Rice County Seepage Pit (Dry Well) Research Summary

Summer 2011

Onsite Sewage Treatment Program - University of Minnesota

EXECUTIVE SUMMARY

In the summer of 2011, the University of Minnesota Onsite Sewage Treatment Program field-investigated 16 dry well systems in the Roberds Lake watershed, Wells Township and Forest Township. The primary purpose was to determine whether any of these systems meet the current compliance criteria in the State of Minnesota. Additional research was conducted on a subset of these systems to investigate potential for impacting the environment. None of the 16 systems meet the compliance criteria based on our data collection. All systems (16) lacked the proper amount of unsaturated soil below the dry well for proper aerobic treatment as well as having undersized distribution area. Our additional research results from water samples for coliform bacteria were inconclusive due to high amounts of sediment in our samples. Data on soil phosphorus and chlorides in the ground water clearly showed the dry wells at the studies sites are having an impact on the surrounding soils and shallow groundwater.

PROJECT BACKGROUND

In the 1990s French Lake, comprised of 154 developed lake lots, determined that the septic systems serving these lots were contributing approximately 100 kilograms of phosphorous per year (5-10% of the total) to the lake's phosphorus (P) budget. Although this was a small proportion of the total, the lots went through a septic system inspection and replacement program with 107 of the parcels along the shore upgrading including a new cluster soil-based septic system and numerous new individual septic systems. This project served as a model for other lakeshores both in and outside of Rice County, MN (McComas & Stuckert, 2002).

A random study was performed to evaluate the barriers and motivations of Southeastern Minnesota rural residents to maintain and repair their septic systems (Draeger, 2003). 300 of these surveys were sent to rural Rice County, MN, residents. Nearly all the residents said they would repair or replace their system if it was not working, while 60% supported government inspections to determine if repair or replacement was needed. 33% of Rice County respondents to the survey believe that regular county inspections of existing septic systems were necessary. Overall survey responses indicated 55% agreement that more needs to be done to address water quality impacts from septic systems.

In a study published in 2007 (Croteau-Kallestad, 2007), it was reported that the Cannon River Watershed has known for at least 13 years that phosphorus input is a major problem for Roberds Lake and identified its source coming from agricultural fields, feedlots, septic systems, residential storm water runoff, and the natural background levels. Although rural residential areas make up approximately 4% of land use around the lake, these areas do still contribute phosphorus to the lake through storm water runoff and septic systems (more contribution is expected from non-compliant septic systems). There were 280 dwelling parcel records on file around Roberds Lake. Of these approximately 50% of the systems appeared to be in compliance (based on county records on file), 25% of the systems have a record on file but the status is uncertain, and 25% have no record on file. Some of the systems with a record on file but with uncertain status are listed as "dry wells" and are considered imminent public health threats by Rice County ordinance.

The recognition of that some sources of phosphorus can be controlled, initiated action among lakeshore residents and Rice County Planning and Zoning staff. Collaboration between County staff, Roberds Lake residents and the Southeast Minnesota Wastewater Initiative has led to the development of a subgroup focused on addressing these concerns, the delivery of educational opportunities regarding septic systems and a septic system inspections and upgrade program.

According to a recent SSTS inventory conducted by Rice County in Forest Township and Wells Township including Roberds Lake Watershed, over 60 active dry well septic systems were discovered serving as wastewater disposal for these properties. Many of the properties investigated were around Roberds, Circle and Union Lakes which all are listed on the MPCA's impaired waters list. They are all impaired for aquatic recreation with the pollutant being related to Nutrients/Eutrophication/Biological (MPCA, 2010).

HISTORY OF SEEPAGE PIT REGULATIONS

Prior to 1967, the US Public Health Service had design standards for seepage pits with four feet of separation, but identified they should not be used where there is a likelihood of contaminating underground waters, nor where adequate seepage beds or trenches can be provided.

Following this, the MN Health Code in 1969 and 1971 had similar design standards which also made their way into the MPCA's design standards, WPC-40, which only allowed them to be installed as alternative systems because their treatment is less than trench and bed systems. Then in 1989 the MPCA changed MN Rules Chapter 7080 (re-codified WPC-40) and defined existing seepage pits and dry wells as failing, leaving the upgrade time period up to local units of government.

