Ex Situ Advanced Oxidation Processes, Granular Activated Carbon, and Synthetic Resin Adsorption Treatment at the Charnock Wellfield

Site Name: Charnock Wellfield

Site Location: Santa Monica, California

Contaminants: MTBE, TBA

Media: Drinking Water

Technology: Advanced Oxidation Processes (AOP), Granular Activated Carbon (GAC), and Synthetic Resin Adsorption

Technology Scale: Pilot

Period of Operation: July 1998 - April 1999

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Site History [1,3]:

The Charnock Sub-basin, located in the Mar Vista section of West Los Angeles, includes the Upper Silverado aquifer containing two municipal wellfields. The Charnock Wellfield is operated by the City of Santa Monica and contains five production wells. The second well field contains two production wells and is operated by the Southern California Water Company.

In March 1996, MTBE was detected in drinking water at the Charnock Wellfield, and the five production wells were subsequently shut down in June 1996. In October 1999, the Southern California Water Company production wells also were shut down. MTBE concentrations in groundwater ranged from 130 micrograms per liter (ug/L) to 610 ug/L. In August 1998, tertiary butyl alcohol (TBA) was discovered in the shallow groundwater near the Charnock Wellfield.

Two intrastate gasoline pipelines and 24 underground storage tank sites have been identified as possible sources of the groundwater contamination. In April 1998, the potentially responsible party (PRP) group's engineering consultant, Kennedy/Jenks (KJ), began pilot studies to evaluate treatment technologies for the removal of MTBE. When TBA was discovered in the groundwater, the pilot studies were expanded to include evaluation of TBA removal. Technologies identified for pilot testing included air stripping, ultraviolet light (UV)/peroxide, and UV/peroxide followed by liquid-phase granular activated carbon (GAC).

Technology Description [1, 2,3]:

Air Stripping

Air stripping was initially identified as a treatment technology for the pilot test, and an air stripper with off-gas treatment using a 250-cfm catalytic oxidation unit was installed at the site. However, the pilot test was canceled after TBA was identified as a contaminant of concern. A review of the literature by KJ indicated that although MTBE groundwater concentrations would likely be reduced by air stripping, TBA concentrations would not be significantly lowered because of poor mass transfer of TBA from the aqueous phase to the vapor phase during the air stripping process. In addition, KJ expressed concern that the permitting process for the air stripper could be lengthy.

AOP - UV/Peroxide and UV/Peroxide Followed by GAC

Pilot testing was conducted on UV/peroxide, UV/peroxide followed by GAC units operated in series, and UV/peroxide followed by three sets of GAC units operated in parallel, as shown on Figure 1.

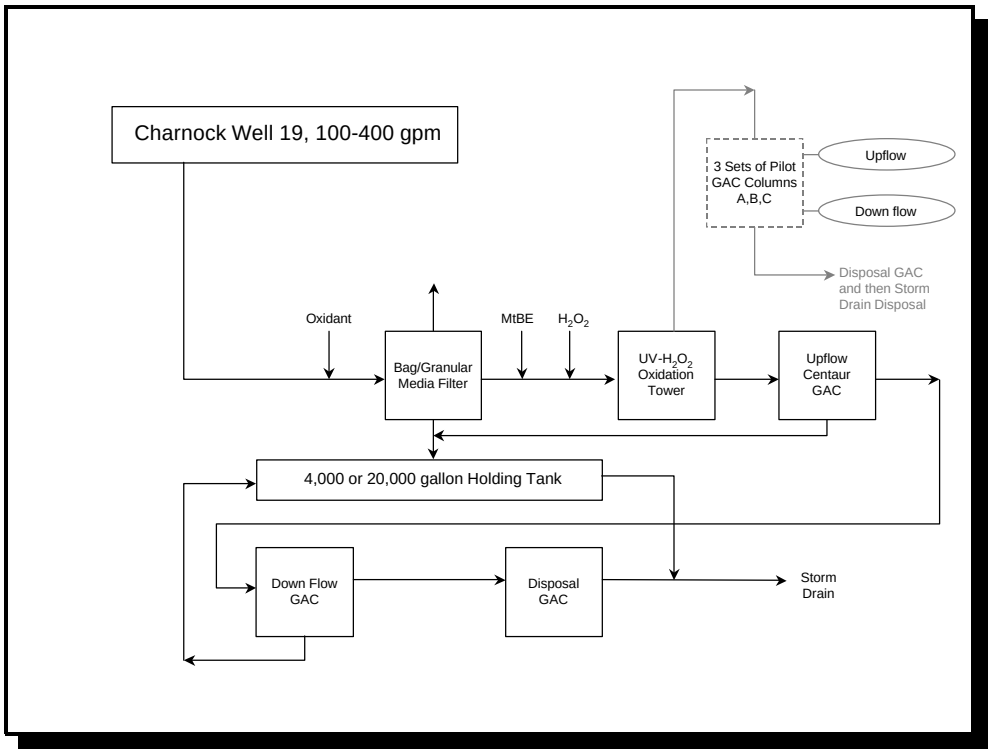
<u>UV/Peroxide Process</u>

Pilot testing of the UV/peroxide process was performed from July 1998 to December 1998 to evaluate the removal efficiency for MTBE and from December 1998 to April 1999 to evaluate the removal efficiency of MTBE and TBA. The UV/peroxide unit was a Calgon Rayox™ tower configured for upflow operation which consisted of three UV lamps that operate at 23.5 kilowatts (kW). Steady-state conditions were maintained by operating the pilot plant 24 hours/day, seven days a week. Peroxide dosing occurred upstream of the tower and resulted in peroxide concentrations of 20 to 60 mg/L. Water retention times for the tower were 2 to 4 minutes for flow rates of 150 to 300 gpm, respectively. The electrical energy per

order (EE/O) rating[1] observed during testing of MTBE-only treatment was 3.5; the observed EE/O during MTBE and TBA treatment was 5.0.

