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This photo shows the use of yellow-green fluorescent dye to determine the flow pattern in a three-cell lagoon. In this case, KRWA staff were able to confirm that an entire cell of the lagoon system was being bypassed and not used.

Why Is My Lagoon Not Meeting Effluent Limits?

A Review of Common Problems Causing Compliance Issues

Let's suppose that you have just been hired as the new public works director for a small community serving 750 people. The community has a gravity-flow collection system, influent lift station and three-cell, discharging lagoon. After a month on the job, you discover you have taken on a much bigger challenge than you ever realized: the lagoon has compliance issues and is having problems meeting effluent limits as dictated in the city's permit. The lagoon is not consistently meeting effluent limits of 30 mg/L for biochemical oxygen demand (BOD) and 80 mg/L for total suspended solids (TSS). The mayor, your certified operator and you met with staff from the Kansas Department of Health & Environment (KDHE) in Topeka and the community has been informed that when its NPDES Permit is reissued in the near future, it will contain a Schedule of Compliance due to the aforementioned problems. You learn that the newly reissued permit will increase the frequency of monitoring for BOD and TSS from quarterly to monthly. Also, the Schedule of Compliance will give the city a year in which to demonstrate that the lagoon can consistently meet effluent limits. If after a year consistent compliance is not achieved, the city will be required to retain the services of a Kansas-licensed consulting engineer to evaluate the city's sewage collection and treatment systems and draft an engineering report. That report will describe the existing system, explain why effluent limits are not being met and provide recommendations for upgrading the system so that effluent limits are again met and the system can return to compliance. KDHE staff may also suggest contacting KRWA for technical assistance with operational changes that might help in meeting limits.

This is not an uncommon scenario; it happens to many small lagoon systems each year. I recommend the city consider the year during which more frequent monitoring is required as a "grace period" in which attention should be given to evaluating operational and maintenance issues to determine if effluent quality can be improved without having to retain an engineering consultant and implementing upgrading options. The purpose of this article is to review many of the more common problems KRWA staff have found with lagoon operation and maintenance that can lead to compliance issues. Problems need to be thoroughly investigated as most operational changes are far less

expensive to implement than upgrading the collection system and/or lagoon and incurring construction costs.

Never assume correct flow patterns

Checking the lagoon flow pattern may seem obvious but often this is missed. KRWA staff have helped several lagoon systems that assumed the lagoon was operating in series, only to learn otherwise. In series operation, all raw flow is directed to the primary cell. Parallel operation is where raw flow is split between two cells. As most operators know, it is best to operate lagoon systems in series to maximize detention time and produce the best effluent quality possible. But never assume the lagoon system you oversee is necessarily operating in this manner. New operators would not be aware of any such issue. Surprisingly, KRWA staff have found lagoons that unbeknownst to the operator were either operating in parallel or even totally bypassing one of the lagoon cells. Obviously such a situation can adversely affect effluent quality.

I encourage all operators to locate the system's as-built plans and check to make sure the lagoon is operating properly and as designed. The proper flow pattern is very important and especially those with transfer systems between cells that use buried pipes with valves. If your system has open control boxes with metal weir plates, then you can visually inspect them to determine the lagoon flow pattern. However, if you have buried pipes and valves, there is no way to visually inspect flow. Consequently, it is imperative to check each valve to make sure it is in the proper position. You may be surprised what you find. It is a good idea to exercise these valves at least annually, so checking them is a good idea anyway. If you are still unsure of valve positions or the possibility that a valve is stuck in the wrong position, fluorescent dyes can be used to confirm flow patterns. Such dyes are non-toxic, biodegradable and an invaluable tool when trying to confirm the flow pattern in a lagoon. If you ever need help using such dyes or checking the flow pattern in your lagoon, please feel free to call KRWA staff for assistance.

Smoke testing can help locate sources of infiltration and inflow. Smoke is emitting from an uncapped cleanout in the homeowner's service line. This same opening will also allow rainwater to enter.

Is there short-circuiting within cells?

Another issue closely related to flow pattern is "short-circuiting". By definition, short-circuiting occurs when transfer boxes between cells are poorly located so that detention time within a cell is dramatically reduced. In order to ensure maximum detention time, the influent and effluent transfer boxes within any cell must be located diagonally

Milk waste from a bottling operation is overloading this small lagoon system. The bottling operation was discharging spilled milk and floor washdown to a floor drain connection to the city's sanitary sewer. Notice the white grease balls and surface scum. Lagoons can have difficulty treating such wastewater.

across from each other to take advantage of the longest dimension in the cell. That should ensure maximum detention time. Unfortunately, many of the older lagoon systems first built in Kansas were designed and constructed with influent pipes that terminate in the middle of the primary cell. I am guessing this was done to help promote mixing and take advantage of the entire volume of the primary cell. Unfortunately that can also lead to short-circuiting, as the transfer box to the second cell cannot be that far away. Most new lagoons designed today have the influent pipe terminate near a corner of the primary cell. The transfer box to Cell 2 is then located diagonally from the end of the influent pipe in order to maximize detention time within the cell. Fluorescent dyes can also be used to evaluate short-circuiting in lagoons if you are unsure whether there is a problem.

