Mandeville Assimilation Wetland Monitoring Report

January-March 2019

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March 20, 2019

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Mandeville Assimilation Wetland Monitoring Report

Summary of Activities: January – March 2019

Water Nutrient Analysis

Data from water samples taken on December 12, 2018, have been received from the laboratory and are provided at the end of this report.

Turner Rebuttal

The rebuttal to the Turner et al. (2017) paper, which also rebuts the Bodker et al. (2015) paper, has been published in the journal Wetlands Ecology & Management. The rebuttal shows that the hypotheses presented by Turner et al. (2017) and Bodker et al. (2015) that nutrients were the cause for the wetland loss at the Hammond assimilation wetlands are flawed and biased, with the underlying premise without supporting evidence. The publication has been appended to this report.

Site visits

January 10 & 11, 2019: Comite Resources personnel traveled to the Mandeville and Tchefuncta Marsh assimilation wetlands and carried out annual DBH measurements at all forested sites including the seedling site located near the end of the TM boardwalk.

January 17, 2019: Comite Resources field crew Jason Day and Joel Mancuso visited the Mandeville and Tchefuncta Marsh assimilation wetlands to carry out monthly monitoring. Leaf litter biomass was collected from each forested site (M-Tmt, M-Mid, M-Ref & TM-Tmt). Dissolved oxygen, conductivity, temperature, salinity and pH were measured at all sites including the discharge pipe (see data below). Free chlorine measurements were taken along the canal north of the Tchefuncta marsh. The package plant chlorine concentration was 1.26 ppm while at the receiving wetland was 0.20 ppm. Water levels were measured at all sites, Mand-Ref, Mand-Mid, Mand-Out, TM-Mid, TM-Out & TM-Ref had no standing water on site.

Dr. Hunter recording dbh measurements at the end of the Tchefuncte Marsh boardwalk on January 10, 2019.

Discrete water quality data from the Mandeville and Tchefuncta Marsh assimilation wetlands on January 17, 2019.

Site	Date	DO (mg/l)	Cond (mS)	Temp. (°C)	Sal (PSU)	pH	Water Level (cm)
M-PIPE	1/17/19	6.0	503.9	11.8	0.3	6.9	.
M-TMT	1/17/19	6.9	152.5	12.6	0.1	7.4	19.1
M-MID	1/17/19	4.5	119.7	10.0	0.1	7.5	dry
M-OUT	1/17/19	8.5	1778.7	12.0	1.2	7.3	dry
M-REF	1/17/19	4.5	110.8	11.5	0.1	7.7	dry
TM-TMT	1/17/19	2.2	426.4	11.7	0.3	7.3	34.1
TM-MID	1/17/19	4.4	307.0	9.8	0.2	7.9	dry
TM-OUT	1/17/19	10.4	2578.3	12.1	1.8	7.0	dry
TM-REF	1/17/19	8.8	458.8	12.6	0.3	7.8	dry

February 13, 2019: Comite Resources biologists Jason Day and Joel Mancuso traveled to the Mandeville and Tchefuncta Marsh assimilation wetlands to carry out monthly monitoring. Dissolved oxygen, conductivity, temperature, salinity and pH were measured at all sites including the discharge pipe (see data below). Leaf litter biomass was collected from each forested site (M-Tmt, M-Mid, M-Ref & TM-Tmt). Free Chlorine measurements were taken at the package plant discharge pipe (0.68 ppm) and where the discharge enters the wetland (0.06 ppm). Water samples were delivered to Pace Analytical (formally A&E) located in Baton Rouge to be analyzed for nutrient and BOD.

Discrete water quality data from the Mandeville and Tchefuncta Marsh assimilation wetlands on February 13, 2019.

Site	Date	DO (mg/l)	Cond (mS)	Temp. (˚C)	Sal (PSU)	pH	Water Level (cm)
M-PIPE	2/13/19	8.8	626.5	14.9	0.4	7.0	.
M-TMT	2/13/19	6.8	188.7	14.9	0.3	7.0	29.0
M-MID	2/13/19	4.3	108.2	12.9	0.1	6.8	8.8
M-OUT	2/13/19	4.5	191.5	12.7	0.1	6.9	dry
M-REF	2/13/19	6.8	80.6	14.9	0.0	8.1	dry
TM-TMT	2/13/19	1.4	287.9	16.4	0.2	6.9	18.4
TM-MID	2/13/19	4.4	670.5	11.6	0.4	6.7	5.4
TM-OUT	2/13/19	6.0	1273.7	13.0	0.8	6.9	dry
TM-REF	2/13/19	6.2	566.3	12.8	0.4	7.3	dry

Joel Mancuso collecting a water sample at the TM-Mid site on February 13, 2019.

March 13, 2019: Comite Resources biologist Jason Day and Joel Mancuso visited the Mandeville and Tchefuncta Marsh assimilation wetlands to carry out monthly monitoring. Leaf litter biomass was collected from each forested site (M-Tmt, M-Mid, M-Ref & TM-Tmt). Dissolved oxygen, conductivity, temperature, salinity and pH were measured at all sites including the discharge pipe (see data below).

Discrete water quality data from the Mandeville and Tchefuncta Marsh assimilation wetlands on March 13, 2019.

Site	Date	DO (mg/l)	Cond (mS)	Temp. (˚C)	Sal (PSU)	pH	Water Level (cm)
M-PIPE	3/13/19	5.4	621.9	19.6	0.3	7.5	.
M-TMT	3/13/19	2.8	383.5	19.6	0.2	7.6	39.1
M-MID	3/13/19	6.5	1703.0	20.2	1.0	7.3	18.5
M-OUT	3/13/19	4.4	2001.1	19.9	2.5	7.6	11.6
M-REF	3/13/19	3.7	137.6	19.7	0.1	7.7	18.1
TM-TMT	3/13/19	0.4	539.5	19.8	0.3	7.3	26.5
TM-MID	3/13/19	1.0	569.3	13.4	0.4	7.0	3.8
TM-OUT	3/13/19	6.8	835.5	14.8	0.5	7.3	2.0
TM-REF	3/13/19	7.4	1157.6	18.3	0.7	7.7	2.2

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Baton Rouge, LA 70810
(225) 769-1930

