TETON COUNTY SEPTIC SYSTEM

EFFLUENT MONITORING

Executive Summary

The intent of the Septic System Effluent Monitoring Project is to determine the impact of typical septic tank soil absorption systems on groundwater in Teton County, WY. With this stated purpose in mind and the fact that residents have expressed concern about nutrient and pathogen contamination of drinking water supplies and the overall nutrient contribution to the groundwater and the subsequent impact on surface water, the Teton Conservation District and Teton County jointly funded this effort.

Onsite Wastewater Treatment System

A conventional onsite wastewater treatment system in Teton County consists of a septic tank and subsurface infiltration system, which discharges to groundwater and usually relies on the unsaturated or vadose zone for final polishing of the wastewater before it enters the saturated zone.

The septic tank is a watertight box, usually made of concrete, with an inlet and outlet pipe. Wastewater flows from the home to the septic tank through the sewer pipe. The septic tank treats the wastewater naturally by holding it in the tank long enough for solids and liquids to separate. The wastewater forms three layers inside the tank. Solids lighter than water (such as greases and oils) float to the top forming a layer of scum. Solids heavier than water settle at the bottom of the tank forming a layer of sludge. This leaves a middle layer of partially clarified wastewater.

The layers of sludge and scum remain in the septic tank where anaerobic bacteria found naturally in the wastewater work to break the solids down. The sludge and scum that cannot be broken down are retained in the tank until the tank is pumped. The layer of clarified liquid flows from the septic tank to the drainfield or to a distribution device, which helps to uniformly distribute the wastewater in the drainfield. A standard drainfield (also known as a leachfield, disposal field, or a soil absorption system) is a series of trenches or a bed lined with gravel or coarse sand and buried one to three feet below the ground surface. Perforated pipes or drain tiles run through the trenches to distribute the wastewater. The drainfield treats the wastewater by allowing it to slowly trickle from the pipes out into the gravel and down through the soil. The gravel and soil act as biological filters.

Site Selection and Characteristics

A solicitation for volunteers was drafted and released to the public in December of 2019. Only a handful of responses were received, so additional research and more pointed and direct requests were required in order to obtain a list of suitable candidates.

Four primary or preferred sites and four secondary sites were then chosen for site visits and detailed evaluation. The criteria for the selection of a site included the following:

- the system should have documented design records, installation inspections and regular maintenance to reduce the number of variables that could invalidate the statistical analysis of the monitoring program;
- the leachfield should be situated above relatively shallow groundwater (10 feet deep or less) to facilitate easier installation and sampling of the groundwater;
- the system should serve two or more full-time residents;

- the age of the system should be between 5 and 30 years, rather than brand new construction, ensuring a healthy and functioning biomat is in place; and
- ideal sites would have relatively open space downgradient from the leachfield for placement of monitoring wells.

Parameters Sampled

The initial project scope required that the parameters to be sampled would be as follows:

- Field parameters (Specific Conductivity, pH, temperature, and Dissolved Oxygen)
- Laboratory analysis (Nitrate, Nitrite, Ammonia, Orthophosphate, Phosphorus, Chloride, and E.coli)

Sampling Parameters Overview

The methods for sampling and measuring chemical water quality parameters generally followed the techniques described in the USGS' *National Field Manual for the Collection of Water-Quality Data*. For the lab analyses, Energy Laboratories performed the nutrient parameter analysis in accordance with EPA standard methods.

Summary of Primary Findings

In general, the data supports the fact that the septic systems—in specific the leachfields—work well during the summer months; the onsite treatment systems are removing nitrogen, phosphorus, phosphate and E.coli from the wastewater effluent. It seems that leachfield sites are achieving a good level of dilution as well, based on the sample results at the 10-foot monitoring wells and the 50-foot monitoring wells. The winter data set indicates that nitrification and denitrification are, however, reduced in the colder months.

Other than the high groundwater months of June through September, the groundwater at Site 3 dropped below the installed monitoring wells, therefore the reported results are from Sites 1, 2 and 4.

Pump Chamber Effluent Observations

Following are some observations from studying the data from the effluent samples taken from the pump chamber of three sites prior to discharge to the leachfield.

1. The effluent temperature varies based on the time of year, and more specifically, the climatic temperatures. A low of 2.4 ^{o}C-6.4 ^{o}C was observed in January, and a high of 16.6 ^{o}C-21.4 ^{o}C was observed in June and July. Effluent temperatures have a direct effect on the temperature of the leachfield. There could be a benefit to insulating the septic and pump tanks from the frost in the ground.
2. The effluent pH is fairly constant throughout the year, averaging 7.55.
3. The effluent Ammonia, NH_4, is fairly consistent, averaging 38.4 mg/l, with a standard deviation of 4.9. Published data indicates a weighted average of 42 mg/l.
4. The effluent Nitrate is essentially nonexistent due to anaerobic digestion of organic Nitrate to Ammonia.
5. The effluent Chloride averages 27.6 mg/l, with a standard deviation of 3.8.
6. The effluent Phosphorus averages 4.6 mg/l, with a standard deviation of 1.4, and Phosphate averages 14 mg/l, with a standard deviation of 4.3. Published data indicates a Total Phosphorus average of 15 mg/l.

