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Spatial Patterns in Dissolved Inorganic Nitrogen Along a Newly Constructed Stream Corridor in Loudoun County, Virginia

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Abstract

Nutrient enrichment remains a persistent driver of water quality impairment throughout the Potomac River and Chesapeake Bay watershed, motivating localized stream restoration efforts aimed at reducing downstream nitrogen transport. This study characterized spatial patterns in dissolved inorganic nitrogen along a newly constructed stream corridor in Loudoun County, Virginia, during active restoration construction. Five monitoring sites spanning an upstream control, three construction zone locations, and a downstream reference were sampled twice daily over three weeks and analyzed for nitrate, nitrite, and ammonium using colorimetric methods. Nitrate concentrations did not decline systematically downstream; the two sites nearest active earthwork exhibited the highest mean values, exceeding the upstream control, while no statistically significant differences were detected across sites for any nitrogen species (Kruskal-Wallis, $p > 0.05$). However, pooled nitrite concentrations within the construction zone were significantly elevated relative to the downstream reference (Mann-Whitney $U = 867.5$, $p = 0.033$), consistent with active nitrification of ammonium released from disturbed sediments. These findings suggest the corridor functions during construction as a biogeochemically active zone where nitrogen speciation is transiently altered rather than reduced, contrasting with the denitrification the restoration is designed to promote long-term. This work provides field-based baseline data and a replicable monitoring framework for evaluating post-construction nutrient attenuation.

Key words: dissolved inorganic nitrogen, stream restoration, nitrate attenuation, denitrification, suburban watershed, Potomac River, nutrient cycling

Introduction

Nutrient pollution remains a persistent driver of ecological degradation throughout the Chesapeake Bay watershed. Excessive nitrogen and phosphorus loading from agricultural, urban, and wastewater sources has fueled decades of eutrophication, hypoxia, and habitat loss in the Bay and its tributaries (U.S. Environmental Protection Agency, 2023). The Potomac River, one of the largest contributors to the Bay's nutrient budget, transports substantial quantities of dissolved inorganic nitrogen from its headwaters through rapidly developing suburban corridors in Northern Virginia before reaching tidal waters (U.S. Geological Survey, 2023). Regulatory efforts, including the Chesapeake Bay Total Maximum Daily Load (U.S. Environmental Protection Agency, 2010), have established watershed-wide nitrogen reduction targets, yet achieving these goals depends on localized interventions capable of intercepting nutrient transport at the sub-watershed scale.

Nitrogen enters surface waters in several reactive forms with distinct biogeochemical fates. Nitrate (NO_3^-), the most oxidized and stable species, is highly soluble and mobile in oxygenated environments, allowing it to persist across long transport distances without substantial transformation (Camargo & Alonso, 2006; U.S. Geological Survey, 2019) Nitrite (NO_2^-), a more transient intermediate, typically occurs at lower concentrations but exerts greater direct toxicity on aquatic organisms by converting hemoglobin to methemoglobin and impairing oxygen transport (Camargo and Alonso, 2006). Ammonium (NH_4^+), produced through organic matter decomposition and biological excretion, can accumulate under conditions that suppress nitrification and become acutely toxic in warmer or more alkaline waters(Edwards et al., 2024). In excess, these species collectively drive eutrophication, stimulating algal blooms that deplete dissolved oxygen upon decomposition and create hypoxic conditions detrimental to fish, invertebrates, and broader aquatic food webs (Paerl & Otten, 2013; Smith et al., 1999)

In suburban landscapes, nitrogen loading originates from a combination of lawn and athletic field fertilization, stormwater runoff from impervious surfaces, and wastewater or septic discharge (Galloway et al., 2003; Spalding & Exner, 1993; Tong & Chen, 2002) Stream restoration has emerged as a practical approach for attenuating nutrient transport within these settings. Restored or constructed stream corridors can facilitate nitrogen removal through microbial denitrification in anaerobic sediment zones, assimilatory uptake by aquatic and riparian vegetation, and enhanced hyporheic exchange that extends water-sediment contact time (Rivett et al., 2008). However, field-level evaluations of individual suburban restoration projects remain limited, and few studies have characterized the nitrogen-processing capacity of newly constructed stream corridors in rapidly developing watersheds.

