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Unique Approach to Complying with Very Low National Pollutant Discharge Elimination System (NPDES) Permit Limits for Copper

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ABSTRACT

The NPDES permit issued to the Savannah River Site (SRS) in 2003 contained copper limits as low as six micrograms per liter. It also contained compliance schedules that provided SRS with anywhere from three to five years to select and implement projects that would enable compliance at several outfalls. Some outfall problems were much more difficult to correct than others. SRS personnel implemented several innovative projects in order to meet compliance schedule deadlines as inexpensively as possible. One innovation, constructing a humic acid feed system to increase effluent dissolved organic carbon (DOC) content, has proven to be very successful.

KEYWORDS: NPDES, biotic ligand model (BLM), copper, dissolved organic carbon (DOC)

INTRODUCTION

SRS is a sixty year old Department of Energy (DOE) facility located on a 310 square mile tract of land near Aiken, South Carolina. Situated in the Savannah River watershed, many of the industrial facilities scattered throughout the Site discharge wastewater into headwater streams that carry surface water only during rain events. These ephemeral streams are classified as waters of the State of South Carolina and must meet the same water quality standards as perennial streams. Typically, the 7Q10 (low flow condition) of these streams is at or near zero. Thus, they provide no blending when NPDES permit limitations are calculated. The result is very low NPDES permit limits for hardness dependent metals.

The SRS NPDES permit was issued by the South Carolina Department of Health and Environmental Control (SCDHEC) in 2003 and contains very stringent limits for copper. One outfall in particular (H-12) had average and maximum limits of six and eight micrograms per liter (ug/l), respectively. Although the copper concentration in the discharge is relatively low, it usually exceeds the average future limit (Figure 1).

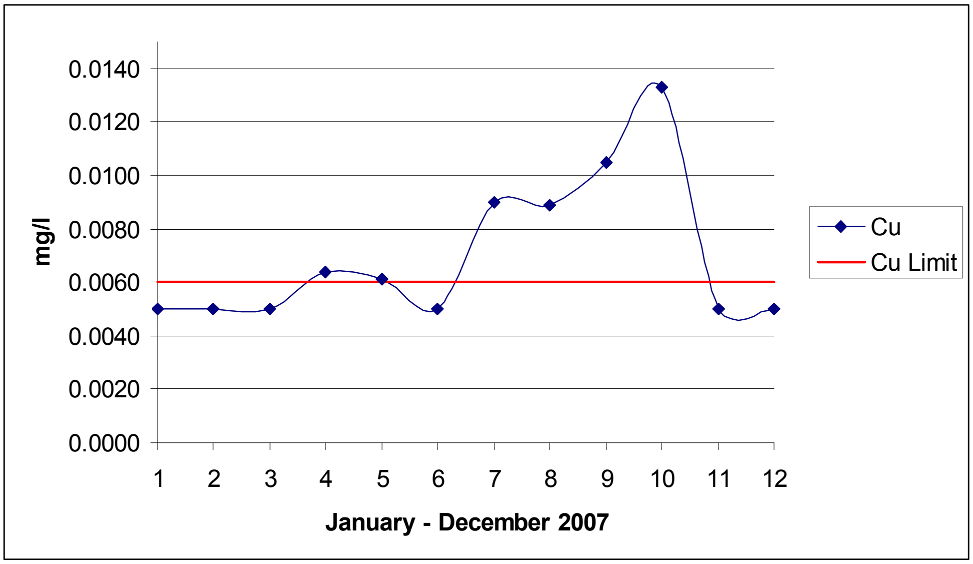

Figure 1. Outfall copper concentrations versus future average limit

The flow through this outfall is extremely variable, adding complexity to the identification of a compliance solution (Figure 2). Variability in the flow is due mainly to the batch discharge of cooling water from one of the operational processes. However, in addition to the batch discharge that occurs two to three times per day, rain water exiting through this outfall also causes significant fluctuations in flow.

