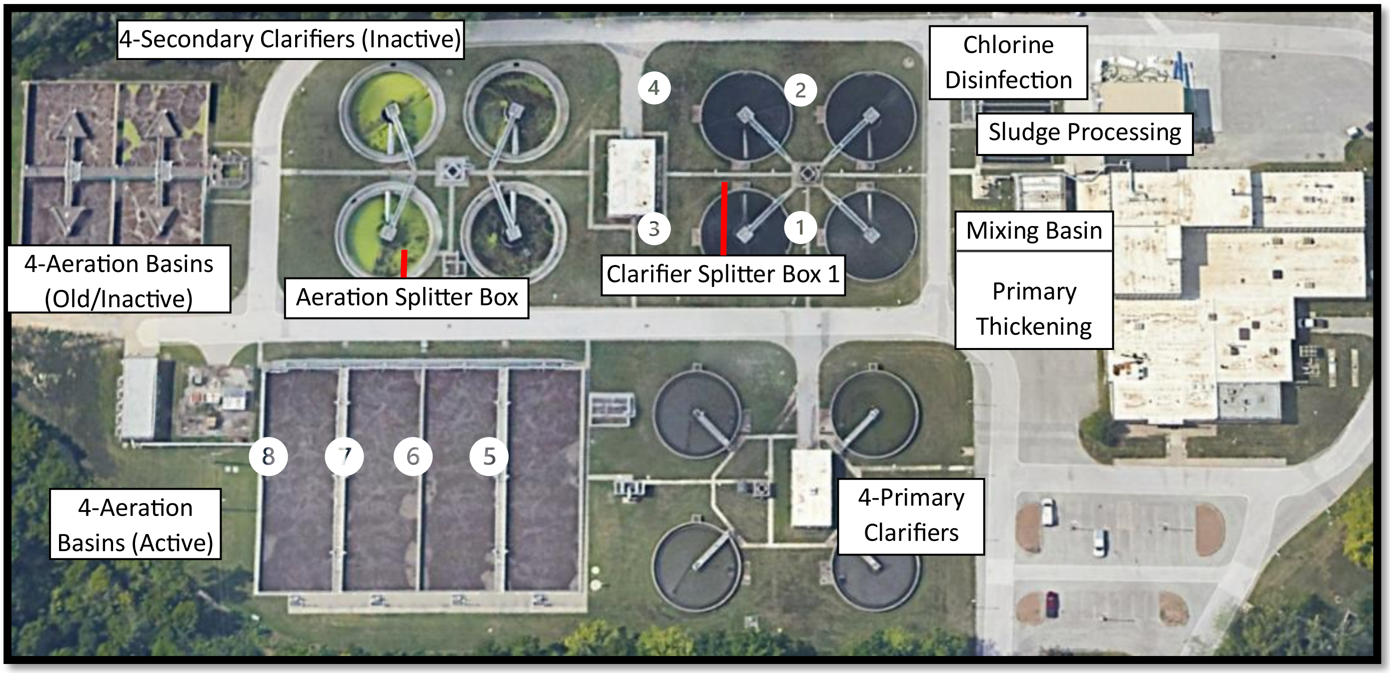
Independence, Missouri

MO 0089681

MoDNR Municipal Wastewater Nutrient Optimization Pilot Project

August 2025

Independence Rock Cr Wastewater Treatment Plant (WWTP)



Complete Mix Activated Sludge

Design Flow: 10.0 MGD

Actual Flow: 6.4 MGD

9600 Norledge Ave

Independence, MO 64053

Latitude 39.11441/ Longitude -94.46251

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Summary of Optimization Efforts:

Nitrogen Removal

The biological treatment at the Independence WWTP is complete mix activated sludge (CMAS). The WWTP has four newer aeration basins that are configured the same for aeration. At the start of the project, only two of the newer basins were in operation as treatment units. By the end of the project three basins were in use. The current aerators are so oversized that all aeration basins not in use for treatment are filled with non-potable water and aerated in order to blow off excess air. It is not possible to turn the existing blowers down (no speed control) and the blowers would be damaged trying to restrict air to only the active basins. The 300 HP blowers cannot be shut off and turned back on routinely as can be done in many optimization projects with smaller blowers and motors. The only way to reduce air to set up an anoxic zone is to shut select air drops off, which forces more air to the remaining drops. To try to create anoxic zones, either zones in a basin have to be turned off, or the air drops in an entire basin must be turned off. Both were tried with some success.

