Jamestown Water Contact Tank Proposed Modifications

December 7, 2012

The case study of the chlorine contract tank in Jamestown Colorado consisted of three phases. The first phase consisted of meeting with the two plant operators and a site visit. During this meeting the plant operators expressed their concern that the contact tank was performing poorly during their winter flow rates and that they would like to find a way to cheaply improve the tanks baffle factor. According to the plant operators the flow rates that the plant typically operated were between 20,000 GPD in winter and 80,000 GPD in summer. This initial site visit was also used to take measurements on the inlet, as these were not included in the "As Built" drawings that the plant had.

The second phase consisted of making a CFD model of the existing tank and running this model at the two flow rates that the plant typically operated between. While these simulations were being performed it was found that the lower flow rate of 20,000 GPD caused the flow regime to change from turbulent to a laminar regime. The velocity field formed by this flow regime was not did not resemble what is typically thought of as a laminar flow. When a laminar flow has been allowed to reach a fully developed profile the flow field from wall to wall resembles the blue solid line in Figure 1 while turbulent flow resembles the green dashed line. Instead the most notable difference between the turbulent and laminar flow fields within the contact tank was a formation of a jet directly downstream of the inlet. While this jet formed with both flow rates it was much more prominent in the laminar 20,000 GPD flow. This is because there was no turbulence within the flow to dissipate this jet. In the laminar flow the only things capable of dissipating this jet were the viscosity of the water and the design of the tank itself.

In order to verify that the CFD simulations were indeed correct tracer studies using the existing system were needed. For each flow rate the tracer studies were conducted up to a time of 2*TDT: for the 20,000 GPD case this meant the test would last 12 hours while the 80,000 GPD case could be completed in 4 hours. A solution of lithium chloride was injected just upstream of the existing chlorine feed and was mixed so that the effluent concentration would not exceed 0.04 mg/l. Then water samples were taken at the weir at various time intervals so that they could be sent to the CSU Soil, Water, and Plant Testing laboratory so that the concentration of lithium in each sample could be determined. Then these samples were used to generate a RTD curve to compare with the the CFD simulation results. Figures 2 and 3 show the results of the tracer studies and the CFD results. As these figures show there is a very good agreement between the model and the existing physical system. These figures coupled with the CFD models prove that under the low flow conditions the flow is no longer turbulent.

