Attachment 2A

UNIVERSITY OF FLORIDA
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IFAS

CONTRIBUTION OF INTERNAL PHOSPHORUS LOADS IN SOUTH FLORIDA WATER CONSERVATION AREA CANAL SEDIMENTS

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Introduction

Phosphorus (P) has been identified as a major limiting nutrient to productivity in south Florida freshwater ecosystems. As a result, significant efforts have focused on reducing P loading to sensitive wetland areas of South Florida such as Everglades National Park, and the Water Conservation Areas. Part of this effort has included the creation of wetland Stormwater Treatment Areas (STA's) to intercept water coming from Agricultural and Urban Landscapes and to remove P prior to discharge into canals. The south Florida canal network is then used to convey this water to discharge points to the south and east. However, sedimentation and historic P loading to these canals may have resulted in a significant amount of P stored in the sediment. Because of this potential P load within the canals, questions have been raised regarding the release of the internal P load to the water column and elevation of P concentrations as water moves from the STA's to discharge points. This investigation was initiated to characterize and evaluate the forms of sediment P present in canal sediments and to evaluate the potential flux rate of P from sediments within the canals to overlying "low P concentration" floodwaters.

In this investigation we assessed the labile and non-labile pools of P_i and P_o in canal sediments from 20 different locations to the south and east of existing and proposed STA's. We also estimated the potential P flux from canal sediments to the overlying water column at these same sites. Characterization of sediment P and potential P flux determined in this study will provide a better assessment of the short and long term potential contribution of internal sediment P loads to the water column of those canals surveyed.

Materials and Methods

Site Description

The project area is located within, south, and east of the Everglades Agricultural Area. Twenty sampling locations were selected in seven principal canal systems located downstream of the six existing or proposed STA's (Figure 1). Coordinates for each sampling site and associated upstream STA are identified in Table 1. At each canal site, collection of cores was attempted along a transect within the middle two thirds of the canal cross sectional area. However, due to differences in water depths, bathymetry of the

bottom, and variations in sediment thickness, core collection was often skewed toward one bank or another. Information regarding site-specific coring locations can be found in appendix A.

Sample collection

Two sampling events, summer 2001, and summer 2002, were used to collect sediment cores for this study. In 2001, six intact sediment cores were obtained from each of the twenty canal sites. Sampling at 19 sites was conducted between June 18 and June 22, 2001. Site L38-C6 was sampled on July 13, 2001. In 2002, a subset of five canal sites, MC-C2, L38-C6, L7-C26, L39-C2, and L40-C24 were sampled between April 2, 2002 and April 3, 2002. Sediment cores were obtained using a piston core sampler designed for sampling fine textured soft bottom sediments (Fisher et al., 1992). Cores were collected in clear acrylic tubing with a core section area of 36.3 cm^2 and taken to a depth of at least 30 cm. Three cores from each site (used for flux experiments) were left intact, sealed at the bottom using a rubber stopper, and transported to the Wetland Biogeochemistry Laboratory at the University of Florida in Gainesville. The remaining three cores were sectioned in the field into 0-10 and 10-30 cm increments. Sectioned sediment samples were stored in polyethylene bags on ice, and transferred to the laboratory for further analysis.

Sediment Analysis

Sediments were homogenized, and the following physico-chemical parameters determined: moisture content, bulk density, loss on ignition, porewater P and NH_4-N, total P, total P_i, KCl extractable P_i, NaOH extractable P_i, HCl extractable Pi, $NaHCO_3$ extractable P (bioavailable P), and microbial P. Extraction methods are similar to those described by Ivanoff et al., 1998; and Reddy et al., 1998. Phosphorus analysis in extracted solutions was performed using standard methods (USEPA, 1993). Specific information for each method follows:

A known amount of oven-dry sediment was combusted at 550ºC for 5 hours. The loss in weight after combustion was used to calculate the amount of organic matter, expressed as percent of volatile solids (APHA, 1985).

Porewater P and NH_4-N were extracted from the bulk sample using centrifugation. Wet samples were homogenized and 100 g placed in a centrifuge tube. Samples were spun at

6000 rpm for 10 minutes. Supernatant was decanted and filtered through a 0.45 m membrane filter. Solutions were then analyzed for dissolved reactive P (DRP) and NH_4-N on an auto-analyzer. Residual sediments were fractionated into inorganic and organic pools using two different methods (Ivanoff et al., 1998; Reddy et al., 1998).

Inorganic P fraction (Reddy et al., 1998)

Phosphorus in sediment extracted with 1*M* KCl solutions (sediment to solution ratio of 1:100) represented the readily available pool of P (water soluble + exchangeable pool). Sediment suspensions were equilibrated for a period of 1 hour by continuously shaking on a mechanical shaker, followed by centrifugation at 5000 rpm for 15 minutes. Supernatant solutions were filtered through a 0.45 m membrane filter and the filtrates were acidified to pH 2. Solutions were analyzed for DRP.

The residual sediment obtained from the above extraction was treated with 0.1*M* NaOH to obtain a-sediment to solution ratio of 1:100. Sediment suspensions were allowed to equilibrate for a period of 17 hours by continuously shaking on a mechanical shaker, followed by centrifugation at 5000 rpm. Supernatant solution was filtered through 0.45-µm-membrane filter and the residual solution was used in the following sequential extraction. Filtered solutions were analyzed for both DRP and TP and these fractions are referred as NaOH-P_i and NaOH-TP, respectively. The NaOH-P_i is considered to represent Fe-/Al-bound P. Extraction with 0.1*M* NaOH also removes the P associated with humic and fulvic acids. The difference between NaOH-TP and NaOH-P_i was organic P (NaOH-P_o) associated with fulvic and humic acids.

The residual sediment obtained from the above extraction was treated with 0.5*M* HCl to obtain a-sediment to solution ratio of 1:100. Sediment solutions were allowed to equilibrate for a period of 24 hours by continuously shaking on a mechanical shaker, followed by centrifugation at 5000 rpm. Supernatant solution was filtered through 0.45 µm membrane filter and the residual sediment was discarded. The filtered solutions were analyzed for DRP. This fraction will be referred to as HCl-P_i, representing Ca and Mg bound P.

The P not extracted in any of the above fractions is termed residual P. This fraction was calculated by subtracting the sum of all fractions from total P. Residual P fraction was

assumed to represent organic P and any other mineral P fractions not extracted with water, KCl, NaOH or HCl reagents.

Total P

Total P was determined on an oven-dried sediment sample combusted at 550 C for 4 hours. The ash was dissolved with 6M HCl, followed by heating. The solutions were further diluted and analyzed for total P on an autoanalyzer (Anderson, 1976).

Organic P fractionation (Ivanoff et al., 1998)

The labile inorganic and organic P fractions were extracted with 0.5*M* $NaHCO_3$ solution (pH = 8.5) at a sediment to solution ratio of 1:50 and shaking period of 30 minutes. Filtered solutions were analyzed for DRP and total P. The difference between TP and DRP is assumed to be labile organic P.

Microbial biomass P was determined using chloroform fumigation techniques (Ivanoff et al., 1998). The procedure involved extracting duplicate sediment samples with 0.5*M* $NaHCO_3$ (pH = 8.5) in chloroform treated and untreated sediments. Since the chloroform acts as a cell-lysing agent, increased amounts of P in the extracts of chloroform-treated sediments should originate from P held in the microbial biomass. Microbial biomass P was calculated by taking the difference in the total P of the extracts of chloroform-treated and chloroform-untreated sediments.

Residual sediments were extracted with 1*M* HCl (3 hours shaking) to remove inorganic P, followed by an alkaline extraction (16 hours shaking) to remove organic P. P_i is determined by analyzing the extracted solutions for soluble reactive P, while P_o was determined from the difference between total P and DRP of the extracted solutions.

Organic P forms were presented as four major groups, i.e. (1) labile organic P (includes porewater and microbial biomass associated organic P), (2) moderately labile organic P (includes acid soluble organic P and alkali hydrolyzable fulvic acid P recovered as inorganic P), (3) moderately resistant organic P (includes acid soluble fulvic acid organic P), and (4) highly resistant organic P (acid insoluble organic P associated with humic acid).

Analytical methods

Phosphorus and NH_4-N in the interstitial water and in the extracted solutions were analyzed using standard methods (APHA, 1985) on an autoanalyzer. Total P (after ashing) was analyzed on an autoanalyzer using standard methods (APHA, 1985).

Sediment Flux Analysis

Intact sediment cores were incubated in the dark at room temperature (see appendix B for core environmental conditions). Four floodwater exchanges were conducted on cores collected in 2001 and two exchanges conducted on cores collected in 2002. For the 2001 first three-floodwater exchanges, non-filtered water from STA-1W (cell-4 effluent) was added carefully to each core, with care to minimize sediment disturbance. On exchange #4 of 2001, and on both floodwater exchanges of 2002 collected cores, filtered STA-1W water was used. Floodwater depth in 2001 was maintained at 30 cm, and in 2002 maintained at 23 cm, for a total floodwater volume of 1154.5 ml and 900 ml, respectively. Exchange of floodwater was conducted on days 0, 30, 93, and 156 in 2001 and on day 0 and 30 in 2002. During the period after each floodwater exchange, water column DRP, TDP and TP concentrations were monitored according to the schedule identified in Appendix C-1. Water column change in volume after sampling was maintained by adding an equivalent volume of STA-1W water. Deionized water was used to compensate for water loss due to evaporation. The water column was maintained under aerobic conditions by bubbling air through the upper portion of the water column. Floodwater removed from the cores for DRP and TDP analysis was filtered (< 0.45 m), samples for TP analysis were not filtered. Dissolved reactive P was analyzed using the ascorbic acid colorimetric method (EPA 1993, Method 365.1), and TDP and TP were determined after digestion with persulfate (Method 365.1, EPA 1993, Bowman 1989).

Phosphorus- flux calculations

Max flux rate: After correcting for initial floodwater P, makeup water P added to the column, and P removed as a result of sampling, P mass release/retention at each sampling event was determined. Phosphorus mass release/retention at each sampling event was then

converted to a rate based on the time elapsed between sampling periods. Maximum flux was based on the largest P release rate that occurred during the first 30 days of any one of the four-floodwater exchange periods during 2001, and of either floodwater exchange during 2002.

Average flux rate: Average flux rate was determined based on P mass released to the water column from the sediments during the first 30 days of each floodwater exchange, divided by the time elapsed (30 days).

Maximum cumulative P release: Maximum cumulative P release was determined by adding the maximum P mass release values during the first 30 days for each of the four-floodwater exchange cycles during 2001 and for the two-floodwater exchanges in 2002.

Average cumulative P release: Average cumulative P release was determined by adding the average P mass released over the first 30 days for each of the four-floodwater exchange cycles in 2001 and the two-floodwater exchange cycles in 2002.

Biofilm removal and effects

Due to the long duration of this study, some accumulation of particulate material was noted on the inside walls in most core microcosms. This was not the result of algal colonization since cores were kept in complete darkness with the exception of sampling events. These particulate accumulations may have been the result of particulate sediment resuspension during floodwater exchange or ebullition events or the result of microbial biofilms. These particulate accumulations were not disturbed during the first three floodwater exchanges. However, between the third and fourth floodwater exchange, when the water column for each core was removed, clean sponges were used to wipe clean and remove any residue on the sidewalls.

To determine the potential effect of these particulate accumulations might have on water column DRP concentrations. In this experiment, six additional cores were collected from sites MC-C2 and L40-C24. All 12 cores were allowed to incubate for 30 days after the initial floodwater exchange, similar to other cores. During the second floodwater exchange, floodwater from three cores of the two sites was removed and refilled using the procedure described previously. The other three cores from each site, the floodwater was removed then the inside walls of the core were swabbed with clean sponges and then UV sterilized (2537 angstroms) for 10 seconds. Care was taken only to sterilize the walls of the core

microcosm without exposing the sediment surface to any UV radiation. It was expected that this level of radiation would kill any microbial communities that may have colonized the core microcosm walls and therefore effectively neutralize a potential P sink during the subsequent 30 day P flux exchange period (Wheaton, 1977).

Data Analysis

Data correlations were conducted using Pearson product-moment pairwize analysis of variance after determination that data had a bivariate normal frequency distribution (JMP/SAS 2001). If one of the parameters was not normally distributed a log transformation was conducted on the data prior to correlation analysis. If transformation of the data was not possible, or in cases where a parametric correlation was not significant and neither a prediction equation or a functional relationship was desired, Spearman's Rho non-parametric test of association was performed on the data to establish whether the two parameters being compared were simply monotonically increasing or decreasing as a function of the independent variable. Distinction in the text, between these two statistical tests, is made by indicating a comparison as either a correlation (Pearson's pairwise analysis), or an association (Spearman Rho's).

Results

Results for sediment characteristics and P flux estimates have been aggregated based on canal sampling locations downstream of proposed or existing STA's. This aggregation of sites allows for a better assessment of the sediment conditions over which STA treated discharge waters will be flowing. Reference to specific parameters and values at a particular sampling location that are not provided in tables can be found in appendix C.

Sediment Physico-Chemical Properties

Bulk Density and Loss on Ignition

Canal sediments showed a wide range in bulk density and organic matter content, with values generally being higher in surface than in subsurface sediments. Bulk density ranged from 0.034 $\pm$ 0.006 g cm^{-3} (L40-C24) to 0.859 $\pm$ 0.043 g cm^{-3} (MC-C3) in surface sediments and 0.062 $\pm$ 0.004 g cm^{-3} (L40-C24) to 0.786 $\pm$ 0.087 g cm^{-3} (MC-C17) in subsurface sediments. Bulk density values were positively correlated with organic matter content in both surface ($p = 0.000$, $r^2 = 0.864$) and subsurface sediments ($p = 0.000$, $r^2 = 0.916$). Organic matter content (expressed as loss on ignition or LOI) in surface sediments ranged from a low of 8.7 $\pm$ 0.7 % at site MC-C3 to a high of 74.3 $\pm$ 5.9 % at site L40-24. In subsurface sediments this range was not as extreme with a low value of 11.8 $\pm$ 2.1 % at MC-C27 and a high of 64.0 $\pm$ 5.2 % at site L5-C5.

Aggregating canal sites based on proximity to proposed or existing STA's indicates the lowest sediment bulk density values are near STA-1E (Table 2). Surface sediments at these sites are higher in organic matter content than other aggregate sites with an average mass loss on ignition of 56.5 $\pm$ 13.3 %. Sediments with the lowest organic matter content were associated with canal sites adjacent to STA's 5 and 6.

Porewater Phosphorus and NH_4-N

Porewater concentrations of DRP and NH_4-N approximately represent the solution equilibrium concentration between sorbed and soluble fractions of DRP-P and NH_4-N at the time of sample collection. This fraction is most readily released to the overlying water column and responds to concentration gradients across the sediment-floodwater interface. Porewater P concentrations in the surface sediment (0-10 cm) were generally below 0.15 mg L^{-1}. However, site L39-C25 and L38-C6 had concentrations of 0.35 mg L^{-1} or above. Porewater P concentration in subsurface sediments (10-30 cm) had higher concentrations, typically above 0.125 mg L^{-1} with the highest concentration occurring at L38-C6 (0.762 $\pm$ 0.303 mg L^{-1}). Aggregate canal sites indicate that porewater DRP concentrations adjacent to STA-1W (0.168 + 0.94 mg L^{-1}) were the highest among the four aggregate areas, with Miami Canal sites adjacent to STA's 5 and 6 having the lowest concentrations (0.056 $\pm$ 0.030 gm L^{-1}) (Table 2).

Concentrations of porewater NH_4-N in the surface sediment ranged from 1.34 ± 0.04 mg L^{-1} (L6-C7) to 19.63 ± 2.04 mg L^{-1} (MC-C2). Concentrations in subsurface sediment were higher, and positively correlated with porewater NH_4-N concentrations in the surface sediments ($p = 0.000$, $r^2 = 0.847$). Concentration in the sub-sediment ranged from 2.56 ± 0.12 mg L^{-1} (L6-C7) to 38.8 ± 7.6 mg L^{-1} (MC-C2). Trend in porewater NH4-N concentrations among aggregates sites did not follow that of DRP with lowest concentrations occurring in canal sites adjacent to STA's 2, 3 and 4 (3.01 ± 1.24 mg L^{-1}), and highest concentrations found in the proximity of STA-1E (8.27 ± 0.51 mg L^{-1}).

Inorganic P- fractionation (Reddy et al., 1998):

Sediment P was fractionated into five groups: 1) KCl extractable P_i (readily available P), 2) NaOH-extractable P_i (Fe and Al-bound P), 3) HCl extractable P_i (Ca and Mg-bound P), 4) NaOH extractable P_o (Fulvic and humic bound P), and 5) residual P_o. Results are presented in Tables 3 and 4.

Inorganic P_i extracted with salts such as 1M KCl represents loosely adsorbed P, which can be readily released into the water column. As a fraction of the inorganic P pool, KCl extractable P represented less than 1% of TP in surface sediments and less than 4% of the P in subsurface sediments at any of the canal sites (Table 3). Surface KCl-Pi values ranged from 0.18 ± 0.01 mg kg^{-1} (MC-C3) to 9.81 ± 3.34 mg kg^{-1} (L39-C10). In subsurface sediments, extent of the range occurred at the same sites, 0.15 ± 0.01 mg kg^{-1} and 12.88 ± 3.90 mg kg^{-1} respectively.

Inorganic P extracted with 0.1M NaOH represents P associated with Fe and Al. The Fe and Al-bound P accounted for less than half of the surface sediment inorganic P pool at all sites with the exception of site L40-C24 that had a value of 389 ± 90 mg kg^{-1} or 51 % of TPi (Table 3). The smallest NaOH-Pi concentration was found at site L6-C7 (2.62 ± 0.42 mg kg^{-1}). Subsurface sediments had similar amounts of Pi associated with Fe and Al with values ranging from 3.73 ± 1.19 mg kg^{-1} (L6-C7) to 216.8 ± 17.6 mg kg^{-1} (L40-C24). Fe and Al bound P represented less than 7% of the total P fraction at 75% of the sites sampled. The highest % of TP associated with Fe/Al bound P was found at L40-C24 (28%), with three of the four highest values identified for this parameter associated with the L40 canal.

In this sequential extraction scheme, P_i extracted with HCl represents P bound to Ca and Mg. The Ca and Mg-bound Pi pool represented the largest inorganic storage of phosphorus found at all canal sites with exception of surface sediments at site L40-C24. Surface sediment Ca bound P at all other sites accounted for over 70% of the Pi pool and averaged 54% of the total P pool in surface and subsurface sediments (Table 3). In the case of site MC-C3, Ca bound P accounted for as much as 73% of TP (1022 $\pm$ 360 mg kg^{-1}), which was the highest value in surface sediments. Values of Ca bound P in subsurface sediments ranged from 50 $\pm$ 45 mg kg^{-1} (MC-C23) to 947 $\pm$ 136 mg kg^{-1} (MC-C2).

The Total P_i (of this fractionation scheme) is the sum of P extracted with KCl, NaOH and HCl. Total P_i represented 47-74% of the total P recovered at 0-10 cm sediment depth (MC-C27 and L38-C6, respectively) and 19-86% of total P in 10-30 cm sediment depths (MC-C3 and L38-C6, respectively) (Table 3). The average inorganic pool in surface and subsurface sediments at all sites was approximately 60% of TP. Surface sediment TPi concentrations ranged from 84.2 $\pm$ 5.7 mg kg^{-1} (L6-C7) to 1029.4 $\pm$ 360.7 mg kg^{-1} (MC-C3). Subsurface TPi ranged from 59.5 $\pm$ 43.9 mg kg^{-1} (MC-C23) to 1084.4 $\pm$ 129.8 mg kg^{-1} (MC-C2).

Organic P extracted with NaOH is considered to consist of P associated with humic and fulvic acids. The NaOH-P_o was estimated by the difference between TP and DRP concentration in the NaOH extracts. Up to 21% of TP in surface (L40-C24) and 24% in subsurface sediments (L40-C24) was associated with humic and fulvic acids (Tables 6). Values for this fraction of organic phosphorus ranged from 6.58 $\pm$ 0.28 mg kg^{-1} (MC-C3) to 285.52 $\pm$ 53.30 mg kg^{-1} (L40-C24) in surface sediments and 2.86 3.90 mg kg^{-1} (MC-C27) to 333.20 75.83 mg kg^{-1} (L40-C24) in subsurface sediments.

The residual P was calculated as the difference between the sums of P recovered in all extractions and the TP as determined by digestion. It is not possible to differentiate this pool of P into recalcitrant organic or tightly bound mineral P. However, it can be assumed that this fraction of total phosphorous is not readily available to release and therefore accounts for a very stable pool of P. Residual P represented between 18% and 52% of the surface TP pool and 11% to 88% of the subsurface TP. Average % of total P for all sites was 28% of surface and 32% of subsurface sediment TP. Concentration of recalcitrant P ranged from 78.8 $\pm$ 43.3 mg kg^{-1} (MC-C28) to 529.9 $\pm$ 351.7 mg kg^{-1} (MC-C27) in surface sediments and 38.6 $\pm$ 4.8 mg kg^{-1} (L6-C7) to 725.0 $\pm$ 75.1 mg kg^{-1} (MC-C3) in subsurface sediments.

Total P_o is the sum of P_o extracted with NaOH and the recalcitrant P that was left after all extractions in the fractionation scheme were conducted. The TP_o estimated using this procedure represented 26% to 53% of the total P in surface sediments (L38-C6 and MC-C27, respectively), and 14-81% of total P in subsurface sediments (L38-C6 and MC-C3, respectively) (Table 4). The average value for TP_o was approximately 40% in the surface and subsurface sediments among all sites. Surface sediment TPo concentrations ranged from 33.4 $\pm$ 14.2 mg kg^{-1} (L6-C7) to 616.7 $\pm$ 32.8 mg kg^{-1} (L40-C24). Subsurface TPo concentrations ranged from 44.6 $\pm$ 6.3 mg kg^{-1} (L6-C7) to 729.1 $\pm$ 76.1 mg kg^{-1} (MC-C3).

Surface sediment TP concentrations were lowest at L6-C7 (surface 119.9 $\pm$ 13.9 mg kg^{-1}, subsurface 128.0 $\pm$ 4.0 mg kg^{-1}), and highest at site MC-C2 (surface 1455.4 $\pm$ 31.3 mg kg^{-1}, subsurface 1559.3 $\pm$ 131.5 mg kg^{-1}). When sites are aggregated, total P concentrations adjacent to STA-1E and STA's 5 and 6 are similar, 1142 $\pm$ 141 mg kg^{-1} and 1110 $\pm$ 374 mg kg^{-1}, respectively (Table 2). Total inorganic P concentrations showed a slightly different trend where aggregates sites adjacent to STA's 5 and 6 had a higher concentration and percentage of P in the inorganic fraction than sites adjacent to STA-1E, STA-1W or STA's 2, 3, or 4. Relative high and low concentrations between surface and subsurface sediments were similar among aggregate sites with sites adjacent to STA's 1E and 1W showing little difference or a slight increase in TP_i and TP concentration between surface and subsurface sediments, and sites adjacent to STA's 2-6 having up to a 28% decrease in TP and TPi concentration between surface and subsurface sediments.

Total P and storage fractions of P in canal sediments are summarized in Figure 2. Canal sites adjacent to proposed and existing STA's have been aggregated such that an assessment of the sediment conditions over which STA treated discharge waters will be flowing can be made. At three of the four aggregate sites the majority of the phosphorus is Ca bound, and approximately 30 % of the sediment P is in the recalcitrant pool. Only sites adjacent to STA-1E had less than 50% of the P fraction bound to Ca. At sites adjacent to STA-1E (L40 canal sites), a greater percentage of P was associated with the Fe/Al and humic and fulvic acid bond fractions. In all cases labile inorganic phosphorus provided less than 0.5% of the overall TP. Total P concentrations at aggregate sites occurred in three general concentrations groupings, STA-1E and STA's 5 and 6 had sediment TP concentrations of approximately 1100 mg kg^{-1}, sites adjacent to STA-1W with average concentrations of 790 $\pm$ 200 mg kg^{-1}, and STA's 2, 3, and 4 with average concentrations of 661 $\pm$ 346 mg kg^{-1}.

Labile Organic, and Inorganic P Pools:

The labile organic P fractionation scheme that was used to extracts both labile-P_i and labile-P_o. In this fractionation scheme, labile Pi and Po fractions were extracted with 0.5 *M* $NaHCO_3$ (pH = 8.5) with no chloroform treatment. A duplicate batch of field-moist samples was treated with chloroform to lyse microbial cells, followed by extraction with 0.5 *M* $NaHCO_3$. Total labile organic Po was calculated as the difference between total P in solution extracted with $NaHCO_3$ from sediments subjected to chloroform fumigation, and Pi extracted from sediments without chloroform. Microbial Biomass P was calculated as the difference between total P in the extracts from chloroform-treated and untreated sediments. Results are presented in Table 5.

Labile inorganic P (P_i):

Labile P_i was extracted with $NaHCO_3$, and this pool of P represents loosely sorbed P. The $NaHCO_3$ reagent extracts the same fraction as the P_i extracted with 1*M* KCl in the inorganic P fractionation scheme, however, under calcareous, alkaline, or neutral sediments containing high levels of Ca, this extractant was shown to decrease Ca activity in solution by precipitation as $CaCO_3$ and thereby may be more effective in representing labile-Pi under these conditions (Soltanpour and Schwab, 1977). Measurements of labile-Pi using $NaHCO_3$ were one to two orders of magnitude greater than KCl-Pi estimates. The $NaHCO_3$-Pi values in surface sediments ranged from 10.08 $\pm$ 0.81 mg kg^{-1} (L6-C7) to 124.00 $\pm$ 5.36 mg kg^{-1} (MC-C2). Values in subsurface sediments ranged from 9.12 $\pm$ 1.75 mg kg^{-1} (L6-C7) to 146.58 $\pm$ 12.30 mg kg^{-1} (MC-C2). These concentrations represents between 1 and 24% of TP recovered as part of the inorganic P fractionation scheme. Average surface and subsurface sediment concentrations at all sites represented 7% and 8% of the TP pool respectively.

Labile organic P_o:

Labile P_o was calculated as the difference between the TP (by digestion) and DRP content of the $NaHCO_3$ extracts. The $NaHCO_3$-Po values in surface sediments ranged from 0.00 mg kg^{-1} (-2.22 $\pm$ 1.51 mg kg^{-1}, MC-C3) to 372.88 $\pm$ 63.79 mg kg^{-1} (L40-C24). Values in subsurface sediments ranged from 0.00 mg kg^{-1} (-5.35 $\pm$ 0.78, MC-C28) to 174.69 $\pm$ 23.5 mg kg^{-1} (L40-C24). Using this fractionation scheme, labile Po concentration accounted for an average 6% of the surface and 2.5% of the subsurface TP pool.

