Characterization of physical dimensions and nutrient reduction in an experimental treatment wetland

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Executive Summary

The purpose of this study was to quantify the nutrient reduction potential of a constructed treatment wetland on California's Central Coast. Specifically, we calculated wetland surface area, volume, and nutrient reduction rates of phosphate and nitrogen.

Nutrient reduction in runoff is especially important in agriculture-dominated landscapes, like those of the Central Coast, because of high nutrient loads in surface and groundwaters. These high loading rates result from runoff contaminated with nitrogen fertilizers and animal wastes, and are subject to increasingly strict regulations on maximum allowable contaminant levels.

The Central Coast Wetlands Group of Moss Landing Marine Laboratories (CCWG) constructed an experimental treatment wetland on land leased by Pacific Gas & Electric (PG&E) to support ongoing research into effective and cost-efficient nutrient reduction methods for on-farm treatment of nutrient-contaminated runoff. To best understand how to maximize the efficacy of water treatment techniques such as treatment wetlands, it is critical to establish how nutrient concentrations throughout the wetland are related to wetland characteristics such as spatial dimensions, retention time, and vegetation.

In this study, we surveyed cross sections of the constructed wetland channel and used a drone to capture high resolution aerial imagery of the extent of the open water surface and vegetation across the site. We used the cross sections to estimate volume at measured flow rates. We estimated that at a 0.0028 m^3/s flow rate, the wetland volume is approximately 3,697 m^3. We also designed and tested a nutrient sampling protocol that could be used to further refine our understanding of where most of the nutrient reduction occurs.

We found that at a 0.0028 m^3/s flow rate in early fall, nitrate was reduced by 99.97%. Most of the dissolved inorganic nitrogen (DIN) and nitrate reduction occurs within the first 7.72% of the wetland (113 m; 3,674 m^2; 285 m^3), and is reduced to near zero within the first 24.95% of the wetland (320 m; 8,199 m^2; 920 m^3). We found that phosphate was reduced by 81.43% throughout the length of the wetland. These baseline data will provide a foundation for future exploration of nutrient reduction in treatment wetland systems on the Central Coast.

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1 Introduction

1.1 Background

Wetlands provide many ecosystem services, including important wildlife habitat, improved water quality, soil stabilization and flood control (Mitsch and Gosselink 2000; Verhoeven et al. 2006). Wetlands are used to manage water quality, especially in intensively farmed agricultural areas that produce nutrient-loaded runoff. Riparian habitats, such as wetlands, reduce nitrate and phosphorus loads through denitrification, plant uptake and sedimentation, with denitrification considered to be the leading mechanism of nitrate loss (Trepel and Palmeri 2002: Ingersoll and Baker 1998). Despite these recognized values, natural wetland landscapes are continually reduced to make way for agriculture or commercial applications and urban growth (Turner et al. 2000).

Land use within the Salinas Valley is primarily agricultural, producing strawberries, artichokes, leafy greens, brussel sprouts, wine grapes and other specialty food crops. Agriculture is a major source of income for the California Central Coast region, generating approximately $4.8 billion in revenue each year in Monterey County alone (MCAC 2016). This industry provides 76,054 jobs locally, which provides support for approximately 1 in 4 households (FBM 2015). One of the most important negative externalities produced by this prosperity, however, is high concentrations of excess nutrients in agricultural runoff.

Nitrogen, phosphate and ammonia are commonly found in fertilizers used in agriculture and can lead to eutrophication in wetlands and other bodies of water (Verhoeven et al. 2006; Dowd et al. 2008). Eutrophication can cause a surge in phytoplankton growth, which can lead to algal blooms in both freshwater and marine ecosystems. Additionally, high nitrate levels are found in drinking water in rural agricultural communities which has led to health problems, particularly for infants, the elderly and people with compromised immune systems (Bouchard et al. 1992).

In California, the drinking water standard for nitrate is 10 mg/L (as N) (SWRCB 2016). However, studies have found that nitrate concentrations at this level can adversely affect, or be lethal to freshwater animals such as rainbow trout (*Oncorhynchus mykiss*) and amphibians (Camargo and Alonso 2006, Rouse et al. 1999, Massal et al. 2007). A maximum level of 2 mg/L (NO_3-N) is recommended for the most sensitive freshwater species (Camargo et al. 2005).

There is no state drinking water standard for phosphate, although the San Diego Regional Water Quality Control Board has enacted a total phosphorus limit of 0.1 mg/L for streams (CSWRCB 2007). Surface waters with total phosphorus levels between 0.01 mg/L and 0.03 mg/L tend to remain uncontaminated by algal blooms, but this range varies by location (USEPA 1988).

The Central Coast Regional Water Quality Control Board (CCRWQCB), is mandated by the Clean Water Act (CWA) to assess California's water quality data (CCRWQCB 2017). Several water bodies in the Lower Salinas River region are listed as impaired under the CWA, due to poor water quality which has resulted in a decrease of sustainable ecosystem services (CCRWQCB 2013). In March of 2017, the CCRWQCB updated a conditional waiver for agricultural dischargers, requiring dischargers to implement or update management practices to reduce impacts to water quality (CCRWQCB 2017). Methods to reduce nutrient loads from agriculture, including new technologies like woodchip bioreactors and constructed treatment wetlands, are being implemented and monitored at multiple locations within the region (CCWG 2017). Furthermore, nutrient management plans are increasingly employing constructed treatment wetlands to reduce nonpoint source pollution runoff into sensitive ecosystems like estuaries and sloughs (Poe et al. 2003).

Woodchip bioreactors and constructed treatment wetlands are among the most promising methods for diminishing nutrient loads in agricultural runoff. In areas like the Central Coast of California, with an extensive and economically important agricultural industry facing increasingly stringent nutrient runoff policies, stakeholder interest in the viability of constructed treatment wetlands has grown. Experimental treatment wetlands offer an opportunity to refine our understanding of design criteria that will provide maximum efficiency both in nutrient reduction and land use, while reducing construction and maintenance costs.

The efficacy of constructed wetlands, with regard to decontaminating surface water, depends on design parameters such as surface area, volume, residence time, quantity and type of vegetation and hydraulic efficiency, as well as environmental variables like temperature, dissolved oxygen and pH (Kadlec 2009; Trepel and Palmeri 2002).

At the onset of this study we knew that water exiting an experimental woodchip bioreactor had substantially reduced nutrient loads compared to the bioreactor's source water, but regularly entered the treatment wetland at concentrations well exceeding drinking water standards for nitrate and nitrite. Water exiting the approximately 1,100 m-long treatment wetland channel, however, contained nutrient loads well below drinking water standards.

