THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**ELECTROFLOCCULATION AND MEDIA FILTRATION USED IN DRINKING WATER TREATMENT SYSTEMS**	
APPLICATION:	**REMOVAL OF ARSENIC IN DRINKING WATER**	
TECHNOLOGY NAME:	**ARS CFU-50 APC ELECTROFLOCCULATION AND FILTRATION WATER TREATMENT SYSTEM**	
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The U.S. Environmental Protection Agency (EPA) supports the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by accelerating the acceptance and use of improved and more cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations, stakeholder groups (consisting of buyers, vendor organizations, and permitters), and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

NSF International (NSF), in cooperation with the EPA, operates the Drinking Water Systems (DWS) Center, one of six technology areas under the ETV Program. The DWS Center recently evaluated the performance of an electroflocculation and media filtration system for the removal of arsenic from drinking water. This verification statement provides a summary of the test results for the ARS CFU-50 APC Electroflocculation and Filtration Water Treatment System (ARS CFU-50 APC). The NSF Drinking Water Treatment Systems Laboratory (DWTS) was the field testing organization (FTO) that performed the verification testing. The verification report contains a comprehensive description of the complete verification test.

ABSTRACT

Verification testing of the ARS CFU-50 APC Electroflocculation and Filtration Water Treatment System (ARS CFU-50 APC) for arsenic removal was conducted at the Town of Bernalillo Well #3 site from April 18 through May 2, 2006. The source water was chlorinated groundwater from two supply wells, and the feed water for the verification test was withdrawn from the pressure tank at the site. Verification testing was conducted at the operating conditions specified by the manufacturer. The feed water, with a pH in the range of 7.6 to 7.9, was pumped into a reaction vessel where electricity is applied to aluminum and graphite plates to create flocculent to which arsenic adsorbs. When operated under the manufacturer's specified conditions at this site, at an average flow rate of 32.1 gallons per minute (gpm), the ARS CFU-50 APC reduced the total arsenic concentration from an average of 12 micrograms per liter (µg/L) in the feed (untreated) water to 6 µg/L in the filtrate (treated) water.

TECHNOLOGY DESCRIPTION

The following technology description was provided by the manufacturer and has not been verified.

The ARS CFU-50 APC is a standard, full-scale, modular system for the removal of arsenic and other contaminants from water. The ARS CFU-50 APC is a self-contained, complete system that connects to a water supply source. If the source is not pressurized, a pump, supplied with the unit, is used to pump the water through the treatment system. The ARS CFU-50 APC requires a three-phase 480-volt AC electric power source to operate the reaction vessel, programmable logic controller (PLC), and ancillary equipment. The system used for this test is designed to treat flows up to a maximum flow rate of approximately 35 gpm (50,000 gallons per day [gpd]), from either a pressurized or unpressurized water source.

Untreated/contaminated water enters the unit through a regulated influent pipe. The flocculent generation and decontamination process occurs in the reaction vessel in a continuous process. Flocculent particles in the holding pipe/tank are subject to further growth and reaction after the electrolytic process. Sand filters separate the flocculent from the treated water. The filter surfaces are cleaned by automatic backwashing, and the flocculation sludge is flushed into the floc water reservoir tank. The low volume, thickened flocculation sludge accumulated in the floc water reservoir tank is pumped into the filter press by a pump, where it is pressed into a filter cake. After the treated water passes through the filter press, it is stored in the clean water tank for later use in filter backwashing and rinsing. As the clean water tank level reaches its maximum level, it is pumped out of the unit through the filtrate water pipe.

The ARS CFU-50 APC treatment system is fully automated and programmed to control all aspects of the treatment and filter operation. The control system automatically initiates backwash cycles based on an inlet pressure level set by the operator. The backwash cycle time is a fixed time duration that is programmed in the PLC. The control system monitors data from the system operation. This information is available to the on-site operator.

VERIFICATION TESTING DESCRIPTION

Test Site

The Bernalillo Well #3 site is a fenced property that includes a building that houses the well pump and chlorination equipment, a primary storage tank (approximately 1,000,000 gallons [gal]), and a secondary storage tank (approximately 200,000 gal). Water pumped at the site is a mixture from two wells, both of which pump water from the Rio Grande Group aquifer. The average daily water use for the Town of Bernalillo is approximately 2,000,000 gpd. Water quality data based on data collected between June 2002 and March 2004 shows total arsenic in the combined well water ranges from 14 to 68 µg/L and the primary arsenic species is arsenic (V). The water has a total hardness of approximately 70 to 90 milligrams per liter (mg/L) as $CaCO_3$ and the pH is approximately 7.3.