That portion of the labile TPo pool held in microbial biomass was calculated by taking the difference between 0.5 *M* $NaHCO_3$ extracted P from chloroform-treated and chloroform-untreated sediments. Microbial biomass P was consistently greater in the surface sediment (0-10 cm), than subsurface sediments (10-30 cm) (Table 5). Microbial biomass P ranged from 0.74 $\pm$ 0.48 mg kg^{-1} (MC-C28) to 349.17 $\pm$ 55.32 mg kg^{-1} (L40-C24) in the surface sediment, and 0.00 mg kg^{-1} (-2.92 $\pm$ 1.39 mg kg^{-1}, MC-C27) to 161.27 $\pm$ 24.44 mg kg^{-1} (L40-C24) in the subsediment. Microbial biomass P accounted for greater than 75% of the labile Po in the surface and subsurface sediments of almost all canal sites, and represented and average 5.6% (surface) and 2.8% (subsurface) of the overall TP in the sediments.

Phosphorus Flux

All calculations and data reported for flux potentials are based on the first 30 days of each floodwater exchange cycle. Site water from STA-1W (Cell-4) was used to flood the sediment cores and had DRP concentrations of 0.005 mg L^{-1} (2001 floodwater exchanges #1, #3, and #4), 0.008 mg L^{-1} (2001 floodwater exchange #2), and 0.006 and 0.003 mg L^{-1} (2002 floodwater exchanges #1 and #2). During the first floodwater exchange, correlations between DRP, TDP and TP were evaluated (Figure 3). The significant and near 1:1 relationship between TDP:DRP (r^2 = 0.95) and TP:DRP (r^2 = 0.96) suggests that almost all of the P released or present in the core water column was in the form of DRP. Based on this relationship, flux estimates that follow, unless otherwise expressed, are based on DRP water column concentrations and are assumed to represent greater than 95% of the Total P released from the sediment.

There are several estimates of sediment P release that can be inferred from water column P concentrations monitored in this study. We will focus on two potential rates; average and maximum flux rate, and two total P mass quantities, average and maximum cumulative P release. The first section of flux results will focus on cores collected in 2001. Then additional data from cores collected in 2002 will be presented.

Core Microcosms 2001

Water column Concentration

Changes in DRP concentration within the water column over time allows us to establish P flux from the sediment and to determine the total P released from the sediment during sequential floodwater exchanges. Concentration and P mass values provided in Table 6 represent the average water column DRP concentrations that developed during each of the four-floodwater exchange cycles. Floodwater DRP concentrations were generally highest during the first floodwater exchange and declined during sequential floodwater cycles (Figure 4). Range in DRP concentration during the first floodwater exchange was 0.012 $\pm$ 0.001 mg L^{-1} (L6-C7) to 0.073 $\pm$ 0.019 mg L^{-1} (L39-C25). Range in floodwater concentration during the fourth floodwater exchange was 0.003 $\pm$ 0.001 mg L^{-1} (L6-C9) to 0.027 $\pm$ 0.01 mg L^{-1} (L40-C24). This indicates an overall decline in average DRP concentration in the water column during the four-floodwater cycles and in the case of four canal sites, average water column concentration was below the initial cell 4-floodwater concentration of 0.005 mg L^{-1}**.**

Sediment P Flux Rate

Sediment P flux was calculated for potential maximum and average rates of P release from sediments and presented by aggregate sites (Table 7) and individual canal sites (Appendix C, Table C-4). Maximum flux rate was defined as the greatest increase in P release per unit time between day 1 and day 30 of each floodwater exchange cycle. Greater initial rates between time 0 and the first sampling period (4-6 hours) may occur in some cores, but were not used in the maximum or average flux measurement. This initial/instantaneous flux is presumed to be the result of sediment disturbance and resuspension during the floodwater exchange procedure since water column concentrations often decreased during the next sampling event. However, it is interesting to note that flux rates during this disturbance period were often an order of magnitude greater than that reported as maximum flux rates. The significance of this is, if resuspension of canal bottom sediments should occur due to scouring, initial P flux rates from sediments may be significantly higher than those reported here and should be considered in evaluating P release as a result of physical disturbance to bottom sediments. Average flux rates were

defined as the average P release rate during the first 30 days of each floodwater exchange cycle divided by 30 days. At all canal sites, maximum P flux occurred during the first or second floodwater exchange cycles and therefore only these two cycles are presented in Table 7.

The highest maximum flux rate was 22.0 $\pm$ 14.2 mg m^{-2} day^{-1} (L40-C24, 2nd exchange). Site aggregation indicates that the highest maximum and average flux rates occurred in the L-40 canal adjacent to STA-1E (5.73 $\pm$ 2.62 and 8.43 $\pm$ 9.64 mg P m^2 day^{-1} for the 1st and 2nd floodwater exchanges) (Table 7). Rates of DRP flux were lowest in canal sites adjacent to STA's 2-4, however, maximum and average flux values among STA-1W, STA's 2-4 and STA's 5 and 6 were similar during the 2nd floodwater exchange. Figures 5 and 6 give maximum and average flux rates, respectively, of the four aggregated canal areas. Similar to individual canal sites, maximum and average flux rates tended to be greatest during the first floodwater exchange and declined with consecutive exchanges. Overall, flux rates tended to trend from the northeast to the southwest of the sampling area where canals associated with STA-1E > STA-1W > STA's 5 and 6.

Correlation of maximum and average flux rates with sediment physico-chemical parameters provided some indication of which sources of P may be influencing P flux from the sediment. Although these correlations do not identify a cause and effect relationship, four sediment parameters gave significant and relatively strong correlation coefficients with maximum and average flux measurements. Labile Pi and Po, microbial biomass P, Fe and Al-bound P, and fulvic and humic bound P, all showed some degree of correlation during three of the four floodwater exchange periods ($p = 0.05$, Table 8). In most cases, significant correlations that occurred showed a higher degree of correlation in surface sediments than that of subsurface sediments.

Cumulative Sediment P Release

Cumulative sediment P release represents the total amount of P that was released from the sediment to the water column during the four-floodwater exchanges. Ideally this would be calculated as the sum of the P mass within the water column at the end of each floodwater cycle. However, due to the decline in DRP in many cores during the 2nd and 3rd floodwater exchange, it was decided to use the sum of the average P mass released during the first 30 days of each floodwater exchange as an estimate of the total P mass released.

A maximum P release estimate was also calculated where the sum of the maximum P mass values (within the first 30 days) for each of the four floodwater exchange cycles was used to estimate the total P mass released. The greatest average and maximum cumulative P release values were located at canal sites adjacent to STA-1E (Table 7). Cumulative P release from sediments was lowest at canal sites adjacent to STA's 2, 3 and 4. The greatest maximum P release was similar at two sites L40-C24 (80.00 $\pm$ 30.38 mg m^{-2}) and L39-C25 (80.43 $\pm$ 17.07 mg m^{-2}). The smallest average P release at any canal site was from canal L6 sites C7 (4.58 + 0.82 mg m^{-2}). The smallest maximum P release was similar between sites L6-C9 (18.64 $\pm$1.55 mg m^{-2}) and MC-C23 (18.96 $\pm$ 2.43 mg m^{-2}). Cumulative P release profiles for each sampling site are given in appendix D.

Cumulative P release from sediments had similar correlations with sediment physico-chemical parameters to that of maximum and average P flux (Table 8). Significant correlations were found between maximum cumulative P release and porewater NH_4-N, NaOH-P_i, NaOH-P_o, $NaHCO_3$-P_i + -P_o, and microbial P. Average P release was also correlated with KCl-P_i and $NaHCO_3$-Pi in surface sediments.

Core Microcosms 2002

Resampling of five canal locations was conducted in the early summer of 2002 to evaluate core microcosm techniques and determine the temporal variability in P flux between 2001 and 2002. Sediment characterization was not conducted in 2002, only potential P flux rates were determined on cores collected.

Sediment P Flux Rate

Sediment P flux was calculated in a similar manner to that described in 2001. Core micrososms were only run for two floodwater exchange cycles. A comparison of maximum and average flux rates between the 2001 and 2002 sampling periods for each floodwater exchange cycle is presented in Table 9. In general, both maximum and average flux rates were an order of magnitude or greater in 2001 than in 2002. The exception to this was site L38-C6 where flux rates were greater in 2002 than in 2001 during the first-flood water exchange. Ranking of canal sites based on maximum or average P flux varied considerably

both between 2001 and 2002 sampling events and between the first and second floodwater exchanges.

Cumulative Soil P Release

Cumulative soil P release from sediments collected in 2002 had an order of magnitude lower P mass release in 2002 than in 2001 for all sites with exception of L38-C6 (average and maximum release) and L40-C24 (maximum release) (Table 9). Site L38-C6 was the only site that had higher cumulative P release values in 2002 than in 2001. Average P release values ranged from 7.56 $\pm$ 1.11 to 29.1 $\pm$ 8.27 mg P m^{-2} in 2001 and from 2.35 $\pm$ 0.02 to 18.7 $\pm$ 16.7 mg P m^{-2} in 2002.

Results of Biofilm Experiment

Build up of particulate material on microcosm sidewalls was noted during the 2001 core microcosm flux experiments. To determine if this material was acting as a DRP sink during the flux study a side experiment was developed to compare untreated core microcosms, similar to those used in the first flux experiment, with UV-treated microcosms where core tube sides were swabbed with clean sponges and sterilized with UV radiation. This experiment was run in triplicate on sediments from two canal sites, MC-C2 and L40-C24. This experiment was run for a single floodwater exchange cycle of 28 days. During this period no significant differences in water column DRP concentration ($p <= 0.05$) were found between treated and untreated microcosms (Figure 7).

Discussion

Sediment P Storage and Stability

Results of sediment cores from twenty canal sites provided insight into the storage and mobility of P in canals adjacent to the Everglades Agricultural Area and the Water Conservation Areas. These results indicate that the majority of P at these sites is bound to Ca and Mg and is relatively stable under elevated pH conditions. However, this pool of P, similar to most sorbed forms of P, is in equilibrium with the P in sediment porewater and therefore can be released if porewater concentrations drop below the equilibrium constant at a given canal environmental condition. As indicated however, due to the relatively high pH conditions within much of the

aquatic ecosystems of south Florida this P pool is relatively stable and release to the water column should be relatively slow.

Sediments within these canals also have a significant pool of recalcitrant P that could not be extracted during any of the inorganic P extraction process. This P fraction could be bound to highly recalcitrant organic compounds or tightly bound to minerals. This pool, by definition, constitutes very stable forms of P within the sediment and can be though of as the most stable of all P forms present.

The Fe and Al bound P pool, represented by the NaOH $-P_i$ fraction can be relatively stable, but in the case of Fe bound P is sensitive to changes in redox conditions (Moore and Reddy, 1994; Olila and Reddy, 1997). Iron bound P can be released if ambient conditions shift from aerobic to anaerobic causing the redox state of the sediment to decrease. As Iron becomes reduced it can release previously bound P into solution. This may be a dynamic environmental condition occurring within south Florida canals that was not simulated under laboratory conditions. Water column in sediment cores was constantly aerated to maintain an aerobic condition. Therefore, redox state represented in this core flux study would likely have maintained surficial iron in the sediments in an oxidized state, and thereby retain any previously Fe bound P. Under in-situ conditions, diurnal fluctuations in dissolved oxygen conditions may cause canal surface sediments to oscillate between aerobic and anaerobic conditions on a daily basis. Fluctuation in surficial sediment redox condition is more likely to occur at canal sites with low or pulsed flow, sites with elevated organic matter loading or sites with high productivity within the water column. This fraction of the total sediment P pool accounted for between 4 and 17 % or up to 186 mg kg^{-1} at sites adjacent to STA-1E. Stability of this P fraction will vary depending on the stability of redox conditions within the surface canal sediments.

The last significant pool of P identified at most canal sites was that of NaOH extractable organic P. This pool includes both living and dead sources of organic P associated with humic and fulvic acid compounds. At almost all sites NaOH-P_o content was higher in surface sediments than that of subsurface sediments, likely indicating the source of this P pool was from organic matter deposition at the surface and not historic buried horizons. The percent fraction of total P associated with NaOH-P_o was also greater in surface sediments than subsurface sediments indicating an accumulation of organic matter and potentially reduced availability of Ca, Fe, or Al sorption sites. The range in NaOH-P_o as a fraction of total P was less than 1% to over 20 % with P concentrations significantly correlated with sediment organic

matter content of surface sediment. The relative stability of this organically bound P is unknown and dependant on environmental conditions regulating the rate of organic P mineralization. Under hypoxic conditions, this pool is relatively stable as the rate of organic decomposition is significantly regulated by availability of oxygen. However, increased oxygen availability at the sediment water interface could result in an increased rate of P release from this fraction of sediment P.

The most labile form of P (KCL-P_i) extracted as part of the inorganic P fractionation scheme indicated a very small pool of readily available phosphorus. However, $NaHCO_3$ extraction of this same pool indicated a significantly greater amount of relatively labile P_i. As indicated previously; under calcareous, alkaline, or neutral sediments containing high levels of Ca; this extractant was shown to decrease Ca activity in solution by precipitation as $CaCO_3$ (Soltanpour and Schwab, 1977). The high $CaCO_3$ found in canal sediment of south Florida would suggest that this extraction procedure might be more representative of the true labile-P_i fraction when compared to KCL-P_i extraction estimates. This would indicate that the percent of labile inorganic P in sediments might be more on the order of 2-8% of the total P sediment concentration. However, due to the high scavenging capability of $CaCO_3$ apparent during the KCL-P_i extraction procedure, release of this labile pool to the sediment solution may be quickly regulated by the apparently large sediment Ca binding capacity at most of the sites sampled.

Phosphorus Retention and Release

Phosphorus release to the water column is regulated by sorption/desorption equilibria between the solid and liquid phase within the sediment and by diffusion and convective movement of P between the interstitial porewater and the overlying water column. Findings from this study indicated that initial flux rates from the sediment were significantly higher than flux rates during later floodwater exchange cycles. This pattern of P release would suggest that the initial P mass in solution and P bound to easily desorbed or mineralizable particulates were quickly released to the water column during the first and second floodwater exchange due to low floodwater P concentrations. As rates of desorption and mineralization decreased as more tightly bound P and more recalcitrant compounds became the only P supply, then the rate of P release to the floodwater decreased, as indicated by lower P flux rates during the 3rd and 4th floodwater exchange cycles. This explanation of decreasing P release with sequential floodwater exchanges is supported by correlations between P flux and NaOH-P_i, NaOH-P_o,

NaHCO3-P_i + P_o, and Microbial P. The finding that NaOH-P_o, $NaHCO_3$-P_i + P_o and Microbial P are all correlated with P flux suggest a possible role of P release resulting from mineralization of organic bound P. The relative contribution of P to the water column resulting from mineralization is likely to increase with time as long as organic bound P is still available and labile forms of P become increasingly depleted.

Sediment P and resultant P flux rates were greatest at sites located in the L-40 canal. These locations had some of the highest organic matter content and the lowest combined bulk density of all aggregate sites. Phosphorus at these sites had the lowest Ca and Mg-bound fraction and the highest NaOH-P_i and NaOH-P_o fraction. In contrast, aggregate sites within the Miami Canal had similar total P concentrations, but distribution of P within the sediment was greatest in the Ca and Mg-bound pool and smallest in the NaOH-P_i and NaOH-P_o fraction. Subsequently, average and maximum P flux rates were generally lower and certainly lower as a percentage of total sediment P at the Miami Canal sites. This would suggest that sites having a large percent of Ca and Mg-bound P are more stable with respect to release of P to the overlying water column, where as P bound to organic or Fe and Al may be more reactive and more likely to release P to the overlying water column.

Conclusions

Findings from this investigation of twenty sampling sites within major canal systems to the south and east of the Everglades Agricultural Area and adjacent to existing or proposed STA's provided the following conclusions.

1) There is a wide spatial variability in internal P load and P release potential within south Florida canals adjacent to the Everglades Agricultural Area and the Water Conservation Areas.

2) Temporal variation may also be a significant factor in evaluating P flux from sediments, where in this study P flux at five sites increased or decreased by up to an order of magnitude between 2001 and 2002.

3) The distribution of P within the sediment, although dominated at all sites by Ca and Mg-

bound P, also show significant P fractions associated with the Fe and Al-bound P, and P bound to fulvic and humic acids.

4) Based on correlations between P flux and physico-chemical parameters measured, mineralization of organic bound P and release from Fe and Al-bound fractions are likely significant storage pools influencing release of P to the overlying water column in canals.

5) Readily available sources of P may be quickly depleted from the sediment at some sites, with two to three floodwater exchanges typically reducing P flux rates to the point at which additional floodwater exchanges resulted in only minimal P release to the water column.

6) Sediments with the highest Total P concentrations were found adjacent to STA-1E (L-40) and STA's 5 and 6 (Miami Canal).

7) Although highest in TP concentration, P availability in the Miami Canal is relatively low due to a high fraction of P being Ca and Mg-bound.

8) Sediment P at sites in the L-40 canal are more labile due to elevated Al and Fe-bound fractions making it more susceptible to changes in redox state, and a high organic bound fraction resulting in long-term slow release through mineralization.

9) Additional information regarding existing and projected environmental conditions that occur at the sediment water interface within canals would be helpful in use of this data, especially at sites with high Fe and Al-bound P due to their sensitivity to changes in redox condition.

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Table 1. Location of sites used for collection of intact and sediment characterization cores.

STA	Associated Canal	Sample Site ID	Latitude	Longitude
STA-1E	L40	C22	26.67423	-80.36092
	L40	C12	26.58232	-80.26297
	L40	C24	26.50102	-80.22049
STA-1W	L7	C21	26.67186	-80.38467
	L7	C11	26.58659	-80.44608
	L7	C26	26.52494	-80.44580
	L39	C25	26.41201	-80.39972
	L39	C10	26.37504	-80.36358
STA's 2,3 and 4	L6	C9	26.45606	-80.45732
	L6	C7	26.38539	-80.50319
	L38	C6	26.32724	-80.53133
	L38	C8	26.20865	-80.45641
	L5	C5	26.33383	-80.54995
	L5	C4	26.33351	-80.62694
STA's 5 and 6	Miami	C28	26.45830	-80.81687
	Miami	C27	26.35474	-80.79271
	Miami	C3	26.32503	-80.76913
	Miami	C2	26.22079	-80.69381
	Miami	C1	26.12397	-80.61752
	Miami	C23	26.03160	-80.53864

Table 2. Surface and subsurface sediment physical and chemical characterization of canal sites adjacent to existing or proposed STA's . Values represent mean ± S.D. of triplicate cores collected in 2001.

Sites	Bulk Density	LOI	Porewater DRP	Porewater NH4-N	Total Inorganic P	Total P
	g cm^{-3}	%	mg L^{-1}	mg L^{-1}	mg kg^{-1}	mg kg^{-1}
0-10 cm depth						
STA-1E (L-40)	0.069 ± 0.027	56.5 ± 13.3	0.076 ± 0.053	8.27 ± 0.51	607.1 ± 47.1	1142.4 ± 141.3
STA-1W (L-7 and L-39)	0.147 ± 0.065	46.4 ± 10.9	0.168 ± 0.94	6.17 ± 1.60	442.7 ± 118.1	807.5 ± 232.4
STA's - 2, 3, and 4 (L6, L38, and L5)	0.210 ± 0.152	43.9 ± 14.6	0.125 ± 0.114	3.01 ± 1.24	452.7 ± 233.9	735.7 ± 375.6
STA's - 5 and 6 (Miami Canal)	0.404 ± 0.302	27.8 ± 16.2	0.056 ± 0.030	7.35 ± 5.84	903.8 ± 337.9	1110.0 ± 373.8
10-30 cm depth						
STA-1E (L-40)	0.101 ± 0.039	51.4 ± 7.53	0.272 ± 0.169	16.7 ± 5.84	602.7 ± 36.8	1156.1 ± 152.5
STA-1W (L-7 and L-39)	0.208 ± 0.150	47.7 ± 13.4	0.380 ± 0.200	8.88 ± 5.52	512.6 ±216.7	807.3 ± 320.9
STA's - 2, 3, and 4 (L6, L38, and L5)	0.280 ± 0.132	37.5 ± 14.4	0.328 ± 0.233	0.56 ± 2.18	390.0 ± 210.0	522.1 ± 255.3
STA's - 5 and 6 (Miami Canal)	0.433 ± 0.262	27.2 ± 14.6	0.133 ± 0.091	12.3 ± 12.0	783.8 ± 318.0	935.8 ± 414.5

Table 3. Labile, Fe and Al-bound and Ca and Mg-bound pools of P based on P_i fractionation scheme. Mean ± SD represents average of triplicate core samples. "% of TP" represents % of total P recovered in inorganic P fractionation scheme.

		KCl - Pi		NaOH - Pi		HCl - Pi		Total Pi	
Site	Depth	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP
	cm	------mg/kg -------	%	------mg/kg -------	%	------mg/kg -------	%	------mg/kg -------	%
L40-C22	0-10	2.36 ± 0.25	0.3	70.1 ± 22.3	8.0	419.1 ± 22.1	48.0	491.6 ± 41.9	56.3
L40-C12	0-10	1.63 ± 0.35	0.2	111.1 ± 33.5	10.8	428.6 ± 44.0	41.8	541.3 ± 55.9	52.7
L40-C24	0-10	4.27 ± 0.91	0.3	389.1 ± 89.9	28.2	369.7 ± 82.0	26.8	763.1 ± 10.6	55.3
L7-C21	0-10	1.28 ± 0.07	0.2	49.0 ± 4.9	5.8	494.5 ± 43.5	58.7	544.8 ± 44.0	64.7
L7-C11	0-10	0.99 ± 0.12	0.1	24.8 ± 7.8	3.1	491.7 ± 152.9	62.5	517.5 ± 147.0	65.8
L7-C26	0-10	1.60 ± 0.24	0.2	57.8 ± 3.1	6.4	430.9 ± 31.8	47.4	490.3 ± 30.9	53.9
L39-C25	0-10	3.20 ± 0.76	0.8	27.7 ± 6.7	6.7	205.4 ± 39.2	49.5	236.3 ± 45.0	57.0
L39-C10	0-10	7.58 ± 1.39	0.8	92.4 ± 7.1	9.3	381.3 ± 7.5	38.2	481.2 ± 1.8	48.3
L6-C9	0-10	1.54 ± 0.08	0.5	12.5 ± 1.8	4.3	151.0 ± 7.5	51.9	164.7 ± 9.5	56.6
L6-C7	0-10	0.36 ± 0.03	0.3	2.6 ± 0.4	2.2	81.2 ± 5.4	69.0	84.2 ± 5.7	71.6
L38-C6	0-10	1.69 ± 0.47	0.2	24.0 ± 11.1	2.6	652.3 ± 101.3	71.2	678.0 ± 92.4	74.0
L38-C8	0-10	1.31 ± 0.39	0.1	65.4 ± 17.3	6.1	491.3 ± 25.0	45.7	557.9 ± 24.3	51.9
L5-C5	0-10	1.74 ± 0.06	0.3	26.3 ± 11.8	3.9	421.1 ± 59.0	61.6	449.1 ± 53.0	65.7
L5-C4	0-10	2.13 ± 0.40	0.2	57.0 ± 6.9	6.5	381.0 ± 10.5	43.2	440.1 ± 17.0	49.9
MC-C28	0-10	0.73 ± 0.21	0.2	6.5 ± 1.7	1.9	244.4 ± 63.0	71.8	251.6 ± 64.3	73.9
MC-C27	0-10	0.61 ± 0.57	0.1	14.3 ± 7.5	1.4	462.7 ± 266.1	45.6	477.6 ± 266.8	47.1
MC-C3	0-10	0.18 ± 0.01	0.0	6.8 ± 1.8	0.5	1022.4 ± 359.9	73.4	1029.4 ± 360.7	73.9
MC-C2	0-10	1.94 ± 0.28	0.1	111.8 ± 3.6	8.6	719.7 ± 57.6	55.1	833.4 ± 54.0	63.9
MC-C1	0-10	1.07 ± 0.11	0.1	53.1 ± 7.9	4.4	725.7 ± 168.0	59.5	779.9 ± 174.7	64.0
MC-C23	0-10	1.07 ± 0.16	0.1	51.6 ± 6.2	4.7	655.9 ± 20.1	59.2	708.5 ± 16.1	64.0

		KCl extractable Pi		NaOH extractable Pi		HClPi		Sum-TPi	
Site	Depth	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP
	cm	------mg/kg -------	%	------mg/kg -------	%	------mg/kg -------	%	------mg/kg -------	%
L40-C22	10-30	1.85 ± 0.33	0.2	65.9 ± 15.9	7.4	504.8 ± 55.4	56.7	572.6 ± 60.4	64.3
L40-C12	10-30	1.77 ± 0.55	0.1	76.7 ± 33.6	6.1	668.2 ± 308.8	53.5	746.7 ± 283.9	59.8
L40-C24	10-30	3.76 ± 0.37	0.3	216.8 ± 17.6	15.5	477.4 ± 2.3	34.0	698.0 ± 15.7	49.8
L7-C21	10-30	2.18 ± 0.43	0.2	75.1 ± 19.4	8.3	513.0 ± 24.8	56.6	590.3 ± 9.9	65.2
L7-C11	10-30	1.88 ± 0.23	0.2	23.1 ± 5.0	2.8	511.7 ± 13.6	62.2	536.7 ± 12.6	65.3
L7-C26	10-30	2.72 ± 0.52	0.3	50.2 ± 16.8	5.1	552.9 ± 29.9	56.8	605.8 ± 23.0	62.2
L39-C25	10-30	0.79 ± 0.10	0.3	8.5 ± 1.6	3.5	153.3 ± 19.8	63.7	162.6 ± 21.4	67.6
L39-C10	10-30	12.9 ± 3.90	1.5	75.9 ± 22.1	9.0	311.3 ± 16.4	36.7	400.1 ± 42.3	47.2
L6-C9	10-30	3.38 ± 0.78	1.2	40.0 ± 39.0	13.6	175.5 ± 12.1	59.9	218.9 ± 28.8	74.7
L6-C7	10-30	0.26 ± 0.05	0.2	3.7 ± 1.2	2.6	95.1 ± 6.2	66.2	99.1 ± 6.3	69.0
L38-C6	10-30	2.09 ± 0.64	0.3	7.8 ± 2.4	1.1	602.4 ± 201.4	84.2	612.3 ± 202.7	85.6
L38-C8	10-30	2.51 ± 0.99	0.3	28.0 ± 2.1	3.6	477.2 ± 78.4	61.8	507.8 ± 80.5	65.8
L5-C5	10-30	4.44 ± 0.80	1.0	39.0 ± 26.2	8.7	237.3 ± 36.2	53.2	280.7 ± 58.2	63.0
L5-C4	10-30	1.01 ± 0.16	0.2	21.7 ± 7.4	4.0	325.2 ± 77.2	60.4	347.9 ± 80.0	64.6
MC-C28	10-30	1.19 ± 0.08	0.2	8.8 ± 0.5	1.8	373.0 ± 29.3	78.0	383.0 ± 29.2	80.1
MC-C27	10-30	0.19 ± 0.11	0.0	7.8 ± 0.9	0.8	392.4 ± 466.7	39.9	400.4 ± 467.5	40.7
MC-C3	10-30	0.15 ± 0.02	0.0	15.5 ± 1.6	1.7	159.3 ± 86.1	17.6	174.9 ± 87.7	19.3
MC-C2	10-30	2.55 ± 0.20	0.2	134.5 ± 11.9	8.9	947.3 ± 136.4	63.0	1084.4 ± 129.8	72.1
MC-C1	10-30	2.06 ± 0.55	0.2	49.3 ± 8.9	4.1	718.2 ± 194.6	60.3	769.5 ± 198.1	64.6
MC-C23	10-30	0.23 ± 0.05	0.1	8.9 ± 1.4	4.0	50.3 ± 44.9	22.4	59.5 ± 43.9	26.5

Table 4. Labile and recalcitrant pools of P based on P_i fractionation scheme. Mean ± SD represents average of triplicate core samples. "% of TP" represents % of total P recovered in inorganic P fractionation scheme.

