COMMONWEALTH of VIRGINIA

DEPARTMENT OF HEALTH

OFFICE OF DRINKING WATER

Richmond Field Office

Karen Shelton, MD
State Health Commissioner

Madison Building
109 Governor St., 6th Floor Richmond, VA 23219
Phone: 804-864-7409
Fax: 804-864-7520

Memo to File: May 2025 Boil Water Advisory at City of Richmond (PWSID 4760100)

June 16, 2025

Authors: **James Reynolds, PE, Field Director, Richmond Field Office**
Tanni Sarker, Ph.D., Deputy Field Director, Richmond Field Office

About midnight on May 27, 2025, ODW was contacted by City of Richmond (City) Department of Public Utilities (DPU) staff about the potential for reduced water pressure from decreased water production at the water treatment plant (WTP) that is part of the City of Richmond Waterworks (Waterworks). DPU staff reported filter performance at the WTP was likely impacted from plate settler clogging. The decrease in water production at the WTP affected the Waterworks' ability to fill the distribution storage tanks. DPU staff had shut down the WTP to clean the plate settlers and empty and clean the sedimentation basins to ensure proper finished filter performance. DPU expected the WTP would return to normal operations in a few hours.

After the WTP restarted operation, DPU staff slowly increased production on individual finished filters as headloss and filter effluent turbidities allowed. This process was a delicate balance between mitigating turbidity breakthrough in the filters, increasing filter flow rates incrementally, maintaining water levels in the clearwells and finished water basins, and filling distribution system tanks. To fill the distribution system storage tanks, DPU staff decided to avoid backwashing of filters until late May 27, 2025, through early May 28, 2025. This decision was made to conserve finished water for customer use.

The Waterworks' Ginter Park tank experienced a drop in water level, which reduced pressure in one zone of the distribution system below 20 pounds per square inch (psi). The reduced pressure specifically impacted the Zone 2N pressure zone and the City appropriately issued a BWA around 1:00 p.m. on May 27, 2025. Later that day, the City added Zone 1S pressure zone to the BWA because of a temporary drop in water pressure below 20 psi. The City's actions responding to the low-pressure event were appropriate and necessary.

The City restored pressure above 20 psi at about 6:00 p.m. on May 27, 2025. The City collected two sets of bacteriological samples in the impacted pressure zones 16 hours apart. Both

sets of bacteriological samples were negative for total coliform and E. coli. The City lifted the BWA with ODW's concurrence on May 29, 2025, around 2:30 p.m.

ODW has completed its investigation. As part of its investigation, ODW reviewed operating records from the Waterworks and two upstream WTPs that also use the James River as their water source. These two upstream WTPs are referenced in this document as Plant A and Plant B. In addition, ODW reviewed United States Geological Survey (USGS) data and weather data in May 2025. The Waterworks' WTP, Plant A, and Plant B all required coagulation and floc formation to settle solids from the James River prior to filtration.

Based on ODW's review of data, all three WTPs experienced an increase in raw water turbidity and a drop in raw water alkalinity from May 14 through May 19, 2025. This change in raw water quality is associated with the James River reaching flood stage levels due to heavy rain events. While all three WTPs experienced lower water quality from their water source, only the City WTP experienced clogged filters and only the City had to issue a BWA due to loss of water production at its WTP. DPU staff delaying preventative maintenance, including sedimentation basin and plate settler cleaning, at the WTP, along with the potential of inefficient coagulation chemical feed processes by DPU staff, are likely contributing factors of the low-pressure incident at the Waterworks and resulting BWA.