INTRODUCTION

Dry wells are a relic wastewater technology that have been linked to contamination of groundwater and surface waters due to the large volumes of effluent moving through soil too quickly to allow for proper removal or treatment of the contaminants (see below). In fact, cesspools and dry wells have been prohibited for wastewater disposal in Minnesota since 1989.

Impacts of dry wells on public health and the environment

The presence of improperly treated sewage is a threat to public health and the environment. Human exposure to sewage has resulted in disease outbreaks, severe illnesses, and in some instances death from the bacteria, viruses and parasites contained in the waste. Wastewater disposal systems that do not adequately treat wastewater also negatively affect our lakes, rivers, and groundwater by potentially introducing sediment, nutrients, and chemicals that result in contamination.

There is also a safety concern with many of these systems because the tank lids may collapse resulting in an unsafe environment for people, animals and infrastructure. In addition, these systems are likely to be built by the homeowner with non-durable materials for the septic environment.

What is proper wastewater treatment?

In Minnesota, we are concerned about all of our water resources for both beneficial use and recreation. One way to minimize damaging our waters is to ensure effective wastewater treatment is achieved across the State. Effective wastewater treatment is simply the removal of solids, nutrients, bacteria and viruses from the wastewater and the predictable acceptance of the treated waste into the natural environment. In the case of individual sewage treatment systems (ISTSs), this level of treatment and acceptance is fundamental to our ISTS design requirements.

Specifically what is required for this level of treatment has been researched for over 100 years and remains true today – three vertical feet of dry, well-aerated soil with a wastewater distribution network sized based on use (e.g. single family home, day care facility, etc.) and soil properties. Often times our older ISTSs placed too much importance on wastewater going away (i.e. disposal), without adequate understanding or concern for treatment.

There are two primary reasons why seepage pits and cesspools do not provide adequate wastewater treatment; size and depth. Sewage is discharged into a small diameter pit and causes the wastewater to disperse under saturated, anaerobic conditions, limiting soil treatment. The small size of these systems also increases the likelihood of sewage back-up into the dwelling and surfacing sewage. Many cesspools and seepage pits were intentionally sited with the bottom of the pit in groundwater, as the natural water movement carried the sewage away. Raw or partially treated sewage should never reach groundwater, as the impacts to an aquifer are similar to the damages in a ditch, stream, or lake. There have been numerous studies documenting contamination of ground and surface water from wastewater systems in contact with groundwater (Allen and Morrison, 1973; Anan'ev and Demin, 1971; Crane and Moore, 1984; Kligler, 1921; Vaisman, 1964).

Nassau County, Long Island, New York provides a large-scale, dramatic demonstration that leaking septic tanks can pollute groundwater. Here, the daily discharge of 300,000,000 liters of wastes into septic tanks and cesspools has caused increases in nitrate in individual and municipal wells above the U.S. Public Health Service drinking water limit of 10 mg/L nitrate nitrogen (Smith and Baver, 1969).

Do I have system with a cesspool or a system with a seepage pit, dry well or leaching pit?

A cesspool is an underground tank with holes in the side and/or bottom through which wastewater coming directly from the dwelling is discharged. The wastewater seeps into the surrounding soil through the bottom and openings in the side of the pit. Some designs may have a septic tank prior to the leaky tank and if so, it is considered a seepage pit, dry well or leaching pit.

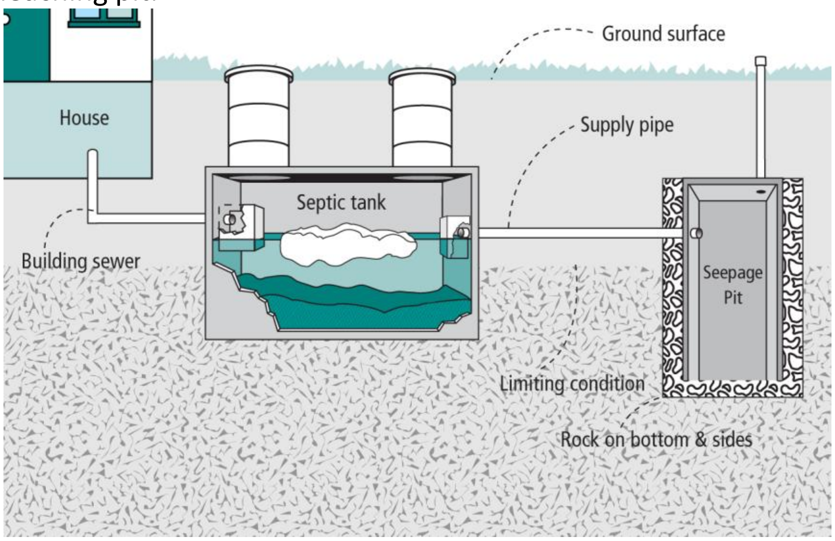

Figure 1. A seepage pit discharges partially treated septic tank effluent into the environment