ANALYTICAL RESULTS

Project: Mandeville
Pace Project No.: 2090919

Sample: Mandeville Control **Lab ID: 2090919001** Collected: 12/12/18 16:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	ND	mg/L	4.0	1		12/18/18 09:32		
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**2.7**	mg/L	1.5	1.5	12/14/18 14:32	12/19/18 14:58		L1
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2 Preparation Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	ND	mg/L	0.10	1	12/19/18 16:33	12/20/18 12:18	7727-37-9	
365.4 Total Phosphorus	Analytical Method: EPA 365.4 Preparation Method: EPA 365.4							
Phosphorus	**0.15**	mg/L	0.10	1	12/19/18 16:34	12/20/18 10:29	7723-14-0	
4500 Ammonia Water	Analytical Method: SM 4500-NH3 G							
Nitrogen, Ammonia	ND	mg/L	0.10	1		12/15/18 12:56	7664-41-7	
SM4500P-E, Phosphate, Ortho	Analytical Method: SM 4500-P E							
Orthophosphate as P	**0.18**	mg/L	0.050	1		12/14/18 09:36		
4500NO3-F, NO3-NO2	Analytical Method: SM 4500-NO3 F							
Nitrogen, NO2 plus NO3	ND	mg/L	0.050	1		12/14/18 12:01		

Sample: Mandeville Control Dupe **Lab ID: 2090919002** Collected: 12/12/18 16:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**1.9**	mg/L	1.5	1.5	12/14/18 14:32	12/19/18 15:01		L1

Sample: Mandeville Control Trip **Lab ID: 2090919003** Collected: 12/12/18 16:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**1.7**	mg/L	1.5	1.5	12/14/18 14:32	12/19/18 15:05		L1

Sample: Mandeville Treatment **Lab ID: 2090919004** Collected: 12/12/18 15:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**5.0**	mg/L	4.0	1		12/18/18 09:33		

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ANALYTICAL RESULTS

Project: Mandeville
Pace Project No.: 2090919

Sample: Mandeville Treatment **Lab ID: 2090919004** Collected: 12/12/18 15:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**3.7**	mg/L	1.5	1.5	12/14/18 14:32	12/19/18 14:49		L1
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2 Preparation Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	**0.32**	mg/L	0.10	1	12/19/18 16:33	12/20/18 12:23	7727-37-9	
365.4 Total Phosphorus	Analytical Method: EPA 365.4 Preparation Method: EPA 365.4							
Phosphorus	ND	mg/L	0.10	1	12/21/18 16:29	12/24/18 10:01	7723-14-0	
4500 Ammonia Water	Analytical Method: SM 4500-NH3 G							
Nitrogen, Ammonia	**0.27**	mg/L	0.10	1		12/15/18 13:48	7664-41-7	
SM4500P-E, Phosphate, Ortho	Analytical Method: SM 4500-P E							
Orthophosphate as P	**0.18**	mg/L	0.050	1		12/14/18 09:34		
4500NO3-F, NO3-NO2	Analytical Method: SM 4500-NO3 F							
Nitrogen, NO2 plus NO3	**0.37**	mg/L	0.050	1		12/14/18 12:02		

Sample: Mandeville Treatment Dupe **Lab ID: 2090919005** Collected: 12/12/18 15:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**3.3**	mg/L	1.5	1.5	12/14/18 14:32	12/19/18 14:51		L1

Sample: Mandeville Treatment Trip **Lab ID: 2090919006** Collected: 12/12/18 15:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**3.3**	mg/L	1.5	1.5	12/14/18 14:32	12/19/18 14:54		L1

Sample: Mandeville Mid **Lab ID: 2090919007** Collected: 12/12/18 11:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**11.0**	mg/L	4.0	1		12/18/18 09:33		
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**3.4**	mg/L	1.5	1.5	12/14/18 08:45	12/19/18 10:44		

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ANALYTICAL RESULTS

Project: Mandeville
Pace Project No.: 2090919

Sample: Mandeville Mid **Lab ID: 2090919007** Collected: 12/12/18 11:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2 Preparation Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	**0.35**	mg/L	0.10	1	12/19/18 16:33	12/20/18 12:25	7727-37-9	
365.4 Total Phosphorus	Analytical Method: EPA 365.4 Preparation Method: EPA 365.4							
Phosphorus	**0.21**	mg/L	0.10	1	12/19/18 16:34	12/20/18 09:28	7723-14-0	
4500 Ammonia Water	Analytical Method: SM 4500-NH3 G							
Nitrogen, Ammonia	**0.32**	mg/L	0.10	1		12/15/18 13:49	7664-41-7	
SM4500P-E, Phosphate, Ortho	Analytical Method: SM 4500-P E							
Orthophosphate as P	**0.21**	mg/L	0.050	1		12/14/18 09:34		
4500NO3-F, NO3-NO2	Analytical Method: SM 4500-NO3 F							
Nitrogen, NO2 plus NO3	**0.35**	mg/L	0.050	1		12/14/18 12:04		

Sample: Mandeville Mid Dupe **Lab ID: 2090919008** Collected: 12/12/18 11:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**2.4**	mg/L	1.5	1.5	12/14/18 08:45	12/19/18 10:44		

Sample: Mandeville Mid Trip **Lab ID: 2090919009** Collected: 12/12/18 11:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**2.3**	mg/L	1.5	1.5	12/14/18 08:45	12/19/18 10:44		

Sample: Mandeville Out **Lab ID: 2090919010** Collected: 12/12/18 11:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**8.0**	mg/L	4.0	1		12/18/18 09:33		
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**1.8**	mg/L	1.5	1.5	12/14/18 11:07	12/19/18 15:10		
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2 Preparation Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	**0.37**	mg/L	0.10	1	12/19/18 16:33	12/20/18 12:25	7727-37-9	

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ANALYTICAL RESULTS

Project: Mandeville
Pace Project No.: 2090919

Sample: Mandeville Out **Lab ID: 2090919010** Collected: 12/12/18 11:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
365.4 Total Phosphorus	Analytical Method: EPA 365.4 Preparation Method: EPA 365.4							
Phosphorus	**0.24**	mg/L	0.10	1	12/19/18 16:34	12/20/18 09:28	7723-14-0	
4500 Ammonia Water	Analytical Method: SM 4500-NH3 G							
Nitrogen, Ammonia	**0.25**	mg/L	0.10	1		12/15/18 13:54	7664-41-7	
SM4500P-E, Phosphate, Ortho	Analytical Method: SM 4500-P E							
Orthophosphate as P	**0.24**	mg/L	0.050	1		12/14/18 09:34		
4500NO3-F, NO3-NO2	Analytical Method: SM 4500-NO3 F							
Nitrogen, NO2 plus NO3	**0.39**	mg/L	0.050	1		12/14/18 12:05		

Sample: Mandeville Out Dupe **Lab ID: 2090919011** Collected: 12/12/18 11:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**1.8**	mg/L	1.5	1.5	12/14/18 11:08	12/19/18 15:10		

Sample: Mandeville Out Trip **Lab ID: 2090919012** Collected: 12/12/18 11:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**1.9**	mg/L	1.5	1.5	12/14/18 11:10	12/19/18 15:10		