River and Weather Data Review

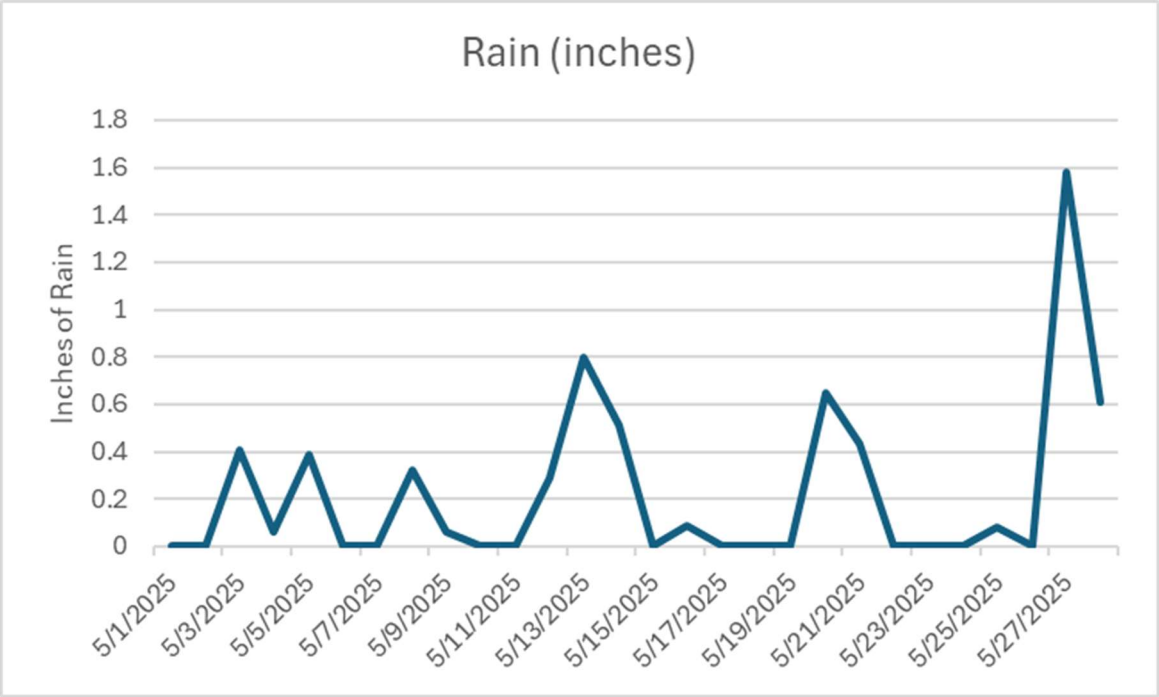

Figure 1. Daily Rain Totals May 2025

Rain happened from May 3 through May 5, May 8 through May 9, May 12 through May 14, May 16, May 20 through May 21, and May 25. The most significant rainfall was recorded between May 12 through May 14, when about 1.6 inches of rain was recorded. The normal rain total for May is 4 inches. About 4 inches of rain was experienced between May 1 and May 25, 2025.

