Review of

East Grand Lake Upper Region Ecolo(g)ical Enhancement Project (AT-0022) Preliminary Maintenance, Monitoring, and Adaptive Management Plan.

Prepared on 02/09/2021 By CPRA

by

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NATURE OF PROJECT

This report reviews a draft Adaptive Management Plan by the CPRA (the applicant) in support of an application to the Corps. The CPRA has requested Department of the Army authorization to clear, grade, excavate, and place fill to improve the north to south hydrologic flow in Bayou Sorrel during moderate river stages for improved circulation and ecological function throughout the back swamp of the East Grand Lake (EGL) Area of the Atchafalaya Basin. Additional enhancement and restoration features proposed include the deposit of excavated material to create marsh and provide nourishment for forested areas within the project site. Within the nourishment areas non-native tallow trees will be removed and native trees will be planted. Approximately 18,261 cubic yards of native material will be excavated and re-deposited to complete the project. The applicant proposes that the area of benefit through hydrologic restoration would be approximately 5,560 acres of swamp habitat (MVN-2016-01163-CM-PN all.pdf).

A preliminary analysis by the US Army Corps of Engineers (USACOE) has determined that the proposed project would convert approximately 4.4 acres of forested wetlands to "other waters of the U.S.," create 2.25 acres of fresh marsh, and enhance 3.6 acres of bottomland hardwood wetlands (MVN-2016-01163-CM-PN all.pdf). The USACOE in their own preliminary assessment state the benefits will only be the enhancement of 3.6 acres of bottomland hardwood forests and create 2.25 acres of fresh marsh!, **not the 5,560 acres claimed by CPRA.**

This project does not meet the goals of CPRA (See https://coastal.la.gov/whats-at-stake/a-changing-landscape/ amongst others).

ADAPTIVE MANAGEMENT?

This document under review relies on a definition of adaptive management that it seems to promote as the CPRA accepted definition, although there is a major problem in what is quoted in this report as will be shown below. Thus, this 2021 CPRA Plan concerning the EGL project states:-

> "Adaptive management, as CPRA defines it, is a structured process for making decisions over time through active learning that enables adjustments to be made in projects and programs as new information becomes available (Raynie, 2017). Adaptive management embraces a scientific approach that involves identifying goals and objectives, developing and implementing actions, assessing the system's response to the actions, and utilizing that knowledge to make management decisions. It also recognizes the importance of stakeholder engagement and consensus building when implementing actions that affect structural, ecological, and socio-economic systems. An adaptive management approach helps identify realistic outcomes that can be expected from project implementation."

This quoted definition of Adaptive Management is reported to have come from Raynie 2017. This proposed East Grand Lake (EGL) adaptive management plan by CPRA (2021) will, according to the authors, "assist in guiding the design, construction, implementation and reporting of the EGL project throughout its project life." They further claim that "As is consistent with the principles of adaptive management, this plan will be living document that can be modified during project implementation as conditions warrant (CPRA)."

So, the authors of the 2021 CPRA report in support of the EGL project claim to quote Raynie (2017) to imply that adaptive management is **a project specific process** without pointing out how over time the project could be modified and how stakeholders will be incorporated. Significantly, the Raynie report relied upon for this understanding and application of adaptive management is not available online through the CPRA. It was ultimately obtained through a public records request to the CPRA, which provided the report and and accompanying email that stated, "This is the report that is cited or referenced in the CPRA's Draft Adaptive Management Plan for East Grand Lake. It is a draft. There is not a final version, so some of the envisioned appendices were never finalized."

The email came from Jennifer Moon of the Legal section of CPRA. She also implies that the CPRA EGL Adaptive Management Plan document under review here is also a draft; communications with the CPRA support this but no further updated version has been found or made available.

The date on the Raynie report is 9th May 2017.

So, the Raynie (2017) report used extensively by CPRA in their 2021 writings in support of the EGL project was a draft of something that was never finished and has never been published. In fact, one of the Appendices in the Raynie Report was not started or completed was **7.2 B. Project-specific Adaptive Management –** a significant omission given that Raynie was the source for supporting project-specific adaptive management in the CPRA Plan.

I did find a similar report by Ann Hijuelos and Denise Reed (2017) as presented in the 2017 Louisiana State Coastal Master Plan. Bingo! This is an officially published CPRA document.

What the CPRA (2021) authors claim about adaptive management (the Raynie draft) differs somewhat from Hijuelos and Reed (2017) who state:-

- "Louisiana's dynamic coastal environment lends itself to adaptive management, given the shifting baselines associated with ongoing landscape change and, consequently, the difficulty in predicting the future effects of protection and restoration actions. The goal of this adaptive management plan is to maximize the success of the coastal protection and restoration program by iteratively incorporating new information into each step of the master plan decision making process. The adaptive management process aims to reduce scientific uncertainty in the development, evaluation, and formulation of the master plan in order to improve programmatic decisions." (Note: focus is on the Master Plan).
- "To meet this challenge, adaptive management within the context of the five year cycle for updating the master plan provides a structured process for making decisions over time

through active learning and enables adjustments in program implementation as new information becomes available."

- "This plan does not describe project-level adaptive management and uncertainty associated with individual projects." (Emphasis added.)

Adaptive management as defined by Hijuelos and Reed (2017) relates to the State's Master Plan and its modification over time and not to specific projects (http://coastal.la.gov/wp-content/uploads/2017/04/Appendix-F_FINAL_04.04.2017.pdf)

These authors do not define a project specific adaptive management plan. Hijuelos and Reed (2017) in their discussion of Adaptive Management state that some of the key differences between programmatic and project-level adaptive management have been previously described (The Water Institute of the Gulf, 2013).

So, the whole basis of the CPRA 2021 report, which basically reads as a proposal to fund the Nature Conservancy to do some project specific monitoring, is a non-starter as it uses as its foundation a definition of Adaptive Management which is not the one envisaged in the CPRA 2017 Plan!!

EXPLANATION OF THE EUTROPHICATION AND HYPOXIA ISSUE IN THE BASIN

Much of the CPRA's Adaptive Management Plan is based on studies cited in the Plan including two by Baustian, et al., which are premised on a limited and atypical data set.

As pointed out by van Heerden (2019a), Mississippi River nutrient levels three times higher than pre-1975 leads to eutrophication and hypoxia in Atchafalaya Floodway swamps during River floods. External pressures are exacerbating internal eutrophication events, leading to hypoxia and its attendant negative impacts socioeconomically as well as to the fragile ecology. van Heerden recognizing how the natural hydrology of the Basin has been modified by human activity and interference, such as oil and gas exploration, navigation, sediment dispersal projects and such. As a consequence, highly mobile suspended sediment is rapidly infilling the swamps being mostly flood induced. Van Heerden (2019a) also concludes that the present management of the Basin (Floodway and original Basin elements outside the Floodway) is exacerbating these detrimental processes as the safety floodway rapidly fills with sediment and loses its capacity to absorb floodwaters – its original purpose.

Van Heerden (2019 a, b, and c) concludes, after presenting real data, that the proposed EGL project will in essence set up additional sediment introduction pathways to the detriment of the ecology of the Basin and its possible **public safety Mississippi River flood reduction role.**

CPRA (2021 report under review herein) uses the conclusions of Baustian et al (2019) extensively in trying to justify this project and as support for the 'management plan proposal.' Baustian et al (2019) state in their Abstract "We found that when water levels were high enough to overtop bayou banks and spoil banks, north-to-south flow patterns were reinstated and water quality in the backswamp was improved. Specifically, hypoxic conditions, which had been common before the flood, were alleviated whereas the swamps were receiving flowing, oxygenated river water. The magnitude and duration of dissolved oxygen improvement was dependent on the length of time a site received river water."

What Baustian et al (2019) failed to mention is that their conclusion was based over a very short study period and is not reflective of the actual longer-term conditions in the Basin. They deployed YSI EXO2 sondes (YSI Inc., Yellow Springs, OH, USA) at selected monitoring station from April 2017 to July 2017 in an attempt to capture the dynamics of the late-spring/early-summer flood. In other words, they used a very limited 4-month study to characterize the whole hydrodynamics of the Basin and explain the eutrophication/hypoxia mechanisms and reason with 4 months of data (anomalous data, as discussed below). This is an impossible task. They had access to data for other years (see van Heerden 2019a for example) but they failed to report the hypoxia increases related to River flooding of those years.

We will now review the detailed study van Heerden (2019a) performed over a 4-year period; so, sampling of 4 different annual floods. The period chosen for this research was 1 January 2016 to 31 December 2019 as it matched measurements that have been acquired in the central part of the Basin, in the vicinity of the proposed East Grand Lake (EGL) project. This thesis looked at the changing water quality cycles in the Basin as against the major source of the nutrients and suspended sediments, namely the Mississippi River. Data at a big picture river scale was reduced and then compared to in-basin and specific monitoring sites - at a small picture scale. Both sets of data independently reveal the **major** role highly nutrient-rich Mississippi River floodwaters play in Eutrophication and Hypoxia in the Basin Floodway (van Heerden, 2019a).

<u>The 2017 Mississippi River flood – a very rare flood source</u>

In this review we will first assess EGL sites data specifically for the time period chosen by Baustian et al (2019) and then review a 4-year comprehensive study (van Heerden 2019a). Figure 1 depicts the Mississippi Catchment and location of its main distributaries. A river catchment is an area of land where water collects when it rains, often bounded by hills. As the water flows over the landscape it finds its way into streams and down into the soil, eventually feeding the river. Some of this water stays underground and continues to slowly feed the river in times of low rainfall. The area of the Mississippi Catchment is depicted in Figure 1. Every inch of land on the Earth forms part of a catchment. Suspended sediment and nutrient loads for each Mississippi/Atchafalaya flood are controlled in part by which Mississippi upstream tributaries are in flood. For example, the extreme Mississippi River flood of 2011, when the major contributor of streamflow to the lower Mississippi-Atchafalaya River sub basin during April and May was the Ohio River, resulted in lower concentrations of suspended sediment, pesticides, and nutrients than water from the upper Mississippi River (Welch et al 2014).

Figure 1. Tributaries of the Mississippi River and its catchment.

Figure 2 represents the daily Floodway stage at Butte la Rose for 2016 and 2017. The Figure also reveals the rather short time period that Kong (2017) sampled her sites in the Basin in 2016 and 2017. Her 2017 sampling coincided with that of Baustian (2019). Kong (2017) is used by CPRA elsewhere in their submissions to justify the EGL project and has been thoroughly reviewed by van Heerden in other submissions concerning the merits of the EGL project.

The 2016 flooding on the Missouri and Upper Mississippi Rivers, which included extensive snow melt, would have contributed very high levels of suspended sediment (Figure 1) during the period of Kong's sampling. By contrast, the 2017 flood peak sampled by Kong represented the result of 1:1000-year rainfall in a relatively narrow east-west band from Joplin MO to New Albany IN in the lower half of the Mississippi catchment across a portion of the Mississippi and Ohio Rivers (Figures 3 and 4). This was a sudden rainfall-induced flood peak <u>and not fed</u> by industrial fertilizer nutrient-loaded upper reaches of any of the main Mississippi River catchment feeders such as the Missouri River - a very different kind of flood to 2016 and not a great suspended sediment producer. So, suspended sediment and nutrient loads reaching the Atchafalaya Floodway were lower than normal for the flood peak associated with this 1:1000-year rainfall event south of St Louis MO. What is evident for each of Kong's sampling periods is that she did get data during a flood peak, part of the overall Atchafalaya flood of each year (Figure 2).

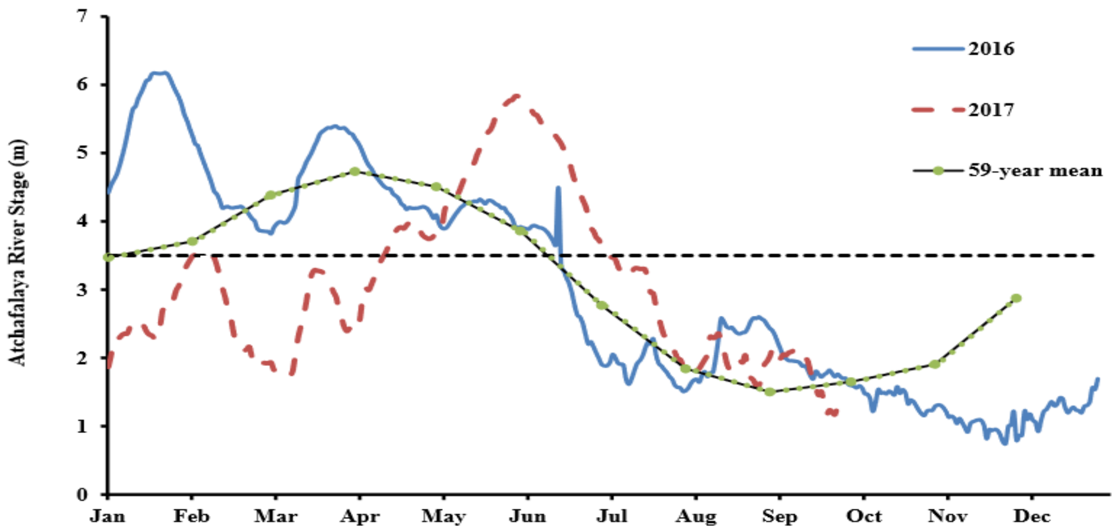

Figure 2. *Daily Atchafalaya River stage at Butte La Rose for 2016 and 2017 and the 59-year monthly mean. Also shown are Kong's sampling period for each of the years. Note the relatively narrow flood band of the 2017 rain induced flood, which was sampled in its ebbing stages.*