Methods and Procedures

Operations, sampling, and analyses were performed in accordance with the Product Specific Test Plan (PSTP) developed and approved for this verification test. The PSTP included a Quality Assurance Project Plan (QAPP) to assure the quality of the data collected and to provide an accurate evaluation of the treatment system under field conditions. Testing included characterization of the feed water, an arsenic loss test (no electricity supplied to the reaction vessel), and a 14-day verification test.

The verification test was performed from April 18, through May 1, 2006. The ARS CFU-50 APC was operated for the 14-day verification test by using water supplied from the Town of Bernalillo. Flow rate, production volume, water temperature, and system pressure were monitored and recorded daily. Feed and filtrate (treated) water samples were analyzed on-site for pH, temperature, turbidity, free and total residual chlorine, color, and dissolved oxygen (DO) by the field operator. Grab samples were collected and delivered to the NSF Analytical Laboratory and were analyzed for alkalinity, aluminum, calcium, magnesium, iron, manganese, sulfate, chloride, total organic carbon (TOC), total suspended solids (TSS), and fluoride. Samples for total arsenic were collected daily, plus 14 samples were collected during a 48-hour intensive survey. In addition to the samples for total arsenic, arsenic samples were speciated during the test to determine the soluble arsenic concentration and the concentrations of arsenic (III) and the arsenic (V) present in the soluble fraction.

Complete descriptions of the verification testing results and quality assurance/quality control (QA/QC) procedures are included in the verification report.

VERIFICATION OF PERFORMANCE

System Operation

ARS performed the system startup and shakedown testing, which included optimization of the electrical feed rates (30 amps) to the reaction vessel. The verification test was conducted under the manufacturer's specified operating conditions. The backwash system was set to backwash when the pressure differential across the filter exceeded 15 pounds per square inch (psi).

System pressure was monitored at the filter influent and filtrate. Head loss fluctuated between 6.4 and 15.9 psi during the inspections. The ARS CFU-50 APC PLC was not programmed to record pressure differentials at the start of backwash cycles, so the pressure differential evaluation for this verification was limited to whether the differential exceeded 15 psi during the time the FTO personnel inspected the device.

During the test, there were a total of four incidences (April 20, 21, 28, and 30) where a sensor triggered the PLC to shut down operations. During each incident, the sensor indicated that either the floc water reservoir tank had exceeded capacity or the filter press alarm went off. In each instance, the filter press had clogged to a point where it was prohibiting sufficient filtration to maintain the device's rated throughput. ARS personnel recommended that the filter press be cleaned a minimum of once every 24 hours to prevent the ARS CFU-50 APC from automatically shutting down. After each shutdown incident, FTO personnel cleaned the filter press and resumed operation in accordance with the startup procedures outlined in the ARS Operations and Maintenance (O&M) manual. As a result of these incidents, the ARS CFU-50 APC experienced approximately 36 hours of downtime during the 14-day verification test.

The filtrate flow rate was 32.1 gpm over the 14 days. The total filtrate volume produced each day was also consistent, except for those days when operating time was lost due to the filter press alarm shutting down the system.

Water Quality Results

The results of total arsenic analyses are shown in Figure VS-1. The feed water total arsenic averaged 12 µg/L with most of the arsenic as arsenic (III), but with some arsenic (V) also present. The filtrate water total arsenic concentration averaged 6 µg/L. The data collected during the 48-hour intensive survey were

consistent with the data collected each day during the verification test. There was no indication of any transient or short time changes in the arsenic concentration or in any other monitored parameters.