This study assessed spatial patterns in dissolved inorganic nitrogen along a newly constructed stream corridor between River Bend Middle School and Potomac Falls High School in Loudoun County, Virginia. Five monitoring sites were established along a longitudinal gradient: an upstream control (Site A), three locations within the restored reach (Sites B–D), and a downstream reference site (Site E). Water samples were collected twice daily over three weeks and analyzed for nitrate, nitrite, and ammonium concentrations alongside supporting physicochemical parameters. The primary objective was to evaluate whether the constructed stream corridor attenuates nitrate concentrations along its length and to characterize spatial variability in nitrogen speciation across the restoration reach and adjacent reference points.

Materials and Method

Study Area

This study was conducted along a newly constructed stream corridor located between River Bend Middle School and Potomac Falls High School in Sterling, Virginia (Loudoun County). The stream corridor lies within the Potomac River watershed and drains into the Potomac River, a major tributary of the Chesapeake Bay. The surrounding landscape is predominantly suburban, characterized by residential neighborhoods, school grounds with maintained athletic fields, parking lots, and other impervious surfaces. These land use features represent potential sources of nitrogen loading through fertilizer application, pet waste, and stormwater runoff (Galloway et al., 2003; Tong & Chen, 2002) The restoration project was initiated by Loudoun County with the stated goal of reducing nutrient and sediment transport to the Potomac River (Loudoun County Government, 2024).

Sampling Sites

Five monitoring sites were established along a longitudinal gradient spanning the stream corridor and adjacent waterway (Figure 1). Site A, the upstream control, was positioned approximately 1,000 feet upstream of the construction zone and represented baseline water quality entering the system. Sites B, C, and D were located within the restored reach, spaced approximately 100 feet apart, and were intended to capture changes in water quality across the length of the constructed corridor. Site E, the downstream reference, was located approximately 5,000 feet downstream of

Fig. 1: Picture derived from Google Earth, displaying the Sterling, Virginia, USA region, and sampling sites

Fig. 2: Picture derived from Google Earth, displaying sample sites A-D with specificity

the construction zone following the stream channel, providing a measure of cumulative water quality after passage through the restoration reach and continued transport downstream. This spatial arrangement allowed for evaluation of longitudinal trends in nitrogen concentrations across the upstream control, active restoration zone, and downstream receiving environment.

Sampling Schedule

Water samples were collected over a three-week period from May 22 to June 6, 2025. Sampling occurred twice daily on weekdays, with a morning session conducted between 8:30 AM and 11:30 AM and an afternoon session conducted between 1:00 PM and 5:00 PM. This frequency was selected to capture potential diel variability in nitrogen concentrations, as nitrate levels in stream systems have been demonstrated to fluctuate across morning and afternoon hours in response to biological uptake, temperature shifts, and hydrological changes (Burns et al., 2016) Three sampling sessions were not completed due to logistical constraints (June 3 morning, June 4 afternoon, and June 6 afternoon), resulting in a total of

130 site-level observations across the study period rather than the initially planned 150.

Water Collection and Analysis

At each site, water samples were collected from the mid-channel at moderate depth using a handmade extended sampling device consisting of a rigid pipe fitted with a collection cup. This approach minimized shoreline sediment disturbance and reduced the likelihood of sampling stagnant or unrepresentative water. Care was taken to avoid areas with visible sediment plumes, stagnant pooling, or recent human disturbance, and sampling locations within each site were kept consistent across sessions.

Concentrations of nitrate, nitrite, and ammonium were determined using the Fritz Aquatics Master Test Kit, a liquid reagent colorimetric assay system. For each analyte, water samples were combined with the appropriate reagent solutions according to the manufacturer's protocol, and concentrations were determined by visual comparison against standardized color reference charts. Liquid reagent colorimetric methods do not require instrument calibration and are widely used in field-based water quality assessments where access to laboratory instrumentation is limited (American Public Health Association et al., 2017). While these methods provide reliable detection of relative concentration differences across sites and sessions, their precision is inherently lower than spectrophotometric or ion chromatography methods, and this limitation is addressed in the discussion.