The US EPA (2001) highlights several reasons why dry wells are deficient for treating wastewater:

1. Dispersal is too deep and oxygen levels too low allowing pathogens to potentially reach the groundwater.
2. Many of the tanks prior to dry wells are not properly sized, installed or maintained; dry wells receive solids and become plugged.
3. Water tables fluctuate and often come above the bottom of the pit, flooding it and allowing direct contact of pathogens and nitrogen with groundwater.
4. Seepage pit construction may open up pathways to cracks and fissures in rock, sending effluent directly to waterways.
5. Seepage pits may allow contaminated groundwater to pollute pristine aquifers.

In addition dry wells pose other hazards not directly related to groundwater for people, animals and property that may fall into them.

Purpose

The University of Minnesota's Onsite Sewage Treatment Program was contacted to further investigate the compliance status of a subset of these dry well systems according to MN Rule Chapter 7080.2550 (MPCA, 2011). The state minimum for compliance criteria evaluated includes:

1. A watertight septic tank preceding the dry well;
2. A minimum inside diameter of the dry well of 5 feet;
3. A minimum of 3 vertical feet of separation to periodically saturated soil;
4. The dry well shall not be in contact with any sandy textured soils;
5. The dry well is not in contact with a drinking water source;
6. The dry well has an absorption area that has been determined by dividing the design flow in parts 7080.1850 to 7080.1885 by the soil loading rate under Table IX or IXa in part 7080.2150, subpart 3, item E, based on the weighted average of each vertical stratum penetrated by the seepage pit, dry well, or leaching pit; and
7. Meets all setback requirements

Beyond these basic compliance criteria, we also further evaluated a subset of these 16 systems to determine likelihood of impacts of these systems on the surrounding environment. We collected soil and water samples for determination of pollutants that can be associated with wastewater in the environment.

METHODS

In the summer of 2011, preliminary selection of sites was conducted by Rice County Planning and Zoning staff by reviewing the existing permit and inventory records. The selection attempted to sort out sites that likely have a dry well system from other types of systems. From this preliminary selection, project information, homeowner surveys and request for permission to inspect systems were sent to the selected properties. From this letter, there were about 28 systems to select from for further field investigation. We collected data from 16 dry well sites from both the Roberds Lake and Forest Township areas for our inspections, but visited 23 potential sites.

On each of the 16 properties, we first located the septic tank and pumped out the contents in order to inspect the tank for water tightness via video camera from inside the tank and the bottom of the tank was probed to determine the existence of a concrete bottom. We then located the dry well. We determined the diameter of the dry well by probing with tile probes out from the inspection pipe (if present). Next we pumped down the contents of each dry well (if needed) in order to inspect the construction method (e.g. concrete block, silo stave, etc.). We were also able to document any overflow tiles leading away from the dry well. During this inspection, the bottom was also probed in order to ascertain the depth of the dry well. The depth was necessary to determine if any of the dry wells are in contact with a drinking water source as well as calculate each dry well's size. We compared depths of the dry wells to the well on the property and the Rice County Water-Table Hydrogeology mapping (MN DNR, 1997).

For each parcel we also investigated soil properties to determine loading rate values, separation to periodically saturated soil, and soil texture(s). This was conducted using a 4-inch diameter open bucket auger along an elevation contour outside of the influence of the dry well. Soil color, texture and depth were recorded down to the periodically saturated soil layer. The last aspect of the field investigations was an inspection of the site for setback issues and a brief search for overflow pipes that outlet to the ground surface.

Phase 2 was additional research conducted at a subset of sites that included soil and water sample collection and analyses for determining impact of the dry well to the surrounding environment. We sampled soil water (if present) at differing distances from the dry well, lake water (if present), and well water (if available). These water samples were analyzed for chloride levels, and coliform bacteria. We also collected soil samples from all layers above the periodically saturated zone to analyze the phosphorus profile of the soil. These results will be presented last.