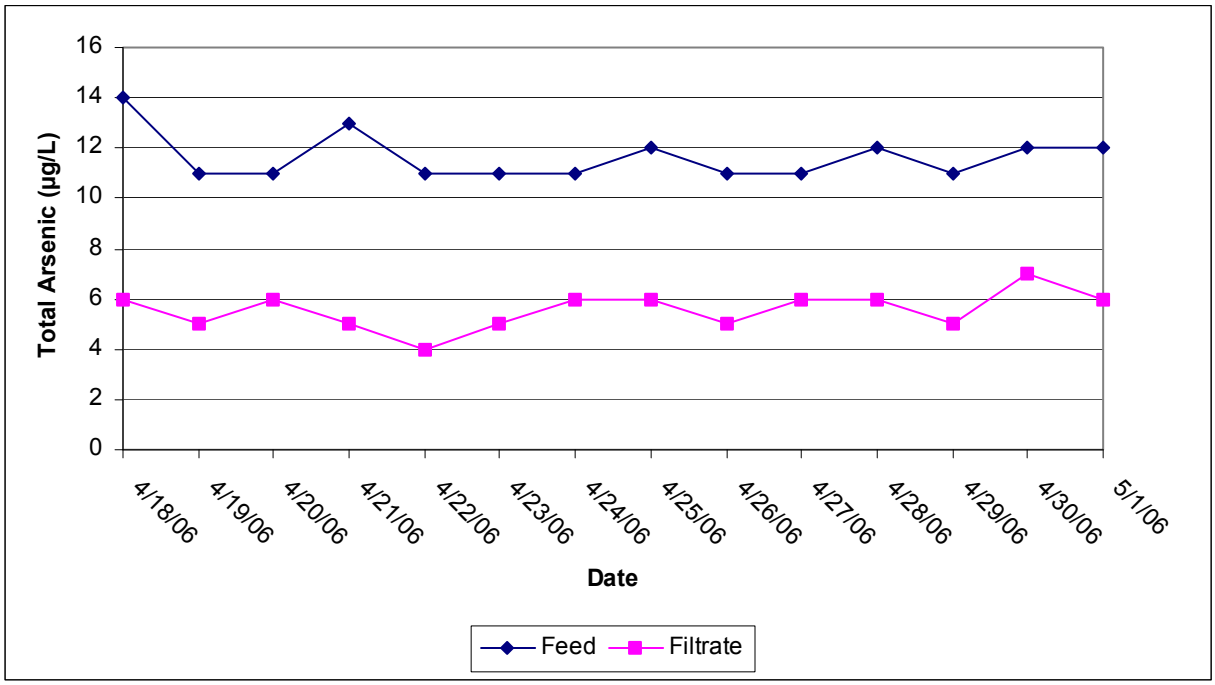

Figure VS-1. Total Arsenic Results.

The feed and filtrate water alkalinity averaged 130 mg/L as $CaCO_3$, indicating that the treatment process had no impact on the alkalinity. The pH of the feed and filtrate water had a median value of 7.7. Aluminum was detected in four of the 14 feed water samples, at concentrations ranging from 13 to 84 µg/L, while the remaining ten feed water samples had aluminum concentrations below the 10 µg/L detection limit. In the filtrate, the average aluminum concentration was 560 µg/L, and ranged from 200 to 890 µg/L. The average filtrate aluminum concentration was 20 times greater than the feed water average concentration and significantly higher than the National Secondary Drinking Water Regulation range of 50 to 200 µg/L. Furthermore, operation of the ARS CFU-50 APC increased the turbidity levels in the filtrate water. The feed water turbidity averaged 0.30 Nephelometric Turbidity Units (NTU), and ranged from 0.20 to 0.45 NTU, while the filtrate water averaged 0.80 NTU, and ranged from 0.35 to 1.2 NTU. Turbidity and aluminum data during the 48-hour intensive survey were similar to those during the 14-day test. The turbidity and aluminum data indicated that filtration mechanisms more efficient than those currently utilized in the ARS CFU-50 APC were required to bring these parameters closer to the feed water concentrations or within the EPA regulations. The ARS CFU-50 APC had little or no impact on free chlorine, total chlorine, DO, chloride, sulfate, TOC, fluoride, calcium, or magnesium concentrations. Manganese and iron concentrations were consistently below detection limits in both the feed and filtrate water.