Water temperature and pH were measured in situ using a Rowyet BLE-C600 7-in-1 Digital Water Quality Tester. The device was submerged at each sampling location, and readings were recorded after stabilization. Between measurements, the probe was rinsed with distilled water to prevent cross-contamination, consistent with standard field sampling protocols.

Data Recording and Statistical Analysis

All measurements were recorded in the field and subsequently organized in a standardized spreadsheet for analysis. Descriptive statistics, including mean, standard deviation, median, and range, were calculated for each analyte and physicochemical parameter at each site.

To assess whether nitrogen concentrations differed significantly across sampling sites, a Kruskal-Wallis H test was performed independently for nitrate, nitrite, and ammonium. This nonparametric test was selected over one-way ANOVA because the data included notable outlier values and the distributions of analyte concentrations were not assumed to meet normality requirements, as is common in environmental field datasets with limited sample sizes and high inherent variability (Helsel and Hirsch, 2002). Where the Kruskal-Wallis test indicated a statistically significant difference ($\alpha = 0.05$), Dunn's post-hoc test with Bonferroni correction was applied for pairwise comparisons between individual sites. Additionally, Mann-Whitney U tests were conducted to compare nitrogen concentrations between the upstream control (Site A) and the pooled construction zone sites (Sites B–D), and between Site A and the downstream reference (Site E). Spearman rank correlation coefficients were calculated to evaluate relationships between nitrogen species and physicochemical parameters (pH, temperature). All statistical analyses were performed using Python (version 3.14.3) with the SciPy and scikit-posthocs libraries.

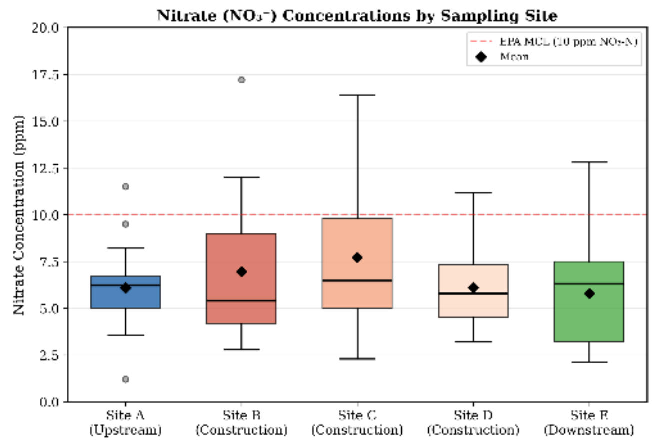

Fig. 3: Box-and-whisker plot of nitrate (NO_3^-) concentrations (ppm) across all five sampling sites. Black diamonds indicate site means. The dashed red line represents the EPA maximum contaminant level of 10 ppm for nitrate-nitrogen. $n = 21$ per site.

Results

Nitrate

Nitrate concentrations varied considerably both within and across sites over the three-week sampling period (Figure 3). The highest mean nitrate concentration was observed at Site C (7.72 ± 3.81 ppm), followed by Site B (6.95 ± 3.67 ppm), Site D (6.11 ± 2.10 ppm), Site A (6.08 ± 2.12 ppm), and Site E (5.79 ± 2.79 ppm). Median values followed a similar pattern, with Site C (6.50 ppm) and Site B (5.40 ppm) exceeding the upstream control (Site A, 6.23 ppm), while Site D (5.80 ppm) and Site E (6.30 ppm) were comparable or slightly lower. Several individual readings exceeded the EPA maximum contaminant level of 10 ppm for nitrate-nitrogen, most notably a single-session spike at Site B of 17.20 ppm recorded on May 29 and a reading of 16.40 ppm at Site C on May 30 (Figure 5). These elevated readings contributed substantially to the high standard deviations observed at the construction zone sites relative to the upstream and downstream references.