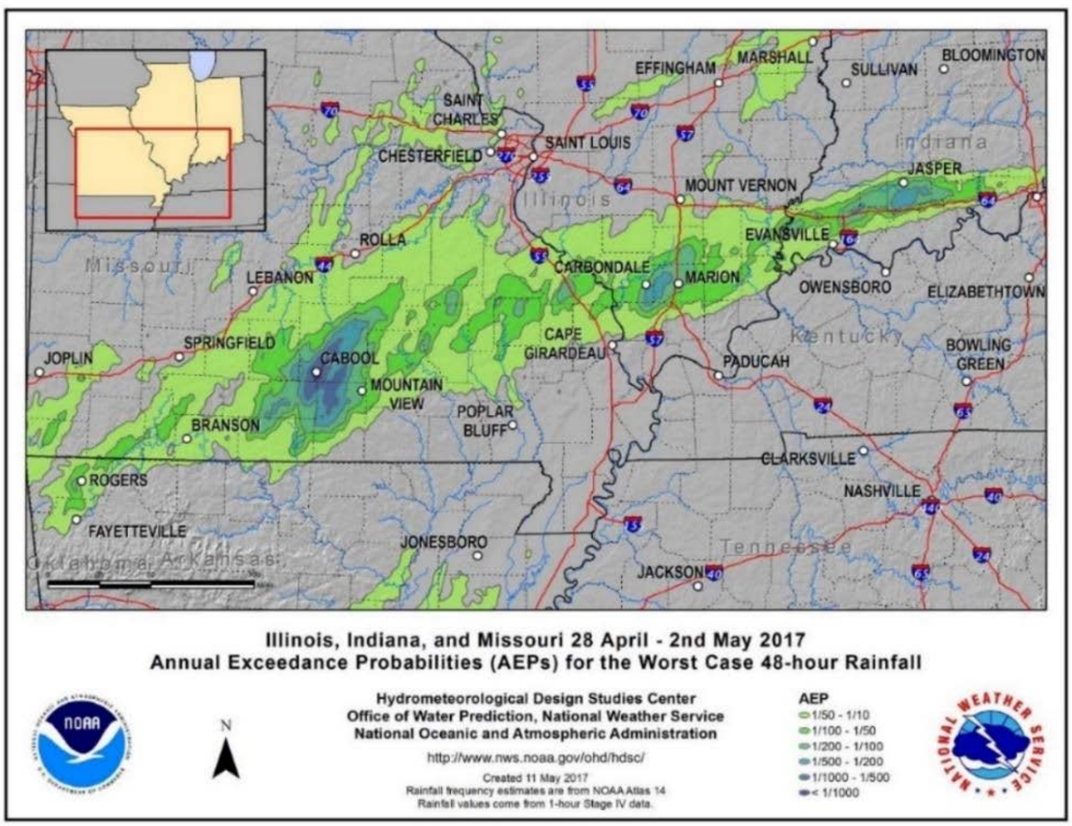

Figure 3. The catastrophic 1:1000-year rainfall event that precipitated a 2017 flood peak event on the Atchafalaya.

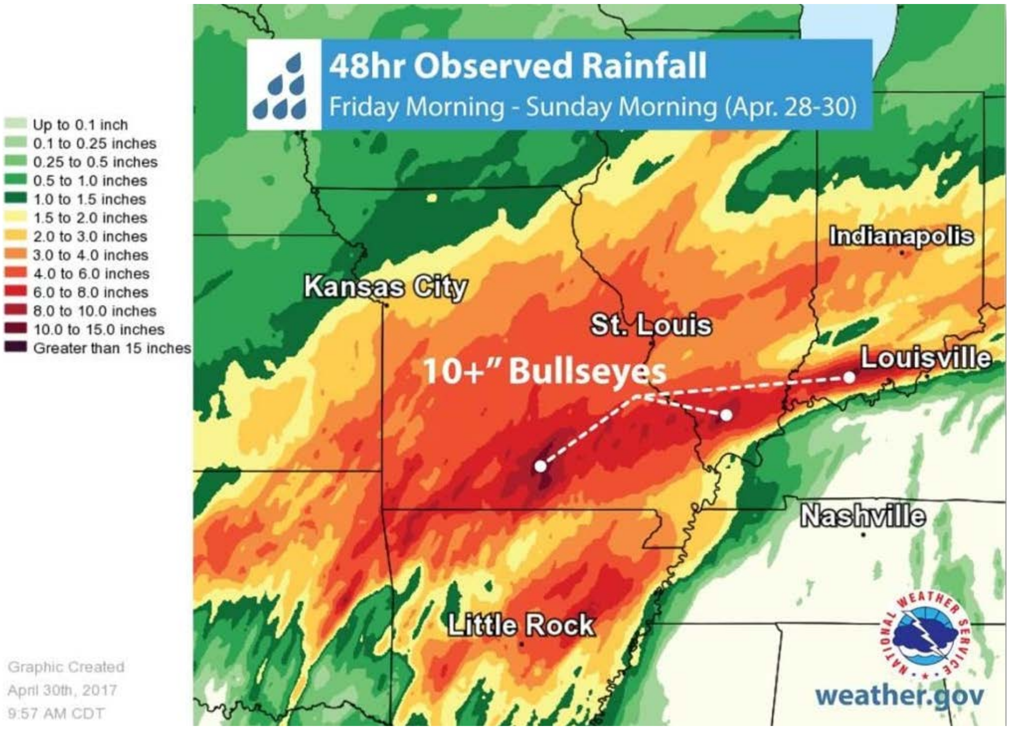

Figure 4. 48 Hour Observed Rainfall during 1:1000- year event, April 2017.

It is important to note that research has shown that turbidity (suspended sediment) and nutrient levels in the Mississippi River are coupled (Rabalais 2007). The higher the turbidity, the higher the nutrient concentrations being carried by the flood water.

<u>Turbidity, nutrient, and dissolved oxygen processes in the swamps and their consequences – the inner basin picture</u>.

a. <u>Data Sources</u>

In trying to better understand the causes of hypoxia an intensive literature search was undertaken by van Heerden (2019a). This included data obtained by review of both a thesis by Kong (2017) and TNC data collected by the state in the Basin. Kong's 2017 thesis titled "Population characteristics of red swamp crayfish *Procambarus clarkii* from hydrologically impaired locations in the Atchafalaya River *Basin*" presents data from locations in the central part of the eastern half of the Floodway for Atchafalaya River for flood events in 2016 and 2017. Unfortunately, her University, although funded by state dollars, would not make available the original data. It appears that The Nature Conservancy (TNC) funded her work. Kong collected data from various locations in the Basin, but her focus was the EGL project area. For example, her sites 12, 13, and 14 are in an area with lots of spoil banks that crawfishermen report does not generally produce crawfish. Site 12 is a dead zone as a consequence of brine waters previously dumped by an oil company; marked by dead cypress. So, where necessary Kong's data as presented in her thesis has been subjected to different plots, and other data sets have been incorporated to further interpret the data. Missing from her thesis is any quality control or assessment of the accuracy of her measurements, no calibration data, and the actual measurements. So, in this respect this thesis is still a working draft as we await Nicholls State University to respond to our requests. van Heerden (2019) discusses Kong's thesis in depth.

Kong (2017) presented data from locations in the central part of the eastern half of the Floodway for Atchafalaya River flood events in 2016 and 2017. Unfortunately, her University, although funded by state dollars, would not make available the original data (two requests). In general Kong (2017) presented means or averages and not temporal data at each site. Her sites for this analysis were chosen on their proximity to the various elements of the proposed EGL project (Figure 5). Where necessary Kong's data has been subjected to different plots and other data sets have been incorporated to further interpret the data. Missing from her thesis is any quality control or assessment of the accuracy of her measurements, nor any calibration data.

Kong (2017) study reflects data that was collected only during a specific flood peak of the Atchafalaya River for each sample site. There was no data collected for the rest of the hydrologic year, so flood vs non-flood comparisons are not possible. She should have sampled throughout the year in each case in order to at least determine seasonal or even flood versus non-flood situations. She sampled only flood peaks in 2016 and one in 2017 (Figure 2). Each of the flood peaks' origin and characteristics were quite different as discussed above, representing typical (2016) and extremely atypical (2017) years (Figures 2, 3 and 4).

Since 2017, the Nature Conservancy (TNC) have collected water quality data in the same region of the Basin although not at the same locations. Figure 5 depicts the location of TNC data collection sites (as provided by TNC) although there is no GPS data, location or environment setting data. On 3/1/2019 a crew from the Atchafalaya Basinkeeper familiar with the area could not locate any of the TNC sites even though they should be readily noticeable. Sites AU1 and AU6 both appear to be on the back slope of a high spoil pile along the bank of an excavated channel. If so, these are not ideally situated to be collecting 'swamp' data. This review will focus on the Kong sites that cluster closest to the TNC sites (Blue box in Figure 5).

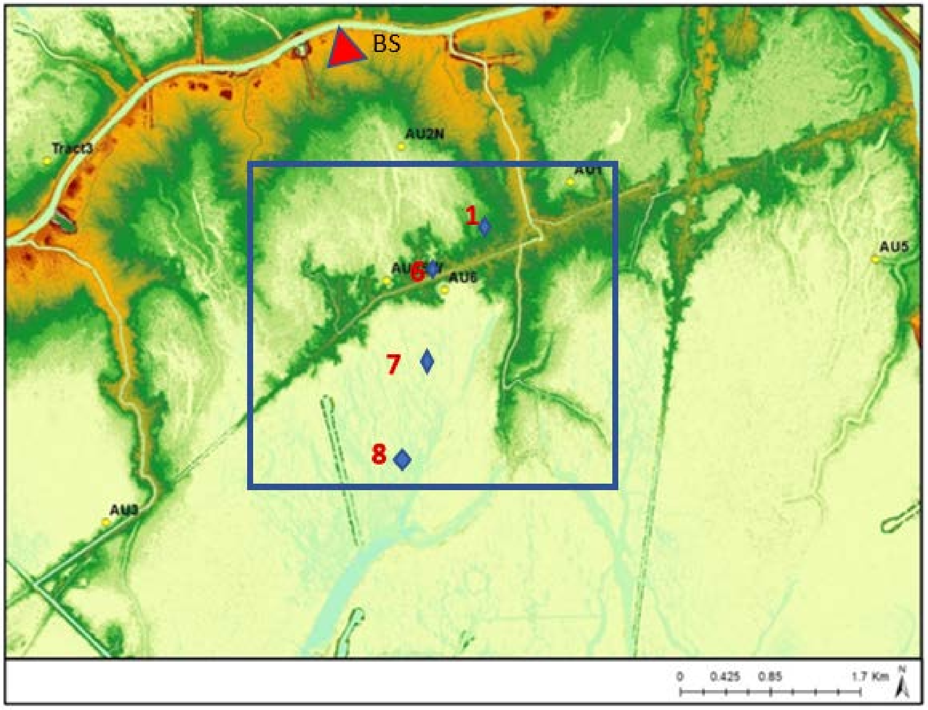

Figure 5. Kong's 2016 sampling sites 1, 6, 7, and 8, same region of the Basin as TNC sites AU1, AU6, and AU2SW in 2017 and 2018. LiDAR image, richer the color higher the elevations. TNC sites and Kong's 1, 6, and 7 are on the edges of levees at higher elevations than interior backswamps. Kong's site 8 is more of a backswamp location. All site location interpolated from small scale diagrams in Kong and TNC reports. No GPS data available. Note the location of gauging station Bayou Sorrel (FWS) marked red diamond BS to be discussed later.

b. Kong's 2016 data explained.

In interpreting Kong's (2017) data it is very important to recognize that the 2016 flood water is sourced from snow melt over the greater Mississippi catchment (Figure 2); as compared to the 2017 flood which reflected a somewhat Localized heavy rainfall induced flood pulse with the flood source being the flooding of land and subsequent runoff water from a narrow portion of the lower Mississippi River (Figures 3 and 4). As mentioned previously, the 2016 flood was a catchment flood with high turbidity (Figure 6) whereas the 2017 flood peak sampled by Kong (2017) was basically a 'clean water' flood with low turbidity (Figure 7). The 2016 turbidity data in the Kong sampling period ranges from a low of 78 NTU to a high of 115 NTU; while in 2017 the turbidity in the sampling period starts at a high of about 100 NTU and falls rapidly to low of 35 NTU before rising a bit. This will be discussed in more depth shortly, but we find very different turbidity responses when comparing 2016 to 2017.

Ground Elevations

The need is to understand hypoxia in swamps rather than levee locations, so 4 swamp locations were chosen (Figure 5). As discussed by van Heerden (2019b), Kong (2017) does not present any elevation data (nor does TNC) at any of her sites. This is of <u>critical importance</u> in trying to understand flooding and duration of inundations, amongst other issues. The measure she uses to determine inundation of her sites is based on an unofficial crawfish season, namely:

"Intensive and extensive sites were sampled twice a month during the crayfish seasons from 19 March to 9 June 2016 and from 7 May to 3 July 2017. There is no official crayfish season set by resource managers in Louisiana, instead, wild crayfish harvest is determined by Atchafalaya River water level. The crayfish season began when the Atchafalaya River level at Butte La Rose, Louisiana (U.S. Army Corps of Engineers gauge 03120, 30°16'57" N, 91°41'17" W) was greater than 3.5 m, which resulted in floodplain inundation at intensive site locations."

So, Kong (2017) seems to be suggesting that the ground elevation, or perhaps the average ground elevation of her sites is 3.5 m or lower as relates to the Butte La Rose gauging station. There is no real or hard data to support her 3.5 m (11.48 ft) assertion. In discussion with commercial crawfishermen in the Basin I am told that they start commercial harvesting once the stage at Butte La Rose has exceeded 7.0 ft for a week. In their experience this inundation level and overtopping takes about a week to fill the swamp so that they can get boat access. Generally, they need about 18 inches of water to move their boats to their trap sites. This suggests about 5 feet (1.5 m) swamp elevation where they fish. There is no scientific justification for Kong's 3.5 m assertion, a major flaw of this study. She gives no indication of the elevations of her sample sites other than water depths must have exceeded 18 inches for her to have boat access and collect crawfish at her sites each time they were sampled. This lack of data becomes critical as we further discuss Kong (2017) thesis and the TNC data.

Van Heerden (2019a) developed techniques to get an indication of the elevation of Kong's sites, but all Kong and TNC interpretations were based on the stage data from Butte La Rose, 15 miles away and further up Basin – not ideal at all. Figure 2 from Kong (2017) presents Butte La Rose daily water level stage data for 2016 and 2017 with her assumed 3.5 m 'line.' TNC for some reason also only utilized the Butte La Rose gauge in all their reports, rather than the gauge at Bayou Sorrel locks which is much closer to the TNC and Kong's sampling sites, and, at about the same latitude.

