 104% | 1.92 | 0.76 | 0.46 | 0.19 |
| **1** | 18.1 | 9.71 | 103% | 2.32 | 0.92 | 0.53 | 0.25 |
| **2** | 18.1 | 9.69 | 103% | 2.50 | 0.75 | 0.55 | 0.30 |
| **3** | 17.8 | 9.65 | 102% | 3.51 | 0.96 | 0.64 | 0.33 |
| **4** | 17.5 | 9.50 | 100% | 2.40 | 0.91 | 0.66 | 0.36 |
| **5** | 17.4 | 9.41 | 98% | 2.82 | 1.02 | 0.76 | 0.38 |
| **6** | 17.4 | 9.38 | 98% | 2.36 | 0.92 | 0.67 | 0.36 |
| **7** | 17.4 | 9.37 | 98% | 3.05 | 0.98 | 0.56 | 0.36 |
| **8** | 17.4 | 9.34 | 98% | 2.84 | 0.88 | 0.51 | 0.39 |
| **9** | 17.4 | 9.31 | 97% | 3.00 | 0.87 | 0.44 | 0.38 |
| **10** | 17.4 | 9.27 | 97% | 3.27 | 1.04 | 0.41 | 0.37 |

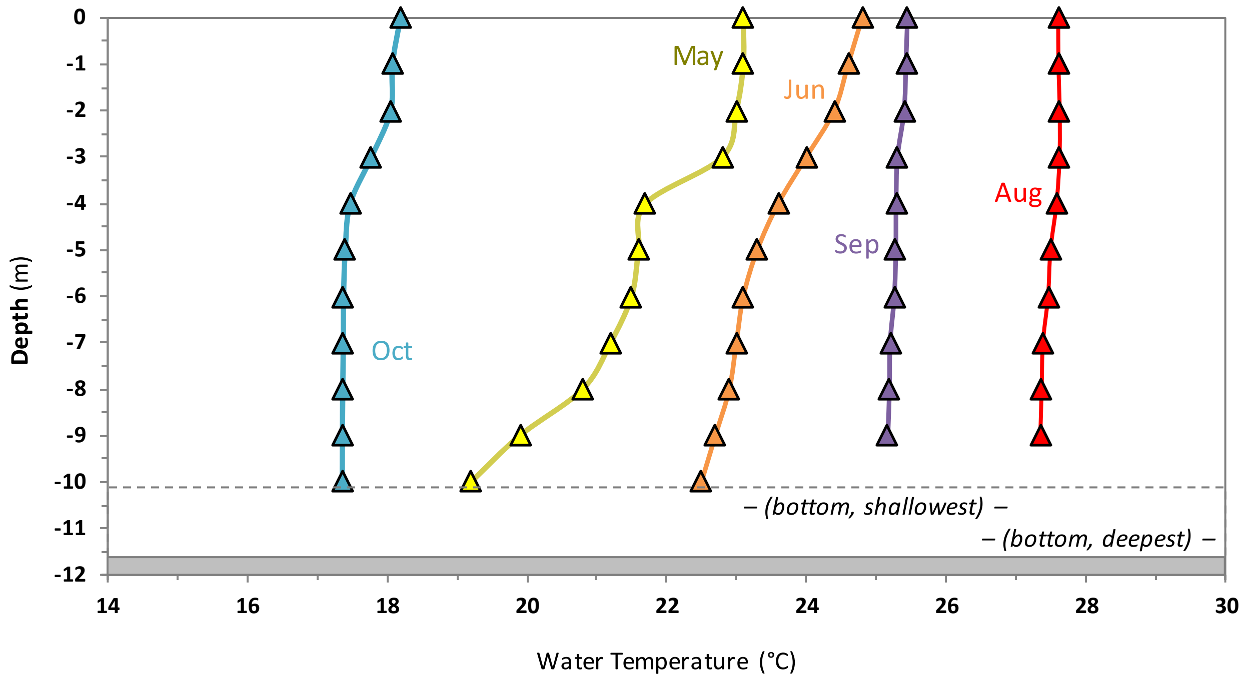



**Figure 2(f). Cemex – Phase 3-4 (East) Pond: 2019 May-Oct TEMPERATURE**

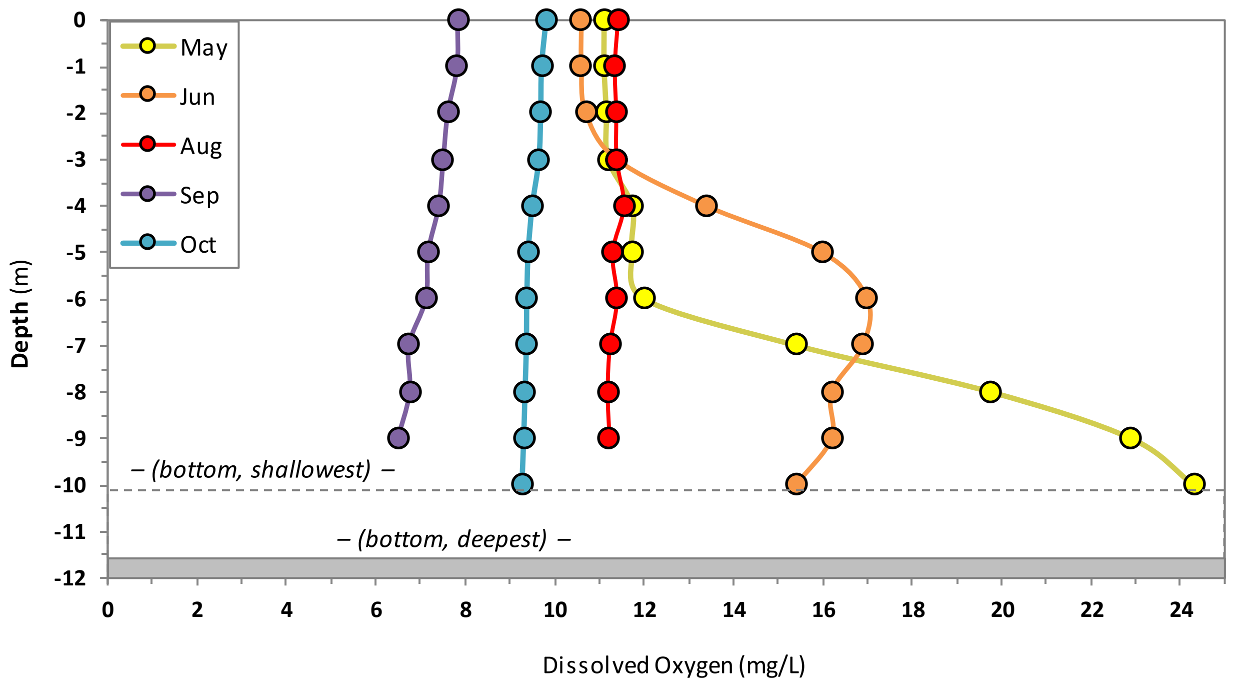



**Figure 2(g). Cemex – Phase 3-4 (East) Pond: 2019 May-Oct OXYGEN**

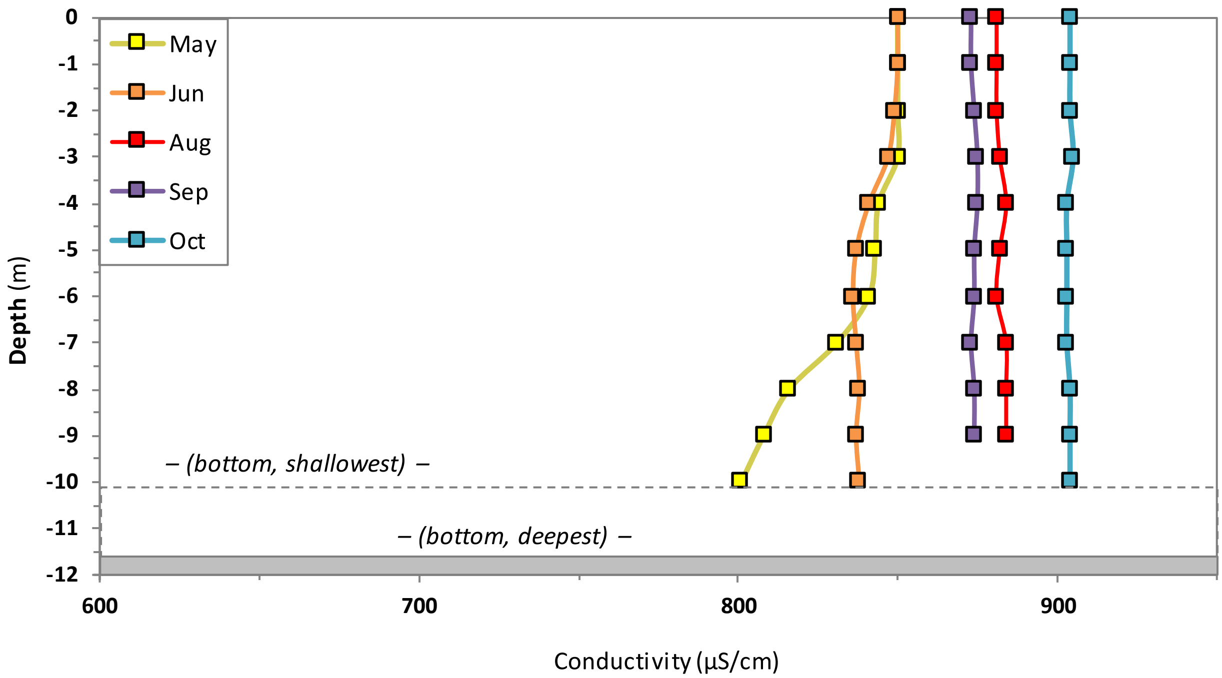



**Figure 2(h). Cemex – Phase 3-4 (East) Pond: 2019 May-Oct CONDUCTIVITY**

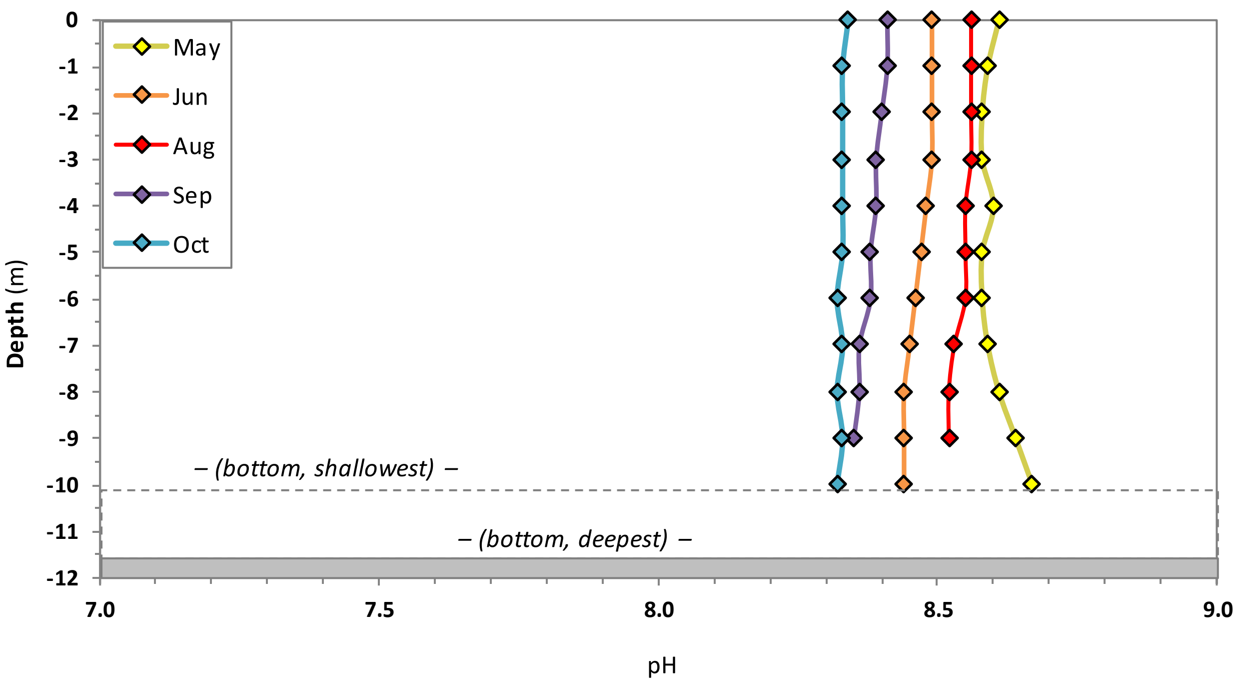



**Figure 2(i). Cemex – Phase 3-4 (East) Pond: 2019 May-Oct pH**

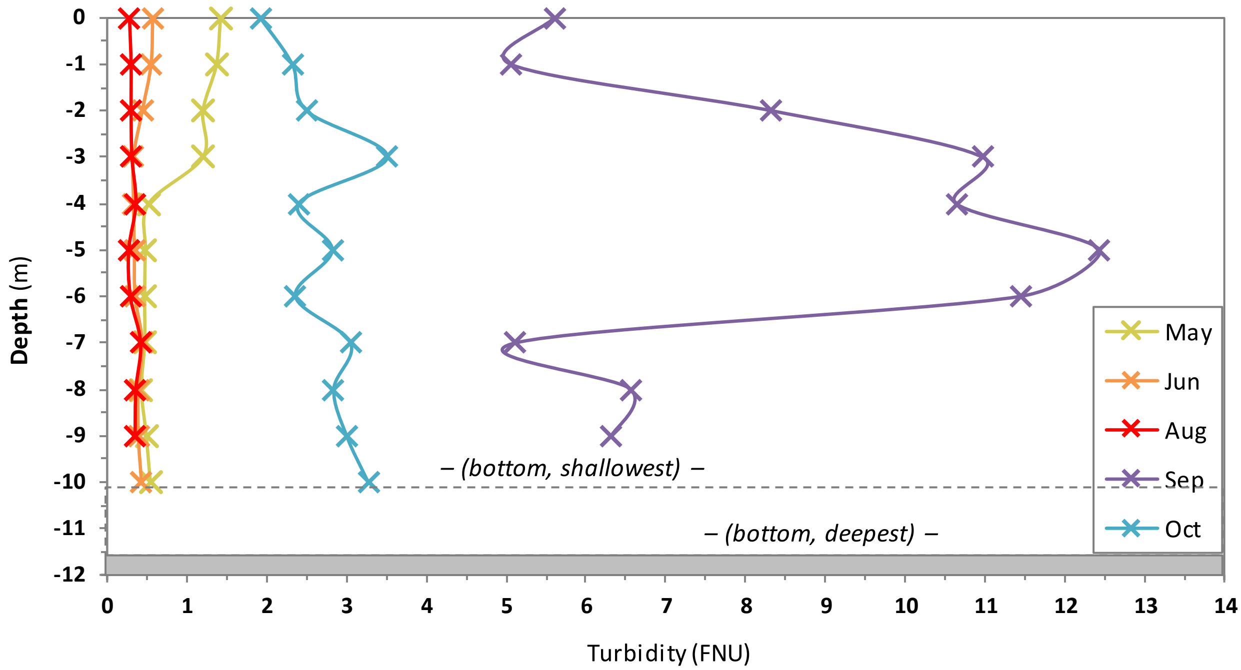



**Figure 2(j). Cemex – Phase 3-4 (East) Pond: 2019 May-Oct TURBIDITY**

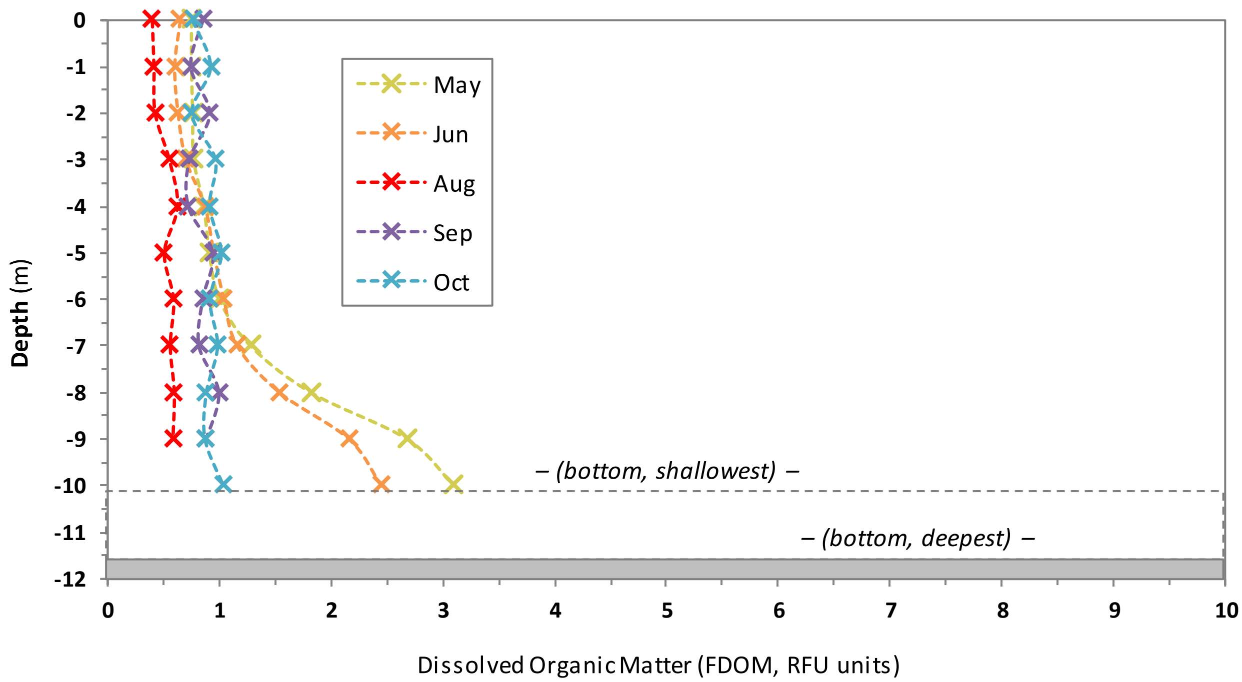



**Figure 2(k). Cemex–Phase 3-4: 2019 May-Oct DISSOLVED ORGANIC MATTER**

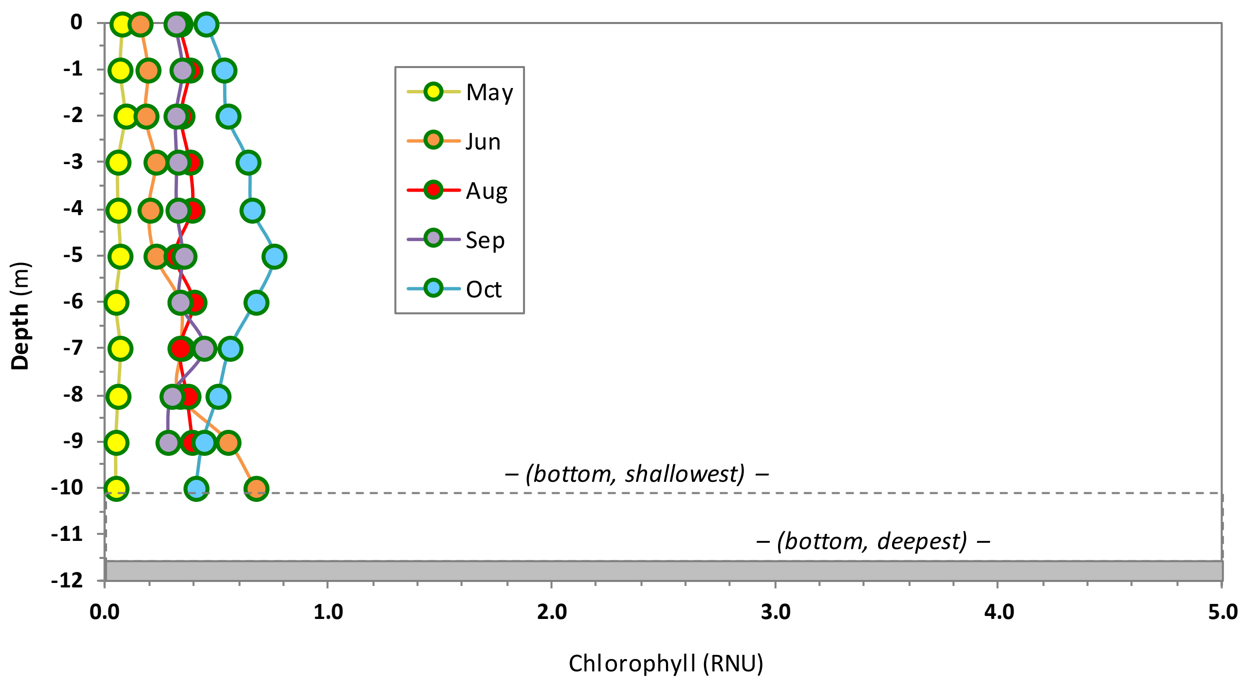



**Figure 2(l). Cemex – Phase 3-4 (East) Pond: 2019 May-Oct CHLOROPHYLL**

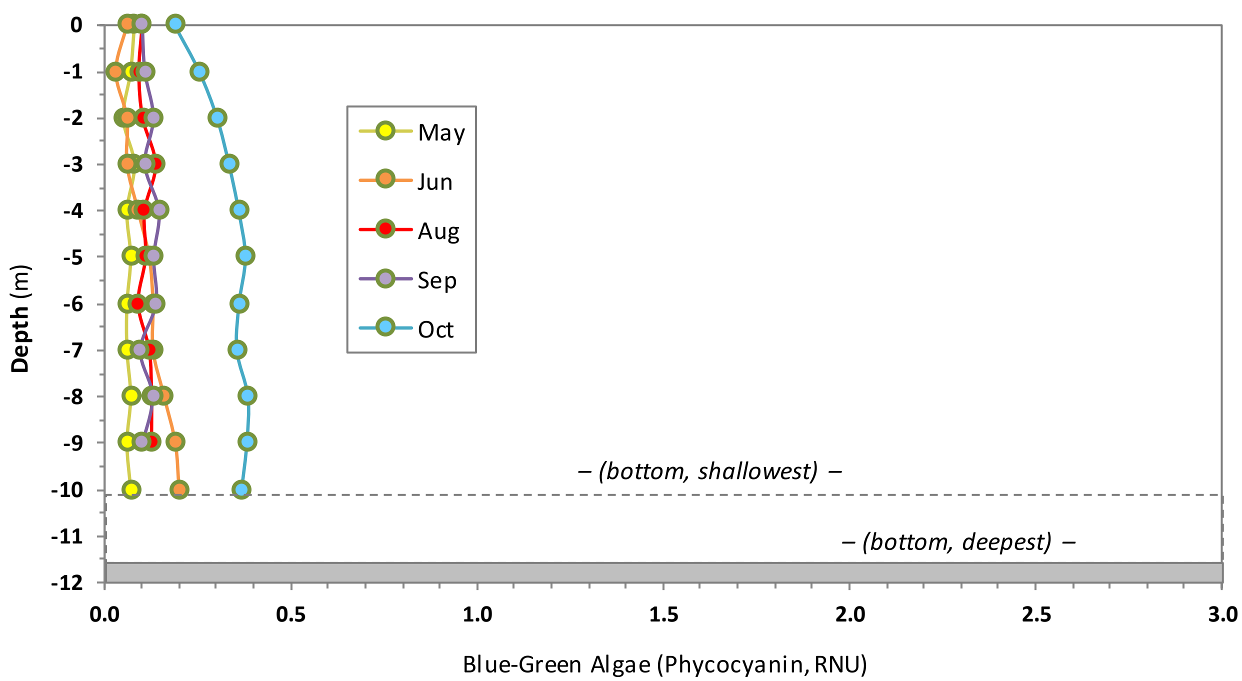



**Figure 2(m). Cemex – Phase 3-4 Pond: 2019 May-Oct BLUE-GREEN ALGAE**

# 3. TEICHERT–REIFF POND

## 3. Teichert–Reiff Pond

The Reiff Pond results are first shown for each survey date, one at a time. Numerical data from each of the five 2019 water profiling surveys are presented in Tables 3(a) (May) through 3(e) (October). For each survey date, some of the key, driving parameters are also shown in figure form, Figures 3(a-e).

After the individual survey information, each water quality parameter is plotted across the year of sampling, in Figures 3(f) (Temperature) through 3(m) (Blue-green Algae). In these figures, the different seasonal profiles are shown together, so you can see the full range of values and the changes across the year.

Before the data tables and figures, results are first discussed below, for each of the monitored water parameters and in summary.

Water Depth (Tables and Figs. 3(a-e): in this shallow pond dropped (through normal evaporation) from 7.6 m (25 ft) in May to 5.2 m (17 ft) in September and October.

Secchi Water Clarity (Tables and Figs. 3(a-e): as in 2018, was uniformly low/turbid, at 1.0-2.5 m (3-8 ft). A function of plant slurry inflows and wind turbulence / sediment resuspension clouding the shallow water.

Temperature (Tables and Figs. 3(a-e), Fig. 3(f)): Overall range 17-29 °C (63-84 °F) between early May and late October. Despite the shallow depth and slurry inflows, a light thermal stratification was apparent between May and August, with bottom waters 3.4-4.4 °C (6-8 °F) cooler than surface water. We note that Reiff Pond had a smaller wind fetch (maximum surface dimension) and more wind-protected exposure than the Cemex Phase 3-4 pond discussed in the last section. The bottom water at Reiff did warm across this period, from 19 °C in May to 22 °C in June and 25 °C in August. This indicates some periodic mixing with the warmer surface waters (without such mixing from above, bottom temperatures would remain almost unchanged through the season).

However, the thermal gradient of 3.4-4.4 °C (6-8 °F) persisted throughout this time, with the surface water always that much warmer. This physically isolated the lower water for periods of time, allowing oxygen to become depleted. Later, in the fall, the water column became well mixed (low gradient between surface and bottom temperatures) as overall temperatures dropped to below 18 °C.

Dissolved Oxygen (Tables and Figs. 3(a-e), Fig. 3(g)): in the top 3 m of depth, remained at or above saturation levels throughout the season, between 7.9 and 10.1 mg/L (ppm) and 102-109% of saturation, similar to 2018. And again as in 2018, even with the light thermal stratification present between May and August, oxygen levels in the bottom water plummeted to under 1 mg/L and under 10% of saturation. These are levels that fish cannot survive in and, most relevant to this mercury-monitoring program, they are levels that can promote methylmercury production and its movement into the water from the bottom sediments, as well as mercury methylation directly in the bottom waters. These processes can significantly increase the uptake of methylmercury by fish and other aquatic organisms (and predators and fishermen that consume them). The Reiff Pond has had among the highest fish mercury levels of the monitored ponds. Another contributing factor is the high turbidity of the water, which blocks photosynthesis and oxygen re-charge at depth here, and also blocks UV light from degrading methylmercury.

Conductivity (Tables 3(a-e), Fig. 3(h)): ranged narrowly between 658 and 747 µS/cm overall, as compared to 767-943 µS/cm in 2018. The somewhat lower range of levels in 2019 were likely due to relatively more dilution by rainwater in early 2019 (note greater depths in 2019, relative to 2018, at most of the ponds).

Salinity (Tables 3(a-e): was fairly uniform, at 0.32-0.36 ppt (parts per thousand, g/L) across all depths and dates, as compared to 0.32-0.40 ppt in 2018. Typical freshwaters range below 0.50 ppt; seawater averages 35 ppt.

Total Dissolved Solids (TDS) (Tables 3(a-e): ranged between 428 and 486 mg/L (ppm) across all dates and depths, as compared to 498-612 mg/L in 2018. As discussed above, the lower levels in 2019 were consistent with relatively more rainfall dilution and a greater starting depth.

pH (Tables 3(a-e), Fig. 3(i)): was notably basic (non-acidic; pH > 7.00) in all of the monitored ponds. This is a function of their mining history and the basic nature of local sediments. Water pH in the Reiff Pond was very uniform at nearly all depths and dates, at 8.3-8.6. However, in the semi-isolated deeper water that experienced major oxygen depletion between May and August, pH dropped as low as 7.67, still basic but considerably less so. This was a direct function of the reduced oxygen, which shifts systems in a more acidic (less basic) direction.

