American Ecological Engineering Society

Journal of Ecological Engineering Design
journals.uvm.edu/jeed

Peer Review File

Coastal Stormwater Pond Age and Phosphorus Cycling within Water and Sediment

Morolake M. Fatunmbi[1], Debabrata Sahoo[2], Amy E. Scaroni[3], Calvin B. Sawyer[4], Erik Smith[5], Sarah A. White[1]

[1] Department of Plant and Environmental Science, Clemson University, Clemson, South Carolina, United States
[2] Department of Agricultural Sciences, Clemson University, South Carolina Water Resources Center, Pendleton, South Carolina, United States
[3] Department of Forestry and Environmental Conservation, Clemson University, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, South Carolina, United States
[4] Department of Agricultural Sciences, Clemson University, Clemson, South Carolina, United States
[5] School of the Earth, Ocean and Environment, University of South Carolina, Baruch Field Laboratory, Georgetown, South Carolina, United States

Revision 1 Response | May 31, 2025

Response to Reviewers

The authors are grateful to the reviewers for providing these comments and suggestions to improve the quality of this study. The following sentences have been provided to show efforts to improve the manuscript based on the comments and suggestions of the reviewers. In what follows, the reviewer's comments are reproduced in black text, with the author responses in blue and italics text.

Editor's Comment

1. I suggest avoiding the use of the term "detention" or "retention", just call them dry or wet pond. These terms mean opposite things and they are used differently through N. America. For instance, in Florida (and apparently SC) we use the terms wet detention ponds and dry retention ponds, but in Maryland they use wet retention ponds and dry detention ponds. It is confuzing!

Response: The authors appreciate the editor for this clarification, we have revised the manuscript to use the terms "wet ponds" and "dry ponds" throughout the document

Line: 94- 96

"SWPs are constructed as either dry ponds that capture and temporarily store stormwater, slowly releasing the water downstream, or as wet ponds that maintain a permanent pool of stormwater and gradually release it. In addition to retaining water, wet ponds also capture nutrients and…"

2. One reviewer mentioned the issue of dredging, which is crucial. How often were the ponds maintained? Were any of them dredged since construction? Make sure to include this information in the Study Area section and in Table 1.

Response: The author appreciates this suggestion by the editor. However, we do not have prior information of dredging done on any of these ponds. The maintenance history for these ponds were not available.

3. Redfield ratios: Mass or molar? Please specify throughout the manuscript. What thresholds did you assume to determine nutrient limitation?

Response: The authors appreciate the editor's request for clarification. Changes have been made to the manuscript to clearly state that the Redfield ratio calculations were based on molar concentrations.

Line 289-292:

"The Redfield ratio, a predictive tool for identifying nutrient limitations that may lead to eutrophication in aquatic environments (Redfield 1958), was calculated based on molar concentration to determine the limiting TN and TP in each pond age category."

We also used the standard molar threshold to assess nutrient limitation where N:P <10 indicates nitrogen limitation and N:P between 10 - 20 indicates balanced or co limitations as established by literatures. A footnote has been added to table 2 to clarify this.

Line 434 – 436:

Nutrient limitation was assessed using the standard threshold N:P <10 indicates nitrogen limitation and N:P between 10-20 indicates balanced nutrient, and N:P >20 indicates phosphorus limitations

Reviewer 1 | Anand Jayakaran and Lea Wilson

Comments: A primer/reminder on the different forms in which phosphorus may enter this system, how it is transformed between forms, and which forms are plant-available would be helpful.

Response: The authors appreciate the reviewer, and additional information has been included in the introduction to briefly discuss phosphorus forms and fractions in ponds as quoted below.

Line: 120-129

"P is a key nutrient of concern in SWPs and is mainly classified into organic and inorganic forms, and they are broadly classified into particulate and dissolved fractions (Reddy et al. 1999). Particulate P is typically bound to sediments or organic matter and is mostly unavailable for plant uptake, while the dissolved P is the form readily available for plant and algal uptake (Tipping et al. 2014; Lin et al. 2018). Although P can exist in forms and fractions that are initially unavailable for use by plants or aquatic organisms, changes in environmental conditions, such as redox changes, pH shifts and microbial activities, can cause transformation in P form into bioavailable P (Zhou et al. 2005; Hupfer and Lewandowski 2008; Lusk and Chapman 2021), which can be remobilized and re-released back into water bodies, leading to internal P load in SWP (Frost et al. 2019)."

Comments: The authors emphasize that the systems of interest to them are coastal SWPs. The introduction, however, does not explore how coastal SWPs may be unique and understudied, or suggest what the specific consequences of that knowledge gap are for coastal ecosystems. It would be useful to expand a little more about how coastal stormwater ponds might differ from their inland counterparts.

Response: The authors appreciate the reviewer. The introduction section has been improved to include discussions of the importance of coastal stormwater pond system and their implication to coastal water bodies as shown below;

Line 101- 106:

"In coastal environments, where land use developments constantly change and intense storm events are common, SWPs are installed to help delay time to peak flow, reduce nutrient loading to downstream aquatic systems by capturing and temporarily storing stormwater (Schroer et al. 2018). These SWPs facilitate the settling of suspended solids and promote biogeochemical processes that reduce the concentration of pollutants (Yang and Lusk 2018)."

