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Optimizing Aeration in Pulp Mill Secondary Treatment Systems

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Optimizing Aeration in Pulp Mill Secondary Treatment Systems

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ABSTRACT

With better spill control and lower carbon loads to the treatment system, there is excess aeration occurring at the lagoon. This leads to unnecessary power costs, especially during peak demand summer periods. A study was conducted to determine lagoon performance so as to prioritize which aerators could be shut off and under what conditions. The two major elements of the study were (a) detailed lithium tracer work to identify the relatively stagnant zones in the pond, and (b) a radiotracer study to measure BOD loss in different parts of the system. Based on these results, it was concluded that about 15% of aeration capacity could be curtailed during routine operations. BOD and COD profiles taken before and after this 15% reduction *showed no deterioration in effluent quality*.

Baseline BOD and COD profiles at various aerators

Samples were collected on 2.15.96 from various locations across the lagoon (Fig. 1) in order to establish the baseline degradation profile of the pond. BOD and COD were determined, and the results are illustrated in Figures 2 and 3, which are annotated with the aerator numbers. The first location "D" refers to the region prior to the pre-settling zone, and "R" is the river. The other locations are evenly spaced throughout the pond. It is clear that the bulk of the reduction occurs in the front end, with the aerators at the back of the lagoon contributing little.

Lithium tracer work at Brunswick

A lithium tracer study was conducted at Brunswick in order to determine flow patterns, estimate hydraulic residence time and dispersion number for the pond, and, in particular, to identify any dead zones so that aerators sited in these regions could be moved to positions where they can be more efficiently utilized.

Primary treatment at Brunswick is provided in a 12.3 million gallon Dorr-Oliver clarifier. Secondary treatment occurs in two pre-settling basins each of surface area of about 5 acres, an ASB of 122 acres, and a post-settling basin of 12.4 acres. Theoretical detention times for the pre-settling basins, ASB, and the post-settling basins are calculated to be about 0.3, 12.5, and 1.25 days, respectively, based on an average flow rate of 38 mgd, a depth of 4 feet, for the pre-settling basins, and 12 feet for the ASB and the post-stabilization zone. Sixty-two aerators provide tapered aeration to the ASB, the effluent from which is reoxygenated and discharged into Turtle River. The reoxygenation system transfers about 20,000 lbs/day of oxygen to the river.