		NaOH - Po		Recalcitrant P		TPo + Recalcitrant P	
Site	Depth	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP
	cm	------mg/kg -------	%	------mg/kg -------	%	------mg/kg -------	%
L40-C22	0-10	133.9 ± 47.3	15.3	247.1 ± 22.8	28.3	381.0 ± 69.8	43.7
L40-C12	0-10	176.4 ± 48.8	17.2	308.5 ± 23.9	30.1	484.9 ± 43.9	47.3
L40-C24	0-10	285.5 ± 53.3	20.7	331.2 ± 28.3	24.0	616.7 ± 32.8	44.7
L7-C21	0-10	61.1 ± 5.3	7.3	236.7 ± 17.6	28.1	297.8 ± 22.2	35.3
L7-C11	0-10	70.1 ± 19.7	8.9	199.3 ± 18.0	25.3	269.4 ± 37.6	34.2
L7-C26	0-10	128.4 ± 13.1	14.1	290.9 ± 14.2	32.0	419.3 ± 26.8	46.1
L39-C25	0-10	56.1 ± 22.3	13.5	122.1 ± 25.0	29.5	178.2 ± 45.7	43.0
L39-C10	0-10	186.2 ± 10.3	18.7	329.7 ± 3.4	33.1	515.9 ± 7.0	51.7
L6-C9	0-10	27.6 ± 7.3	9.5	98.9 ± 5.8	34.0	126.4 ± 12.5	43.4
L6-C7	0-10	8.7 ± 3.5	7.4	24.8 ± 11.1	21.0	33.4 ± 14.2	28.4
L38-C6	0-10	71.7 ± 26.4	7.8	166.6 ± 41.7	18.2	238.3 ± 65.3	26.0
L38-C8	0-10	200.4 ± 60.4	18.7	315.8 ± 14.0	29.4	516.2 ± 67.5	48.1
L5-C5	0-10	63.97 ± 28.1	9.4	170.1 ± 36.9	24.9	234.1 ± 64.6	34.3
L5-C4	0-10	162.0 ± 31.0	18.4	280.5 ± 21.6	31.8	442.5 ± 46.8	50.1
MC-C28	0-10	10.2 ± 2.0	3.0	78.8 ± 43.3	23.1	89.0 ± 43.9	26.1
MC-C27	0-10	7.01 ± 3.9	0.7	529.9 ± 351.7	52.2	536.9 ± 348.5	52.9
MC-C3	0-10	6.6 ± 0.3	0.5	356.9 ± 228.2	25.6	363.5 ± 227.9	26.1
MC-C2	0-10	188.5 ± 5.1	14.4	283.1 ± 24.6	21.7	471.6 ± 22.8	36.1
MC-C1	0-10	148.0 ± 35.2	12.1	291.1 ± 16.1	23.9	439.1 ± 37.2	36.0
MC-C23	0-10	151.8 ± 28.4	13.7	247.2 ± 39.3	22.3	399.0 ± 61.8	36.0

		NaOH - Po		Recalcitrant P		TPo + Recalcitrant P	
Site	Depth	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP
	cm	------mg/kg -------	%	------mg/kg -------	%	------mg/kg -------	%
L40-C22	10-30	92.7 ± 30.2	10.4	225.4 ± 14.5	25.3	318.1 ± 37.3	35.7
L40-C12	10-30	155.6 ± 25.0	12.5	346.0 ± 10.8	27.7	501.6 ± 14.3	40.2
L40-C24	10-30	333.2 ± 75.8	23.8	371.6 ± 18.2	26.5	704.8 ± 66.7	50.2
L7-C21	10-30	58.3 ± 28.7	6.4	257.2 ± 13.1	28.4	315.5 ± 40.3	34.8
L7-C11	10-30	47.2 ± 14.7	5.7	238.6 ± 14.9	29.0	285.8 ± 8.5	34.7
L7-C26	10-30	95.3 ± 40.8	9.8	273.1 ± 7.2	28.0	368.4 ± 46.8	37.8
L39-C25	10-30	9.7 ± 2.5	4.0	68.3 ± 8.9	28.4	77.9 ± 11.3	32.4
L39-C10	10-30	135.2 ± 38.6	15.9	312.6 ± 77.9	36.9	447.8 ± 115.2	52.8
L6-C9	10-30	10.2 ± 10.0	3.5	64.0 ± 2.1	21.8	74.3 ± 8.1	25.3
L6-C7	10-30	6.0 ± 1.5	4.2	38.6 ± 4.8	26.8	44.6 ± 6.3	31.0
L38-C6	10-30	18.3 ± 3.8	2.6	85.1 ± 14.0	11.9	103.4 ± 17.8	14.4
L38-C8	10-30	71.8 ± 10.3	9.3	192.2 ± 4.5	24.9	264.1 ± 11.5	34.2
L5-C5	10-30	18.7 ± 24.7	4.2	146.5 ± 10.0	32.9	165.2 ± 23.3	37.0
L5-C4	10-30	49.8 ± 16.0	9.3	140.7 ± 31.6	26.1	190.5 ± 39.7	35.4
MC-C28	10-30	11.2 ± 2.4	2.3	84.1 ± 30.4	17.6	95.3 ± 29.5	19.9
MC-C27	10-30	2.9 ± 3.9	0.3	580.6 ± 377.9	59.0	583.5 ± 374.1	59.3
MC-C3	10-30	4.0 ± 2.3	0.4	725.0 ± 75.1	80.2	729.1 ± 76.1	80.7
MC-C2	10-30	146.7 ± 21.3	9.8	272.4 ± 30.1	18.1	419.1 ± 49.8	27.9
MC-C1	10-30	113.3 ± 11.9	9.5	307.9 ± 10.0	25.9	421.2 ± 19.4	35.4
MC-C23	10-30	8.8 ± 3.4	3.9	156.4 ± 48.9	69.6	165.3 ± 45.5	73.5

Table 5. Summary of Bicarbonate P fractionation scheme. Values represent mean ± SD of triplicate core samples collected at each canal site. "% of TP" represents % of total P recovered in P fractionation scheme.

Site	Depth	Labile Pi		MBP		Labile Po	
		Mean ± S.D.	% of TP	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP
	cm	------mg/kg -------	%	------mg/kg -------	%	------mg/kg -------	%
L40-C22	0-10	67.6 ± 6.0	7.7	43.1 ± 6.7	4.9	57.3 ± 8.9	6.6
L40-C12	0-10	85.0 ± 24.2	8.3	76.6 ± 22.8	7.5	88.8 ± 14.5	8.7
L40-C24	0-10	103.3 ± 5.5	7.5	349.2 ± 55.3	25.3	372.9 ± 63.8	27.0
L7-C21	0-10	48.9 ± 4.0	5.8	49.0 ± 10.9	5.8	49.4 ± 9.1	5.9
L7-C11	0-10	33.7 ± 6.6	4.3	33.7 ± 10.1	4.3	35.8 ± 9.6	4.6
L7-C26	0-10	45.0 ± 3.4	5.0	42.4 ± 12.3	4.7	45.3 ± 13.9	5.0
L39-C25	0-10	43.1 ± 2.9	10.4	24.2 ± 10.4	5.8	21.1 ± 13.4	5.1
L39-C10	0-10	78.3 ± 6.2	7.9	100.6 ± 4.9	10.1	141.8 ± 47.8	14.2
L6-C9	0-10	15.3 ± 0.9	5.3	16.1 ± 1.3	5.5	16.0 ± 0.9	5.5
L6-C7	0-10	10.1 ± 0.8	8.6	3.8 ± 1.4	3.2	1.4 ± 2.7	1.2
L38-C6	0-10	75.9 ± 4.5	8.3	28.9 ± 12.3	3.2	22.2 ± 17.8	2.4
L38-C8	0-10	68.7 ± 1.9	6.4	67.4 ± 11.1	6.3	78.9 ± 11.3	7.3
L5-C5	0-10	58.5 ± 15.4	8.6	29.0 ± 18.4	4.3	25.2 ± 26.1	3.7
L5-C4	0-10	43.9 ± 2.1	5.0	86.7 ± 21.9	9.8	88.5 ± 11.2	10.0
MC-C28	0-10	27.4 ± 1.3	8.0	0.7 ± 0.5	0.2	-1.0 ± 1.1	-0.3
MC-C27	0-10	23.7 ± 3.5	2.3	1.4 ± 7.0	0.1	0.0 ± 8.4	0.0
MC-C3	0-10	22.1 ± 1.4	1.6	2.5 ± 4.9	0.2	-2.2 ± 1.5	-0.2
MC-C2	0-10	124.0 ± 5.4	9.5	53.4 ± 18.5	4.1	66.7 ± 21.9	5.1
MC-C1	0-10	98.8 ± 5.0	8.1	19.3 ± 10.5	1.6	29.8 ± 9.6	2.4
MC-C23	0-10	70.5 ± 0.7	6.4	55.1 ± 8.1	5.0	62.8 ± 10.1	5.7

Site	Depth	Labile Pi		MBP		Labile Po	
		Mean ± S.D.	% of TP	Mean ± S.D.	% of TP	Mean ± S.D.	% of TP
	cm	------mg/kg -------	%	------mg/kg -------	%	------mg/kg -------	%
L40-C22	10-30	73.4 ± 6.1	8.2	19.8 ± 3.2	2.2	24.6 ± 1.3	2.8
L40-C12	10-30	69.7 ± 16.7	5.6	55.5 ± 16.1	4.4	71.6 ± 10.5	5.7
L40-C24	10-30	106.4 ± 1.5	7.6	161.3 ± 24.4	11.5	174.7 ± 23.5	12.5
L7-C21	10-30	70.1 ± 4.1	7.7	39.6 ± 11.1	4.4	32.9 ± 8.8	3.6
L7-C11	10-30	35.4 ± 2.6	4.3	11.3 ± 1.6	1.4	12.2 ± 3.4	1.5
L7-C26	10-30	48.1 ± 1.8	4.9	36.3 ± 25.1	3.7	34.8 ± 18.9	3.6
L39-C25	10-30	30.7 ± 2.5	12.8	-0.8 ± 2.2	-0.3	-4.0 ± 2.8	-1.7
L39-C10	10-30	63.6 ± 13.0	7.5	73.1 ± 19.8	8.6	79.8 ± 20.8	9.4
L6-C9	10-30	24.8 ± 2.2	8.5	4.9 ± 1.5	1.7	2.1 ± 1.1	0.7
L6-C7	10-30	9.1 ± 1.7	6.4	2.1 ± 0.6	1.5	-0.6 ± 0.6	-0.4
L38-C6	10-30	64.9 ± 21.6	9.1	0.4 ± 3.7	0.1	-2.3 ± 3.6	-0.3
L38-C8	10-30	62.6 ± 9.2	8.1	13.9 ± 9.4	1.8	18.3 ± 9.8	2.4
L5-C5	10-30	38.2 ± 2.9	8.6	17.7 ± 4.8	4.0	12.5 ± 1.1	2.8
L5-C4	10-30	29.8 ± 1.5	5.5	15.4 ± 4.0	2.9	17.1 ± 7.4	3.2
MC-C28	10-30	37.8 ± 1.5	7.9	-2.7 ± 0.9	-0.6	-5.4 ± 0.8	-1.1
MC-C27	10-30	19.8 ± 10.2	2.0	-2.9 ± 1.4	-0.3	-5.3 ± 2.4	-0.5
MC-C3	10-30	18.4 ± 1.9	2.0	-0.3 ± 1.8	0.0	-3.5 ± 1.9	-0.4
MC-C2	10-30	146.6 ± 12.3	9.7	14.0 ± 6.8	0.9	18.2 ± 11.8	1.2
MC-C1	10-30	109.1 ± 22.6	9.2	9.1 ± 18.9	0.8	16.1 ± 17.0	1.4
MC-C23	10-30	41.4 ± 10.3	18.4	17.1 ± 28.7	7.6	10.3 ± 25.7	4.6

Table 6. Average P concentration and P mass in 30 cm water column during each floodwater exchange. Value does not just represent P release from soil, value includes P from initial floodwater concentration and sample make-up water. Mean ± SD values based on concentraton in triplicate intact core microcosms.

	First Floodwater Exchange		Second Floodwater Exchange	
	P - Concentration	P - mass	P - Concentration	P - mass
Site	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.
	----mg / l-----	---mg / m2 ----	----mg / l-----	---mg / m2 ----
L40-C22	0.048 ± 0.010	14.4 ± 3.06	0.034 ± 0.026	10.3 ± 7.78
L40-C12	0.059 ± 0.030	17.6 ± 8.91	0.030 ± 0.022	8.93 ± 6.53
L40-C24	0.016 ± 0.003	4.95 ± 0.92	0.042 ± 0.004	12.5 ± 1.07
L7-C21	0.023 ± 0.004	6.93 ± 1.35	0.014 ± 0.001	4.12 ± 0.25
L7-C11	0.016 ± 0.002	4.89 ± 0.55	0.012 ± 0.001	3.70 ± 0.22
L7-C26	0.040 ± 0.026	12.0 ± 7.78	0.026 ± 0.012	7.68 ± 3.63
L39-C25	0.073 ± 0.019	22.0 ± 5.78	0.023 ± 0.005	6.90 ± 1.38
L39-C10	0.032 ± 0.016	9.54 ± 4.93	0.017 ± 0.003	5.03 ± 0.88
L6-C9	0.013 ± 0.002	3.97 ± 0.59	0.013 ± 0.001	3.80 ± 0.34
L6-C7	0.012 ± 0.001	3.49 ± 0.35	0.012 ± 0.001	3.63 ± 0.17
L38-C6	0.022 ± 0.004	6.67 ± 1.20	0.017 ± 0.000	5.07 ± 0.14
L38-C8	0.012 ± 0.003	3.63 ± 0.93	0.017 ± 0.002	5.22 ± 0.50
L5-C5	0.019 ± 0.001	5.73 ± 0.41	0.017 ± 0.002	5.09 ± 0.47
L5-C4	0.016 ± 0.004	4.88 ± 1.07	0.028 ± 0.015	8.27 ± 4.52
MC-C28	0.028 ± 0.008	8.46 ± 2.35	0.019 ± 0.006	5.70 ± 1.65
MC-C27	0.023 ± 0.005	6.91 ± 1.36	0.016 ± 0.003	4.75 ± 1.04
MC-C3	0.021 ± 0.005	6.44 ± 1.49	0.013 ± 0.001	3.89 ± 0.29
MC-C2	0.061 ± 0.029	18.3 ± 8.84	0.019 ± 0.005	5.78 ± 1.62
MC-C1	0.014 ± 0.001	4.22 ± 0.19	0.012 ± 0.001	3.64 ± 0.28
MC-C23	0.012 ± 0.000	3.74 ± 0.12	0.015 ± 0.003	4.43 ± 0.76

	Third Floodwater Exchange		Fourth Floodwater Exchange	
	P - Concentration	P - mass	P - Concentration	P - mass
Site	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.
	----mg / l-----	---mg / m2 ----	----mg / l-----	---mg / m2 ----
L40-C22	0.012 ± 0.003	3.54 ± 0.92	0.009 ± 0.002	2.56 ± 0.61
L40-C12	0.022 ± 0.012	6.72 ± 3.72	0.025 ± 0.016	7.44 ± 4.83
L40-C24	0.028 ± 0.011	8.37 ± 3.18	0.027 ± 0.010	7.99 ± 2.96
L7-C21	0.008 ± 0.001	2.51 ± 0.23	0.007 ± 0.001	1.98 ± 0.28
L7-C11	0.006 ± 0.000	1.80 ± 0.12	0.004 ± 0.001	1.31 ± 0.33
L7-C26	0.009 ± 0.003	2.77 ± 0.77	0.011 ± 0.007	3.34 ± 2.08
L39-C25	0.017 ± 0.005	5.03 ± 1.61	0.015 ± 0.004	4.57 ± 1.17
L39-C10	0.015 ± 0.003	4.46 ± 0.79	0.021 ± 0.019	6.24 ± 5.62
L6-C9	0.007 ± 0.001	2.07 ± 0.19	0.003 ± 0.001	1.03 ± 0.24
L6-C7	0.008 ± 0.001	2.29 ± 0.19	0.004 ± 0.000	1.19 ± 0.14
L38-C6	0.010 ± 0.002	2.98 ± 0.58	0.007 ± 0.002	2.17 ± 0.63
L38-C8	0.013 ± 0.001	3.96 ± 0.16	0.008 ± 0.002	2.40 ± 0.48
L5-C5	0.007 ± 0.002	2.04 ± 0.57	0.008 ± 0.002	2.30 ± 0.57
L5-C4	0.011 ± 0.001	3.28 ± 0.43	0.023 ± 0.022	6.81 ± 6.60
MC-C28	0.006 ± 0.001	1.85 ± 0.16	0.005 ± 0.001	1.63 ± 0.36
MC-C27	0.007 ± 0.001	2.06 ± 0.17	0.005 ± 0.001	1.49 ± 0.22
MC-C3	0.007 ± 0.001	1.97 ± 0.25	0.004 ± 0.001	1.23 ± 0.43
MC-C2	0.013 ± 0.001	4.03 ± 0.28	0.017 ± 0.007	4.96 ± 1.97
MC-C1	0.008 ± 0.001	2.54 ± 0.40	0.006 ± 0.001	1.71 ± 0.33
MC-C23	0.010 ± 0.001	2.98 ± 0.28	0.007 ± 0.004	2.17 ± 1.13

Table 7. Maximum and average sediment DRP flux rates aggregated by sampling site proximity to proposed or existing STA's. Maximum flux rates are based on the maximum rate change in sediment P release between day 1 and day 30 of each floodwater exchange cycle. Average flux rates are based on the sum of P released or adsorbed between day 0 and day 30, divided by the time elapsed (30 days).

Sites	Maximum Flux		Average flux		Cumulative Sediment P Release	
	1st exchange	2nd exchange	1st exchange	2nd exchange	Average	Maximum
	mg P m^{-2} day^{-1}		mg P m^{-2} day^{-1}		mg P m^{-2}	
STA-1E (L-40)	5.73 $\pm$ 2.62	8.42 $\pm$ 9.64	0.41 $\pm$ 0.21	0.29 $\pm$ 0.15	33.4 $\pm$ 4.42	70.4 $\pm$ 7.02
STA-1W (L-7 and L-39)	3.83 $\pm$ 1.01	1.37 $\pm$ 0.39	0.36 $\pm$ 0.22	0.15 $\pm$ 0.09	19.6 $\pm$ 10.8	45.6 $\pm$ 22.0
STA's - 2,3, and 4 (L6, L38, and L5)	2.52 $\pm$ 0.33	1.43 $\pm$ 0.11	0.11 $\pm$ 0.03	0.13 $\pm$ 0.08	9.84 $\pm$ 5.42	28.6 $\pm$ 10.6
STA's - 5 and 6 (Miami Canal)	3.06 $\pm$ 1.23	1.51 $\pm$ 0.82	0.25 $\pm$ 0.70	0.12 $\pm$ 0.06	12.9 $\pm$ 8.15	32.5 $\pm$ 16.2

Table 8. Simple correlation coefficients between soil P parameters and maximum P and average P flux during each of the four floodwater exchange cycles. Only p values less than 0.05 reported; “ns” = not significant.

	First Exchange		Second Exchange		Third Exchange		Fourth Exchange		Cumulative P Release	
Soil Parameter	Max. Flux	Ave. Flux	Max. Flux	Ave. Flux	Max. Flux	Ave. Flux	Max. Flux	Ave. Flux	Maximum	Average
0-10 cm soil depth										
Organic content	ns	ns	0.458	ns	0.582	ns	ns	0.475	ns	ns
Total P	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Porewater P	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Porewater NH4-N	ns	0.658	ns	ns	ns	ns	ns	ns	0.604	0.601
KCl-Pi	ns	ns	ns	ns	ns	0.471	ns	0.602	ns	0.452
NaOH-Pi	ns	ns	0.909	0.613	0.820	0.864	ns	0.743	0.592	0.605
HCl-Pi	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
TPi	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
NaOH-Po	ns	ns	0.500	ns	0.453	0.667	ns	0.756	0.477	0.528
Recalcitrant-P	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
TPo+Recalcitrant-P	ns	ns	ns	ns	ns	0.514	ns	0.597	ns	ns
NaHCO3-labile P	ns	ns	0.820	0.550	0.730	0.826	ns	0.769	0.5513	0.579
NaHCO3-Pi	ns	ns	ns	ns	ns	0.524	ns	0.568	ns	0.485
Microbial-P	ns	ns	0.905	0.614	0.832	0.835	ns	0.745	0.52	0.530
10-30 cm soil depth										
Organic content	ns	ns	ns	ns	0.501	ns	ns	ns	ns	ns
Total P	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Porewater P	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Porewater NH4-N	ns	ns	ns	ns	ns	ns	ns	ns	ns	0.445
KCl-Pi	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
NaOH-Pi	ns	ns	0.804	0.549	0.764	0.716	ns	0.622	0.587	0.591
HCl-Pi	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
TPi	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
NaOH-Po	ns	ns	0.798	0.544	0.752	0.820	ns	0.729	0.609	0.63
Recalcitrant-P	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
TPo+Recalcitrant-P	ns	ns	ns	ns	ns	0.471	ns	ns	ns	ns
NaHCO3-labile P	ns	ns	0.742	0.476	0.676	0.765	ns	0.681	0.556	0.588
NaHCO3-Pi	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Microbial-P	ns	ns	0.838	0.526	0.806	0.848	ns	0.720	0.5103	0.538

Table 9. Comparison of P flux between the sites sampled in 2001 and 2002. All values reported represent the mean ± SD of triplicate cores.

First Floodwater Exchange

	Average Flux		Maximum Flux	
	2001	**2002**	**2001**	**2002**
Site	------- mg P m^{-2} day^{-1} --------		------- mg P m^{-2} day^{-1} --------	
L38-C6	0.138 ± 0.034	0.152 ± 0.182	2.94 ± 0.32	4.29 ± 2.51
L39-C25	0.776 ± 0.221	0.005 ± 0.001	5.30 ± 0.55	0.27 ± 0.08
L40-C24	0.132 ± 0.035	0.004 ± 0.001	2.38 ± 0.61	0.37 ± 0.18
L7-C26	0.396 ± 0.291	0.013 ± 0.009	4.07 ± 1.14	0.41 ± 0.15
MC-C2	0.643 ± 0.332	0.005 ± 0.002	4.44 ± 1.74	0.68 ± 0.24

Second Floodwater Exchange

	Average Flux		Maximum Flux	
	2001	**2002**	**2001**	**2002**
Site	------- mg P m^{-2} day^{-1} --------		------- mg P m^{-2} day^{-1} --------	
L38-C6	0.127 ± 0.011	0.041 ± 0.036	1.44 ± 0.28	1.16 ± 0.42
L39-C25	0.235 ± 0.067	0.011 ± 0.006	1.59 ± 0.70	0.87 ± 0.07
L40-C24	0.453 ± 0.164	0.048 ± 0.028	22.0 ± 14.2	4.01 ± 1.59
L7-C26	0.274 ± 0.210	0.018 ± 0.006	1.95 ± 0.89	0.93 ± 0.44
MC-C2	0.196 ± 0.100	0.025 ± 0.003	3.25 ± 1.80	0.78 ± 0.25

Table 10. Comparison of cumulative phosphorus release between sites sampled in 2001 and 2002 common sampling sites. All values reported represent the mean ± SD of triplicate cores.