To prevent scaling, groundwater was pre-treated by filtration to remove iron and manganese (after oxidation to an insoluble metal hydroxide) and by acid addition to remove calcium carbonate. Two types of filters were installed for the pilot test - bag filters and dual media filters (anthracite and sand). The filters were initially operated in parallel. However, the bag filters were removed from service because iron accumulation caused plugging problems. The dual media filters initially experienced operation and maintenance problems that were subsequently identified as resulting from infrequent backwashing. Backwashing was increased to twice a week to alleviate the problem.

Figure 1. Pilot Systems Tested at Charnock [1]



UV/Peroxide Followed by GAC - Operated in Series

Tests were conducted to evaluate the use of of GAC following UV/peroxide treatment to adsorb excess peroxide, untreated MTBE, and process by-products, including TBA, tert-butyl formate (TBF), acetone, and formaldehyde. As shown in Figure 1, effluent from the Rayox™ tower was treated using three 2,000 pound vessels containing Calgon Carbon's Centaur carbon to remove residual peroxide followed by three

[1] EE/O is used to compare AOP treatment efficiency for a particular compound, source of water, and system. EE/O is defined as the number of kilowatts of electrical energy required to reduce the concentration of a given pollutant by one order of magnitude in 1000 gallons of water. EE/O = UV Dose/log (c_i/c_f) where c_i is the initial concentration and c_f is the final concentration. The lower the EE/O, the more efficient the treatment as less energy is required.

2,000 pound vessels containing Calgon Carbon's Fitrasorb 300 carbon to remove residual MTBE and by-products. The gas generated from the vessels was released to the atmosphere.

UV/Peroxide Followed by GAC - Operated in Parallel

Tests were also conducted to evaluate three types of GAC units operated in parallel - Calgon Carbon's Centaur carbon, Calgon Carbon's Fitrasorb 300, and coconut shells. As shown in Figure 1 (dashed lines), each of the three units (2,000 pounds each) contained an upflow column, which measured 12 inches in diameter and 8.5 feet in length, and a downflow column, which was 8 inches in diameter and 8.5 feet in length. The flow rate was 2 gpm through each of the units.

Proposed Full-Scale System

A 3,500 gpm treatment system is proposed for construction if the pilot studies find that the UV/peroxide system is technically feasible and cost effective. The planned full-scale treatment system at Charnock will include a UV/peroxide oxidation process followed by liquid phase GAC contactors in series. In addition, a pipeline will be built tying the Charnock Treatment Plant to the Arcadia Treatment Plant. The Charnock plant will be used to remove MTBE and TBA with effluent from this plant pumped to the existing Arcadia Treatment Plant for softening.

Technology Performance [1,3,4]:

The target MTBE treatment goal for the Charnock Treatment Plant is 13 ug/L. This goal is the risk-based drinking water action level established by the California Department of Health Services for chemicals for which primary MCLs have not been adopted.

At the time of this report, only limited data were available on MTBE concentrations in the effluent from the UV/peroxide process Rayox™ tower. According to KJ, one reported value for MTBE in the Rayox tower effluent was below the detection limit of 3 ug/L, based on an influent MTBE concentration of 80 ug/L. In addition, tests run with MTBE-spiked water at 1,000 ug/L and a flow rate of 210 gpm reduced MTBE effluent concentrations to 2 to 4 ug/L. Additional performance data from the pilot tests are expected to be available in late 2000.

Technology Cost [1]:

The estimated capital equipment cost for the proposed full-scale UV/peroxide system is approximately $4 to $5 million, including four 1,200-gpm Rayox™ towers equipped with 24 30-kW UV lamps. This cost does not include installation, purchasing suitable property (approximately 40,000 square feet), or installing a pipeline between Arcadia and Charnock (estimated at $1 million per mile). Operating costs of the full-scale system are estimated to be $1.50 to $1.75 per 1,000 gallons of treated water.

Observations and Lessons Learned [2]:

KJ identified the following observations and lessons learned based on the pilot studies at Charnock Wellfield:

- UV/peroxide treatment of MTBE requires a greater amount of energy than initially calculated. The EE/O of 3.5 observed during the pilot test was about 13% higher than the expected EE/O of 3.1. In

addition, treatment of both MTBE and TBA required an EE/O of 5.0, about 65% higher than the expected EE/O of 3.1. KJ estimates that the higher EE/O observed during the pilot test may increase the operation and maintenance costs of a full-scale system by 34%. Capital cost impacts have not been directly correlated to the EE/O level; however, KJ expects that the capital costs would increase significantly as the EE/O and required number of lamps increases.

- Several operational malfunctions occurred during the pilot test of the UV/peroxide system, including broken light bulbs and sleeves, and venting of gas from the breakdown of residual peroxide, that will need to be addressed in the design of a full-scale system.

References:

1. Ecology and Environment, Inc. *Summary of MTBE Groundwater Treatment Technologies Under Evaluation at Santa Monica Arcadia Wellfield and Charnock Sub-Basin Sites*. May 1999.

2. Craig E. Dial, P.E., Kennedy/Jenks Consultants. Letter to Kathleen Gillmore, Equiva Services, LLC. Response to Request for Information on Charnock Pilot Studies. July 13, 1999.

3. Heather L. Collins, P.E. District Engineer, Central District, Los Angeles Region. Memorandum to Linda Fiedler, EPA/OSWER. Review of Case Study on Charnock MTBE Treatment Report.

4. California Department of Health Services. MTBE in California Drinking Water. December 21, 1999. <http://www.dhs.cahwnet.gov/ps/ddwem/chemicals/MTBE/mtbeindex.htm>