APPLICATION NOTE

OPTIMIZING FILTER BACKWASHING USING SOLITAX™

Case Study at the Town of Bethlehem, NY Water Treatment Plant

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Introduction

Filter backwashing is an essential process used in conventional water treatment systems that use rapid sand filters. It is needed to purge solids removed from water during filtration. During backwashing, solids collected within the filter are removed by reversing water flow up through the filter. The filter bed is typically expanded between 15 and 30% to promote the removal of solids that have deposited within the interstices of the filter media. Filters are often fitted with surface wash mechanisms and/or air scour systems to further enhance particle removal. Backwash schedule is normally determined by filter run time, head loss development, turbidity break-through or some combination of these three factors.

Backwash turbidity profiles exhibit a characteristic shape, showing an initial spike followed by a more gradual decline to lower turbidity levels that eventually approach that of finished water. The American Water Works Association (AWWA) has recommended terminating backwash when the turbidity is in the range of 10 to 20 NTU in order to leave enough particulate matter within the filter to sustain effective performance during the beginning of the next filter run. It has been well documented that both over- and under-washing can diminish filter performance and, over time, decrease filter life as well as reduce the operating capacity of the plant. Despite these concerns, the duration of backwash continues to be based mainly on the qualitative judgment of the operator who considers assumed backwash requirements (i.e., flow, time, etc.) based on experience as well as a visual inspection of turbidity development during backwash.

Purpose

In recent years, Hach Company has been involved with numerous efforts to measure and characterize turbidity trends during backwash. To further this purpose, this study was conducted to monitor filter operating and backwash cycles over sufficient time so that the influence of modified (i.e., shortened) backwash cycles on longer-term filter performance can be more confidently established. The Town of Bethlehem, New York staff was kind enough to accommodate the required length of this study, which extended from the end of August 2009 to December 2009.

Project Description and Approach

This study, similar to previous efforts, utilizes our Solitax solids/turbidity sensor, which can be installed within the filter above the media, in the backwash trough or in a common collection trough or pipe downstream of a bank of filters. Note that any remote measurement should be made as close to the filter as possible to reduce time lag. Typically, the best turbidity trends (i.e., with the least measurement variability or noise) are obtained by installing the sensor directly above the filter media where turbulence and entrained air are minimized (Figure 1). The Solitax is ideally suited for this application because it is easily installed in these locations and, as a result, can be used either as a permanent or portable backwash monitor.

Figure 1. Solitax solids/turbidity sensor installed 12 inches above filter media at the Town of Bethlehem Water Treatment Plant. Solitax is located between the two backwash troughs facing the flow toward the left trough.

The Solitax sensor utilizes an infrared light source to minimize color interference and provide a highly accurate and linear measurement over a wide range, up to 4000 NTU. The sensor can also be programmed to display results as mg/L or g/L solids. This sensor produces a near instantaneous response to turbidity changes, but measurement can be time-averaged to dampen noise from turbulence and/or entrained air. The sensor can be paired with either a 2-input sc100, a 2-input sc200 or an 8-input sc1000 digital controller to interface with the plant control system via digital or analog output. With this configuration, the sensor can be used to automatically terminate backwash based on a set-point turbidity value, however, these controllers also have the capability to store backwash data for subsequent analysis in the event communication with the plant control system is not possible or desired.

The Town of Bethlehem's New Salem Water Treatment Plant (WTP) treats approximately 6 MGD of surface water using coagulation/flocculation with aluminum sulfate followed by upflow clarification and rapid sand filtration through twelve mixed media filters (110 ft^2 each) containing 14 inches anthracite over 10 inches sand. Raw water and finished turbidity typically average 3 NTU and 0.04 NTU, respectively.

The criteria for initiating a backwash at the New Salem plant are a run time of 96 hours, 6 feet of head loss through the filter or a filter effluent of 0.2 NTU, whichever occurs first. Typically, the filters are backwashed at 96 hours, at which time filter head loss is about 6 feet.

For this study, the Solitax was installed as shown in Figure 1 and was connected to an sc100. The plant staff downloaded the data from the sc100 on a routine basis. Filter effluent turbidity was obtained from plant instrumentation (1720E/sc100 to plant SCADA system).

Results

The shape of the backwash turbidity profiles (Figure 2) were highly consistent throughout the baseline period (August 27 to November 18, 2009) and illustrated that the filter had been adequately purged of accumulated solids within 5 to 7 minutes of starting the backwash, or between 3 and 5 minutes after the high rate flow was started. At this point, the backwash turbidity was typically between 10 and 20 NTU, which is consistent with the guidelines recommended by the AWWA.