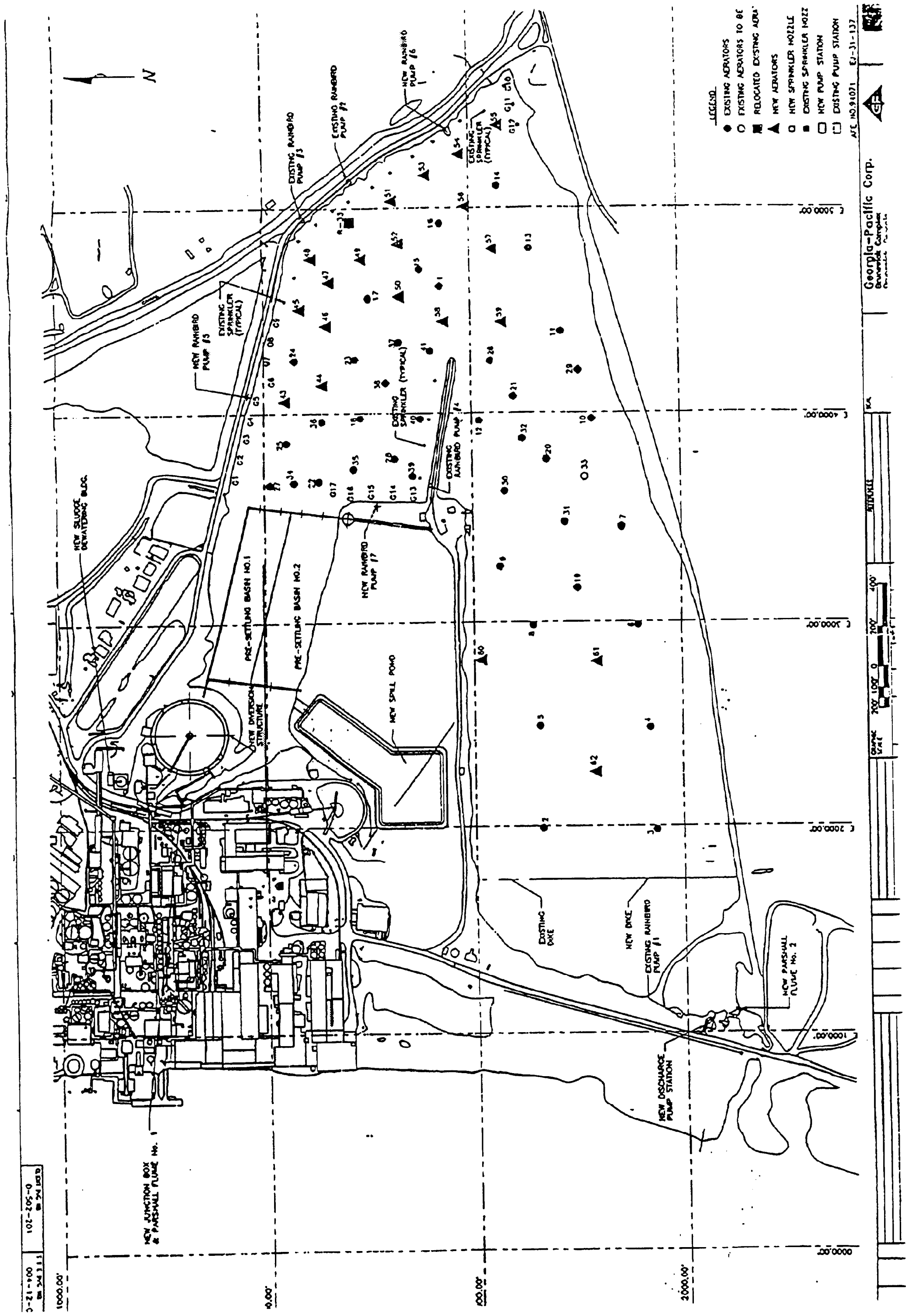

Figure 1: Schematic of the Brunswick lagoon

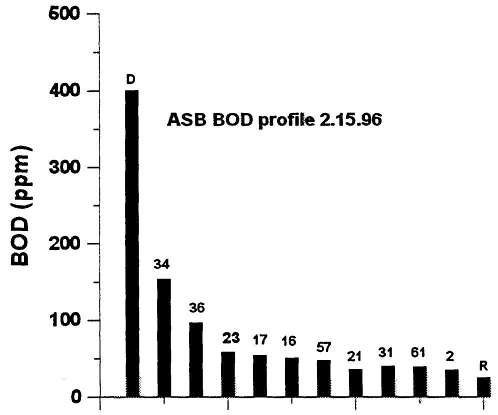

Figure 2: BOD reduction at Brunswick

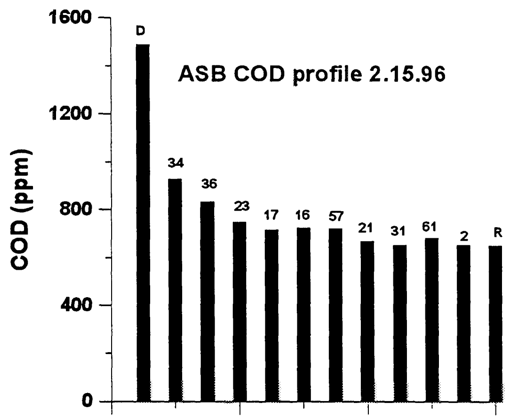

Figure 3: COD reduction at Brunswick

Lithium chloride (400 lbs., 35-40% brine) was introduced on 2/27/96 at parshall flume # 1 where the effluents from the primary clarifier and acid sewer are combined. The high degree of turbulence in the parshall flume ensured thorough mixing of the tracer with the pond influent. The tracer was added rapidly in order to ensure a slug injection. Background lithium was determined at the influent prior to tracer injection. All 62 aerators within the pond were monitored for lithium, which was determined by a Perkin-Elmer atomic absorption spectrophotometer. Tracer recovery was calculated by multiplying the effluent lithium concentration with the actual outfall flow rate. Ninety-four percent of the lithium applied was recovered in the effluent over a period of 20 days after the tracer injection.