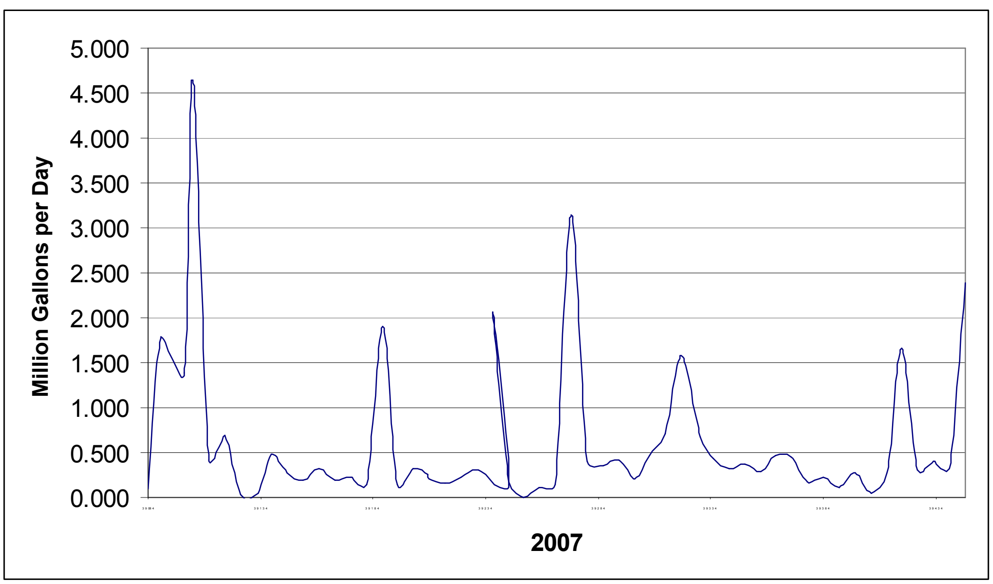

Figure 2. Typical outfall daily flow fluctuations

OPTIONS CONSIDERED

SRS personnel struggled to find the least expensive method for removing copper from this outfall. Treatment options such as ion exchange and constructed wetlands were considered.

Capital and operating costs were determined to be excessive for ion exchange. SRS had already constructed two wetlands treatment facilities that have worked effectively, but enough land was not available to construct wetlands in this location. Due to land constraints, a constructed peat bed was designed. But it was later abandoned due to cost. In February 2007, USEPA published their final biotic ligand model (BLM) for copper. Calculated using the BLM, Figure 3 shows the impact of higher effluent dissolved organic carbon (DOC) concentrations on the copper water quality criterion.

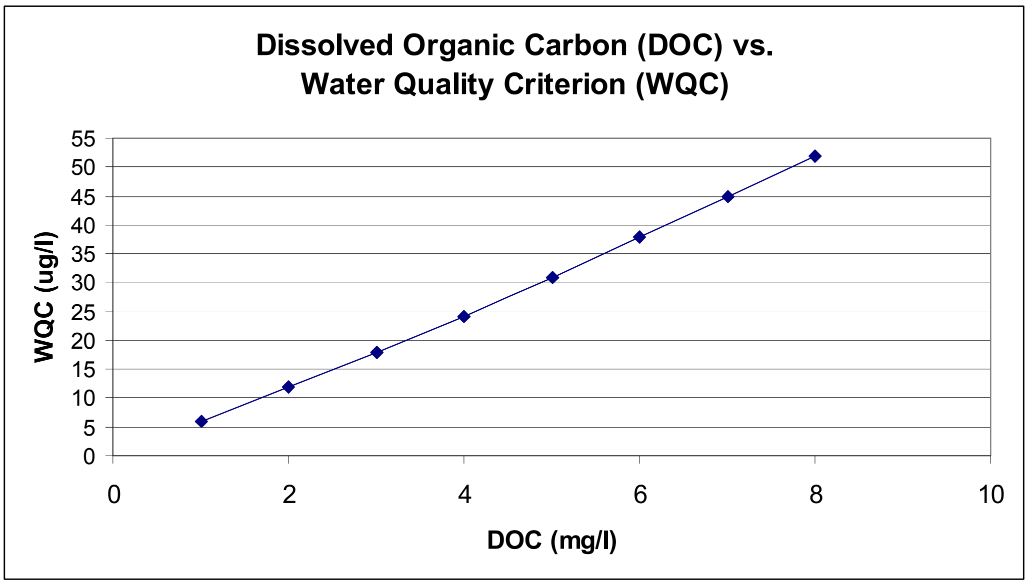

Figure 3. Dissolved organic carbon (DOC) impact on copper water quality criterion

Clearly, the concentration of DOC in an effluent has a significant impact upon the water quality standard used to determine NPDES permit limits. For example, an effluent DOC concentration of just five milligrams per liter (mg/l) raises the copper standard to about thirty ug/l. Such an increase would enable the NPDES permit limit for copper to be raised to a level that could be met consistently.

Increase DOC by Adding Humic Acid

SRS personnel wanted to take advantage of this option to raise the copper limit, but the DOC concentration in the outfall effluent was too low for the BLM to help. While conducting a literature search, it became apparent that DOC is available commercially as humic acid. This product is normally used for agricultural purposes; however, SRS personnel theorized it could be used as an outfall additive to raise the effluent DOC concentration and enable calculation of a higher copper limit via the BLM.