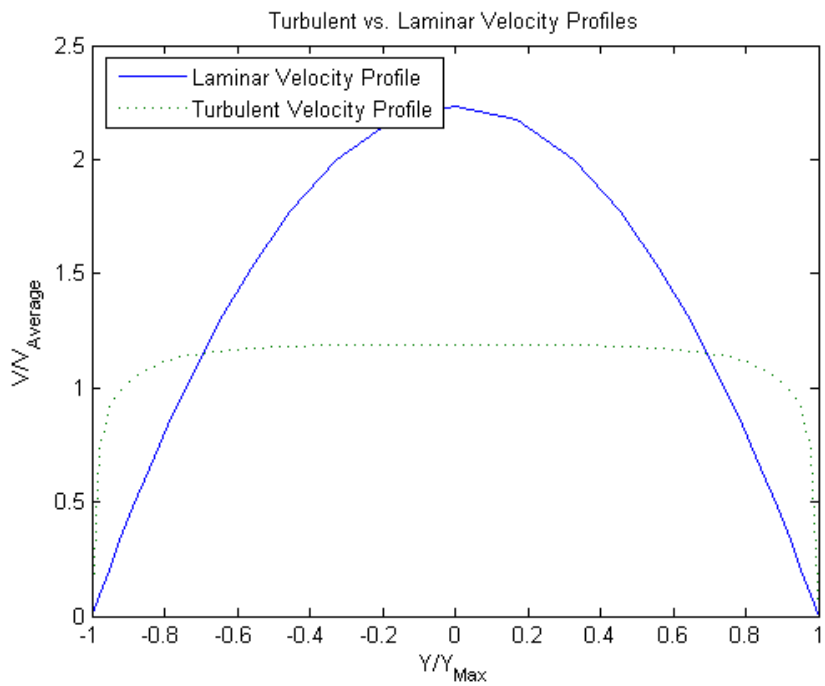

Figure 1: Velocity Profiles for Laminar and Turbulent Flow

The third phase of the study involved exploring different ways to improve the hydraulic efficiency, and therefore the baffle factor, of the contact tank. Since the town of Jamestown did not have sufficient funds for a complete redesign of the tank only simple inlet modifications were examined as possible options.Only simple options that could be easily implemented with minimal costs were considered due to financial constrainsts. First a hypothetical case was modeled to determine what the maximum baffle factor the tank could theoretically reach using only inlet modifications. In this theoretical case the entire front wall of the tank was an inlet so that the flow could be as uniform as possible within the tank. With the maximum baffle factors determined, two inlet modifications were proposed. The first simply involved placing a 90° elbow on top of the inlet to redirect the flow toward the front wall. The second modification involved placing a tee on top of the inlet to split the flow in two then a 90° elbow was placed on either end of the tee to direct the flow towards the front wall like the previous modification. Both of these modifications involved pointing the influent toward the wall so that the geometry of the tank could be utilized in an effort to dissipate energy from the flow. It was hoped that this dissipation of energy would help make the 20,000 GPD flow field more uniform and discourage the formation of the jet. To simplify the two-inlet case it was assumed that the flow would be equal out of both the inlets. Table 1 shows the results of a parametric study performed on inlet structure for this modification. As this table shows assuming an equal flow rate through both inlets is appropriate.

Figures 4 and 5 show how the two proposed modifications would improve the system. In these figures show the envelope of possible baffle factors that can be achieved with only inlet modifications. The top dashed line represents the idealized case while the bottom dashed line represents the unmodified system. Figure 5 shows that both of the proposed modifications

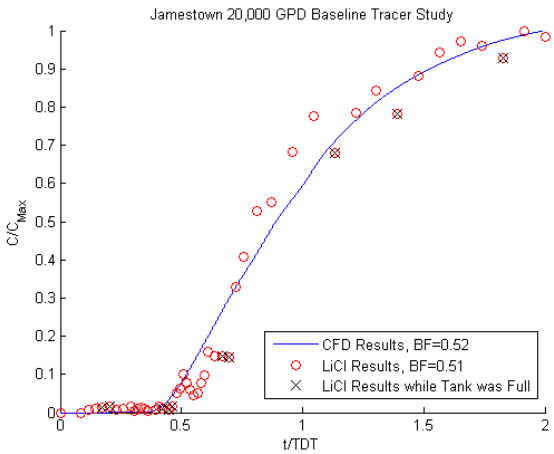

Figure 2: Tracer Results for 20,000 GPD

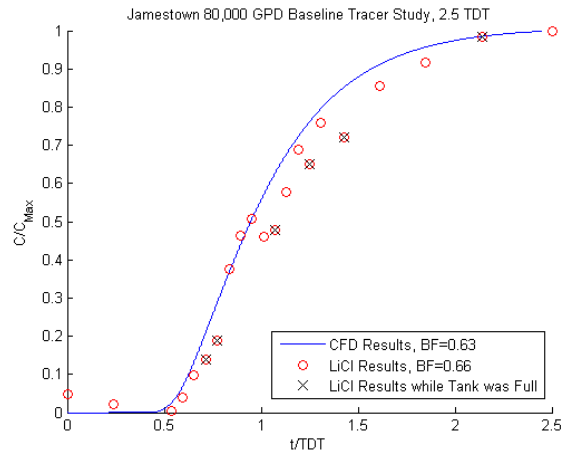

Figure 3: Tracer Results for 80,000 GPD

Table 1: Inlet Flow Rates

Percentage of Total Flow		
	20,000 GPD	80,000 GPD
Inlet A	49.9%	51.9%
Inlet B	50.1%	48.1%

have little effect while the system is operating under a turbulent regime while Figure 4 shows that the system almost reaches the theoretical maximum baffle factor. This was expected as the main issue with the contact tank during the low flow rates was that the jet after the inlet did not dissipate. From these two figures it has been suggested that the modification with the tee be implemented at the site. Figure 6 shows what the modification should resemble when built. This modification will bolt onto the top of the existing inlet pipe and will need no additional support. If this modification is built it should cost about $100 depending on how the tee is connected to the existing inlet pipe.