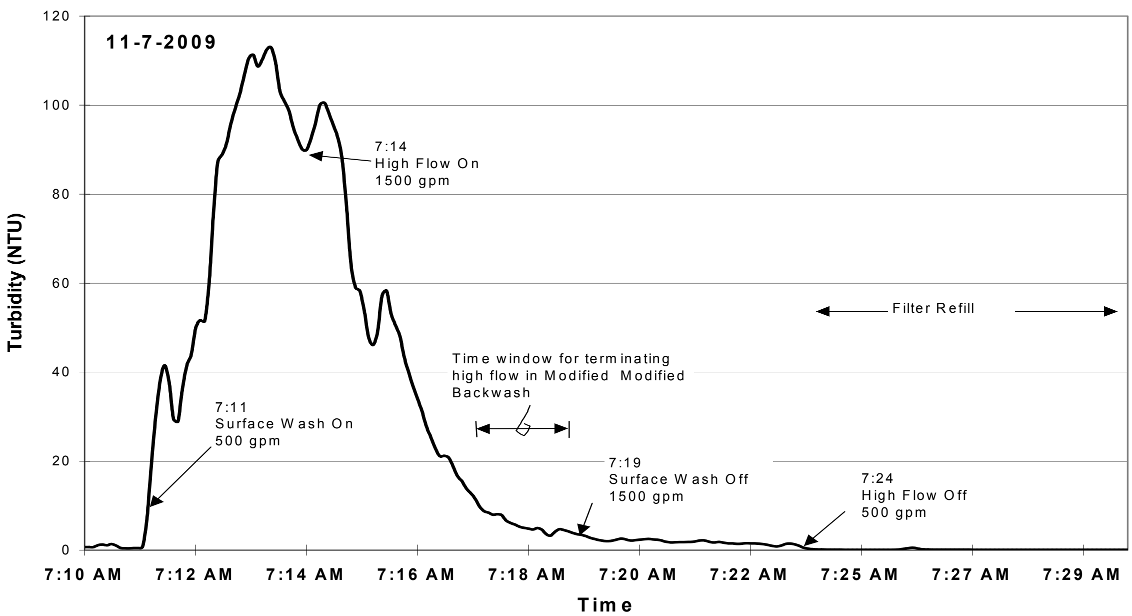

Figure 2. A typical filter backwash turbidity profile for baseline period. Backwash cycle (with total time of 13 minutes) consisted of the following wash sequence: a 3 minute surface wash at a flow of 500 gpm, a 5 minute high rate wash at 1500 gpm with surface wash on, and a 5 minute high rate wash with surface wash off.

The corresponding filter operating performance before and after this backwash is shown in Figure 3, which is representative of the observed performance throughout the baseline period. Based on discussions with the plant staff, it was felt that the high rate filter backwash flow could be safely terminated at the same time as the surface wash, which would reduce the duration of the high rate backwash flow from 10 minutes to 5 minutes (Figure 2).