	Average Release		**Maximum Release**	
	2001	**2002**	**2001**	**2002**
Site	--------- mg P m^{-2} ----------		--------- mg P m^{-2} ----------	
L38-C6	7.56 ± 1.11	18.7 ± 16.7	20.6 ± 4.50	44.6 ± 40.2
L39-C25	29.1 ± 8.27	2.35 ± 0.20	64.7 ± 15.6	5.30 ± 0.98
L40-C24	16.5 ± 5.27	8.05 ± 2.19	41.3 ± 12.4	32.7 ± 12.0
L7-C26	19.2 ± 14.1	3.33 ± 1.52	47.8 ± 31.1	6.97 ± 4.05
MC-C2	24.1 ± 9.64	3.93 ± 0.84	51.3 ± 17.8	8.09 ± 1.74

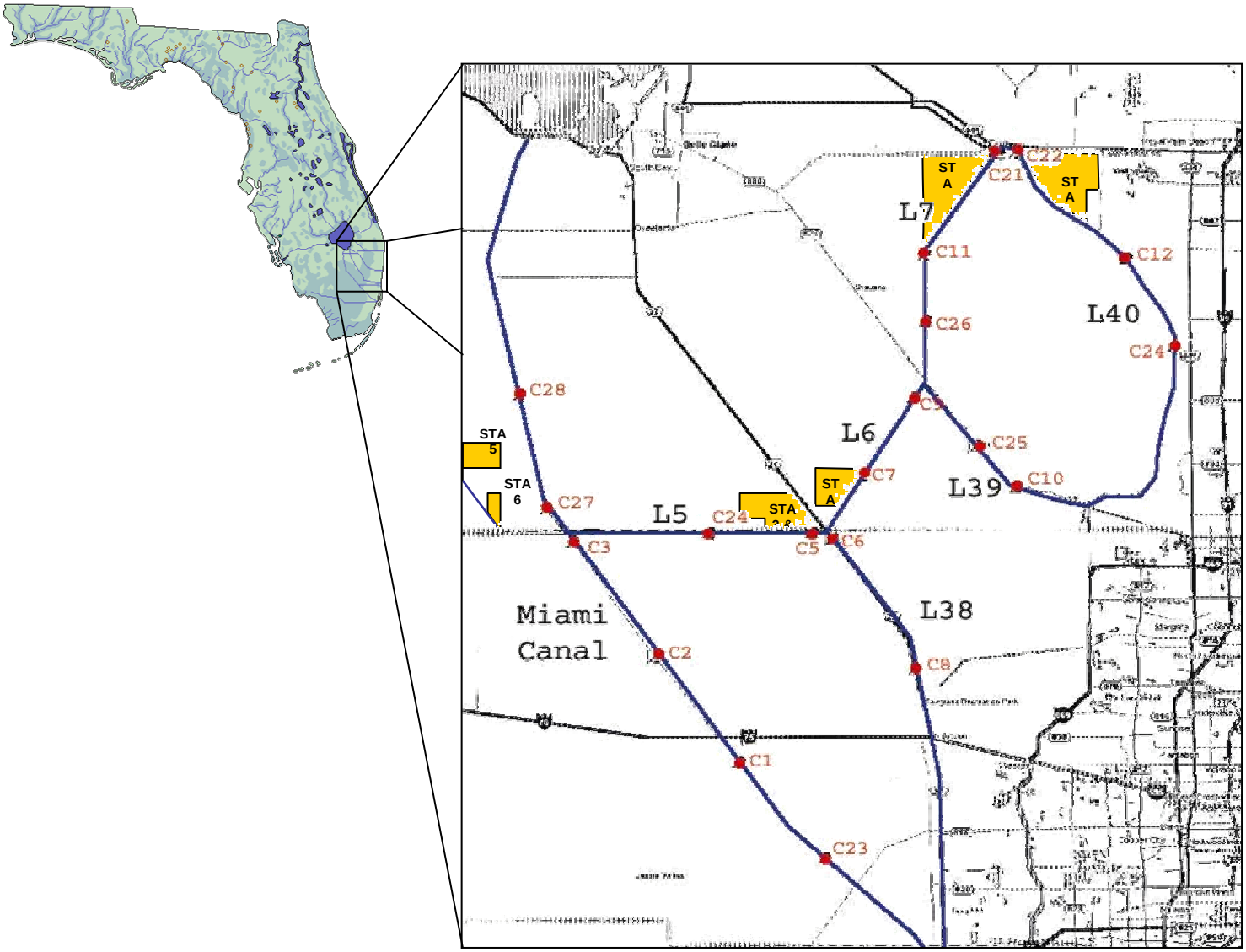


Figure 1. Location of canal sampling sites and existing or proposed STA's.

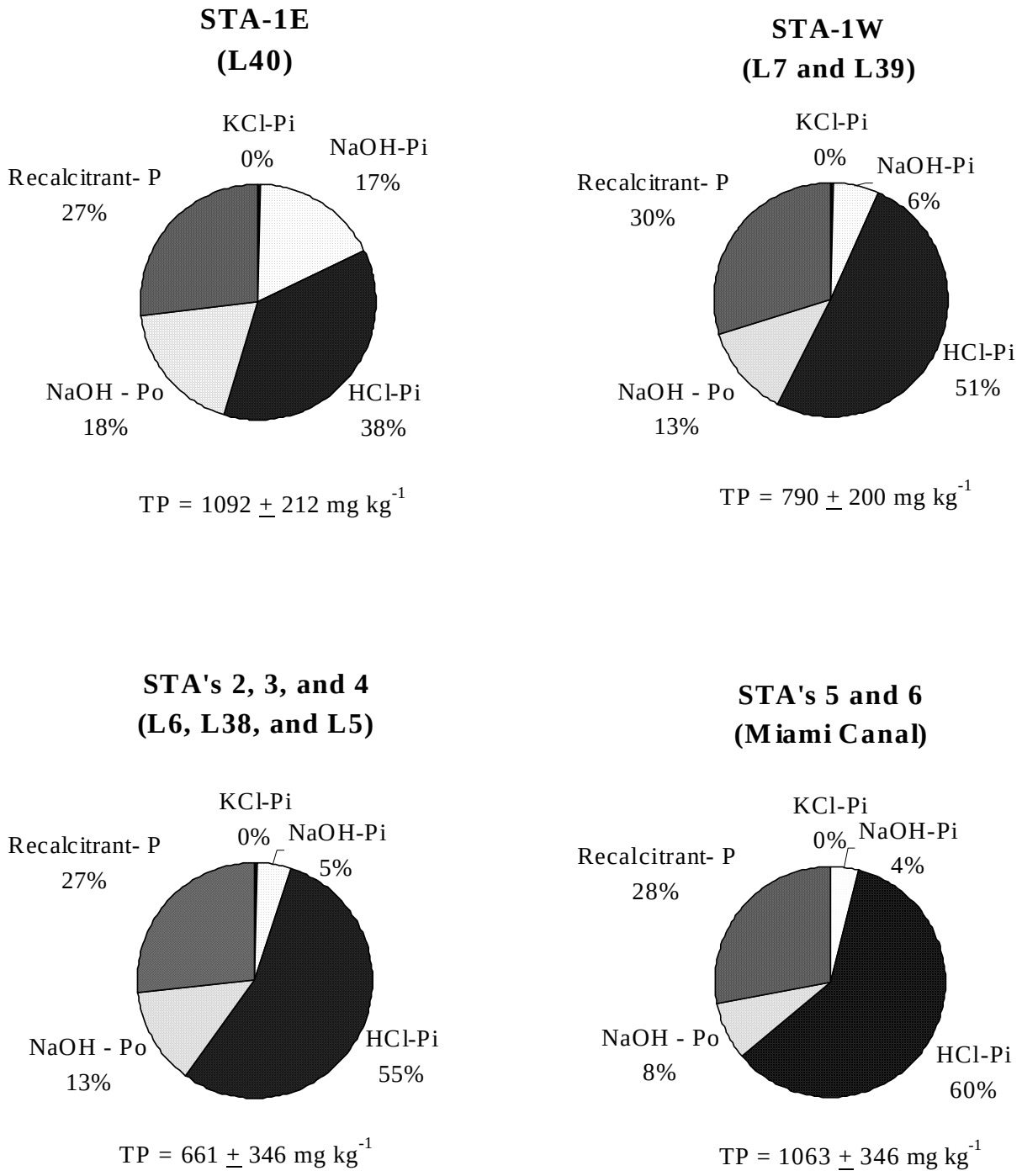


Figure 2. Graphic represents the storage of phosphorus in canal sediments based on inorganic phosphorus fractionation scheme. Values are aggregate mean for selected sediment parameters from canal sites adjacent to existing or proposed STA's.

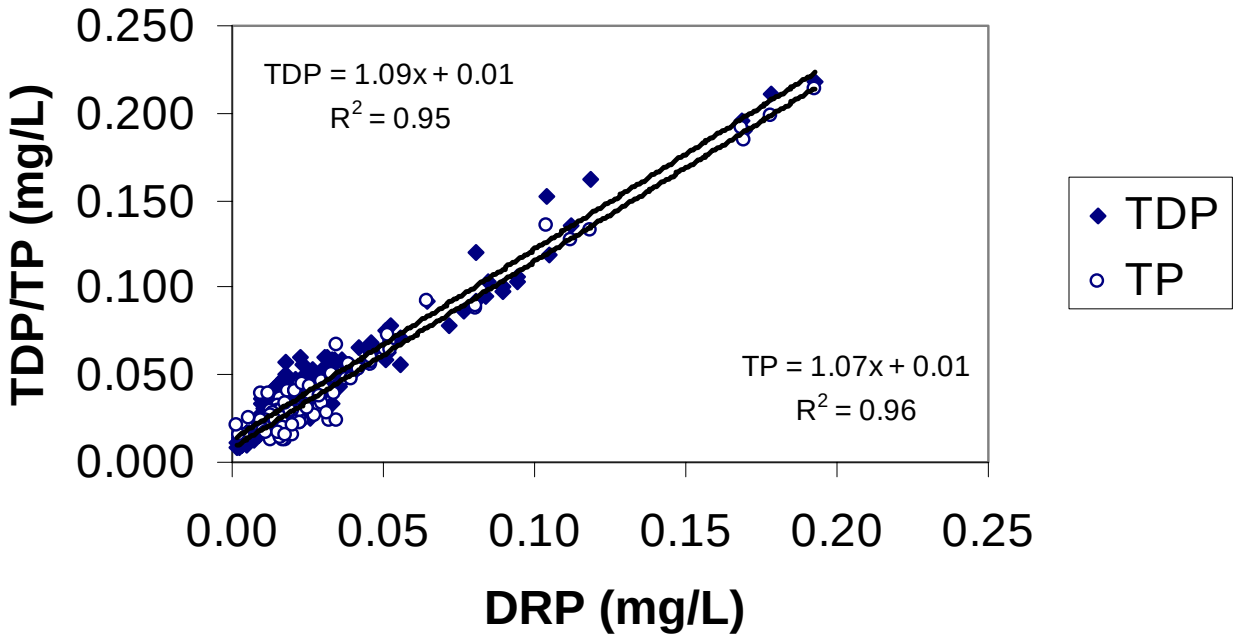


Figure 3. Regression analysis between Dissolved Reactive Phosphorus (DRP) and Total Dissolved Phosphorus (TDP), and between DRP and Total Phosphorus (TP) within the water column of the first floodwater exchange.

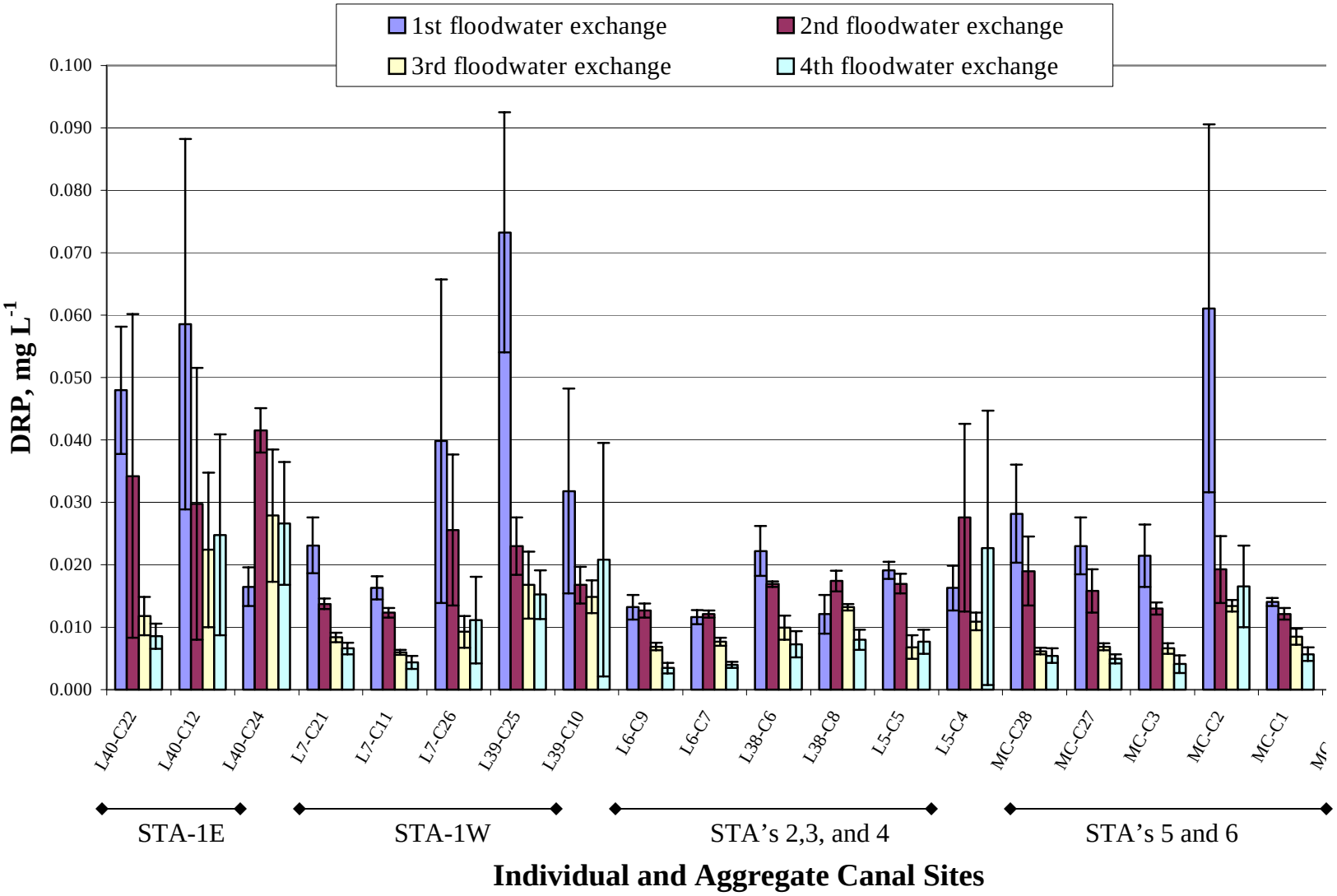


Figure 4. Intact core microcosm floodwater DRP concentration for each canal site sampled. Values represent mean ± SD of site triplicate cores.

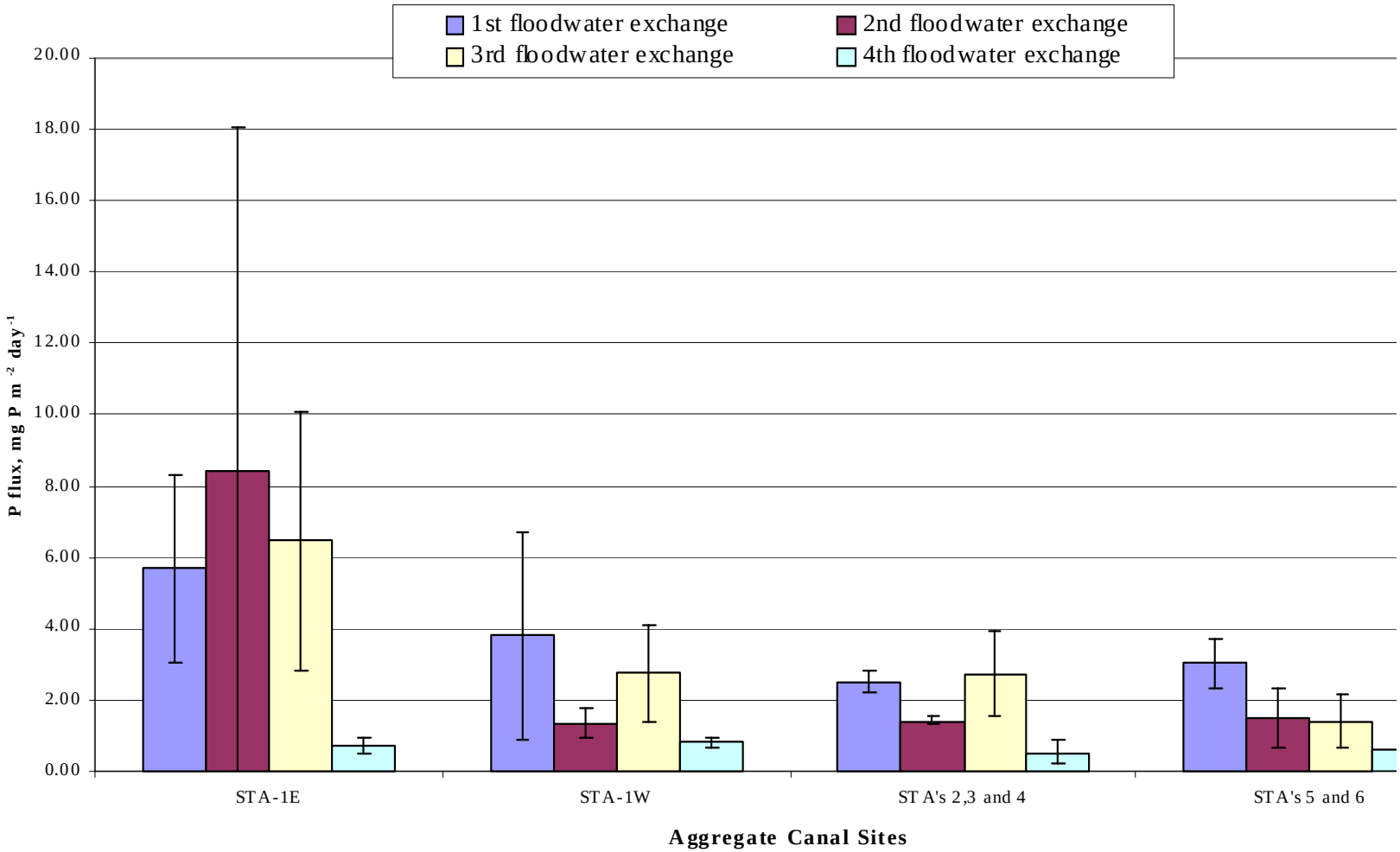


Figure 5. Graphic represents maximum P flux rate from canal sediments. Values are aggregate means ± 1SD of canal sites located adjacent to existing or proposed STA's.

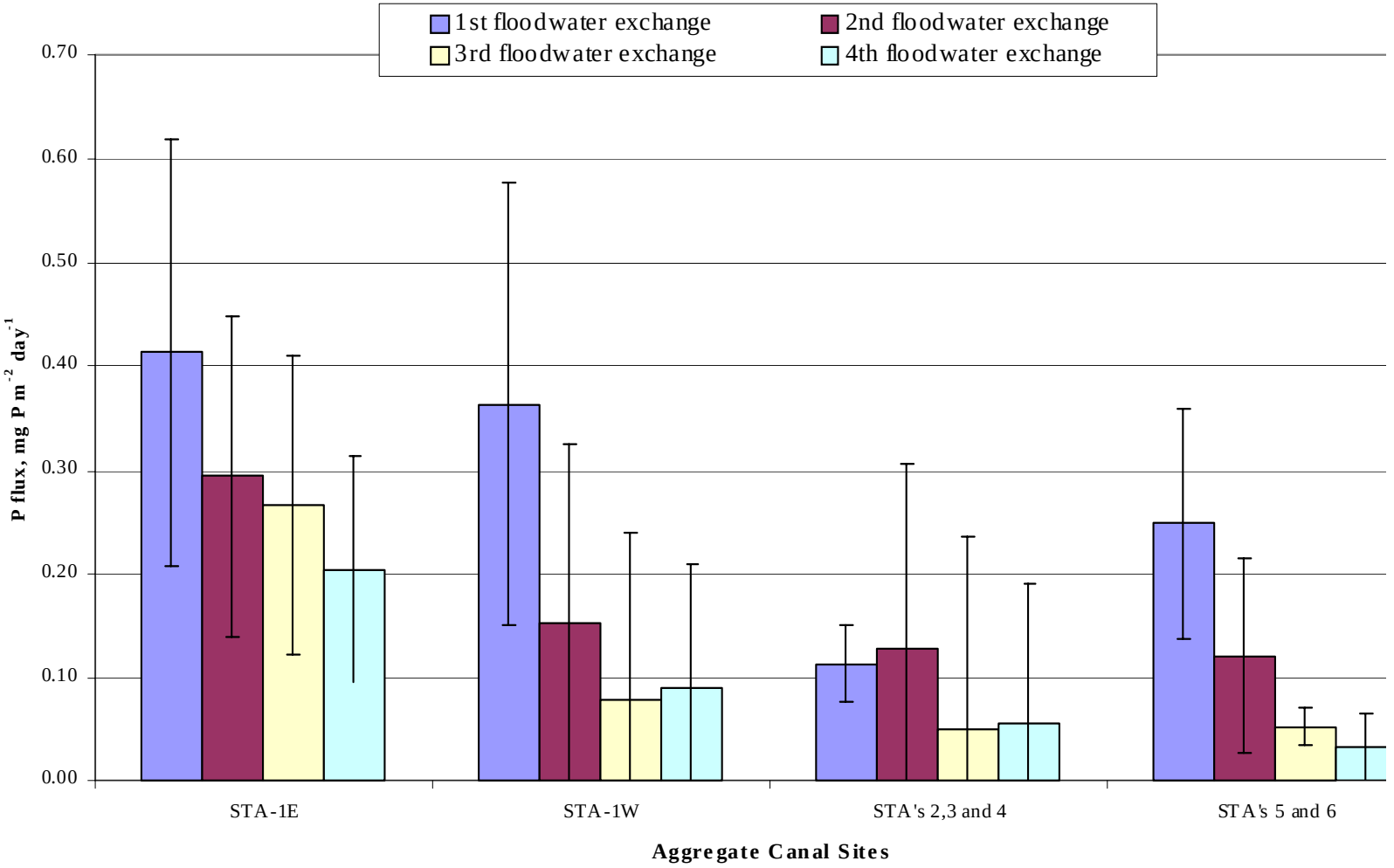


Figure 6. Graphic represents average P flux rate from canal sediments. Values are aggregate means ± 1 SD of canal sites located adjacent to existing or proposed STA's.

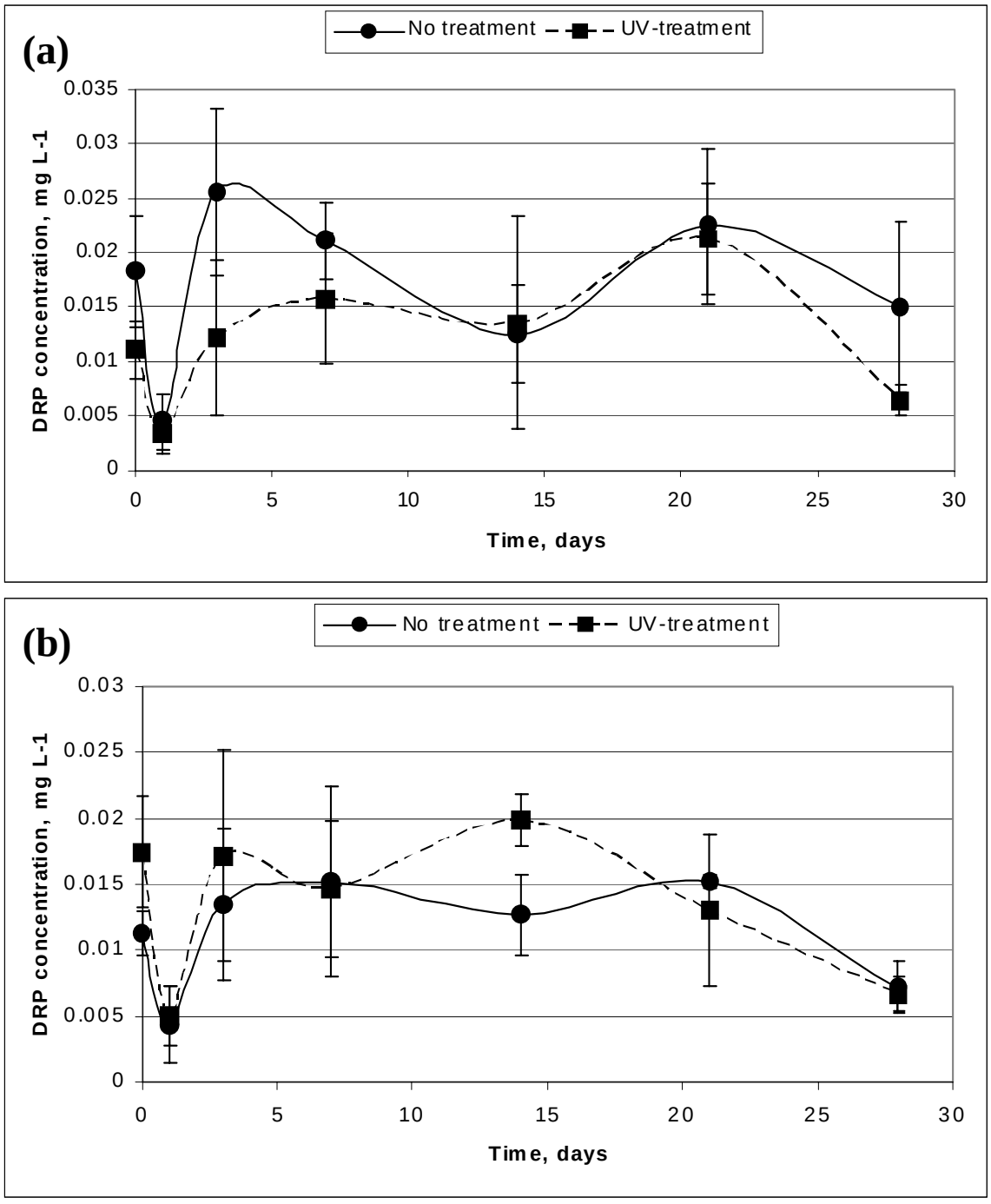


Figure 7. Core microcosm floodwater DRP concentration during first 28 days of biofilm experiment. Values represent mean ± SD from triplicate cores collecte at (a) L40-C24 and (b) MC-C2.

Attachment 2A
Appendix A
Sampling Site Characteristics

L7 – C11 June 18, 2001 14:10

West Side of canal, bottom organic sediments thin to less than 30 cm. Cores collected in eastern half of canal.

L7 – C21 June 18, 2001 15:10

Sediments very flocculent and a large amount of decomposition gases released when core was brought on deck. 2-3 cm below piston was filled with gas released from sediment. Large pockets of gas noted in sediments throughout the core profile.