Oxidation/Reduction Potential (ORP) (Tables 3(a-e): generally ranged from 169-200 mV (millivolts) in May-August, dropping to 93-109 mV in September and October. This compared to a similar overall range in 2018 of 100-185 mV (millivolts).

Turbidity (Tables 3(a-e), Fig. 3(j)): Reiff is one of the ponds that regularly receives aggregate plant slurry discharge and has always been one of the most turbid of the monitored ponds. Turbidity levels ranged from approximately 2-18 FNU across the sampling season. Corresponding Secchi visibilities were very low, as is to be expected, at 1.0-2.5 m (3-8 ft).

Dissolved Organic Matter (FDOM) (Tables 3(a-e), Fig. 3(k)): Measured for the first time in 2019, we will wait a year or two before making any conclusions about this or the other optical parameters. Levels were similar throughout the top 4 m on each date, in the 0.6-1.5 RFU range. In the bottom 2-3 m in May through August, there were accumulations to 1.5-3.2 RFU.

Green Algae (Chlorophyll) (Tables 3(a-e), Fig. 3(l)): in the top several meters on all dates was in a low range similar to the two Cemex ponds (< 0.80 RFU). Interestingly, on all dates except late October, when the water was thoroughly wind-mixed, there was a significant accumulation toward the bottom. Though still low (0.49-1.46 RFU), bottom levels were up to 8x higher than in the surface layer. We note that this is one of the ponds that has a slight stratification each year, partially isolating the bottom water.

Blue-Green Algae (Phycocyanin) (Tables 3(a-e), Fig. 3(m)): was very low throughout, with RFU levels < 0.50 at all depths and dates. Similar to the Chlorophyll profiles, between early May and mid September, Phycocyanin showed a relative accumulation in the bottom few meters of depth, likely for the same reasons.

**In summary,** the Teichert–Reiff Pond, one of the ponds identified as highly elevated in fish mercury, was found in 2019 to be shallow (17-25 feet) and turbid (cloudy water) from processing plant slurry discharges, as in 2018. Despite the shallow depths and slurry inflows, a light temperature stratification (separation) developed in the water column. Bottom waters became strongly anoxic between May and August, almost certainly increasing methylmercury levels. This seasonal cycle presents a clear mercury management option, through disruption of summer anoxia.

**Table 3(a). Teichert – Reiff Pond: 2019 Water Column Profiling Data**
**MAY 14**: max. depth 7.6 m (25 ft); Secchi disk water clarity: 1.8 m (6 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 23.4 | 9.25 | 109% | 660 | 429 | 0.32 | 8.62 | – |
| **1** | 23.4 | 9.26 | 109% | 660 | 429 | 0.32 | 8.60 | – |
| **2** | 23.1 | 9.21 | 108% | 660 | 429 | 0.32 | 8.58 | – |
| **3** | 22.9 | 9.21 | 107% | 659 | 428 | 0.32 | 8.57 | – |
| **4** | 22.8 | 9.19 | 107% | 659 | 428 | 0.32 | 8.56 | – |
| **5** | 22.6 | 9.08 | 105% | 658 | 428 | 0.32 | 8.53 | – |
| **6** | 20.8 | 6.33 | 71% | 661 | 430 | 0.32 | 8.18 | – |
| **7** | 19.0 | 1.21 | 13% | 669 | 435 | 0.33 | 7.71 | – |

*(additional parameters next page)*

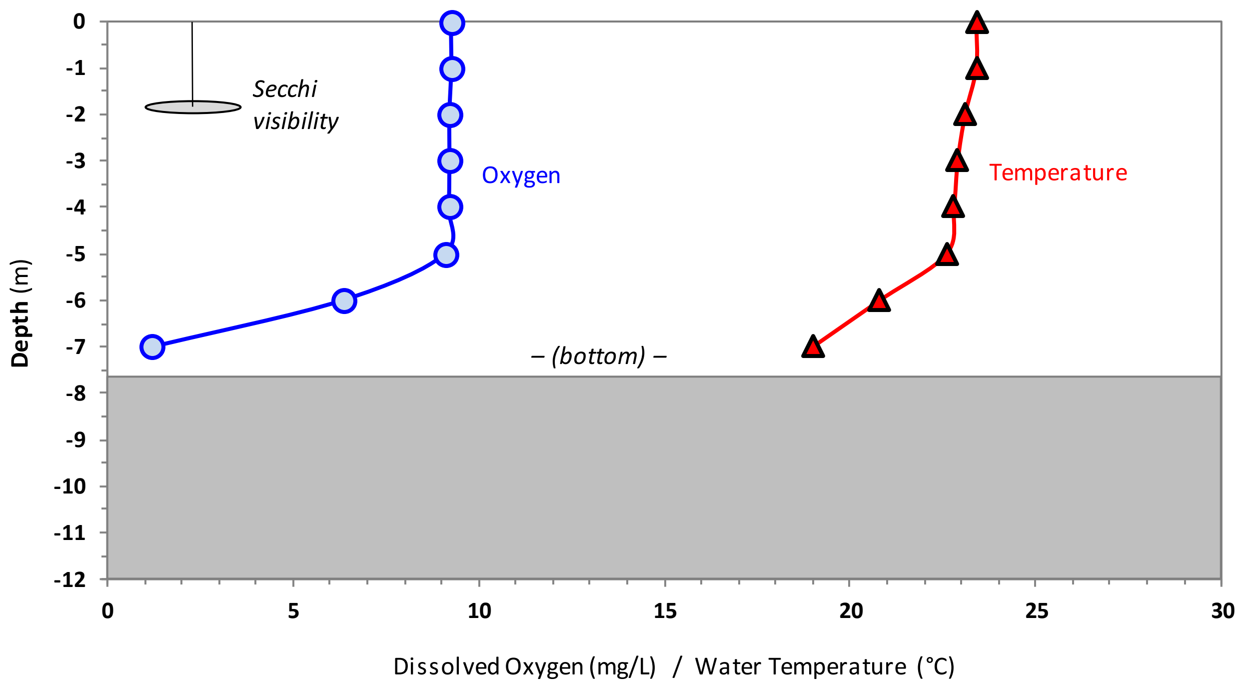



**Figure 3(a). MAY 14, 2019 – Reiff Pond framework parameters**

**Table 3(a).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**MAY 14**: max. depth 7.6 m (25 ft); Secchi disk water clarity: 1.8 m (6 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 23.4 | 9.25 | 109% | 2.82 | 1.17 | 0.14 | 0.03 |
| **1** | 23.4 | 9.26 | 109% | 2.93 | 1.16 | 0.16 | 0.02 |
| **2** | 23.1 | 9.21 | 108% | 2.76 | 1.45 | 0.12 | 0.03 |
| **3** | 22.9 | 9.21 | 107% | 2.89 | 1.45 | 0.14 | 0.06 |
| **4** | 22.8 | 9.19 | 107% | 3.24 | 1.46 | 0.25 | 0.07 |
| **5** | 22.6 | 9.08 | 105% | 6.69 | 1.67 | 0.70 | 0.04 |
| **6** | 20.8 | 6.33 | 71% | 9.06 | 2.90 | 1.25 | 0.08 |
| **7** | 19.0 | 1.21 | 13% | 17.90 | 3.19 | 1.10 | 0.15 |

**Table 3(b). Teichert – Reiff Pond: 2019 Water Column Profiling Data**

**JUN 16**: max. depth 7.3 m (20 ft); Secchi disk water clarity: 2.5 m (8 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 25.7 | 8.81 | 108% | 678 | 441 | 0.33 | 8.36 | 180 |
| **1** | 25.7 | 8.83 | 108% | 679 | 441 | 0.33 | 8.36 | 180 |
| **2** | 25.5 | 8.82 | 108% | 679 | 441 | 0.33 | 8.36 | 181 |
| **3** | 25.3 | 8.87 | 107% | 679 | 442 | 0.33 | 8.33 | 182 |
| **4** | 25.3 | 8.45 | 99% | 676 | 440 | 0.33 | 8.27 | 185 |
| **5** | 22.8 | 8.30 | 97% | 676 | 439 | 0.33 | 8.27 | 187 |
| **6** | 22.1 | 5.89 | 68% | 682 | 443 | 0.33 | 8.13 | 189 |
| **7** | 21.7 | 2.64 | 28% | 689 | 445 | 0.33 | 7.92 | 191 |

*(additional parameters next page)*

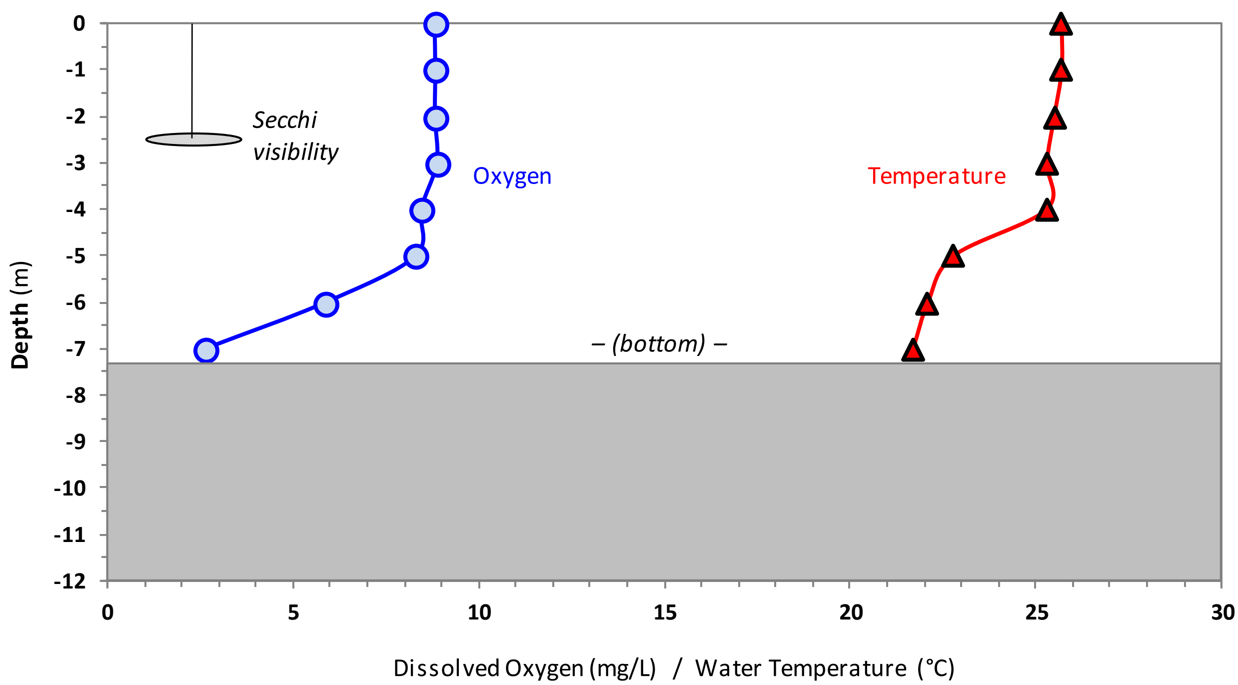



**Figure 3(b). JUN 16, 2019 – Reiff Pond framework parameters**

**Table 3(b).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**JUN 16**: max. depth 7.3 m (20 ft); Secchi disk water clarity: 2.5 m (8 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 25.7 | 8.81 | 108% | 1.83 | 0.62 | 0.28 | 0.01 |
| **1** | 25.7 | 8.83 | 108% | 1.80 | 0.68 | 0.27 | 0.02 |
| **2** | 25.5 | 8.82 | 108% | 1.56 | 0.69 | 0.23 | 0.00 |
| **3** | 25.3 | 8.87 | 107% | 2.69 | 0.90 | 0.24 | 0.04 |
| **4** | 25.3 | 8.45 | 99% | 4.18 | 1.27 | 0.49 | 0.15 |
| **5** | 22.8 | 8.30 | 97% | 2.66 | 1.29 | 0.70 | 0.21 |
| **6** | 22.1 | 5.89 | 68% | 5.88 | 1.53 | 1.05 | 0.29 |
| **7** | 21.7 | 2.64 | 28% | 6.52 | 1.83 | 1.46 | 0.42 |

**Table 3(c). Teichert – Reiff Pond: 2019 Water Column Profiling Data**
**AUG 1**: max. depth 6.1 m (20 ft); Secchi disk water clarity: 1.4 m (5 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 28.8 | 7.98 | 104% | 727 | 473 | 0.35 | 8.45 | 196 |
| **1** | 28.4 | 7.95 | 102% | 726 | 472 | 0.35 | 8.44 | 195 |
| **2** | 27.9 | 8.02 | 103% | 726 | 472 | 0.35 | 8.45 | 195 |
| **3** | 27.6 | 7.85 | 100% | 726 | 472 | 0.35 | 8.44 | 194 |
| **4** | 27.4 | 5.97 | 76% | 729 | 474 | 0.35 | 8.31 | 195 |
| **5** | 26.6 | 0.37 | 5% | 737 | 479 | 0.36 | 7.86 | 200 |
| **5.6** | 25.4 | 0.19 | 2% | 747 | 486 | 0.36 | 7.67 | 169 |

*(additional parameters next page)*

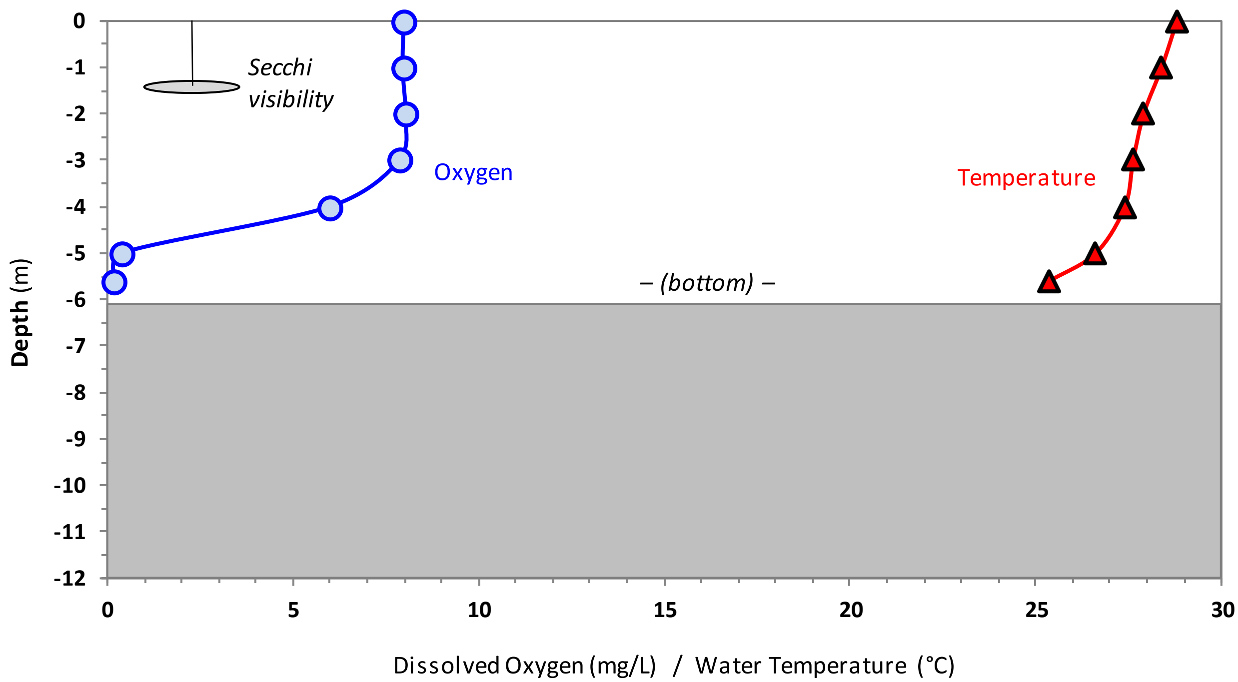



**Figure 3(c). AUG 1, 2019 – Reiff Pond framework parameters**

**Table 3(c).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**AUG 1**: max. depth 6.1 m (20 ft); Secchi disk water clarity: 1.4 m (5 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| **Depth** (m) | **Temp.** (°C) | **Oxygen** (mg/L) | (% Sat.) | **Turbidity** (FNU) | **FDOM** (RFU) | **Chlorophyll** (RFU) | **BG Algae** (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 28.8 | 7.98 | 104% | 7.85 | 0.73 | 0.55 | 0.18 |
| **1** | 28.4 | 7.95 | 102% | 7.78 | 0.89 | 0.65 | 0.21 |
| **2** | 27.9 | 8.02 | 103% | 7.58 | 0.78 | 0.81 | 0.21 |
| **3** | 27.6 | 7.85 | 100% | 7.70 | 0.97 | 1.04 | 0.31 |
| **4** | 27.4 | 5.97 | 76% | 10.13 | 1.03 | 0.99 | 0.29 |
| **5** | 26.6 | 0.37 | 5% | 13.24 | 1.71 | 1.26 | 0.43 |
| **5.6** | 25.4 | 0.19 | 2% | 7.57 | 2.28 | 0.54 | 0.44 |

**Table 3(d). Teichert – Reiff Pond: 2019 Water Column Profiling Data**

**SEP 15**: max. depth 5.2 m (17 ft); Secchi disk water clarity: 1.2 m (4 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 25.1 | 8.36 | 102% | 698 | 454 | 0.34 | 8.49 | 97 |
| **1** | 25.1 | 8.36 | 102% | 698 | 454 | 0.34 | 8.49 | 100 |
| **2** | 25.1 | 8.37 | 102% | 698 | 454 | 0.34 | 8.49 | 102 |
| **3** | 25.1 | 8.37 | 102% | 698 | 454 | 0.34 | 8.49 | 103 |
| **4** | 24.5 | 7.90 | 95% | 697 | 453 | 0.34 | 8.47 | 107 |
| **4.8** | 24.3 | 7.40 | 89% | 697 | 453 | 0.34 | 8.44 | 109 |

*(additional parameters next page)*

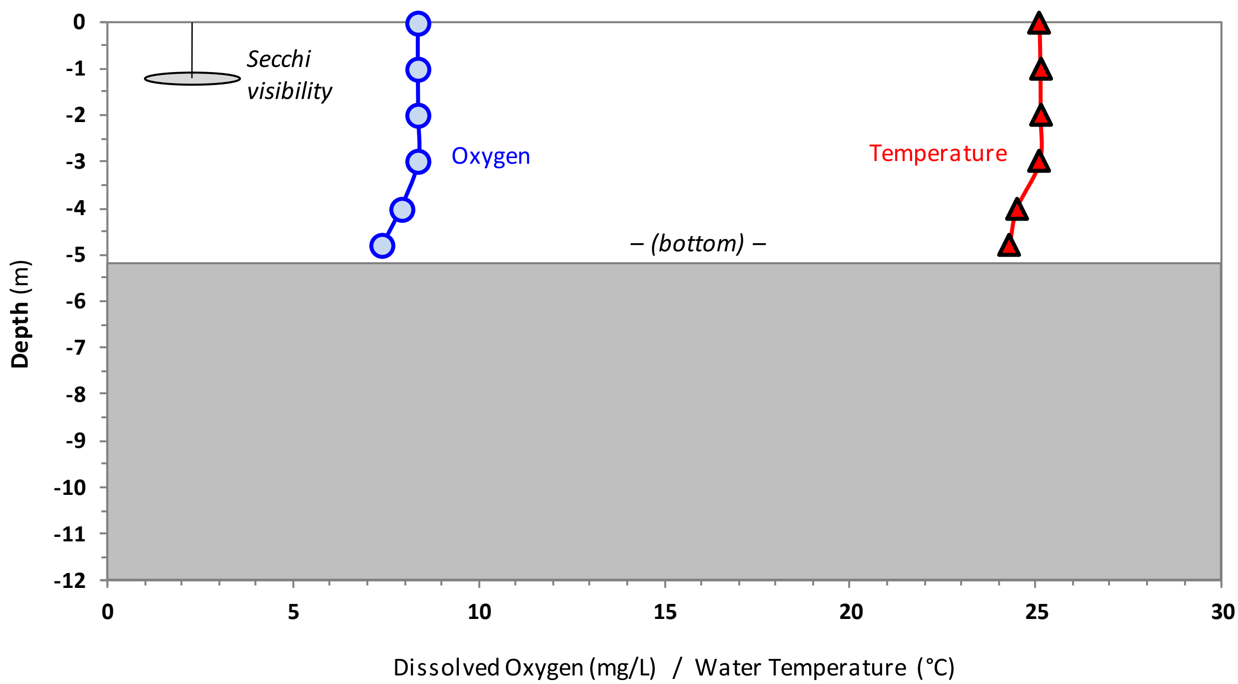



**Figure 3(d). SEP 15, 2019 – Reiff Pond framework parameters**

**Table 3(d).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**SEP 15**: max. depth 5.2 m (17 ft); Secchi disk water clarity: 1.2 m (4 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae;*
*FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 25.1 | 8.36 | 102% | 6.83 | 1.13 | 0.37 | 0.15 |
| **1** | 25.1 | 8.36 | 102% | 7.18 | 1.18 | 0.38 | 0.13 |
| **2** | 25.1 | 8.37 | 102% | 6.80 | 1.16 | 0.36 | 0.13 |
| **3** | 25.1 | 8.37 | 102% | 7.17 | 1.24 | 0.35 | 0.15 |
| **4** | 24.5 | 7.90 | 95% | 7.81 | 1.26 | 0.73 | 0.22 |
| **4.8** | 24.3 | 7.40 | 89% | 12.13 | 1.36 | 0.79 | 0.27 |

**Table 3(e). Teichert – Reiff Pond: 2019 Water Column Profiling Data**
**OCT 27**: max. depth 5.2 m (17 ft); Secchi disk water clarity: 1.0 m (3 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 17.4 | 10.06 | 105% | 692 | 450 | 0.34 | 8.50 | 93 |
| **1** | 17.3 | 10.08 | 105% | 692 | 450 | 0.34 | 8.48 | 94 |
| **2** | 17.3 | 10.07 | 105% | 692 | 450 | 0.34 | 8.49 | 94 |
| **3** | 17.2 | 10.05 | 105% | 693 | 450 | 0.34 | 8.50 | 94 |
| **4** | 17.2 | 10.09 | 105% | 692 | 450 | 0.34 | 8.50 | 94 |
| **4.7** | 17.2 | 10.05 | 105% | 692 | 450 | 0.34 | 8.51 | 94 |

*(additional parameters next page)*

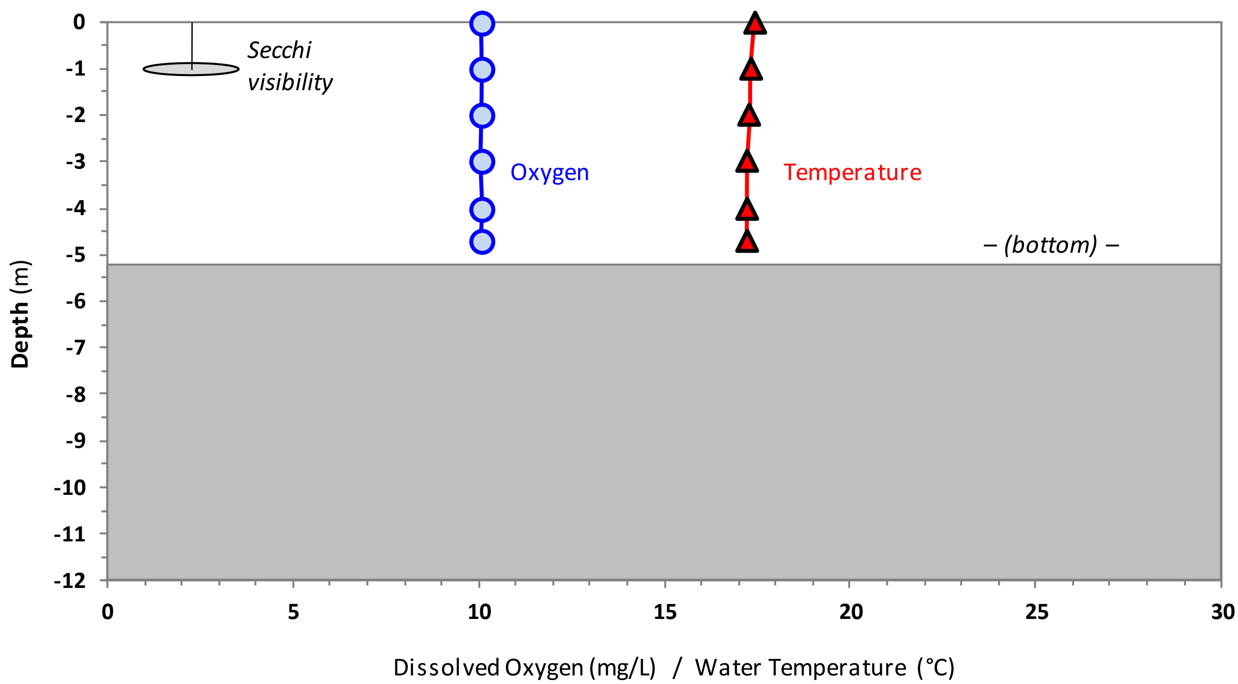



**Figure 3(e). OCT 27, 2019 – Reiff Pond framework parameters**

**Table 3(e).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**OCT 27**: max. depth 5.2 m (17 ft); Secchi disk water clarity: 1.0 m (3 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 17.4 | 10.06 | 105% | 8.27 | 1.05 | 0.72 | 0.31 |
| **1** | 17.3 | 10.08 | 105% | 8.76 | 1.20 | 0.77 | 0.38 |
| **2** | 17.3 | 10.07 | 105% | 8.69 | 1.12 | 0.78 | 0.44 |
| **3** | 17.2 | 10.05 | 105% | 8.79 | 1.27 | 0.71 | 0.46 |
| **4** | 17.2 | 10.09 | 105% | 8.68 | 1.15 | 0.73 | 0.45 |
| **4.7** | 17.2 | 10.05 | 105% | 9.43 | 1.11 | 0.79 | 0.47 |

