Ammonium ISE Sensor Calibration Intervals: Extending Beyond Four Weeks

Water Simplified

Case Study

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Abstract

Regulatory requirements associated with combined sewer overflows (CSOs) and wastewater discharges place increasing pressure on water utilities to maintain high-quality effluent monitoring while managing operational costs. Ammonium ion-selective electrode (ISE) sensors play a critical role in demonstrating compliance and understanding process performance, yet they are typically calibrated every four weeks—a process that requires significant site time and laboratory support. Extending the reliable, calibration-free operating period of these sensors presents an opportunity to reduce operational expenditure, minimize routine maintenance and improve overall monitoring efficiency.

This study documents the performance and stability of four ammonium sensors mounted on a single In-Situ multiparameter sonde, each sensor operated at different calibration intervals ranging from 4 to 12 weeks to evaluate how long reliable data can be maintained at a real-world deployment site without recalibration. The sonde was deployed for 12 weeks in Fall 2025 downstream of an effluent outfall in the U.K. Results showed that for this particular site, longer calibration intervals of 6, 8 and 12 weeks yielded reliable data. The responses of the four ammonium sensors were similar throughout the deployment and during discrete events related to precipitation.

Introduction

Reliable ammonium monitoring is essential for meeting the compliance requirements outlined in the combined sewer overflow (CSO) monitoring regulations of many countries, such as Section 82 of the United Kingdom's 2021 Environment Act. Across many jurisdictions, utilities rely on frequent sensor calibration—commonly every four weeks—to ensure measurement accuracy and to minimize signal drift. While this approach supports data quality objectives, it places a substantial operational burden on monitoring teams, requiring regular site visits, laboratory work and associated resource costs.

As utilities face increasing pressure to improve efficiency and reduce operational expenditures, extending the calibration interval of key instrumentation has become an important area of interest. Ammonium sensors capable of maintaining accuracy over longer deployment periods could significantly reduce routine maintenance effort, decrease downtime associated with recalibration and improve the overall cost-effectiveness of compliance and process monitoring.

This study aims to assess the stability and performance of four ammonium sensors mounted on a single In-Situ multiparameter sonde downstream of an effluent outfall, each sensor operated at different calibration intervals. The objective is to determine whether the sensors can reliably maintain performance for up to eight weeks or longer without calibration, supporting a potential shift to longer, cost-saving maintenance cycles for this particular site. The trial also was an opportunity to document how well four identically deployed sensors agreed in a monitoring configuration meeting common CSO monitoring requirements.

Methodology

Site Characteristics

The monitoring site (Figure 1) is located in the South of the U.K., approximately 100m downstream of a final effluent outfall which also doubles as a consented overflow. This is the permitted release of untreated or partially treated effluent during heavy rainfall events that would otherwise flood the treatment works.

A wooden jetty purpose built for fishing was selected as the fixed structure for securing a stilling tube (Figure 2). This is a very simple and effective deployment method that meets common CSO monitoring requirements.

Figure 1: Site location and surroundings.

Figure 2: Stilling tube (left) and sonde deployment (right) at the monitoring site.

Instrumentation

Sensors were deployed on an In-Situ Aqua TROLL 800 multiparameter sonde (Figure 3), which had special firmware installed to make it possible to take and log readings from duplicate sensors.

The sensors included four ammonium ion-selective electrode sensors, as well as a pH sensor and a conductivity/temperature sensor. The sonde's integrated wiper operated every 15 minutes during the deployment. The sonde was powered by onboard batteries, which needed no replacement over the 12-week study. The deployment of all four ammonium sensors on the same sonde ensured that they were measuring the same water sample.

Figure 3. Sensors deployed on the In-Situ Aqua TROLL 800 multiparameter sonde: four ammonium sensors, pH, and conductivity/temperature.

Figure 4. The VuSitu mobile app was used to download the data from the sonde during weekly site visits.

Data Collection

Parameter readings were gathered every 15 minutes over the 12-week deployment from 22 September to 15 December 2025 and stored on the sonde's onboard data logger. Data was downloaded from the sonde during weekly site visits using the VuSitu mobile app (Figure 4). During some of the visits, any sensors due for calibration were removed from the deployment sonde and calibrated onsite using another sonde (see below for the calibration schedule). Data gathering was interrupted for the calibrations and for weekly 1 mg/L standard measurements during the last half of the deployment. A one-week gap in the sensor data occurred from 24 November to 1 December due to a fault in the logging process. Daily rainfall totals were recorded from the monitoring station approximately 3 kilometers away.

