

## **IDENTIFYING THE POTENTIAL FOR CONSTRUCTED WETLAND TO RELEASE DISSOLVED REACTIVE PHOSPHORUS**

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### **Introduction**

Constructed wetlands (CWs) are tools that attenuate nitrogen, phosphorus, and sediment, originating from agricultural landscapes before these aquatic pollutants from entering and degrading waterways. To effectively attenuate these pollutants, CWs are constructed with two compartments: a sedimentation pond and a planted area. Sedimentation ponds are located at the upstream end of a CW; they are deep areas which slow flow velocities, and trap sediment and sediment-bound phosphorus or nitrogen. The downstream planted area provides conditions suited to the biological uptake of nitrogen (N) and phosphorus (P) and the associated build-up of organic matter creates anoxic conditions that facilitates denitrification. However, anoxic conditions can also lead to the mobilisation dissolved reactive phosphorus (DRP) from phosphorus bound to sediment particles.

P bound to Fe is most susceptible to mobilisation under anoxic conditions as iron reducing bacteria convert  $\text{Fe}^{3+}$  to  $\text{Fe}^{2+}$  which caused the release of any P that was bound to the  $\text{Fe}^{3+}$  (Roden and Edmonds 1997). Additionally, sulphate-reducing bacteria can release phosphate from  $\text{Fe}^{3+}$  binding sites as the  $\text{H}_2\text{S}$  they produce is able to push and P off the  $\text{Fe}^{3+}$  binding sites (Bostrom et al. 1988). These processes both reduce the number of potential sites that can retain P within the soil while releasing any P previously bound to these sites. The loss of DRP from a wetland requires that any mobilised P is not re-bound in the sediment after mobilisation. This is largely determined by the ratio of potentially mobile P to the number of potential P binding sites. Soil and/or sediment extractions, that target the loosely bound P and P bound to Fe, are one method that is used to estimate the size of the P pool that is potentially mobile under anoxic conditions. Similarly, potential P binding sites can be estimated by extractions targeting soil amorphous Fe and Al or using assays investigating soil or sediment anion storage capacity. The ratio between potentially mobile P and potential binding sites, has been used to predict the likelihood of DRP mobilisation from soils (Breeuwsma and Silva 1992, Loeb et al. 2008, Meissner et al. 2008), and is likely to be influenced by several factors including inherent soil properties, land-use history and time elapsed since creation of the CW.

CWs are often created on lands that were once wetlands and were drained to facilitate agricultural production. The initial conversion from wetlands to agriculture can lead to increases in the fraction of soil phosphorus vulnerable to mobilisation under anoxic conditions (Meissner et al. 2008). Drainage of wetlands causes soil oxidation and enhanced rates of organic matter breakdown and the associated conversion of organic phosphorus, that is largely stable under anoxic conditions to DRP, that in the oxygenated agricultural soil can be bound into Fe in the soil matrix. However, some of this newly bound P will sorb to Ca or become recalcitrant and not be available to plants, consequently, agricultural production in

these areas often requires the addition of P fertilizers, increases the total amount of P bound into the soil matrix. After inundation associated with CW creation, a proportion of the P bound into the soil matrix can be mobilised by forms of anaerobic microbial metabolism (Baldwin et al. 1997, Roden and Edmonds 1997). It is also possible that high load of incoming phosphorus could fill up a CW soils capacity to bind P, increasing the ratio of potentially mobile P to potential binding sites increasing the likelihood of DRP mobilisation. Constructed wetlands as sources of DRP has been observed in Northland, Waikato and Southland (Tanner and Sukias 2011) as well as internationally (Koskiaho et al. 2003, Hoffmann et al. 2012).

