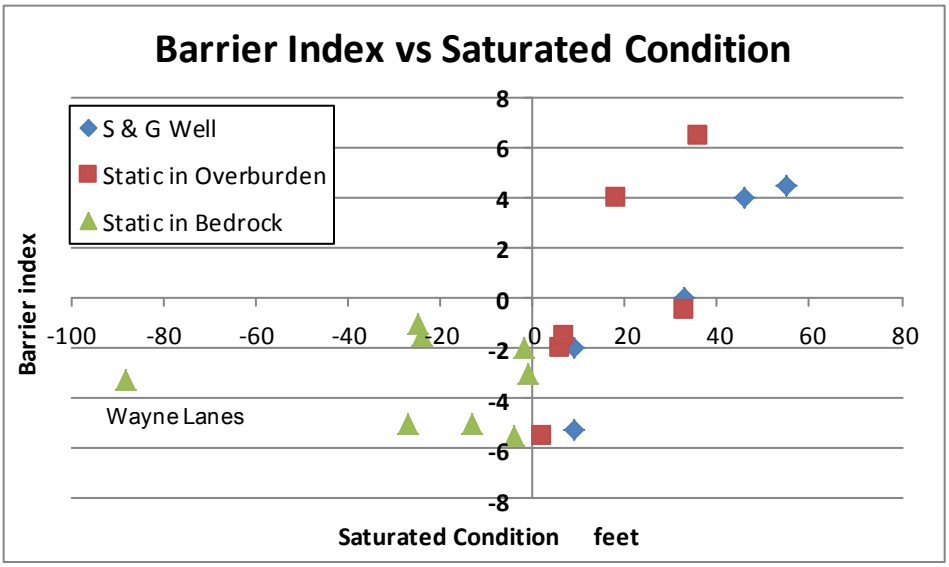
May 2012

Ohio Environmental Protection Agency

Ground Water Rule Pilot Project: Ground Truth for Hydrogeologic Sensitivity Assessment and Assessment Source Water Monitoring Procedures



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Ohio EPA thanks all of the individuals that helped with the Ground Water Rule Pilot Project. The sample plan was developed under the direction of the Ground Water Rule Workgroup with input from the districts. Special thanks go to the PWS operators of the systems that were sampled. DDAGW staff in the districts and central office completed the Ground Water Rule Pilot sampling and generated hydrogeologic sensitivity assessments for the pilot project sites. DDAGW staff in Central Office completed the data analysis and drafted the final report with input from the chair of the Ground Water Rule Workgroup and Ground Water Managers. DDAGW staff that contributed to these activities includes:

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Executive Summary

The Ground Water Rule (GWR) was established to identify ground water-based Public Water Systems (PWSs) that are susceptible to fecal contamination. Source water monitoring is triggered when a routine Total Coliform Rule (TCR) distribution sample is total coliform positive, unless the PWS provides 4-log treatment (removal or inactivation) of viruses. If the triggered source water sampling confirms detections of E. coli in the source water, the PWS will be required to initiate activities to determine appropriate corrective actions.

The Ohio GWR Workgroup developed Hydrogeologic Sensitivity Assessment (HSA) and Assessment Source Water Monitoring (ASWM) as tools to help identify PWSs at higher risk to pathogen contamination. The value of these tools is that they help:

- Identify PWSs that obtain water from pathogen-sensitive geologic settings;
- Confirm the presence and concentration of pathogen indicators; and
- Direct the evaluation processes to identify appropriate corrective actions at sites with confirmed E. coli detections.

The HSA provides the Drinking Water staff with detailed information about the local hydrogeologic setting to help evaluate the pathogen sensitivity, which in turn helps to determine the best corrective action options. The Assessment Source Water Monitoring sampling identifies the pathogen sensitivity by determining the frequency of detections and concentrations of E. coli. In addition, several inorganic parameters are collected as proxies for determining the redox conditions to evaluate isolation from the atmosphere.