The objectives of this study were to identify key changes in nutrient concentrations along the course of the wetland channel and to characterize the physical dimensions of the wetland (e.g., surface area, estimated volume) in order to inform future studies of the processes that contribute to nutrient reductions under varying conditions (e.g., contaminant loads, residence time, flow rates, water volume).

1.2 Study Site

The PG&E experimental treatment wetland is a slow-moving shallow body of water that spans a meandering length of approximately 1,100 m and occupies ~6 ha (15 ac) in the Moro Cojo Watershed just inland of California State Route 1 between Moss Landing and Castroville (Fig. 1). The study site is characterized by clay soils, a coastal climate and occasional high winds. The experimental bioreactor directly upstream of the treatment wetland draws water from the Castroville Ditch, a body of water that normally would convey agricultural runoff from the northern Castroville area directly into the Moro Cojo Slough. Peak nitrate levels in the Castroville Ditch adjacent to the bioreactor have been measured at 120 mg/L (Robert Burton, pers. Comm., September 28, 2017).

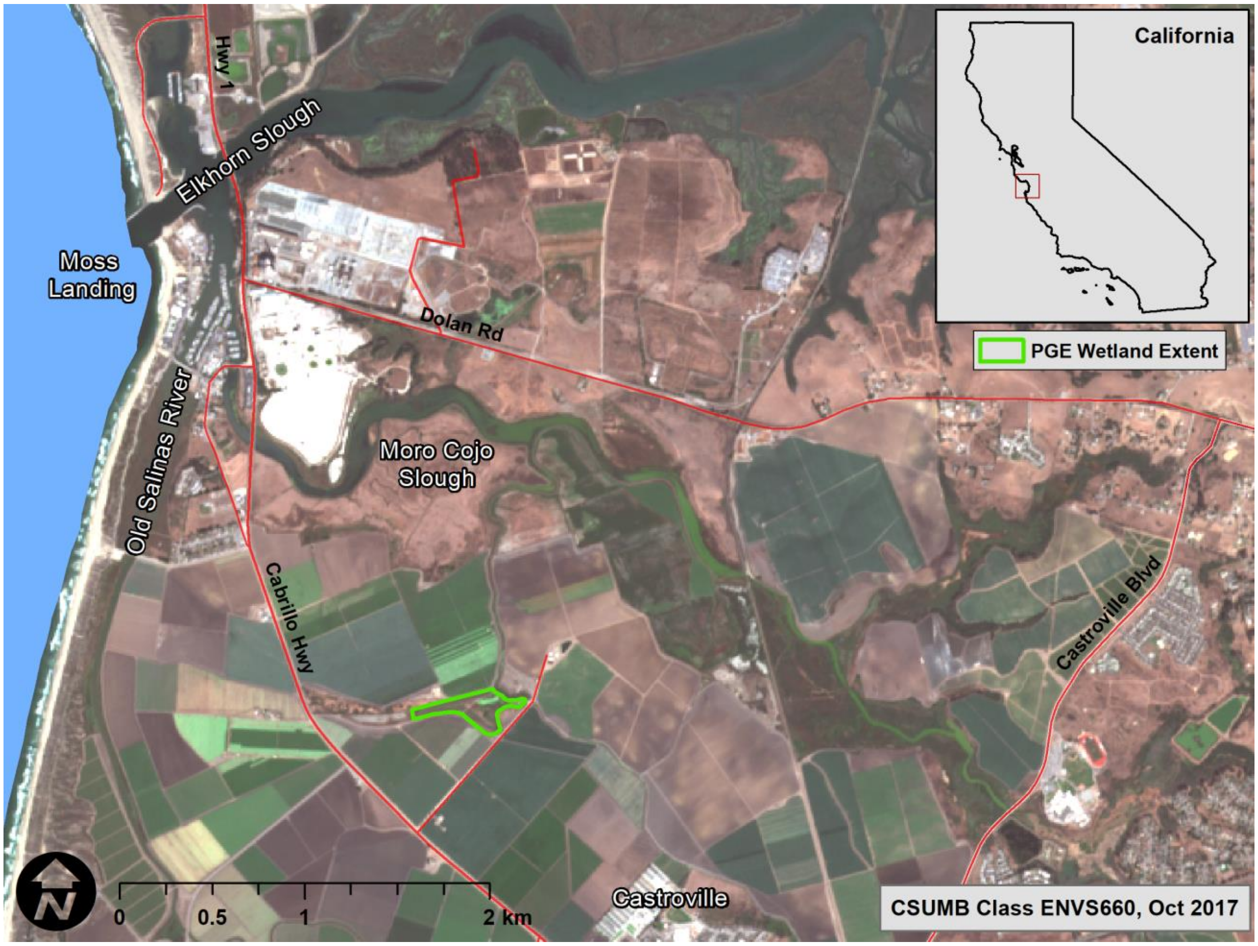

Figure 1. Location of the PG&E treatment wetland between Moss Landing and Castroville, CA.

1.3 Project Description

The PG&E wetland provides water treatment for adjacent farms, which strive to optimize crop yields while maintaining compliance with water quality regulations set by the CCRWQCB and State Water Quality Control Board (SWQCB). The combined treatment systems (bioreactor and wetland) work in tandem to bring nitrate levels to below federal and state drinking water standards. The primary goals of our project were to:

1. Calculate wetland surface area, volume, and nutrient reduction rates of phosphate and nitrogen
2. Provide CCWG with an analytical tool that would enable them to calculate wetland volume and surface area of a given focus areas
3. Provide high resolution orthoimagery of the PG&E bioreactor and wetland site

2 Methods

All data for this study were collected between September 28 and October 12, 2017. We collected low altitude drone imagery of the wetland to inform water surface area estimations, measured channel geometry, measured water flow rate during each field visit, modeled potential wetland volumes and collected 60 water samples (20 samples over the course of three days) for nutrient analysis.

2.1 Wetland imaging

We used a Phantom 4 drone with a 12.4 megapixel camera to obtain a georeferenced orthoimage of the wetland footprint on September 28, 2017. The output included a mosaic of 289 individual images that span an area of 31.53 ha (77.9 ac). Average ground sampling distance of the imagery is 2.57 cm. Water surface area calculations in the following analyses were derived by measuring water extent of the orthoimage in ArcGIS. In cases where duckweed (*Lemna spp.*) obscured the water's edge, surface water was measured at the point where vegetation changed from bright green (indicative of hydrophilic duckweed) to another color.

2.2 Flow rate estimation

We estimated flow rate into the wetland by timing the length it took each of the 13 bioreactor outfalls to fill a container with a known volume (4.4 L). Each outfall fill rate was measured three times and then averaged. We divided the average fill rate by the volume of the container, multiplied the result by 0.001 to convert to cubic meters per second, and summed the results of all outfalls to estimate the total flow rate at the approximate time that water quality data was taken.