The production of DRP within CWs that are designed to attenuate agricultural pollutants is problematic. CWs are often sinks for TP because they are effective traps for sediment and sediment-bound phosphorus (Braskerud 2002) but the prevalence of anoxic conditions means that CWs may be a less effective sink for the DRP component of the TP load. Furthermore, some of bound phosphorus already in the soil or imported with incoming sediment may be converted to DRP and subsequently released potentially making these system sources of DRP. Here, we evaluated approaches that measure the ratio of anoxically mobile soil P fractions to the size of the potential P binding capacity within wetland soils to assess the risk of DRP release. Such an approach could be used to determine the risk of DRP release from soils used to construct a CW and, subsequently, to guide the application of materials, such as alum, Aqual-P<sup>®</sup> or Phoslock<sup>®</sup>, that have a high affinity for DRP, to the older CW soils to enhance or maintain their performance for DRP removal.

## **Methods**

### ***Soil collection***

A (topsoil) and B (subsoil) horizon soils were collected from four constructed wetland sites in different and diverse locations across the North Island of New Zealand (NZ); White wetland from Hawkes Bay, Toenepi wetland from the Waikato, Hicksons wetland from the Bay of Plenty and Awatuna wetland from Taranaki. Stainless steel rings were used to collect a known volume of soil to enable the calculation of bulk density of both the top and sub soils. The collected bulk soils were stored in sealed air-tight plastic containers and transported to NIWA Hamilton where they were homogenised and split into three parts. One part was used for characterisation with standard soil tests, another part to estimate the likelihood of DRP release using three different measures of each soils P stores and its ability to retain P, and the final part for a batch incubation, simulating soil inundation and associated DRP releases.

### ***Standard soil testing***

Soil moisture content was measured at NIWA by weighing the wet soil and oven drying at 80°C to a constant weight. Bulk density (g/cm<sup>3</sup>) was calculated using the volume of the soil ring and soil dry weight. All other standard soil tests were conducted by Hill Laboratories using standard methods and have been briefly outlined below. Olsen P extractions were conducted using sodium bicarbonate. Soil pH was measured using a 1:2 volumetric soil to water ratio with potentiometric pH determination. The soils organic fraction was measured using loss on ignition. The soils total nitrogen content was determined by near infrared spectroscopy and total phosphorus content by nitric/hydrochloric digestion followed by P

molybdate determination. Anion storage capacity (ASC) was measured by incubating 4 g of soil in 200 ml of 1000 mg/l DRP solution until an equilibrium was reached.

### ***Estimating DRP release risk***

Measures of soil P were made using two soil extractions. The first targeted loosely-bound P and water-soluble P and the second Fe and Al bound P. We also estimate the risk of DRP release using measures total P (see standard soils testing for details). The ability of each soil to retain P was measured with extractions targeting amorphous Fe and Al as well as incubations for anion storage capacity (see standard soil testing for details). Loosely-bound P and water-soluble P were determined using 2 g of field moist sediment, shaken for two hours with 25 ml of 1 M NH<sub>4</sub>Cl and then centrifuged for 15 mins at 1000 rpm, the supernatant was collected and analysed for DRP content (Loeb et al. 2008). Following this extraction, the resultant soil pellet was then shaken with 30 ml of 0.05 M Ca-EDTA for 2 hours to determine Fe-bound P and Al-bound P (Loeb et al. 2008). After shaking, the supernatant was isolated by centrifuging at 1000 rpm for 15 minutes and the supernatant collected. The DRP analysis on the extractants was completed at NIWA using Molybdenum blue colorimetry on a flow injection analyser.

To quantify levels of amorphous Fe and Al (potential P binding sites), 2.5 g of fresh soil was shaken with 30 ml of 0.175 M ammonium oxalate + 0.1 M oxalic acid at pH 3 for 2 hours then centrifuged for 15 minutes at 1000 rpm (Loeb et al. 2008, Meissner et al. 2008). The resulting supernatant was collected for Al and Fe analysis. The extract was sent to Flinders Cook (Technical Services) Limited, for analysis using atomic absorption spectroscopy. Unfortunately, the DRP content of these extract was not analysed to calculate the degree of phosphorus saturation (DPS), so we have substituted with the amount of P extraction in the sequential extractions detailed above. Anion storage capacity (ASC) was measured by overnight equilibrium of 4 g of soil with 20 ml of 1000 mg l<sup>-1</sup> P solution and was conducted at Hill Laboratories.