L6 – C9 June 19, 2001 09:30

Sediments were deeper on east side of canal. Cores were collected in eastern third of canal off of centerline. Water depths ranged from 302.3 to 303.5cm

L6 – C7 June 19, 2001 11:00

Previous sediment profiles suggested we sample in eastern half of canal. All samples were collected between 10 and 20 meters from eastern shore. Water depths ranged from 292.1 to 299.7cm

L5 – C4 June 19, 2001 13:15

Relatively narrow canal, *Nuphar luteum* growing 15m from west bank. Sediments in eastern third of canal were less than 30 cm thick. Samples collected 3m east of *N. luteum* edge and across two thirds of remaining open water to east. Large amounts of gas in core sediments often resulting in disturbed surface upon removal of piston. Water depths ranged from 289.6 to 297.2cm

L5 – C5 June 19, 2001 15:00

Samples collected in middle third of canal. Narrow canal, *Nuphar luteum* was distributed in an 8m wide band along western shoreline. Gases in sediments often released during coring resulting in a resuspension of sediments during removal of piston. Water depths ranged from 381.0 to 391.2cm

L7 – C26 June 20, 2001 08:30

Large canal, sampled from eastern third toward center. Sediment thinned to approximately 30 cm in last core. Moderate amount of gases in sediment so only slight resuspension upon piston removal. Water depths ranged from 268.2 to 345.9 cm

L39 – C25 June 20, 2001 10:00

Large Canal, Sampled between eastern third and canal midpoint. Sediments thinned toward center of canal but water depths increased. Minimal decomposition gases yet a lot of sediment resuspension during removal of piston. Water depths ranged from 414.0 to 472.4cm.

L39 – C10 June 20, 2001 11:30

Site is just to west of floating vegetation blockage of canal. Levy to north of canal is below water level for .5 miles to west. Sediments at site are principally loose macrophyte litter. Along one-third the canal width at either side of canal, sediments become more consolidated and more hemic to sapric. Cores were collected just northwest of half to eastern one third. Water depths ranged from 213.3 to 251.5cm.

L40 – C24 June 20, 2001 15:00

A large amount of gas evolved from sediments upon retrieval of cores resulting in resuspension of sediments. Cores collected in middle third of canal. Water depths ranged from 256.5 to 274.3cm.

L40 – C12 June 20, 2001 16:00

A large amount of gas ebullition resulted when sediments are disturbed during coring. Removal of piston resulted in significant resuspension of surface sediments. Cores were collected from middle third of canal. Water depths ranged from 213.4 to 264.2 cm

L40 – C22 June 20, 2001 17:00

Sediments more consolidated and more sapric in texture than fibric characteristics at L 40 C24. Samples were collected in middle third of canal. Water depths ranged from 194.6 to 304.5cm.

MC – C28 June 21, 2001 10:30

Cores collected in middle to western third of canal. Cores had little or not flocculent layer at the sediment surface. Sediments mainly composed of shell fragments, carbonate and nodules of peat. Water depths ranged from 693.4 to 711.2cm.

MC – C27 June 21, 2001 12:00

Site is located approximately 300 meters downstream from a bend in the canal. Cores were collected from canal midpoint toward inner bend shoreline. Sites in the otter bend only had 2-3cm of flocculant above marl. Sites from inside bend half of transect had thick organic sediments >10 cm. Area resembled a point bar deposition profile, however all sedimentation occurred subsurface. Water depths ranged from 721.4 to 777.2cm.

MC – C3 June 21, 2001 13:45

Cores collected in middle third of canal. Sides vegetated with *Schinus terebinthifolius*. Edges of canal appear to be sandy and of gentler slope than other canals previously encountered. Sediments often felt hard upon initial insertion of corer, but then could be penetrated to approximately 40cm depths. 5 cm organic shell, next horizon is fine silt with homogenized small plant fragments. Next horizon is very fine sands interlaced with organic fragments. Water depths ranged from 368.3 to 406.4cm.

MC – C2 June 21, 2001 15:00

Coring site is approximately one half mile upstream of a structure. Sediments very flocculant and have a large production of sediment gases that result in sediment disturbance during piston removal and sectioning. Alligators at the site are very curios and coming within several feet of the boat on several occasions. Water depths ranged from 375.9 to 391.2cm.

MC – C1 June 21, 2001 18:00

Levee vegetated with *Schinus terebinthifolius* and other woody shrubs. Samples collected from middle third of canal. Sediments were sapric to hemic in character with large

pockets of gas. Gas release caused resuspension of sediments during coring and piston removal. Majority of resuspended sediments settle quickly (within 2 min). Water Depths ranged from 411.5 to 439.4cm.

MC – C23 June 22, 2001 09:45

Annona glabra and *Schinus terebinthifolius* dominate vegetation on level. Surface sediment horizon is hemic overlying marl that is homogeneously mixed with fine particulates of organic matter. Lower profile is platy in structure. Some gases in the upper profile caused resuspension of sediment upon sectioning and piston removal. Most resuspended sediments settled quickly. Cores were collected within middle third of canal. Water depths ranged from 355.6 to 358.1cm.

L38 – C8 June 22, 2001 12:20

Cores collected in middle third of canal. Sediment was sapric to hemic organic with surface horizon flocculant. Underlying sediments of fine sand and marl. Lost Piston on 2nd intact core so had to finish site with modified stopper. No apparent effect on Core quality. Water depths ranged from 406.4 to 431.8cm.

L38 – C6 July 13, 2001 09:30

Cores were collected from just west of canal center to eastern third of center. Fine flocculent sediment settled quickly. Deepest horizons collected consisted of course intact peat. This horizon was below a layer of fine sand. Very little gas production was identified within these cores. Water depths ranged from 538.5 to 564.9cm.

Attachment 2A
Appendix B
Core Environmental Conditions

Environmental conditions for the intact core microcosms were as follows:

Light:

Cores were covered with a single layer of 6mil black polyethylene plastic at all times except for water column sampling events and floodwater exchange. This design was sufficient to inhibit any photosynthetic organisms from growing in the core microcosms during the study.

Water Column Dissolved Oxygen:

The Water column of each microcosm was kept under aerobic conditions by gently bubbling ambient air through the upper 10 cm of the column. Aeration in each microcosm was checked daily and regulated such that all cores received the same degree of water column mixing.

Temperature:

When intact cores were initially placed in the laboratory temperature was not controlled and temperature was found to oscillate significantly in the air column surrounding the outside of each microcosm. Oscillation of temperature appeared to occur both on a diurnal cycle and also over 10-14 day cycles (figure B-1). During the early part of the third floodwater exchange cycle, control of ambient temperature conditions was improved, however, swings in temperature were still noticeable. During the fourth floodwater exchange cycle, microcosms were placed in a water bath to reduce any rapid oscillations in temperature. Water bath conditions, although still under ambient temperature control, significantly reduced rapid changes in temperature.

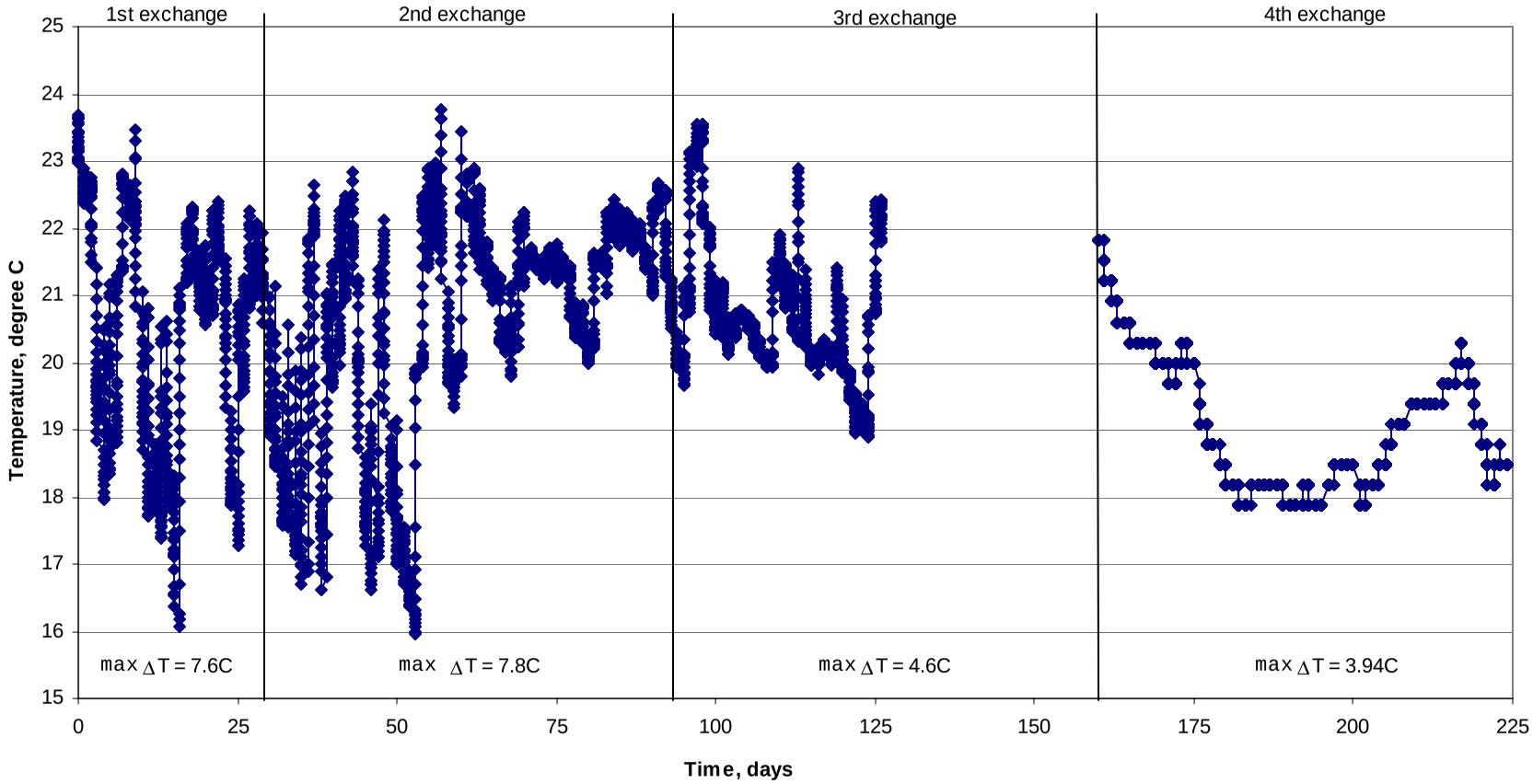


Figure B-1. Core chamber temperature during intact core floodwater exchange cycles. Measurements were made in the air surrounding cores (exchanges 1-3) or in the water column surrounding cores (4th exchange). Actual core microcosm temperature is likely dampened with respect to daily oscillations in temperature noted in exchanges 1-3, and more similar to diurnal variations represented in temperature readings during exchange #4.

Attachment 2A
Appendix C
Sampling Schedule and Site Specific Parameter Values

Table C-1. Sampling schedule and parameters measured during sediment flux experiment. Floodwater exchange cycle #1 was only conducted for 28 days prior to floodwater exchange. Floodwater exchange #4 had only progressed to day 28 when this interim report was written.

	Floodwater Exchange Cycle			
Sampling Day	Exchange #1	Exchange #2	Exchange #3	Exchange #4
0	SRP, TDP, TP	SRP	SRP, TP	SRP, TP
1	SRP	SRP	SRP	SRP
3	SRP	SRP, TP	SRP	ns
4	ns	ns	ns	SRP
7	SRP, TDP, TP	SRP	SRP	SRP
10	SRP	ns	ns	ns
14	ns	SRP	SRP	SRP
15	SRP, TDP, TP	ns	ns	ns
21	ns	SRP	SRP	SRP
28	SRP, TDP, TP	SRP	SRP	SRP, TP
35	ns	SRP	SRP	ns
42	ns	SRP	SRP	ns
49	ns	SRP	SRP	ns
56	ns	SRP	SRP	ns
63	ns	ns	SRP, TP	ns
66	ns	SRP, TP	ns	ns

"ns" indicates no sample was collected

Table C-2. Sediment physical and chemical characteristics of soils collected from 20 canal sampling sites. Values represent mean of triplicate cores samples collected at each canal site

Site	Depth	Bulk density Mean ± S.D.	Loss on ignition Mean ± S.D.	Porewater SRP Mean ± S.D.	Porewater NH4-N Mean ± S.D.
	cm	g / cm3	%	mg/l	
L40-C22	0-10	0.100 ± 0.008	52.8 ± 4.3	0.152 ± 0.023	8.991 ± 1.326
L40-C12	0-10	0.072 ± 0.008	42.4 ± 11	0.044 ± 0.016	7.836 ± 2.774
L40-C24	0-10	0.034 ± 0.006	74.3 ± 5.9	0.033 ± 0.013	7.982 ± 1.730
L7-C21	0-10	0.167 ± 0.018	47.7 ± 2.6	0.171 ± 0.053	6.871 ± 0.034
L7-C11	0-10	0.181 ± 0.015	44.0 ± 2.3	0.110 ± 0.029	3.970 ± 0.380
L7-C26	0-10	0.113 ± 0.004	47.1 ± 1.4	0.107 ± 0.027	6.520 ± 0.667
L39-C25	0-10	0.232 ± 0.022	29.6 ± 2.0	0.350 ± 0.044	8.581 ± 1.425
L39-C10	0-10	0.041 ± 0.007	63.7 ± 1.8	0.101 ± 0.054	4.908 ± 1.447
L6-C9	0-10	0.202 ± 0.005	62.9 ± 1.9	0.120 ± 0.009	2.387 ± 0.119
L6-C7	0-10	0.541 ± 0.135	19.0 ± 7.2	0.028 ± 0.004	1.344 ± 0.039
L38-C6	0-10	0.228 ± 0.091	31.4 ± 10	0.369 ± 0.071	3.156 ± 1.239
L38-C8	0-10	0.109 ± 0.003	48.0 ± 1.5	0.034 ± 0.004	2.018 ± 0.865
L5-C5	0-10	0.149 ± 0.011	54.1 ± 6.1	0.116 ± 0.026	4.445 ± 0.253
L5-C4	0-10	0.087 ± 0.011	48.1 ± 0.7	0.086 ± 0.064	4.746 ± 0.333
MC-C28	0-10	0.655 ± 0.030	11.8 ± 3.4	0.070 ± 0.004	3.076 ± 0.918
MC-C27	0-10	0.574 ± 0.133	15.2 ± 5.2	0.027 ± 0.005	3.312 ± 0.857
MC-C3	0-10	0.856 ± 0.043	8.7 ± 0.7	0.068 ± 0.032	3.553 ± 0.189
MC-C2	0-10	0.115 ± 0.010	42.2 ± 1.6	0.109 ± 0.057	19.63 ± 2.038
MC-C1	0-10	0.117 ± 0.020	48.2 ± 4.4	0.040 ± 0.005	8.753 ± 2.644
MC-C23	0-10	0.110 ± 0.007	40.5 ± 3.6	0.023 ± 0.002	5.776 ± 1.232

Site	Depth	Bulk density Mean ± S.D.	Loss on ignition Mean ± S.D.	Porewater SRP Mean ± S.D.	Porewater NH4-N Mean ± S.D.
	cm	g / cm3	%	mg/l	
L40-C22	10-30	0.154 ± 0.012	42.8 ± 2.1	0.166 ± 0.024	15.48 ± 0.717
L40-C12	10-30	0.087 ± 0.001	50.2 ± 0.9	0.138 ± 0.078	10.61 ± 6.147
L40-C24	10-30	0.062 ± 0.004	61.2 ± 2.0	0.511 ± 0.225	24.12 ± 1.785
L7-C21	10-30	0.158 ± 0.012	51.8 ± 2.4	0.391 ± 0.099	16.83 ± 1.154
L7-C11	10-30	0.171 ± 0.010	58.3 ± 1.8	0.272 ± 0.062	3.294 ± 0.601
L7-C26	10-30	0.139 ± 0.005	50.1 ± 2.8	0.435 ± 0.020	6.664 ± 0.110
L39-C25	10-30	0.499 ± 0.051	21.5 ± 1.8	0.097 ± 0.011	3.652 ± 0.427
L39-C10	10-30	0.070 ± 0.027	56.7 ± 11	0.703 ± 0.110	13.94 ± 1.455
L6-C9	10-30	0.215 ± 0.016	42.2 ± 4.3	0.280 ± 0.018	4.304 ± 0.309
L6-C7	10-30	0.428 ± 0.015	29.9 ± 1.5	0.026 ± 0.002	2.558 ± 0.122
L38-C6	10-30	0.489 ± 0.133	16.2 ± 3.7	0.762 ± 0.303	5.804 ± 2.640
L38-C8	10-30	0.185 ± 0.013	38.8 ± 3.7	0.275 ± 0.096	8.403 ± 0.491
L5-C5	10-30	0.127 ± 0.005	64.0 ± 5.2	0.455 ± 0.019	8.397 ± 0.440
L5-C4	10-30	0.231 ± 0.053	34.0 ± 4.9	0.168 ± 0.002	4.265 ± 1.114
MC-C28	10-30	0.375 ± 0.054	26.5 ± 4.2	0.199 ± 0.025	4.002 ± 0.670
MC-C27	10-30	0.786 ± 0.087	11.8 ± 2.1	0.056 ± 0.032	5.417 ± 2.084
MC-C3	10-30	0.720 ± 0.014	13.6 ± 2.4	0.095 ± 0.010	3.192 ± 0.044
MC-C2	10-30	0.142 ± 0.005	42.7 ± 0.4	0.296 ± 0.218	36.81 ± 7.592
MC-C1	10-30	0.096 ± 0.011	50.4 ± 7.0	0.123 ± 0.061	17.91 ± 5.809
MC-C23	10-30	0.480 ± 0.021	18.1 ± 0.3	0.026 ± 0.001	6.585 ± 1.568

Table C-3. Total Inorganic and Total P concentrations for surface and subsurface canal sediments. Values determined independantly of other fractionation scheme. Values represent mean of triplicate core samples collected at each canal site.

Site	Total Pi Mean ± S.D. -------mg/kg--------	% of TP %	Total P Mean ± S.D. -------mg/kg--------
L40-C22	541.2 ± 26.7	57.2	946.0 ± 82.7
L40-C12	631.5 ± 25.2	52.3	1208.6 ± 88.7
L40-C24	648.5 ± 47.8	51.0	1272.7 ± 65.3
L7-C21	600.8 ± 16.4	65.9	911.1 ± 48.8
L7-C11	424.0 ± 14.3	60.9	696.2 ± 37.0
L7-C26	526.4 ± 42.4	52.9	995.4 ± 9.8
L39-C25	251.9 ± 41.9	62.2	404.8 ± 79.8
L39-C10	410.6 ± 36.0	39.9	1030.1 ± 20.4
L6-C9	196.1 ± 4.0	58.1	337.4 ± 28.3
L6-C7	91.4 ± 4.4	76.2	119.9 ± 13.9
L38-C6	761.3 ± 28.1	74.0	1029.4 ± 154
L38-C8	552.4 ± 20.6	48.3	1144.1 ± 20.4
L5-C5	606.2 ± 145	72.8	832.9 ± 204
L5-C4	508.7 ± 18.5	53.5	950.6 ± 32.7
MC-C28	316.1 ± 24.5	96.7	327.1 ± 19.9
MC-C27	1078.2 ± 80.4	96.9	1112.9 ± 101
MC-C3	1409.5 ± 174	101.4	1390.4 ± 145
MC-C2	927.0 ± 41.1	63.7	1455.4 ± 31.3
MC-C1	998.2 ± 109	78.3	1275.2 ± 86.7
MC-C23	693.9 ± 7.6	63.1	1098.9 ± 95.5

Site	Total Pi Mean ± S.D. -------mg/kg--------	% of TP %	Total P Mean ± S.D. -------mg/kg--------
L40-C22	587.7 ± 14.5	60.6	969.3 ± 16.1
L40-C12	567.1 ± 33.1	49.0	1156.3 ± 55.8
L40-C24	653.4 ± 4.3	48.7	1342.9 ± 31.7
L7-C21	568.4 ± 32.3	64.8	876.5 ± 20.5
L7-C11	546.2 ± 4.2	70.6	773.4 ± 48.5
L7-C26	838.7 ± 223.9	69.4	1207.9 ± 199.0
L39-C25	167.2 ± 13.0	71.7	233.3 ± 29.0
L39-C10	442.6 ± 136.4	46.8	945.6 ± 201.5
L6-C9	233.4 ± 27.2	78.2	298.4 ± 30.3
L6-C7	100.3 ± 1.8	78.4	128.0 ± 4.0
L38-C6	739.6 ± 196.7	96.3	767.8 ± 192.2
L38-C8	559.1 ± 43.9	63.8	875.8 ± 54.9
L5-C5	316.6 ± 51.7	59.5	532.3 ± 38.6
L5-C4	390.9 ± 82.2	73.7	530.4 ± 116.1
MC-C28	403.6 ± 27.7	88.9	453.8 ± 23.9
MC-C27	1012.1 ± 134.5	99.9	1013.2 ± 101.9
MC-C3	911.3 ± 28.4	93.5	974.1 ± 31.1
MC-C2	1200.2 ± 207.0	77.0	1559.3 ± 131.5
MC-C1	855.4 ± 74.6	69.2	1236.7 ± 68.8
MC-C23	320.0 ± 79.6	84.8	377.4 ± 47.3

Table C-4. Maximum DRP and average sediment DRP flux rates. Maximum flux rate based on maximum rate change in soil P release between day 1 and day 30 of each floodwater exchange cycle. Average flux rate based on sum of P released or adsorbed between day 0 and day 30, divided by the time elapsed (30 days). Mean values based on flux from triplicate intact core microcosms.

	First Floodwater Exchange		Second Floodwater Exchange	
	Maximum Flux	Average Flux	Maximum Flux	Average Flux
Site	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.
	----------mg P / m2 / day ----------		----------mg P / m2 / day ----------	
L40-C22	6.04 ± 2.02	0.488 ± 0.115	2.40 ± 0.97	0.342 ± 0.300
L40-C12	8.78 ± 1.46	0.619 ± 0.338	0.84 ± 0.43	0.086 ± 0.010
L40-C24	2.38 ± 0.61	0.132 ± 0.035	22.0 ± 14.17	0.453 ± 0.164
L7-C21	3.02 ± 1.65	0.207 ± 0.050	0.85 ± 0.26	0.094 ± 0.030
L7-C11	2.41 ± 0.20	0.131 ± 0.021	1.04 ± 0.17	0.059 ± 0.013
L7-C26	4.07 ± 1.14	0.396 ± 0.291	1.95 ± 0.89	0.274 ± 0.210
L39-C25	5.30 ± 0.55	0.776 ± 0.221	1.59 ± 0.70	0.235 ± 0.067
L39-C10	4.34 ± 1.78	0.309 ± 0.190	1.44 ± 0.78	0.103 ± 0.025
L6-C9	2.66 ± 1.25	0.095 ± 0.022	1.54 ± 0.62	0.064 ± 0.022
L6-C7	2.09 ± 0.58	0.076 ± 0.013	1.33 ± 0.41	0.045 ± 0.008
L38-C6	2.94 ± 0.32	0.138 ± 0.034	1.44 ± 0.28	0.127 ± 0.011
L38-C8	2.23 ± 0.55	0.082 ± 0.036	1.42 ± 0.38	0.098 ± 0.013
L5-C5	2.30 ± 0.96	0.162 ± 0.016	1.27 ± 0.40	0.141 ± 0.030
L5-C4	2.91 ± 1.49	0.128 ± 0.039	1.61 ± 0.97	0.292 ± 0.293
MC-C28	2.71 ± 1.06	0.266 ± 0.091	1.46 ± 0.50	0.198 ± 0.115
MC-C27	3.40 ± 0.36	0.206 ± 0.051	1.09 ± 0.24	0.127 ± 0.079
MC-C3	3.52 ± 1.67	0.188 ± 0.057	0.93 ± 0.52	0.089 ± 0.013
MC-C2	4.44 ± 1.74	0.643 ± 0.332	3.25 ± 1.80	0.196 ± 0.100
MC-C1	2.30 ± 0.29	0.104 ± 0.007	1.54 ± 0.41	0.040 ± 0.011
MC-C23	2.00 ± 0.25	0.086 ± 0.005	0.80 ± 0.38	0.073 ± 0.036

