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Project Summary

Feasibility Study of Alternative Technology for Small Community Water Supply

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A cooperative demonstration project was funded by the U.S. Environmental Protection Agency (EPA) to enable the Village of Cayuga, N.Y., to install and demonstrate water filtration technology that may be appropriate for small water systems that use surface water sources. The demonstration project was undertaken because the existing facilities were not able to meet the turbidity requirements of the New York State Health Department. A prefabricated filtration system consisting of two cyclone separators in parallel followed by three parallel treatment trains, each employing a contact clarifier, a mixed media filter, and a granular activated carbon filter, was installed at Cayuga's existing water treatment plant. The new equipment replaced facilities built in the 1930's, consisting of aeration, sedimentation, and filtration. After installation, careful records of the first year's operation were kept to document water quality, operating labor needs, and operating costs, including power and chemicals.

Data collected showed that, with respect to turbidity removal, the performance of the treatment plant exceeded the goals set forth in the study.

As for costs, chemicals totaled 5 cents per 1000 gallons, and power, including raw water pumping but excluding treated water pumping, was 10 cents per 1000 gallons, at a rate of 6.2¢ per kilowatt-hour (KWH). Installation cost for the 150 gallons per minute (gpm) system was $268,000.

This Project Summary was developed by EPA's Water Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Village of Cayuga, New York, obtains its drinking water from the shallow northern end of Cayuga Lake. For a number of years the water treatment plant, which employed aeration, sedimentation, and filtration, had from time to time failed to provide water that met the 1 nephelometric turbidity unit (NTU) limit set by the EPA In 1981 Cayuga received a demonstration grant to assist the village in installing, operating, and monitoring a prefabricated 150 gpm water filtration system manufactured by Culligan USA * This report describes the installation and start-up of the system and includes construction cost, operating cost, and water quality data developed during the installation of the system and the subsequent 12-month operating period.

Equipment

The new filtration equipment was installed in the original water filtration plant built in the 1930's. When the initial portion of the filtration system was ready for operation in the remodelled facility, the shutdown for the switch-over was less than 16 hours—well under the 24-hour maximum shutdown stipulated by the New York State Department of Health (NYSDOH). The construction of this initial portion was started about April 1, 1982, and switchover occurred on June 21,

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use

1982. Carbon filters for effluent polishing were completely installed on August 24, 1982, and the full system was operational on August 26, 1982.

In the 150 gpm, prefabricated filtration system (see Fig. 1), raw water first passes through two cyclone separators operated in parallel. The primary treatment train consists of coagulation with alum and a cationic polymer followed by three 36-inch-diameter contact flocculators containing 40 inches of coarse sand operating in parallel at a rate of 7 gpm/ft^2

Next in line are three multimedia filters also operated at 7 gpm/ft^2 in parallel. For effluent polishing, three granular activated carbon (GAC) filters operating in parallel at 5 gpm/ft^2 are used. Chemical feed for coagulation is related to raw water turbidity, which is measured continuously. When raw water turbidity is 35 NTU or lower, a single set of feed pumps is used. When turbidity of the lake water exceeds 35 NTU, a second set of chemical feed pumps is activated, resulting in a doubling of the alum and polymer doses. Backwashing for the contact clarifiers and the multimedia filters is done automatically, based upon differential pressure through the filters The plant operator initiates backwashing of the GAC; this need is also based on head loss.

Results

Results are presented for both costs and water quality. To evaluate the water quality data, results obtained from treatment are compared both to the EPA Maximum Contaminant Levels (MCL) for turbidity (1 NTU) in the Primary Drinking Water Regulations and to the performance criteria set by the NYSDOH, which are set forth in Table A as provided by the NYSDOH (Table 1). The performance criteria are used to evaluate those water filtration processes not designed on the basis of the 1982 Recommended Standards for Water Works (commonly referred to as the "Ten State Standards") Note that performance criteria for turbidity, microscopics, and aluminum vary according to the frequency of occurrence. For example, 95 percent or more of the turbidity values are to be ≤ 0.50 NTU; 75 percent or more, ≤ 0 30 NTU; and 50 percent or more, ≤ 0.20 NTU. These criteria are for process evaluation only. For public drinking water, the NYSDOH uses the 1 NTU MCL.

The contaminant of greatest concern at Cayuga was turbidity. The 1 NTU MCL had been exceeded on numerous occasions by the old treatment plant. During the first year's operation, the prefabricated filtration system was able to meet the MCL. In addition, the system proved capable of meeting the much more stringent NYSDOH process evaluation criteria.

