WATER QUALITY MONITORING OF MANUAL AND AUTOMATED DRAINAGE WATER MANAGEMENT SYSTEMS

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MANUAL SYSTEM

- Installation date: February 2023
- Acres managed: 37.7 acres
- Water control structure size: 12 inches

AUTOMATED SYSTEM

- Installation date: December 2021
- Acres managed: 38.8 acres
- Water control structure size: 12 inches

Background information

Two drainage water management systems were monitored throughout the study period. The manual water control structure was manually adjusted throughout the year , while the automated water control structure utilized sensors and an online system to manage the water table in real time. The latter provides an easier real-time control of the timing of water discharge from tile systems, does it remotely without the producer having to physically manage water control gates in the field, and provides for greater precision in the timing of management actions. Flow and nutrient concentration data was collected from each system for comparison.

Daily rainfall data were obtained from a publicly accessible online weather station located approximately five miles away. From March 2023 to October 2024, water levels at both the manual and automated water control structures were monitored using an In-Situ Inc. level logger and a built-in level reader, respectively. Additionally, weekly water samples were collected from each control structure between June 2023 and October 2024, and nutrient concentrations (nitrate and dissolved phosphorus) were analyzed using the NuLab wet chemistry analyzer at ShoreRivers' facilities.

FLOW RATE DATA

The site received a total of 95.8 inches of precipitation during the study period, including a significant storm in mid-July that brought 7.51 inches of rain (Figure 2). In response, the automated structure was adjusted to lower the water level in the field (Figure 1). Meanwhile, the manual structure remained without boards to help manage in-field water, resulting in maximum recorded flow. Overall, the manual structure experienced higher flow due to less intensive board management, with an average flow rate of 95.2 gallons per minute (gpm), compared to 21.5 gpm for the automated structure.

System	Rainfall (in)	Discharge (in)	% Rainfall as Discharge
Manual	95.8	75.6	78.9
Automated		17.7	17.8

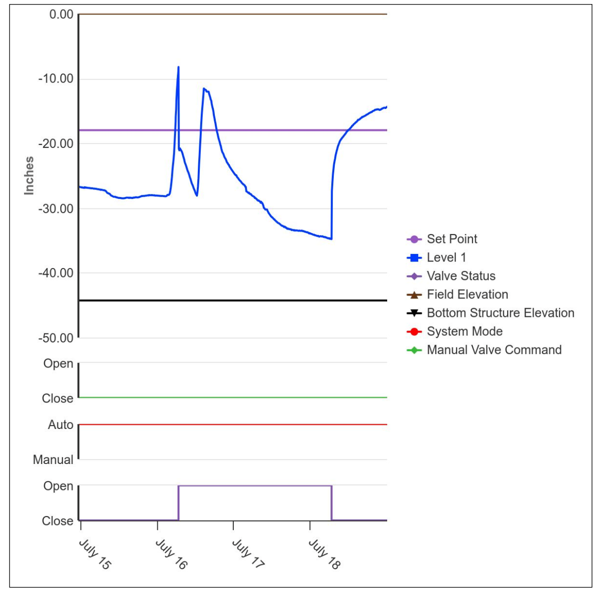

Figure 1. Close-up of the automated structure adjusting the water level to the mid-July rainfall event.

The structures were monitored over a span of 505 days. During this period, the manual structure had flow for 202 days, while the automated structure had flow for only 80 days. The 2024 growing season was abnormally dry and therefore there was no flow from May to the end of the study period.