As van Heerden (2019b) pointed out, TNC do, however, supply data from which it is possible to get a rough representation of the ground elevation at their sites. Using the Butte La Rose gauge data van Heerden (2019b) used two different techniques to determine potential ground elevations in Kong's study area. Figure 8 is TNC representation of the daily mean water stage for 2017 at Butte La Rose and Figure 9 represents mean daily water levels at their 7 monitoring sites for the same time period. TNC communication via email 01/28/2019 informed that the water levels presented in Figure 9 are as follows: "The depth sensor on the Sonde (instrument) is about 15 cm off of the sediment surface, so these data … would be the water levels above the sensor, which is 15 cm above the soil surface." Thus, if one knows the river stage and one knows the water depth at each sample site, by simple subtraction Gauge stage minus water depth and then adding the instruments' height above ground of 15 cm, one can get the elevation of each site as it relates to the datum for the Butte La Rose gauging station. TNC (2017) state that Sonde water level data track the stage at Butte La Rose, but provide no data. As will be shown shortly this assertion does not hold true.

Van Heerden (2019a), recognizing that the head or fall of water from the Butte La Rose gauge to the study area (about 15 miles to the northwest) at high or peak stages is most likely to be the greatest, so his calculations were based on stages of 3 m (9.8 ft) and lower. This was done to

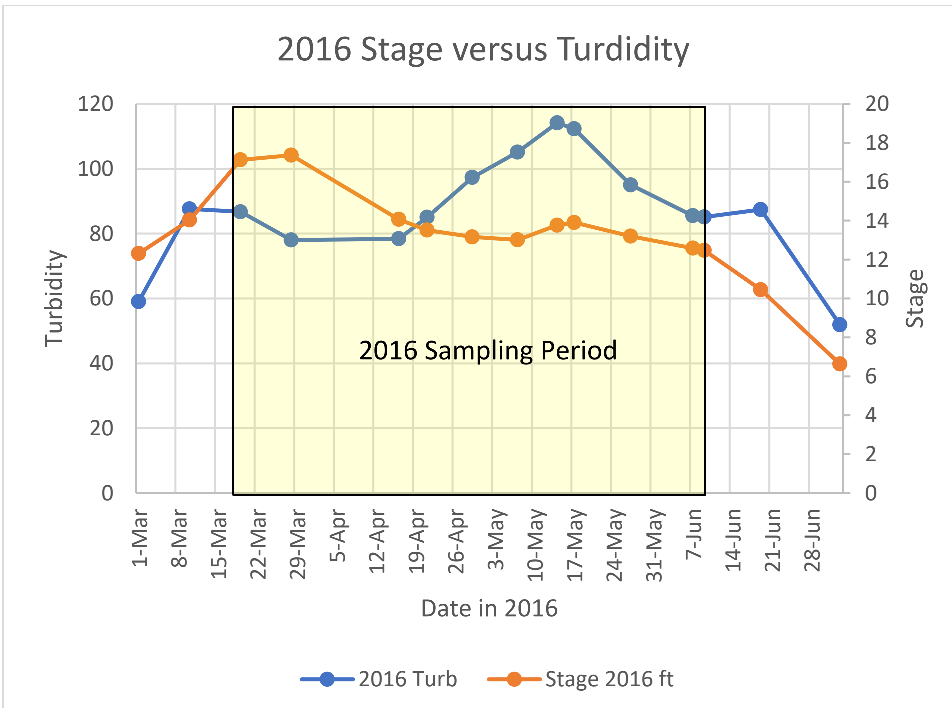

Figure 6. Stage and turbidity comparison of the 2016 flood peak sampled by Kong (2017).

Minimize any slope over the 15-mile fall during the fall of the peak flood. Even though there is a low probability that the water surface at Butte La Rose gauge and the study site were at the same elevation, I proceeded in the face of a lack of any other data. SIGMA, the engineering company contracted by the state to design the EGL project, subsequently claimed, without any supportive data, that in the EGL project area the stages were 6.5 feet below Butte La Rose (van Heerden 2019c). As we will see below that was way off and raises questions about the whole design process.

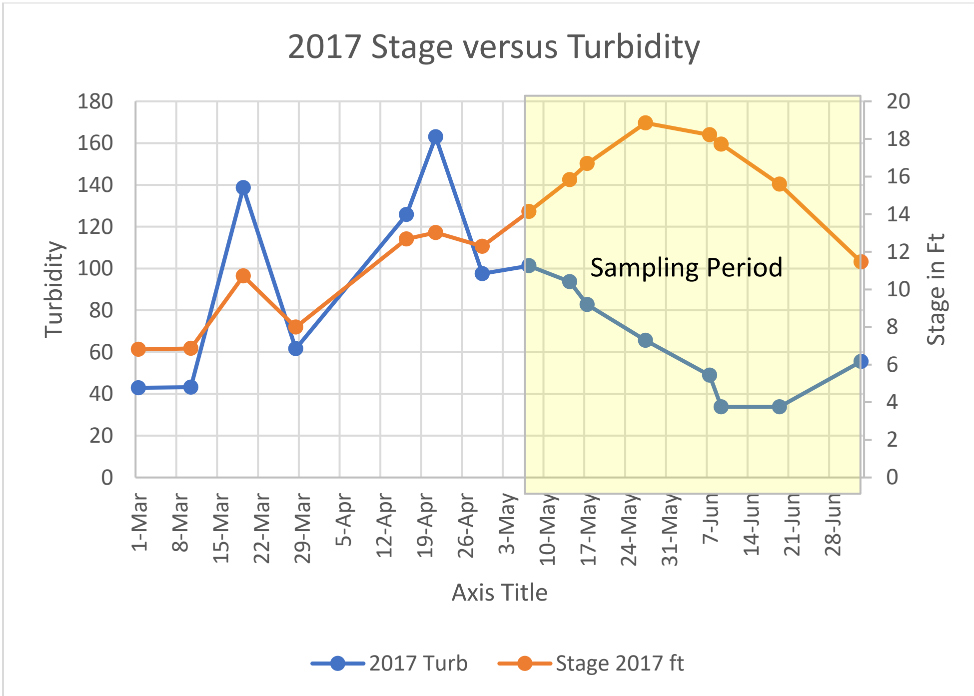

Figure 7. Stage and turbidity comparison of the 2017 flood peak sampled by Kong (2017).

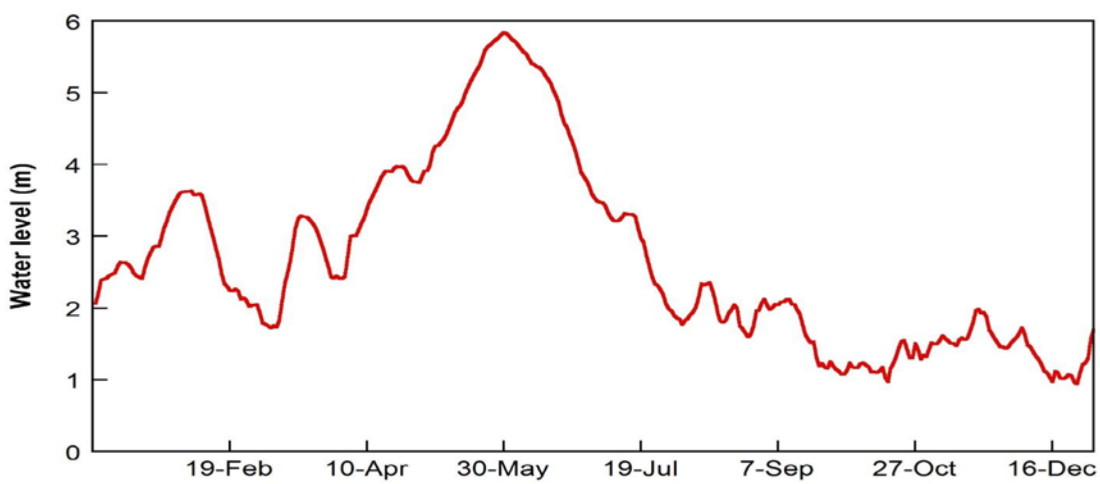

Figure 8. Daily mean water levels at Butte La Rose during 2017. Preliminary data from USGS gage 07381515 Atchafalaya River at Butte La Rose, LA (TNC 2017).

Doing the subtraction for the 2017 TNC sites AU1, AU6, and AU2S gives a ground elevation for each data sampling site and then calculating the average gives a ground elevation at Kong's and TNC sites, as relates to the Butte La Rose gauge datum, of 2.47 meters (8.1 ft) (van Heerden 2019a), which is 1.0 meter (3.28 ft) lower than the 3.5 m unscientific assumption made by Kong (2017).

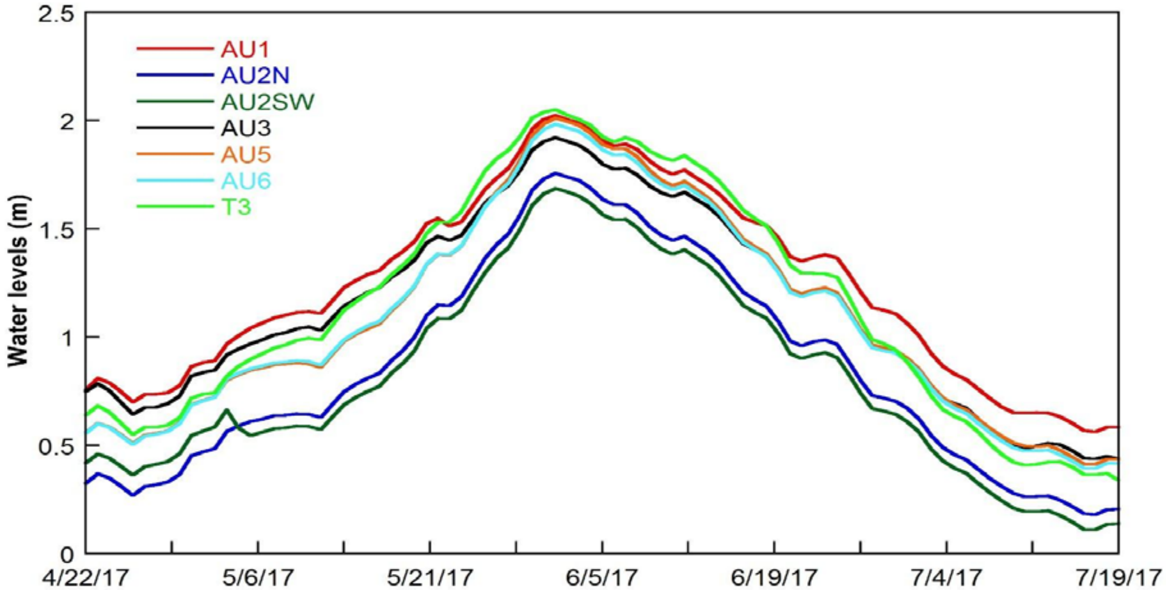

Figure 9. Daily mean water levels during the 2017 flood pulse at the seven TNC (2017) monitoring sites.

A second opportunity to determine site elevations became available from the 2018 TNC data released in 2019. Here the TNC sites AU2S and AU6 were utilized from 6/3/18 to 10/8/18 when the Butte La Rose gauge showed a leveling off of the water level from a peak through to the beginning of another peak – a time with very little if any surface slope. Doing the calculations in a similar manner to that above gives elevations of 8.7 ft at AU2S and 8.5 ft at AU6, not much different from the 8.1 feet found using the first method. However, these are at best approximates, used in van Heerden's 2019a and b reports, until new data became available as will be discussed next.

Late 2019, after a field trip to the area, van Heerden noted a gauging station on Bayou Sorrel very close to the proposed EGL project (Figure 5). After an extensive internet search the Bayou Sorrel (FWS) (49615) site data was located (Figure 5) with a datum of 0.0 NGVD. Figure 10 is a plot of the Bayou Sorrel (FWS) gauge superimposed on the Butte la Rose gauge, using the same axes for the period 12/10/2018 through 03/31/2020. What is strikingly obvious is the Butte La Rose gauge stages are not representative of the Bayou Sorrel - EGL project area, at all. In the flood of 2019, the Butte La Rose gauge was up to 13 feet higher than that at Bayou Sorrel but during low flows is only a few feet higher than at Bayou Sorrel (Figure 10).

As mentioned earlier the SIGMA engineering team claimed a 6.5 feet difference in stage elevations between the two sites, not real except at a very certain stage in 2019, maybe for a day or two. What is clearly demonstrated in Figure 10 is that the variances in stage between the two sites is totally dependent on river regime factors such as discharge and internal Basin hydrodynamics.

Now in order to get a representative elevation for the Kong and TNC sites a similar analysis to van Heerden (2109b) was undertaken using the stage data from the Bayou Sorrel (FWS) gauge. The period 06/10/2019 to 07/10/2019 was chosen being a period when the hydrograph was relatively flat (Figure 10). The range in water depths above the instruments at the various TNC sites (on average) for this period was 2.3 m to 1.7 m (Figure 11), while the Bayou Sorrel (FWS) gauge height varied from 3.96 m (13 ft) to 3.35 m (11 ft). By adding the 0.15 m instrument height above the ground (TNC pers comm) to the water depth measured by the instrument and then subtracting that sum from the gauge height one gets an elevation of the ground at each site sampled, 3.96 – (2.3 + 0.15) = 1.51 m and 3.35 – (1.7 +.15) = 1.5 m! Basically 5 feet of elevation. Similar to the suggestion based on crawfishermen's previous statement!

So, the general elevation at the TNC and Kong's sites chosen for this analysis is NGVD 1.5 m or NGVD 5 feet. Now finally we have a real and defensible elevation for the ground elevation at the relevant Kong and TNC sites, using stage data from a nearby gauging station. One can now proceed with the assessment of the data collected and the implications thereof. Importantly this new elevation data strengthens van Heerden (2019b, 2019c) conclusions.