### ***Wetland simulation incubations***

The inundation incubations were conducted in a constant temperature room set to 21°C using 1 litre glass jars with 400 ml of moist soil and 700 ml of de-ionised water. The glass incubation jars were acid washed, rinsed 3 times then allowed to dry before being weighed. The 400 ml of field moist soil was then added to each jar and the jar was re-weighed to determine the weight of the soil added. Soils incubated were either topsoil only or subsoil only. Jars were sealed with air-tight lids and fitted with gas tight bungs. Any head space remaining in the jars after the addition of soil and water was purged of oxygen using N<sub>2</sub> gas. Any oxygen dissolved in the water was left as bubbling the water with N<sub>2</sub> would have disturbed the soils in the jars and the incubation were long enough to be sure the dissolve oxygen was consumed by soil bacteria.

Water samples for DRP analysis were taken 4 times over a period of 4 weeks. At each sampling time, dissolved oxygen concentrations and pH of the overlying water column were monitored using a TPS WP-91 meter and then 30 ml of water overlying the inundated soil was extracted using a syringe and tubing. The 30 ml of water extracted for DRP analysis was

replaced with deionised water to keep a constant volume in the jars. After sampling the lids were replaced and the headspace purged with N<sub>2</sub> gas again. The DRP analysis was completed at NIWA using Molybdenum blue colorimetry with a flow injection analyser.

### *Data analysis*

#### *Soil characterisation and extractions*

Concentrations resulting from each extraction were multiplied by the extraction volume (l) to calculate the mass of the target solute. These masses were then divided by the dry weight of soil used in each extraction to create units of solute mass per unit mass of dry soil. The solute mass was then converted into units of micromoles, expressed per gram of dry soil.

Anion storage capacity was reported as a percentage by the commercial lab, so we converted this into units of mg of DRP retained per kg of soil. We calculated the ratio of Fe-P to Fe binding sites as  $(\text{Fe-P}/\text{Fe-ox}) \times 100$  (Loeb et al. 2008) as a predictor of DRP release during the soil incubations. The degree of phosphorus saturation (DPS) was calculated as  $(\text{Fe-P} + \text{Al-P})/(\text{Fe-ox} + \text{Al-ox}) \times 100$  as per Meissner et al. (2008). Finally, as a more holistic measure of soil phosphorus saturation that accounts for all fractions of soil P and all potential binding sites we calculated the ratio of TP to anion storage capacity using units of mg/kg.

#### *Sediment incubations*

The DRP concentrations in the overlying water column were converted into masses by multiplying by the volume of water in each jar. The resulting mass of DRP were normalised to the weight of dry soil added to each to create soil mass-based concentrations. These were then converted to an areal estimate, using each soils bulk density, and assuming a soil depth of 10 cm. Average areal concentrations were then calculated for each sampling event during the four-week incubation. These daily average concentrations were then divided by 28 days (the length of the incubation) to create a daily rate of DRP release of  $\mu\text{g}$  of DRP  $\text{m}^{-2} \text{day}^{-1}$ . Finally, these rates were scaled up to yearly releases per hectare creating units of  $\text{kg}$  of DRP  $\text{ha}^{-1} \text{yr}^{-1}$ .

To assess the ability of each different measure of soil phosphorus saturation to predict soil DRP release we generated a linear regression between each soils DRP release ( $\text{kg ha}^{-1} \text{yr}^{-1}$ ) with each of the measures of soil P saturation. To increase the diversity of soil characteristics assessed we used individual replicates rather than averages. The goodness of fit of the relationship was assessed as  $r^2$  and used R to undertake Pearson's correlation analysis to investigate if there was a significant relationship between the measure of soil P saturation and DRP release. We identified outliers in both the DRP releases and DPR release predictors using the Tukey-Fenc test in R. The data as been assess with and without identified outliers.