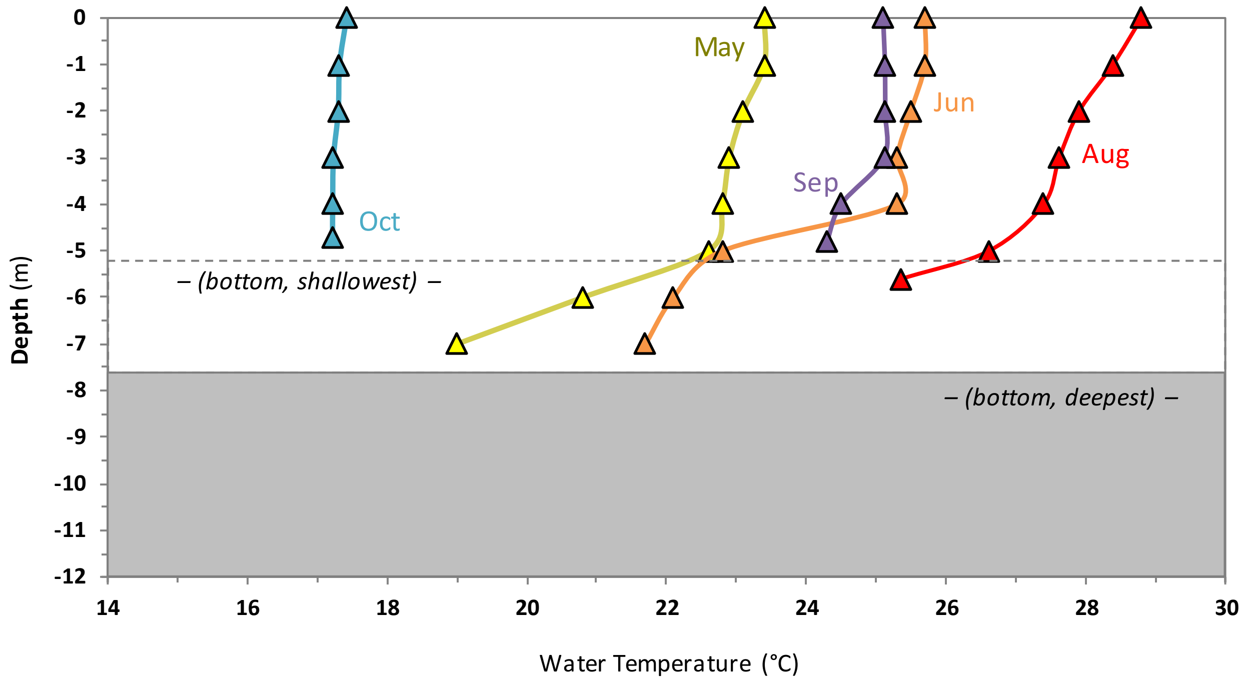



**Figure 3(f). Teichert – Reiff Pond: 2019 May-Oct TEMPERATURE**

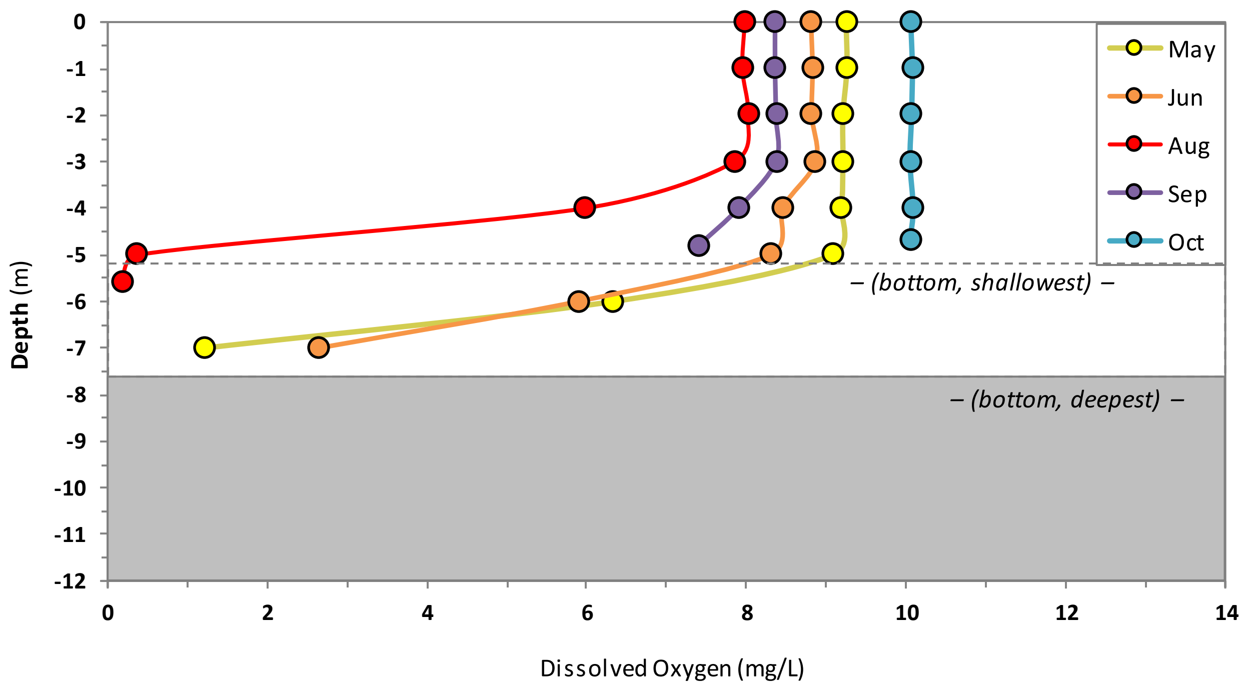



**Figure 3(g). Teichert – Reiff Pond: 2019 May-Oct OXYGEN**

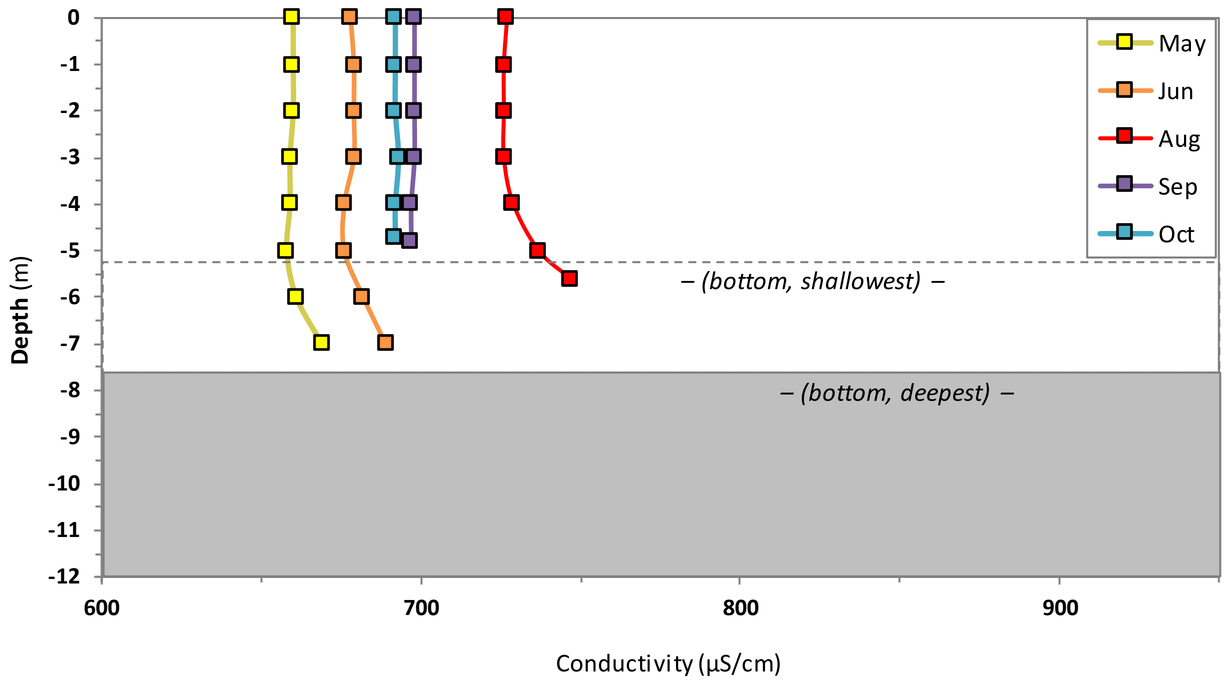



**Figure 3(h). Teichert – Reiff Pond: 2019 May-Oct CONDUCTIVITY**

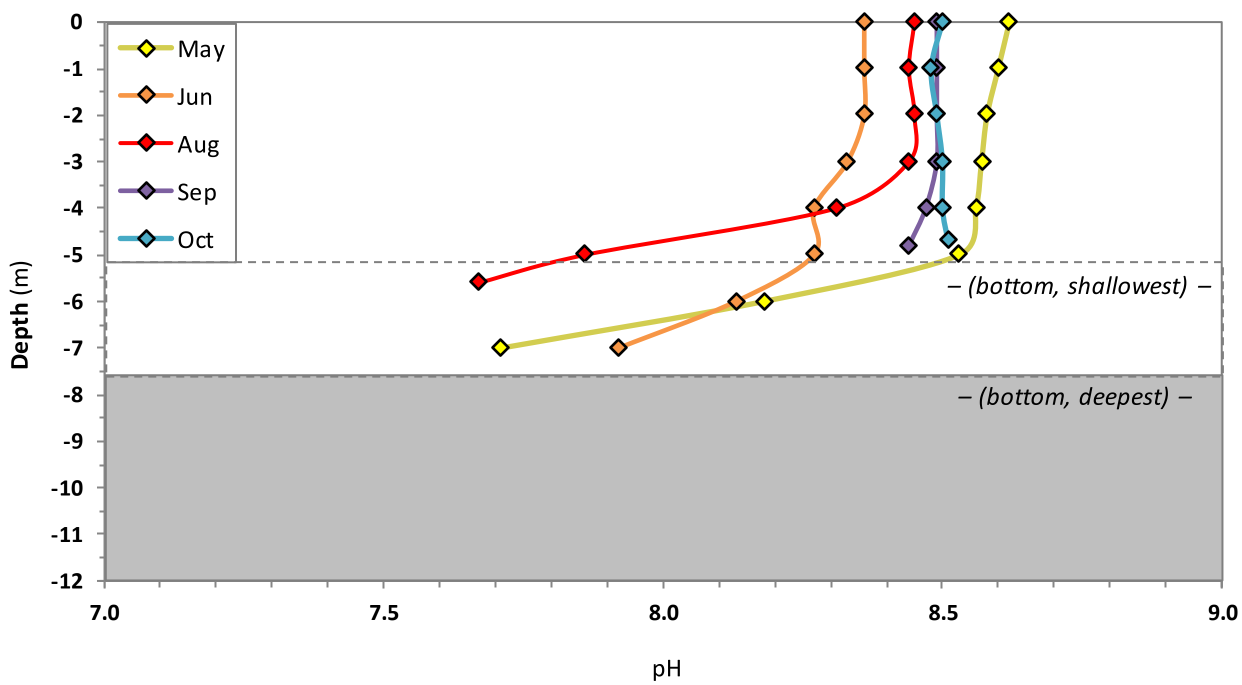



**Figure 3(i). Teichert – Reiff Pond: 2019 May-Oct pH**

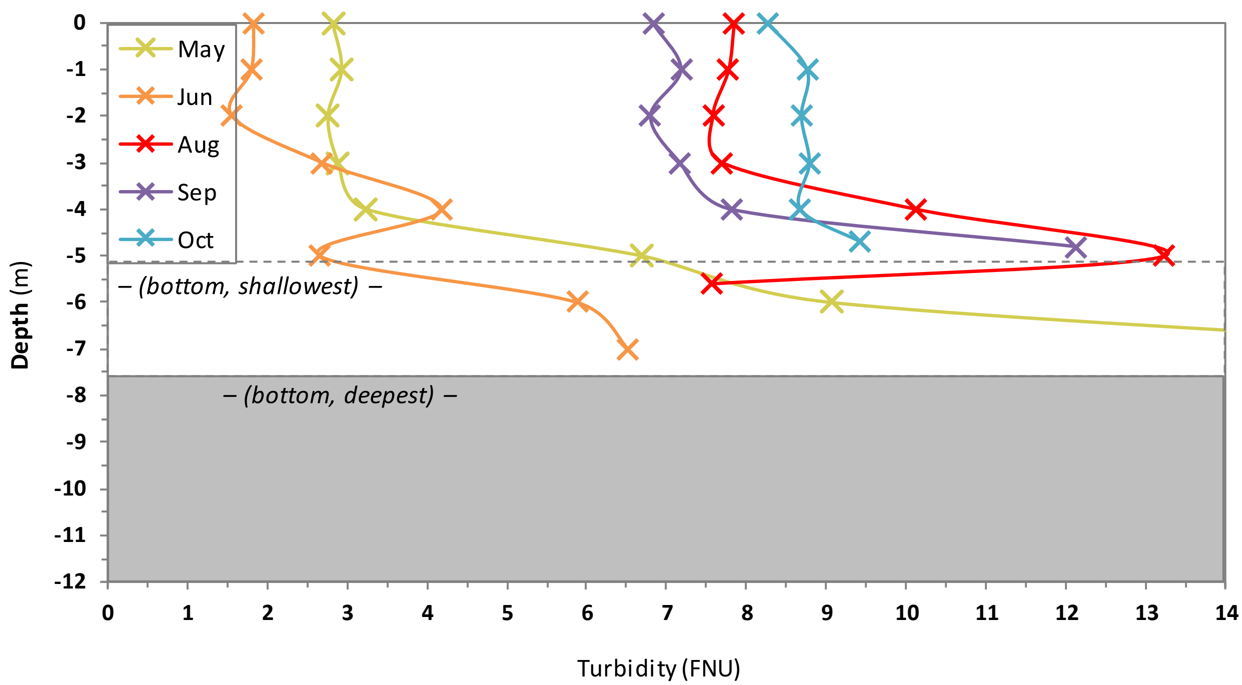



**Figure 3(j). Teichert – Reiff Pond: 2019 May-Oct TURBIDITY**

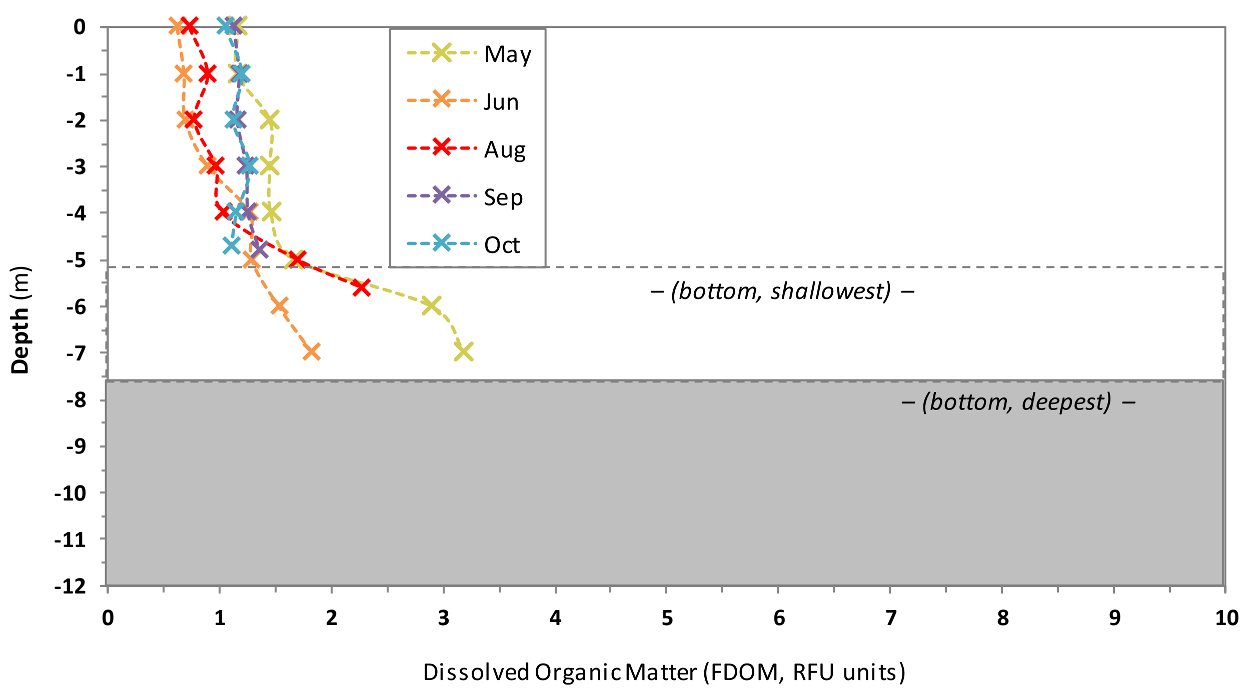



**Figure 3(k). Reiff Pond: 2019 May-Oct DISSOLVED ORGANIC MATTER**

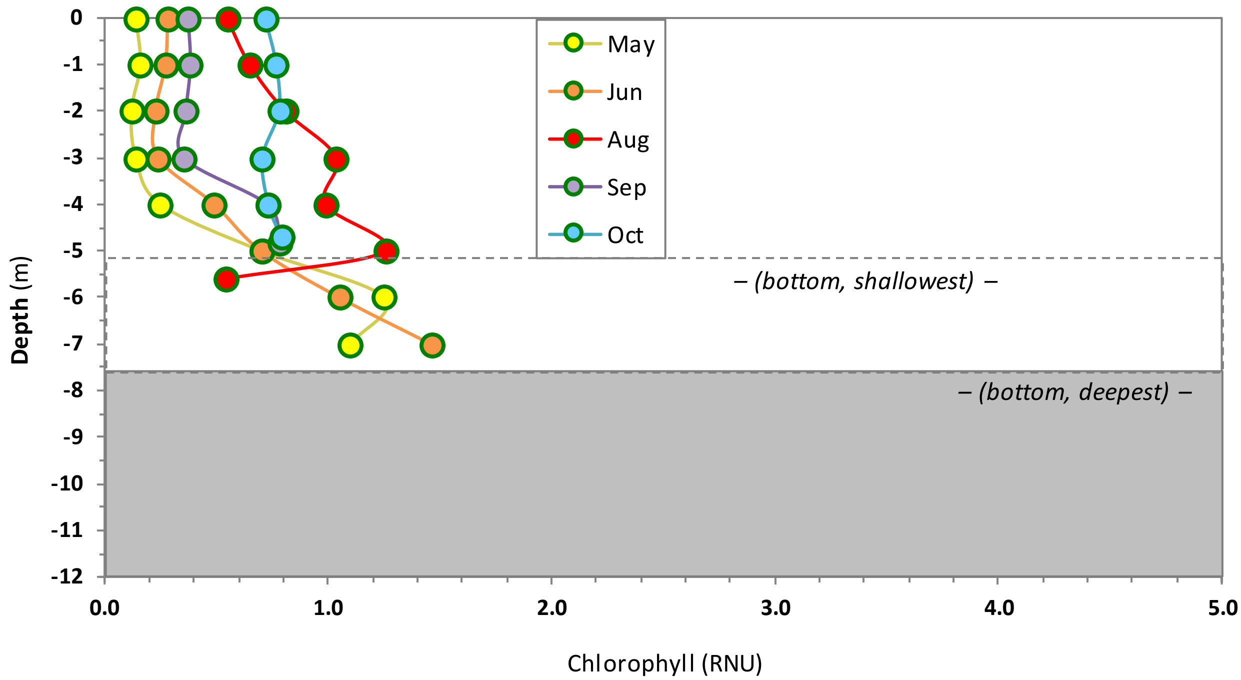



**Figure 3(l). Teichert – Reiff Pond: 2019 May-Oct CHLOROPHYLL**

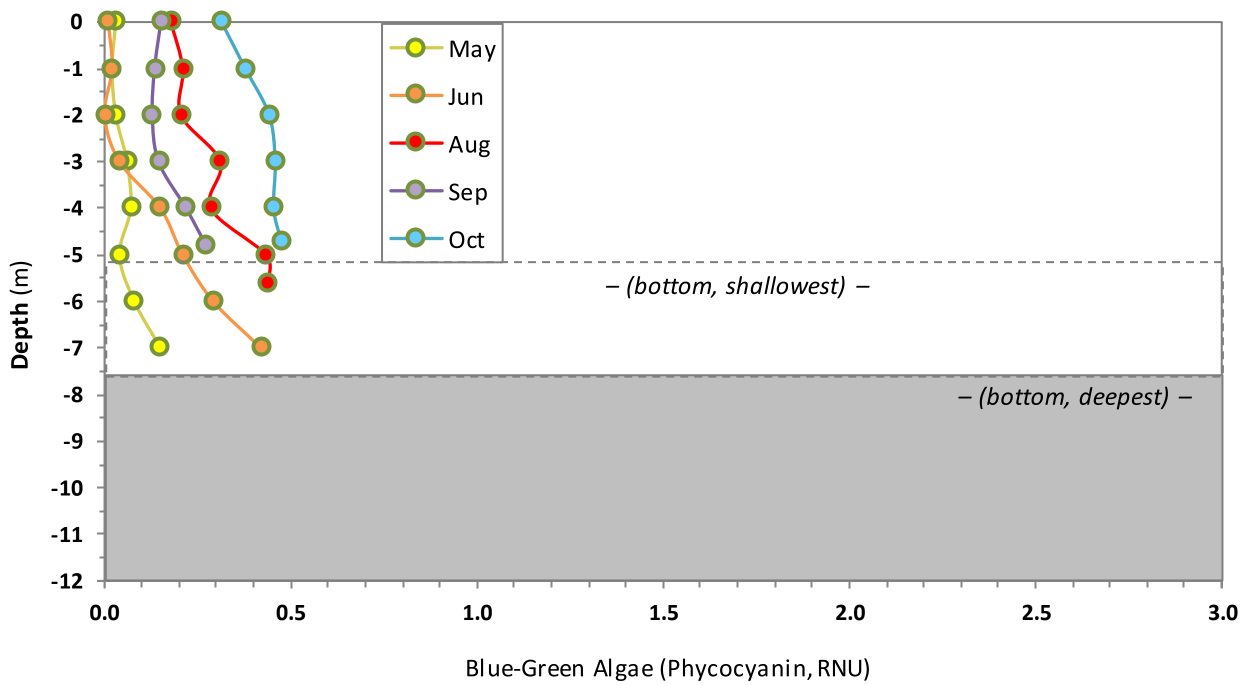
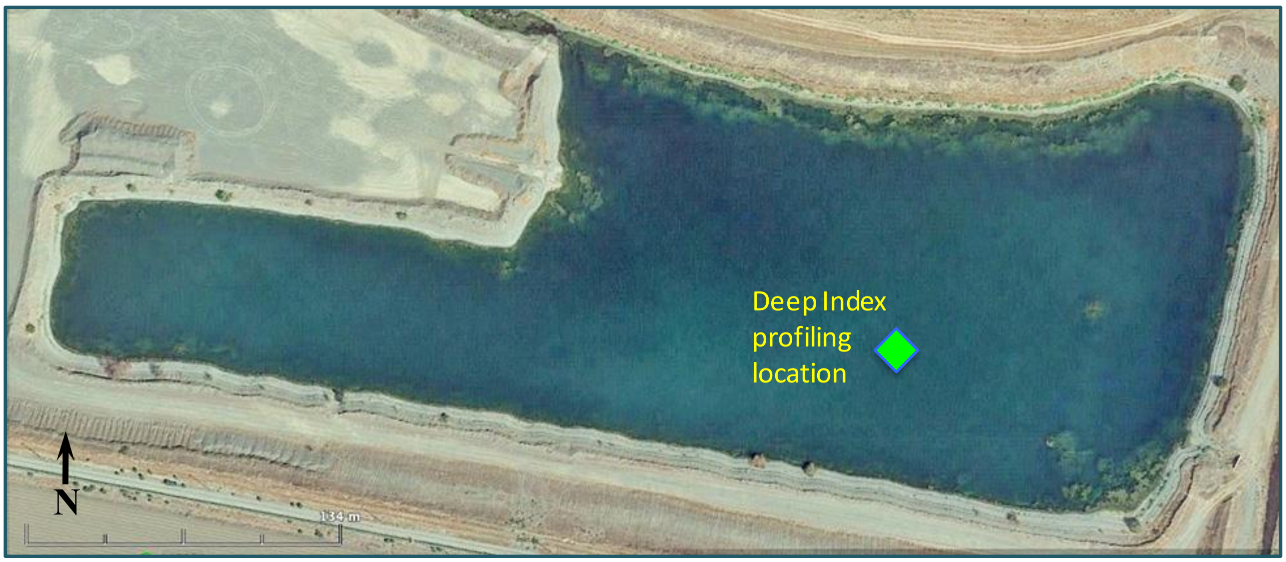



**Figure 3(m). Teichert – Reiff Pond: 2019 May-Oct BLUE-GREEN ALGAE**

# 4. SYAR–B1 POND



## 4. Syar–B1 Pond

The B1 Pond results are first shown for each survey date, one at a time. Numerical data from each of the five 2019 water profiling surveys are presented in Tables 4(a) (May) through 4(e) (October). For each survey date, some of the key, driving parameters are also shown in figure form, Figures 4(a-e).

After the individual survey information, each water quality parameter is plotted across the year of sampling, in Figures 4(f) (Temperature) through 4(m) (Blue-green Algae). In these figures, the different seasonal profiles are shown together, so you can see the full range of values and the changes across the year.

Before the data tables and figures, results are first discussed below, for each of the monitored water parameters and in summary.

Water Depth (Tables and Figs. 4(a-e): began in May at 10.7 m (35 ft; 2 ft more than in 2018) and dropped through the season, from normal evaporation, to 7.9 m (26 ft).

Secchi Water Clarity (Tables and Figs. 4(a-e): was fairly clear as in other years, ranging from 2.8-6.6 m (9-22 ft). This pond, like Cemex Phase 3-4, is dominated by macro aquatic plants, as compared to the murkier systems dominated by microscopic algae. This is because enough sunlight can reach the botttom to allow various aquatic plants to take root and grow upwards. This isn't possible in ponds with low water clarity.

Temperature (Tables and Figs. 4(a-e), Fig. 4(f)): Overall range between 14.6 and 29.5 °C (58-85 °F) between May and October. High surrounding berms give some protection from wind mixing. A light thermal stratification developed between May and June, with bottom waters up to 5 °C (9 °F) cooler than surface water. However, as at some of the other shallow and mid-depth ponds discussed above, the overall change in bottom water temperatures during this time (to temperatures nearer surface levels) indicates periodic mixing of the water column, presumably due to wind mixing. The surface exposure and area relative to depth in this system was apparently enough to transmit wind energy to the bottom periodically. The water column became fairly well mixed (low gradient between surface and bottom temperatures) this year some time before the early August survey, continuing in September and October as surface temperatures dropped, though temperatures on each date were always lowest at the bottom and warmer toward the surface, maintaining some separation.

Dissolved Oxygen (Tables and Figs. 4(a-e), Fig. 4(g)): in the top 6 m remained at or above saturation levels throughout the season, between 7.8 and 11.9 mg/L (ppm) and between 95 and 141% of saturation. This can be attributed to photosynthesis in the clear water. Cooler water can hold more dissolved oxygen than warm water. However, the coolest water, below 6 m depth, was *lowest* in oxygen, indicating depletion, particularly on the dates with the most thermal stratification (figs. 4(f-g)). In May, this included a decrease from a surface average of 10.2 mg/L and 115% of saturation – to 5.2 mg/L and 53% near bottom. In June, bottom oxygen dropped to 3.1 mg/L and 35% of saturation, far below levels in the surface 6 m (11.4 mg/L, 136%). It is notable that, like Reiff Pond, the BI Pond has been one of the ponds with the most elevated bass mercury levels.

Conductivity (Tables 4(a-e), Fig. 4(h)): ranged narrowly between 632 and 686 µS/cm overall, as compared to 815-936 µS/cm in 2018. As at the other ponds, lower levels in 2019 were likely related to somewhat greater rainfall dilution early in the year.

Salinity (Tables 4(a-e): was nearly identical, at 0.31-0.32 ppt (parts per thousand, g/L) across all dates and water depths. This was a bit lower than the 2018 levels of 0.34-0.39 ppt. Typical freshwaters range below 0.50 ppt; seawater averages 35 ppt.

Total Dissolved Solids (TDS) (Tables 4(a-e): fell within the narrow range of 411-446 mg/L (ppm) across all dates and water depths. This compared to 529-608 mg/L in 2018.

pH (Tables 4(a-e), Fig. 4(i)): as in the other ponds, was notably very basic (non-acidic; pH > 7.00) in all of the monitored ponds. This is a function of their mining history and the basic nature of local sediments. Water pH in the B1 Pond fell between 8.5 and 8.8 across nearly all depths and dates. The exception, as at Teichert–Esparto Reiff Pond, was near the bottom when there was oxygen depletion and pH went as low as 7.7, still basic but substantially less so.

Oxidation/Reduction Potential (ORP) (Tables 4(a-e): ranged between 50 and 227 mV (millivolts) across all depths and dates, similar to 2018 (46-180 mV). Levels were consistently at the higher end of this range in June-August (189-227 mV), dropping in September (124-132 mV) and October (50-55 mV).

Turbidity (Tables 4(a-e), Fig. 4(j)): The B1 Pond has no active mining or plant discharge, so water clarity here is controlled by natural phenomena, mainly the wind occasionally stirring up bottom sediments. The water can become quite clear here, allowing aquatic plants to take root across most of the bottom. Turbidity levels were generally under 1.0 FNU in the top 5-8 m, with a 'murky layer' up to 3 FNU in the bottom meter or two, as is common. During the windier fall months of September and October, the upper water layers rose in turbidity to 1-2 FNU.

Dissolved Organic Matter (FDOM) (Tables 4(a-e), Fig. 4(k)): Measured for the first time in 2019, we will wait a year or two before making any conclusions about this or the other optical parameters. Similar to the other ponds, levels were similar throughout the upper layers on each sampling date, in the range of 0.7-1.9 RFU in the top 7-8 m. Also as seen in some of the other ponds, a buildup of higher levels (2.7-5.4 RFU) occurred in the bottom several meters in May and June, when the pond was at its deepest and was partially stratified.