Dissolved oxygen implications

The only time series (temporal) data in Kong's thesis is oxygen concentrations (Figure 12). The replot of the Kong data for Site 1 (Figure 13) reveals that for the full study period the site was flooded with at least 7 feet of water using a ground elevation of 5.0 feet as determined for this site based on the TNC and Bayou Sorrel (FWS) gauge data. It was being flushed by Atchafalaya River flood waters. So, there was a hydrologic connection to a channel somewhere. If such is good for improving Dissolved Oxygen ("DO") levels for the system, then there is obviously something else going on that is driving down the oxygen levels as the flood progresses as depicted in Figure 13. If connectivity to a channel and flushing were healthy for this site, then the DO should remain above the hypoxic zone. Kong (2017) states categorically without any justification that there was no hydrologic connection from at least 04/29/2016 onwards! Figure 25 reveals otherwise. This misrepresentation and conclusion seem random, and no scientific basis or explanation is presented. The question at this site then becomes: what is driving down the oxygen concentrations as the flood progresses? Kong's sites 6, 7, and 8 all repeat the same pattern of DO falling over time (Figure 12).

What about seasonal temperature corrections? Kong's data shows temperatures during her sampling varying from 18 C to 24 C which means about a 1 mg/l drop in DO – this does not explain the much higher DO drops observed. TNC 2017 shows temps from 22.8 C to 25.7 C, so less than 1 mg/l DO drop. TNC 2018, the data is a bust as in one figure the May temps are 15 C while the next 25 C – so what is real? The data is spread over two images in the TNC report and the use different Temperature scales on each so the data from one does not transfer to the other even though they share a common image boundary. TNC 2019 has a warming from 14 C to 24 C which would have resulted in a 2 mg/l DO drop. So, even though there are temperature issues, temperature data from Kong and TNC cannot account for more than a 2 mg/l drop in DO levels.

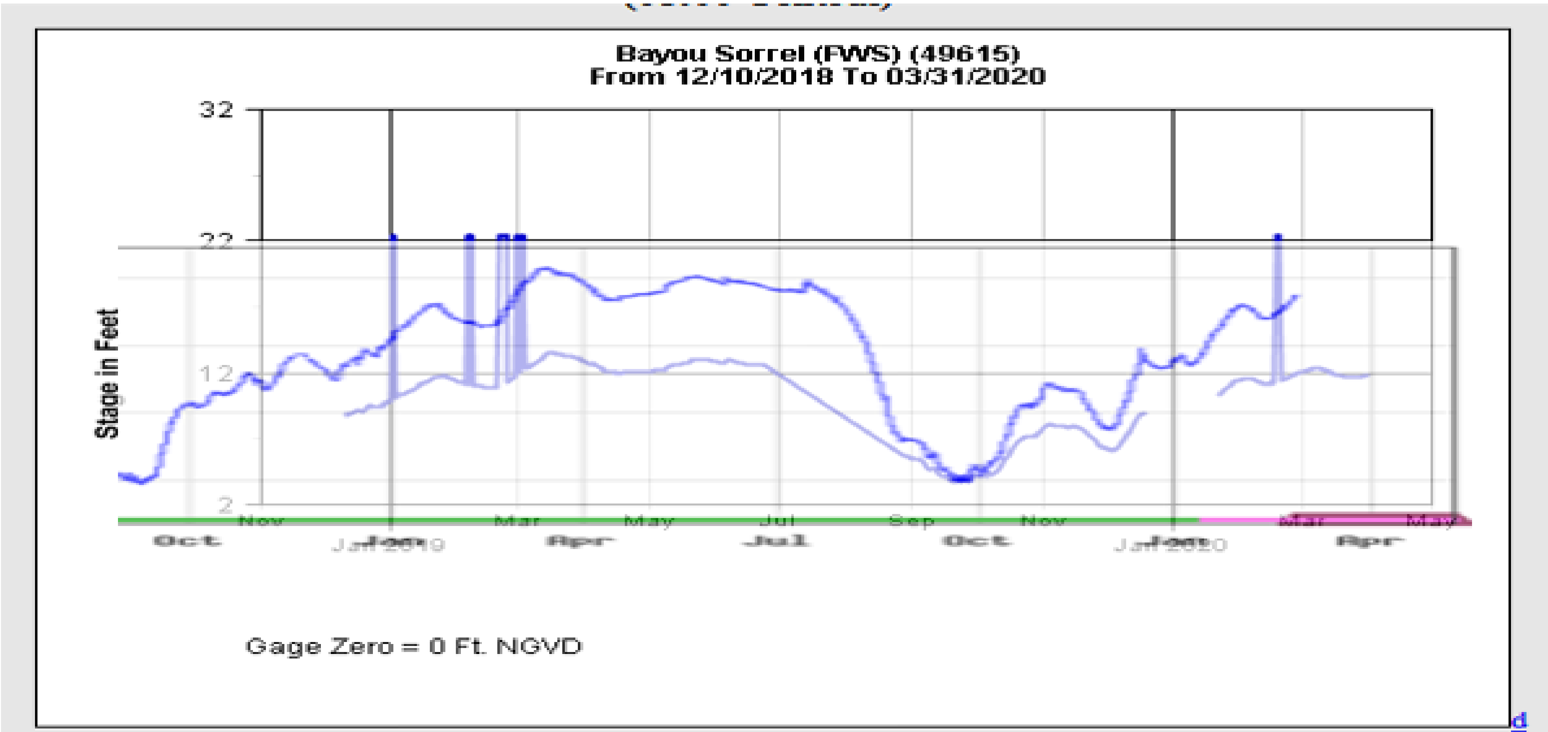

Figure 10. Butte La Rose gauge overlaid on Bayou Sorrel (FWS) late 2018 through early 2020. Butte La Rose the upper darker blue

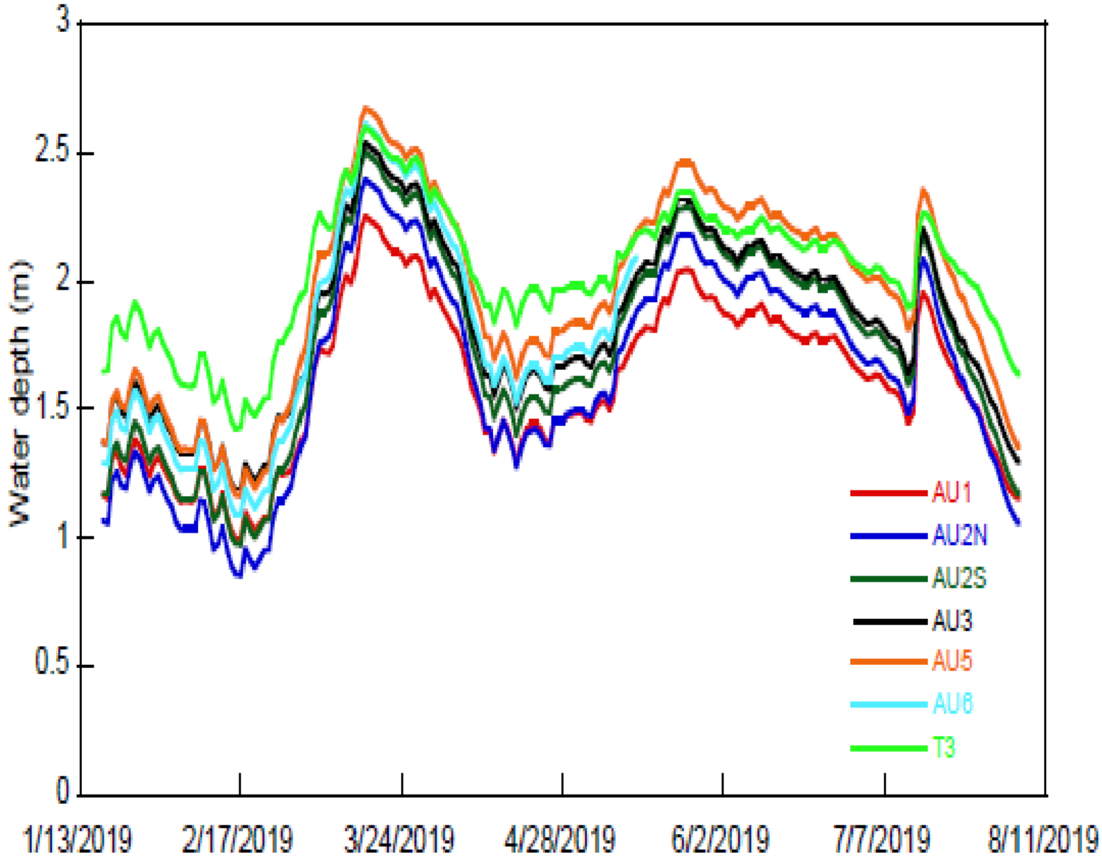

Figure 11. Mean Daily water levels at TNC monitoring stations 2019.

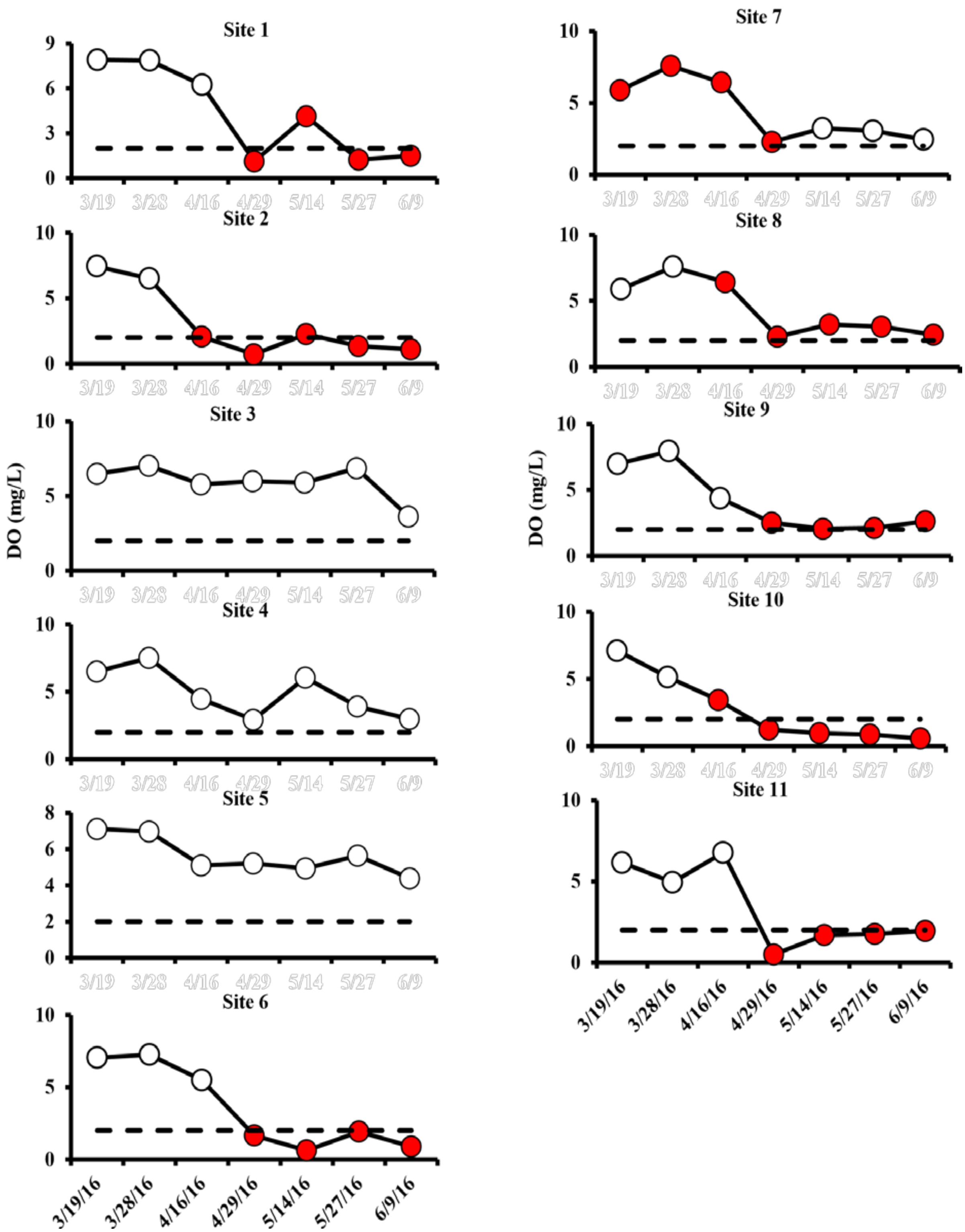

Figure 12. Dissolved oxygen (DO) concentration and hydrologic connectivity at Atchafalaya Basin Preserve sample locations during the 2016 sample season (Kong 2017). The red dots indicate when Kong assumes the site is hydrologically disconnected from flood water input, an invalid conclusion as this manuscript reveals.

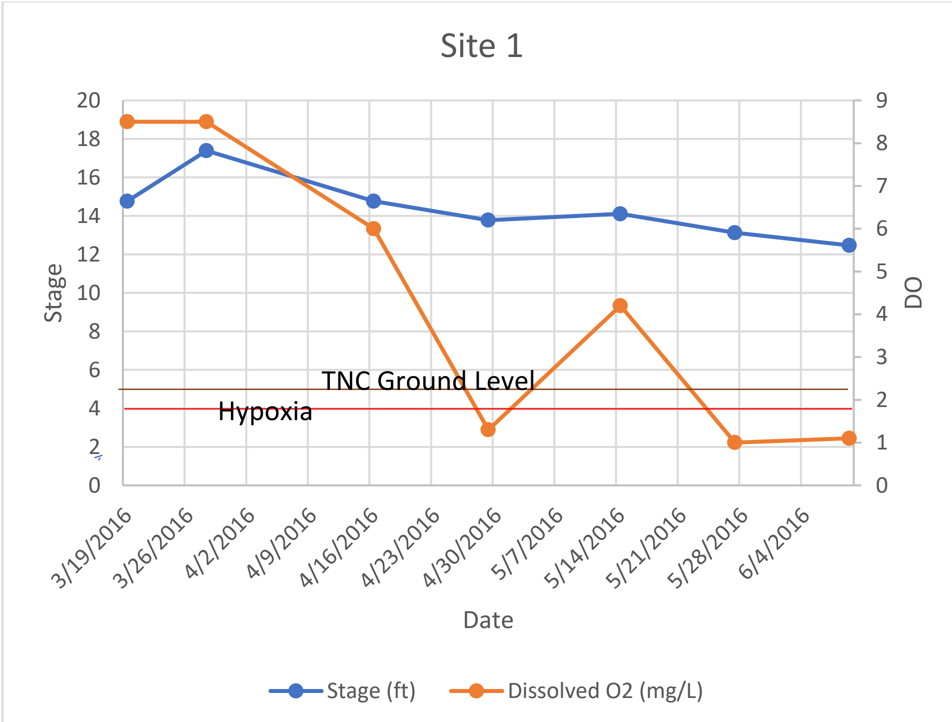

Figure 13. Site 1 - Plot of data from Kong (2017) of Butte la Rose stage and DO over the time data was collected for Site 1. See Figure 12 for comparison.