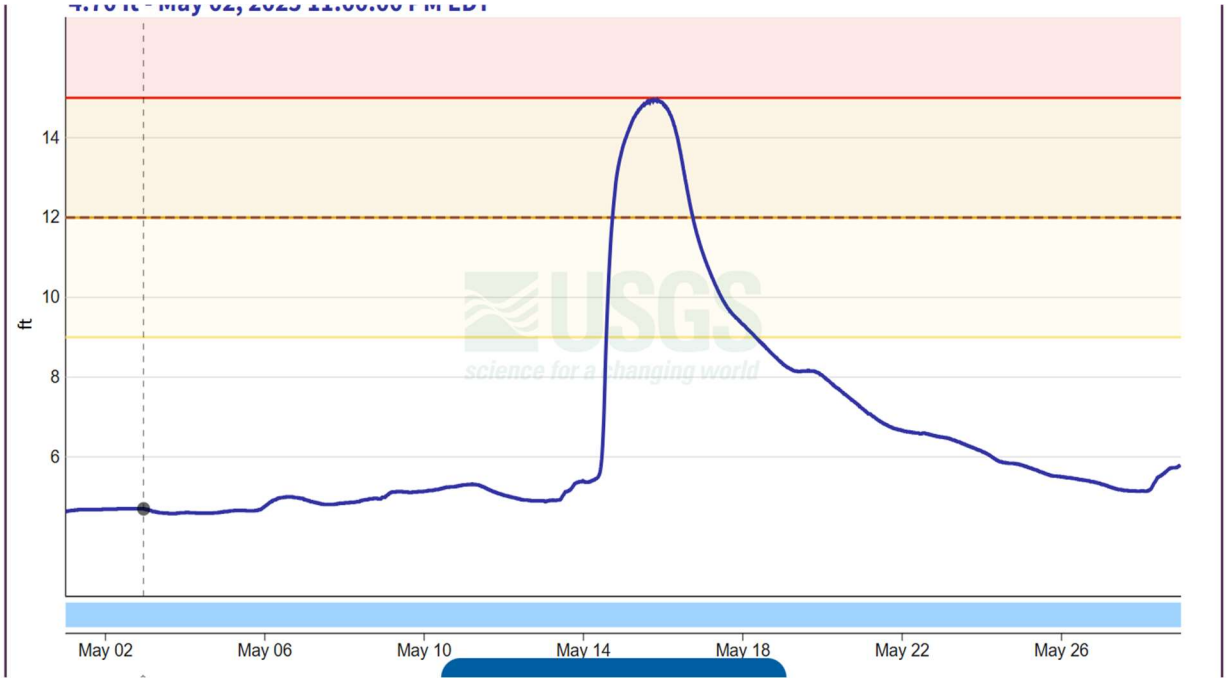

Figure 2. USGS River Gage Height Info May 2025

The James River water level averaged around 5.4 feet until May 14, 2025, where it increased to 13.74 feet. The river crested at about 14.9 feet around 7 p.m. on May 15, 2025. The river did not return to 5.4 feet until May 26, 2025. The minor flood stage for the James River is 12 feet and moderate flood stage is 15 feet.

Water Quality Data Review

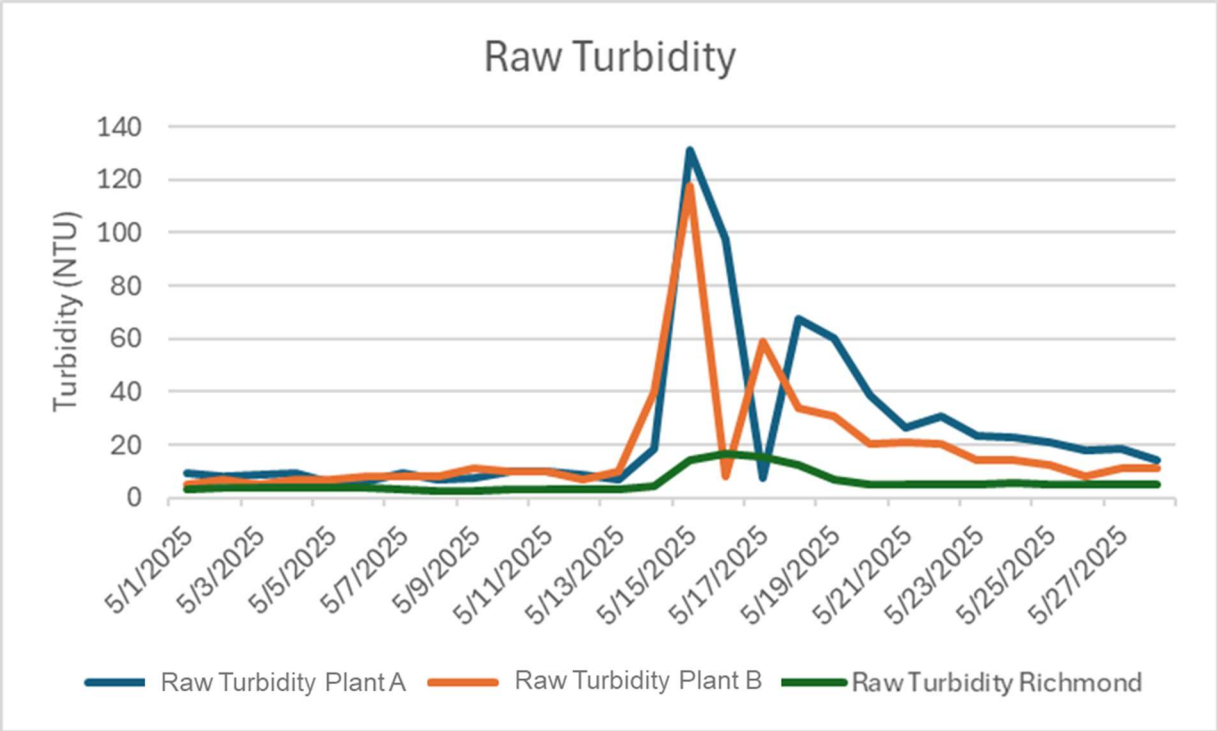

Figure 3. Average Raw Water Turbidity

Raw Turbidity

All three WTPs experienced a spike in raw water turbidity from the James River between May 14, 2025, and May 19, 2025. Raw water turbidity is still slightly elevated in Plant A and Plant B into May 26, 2025, but the City WTP's raw water turbidity appears to have returned to pre-May 14 levels after May 19, 2025.

The City WTP's raw water turbidity is lower and less variable because the City utilizes a channel to act as a pre-sedimentation basin where the raw water can settle out turbidity before it reaches the WTP.