A Kruskal-Wallis H test revealed no statistically significant difference in nitrate concentrations across the five sampling sites (H = 2.68, $p = 0.613$). Mann-Whitney U tests similarly indicated no significant difference between the upstream control and the pooled construction zone sites ($U = 621.0$, $p = 0.679$), between the upstream control and the downstream reference ($U = 222.5$, $p = 0.970$), or between the pooled construction zone and the downstream reference ($U = 778.0$, $p = 0.231$). The absence of statistical significance is attributable in large part to the high within-site variability observed across the construction zone, where standard deviations at Sites B and C approached or exceeded their respective means.

Despite the lack of statistical significance, the descriptive spatial pattern is notable. The two construction zone sites nearest to active earthwork (Sites B and C) exhibited the highest mean and maximum nitrate concentrations of any sites in the study, while the site furthest downstream within the corridor (Site D) and the downstream reference (Site E) both returned mean values at or below the upstream control. The time-series data (Figure 5) confirmed that this pattern was not driven by a single anomalous session but recurred across multiple sampling days, though with substantial day-to-day variability at all sites.

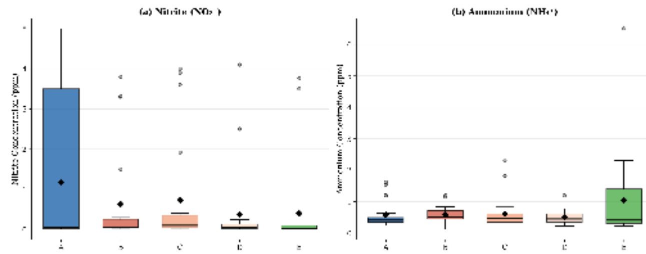

Fig. 4: Box-and-whisker plots of (a) nitrite (NO_2^-) and (b) ammonium (NH_4^+) concentrations (ppm) across all five sampling sites. Black diamonds indicate site means. $n = 21$ per site.

Nitrite

Nitrite concentrations were generally low across all sites, with median values at or below 0.10 ppm (Figure 4). Mean concentrations were highest at Site A (1.17 ± 1.83 ppm), followed by Site C (0.73 ± 1.36 ppm), Site B (0.63 ± 1.23 ppm), Site E (0.40 ± 1.08 ppm), and Site D (0.38 ± 1.01 ppm). The elevated mean at Site A was driven by intermittent spikes, including readings of 5.00, 4.50, and 3.56 ppm recorded on individual sessions, rather than a consistently elevated baseline. Similar sporadic elevations occurred at Sites B and C, with Site B reaching 3.80 ppm on May 28 and Site C reaching 4.00 ppm on June 5.

The Kruskal-Wallis test did not indicate a statistically significant difference in nitrite concentrations across sites (H = 6.15, p = 0.188). However, a Mann-Whitney U test comparing the pooled construction zone (Sites B–D) against the downstream reference (Site E) returned a marginally significant result (U = 867.5, p = 0.033), suggesting that nitrite levels within the construction zone were elevated relative to downstream. This pattern is consistent with active nitrification within the disturbed reach, where ammonium released from exposed soils and sediment may undergo partial oxidation to nitrite before completing conversion to nitrate.

Ammonium

Ammonium concentrations remained relatively low and stable across most sites, with means ranging from 0.52 to 0.62 ppm at Sites A through D (Figure 4). Site E exhibited a higher mean (1.05 ± 1.40 ppm), though this value was heavily influenced by a single outlier reading of 6.50 ppm recorded on June 5. With the outlier excluded, Site E's ammonium profile was comparable to the other sites. The Kruskal-Wallis test confirmed no significant difference in ammonium concentrations across sites (H = 2.05, p = 0.726), and no Mann-Whitney comparisons reached significance.