The purpose of the GWR Pilot sampling was to apply the HSA and ASWM procedures to ground water-based PWSs with a history of total coliform or E. coli in source water to evaluate Ohio's HSA and ASWM approaches. The GWR Pilot sampling objectives were:

- Collect data to evaluate the frequency of detections and concentrations of E. coli, total coliform and enterococci;
- Collect inorganic data to evaluate the degree of ground water isolation from the atmosphere through recent, rapid recharge; and
- Generate HSAs for the GWR Pilot PWSs and evaluate the effectiveness/consistency of the HSA results with the microbiologic and inorganic data collected in the ASWM.

Overall, the correlations between the microbiologic and inorganic results and the barrier index presented in this report document that the HSA procedures provide a reasonable, relative measure of the sensitivity of pathogen migration in a range of hydrogeologic settings. The GWR Pilot study focused on a small group of PWSs that were considered sensitive to pathogen contamination. The data analysis indicates that:

- The barrier index exhibits indirect relationships with pathogen indicator concentrations - negative Barrier Indices are associated with higher concentrations of pathogen indicators;

- Selected inorganic parameters can be used effectively as proxies for redox conditions. This was demonstrated by correlations with ORP and relationships between concentrations of TEAPS parameters;

- ORP exhibits an indirect correlation with the barrier index - high ORP correlates with low barrier index values, indicating that sites with rapid recharge are not isolated from the atmosphere;

- ORP exhibits an inverse relationship with overburden thickness and saturated conditions – higher ORP is associated with thin overburden, thin saturated overburden and the lack of overburden;

- Barrier Index exhibits a direct relationship with overburden thickness and saturated conditions - high Barrier Indices are associated with thick overburden and larger values of saturated conditions.

These conclusions support the approach utilized to generate the HSA Barrier Index and indirectly support the utility of microbiologic data and the inorganic parameters for evaluating the sensitivity of hydrogeologic settings. Microbiological and inorganic results are not utilized in the HSA procedures to generate the Barrier Index. Thus, correlations between the geochemical results and the Barrier Index or inorganic TEAPS parameters provide significant documentation that the HSA procedures are accomplishing the goal of providing a reliable, relative indicator of pathogen sensitivity.

The data presented here confirms that the HSA provides a relative ranking of PWS sensitivity to pathogens that can be correlated to geochemical parameters. Thus, the HSA procedures are a reasonable starting point and a useful measure of pathogen-sensitivity that can help select appropriate corrective action for a PWS with confirmed E. coli. Nevertheless, it is an imperfect tool to identify gradational boundaries on a continuum of sensitivity. There is no question that additional data needs to be collected to confirm these conclusions and to refine the processes. Three steps are proposed to collect additional data to refine the HSA and ASWM procedures:

- HSAs and ASWM will generate additional data for analysis;

- Set up an Excel spreadsheet process for the HSA to promote uniform HSAs and to capture a consistent set of data for completed HSAs; and

- Consider application of multivariate analysis to evaluate which factors exert the most influence on the Barrier Index. This analysis may generate significant refinement of the Barrier Index equation.

Ground Water Rule Pilot Project
Ground Truth for Hydrogeologic Sensitivity Assessment and Assessment Source Water Monitoring Procedures

Summary Report
May 11, 2012

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Introduction

The Ground Water Rule (GWR) was established to identify ground water-based Public Water Systems (PWSs) that are susceptible to fecal contamination. Source water monitoring will be triggered when a routine Total Coliform Rule (TCR) distribution sample is total coliform positive unless the PWS provides 4-log treatment (removal or inactivation) of viruses. If the triggered source water sampling confirms detections of E. coli in the source water, the PWS will be required to initiate activities to determine appropriate corrective actions.

The Hydrogeologic Sensitivity Assessment (HSA) and Assessment Source Water Monitoring (ASWM) are tools to help identify PWSs at higher risk to pathogen contamination as outlined in the Federal GWR (Federal Register, Vol. 216, No. 216, November 8, 2006, pg. 65594-65597) and the Ground Water Rule - Source Assessment Guidance Manual (EPA 815-07-023, July 2008). The Ohio EPA GWR Workgroup identified the HSA and ASWM as essential components of the GWR and included requirements for HSAs and ASWM in Ohio Administrative Code (OAC) 3745-81-42 (B). The value of these tools is that they help:

- identify PWSs that obtain water from pathogen-sensitive geologic settings;
- confirm the presence and concentration of pathogen indicators; and
- direct the evaluation processes to identify appropriate corrective actions at sites with confirmed E. coli detections.