Backwash was initiated automatically based on pressure differential. Backwash waste was treated by a filter press designed to remove the solids (floc) from the backwash water. The filtrate from the filter press was transferred back to the reaction vessel for re-treatment. The backwash cycle was set for a fixed time duration of 120 seconds for backwash and 30 seconds for rinsing. The combined backwash and rinsing resulted in approximately 250 gallons of waste per backwash sequence. Solids retained in the filter press were removed manually during filter press maintenance. At the end of testing, approximately 572,550 gallons of water were treated, and approximately 1,425 pounds of solids (wetted floc) was created. This calculates to an approximate suspended solids concentration of 300 mg/L. The backwash

solids were not considered a hazardous waste, based on Toxicity Characteristic Leaching Procedure (TCLP) metals analyses, which were below the regulatory limits under the Resource Conservation and Recovery Act (RCRA).

Operation and Maintenance Results

The ARS CFU-50 APC was found to be easy to operate and required little time for daily maintenance. The field staff was on-site for two to three hours per day. Most of the time on-site was spent performing field activities, including flow checks, calibrations, cleaning the filter press, and other verification-related activities.

The ARS CFU-50 APC O&M manual provides a detailed description of the system, appropriate safety precautions, and detailed descriptions of operating procedures, capability and operation of the computer control system, and specific instructions for utility operators. The maintenance section of the manual includes some descriptions of required maintenance, but refers the reader to the individual equipment literature supplied by the various pump and instrument manufacturers. A review of the O&M manual shows that the manual is well organized and easy to read.

The ARS CFU-50 APC was equipped with two sand filters, so that one filter could be in operation while the other was in backwash mode or standby. During the testing at this installation, there were no conditions where the pressure differential across both sand filters required that both filters backwashed at the same time. Issues regarding the efficacy of the filtration process, as shown in the aluminum and turbidity data, were noted during the verification test.

Backwash waste was treated by a filter press designed to remove the solids from the backwash water. During the testing, when the flocculent caked in the filter press to a point where water would no longer pass through it, the PLC shut down the entire system, as it was programmed to do. When this occurred, field personnel cleaned the filter press and restarted the system. Verification testing substantiated the importance of the filter press and its appropriate maintenance as a critical aspect of the function of the ARS CFU-50 APC.

The system PLC was designed to operate and monitor many of the operating functions of the device. The PLC readings were easy to use, but required an understanding of the PLC operating keys to display the readings. The PLC was not programmed to record data, so readouts on component performance, such as flow, pressure, and electrical settings had to be monitored and recorded manually. Because the PLC did not record data, information regarding the duration of filter runs, frequency of backwash cycles, and the pressure differentials across the sand filters could not be accurately recorded. The PLC was designed to shut the entire system down in the event any sensor recorded a condition outside preset operating limits. This condition was experienced four times during the verification. The cause of each shutdown was the filter press clogging to a point where water could not pass through it at the system's rated throughput. During each shutdown condition, after the filter press was cleaned, the alarm conditions in the PLC were cleared and the system was restarted without difficulty.

Electrical power consumption was estimated based on the floc pump, clean water pump, backwash pump, reaction vessel, waste pump, and miscellaneous other devices (air compressor, PLC, lights, etc.). The power consumption was estimated to be 4.2 kilowatt hours (KwH).

Quality Assurance/Quality Control

NSF provided technical and QA oversight of the verification testing as described in the verification report, including an audit of nearly 100% of the data. The NSF QA department conducted a technical systems audit during testing to ensure the testing was in compliance with the test plan and performed a QA review of the analytical data. A complete description of the QA/QC procedures is provided in the verification report.

Original signed by Sally Gutierrez *September 22, 2006*	*Original signed by Robert Ferguson* *September 12, 2006*
Sally Gutierrez Date	Robert Ferguson Date
Director	Vice President
National Risk Management Research Laboratory	Water Systems
Office of Research and Development	NSF International
United States Environmental Protection Agency	

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Availability of Supporting Documents

Copies of the *ETV Protocol for Equipment Verification Testing for Arsenic Removal* dated September 2003, the product-specific test plan, the verification statement, and the verification report (NSF Report #06/ARS1/EPADWCTR) are available from the following sources:
(NOTE: Appendices are not included in the verification report. Appendices are available from NSF upon request.)

1. ETV Drinking Water Systems Center Manager (order hard copy)
   NSF International
   P.O. Box 130140
   Ann Arbor, Michigan 48113-0140
2. NSF web site: http://www.nsf.org/info/etv (electronic copy)
3. EPA web site: http://www.epa.gov/etv (electronic copy)