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KDHE considers the moving of transfer boxes as a major change in design of a lagoon. Consequently, the system must retain an engineer to develop plans of the changes in transfer box location and submit the plans to KDHE for approval prior to making any actual physical changes.

Is there sufficient detention time?

Another issue that needs to be evaluated in any lagoon not meeting effluent limits is detention time. Detention time, also called hydraulic loading, is the rate of inflow volume into a lagoon (in gallons per day) as it relates to the lagoon volume (in gallons) available for treatment. Of course seepage and evaporation rates affect detention time calculations also, but the most basic formula for calculating detention time is:

$$\text{Detention time (days)} = \frac{\text{Total Lagoon Volume (gallons)}}{\text{Inflow Rate (gallons/day)}}$$

When designing new lagoons, consultants typically follow *KDHE's Minimum Standards of Design for Water Pollution Control Facilities* and provide a minimum 120 days of detention time in three-cell lagoons. KDHE is assuming that if a detention time of 120 days (or more) is provided in a lagoon at average design flow, that

is sufficient time for bacteria and other microorganisms to break down organic matter so that an effluent BOD limit of 30 mg/L can be met. Obviously, relatively accurate estimates of flow can be made for all homes, businesses and industries to be served so that a new lagoon can be properly sized. However, the huge variable in this calculation, which can be very difficult to quantify, is the gallons of infiltration and inflow (I & I) entering the collection system.

Infiltration and inflow: is it a problem in your system?

Infiltration and inflow (I&I) is the amount of extraneous water entering the collection system, from both groundwater and surface water sources. Water from I&I sources does not typically require treatment, should not be discharged to public sewers and tends to decrease lagoon detention time. I&I can also overload the collection system and cause the bypassing of raw sewage in the collection system and basement backups. Infiltration typically consists of groundwater sources and includes seepage into the collection system from deteriorating sewers and manholes. When the ground is saturated, a significant volume of groundwater can enter through defective pipe joints, broken or cracked sewer pipes and brick manholes with missing grout. Inflow typically comes from illegal surface water sources and includes sump pumps, roof downspouts, foundation drains and uncapped or broken cleanouts.

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The best way to determine if I&I is a problem s to use the aforementioned calculation. Either calculate lagoon volume or check the original plans, which usually indicate the volume (in gallons) for each cell. Also estimate the flow rate into the lagoon (in gallons/day). Unfortunately, unless you have an accurate flow meter or influent lift station equipped with hour meters, the inflow rate to the lagoon can be very difficult to accurately estimate. Regardless, if your system is not meeting effluent limits, I encourage you to try to calculate the lagoon's detention time as accurately as possible. I am available to assist with this. All sewer systems have I&I to some degree. It's the amount of I&I that determines whether or not a system has a problem with inadequate detention time.

Is I&I affecting effluent quality? If so, how can it be corrected?

If it is determined that a lagoon has insufficient detention time, the next step is to locate as many sources of I&I as possible and eliminate them. This includes I&I sources in that part of the collection system owned and maintained by the city or sewer district. But it should also include sources of I&I in that part of the system owned by

Smoke is emitting from several sources during this test conducted by KRWA. These sources likely include broken or cracked clay pipe and deteriorating brick manholes. Once the ground becomes saturated following heavy rainfall, water can infiltrate through these sources and into the collection system day after day. The result is reduced detention time in the lagoon that can adversely affect effluent quality.

individual home and business owners. This includes not only the customer's service line to the main, but also any inflow sources such as sump pumps and roof downspouts illegally connected. Be sure to check the city's or sewer district's Sewer Use Ordinance which provides legal standing to require the elimination of private I&I sources.

The "out of sight, out of mind" mentality doesn't work when it comes to controlling I&I.

The two most common ways of locating I&I sources are through smoke testing and televising of sewer mains. Typically, KRWA recommends starting with smoke testing to hopefully find all large sources of I&I. Smoke testing is a relatively inexpensive locating method. Televising is more expensive as more complex equipment and expertise is required. Smoke testing will locate and eliminate enough I&I sources to increase lagoon detention time sufficiently that televising may not be needed. Just remember, the identification and elimination of I&I sources should be an ongoing process for all utilities. As components in the collection system deteriorate over time, infiltration and inflow will only increase. The "out of sight, out of mind" mentality doesn't work when it comes to controlling I&I.