Nitrogen Speciation Across Sites

When examined collectively (Figure 6), nitrate dominated the dissolved inorganic nitrogen pool at all five sites, accounting for the majority of measured nitrogen at each location. Nitrite and ammonium contributed comparatively minor fractions, though their spatial variability provided additional insight into nitrogen cycling dynamics. The co-occurrence of elevated nitrate and intermittent nitrite spikes at the construction zone sites, paired with relatively stable ammonium concentrations, suggests active but incomplete nitrogen transformation within the disturbed corridor rather than conservative transport of a single nitrogen species.

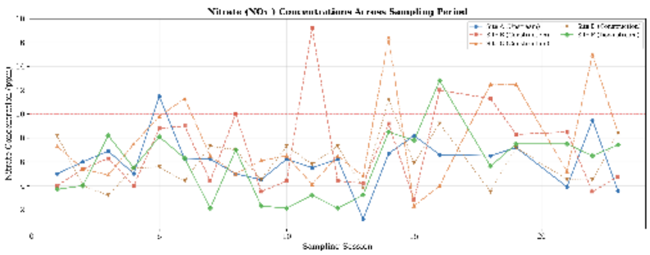

Fig. 5: Nitrate (NO_3^-) concentrations (ppm) across all sampling sessions from May 22 to June 6, 2025, by site. Each point represents a single session measurement. The dashed red line represents the EPA maximum contaminant level of 10 ppm for nitrate-nitrogen.

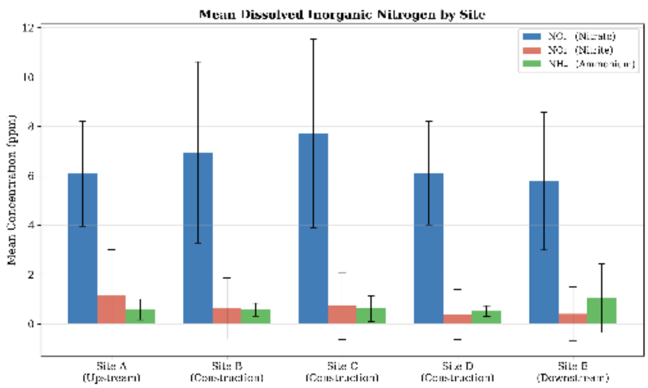

Fig. 6: Mean concentrations of nitrate (NO_3^-), nitrite (NO_2^-), and ammonium (NH_4^+) at each sampling site. Error bars represent one standard deviation. $n = 21$ per site.

Physicochemical Parameters

Mean pH values were similar across all sites, ranging from 6.82 (Site B) to 6.96 (Site D), and fell within the acceptable range for freshwater aquatic systems (Figure 7). No systematic spatial trend in pH was observed along the sampling gradient. Water temperature was likewise consistent across sites, with means ranging from 18.64°C (Site D) to 19.04°C (Site E), reflecting the uniform thermal environment of the stream corridor during the late spring sampling period (Figure 7). Spearman rank correlation analysis revealed no significant association between nitrate concentration and pH ($\rho = 0.090$, $p = 0.362$) across the pooled dataset. A weak but statistically significant positive correlation was observed between nitrate concentration and water temperature ($\rho = 0.212$, $p = 0.030$), which may reflect the coincidence of warmer afternoon sessions with higher runoff-driven nitrate inputs rather than a direct mechanistic relationship.

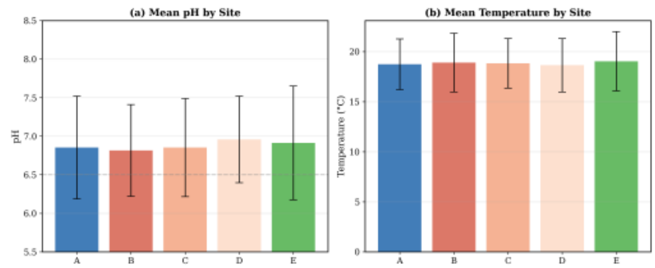

Fig. 7: Mean (a) pH and (b) water temperature (°C) at each sampling site. Error bars represent one standard deviation. Dashed gray lines in (a) indicate the typical freshwater tolerance range of 6.5–8.5. $n = 21$ per site.