The Ohio procedure for completing an HSA was developed as part of assessment source water monitoring (OAC Rule 3745-81-42(B)) to help implement the GWR. The HSA in Ohio is a standard approach to evaluate the pathogen sensitivity of PWS wells with confirmed E. coli or wells located in sensitive hydrogeologic settings. The HSA generates a relative ranking of pathogen sensitivity by evaluating the series of hydrogeologic barriers that water moves through in the process of recharging a local aquifer. HSAs are completed rapidly using available geologic, well attribute and PWS data by Division of Drinking and Ground Water (DDAGW) GW staff. The HSA provides the Drinking Water staff detailed information about the local hydrogeologic setting to help evaluate the pathogen sensitivity, which in turn helps to determine the best corrective action options.

The Assessment Source Water Monitoring sampling identifies the pathogen sensitivity by determining the frequency of detections and concentrations of E. coli, as well as collecting several inorganic parameters. The inorganic data are used to assess the isolation of the local aquifer from the atmosphere by using the inorganic results as oxidation-reduction proxies. Assessment Source Water Monitoring is an option for requiring PWSs to collect additional raw water quality data to help confirm pathogen sensitivity. **The purpose of the GWR Pilot sampling was to collect empirical data to evaluate Ohio's HSA and ASWM approaches**.

The GWR Pilot approach was to apply the HSA and ASWM procedures to ground water-based PWSs with a history of total coliform or E. coli in source water. Data was also collected to characterize the hydrogeologic setting around the PWSs sampled. The GWR Pilot sampling objectives were to:

- collect data to evaluate the frequency of detections and concentrations of E. coli, enterococci, and total coliform;
- Collect inorganic data to evaluate the degree of ground water isolation from the atmosphere through recent, rapid recharge;
- Compile attribute data that characterizes the hydrogeologic setting of the PWS wells and the hydrogeologic barriers present; and
- Generate HSAs for the pilot PWSs and evaluate the effectiveness/consistency of the HSA results with the microbiologic and inorganic data collected in ASWM.

Summary of HSA and ASWM

An understanding of the conceptual basis of the HSA to identify local pathogen sensitivity is necessary to evaluate the GWR Pilot results. Likewise, a conceptual understanding of the rationale for the ASWM is necessary. This summary of the HSA and ASWM provides a conceptual basis. The reader is directed to the "Guidance for Hydrogeologic Sensitivity Assessment and Assessment Source Water Monitoring" (Ohio EPA, June 2012) for detailed descriptions of the standard procedure for completing HSAs and for selecting parameters for ASWM.

Hydrogeologic Sensitivity Assessment (HSA) is a standard, but flexible approach for evaluating the likelihood that a local aquifer or well will be contaminated by pathogens. It identifies pathogen sensitive-aquifers by evaluating the interaction between recharge flow paths and local hydrogeologic barriers associated with PWS wells. The purpose is to provide a relative measure of the pathogen sensitivity of a PWS well or well field based on the hydrogeologic setting and well construction parameters. The conceptual approach is to sum the relative rankings of the hydrogeologic barriers that water moves through to recharge the local aquifer. Figure 1 illustrates simple flow paths of recharge in the vadose zone moving to the saturated zone and then flow as recharge/ground water flow to wells in unconsolidated and bedrock aquifers.

In unconsolidated material ground water flow is characterized by inter-granular flow with significant natural filtration. In contrast, ground water flow in karst and fractured bedrock is characterized by fracture flow, with limited natural filtration. The relative effectiveness of the hydrogeologic barriers in the vadose zone, the saturated zone, the aquifer and the potential for horizontal flow paths (induced recharge) to the well are determined by selecting relative barrier values provided in the HSA Guidance. In addition, well construction characteristics that help to restrict rapid flow to the production aquifer are given relative barrier values.