Is your lagoon organically overloaded?

Here are other problems: 1) red wastewater in lift station; 2) excessive solids or grease; 3) lagoon frequently appears to be overloaded. What's the cause?

As mentioned previously, when designing a new lagoon the consulting engineer must ensure the lagoon has sufficient detention time. However, he/she must also ensure that the lagoon is sized adequately to handle the

incoming organic loading. If the only customers served are homes and/or small businesses, this is usually not a problem as the organic loading can be accurately calculated. Since most domestic (human) waste is consistent and has an approximate BOD concentration in the 150-200 mg/L range, accurate organic loading can be estimated. However problems can result if the system has a significant amount of flow from commercial or industrial customers that discharge not only domestic wastewater, but also process wastewater. And process wastewater can include all sorts of things such as whole blood from slaughtering operations, milk from dairy or bottling operations, grain from pet food manufacturing, whey from cheese production, discharges from commercial car/truck washes and even grease from restaurants and public kitchens, especially if they do not have grease traps. And some of these type operations may not even discharge that much flow to the system's collection system. For example, many small locker plants are only open several days each week. But the issue here is not the amount of flow. Instead it is the BOD concentration that can dramatically increase the overall organic loading on a lagoon and eventually cause compliance issues. Many of the mentioned discharges have BOD concentrations of 100,000 mg/L or more, significantly greater than the 150-200 mg/L BOD of domestic wastewater. Because of the organic strength, sometimes it doesn't take that much flow from such operations to cause treatment problems in lagoons.

Such a predicament can present a challenge for governing bodies. Usually such businesses provide needed jobs in the community. But the challenge becomes how to deal with such high-strength, high-BOD wastewater discharges. A city council for example, must decide to either accept such wastewater and ensure the city's treatment facilities are sufficiently sized to treat it or require

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the individual commercial and industrial customers to either find an outlet to recycle their wastewater or pre-treat their wastewater in order to lower the BOD to an acceptable level that the city's treatment facilities can handle.

Regulating high-strength BOD discharges

If you frequently notice a lot of odd-colored wastewater or wastewater high in solids or grease at a lift station, efforts should be made to track the flow upstream to determine the source. In the case of blood from slaughtering operations, the whole blood can be easily captured in 55-gallon barrels and recycled through commercial rendering operations. Washdown of the kill floor is usually not a problem. Another possible solution is to encourage all commercial and industrial customers to make improvements in their housekeeping procedures, limiting discharges of process wastewater to floor drains, sumps, etc. Periodically sweeping floors at plants that use grains to manufacture products such as pet foods and corn chips can dramatically reduce the BOD in their discharges. Getting a handle on dealing with spills, especially if frequent, can also prove beneficial. And finally, requiring restaurants and school or senior center kitchens to install and maintain grease traps can help solve the problem of high-BOD discharges.

If the problem cannot be solved by these means, then the system may need to take a harder line and enforce their Sewer Use Ordinance. This is the same ordinance previously mentioned that can prove helpful in eliminating private sources of I&I. And almost all wastewater systems in Kansas have such an ordinance. Unfortunately, many operators are unaware of their ordinance. Most state and federal agencies that grant or lend money for wastewater projects require systems to adopt a Sewer Use Ordinance as a condition of the grant or loan. In fact, KDHE has a model ordinance that they suggest systems use when drafting their own ordinance. Regardless, such an ordinance typically has a section that deals with limits on what can be discharged to the system's collection system due to either safety or treatment issues. In the case of BOD, many Sewer Use Ordinances limit the BOD concentration in discharges from customers to 300 to 400 mg/L. There is also usually a limit on the TSS concentration that can be discharged. Discharges of oil and grease are also usually regulated. I encourage all operators to locate a copy of your system's Sewer Use Ordinance and become familiar with it.

Part 2 of this topic, Why Is My Lagoon Not Meeting Effluent Limits? will be published in the March 2017 issue of The Kansas Lifeline. Part 2 will cover additional issues than can lead to non-compliance including excessive sludge accumulation in lagoons, options for dealing with high TSS in lagoon effluent due to algae and how poor sampling techniques could be hurting your system, resulting in the collection of unrepresentative samples that do not truly measure lagoon performance. In the meantime, if anyone has compliance issues with lagoons, please feel free to contact me at 913-850-8822 or email me at jeff@krwa.net.

Jeff Lamfers began work for KRWA in November 2008. Jeff has more than thirty years of regulatory experience in the oversight and operation of water and wastewater systems with the Kansas Department of Health and Environment. He is a graduate of the University of Kansas with a degree in Environmental Studies with an emphasis in aquatic biology.