Weekly 1 mg/L Standard Measurements

Starting at week #6 of the weekly site visits, sensor performance was monitored by taking live readings of a 1 mg/L ammonium standard solution (Figure 5a). A fresh bottle of the standard solution was used each week. Week 11 of the standard measurements was not completed because the site could not be accessed due to flooding.

For this standard measurement, the sonde was removed from the stilling tube and rinsed with water in a pressurized spray bottle to remove any obvious debris. The sonde's restrictor was removed, reversed and reinstalled to use the integrated mini-calibration cup of the sonde for the standard measurement. The cup and sensor faces were rinsed with some of the standard solution and the rinse discarded. Then as shown in Figure 5b, 100 ml of the 1 mg/L standard solution was poured into the calibration cup. After stabilizing, the readings of the four ammonium sensors were recorded. These readings were taken before calibrating any sensors that were due for calibration according to the calibration schedule (described below).

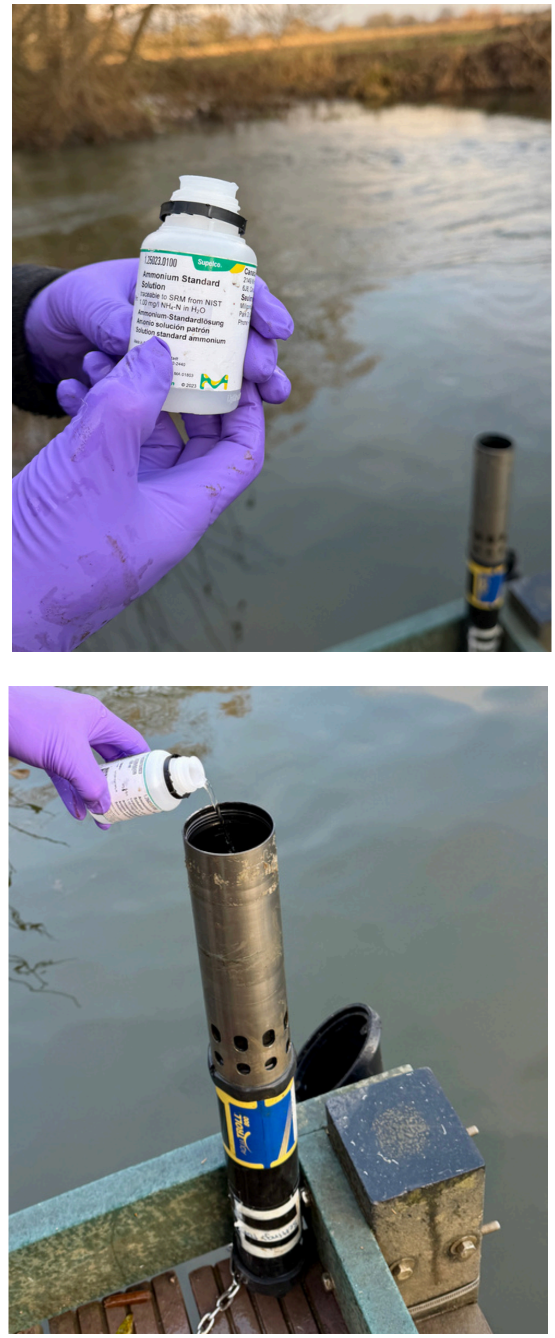


Figure 5. (a) The 1 mg/L ammonium standard solution (top) and (b) the sonde with restrictor reversed to use the mini-calibration cup for the weekly standard measurement (bottom).

Calibration Schedule

Table 1 shows the calibration schedule for the sensors installed on the sonde, including ammonium sensors A, B, C and D. All four ammonium sensors were calibrated at the start of the deployment. Sensor A was then calibrated every 4 weeks, Sensor B every 6 weeks, Sensor C every 8 weeks and Sensor D every 12 weeks. The pH and conductivity sensors were calibrated at the start of the deployment and at 8 weeks.

By the design of this experiment, one sensor (Sensor D) operated for the full duration of the 12-week deployment without being calibrated.

Other than the rinse-off for scheduled calibrations, no other maintenance was performed on the deployed sensors. For example, electrode reference solutions of the ISEs were not refilled and the wiper was not maintained or replaced during the 12-week deployment.

	Sensor A	Sensor B	Sensor C	Sensor D	pH Sensor	Conductivity
Week 0 - 09/22/2025						
Week 1 -09/29/2025						
Week 2 - 10/06/2025						
Week 3 - 10/13/2025						
Week 4 - 10/20/2025						
Week 5 - 10/28/2025						
Week 6 - 11/03/2025						
Week 7 -11/10/2025						
Week 8 - 11/17/2025						
Week 9 - 11/24/2025						
Week 10 - 12/01/2025						
Week 11 - 12/08/2025						
Week 12 - 12/15/2025						

Table 1. Calibration schedule for the sensors.