## **Results**

Table 1 shows the results of the standard soil tests. All soils were slightly acidic. With the exception of the Hickson wetland soil, all Olsen P values were within bounds of what would be expected of agricultural soils. The Hickson wetland site has very high levels of both Olsen P and Total phosphorus compared to the other sites and for what would be expected of an agricultural soil. The White wetland site had the highest organic content and total carbon and nitrogen of all the sites tested. In terms of anion storage capacity, the Awatuna soils

were able to retain the highest amount of DRP, followed by White, Toenepi and Hickson, respectively.

Table 1: Results from standard soil testing.

Wetland soil	pH (units $\pm$ SD)	Olsen P (mg L <sup>-1</sup> $\pm$ SD)	Organic matter (% $\pm$ SD)	Total Carbon (% $\pm$ SD)	Total Nitrogen (% $\pm$ SD)	Total Phosphorus (mg kg <sup>-1</sup> $\pm$ SD)	Anion storage capacity (% $\pm$ SD)	Bulk density (dry g cm <sup>-3</sup> $\pm$ SD)
Awatuna top	5.8 $\pm$ 0.1	11 $\pm$ 7.5	11.7 $\pm$ 1.6	6.8 $\pm$ 0.9	0.53 $\pm$ 0.11	1159 $\pm$ 393	95.0 $\pm$ 3.4	0.81 $\pm$ 0.08
Awatuna sub	5.9 $\pm$ 0.1	2.6 $\pm$ 0.5	7.3 $\pm$ 1.2	4.2 $\pm$ 0.7	0.26 $\pm$ 0.08	569 $\pm$ 164	98.3 $\pm$ 1.2	0.74 $\pm$ 0.02
Hickson top	6.2 $\pm$ 0.4	145 $\pm$ 47	15.7 $\pm$ 4.5	9.1 $\pm$ 2.6	0.81 $\pm$ 0.24	6913 $\pm$ 2327	40.6 $\pm$ 21.9	0.67 $\pm$ 0.17
Hickson sub	5.6 $\pm$ 0.4	118 $\pm$ 138	10.4 $\pm$ 10.1	6.0 $\pm$ 5.8	0.51 $\pm$ 0.45	2055 $\pm$ 1291	40.3 $\pm$ 22.0	NA
Toenepi top	6.0 $\pm$ 0.1	19 $\pm$ 15	7.5 $\pm$ 1.2	4.4 $\pm$ 0.7	0.39 $\pm$ 0.06	952 $\pm$ 353	50.3 $\pm$ 6.7	0.96 $\pm$ 0.06
Toenepi sub	5.8 $\pm$ 0.1	4 $\pm$ 2	2.1 $\pm$ 0.5	1.2 $\pm$ 0.3	0.1 $\pm$ 0.02	123 $\pm$ 52	49.6 $\pm$ 2.1	1.07 $\pm$ 0.06
White top	5.5 $\pm$ 0.1	28 $\pm$ 22	23.0 $\pm$ 2.7	12.7 $\pm$ 1.5	1.09 $\pm$ 0.09	1820 $\pm$ 736	91.6 $\pm$ 4.5	0.64 $\pm$ 0.19
White sub	5.2 $\pm$ 0.4	19 $\pm$ 12	19.2 $\pm$ 7.0	11.2 $\pm$ 4.0	0.97 $\pm$ 0.32	1591 $\pm$ 506	95.3 $\pm$ 1.5	0.63 $\pm$ 0.08

NA = sample not available

Table 2: Measures making up soil P saturation and levels of saturation.