Green Algae (Chlorophyll) (Tables 4(a-e), Fig. 4(l)): was fairly uniform throughout the top 4-8 m on most dates, and from top to bottom in October after complete wind-mixing. Overall levels rose each sampling between early May and mid September, and then dropped in October. Like Teichert-Esparto Reiff Pond, this pond has also shown slight stratification near the bottom in all years and, like the Reiff profiles, Chlorophyll accumulated to higher levels toward the bottom in May through September samplings, to 1.0-2.4 RFU.

Blue-Green Algae (Phycocyanin) (Tables 4(a-e), Fig. 4(m)): was low throughout, especially between early May and mid September (< 0.30 RFU across the top 8 m). As seen with the above parameters, between May and September somewhat higher levels built up toward the bottom (to 0.49 RFU). Overall levels were highest in October (0.36-0.54 RFU).

**In summary,** the Syar–B1 Pond, one of the ponds identified as highly elevated in fish mercury, was found in 2019 to be of shallow/medium depth, inactive (re mining) and clear, similar to 2018. High surrounding berms give some protection from wind mixing, and a light stratification of the water column was seen as in 2018. Bottom waters, though not going fully anoxic this year, became significantly reduced in oxygen during the early parts of the warm season, likely enhancing methylmercury exposure levels as in other years. This pond, like Teichert–Esparto Reiff, may also get mercury management benefits from disruption of summer anoxia.

**Table 4(a). Syar – B1 Pond: 2019 Water Column Profiling Data**
**MAY 17:** max. depth 10.7 m (35 ft); Secchi disk water clarity: 5.5 m (18 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| 0 | 21.1 | 10.16 | 114% | 648 | 421 | 0.32 | 8.70 | – |
| 1 | 21.1 | 10.21 | 115% | 648 | 421 | 0.32 | 8.68 | – |
| 2 | 21.0 | 10.28 | 116% | 647 | 421 | 0.32 | 8.67 | – |
| 3 | 20.9 | 10.29 | 115% | 647 | 421 | 0.32 | 8.65 | – |
| 4 | 20.7 | 10.28 | 115% | 647 | 420 | 0.32 | 8.64 | – |
| 5 | 20.6 | 10.24 | 114% | 647 | 420 | 0.31 | 8.63 | – |
| 6 | 20.6 | 10.25 | 114% | 647 | 420 | 0.31 | 8.62 | – |
| 7 | 20.5 | 10.23 | 114% | 647 | 420 | 0.31 | 8.60 | – |
| 8 | 20.1 | 10.40 | 114% | 646 | 421 | 0.32 | 8.55 | – |
| 9 | 17.9 | 8.15 | 86% | 657 | 427 | 0.32 | 8.22 | – |
| 10 | 17.3 | 5.20 | 53% | 664 | 432 | 0.32 | 7.94 | – |

*(additional parameters next page)*

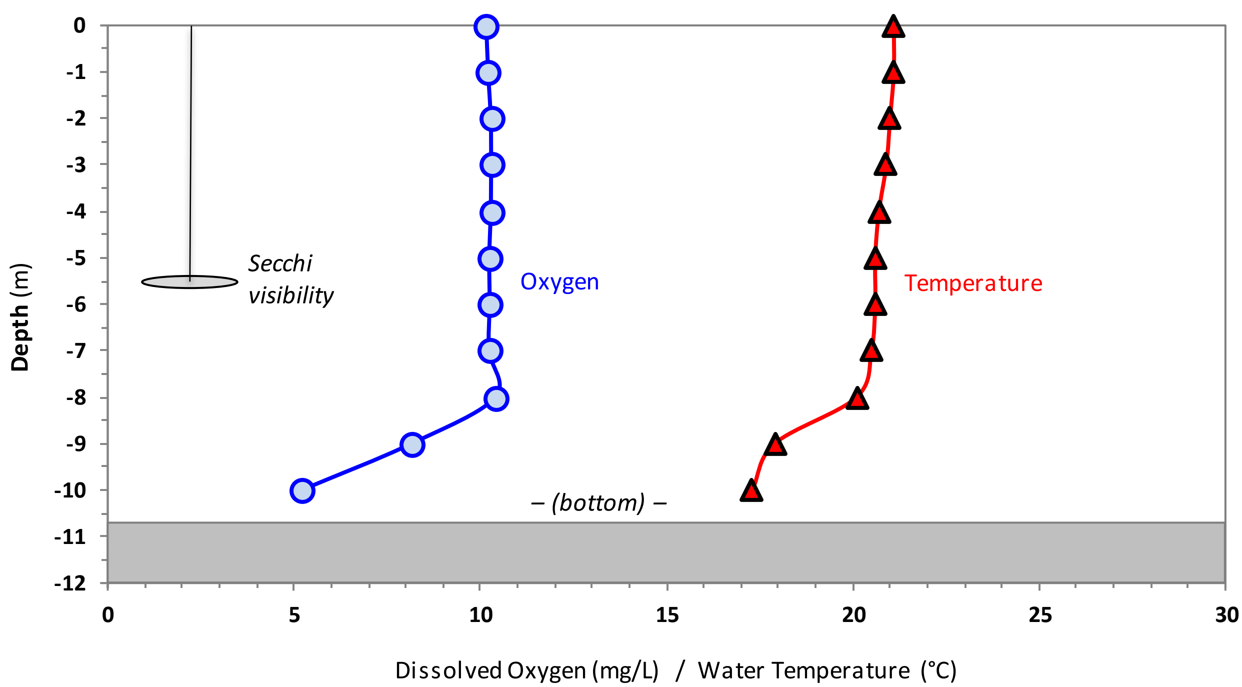



**Figure 4(a). MAY 17, 2019 – B1 Pond framework parameters**

**Table 4(a).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**MAY 17:** max. depth 10.7 m (35 ft); Secchi disk water clarity: 5.5 m (18 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 21.1 | 10.16 | 114% | 0.63 | 1.70 | 0.10 | 0.08 |
| **1** | 21.1 | 10.21 | 115% | 0.65 | 1.69 | 0.11 | 0.04 |
| **2** | 21.0 | 10.28 | 116% | 0.62 | 1.72 | 0.09 | 0.03 |
| **3** | 20.9 | 10.29 | 115% | 0.69 | 1.73 | 0.10 | 0.03 |
| **4** | 20.7 | 10.28 | 115% | 0.72 | 1.73 | 0.10 | 0.04 |
| **5** | 20.6 | 10.24 | 114% | 0.69 | 1.79 | 0.11 | 0.05 |
| **6** | 20.6 | 10.25 | 114% | 0.73 | 1.80 | 0.15 | 0.05 |
| **7** | 20.5 | 10.23 | 114% | 0.73 | 1.87 | 0.13 | 0.06 |
| **8** | 20.1 | 10.40 | 114% | 0.97 | 2.67 | 0.23 | 0.05 |
| **9** | 17.9 | 8.15 | 86% | 2.26 | 5.18 | 1.27 | 0.21 |
| **10** | 17.3 | 5.20 | 53% | 3.53 | 5.43 | 1.03 | 0.15 |

**Table 4(b). Syar – B1 Pond: 2019 Water Column Profiling Data**
**JUN 16:** max. depth 10.2 m (34 ft); Secchi disk water clarity: 6.6 m (22 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 25.8 | 10.60 | 131% | 658 | 427 | 0.32 | 8.67 | 195 |
| **1** | 25.8 | 10.70 | 132% | 658 | 428 | 0.32 | 8.66 | 191 |
| **2** | 25.1 | 11.20 | 135% | 657 | 427 | 0.32 | 8.84 | 190 |
| **3** | 24.9 | 11.00 | 135% | 658 | 427 | 0.32 | 8.64 | 189 |
| **4** | 24.3 | 11.70 | 139% | 657 | 427 | 0.32 | 8.64 | 189 |
| **5** | 23.7 | 11.90 | 141% | 657 | 427 | 0.32 | 8.63 | 190 |
| **6** | 23.3 | 11.80 | 139% | 658 | 427 | 0.32 | 8.64 | 191 |
| **7** | 22.9 | 11.70 | 137% | 657 | 427 | 0.32 | 8.62 | 192 |
| **8** | 22.4 | 10.90 | 125% | 659 | 429 | 0.32 | 8.56 | 194 |
| **9** | 21.7 | 6.80 | 78% | 674 | 438 | 0.32 | 8.16 | 199 |
| **10** | 20.8 | 3.10 | 35% | 686 | 446 | 0.32 | 7.72 | 206 |

*(additional parameters next page)*

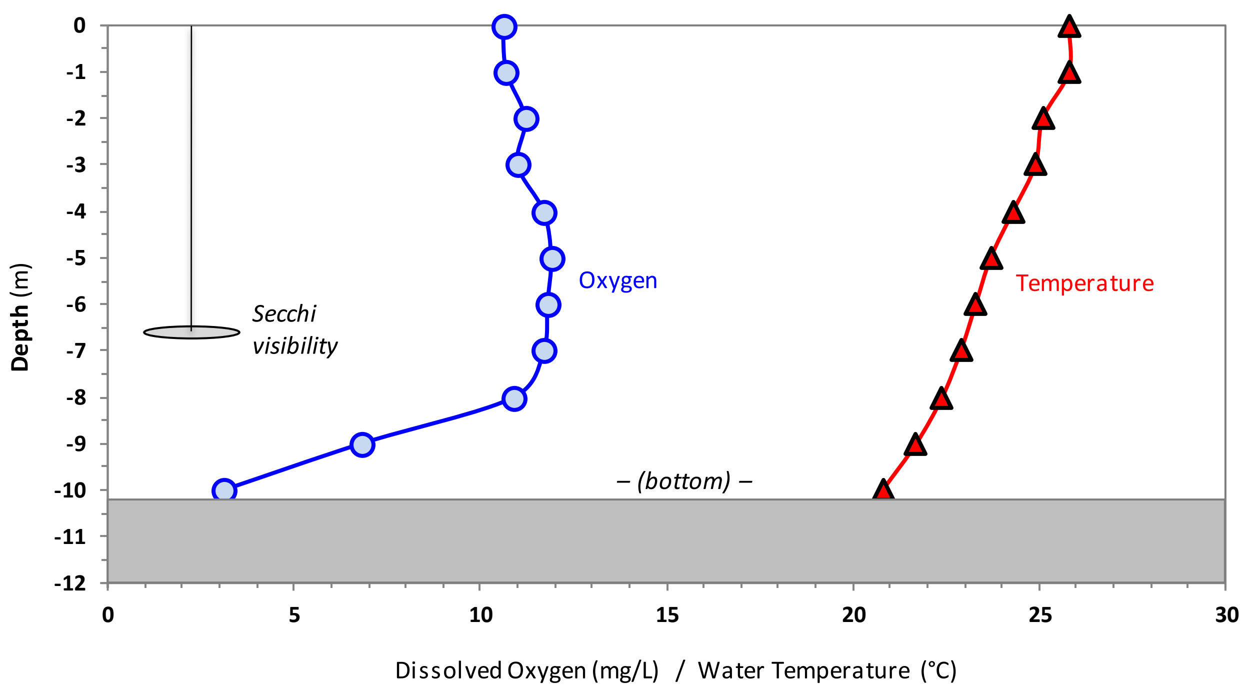



**Figure 4(b). JUN 16, 2019 – B1 Pond framework parameters**

**Table 4(b).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**JUN 16:** max. depth 10.2 m (34 ft); Secchi disk water clarity: 6.6 m (22 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae;*
*FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 25.8 | 10.60 | 131% | 0.49 | 0.76 | 0.35 | 0.05 |
| **1** | 25.8 | 10.70 | 132% | 0.47 | 0.68 | 0.36 | 0.00 |
| **2** | 25.1 | 11.20 | 135% | 0.48 | 0.72 | 0.39 | 0.06 |
| **3** | 24.9 | 11.00 | 135% | 0.50 | 0.74 | 0.42 | 0.05 |
| **4** | 24.3 | 11.70 | 139% | 0.52 | 0.85 | 0.41 | 0.07 |
| **5** | 23.7 | 11.90 | 141% | 0.56 | 1.01 | 0.55 | 0.16 |
| **6** | 23.3 | 11.80 | 139% | 0.61 | 1.17 | 0.76 | 0.21 |
| **7** | 22.9 | 11.70 | 137% | 0.73 | 1.31 | 0.82 | 0.22 |
| **8** | 22.4 | 10.90 | 125% | 0.97 | 1.56 | 0.97 | 0.24 |
| **9** | 21.7 | 6.80 | 78% | 2.32 | 3.12 | 0.97 | 0.32 |
| **10** | 20.8 | 3.10 | 35% | 3.02 | 4.34 | 2.40 | 0.49 |

**Table 4(c).** **Syar – B1 Pond: 2019 Water Column Profiling Data**
**JUL 30:** max. depth 9.1 m (30 ft); Secchi disk water clarity: 4.5 m (15 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 29.5 | 10.40 | 137% | 672 | 437 | 0.32 | 8.78 | 227 |
| **1** | 29.5 | 10.45 | 137% | 672 | 437 | 0.32 | 8.77 | 215 |
| **2** | 29.0 | 10.75 | 140% | 671 | 436 | 0.32 | 8.77 | 204 |
| **3** | 28.9 | 10.79 | 140% | 671 | 436 | 0.32 | 8.77 | 195 |
| **4** | 28.7 | 10.76 | 139% | 671 | 436 | 0.32 | 8.77 | 191 |
| **5** | 28.6 | 10.59 | 137% | 671 | 436 | 0.32 | 8.76 | 191 |
| **6** | 28.6 | 10.61 | 137% | 671 | 436 | 0.32 | 8.76 | 190 |
| **7** | 28.5 | 10.57 | 136% | 671 | 436 | 0.32 | 8.74 | 191 |
| **8** | 28.4 | 10.54 | 136% | 671 | 436 | 0.32 | 8.73 | 191 |

*(additional parameters next page)*

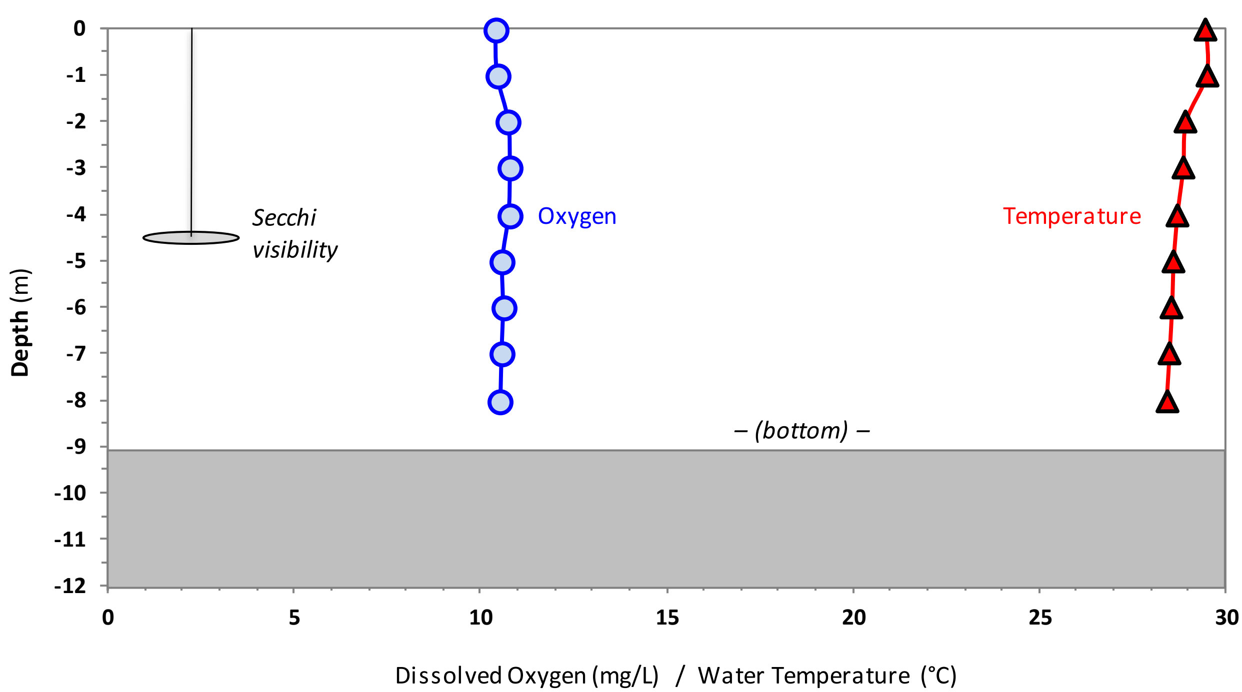



**Figure 4(c).** **JUL 30, 2019 – B1 Pond framework parameters**

**Table 4(c).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**JUL 30:** max. depth 9.1 m (30 ft); Secchi disk water clarity: 4.5 m (15 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 29.5 | 10.40 | 137% | 0.75 | 0.86 | 0.48 | 0.09 |
| **1** | 29.5 | 10.45 | 137% | 0.75 | 0.84 | 0.56 | 0.09 |
| **2** | 29.0 | 10.75 | 140% | 0.63 | 0.83 | 0.66 | 0.07 |
| **3** | 28.9 | 10.79 | 140% | 0.82 | 0.93 | 0.72 | 0.10 |
| **4** | 28.7 | 10.76 | 139% | 0.75 | 1.01 | 0.72 | 0.10 |
| **5** | 28.6 | 10.59 | 137% | 0.79 | 1.12 | 0.69 | 0.10 |
| **6** | 28.6 | 10.61 | 137% | 0.67 | 1.12 | 0.70 | 0.11 |
| **7** | 28.5 | 10.57 | 136% | 1.17 | 1.21 | 1.03 | 0.16 |
| **8** | 28.4 | 10.54 | 136% | 1.52 | 1.15 | 1.35 | 0.23 |

**Table 4(d). Syar – B1 Pond: 2019 Water Column Profiling Data**
**SEP 15**: max. depth 8.5 m (28 ft); Secchi disk water clarity: 2.8 m (9 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 25.9 | 8.42 | 104% | 633 | 411 | 0.31 | 8.82 | 124 |
| **1** | 25.9 | 8.41 | 104% | 633 | 411 | 0.31 | 8.82 | 125 |
| **2** | 25.9 | 8.37 | 103% | 633 | 411 | 0.31 | 8.82 | 126 |
| **3** | 25.9 | 8.37 | 103% | 633 | 411 | 0.31 | 8.82 | 126 |
| **4** | 25.7 | 8.18 | 100% | 632 | 411 | 0.31 | 8.82 | 128 |
| **5** | 25.6 | 8.04 | 99% | 632 | 411 | 0.31 | 8.81 | 129 |
| **6** | 25.5 | 7.84 | 96% | 632 | 411 | 0.31 | 8.80 | 130 |
| **7** | 25.4 | 7.54 | 92% | 632 | 411 | 0.31 | 8.79 | 131 |
| **8** | 25.4 | 7.27 | 89% | 633 | 411 | 0.31 | 8.77 | 132 |

*(additional parameters next page)*

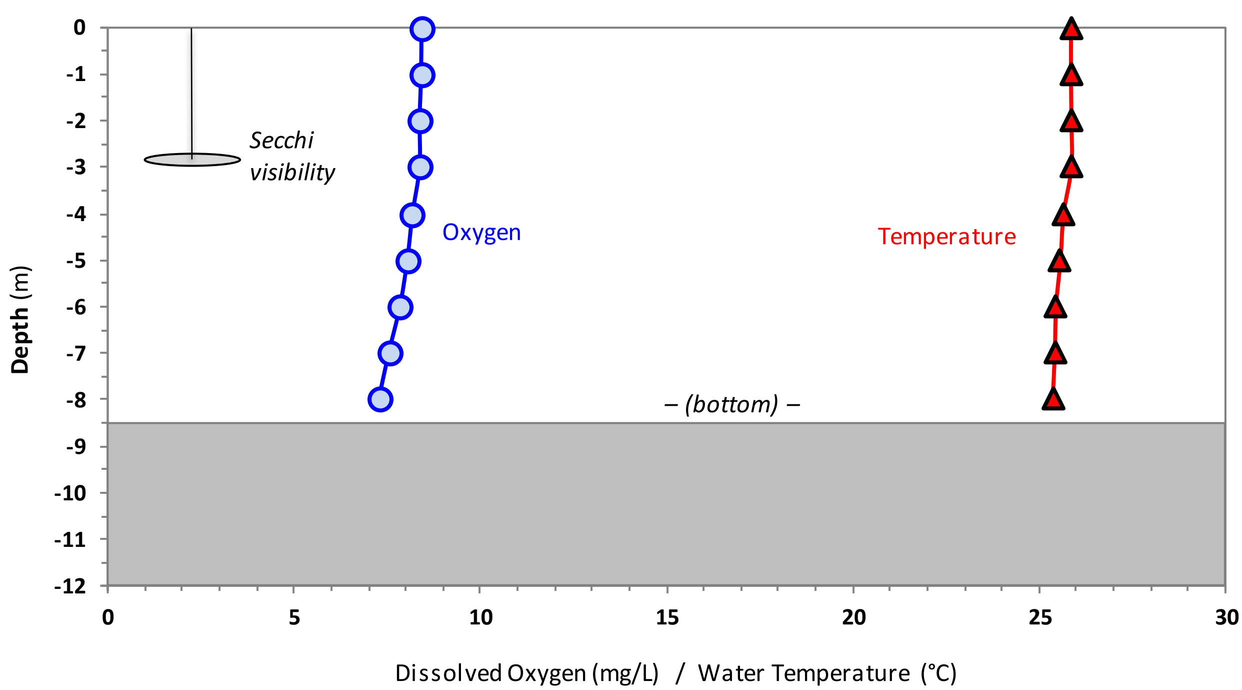



**Figure 4(d). SEP 15, 2019 – B1 Pond framework parameters**

**Table 4(d).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**SEP 15**: max. depth 8.5 m (28 ft); Secchi disk water clarity: 2.8 m (9 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae;*
*FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 25.9 | 8.42 | 104% | 1.03 | 1.47 | 0.90 | 0.18 |
| **1** | 25.9 | 8.41 | 104% | 1.03 | 1.44 | 0.96 | 0.17 |
| **2** | 25.9 | 8.37 | 103% | 1.04 | 1.51 | 0.97 | 0.18 |
| **3** | 25.9 | 8.37 | 103% | 1.04 | 1.54 | 0.98 | 0.21 |
| **4** | 25.7 | 8.18 | 100% | 1.19 | 1.56 | 1.10 | 0.25 |
| **5** | 25.6 | 8.04 | 99% | 1.15 | 1.63 | 1.32 | 0.25 |
| **6** | 25.5 | 7.84 | 96% | 1.14 | 1.72 | 1.46 | 0.29 |
| **7** | 25.4 | 7.54 | 92% | 1.49 | 1.81 | 1.56 | 0.29 |
| **8** | 25.4 | 7.27 | 89% | 2.86 | 1.77 | 1.49 | 0.28 |

**Table 4(e). Syar – B1 Pond: 2019 Water Column Profiling Data**
**OCT 27**: max. depth 7.9 m (26 ft); Secchi disk water clarity: 4.5 m (15 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 14.8 | 9.72 | 96% | 645 | 419 | 0.32 | 8.66 | 50 |
| **1** | 14.8 | 9.74 | 96% | 645 | 419 | 0.32 | 8.65 | 51 |
| **2** | 14.8 | 9.74 | 96% | 645 | 419 | 0.32 | 8.64 | 52 |
| **3** | 14.8 | 9.73 | 96% | 645 | 419 | 0.32 | 8.64 | 52 |
| **4** | 14.7 | 9.69 | 96% | 645 | 419 | 0.32 | 8.64 | 53 |
| **5** | 14.6 | 9.64 | 95% | 645 | 419 | 0.32 | 8.64 | 54 |
| **6** | 14.6 | 9.61 | 95% | 645 | 419 | 0.32 | 8.64 | 55 |
| **7** | 14.6 | 9.61 | 95% | 645 | 419 | 0.32 | 8.64 | 55 |

*(additional parameters next page)*

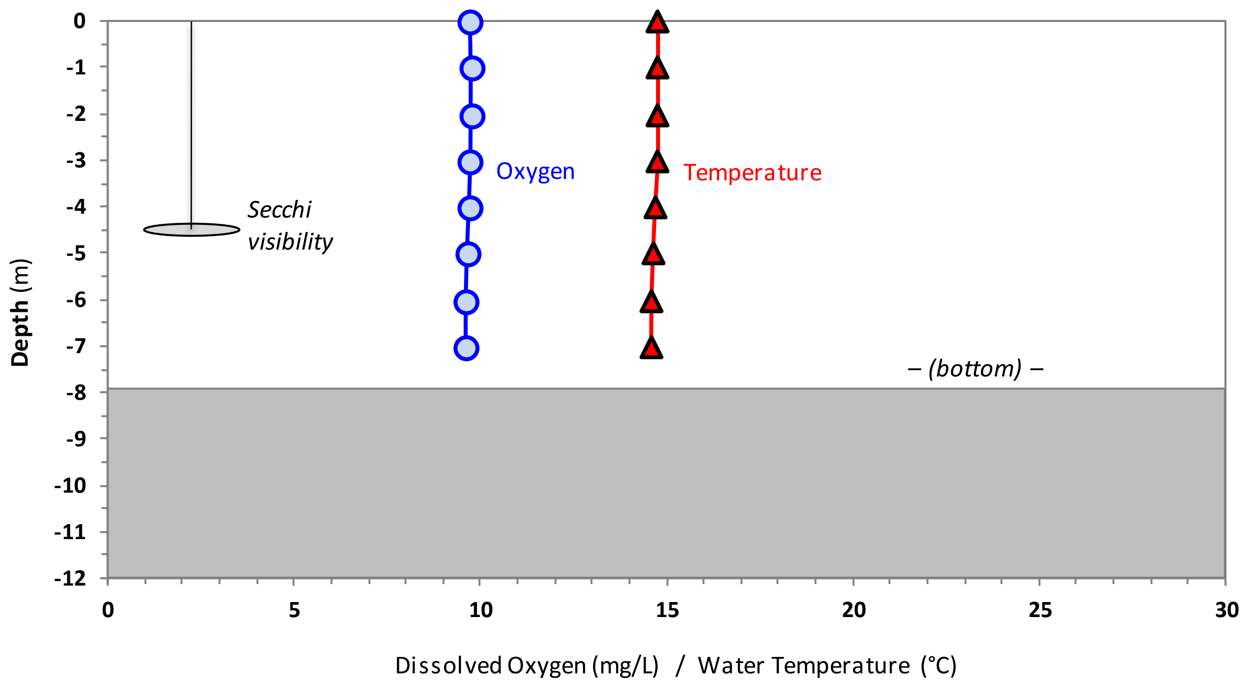



**Figure 4(e). OCT 27, 2019 – B1 Pond framework parameters**

**Table 4(e).** ***(continued)*** **– OPTICAL PARAMETERS (with framework data for reference)**
**OCT 27**: max. depth 7.9 m (26 ft); Secchi disk water clarity: 4.5 m (15 ft)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae;*
*FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 14.8 | 9.72 | 96% | 1.64 | 1.51 | 0.42 | 0.36 |
| **1** | 14.8 | 9.74 | 96% | 1.60 | 1.65 | 0.43 | 0.42 |
| **2** | 14.8 | 9.74 | 96% | 1.58 | 1.55 | 0.47 | 0.42 |
| **3** | 14.8 | 9.73 | 96% | 1.62 | 1.69 | 0.46 | 0.44 |
| **4** | 14.7 | 9.69 | 96% | 1.87 | 1.71 | 0.47 | 0.45 |
| **5** | 14.6 | 9.64 | 95% | 2.10 | 1.62 | 0.53 | 0.48 |
| **6** | 14.6 | 9.61 | 95% | 2.23 | 1.63 | 0.58 | 0.54 |
| **7** | 14.6 | 9.61 | 95% | 2.32 | 1.67 | 0.61 | 0.51 |