Sample: Mandeville Pipe **Lab ID: 2090919013** Collected: 12/12/18 15:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**20.0**	mg/L	4.0	1		12/18/18 09:33		
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2 Preparation Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	**11.2**	mg/L	0.40	4	12/19/18 16:33	12/20/18 12:52	7727-37-9	
365.4 Total Phosphorus	Analytical Method: EPA 365.4 Preparation Method: EPA 365.4							
Phosphorus	**2.8**	mg/L	0.10	1	12/19/18 16:34	12/20/18 09:29	7723-14-0	
4500 Ammonia Water	Analytical Method: SM 4500-NH3 G							
Nitrogen, Ammonia	**12.0**	mg/L	0.10	1		12/15/18 13:55	7664-41-7	

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ANALYTICAL RESULTS

Project: Mandeville
Pace Project No.: 2090919

Sample: Mandeville Pipe **Lab ID: 2090919013** Collected: 12/12/18 15:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
SM4500P-E, Phosphate, Ortho	Analytical Method: SM 4500-P E							
Orthophosphate as P	**2.2**	mg/L	0.50	10		12/14/18 09:43		
4500NO3-F, NO3-NO2	Analytical Method: SM 4500-NO3 F							
Nitrogen, NO2 plus NO3	**4.3**	mg/L	0.50	10		12/15/18 17:07		

Sample: TM Treat **Lab ID: 2090919014** Collected: 12/12/18 14:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**53.0**	mg/L	4.0	1		12/18/18 12:06		
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**20.7**	mg/L	3.0	3	12/14/18 13:13	12/19/18 14:31		L1
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2 Preparation Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	**12.5**	mg/L	0.40	4	12/19/18 16:33	12/20/18 12:53	7727-37-9	
365.4 Total Phosphorus	Analytical Method: EPA 365.4 Preparation Method: EPA 365.4							
Phosphorus	**2.8**	mg/L	0.10	1	12/19/18 16:34	12/20/18 09:29	7723-14-0	
4500 Ammonia Water	Analytical Method: SM 4500-NH3 G							
Nitrogen, Ammonia	**11.2**	mg/L	0.10	1		12/15/18 13:56	7664-41-7	
SM4500P-E, Phosphate, Ortho	Analytical Method: SM 4500-P E							
Orthophosphate as P	**1.9**	mg/L	0.50	10		12/14/18 09:43		
4500NO3-F, NO3-NO2	Analytical Method: SM 4500-NO3 F							
Nitrogen, NO2 plus NO3	**4.6**	mg/L	0.50	10		12/15/18 17:30		

Sample: TM Treat Dupe **Lab ID: 2090919015** Collected: 12/12/18 14:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**14.9**	mg/L	4.0	4	12/14/18 13:32	12/19/18 14:36		L1

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ANALYTICAL RESULTS

Project: Mandeville
Pace Project No.: 2090919

Sample: TM Treat Trip **Lab ID: 2090919016** Collected: 12/12/18 14:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**15.2**	mg/L	4.0	4	12/14/18 13:32	12/19/18 14:38		L1

Sample: TM Mid **Lab ID: 2090919017** Collected: 12/12/18 12:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	ND	mg/L	4.0	1		12/18/18 12:06		
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	ND	mg/L	1.5	1.5	12/14/18 11:14	12/19/18 15:10		
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2 Preparation Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	**0.45**	mg/L	0.10	1	12/19/18 16:33	12/20/18 12:30	7727-37-9	
365.4 Total Phosphorus	Analytical Method: EPA 365.4 Preparation Method: EPA 365.4							
Phosphorus	**0.24**	mg/L	0.10	1	12/19/18 16:34	12/20/18 09:32	7723-14-0	
4500 Ammonia Water	Analytical Method: SM 4500-NH3 G							
Nitrogen, Ammonia	**0.17**	mg/L	0.10	1		12/15/18 13:58	7664-41-7	
SM4500P-E, Phosphate, Ortho	Analytical Method: SM 4500-P E							
Orthophosphate as P	**0.29**	mg/L	0.050	1		12/14/18 09:34		
4500NO3-F, NO3-NO2	Analytical Method: SM 4500-NO3 F							
Nitrogen, NO2 plus NO3	**0.10**	mg/L	0.050	1		12/15/18 17:31		

Sample: TM Mid Dupe **Lab ID: 2090919018** Collected: 12/12/18 12:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	ND	mg/L	1.5	1.5	12/14/18 11:20	12/19/18 15:10		

Sample: TM Mid Trip **Lab ID: 2090919019** Collected: 12/12/18 12:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	ND	mg/L	1.5	1.5	12/14/18 11:20	12/19/18 15:10		

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: Mandeville
Pace Project No.: 2090919

Sample: TM Out **Lab ID: 2090919020** Collected: 12/12/18 12:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**16.0**	mg/L	4.0	1		12/18/18 12:06		
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	ND	mg/L	1.5	1.5	12/14/18 11:27	12/19/18 15:10		
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2 Preparation Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	**0.40**	mg/L	0.10	1	12/19/18 16:33	12/20/18 12:30	7727-37-9	
365.4 Total Phosphorus	Analytical Method: EPA 365.4 Preparation Method: EPA 365.4							
Phosphorus	**0.12**	mg/L	0.10	1	12/19/18 16:34	12/20/18 09:32	7723-14-0	
4500 Ammonia Water	Analytical Method: SM 4500-NH3 G							
Nitrogen, Ammonia	ND	mg/L	0.10	1		12/15/18 13:59	7664-41-7	
SM4500P-E, Phosphate, Ortho	Analytical Method: SM 4500-P E							
Orthophosphate as P	**0.16**	mg/L	0.050	1		12/14/18 09:34		
4500NO3-F, NO3-NO2	Analytical Method: SM 4500-NO3 F							
Nitrogen, NO2 plus NO3	ND	mg/L	0.050	1		12/15/18 17:33		

Sample: TM Out Dupe **Lab ID: 2090919021** Collected: 12/12/18 12:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	ND	mg/L	1.5	1.5	12/14/18 11:27	12/19/18 15:10		

Sample: TM Out Trip **Lab ID: 2090919022** Collected: 12/12/18 12:30 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	ND	mg/L	1.5	1.5	12/14/18 11:27	12/19/18 15:10		

Sample: TM Ref **Lab ID: 2090919023** Collected: 12/12/18 13:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**15.0**	mg/L	4.0	1		12/18/18 12:06		

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: Mandeville
Pace Project No.: 2090919