Phosphorus Removal

Phosphorus removal at the Independence WWTP focused on sidestream treatment – returning a small amount of solids from the mixing basin to the head of the plant. Unfortunately, the mixing basin released too much phosphorus which was returned to the head of the plant and caused effluent phosphorus to rise until the experiment was abandoned. Inline phosphorus reduction was also attempted by letting solids settle in the bottoms of the basins and become septic.

Nutrient and Energy Reductions

As indicated in Table 1, the Independence WWTP did not reduce the concentration of TN overall but did show a reduction in TP concentration of 21% during the project. It should be noted that late in the project when three aeration basins were utilized, TN has dropped to around 10 mg/L.

The facility removed additional mass of both TN and TP post-optimization. The main reason for the increased mass of TN removed while the TN concentration degraded slightly is the fact the TN influent concentration went up 27% during the optimization project, thus creating more TN mass to remove.

For all mass-based calculations, the results were normalized for flow to fairly compare pre- and post-optimization since flows during the pilot period were 8% lower than previous flows. Without normalizing for flow, discharging the same concentration (mg/L) pre- and post-optimization would yield more mass reduced pre-optimization simply because of higher flows. Normalization involved increasing the mass removed post-optimization by the change in flow – 8%.

Table 1 – Nutrient and Energy Reductions

	Pre-Optimization	**Post-Optimization**	**% Improvement**
TN - mg/L	13.6	16.1	-18
TP – mg/L	2.1	1.7	21
TN – lb/day Reduced	162	305	89
TP – lb/day Reduced	17.2	20.4	19
Energy Use – kWh/MG	1,325	1,433	-8
Energy Cost - $/MG	188	237	-26

Costs and Return on Investment

Three factors contribute to the cost of optimization: (a) MoDNR's investment in consulting support, (b) Independence investment in equipment and instrumentation, and (c) ongoing operational expenses relating to energy (i.e., electricity), chemicals, lab supplies and personnel.

Energy savings were not expected at Independence. As noted previously, the aeration is greatly oversized and the large blowers cannot be turned on and off throughout the day, so there is no way to reduce energy use. While no appreciable energy savings was observed – cost or kWh – the efficiency of energy use improved by 6%. This means that for every kWh used in treatment, more pollutants are now being removed.

MoDNR's cost for optimizing the Independence plant was $30,596, one-eighth of the $244,765 pilot project contract fee awarded to Grant Tech, Inc. and T8 Environmental LLC. One-eighth because there were eight municipal wastewater treatment plants in the pilot study. Independence costs (as estimated by facility staff) total $93,529 as shown in Table 2.

The total cost of optimization therefore was $124,125 ($30,596 + $93,529), around $12,400 per MGD of treatment capacity. The added energy cost is significant. Although the energy use (kWh) increase was modest at 8%, the cost of energy increased 26% - indicating a rate increase or increased peak demand use.

As shown in Table 1, the year-long optimization effort resulted in an increased TN removal of 143 lbs/day (52,195 pounds per year) and an increased TP removal of 3 lb/day (1,168 pounds per year). Dividing the cost of the project by the sum of the additional annual mass of TN and TP removed results in pilot project cost of $2.33 per pound per year ($124,125 ÷ (52,195 lb/yr + 1,168 lb/yr)).