Line 163- 165:

"Coastal SWPs are particularly vulnerable to nutrient enrichment due to shallow groundwater tables, tidal influence and their proximity to developed areas (Beckingham et al. 2019)"

Comments: A little more effort in the Conclusions section on how pond management might be informed by this work would be beneficial to JEED readers.

Response: The authors appreciate the valuable suggestions. In response, we have added a new paragraph to the conclusion section, highlighting how our findings can guide pond management strategies.

Line 527-546: "Our findings emphasize the importance of pond age as an important factor to consider for SWPs system management as it influences nutrient retention, accumulation and potential releases.

While seasonal changes had nearly no effect on most of the measured parameters, nutrients and ion concentrations were significantly influenced by the structural and ecological maturity of SWPs. The observed variations in the physicochemical properties across SWP categories suggest that these SWPs undergo distinct functional transitions as they age. Young ponds will likely benefit from any early intervention, such as vegetative planting, floating treatment wetlands, to enhance nutrient uptake capacity. Middle–age SWPs seemingly appear to function optimally in terms of nutrient retention and reduction, suggesting a possible lifespan target for peak performance. Old ponds may require time to time dredging to maintain nutrient removal efficiency. It is important to note that management strategies, particularly involving sediment removal from ponds (dredging) might disrupt or reset natural sediment-water interactions and biota community (Søndergaard et al. 2003; Lürling and Faassen 2012; Cooke et al. 2016). As a result, the SWPs operational state might not necessarily align with its construction date. This emphasizes the need to differentiate between SWPs ecological and chronological ages when assessing their performance. Generally, future assessment and monitoring initiatives should consider SWP's maintenance history in addition to construction dates to more accurately characterize the ecological performance of SWP. Additionally, management practices should be adopted for SWPs based on their ecological age and should be supported by external management practices, including source control measures to help sustain water quality over time."

Comments: The stated variable of interest in this study is the age of the SWP which raises a couple of issues. One of the management techniques the authors highlight is "regularly removing deposited sediments to maintain storage capacity." With regular dredging, the construction date of the facility might not match the "ecological age" of the stormwater pond. Maintenance practices, perhaps combined with age, may be a more relevant study variable. I suggest the authors address the issue that maintenance might be resetting some ecological processes that might otherwise be self-designing or attaining some sort of equilibrium had it not been for maintenance like dredging.

Response: The authors appreciate the reviewer and has adopted the suggestion into the conclusion section of the article.

Line 537-544:

" It is important to note that management strategies, particularly involving sediment removal from ponds (e.g., dredging), might disrupt or reset natural sediment-water interactions and biota community (Søndergaard et al. 2003; Lürling and Faassen 2012; Cooke et al. 2016). As a result, the SWPs operational state might not necessarily align with its construction date. This emphasizes the need to differentiate between SWPs ecological and chronological ages when assessing their performance. Generally, future assessment and monitoring initiatives should consider SWP's maintenance history in addition to construction dates to more accurately characterize their ecological performance".

Comments: The second stated objective is to determine "whether benthic sediment is a source or sink for phosphorus in the water column". Especially considering that the authors include soil texture in their later

analysis, some conjectures on which SWP qualities (perhaps soil texture, depth, temperature) are likely to influence phosphorus sorption or desorption to/from sediment would be helpful.

Response: To address these comments, we have included statements on how sediment particle size can play roles in P dynamics, along with several factors initially stated in the article.

Line 145-147:

"Effective management of SWPs to remove total phosphorus (TP) depends on several factors (Janke et al. 2021). For instance, soil texture can affect P binding capacity, with finer particle sizes offering greater surface area for sorption than coarser sandy sediments (Zhou et al. 2005)."

Comments: The results and discussion section needs more discussion. As an example, the authors report that temperature was similar between age classes during the same season then provide a single sentence noting other research has found pond depth, surrounding landscape (i assume land cover), and season affect pond temperatures. The reader is left asking, "yes, and….?" Was the summer temperature of 30-32 C higher than expected? Lower? How do the authors think that pond depth or landscape might be impacting the temperatures in their study? And how does that link back to their main objective of understanding phosphorus cycling in stormwater ponds through time?

Response: The authors appreciate the reviewer and have implemented several changes to the discussion to improve the section as suggested by the reviewer. Changes that were made to the discussions are highlighted in detailed reviews below.

Line 319-326:

"Pond depth particularly affects how the water body is influenced by atmospheric conditions, shallow ponds tend to be warmer and cool more rapidly than deeper ponds, which are less affected by daily temperature fluctuations due to the surface area to volume ratio(Nelson and Palmer 2007). However, deeper ponds may develop thermal stratification with warmer water at the surface and cooler layers below (Song et al. 2013). P cycling in SWP can be influenced by variation in temperature. Warmer surface temperature in shallow ponds can increase microbial activities, mineralization of organic matters and aid release of P from sediments (Wu et al. 2014). In stratified ponds, bottom layers of the water column may become anoxic and can enhance dissolution of iron-bound P, leading to internal P loading from sediments (McEnroe et al. 2013; Wang et al. 2024)."