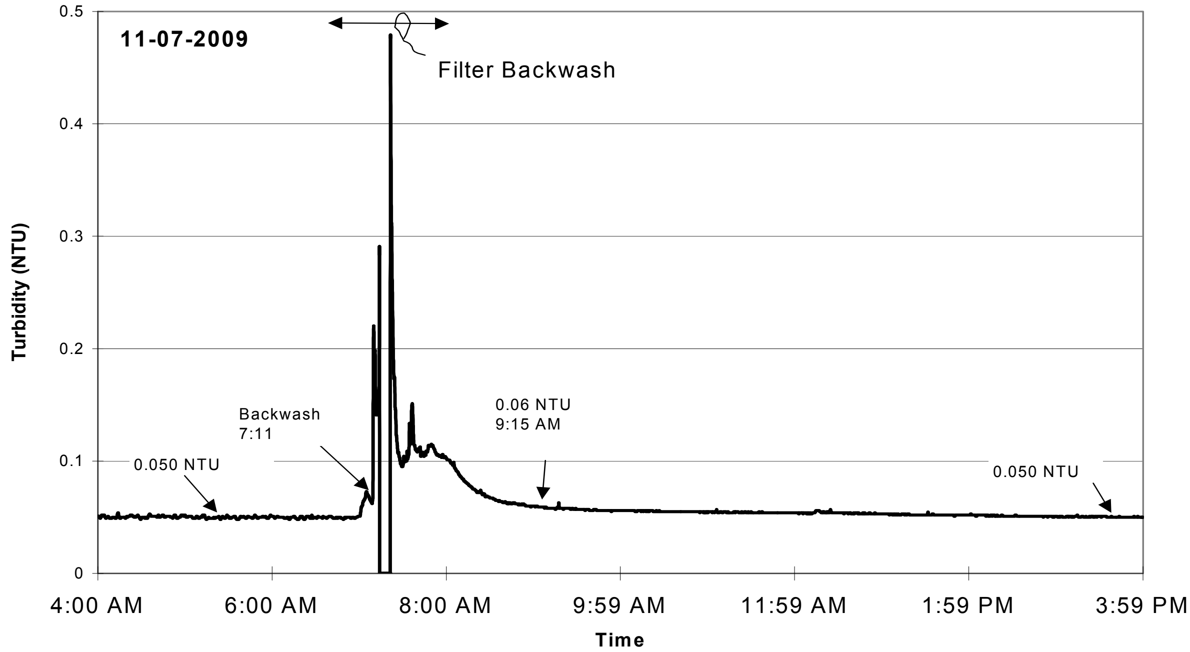

Figure 3. Filter performance before and after a baseline backwash shown in Figure 2. Note filter recovery period is approximately two hours.

Modified (i.e., shortened) filter backwashing was begun in November 2009 and continued through January, 2010. Backwash turbidity monitoring showed that shortening the duration of high rate flow from 10 minutes to 5 minutes had little effect on the timing of the return of backwash turbidity to levels below 20 NTU (Figure 4), and that the end of modified (shortened) high rate wash occurred well after reaching the 20 NTU threshold recommended by AWWA.

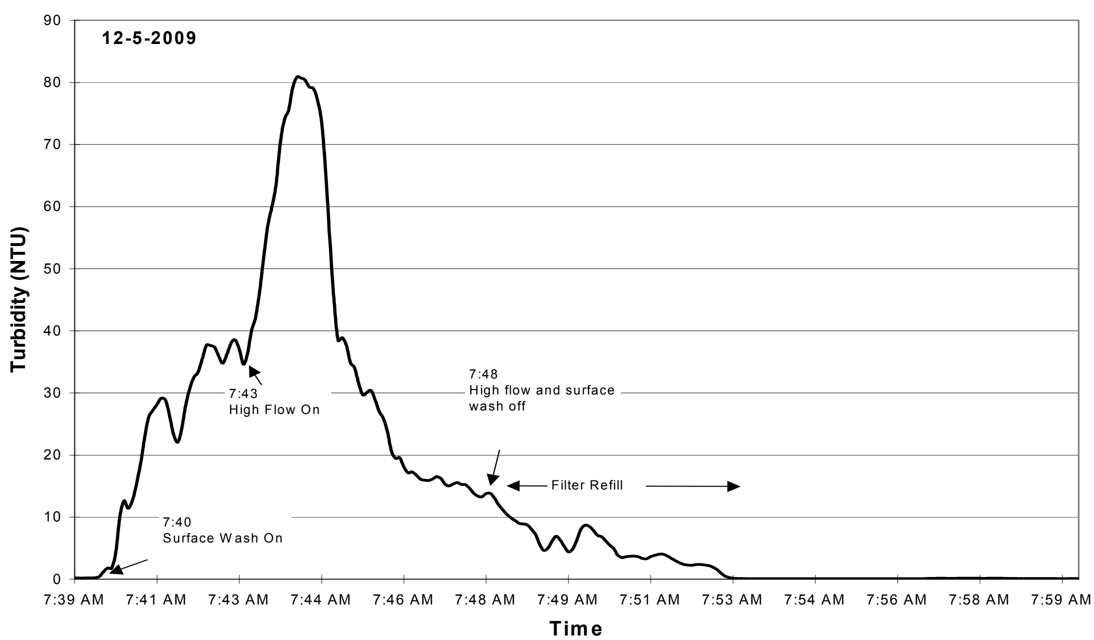

Figure 4. Typical turbidity profile for a modified (shortened) backwash with the duration of high wash flow reduced from 10 to 5 minutes.

