Innovative Applications of Treatment Processes for Spent Filter Backwash [Project #3114]

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OBJECTIVES:
The overall objectives were to evaluate and characterize high-rate spent filter backwash (SFBW) treatment processes, in particular their potential to meet treatment objectives while requiring limited footprint at space-limited locations. This report describes available information from previously unpublished studies and studies conducted as part of this research regarding treatment alternatives for clarification of SFBW, including plate and tube settlers, standard- and high-rate dissolved air flotation (DAF), high-rate solids contact processes, sand-ballasted coagulation, and membranes.

BACKGROUND:
Although there are numerous reasons why utilities treat SFBW prior to recycle, one of the main reasons is a proactive concern over process or water quality impacts associated with recycle. Previous research has shown that untreated SFBW can contain elevated levels of microorganisms, DBP precursors, and manganese. These research efforts have also shown that solids removal from SFBW, if efficient enough, eliminates most of the contaminant carryover.

APPROACH:
Limited available literature, mostly unpublished reports from studies conducted by equipment manufacturers for drinking water utilities, were reviewed to evaluate the extent of available information on treatment of SFBW. These studies included standard-rate DAF, sand-ballasted coagulation, and one study with a high-rate solids contact process.

High-rate DAF and high-rate solids contact clarifiers, including two different manufacturers for each, were evaluated at field sites in Utah and Ohio during this research. Characteristics evaluated included turbidity, particle count, iron, manganese, aluminum, total organic carbon (TOC), dissolved organic carbon (DOC), UV-254, color, and percent solids concentration of the residuals stream generated by the SFBW treatment process.

Membrane treatment alternatives for SFBW were evaluated in bench-scale studies. Technologies evaluated included low pressure microfiltration/ultrafiltration (MF/UF) types, such as hollow fiber membranes, tubular membranes, and ceramic membranes.

RESULTS/CONCLUSIONS:
- Equalization (including mixing) improves SFBW treatment effectiveness and minimizes treatment sizing/cost.
- Optimal polymer addition and flocculation conditions produce best clarification performance.
- When clarification rate was expressed relative to clarification area alone, certain high-rate processes demonstrated acceptable performance of 15 gpm/ft² or higher. When expressed relative to total footprint (i.e., including space for flocculation, chemical addition, etc.) the rates for these processes were 0.8 to 1.5 gpm/ft².
- SFBW treatment processes evaluated were able to meet project performance objectives of 95th percentile turbidity <2 ntu and median or steady-state turbidity <1 ntu.
- High-rate DAF and certain high-rate solids contact clarification processes produce residuals with ≥3 percent solids. Other processes (e.g., tube or plate settlers, sand-ballasted coagulation, etc.) typically produce about 0.3 percent solids (often less).
- Membranes
  - SFBW treatment at high specific permeate flux rates of 10 to 200 gfd/psi using either hollow fiber or ceramic membranes appears technically feasible.
  - Although SFBW has a relatively high solids level, large bore (i.e., 1 cm) tubular membranes (like those used in these studies) may not be necessary.
  - Due to the significant impact of SFBW quality on membrane performance, site-specific pilot testing of membranes is recommended.

APPLICATIONS/RECOMMENDATIONS:
The following observations and information items are provided for utilities wishing to evaluate SFBW treatment, including high-rate treatment options, for their facilities:

**Equalization**
Equalization will reduce the hydraulic impact of recycle return to the main process, plus it will improve performance of any SFBW treatment systems utilized prior to recycle. Furthermore, equalization will minimize the size of any SFBW treatment needed, thereby minimizing the cost of the SFBW treatment facilities. Equalization basins must be designed with sufficient mixing to keep solids from settling out in the equalization basin. The only exception to this is for large plants with many filters such that the instantaneous backwash flow is low relative to the influent flow. Still a small mixed equalization basin will reduce slug particulate loading to a treatment device.

**Pre-Treatment**
Polymer addition and provision of sufficient flocculation time are often necessary for achievement of desired performance in high rate SFBW treatment systems. In some instances, performance objectives can be met without adding polymer or without providing any flocculation prior to clarification, although even in these cases high rate clarification processes perform better when polymer addition and sufficient flocculation time are provided. Furthermore, even though all SFBW clarification processes evaluated were sensitive to fluctuations, especially spikes in the amount of particulate material in the incoming untreated SFBW, the use of proper polymer at optimal dose, and allowance for sufficient flocculation time, made SFBW treatment processes more robust with respect to these fluctuations. As in other processes involving chemical addition, if polymer is added then it is also important to provide sufficient rapid mix.

**Performance Criteria**
Each utility needs to set its treatment objective for the treated water quality whether the water is to be recycled or discharged. For discharge situations, the state will dictate the quality requirement. For a recycle situation, one approach to SFBW treatment would be to reduce contaminants, including particulate matter, to levels equal to or below levels in raw water at point of recycle return. In this way the recycle cannot increase contaminants entering the plant above that initially present in the raw water. Reducing some contaminants like manganese to levels below raw water levels can require the production of a very low turbidity water.

**Area Requirements**
Lower-rate clarification processes (e.g., “quiescent gravity settling” as described in this report) for SFBW treatment need to include sufficient surface area to produce surface loading rates low enough to reliably achieve the treatment objectives. Furthermore, additional area for chemical addition and flocculation could be needed in some instances to properly prepare the SFBW prior to clarification. It may not be possible to obtain enough area at space-limited sites to meet treatment objectives using the lower rate processes. Consequently, high-rate processes with smaller...
footprint (like those discussed in this report) may need to be evaluated.

**Retrofitting**
If existing SFBW treatment facilities are undersized, either under current conditions or under conditions projected after a planned expansion of filtration capacity, it may be possible to retrofit components of high-rate processes to replace existing lower rate processes, thereby providing sufficient treatment capacity to reliably treat more SFBW without requiring more area at space-limited sites. Appendix B includes examples of high-rate processes retrofitted into space occupied by existing lower rate SFBW treatment processes.

**Residuals Handling**
Some of the SFBW clarification processes evaluated (standard- and high-rate DAF, solids contact clarification with solids recycle) produced residuals with three to five percent solids concentration, or higher, under conditions tested. These residuals may not need further thickening prior to dewatering. Other low- and high-rate processes evaluated (quiescent gravity settling with or without plates or tubes, sand ballasted coagulation, upflow clarification in a bed of buoyant media) produced residuals that are typically 0.3 percent solids concentration or lower, and rarely exceed one percent solids concentration under most conditions. These residuals will probably need some thickening prior to dewatering. Consequently, utilities without existing SFBW treatment who plan to install systems producing the less concentrated residuals will not only have to provide sufficient area for the processes themselves (including equalization, chemical addition, flocculation, and clarification), but may also need to install thickening facilities or expand existing thickening capacity.

**Pilot Testing**
Pilot testing of low- or high-rate clarification processes is strongly encouraged in order for a utility to evaluate site specific conditions on performance of different alternative treatment technologies. Piloting is not only important to evaluate the clarification technology itself, but also to evaluate chemical addition and flocculation conditions preparing the SFBW prior to clarification.

**MULTIMEDIA:**
The report includes a Web Tool that incorporates example drawings for different facility sizes using the technologies evaluated in this project, as well as a calculation tool to estimate facility cost and footprint for different sizes of high-rate clarification facilities.

**RESEARCH PARTNERS:**
- U.S. Environmental Protection Agency
- City of Cleveland Division of Water

**PARTICIPANTS:**
Six utilities from throughout the United States participated in this project.