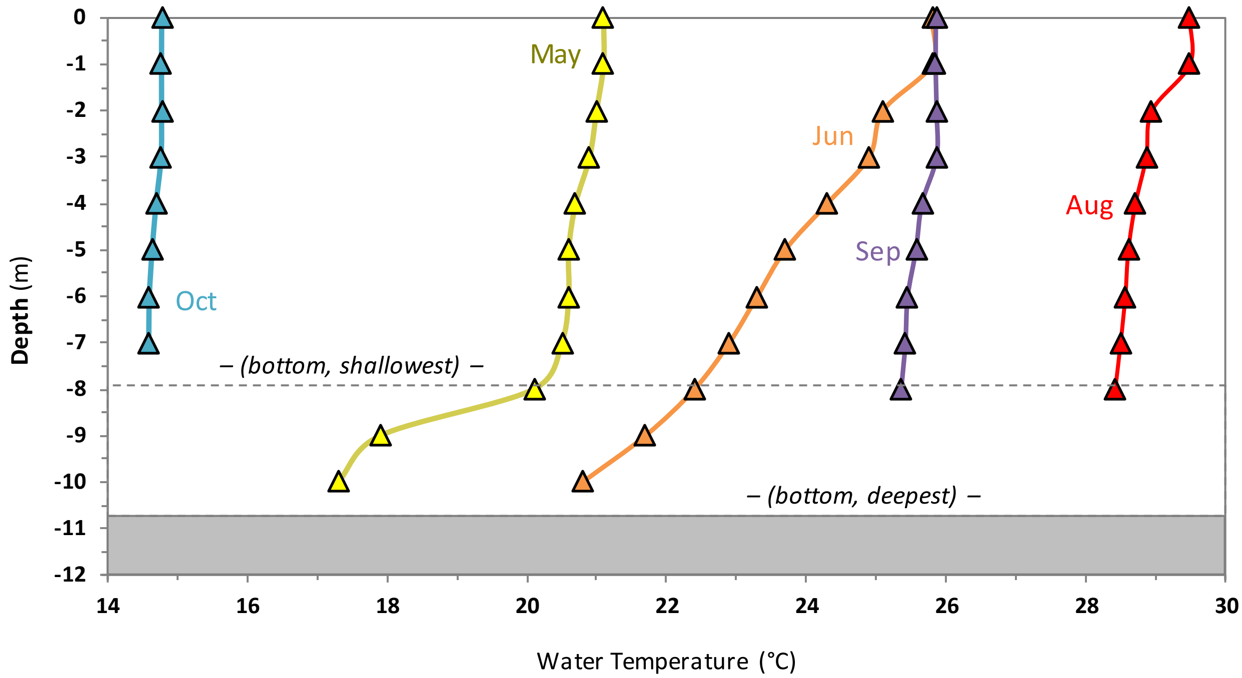



**Figure 4(f). Syar – B1 Pond: 2019 May-Oct TEMPERATURE**

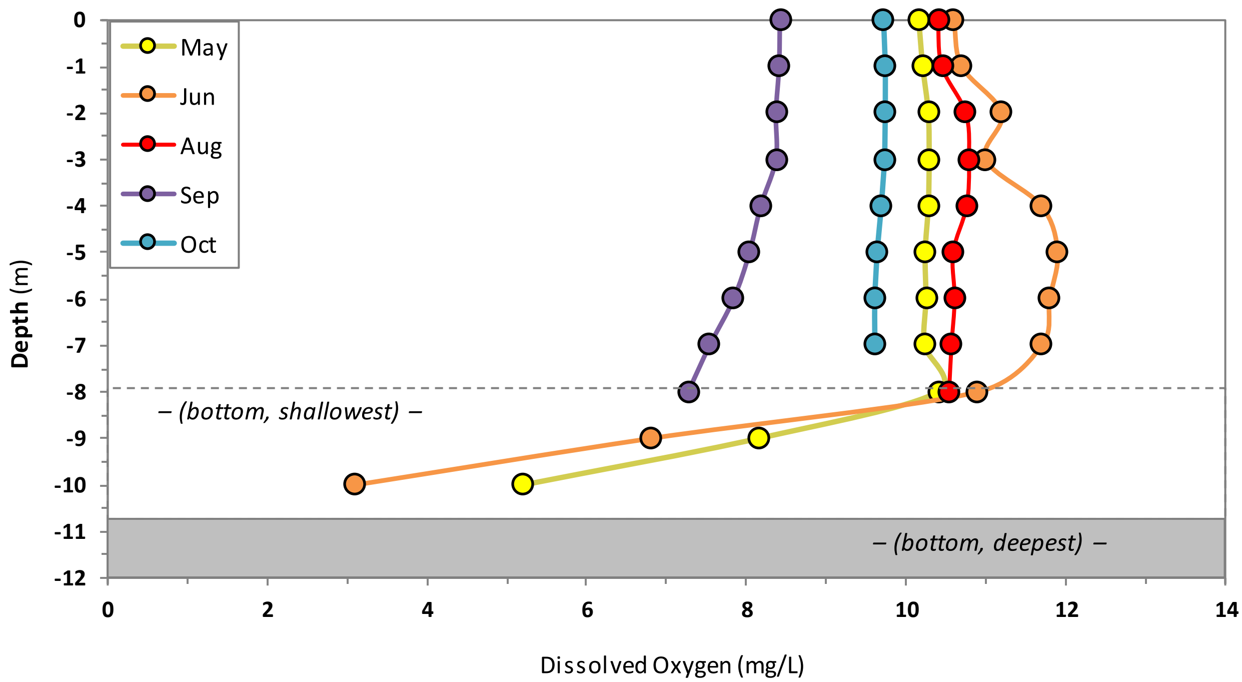



**Figure 4(g). Syar – B1 Pond: 2019 May-Oct OXYGEN**

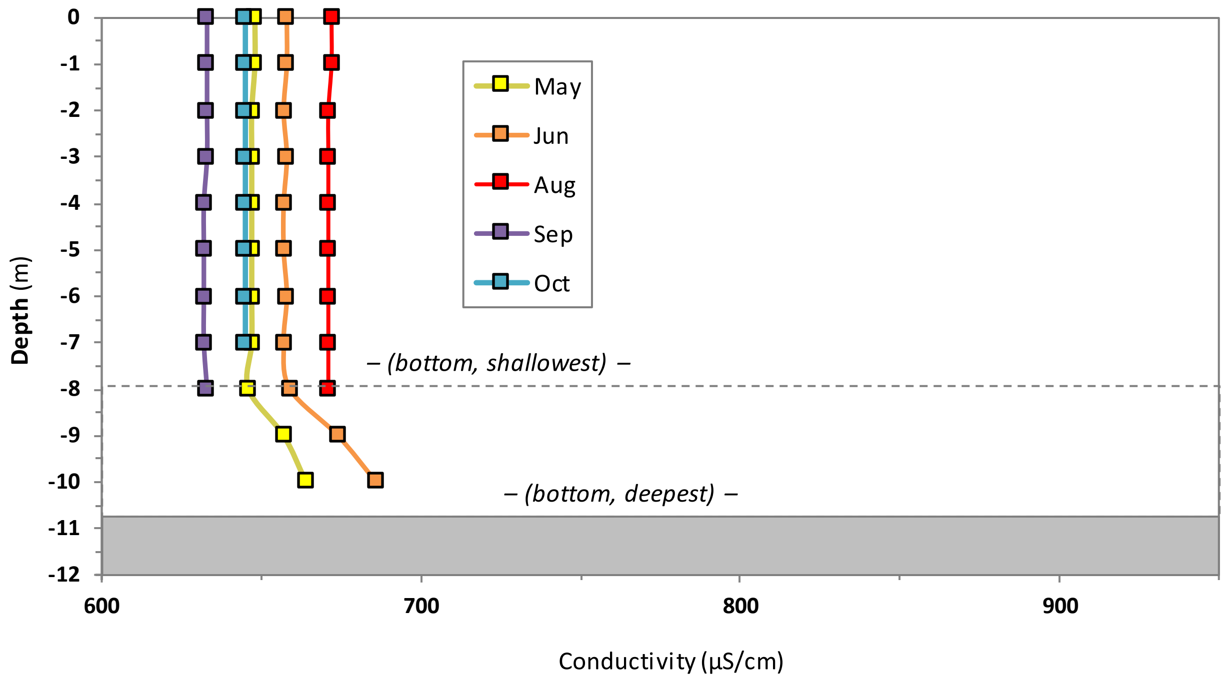



**Figure 4(h). Syar – B1 Pond: 2019 May-Oct CONDUCTIVITY**

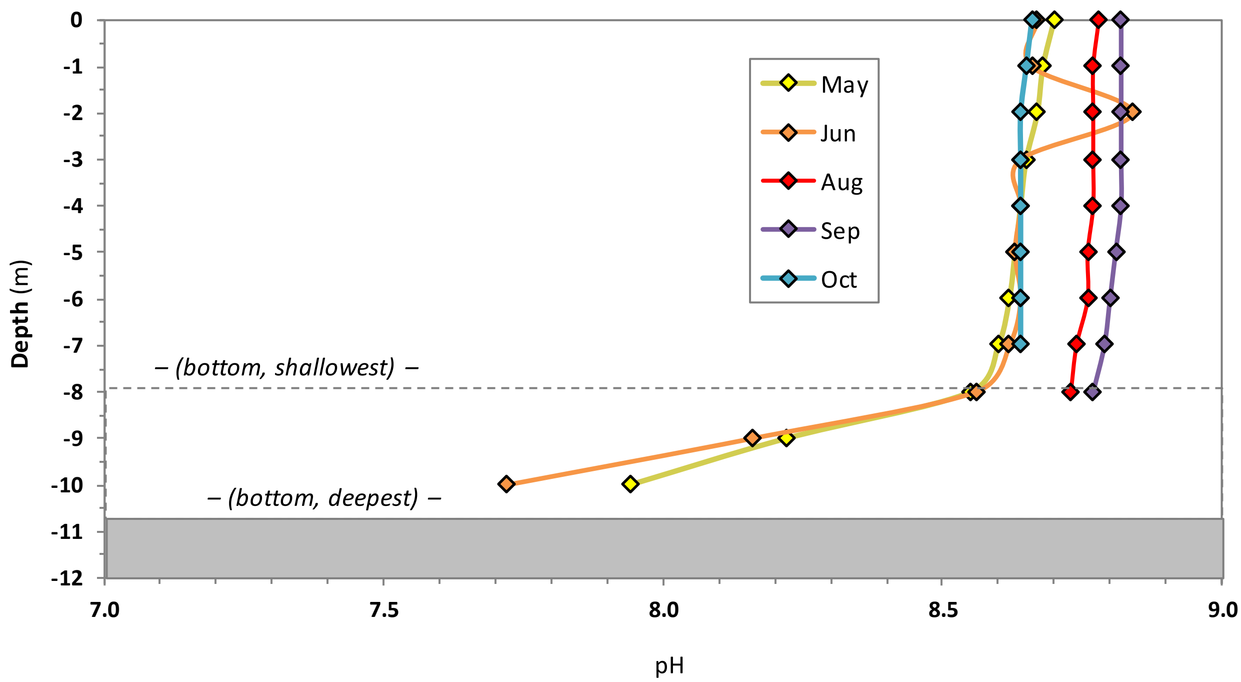



**Figure 4(i). Syar – B1 Pond: 2019 May-Oct pH**

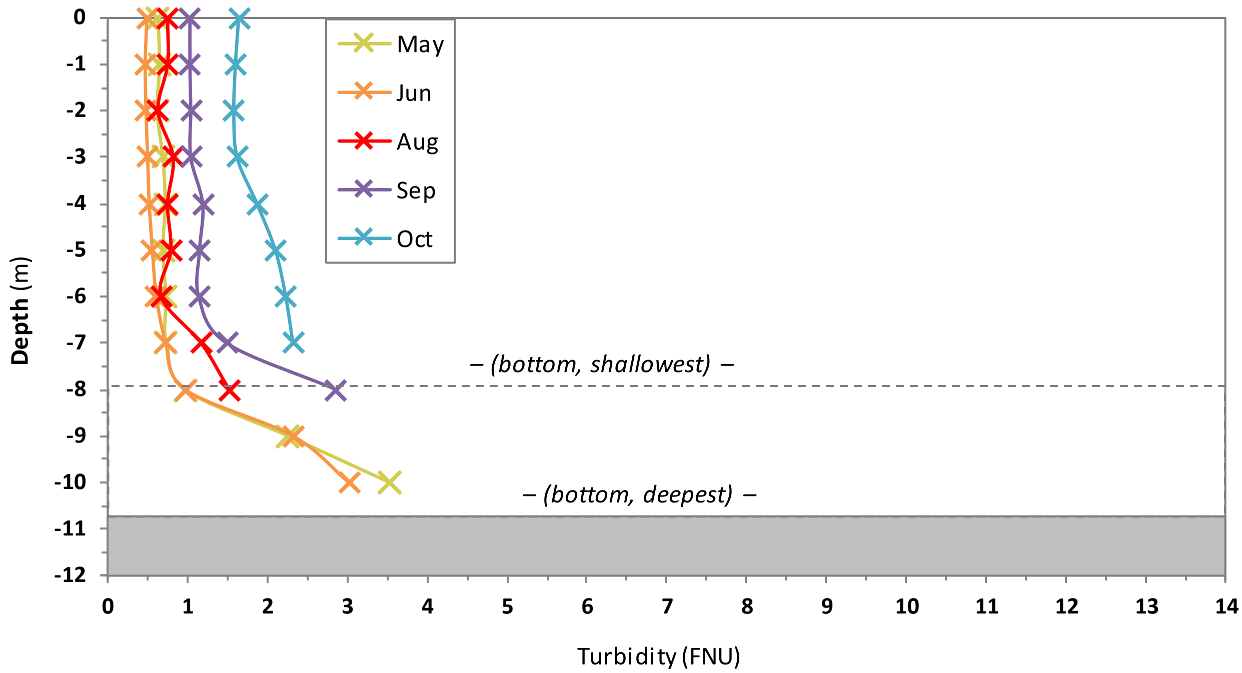



**Figure 4(j). Syar – B1 Pond: 2019 May-Oct TURBIDITY**

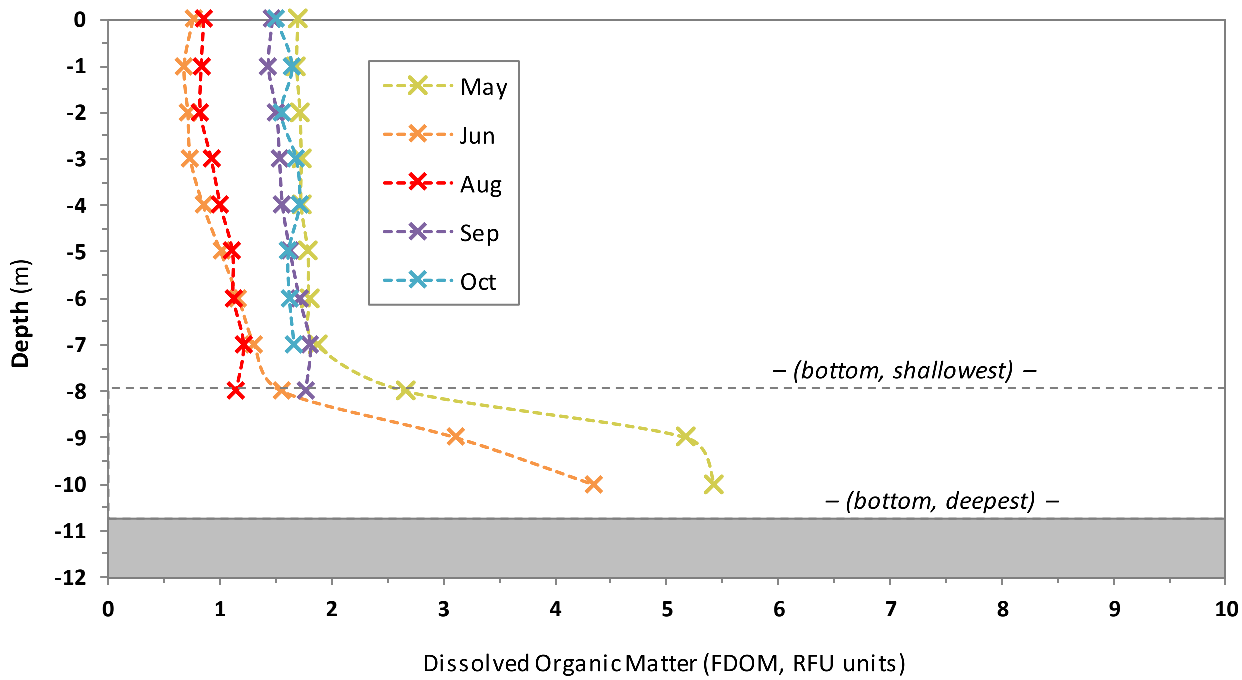



**Figure 4(k). Syar–B1 Pond: 2019 May-Oct DISSOLVED ORGANIC MATTER**

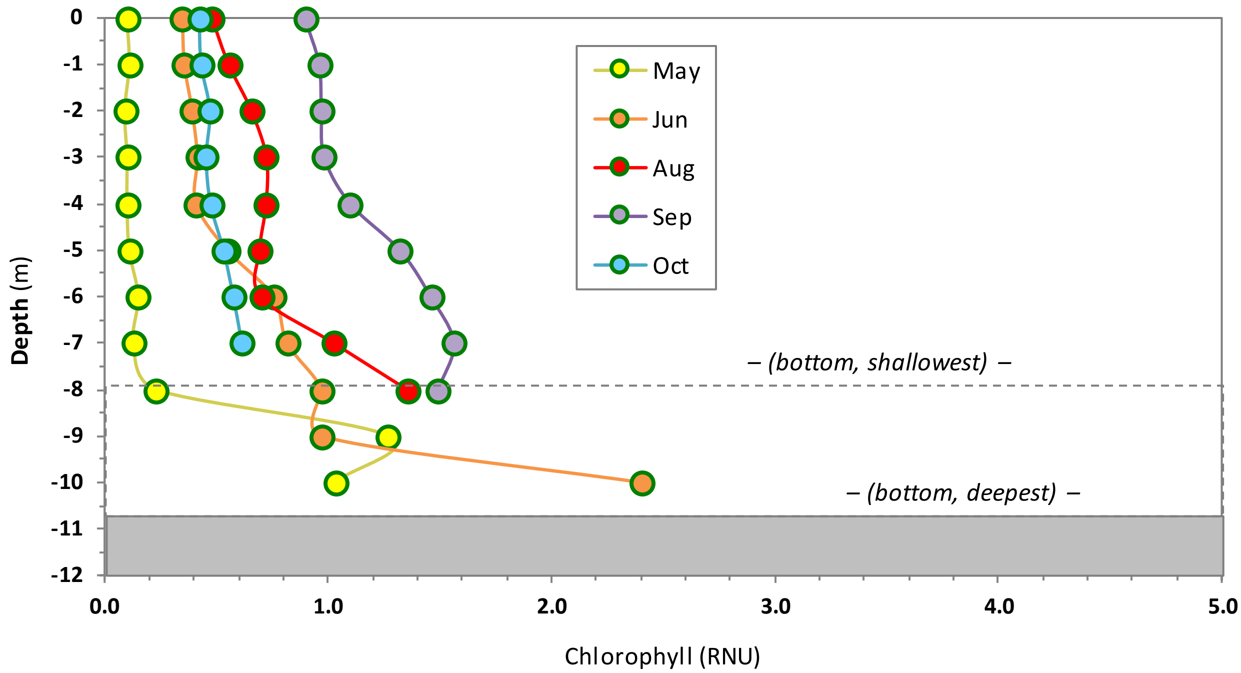



**Figure 4(l). Syar – B1 Pond: 2019 May-Oct CHLOROPHYLL**

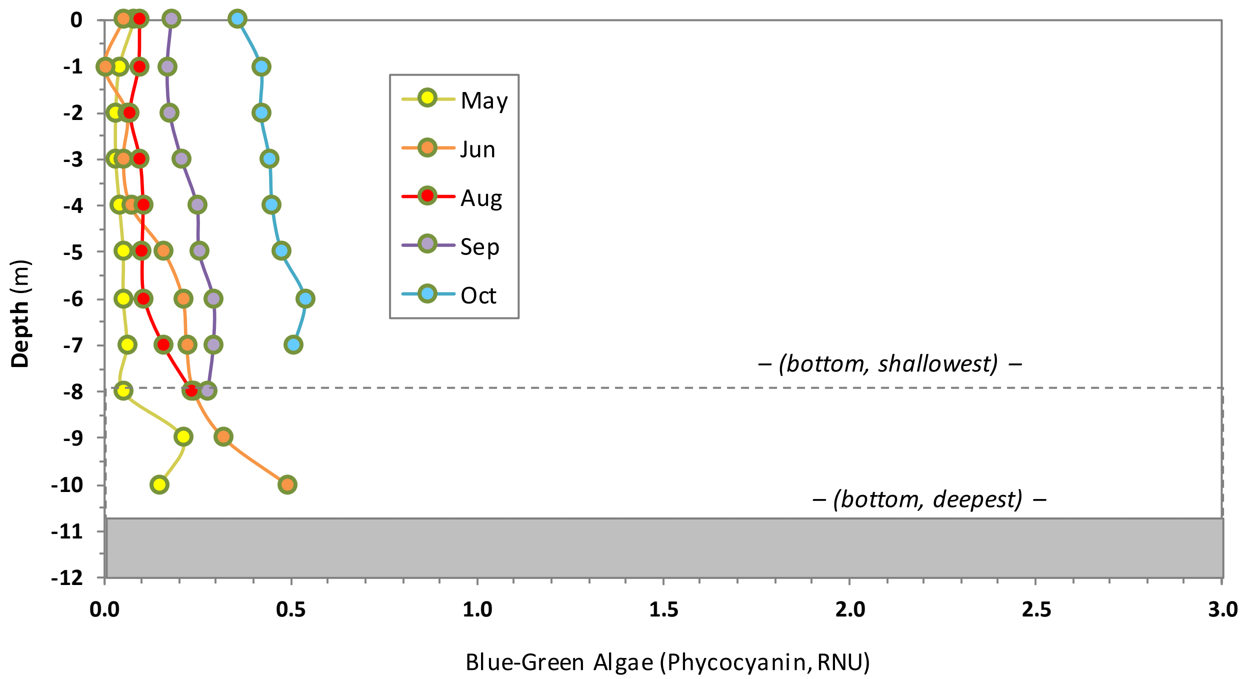



**Figure 4(m). Syar – B1 Pond: 2019 May-Oct BLUE-GREEN ALGAE**

# 5. SYAR–WEST POND

## 5. Syar–West Pond

The West Pond was added to the water profiling program in 2019. Fish mercury there has been borderline high. This pond is especially interesting because it is currently the only one that is deep enough (15+ m, 50-60 feet) to have a full thermal stratification (separation of water layers) develop in the warm season. If present, this could lead to extensive summer anoxia (loss of oxygen) in the bottom waters and the acceleration of methylmercury production and movement into the pond water and, eventually, the fish.

Results are first shown for each survey date, one at a time. Numerical data from each of the five 2019 water profiling surveys are presented in Tables 5(a) (May) through 5(e) (October). For each survey date, some of the key, driving parameters are also shown in figure form, Figures 5(a-e).

After the individual survey information, each water quality parameter is plotted across the year of sampling, in Figures 5(f) (Temperature) through 5(m) (Blue-green Algae). In these figures, the different seasonal profiles are shown together, so you can see the full range of values and the changes across the year.

Before the data tables and figures, results are first discussed below, for each of the monitored water parameters and in summary.

Water Depth (Tables and Figs. 5(a-e): is much greater in this pond as compared to the others. This is in fact why it was added to the monitoring. Starting depth in May was 18.6 m (61 ft), 7 m (23 ft) deeper than the next deepest pond. Warm season evaporation gradually lowered the depth to 16.5 m (54 ft).

Secchi Water Clarity (Tables and Figs. 5(a-e): was always very clear, ranging from 6.0-9.3 m (20-30 ft). This pond, like Syar–B1 and Cemex–Phase 3-4, is dominated by macro aquatic plants, as compared to the murkier systems dominated by microscopic algae.

Temperature (Tables and Figs. 5(a-e), Fig. 5(f)): As suspected, this deep, relatively wind-sheltered pond developed a full, classic seasonal thermal stratification, with a large volume of bottom water isolated from the upper water and the air. The surface 6-8 m (20-26 ft) warmed, as at the other ponds, to summer temperatures of 25-29 °C (77-84 °F). But, while the other ponds had their bottom waters ultimately rise to over 25 °C (77 °F), the much deeper Syar–West bottom zone remained very cool at 13.3-15.3 °C (56-59 °F). More important, for keeping the water layers separated, was the *difference* between the high and low temperatures. At Syar–West between May and September, this difference was 8.0-14.9 °C (14-27 °F), a much larger spread than at any of the other ponds. And, it persisted throughout the season. The zone of rapid temperature change, with over 1 °C change per m, called the *thermocline*, set up at around 7-10 m depth, creating a 'density barrier' and isolating the bottom levels of the water column from above. Later, in the fall, when surface water cooled to temperatures similar to the bottom water, there was no longer a density barrier; days with high winds could mix the water column top to bottom, as seen in the late October profile. This full-lake mixing typically continues until the following spring, when the surface water is warmed again.

Dissolved Oxygen (Tables and Figs. 5(a-e), Fig. 5(g)): Bottom water oxygen depletion occurred here, just as suspected. From May through September, when the thermocline was strong, oxygen was depleted in the bottom 4 m (13 ft) to < 60% of saturation levels, with the bottom 2-3 meters dropping to 0-2% between June and September. The clear water allowed sunlight to penetrate deep into the water column, allowing phytoplankton to photosynthesize and produce saturation or super-saturation levels of oxygen to as deep as 12 m (39 ft). Interestingly, the very highest oxygen production was right around the thermocline, at depth, as often occurs due to a 'pile-up' of phytoplankton. Below this, though, oxygen levels dropped rapidly, presumably increasing methylmercury production and incorporation into the water.

Conductivity (Tables 5(a-e), Fig. 5(h)): ranged between 614 and 710 µS/cm overall.

Salinity (Tables 5(a-e): was fairly uniform, at 0.30-0.35 ppt (parts per thousand, g/L) across all dates and water depths. Typical freshwaters range below 0.50 ppt; seawater averages 35 ppt.

Total Dissolved Solids (TDS) (Tables 5(a-e): fell within the narrow range of 399-463 mg/L (ppm) across all dates and water depths.

pH (Tables 5(a-e), Fig. 5(i)): as in the other ponds, was notably very basic (non-acidic; pH > 7.00). This is a function of their mining history and the basic nature of local sediments. From May through September, pH in the top 6-9 m (20-30 ft) fell narrowly between 8.5 and 8.8. However, with the oxygen depletion that occurred below that, the water became less basic, dropping into the pH 7.2-7.5 range.

Oxidation/Reduction Potential (ORP) (Tables 5(a-e): The ORP sensor was not functioning at the May sampling. Levels in June-August were approximately 180-200 mV (millivolts) in the top 10 m, and approximately 200-225 mV below that, consistent with the separated water masses. While the bottom waters remained higher in ORP than the surface, the overall levels decreased to 129-165 mV in September and 23-35 mV in October.

Turbidity (Tables 5(a-e), Fig. 5(j)): The Syar–West pond remains one of the clearest of the ponds in the monitoring program. It is protected from high winds by steep, tall surrounding slopes and is by far the deepest of the ponds. Additionally, most of the shore slopes within the pond are steep. As a result, this pond is rarely disturbed by heavy wind action and associated resuspension of bottom sediments. Turbidities were well under 1.0 FNU throughout the top 10 m or more, across the seasons. In August and September, a 'murky layer' developed in the bottom several meters, with turbidity levels of 2-8 FNU.

Dissolved Organic Matter (FDOM) (Tables 5(a-e), Fig. 5(k)): Measured for the first time in 2019, we will wait a year or two before making any conclusions about this or the other optical parameters. Similar to the other ponds, levels were similar throughout the upper layers on each sampling date, in the range of 0.5-2.5 RFU in the top 7-9 m, and to the bottom in late October after the pond had thoroughly mixed. Also, as in most of the other ponds, a buildup of higher levels (2.9-4.8 RFU) occurred in deeper water layers. This was the case on all dates before late October. The profiles through 9-10 m depth (the general extent of the other ponds) look similar to the other ponds, with general increases lower down. With an additional 7+ m (23+ ft) of additional depth in the Syar–West pond, it is interesting to see that these higher levels continued throughout the deep layers. Also interesting are apparent 'bulges' in the FDOM profiles in the region of the thermocline (~8-13 m) when the water was well stratified (early May – mid-September; see Fig. 5f).