Graphical abstract – add the numerical year ranges from this study for each age group. So add "young-aged ponds (0 to 5 years)" as the label. With the year range listed, you might even drop the awkward "aged" from the label – so simply "young ponds (0 to 5 years)"

Response: Changes have been made to the graphical abstract to implement suggestions made by the reviewer.

Graphical Abstract

[image]

Lines 102-109 describing sources of excess nutrient loading are somewhat redundant given lines 72-75.

Response: Lines 102-109 (in the previous document) were removed. It contained the statement "When managing the landscape of urban or developing areas, fertilizers with nitrogen (N) and phosphorus (P) are often applied to yards and lawns to enhance their visual appeal and beauty (Toor et al. 2017). Sometimes the fertilizer

applied is neither completely absorbed by the plants nor by the soil. Unassimilated N and P are carried into the stormwater ponds via runoff, increasing the nutrient load and potentially degrading water quality (Hobbie et al. 2017; Toor et al. 2017). Pet waste, grass clippings, and leaf litter also contain significant levels of nutrients that can contribute to nutrient loads in SWPs when carried by stormwater runoff (Hobbie et al. 2017; Yang and Lusk 2018)"

Line 124 – citation needed

Response: Citation was included to the statement.

Line 145

" Effective management of SWPs to remove total phosphorus (TP) depends on several factors (Janke et al. 2021)."

Janke BD, Natarajan P, Shrestha P, Taguchi VT, Finlay JC, Gulliver JS. 2021. Detecting phosphorus release from stormwater ponds to guide management and design. https://www.wrc.umn.edu/projects/storm-waste-water.

Figure 1 - Pond locations not very clear in the map - maybe make circles bigger. Apart from showing where in SC the sites are located, what is the point in showing the mid-scale map - could it not be eliminated?

Response: The authors appreciate the recommendations for the study area map and the suggestion has been implemented to improve the maps to show clearer points of the study locations

[image]

Figure 1. Charleston map showing the selected nine coastal stormwater ponds, between 2- 15 years of age, all located within residential areas.

Comments: The authors state that O3 was removed due to suspected saltwater intrusion. However, measurements for O3 are included in Table 3 and Table 4. This makes it unclear whether and for which calculations O3 was excluded.

Response: The author appreciates the reviewer for seeking clarification. For the purpose of general water quality, the O3 pond was removed from the assessment. However, EPC0 was assessed on individual SWPs, including O3, and hence included in Tables 3 and 4. We have provided this sentence in the manuscript to highlight this.

Line 307-309:

"As such, O3 values were considered outliers and excluded from water quality assessment to avoid skewing results and ensure an accurate representation of conditions measured in the Old SWP category (n =2 going forward)".

Lines 199-203 - part of the water sampling methods have ended up in the sediment sampling section. Consider compiling methods by medium being sampled.

Response: The author appreciates the reviewer for their observation. To estimate EPC0, water samples from the ponds were used to prepare stock solutions, and the description was included in the sediment analysis and laboratory procedure section. However, changes have been made for clarification purposes:

Line 228:

"… To prepare phosphate stock solution for sediment P interaction, two 1-liter water samples were also collected from each SWP section…"

Table 1 - seems like the ages are off by two years. If sampling was in 2023, then the age of Y1 should be 5 years. Also, do you have sediment depths for the ponds? Those data in Table 1 would corroborate the opening graphical abstract.

Response: Corrections have been made to the tables to reflect the accurately estimated year. The average depth of each pond was also included in the table.

Table 1. Description and characteristics of selected coastal stormwater ponds.

[revised table]

Line 194 – Is a jon boat different from a flat bottomed motorless boat? I would just use one term if both are the same.

Response: Correction was made to chang "flat bottomed motorless boat" to "jon boat"

Line 206: "A jon boat was used to access the sites within each SWP."

Line 215 – rewrite "After properly shaken,…"

Response: The sentence has been changed

Line 244: "After proper shaking…"

Line 222 – change "loos" to "loss"

Response: The author thanks the reviewer for their observation. The spelling has been changed from loos to "loss"

Line 251: "…content using loss on ignition method"

Line 256 – Chemical seems redundant when physicochemical is also listed

Response: The authors agree with the reviewer.

Line 286: "Physicochemical" was retained and chemical removed from the sentence

Line 265 - The authors simply say there is a significant relationship but the importance of the pairwise test is made clear here: there is something going on with the middle-aged pond specifically. Young and Old do not appear to be significantly different. The Middle-age plots in Figure 4 also stand out in terms of a wide range of sulfate values, low Nitrate/Nitrite, and winter fluoride. An exploration of why the medium-aged facilities is so different should be explicit in the discussion.

Response: Additional discussion was made here to explain the behavior observed in SWP.

Line 390-392:

"…suggesting that the SO42- dynamics may be influenced by stable external input such as atmospheric deposition (Berner and Berner 2012) or they might be less transported into the system".