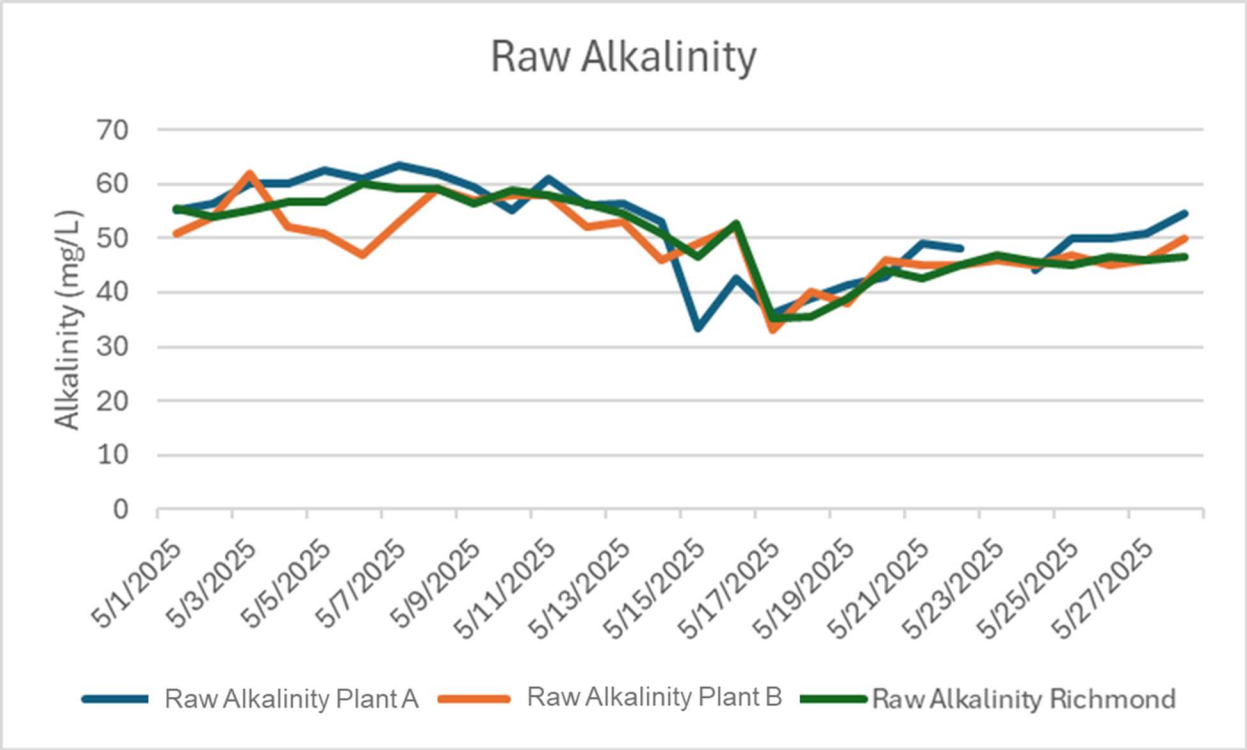

Figure 4. Raw Alkalinity

Raw Alkalinity

All three WTPs experienced a drop in raw water alkalinity between May 14, 2025, and May 19, 2025. The three WTPs had similar raw water alkalinity after May 19, 2025. Alkalinity is an important parameter related to coagulation performance. The coagulation process should maintain an alkalinity level above 10 mg/L to avoid issues with coagulation effectiveness. Ideally, alkalinity should be maintained above 15 mg/L to ensure it does not impact coagulation performance. Higher raw water alkalinity gives a WTP greater ability to add coagulant without impacting the efficiency in coagulation processes.

All three WTPs utilize alum as their coagulant which consumes approximately 0.5 mg/L of alkalinity for every 1.0 mg/L of alum used. Alkalinity adjustment utilizes a chemical feed to increase alkalinity in the water to ensure adequate alkalinity is available for effective coagulation. Plant A and Plant B utilize caustic to offset alkalinity that may be consumed by the alum dosage. The City does not feed alkalinity adjustment at the head of the City WTP.

