Celina, OH

GAC Solution for Ohio's Most Challenging Water
City of Celina – A Tale of Two Waters

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Over the course of many years the City of Celina, Ohio has been challenged with supplying drinking water to the 11,647 residents of the city and the East Jefferson District. The difficulty arises from the source water, Grand Lake, a 21 square mile water body that contains high amounts of total organic carbon (TOC) and supports a high concentration of Planktothrix algae. The high TOC and algal content of the lake water has caused severe taste and odor problems and fostered the formation of very high concentrations of disinfection by-products (DBPs).

Much of the watershed for Grand Lake is agricultural land (Figure 1). The lake itself averages only seven feet in depth. These conditions lead to massive algal blooms and TOC concentrations that average 12.5 mg/l and peak at over 20 mg/l. There are also fluctuations in pH and turbidity that ranges from 10 to 300 Nephelometric Turbidity Units (NTU).

Traditional Water Treatment

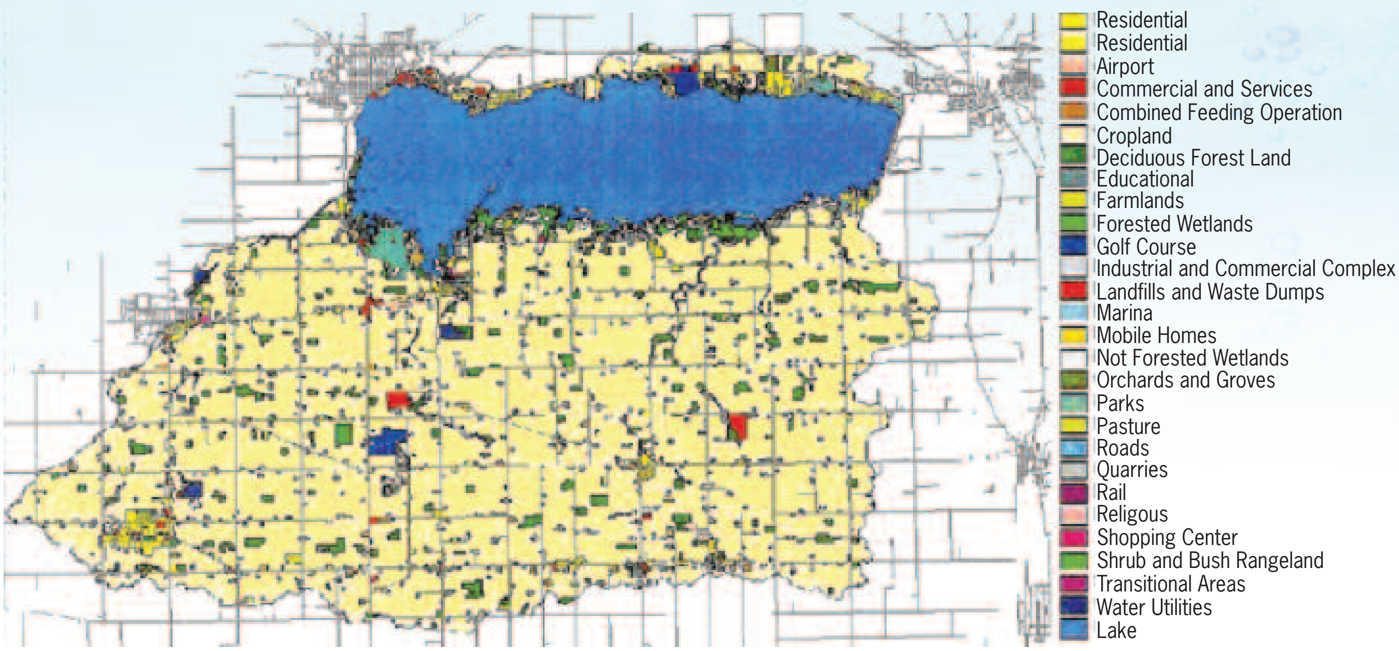
Drinking water was supplied to the city for several years through a series of treatment processes including lime slakering, upflow clarification, recarbonation, sand filtration, ozonation, as well as chlorination to maintain a residual disinfectant level. These processes were effective in removing solids along with taste and odor from the water. Powdered activated carbon (PAC) was used as a treatment to improve taste and odor, but was found to be ineffective and ultimately discontinued.

In 1995, the DBP levels in the drinking water became an issue. The total trihalomethane (TTHM) four-quarter running average was found to be 221.5 µg/L, well above the 80 µg/L regulatory levels set by the US and Ohio EPA. On May 31, 2003, the Ohio EPA placed the facility under a Findings and Orders consent decree with a scheduled compliance date for TTHM of November 2007.