Green Algae (Chlorophyll) (Tables 5(a-e), Fig. 5(l)): As above for Dissolved Organic Matter, the deep water showed substantial accumulations relative to the surface layers. The top 10 m had levels below 0.80 RFU on all dates. Between early May and mid September, Chlorophyll below that depth rose as high as 4.65 RFU, a function of both live and dead cells accumulating.

Blue-Green Algae (Phycocyanin) (Tables 5(a-e), Fig. 5(m)): similarly, showed May-September accumulations in the deep water relative to the surface 8-10 m. Surface layer levels were at or well below 0.50 RFU on all dates; increasing to as high as 2.63 in the deep water, similar to chorophyll. In late October, after initial fall water column mixing, Phycocyanin levels averaged across the water column, in the range of 0.37-0.50 RFU.

**In summary,** the Syar–West Pond was monitored to see if this significantly deeper pond would develop a stronger, more permanent thermal stratification in the warm season than the shallower ponds, with the possible depletion of oxygen in the bottom waters. This was found to be the case. The bottom water remained much cooler than the surface layers, isolating it and leading to buildups of some water quality constituents in the bottom water and the consumption of oxygen through normal microbial metabolism – with no replenishment from above, because of the thermal barrier. This 'classic warm season thermal stratification' pattern at Syar–West makes it a straightforward candidate pond for a possible mercury management trial, through warm season aeration of the bottom water by mixing.

## Table 5(a). Syar – West Pond: 2019 Water Column Profiling Data

**MAY 17:** max. depth 18.6 m (61 ft); Secchi disk water clarity: 6.0 m (20 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| 0 | 21.3 | 10.04 | 114% | 655 | 426 | 0.32 | 8.64 | – |
| 1 | 21.3 | 10.05 | 114% | 655 | 426 | 0.32 | 8.64 | – |
| 2 | 21.3 | 10.02 | 113% | 655 | 426 | 0.32 | 8.64 | – |
| 3 | 21.3 | 10.03 | 113% | 655 | 426 | 0.32 | 8.64 | – |
| 4 | 20.9 | 10.52 | 118% | 653 | 424 | 0.32 | 8.65 | – |
| 5 | 20.8 | 10.21 | 114% | 654 | 425 | 0.32 | 8.63 | – |
| 6 | 20.7 | 10.36 | 116% | 653 | 425 | 0.32 | 8.64 | – |
| 7 | 20.6 | 10.17 | 114% | 653 | 425 | 0.32 | 8.62 | – |
| 8 | 18.3 | 11.68 | 124% | 648 | 421 | 0.32 | 8.44 | – |
| 9 | 16.7 | 11.95 | 123% | 641 | 417 | 0.31 | 8.36 | – |
| 10 | 15.7 | 11.32 | 114% | 639 | 416 | 0.31 | 8.26 | – |
| 11 | 14.5 | 11.02 | 108% | 642 | 418 | 0.31 | 8.10 | – |
| 12 | 13.9 | 10.20 | 99% | 645 | 418 | 0.32 | 7.91 | – |
| 13 | 13.7 | 8.74 | 84% | 650 | 420 | 0.32 | 7.69 | – |
| 14 | 13.5 | 6.03 | 58% | 653 | 423 | 0.32 | 7.48 | – |
| 15 | 13.4 | 1.66 | 16% | 652 | 422 | 0.32 | 7.31 | – |
| 16 | 13.3 | 1.26 | 12% | 654 | 423 | 0.32 | 7.33 | – |
| 17 | 13.3 | 1.05 | 10% | 652 | 421 | 0.32 | 7.32 | – |
| 18 | 13.3 | 1.05 | 10% | 653 | 423 | 0.32 | 7.34 | – |

**Optical Parameters** (with framework data for reference)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| 0 | 21.3 | 10.04 | 114% | 0.52 | 1.96 | 0.12 | 0.03 |
| 1 | 21.3 | 10.05 | 114% | 0.52 | 1.95 | 0.13 | 0.05 |
| 2 | 21.3 | 10.02 | 113% | 0.51 | 1.94 | 0.08 | 0.03 |
| 3 | 21.3 | 10.03 | 113% | 0.52 | 1.97 | 0.11 | 0.04 |
| 4 | 20.9 | 10.52 | 118% | 0.62 | 2.21 | 0.10 | 0.05 |
| 5 | 20.8 | 10.21 | 114% | 0.55 | 2.21 | 0.09 | 0.07 |
| 6 | 20.7 | 10.36 | 116% | 0.52 | 2.32 | 0.10 | 0.08 |
| 7 | 20.6 | 10.17 | 114% | 0.56 | 2.46 | 0.12 | 0.14 |
| 8 | 18.3 | 11.68 | 124% | 0.59 | 3.91 | 0.29 | 0.15 |
| 9 | 16.7 | 11.95 | 123% | 0.65 | 3.89 | 0.38 | 0.17 |
| 10 | 15.7 | 11.32 | 114% | 0.76 | 3.79 | 0.47 | 0.24 |
| 11 | 14.5 | 11.02 | 108% | 0.80 | 3.98 | 0.73 | 0.28 |
| 12 | 13.9 | 10.20 | 99% | 0.82 | 4.13 | 0.85 | 0.39 |
| 13 | 13.7 | 8.74 | 84% | 0.88 | 4.27 | 0.98 | 0.58 |
| 14 | 13.5 | 6.03 | 58% | 0.94 | 4.42 | 1.06 | 0.65 |
| 15 | 13.4 | 1.66 | 16% | 1.00 | 4.49 | 1.18 | 0.70 |
| 16 | 13.3 | 1.26 | 12% | 1.08 | 4.68 | 1.27 | 0.67 |
| 17 | 13.3 | 1.05 | 10% | 1.12 | 4.72 | 1.02 | 0.65 |
| 18 | 13.3 | 1.05 | 10% | 1.27 | 4.77 | 1.33 | 0.78 |

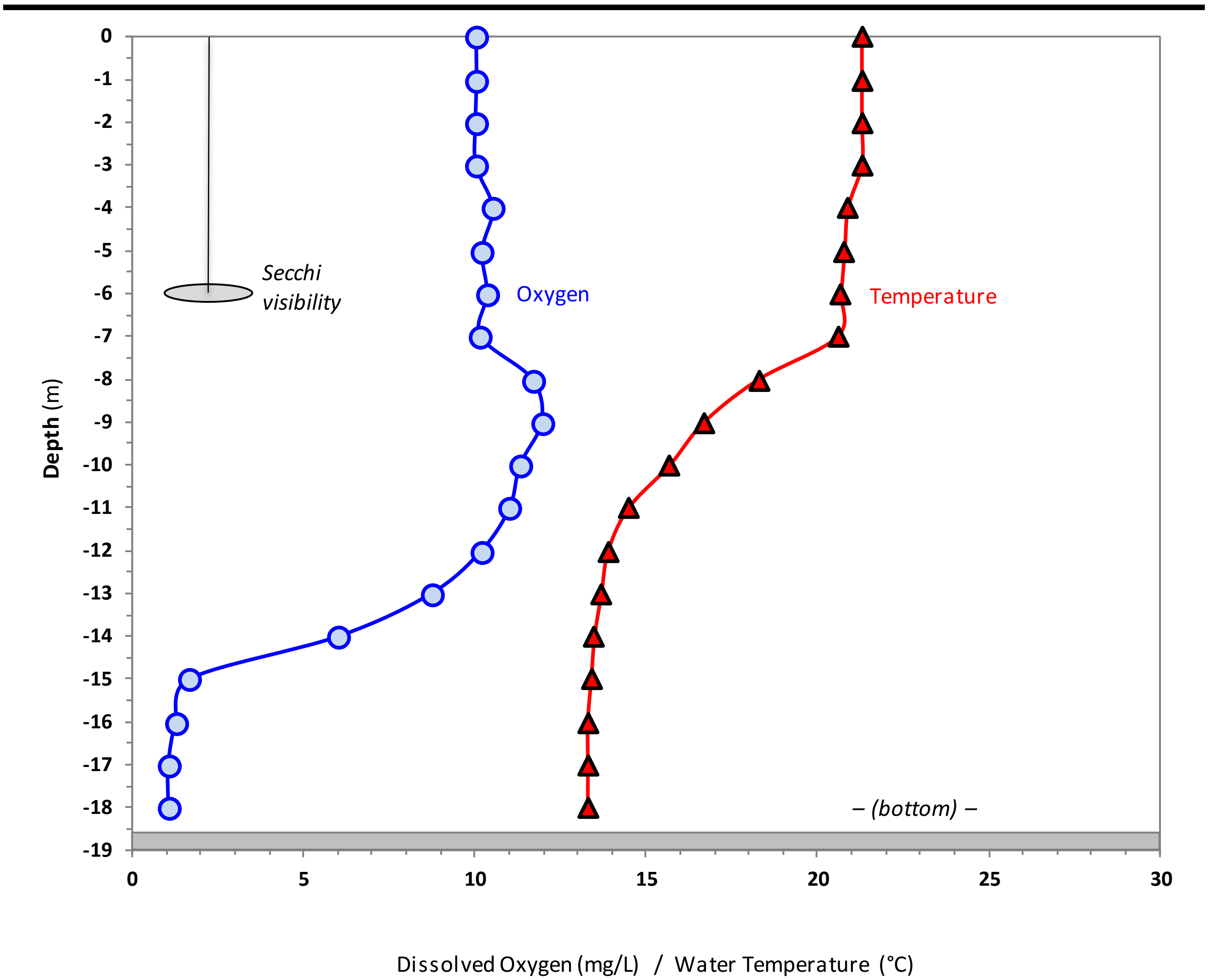



**Figure 5(a). MAY 17, 2019 – West Pond framework parameters**

**Table 5(b). Syar – West Pond: 2019 Water Column Profiling Data**
**JUN 16:** max. depth 18.3 m (60 ft); Secchi disk water clarity: 6.5 m (21 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 26.0 | 10.80 | 133% | 660 | 429 | 0.32 | 8.53 | 180 |
| **1** | 26.0 | 10.30 | 127% | 664 | 432 | 0.32 | 8.50 | 180 |
| **2** | 25.1 | 10.70 | 130% | 664 | 431 | 0.32 | 8.50 | 181 |
| **3** | 24.9 | 10.90 | 131% | 663 | 431 | 0.32 | 8.49 | 183 |
| **4** | 24.4 | 11.30 | 136% | 659 | 428 | 0.32 | 8.41 | 186 |
| **5** | 23.9 | 12.80 | 152% | 660 | 429 | 0.32 | 8.51 | 187 |
| **6** | 23.4 | 13.20 | 155% | 659 | 428 | 0.32 | 8.46 | 189 |
| **7** | 22.7 | 11.40 | 133% | 659 | 429 | 0.32 | 8.38 | 192 |
| **8** | 22.0 | 10.80 | 124% | 663 | 431 | 0.32 | 8.34 | 195 |
| **9** | 19.1 | 12.10 | 131% | 658 | 427 | 0.32 | 8.04 | 201 |
| **10** | 17.1 | 11.90 | 124% | 655 | 426 | 0.32 | 7.94 | 205 |
| **11** | 16.2 | 11.00 | 112% | 655 | 426 | 0.32 | 7.87 | 210 |
| **12** | 15.3 | 8.60 | 87% | 656 | 426 | 0.32 | 7.69 | 214 |
| **13** | 14.9 | 6.80 | 68% | 658 | 428 | 0.32 | 7.58 | 217 |
| **14** | 14.5 | 4.80 | 47% | 660 | 429 | 0.32 | 7.47 | 219 |
| **15** | 14.1 | 1.30 | 14% | 663 | 431 | 0.32 | 7.27 | 223 |
| **16** | 13.9 | 0.30 | 3% | 665 | 432 | 0.33 | 7.23 | 226 |
| **17** | 13.9 | 0.10 | 1% | 666 | 433 | 0.33 | 7.23 | 226 |
| **18** | 13.9 | 0.00 | 0% | 667 | 434 | 0.33 | 7.23 | 225 |

**Optical Parameters** (with framework data for reference)
*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 26.0 | 10.80 | 133% | 0.46 | 0.77 | 0.33 | 0.05 |
| **1** | 26.0 | 10.30 | 127% | 0.45 | 0.73 | 0.38 | 0.01 |
| **2** | 25.1 | 10.70 | 130% | 0.45 | 0.87 | 0.37 | 0.04 |
| **3** | 24.9 | 10.90 | 131% | 0.46 | 0.88 | 0.36 | 0.04 |
| **4** | 24.4 | 11.30 | 136% | 0.47 | 1.10 | 0.33 | 0.08 |
| **5** | 23.9 | 12.80 | 152% | 0.57 | 1.20 | 0.51 | 0.15 |
| **6** | 23.4 | 13.20 | 155% | 0.73 | 1.62 | 0.58 | 0.20 |
| **7** | 22.7 | 11.40 | 133% | 0.71 | 1.75 | 0.65 | 0.29 |
| **8** | 22.0 | 10.80 | 124% | 0.80 | 1.96 | 0.63 | 0.31 |
| **9** | 19.1 | 12.10 | 131% | 0.85 | 3.16 | 0.63 | 0.42 |
| **10** | 17.1 | 11.90 | 124% | 0.91 | 2.96 | 0.75 | 0.55 |
| **11** | 16.2 | 11.00 | 112% | 0.93 | 2.90 | 0.93 | 0.66 |
| **12** | 15.3 | 8.60 | 87% | 1.12 | 2.94 | 3.80 | 0.90 |
| **13** | 14.9 | 6.80 | 68% | 1.18 | 2.88 | 3.26 | 1.06 |
| **14** | 14.5 | 4.80 | 47% | 1.19 | 3.11 | 2.13 | 0.98 |
| **15** | 14.1 | 1.30 | 14% | 1.08 | 3.04 | 1.59 | 0.98 |
| **16** | 13.9 | 0.30 | 3% | 0.94 | 3.00 | 0.70 | 0.84 |
| **17** | 13.9 | 0.10 | 1% | 1.04 | 3.00 | 1.02 | 0.93 |
| **18** | 13.9 | 0.00 | 0% | 1.17 | 3.15 | 0.95 | 1.02 |

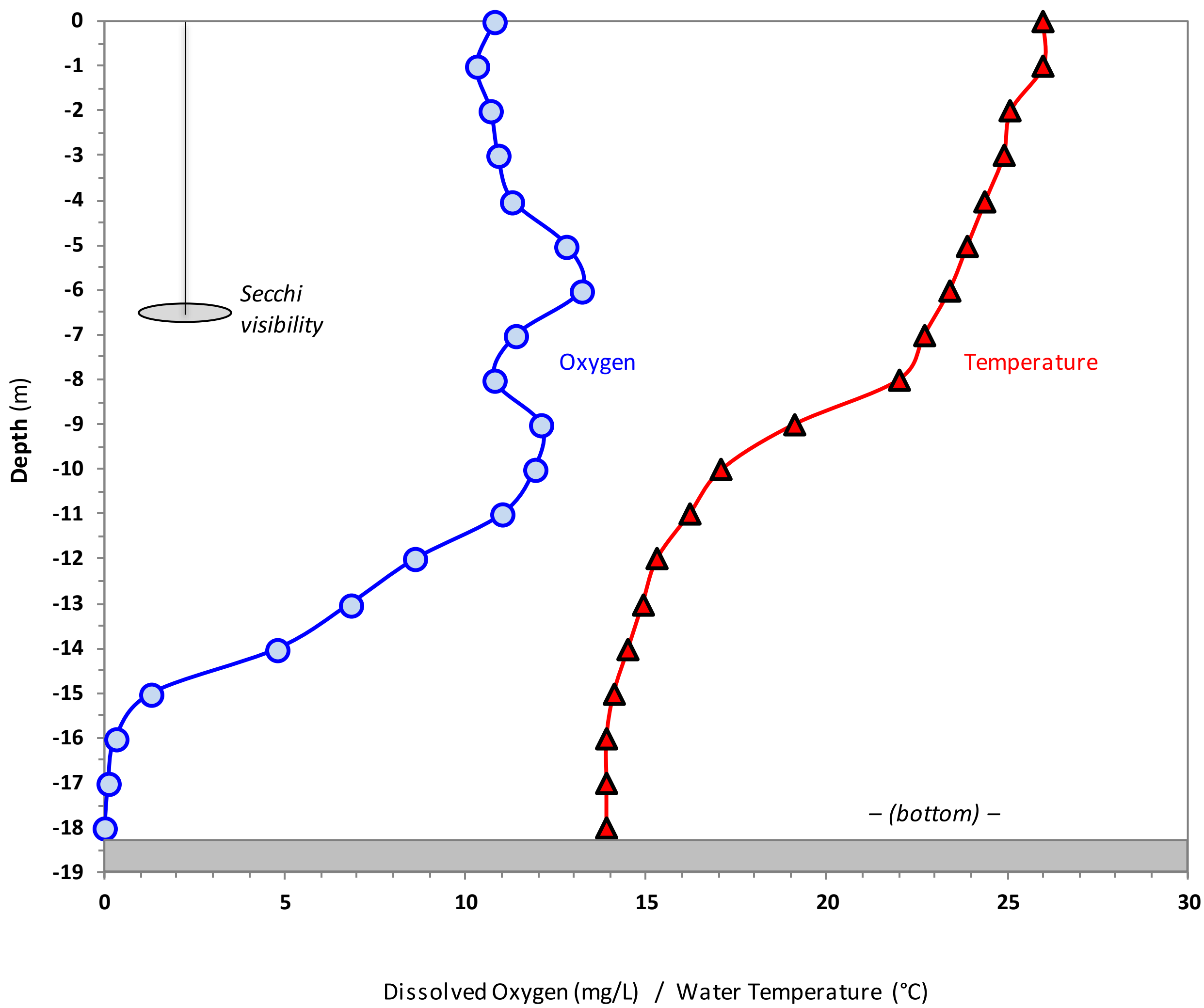



**Figure 5(b). JUN 16, 2019 – West Pond framework parameters**

**Table 5(c). Syar – West Pond: 2019 Water Column Profiling Data**

**JUL 30:** max. depth 17.7 m (58 ft); Secchi disk water clarity: 7.2 m (24 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| 0 | 29.1 | 10.88 | 142% | 660 | 429 | 0.32 | 8.71 | 182 |
| 1 | 29.1 | 10.98 | 143% | 660 | 429 | 0.32 | 8.71 | 182 |
| 2 | 28.9 | 12.22 | 159% | 657 | 427 | 0.32 | 8.74 | 182 |
| 3 | 28.5 | 12.16 | 157% | 657 | 427 | 0.32 | 8.72 | 183 |
| 4 | 28.4 | 11.63 | 150% | 659 | 428 | 0.32 | 8.71 | 183 |
| 5 | 28.3 | 11.55 | 149% | 658 | 428 | 0.32 | 8.70 | 184 |
| 6 | 28.2 | 11.59 | 149% | 658 | 427 | 0.32 | 8.69 | 184 |
| 7 | 28.1 | 11.26 | 144% | 660 | 429 | 0.32 | 8.66 | 186 |
| 8 | 27.1 | 11.53 | 145% | 677 | 440 | 0.33 | 8.50 | 189 |
| 9 | 23.6 | 17.49 | 207% | 682 | 443 | 0.33 | 8.47 | 193 |
| 10 | 20.4 | 19.01 | 211% | 675 | 439 | 0.33 | 8.47 | 197 |
| 11 | 18.2 | 15.92 | 169% | 684 | 445 | 0.33 | 8.37 | 202 |
| 12 | 16.9 | 9.70 | 100% | 693 | 451 | 0.34 | 8.04 | 209 |
| 13 | 15.7 | 2.64 | 27% | 700 | 455 | 0.34 | 7.52 | 217 |
| 14 | 15.0 | 0.74 | 7% | 698 | 454 | 0.34 | 7.44 | 219 |
| 15 | 14.5 | 0.14 | 1% | 703 | 457 | 0.34 | 7.41 | 215 |
| 16 | 14.3 | 0.10 | 1% | 706 | 459 | 0.35 | 7.40 | 196 |
| 17 | 14.2 | 0.06 | < 1% | 710 | 463 | 0.35 | 7.38 | 182 |

**Optical Parameters** (with framework data for reference)

*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| 0 | 29.1 | 10.88 | 142% | 0.56 | 0.64 | 0.34 | 0.02 |
| 1 | 29.1 | 10.98 | 143% | 0.56 | 0.56 | 0.36 | 0.00 |
| 2 | 28.9 | 12.22 | 159% | 0.53 | 0.63 | 0.35 | 0.01 |
| 3 | 28.5 | 12.16 | 157% | 0.48 | 0.79 | 0.40 | 0.03 |
| 4 | 28.4 | 11.63 | 150% | 0.60 | 0.64 | 0.37 | 0.06 |
| 5 | 28.3 | 11.55 | 149% | 0.50 | 0.74 | 0.41 | 0.05 |
| 6 | 28.2 | 11.59 | 149% | 0.51 | 0.88 | 0.48 | 0.05 |
| 7 | 28.1 | 11.26 | 144% | 0.47 | 0.84 | 0.54 | 0.09 |
| 8 | 27.1 | 11.53 | 145% | 0.45 | 1.77 | 0.58 | 0.12 |
| 9 | 23.6 | 17.49 | 207% | 0.66 | 4.82 | 0.48 | 0.18 |
| 10 | 20.4 | 19.01 | 211% | 0.82 | 4.79 | 0.71 | 0.37 |
| 11 | 18.2 | 15.92 | 169% | 1.31 | 3.65 | 1.22 | 0.70 |
| 12 | 16.9 | 9.70 | 100% | 1.80 | 3.30 | 1.57 | 1.03 |
| 13 | 15.7 | 2.64 | 27% | 1.94 | 3.40 | 1.25 | 1.05 |
| 14 | 15.0 | 0.74 | 7% | 1.34 | 3.27 | 0.74 | 1.05 |
| 15 | 14.5 | 0.14 | 1% | 2.48 | 3.29 | 2.29 | 1.91 |
| 16 | 14.3 | 0.10 | 1% | 5.10 | 3.39 | 1.42 | 1.37 |
| 17 | 14.2 | 0.06 | < 1% | 6.32 | 3.44 | 1.17 | 1.12 |

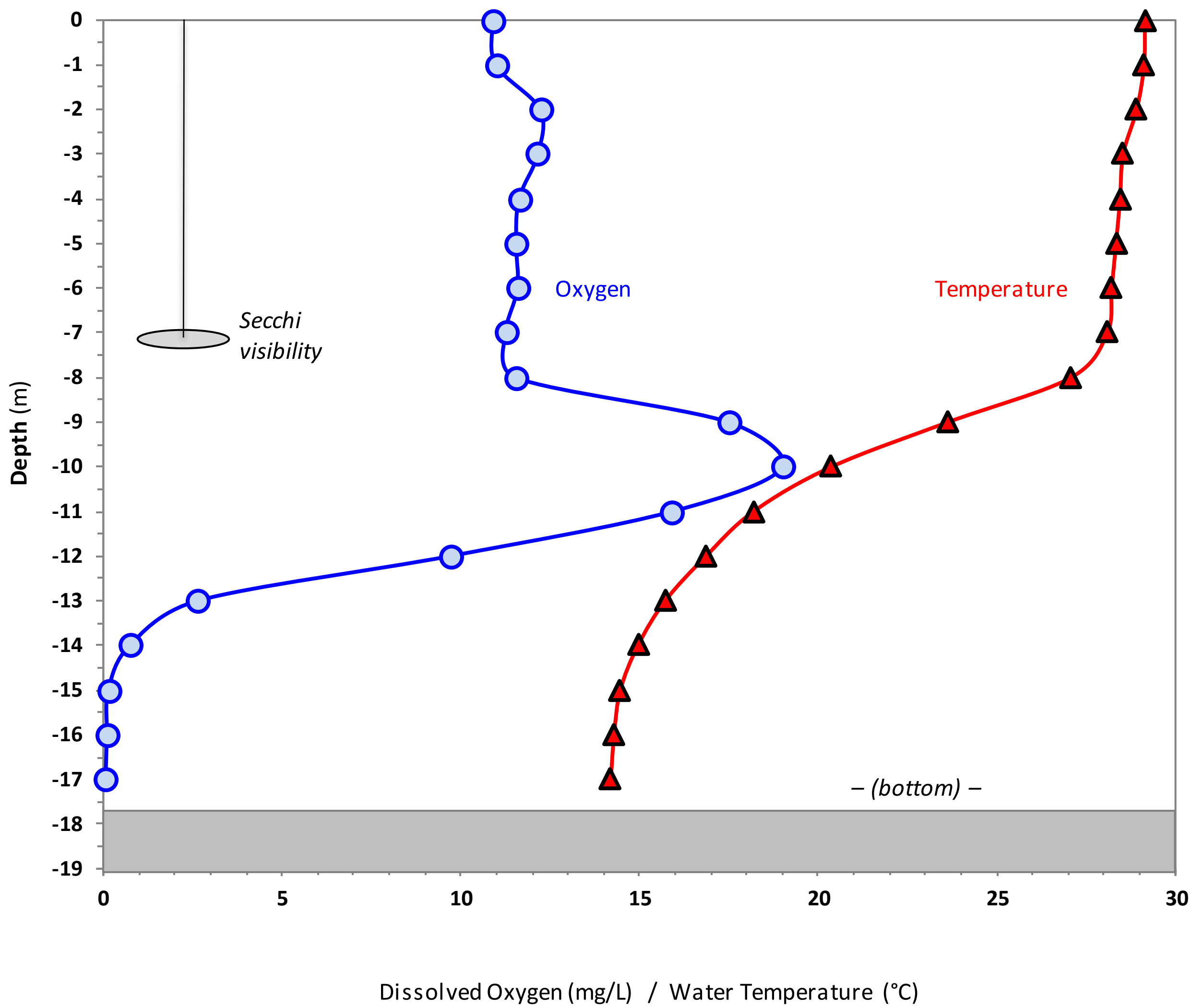



**Figure 5(c). JUL 30, 2019 – West Pond framework parameters**

**Table 5(d). Syar – West Pond: 2019 Water Column Profiling Data**
**SEP 15**: max. depth 16.9 m (56 ft); Secchi disk water clarity: 8.2 m (27 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| **0** | 25.7 | 10.44 | 128% | 614 | 399 | 0.30 | 8.78 | 129 |
| **1** | 25.7 | 10.51 | 129% | 614 | 399 | 0.30 | 8.78 | 130 |
| **2** | 25.7 | 10.48 | 129% | 614 | 399 | 0.30 | 8.78 | 130 |
| **3** | 25.7 | 10.50 | 129% | 614 | 399 | 0.30 | 8.78 | 131 |
| **4** | 25.5 | 10.53 | 129% | 614 | 399 | 0.30 | 8.77 | 131 |
| **5** | 25.5 | 10.47 | 128% | 614 | 399 | 0.30 | 8.77 | 132 |
| **6** | 25.4 | 10.38 | 127% | 614 | 399 | 0.30 | 8.76 | 133 |
| **7** | 25.3 | 10.17 | 124% | 615 | 400 | 0.30 | 8.75 | 134 |
| **8** | 25.2 | 10.05 | 122% | 615 | 400 | 0.30 | 8.74 | 134 |
| **9** | 24.9 | 10.07 | 122% | 617 | 401 | 0.30 | 8.70 | 135 |
| **10** | 22.1 | 14.24 | 163% | 650 | 423 | 0.32 | 8.25 | 148 |
| **11** | 19.6 | 11.54 | 126% | 658 | 427 | 0.32 | 8.14 | 152 |
| **12** | 18.1 | 4.39 | 47% | 665 | 432 | 0.33 | 7.69 | 159 |
| **13** | 17.0 | 0.66 | 7% | 667 | 433 | 0.33 | 7.50 | 162 |
| **14** | 16.2 | 0.45 | 5% | 666 | 433 | 0.33 | 7.48 | 164 |
| **15** | 15.7 | 0.15 | 2% | 669 | 435 | 0.33 | 7.39 | 165 |
| **16** | 15.0 | 0.12 | 1% | 695 | 452 | 0.34 | 7.26 | 162 |