2.3 Wetland volume estimation

2.3.1 Channel geometry measurements

We measured channel geometry at ten cross sections spaced in a way to best inform total volume measurements (Fig. 2). To survey each cross section, we installed temporary rebar benchmarks on either side of the channel, stretched a 100-meter transect tape taught between the two benchmarks and then measured the cross section using an auto level and leveling rod (Harrelson et al. 1994). Benchmark locations were recorded with a Trimble Juno 3B handheld unit (accuracy 2-5 m) using a generic data dictionary and a minimum of five points logged at each benchmark (Table 1). Leveling rod elevation readings along each transect were shot at 1-1.5 m increments with additional shots to record breaks in slope and right and left edges of water. Surveys were opened and closed on the same benchmark to assess measurement error. Instrument accuracy was 0.001 m and average measurement error was zero.

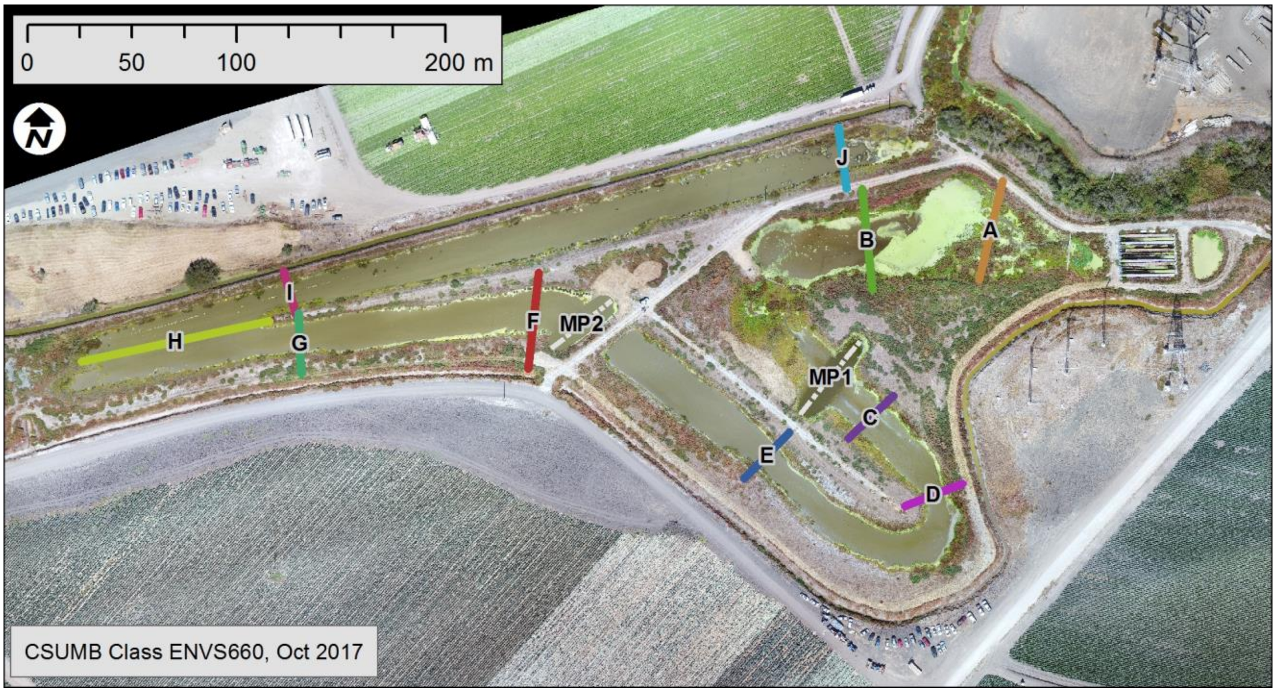

Figure 2. Locations of ten cross sections used to measure wetland channel geometry and locations of two abbreviated cross sections across mixing pool 1 (MP1) and mixing pool 2 (MP2).

Table 1. GPS coordinates of benchmark locations.

Cross	Right Benchmark		Left Benchmark	
Section	Easting	Northing	Easting	Northing
A	609883	4071574	609872	4071527
B	609816	4071570	609821	4071522
C	609809	4071451	609830	4071471
D	609836	4071418	609864	4071429
E	609781	4071454	609759	4071431
F	609661	4071530	609656	4071484
G	609546	4071511	609547	4071482
H	609531	4071507	609441	4071489
I	609544	4071510	609539	4071531
J	609808	4071571	609804	4071599

The two mixing pools along the wetland channel are deeper than the depth of the main channel and extend beyond the normal edge of water. Due to time constraints, we took five to six shots evenly spaced through the center of each pool starting and ending at the water's edge to roughly estimate channel depth to inform volume estimations. Opening and closing shots were taken on the same benchmarks used for cross sections C and F (Fig. 2).

2.3.2 Volume calculations

We calculated the cross-sectional area for each cross section measured in the field. We used a midpoint formula to calculate the wetted area between cross section benchmarks using the following equation:

$$(x2 - x1)(d1 + d2) \times 0.5$$

where x is the length of the cross section and d is water depth. Total cross-sectional area was calculated by summing all areas within a single cross section. We used the cross-sectional areas to calculate channel volume with the assumption that the engineered channel morphology is relatively uniform throughout the wetland. Based on this assumption, a single cross-sectional area was used to represent a larger section of channel that extended to the midpoint between cross sections (Fig. 3). The volume of each section was found by multiplying the cross-sectional area by the distance between the cross section midpoints. For channel reaches containing a mixing pool cross-section, midpoints were placed at the beginning of the pool.

2.3.3 Volume calculation tool

We developed a volume calculation tool to aid in rapid spatial analysis of wetland volume. We designed the tool to return a total wetland volume above any sampling point at one-meter intervals. The tool relies on commonly used Microsoft Excel functions (e.g., match, index) to provide volume calculations when given a distance along the channel thalweg from the bioreactor outflow pipes. The volume calculations provided as tool outputs are described in section 2.3.2.