Samples were taken daily at the basin outfall over 36 days. The effluent lithium concentrations were used in conjunction with the flow rate data to obtain the mean residence time and the recovery of the lithium tracer. Each aerator was also sampled daily for 9 days following the injection. Lithium was detected in the pond effluent between one and two days after the slug injection, and the concentration maximum at the outfall occurred on days 3 and 4, after which the tracer concentration decreased gradually until a background level concentration of 21 ppb was reached after 20 days. Outfall sampling was, however, continued for 36 days after the slug injection.

All 62 aerators within the pond were monitored daily for lithium for 9 days. High tracer concentrations were observed within 24 hours at all the aerators upstream of aerators 29 and 28. Elevated tracer concentrations were even observed at aerators 7 and 6. Aerators sampled downstream (2, 3, 8, 9, 61, and 62) were all at background at 21 ppb. After 48 hours, lithium levels at all the aerators were high. Hence, with some exceptions, the ASB, to a first approximation, is generally well mixed over the entire surface within 48 hours. Samples collected 96 hours after slug injection showed a decline in tracer concentration toward the front end of the pond, which is attributed to the dilution caused by the pond influent. A similar but slightly steeper concentration gradient was observed 120 hours after injection.

The mean residence time of the lagoon was calculated to be 8.3 days. This includes residence times of the pre-settling and post-settling basins, since the point of lithium injection was upstream of the pre-settling basin, while the effluent concentration was monitored downstream of the post-settling basin. The experimentally obtained detention time (8.3 days) is significantly smaller than the theoretical detention time of 12.5 days, which suggests some short circuiting, and therefore, the presence of relatively isolated zones, or dead zones. The pond dispersion number was calculated to be 0.2, which corresponds to a peclet number of 5, and predicts a large degree of dispersion. The hydraulic regime of the pond is, therefore, neither close to an ideal plug flow type, nor to an ideal CSTR. Instead, the pond behaves like a plug flow dispersion reactor.

Radiotracer work at Brunswick

The biodegradation efficiency of the Brunswick ASB was mapped with the IPST sampler in May 1996. The device used consists of a PVC pole extending to the bottom of the lagoon with holes drilled horizontally at 1-foot intervals. These accommodate 20 mL glass vials, which are held in place with plastic screws. The vials are capped at both ends with semi-permeable membranes. Samples are pulled from the lagoon at various depths at the location of a given aerator. Radioactive oleic acid (^{14}C) and $^{36}Cl^-$ are added to each sample which is then transferred to a vial. Oleic acid is one of various resin acids released by the pulp mill. The $^{36}Cl^-$ is added to normalize diffusion from the vials. Owing to differences in agitation, the diffusion of oleic acid from the vials may differ. Since $^{36}Cl^-$ is only lost by diffusion, it is used to normalize diffusion rates across the vials. The membranes restrict outflow of the microorganisms and much of the oleic acid, but allow free flow of oxygen and nutrients. The vials are placed in the sampler which is then tied to the aerator support in the lagoon. Thus, the oleic acid experiences the natural environment of the lagoon, but is kept in place by the membranes. The samplers are retrieved after one day, and the amount of oleic acid remaining is measured, yielding site and depth-specific biodegradation data.

The biodegradation of radioactive oleic acid at aerators 34, 17, 56, 31, and 3 was monitored as a function of depth, and samples were collected from regions both adjacent to and outside the aerator throw. Controls to measure non-biological loss of oleic acid were run by inactivating the biological activity of alternate cells by adding a small amount of formaldehyde. Hence, "live" cells were alternated with "dead" ones, with the difference in ^{14}C oleic acid content representing biodegradation.