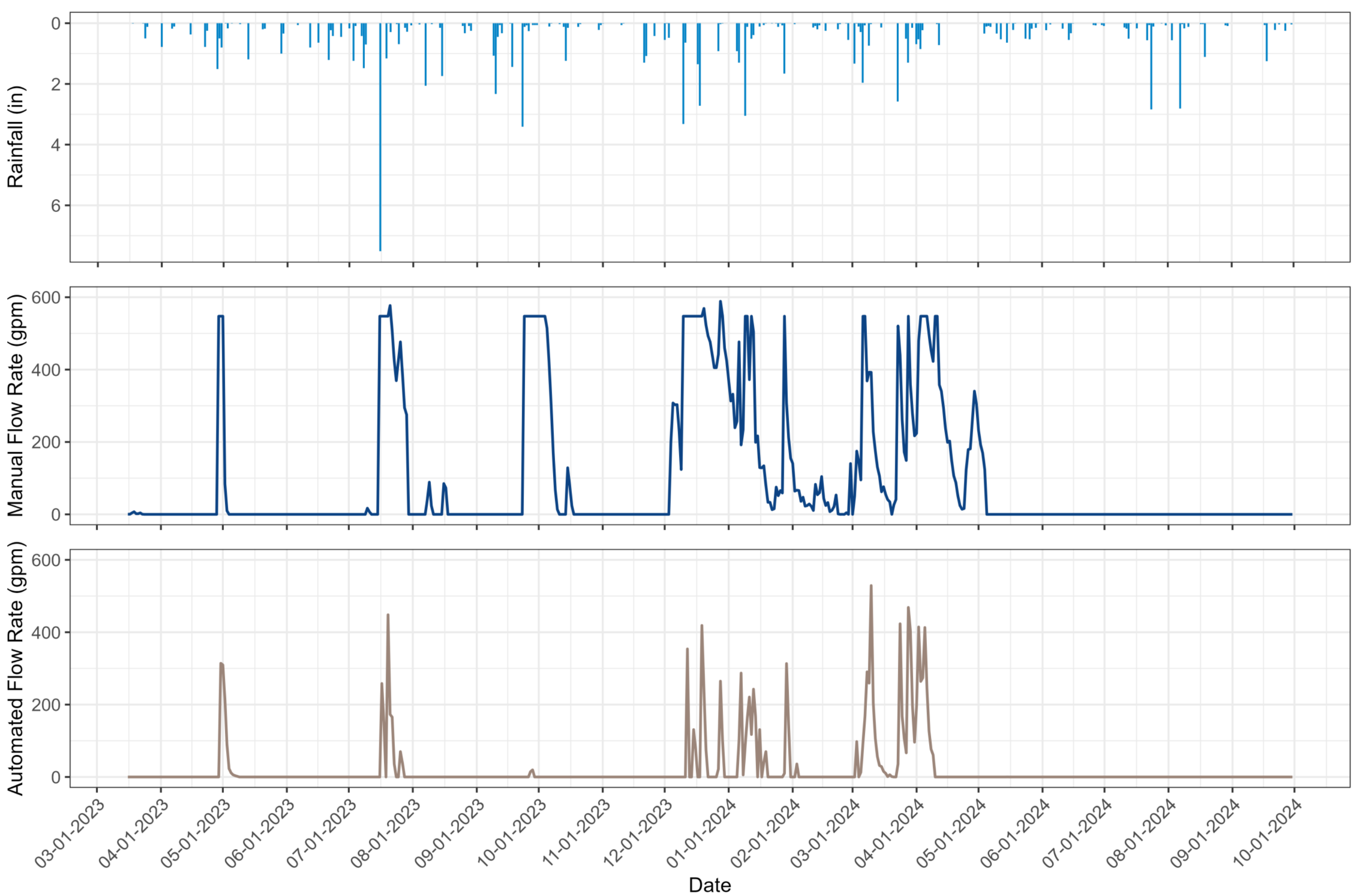

Figure 2. Flow rates for manual and automated structures, and daily rainfall from the closest weather station

WATER QUALITY —NITROGEN

The nitrate (NO_3) concentrations in the tile drainage water from both systems (~8 mg/L) fell within the typical range for agricultural fields (6–16 mg/L). Observed concentrations ranged from a minimum of 1 mg/L to a maximum of 27 mg/L (Figure 3). The flow-weighted NO_3-N concentrations were 10.4 mg/L and 7.8 mg/L for the manual and automated structures, respectively.

Flow weighted mean concentrations represent the average concentration of a pollutant that has passed by a particular site during a monitoring