Results

Weekly 1 mg/L Standard Readings of the Four Ammonium Sensors

Figure 6 shows the results of the weekly measurements of the 1 mg/L ammonium standard solution, which began at week 6. The site could not be accessed during week 11, so six standard measurements occurred during weeks 6 through 12 of the deployment.

Regardless of their calibration schedule, the four ammonium sensors gave readings of the 1 mg/L standard that were in good internal agreement with each other. The largest difference in the readings, about 0.5 mg/L, occurred during week 7. For the other weekly standard measurements, the four sensors gave readings within a 0.1 to 0.4 mg/L range. In addition, all but one reading was within 0.6 mg/L of the 1 mg/L standard solution. These results are within the accuracy limits of the In-Situ ammonium sensor, which is ±10% or 2 mg/L, whichever is greater (±2 mg/L in this case).

Monitoring Data

The 15-minute sampling data for the four ammonium sensors is shown in Figure 7a and daily rainfall totals are shown in Figure 7b.

Ammonium levels were low throughout the study, with most values falling between 0.2 and 0.4 mg/L. However, spikes were seen in the data for all four ammonium sensors during rainfall events. The first significant rainfall occurred about 11 days into the deployment, on 4 October 2025. A corresponding ~0.2 mg/L increase in the ammonium data from all four sensors occurred, as shown in Figure 8a. Several other spikes in ammonium values occurred during the deployment that corresponded with precipitation events. A spike on 22 October is shown in Figure 8b, and again all four ammonium sensors responded similarly, increasing by ~0.2 mg/L.

A stretch of sustained rainy weather occurred from 19 October to 14 November (Figure 7). Measured ammonium values were noticeably more variable for all four sensors during this rainy period, as would be expected.

Throughout the deployment, the four sensors were similar in how they responded daily and were similar even in the 15-minute ups and downs in ammonium levels. As shown in Figure 7a, the four sensor readings fall within a ~0.2 mg/L range during the beginning of the deployment, and in the later weeks the range narrows to ~0.1 mg/L. The agreement of the four sensors is shown in more detail in Figure 9, which focuses on two different 2-week periods that occurred near the end of the deployment, from 10-24 November and from 1-15 December.

The 8-week calibration of Sensor C is evident on 17 November in Figure 9a. The calibration resulted in a new offset for Sensor C, causing readings to increase by ~0.1 mg/L, but the similar response of Sensor C compared with the other sensors continued after the calibration.