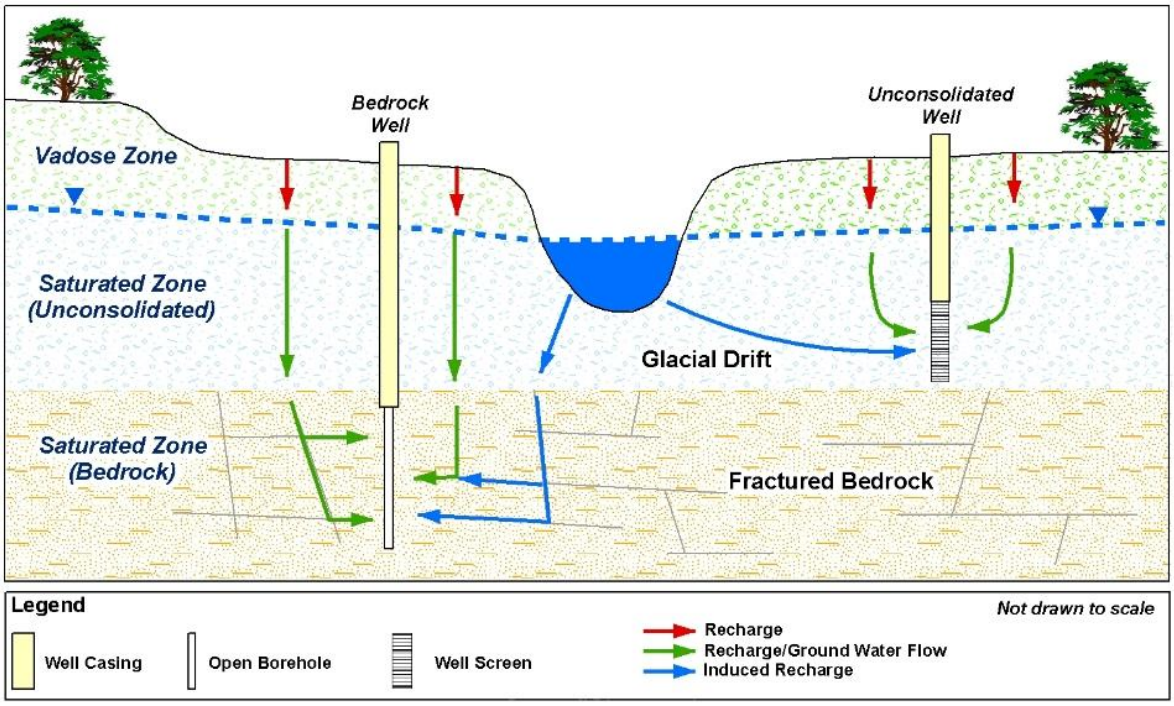


Figure 1. Generalized flow paths of recharge to local aquifers emphasizing the sequential flow through the vadose zone, the saturated zone and then the aquifer.

Summing these relative barrier values for each hydrogeologic barrier along recharge flow paths generates a Barrier Index. This provides a relative number that characterizes the pathogen sensitivity of the geologic setting around a well or wellfield. The Barrier Indices calculated for HSAs completed in 2010 and 2011 ranged from -7 to 14. The more negative the Index, the more sensitive a site is to pathogen contamination. The Barrier Index boundaries are identified in Figure 2. Barrier Indices equal to and below -1 are pathogen-sensitive and Barrier Indices equal to and above 4 are pathogen non-sensitive. The Barrier Indexes between -1 and 4 are of intermediate pathogen sensitivity. It is important to remember that the Barrier Index is a relative scale to identify a physical property characterized by gradational boundaries.