RESULTS

None of the 16 (0%) dry well sites visited met all of the required compliance criteria in MN Rule Chapter 7080 (Table 1). Most importantly, zero of the systems meet the required vertical separation distance to the periodically saturated soil or the proper sizing to adequately distribute septic tank effluent at the sites. Lacking compliance with these two criteria, which are proven to influence contaminant movement away from septic systems, the likelihood of negative impacts from these dry well systems to surface and subsurface waters is high (investigated further in Phase 2 below).

Parcel No.	--Compliance Criteria Met--						
	Watertight Septic	5' Inside Dia.	3' Vertical Sep.	Fine Textured Soil	Drinking Water Separation	Correct Sizing	Setbacks Met
1	U	Y	N	Y	Y	N	Y
2	U	Y	N	Y	Y	N	Y
3	Y	Y	N	Y	Y	N	Y
4	Y	N	N	N	Y	N	Y
5	U	N	N	Y	Y	N	Y
6	N	N	N	Y	N	N	N
7	Y	Y	N	Y	Y	N	N
8	Y	N	N	Y	Y	N	Y
9	Y	Y	N	Y	Y	N	Y
10	Y	Y	N	Y	Y	N	Y
11	Y	Y	N	Y	N	N	N
12	Y	Y	N	Y	Y	N	Y
13	Y	N	N	Y	Y	N	Y
14	N	Y	N	N	N	N	Y
15	Y	N	N	Y	Y	N	N
16	N	Y	N	Y	Y	N	Y
U = Unknown if compliant, Y = Yes compliant, N = Not compliant							

Table 1. The seven seepage pit compliance criteria results by parcel.

The combination of a lack of separation to the periodically saturated soil and overloading of effluent to these small areas, as shown in Table 2, results in saturated movement of effluent through the underlying soils. This type of movement is less effective at removal of pathogens or nutrients that may contaminate the surrounding waters. 11 of the 16 systems investigated only have sufficient area to adequately treat and distribute 10-20% of the daily design flow values for household ISTSs. This degree of undersizing systems likely explains the numerous overflow pipes observed in our study used to outlet the excess partially treated effluent.

Parcel No.	Weighted SHLR (gpd/ft^2)	Design Flow (gpd)	Required Size (ft^2)	Actual Size (ft^2)	% Too Small
1	0.45	450	1000	153	85
2	0.45	300	667	98	85
3	0.99	450	455	231	49
4	0.6	450	750	5	99
5	0.45	450	1000	70	93
6	0.6	450	750	119	84
7	0.47	300	643	151	77
8	0.45	450	1000	54	95
9	0.45	450	1000	170	83
10	1.2	300	250	120	52
11	0.42	600	1429	147	90
12	1.2	450	375	254	32
13	0.45	450	1000	149	85
14	1.2	450	375	141	62
15	0.5	600	1200	147	88
16	0.45	300	667	128	81

Table 2. Determination of the correct sizing of the dry well system based on the soil properties at each parcel.

Based on the Rice County Water-Table Hydrogeology mapping (MN DNR, 1997), only three of the dry wells lack separation from drinking water aquifers. These sites tend to be in low-lying areas close to lake shores where the water tables intersect the land surface. These shallowest aquifers in Rice County are seldom used for drinking water supply, but several shallow wells are documented in these near-lakeshore properties. Even though the majority of the seepage pit properties investigated do not discharge into drinking water aquifers, they all discharge effluent below a periodically saturated soil condition, which could transport effluent and any potential contaminants off-site to surface or subsurface waters. This potential was investigated during our Phase 2 research.

Compliance status of the 5’ dry well diameter varied by parcel (Table 1), but this finding does not indicate some of these dry wells are superior to others. The more important value is the comparison of the required size (ft^2) to actual size (ft^2) where all 16 parcels fail to meet the minimum sizing requirement (Table 2).