Modified and baseline backwash cycles are overlain in Figure 5 to further illustrate the comparability of these two backwash schemes. Filter operating performance before and after modified backwashes also showed similar trends related to both shorter- and longer-term filter recovery after backwash (Figure 6). This validated the 20 NTU termination value for this filter design. Filter performance monitoring throughout the period of modified backwashing suggests that, with good agreement between backwash turbidity profiles, alternative backwash methods can be used with good confidence on the basis of backwash turbidity profiles alone and, as a result, can be implemented relatively quickly.

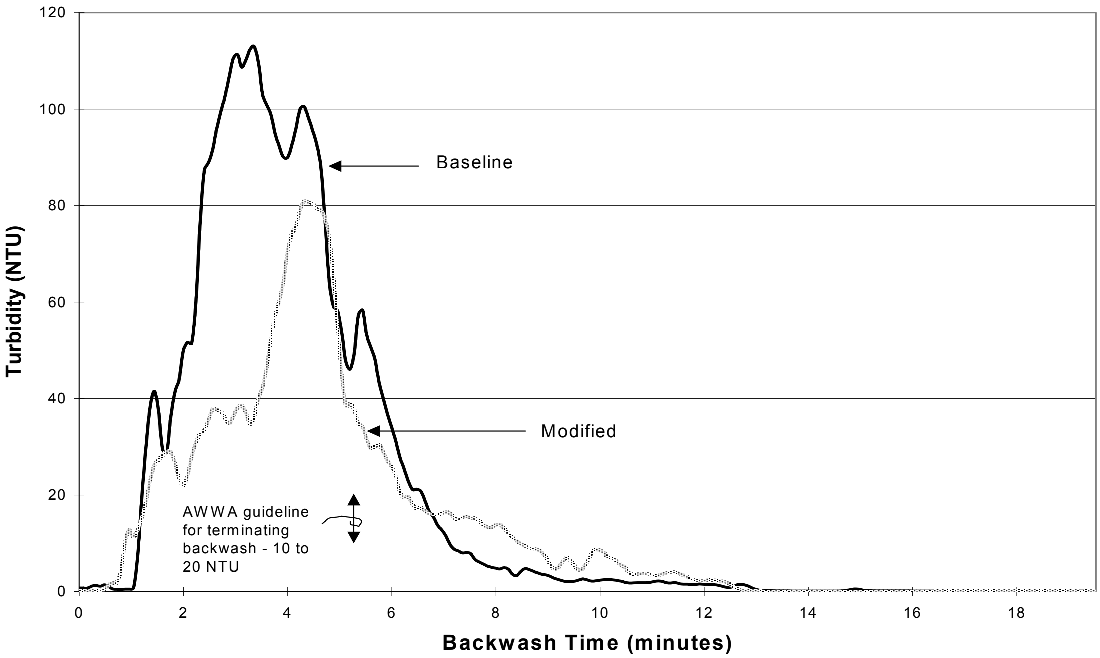

Figure 5. A comparison of baseline (10 minute high rate flow) and modified (5 minute high rate flow) filter backwash turbidity cycles.

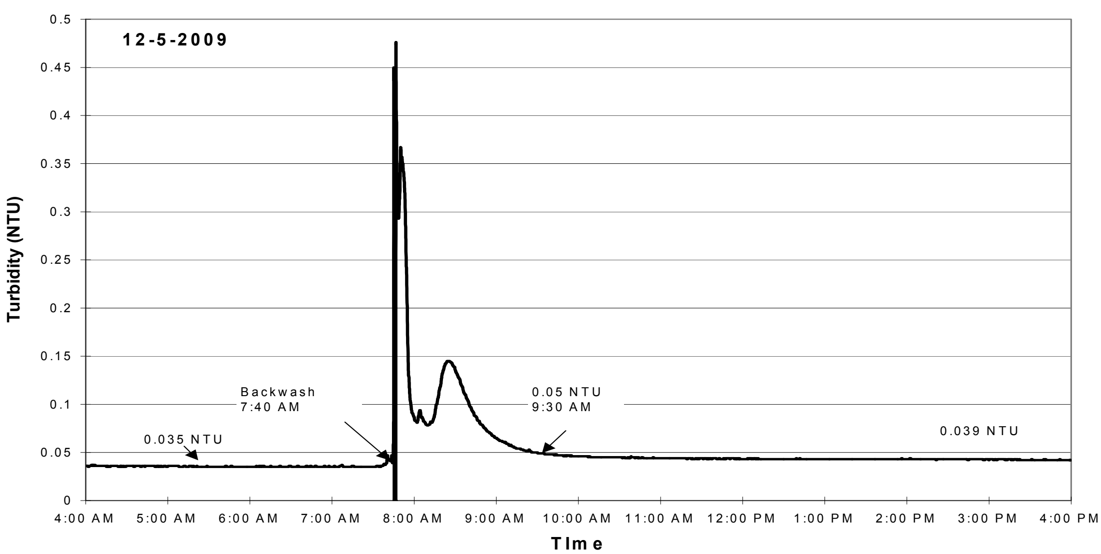

Figure 6. Filter performance before and after a modified backwash shown in Figure 4. The filter recovery period of two hours is nearly identical to baseline period (Figure 3).