Table 2 – Facility Reported Costs

Item	(Cost) / Savings
Instrumentation	($2,532)
Lab Supplies	($1,392)
Added Personnel Time	0
Other	($1,739)
Energy Savings/Increase	($87,866)
Total	($93,529)

Unfortunately, the story is yet to be told at Independence. As noted previously, Independence aeration is so oversized the energy costs are much larger than peer facilities. However, a new project is ongoing to replace the oversized aeration blowers with newer, smaller blowers which should be operational around August 2025. The variable frequency drive blowers will allow better control of DO, thus adding more ability to create anoxic and anaerobic zones in the process. More TN and TP reduction is expected with the upgraded blower system.

Initial Optimization Strategy:

The initial Optimization Strategy focused on inline TN reduction. By creating an anoxic area in the treatment basins, nitrate reduction should occur. Nitrate reduction would also provide more alkalinity which should raise the pH in the aeration basin. It had been noted the pH in the aeration basins was low – around 6.5 pH, so increasing the pH would be needed later to promote phosphorus reduction.

The influent biochemical oxygen demand (BOD) at the Independence was relatively weak – averaging less than 120 mg/L. It was thought there might not be enough BOD reaching the aeration basins to drive denitrification (nitrate reduction). Therefore, prior to creation of anoxic zones, the contractor wanted the operators to take two of the three operating primary clarifiers out of service to deliver more BOD to the aeration basins. This would be accomplished by taking one clarifier offline at a time and assessing the impact on the effluent. No impacts were observed, so aeration began.

The aeration basins had three aeration zones – the head of the basin, the middle, and the end. Aeration was turned off at the head of the operating basins to create anoxic areas with a target ORP of -100 mV. The anoxic zones were aerated for one hour twice per day to mix solids. By the end of July 2024 TN had dropped below 10 mg/L. Therefore, the contractor and operators decided to begin sidestream phosphorus reduction.

Sidestream phosphorus reduction involved pumping back a volume of solids equivalent to 10% of the waste activated sludge (WAS) volume from the mixing basin. Return of solids began but was abandoned by September 2024 when it became apparent the return solids were so septic, they released more than 100 mg/L of phosphorus. The amount of phosphorus returned could not be taken up in the aerated portion of the basin.

Modifications to Initial Strategy:

With sidestream phosphorus reduction not feasible using existing tankage at the plant, setting up an anaerobic zone in the aeration tanks was explored. Using only one treatment basin, the air to zone 2 (middle zone) was shut off. The plant operated in that mode until a power failure at the plant caused all aeration to shut down over several hours. When power was restored, the operators noted solids had built up and "parked" in the first zone and become very septic causing high ammonia values. The first zone is separated by a wall from the remainder of the basin. The wall extends from the floor of the basin to a point below the surface of the basin. The parking of solids eliminated using the first zone as an anoxic area.

Next, the plant was operated in a manner similar to a sequencing batch reactor (SBR) – an entire basin was aerated, then the air was turned off for short periods. The operators chose not to begin the SBR mode until November 2024 because they did not want to affect the results of their whole effluent toxicity (WET) test scheduled for October 2024. Initial results were promising (nitrate below 4 mg/L) when shutting air off to an entire basin for four hours per day, alternating days between the two operating treatment basins. The operators increased the aeration off time to six hour off per day.

In December 2024 the operators reported that ammonia increased to above 10 mg/L. The operators were monitoring each operating basin and interestingly one basin was half the ammonia concentration of the other. By the end of December 2024, the ammonia had climbed to 20 mg/L indicating the basins were basically digesting solids to release that much ammonia, and both basins were fully aerated to recover. The contractor also suggested operating three basins to increase the hydraulic retention time to better treat the wastewater and provide more flexibility in air-OFF cycles when optimizing began again. Staff agreed and began using three basins in late January 2025.