An important concern was the system's ability to react to rapid changes in raw water quality. Cayuga Lake, with abun-

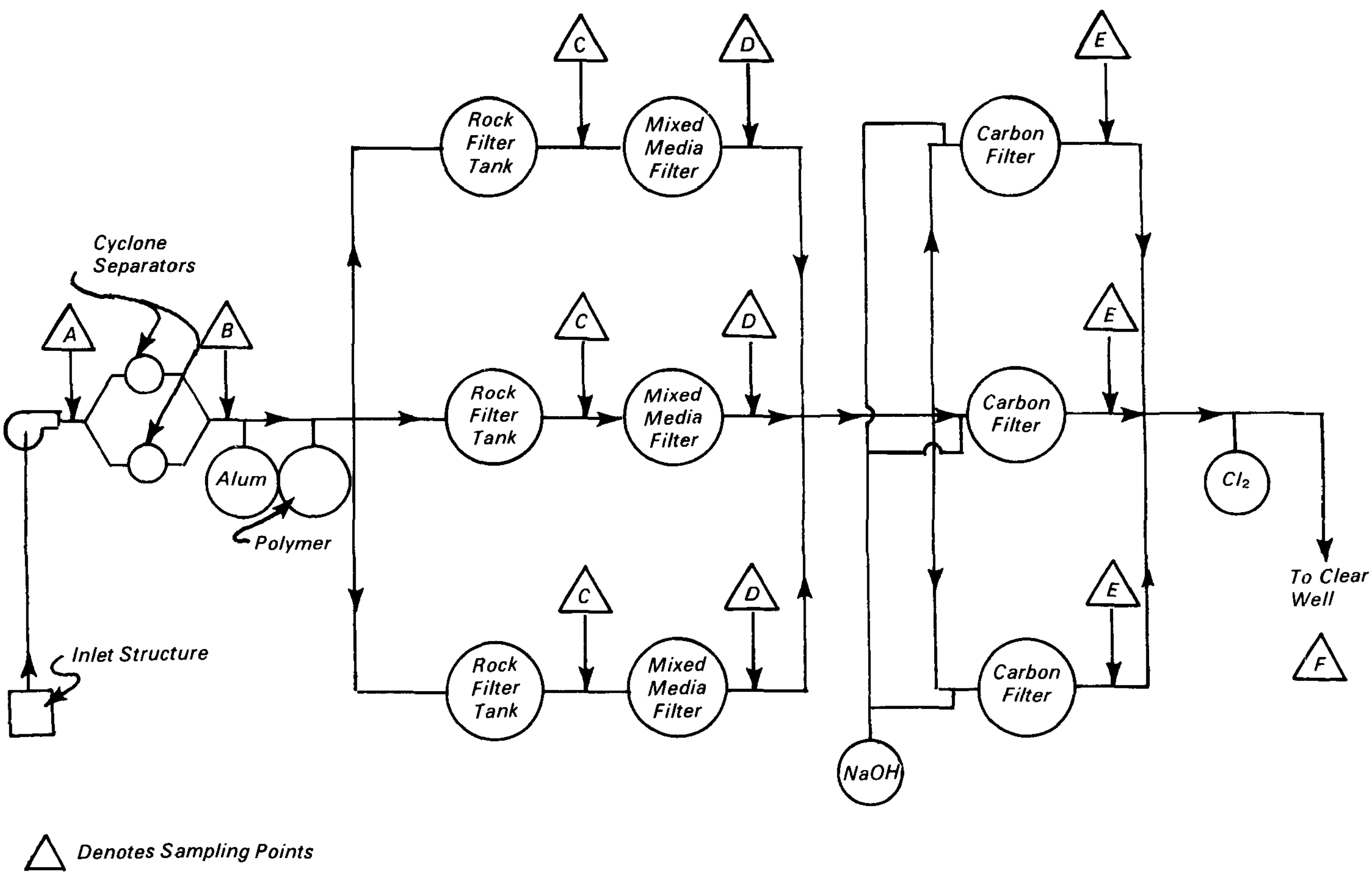

Figure 1. Pilot study pressure filtration system schematic pilot study, Village of Cayuga, NY.

Table 1. *Water Quality Criteria to be Met at New Facilities not Designed in Accordance with Recommended Standards for Water Works, from New York State Sanitary Code, Chapter 1, Part 5*

Performance Criteria· Pretreatment and Filtration

Table A

Process

% of values	Pretreatment Effluent				Filter Effluent			
	Turbidity	Microscopics	Aluminum	Color	Turbidity	Microscopics	Aluminum	Color
	units	areal std units/ml	mg/l	units	units	areal std units/ml	mg/l	units
95 or more	≦5 0	≦14,000	≦0 70	≦10	≦0 50	≦1000	≦0 15	≦5
75 or more	≦2.3	≦9,000	≦0 45	≦10	≦0 30	≦400	≦0 09	≦5
50 or more	≦1 0	≦6,000	≦0 30	≦10	≦0 20	≦300	≦0 05	≦5
		AWWA Goals (for comparison)	→	→	≦0 10	no live organisms	≦0 05	≦3

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dant summer weed growth, is generally less than 10 feet deep near Cayuga. Winds from the south can cause big waves at the northern end of the lake. The new filtration equipment was able to cope with turbidity increases from about 10 NTU to 60-100 NTU in times as short as 2 or 3 hours and meet the 1 NTU MCL.