Sample: TM Ref **Lab ID: 2090919023** Collected: 12/12/18 13:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**1.6**	mg/L	1.5	1.5	12/14/18 11:44	12/19/18 15:10		
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2 Preparation Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	**1.2**	mg/L	0.10	1	12/19/18 16:33	12/20/18 12:32	7727-37-9	
365.4 Total Phosphorus	Analytical Method: EPA 365.4 Preparation Method: EPA 365.4							
Phosphorus	ND	mg/L	0.10	1	12/19/18 16:34	12/20/18 09:33	7723-14-0	
4500 Ammonia Water	Analytical Method: SM 4500-NH3 G							
Nitrogen, Ammonia	ND	mg/L	0.10	1		12/15/18 14:01	7664-41-7	
SM4500P-E, Phosphate, Ortho	Analytical Method: SM 4500-P E							
Orthophosphate as P	ND	mg/L	0.050	1		12/14/18 09:34		
4500NO3-F, NO3-NO2	Analytical Method: SM 4500-NO3 F							
Nitrogen, NO2 plus NO3	**0.11**	mg/L	0.050	1		12/15/18 17:34		

Sample: TM Ref Dupe **Lab ID: 2090919024** Collected: 12/12/18 13:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**1.9**	mg/L	1.5	1.5	12/14/18 11:44	12/19/18 15:10		

Sample: TM Ref Trip **Lab ID: 2090919025** Collected: 12/12/18 13:00 Received: 12/13/18 09:00 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5210B BOD, 5 day	Analytical Method: SM 5210B Preparation Method: SM 5210B							
BOD, 5 day	**1.7**	mg/L	1.5	1.5	12/14/18 11:44	12/19/18 15:10		

REPORT OF LABORATORY ANALYSIS

Wetlands Ecol Manage
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ORIGINAL PAPER

Response to: Turner, R.E., J.E. Bodker, and C. Schulz. 2017. The belowground intersection of nutrients and buoyancy in a freshwater marsh. Wetlands Ecology & Management: 1–9

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Keywords Treatment wetlands · Soil strength · Nutria · Wetland restoration

Turner et al. (2017) report on wetland degradation following introduction of secondarily-treated municipal effluent into a freshwater emergent and forested wetland in southeastern Louisiana, referred to as the Hammond assimilation wetland (HAW). They assign the cause of the wetland loss to a combination of increased decomposition and decreased soil strength due to the presence of nutrients from the effluent that led to buoyancy in the marsh soil. They do not, however, discuss or even cite two other papers that have examined the same wetland and have come to different conclusions (Shaffer et al. 2015; Lane et al. 2015), specifically that nutria herbivory was the main cause of the wetland deterioration (Fig. 1), or a workshop in October 2016 where these issues were discussed in detail. Most importantly, the authors fail to mention or consider that the wetland vegetation began to recover as soon as nutria control was implemented (Fig. 2), though with a different species assemblage most likely due to the combined impacts of herbivory (Shaffer et al. 2015) and perhaps increased water levels (Lane et al. 2015). In general, Turner et al. (2017) selectively cite the literature to support their conclusions. There have been recent concerns that because denitrification, defined as the microbially-mediated reduction of nitrogenous oxides to nitrogen gas, is coupled to the oxidation of organic matter, there is the potential for marsh soil weakening or destabilization as a result of this nitrate addition (Bodker et al. 2015; Turner 2010; Kearney et al. 2011). The observations have primarily been anecdotal or based on simple correlations of nitrate loading and soil strength measurements or measurements of belowground biomass (Darby and Turner 2008a, b, c; Deegan et al. 2012) that do not clearly indicate causation. The two central issues in this paper are the role of nutria in the marsh deterioration and the role of nutrients in causing marsh deterioration. We show below that there is strong evidence that nutria were the primary cause of marsh deterioration at the Hammond assimilation wetland and that based on stoichiometry, the amount of nitrate in the effluent could not explain the observed wetland loss.

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Fig. 1 Photo of a fenced 2 × 2-m exclosure that prevented nutria entry established in the wetland in 2008 after intense grazing over the fall and winter of 2007–2008 (left), and another exclosure (center of photo surrounded by wetland vegetation) during the Summer of 2011 (right) after substantial recovery of the vegetation at the assimilation wetland (note different species assemblage inside the exclosure compared to outside. Typha domingensis was the dominant plant in the exclosures). The discharge pipe is located near the trees in the background of both photos

Fig. 2 Panoramic photograph of the assimilation wetland looking south approximately 100 m from the discharge pipe on September 27, 2017. The area between the boardwalk and the power lines in the background was open water in 2010 but recovered after nutria removal began

Turner et al. (2017) state that 'An oligotrophic coastal freshwater marsh converted to open water within months after receiving partially-treated sewage water in fall 2006.' The assimilation wetland does not receive 'partially-treated sewage', but rather secondarily treated and disinfected municipal wastewater. In essence, all municipal effluent is 'partially-treated sewage' in the sense that effluent is not treated to the level of drinking water that is the primary water source of the effluent. The term 'partially-treated' is not used in the wastewater treatment literature to refer to required levels of treatment. Rather, standards are set for different levels of treatment that are governed by the type of treatment and the status of the receiving water body.

Turner et al. also state that 'Consideration should be given to the possibility that the partially-treated sewage can vary in toxicity strength and that toxic effluent spikes could be fatal or produce a profound stress to the trees and various species of marsh vegetation.' This is speculation and no evidence is presented to show that this has ever happened at the site or at any assimilation wetland in Louisiana or elsewhere. The secondarily-treated and disinfected effluent that is discharged into an assimilation wetland is subject to the same toxicity testing as effluent discharged into an open water body, as per the

requirements of the Louisiana Pollutant Discharge Elimination System permit. Whole effluent toxicity testing with *Daphnia pulex* and *Pimephales promelas* is conducted twice per year, as well as monitoring for magnesium, lead, cadmium, chromium, iron, nickel, silver and selenium. Periodically, all treatment systems are required to carry out a priority-pollutant-scan that includes over 50 organic and inorganic potential pollutants (referred to as PPS). The LDEQ currently requires cadmium, chromium, copper, iron, lead, magnesium, nickel, selenium, silver, and zinc concentrations to be measured at specific time increments for surface water, soils, and vegetation of wetlands receiving treated municipal effluent. Metal concentrations of surface waters at the assimilation wetlands of Breaux Bridge, Thibodaux, St. Bernard, and Hammond have been very low, with most concentrations below the detectable limit at both assimilation and reference wetlands (Hunter et al. 2018). There also have been no detectable differences in metal concentrations for sediments or vegetation between the assimilation wetlands and reference wetlands. Similar results have been obtained for all assimilation wetlands in Louisiana. In general, there is little evidence that toxicity or metal contamination is an issue of concern for assimilation wetlands. Turner et al. (2017) also state that 'There are other issues, including that the un-managed distribution of pathogens into a nutrient- and organic-rich system is a fertile growth medium for organisms.' No data are provided to support this statement. The secondarily treated effluent is disinfected using chlorination-dechlorination, so there is no un-managed distribution of pathogens. That is one of the primary goals of the wastewater treatment process.