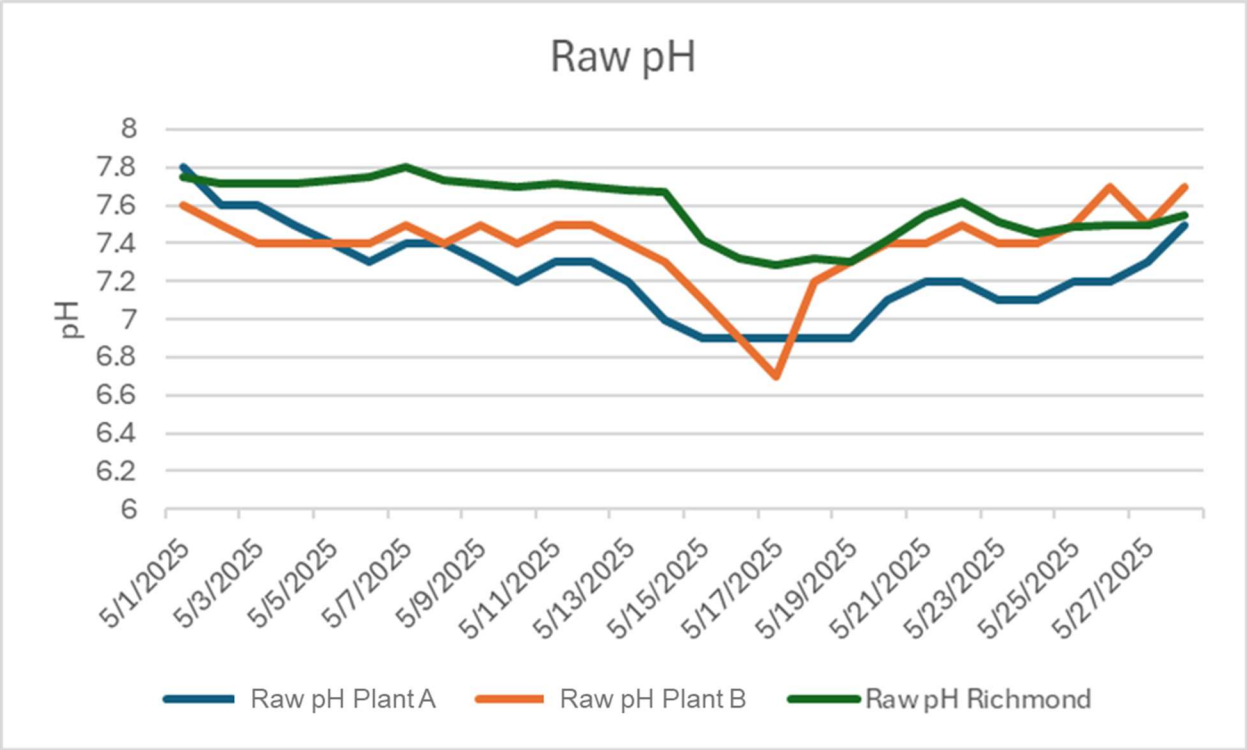

Figure 5. Raw pH

Raw pH

As noted with turbidity and alkalinity, all three WTPs experienced a drop in raw water pH during the May 14, 2025, and May 19, 2025, time period. Raw water pH at the City WTP was higher than Plant A and Plant B from the pre-sedimentation basin.