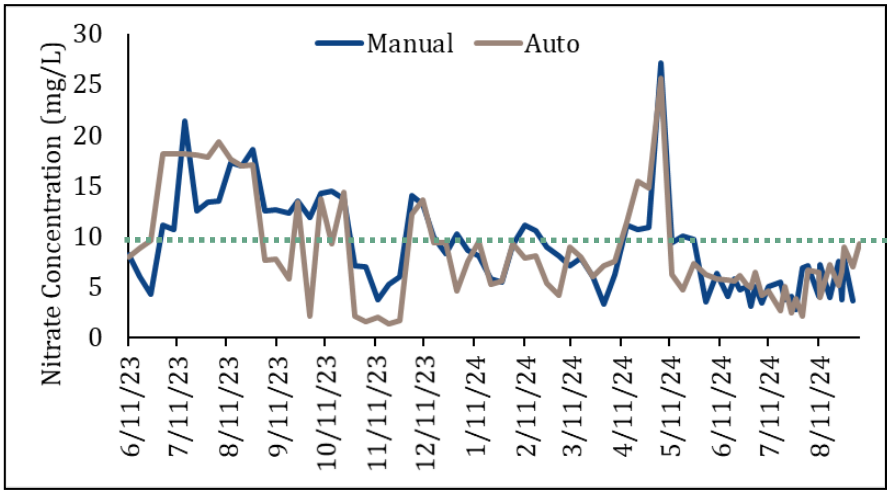

Figure 3. Nitrate concentrations for both structures. The EPA limit of 10 mg/L for drinking water is represented with a green dotted line.

Loads (flow x nutrient concentrations) are important when discussing water quality. Unlike concentration (which provides a snapshot of nutrient levels at a specific location and time), loads provide a better understanding of the total input of nutrients from fields. The manual system had higher loads than the automated structure, especially during high rainfall events with high nitrate concentrations (Figure 4), this is due to the active management of the automated system through it's real time data platform.

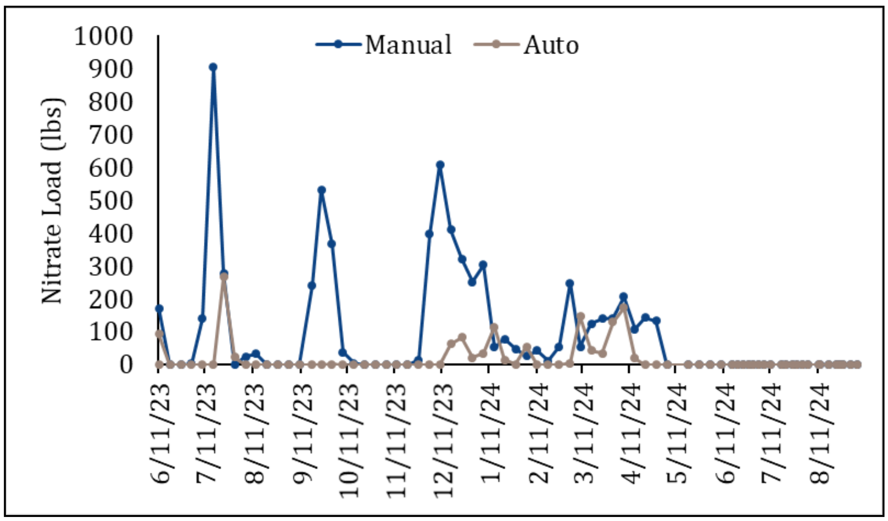

Figure 4. Incremental nitrate load for both structures.

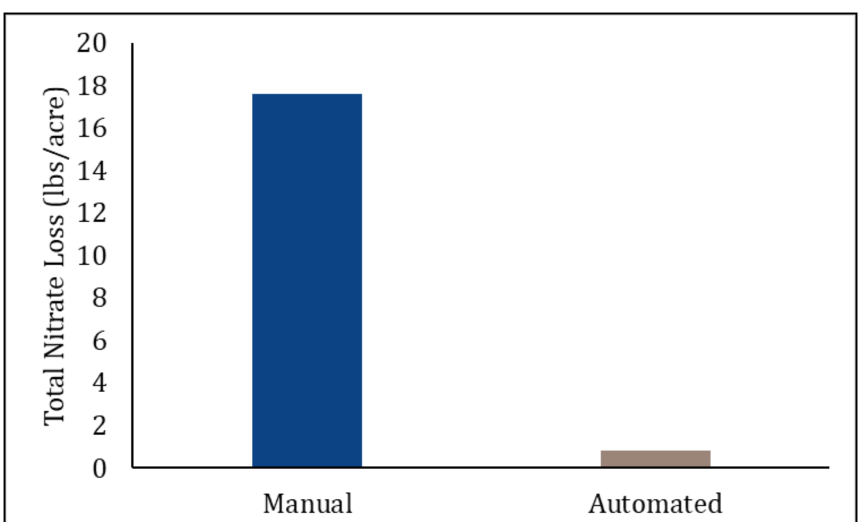

Figure 5. Total nitrate loss (also called yield) for both structures in 2024 growing season.