It is also important to consider in detail the time line of events at the Hammond assimilation wetland when discussing the cause of the wetland deterioration. The wetland did not convert to open water within months of the initiation of effluent discharge. Effluent discharge began in November 2006. During the 2007 growing season, there was robust growth of marsh vegetation with a near doubling of biomass compared to controls, and a pronounced increase in the height of emergent vegetation, which more than doubled (see Fig. 9 from Shaffer et al. 2015). There was no evidence of a negative effect on the vegetation until nutria began to impact the area late Fall of 2007 (Shaffer et al. 2015).

Turner et al. (2017) state 'The majority of cypress trees planted with protective collars (5000) within the marsh receiving partially-treated sewage either died, floated out of their anchorage, lodged over or manifested signs of abnormal growth (hypertrophy and stunted height). Some cypress trees planted in the firm soil of the pipeline embankment grew well, but other species on this spoil embankment died after the project began'. This is simply inaccurate. As noted above, there was vigorous growth of marsh vegetation in 2007 with much of the emergent vegetation reaching heights of 1.5–2.0 m. Shaffer et al. (2015) concluded that the seedlings died mainly as a result of shading from surrounding vegetation, which grew taller than the seedlings. Hillmann et al. (2018) fertilized baldcypress and water tupelo seedlings in a 16-month mesocosm study at loading rates of 0–400 g N m^{-2} $year^{-1}$. Aboveground biomass production increased to 400 g m^{-2} $year^{-1}$ for both species, whereas belowground biomass production increased to 100 g m^{-2} $year^{-1}$ then decreased slightly at higher loading rates. Diameter increase for seedlings planted within 100 m of effluent discharge at five assimilation wetlands averaged from 1.1 to 2.5 cm $year^{-1}$over 3–10 years and was about 5–10 times higher than that of nearby natural swamps in the Joyce wetlands. The trees that died were on the low part of the spoil bank and were almost all Chinese tallow (*Triadica sepifera*), an invasive species that has replaced native vegetation in upland areas and is difficult to control. These trees died due to higher water levels and are being replaced by planted baldcypress and water tupelo. We also maintain a nursery of thousands of healthy bald cypress and water tupelo seedlings located adjacent to the discharge pipe and inundated with the effluent. In addition, wetlands have received nutrients from treated municipal effluent for decades in Louisiana and elsewhere without deterioration (Hesse et al. 1998; Brantley et al. 2008; Day et al. 2006, 2018b; Hunter et al. 2009a, b, 2016, 2018).

Based on results from manipulative exclosure experiments, observations of nutria activity, and vegetation recovery after nutria control, it is clear that nutria were the dominant cause of marsh deterioration. Effluent discharge began in November 2006, vegetation grew dramatically through the spring and summer of 2007, then nutria heavily grazed the site within six months (Fall 2007–Spring 2008). Intensive nutria removal began in the spring of 2008 and continued

through the winter of 2008–2009. Approximately 2000 nutria were killed by shooting. Vegetation recovery began during the Spring of 2009 and was most pronounced and consistent nearest the discharge pipe. By 2015, there was considerable recovery of wetland vegetation (Allen 2016). There is now a diverse vegetation community that includes floating aquatics as well as shallow and deep-rooted emergent marsh (Table 1).

The recovery of the site followed a similar trajectory as documented by Izdepski et al. (2009) for the Thibodaux assimilation wetland where floating aquatics first became established followed by rooted emergent floating marsh. When discharge of secondarily treated effluent began in 1992 at the Thibodaux site, there was considerable open water area adjacent to the discharge pipe. In less than a decade, *Alternanthera* and *Hydrocotyle* had grown over much of the open areas and by 2002 *Panicum* had begun to form a thick mat that spread over the area. The marsh has persisted until present. Stable isotope analysis showed that *Panicum* took up nitrate from the effluent and formed the mat (Izdepski et al. 2009).

Turner et al. (2017) state that 'There was a lack of herbivory damage in April 2009 where the outer boundary of the soil profile was weakened at 50–60 cm depth, and eventually converted to open water.' Herbivore damage was occurring, as documented by Shaffer et al. (2015) from fall of 2007 through the spring of 2008, and nutria populations were greatly reduced by April 2009.

Turner et al. (2017) question whether the exclosures indicate nutria grazing—'Wetland-to-open water conversion through the buoyant uplift and the subsequent movement of floating mats has a consequence to interpreting results from experiments using small exclosures used to experimentally test for herbivore grazing effects. Exclosures keep out the herbivore grazers, but also trap and maintain floating organic matter, *perhaps* (emphasis added) to re-connect to the bottom layer. If the mat rises when disconnecting during flooding water, but cannot float away because of restraint by the exclosure wall, then the continuing presence of emergent vegetation could be interpreted as evidence for herbivore grazing outside the plot, whereas none happened. This problem of misinterpretation is one arising from omitting a disturbed control as part of an experiment. A disturbed control allows access for herbivores, yet maintains the support offered by the wall structure, thereby testing for a 'cage effect' on emergent vegetation stability. We have seen exclosure cages at our study area that have one cage wall collapsed, but whose vegetation inside was intact; the area around it was devoid of emergent vegetation. In this case we concluded that herbivore grazing was insignificant.'

Turner et al. (2017) provide this interpretation of the exclosure experiments, however, they do not discuss the experimental design or timeline, and do not have any data to support their claims. The exclosures were constructed on bare mud and the fencing prevented floating organic matter larger than 2–3 cm from entering. Plants in the exclosures were immediately planted and established quickly and were almost completely deeply rooted marsh vegetation, mainly planted *Typha domingensis,* which have roots that

Table 1 List of species currently growing in the area that was impacted by nutria grazing

Most common species	Other vegetation at the site includes
Giant cutgrass (*Zizaniopsis miliacea*)[a]	Deer pea (*Vigna luteola*)
Pennywort (*Hydrocotyle* sp.)	Marsh morning glory (*Ipomoea sagittata*)
Bulltongue (*Sagittaria lancifolia*)[a]	Walter's millet (*Eichinochloa walteri*)
Alligatorweed (*Alternanthera philoxeroides*)	Water primrose (*Ludwigia peploides)*
Scurgeweed (*Ludwigia leptocarpa*)	Climbing hempweed (*Mikanea scandens*)
Swamp smartweed (*Polygonum punctatum*)	Sheetflow grass (*Panicum gymnocarpon*)
Thin-leaved cattail (*Typha domingensis*)[a]	arrow arum (*Peltandra virginica*)
	Pickerelweed (*Pontederia cordata*)
	American cupscale (*Sacciolepis striata*)
	Duck potato (*Sagittaria platyphylla*)
	Giant bullrush (*Schoeplectus californicus*)
	Soft rush (*Juncus effusus*)

[a]Zizaniopsis, Sagittaria, and Typha are deeply rooted

penetrate a meter or more. If the rooted vegetation detached from the soil and floated with rising water, it would tend to fall over and be readily obvious that floating had occurred. This was not the case. In addition, *T. domingensis* repeatedly planted in uncaged paired controls was eaten within 48 h. The authors may have seen vegetation in exclosures where walls were not intact, but this depends on how long the walls were down, and the exclosures were not maintained after the experiment concluded. We have observed instances where a wall was breeched and nutria consumed the vegetation within days or weeks. In addition, when larger cages were built (20 m × 20 m), waterfowl landed inside the exclosures and consumed vegetation. The authors made all of their assumptions regarding the exclosures without knowledge of the experimental design or timeline, and without trying to consult with the scientists conducting the experiment.