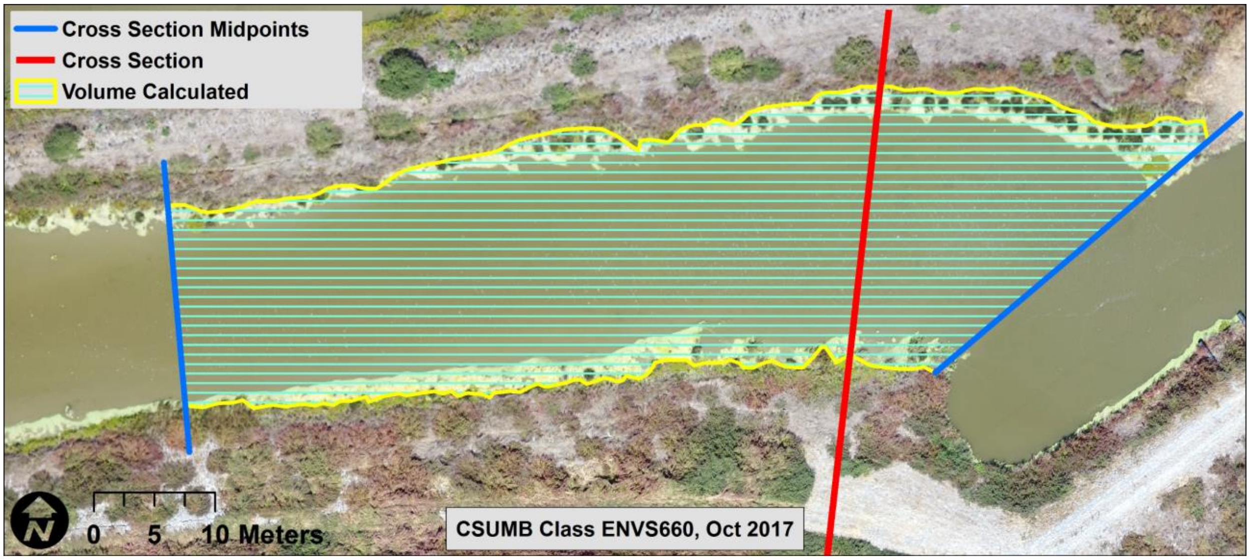

Figure 3. Example of a channel section where one cross-sectional area based on a single measured cross section (red line) was used to calculate the volume of the entire channel section (highlighted in yellow). The area which is assumed to be similar in channel morphology, extends from the measured cross section to the midway point to the next downstream cross section (blue line on the left) and upstream to the edge of a mixing pool (blue line on the right).

2.4 Nutrient reduction

2.4.1 Preliminary nitrate reduction study

To inform the selection of water quality sampling locations throughout the wetland, we conducted an initial nitrate reduction study using WaterWorks™ Nitrate/Nitrite test strips. Two samples were taken every 50 m starting at the hay bales just upstream of the wetland outlet and ending just downstream of the hay bales at the wetland start. Standard methodology for using nitrate test strips was followed. The results of this initial study showed that the highest decrease in nitrate occurred in the first half of the wetland.

2.4.2 Water sampling

On three different days, we collected grab samples from 20 locations along the channel (Fig. 4). We chose to take the majority of samples from the upper reaches of the wetland due to the results of our preliminary nitrate reduction study. Specifically, the first 270 m of the wetland were assigned sampling points approximately 30 m apart, the next 280 m had points approximately 40 m apart and the remainder of the channel had points approximately 200 m apart. All samples were collected between the hours of 12:00 PM and 5:00 PM on 10/5/17, 10/9/17 and 10/12/17. GPS points of grab sample locations were recorded using a Garmin GPSMAP 64st handheld device (3 m accuracy) on the right bank of the channel lined up directly with the channel center sampling location (Table 2).

Table 2. GPS coordinates of in-channel water quality sampling locations.

Sample Site	Easting	Northing
1	609919	4071563
2	609914	4071559
3	609902	4071562
4	609887	4071575
5	609853	4071582
6	609820	4071574
7	609779	4071562
8	609768	4071532
9	609766	4071488
10	609786	4071459
11	609821	4071432
12	609837	4071415
13	609807	4071422
14	609775	4071455
15	609740	4071485
16	609715	4071503
17	609691	4071499
18	609531	4071508
19	609682	4071539
20	609854	4071596

To collect the samples, we flushed a 30 ml syringe three times to remove residue from previous samples. We then filled the syringe with water from the center of the channel in the middle of the water column, passed water through a Whatman filter, collecting at least 20 ml of sample water for lab processing. Samples were maintained at a cool temperature in the field and then frozen. Each time a water sample was collected, we also measured dissolved oxygen (DO) and temperature with a YSI model 55 handheld multiparameter meter.