Thus, based on Kong's 2016 data, the explanation of the impacts of allowing suspended sediment laden flood waters to enter swamp and pond environments is that <u>these waters bring in vast amounts of nutrients that result in a rapid lowering of oxygen concentrations from background levels and lead to hypoxia – due to microorganisms having a glutenous feast.</u> Kong's data bears this out very clearly and raises questions about the viability of the EGL project's use of channel cuts as a means to flush backswamp environments to improve water quality. This 2016 data set does not support this hypothesis as advocated by those who believe opening up the Basin to Atchafalaya River flows will improve water quality.

One important management consequence of flooding back swamps with suspended sediment laden water that Kong (2017) did not consider is the infilling and eventual loss of these unique forested wetlands.

<u>c. Discussion of Kong's 2017 data and results</u>

An important question she should have asked should have been along the lines of what about the river turbidity while she was sampling – what was the river supplying to her study sites by way of nutrients and suspended sediments? Unfortunately, data on turbidity or suspended sediment loads is not recorded at Butte La Rose, but turbidity data is collected (mostly hourly) on the Atchafalaya River at Morgan City (Figure 7). The higher the turbidity number the greater the concentration of suspended material in the water column. Figure 6 reveals that the turbidity ranged from 86.7 to 114.1 during Kong's 2016 flood sampling. In contrast during the peak of the 2017 flood (Figure 7) the turbidity was constantly dropping from 100 to a low of 33.8, reflecting that this river flood pulse was a rainfall induced event (Figures 3 and 4) and the sediment and nutrient load reflected by the turbidity measurements was very low meaning significantly lower nutrient inputs.

The only data that Kong (2017) presents for actual measurements over time, during 2017, at each of her sample sites is dissolved oxygen (Figure 14). The replot of the Kong data for Site 1 (Figure 15) reveals that for the full study period in 2017 the site was flooded with at least 6 feet of water using a ground elevation of 5.0 feet determined for this site. Maximum flooding would have been at least 13 feet above ground! It was being flushed by Atchafalaya River flood waters for the duration of Kong's 2017 study. So, there was a hydrologic connection to a channel somewhere. As this was a low turbidity rainwater induced flood the lack of nutrients is reflected in that the DO concentration rises from being hypoxic early May 2017 to 5 mg/l at the peak of the flood, but then drops back to hypoxic once this "clear" water flush has past (Figure 15). Kong (2017) states categorically without any justification that there was no hydrologic connection 5/7/2017 and 7/3/2017. Figure 15 reveals otherwise. Sites 2, 6, 7, 8, 9, and 11 all follow the same pattern over time (Figure 14) (van Heerden 2019a).

Unfortunately, Kong (2017) only presents means (with standard deviations) for turbidity data for each of her 14 sites. In 2017 the means for the sites under consideration, namely 1, 6, 7, and 8, the Secchi Disk readings range from 30.6 – 36.0 cm. By contrast the 2016 data ranged from 17.7 to 24.0 cm being far more turbid than the 2017 sampling at the same sites, reflecting the 2017 1:1000-year rain induced flood peak versus the Mississippi catchment flood of 2016 (See Figures 6 and Figure 7 for comparison).

This data strongly points to the impacts of allowing suspended sediment laden Mississippi catchment (the norm) flood waters to enter swamp and pond environments; these waters bring in vast amounts of nutrients associated with suspended sediments that result in a rapid lowering of oxygen concentrations from background levels and lead to hypoxia. Kong's data bears this out very clearly and raises questions about the validity of using channel cuts to flush back swamp environments to improve water quality, as the EGL project proposes to do. This data set does not support this management hypothesis as advocated by those who wish to flush the swamp with Atchafalaya River water with projects such EGL.

One important management consequence of flooding back swamps with suspended sediment laden water that Kong (2017) did not consider is the infilling and eventual loss of these unique forested wetlands. An EPA Report (EPA 1979) expressly pointed out this loss, amongst other earlier reports.

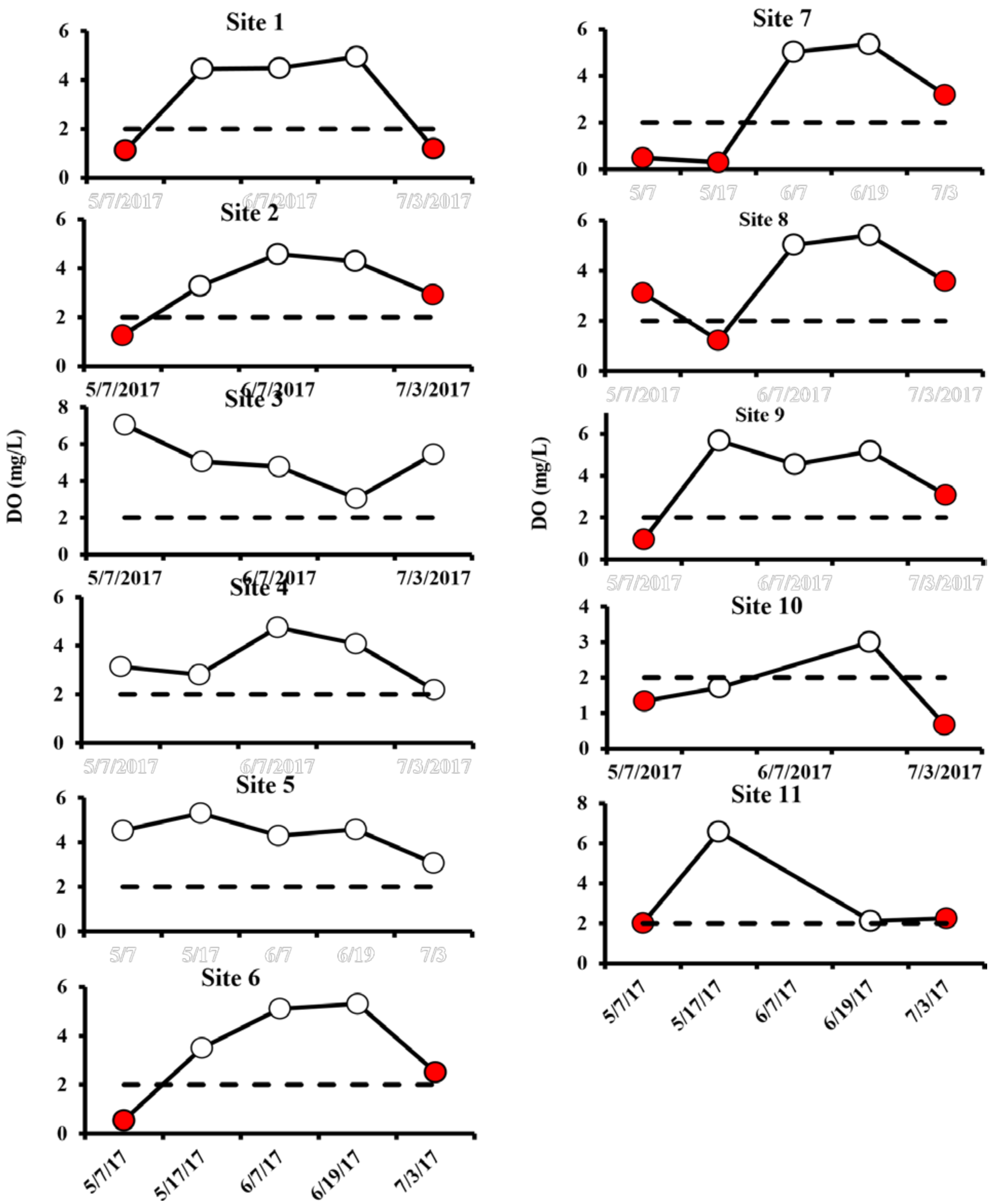

Figure 14. Dissolved oxygen (DO) concentration and hydrologic connectivity at Atchafalaya Basin sample locations during the 2017 sample season (Kong 2017). The red dots indicate when Kong assumes the site is hydrologically disconnected from flood water input which this manuscript proves is an invalid conclusion. The dashed horizontal line on the graphs indicates hypoxic level (DO < 2 mg/l).

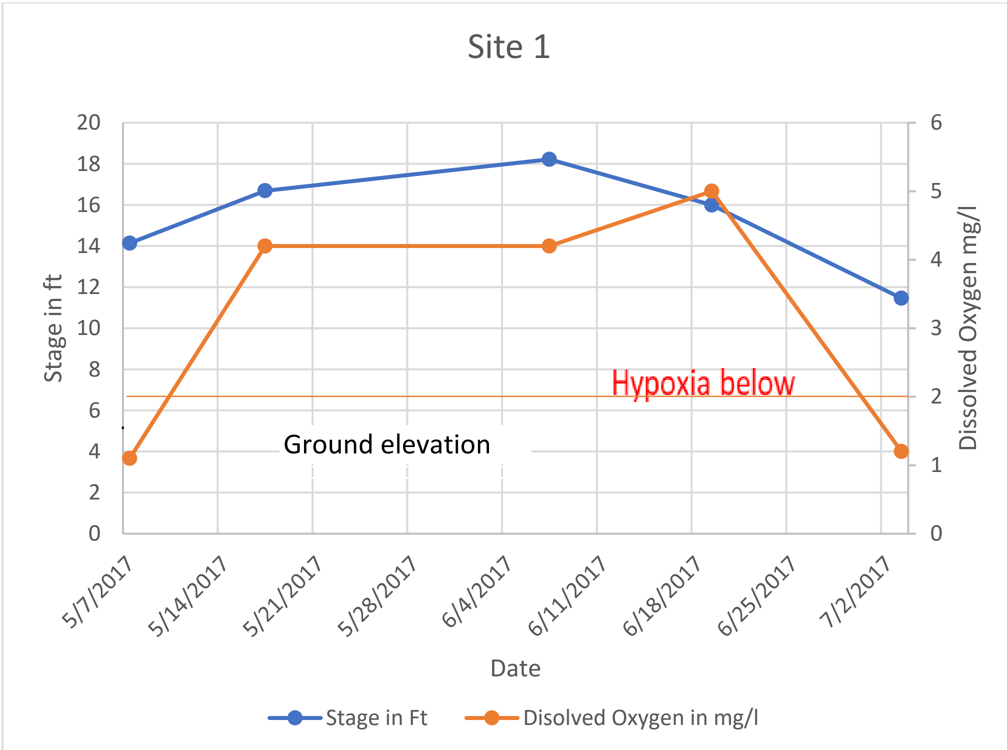

Figure 15. Site 1, Stage at Butte La Rose in feet and Dissolved Oxygen collected by Kong (2017). See Figure 26 by comparison.

So, in summary, 2016's flood was a catchment flood peak with high turbidity; in contrast 2017 was a rain-induced flood with much lower turbidity (Figures 6 and 7). Kong's data collected within a Basin swamp for the flood peak in 2016 reveal that as the flood starts peaking DO levels are high and as the flood progresses, they decline to hypoxic conditions. For 2017 it was almost the opposite. The DO levels rose as the flood progressed, reflecting that a very rare (1:1000 years) low turbidity rainfall induced flood peak crossed her study area in 2017. This data is strong evidence that, barring any unique rainfall events in the Mississippi Catchment, Eutrophication and eventually Hypoxia are the result of the very high Mississippi nutrient loads entering the swamps and the rapid reduction in DO follows as microorganisms feast and consume the DO, except with very unique flood peaks.

DISCUSSION OF THE NATURE CONSERVANCY DATA COLLECTED FOR LaDNR/CPRA 2017 to 2019.

The Nature Conservancy (TNC), since 2017, collected water quality data for the LaDNR in the same region of the Basin as Kong (2017), although not at the same locations (Figure 5). There is no GPS position data to make a determination where the TNC sites were located; i.e., was it on a levee or was it in an open pond or in a forested swamp? There is no weather data either. Strong winds, rain, other boat traffic etc. before or during a sample event can markedly change the readings.

The TNC Data for 2017

The TNC data was collected from 04/22/2017 till 07/19/2017 – a 3-month period that included the time Kong (2017) was sampling around the same flood peak (Figure 16). A comparison is thus possible between the two data sets. Figure 16 reveals that the flood rose to its peak on 28th May 2017, during the sampling period, and then fell thereafter. TNC states "During the passage of the flood pulse dissolved oxygen levels increased at all sites, but the magnitude and duration of that response varied from site to site" (TNC 2017). This is a result that matches Kong data and strengthens the argument that a low turbidity flood is far better for the system than a high turbidity flood which is the norm; the former being a 1 in 1000 year event.

a. Synoptics of DO levels at the 2017 TNC sites.

The TNC data do reveal that there is a marked temporal fluctuation in the DO against the background of a general rise during the flood (Figure 17 and 18). The sites displayed in Figure 10, AU6 and AU2SW, are close together being on either side of a pipeline canal (Figure 5). Depending on prevailing wind direction; major windstorms; major rainfall events; and the stage of river flooding; water flow direction at these sites could be from all points of the compass and vary almost from day to day and as these waters flow back and forth, here and there, they occasionally bring in pockets of low DO waters from stagnant areas. Stagnation possibly due to impoundment, or biological degradation of submerged plant matter, or both. However, the overall DO picture, as TNC stated, is for the DO to increase as the 2017 flood progressed.

b. Comparison of TNC Site AU6 to Kong's Sites 6, 7, and 8 For 2017 (Figures 17 to 22).