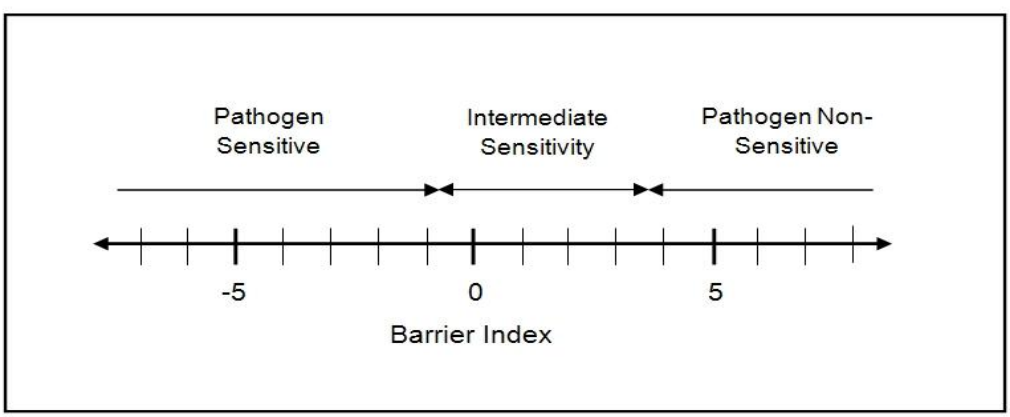


Figure 2. A number line representation of the Barrier Index continuum.

The HSA uses available geologic and well log data and is produced in a short time frame. This risk assessment of the pathogen sensitivity of the local hydrogeologic setting is used to evaluate appropriate corrective actions for addressing pathogen contamination. Neither water quality nor microbial data are used directly in generating the HSA Barrier Index. Available water quality data, however, is used to help evaluate and confirm the HSA results. Additional water quality data may be collected with ASWM.

Assessment Source Water Monitoring (ASWM) is monitoring for a subset of parameters with the goal of identifying the presence and concentration of E. coli, other microbial indicators, and useful inorganic parameters in PWS source water. Typically, ASWM will include monthly sampling for a year. Using microbiologic analysis to document the presence of pathogen indicators is the critical test for documenting pathogen sensitivity. The lack of detections does not assure a low risk of contamination since a site may have a low barrier index but no sources of pathogens. Nevertheless, the detection of pathogen indicators does document the presence of a rapid recharge pathway. Quantitative methods, such as Quantitray or membrane filtration, are particularly useful because they provide quantitative results which can be correlated with factors controlling pathogen migration. For source water results indicating pathogen contamination, the evaluator needs to consider the possibility that improper well construction or deteriorated casing may be providing short or rapid pathways for surface pathogen migration to the production zone.

Inorganic parameters are used to support HSA pathogen-sensitivity determinations by using water chemistry parameters as indirect measures of redox conditions. The more oxidized the water, the more likely the ground water is in close communication with the atmosphere. Oxidized ground water is more likely to be receiving rapid surface recharge, and associated surface contaminants. At the water table, ground water interacts with the atmosphere and is oxidized. At depths below the water table, dissolved oxygen concentrations are lower because the dissolved oxygen is consumed by microbes or interactions with aquifer materials. At some depth below the top of the saturated zone, all of the dissolved oxygen is consumed and the ground water becomes more reduced. An aquifer that demonstrates consistent reduced conditions indicates isolation from the atmosphere and thus, supports the lack of rapid recharge pathways from the surface to the aquifer. The sampling completed at the GWR Pilot sites includes the parameters identified for ASWM. Thus, these water quality results provide independent empirical data that can be used to evaluate the conceptual basis and effectiveness of the HSA procedures.

GW Rule Pilot

Sample Location Selection

PWSs with a history of E. coli detections associated with TCR sampling in 2007 and into 2008 were selected for inclusion in the GWR Pilot Project. These PWSs were reviewed by the districts and systems that applied corrective actions were excluded. Several sites identified by the districts as sensitive were added as favorable candidates for the pilot study. This subset of PWSs was reviewed using available GIS data to identify the PWSs that appear to be sensitive based on geologic setting.

The primary factor considered for identifying pathogen-sensitive settings on a regional basis was the thickness and type of the glacial material overlying bedrock aquifers. Fractures and macropores in thin, fined-grained, glacial deposits increase the probability that recharge may pass through the glacial material quickly into fractured bedrock aquifers. Consequently, areas

of thin till or thin lacustrine deposits are considered sensitive to pathogen transport to ground water. The distribution of thin tills and thin lacustrine deposits (less than 25 feet of glacial cover) is exhibited in Figure 3 based on the ODNR Glacial Aquifer Map (2000). The regional HSA is only used as a general guideline. The HSA for a PWS well is site-specific and incorporates information on the local geologic setting and well construction. Where till and lacustrine deposits are thicker or saturated, these deposits provide more effective hydrogeologic barriers.