**Optical Parameters** (with framework data for reference)
*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| **0** | 25.7 | 10.44 | 128% | 0.26 | 1.06 | 0.38 | 0.00 |
| **1** | 25.7 | 10.51 | 129% | 0.26 | 1.03 | 0.41 | 0.04 |
| **2** | 25.7 | 10.48 | 129% | 0.28 | 1.08 | 0.40 | 0.01 |
| **3** | 25.7 | 10.50 | 129% | 0.27 | 1.08 | 0.40 | 0.02 |
| **4** | 25.5 | 10.53 | 129% | 0.28 | 1.09 | 0.42 | 0.03 |
| **5** | 25.5 | 10.47 | 128% | 0.30 | 1.26 | 0.47 | 0.06 |
| **6** | 25.4 | 10.38 | 127% | 0.27 | 1.21 | 0.44 | 0.04 |
| **7** | 25.3 | 10.17 | 124% | 0.28 | 1.34 | 0.49 | 0.08 |
| **8** | 25.2 | 10.05 | 122% | 0.31 | 1.26 | 0.58 | 0.06 |
| **9** | 24.9 | 10.07 | 122% | 0.34 | 1.41 | 0.59 | 0.10 |
| **10** | 22.1 | 14.24 | 163% | 0.31 | 3.22 | 0.58 | 0.23 |
| **11** | 19.6 | 11.54 | 126% | 0.31 | 3.80 | 0.56 | 0.37 |
| **12** | 18.1 | 4.39 | 47% | 0.59 | 4.19 | 0.52 | 0.48 |
| **13** | 17.0 | 0.66 | 7% | 0.54 | 4.07 | 1.13 | 0.77 |
| **14** | 16.2 | 0.45 | 5% | 2.51 | 3.78 | 1.57 | 1.12 |
| **15** | 15.7 | 0.15 | 2% | 6.77 | 3.50 | 4.65 | 2.63 |
| **16** | 15.0 | 0.12 | 1% | 8.26 | 4.12 | 2.79 | 2.53 |

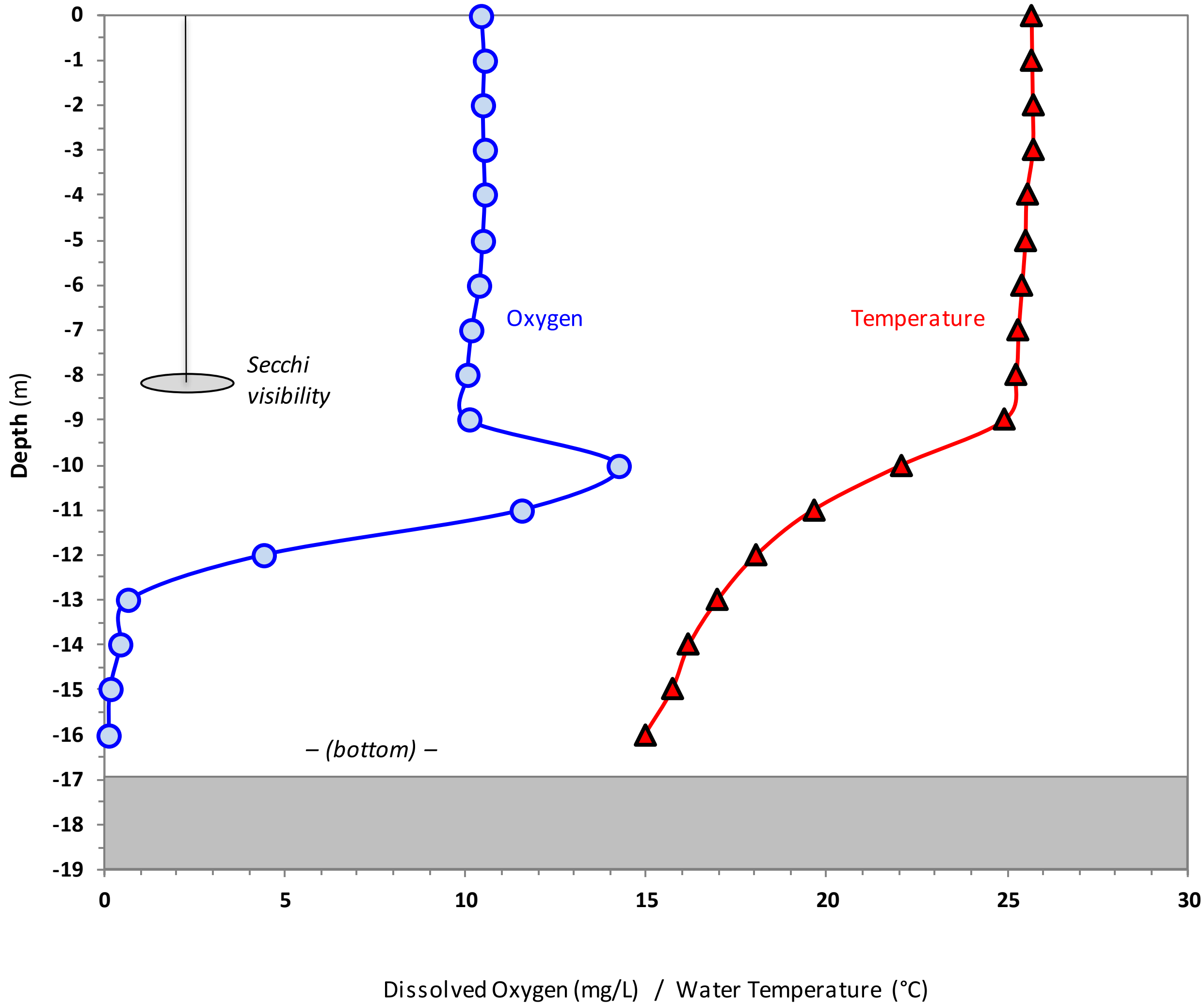



**Figure 5(d). SEP 15, 2019 – West Pond framework parameters**

**Table 5(e).** **Syar – West Pond: 2019 Water Column Profiling Data**
**OCT 27**: max. depth 16.5 m (54 ft); Secchi disk water clarity: 9.3 m (31 ft)

*(% Sat. = % of saturation; µS = micro Siemens; ppt = parts per thousand; ORP = oxidation/reduction potential); mV = millivolts)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Conduct. (µS/cm) | Salinity (ppt) | TDS (mg/L) | pH | ORP (mV) |
|---|---|---|---|---|---|---|---|---|
| 0 | 16.1 | 9.00 | 92% | 635 | 413 | 0.31 | 8.27 | 24 |
| 1 | 16.0 | 9.60 | 98% | 635 | 413 | 0.31 | 8.31 | 23 |
| 2 | 15.7 | 8.83 | 89% | 635 | 413 | 0.31 | 8.27 | 24 |
| 3 | 15.6 | 8.75 | 88% | 635 | 413 | 0.31 | 8.27 | 24 |
| 4 | 15.5 | 8.74 | 88% | 635 | 413 | 0.31 | 8.27 | 25 |
| 5 | 15.5 | 8.75 | 88% | 635 | 412 | 0.31 | 8.27 | 26 |
| 6 | 15.4 | 8.70 | 87% | 635 | 413 | 0.31 | 8.27 | 27 |
| 7 | 15.4 | 8.66 | 87% | 635 | 413 | 0.31 | 8.27 | 27 |
| 8 | 15.4 | 8.63 | 86% | 635 | 413 | 0.31 | 8.27 | 28 |
| 9 | 15.4 | 8.64 | 87% | 635 | 412 | 0.31 | 8.27 | 29 |
| 10 | 15.4 | 8.63 | 86% | 635 | 413 | 0.31 | 8.27 | 29 |
| 11 | 15.3 | 8.61 | 86% | 635 | 413 | 0.31 | 8.27 | 30 |
| 12 | 15.3 | 8.60 | 86% | 635 | 413 | 0.31 | 8.27 | 31 |
| 13 | 15.3 | 8.59 | 86% | 635 | 413 | 0.31 | 8.27 | 32 |
| 14 | 15.3 | 8.55 | 86% | 635 | 413 | 0.31 | 8.27 | 33 |
| 15 | 15.3 | 8.54 | 85% | 635 | 413 | 0.31 | 8.27 | 34 |
| 16 | 15.3 | 8.54 | 85% | 635 | 413 | 0.31 | 8.27 | 35 |

**Optical Parameters** (with framework data for reference)
*(FDOM = Fluorescent Dissolved Organic Matter; BG Algae = Blue-Green Algae; FNU = Formazin Nephelometric Units; RFU = Relative Fluorescence Units)*

| Depth (m) | Temp. (°C) | Oxygen (mg/L) | Oxygen (% Sat.) | Turbidity (FNU) | FDOM (RFU) | Chlorophyll (RFU) | BG Algae (RFU) |
|---|---|---|---|---|---|---|---|
| 0 | 16.1 | 9.00 | 92% | 0.40 | 1.60 | 0.24 | 0.37 |
| 1 | 16.0 | 9.60 | 98% | 0.37 | 1.70 | 0.26 | 0.38 |
| 2 | 15.7 | 8.83 | 89% | 0.46 | 1.61 | 0.30 | 0.39 |
| 3 | 15.6 | 8.75 | 88% | 0.48 | 1.68 | 0.38 | 0.46 |
| 4 | 15.5 | 8.74 | 88% | 0.52 | 1.67 | 0.49 | 0.46 |
| 5 | 15.5 | 8.75 | 88% | 0.50 | 1.79 | 0.75 | 0.51 |
| 6 | 15.4 | 8.70 | 87% | 0.59 | 1.76 | 0.66 | 0.50 |
| 7 | 15.4 | 8.66 | 87% | 0.70 | 1.76 | 0.65 | 0.50 |
| 8 | 15.4 | 8.63 | 86% | 0.68 | 1.86 | 0.53 | 0.48 |
| 9 | 15.4 | 8.64 | 87% | 0.56 | 1.83 | 0.40 | 0.48 |
| 10 | 15.4 | 8.63 | 86% | 0.56 | 1.71 | 0.40 | 0.49 |
| 11 | 15.3 | 8.61 | 86% | 0.52 | 1.76 | 0.50 | 0.46 |
| 12 | 15.3 | 8.60 | 86% | 0.53 | 1.87 | 0.38 | 0.48 |
| 13 | 15.3 | 8.59 | 86% | 0.57 | 1.84 | 0.29 | 0.49 |
| 14 | 15.3 | 8.55 | 86% | 0.61 | 1.72 | 0.28 | 0.43 |
| 15 | 15.3 | 8.54 | 85% | 0.62 | 1.86 | 0.30 | 0.47 |
| 16 | 15.3 | 8.54 | 85% | 0.54 | 1.87 | 0.26 | 0.47 |