Line 401-404:

"Likely suggest that Middle age ponds may have attained equilibrium between external inflow and internal loading where microbial organisms and established vegetation may facilitate N removal (Hohman et al. 2021). This might indicate some potential functionality peak in N processing capacity during this stage of SWPs."

Line 412- 414:

"This pattern suggests a possible P retention period in the Middle age SWPs, where sediments are still capable of effectively binding P and internal loading is reduced."

A broader explanation was included in the conclusion section to explain the observations that were made in middle-age ponds.

Line 527-537:

"Our findings emphasize the importance of pond age as an important factor to consider for SWPs system management as it influences nutrient retention, accumulation and potential releases.

While seasonal changes had nearly no effect on most of the measured parameters, nutrients and ion concentrations were significantly influenced by the structural and ecological maturity of SWPs. The observed variations in the physicochemical properties across SWP categories suggest that these SWPs undergo distinct functional transitions as they age. Young ponds will likely benefit from any early intervention, such as vegetative planting, floating treatment wetlands, to enhance nutrient uptake capacity. Middle – age SWPs seemingly appear to function optimally in terms of nutrient retention and reduction, suggesting a possible lifespan target for peak performance, Old ponds may require time to time dredging to maintain nutrient removal efficiency."

Line 289 – First sentence in this paragraph needs to be written as a complete sentence for easier reading.

Response: Correction was made to this section, "was" has been removed to improve the grammar.

Line330: "DO differed by age ($p = 0.006$) and season ($p < 0.0001$) (Figure 3b)."

Line 303 – "…. contribute to higher specific conductivity in older ponds compared to younger ones." - This does not explain why middle age ponds have the lowest sp. cond.

Response: Additional discussion has been included to provide more explanations.

Line 353-355:

"In contrast, middle-aged SWP may represent a transitional phase where flushing processes and vegetation uptake help regulate and improve concentrations."

Figure 3 - Provide the n for each category of box plots. I am assuming each age/season boxplot comprises 3 values, (3 ponds per age group * 1 reading per season). Is that right? Better to state explicitly so reader isn't doing

their own math. However, if I am right and there are only 3 readings per boxplot - then I recommend not using boxplots because they are not appropriate for such small datasets. Consider just showing all three data points, or a stem-leaf plot.

Response: The author thanks the reviewer, regarding the appropriateness of boxplots given the small sample size, each pond age/season category in the boxplots represents three ponds (three ponds per age group × one measurement per season). However, 3 measurements were taken on each pond (inlet, middle and outlet), given 9 measurement values for each pond categories hence why we used box plot. For clarification, we have provided additional details to the data analysis section

Line 286-288:

". Each SWP was sampled at three locations (inlet, middle, and outlet) providing a total of nine measurements per pond age per season." And the caption for the figure has been revised to include the following below "For each box plots in the young and middle age category, n= 9, representing 3 ponds * 3 measurements (inlet, mid and outlet). For the old age category box plots n = 6, representing 2 ponds * 3 measurements (inlet, mid and outlet)."

Figure 3. Box plot of physicochemical measurements in stormwater pond water columns, categorized by pond age and sampling season. For each box plots in the young and middle age category, n= 9, representing 3 ponds * 3 measurements (inlet, mid and outlet). For the old age category box plots n = 6, representing 2 ponds * 3 measurements (inlet, mid and outlet).

[revised figure 3]

Reviewer 2 | Anonymous

Comments: Several areas in the paper can be improved such as more specificity in the abstract regarding number of water samples and sediment cores collected. In addition to this, while pond age is a major focus in this research study, it is not discussed thoroughly in the introduction. Why should we focus on pond age? It is recommended to expand on the limited literature that is available on the role of stormwater pond age on cycling nutrients or general pollutants in stormwater ponds and connecting waterbodies.

Response: The author appreciates the reviewer for their recommendation on improving the abstract. The abstract section has been amended to include more information on sampling methodology, this line has been added to the abstract;

Line 56-58:

"Water samples and sediment cores were collected from 3 different sections of each SWP in summer 2023 and winter 2024 to assess temporal variation in water quality. "

Line 60- 64:

"Old SWPs had higher total P and nitrogen levels, indicating accumulations of nutrients over time, while lower nutrient levels measured in Middle-age SWPs showed indications of enhanced nutrient sediment processing. EPC0 measurements showed sediments in all ponds served as a source of P, releasing P back into the water column, contributing to internal P loading."

Literature has been included in the introduction to highlight "limited literature" on the importance of assessing pond age and provide more expansion on nutrient cycling in SWPs. The sentence below has been added to the introduction to improve this section.

Line 158-160:

"However, as SWPs age, their physical structure, biota community and biogeochemical processes will begin to change, potentially altering the sediment capacity to retain or release P (Taguchi et al. 2020)".

Comments: Lastly, the conclusion can be improved to provide more management recommendations based on the findings of this study. Leaving a vegetative buffer around the edge of stormwater ponds is a commonly recommended practice for management. What else can be recommended? Are there any recommended vegetative species to plant, especially based on salt tolerance?

Response: The authors appreciate the reviewer for these insights. An Additional paragraph has been included in the conclusion to improve the quality.

Lines 527-546:

"Our findings emphasize the importance of pond age as an important factor to consider for SWPs system management as it influences nutrient retention, accumulation and potential releases.