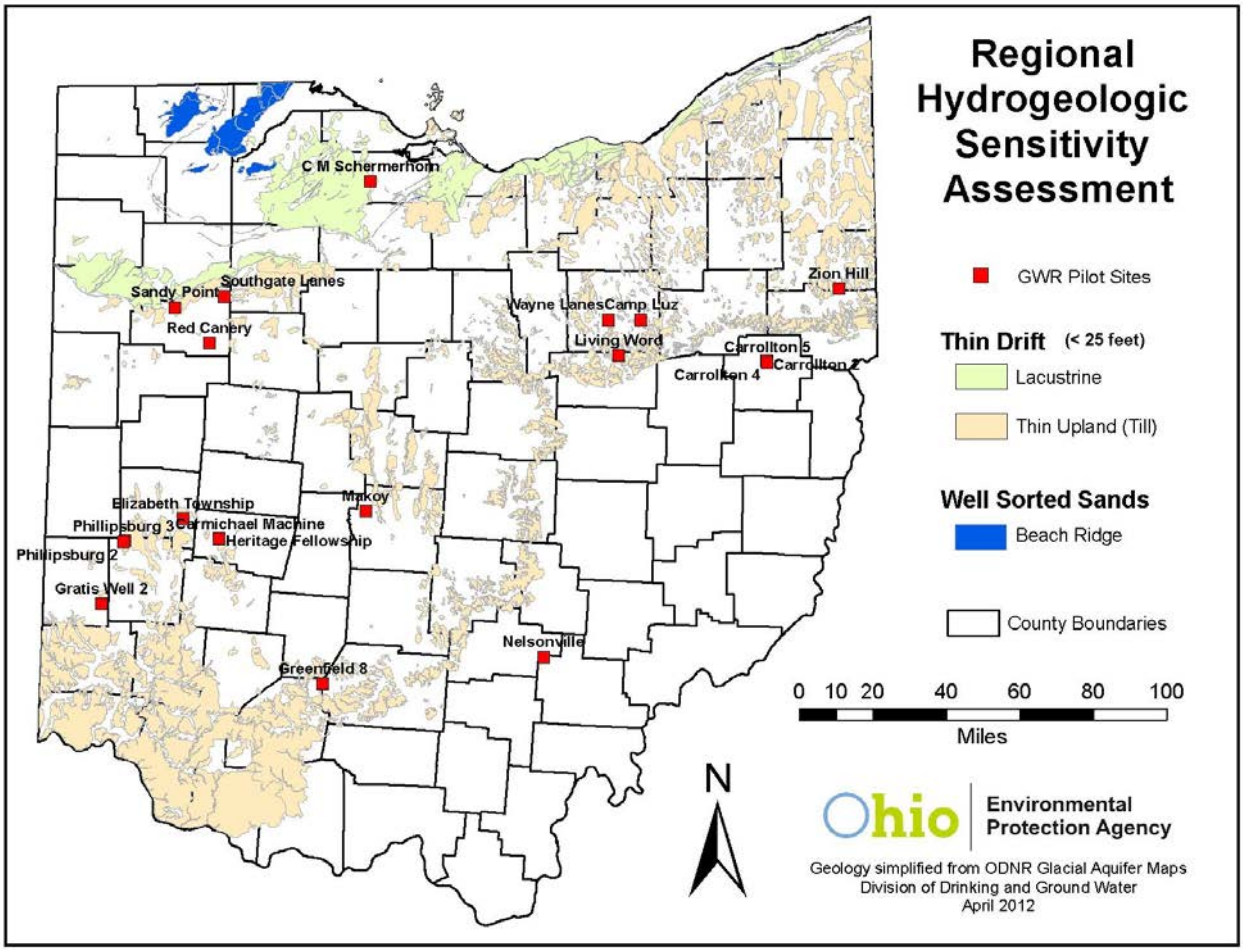


Figure 3. Locations of GWR Pilot Sites on map of regional pathogen-sensitive areas.