Conclusions

Based the results of this study, the plant staff has concluded that the duration of high rate backwash flow can safely be reduced from 10 to 5 minutes. For an average annual high rate flow of 1900 gpm (note actual flow is temperature dependent) relative to end of backwash flow of 500 gpm, the Town of Bethlehem estimates they will save approximately 7000 gallons of treated water per backwash per filter (plant has 12 filters). Using a backwash frequency corresponding to a 96-hour filter run time, the plant will save approximately 7,500,000 gallons of water (for 12 filters) annually. In addition to water conservation, which may not be as much of a concern in areas where water is plentiful, there are other significant savings associated with backwash optimization. Considering the cost of treated water ($1.10/1000 gallons), plus power and labor savings, the plant staff estimated it will save approximately $10,000 annually.

For a plant with 12 filters, a backwash schedule of 96 hours, and the ease of moving a Solitax between filters (Figures 7 and 8) the New Salem plant could operate with one or two Solitax sensors and an sc100. The payback for this system would be approximately one year. Bearing in mind that all applications are unique, many plants need to backwash on at least a daily basis. If this were the situation at the Town of Bethlehem, annual cost savings would have been about $40,000, which would justify the cost of a permanently installed Solitax on each filter. The ability of the Solitax sensor to be used in both portable and permanent installations makes it readily adaptable to meeting end user requirements.

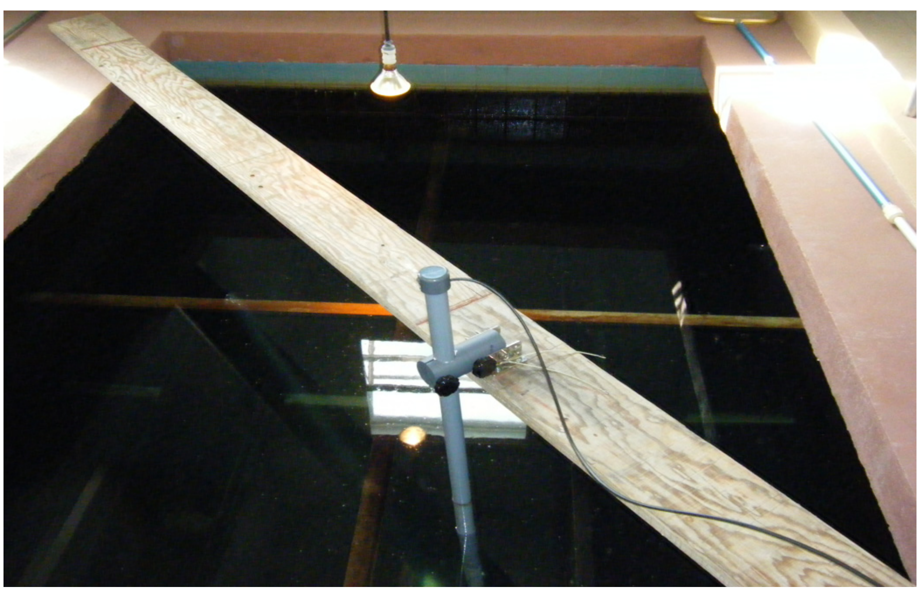

Figure 7. Solitax installation used for backwash study has been easily modified for long–term portable use at the Town of Bethlehem water treatment plant.

Figure 8. Data collection system including notebook PC and sc100 used for backwash study.

Since the conclusion of the study in 2009, the Town of Bethlehem has made significant changes to operations at the New Salem plant to comply with the Stage 2 D/DBPR, resulting in multiple adjustments to the backwash cycle time. The data from this study was used consistently to test and support these adjustments.

The town also concluded another backwash profiling study in May 2014 at its Clapper Road plant using the same portable Solitax configuration, which resulted in reduction of high rate wash time by almost 60%. This will provide about $30,000 of additional annual retreatment, energy, and labor savings for the Town of Bethlehem.

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