While seasonal changes had nearly no effect on most of the measured parameters, nutrients and ion concentrations were significantly influenced by the structural and ecological maturity of SWPs. The observed variations in the physicochemical properties across SWP categories suggest that these SWPs undergo distinct functional transitions as they age. Young ponds will likely benefit from any early intervention, such as vegetative planting, floating treatment wetlands, to enhance nutrient uptake capacity. Middle–age SWPs seemingly appear to function optimally in terms of nutrient retention and reduction, suggesting a possible lifespan target for peak performance. Old ponds may require time to time dredging to maintain nutrient removal efficiency. It is important to note that management strategies, particularly involving sediment removal from ponds (dredging) might disrupt or reset natural sediment-water interactions and biota community (Søndergaard et al. 2003; Lürling and Faassen 2012; Cooke et al. 2016). As a result, the SWPs operational state might not necessarily align with its construction date. This emphasizes the need to differentiate between SWPs ecological and chronological ages when assessing their performance. Generally, future assessment and monitoring initiatives should consider SWP's maintenance history in addition to construction dates to more accurately characterize the ecological performance of SWP. Additionally, management practices should be adopted for SWPs based on their ecological age and should be supported by external management practices, including source control measures to help sustain water quality over time.".

Line 36- The graphic abstract is hard to understand. The ponds' water quality parameters are divided into summer and winter however, seasonality is not mentioned in the abstract. Either the abstract would need to be amended to reflect the graphic abstract or vice versa. What do the arrows in the graphic abstract mean?

Response: The abstract has been amended to include similar details provided in the graphical abstract. The arrow in the graphical abstract helps to indicate the levels of each measured parameter in each SWP category per season.

Graphical Abstract: [image]

Line 50- Add specificity in terms of the number of water samples and sediment cores collected.

Response: The authors thank the reviewer for their suggestions. The abstracts has been amended to include more information on the sampling strategy. Providing an exact number of water samples in the abstract may be confusing due to varying sample volumes and bottles used to collect the samples for the various analyses. However, we have clarified the sampling design to improve the abstract. We have now stated that water and sediment samples were collected from three sections of each pond during two sampling seasons.

Line 56-58:

"Water samples and sediment cores were collected from three different sections of each SWP in summer 2023 and winter 2024 to assess temporal variation in water quality."

Line 92- Remove the slash between "land-altering/development".

Response: The slash in between the words "land-altering/development" was removed and replaced with "and".

Line 108:

"…regulatory requirements for land-altering and development activities."

Line 136-137- While we know that the literature is limited on the role of pond age on stormwater pond dynamics, it is important to reference the limited literature. Prior to this line, there has been no discussion on pond age.

Response: Additional lines to improve on the introduction section and discussion on pond age has been included to the introduction and literature were added to highlight the gap in the study

Lines 158- 165

"…(Frost et al. 2019; Vinicius J Taguchi et al. 2020; Janke et al. 2021). However, as SWPs age, their physical structure, biota community and biogeochemical processes will begin to change, potentially altering the sediment capacity to retain or release P (Taguchi et al. 2020). Despite its importance, very little is known about how pond age influences sediment characteristics, water quality, or P-cycling dynamics within SWPs particularly in coastal environments (Mallin et al. 2002; Kaye et al. 2006; Song et al. 2013; Schroer et al. 2018) . Coastal SWPs are particularly vulnerable to nutrient enrichment due to shallow groundwater tables, tidal influence and their proximity to developed areas (Beckingham et al. 2019). "

Line 155- Overall, Figure 1 is well-made. However, the symbols for the ponds are very small and hard to identify. I recommend either making them larger or assigning a different shape to each pond age category to distinguish them from one another. I also recommend adding labels (i.e. Y1, Y2, M1, O1, etc…) to each stormwater pond. Please also specify where the coastline lies, and which areas are ocean.

Response: The authors appreciate the recommendations for the study area map and the suggestion has been implemented to improve the maps to show clearer points of the study locations.

[revised image]

Figure 1. Charleston map showing the selected nine coastal stormwater ponds, between 2- 15 years of age, all located within residential areas.

Line 172- Great work on the methodology and analysis portion of this paper. My recommendation for this line is to provide a reference to justify how dividing each SWP into 3 sections to account for spatial variability is appropriate.

Response: The authors thank the reviewer for their recommendations. Reference has been added to this section.

Lines 200-201

"…Each SWP was divided into 3 sections (inlet, mid-point and outlet) where samplings were carried out to account for spatial variabilities (Kermorvant et al. 2019)."

"Kermorvant C, D'Amico F, Bru N, Caill-Milly N, Robertson B. 2019. Spatially balanced sampling designs for environmental surveys. Environ Monit Assess. 191(8). doi:10.1007/s10661-019-7666-y."

Line 289- Grammar mistake. Take out "was".

Response: Correction was made to this section, "was" has been removed to improve the grammar.

Line 330: "DO differed by age ($p = 0.006$) and season ($p < 0.0001$) (Figure 3b)."

Lines 296-298- The last line starting with "pH did not vary between summer and winter…" is a bit confusing. I recommend breaking this into two sentences.