Well sorted sands, sand deposits that are characterized by sand grains of similar size like beach ridges, have high porosity and do not provide significant natural filtration for pathogens (ARGOSS, 2001). Consequently the beach ridge deposits and the reworked sands in the Maumee Lake Plains and the Eire Lake Plains are considered sensitive to pathogen contamination. Figure 3 illustrates the distribution of these well sorted sands. The sand and gravel deposits in Ohio's buried valleys are poorly sorted deposits typical of glacial outwash deposits. Poorly sorted glacial sand and gravel aquifers have a wide range of particle sizes and, consequently, their porosity is less than that of well sorted sand deposits. Poorly sorted sand and gravel deposits are sensitive settings for dissolved contaminants but they appear to have good natural filtering capacity and are not considered sensitive settings for pathogens (LT2ESWTR Toolbox Guidance Manual, 2009; Ohio EPA, 2007).

The sites sampled for the GWR Pilot are plotted in Figure 3. Many of the sites are within or close to regionally mapped areas of thin till (<25 feet thick, ODNR Glacial Aquifer Map). The C. M. Schermerhorn well is associated with thin lacustrine deposits and the Carrolton wells are outside the glaciated area with colluvium overlying the bedrock aquifer. Gratis, Greenfield and Nelsonville are located in poorly sorted glacial outwash sand and gravel aquifers and they were selected with the purpose of evaluating the pathogen sensitivity of sand and gravel aquifers with induced recharge. The GWR Pilot sites are listed in **Appendix A** with location and well attribute data.

The sampling at several pilot sites was discontinued, and these sites are not included in Figure 3 as limited or incomplete data was collected. The Double J Market in Fairfield County moved before GWR sampling started so the original well targeted was not the well sampled. No well log was available for the new well, and then the Double J Market closed so their well was not available for sampling. Sampling of wells at Longs Retreat (Pike County), well 13 and 16, was discontinued due to their procedure of regular chlorination of the wells. This resulted in collection of chlorinated samples, which voided the sample results for the purpose of the GWR Pilot. Danville Church of Christ in Knox County requested that the sampling be discontinued after several samples had been collected. Enforcement action was initiated at this Danville Church site in July 2011. All of the wells for which sampling was discontinued do appear pathogen-sensitive, but are incomplete for inclusion in the GWR Pilot analysis.

Parameter Selection

Samples collected for the GW Rule Pilot were analyzed for microbiologic and inorganic parameters. The purpose of the microbiologic sampling was to determine the frequency of detections and the concentrations of total coliform, E. coli and enterococci. The bacteria samples were analyzed using the Quantitray method (MMO-MUG enzyme methodology) to provide quantitative results (most probable number/100 mL; MPN/100 mL).

The purpose of the inorganic samples was to help evaluate the degree of ground water isolation from the atmosphere. The following parameters were selected to indicate oxidation-reduction conditions of the ground water and/or to indicate possible surface contaminant inputs:

- Nitrate/TKN/Ammonia (nutrient input, oxidation proxy);
- TOC (measure of organic carbon input);
- Fe, Mn, As (oxidation/reduction proxy);
- Cl, TDS (indicator of septic input relative to background);
- Br (Br/Cl ratio used to ID characteristics of source water);
- Phosphate (as septic input indicator); and
- Sulfate (added for redox determination).

Sampling Frequency and Collection Protocol

Microbiologic samples were collected on a monthly schedule from June 2009 to July 2010. The schedule was not rigid. Two sites, Carrollton well 5 and Heritage Fellowship, were added during the pilot sampling. Several sites were not sampled every month due to missed sample runs, difficulty coordinating with site operators, frozen sampling taps, etc. Most sites have ten or more samples but one seasonal PWS (Sandy Point Lake) had only four. Inorganic samples were collected on a quarterly schedule. Samples were collected by district and central office staff members using a standard protocol that was tailored to GW Rule Pilot sampling (**Appendix B** - GW Rule Pilot Sampling Protocol).