Table 3 - Basin Operating Schedule

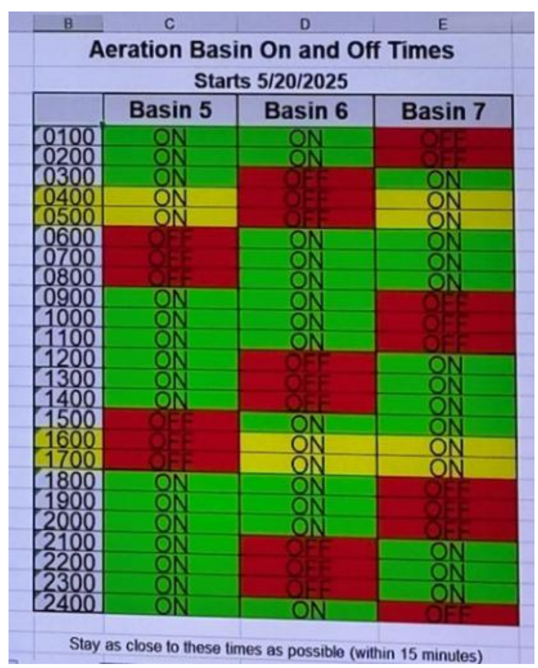
1	OFF	ON	ON
2	ON	ON	ON
3	ON	OFF	ON
4	ON	ON	ON
5	ON	ON	ON
6	ON	ON	OFF
7	OFF	ON	ON
8	ON	ON	ON
9	ON	OFF	ON
10	ON	ON	ON
11	ON	ON	OFF
12	ON	ON	ON
13	OFF: pH & ORP	ON	ON
14	ON	ON	ON
15	ON	OFF	ON
16	ON	ON	ON
17	ON	ON	ON
18	ON	ON	OFF
19	OFF	ON	ON
20	ON	ON	ON
21	ON	OFF	ON
22	ON	ON	ON
23	ON	ON	OFF
24	ON	ON	ON

By February 2025 the plant had recovered. However, due to cold weather, high flows, and disinfection requirements starting April 1, 2025, the operators wanted to maintain the current operating scheme.

Beginning mid-April 2025, staff began to operate the three basins in an air-ON and air-OFF mode for 1 hour at a time per the schedule in Table 3. The plant was running well, but little TN or TP reduction was noted. The air-OFF was upped to 1.5 hours and both TN and TP reductions were observed.

By the end of May, the operators had chosen to up the air-OFF to 3 hours. A screen shot of the plant operating schedule is shown in Figure 1. This scheme produced TN of 12 mg/L and TP of 1.5 mg/L indicating the plant is moving in the right direction.

The operators also provided 24-hour ORP and DO sampling read at 15-minute increments when operating in air-ON and air-OFF mode, which was very revealing. The dissolved oxygen (DO) just prior to the air being turned off was 7 mg/L. While it was expected the DO would be high based on the previously discussed issues with oversized aeration, 7 mg/L was surprisingly high. With the DO that high at the beginning of the air-OFF cycle, it takes a significant amount of time off to depress the DO to the point of creating anoxic and anaerobic conditions. This was also reflected in ORP values rarely becoming negative. Regardless, the plant is heading in the right direction.



Aeration Basin On and Off Times

Starts 5/20/2025

	Basin 5	Basin 6	Basin 7
0100	ON	ON	OFF
0200	ON	ON	OFF
0300	ON	OFF	ON
0400	ON	OFF	ON
0500	ON	OFF	ON
0600	OFF	ON	ON
0700	OFF	ON	ON
0800	OFF	ON	ON
0900	ON	ON	OFF
1000	ON	ON	OFF
1100	ON	ON	OFF
1200	ON	OFF	ON
1300	ON	OFF	ON
1400	ON	OFF	ON
1500	OFF	ON	ON
1600	OFF	ON	ON
1700	OFF	ON	ON
1800	ON	ON	OFF
1900	ON	ON	OFF
2000	ON	ON	OFF
2100	ON	OFF	ON
2200	ON	OFF	ON
2300	ON	OFF	ON
2400	ON	ON	OFF

Stay as close to these times as possible (within 15 minutes)

Figure 1 -Basin Operating Schedule

It should also be noted the staff at the Independence WWTP were outstanding in collecting and presenting operational data. The granular data they were able to provide helped everyone to better understand what was occurring operationally. They are to be commended.