Widespread damage due to nutria herbivory has been extensively reported for coastal Louisiana (Ford and Grace 1998a, b; Evers et al. 1998; Keeland et al. 2011; McFalls et al. 2010; Sasser et al. 2018; Shaffer et al. 1992). In the Big Branch Marsh National Wildlife Refuge (NWR) located about 50 km east of the Hammond assimilation wetland, a large area of marsh deterioration occurred due to nutria during the same period as the damage that occurred at Hammond (Shaffer et al. 1992; Sasser et al. 2018). Over 7000 nutria were culled by shooting and trapping during 2007 and 2008 at Big Branch Marsh NWR (Table 1 in Sasser et al. 2018). One of the individuals involved in the culling at Big Branch Marsh (Christopher Carrell) also was the primary shooter at Hammond. In total, eight scientists observed and killed nutria at the Hammond assimilation wetland.[1] After the nutria population was reduced, vegetation recovery occurred, with the most robust recovery nearest the discharge pipe. Exclosures that excluded nutria had robust growth, but when nutria were allowed to enter the exclosures, the vegetation was greatly reduced (Fig. 5 from Shaffer et al. 2015). Similar exclosure experiments have demonstrated the impacts of nutria in the Atchafalaya delta, Bayou Penchant wetlands, and other areas in Louisiana (Ford and Grace 1998a, b; Geho et al. 2007; Gough and Grace 1998a, b; Sasser et al. 2004, 2018; Shaffer et al. 1992). Assimilation wetlands may be more susceptible to nutria damage because nutria preferentially graze on nutrient-enriched wetland vegetation (Ialeggio and Nyman 2014).

Weller and Bossart (2017) reported that insect community diversity tracked the overall condition of the Hammond assimilation wetland over time. Simpson's diversity was highest before degradation occurred, lowest at the height of degradation, and intermediate during the period of partial recovery. Species richness, however, was highest in the partially revegetated marsh community. The community included species characteristic of both the intact and degraded communities, but it shared greatest affinity with the intact marsh. The dominant taxa present in these communities shifted from various beetles to chironomid flies and then back to beetles.

Did nutrients increase wetland soil organic matter decomposition at the Hammond site?

Turner et al. (2017) claim that the damage to the Hammond assimilation wetland was the result of nutrient impacts on vegetation. They draw on Bodker et al. (2015) who reported that nutrients in treated municipal effluent led to the marsh deterioration at Hammond. These studies were developed based on other recent studies suggesting that nutrient additions have deleteriously impacted wetlands (Turner 2010; Kearney et al. 2011). In particular, it has been claimed that denitrification, which is the microbially-mediated reduction of nitrogenous oxides to nitrogen gas, is coupled to the oxidation of organic matter, and this leads to marsh soil weakening or destabilization as a result of nitrate addition to wetlands (Bodker et al. 2015; Turner et al. 2017).

There are many reports of nutrient additions having no or positive impacts on above- and belowground production and decomposition (Haines and Dunn 1976; Valiela et al. 1976; Buresh et al. 1980; Day et al. 2004, 2006; Ravit et al. 2007; Hunter et al. 2009a, b; Carrell 2009; Shaffer et al. 2009; Hillmann

[1] Researchers who observed high nutria populations, some of whom participated in shooting nutria populations included Chris Carrell (SELU), Jason Day (CRI), Eva Hillman (SELU), Montgomery Hunter (CRI), Chris Lundberg (SELU), Joel Mancuso (SELU), Gary Shaffer (SELU), Bernard Wood (SELU). Mr. Carrell also participated in the culling of about 7000 nutria at the Big Branch Marsh National Wildlife Refuge during the same period. Nick Stevens (SELU) is currently involved in monitoring and shooting nutria at the site.

et al. 2015; Anisfeld and Hill 2012; Fox et al. 2012; Zhang et al. 2013; Morris et al. 2013; Graham and Mendelssohn 2014; Steinmuller et al. 2016), while some show negative impacts (Darby and Turner 2008a, b, c; Deegan et al. 2012; Morris and Bradley 1999; Swarzenski et al. 2008; Wigand et al. 2009). The reason for varied responses to nutrient addition is likely associated with variation in localized environmental conditions (e.g., salinity, flooding, soil composition, mineral sediments) that interact to affect nutrient uptake and biomass, and with differences in nutrient loading rates.

Bodker et al. (2015) reported that high nutrients caused increased decomposition that led to the dramatic loss of wetland vegetation at the Hammond assimilation wetland. While there are numerous studies that show both positive and negative impacts of nutrient additions on wetlands, there is no study that shows that nutrient addition led to such a dramatic and rapid loss of wetland vegetation in such a short period of time. Bodker et al. (2015) carried out several short-term experiments (4–6 weeks) that they contend to show that excess nutrients led to the wetland loss. In one experiment, they measured loss of organic matter from marsh soils with added reference water and effluent. The results of their six-week study are consistent with the 18-month litterbag decomposition study by Shaffer et al. (2015) that found no impact of the discharge on decomposition. Typically, litterbag studies find that initial decomposition is rapid followed by a log decrease over time. In addition, the decomposition experiment by Bodker et al. (2015) was carried out at 35 °C 'to maximize the decomposition rates anticipated during the summer temperature.' However, 35 °C is much higher than water temperatures measured at the site, which had mean of 21.9 ± 0.6 °C over an 8-year period and never reached 35 °C, and from October to March, 2007–2008 when marsh deterioration occurred, mean water temperature was about 16–17 °C.