Response: Changes were made to this section to give more clarity as recommended by the reviewer.

Lines 337-339:

"…pH did not vary between summer and winter ($p = 0.5$), but did differ by pond age ($p = 0.0001$), with middle age pond having the highest pH-values reported in summer but not winter (Figure 3c) potentially indicating increased biological activities with changes in buffering capacities in SWPs during warmer months."

Line 337- Missing "u" in Fluoride.

Response: The authors appreciate the reviewer for their observation. The spelling of Floride was changed to "Fluoride".

Line 419:

"Figure 4. Boxplot showing water quality data of (a)Chloride (b)Fluoride (c)Sulfate, (d)Ammonia-N (e)Nitrate + Nitrite – N (f)Total Nitrogen (g)SRP (soluble reactive phosphorus)…"

Line 410- Conclusion. As mentioned above, the conclusion can be further improved by providing more management recommendations based on the results of this study. What can be done now that we know that sediments served as a source of P to the water column?

Response: Additional section was added to the conclusion to cover more details on management recommendations.

Lines 527-546:

"Our findings emphasize the importance of pond age as an important factor to consider for SWPs system management as it influences nutrient retention, accumulation and potential releases.

While seasonal changes had nearly no effect on most of the measured parameters, nutrients and ion concentrations were significantly influenced by the structural and ecological maturity of SWPs. The observed variations in the physicochemical properties across SWP categories suggest that these SWPs undergo distinct functional transitions as they age. Young ponds will likely benefit from any early intervention, such as vegetative planting, floating treatment wetlands, to enhance nutrient uptake capacity. Middle–age SWPs seemingly appear to function optimally in terms of nutrient retention and reduction, suggesting a possible lifespan target for peak performance. Old ponds may require time to time dredging to maintain nutrient removal efficiency. It is important to note that management strategies, particularly involving sediment removal from ponds (dredging) might disrupt or reset natural sediment-water interactions and biota community (Søndergaard et al. 2003; Lürling and Faassen 2012; Cooke et al. 2016). As a result, the SWPs operational state might not necessarily align with its construction date. This emphasizes the need to differentiate between SWPs ecological and chronological ages when assessing their performance. Generally, future assessment and monitoring initiatives should consider SWP's maintenance history in addition to construction dates to more accurately characterize the ecological performance of SWP. Additionally, management practices should be adopted for SWPs based on their ecological age and should be supported by external management practices, including source control measures to help sustain water quality over time.".

Reviewer 3 | Lauren McPhillips

This study evaluates water quality parameters, with a particular focus on phosphorus, in wet stormwater ponds in coastal South Carolina. In general, there are some useful insights, and the paper is well written. However, some additional details need to be provided on water sampling methods, as well as statistics- specifically, there is an assumption that observed patterns are due to pond age, but it seems like there could be some more robust evaluation to better confirm that there aren't other possible explanatory factors. Additionally, there is some similar work in other locations (e.g. Minnesota via Taguchi et al 2020 and other papers/reports by Gulliver et al.) that could be more deeply discussed and compared with this work to deepen overall understanding of phosphorus dynamics in stormwater ponds. Given the journal focus, there could also be more discussion of implications for pond design and management.

Response: The authors appreciate the reviewer for their recommendation, and changes have been implemented as recommended to the general body of the manuscript. Details of changes made are highlighted below.

line 68- suggest changing 'peak flow time' to 'time to peak flow'

Response: Changes were made, and 'peak flow time' was changed to 'time to peak flow'

Line 78-79: "Urban expansion also compresses the time to peak flow, increases flashiness, and increases peak flow…"

line 86- this wording about wet ponds storing water temporarily makes them sound the same as dry ponds. I suggest modifying to something that mentions more extended detention with a permanent pool.

Response: The authors appreciate the reviewers' suggestions for clarification between wet ponds and dry ponds. Changes have been made to provide clarification between wet ponds and dry ponds

Lines 94-96:

"…SWPs are constructed as either dry ponds that capture and temporarily store stormwater, slowly releasing the water downstream; or as wet ponds which maintains a permanent pool of stormwater and gradually release it"

line 89- this feels a bit misleading to me- stormwater ponds are designed to mimic ponds more than wetlands (due to their bathymetry)- there is a separate group of designs for stormwater wetlands.

Response: The authors appreciate the reviewer for their observation. In these sentences, our intent is to emphasize the ecological function provided by SWPs and wetlands. However, to avoid confusion, the statement has been revised.