Typical results of the biodegradation experiments are shown in Figures 4 through 7. Paired measurements were made where one probe was situated within the throw of the aerator and one outside. The most important finding is that little degradation occurs at the back end of the pond because of reduced biological activity, and the aerators there should be among the first to be shut off during periods of low BOD.

Reduction of aeration units at Brunswick

Based on the lithium tracer study and the radiotracer work, we recommended that a number of aerators be shut off at Brunswick. On August 6, 1996, the mill shut off aerators 3, 4, 5, 61, 62, and 55. On August 26, aerators 53, 54, and 60 were also shut off. In all, this represents about 15% of total aeration capacity in the pond. The BOD and COD profiles are illustrated in Figure 8.

DO values at aerators 20 and 6, which are located roughly halfway into the pond, were acceptable. Hence, the pond received adequate aeration even with the reduced number of aerators. No increase in effluent BOD was noted after the aerators were shut off. The DO at the end of the pond was low since this region went anerobic due to insufficient oxygen, and a mild odor was noted. Even though this is only a cosmetic issue, we recommended that the last two aerators be turned on, and two others in the middle of the pond be shut off. All the aerators will need to be functional during spills, and we recommend that the aerators be tied to the pulp mill conductivity and turned on during upsets.

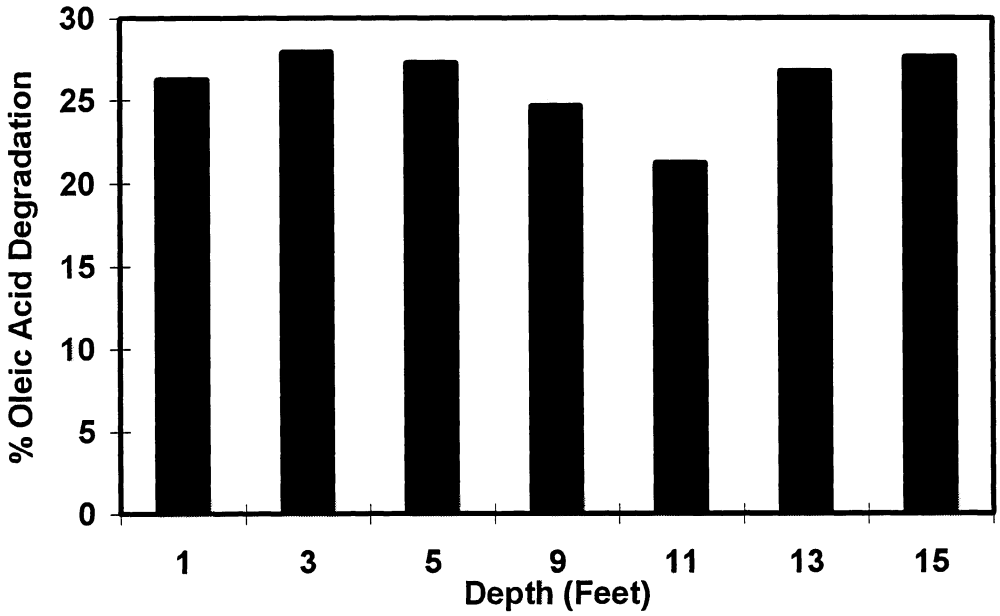

Figure 4: Degradation of oleic acid in a non-aerated zone near aerator 34

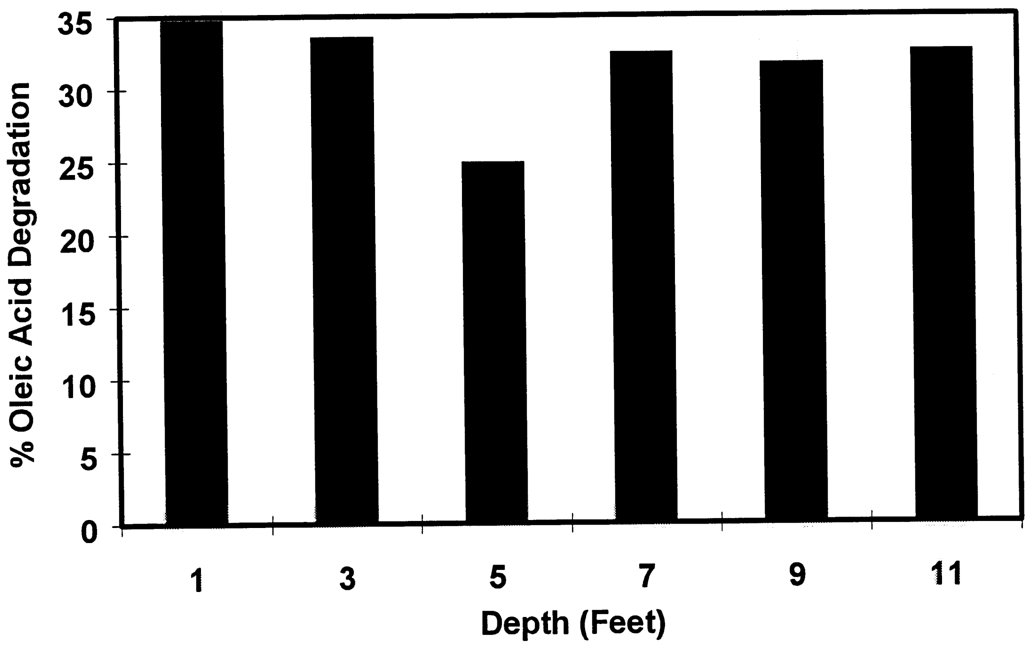

Figure 5: Degradation of oleic acid in an aerated zone near 34

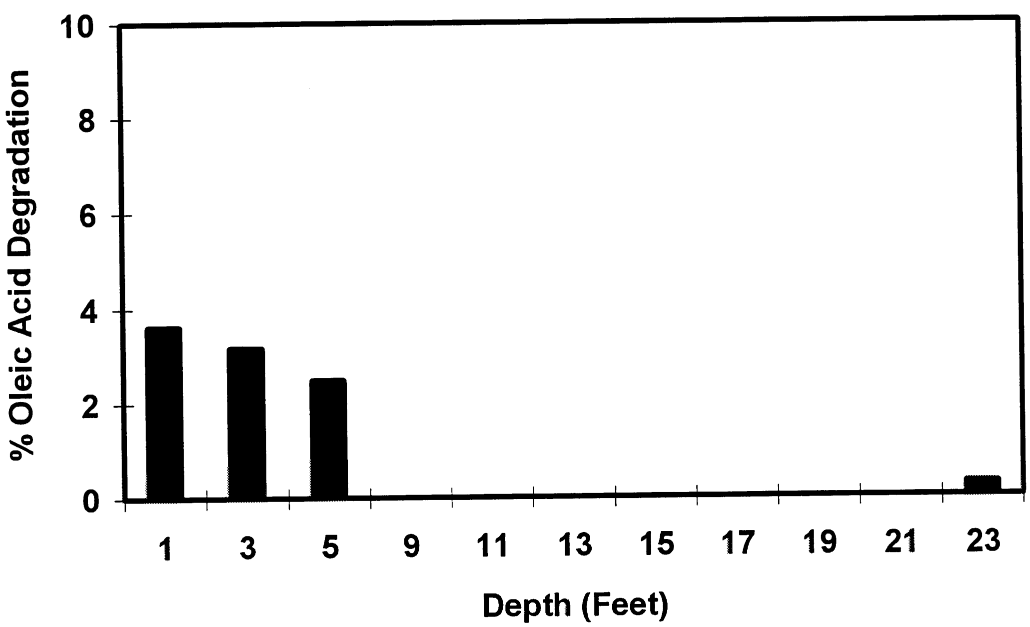

Figure 6: Degradation of oleic acid in a non-aerated zone near aerator 3

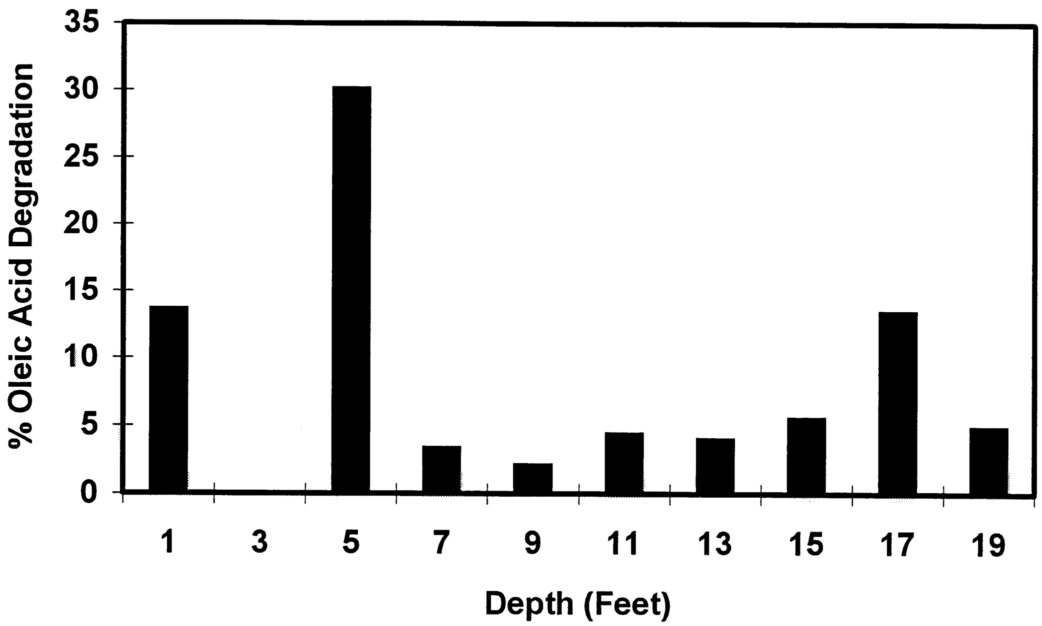

Figure 7: Degradation of oleic acid in an aerated zone near aerator 3

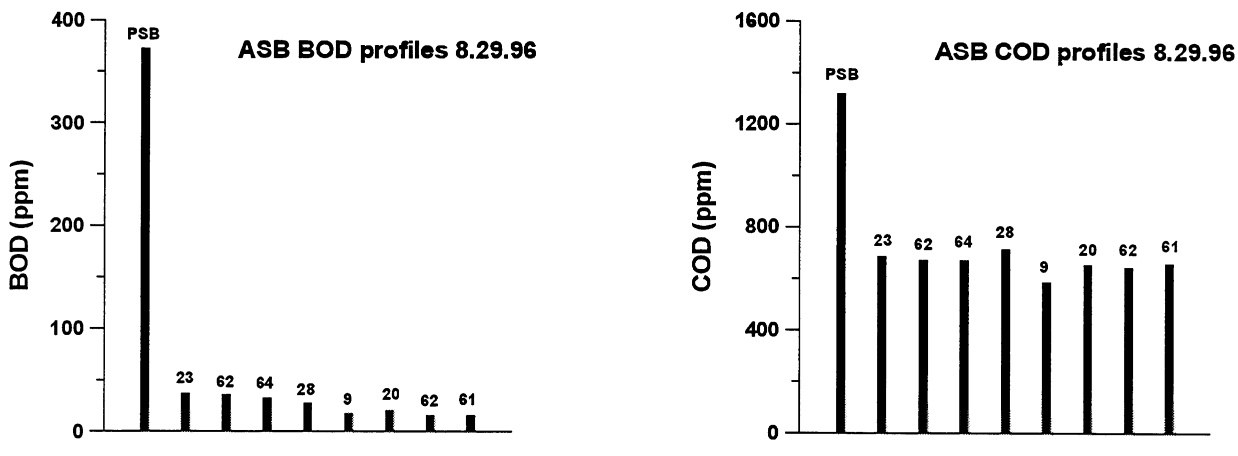

Figure 8: BOD and COD reduction at Brunswick after selective aerator shutoff