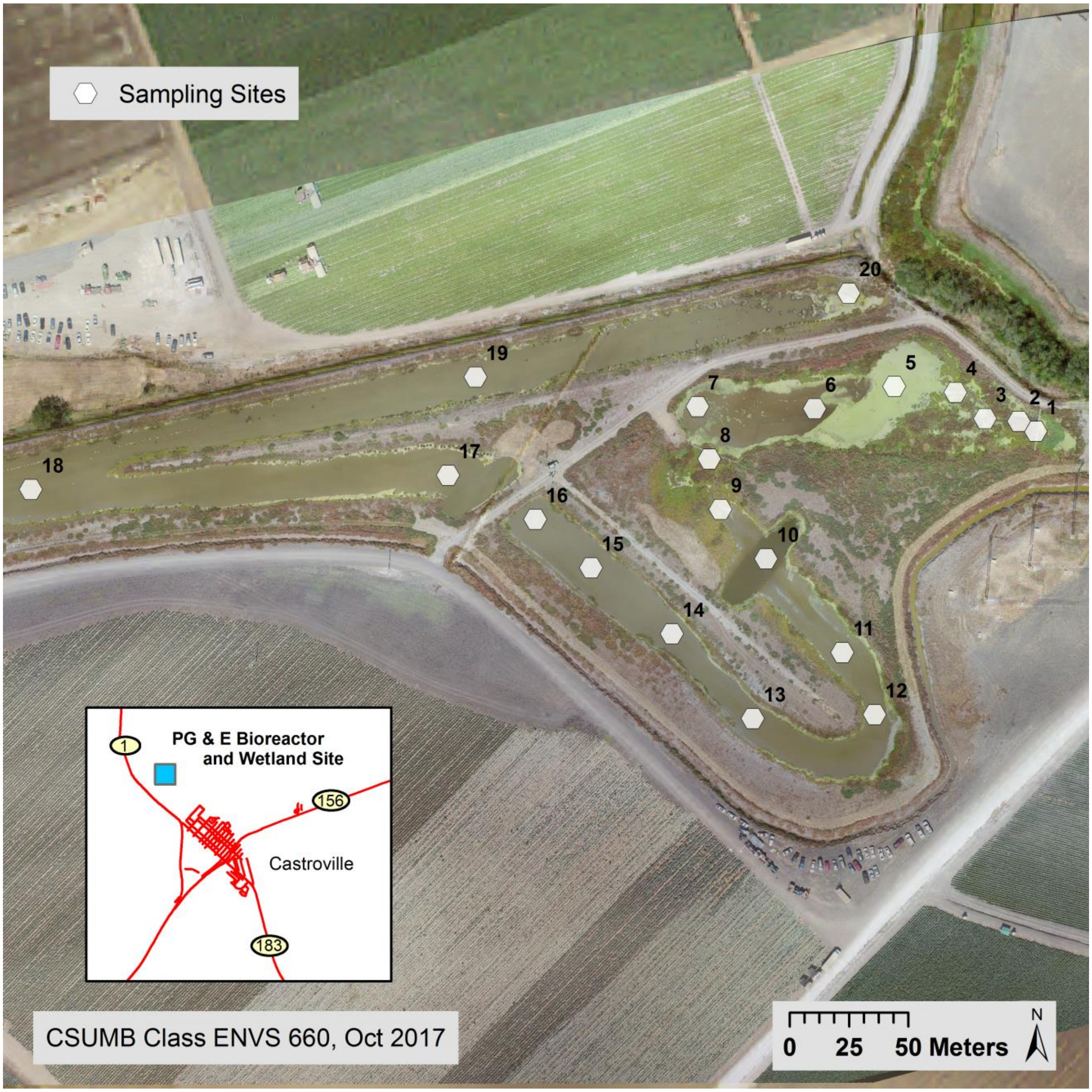

Figure 4. Water quality sampling locations along the wetland channel.

2.4.3 Water quality analysis

All water samples were analyzed colormetrically using a Lachat Quickchem 8000 Flow Injection Analyzer with an autosampler in Dr. Kimberly Null's lab at Moss Landing Marine Laboratories (Appendix). Water was tested for phosphate (mg/L), nitrite (mg/L), nitrate/nitrite (mg/L) and ammonia (mg/L). From these results we calculated nitrate (mg/L) and total dissolved inorganic nitrogen (DIN: nitrate+nitrite+ammonia mg/L). Negative values of calculated nitrate were denoted as 'below detectable limit'; we assumed that negative numbers indicated significant denitrification, where most or all nitrogen is in the form of nitrite. We averaged nutrient concentrations from our three sampling days. We calculated total and percent reduction using the following equations:

$$Total\ reduction = site\ 1 - site\ 20$$

$$Total\ percent\ reduction = \left(\frac{site\ 1 - site\ 20}{site\ 1}\right) \times 100$$

We analyzed the results graphically and quantitatively to determine trends in nutrient concentrations throughout the wetland, locations of substantial nutrient reduction and possible correlation between nutrient concentration and environmental variables.

3 Results

3.1 Volume calculation

We calculated the following wetland dimensions: length 1,103 m, surface area 22,741 m^2 and volume 3,787 m^3 (Table 3).

The volume calculation tool uses the distance of a sample point from the bioreactor outflow pipes to provide the volume of the wetland upstream of the given sample point. The input distance is found by projecting a GPS coordinate of a sample point onto the orthophoto of the wetland in ArcGIS, and measuring its distance along the thalweg from the outflow pipes at the beginning of the wetland. On the main page of the volume calculation tool there is a drop-down menu labeled "Distance." To find the total estimated volume between the outflow pipes and a specific sampling point, input the distance measured in ArcGIS into that cell, or choose it from the drop-down menu. When the distance is entered, the empty cells below the drop-down menu will automatically populate with values of the total volume (m^3) of the wetland above the sample point, and the cross-sectional area (m^2) of the cross section nearest the sample point.

Table 3. Volume calculations for notable points of nutrient reduction.

Location	Distance m	Surface area m^2	Volume m^3
Before site 6	113	3,674	285
Before site 12	320	8,199	920
Entire wetland	1,103	22,741	3,687

3.2 Nutrient reduction

Nitrate was reduced by an average of 99.97% through the length of the wetland, resulting in a total reduction of 6.02 mg/L (Table 4). A substantial portion of the nitrate reduction occurred in the first 113 m of the wetland, before site 6 (Figure 7). The surface area of this section is 3,674 m^2 and the volume is 285 m^3 (Table 4). Nitrate was reduced by an average of 44.82%, or 2.70 mg/L, of the total reduction by site 6.

Table 4. Total and percent load reductions of four key nutrients throughout the entire wetland. Average nutrient concentrations at the beginning and end of the wetland are included to show the scale of reduction.

Nutrient	Load reduction (mg/L)	Load reduction (%)	Start value (mg/L)	End value (mg/L)
Average Nitrate	6.02	99.97	6.02	0.00
Average DIN	8.95	99.10	9.03	0.08
Average Phosphate	1.09	81.43	1.34	0.25
Average Ammonia	2.19	96.95	2.25	0.07

Total ammonia was reduced by an average of 96.95% through the length of the wetland, equating to a total reduction of 2.18 mg/L (Table 4). The majority (85.62% or 1.87 mg/L) of total ammonia reduction also occured in the first 113 m (Table 3; Figure 7).

Total DIN was reduced by an average of 99.10% through the wetland, equating to a total reduction of 8.95 mg/L (Table 4). The majority of DIN reduction (53.61% or 4.80 mg/L) likewise occurred in the first 113 m of the wetland (Table 3; Figure 5).

The majority of ammonia and DIN concentrations were reduced by site 6, with a substantial portion of nitrate reduced at this location as well. The most substantial drop in nitrate, ammonia and DIN concentrations was between sites 5 and 6 (Figure 5). DIN, nitrate and ammonia were all reduced to near 0 by site 12, meaning almost all traces of nitrates were filtered out within 24.95% of the wetland (320 m; 8,199 m^2; 920 m^3; Table 3).

Total phosphate was reduced by an average of 81.44% through the wetland, equating to a total reduction of 1.09 mg/L (Table 4). Phosphate dropped off steadily in the first 500 m of the wetland, leveling off at slightly over 0.2 mg/L between sites 17 and 18, just after the second mixing pool (Figures 6 and 7).

We recorded DO and temperature at each sampling site to determine whether a relationship existed with nutrient concentration. We did not find an appreciable correlation between DO or temperature with nitrate, ammonia, DIN and/or phosphate.