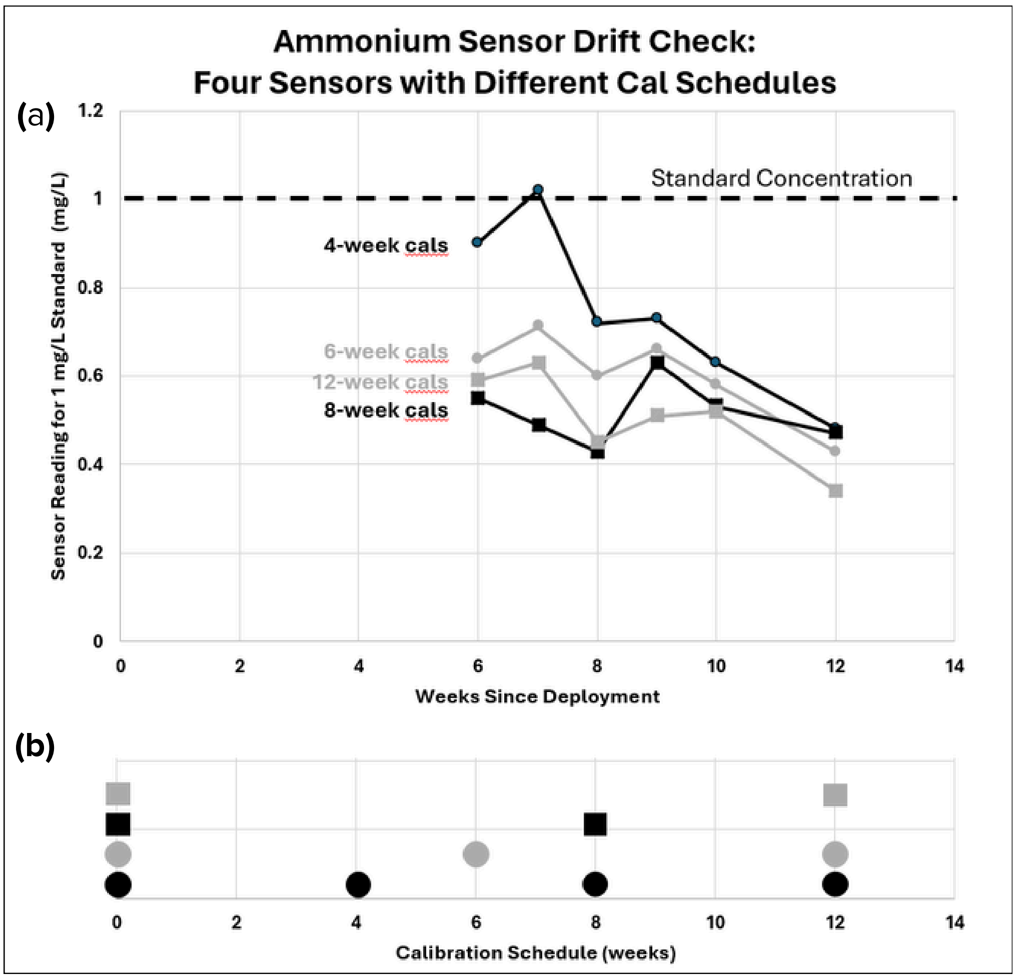
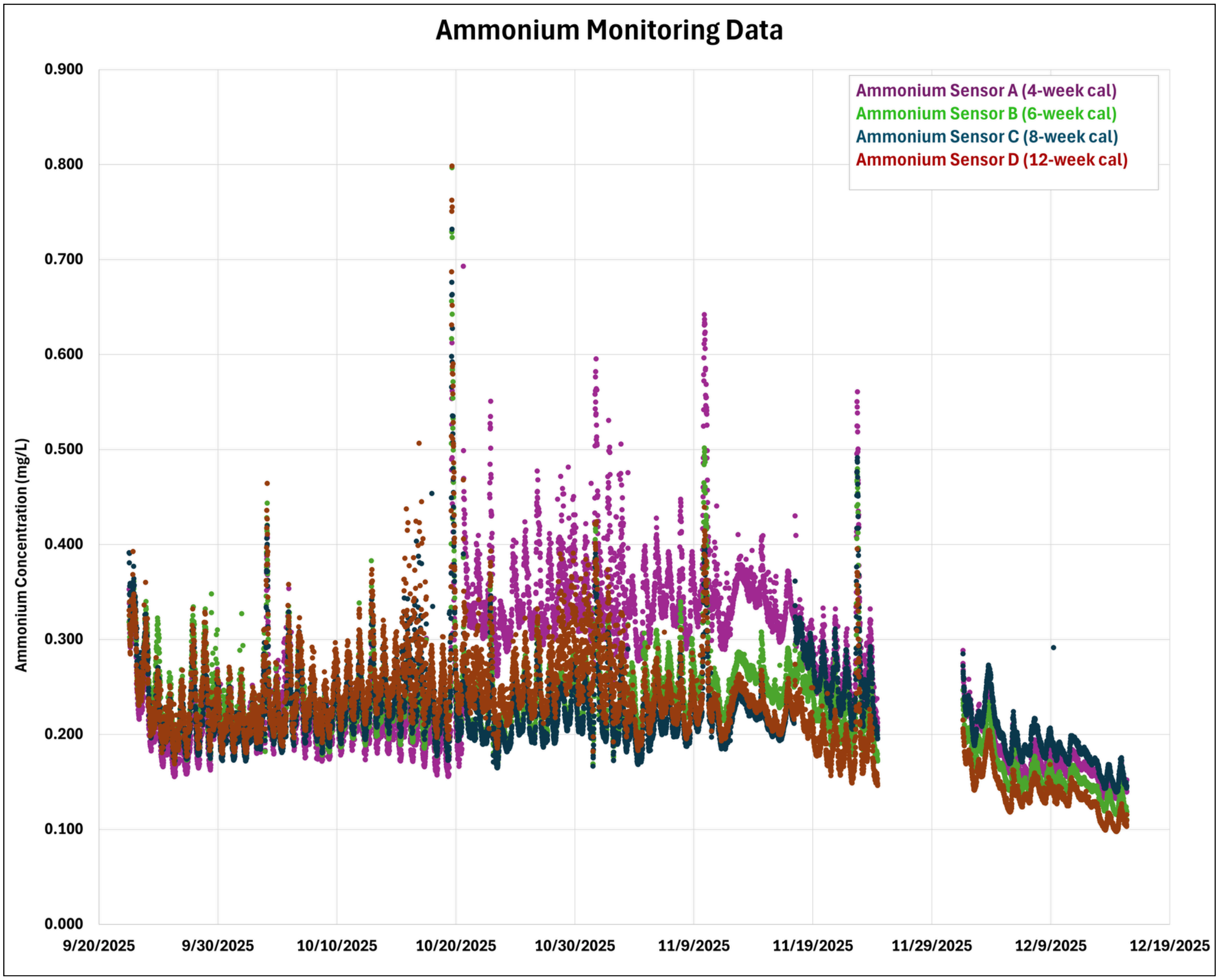


Figure 6. (a) Weekly readings for the four ammonium sensors in the 1 mg/L standard solution. (b) Calibration schedule for the four ammonium sensors. Scheduled calibrations were carried out after the standard measurements.