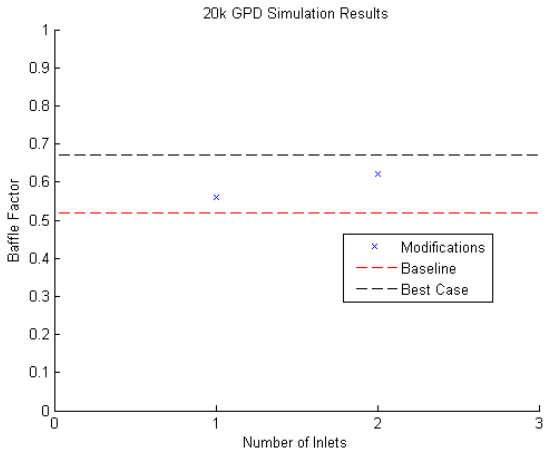

Figure 4: Baffle Factor Envelope for the 20,000 GPD Simulations

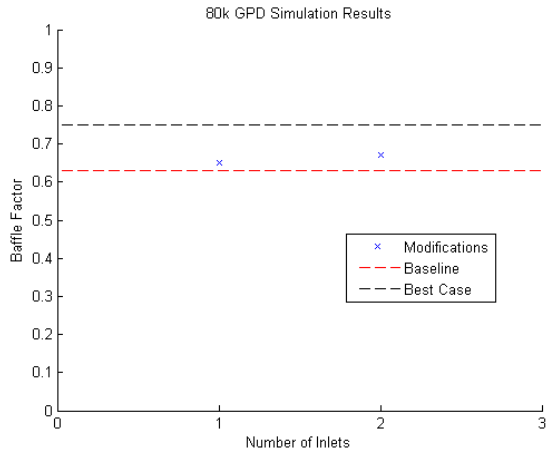

Figure 5: Baffle Factor Envelope for the 80,000 GPD Simulations

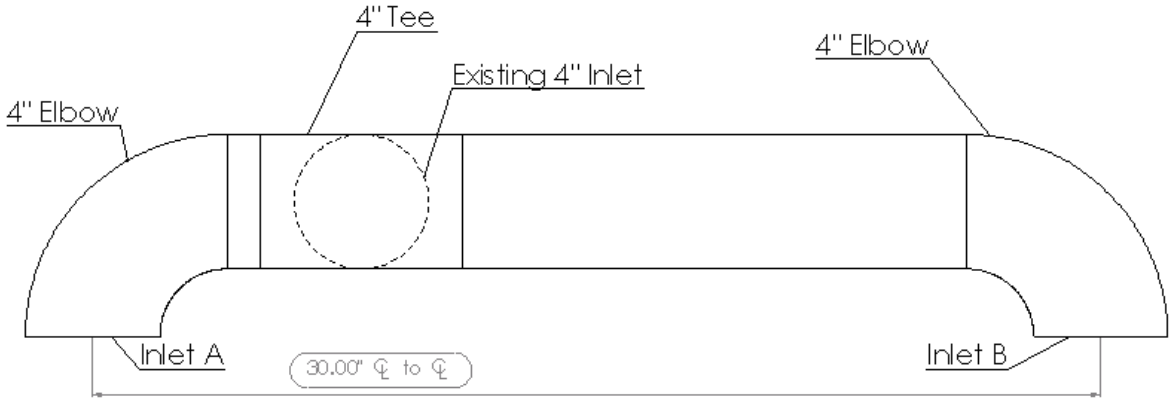

Figure 6: Proposed Modification to Tank