Wetland soil	Loosely bound P ( $\mu\text{mol g}^{-1}$ dry soil)	Fe ad Al bound P ( $\mu\text{mol g}^{-1}$ dry soil)	Total Phosphorus ( $\text{mg kg}^{-1}$ )	Amorphous Fe ( $\mu\text{mol g}^{-1}$ dry soil)	Amorphous Al ( $\mu\text{mol g}^{-1}$ dry soil)	Anion storage capacity ( $\text{mg kg}^{-1}$ )	Fe-P/Fe-ox	DPS	TP/ASC
Awatuna top	$0.1 \pm 0.0$	$0.0 \pm 0.0$	$1159 \pm 393$	$96.1 \pm 17.1$	$674.4 \pm 74.2$	$4750 \pm 100$	$0.007 \pm 0.001$	$0.01 + 0.00$	$0.25 + 0.05$
Awatuna sub	$0.1 \pm 0.0$	$0.0 \pm 0.0$	$569 \pm 164$	$64.2 \pm 16.6$	$1193.7 \pm 69.9$	$4916.7 \pm 33.3$	$0.002 \pm 0.000$	$0.01 + 0.00$	$0.12 + 0.02$
Hickson top	$1.6 \pm 0.8$	$6.11 \pm 1.1$	$6913 \pm 2327$	$118.7 \pm 35.7$	$166.3 \pm 45.5$	$2033.3 + 633.3$	$6.61 \pm 2.42$	$3.84 + 1.24$	$4.34 + 1.54$
Hickson sub	$1.1 \pm 0.6$	$5.00 \pm 3.3$	$2055 \pm 1291$	$68.1 \pm 15.6$	$188.7 \pm 86.8$	$2016.6 + 669.7$	$7.46 \pm 3.77$	$1.25 + 0.91$	$1.44 + 0.64$
Toenepi top	$0.1 \pm 0.0$	$0.0 \pm 0.0$	$952 \pm 353$	$69.1 \pm 2.7$	$199.1 \pm 35.1$	$2516.7 \pm 192.2$	$0.031 \pm 0.014$	$0.05 + 0.01$	$0.37 + 0.06$
Teonepi sub	$0.00 \pm 0.0$	$0.0 \pm 0.0$	$123 \pm 52$	$55.6 \pm 10.7$	$137.0 \pm 29.0$	$2483.3 \pm 60.1$	$0.004 \pm 0.002$	$0.04 + 0.00$	$0.05 + 0.01$
White top	$0.1 \pm 0.0$	$0.0 \pm 0.0$	$1820 \pm 736$	$95.1 \pm 18.1$	$714.0 \pm 248.4$	$4583.3 + 130.2$	$0.009 \pm 0.003$	$0.02 + 0.00$	$0.40 + 0.09$
White sub	$0.1 \pm 0.0$	$0.0 \pm 0.0$	$1591 \pm 506$	$100.3 \pm 14.9$	$869.7 \pm 174.6$	$4766.7 + 44.1$	$0.015 \pm 0.007$	$0.01 + 0.00$	$0.33 + 0.06$

### ***Soil phosphorus saturation***

The Hickson soils had the highest levels of both water soluble and loosely bound P, Fe and Al bound P, as well as TP. It also had relatively low levels of Amorphous Al and Fe and showed a moderate ability to retain DRP in the anion storage capacity assays. Combined, the high levels of P and low amounts of storage within the Hickson soil, it had by far the highest levels of P saturation of any soil, regardless of how P saturation was measured. Across the other soils, there was more variability for the different measures of soil P saturation. With the Hickson soils excluded, the most P saturated soil according to the Fe-P/Fe-ox was the Toenepi topsoil followed by the White sub and topsoil, respectively. Comparatively, DPS found that Toenepi topsoil was the most P saturated but then varied from aligning with Fe-P/Fe-ox placing the Toenepi subsoil and then the White subsoil as the next most saturated. Finally, the TP/ASC ratio placed the White topsoil as the most saturated followed by the topsoil from Toenepi and then the White subsoil.

### ***Predicting DRP release from CW soils***

Given high P saturation of the Hickson soils and the large DRP releases from it that occurred during inundation (ranging from 0.8 to 167 kg DRP ha<sup>-1</sup> yr<sup>-1</sup>) and that the site was very near a fertilizer depot, it was excluded from this assessment of the ability of the different measures of P saturation to predict DRP release during inundation. Further, the Tukey Fenc test identified two White topsoil DRP releases as outliers from the other DRP releases found during the soil inundation incubations. Thus, we have analysed the data with and without including these data points.