(a)



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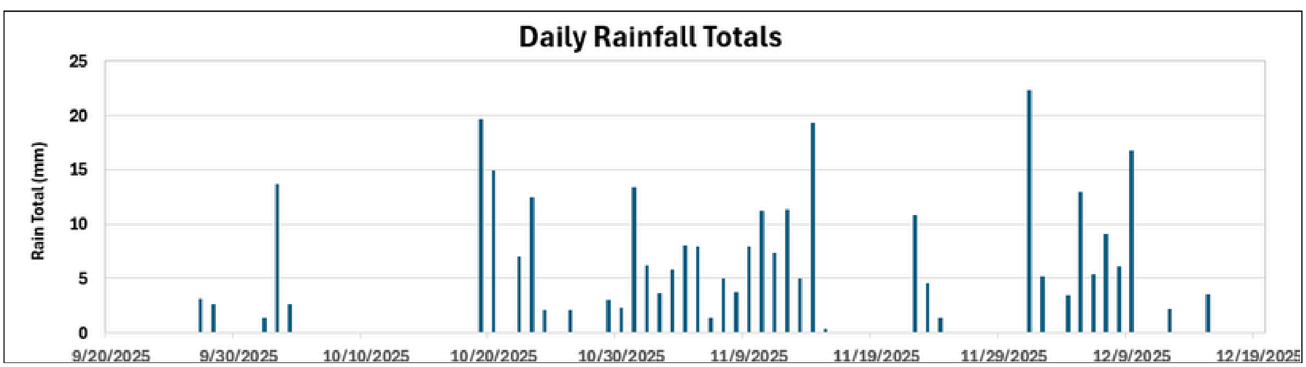
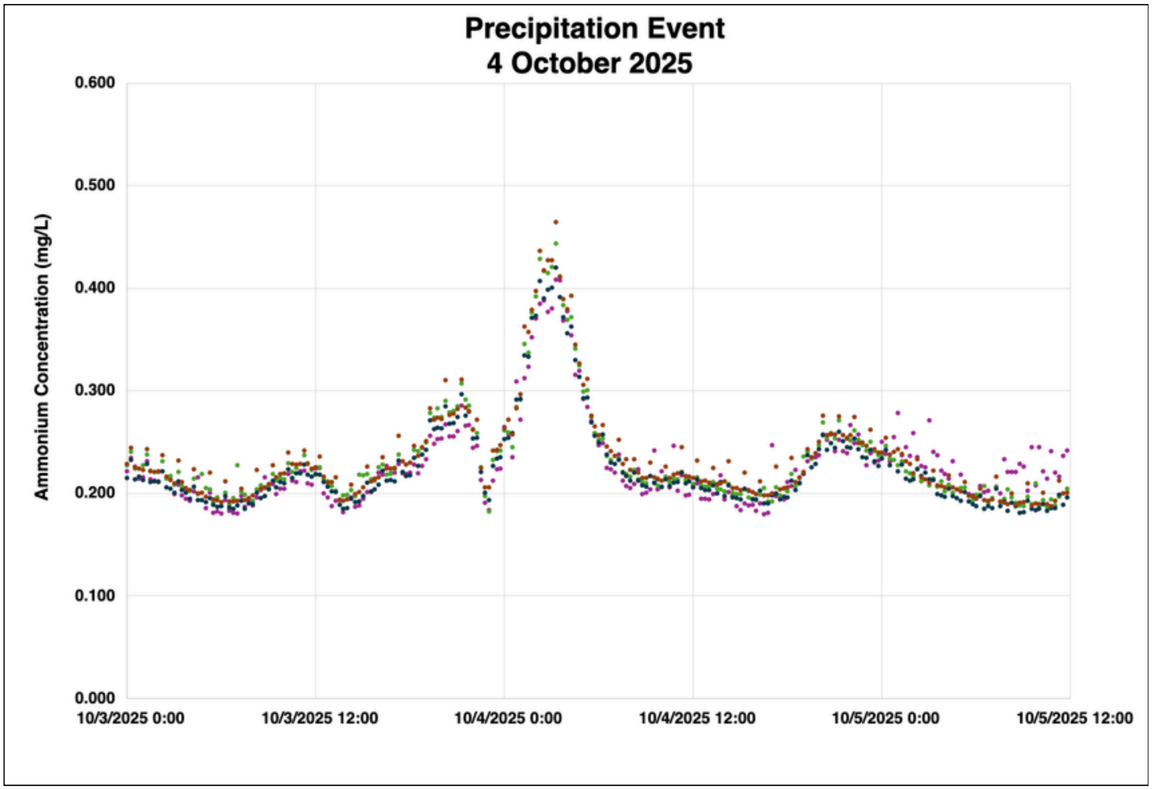