Watertightness of the preceding septic tank varied by parcel, but 10 of the 16 parcels had compliant septic tanks (Table 1). A watertight septic tank is important to the overall functioning of the septic system as it prevents groundwater intrusion that adds more water to the dispersal area, increasing the likelihood of hydraulic overload. The solid tank also prevents leaking of septic tank effluent into the surrounding environment where treatment potential of the liquid is unknown. A properly operating and maintained septic tank also does primary treatment allowing heavier solids to settle, lighter materials to float and anaerobic decomposition of some of the organic material. The three systems that we could not verify the watertightness was due to the lack of proper septic tank pumping. At least one homeowner survey stated the system had never been serviced in over 30 years. It is clear from inspecting this tank that no settling of solids occurs in this tank, as it is completely full of thick sewage sludge that could not be pumped through the inspection pipe. The result of this condition is that all wastewater constituents continue to the next septic system component, which is the dry well. With the solids reaching the dry well, plugging is likely which will diminish the effluent acceptance over time. This may be the best explanation for the finding that 9 of the 16 dry wells inspected had visible overflow pipes to remove effluent with others likely but could not be verified due to build-up of sewage sludge, limited access, poor light conditions, etc. Such a pipe clearly results in the system classification of an imminent threat to public health and safety.

Phase 2

In order to determine the potential impacts of the dry wells on the surrounding environment, we selected seven sites from the initial 16 for further study. These sites were selected largely because there were no obvious overflow pipes connected to the dry wells based on our initial inspections. Systems with an outlet will impact the environment at the discharge point and we wanted to study the migration of potential contaminants (soil and water) from the dry well vertically to the periodically saturated zone and horizontally away from the dry well.

Soil Phosphorus

In temperate regions, such as Minnesota, phosphorus (P) is the nutrient primarily responsible for accelerating eutrophication of lakes, rivers and streams because phosphorus is usually in limited supply relative to plant demand. Wastewater contains phosphorus primarily from feces and detergents.

We chose 4 of the dry well sites to conduct two soil borings:

i.) within 5 horizontal feet down gradient from the dry well and

ii.) approximately 40 horizontal feet down gradient from the dry well.

At these two locations we collected soil samples from soil horizons (layers) likely influenced by water from the dry well. For each soil observation, we sampled horizons around the saturated soil depths while the soil borings conducted further from the dry well were sampled from the surface down to the saturated soil in order to determine the P profile with depth. Each of these layers were tested for soil test phosphorus to determine if P levels were elevated which would indicate contributions from the dry well to this area.

Results from these four sites indicate there is excessive soil phosphorus throughout the soils sampled (Table 3). The University of Minnesota recommended maximum P levels for crop growth, turf grass or gardening is 25ppm (Rosen and Horgan, 2009). Our results produced results ranging from a low of 4 times this amount (98 ppm) to over 60 times the recommended amount (1730 ppm)! The three values over 1000 ppm came from two properties (Site 1 and Site 3) where surfacing effluent had been reported (Table 3.). Two of the excessively high P soil samples were collected from the surface soils at the down gradient location. The third soil sample with over 1000 ppm P came from the soil adjacent to the dry well at the depth of saturation. Data from the remaining horizons sampled at these two sites shows excessive soil P values, but the concentrations did decrease with depth. This decrease at these two sites is consistent with the discharge of the effluent at the soil surface.

Site	Sample - Horizon	Sample Depth (inches)	pH	Total Phosphorus (ppm)
1	Near Dry Well - 2	48-72	7.8 / 7.8	1408 / 1774
1	Near Dry Well - 3	72+	8.0	605
1	40' Downgradient - 1	0-12	7.0	1730
1	40' Downgradient - 2	12-22	7.8	412
1	40' Downgradient - 3	22-28	8.0	283
2	Near Dry Well - 6	84+	8.5	401
2	40' Downgradient - 3	32-36	7.5	396
2	40' Downgradient - 4	36-44	7.5	733
3	Near Dry Well - 1	0-12	7.5	468
3	Near Dry Well - 2	12-16	7.8	462
3	40' Downgradient - 1	0-20	7.0	1055
3	40' Downgradient - 2	20-30	6.8	156
3	40' Downgradient - 3	30+	7.0	98/99
4	Near Dry Well - 6	52+	8.6	542
4	40' Downgradient - 1	0-2	7.2	792
4	40' Downgradient - 2	2-26	8.1	463
4	40' Downgradient - 3	26-30	7.8	576
4	40' Downgradient - 4	30-48	7.6	497

Table 3. Soil test phosphorus comparisons with depth and distance away from dry wells for four sites in Rice County, MN.

The remaining two sites (Site 2 and Site 4) had soil layers with excessive soil test P values that likely indicate a contribution from the dry wells at these sites. When the deep sample is taken adjacent to the dry well and elevated P levels are found (401 and 542 ppm respectively), there is little other opportunity for P inputs at these depths over 4 feet below the ground surface. At the 40 foot distance, there was elevated P values found in our samples collected from all depths in seasonally saturated soil layers. This finding indicates these sites likely have increased total P from subsurface dry well effluent.