DPS was not significantly correlated ( $p > 0.05$ ) with DRP release from the constructed wetlands soils with or without the White topsoil outliers in the analysis. In fact, as the degree of P saturation increased the releases of DRP were predicted to decrease according to a linear relationship between DPS and DRP release. With the White topsoil outliers included, the Fe-P/Fe-ox ratio was a better predictor of DRP release than DPS, but it still had a low  $r^2$  (0.06) and the relationship was not significant ( $p > 0.05$ ). However, if the two White subsoil outliers were removed the  $r^2$  improved to 0.33 and there was a significant relationship between Fe-P/Fe-ox and DRP release ( $p < 0.05$ ). With the two outliers included, the TP/ASC ratio was not significantly related to DRP releases ( $p < 0.05$ ) with an  $r^2$  value of 0.16, when the two outliers were removed  $r^2$  improved to 0.6 and there the relationship became significant ( $p < 0.001$ ).



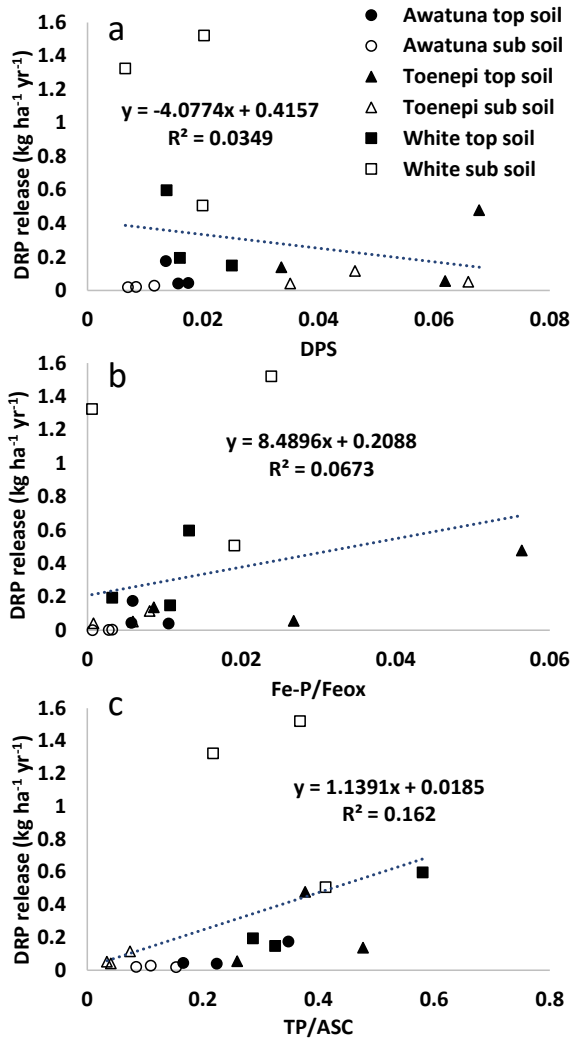


Figure-1: Relationships between the three different measure of soil phosphorus saturation and DRP release during the soil inundation assays.

## Discussion

### *Assessing the risk of DRP release*

Phosphorus can be bound to soil in several ways and is functionally defined by the amount of P that can be extracted using extractants of different strengths. The accuracy of the Fe-P/Fe-ox and DPS tests will be determined by the overlap between the soil P fractions extracted and the role that these fractions play in DRP mobilisation during the inundation assays. Previous investigations into DPS have found that it is a good predictor of DRP release likelihood in mineral soils. In fact, Breeuwsma and Silva (1992) and Schoumans and Groenendijk (2000) both identified that below a saturation level of 25% there was minimal likelihood of DRP release from mineral soils. However, Meissner et al. (2008) found that DPS was a poor predictor of DRP mobilisation from peat soils as it was likely that fractions of soil P not included in this assessment methodology were influencing DRP mobilisation. The studies above used oxalate as the P extractant for both loosely and Fe and Al bound P, while we used sum of 1 M  $\text{NH}_4\text{Cl}$  (loosely bound P) and 0.05 M Ca-EDTA (Fe and Al P) as a surrogate, potentially influencing the accuracy of DPS to predict DRP releases.