Ongoing Optimization Strategies for Independence:

- Continue operating as is until the new blowers are installed and operational.
- As has been noted previously, the Independence WWTP is in the middle of an aeration upgrade that includes smaller, VFD-controlled blowers. This will allow the operators significantly more control of the treatment process and allow for better set up of anoxic and anaerobic zones. However, it is doubtful the effects will be seen immediately. The operators will need time to become comfortable with the new blowers and understand how to best utilize the aeration system. In a way, it will be like the start up of a new plant.
  That said, the operators can apply what was learned throughout the Pilot Project in terms of creating low DO environments to improve TN and TP reduction.
- After establishing a routine operating mode with the aeration upgrade, Independence may want to consider installing additional in-line instrumentation such as ammonia, nitrate, and orthophosphate analyzers. These would allow operators to more quickly respond to changes in treatment efficiency.

Additional Plant Information:

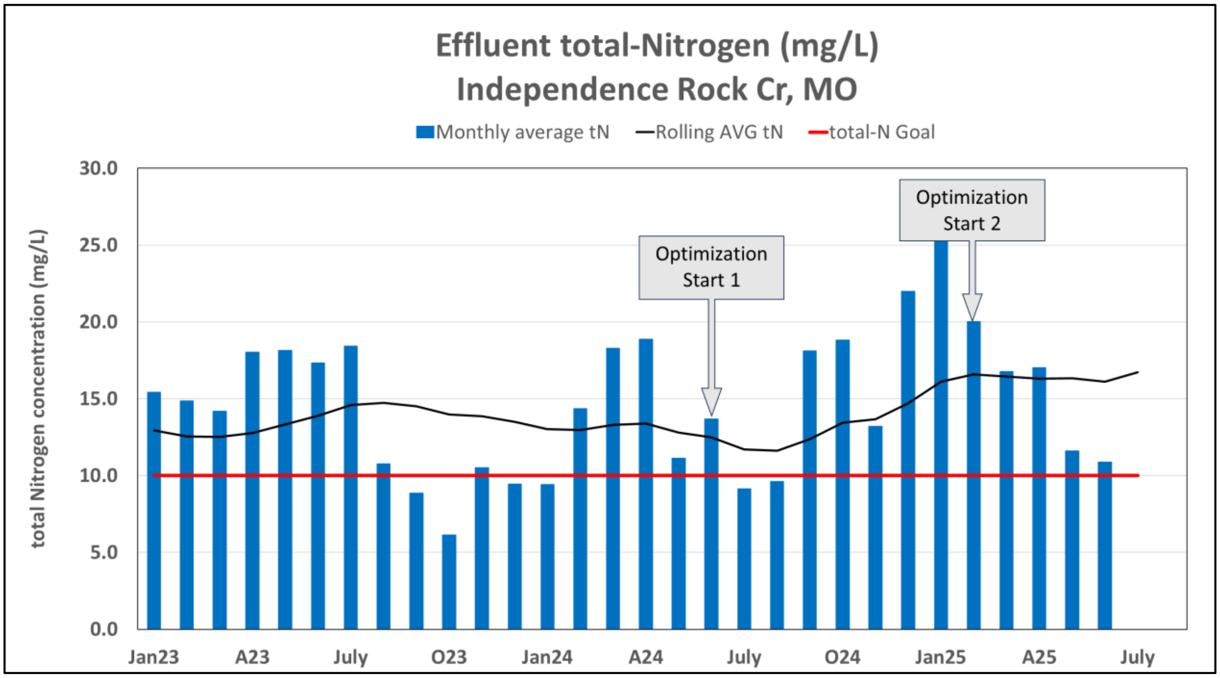
The independence Rock Creek Wastewater Treatment Plant operates with a daily average flow of 6.4 MGD versus a design flow of 10 million gallons per day. The treatment facility includes four primary clarifiers, four newer and four older unused aeration basins, four active secondary clarifiers and four older unused secondary clarifiers. Disinfection is provided by a hypochlorite disinfection system followed by de-chlorination.