Discussion

This study characterized spatial patterns in dissolved inorganic nitrogen along a newly constructed stream corridor in Loudoun County, Virginia, during an active phase of restoration construction. Contrary to initial expectations, nitrate concentrations did not decline systematically from the upstream control to the downstream reference. Instead, the two construction zone sites nearest to active earthwork (Sites B and C) exhibited the highest mean nitrate concentrations in the study (7.72 ± 3.81 ppm and 6.95 ± 3.67 ppm, respectively), exceeding the upstream control (Site A, 6.08 ± 2.12 ppm). Site D, located at the downstream end of the restored reach, and Site E, approximately 5,000 feet further downstream, returned mean concentrations at or below the upstream baseline (6.11 and 5.79 ppm, respectively). No statistically significant differences were detected across sites for any of the three nitrogen species measured. However, the descriptive spatial patterns, combined with a marginally significant elevation of nitrite within the construction zone relative to the downstream reference ($p = 0.033$), suggest that the restored corridor is functioning as a biogeochemically active zone rather than a passive conduit for nutrient transport.

The elevation of nitrate at Sites B and C is consistent with the well-documented nutrient release associated with active stream restoration earthwork. Construction activities such as grading, sediment excavation, and channel reshaping expose subsurface soils that contain stored organic nitrogen and ammonium, both of which undergo rapid nitrification upon contact with oxygenated surface water (Bernhardt and Palmer, 2011). This mechanism produces a short-term pulse of dissolved inorganic nitrogen that can temporarily elevate concentrations within and immediately downstream of the construction zone. Similar nutrient spikes during the construction phase of stream restoration projects have been reported in Chesapeake Bay tributaries, where nitrate concentrations increased during active earthwork before declining over subsequent months as vegetation established and sediment stabilized (Filoso and Palmer, 2011). The pattern observed in this study, in which the sites closest to active disturbance exhibited the highest concentrations while the furthest construction site (Site D) and the downstream reference (Site E) approached upstream baseline values, aligns with this transient disturbance model. Notably, the high within-site variability at Sites B and C (standard deviations of 3.67 and 3.81 ppm, respectively, compared to 2.12 ppm at Site A) further supports the interpretation that nitrogen release from the construction zone was episodic rather than continuous, likely driven by the timing and intensity of earthwork on individual sampling days.

Beyond the spatial pattern in nitrate, the nitrite data provided additional evidence that the construction zone is functioning as a site of active nitrogen transformation. Nitrite is a transient intermediate in both nitrification (the oxidation of ammonium to nitrate via nitrite) and denitrification (the reduction of nitrate to nitrogen gas via nitrite), and its presence at detectable concentrations typically indicates that one or both of these processes are actively occurring rather than at equilibrium (Camargo and Alonso, 2006). In this study, intermittent nitrite spikes were recorded at multiple sites, including readings of 5.00 and 4.50 ppm at Site A, 3.80 ppm at Site B, and 4.00 ppm at Site C. These spikes were not sustained across consecutive sessions, suggesting episodic bursts of nitrification activity rather than a steady-state process. The marginally significant elevation of nitrite within the pooled construction zone relative to the downstream reference ($p = 0.033$) is consistent with enhanced nitrification in the disturbed reach, where freshly exposed ammonium-rich sediments encounter well-oxygenated water and undergo partial oxidation. The concurrent stability of ammonium concentrations across most sites (means ranging from 0.52 to 0.62 ppm at Sites A through D) further supports this interpretation: ammonium released from disturbed soils appears to undergo relatively rapid conversion rather than accumulating in the water column. At Site E, ammonium concentrations were slightly elevated (1.05 ± 1.40 ppm), though this was driven almost entirely by a single outlier of 6.50 ppm on June 5, without which the downstream profile was comparable to the construction zone. Taken together, these patterns indicate that the stream corridor, even during active construction, supports measurable nitrogen cycling that alters the speciation of dissolved inorganic nitrogen prior to downstream export.