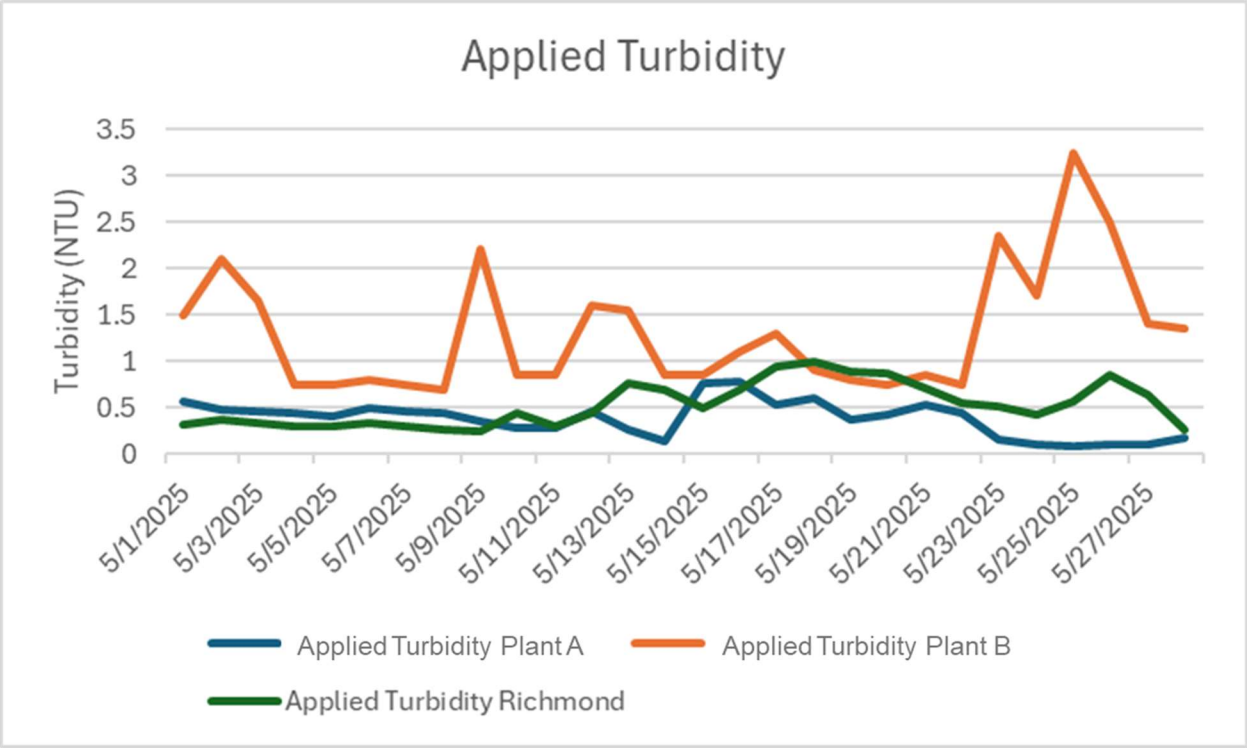

Figure 6. Applied turbidity

Applied Turbidity

Applied turbidity is the turbidity measurement after the sedimentation process and is an indicator on the water going to the filters.

Plant B utilizes a different clarification process and shows higher and less stable applied turbidity due to that process (superpulsators). Plant B has a smaller clarification process footprint compared to traditional clarification due to the use of the superpulsator process.

Plant A and the City WTP experienced some elevated applied turbidity between May 13, 2025, and May 22, 2025. The City WTP also appears to have experienced a spike in applied turbidity on May 26, 2025.