Line 99-101:

"SWPs are constructed to mimic some of the ecological services provided by natural wetlands such as reduction of flood risk and water filtration, but do not necessarily offer the same ecological benefits as natural wetlands (Perron and Pick 2020; Sinclair et al. 2020)"

line 93-95- I suggest a bit clearer wording here- this implies that all runoff is supposed to be permanently retained at the site. But unless there is 100% infiltration and ET, that isn't true. Also, typically peak flow reduction is the primary goal of wet ponds. I suggest including this reference by Lusk et al. that talks about this and differences with wetlands, and other relevant insights to this study (https://www.sciencedirect.com/science/article/pii/S030147972500146X)

Response: The author thanks the reviewer for their recommendation, the wording in this paragraph has been revised to provide more clarifications on the use of SWPs and additional reference was cited

Line 103- 105:

"SWPs are installed to help delay time to peak flow, reduce nutrient loading to downstream aquatic systems by capturing and temporarily storing stormwater (Schroer et al. 2018; Lusk et al. 2025). "

Line 107-108:

"…In South Carolina, SWPs are constructed not only to control flooding but are also mandated to comply with regulatory requirements for land-alteration and development activities."

line 97- suggest adding sediment to organic matter and high nutrient loads

Response: Sediment was added as suggested to the section

Line 113: "…One of the major challenges to SWP function is the accumulation of sediment organic matter and high nutrient loads from runoff…"

line 112-114- this line is confusing as the first part states PO4 as a concern, then then the second part implies that it is not a concern (sorbed well, not leached)

Response: The authors appreciate the reviewer. The statement has been revised to clarify these contradictions. An additional line has been added for further clarification

Line 130-134:

"Phosphate (PO4-P) is often considered a major concern for surface runoff due to its binding affinity with soil iron and calcium which limits its leaching potential into groundwater (Hartshorn et al. 2016). However, it can be transported in particulate form, attached to eroded soil and released into water bodies under changes in environmental conditions that break its binding."

line 136- glad to see some important refs mentioned like Taguchi et al. 2020. Given the similarity of the Taguchi study to yours, it would be good to have more in depth discussion (perhaps later in the results) of similarities and differences to what they observed in water and sediment P patterns.

Response: The author appreciates the reviewers' recommendations. Additional discussions have been included to cover some similarities and changes in patterns comparing previous studies. These changes have been highlighted in the comments below.

Line 472-474:

"This internal P release from sediments, especially in older ponds, has been shown in earlier studies to contribute significantly to higher chances of eutrophication, particularly in warm and deoxygenated conditions (Søndergaard et al. 2003; Taguchi et al. 2020)."

Line 477-478:

"Previous study by (Janke et al. 2022) similarly noted that biological assimilations can temporarily mask the effect of internal P loading in SWPs."

line 146- there are at least two spots where there is an error noted for a parenthetical reference

Response: The authors thank the reviewer for pointing this out. The line highlighted by the reviewer falls within the study area description section, where there was no reference included. However, the authors have carefully gone through the references in this manuscript to ensure all in-text citations and bibliography are correct and adhere to the journal's referencing style.

Figure 1- just FYI, the colors are completely indistinguishable in greyscale. you might consider alternate options (and it's a bit un-intuitive to have green as developed areas)

Response: The authors appreciate the recommendations for the study area map and the suggestion has been implemented to improve the maps to show clearer points of the study locations

[image]

Figure 1. Charleston map showing the selected nine coastal stormwater ponds, between 2- 15 years of age, all located within residential areas.

Table 1- It would be helpful to also report on the ratio of drainage area: pond area. You might also consider reporting the median value for each column at the bottom so it is a bit easier to tell how much variation there is amongst the different sites and age groupings.

Response: The authors appreciate the reviewer's suggestions regarding the drainage to pond ratio. A column containing estimated ratio of drainage area to pond area has been included to the table. Median for each column on the table has also been created by pond age

page 10- more detail is needed about water sampling. What depth/ where in the water column was the water sample taken? This could affect the results depending on if water is well mixed or stratified, and oxygen status could in turn affect P availability. How many water samples were taken per pond?

Response: The authors appreciate the reviewer's recommendations and request for clarifications. Water samples and measured parameters were collected and measured from 3 different locations on each pond: the inlet, middle, and outlet. The exact depth at which water samples were collected was not measured but all water samples were collected and measured from top 10 cm of the water column.

Line 206-208:

"From each pond section, subsurface water samples were collected from the top 10cm, into 3 250ml HDPE sample bottles, using the grab sampling method for analysis of water quality indicators and nutrient levels following the protocols prescribed by the Arkansas Water Resources Center."

line 199- it is confusing to mention water sampling again, but I think this sampling is for the sediment incubations. Make sure to make the various types of sampling clear.

Response: The author appreciates the reviewer's request for clarification. All water samples collected were mentioned in the water sampling section.

Line 206- 208:

"From each pond section, subsurface water samples were collected from the top 10cm, into 3 250ml HDPE sample bottles…"

And Line 219- 220:

"An additional 2L of water sample was collected from the same depth to carry out laboratory EPC0 analysis.

Line 228 has been included for further clarification:

"To prepare phosphate stock solution for sediment P interaction, two, 1-liter water samples were also collected from each SWP section"

line 207- define what EPC0 is.

Response: The authors appreciate and agree with the reviewer and the definition of EPC0 has been included

Line 235- 238:

"EPC0 is described as the concentration of dissolved P in the water at which there is no net exchange of P between the sediment and overlaying water column, this means the point at which sediments neither adsorbs nor releases P"

line 221- did you also analyze sediment P concentration?

Response: The authors appreciate the reviewer. Sediment P concentration was not measured in our research.

line 290- remove 'was'

Response: Correction was made to this section, "was" has been removed to improve the grammar.