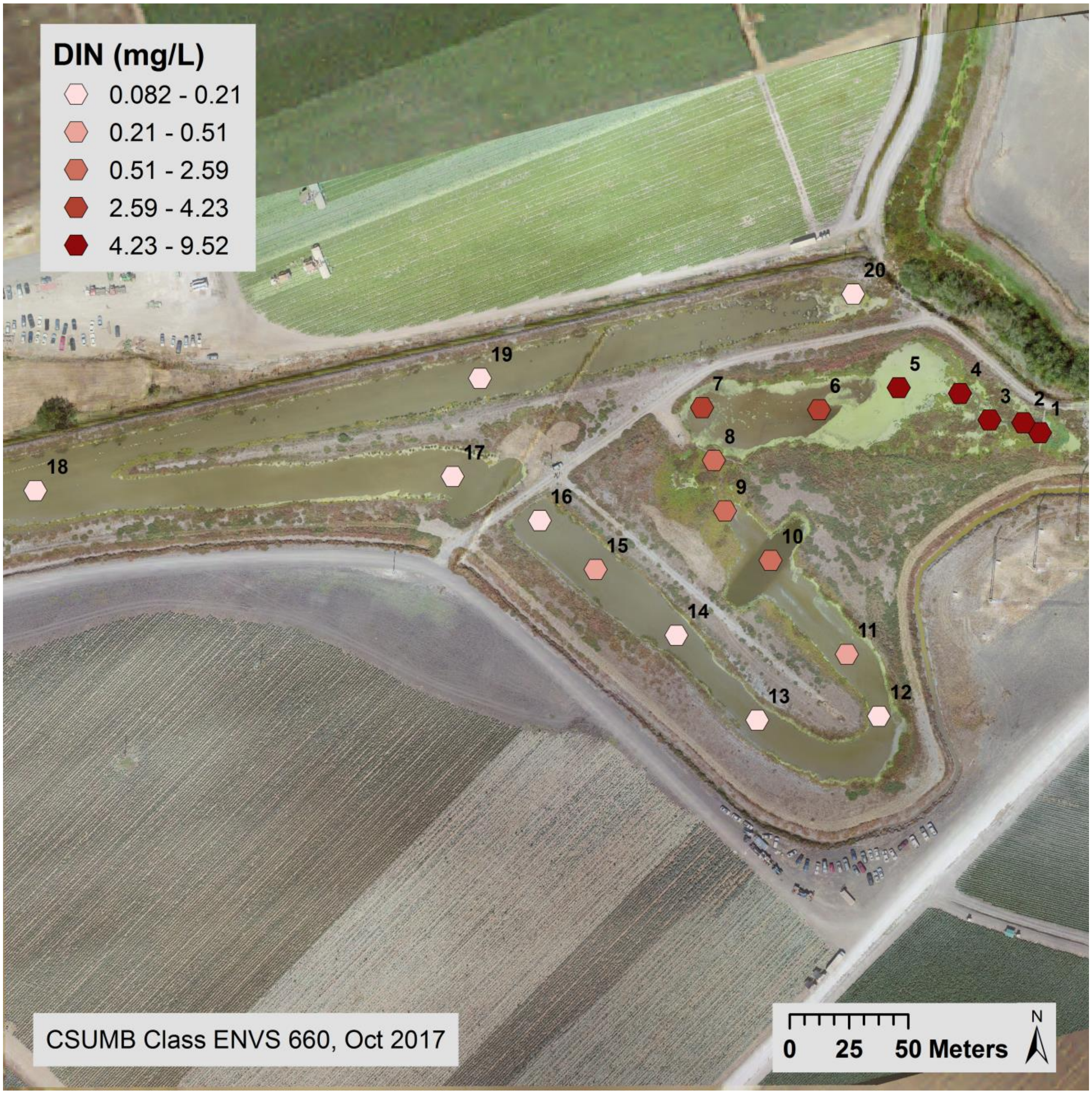

Figure 5. Changes in DIN concentration by site.

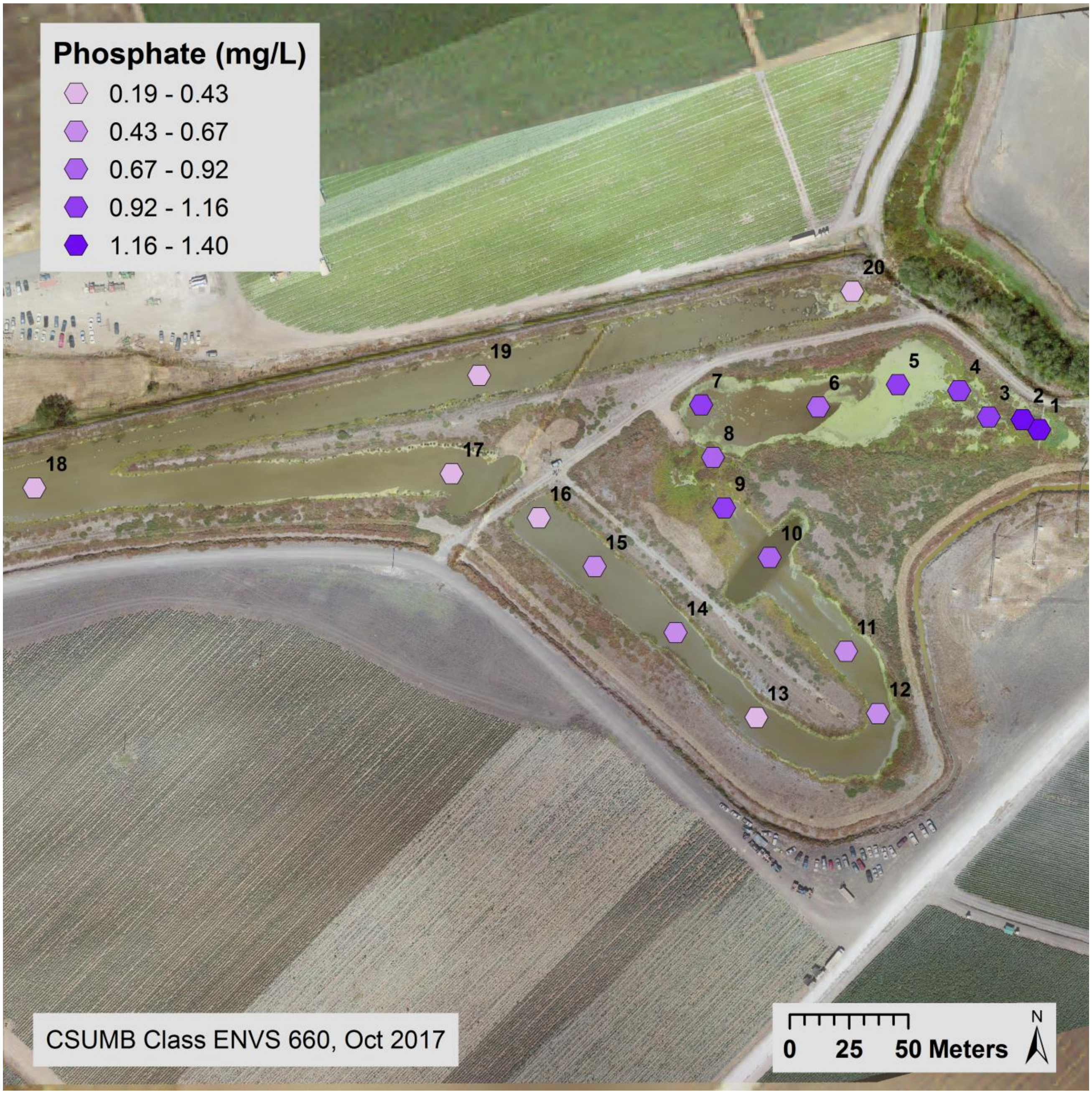

Figure 6. Changes in phosphate concentration by site.