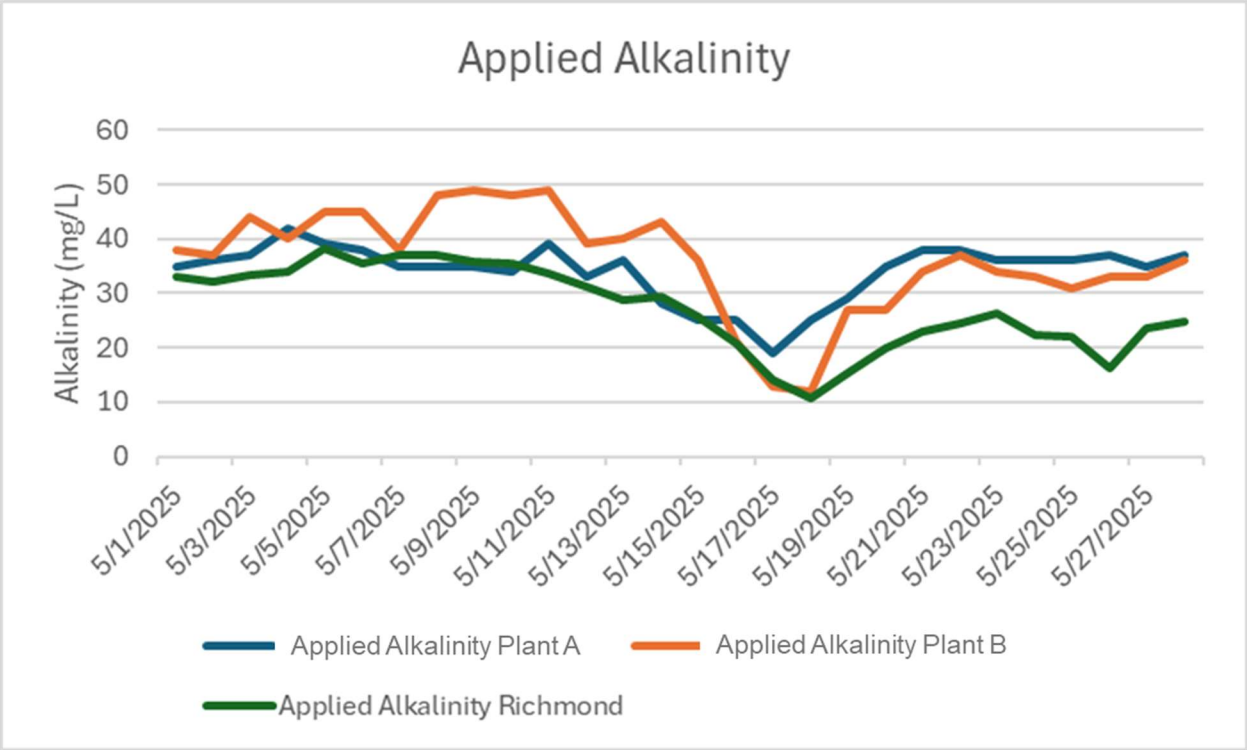

Figure 7. Applied alkalinity

Applied Alkalinity

Applied alkalinity shows the alkalinity remaining after the coagulation process. This alkalinity should be above 10 mg/L and ideally above 15 mg/L at a minimum to ensure the coagulation process had enough excess alkalinity to be effective and not drop below optimal pH for treatment.

All three WTPs (the City, Plant A, and Plant B) experienced a dip in applied alkalinity from May 15, 2025, through May 19, 2025. This observation is likely from the increased coagulant doses to overcome the heavier sediment load from the higher raw water turbidity. Plant B and the City WTP's applied alkalinity levels fell to about the 10 mg/L threshold on May 18, 2025. The City WTP also experienced a temporary dip in alkalinity on May 26, 2025 - 16 mg/L (average).

Plant B utilizes a different clarification method, which could handle temporary drops in coagulation performance. Plant B's technology utilizes a sludge blanket to provide additional clarification before the end of the treatment process. The design of this technology can handle higher sludge levels and is continuously removing sludge to maintain a consistent sludge blanket thickness.