In additional experiments, Bodker et al. (2015) incubated several marsh substrates with different nutrient amendments (distilled water, water from a reference wetland, surface water from the wetland receiving treated effluent) and measured gas production over 26 days. Gas production in chambers with effluent was 12% (*Panicum* mat) to 83% (cypress needles) and averaged 34% compared to experiments with water from a reference site. They did not identify the gas produced or relate gas production to organic matter decomposition. To do this, we carried out stoichiometric calculations that showed that the differences in gas production could explain only a small fraction of observed organic matter decomposition in the experiments. Below is the equation for denitrification (Reddy and DeLaune 2008):

$$5(C_6H_2O_6) + 24(NO_3^-) + 24H^+ \rightarrow 30(CO_2) + 12(N_2) + 42(H_2O)$$

Based on this equation, 30 mol of carbon are utilized for every 24 mol of N. Thus, one mole of NO_3-N (14 g) reduced in denitrification results in the oxidation of 1.25 mol of C (12 × 1.25 = 15 g) or 30 g organic matter, assuming a 50% carbon content. For the gas production experiments, from 0.7% to 4.9% of the marsh substrate was decomposed with the lowest value being *Panicum* marsh mat. We assumed that all NO_3 introduced was denitrified therefore our calculations over-estimate organic matter decomposition due to denitrification. The calculations are the same whether CO_2 or CH_4 is produced. Day et al. (2018a) calculated the amount of organic carbon needed to support denitrification of all introduced nitrate at the Hammond assimilation wetland. Nitrate concentration drops to background levels (< 0.1 mg/L) within one km of discharge and the smaller area where marsh deterioration occurred (Shaffer et al. 2015). The amount of soil organic matter that could be decomposed annually by denitrification if all NO_3 were reduced to N_2 via denitrification would range from 1.5 to 4.7% of the marsh soil organic matter if the marsh soil was the organic substrate used in denitrification. Note that the same results are obtained if the equation is only for the decomposition of organic matter without consideration of NO_3. These calculations show that any heterotrophic nutrient interaction in wetlands such as denitrification that involves oxidation of organic matter cannot lead to significant soil organic matter decomposition because ppm concentrations of nutrients demand ppm organic matter while soil organic matter concentration is parts per hundred (Day et al. 2018a).

It is unlikely that denitrification could lead to significant marsh soil organic matter decomposition because direct denitrification uses low molecular weight compounds as an organic substrate, and the great majority of soil organic carbon components

cannot serve as an organic substrate for denitrification (Reddy and DeLaune 2008). Labile and low-molecular weight organic matter, such as that found in the treated effluent, can serve as a carbon source for denitrifiers thus organic compounds in the effluent added to the experiments likely served as an organic substrate that yielded gas production. Thus, there are two potential sources of labile organic matter that could support denitrification, organic matter in the wetland soils and that in the municipal effluent. For example, the mean 5-day biochemical oxygen demand (BOD_5) concentration of municipal effluent is about 30–40 mg/L, which is more than sufficient for the denitrification of the available NO_3, and is most likely preferable since most organic matter is already in dissolved form and is readily available, not requiring a microbial enzymatic hydrolysis step.

Aboveground productivity in the area receiving the municipal effluent has been measured annually since discharge began and has always been above 600 g m^{-2} $year^{-1}$ (Shaffer et al. 2015) and often above 1500 g m^{-2} $year^{-1}$ depending on year and location (LPDES reports for the Hammond assimilation wetland). The contention that tight coupling of denitrification and oxidation of soil carbon stores decreases soil strength and, hence, marsh stability, is not supported by these data or the published literature.

Bodker et al. (2015) also measured relative decomposition at the Hammond assimilation wetland using loss of tensile strength of cotton strings inserted vertically into the soil. Their results ranged from $\sim$ 0.1 to 1.0% day^{-1} with an average difference between treatment and reference of $\sim$ 0.3% day^{-1}. Cotton-tensile-strength-loss (CTSL) is a measure of cellulose degradation, and most plant roots and leaves are composed of much more than just cellulose. It is a measure of relative decomposition rather than a direct measure of celluloytic activity (Harrison et al. 1988). By contrast, litter bag decomposition (used by Shaffer et al. 2015) is a direct measure of plant organic matter from a site. The values for CTSL from Bodker et al. (2015) were about an order of magnitude less than values reported for other wetlands in Louisiana and elsewhere that ranged from about 1 to 8% day^{-1} (Mendelssohn et al. 1999; Mendelssohn and Slocum 2004; Verhoeven et al. 2001; Slocum et al. 2009; Day et al. 2013), suggesting a possible error in their calculations.

Turner et al. (2017) state that 'Hunter et al. (2009a) calculated the loading rates at Joyce WMA using the area of 4047 ha at 2.10 g N m $year^{-1}$, which was equivalent to 21 kg N ha $year^{-1}$. But the impact area where land turned to water is much smaller (122 ha) which equates to an annual total N loading rate of about 697 kg N ha $year^{-1}$ over the impacted area. The loading rate would be even higher closer to the first exposure to effluent additions. A 10 ha exposure zone at the beginning of waste delivery, for example, would be 8499 kg N ha $year^{-1}$.' With this logic a loading rate could be extremely large provided smaller and smaller areas are used to calculate it. This is clearly misguided. Only a limited amount of exchange occurs between sediments and the overlying water column, with nitrate disappearing within a few cm (Smith et al. 1982; Reddy and DeLaune 2008). The 'effective loading rate' is the loading rate at which nutrient concentrations in the entire water column are processed. It can be determined by the distance needed for surface water nutrient concentrations to drop to background levels, and using the area between that distance and the discharge point as the 'exposure zone' to calculate loading rate as Turner et al. (2017) did above. Figure 3 below, for example, shows that the exposure zone for NO_x is much less than TN since

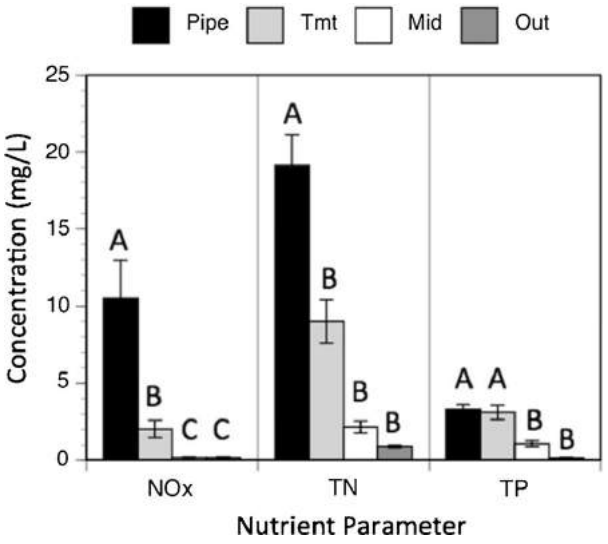

Fig. 3 Long-term (2007–2013) water quality data from quarterly sampling from the Hammond Assimilation Wetland ($\pm$ 1 s.e.). NO_x: nitrate + nitrite; TN: total nitrogen; TP: total phosphorus. Bars with different letters differ according to Tukey–Kramer multiple comparison (from Shaffer et al. 2015). Tmt is 100 m from the discharge, Mid is 1.7 km from the discharge, and Out is $\sim$ 10 km

NO_x concentrations drop to near background levels by the Mid site (~ 1 km) compared to the Out site (~ 9.5 km) for TN. The area of wetland where nitrate is present is larger than the 122 ha area where marsh degradation took place. TN is still present at the Out site located ~ 10 km distant. The area potentially affecting nutrient concentrations is several thousand ha so that the loading rate for TN reported by Hunter et al. (2009a) is correct.