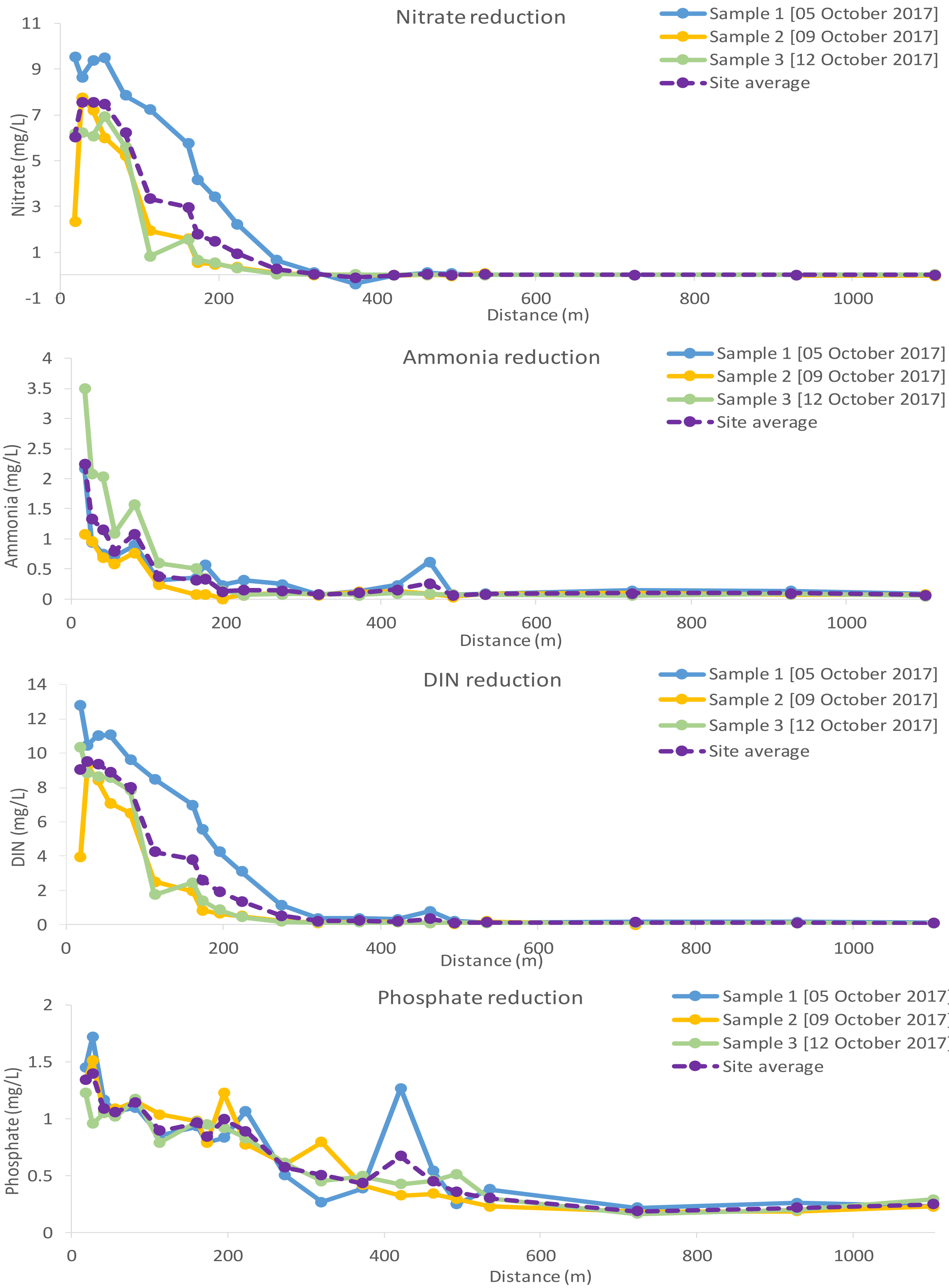

Figure 7. Nutrient load reductions along the 1,100 m wetland channel.

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4 Discussion

We found substantial evidence that the treatment wetland reduces nitrates in agriculture runoff. We did not, however, conduct further statistical analysis because the limited dataset did not meet assumptions of normality and could not be readily transformed. Additional sampling should resolve this issue.

Nonetheless, a marked reduction of nitrate, ammonia, phosphate, and DIN was revealed through our sampling and analysis. We assessed ammonia levels to ensure that the nitrate reduction was not due to transformation from nitrate to ammonia. Because ammonia levels also decreased at a similar rate, we assume that the reduction is due to denitrification.

Much of the reduction occurs in the first 113 m of the 1,100 m wetland, with a notable drop occurring between sites 5 and 6, or between 78 m and 113 m from the inflow into the wetland. The wetland leading up to and including site 4 is heavily vegetated, channelized and partially covered in duckweed. The area between sites 5 and 8 is a wide, shallow area with less vegetation coverage, less channelization and more UV exposure. We recommend further research on the effects of channel characteristics, such as vegetation and UV exposure, on nitrate reduction.

Because the water passed through the bioreactor before entering the wetland, nitrate levels were already reduced to near the drinking water standard of 10 mg/L. However, the further reduction provided by the wetland after bioreactor treatment brings toxicity levels below the threshold for the most sensitive species (2 mg/L). Combining bioreactor and wetland treatments may offer a comprehensive mitigation method that efficiently reduces nitrates and phosphates to levels suitable for the most sensitive organisms while also providing wetland habitat. Future research should examine the efficiency of a treatment wetland to reduce nitrates at higher input concentrations in order to directly compare the reduction efficiency of a wetland to a bioreactor.

We found that phosphate levels declined notably in the wetland, though they leveled off slightly above 0.2 mg/L after the second mixing pool. Although the reduction in phosphate did not result in levels below ranges deemed environmentally acceptable (0.1 mg/L and below), the trend is very promising. Further research may examine the conditions that contribute to phosphate reduction.

Our results are based on three days of sampling over an eight-day period in the fall season with an average incoming flow rate of 0.0028 m^3/s. We suspect that with seasonally changing flow rates and varying nutrient loading rates, the area and volume of wetland required to achieve the same reduction will likely vary.