The turbidity at TNC AU6 (Figure 17) is lower than that in the Atchafalaya River (Figure 19) around 05/07/17 but rises up to the same level as the River at its peak of 34 FNU mid-June and then falls rapidly thereafter. The River turbidity at the lower end of the Basin for the period is almost a reverse mirror image, being highest (100 FNU) in early May falling to a low of 34 FNU around 20 June 2017 and thereafter rising again to the end of the record. Kong's data was not measured daily by rather fortnightly, so it lacks the synoptics of the TNC data. But comparisons of the two data sets are permissible. Notably the DO rises faster at Kong 6 (Figure 20) as compared to AU6 (Figure 17) as the 2017 flood progresses.

Kong 7 (Figure 21) and Kong 8 (Figure 22) more resemble AU 6 as they appear to be in the same general water body.

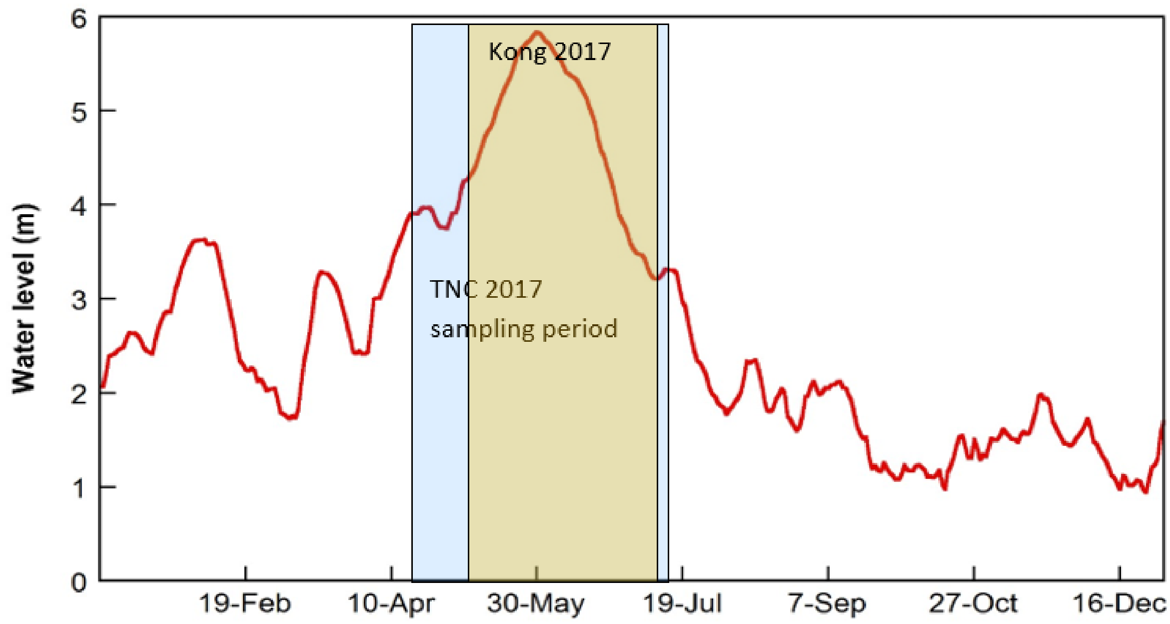

Figure 16. Daily mean water levels at Butte La Rose during 2017. Preliminary data from USGS gage 07381515 Atchafalaya River at Butte La Rose, LA.

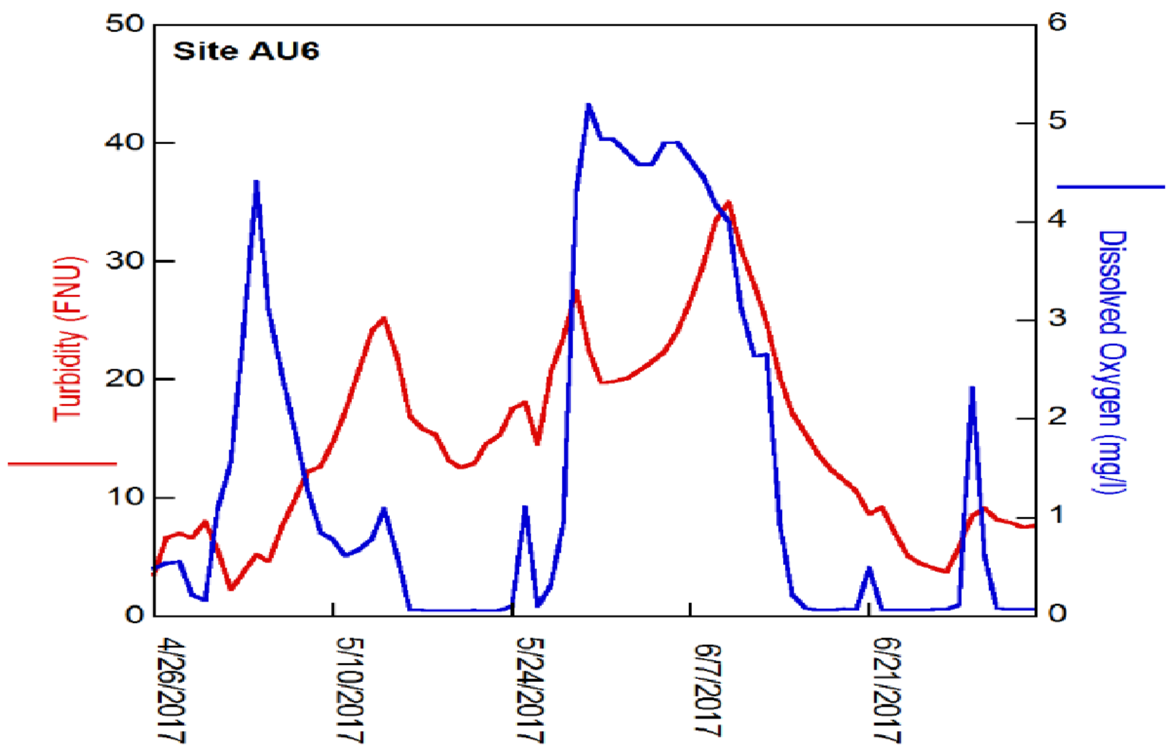

Figure 17. Turbidity and dissolved oxygen from April to July 2017. TNC Sites AU6

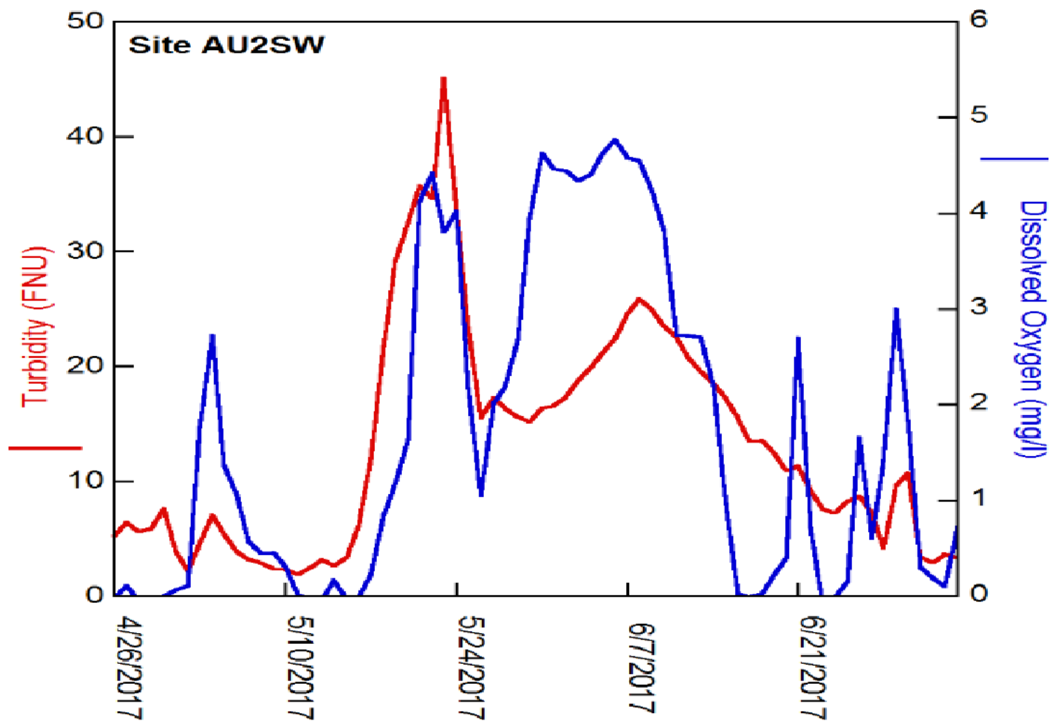

Figure 18. Turbidity and dissolved oxygen from April to July 2017. TNC Sites AU2SW

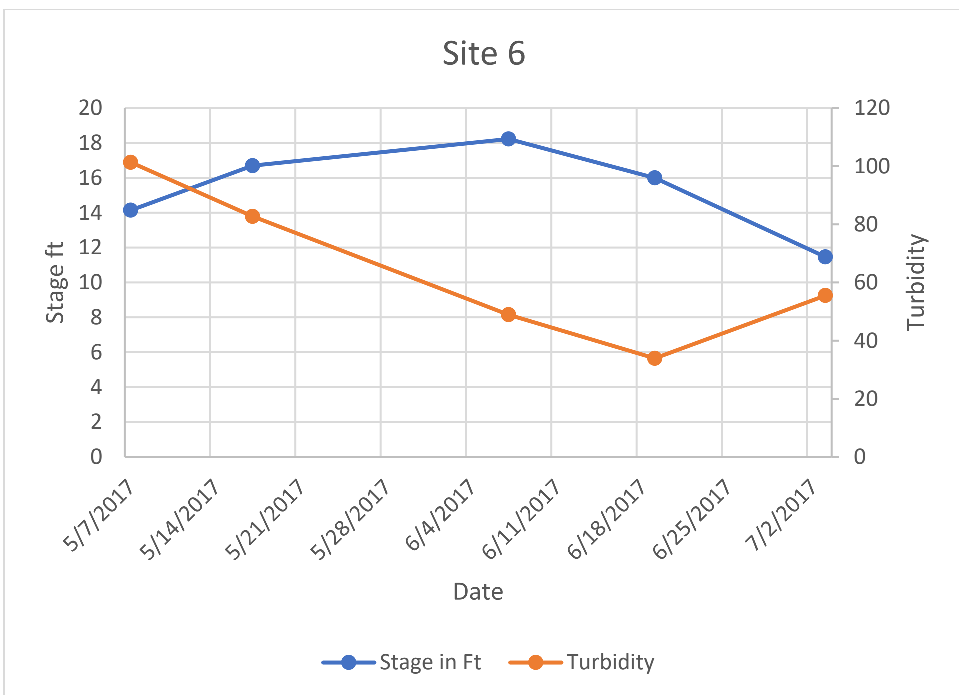

Figure 19. Kong 6. Stage in feet at Butte La Rose and Morgan City Turbidity for duration of 2017 study

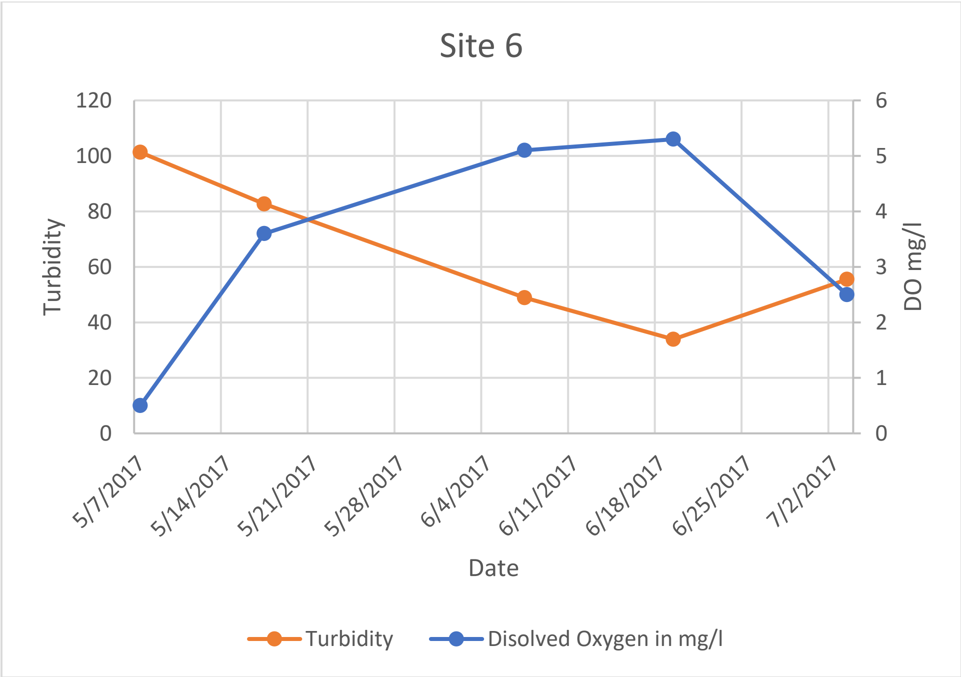

Figure 20. Site 6 Plot of Dissolved Oxygen from Kong (2017) and Turbidity from Morgan City over the time data collected in 2017.