The timing of this study within the late spring period (May 22 to June 6) carries important implications for interpreting the observed nitrogen concentrations. Seasonal analyses of nitrate in the Potomac River have demonstrated that spring represents the second-highest period of nitrate loading after winter, driven largely by rainfall-associated runoff that mobilizes nitrogen from fertilized soils, impervious surfaces, and shallow groundwater into surface waterways (Burns et al., 2016). The suburban landscape surrounding the study area, which includes maintained school athletic fields, residential lawns, and extensive parking infrastructure at both River Bend Middle School and Potomac Falls High School, provides ample sources of nitrogen available for mobilization during precipitation events. Spring conditions therefore represent a period of elevated background nitrogen loading against which the influence of the construction corridor must be evaluated. The weak but statistically significant positive correlation between nitrate concentration and water temperature ($\rho = 0.212$, $p = 0.030$) observed across the pooled dataset likely reflects diel sampling dynamics rather than a direct mechanistic relationship between temperature and nitrate production. Burns et al. (2016) documented consistent diel variation in Potomac River nitrate, with spring concentrations peaking in the morning around 9:30 AM and reaching their minimum near 4:30 PM. Afternoon sampling sessions in this study, which coincided with warmer water temperatures, may also have coincided with periods of greater surface runoff or reduced biological uptake, contributing to the observed correlation. Future studies would benefit from higher-resolution temporal sampling to disentangle diel cycling from the spatial patterns attributable to the restoration corridor itself.

The majority of nitrate concentrations recorded across all sites fell below the EPA maximum contaminant level of 10 ppm for nitrate-nitrogen, which serves as the regulatory benchmark for drinking water safety (U.S. Environmental Protection Agency, 2023). However, several individual readings at the construction zone sites exceeded this threshold, including a peak of 17.20 ppm at Site B on May 29 and 16.40 ppm at Site C on May 30. Site A also reached 11.50 ppm on a single session (May 26 morning), indicating that exceedances were not confined to the construction zone alone but occurred at reduced frequency and magnitude upstream. While the 10 ppm standard applies specifically to drinking water and the stream corridor in this study does not serve as a direct potable source, these exceedances remain ecologically relevant. Nitrate concentrations above 10 ppm have been associated with physiological stress in sensitive freshwater macroinvertebrates and fish, including impaired reproduction and growth (Camargo et al., 2005). For nitrite, all site means fell well below the 1.0 ppm acute toxicity threshold for most freshwater species, though the sporadic spikes observed at Sites A, B, and C approached or exceeded levels at which sublethal effects on oxygen transport in fish have been documented (Camargo and Alonso, 2006). Ammonium concentrations remained consistently low and posed minimal ecological concern under the pH and temperature conditions observed during the study, as the fraction of toxic un-ionized ammonia (NH_3) increases with pH and temperature, and both parameters remained within moderate ranges across all sites (Edwards et al., 2024). These threshold comparisons underscore that while the stream corridor does not currently present a persistent water quality violation, the episodic exceedances at the construction zone sites warrant continued monitoring as the restoration matures.

Several methodological limitations should be considered when interpreting these findings. The Fritz Aquatics Master Test Kit, while reliable for detecting relative differences in concentration across sites and sessions, determines analyte concentrations through visual color matching against a standardized reference chart. This approach introduces observer-dependent variability and provides lower resolution than spectrophotometric or ion chromatography methods, particularly at intermediate concentrations where color gradations are subtle. The precision of these measurements is therefore best understood as semi-quantitative, and small differences between sites should be interpreted with caution. The three-week sampling window, while sufficient to capture a meaningful number of observations per site ($n = 21$), represents a narrow temporal snapshot of a system that is likely to undergo substantial biogeochemical changes as construction concludes and the corridor matures. The absence of pre-construction baseline data further limits the ability to attribute observed patterns directly to the restoration project rather than to pre-existing spatial variability in the waterway. Additionally, several parameters relevant to nitrogen dynamics were not measured in this study, including dissolved oxygen, stream discharge, and flow velocity. Dissolved oxygen in particular governs the balance between nitrification and denitrification and would have provided critical context for interpreting the observed nitrogen speciation patterns (Rivett et al., 2008). Finally, the use of a single upstream and single downstream reference site, while appropriate for a preliminary characterization, limits the ability to account for localized inputs or losses of nitrogen between Site A and the construction zone or between Site D and Site E. Tributary inflows, groundwater seepage, or additional runoff sources along the 5,000-foot reach between the construction zone and the downstream reference could confound direct comparisons between these sites.