None of the treatment processes that the city used to date were found to be effective in removing the organic DBP precursor compounds. In fact, it was believed that the ozonation actually caused an increase in DBPs by breaking down some of the TOC into compounds that would more easily react with chlorine to produce TTHM and haloacetic acids (HAA). This resulted in the need for further research on alternative treatments.

Grand Lake / St Marys Watershed

Figure 1



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Alternatives Investigated

The city began an investigation of possible alternative solutions to the DBP issue. In 2003 and 2004, the city explored the possibility of finding a groundwater source for the water supply. This proved to be unrealistic when it was determined that the Great Lakes Water Compact of 1986 prohibits the withdrawal of water from within the Great Lakes watershed for expulsion into another basin. The city discharges water into the Gulf of Mexico watershed.

New treatment technologies were considered. A trial of sulfur modified iron (SMI) as a secondary coagulant produced no appreciable differences in water quality over the existing treatments and was quickly discarded as a viable option.

A conventional-type water clarification system was able to produce a 67-69% removal of TOC and dissolved organic carbon (DOC) but was not capable of sufficiently reducing the TTHM to the required levels, leaving a residual up to 170 µg/L. In addition, there were pH and stability issues with the treated water that would require additional control.

Magnetic ion exchange technology was considered next. Trials of this technology achieved a 38 to 48% DOC removal, but were unable to reduce the TTHM levels below 100 µg/L, except when chloramine was substituted for free chlorine as a final disinfectant. This technology was viewed as insufficient to bring the plant into compliance.

In September 2004, the City Counsel authorized the Water Department to issue a Request for Quotation for facility improvements. Floyd Brown and Metcalf & Eddy/AECOM were selected to lead the plant improvement project. A short list of treatment technologies was developed for consideration:

* Switching to chloramine disinfection
* Installation of a reverse osmosis (RO) system
* Installation of a granular activated carbon (GAC)

Chloramine disinfection was viewed as a potential short-term solution. Chloramine disinfection involves the addition of ammonia to the existing chlorine chemical feed to form chloramines. Although the use of chloramines in place of chlorine can reduce the formation of currently regulated DBPs, the technology carries with it the potential to form a new set of DBPs including N-Nitrosodimethylamine and cyanogen chloride, which, while not currently regulated, are suspected to be more toxic to humans than the currently regulated DBPs. When these potential concerns were added to the known effects of chloramination, such as toxicity to fish and the potential for nitrification in distribution lines, this alternative disinfection technology was determined to be undesirable.

Reverse osmosis (RO) to remove the organic DBP precursors was considered an attractive technology for achieving the required compliance levels. In addition, with the small scale of the city of Celina's operation, the overall cost of RO treatment was not viewed as prohibitive. However, problems arose in the piloting efforts. These problems centered on the required pretreatment of the water in order to protect the sensitive RO membranes from fouling. It became clear that solving this problem would prove both complicated and time consuming. The high degree of urgency in meeting the water quality consent decree compliance date therefore made this alternative unfeasible.

Ultimately granular activated carbon (GAC) adsorption was selected as the treatment technology to pursue. The technology was well-known and widely effective for a broad variety of drinking water sources throughout the country. Piloting was also considered to be simple and easily implemented. The following describes the details and results of the GAC technology study conducted by the city.

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Pilot Testing

A 3-Phase pilot study was begun on December 13, 2005. Phase I evaluated different GAC products. Phase II simulated a two-vessel series system containing the selected GAC. Phase III studied the operation of two vessels in a lead/lag staged bed operation. The water plant operation was expanded to three shifts to accommodate the pilot operation and testing. Calgon Carbon Corporation provided the pilot column system and various grades of GAC for testing. Individual pilot columns were filled to a 4-ft depth with the selected products and run in various combinations to simulate beds with an 8-ft. depth of media.

In the process of piloting, it was determined that Calgon Carbon's FILTRASORB® 300 GAC was best suited for this application. When used in series operation with "staged" replacement (i.e. the spent in the lead vessel is exchanged with fresh activated carbon and valved to operate second in the series), there was a significant reduction in carbon usage over a single bed operation. Staged filter operation is not common in drinking water treatment operations, but the high TOC concentration of this application made this approach the unique and economical choice. Results of piloting, summarized in the following graph (Figure 2), showed that GAC adsorption could easily and consistently achieve the targeted TOC level of 2.5 mg/l. The projected annual GAC operating cost, based on the use of virgin GAC only, was calculated to be $1.21/1,000 gallons treated at the ultimate design flow of the system, assuming the TOC of the incoming water to the GAC filters was 10 mg/l. This annual operating cost is above the average for municipal GAC systems, which is generally in the range of $0.15 to $0.70/1,000 gallons treated. This above average cost at Celina reflects the extraordinarily high levels of TOC present in the water and consequently, higher removal rates necessary to bring the TOC level down to a point where the DBP standards would not be exceeded.