Lysimeter Sample Observations

The loading rate of the leachfield in gpd/ft^2 at all three sites was below the design rate. The average leachfield loading rate was 31% of the design rate, and the maximum month loading rate average was 56% of the design rate.

1. The lysimeter water temperatures vary with time of year, and more specifically, the ground temperature. Lysimeter temperatures are affected by the temperature of the applied effluent and ground temperature/frost. LY1 temperatures are slightly higher than the LY2 temperatures.
2. LY1 pH is generally similar to the effluent pH. LY2 pH was lower due to nitrification that occurs in the aerobic zone of the leachfield. Nitrification reduces the alkalinity (pH buffer) 7 ppm for each NH_4 ppm that is reduced to Nitrate.
3. LY1 Ammonia was variable, probably due to the time that it takes the vacuum pump to collect a sample and the continuing nitrification during that time. LY2 sample tests showed that the Ammonia was reduced to Nitrate by nitrification, average 96.6%. Nitrification is affected by available Oxygen, temperature, and pH. There is a reduction in nitrification efficiency in the winter months versus the summer months due to the lower temperatures.
4. LY1 and LY2 Nitrogen (NO_2 plus NO_3) levels were highest in the winter and lowest in the summer months. Denitrification, the conversion of NO_3 to Nitrite and Nitrogen gas, occurs in an anoxic condition where there is insufficient Dissolved Oxygen (DO) for the biological activity, resulting in the bacteria using the Oxygen in the NO_3 for metabolism. Denitrification is dependent upon DO, temperature, and a carbon source for the biological degradation. Average denitrification was 32.1% with a standard deviation of 31.8%. The large deviation is due to the different site conditions, carbon source and temperature. The lower denitrification levels observed in the winter are probably due to temperature.
5. Chloride concentration in the samples from the lysimeters is variable but generally similar to the Chloride levels in the effluent.
6. Phosphorus and Phosphate concentration in the lysimeters is variable and much lower than the effluent concentrations, probably due to adsorption to the soil particles.

Monitoring Well Sample Observations

Following are some observations from studying the data from the monitoring well samples. Monitoring Well 1 (MW1) is the upgradient monitoring well. Monitoring Well 2 (MW2) is located in the center of the leachfield. Monitoring Wells 3 through 5 (MW3, MW4 and MW5) are located approximately 10 feet downgradient of the leachfield. Monitoring Wells 6 and 7 (MW6 and MW7) are approximately 50 feet downgradient of the leachfield.

1. Monitoring well sample temperatures are indicative of the groundwater temperature. Monitoring well water temperatures vary seasonally and are generally the same for MW1 and MW3 through MW7.
2. Monitoring well water pH was very consistent and generally the same for MW1 and MW3 through MW7. The water in MW2 had a lower pH than the other monitoring wells, probably due to the nitrification process that was occurring in the leachfield.
3. Monitoring well Dissolved Oxygen (DO) did not show a consistent pattern of reduction from MW1 to MW3 through MW7. Some monthly samples (August and September) did show a downgradient decrease in DO, indicating that there could be some Oxygen demand imposed on the groundwater by the effluent from the leachfield. Overall, DO levels increased with the decrease in groundwater temperature in sync with the DO saturation, but there was still DO available for biological activity.
4. Specific Conductance measurements in the monitoring wells show the effect of the groundwater diluting the dissolved solids in the effluent.

5. Ammonia concentrations in the monitoring wells were not measurable.
6. Nitrate nitrogen concentrations in MW1 (upgradient) and MW6 and MW7 (50 feet downgradient) averaged from 0.05 to 0.65 ppm, being the highest in April. The Nitrogen concentrations in MW3, MW4 and MW5 were highest in April, 0.93-2.06 mg/l, indicating reduced denitrification. The Nitrate concentrations in MW6 and MW7 were considerably lower than MW2 through MW5 due to additional denitrification and dilution with groundwater.
7. Chloride concentrations in the monitoring wells show the effect of the groundwater diluting the Chloride from the effluent. Chloride concentrations in MW3, MW4 and MW5 10 feet downgradient averaged 0.5-0.3 mg/l higher than MW1. MW6 and MW7 Chloride concentrations average the same as MW1 indicating complete dilution of Chlorides 50 feet from the leachfield.
8. The reduced Phosphorus and Phosphate concentrations in the monitoring wells show the effect of the groundwater diluting the effluent leachate and the adsorption in the soil. MW2 did show some measurable Phosphorus and Phosphate concentration, but the concentration was at background levels in the downgradient monitoring wells.
9. Monitoring well MW1 and MW3 through MW7 water samples did not have any total coliform or E.coli bacteria. MW2 did occasionally show concentrations of bacteria; this could be due to short circuiting of leachate into MW2 or sampling contamination.