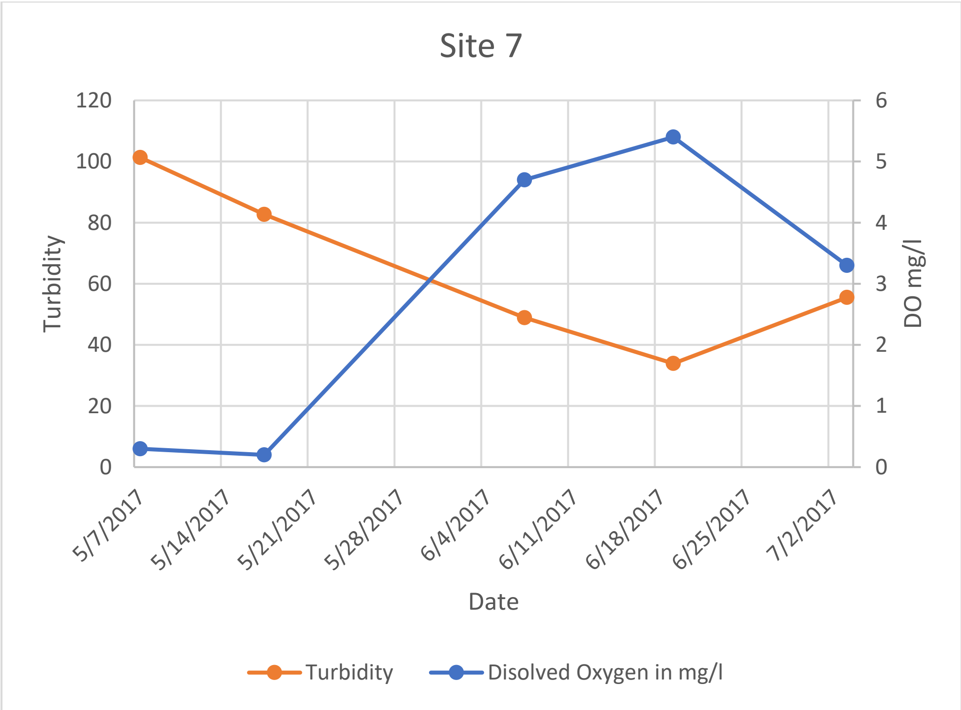

Figure 21. Site 7 Plot of Dissolved Oxygen from Kong (2017) and Turbidity from Morgan City over the time data was collected in 2017.

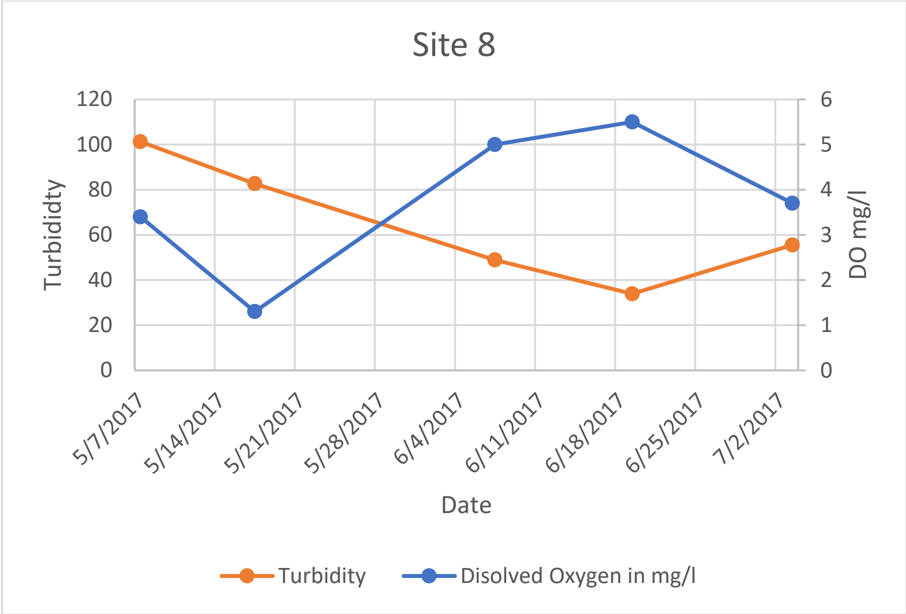

Figure 22. Site 8. Plot of Dissolved Oxygen from Kong (2017) and Turbidity from Morgan City over the time data was collected for Site 8 in 2017.

So, in summary, 2017 was a rain-induced flood with much lower turbidity than a regular flood such as 2016 (Figures 18 and 19). Kong's data for the flood peak in 2017 reveal that the DO levels rose as the flood progressed, reflecting a low turbidity rainfall-induced flood peak. During the flood, eutrophication and hypoxia were not an issue. The TNC 2017 data support and parallel the Kong data. Suffice to say, low turbidity floods (unique, very rare since 1973) drive up the DO in contrast to high turbidity floods (the norm) where often Hypoxia results due to the rapid reduction in DO, as microorganisms feast on the abundant nutrients especially N, and consume the DO.

2016 TO 2019 TRENDS IN DISCHARGE, NUTRIENT LOADING, AND DISSOLVED OXYGEN IN THE MISSISSIPPI AND ATCHAFALAYA RIVERS - The Big Picture.

Recently it has become much easier to access data from the USGS National Water Information System web page (https://nwis.waterdata.usgs.gov/nwis). This allows multi-year comparisons of different water quality measures as well as comparisons of basin to basin. The following discussions will specifically review and compare data from the Mississippi River at Baton Rouge and the Atchafalaya at Morgan City. The Baton Rouge site was chosen as being representative of the inflow from the Mississippi via the Old River diversion into the upper part of the Atchafalaya Basin Floodway – in other words what is coming in at the top. The Morgan City gauging station is representative of what is flowing out of the bottom of the Basin and thus, in comparison to the Baton Rouge data, allows a quantification and assessment of water quality changes occurring as the flow moves through the Basin.

a. Nitrogen Data, 2016 to 2019.

Figures 23 a, b, c, and d for the years 2016 through 2019 reveal that in general the nitrogen (or "N") concentration in the Atchafalaya tracks that of the Mississippi, although there are differences. Higher N in the Mississippi River January to August, except for the major flood year of 2019. (Figure 23d). This year was marked by a major long duration flood with discharges rising again in October and it would appear as a consequence the Mississippi N levels were always higher than those of the lower Atchafalaya River. In some years the N concentration is the Atchafalaya is half that of the Mississippi River. Why the difference one would ask, where is the Nitrogen going; or in other words, what is absorbing or consuming the Nitrates and Nitrides as the Atchafalaya River flood water crosses the swamp Basin from the North to the South? The Nitrogen levels fall as the flood waters from the Mississippi passing down and through the Atchafalaya Basin increase in turbidity! (van Heerden2019a). Intuitively this does not make sense. Now we need to see what is happening to the dissolved Oxygen concentrations as the flood waters cross the Basin from the Mississippi River water input at Old River, to exiting of the Basin at Morgan City.

a. Dissolved Oxygen concentrations, 2016 to 2019.

In general, the dissolved Oxygen levels in the Atchafalaya River, at its southern end once crossing the Basin, are lower than that of the Mississippi River; its original source (Figure 24). This may be key to understand the N variances. The biggest difference is when the river flood is waning and temperatures are on the increase, May to August.

Figure 25 a, b, c, and d represent the USGS data for the Mississippi River location of dissolved Oxygen (brown) vs Nitrogen (Green) for the full study period, 2016 through 2019. There is a seasonal variation in the Oxygen with a high of about 12 mg/l in the colder winter months and a low of about 6 mg/l in the summer. During the 4-year study period the temperature of the Mississippi varied from a winter low of about 5 deg C (41 deg F) to a summer high of about 30 Deg C (86 deg F). According to dissolved oxygen versus temperature curves found at www.fondriest.com for this temperature range the data in Figure 25 a-d imply the Mississippi River is at or close to total saturation in terms of dissolved Oxygen as it flows past Baton Rouge in the confined river channel.

The Atchafalaya Picture is different. Figures 26 a-d reveal a time series, broken into calendar years, of Nitrogen and Oxygen measurements as collected by the USGS for 2016 through 2019. Again there seems to be a seasonal variation in Oxygen high of about 10 mg/l in the colder months and an average low of 4-5 mg/l with 2019 being marked by lows of 2.5 mg/l. Two mg/l is considered the lowest the dissolved Oxygen can get to before Hypoxia sets in, so the winter flood of 2019 was close to this cut off. So once again it raises the question, is flushing of

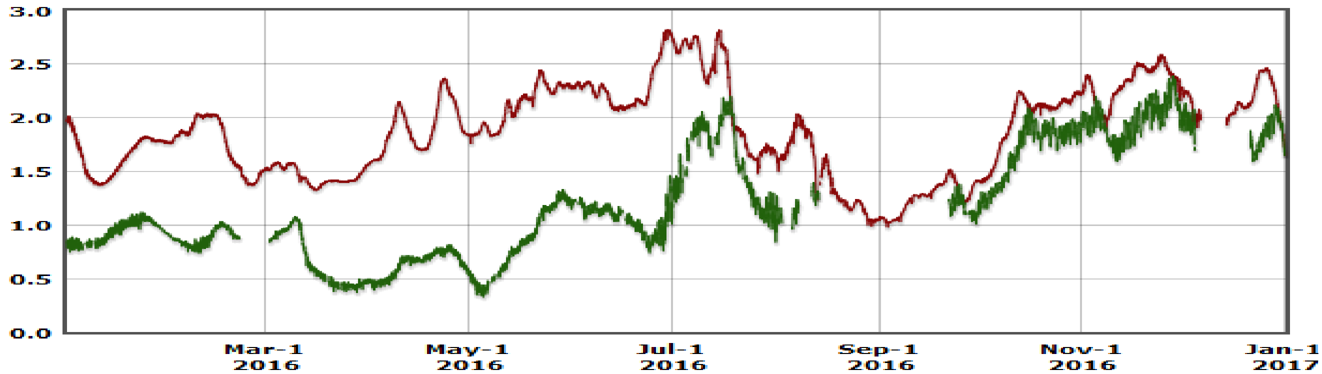

Figure 23a. Mississippi (Brown) and Atchafalaya Rivers (Green) Nitrate plus Nitrite mg/l, 2016.

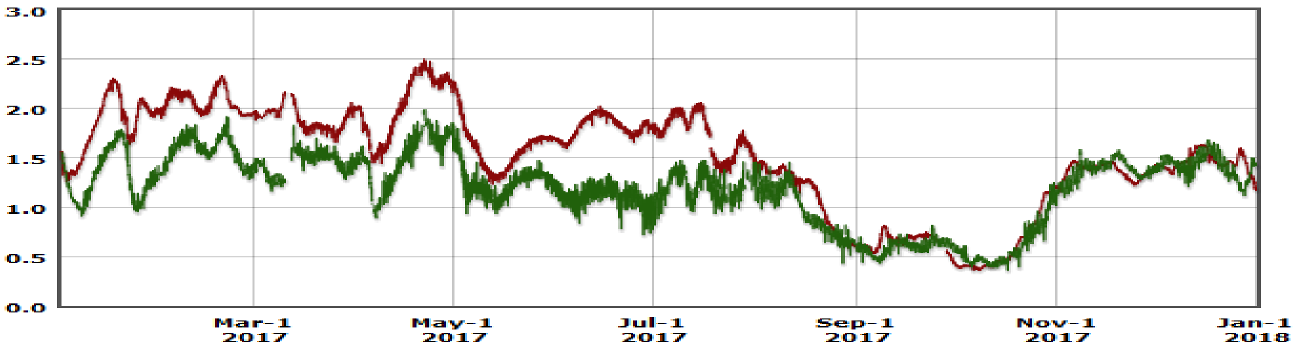

Figure 23b. Mississippi (Brown) and Atchafalaya Rivers (Green) Nitrate plus Nitrite mg/l, 2017.

Figure 23c. Mississippi (Brown) and Atchafalaya River (Green) Nitrate plus Nitrite mg/l, 2018.

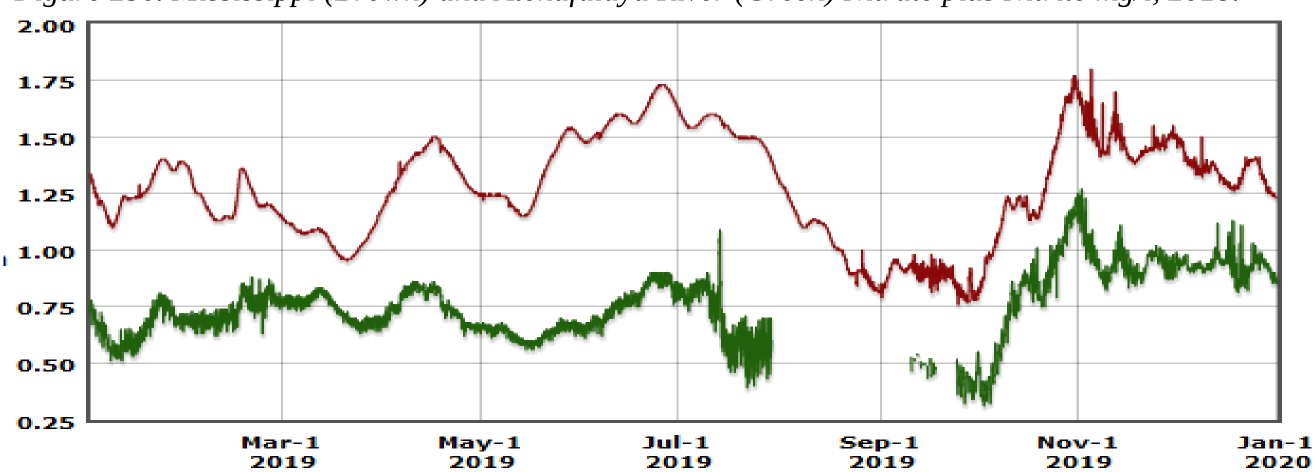

Figure 23d. Mississippi River and Atchafalaya River Nitrate plus Nitrite mg/l, 2019. Brown is Miss at Baton Rouge, green Atchafalaya River at Morgan City.