Figure 7. (a) The 15-minute data for the four ammonium sensors during the 12-week deployment. (b) Daily rainfall totals during the deployment.

(a)



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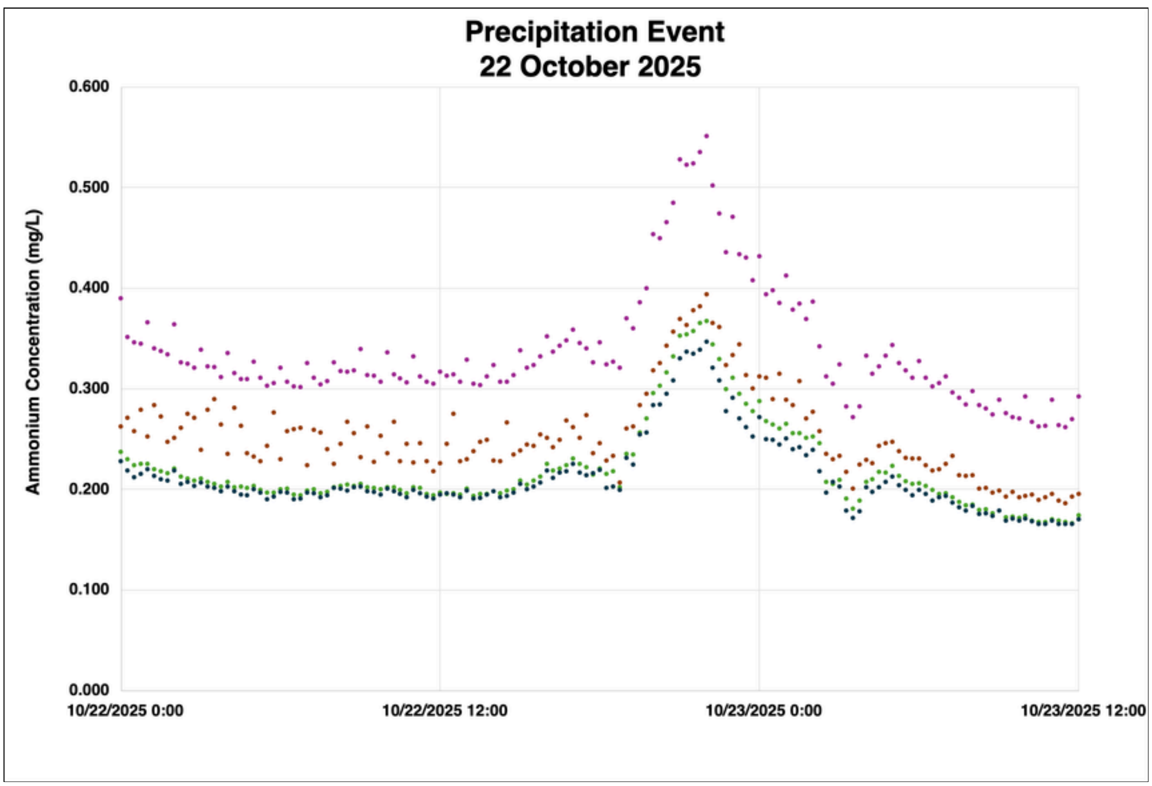
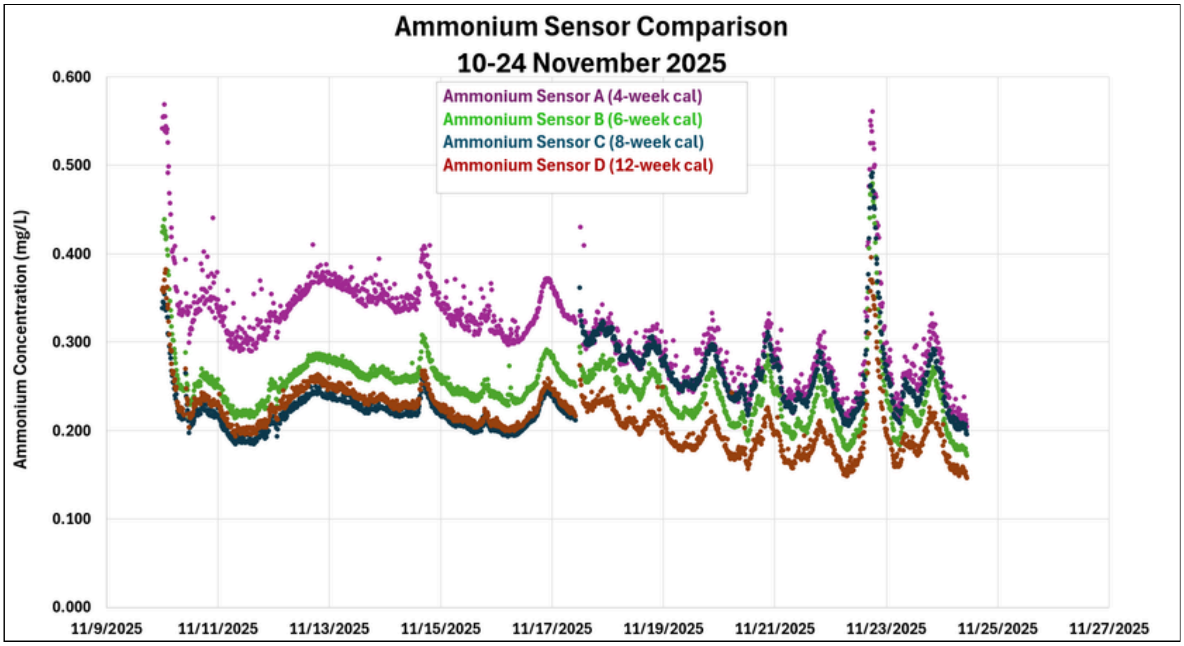