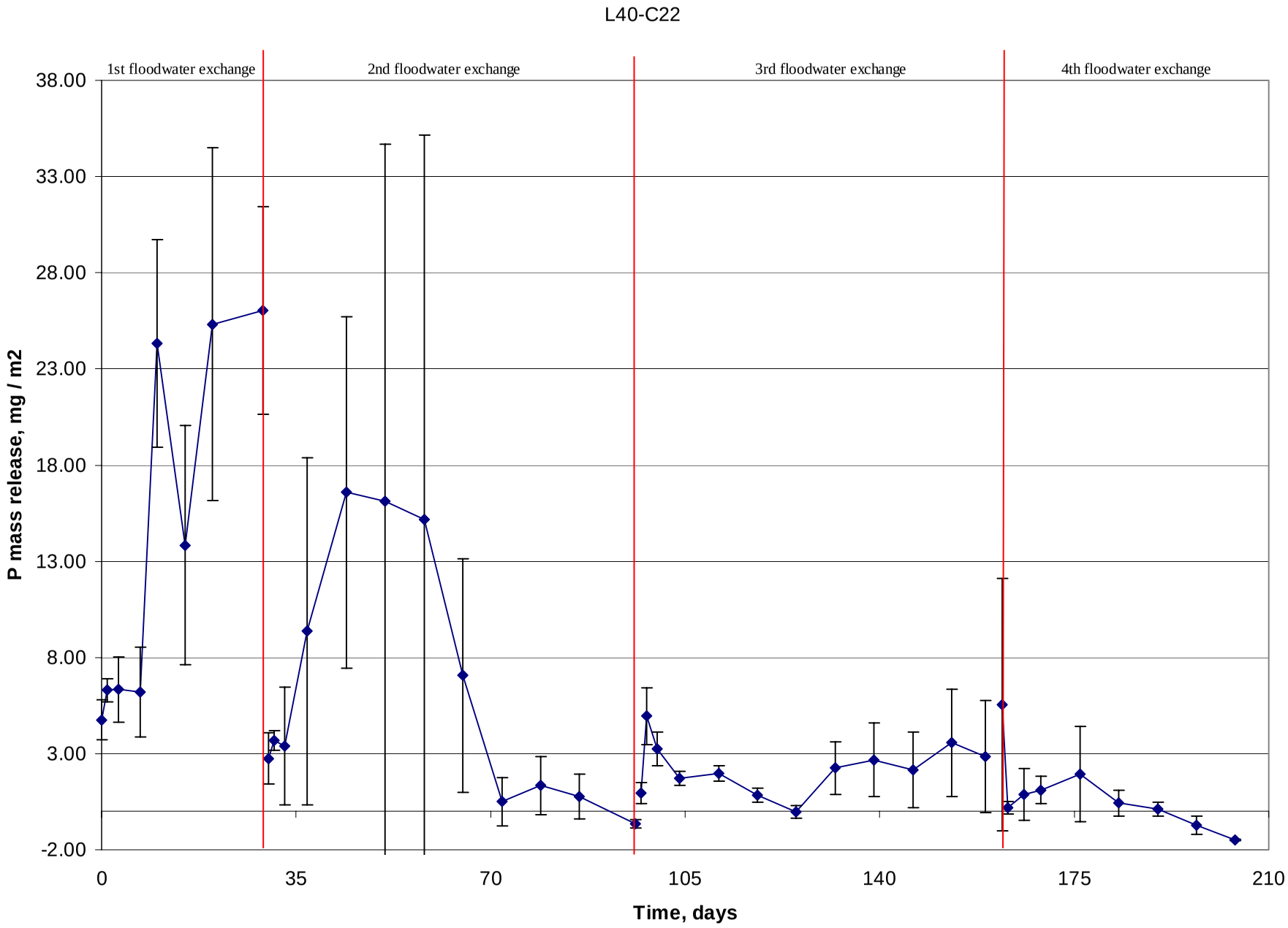
	Third Floodwater Exchange		Fourth Floodwater Exchange	
	Maximum Flux	Average Flux	Maximum Flux	Average Flux
Site	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.
	----------mg P / m2 / day ----------		----------mg P / m2 / day ----------	
L40-C22	4.58 ± 1.40	0.070 ± 0.013	0.40 ± 0.21	0.052 ± 0.029
L40-C12	3.26 ± 0.44	0.318 ± 0.231	0.97 ± 0.77	0.267 ± 0.218
L40-C24	11.5 ± 9.02	0.411 ± 0.201	0.81 ± 0.37	0.294 ± 0.134
L7-C21	3.29 ± 0.17	0.035 ± 0.003	0.71 ± 0.59	0.024 ± 0.013
L7-C11	2.43 ± 0.21	0.007 ± 0.007	0.61 ± 0.13	-0.004 ± 0.013
L7-C26	2.46 ± 0.37	0.051 ± 0.021	0.90 ± 0.38	0.078 ± 0.084
L39-C25	3.33 ± 1.72	0.133 ± 0.024	1.02 ± 0.22	0.132 ± 0.053
L39-C10	2.36 ± 1.59	0.172 ± 0.083	0.97 ± 0.32	0.215 ± 0.249
L6-C9	3.45 ± 0.56	0.028 ± 0.003	0.42 ± 0.37	-0.015 ± 0.010
L6-C7	4.06 ± 0.56	0.047 ± 0.015	0.51 ± 0.28	-0.007 ± 0.006
L38-C6	0.98 ± 0.75	0.057 ± 0.012	0.70 ± 0.22	0.035 ± 0.027
L38-C8	1.45 ± 0.93	0.075 ± 0.016	0.74 ± 0.23	0.044 ± 0.023
L5-C5	2.78 ± 0.16	0.017 ± 0.010	1.00 ± 0.22	0.035 ± 0.022
L5-C4	3.78 ± 0.54	0.079 ± 0.016	0.01 ± 0.33	0.243 ± 0.295
MC-C28	1.43 ± 0.64	0.037 ± 0.010	0.59 ± 0.32	0.011 ± 0.014
MC-C27	0.44 ± 0.09	0.038 ± 0.008	0.72 ± 0.09	0.005 ± 0.009
MC-C3	0.96 ± 0.24	0.040 ± 0.013	0.63 ± 0.36	-0.007 ± 0.019
MC-C2	2.31 ± 1.11	0.083 ± 0.016	1.03 ± 1.07	0.130 ± 0.061
MC-C1	2.42 ± 1.64	0.044 ± 0.022	0.47 ± 0.31	0.015 ± 0.015
MC-C23	1.01 ± 0.43	0.072 ± 0.014	0.28 ± 0.06	0.036 ± 0.049

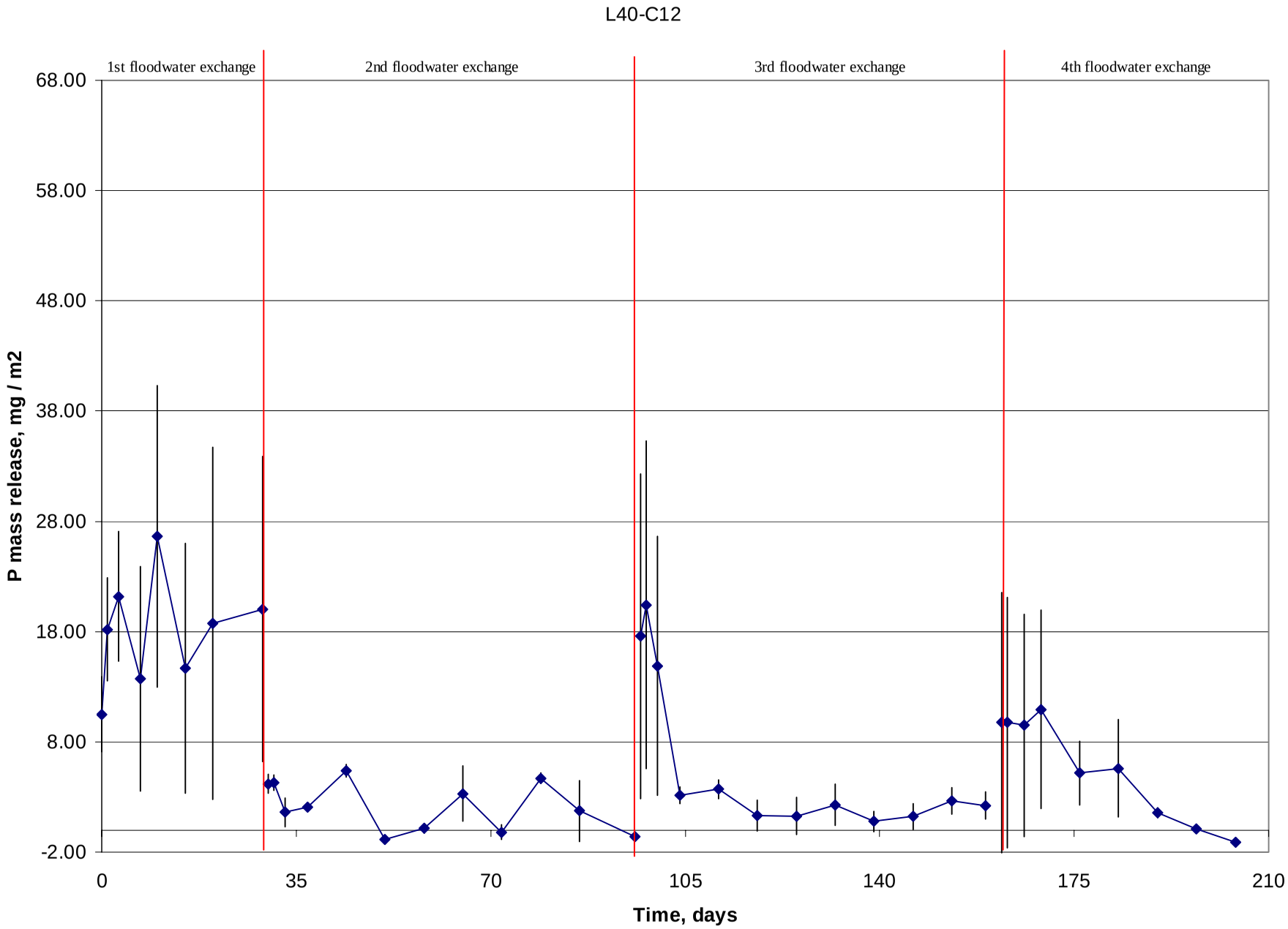
Table C-5. Cumulative sediment P release during the four floodwater exchange cycles. Average P mass represents the sum of average P released during each floodwater exchange. Maximum P mass represents the sum of the greatest mass released at any single sampling event during each of the four floodwater exchange cycles.

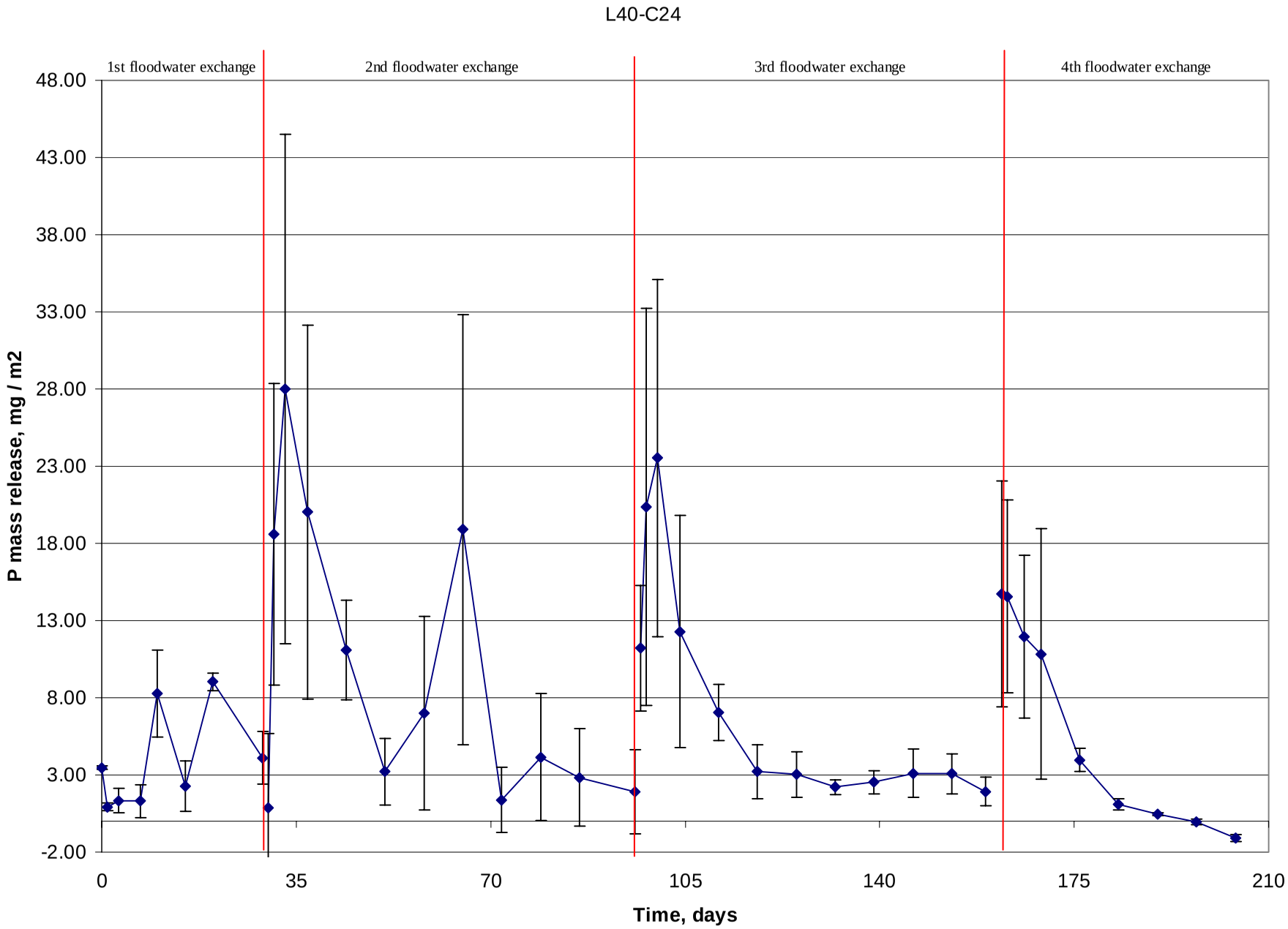
	Cumulative sediment P release	
	Average P Mass	Maximum P mass
Site	Mean ± S.D.	Mean ± S.D.
	------mg / m2 -------	-------mg / m2 ------
L40-C22	27.1 ± 12.3	63.4 ± 26.9
L40-C12	36.7 ± 14.2	67.9 ± 24.7
L40-C24	36.3 ± 14.6	80.0 ± 30.4
L7-C21	10.3 ± 2.07	26.3 ± 4.20
L7-C11	5.54 ± 0.65	19.4 ± 0.97
L7-C26	22.8 ± 16.9	57.5 ± 36.0
L39-C25	36.5 ± 9.10	80.4 ± 17.1
L39-C10	22.7 ± 14.6	44.4 ± 22.4
L6-C9	4.90 ± 1.17	18.6 ± 1.55
L6-C7	4.58 ± 0.82	19.4 ± 2.35
L38-C6	10.1 ± 1.52	28.4 ± 5.24
L38-C8	8.43 ± 1.42	23.7 ± 2.87
L5-C5	10.1 ± 1.22	31.0 ± 1.58
L5-C4	20.9 ± 17.5	50.2 ± 34.8
MC-C28	14.6 ± 5.75	34.7 ± 8.08
MC-C27	10.7 ± 3.95	31.2 ± 7.96
MC-C3	8.88 ± 0.70	24.2 ± 3.07
MC-C2	30.1 ± 9.81	66.4 ± 20.0
MC-C1	5.76 ± 0.63	19.5 ± 2.06
MC-C23	7.54 ± 2.21	19.0 ± 2.43

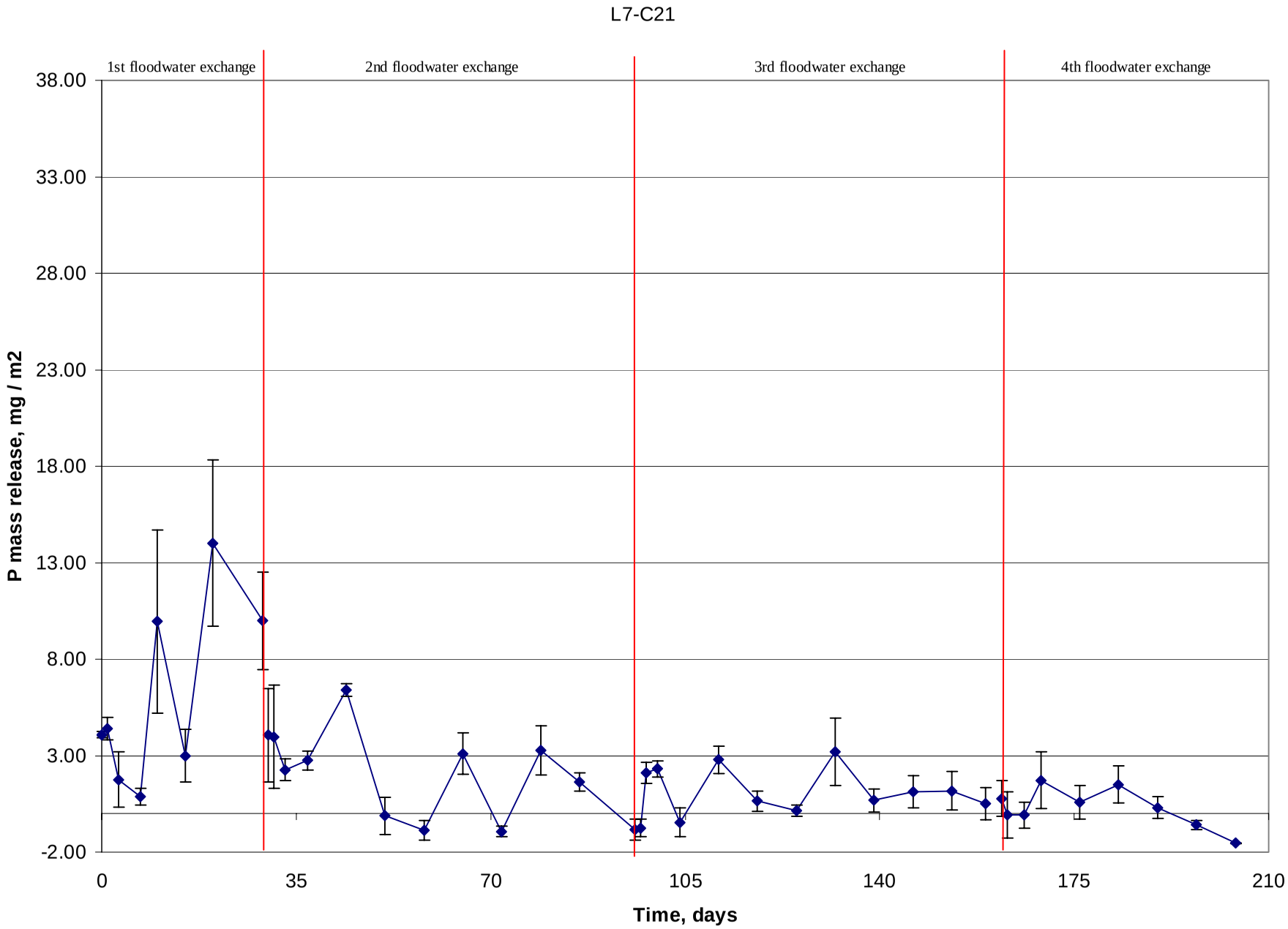
Attachment 2A
Appendix D
Phosphorus Flux from Core Microcosms

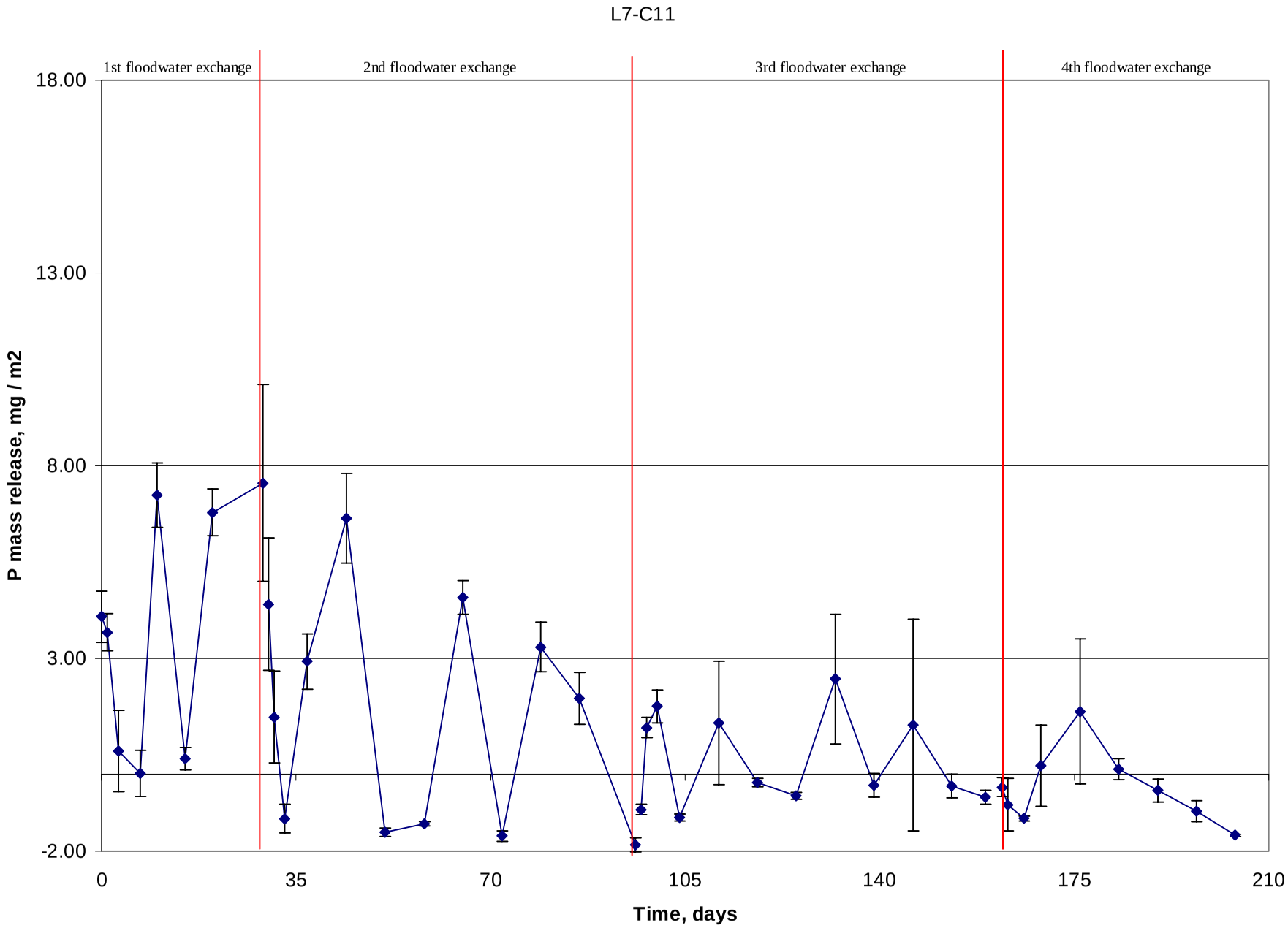
The graphics that follow represent the cumulative P released during each floodwater exchange cycle from soils at each of the twenty canals sites sampled in this investigation. P mass is additive only within the same floodwater exchange cycle, values do not represent a cumulative P mass from time 0 through all four floodwater exchanges. Sampling points represent mean $\pm$ 1SD of three triplicate intact core microcosms.

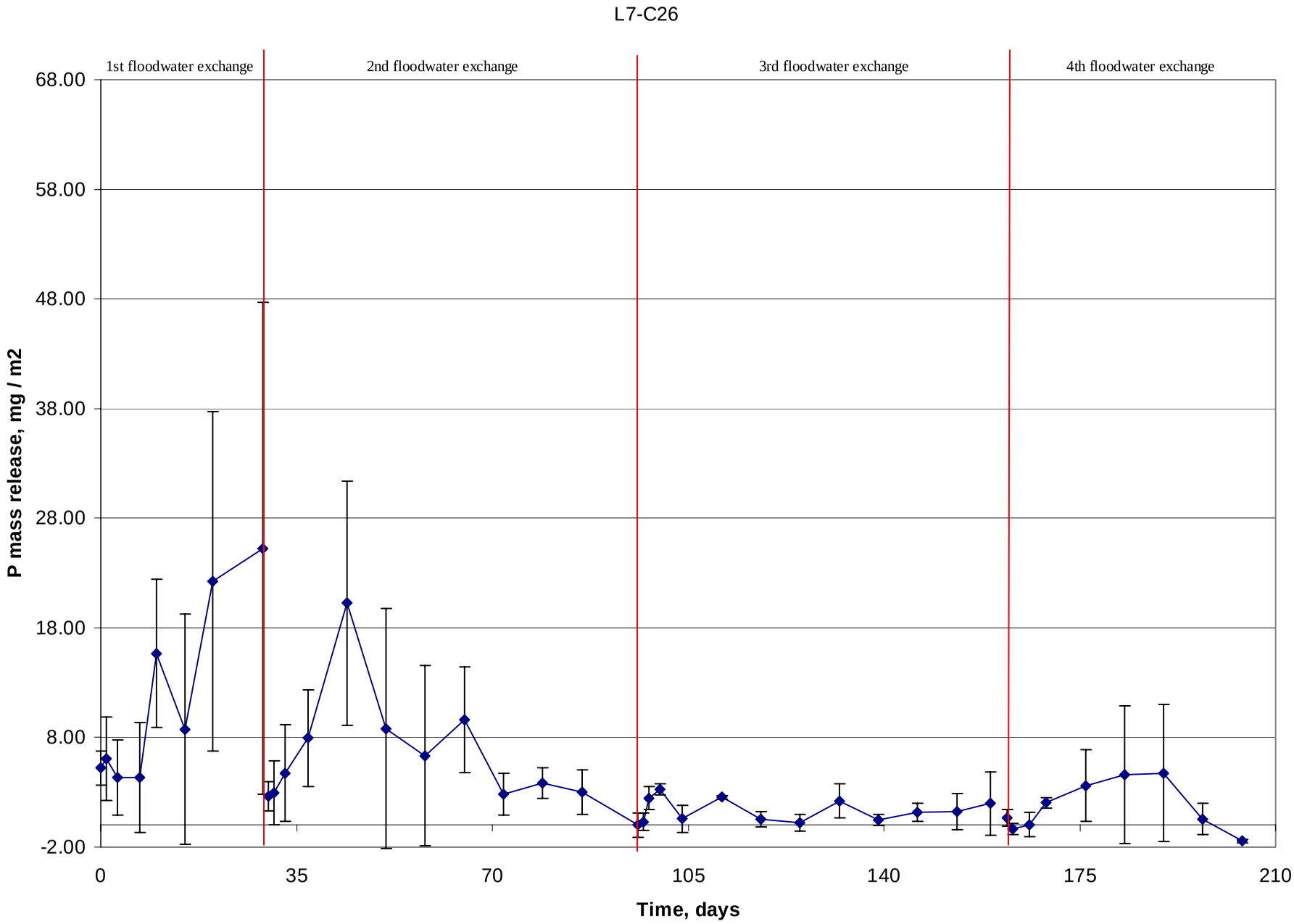

L40-C22
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
38.00
33.00
28.00
23.00
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