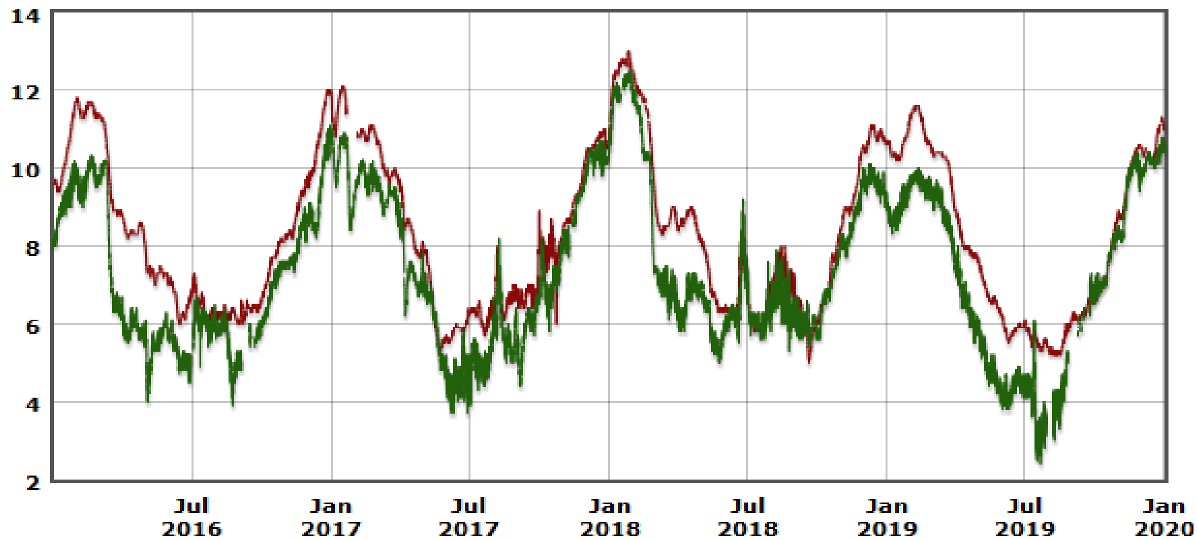

Figure 24. Dissolved oxygen Mississippi (Brown) vs Atchafalaya Rivers at Morgan City (Green), 2016 -2019.

Atchafalaya Swamps with Atchafalaya flood water the best management tool to prevent eutrophication and hypoxia in these regions of the swamp. The 2019 flood was a monster with very high flood levels with strong flows yet the Oxygen got down to 2.5 mg/l (Figure 26d). By comparison the Mississippi low was 5.5 mg/l.

Considering seasonal temperature differences as measured by the USGS at Morgan City we can explain the seasonality in the drop of Oxygen levels but not the much lower dissolved Oxygen levels as compared to the source Mississippi waters. If all things are equal, then the Oxygen levels should exactly follow the trend and values of Oxygen in the Mississippi River (Figures 25 a-d).

During the summer warmth the Atchafalaya Oxygen levels should be about 8 mg/l, not the 4-5 mg/l and the 2019 low of 2.5 mg/l as displayed in Figure 26 a-d. Why this huge difference in Oxygen levels in the flow exiting the Basin at Morgan City? Something is ‘sucking’ the oxygen out of the water. In the shallow waters of the Basin swamps and lakes photosynthesis is taking place so one would expect, as explained in the introduction, that Oxygen levels would be helped by Photosynthesis. Why are the Oxygen levels in the range of 4-5 with a 2019 low of 2.5mg/l being half of what one would expect based on the source water (Figures 26 a-d)?

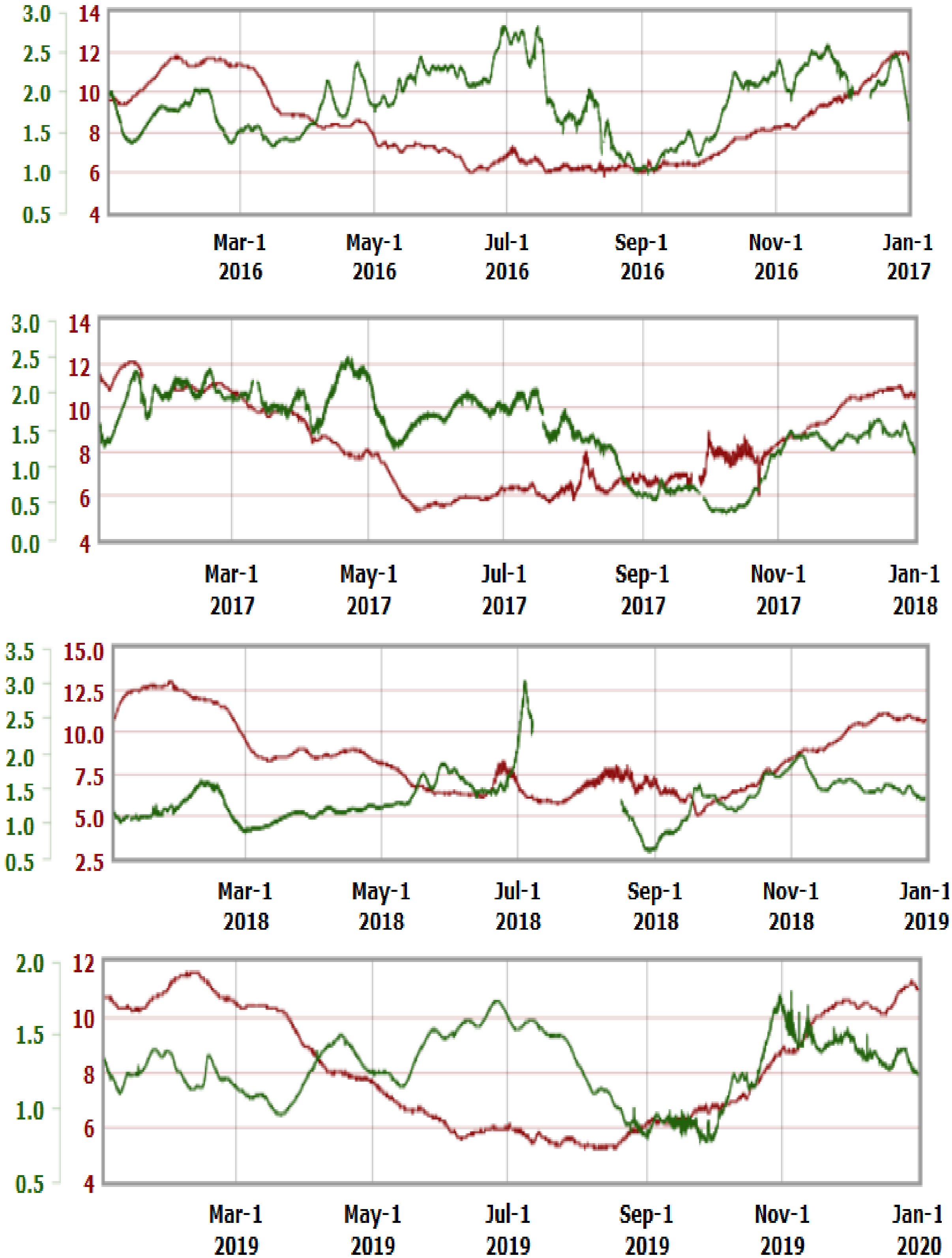

Figure 25 a, b, c, and d. Mississippi River dissolved Oxygen (brown) vs Nitrogen (Green) 2016 through 2019.

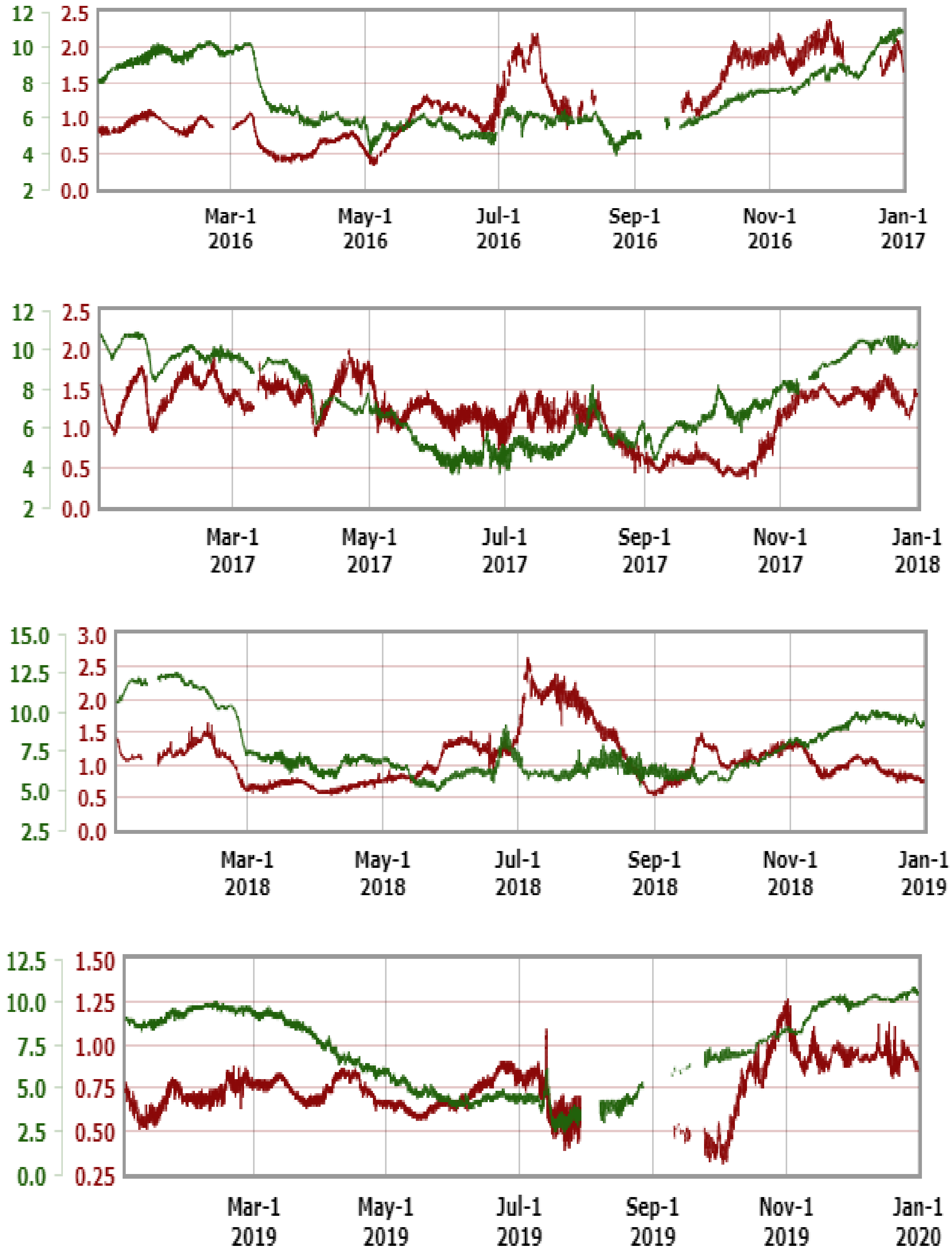

Figure 26 a, b, c, and d. Atchafalaya River Nitrogen (brown) vs dissolved oxygen (green). 2016 through 2019

Figures 26 a-d graphically illustrates the difference between the Mississippi River Dissolved Oxygen as input to the Basin, and the manipulations characterizing the flow through the Floodway Basin. The extremely high nutrient (N amongst others) loaded Atchafalaya floodwaters that overtops levees or exits the River via manmade channels, becomes fodder for various organisms such as algae, bacteria, fungi and other microbes and allows such to have a massive feast and in the process utilize a huge amount of the available DO. This consumption of DO is so pervasive that even photosynthesis and natural physical aeration process such as wavelets and rain splatter do not make up for that which is consumed. Certainly there is some denitrification by subaerial and subaqueous vegetation but this role is is not expected to be significant when the wetlands are flooded.

What these figures reveal that for most of any calender year, Atchafalaya DO levels are mostly lower than those of the Mississippi feeder. Interestingly, the curves do show contemporaneous spikes in the DO of both rivers. Hurricanes, thunderstorms, cold front passages and other windstorms do through surface aeration increase DO levels. Some aquatic plants may utilize the excess N. Unfortunately the scope of this study would not allow the author the opportunity to chase down the origins of some of the DO spikes revealed in Figures 26 a, b, c and d.

CONCLUSIONS

1. So, the whole basis of this CPRA 2021 report, which basically reads as a proposal to fund the Nature Conservancy to do some project specific monitoring, is a non-starter as it uses as its foundation a definition of Adaptive Management which is not the one envisaged in the actually published CPRA 2017 document defining adaptive management. Instead, they use a definition of Adaptive management from an unpublished 2017 draft document which uses a different definition for Adaptive Management. CPRA lacks support at an agency level from project-specific adaptive management planning.
2. Based on Kong's 2016 data, the explanation of the impacts of allowing suspended sediment laden flood waters to enter swamp and pond environments is that <u>these waters bring in vast amounts of nutrients that result in a rapid lowering of oxygen concentrations from background levels and lead to hypoxia – due to microorganisms having a glutenous feast.</u> Kong's data bears this out very clearly and raises questions about the viability of using channel cuts as a means to flush backswamp environments to improve water quality. This 2016 data set does not support the hypothesis advocated by EGL project proponents who believe opening up the Basin to Atchafalaya flows will improve water quality.
3. One important management consequence of flooding back swamps with suspended sediment laden water that Kong (2017) did not consider is the infilling and eventual loss of these unique forested wetlands. An EPA Report (EPA 1979) expressly pointed out this loss, amongst other earlier reports. During the summer warmth the Oxygen levels in the Atchafalaya Basin waters should be about 8 mg/l, not the 4-5 mg/l and the 2019 low of

2.5 mg/l as displayed in Figure 26 a-d. This is a huge and unexplained difference in Oxygen levels in the flow exiting the Basin at Morgan City. Something is 'sucking' the oxygen out of the water. In the shallow waters of the Basin swamps and lakes photosynthesis is taking place so one would expect, as explained in the introduction, that Oxygen levels would be helped by photosynthesis which would cause the plants to release oxygen into the water column.

4. The Atchafalaya Nitrogen levels are lower that the Mississippi River especially during the spring and summer months when the temperature is rising and the days getting longer. The Mississippi River is a confined channel, as against the Atchafalaya where flood waters spread laterally over a vast shallow area, In the Atchafalaya Basin shallows, billions of microorganisms and some algae and aquatic plants suck up (ingest) Nitrogen, and flourish, depressing the DO levels.
5. The DO levels in Atchafalaya, as evidenced where the waters leave the Basin at its southern end, are at times half that of the basically saturated DO Mississippi flow inputs to the Basin. The drop in DO levels cannot be explained by seasonal temperature differences. Instead this is classical eutrophication. Micro organisms and such are having a huge feast due to the heavy nutrient loads of the Mississippi River precipitating marked lowering of DO, as they consume the DO – a real management consideration that the EGL project's supporting documents do not address!
6. The East Grand Lake project as proposed by CPRA will only enhance and exacerbate the Eutrophication and Hypoxia in the Basin.

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