Figure 8. Readings of four ammonium sensors during precipitation events on (a) 4 October 2025 and (b) 22 October 2025.

(a)



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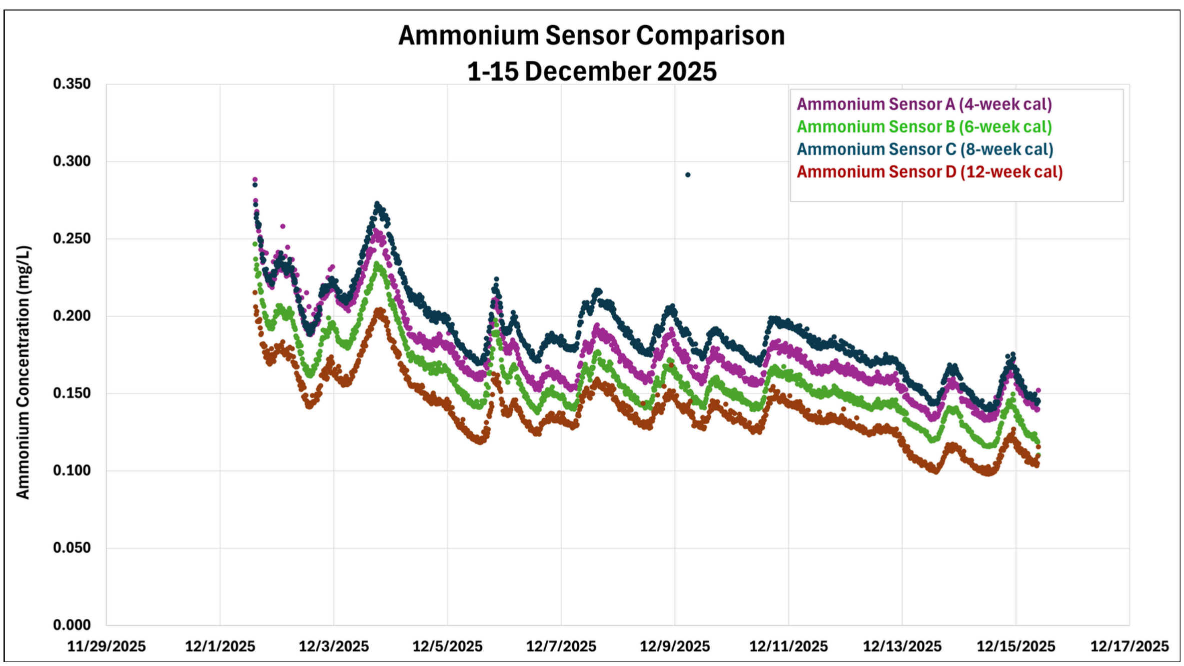

Figure 9. Readings of the four ammonium sensors during two 2-week periods on (a) 10-24 November 2025 and (b) 1-15 December 2025. These are weeks 7 & 8 and weeks 11 & 12 of the deployment, respectively.