Conclusions

The Wyoming DEQ and Teton County minimum design standards for septic tanks and leachfields are reasonable and adequate to provide good treatment of residential wastewater.

It appears that Site 1 has a leaking septic tank or pump chamber based on the low pumping rate in winter and high pump rate in June. The leak could be at the opening in the chamber where the pipe enters or exits. Site 4 septic tank effluent and leachfield had the highest temperature in winter; this could be because it had more earth cover over the infiltrators than the other sites. Site 2 had the lowest Nitrogen removal, had nitrification but no denitrification as measured by the lysimeters. Site 2 was a gravel bed, not infiltrators. However, Site 2 did have Nitrogen removal below the lysimeters as evidenced by the Nitrogen concentration in the downgradient monitoring wells. Overall, the three sites showed an average Ammonia (nitrification) removal of 97.1%. The majority of the nitrification occurred in the first 12 inches of the leachfield.

Based on the samples from the lysimeters, the three sites showed an average Total Nitrogen removal of 46.2%; Site 1 Nitrogen removal was 48.2%, Site 2 was 0, and Site 4 Total Nitrogen removal was 92.1%. Average Chloride removal for all three sites was 7.4%. Average Phosphorus removal for all three sites was 71.4%. Site 1 was lowest at 35.5%, while Site 2 and Site 4 had Phosphorus removal of 92.1% and 90.7%, respectively. Average Phosphate removal for all three sites was 72.2%. Site 1 was the lowest at 33.4%, while Site 2 and Site 3 had Phosphate removal of 91.9% and 92.2%, respectively. Based on tracer constituents, Chloride and Specific Conductance, there is significant dilution of Nitrogen and Phosphorus when they reach the groundwater.

The Nitrogen concentration in the immediate downgradient monitoring well 10 feet from the leachfield increased, over upgradient MW1, an average of 0.89 mg/l at Site 1, 0.14 mg/l at Site 2, and 1.44 mg/l at Site 4. The Nitrogen concentration in the immediate downgradient monitoring well 50 feet from the leachfield increased, over upgradient MW1, an average of 0.27 mg/l at Site 1, 0.07 mg/l at Site 2, and 0.07

mg/l at Site 4. The largest increase in the monitoring well Nitrogen concentration occurred during the winter months.

The Total Phosphorus concentration in the immediate downgradient monitoring well 10 feet from the leachfield increased, over upgradient MW1, an average of 0.020 mg/l at Site 1, 0.015 mg/l at Site 2, and 0.34 mg/l at Site 4. The Total Phosphorus concentration in the immediate downgradient monitoring well 50 feet from the leachfield increased, over upgradient MW1, an average of 0.001 mg/l at Site 1, 0.001 mg/l at Site 2, and 0.037 mg/l at Site 4.

If future studies are conducted it would be helpful, if budget allows, to track the Total Organic Carbon (TOC) from the septic tank effluent through the lysimeters and monitoring wells. TOC has become an important parameter used to monitor overall levels of organic compounds present. TOC does not provide direct quantitative correlation between Total Organic Carbon and the Biochemical Oxygen Demand (BOD) but is an easy-to-measure, general indicator of the approximate level of organic contamination in the water. Tracking the reduction in TOC would provide an indication of the aerobic reduction of organic matter through the leachfield and groundwater aquifer.

For the leachfield wells (MW2), it could be helpful to have only the lower section of the PVC well within groundwater be perforated and the top portion solid PVC, to help reduce the likelihood of leachate short circuiting into the well. Also, it would be advantageous to place bentonite in the annular space between the steel well pipe and the PVC monitoring pipe for at least four feet below the bottom of the leachfield prior to pulling the steel pipe to provide a monitoring well surface seal.

Recommendations

Septic System Design Modifications

1. Require that septic tank and pump chamber be insulated to retain heat from household wastewater and reduce cooling effect of frozen ground. Do not allow tank and pump chamber to be placed under plowed surfaces without additional insulation.
2. Encourage the use of infiltrators and require a minimum of 1.5 to 2 feet of cover to provide more insulation above the drainfield.
3. Leak test septic tank and pump chamber after construction.

Septic System Operational Suggestions

1. Assure that septic tanks are pumped at least every 5 years.
2. Assure an inspection of the septic system, at least, each time the septic tank is pumped.
3. Close leachfield vents in winter.