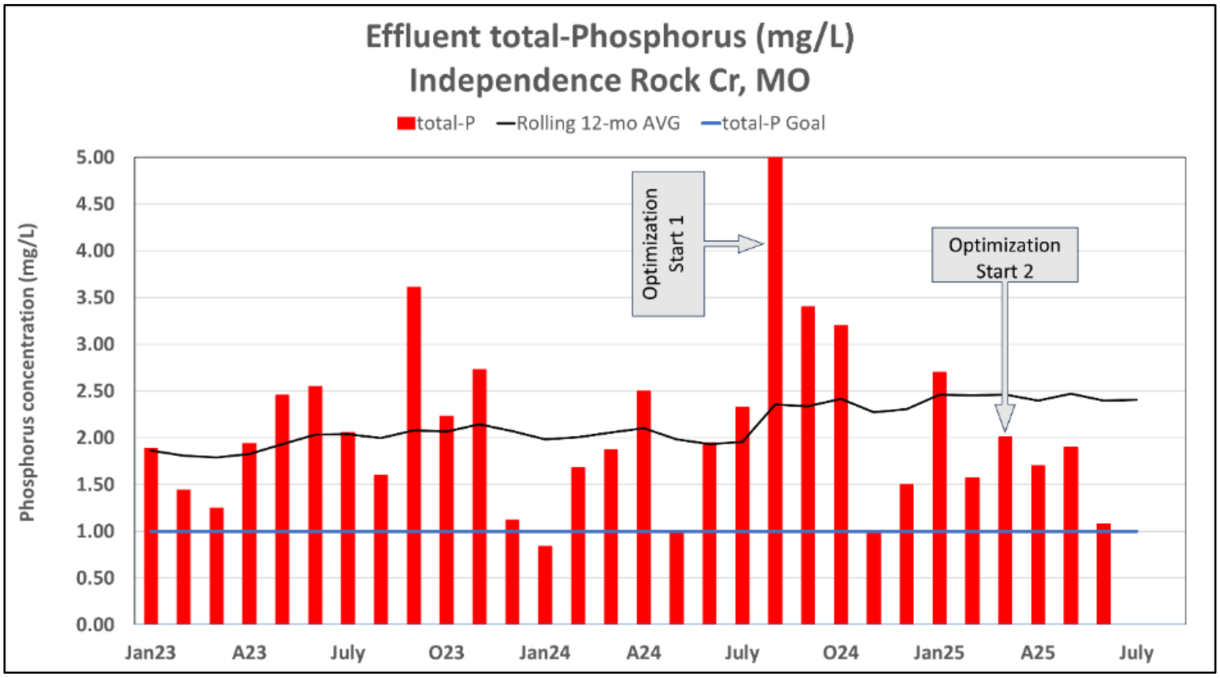
Solids handling consists of a primary thickening basin (PTB) with waste activated sludge (WAS) thickened by two dissolved air flotation (DAF) units. The thickened sludges are mixed and run through two belt filter presses followed by lime stabilization prior to land application.