Line330: "DO differed by age ($p = 0.006$) and season ($p < 0.0001$) (Figure 3b)."

line 330- some water quality constituents are reported by not really interpreted at all. Like fluoride. It seems like it was just included because the ion chromatograph reports it.

Response: The author appreciates the reviewer for pointing this out and we agree with the reviewer. To address this, we have revised the manuscript to include a brief interpretation of the observed trend.

Line 386 – 388:

"F- concentrations serve as conservative tracers indicating ground water contribution or anthropogenic inputs (Xu et al. 2022). The relatively low concentrations suggest limited influence from groundwater discharge."

general results comment- age is assumed to be the main explanatory factor. But it is unclear if there are other co-varying factors related to pond design or drainage area, etc. Did the authors do mix effects or multi-variate regression to try to verify that age is indeed the main explanatory factor for some of these water quality relationships?

Response: The authors appreciate the reviewer's observation. For this study, pond age was the primary variable of interest, and while we acknowledge that other factors, such as pond design and drainage area may also influence water quality and sediment P dynamics, detailed data on those covariates were not consistently available for all ponds. As such, we used a univariate statistical framework focused on pond age and season. We agree that future studies would benefit from incorporating multivariate or mixed-effects models to assess the effects of pond age from other potentially confounding variables.

line 370- it would be good to briefly note why these data were excluded

Response: The authors appreciate the reviewer's suggestions. These data were considered outliers due to the negative values and this was removed for regression analysis.

Line 446:

"Outliers in our data were in SWP Y1 (both seasons) and M2 (winter) when the calculated EPC0 was negative."

Revision 2 Response | August 1, 2025

The authors are grateful to the reviewers for providing these comments and suggestions to improve the quality of this study. This is the second round of revision. The following sentences have been provided to show efforts to improve the manuscript based on the comments and suggestions of the reviewers. In what follows, the reviewer's comments are reproduced in **black text**, with the author responses in **blue** text.

Additionally, to ensure consistency with the formatting of other tables in the manuscript, **Table 2** has been revised.

Below is the initial format:

TN:TP		
	Summer	**Winter**
Young-age pond	13:1	16:1
Middle-age pond	20:1	10:1
Old-age pond	16:1	5:1

The new format: it has been updated to include a column header for pond age

TN:TP		
Pond age	**Summer**	**Winter**
Young	13:1	16:1
Middle	20:1	10:1
Old	16:1	5:1

Reviewer 1 | Anonymous

Comments: Consider removing line 129 (after all track changes have been accepted), starting with "elevated P concentrations contribute to eutrophication…" as it appears redundant with the preceding text (lines 113-118).

Response: The author thanks the reviewer for pointing this out. The sentence has been removed (no new line number).

Reviewer 2 | Lauren McPhillips

Comments: The minor typo- based on the values, I believe that the column name 'pond area: drainage area' in Table 1 should be 'drainage area: pond area.'

Additionally, I wanted to revisit my comment about the statistical analysis only considering age. The response indicated that other variables weren't considered in a multivariate analysis due to a lack of consistent information for all sites. However, there are some other variables, like area ratio or impervious%, that are available for all ponds. Even if further statistical analysis is not conducted, I still feel that it would be good to

indicate in discussion that there may be other variables that were not explored that may be able to explain some observed patterns.

Response: The author thanks the reviewer for the observation, the column name in **table 1** has been corrected from "pond area: drainage area" to "Drainage area: pond area."

The author has also appreciated your suggestion. The following sentence was added to **lines 503-506**:

"Although Pond age was the main factor that was examined in our study, it is worth noting that several characteristics, such as the ratio of impervious to pervious area surrounding the pond or the size of the watershed compared to the size of the pond, might also influence nutrient accumulation and movements through sediment P behavior."

Reviewer 3 | Anand Jayakaran and Lea Wilson

Comments: Increase size of stormwater pond markers and label text in the main image

Response: The author thanks the reviewer for the suggestion. The label and font size in **Figure 1** have been enlarged. [image]

Comments: Consider using "sulfate", which is recommended by the International Union of Pure and Applied Chemistry (IUPAC)

Response: The author thanks the reviewer for their suggestions. The term "sulphate" on **line 216** has been changed to "sulfate"

Comments: I have been changing to "mL", but use "ml" if preferred. I believe "mL" is the preferred abbreviation in the US and is recommended by organizations like the National Institute of Standards and Technology

Response: The author thanks the reviewer for the suggestion. All instances of "ml" have been updated to "mL" throughout the manuscript.

Comments: Please check that I did not change the meaning intended - this sentence was so awkwardly written that I had to attempt to smooth it out - but hopefully not too smooth!

Response: The author thanks the reviewer for the careful revision. The updated sentence is clear, and the intended meaning has been preserved.

Line 402-404:

"Additionally, our results suggest that there may be a potential functional significance of a peak in N-processing capacity during this stage of SWPs."

Comments: Middle-age or Middle age - need to be consistent

Response: The author thanks the reviewer for pointing this out. The term has been reviewed throughout the manuscript and changed to "Middle-age" for consistency.