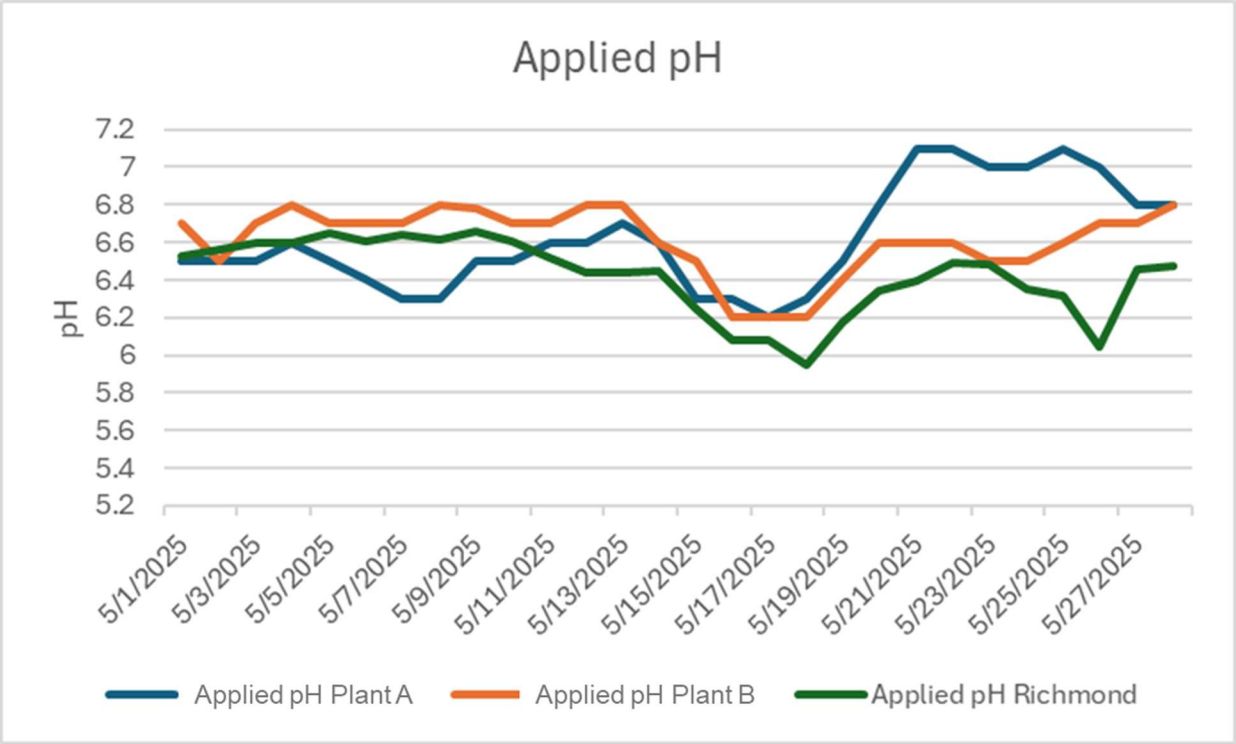

Figure 8. Applied pH

Applied pH

The applied pH is correlated with coagulant dosage and alkalinity. As coagulant is increased, applied pH is decreased due to the consumption of alkalinity. For alum, ODW's experience is that most WTPs do not allow pH to fall below 6.1. ODW cannot determine from the data how many hours, if any, the applied pH was below 6.0 since recordings at the City WTP are average readings. ODW concludes that an over dosage of alum was possible from an error in chemical feeds. The effectiveness of coagulation decreases as the pH drops and approaches 5.5.

Unlike the City WTP, Plant A and Plant B can add caustic to the head of each WTP, which provides alkalinity to the water and reduces the likelihood of dropping below a pH of 6.1. Between May 15, 2025, and May 19, 2025, the City WTP was likely below the optimum pH of 6.1. This reflection is most likely from the lower raw water alkalinity and pH. The City has no ability to add alkalinity adjustment, which would likely be an important consideration going forward with operational improvements. ODW observed a dip in alkalinity and pH on May 26, 2025, however the pH had an average of 6.0 to 6.2.

Shurm Flow

From a review of flows from Sunday May 25, 2025 until May 29, 2025 at Shurm. The City initially thought that Henrico County had reduced flows to help mitigate a possible BWA within the distribution zones for the City of Richmond. The City also thought that Henrico County isolated flow during the BWA. However, upon review, data shows an increase in flows for Henrico County during the most vulnerable period of time. This misunderstanding might have prevented the need for a BWA according to the City of Richmond.

Final ODW Analysis

About May 15, 2025, and lasting for several days, there was a spike in turbidity that was observed at all three WTPs. This was accompanied by a drop in raw water alkalinity. This correlates to a high river level observed around May 14, 2025, which likely included increased scouring and turbulence that increased turbidity while decreasing alkalinity. Plant A also experienced a spike in manganese during this same time period. This increase in turbidity would increase the amount of sludge produced during the coagulation process.

The City WTP's alum dosages ranged between 50 to 72 mg/L during the May 20 through May 28, 2025, time period. A review of bench reports shows that a reported 66 mg/L alum dose was applied on May 25, 2025, and was increased to 72 mg/L on May 26, 2025.

Industry standards and common practice, as ODW understands them, would recommend keeping applied alkalinity above 20 mg/L for optimal floc formation. As the applied alkalinity reaches 10 mg/L, floc formation effectiveness decreases. The alkalinity of the raw water also dropped and applied alkalinity was observed to be averaging 13 mg/L during that time period for the City. This may have resulted in increased sludge at the City WTP, which did not settle as effectively as it should have, increasing clogging potential at the finished filters.

With potentially less effective settling in the sedimentation basin, the plate settlers may have experienced an increased loading of sludge. Around May 13 to May 15, two sedimentation basins were showing elevated settled water turbidities indicating some floc carryover from the sedimentation basin to the filters.

Sedimentation Basin 4 at the City WTP appears to have started showing signs of floc carryover on or around May 13, 2025, prior to the changes in water quality on May 15, 2025. This may correlate with the May 12, 2025, work order for cleaning the plate settlers. This information suggests to ODW that more proactive maintenance would have prevented this BWA incident.

On May 26, 2025, there was a drop in applied water alkalinity, which does not appear to correlate with a similar lower raw water alkalinity. Lower raw water alkalinity was not observed at any of the WTPs. A drop in alkalinity could occur when there is an overfeed of alum and

when there is not higher raw water turbidity or lower raw water alkalinity. Once the plate settlers were excessively loaded, flow through the plate settlers would negatively impact WTP performance. Subsequent need to clean the plate settlers may have resulted in a slug of sludge going to the filters resulting in filter performance issues. Bench sheet data supports that an alum feed likely happened at the City WTP. Basin 2 at the City WTP was taken offline for service cleaning at 9:00 PM on May 26.

Based on the review of data, raw water quality changes were observed in the three WTPs during the evaluated time period. While similar changes in coagulant dosage were made, it appears the City WTP was more impacted due to excessive sludge on the plate settlers and low alkalinity raw water without the ability to adjust alkalinity on incoming raw water.