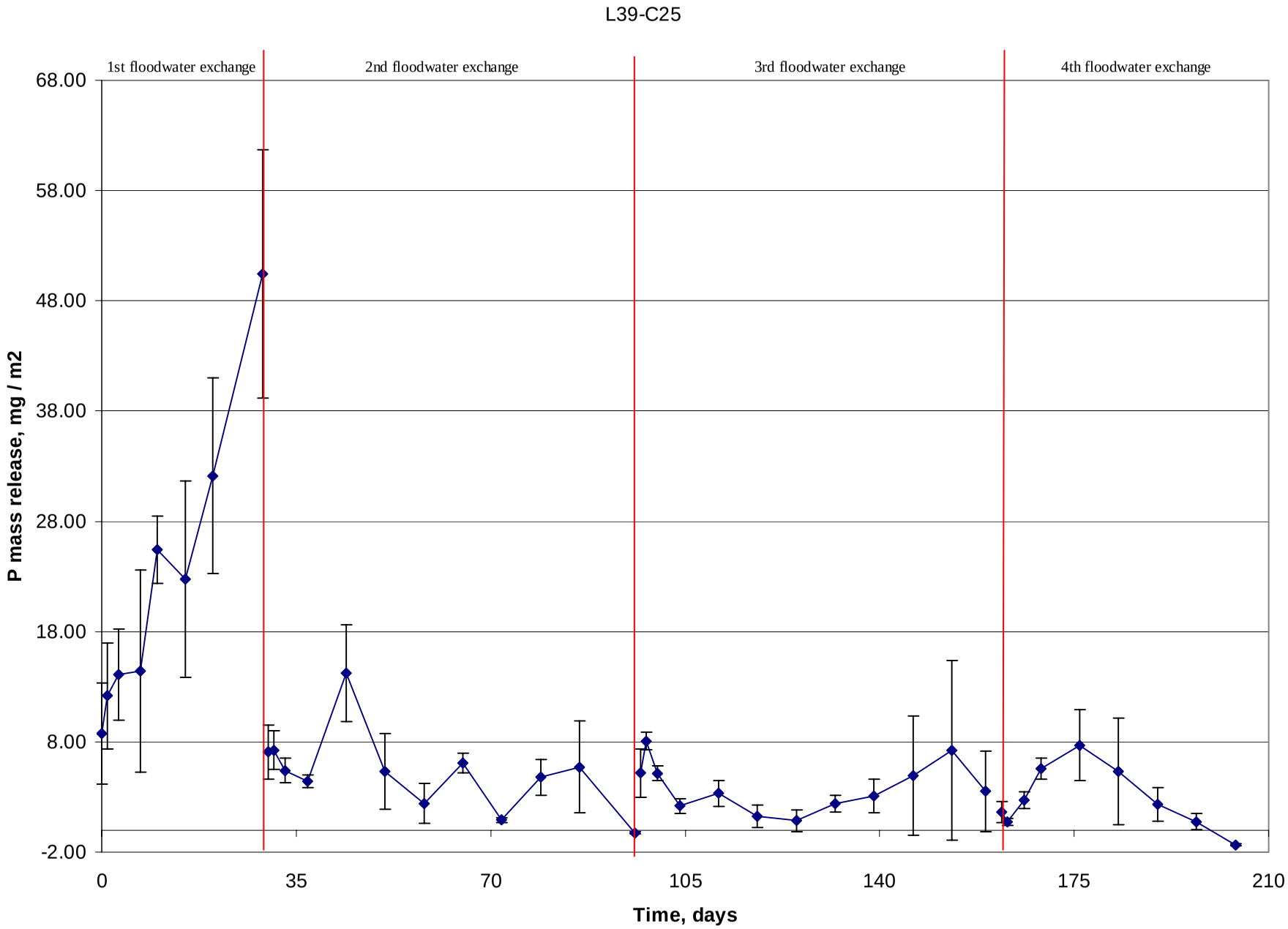

L40-C12
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
68.00
58.00
48.00
38.00
28.00
18.00
8.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

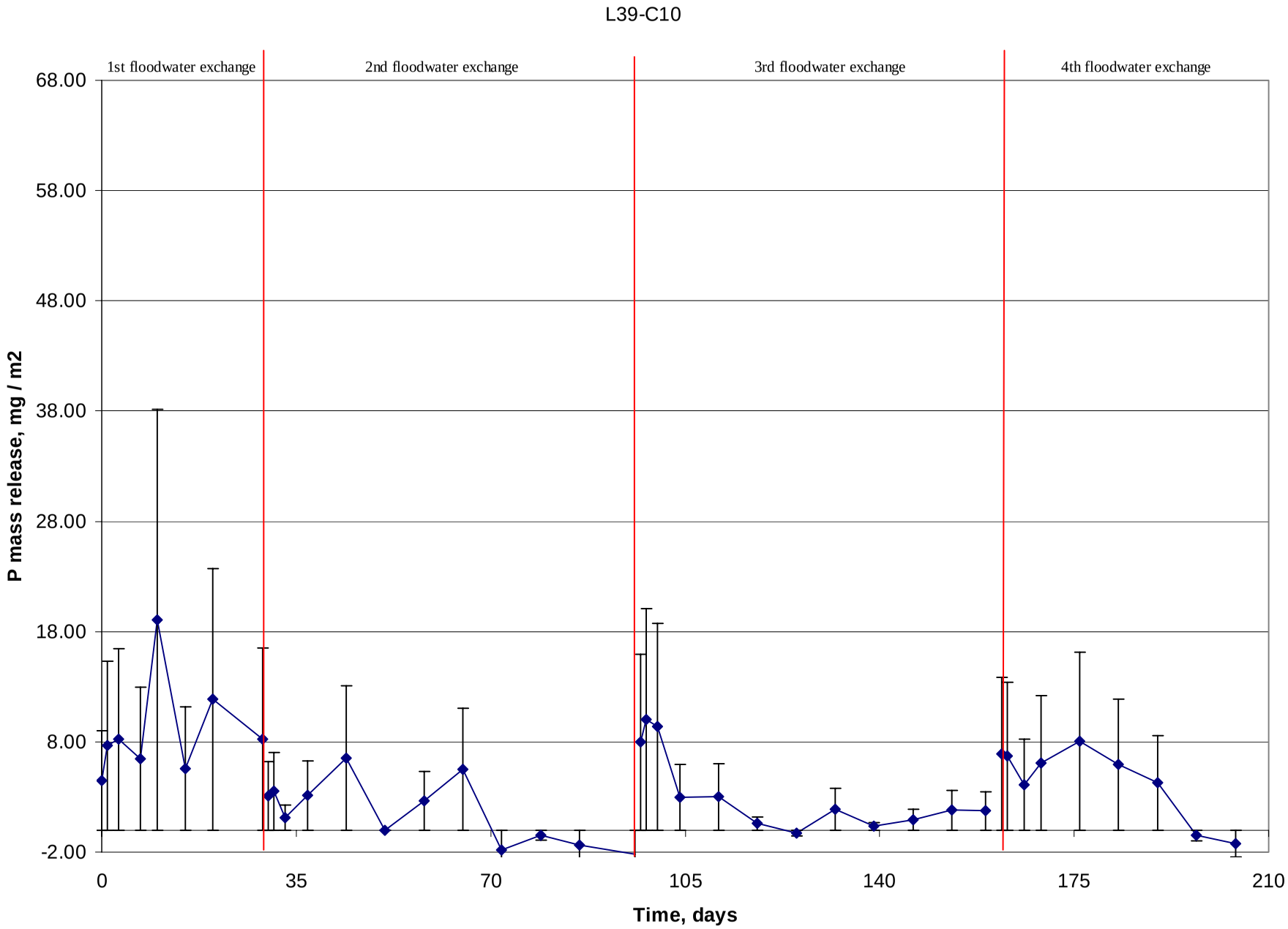

L40-C24
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
48.00
43.00
38.00
33.00
28.00
23.00
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

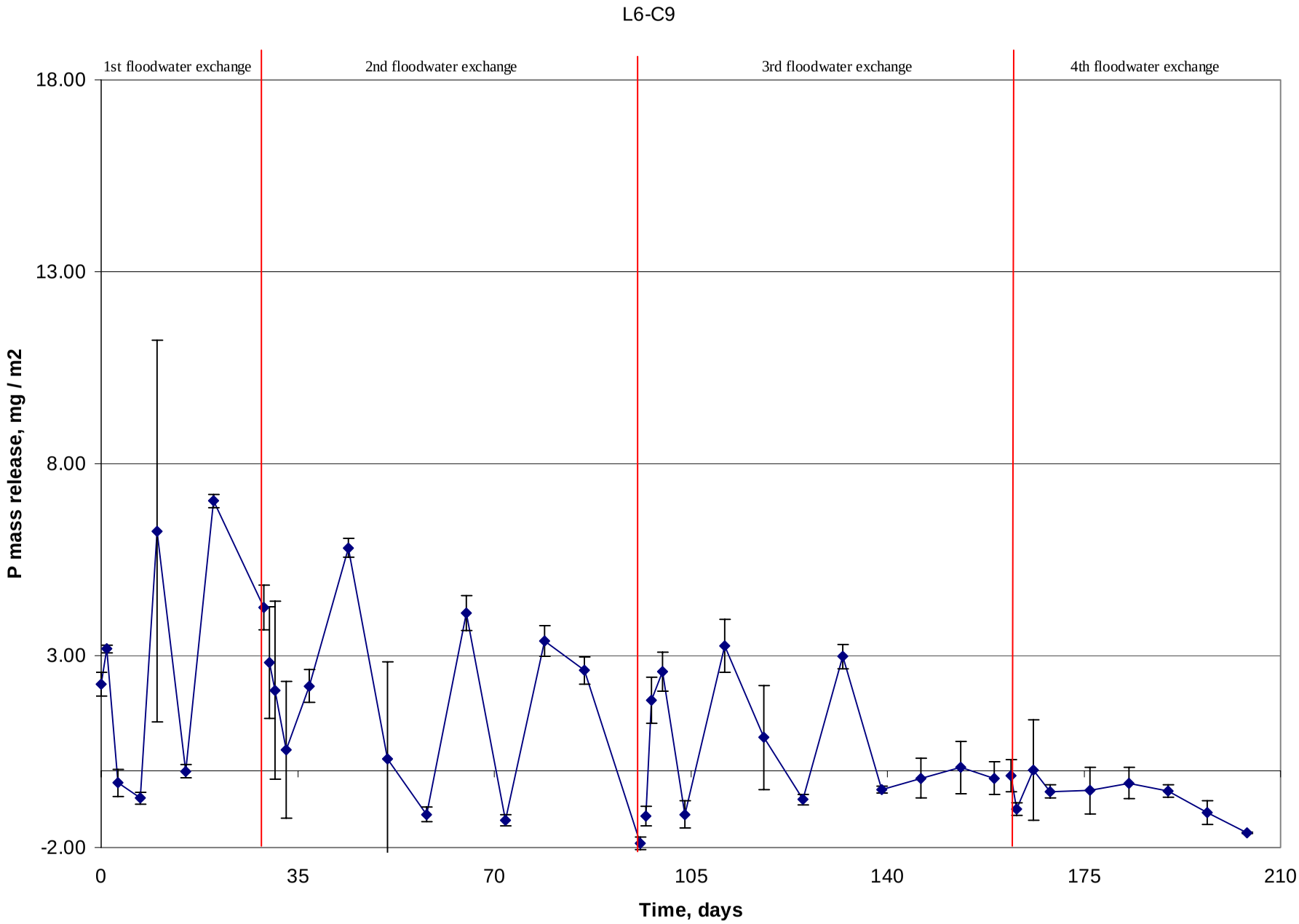

L7-C21
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
38.00
33.00
28.00
23.00
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

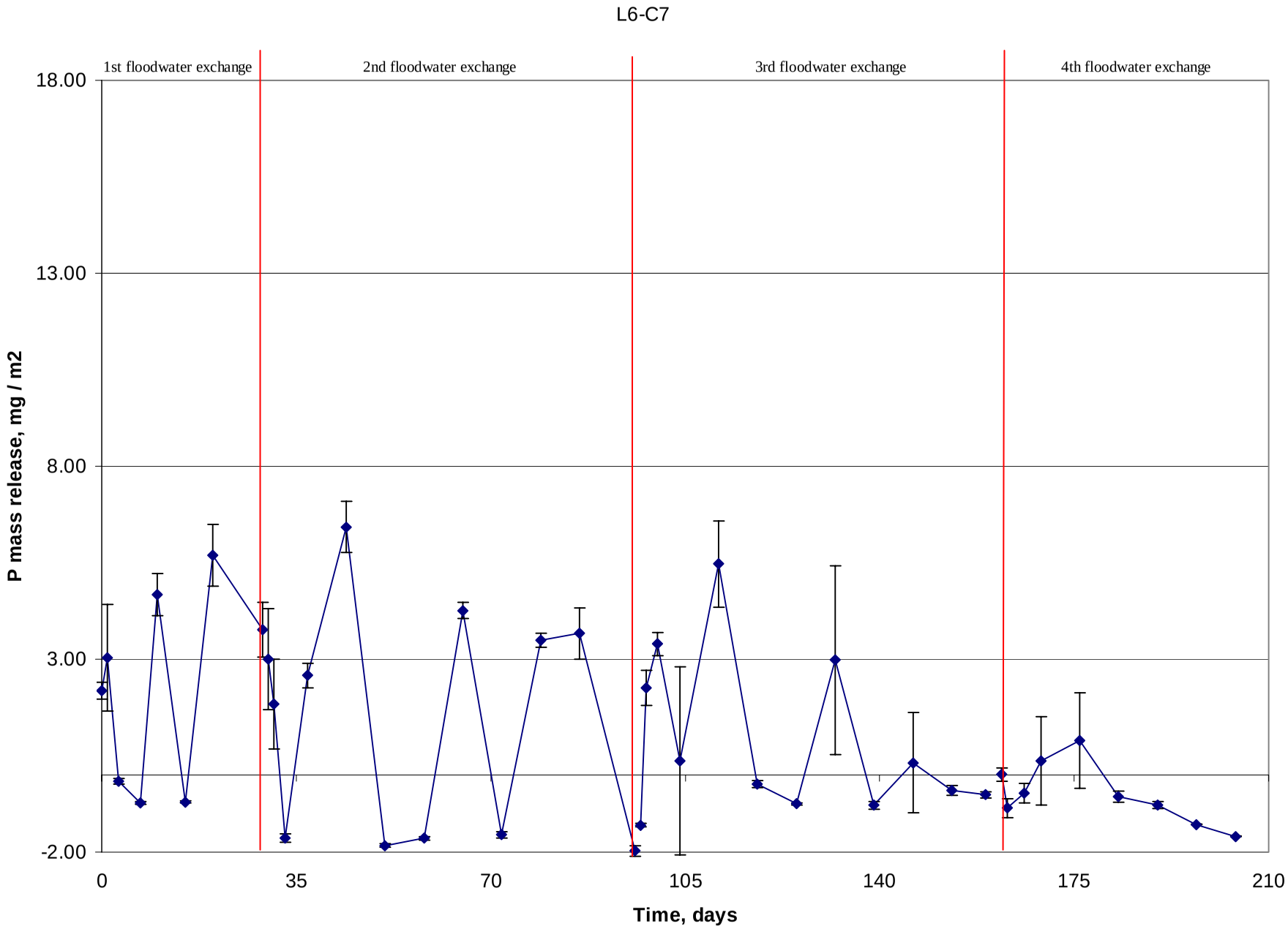

L7-C11
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

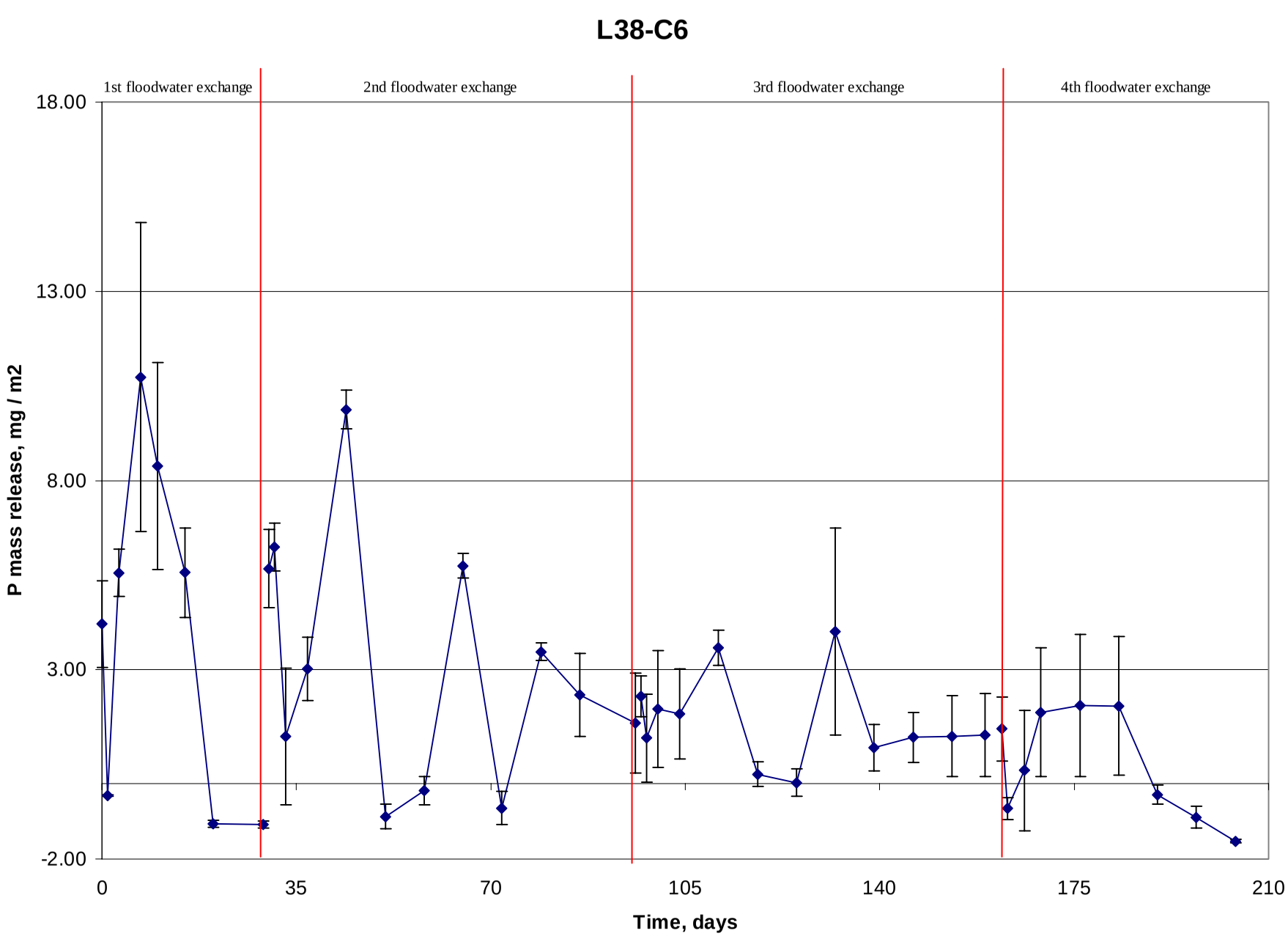

L7-C26
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
68.00
58.00
48.00
38.00
28.00
18.00
8.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

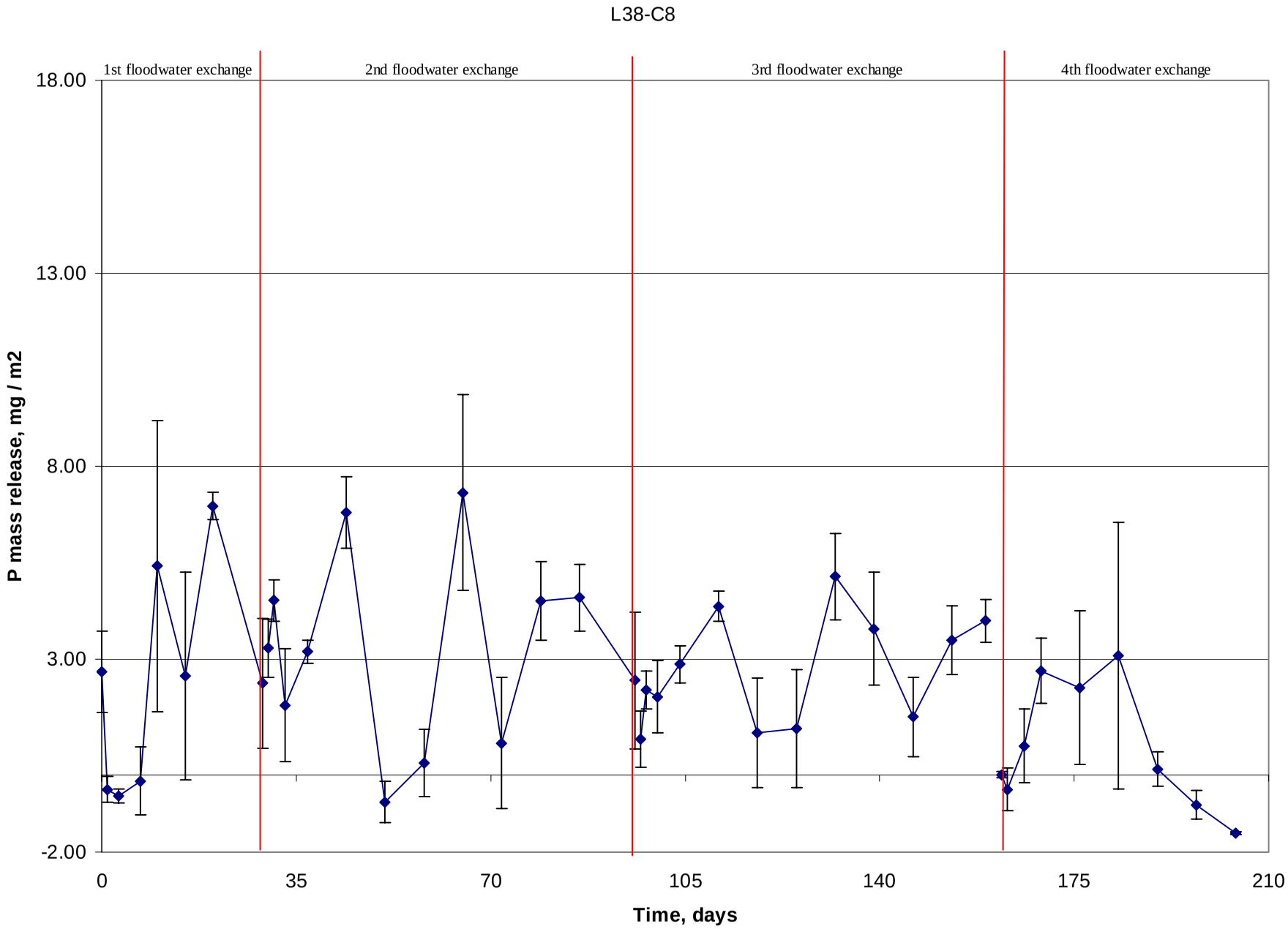

L39-C25
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
68.00
58.00
48.00
38.00
28.00
18.00
8.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

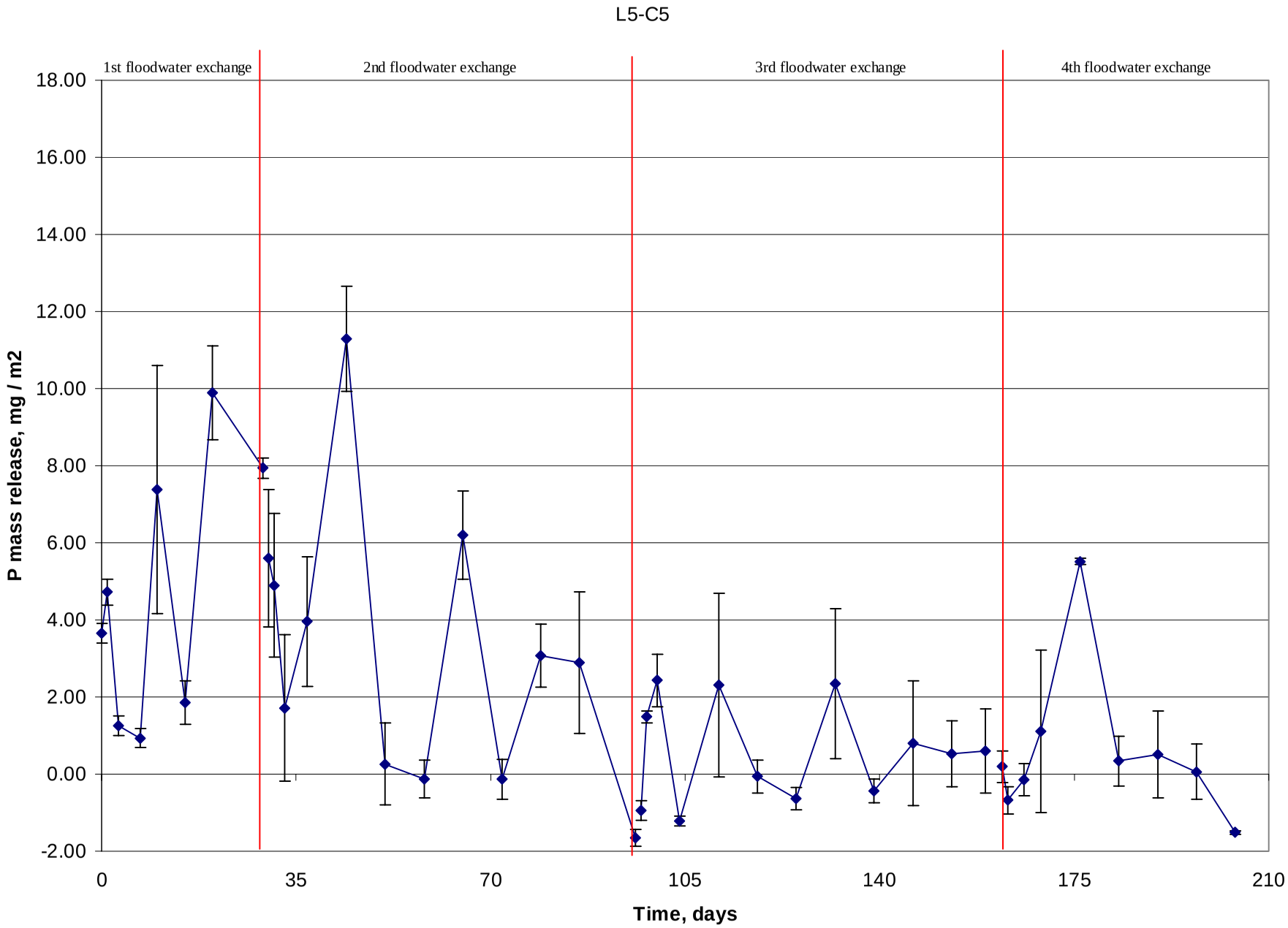

L39-C10
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
68.00
58.00
48.00
38.00
28.00
18.00
8.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