For the 2024 growing season, the total nitrate loss per acre was 17.6 lbs/acre for the manual system and 0.8 lbs/acre for the automated system (as shown in Figure 5). The fields had a soybean crop for this growing season with minimum rainfall, therefore less N loss was expected.

WATER QUALITY —PHOSPHORUS

The average flow-weighted dissolved phosphorus concentrations for the manual and automated systems were 0.005 and 0.05 mg PO4/L, respectively (Figure 6). Although slightly higher than the EPA dissolved phosphorus limit of 0.02 mg P/L to avoid eutrophication, these concentrations were lower than the average of 0.012-0.253 from other tile drainage studies across the US. The minimum concentrations were 0 mg/L, while the maximum concentrations were 2.4 mg/L.

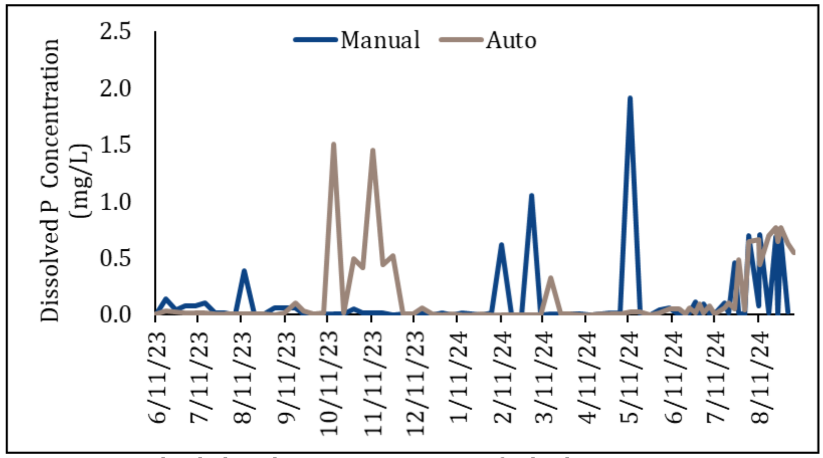

Figure 6. Dissolved phosphorus concentrations for both structures.

The manual system exhibited higher dissolved phosphorus loads, especially during a significant rainfall event in mid-July 2023, as well as an isolated peak in March 2024 (not shown here; see Figure 7). In contrast, the automated system experienced several non-flow days with concentrations of 1 .5 mg/L. However, since loads account for flow, ultimately, no nutrients were leaving the field from the tile system.

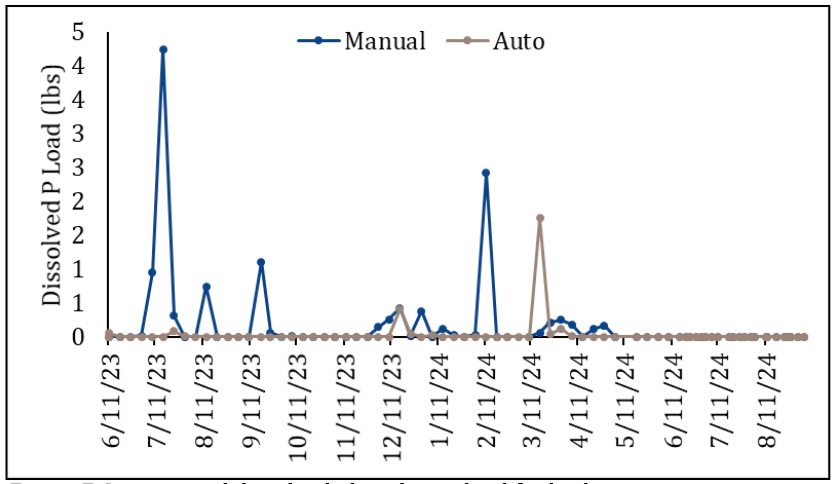

Figure 7. Incremental dissolved phosphorus load for both structures.

Overall, the automated had less nutrient inputs downstream due to more precise drainage water management during higher flow events. Nonetheless, any form of controlled drainage is an effective way to reduce the volume of water leaving the field and thereby decreasing the amount of nutrients.


Tile installation at manual drainage water management system in February 2023.


Automated drainage water management being explained at a field day in December 2021.