Data needed to run the BLM was collected on the outfall discharge. It was also collected on the receiving stream. Receiving stream data was needed in order to ensure that the amount of DOC required at the outfall would not raise the naturally occurring stream DOC concentration, possibly altering indigenous macroinvertebrate populations. BLM calculations were completed at varying pH and DOC concentrations since the model is most sensitive to these parameters. The results were provided to SCDHEC along with a permit application to construct a chemical feed wastewater facility to add humic acid to the outfall effluent. SCDHEC approved the request under the conditions that (1) DOC would not be added at a concentration that would raise the naturally occurring stream concentration, and (2) that antibacksliding provisions of the regulations would be met (the copper limit could not be raised above the existing average limit of twenty-five ug/l). SRS personnel proceeded with design of the chemical feed system and hired a contractor to construct it early in 2009.

RESULTS

The SRS NPDES permit has not yet been re-issued due to an unrelated total maximum daily load that is pending. However, the draft permit prepared by SCDHEC contains an average copper limit of twenty-five ug/l. At the time this paper was written, the Humic Acid Addition System had been operational for nearly two years. Generally, it has operated well and has experienced only minor glitches (see section on operational challenges). All indications are that it will enable compliance with the future NPDES permit. Although normally translucent effluent has become amber in color due to the addition of humic acid (Figure 4), this is not problematic since it enters a black water receiving stream.

Figure 4. Outfall effluent showing amber color from humic acid

A picture of the Humic Acid Addition System is shown in Figure 5.

Figure 5. Humic acid addition system

DISCUSSION

In recent years, changes in the way water quality standards are converted into NPDES permit limits for hardness-dependent metals such as copper have resulted in the need for creative compliance solutions. Rather than basing limits on a default stream hardness of fifty milligrams per liter, regulators are basing them upon the measured stream hardness. In addition, laboratory detection capabilities have improved to the point that metals are now measured at very low concentrations. For permittees who discharge into low-flow receiving streams, these factors are resulting in extremely low metals limits.

After issuance of a new NPDES permit in 2003, SRS was faced with very low metals limits at several outfalls. The total cost to comply was estimated to be over $25,000,000. These expenses would have been incurred at a time when the SRS budget was declining annually. The humic acid addition system described herein saved SRS several million dollars in capital outlays at H-12 outfall alone.

In order to take advantage of this creative option, it was important that regulating authorities (in this case SCDHEC and EPA-4) be open-minded and flexible. Compliance with copper limits required the addition of humic acid in conjunction with biotic ligand modeling. This unique idea required that SRS personnel work closely with SCDHEC to help ensure success.

As is often the case with new ideas, this project experienced some problems. Since the algorithm that was developed to control the feed rate from the Humic Acid Addition System is impacted greatly by pH, it became apparent that it was very important to maintain effluent pH as close to neutral as possible. Low outfall pH values would result in higher feed rates, thus increasing operational costs. Activities that helped control effluent pH required operational adjustments that increased work activities slightly, but were not expensive.

Minor Operational Challenges

The idea of adding humic acid to control the effluent DOC concentration has been patented by SRS. Nevertheless, it has not been without some minor operational problems. For example, the original pumps were incapable of feeding humic acid at a slow enough rate when outfall flow was low. This resulted in excess humic acid being added at times, wasting money and causing the outfall pH to often approach the low end of the pH limit. The pumps were replaced in 2011 and the new pumps are working fine. It is also worth noting that the humic acid solution is made by dissolving dry material in water. A recirculation line was installed to prevent solids from accumulating in pump tubing when pump flow rates are low. Other than these two minor problems and some tweaking of system operation, no major operational problems have been experienced during the first two years of operation.

CONCLUSIONS

There are several conclusions that may be drawn and lessons that may be learned from the work undertaken to meet stringent effluent metals limits, as outlined below.

- Due to improvements in laboratory techniques and tightening of water quality standards, NPDES permit limits for hardness dependent metals such as copper are declining. Many permit holders are being faced with increased expenses to comply.
- It is important to work closely with regulatory authorities on unique compliance ideas in order to ensure successful implementation.
- Under the right circumstances, it is possible to achieve considerable cost savings from the use of unique treatment systems instead of conventional treatment options.
- Where the costs to remove hardness-dependent metals such as copper from a discharge are prohibitive, it may be possible to add humic acid and complete a biotic ligand model to have limits raised, enabling compliance in a more cost-effective manner.
- Considering the fact that storm water regulations are becoming more stringent, humic acid addition should be considered as a possible storm water best management practice (BMP), under the right circumstances.

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