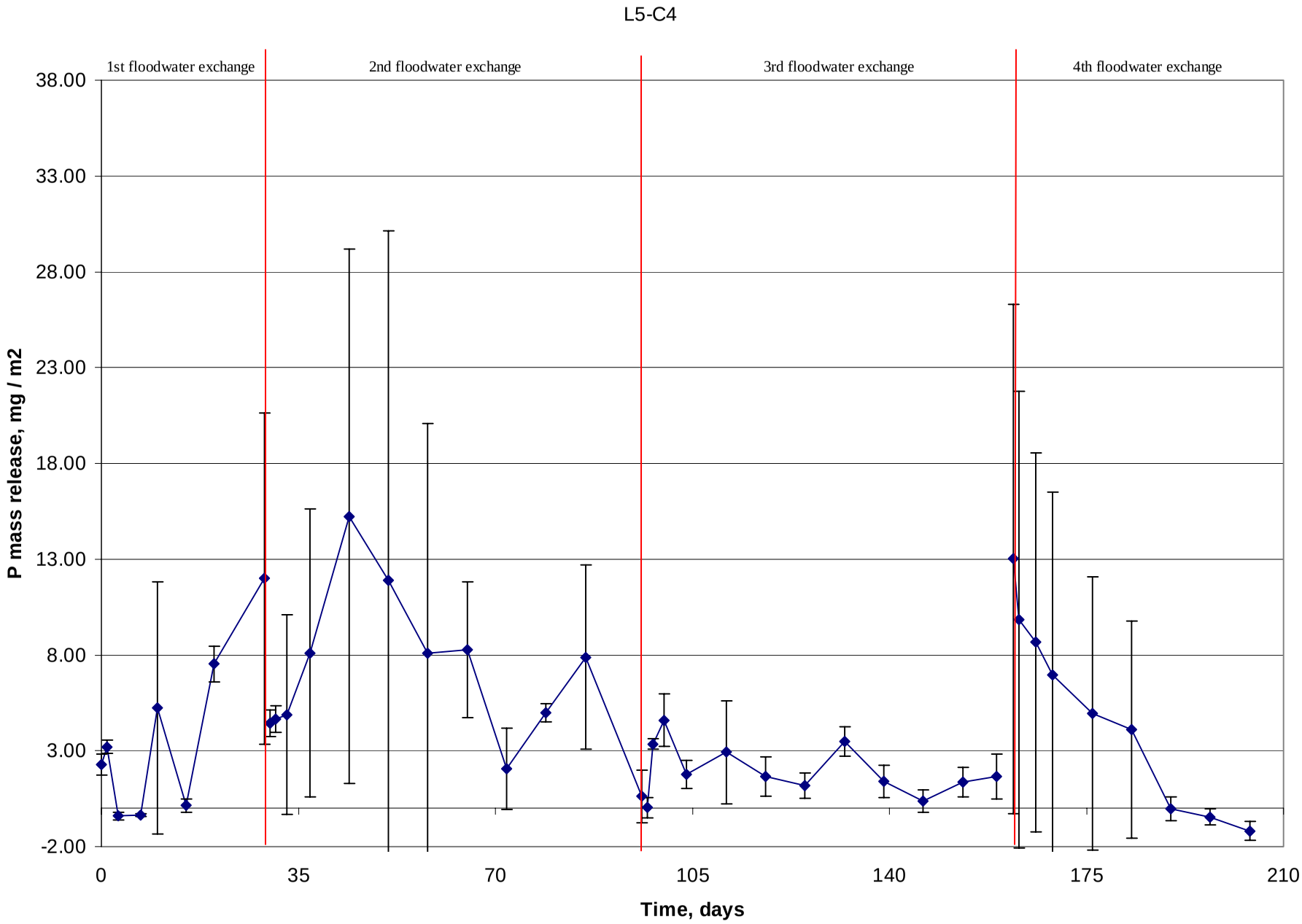

L6-C9
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

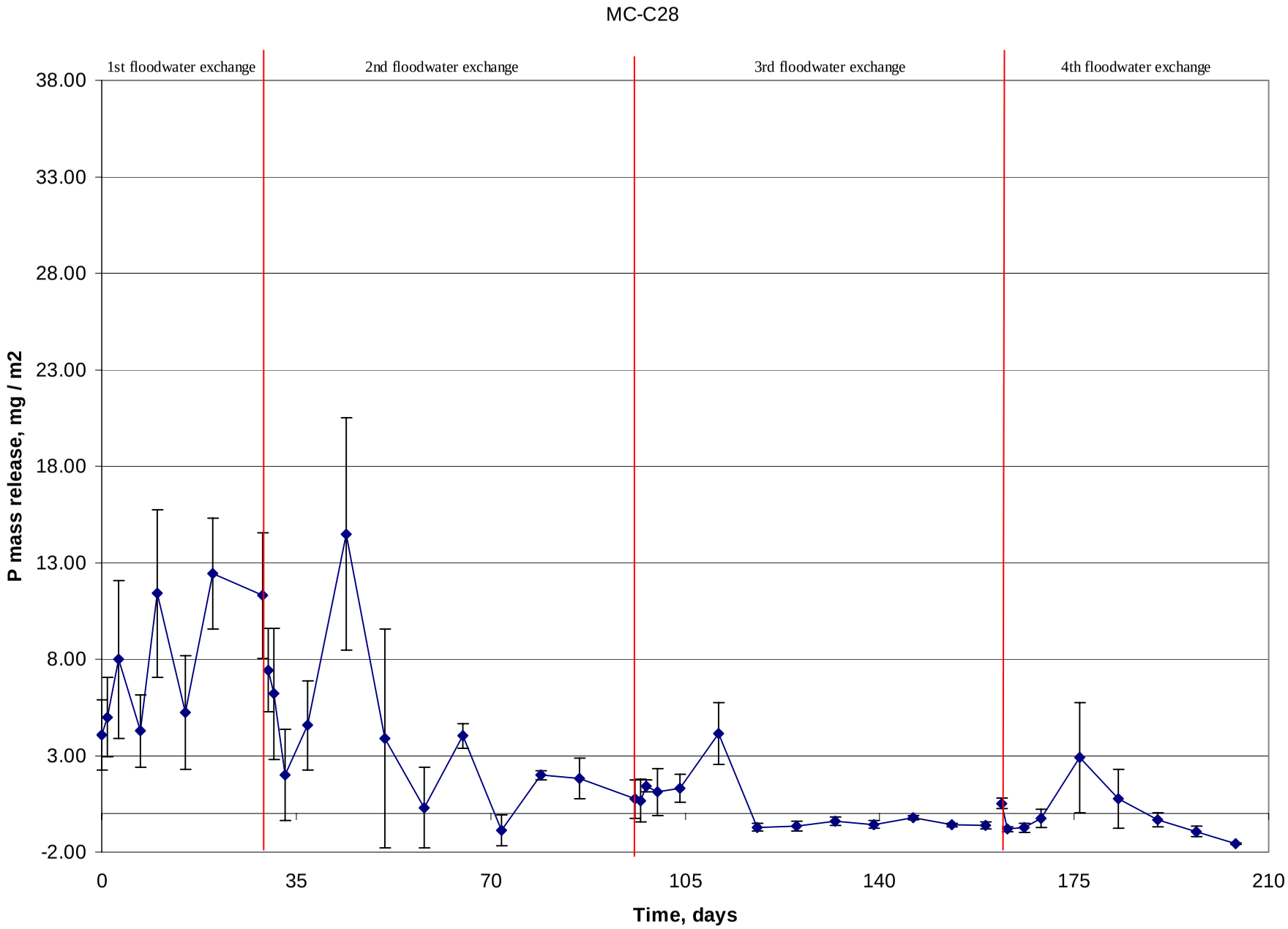

L6-C7
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

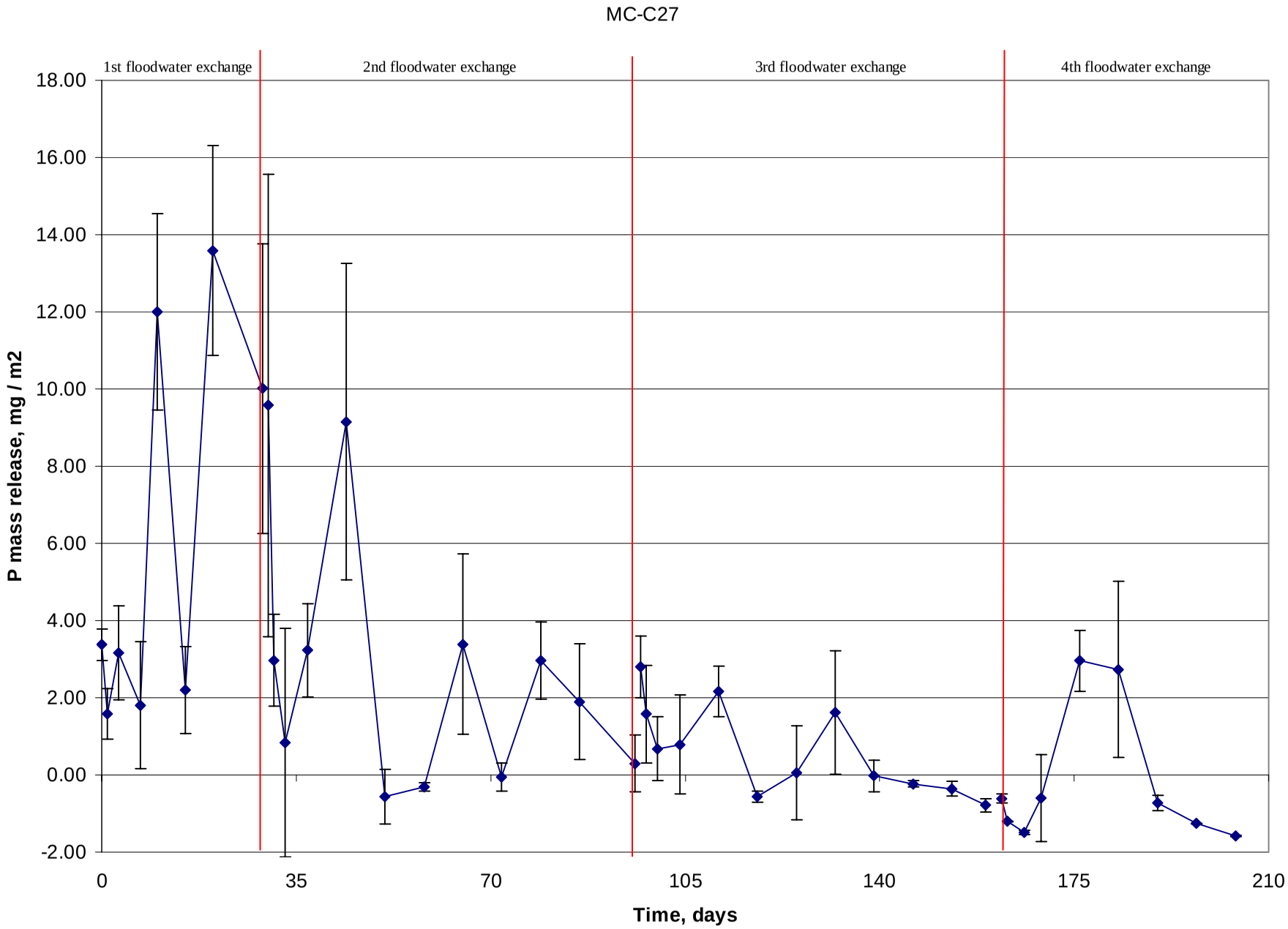

L38-C6
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

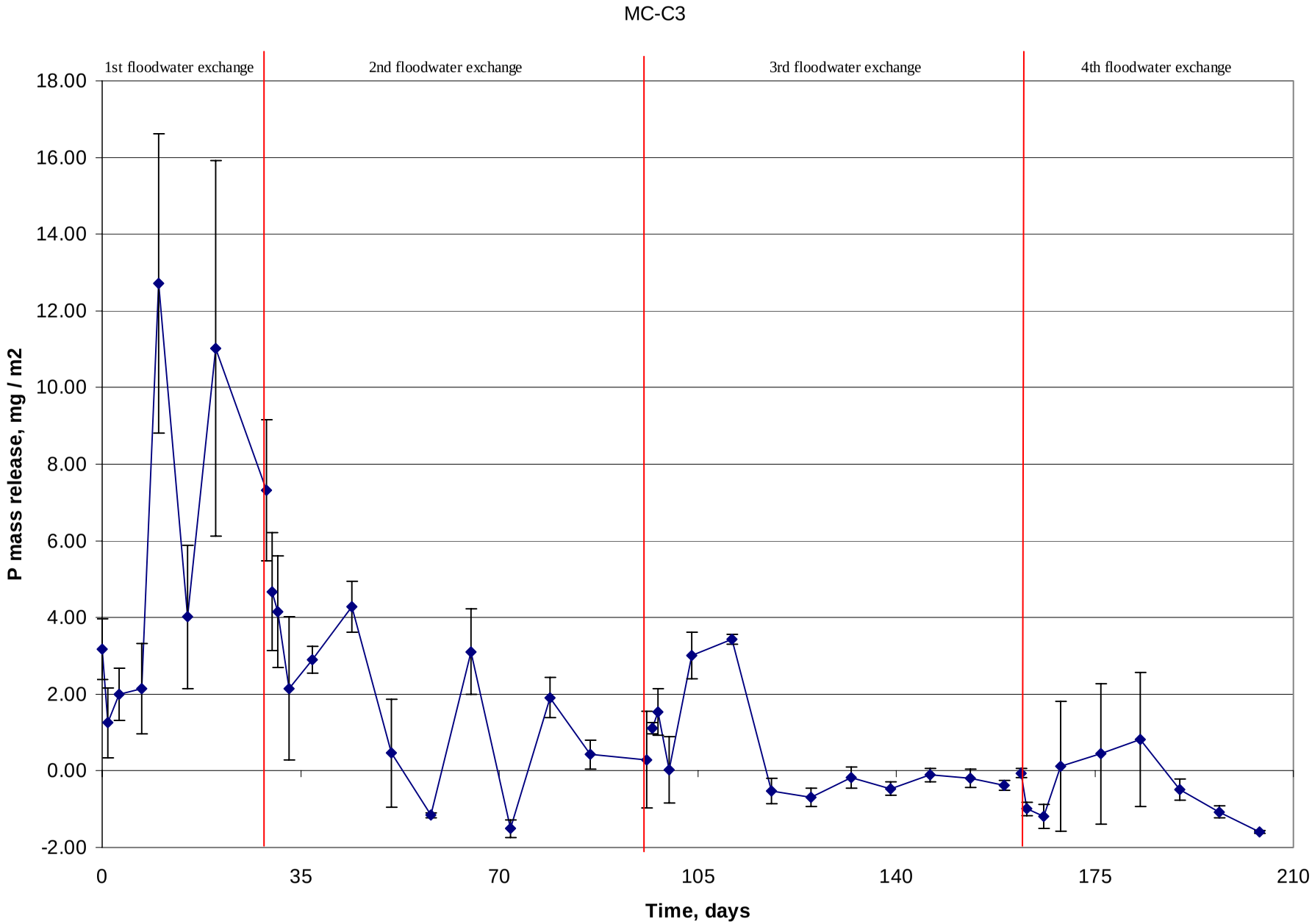

L38-C8
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

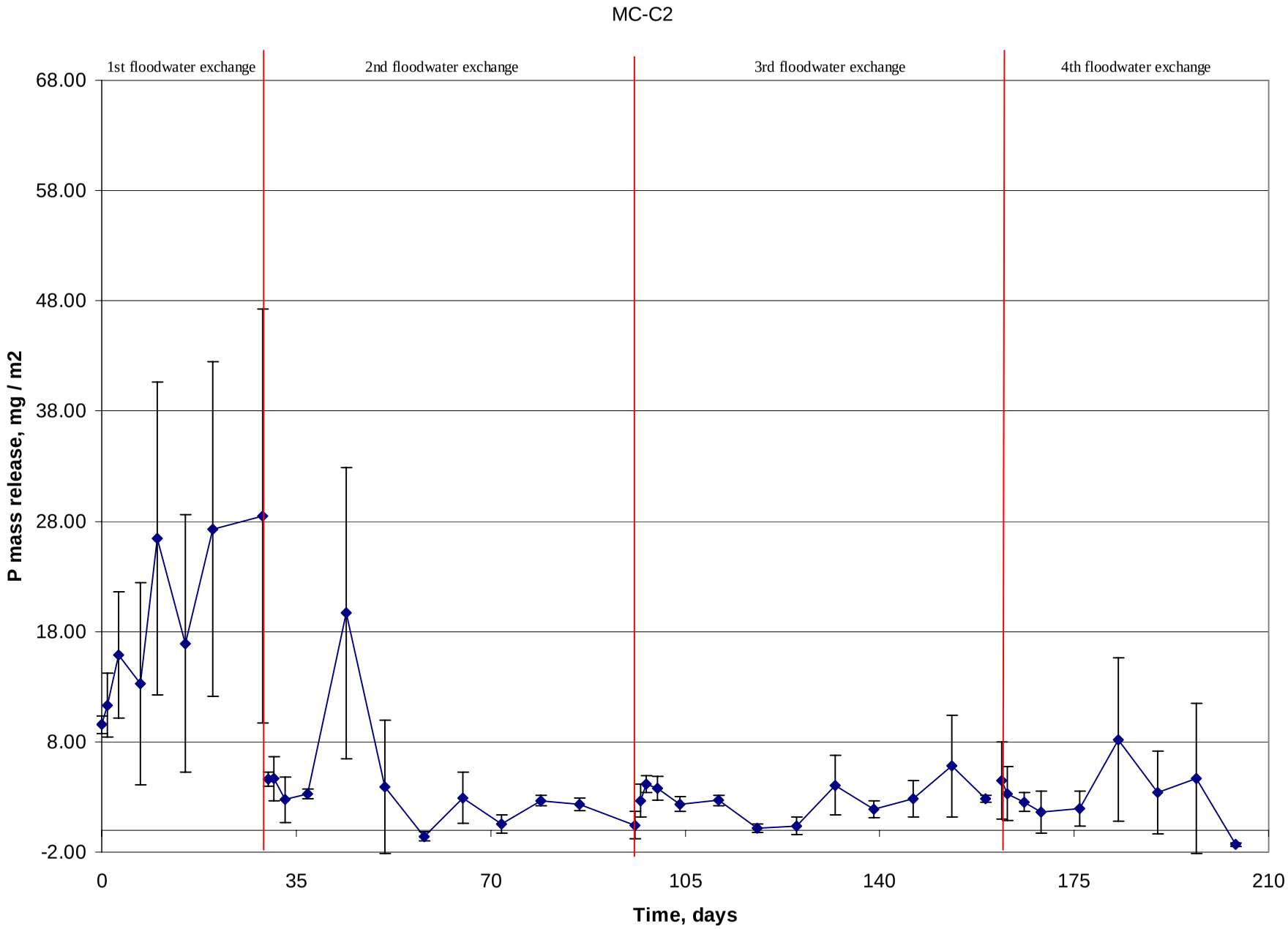

L5-C5
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

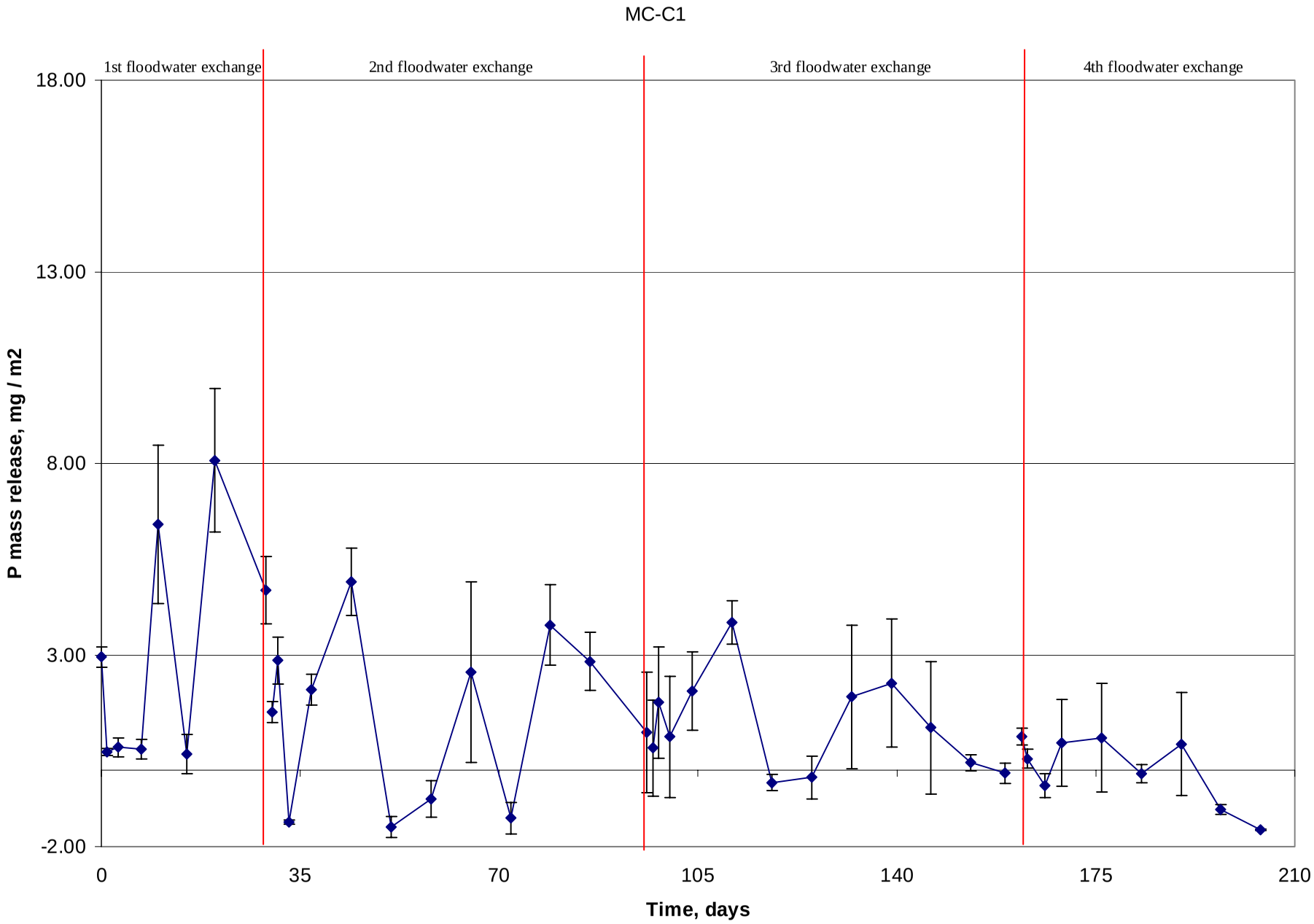

L5-C4
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
38.00
33.00
28.00
23.00
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days

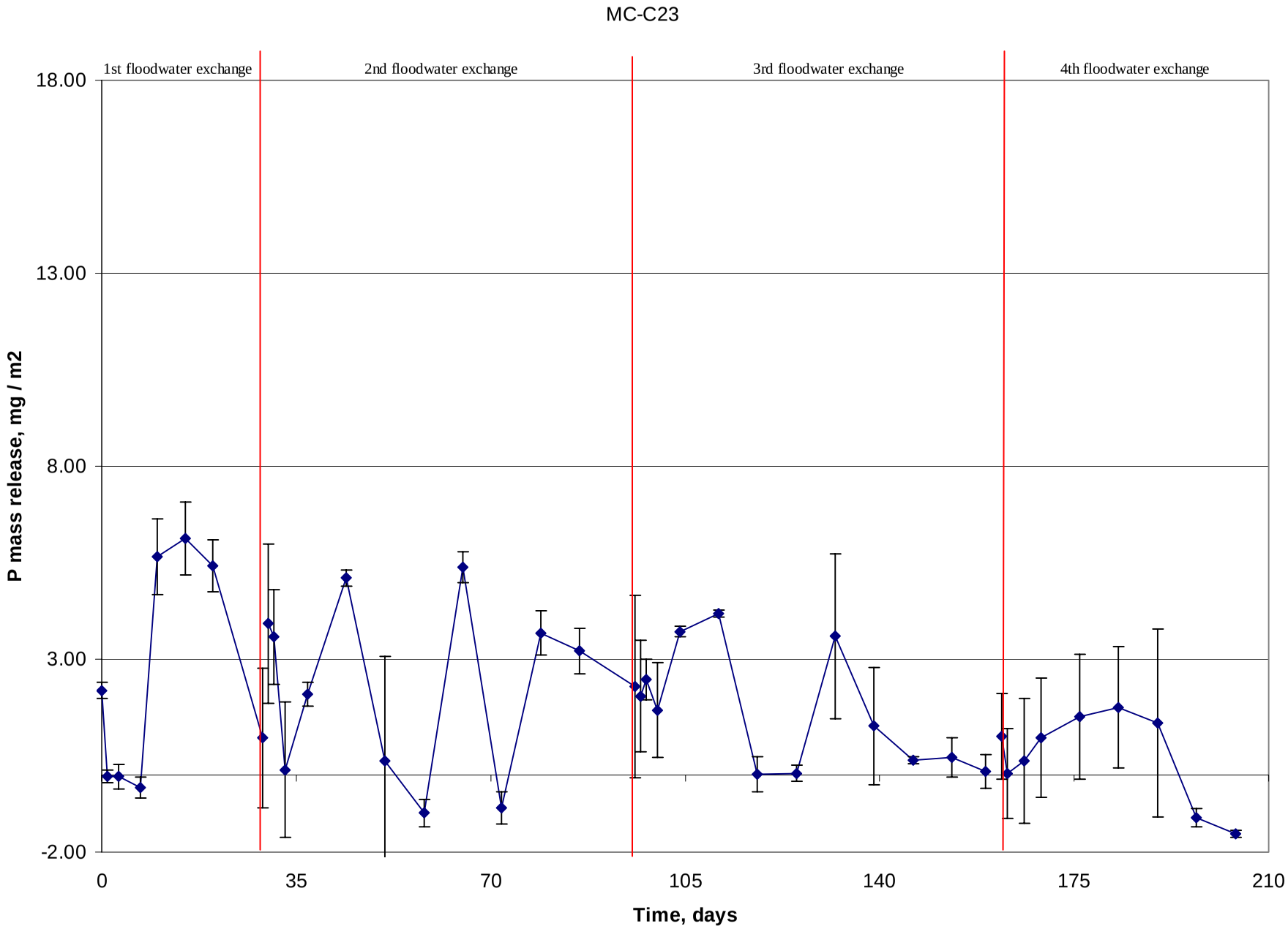

MC-C28
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
38.00
33.00
28.00
23.00
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days


MC-C27
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days


MC-C3
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days


MC-C2
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
68.00
58.00
48.00
38.00
28.00
18.00
8.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days


MC-C1
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days


MC-C23
1st floodwater exchange
2nd floodwater exchange
3rd floodwater exchange
4th floodwater exchange
18.00
13.00
8.00
3.00
-2.00
P mass release, mg / m2
0
35
70
105
140
175
210
Time, days