Soil strength change at the Hammond assimilation wetland

The only quantitative data collected by Turner et al. (2017) were soil strength measurements made with a shear vane (Fig. 4). There were no significant differences in soil strength of the living marsh mat between control and transition zone marshes. Below the living mat, the only depth where standard error bars did not overlap was at 80–90 cm. Thus, there was no impact on soil strength in living marsh soils. These measurements were taken 2 years after marsh deterioration occurred and after significant recovery had taken place. The nutrient data in Fig. 3 show that nutrients were reduced significantly by the time water reached the site measured, and soil strength is different at only one depth (approximately 80–90 cm) and there is high variability in the measurements. An alternative explanation of marsh buoyancy was that the marsh that floated had been killed by nutria and that decomposition produced gas bubbles that caused the marsh to float during the high water period. Morton and Barras (2011) reported on hurricane impacts on coastal wetlands in Louisiana over a half-century period and created a classification of impact types including floating and redistribution of marsh. Those marshes often recovered to varying degrees after hurricanes, as was the case at Hammond.

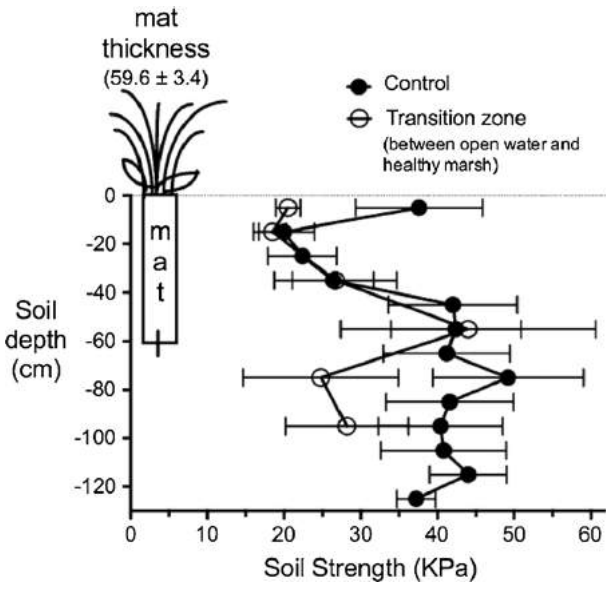

Fig. 4 Soil strength at control and transition zone at the edge of the open water in the Hammond assimilation wetland (from Turner et al. 2017)

Organic matter accumulation and the volume of soil that it generates are primarily functions of the production of refractory organic matter such as lignin, which is not used by denitrifiers as a substrate. The labile fraction of primary production, which is most readily used by denitrifiers, does not significantly contribute to sediment volume (Morris et al. 2014). Based on stoichiometric calculations at the Caernarvon river diversion and the Hammond assimilation wetland, a very small portion of soil organic matter would be decomposed during denitrification if all effluent NO_3 were reduced (Day et al. 2018a). Thus, it is not likely that nutrient additions are increasing decomposition rates and causing marsh instability.

We know of no example of such rapid dramatic wetland deterioration occurring due to nutrient addition as observed at the Hammond assimilation wetland. There are numerous studies of the impact of nutrients on wetlands, some of which lasted for decades. These include experimental nutrient addition studies, river diversions, and wetlands receiving treated municipal effluent either as planned assimilation wetlands or situations where there was opportunistic discharge that flowed over wetlands. There have been reports of effects of added nutrients, both positive and negative, on above- and belowground biomass, decomposition, soil strength, and accretion, but no study has reported rapid, dramatic deterioration of a wetland such as occurred at Hammond. By contrast, nutria eat outs have occurred often with destruction of hundreds of ha of herbaceous marsh and destruction of bald cypress seedlings (Sasser et al. 2018). The study of Turner et al. (2017) and that of Bodker et al. (2015) show small and subtle direct impacts of nutrients and are consistent with the decomposition study of Shaffer et al. (2015) who found no significant impact of the effluent discharge on above- or belowground decomposition.

Summary

In summary, Turner et al. (2017) propose that nutrient loading led to marsh deterioration due to elevated levels of belowground organic matter decomposition, which then led to a more buoyant marsh that floated and was misplaced. In drawing their conclusions they selectively cite the literature and make a number of misleading and erroneous statements about the area that are not supported by any data. Turner et al. (2017) rely on an unpublished opinion to dismiss the importance of nutria at the Hammond cite. They contend that a hurricane that affected the area in 2012 was a factor, but it occurred 4–5 years after marsh deterioration and during the time wetland vegetation was recovering. The most robust recovery was in the area adjacent to the discharge where nutrient loading was highest. Stoichiometric calculations show that measured nutrient inputs could not have supported the organic matter deterioration that occurred. Though the issues are probably more complex than an argument about whether nutria herbivory or changes in decomposition caused the dieback, the results presented by Turner et al. (2017) are consistent with marsh degradation due to nutria grazing and the subsequent recovery of the marsh.

Although it seems clear that nutria herbivory was the main cause of the marsh deterioration at Hammond and that research carried out at the site do not demonstrate an impact on belowground production or decomposition, nutrient additions may also likely cause a variety of changes to the marsh ecosystem that could take years to unfold (see reviews by Morris et al. 2014; Day et al. 2018a, b). Changes in plant species composition, changes in growth of above- versus belowground plant biomass, and changes in decomposition rates could alter the structure, function, and persistence of the marsh ecosystem. Long-term impacts should be studied to assess the desirability and sustainability of discharging secondarily treated sewage to coastal wetlands, especially marshes to reduce nutrient inputs to receiving waters. Insights into the long-term impact of discharge of secondarily treated municipal effluent on coastal wetlands comes from five assimilation wetlands that have functioned from 27 to 70 years (Hunter et al. 2016; Day et al. 2018b). There are both freshwater forested and emergent wetlands. These studies demonstrate that after decades of discharge, productivity is enhanced, accretion is increased and nutrient levels are reduced to background levels.

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Compliance with ethical standards

Conflict of interest JWD, RRL, and RGH acknowledge that they carried out both ecological baseline studies and routine monitoring as employees of Comite Resources (comiteres.com), which received funding from the City of Hammond, however no funds from the city were used for this work.

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