Full Scale System Implementation

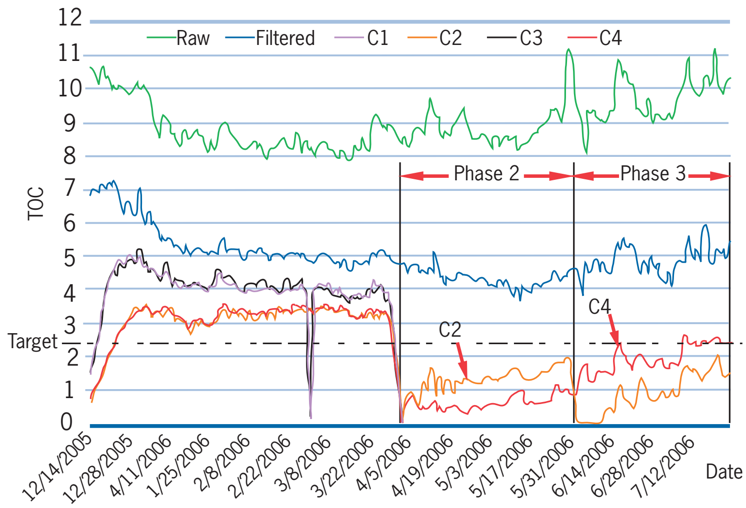
Based on the pilot testing, a full-scale GAC system was designed consisting of eight (8) vessels, each containing 40,000 lbs. of GAC, to be operated in four (4) parallel trains. The adsorbers would be operated in a staged sequence to maximize TOC loading on the GAC. The design flow per train was determined to be 520 gallons per minute (gpm), although the system currently operates at less than half that volume, 240 gpm, which equates to roughly 1.5 millions of gallons per day (MGD) of water treated for the entire system. The current flow rate results in an empty bed contact time of 78 minutes per vessel. The project timing was approximately one (1) year from project award to system start-up. This included performing the site concrete work, erecting the treatment building, setting equipment, completing the building and, installing piping and wiring.

Operating Data

The GAC system was brought on-line in July 2008. The system reduced the finished water TOC to below 2.0 mg/L. The GAC system was also able to consistently reduce TTHM and HAA5 to below the required levels of 80 µg/L and 60 µg/L, respectively (Figure 3).

GAC Pilot Results

Figure 2



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Treatment costs

The total capital cost of the project to upgrade the treatment plant amounted to $7 million. This cost included building construction, new pumps, new wet well, automated controls, laboratory, replacement sand filter valves, replacement intake structure, piloting, and engineering, as well as the addition of the GAC system. Out of the $7 million total project cost, $1.73 million was for the GAC adsorption system, including the initial fill of GAC.

The plant has recently switched to custom reactivated carbon. This change has resulted in a significant reduction in carbon operating costs, with no measurable reduction in performance. The operating cost includes the reactivation of the spent carbon, the addition of make-up carbon, transportation, and warehousing. With the switch to custom reactivation, the resulting annual GAC operating cost is now approximately $384,000 per year, which translates to $0.35/1,000 gallons, based on the installed capacity of the system. On the basis of a ten (10) year life, the GAC system annual cost, including consideration of the initial capital expense as well as ongoing annual operating costs, is expected to be $0.51/1,000 gallons of installed capacity.

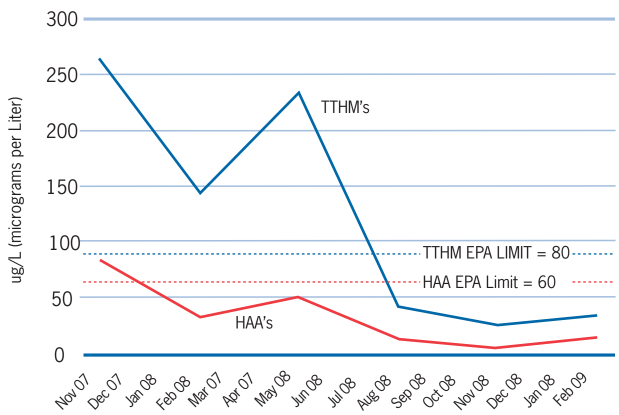
Current Status

Since start-up of the operation, the expanded and improved water treatment plant has produced an average of 1.5 million gallons per day (MGD) of drinking water that has consistently measured below the treatment goals for TTHM and HAA. As of September 30, 2009 the Findings and Orders decree has been lifted. If required, space exists for an additional four (4) adsorbers in the facility. Should an alternative disinfection process be required, the facility has been equipped with risers on the finished water lines where UV modules can be fitted.

At this point, the addition of GAC appears to have completely solved the issues associated with DBP compliance while also significantly improving the taste, odor, and appearance of the Grand Lake water.

TTHM and HAA Data

Figure3



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