The primary value of this dataset lies in its function as an early-construction baseline against which future post-restoration monitoring can be compared. As the stream corridor matures and vegetation colonizes the riparian zone and channel margins, the biological infrastructure necessary for sustained nitrogen processing, including microbial biofilms, root-associated denitrifying communities, and organic-rich sediment layers, is expected to develop and strengthen over time (Bernhardt and Palmer, 2011). Repeated sampling at the same five sites following the completion of construction would allow for a direct before-and-after comparison of nitrogen concentrations and speciation, providing a more definitive assessment of the corridor's nutrient attenuation capacity. Such follow-up studies should incorporate dissolved oxygen measurements, which would enable the identification of aerobic and anaerobic zones within the reach and clarify whether denitrification is occurring at rates sufficient to produce measurable nitrate removal. Stream discharge and flow velocity data would further strengthen the analysis by allowing the calculation of nitrogen mass fluxes rather than concentration-only comparisons, which can be confounded by dilution effects during high-flow events. Seasonal replication across winter, spring, summer, and fall would address the temporal limitations of this study and capture the full range of hydrological and biological conditions that govern nitrogen transport in the Potomac watershed (Burns et al., 2016). Finally, the adoption of professional-grade analytical instrumentation, such as portable spectrophotometers or laboratory-analyzed grab samples, would substantially improve measurement precision and allow for the detection of smaller spatial differences that colorimetric field kits may not resolve.

Conclusion

This study provides an early-construction baseline characterization of dissolved inorganic nitrogen along a newly constructed stream corridor between River Bend Middle School and Potomac Falls High School in Loudoun County, Virginia. Nitrate concentrations did not decline systematically from upstream to downstream during the sampling period; instead, the construction zone sites nearest to active earthwork exhibited the highest mean concentrations, consistent with transient nitrogen mobilization from disturbed soils and sediments. No statistically significant differences in nitrate or ammonium were detected across the five sampling sites, though the marginally significant elevation of nitrite within the construction zone relative to the downstream reference suggests that active nitrogen cycling is occurring within the corridor even prior to the establishment of mature biological communities. The absence of a clear attenuation signal does not indicate that the restoration has failed to function, but rather that the corridor was sampled during a period in which construction-related disturbance temporarily overwhelmed the biogeochemical processing capacity that the project is designed to support.

The findings underscore both the importance and the difficulty of evaluating restoration outcomes during the construction phase itself. Nutrient dynamics in newly constructed stream corridors are expected to shift substantially as vegetation establishes, sediment stabilizes, and microbial communities colonize the restored reach. The spatial framework and monitoring protocol developed in this study provide a directly replicable foundation for post-construction follow-up, and the data collected here will serve as the reference point against which future nitrogen attenuation can be measured. Continued monitoring of this corridor, paired with improved instrumentation and expanded parameter coverage, will clarify whether the restoration achieves its intended goal of reducing nitrogen transport to the Potomac River and, by extension, the Chesapeake Bay.

Competing interests

We have no known conflict of interest to disclose.

Author contributions statement

C.S. and R.N. conceived the experiment(s) and designed the study. C.S. and R.N performed the experiments, C.S. and R.N. analyzed the data. R.N. wrote the initial draft, and R.N and C.S. edited and formatted the manuscript. Both authors contributed to the interpretation of results and reviewed the final manuscript.

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Data Availability

The complete dataset supporting this study is available from the corresponding author upon reasonable request.

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