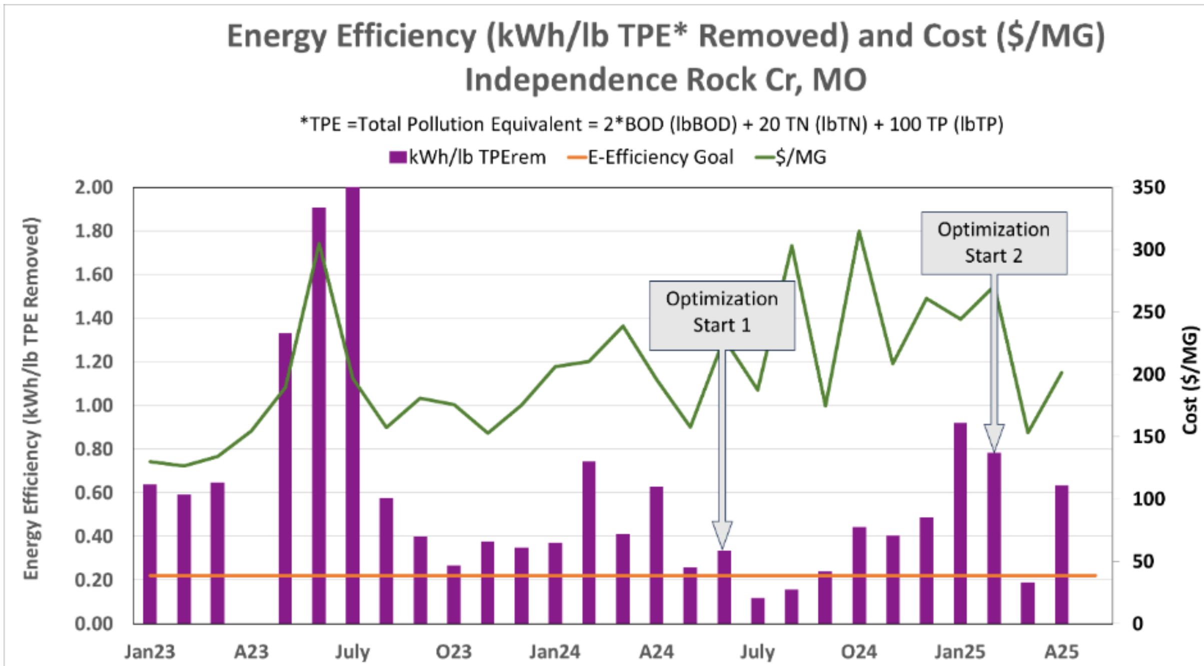
Contractor Information:

The year-long MoDNR funded nutrient optimization study was initiated in May 2024 by Grant Weaver of Grant Tech, Inc. and Mike Tate of T8 Environmental LLC and completed July 2025. The contractors made four site visits and held 16 video call meetings with Independence plant staff.

Nutrient Removal & Energy Efficiency Graphs:







Lessons Learned / Guidance for Others Considering Optimization:

Facilities not designed for nutrient removal must be operated differently than those designed to achieve nutrient removal. Data beyond that required to meet permit conditions need to be collected and compared against targets. This is also true for most facilities designed for nutrient removal as well.

The air-ON, air-OFF cycles of CMAS plants can and should be adjusted to optimize nitrate removal while maintaining effective ammonia TN removal. Frequent testing and periodic adjustments are advised. For facilities with fixed speed and/or oversized aeration the challenges are often greater – as is the case at Independence. For any facility considering ramping down aeration, the ramp-down should be done slowly. Ammonia should be closely monitored and if it begins to rise above target levels, the plant needs to increase aeration immediately.

For phosphorus removal, the air-OFF cycles can often be extended to provide sufficiently septic conditions in the solids settling in the bottom of a basin for VFA formation and uptake by PAOs. Sidestream phosphorus removal is a viable option when appropriately sized tankage is available. Sidestream fermenters need to be big enough to provide enough retention time and be septic enough for the generation of volatile fatty acids, but not so septic and not so large as to allow the microbes within to decay enough to release too much phosphorus into solution. Utilizing existing tankage at Independence did not lend itself to sidestream treatment. The solids handling basins were too septic and released too much phosphorus for sidestream treatment to be viable.

An empirical approach to optimization is greatly enhanced with regulatory encouragement and support as was the case in Missouri. Offers of enforcement discretion are a strong motivator for highly regulated and therefore risk-adverse municipalities to seek optimization opportunities.

Given that Nitrogen and Phosphorus are chronic pollutants, permitting discharges as rolling average mass loadings accommodates day-to-day and month-to-month variability with minimal environmental consequence while accommodating the impacts of infiltration and inflow (I/I), seasonality, and day of week variability in flows and loadings.