Although these data represent a snapshot perspective of nutrient reduction under specific conditions, the trends are very encouraging. The ability to estimate the upstream volume at any location within the wetland would be expected to contribute significantly to future studies of nitrate and phosphate reduction with a statistically robust sampling protocol analyzing a range of conditions.

5 Areas for Future Study

This is a preliminary study on nutrient reduction rates in the PG&E treatment wetland. Results from this study indicate substantial nutrient load reductions for nitrogen and phosphate constituents. These results inform the extent and detail of future studies to determine the effectiveness and volume requirements of treatment wetlands to reduce nutrient pollution from agricultural runoff. We recommend further study to include:

- Focused water quality sampling in the initial 113 m stretch of wetland channel for nitrate, ammonia and DIN, and within the initial 550 m for phosphate
- Water quality sampling that captures seasonality of nutrient concentrations and fluctuations in flow rate
- Examination of wetland effectiveness at higher initial nutrient loads
- Further examination of factors in phosphate reduction
- Robust sampling scheme to allow for statistical analyses
- Detailed analysis of wetland sections that produce substantial nutrient load reductions, including: vegetation type and density, channel geometry, residence time and temperature

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7 Appendix

Sampling date	Location ID	Phosphate (mg/L)	Nitrite (mg/L)	Nitrate/Nitrite (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	DIN (mg/L)
10/5/2017	1	1.452	1.092	10.62	2.178	9.528	12.798
10/5/2017	2	1.719	0.861	9.51	0.948	8.649	10.458
10/5/2017	3	1.167	0.906	10.29	0.753	9.384	11.043
10/5/2017	4	1.059	0.855	10.35	0.72	9.495	11.07
10/5/2017	5	1.098	0.87	8.73	0.894	7.86	9.624
10/5/2017	6	0.855	0.933	8.16	0.309	7.227	8.469
10/5/2017	7	0.933	0.888	6.63	0.351	5.742	6.981
10/5/2017	8	0.795	0.816	4.98	0.57	4.164	5.55
10/5/2017	9	0.834	0.609	4.02	0.2304	3.411	4.2504
10/5/2017	10	1.068	0.576	2.79	0.312	2.214	3.102
10/5/2017	11	0.501	0.2589	0.9	0.2481	0.6411	1.1481
10/5/2017	12	0.2691	0.1641	0.2868	0.0714	0.1227	0.3582
10/5/2017	13	0.387	0.621	0.24	0.1281	BDL	0.3681
10/5/2017	14	1.269	0.0884	0.0638	0.23	BDL	0.2938
10/5/2017	15	0.543	0.0609	0.1564	0.62	0.0955	0.7764
10/5/2017	16	0.254	0.057	0.12	0.072	0.063	0.192
10/5/2017	17	0.378	0.0274	0.0264	0.0892	BDL	0.1156
10/5/2017	18	0.218	0.01332	0.0218	0.1402	0.00848	0.162
10/5/2017	19	0.261	0.02289	0.0232	0.1366	0.00031	0.1598
10/5/2017	20	0.228	0.0121	0.0139	0.0795	0.0018	0.0934
10/9/2017	1	1.347	0.525	2.871	1.074	2.346	3.945
10/9/2017	2	1.515	0.549	8.31	0.966	7.761	9.276
10/9/2017	3	1.059	0.498	7.71	0.687	7.212	8.397
10/9/2017	4	1.086	0.477	6.48	0.588	6.003	7.068
10/9/2017	5	1.158	0.519	5.73	0.771	5.211	6.501
10/9/2017	6	1.038	0.33	2.262	0.2394	1.932	2.5014
10/9/2017	7	0.981	0.306	1.884	0.0729	1.578	1.9569
10/9/2017	8	0.786	0.2136	0.732	0.0846	0.5184	0.8166
10/9/2017	9	1.227	0.1854	0.645	0.00771	0.4596	0.65271
10/9/2017	10	0.774	0.104	0.432	0.0676	0.328	0.4996
10/9/2017	11	0.604	0.0468	0.1154	0.0957	0.0686	0.2111
10/9/2017	12	0.795	0.0375	0.0406	0.0654	0.0031	0.106
10/9/2017	13	0.416	0.0432	0.0498	0.1224	0.0066	0.1722
10/9/2017	14	0.324	0.0321	0.00806	0.1353	BDL	0.14336
10/9/2017	15	0.342	0.0012	0.003	0.0804	0.0018	0.0834
10/9/2017	16	0.296	0.0411	0.000944	0.0387	BDL	0.039644
10/9/2017	17	0.23	0.02901	0.0969	0.0786	0.06789	0.1755
10/9/2017	18	0.1814	0.02574	BDL	0.093	BDL	BDL
10/9/2017	19	0.1882	0.02112	0.00608	0.0768	BDL	0.08288
10/9/2017	20	0.228	0.0372	0.0001412	0.0729	BDL	0.0730412
10/12/2017	1	1.23	0.648	6.84	3.51	6.192	10.35
10/12/2017	2	0.957	0.537	6.75	2.088	6.213	8.838
10/12/2017	3	1.05	0.525	6.6	2.043	6.075	8.643
10/12/2017	4	1.02	0.534	7.47	1.098	6.936	8.568
10/12/2017	5	1.176	0.63	6.24	1.581	5.61	7.821
10/12/2017	6	0.792	0.315	1.128	0.6	0.813	1.728

10/12/2017	7	0.975	0.387	1.944	0.51	1.557	2.454
10/12/2017	8	0.948	0.393	1.053	0.345	0.66	1.398
10/12/2017	9	0.921	0.198	0.72	0.1443	0.522	0.8643
10/12/2017	10	0.829	0.0879	0.375	0.0639	0.2871	0.4389
10/12/2017	11	0.611	0.0494	0.0817	0.084	0.0323	0.1657
10/12/2017	12	0.454	0.0339	0.0517	0.0817	0.0178	0.1334
10/12/2017	13	0.493	0.0354	0.0483	0.064	0.0129	0.1123
10/12/2017	14	0.427	0.0197	0.0164	0.0994	BDL	0.1158
10/12/2017	15	0.458	0.0317	0.0218	0.089	BDL	0.1108
10/12/2017	16	0.515	0.0248	0.0175	0.077	BDL	0.0945
10/12/2017	17	0.3	0.019	0.0127	0.0759	BDL	0.0886
10/12/2017	18	0.1634	0.0138	0.0118	0.0619	BDL	0.0737
10/12/2017	19	0.2	0.0138	0.0116	0.0786	BDL	0.0902
10/12/2017	20	0.292	0.00788	0.0236	0.0536	BDL	0.0772