We did not find that DPS was a useful predictor of DRP mobilisation during our soil inundation assays. Removing the two White subsoil outliers did not improve the regression coefficient ( $r^2$ ), in fact, it decreased from 0.03 to 0.00. Our use of a different P extractant in replacement of the missed DRP content from the oxalate extract is likely to have decreased the efficacy of DPS as a DRP mobilisation prediction tool but it is unlikely that the effect was strong enough to be the sole cause of DPS inability to predict DRP mobilisation in our assays. Our soils had highly variable organic contents (table 1) and given that the accuracy of DPS is affected by if a soil is mineral or peat (Breeuwsma and Silva 1992, Schoumans and Groenendijk 2000, Meissner et al. 2008), its likely that this variability in organic content influenced our results.

The Fe-P/Fe-ox ratio was somewhat better than DPS at predicting the release of DRP during the soil inundation assays but the correlation coefficient was not statistically significant when the two White topsoil outliers were included. Largely, the soil P fraction most susceptible to mobilisation as DRP during inundation and associated anoxic events is Fe bound P. In fact, Loeb et al. (2008) found the Fe-P/Fe-ox ratio was able to explain 79% of the variation in DRP release from five European floodplain soils. This is much higher than its explanatory power for our three wetland soils, even when the two White subsoil outliers were removed of 33%. This suggest that other sources of P in addition to Fe-P were being converted into DRP during our wetland inundation assays and/or there were potentially other sinks for DRP than Fe-ox. It is likely that sources such as organic matter mineralisation and potentially, if the pH become low enough, Ca or Al could release DRP, while biological uptake could have been a DRP sink not accounted for in the Fe-P/Fe-ox extractions.

The TP/ASC ratio includes all potential sources of P that could be converted into DRP during assays. However, it is also likely to include many fractions of soil P that are considered recalcitrant and were unlikely to be converted into DRP during our assays potentially obscuring its accuracy. In terms of sinks, the ASC assay would likely provide an overestimate of a soils ability to bind DRP as the soil is dispersed into the water column as the dispersed soil would increase access to potential binding sites. The four-week duration of our nutrient release assay is probably similar to the ASC assay which were run until equilibrium. The TP/ASC ratio was the best predictor of DRP mobilisation that we tested and was found to be significantly correlated with DRP release if the two White topsoil outliers were removed. It appears that the broad nature of these two measures of P (TP and ASC) provide a versatility that is useful when investigating DRP from a range of soil types.

It is possible that there are more accurate predictors of DRP mobilisation available for specific soils than the TP/ASC ratio, like the DPS for mineral soils (Breeuwsma and Silva 1992, Schoumans and Groenendijk 2000) or the Fe-P/Fe-ox for floodplain soils (Meissner et al. 2008). However, the broad applicability of the TP/ASC ratio, which requires no background knowledge of soil type, and is a highly generalisable test, may be advantageous for use by the farming community and environmental managers. Furthermore, the availability of these two tests makes this test highly accessible to farmers and land managers being commercially available from laboratories across the country. Thus, with a simple analysis of the soil to be used in the construction of a wetland famers and land managers may be able to assess the risk of DRP release from a CW. This would enable the use a different soil, with less DRP mobilisation risk, to be used construction of the wetland, or if that is not feasible, to amend the soil to increase in Fe and Al content with the addition of material such as alum, Aqual-P<sup>®</sup> or Phoslock<sup>®</sup> that add additional P binding sites. However, our testing has

been limited to 3 soils, we recommend that this testing is extended to include a more extensive, diverse, and representative set of soils that have the potential to be used for wetland construction.

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