Chlorides and Coliform

We also collected water samples at 5 sites in order to determine movement of potential contaminants in the shallow periodically saturated soils. We collected soil-water from our two soil borings 5 and 40 feet down gradient of the dry well (when a water-table was present), surface water (when adjacent to property), and/or well water (when homeowner availability allowed). These samples were analyzed for chlorides, which are salts that humans add to water via road salts, fertilizers, and human and animal wastes. In a study of 954 groundwater wells across MN, the highest background level of chloride in the water was 5.8 mg/L (MN PCA, 1999). Chloride levels over approximately 10mg/L would clearly indicate influences from human sources. Chlorides themselves typically do not present a problem in surface or ground water, but are commonly used as a marker for other human-induced contaminants in the water (MN PCA, 1999).

Table 4 shows the values for chlorides from all of the sampled locations. It is clear that each site (10/13) has elevated chlorides present in the water. For all of the samples collected near the dry wells, high chloride values indicate high potential for contamination. For the samples further away from the systems, the chloride levels vary due to water movement patterns and dilution from groundwater.

Site	Sample Location	Chlorides (mg/L)	Total Coliform
1	Near Dry Well	1240	G
2	40' Down Gradient	132	G
3	Near Dry Well	1080	G
3	40' Down Gradient	8.8	G
3	Domestic Well	197	ND
3	Lake Surface	18.5	-
4	40' Downgradient	147	G
4	Domestic Well	2.9	-
4	Lake Surface	38.8	-
5	Near Dry Well	13.3	G
5	40' Downgradient	3.8	G
5	Lake Surface	10.7	-
6	Domestic Well	36.5	ND

Table 4. Locations of water samples with chloride and total coliform for six dry well sites ("G" = growth detected, "ND" = No detect, "-" = no sample collected).

We also tested the water samples for coliform bacteria. Coliform bacteria tests are used commonly in testing drinking water for signs of contamination. It is not ideal for use in soil-water sampling because there are many forms of coliform that live and reproduce naturally in the soil without a warm blooded host. Additionally, our water sampling from a fresh soil boring resulted in a large amount of sediments suspended in the water. The sediment prevented discrete colonies of bacteria to be counted, so the results are reported as either growth or no detect.

Even though growth was detected in all of the water samples extracted from the soil borings, the coliform data presented in Table 4 is of limited value in determining the impact of dry wells on the surrounding environment. However when that information is coupled with chloride and phosphorus data, the determination of wastewater impacts is much more certain.

CONCLUSIONS

None of the 16 sampled dry well systems in Rice County, MN, met all seven of the compliance criteria as required by the State of Minnesota. Every system did not achieve two of the most important compliance criteria, vertical separation and correct sizing. Without these two conditions being met, rapid movement of water into the surrounding environment has been well documented. This movement will allow any contaminants in the waste water to also move into surface and subsurface waters.

Upon a more in-depth investigation into evidence of contamination, we found elevated levels of phosphorus in all of the soil layers analyzed. This indicates that phosphorus is moving along with the subsurface water away from the dry wells and building up soil test phosphorus to excessive levels even 40' away from the selected dry wells.

Total coliform growth occurred in all of our soil-water samples in the five sampled sites. This finding is largely inconclusive due to sediment in the water samples and the presence of coliform bacteria commonly occurring in many soils.

Elevated chlorides are a marker of human influences on the water. While we cannot say with certainty that all of the chlorides are solely the result of dry wells, the dry wells are adding to elevated chlorides which are leaving the various sites. Since chlorides are commonly used as a marker for other water soluble contaminants, we can conclude that the dry wells sampled are impacting the surface and subsurface waters.

Three sites were sampled for soil phosphorus, chlorides and coliform. All three of these sites show P contamination of the soils both adjacent to the dry wells and at 40' down gradient. At these same locations where soil-water was present, chlorides were elevated above natural water levels. At these same sample points, growth for coliform bacteria was also detected.

All together the further data collection presents several markers used to determine contamination. On many of these sites, more than one indicator of human influences is found. Based on this data collection and summary, it is clear that many of the sampled dry well sites have adversely impacted the surrounding soil and water. We expect that similar data collected on other dry well sites around Rice County, MN, would yield comparable results.

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