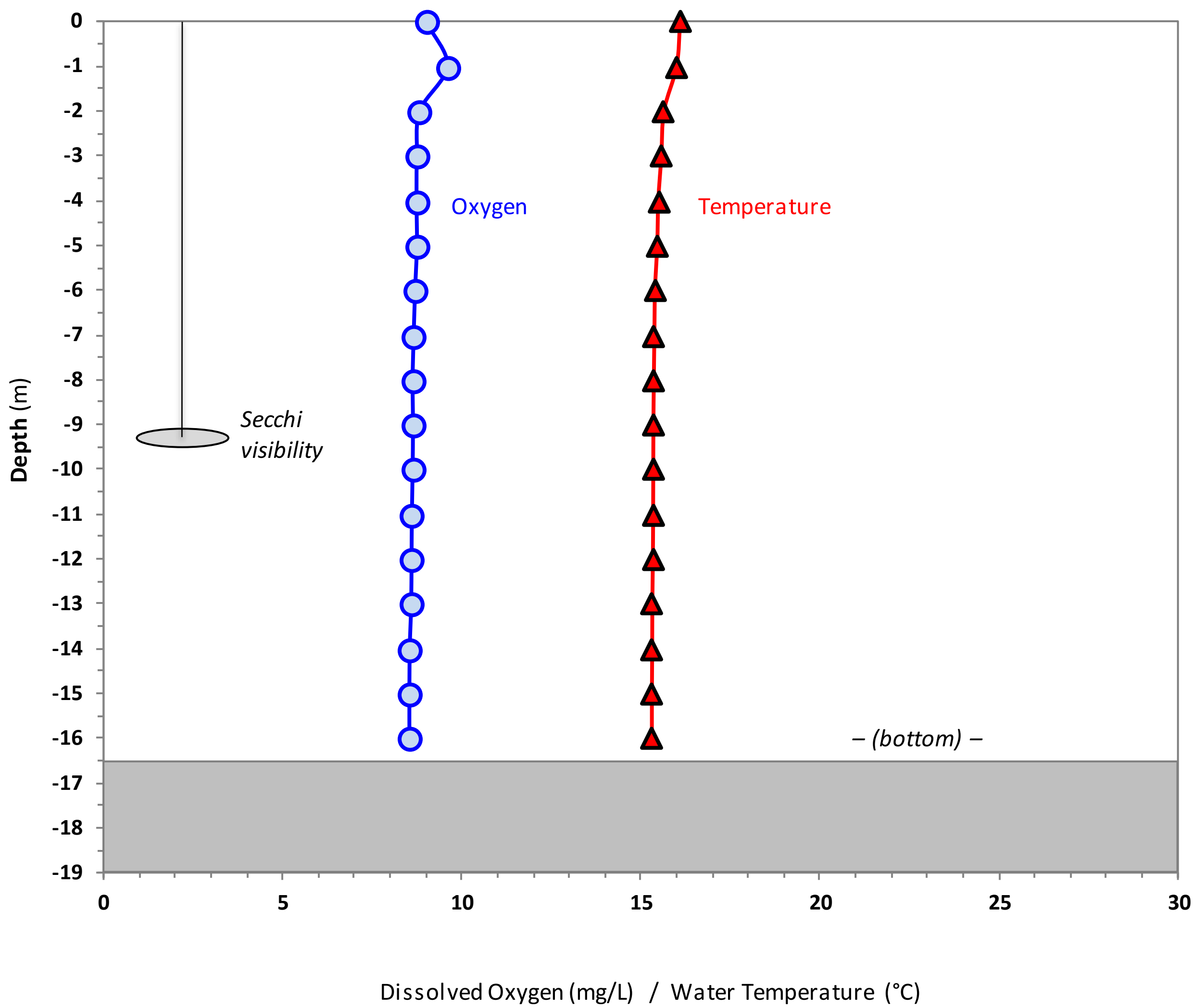



**Figure 5(e). OCT 27, 2019 – West Pond framework parameters**

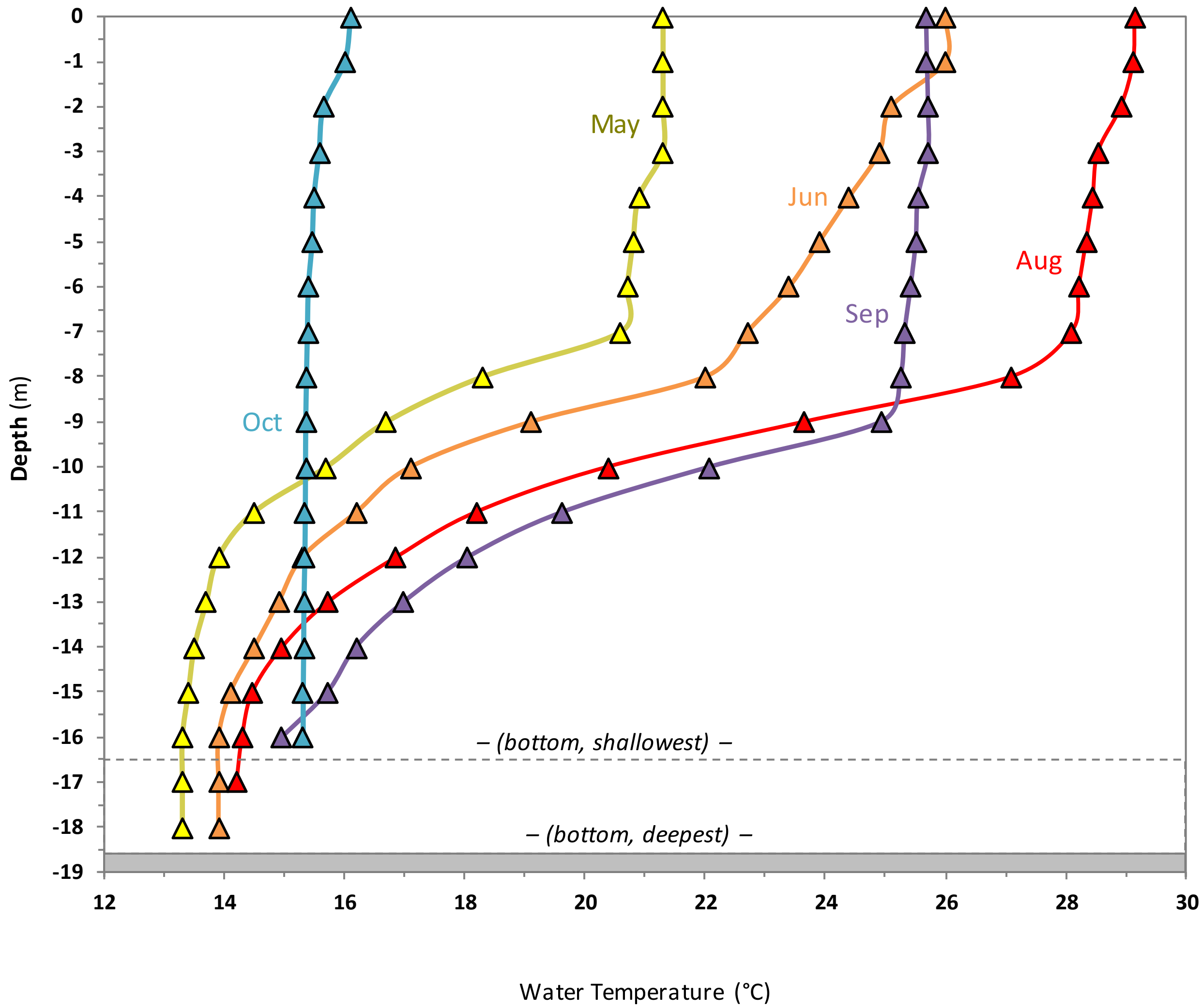



**Figure 4(f). Syar – West Pond: 2019 May-Oct TEMPERATURE**

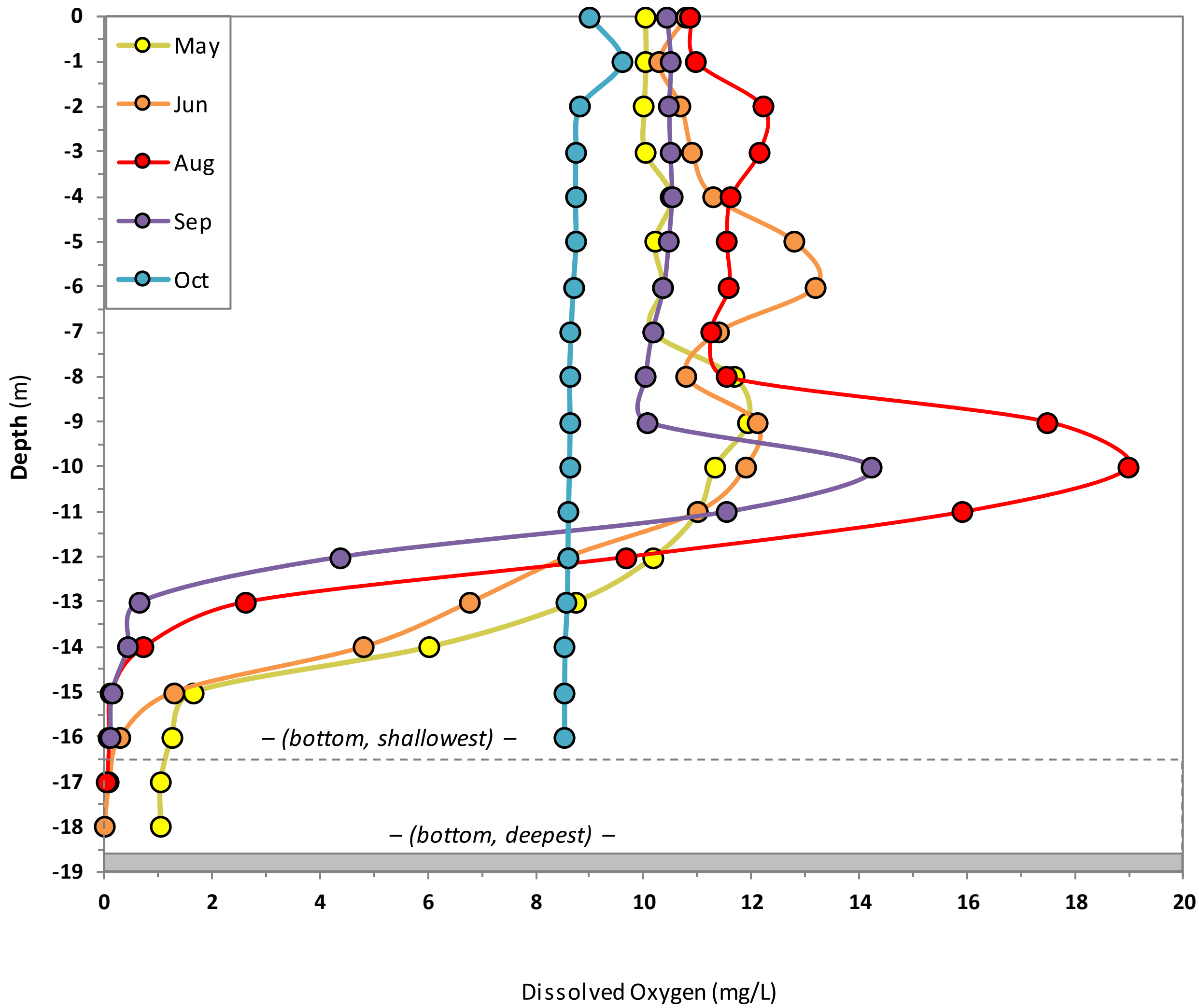



**Figure 4(g). Syar – West Pond: 2019 May-Oct OXYGEN**

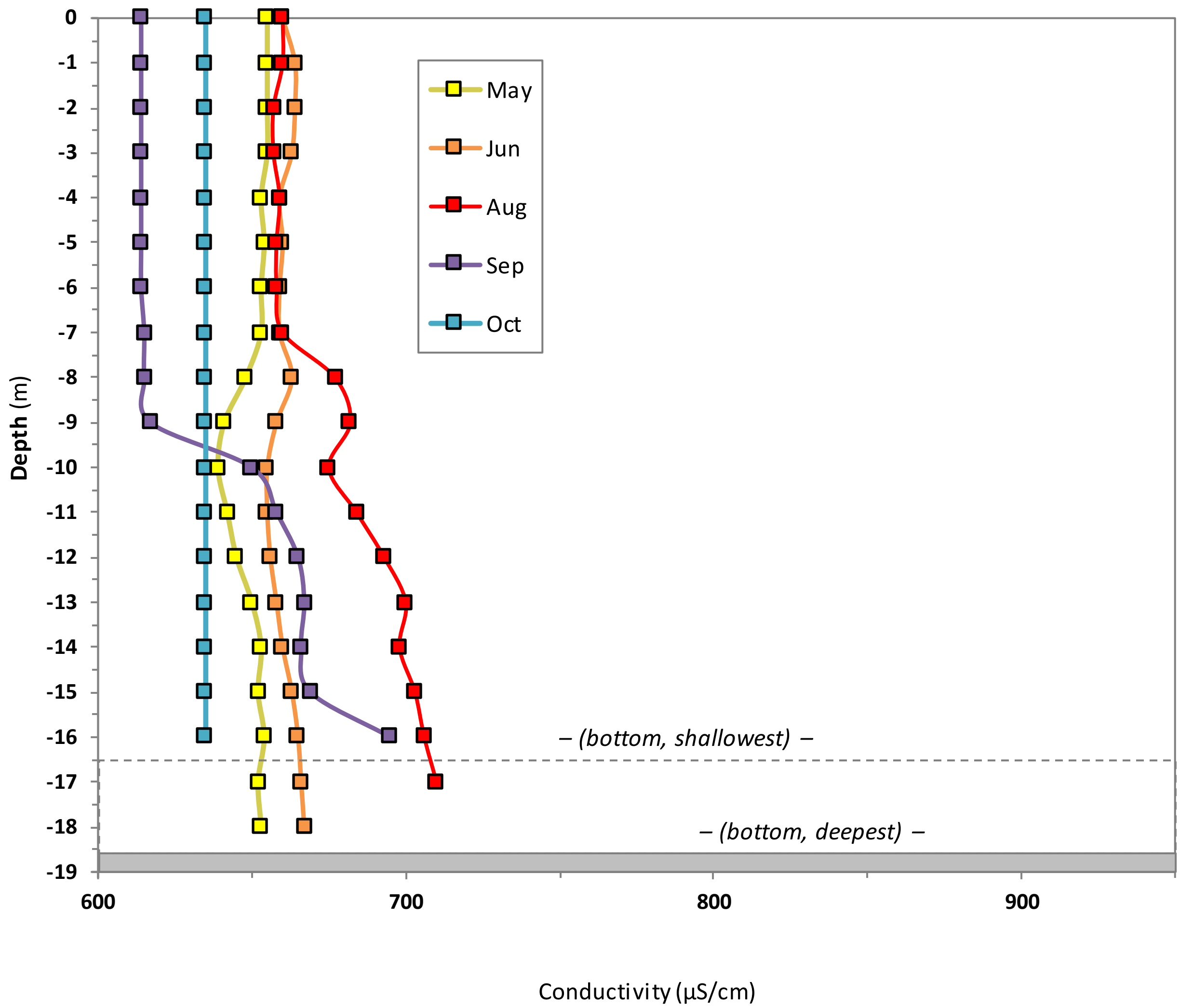



**Figure 4(h). Syar – West Pond: 2019 May-Oct CONDUCTIVITY**

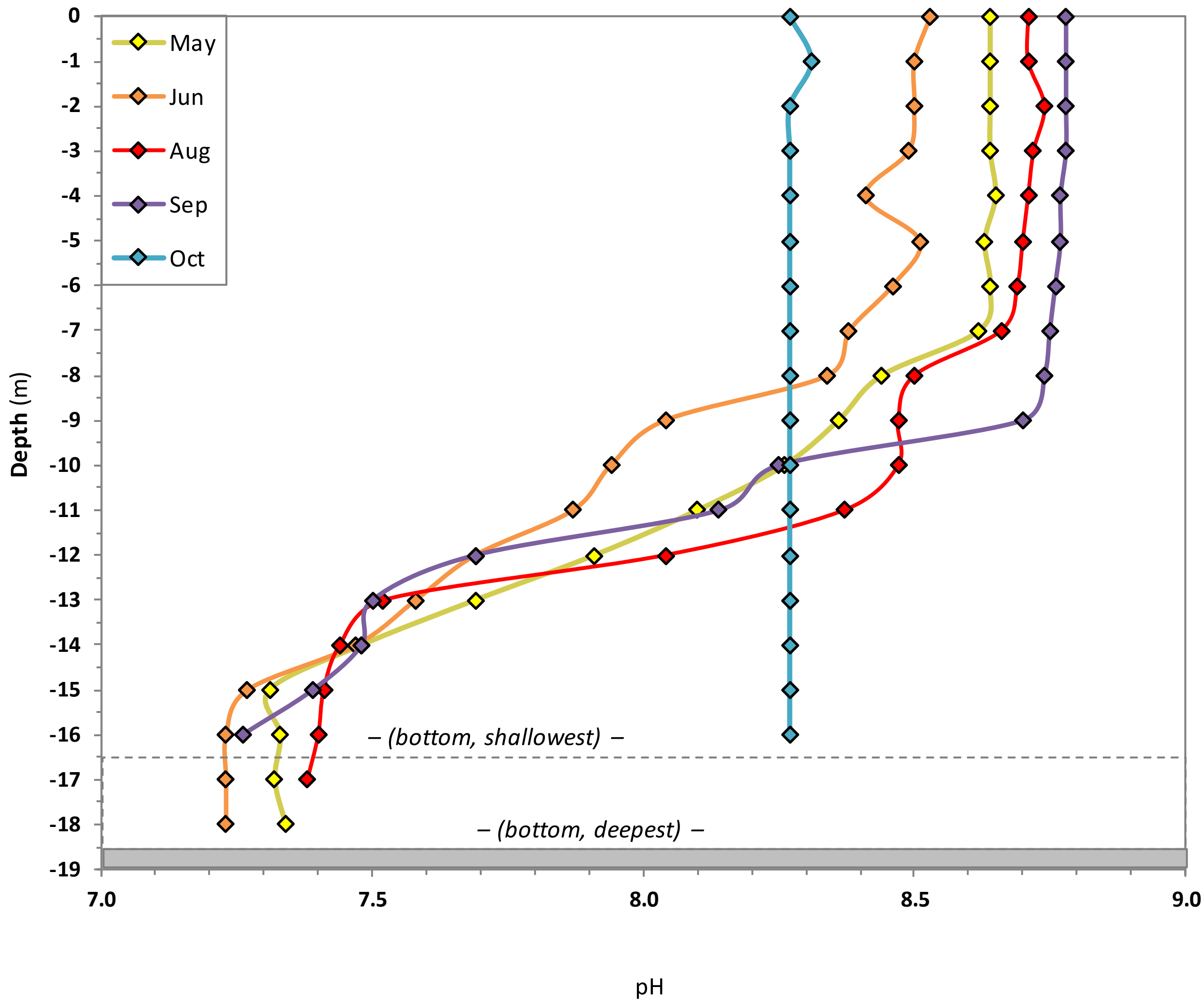



**Figure 4(i). Syar – West Pond: 2019 May-Oct pH**

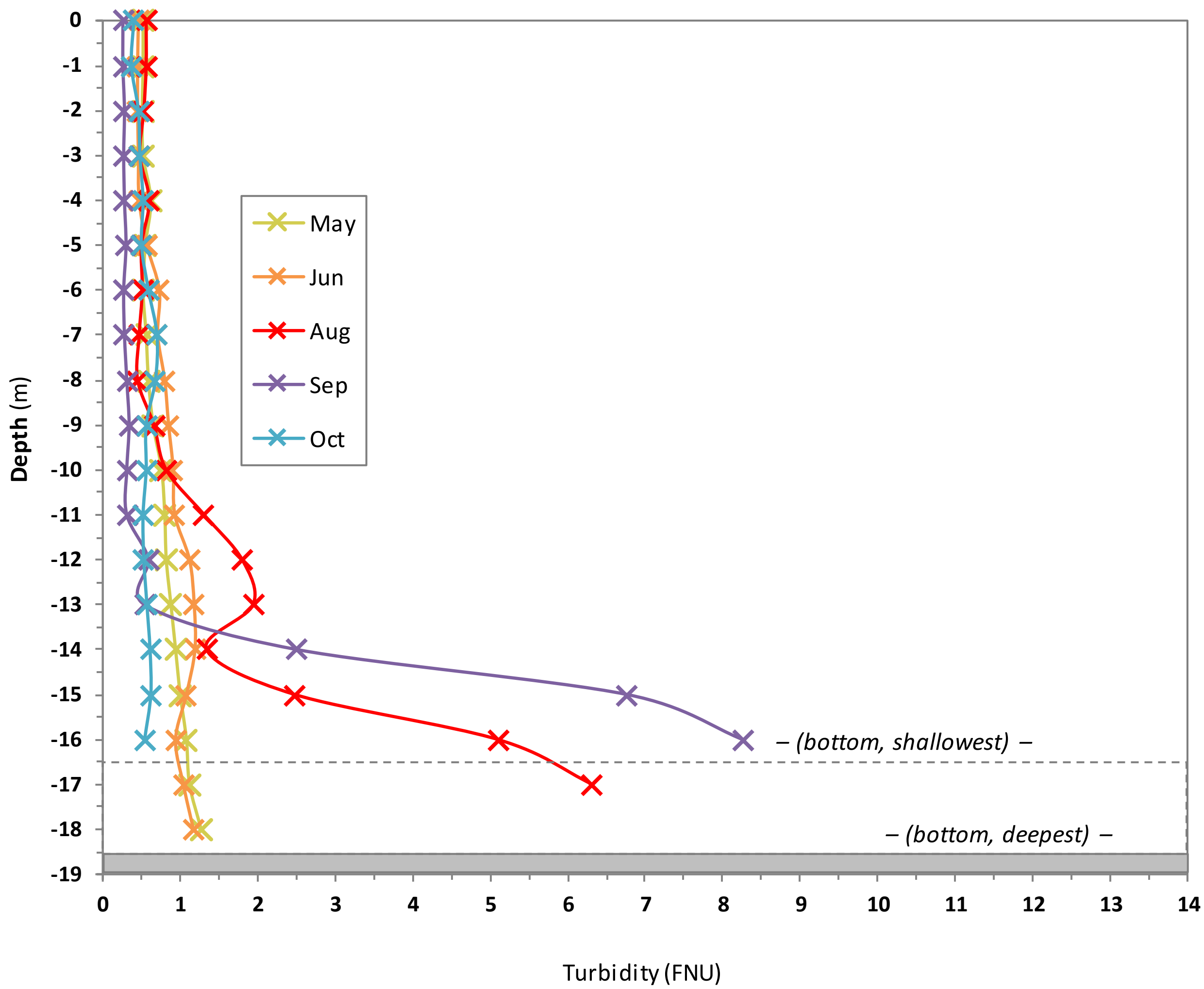



**Figure 4(j). Syar – West Pond: 2019 May-Oct TURBIDITY**

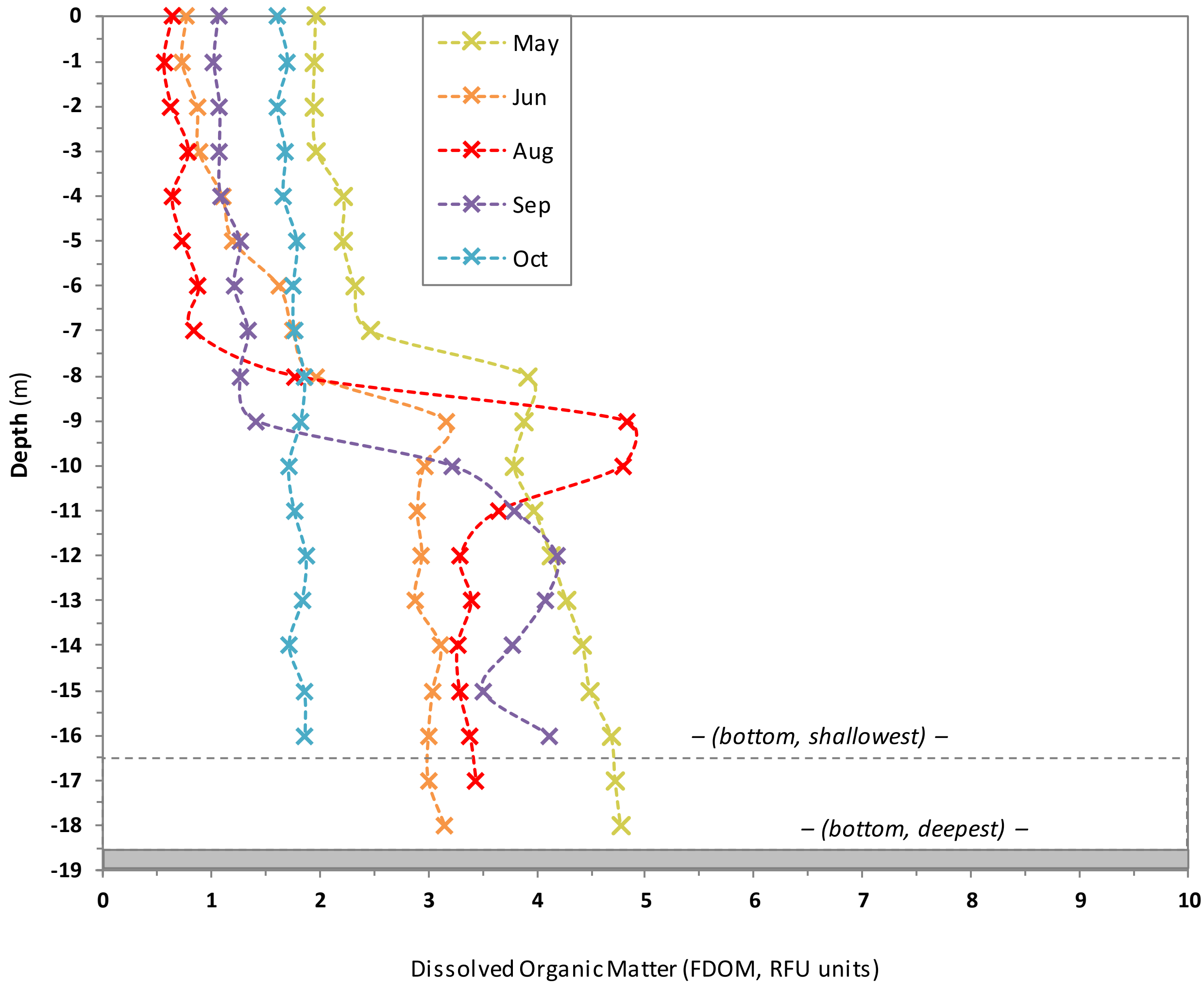



**Figure 4(k). Syar – West Pond: 2019 May-Oct DISSOLVED ORGANIC MATTER**

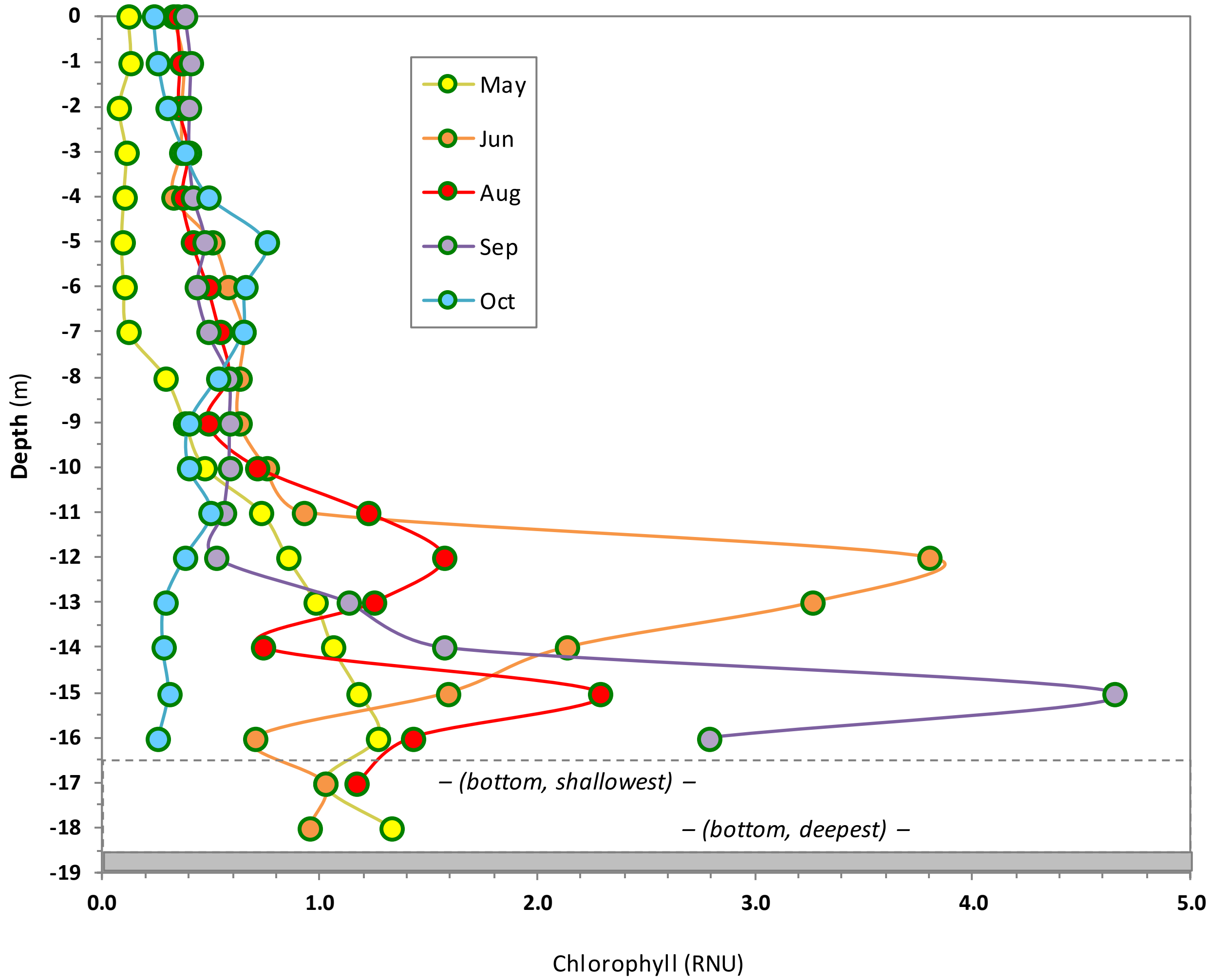



**Figure 4(l). Syar – West Pond: 2019 May-Oct CHLOROPHYLL**

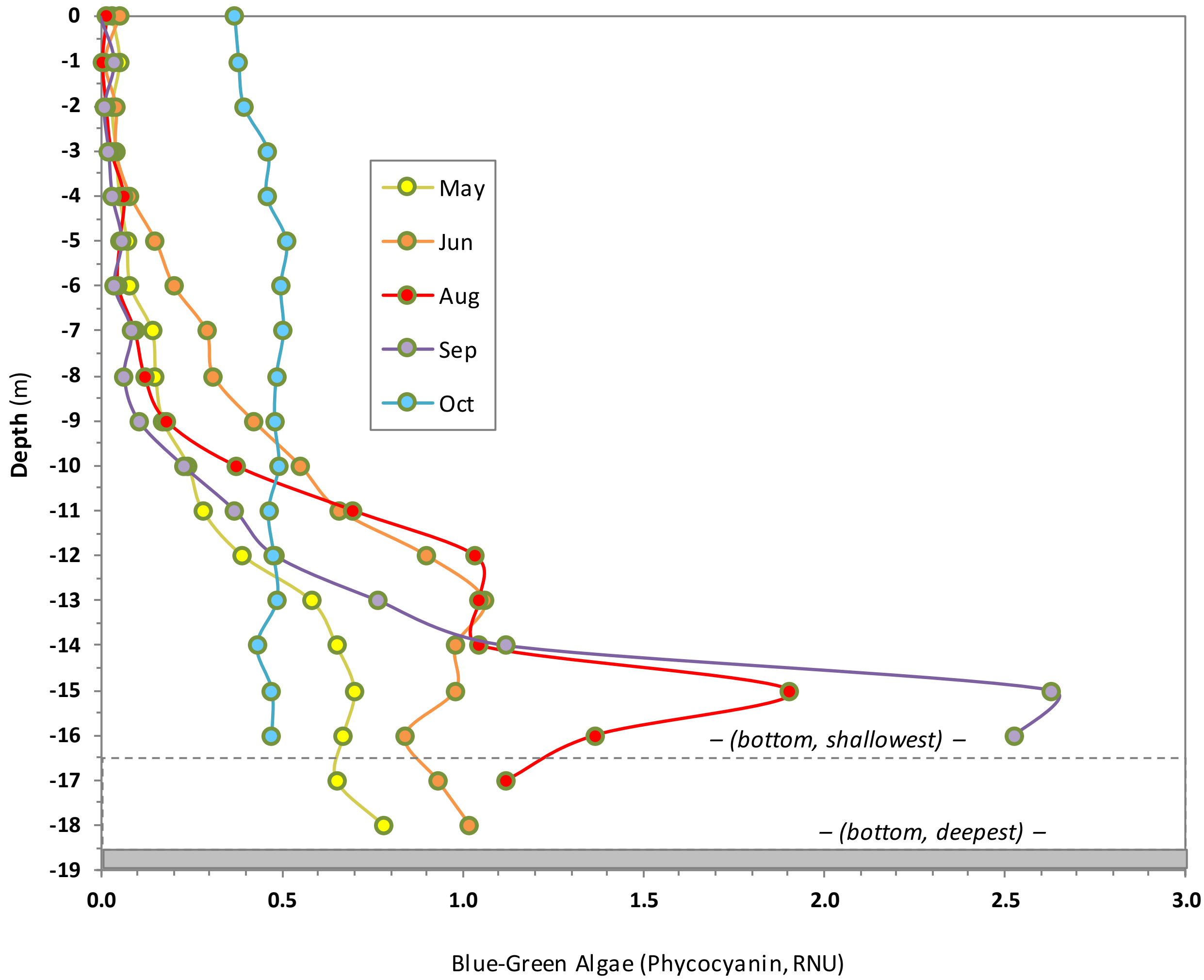



**Figure 4(m). Syar – West Pond: 2019 BLUE-GREEN ALGAE**

## CONCLUSIONS

Table C below summarizes the 2019 water profiling data from all of the tested ponds. Many of the parameters fell within similar overall ranges, including conductivity, salinity, dissolved solids, pH, and oxidation/reduction potential. Turbidity (mainly sediment in the water) was most strongly tied to active mining or plant slurry water returns. The particle-based measures, including the algal parameters and turbidity, tended to accumulate near the bottom. Some of the greatest accumulations or changes were found in the lower water of ponds that stratified thermally. Most of the monitored ponds were too shallow to stratify completely (isolate water layers from each other) in the warm season but two, Teichert-Esparto–Reiff and Syar–B1, stratified enough for many of the measured water parameters to shift significantly, including oxygen, pH, and ORP, with deep accumulations of turbidity and algal cells.

Among the three ponds identified as elevated in fish mercury – Syar-B1, Teichert-Esparto Reiff, and Cemex-Phase 3-4 – there was not a single, consistent trend. While the two most elevated ponds, Syar-B1 and Teichert-Esparto Reiff have consistently shown evidence of seasonal water column anoxia, that was not the case at Cemex-Phase 3-4. However, as last year, the data give some important clues. In particular, there were key differences in bottom water anoxia and general water clarity. The new data from the much deeper Syar–West pond confirmed it as a site of strong seasonal water stratification and bottom water anoxia (loss of oxygen).

Seasonal bottom water anoxia was expected to maybe be an important driver of increased methylmercury production and movement into fish in some of the ponds. That is because of the way methylmercury is produced. Methylmercury is almost entirely generated *biologically* – as a peripheral byproduct of the normal metabolism of important, naturally occurring microbes, mainly sulfur-reducers and iron-reducers. These microbes congregate just below the transition zone between oxygenated (oxic, aerobic) and anoxic conditions, where they obtain their energy by converting the oxidized forms of sulfur or iron (sulfate, ferric iron) to the reduced forms (hydrogen sulfide, ferrous iron). They do not purposely consume mercury or use it in any way. But mercury, if present, can move through their metabolic pathways – and be converted into toxic methylmercury, the form that bioaccumulates in organisms.

**Table C. Summary Comparisons of Profiling Data From Each of the Tested Ponds**

| | Cemex-Phase 1 | Syar-West | Cemex-Phase 3-4 | Syar-B1 | Teichert-Reiff |
|---|---|---|---|---|---|
| ***Fish Mercury*** | low | med-high | high | **very high** | **very high** |
| ***Active Mining?*** | – | – | **Yes** | – | – |
| ***Plant Slurry Inflows?*** | **Yes** | – | – | – | **Yes** |
| **Pond Depth** (average) | 6.1 m (20 ft) | 17.6 m (58 ft) | 10.8 m (35 ft) | 9.3 m (30 ft) | 6.3 m (21 ft) |
| **Water Clarity** (avg visibility) | 2.0 m (7 ft) | 7.5 m (25 ft) | 4.1 m (14 ft) | 4.8 m (16 ft) | 1.6 m (5 ft) |
| **Temperature Gradient** (max btw surface and bottom) | 3.5 °C (6.3 °F) | 14.9 °C (27 °F) | 3.9 °C (7.0 °F) | 5.0 °C (9.0 °F) | 4.4 °C (7.9 °F) |
| **Bottom Anoxia?** | **NO** | **YES** | **NO** | Yes | **YES** |
| **Conductivity** (µS/cm) | 646-770 | 614-710 | 801-905 | 632-686 | 658-747 |
| **Salinity** (ppt) | 0.31-0.37 | 0.30-0.35 | 0.39-0.45 | 0.31-0.32 | 0.32-0.36 |
| **Total Dissolved Solids** (mg/L) | 420-501 | 399-463 | 521-589 | 411-446 | 658-747 |
| **pH** | 8.1-8.5 | 7.23-8.78 | 8.3-8.7 | 7.7-8.8 | 7.7-8.6 |
| **Oxid.-Reduct. Potential** (mV) | 55-189 | -125-226 | 35-196 | 50-206 | 93-200 |
| **Turbidity** (FNU) | 0.86-24.3 | 0.26-8.26 | 0.27-12.44 | 0.47-3.53 | 1.56-17.9 |
| **Diss. Org. Matter** (RFU) | 0.63-2.26 | 0.56-4.82 | 0.10-9.96 | 0.68-5.43 | 0.62-3.19 |
| **Chlorophyll** (RFU) | 0.02-0.80 | 0.08-4.65 | 0.05-0.76 | 0.09-2.40 | 0.14-1.46 |
| **Blue-Green Algae** (RFU) | 0.05-0.83 | 0.00-2.53 | 0.03-0.39 | 0.00-0.54 | 0.00-0.47 |

Ordinarily, the oxic/anoxic transition zone and its associated microbes is located deep in the bottom sediments, below the pond water and below the sediment surface. Sediments beneath the transition to anoxia are typically black and have a 'rotten egg' (hydrogen sulfide) smell. When the oxic/anoxic transition zone is located deep in the sediments, any methylmercury that is produced there has a layer of oxic sediments between it and the pond water. Those sediments contain a tremendous number of potential binding sites that slow down or stop the transfer of the methylmercury into the overlying water. However, if the bottom water of the pond becomes anoxic, the oxic/anoxic transition zone moves up into the water itself – together with the mercury-methylating microbes. Under those conditions, any methylmercury that is produced can move directly into the aquatic food web.

For a water body to become seasonally anoxic in its bottom water, the bottom water must first become isolated from aerated surface layers. This normally occurs during the warm season, mainly in systems deeper than most of these ponds, when the surface app. 6 m (20 ft) is warmed by the sun to temperatures well above that of the cool lower water. Water of different temperatures has different densities, and these are strongly resistant to mixing. This results in a warm season 'mixed surface layer' (by wind) and an isolated, cool hypolimnion (bottom waters). Warm season separation of the water column into non-mixing layers is called 'thermal stratification'. If there is a net consumption of dissolved oxygen in the hypolimnion during the time it is isolated (through normal metabolism by macro- and micro-organisms, just like we consume oxygen), the bottom water can eventually become anoxic. This will persist until the surface waters cool in the fall to a temperature and density matching the bottom layers, and strong winds can re-mix and aerate the entire water column. This annual phenomenon is known as 'fall turnover'. Long term, climate change can be expected to increase the seasonal surface warming of ponds/lakes in Yolo County, increasing the isolation of bottom waters and the development of seasonal anoxia.

Most of these aggregate-mining ponds – except for Syar–West – currently have depths and basin configurations that do not allow for the development of full thermal stratification across the warm season. If they did, as at Syar–West, the temperature profiles would show a nearly un-changing cool temperature in the bottom water from winter and throughout the summer. Instead, at the shallower ponds, the bottom temperatures eventually rose closer to surface levels, showing that there was at least occasional mixing from above. Despite this, the relatively small temperature gradients that persisted were enough to allow significant drops in dissolved oxygen at two of the shallow ponds – the same two that have the very highest fish mercury levels (Teichert-Esparto–Reiff and Syar–B1). The Syar-West pond, with the most extensive bottom anoxia cycle, was also a fairly high fish-mercury site. In contrast, at the low fish mercury Cemex-Phase 1 Pond, there was no seasonal anoxia. These four cases were all consistent with the factor of deep water anoxia correlating with elevated fish mercury, and vice-versa.

However, the Cemex–Phase 3-4 Pond was also an elevated fish mercury site, but it showed no sign of bottom anoxia. This illustrates the complex, potentially multi-factor nature of mercury cycling in aquatic systems. All of these ponds occupy former depositional zones impacted by historic mercury mining upstream in the watershed; all likely contain sediment inorganic mercury at concentrations and bioavailabilities sufficient to lead to problem levels of methylmercury production and movement into fish – under certain conditions. Seasonal bottom water anoxia appears to be one important factor.

Additionally, the observed differences in general water clarity (Secchi disk visibility) were almost certainly linked to differences in fish bioaccumulation of methylmercury. However, there are multiple factors linked to water clarity, some of which can influence the cycle in opposite directions. Low clarity / highly turbid water, which by definition contains a lot of suspended particles, also contains a lot of alternate binding sites for methylmercury, potentially making it less available for uptake into the food web. However, low clarity / high turbidity also acts to block sunlight from reaching below the top meter or two of water, shutting down algal photosynthesis and the production of dissolved oxygen. This can accelerate the development of bottom water anoxia and methylmercury production. In contrast, high clarity / low turbidity water, which contains fewer suspended particles, has far fewer alternate binding sites for methylmercury to be deflected to. Even if the total amount of aqueous methylmercury is lower in a clearwater system, the lack of competing binding sites can result in a higher proportion of it accumulating in the food web. In a competing effect, though, high water clarity also brings sunlight, photosynthesis, and oxygen production to much greater depths, potentially all the way to the bottom of some of these relatively shallow ponds, keeping bottom water oxygenated and driving methylmercury production down into the sediments. Additionally, methylmercury can be broken down or 'de-methylated' by ultraviolet light, the component of sunlight that gives us sunburns and degrades things left out in the sun. With high water clarity, this can become an important methylmercury removal process, a 'natural remediation'. In contrast, at the very turbid ponds with slurry inflows, sunlight-based de-methylation of mercury is blocked. It is likely that these and additional related effects played a role in the differences seen in ultimate mercury accumulations in fish of the different ponds. After mining and reclamation is completed, many of the current ponds can be expected to become clearer water systems, which will affect both of these processes.

We went into detail here about some of the many processes that can be in effect – around this single issue of water clarity – to give you a sense of how the methylmercury cycle can be complex, sometimes confusing, and often different in different aquatic systems. Rather than being a straightforward function of physical chemistry, it also hinges on biological processes, each with its own set of factors.

At this point with the new water profiling data, seasonal bottom water anoxia – or its absence – appears to be an important link to the observed fish mercury trends. Since seasonal anoxia is known to enhance the production of methylmercury and its movement into fish, management approaches that disrupt that pattern may reduce the problem. This is something to consider for ponds identified as elevated in fish mercury and requiring management. The profiling results to-date support management approaches that could provide summer mixing and the disruption of bottom water anoxia – specifically for ponds that require mercury management and that have seasonal anoxia. The case of Cemex–Phase 3-4 though, with high fish mercury but no seasonal anoxia, is a reminder that there may not be any single 'magic bullet' management approach; different approaches may be needed at different sites. Many different physical, chemical, and biological factors can influence the mercury cycle in each pond. Seasonal anoxia is the most straightforward one to tackle – when it is present. When it isn't, and fish mercury is still elevated, other mechanisms will need to be identified for possible alternate management approaches. This water column profiling is an important step to better understand the options.

## REFERENCES CITED

Slotton, D.G., and S.M. Ayers. 2020. Cache Creek Off-Channel Aggregate Mining Ponds – 2018 Water Column Profiling; May 2020 final draft. *Report for Yolo County*. 53 pp.

Slotton, D.G., and S.M. Ayers. 2020. Cache Creek Off-Channel Aggregate Mining Ponds – 2018 Mercury Monitoring (fish); May 2020 final draft. *Report for Yolo County*. 138 pp.

Yolo County Code, Title 10. Chapter 5 (Surface Mining Reclamation), Section 10.5.517. 2020 update and revision. Mercury Bioaccumulation in Wildlife.