Discussion

Calibration Interval

By deploying four identical ammonium sensors in the same sonde, the design of the 12-week study provided a means to isolate the calibration frequency as the only variable. The calibration intervals tested were 4, 6, 8 and 12 weeks. The 1-mg/L standard measurements of Figure 6 and monitoring data of Figures 7a and 9a demonstrate that for the conditions of this particular monitoring site, the In-Situ ammonium sensor calibration interval could be extended beyond the 4-week frequency that is typically used in water quality monitoring. At the end of the deployment, even the ammonium sensor that was not calibrated for 12 full weeks showed readings that were within 0.1 mg/L of the data from the other three ammonium sensors (Figures 7a, 9a).

The In-Situ ammonium sensor is compatible with the use of the sonde's wiper, and the automatic 15-minute wiper cycle used throughout the deployment was likely a key factor enabling the extended calibration protocols. It is evident that the wiper performed well for the entire deployment, even without maintenance or replacement of the wiper. The performance of the sensors would likely differ without the use of the wiper.

We note that calibration is highly site-specific and our findings cannot be generalized or extended to other sites and conditions. Also, continuous ammonium monitoring using ISEs is not intended to be a substitute for grab samples and laboratory analyses. However for this particular monitoring site, the sensors performed well enough to capture precipitation events regardless of their calibration frequency.

Sensor Performance

The 1-mg/L standard measurements in Figure 6a showed that all four sensors consistently read below the 1 mg/L value of the ammonium standard solution. This likely cannot be attributed to an inaccurate or deteriorating standard solution, because a fresh bottle of standard solution was used for each weekly standard measurement. It appears that there is an offset of about −0.4 mg/L in the sensors, which is within the accuracy limits of the sensors as mentioned earlier.

Detailed monitoring data in Figures 7, 8 and 9 showed that the four sensors performed similarly throughout the 12-week deployment regardless of calibration frequency. The four readings spanned about 0.2 mg/L at the beginning of the deployment, which increased to about 0.25 mg/L during the rainy period mid-deployment. It is notable that the readings of the four sensors were especially close to each other (within 0.1 mg/L) during the last 2 weeks of the deployment (Figure 9b), even though Sensor D had not been calibrated since the beginning of the experiment.

The data also showed that the four sensors spiked in similar ways during precipitation events. This is visually evident in the two events shown in Figure 8a (envelope of measurements of <0.05 mg/L) and Figure 8b (envelope of measurements ~0.1-0.2 mg/L). We did not monitor for overflows or other inputs to the stream, but the spikes in ammonium during these events would be consistent with an influx of ammonium and other contaminants into the watershed through effluent overflows, runoff or atmospheric cleansing. In an extended rainy period, the sensors showed expected higher variability, also consistent with changing conditions affecting the nutrient loading of the stream.

Though no routine maintenance was performed on the sonde and sensors, the experiment did entail some disturbances that would differ from a fully unattended deployment. Because all four ammonium sensors were deployed on the same sonde, all sensors were disturbed by the calibrations. They were also disturbed by the 1 mg/L standard measurements in weeks 6-12, which required rinsing the sonde and sensor faces with a pressurized water bottle before immersion in 100 ml of the clean ammonium standard solution. These disturbances no doubt had an overall positive effect on the sensors because they did remove some debris from the sensor faces on a weekly basis.

However, the advantage of deploying all ammonium sensors on the same sonde was that the water sample was the same for each sensor. We found this to be an acceptable trade-off of the experimental design, but we note that results might vary for fully unattended deployments of various durations. Further tests in different configurations and monitoring conditions would yield even more insight into the sensors' real-world performance.

In addition, tests in locations with higher ammonium levels and with larger discharge spikes would be desirable to further investigate the performance of the ammonium ISE sensors at different calibration intervals.

Conclusion

This study showed that with the Aqua TROLL 800 multiparameter sonde's automatic wiper set for 15 minutes and no routine maintenance during site visits, four In-Situ ammonium sensors calibrated at different intervals gave similar readings during 12 weeks at the particular monitoring site studied, and all four captured multiple precipitation events. At the end of the deployment, the four ammonium sensors were reading within 0.1 mg/L of each other during the 1 mg/L standard measurements and for monitoring data, regardless of whether calibrated at 4-, 6-, 8- or 12-week cycles.