One aspect of the filtration equipment seemed to be related to slightly elevated filtered water turbidities. When the raw water turbidity rose or fell to and remained at the point (35 NTU) at which a second set of chemical feed pumps turned on to double the alum and polymer doses, filtered water turbidity rose somewhat but did not exceed 1 NTU. A series of changes (increases and decreases) in chemical dose caused by the system's response to raw water having a turbidity close to 35 NTU may have caused the rise in turbidity Use of proportional feed pumps might have eliminated this problem

Another aspect related to raw water quality and process equipment was that aluminum passed through the treatment plant when the raw water pH exceeded 7 5. Often the NYSDOH criteria for aluminum in filtered water were not met because the treatment plant had no provision for lowering the raw water pH to the best pH range for alum coagulation When the raw water pH was above 7.5, monthly average aluminum concentrations in the filtered water ranged from 0.1 to 0.5 mg/L. During winter and spring, when pH was generally below 7.5, concentrations generally averaged well under 0.1 mg/L.

Direct filtration processes (such as the one at Cayuga) that do not employ settling basins have sometimes been found to be sensitive to water temperature, filtered water quality declines when the water temperature approaches the 0° to 5°C range. On the other hand, cold temperatures sometimes have no detrimental effect on treated water quality. One factor for this may be the time available for the alum coagulant to be in contact with the water before it is filtered. Some evidence for this was seen at Cayuga· in the first removal process (the contact clarifier) when raw water temperature was ≥10°C, turbidity removal ranged from about 65 to 90 percent; when raw water was 0° to 5°C, removal ranged from about 45 to 60 percent. Theoretical detention time from the point of alum addition to the discharge from this unit was just under 4 minutes, and total time through both the contact clarifier and the multimedia filter, just under 7 minutes. When the monthly average raw water temperature was ≤5°C, the multimedia filter was removing 20 to 30 percent of the raw water turbidity Perhaps of more significance, the GAC filter (the third filtration process in the treatment train) was removing from 10 to 30 percent of the raw water turbidity during the low temperature (≤5°) condition. Consideration should be given to providing additional contact time when water temperatures are expected to be below 10°C to prevent formation of alum floc after the water has been filtered and to attain the most effective turbidity removal.

The study showed that the filtration equipment installed at Cayuga is well suited to small water systems The prefabricated filtration equipment could be installed in an existing structure without extensive structural retrofitting—an important consideration in some communities

The capital cost for this project was $268,000: about $200,000 was spent for filtration equipment, pumps, piping, instruments, controls, etc , and about $68,000 for structural changes, electrical work, painting, and raw water intake repairs

The system needs about 2 7 hours operating time per day for inspection, adjustments to inflow and feed rates, sample analysis, and maintenance This amounted to 0.022 hour of labor per 1,000 gallons of water pumped to the distribution system.

The costs for treated water were

- power (including raw water pumping but excluding pumping to the distribution system) $0 102/1,000 gal
- distribution system pumping $0 11/1,000 gal
- chemicals (alum, polymer, chlorine, and sodium hydroxide) $0.049/1,000 gal
- sludge disposal to approved landfill $0.014/1,000 gal
- electric power rate $0 062/KWH

Results obtained at Cayuga suggest that pilot studies should be conducted before filtration plants are designed and built, especially when direct filtration is proposed Because turbidity in raw water has various causes, the suitability of treatment processes should be determined at the pilot scale. Determining process and equipment suitability in this way can help provide the maximum return on the investment in a treatment plant

Conclusions

The prefabricated water filtration system installed at the Village of Cayuga perfomed well under a number of raw water conditions.

The system could be operated successfully by a conscientious small system operator

The amount of detention time available in direct filtration systems can influence process performance when the raw water temperature is <10°C.

When alum is used as a coagulant, raw water quality may be such that only adding alum to the raw water does not give the best pH for coagulation. Equipment for raising or lowering the pH may be needed to attain the most effective coagulation.

When direct filtration plants are under consideration, questions about factors such as the effect of very low raw water temperatures or the pH range for effective coagulation can best be answered by performing pilot plant studies.

The full report was submitted in fulfillment of Cooperative Demonstration Agreement CS809411 by the Village of Cayuga, NY, under the sponsorship of the U S. Environmental Protection Agency.

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Gary S. Logsdon *is the EPA Project Officer (see below).*
The complete report, entitled "Feasibility Study of Alternative Technology for Small Community Water Supply," (Order No PB 85-143 287, Cost. $14 50, subject to change) will be available only from
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