Data Analysis

HSAs were completed for all the GWR Pilot sites and the GWR Pilot sampling provides ASWM data for the sites. The purpose of this report is to utilize the results of the GWR Pilot to evaluate the effectiveness of the HSA and ASWM procedures by documenting correlations between the Barrier Index generated by the HSA and chemical and physical parameters that indicate pathogen sensitivity. The data analysis is divided into several sections:

- The first relates Quantitray results to the Barrier Index to determine if the Barrier Index determined by the HSA procedures is an effective measure of pathogen sensitivity.

- The second section presents correlations between inorganic parameter data collected to test their usefulness as oxidation-reduction indicators and to evaluate the assumption that reduced aquifers are pathogen non-sensitive.

- The third section presents data correlations between the well attributes, such as well depth or casing length, to the HSA Barrier Index or water quality indicators. This analysis illustrates the main factors that control the Barrier Index. It is intended that these relationships reflect physical processes that provide natural filtration during recharge, but the fact is they reflect the relative ranking system used in generating the HSA Barrier Index. This analysis illustrates the judgment calls made in the development of the HSA procedures, and documents the logic of relating the Barrier Index to water quality parameters.

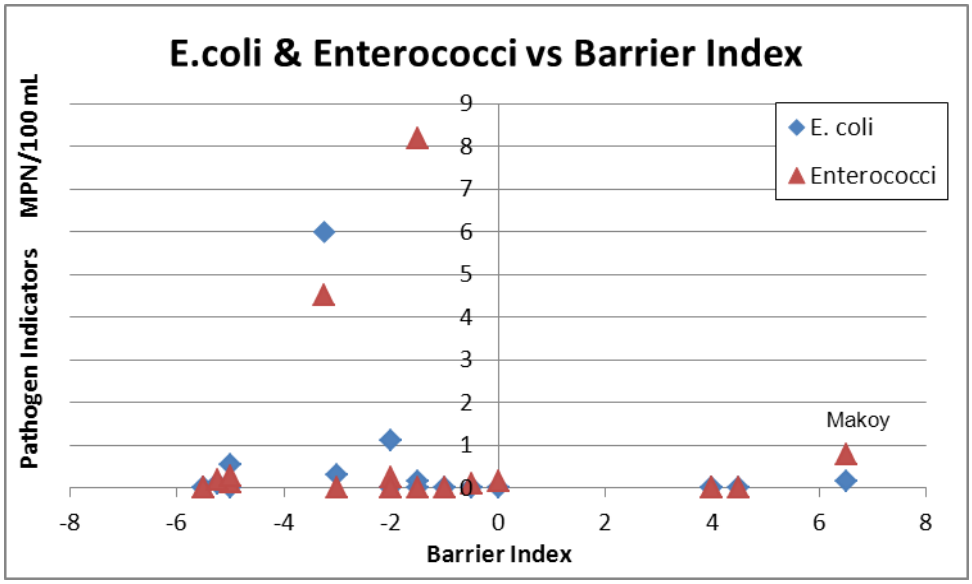
The microbiologic and inorganic results are presented in **Appendix C**. The data presented are the average values for the microbiologic samples (non-detect = 0) along with frequency of detections data (ratio of the number of samples with detections to total number of samples). The inorganic data are the average of the quarterly samples. The data in Appendix A and C are the attribute data and results data used in the graphs presented in the data analysis sections. **Appendix D** lists the individual sample results by site.

Barrier Index and Quantitray Correlations

If the HSA procedures to generate the Barrier Index are valid, we expect a strong correlation between the Barrier Index and the concentration of pathogen indicators. Correlations using presence and absence MMO-MUG data cannot be very precise. The Quantitray data, which provides a quantitative result (MPN/100mL - most probable number/100 mL), provides a measure of the concentration of bacteria or pathogen indicators and thus, can, identify a range of pathogen sensitivities. We are working with multivariate systems, so no single factor explains the concentration of pathogen indicators. Since microbial or inorganic data are not used to develop the Barrier Index for a site, a correlation between the Barrier Index and concentrations of pathogen indicators or redox indicators provide independent support for the validity and/or effectiveness of the Barrier Index.

Figure 4 illustrates the concentrations of the averaged Quantitray results for each GW Rule Pilot site plotted against the HSA Barrier Index calculated for that site. The results demonstrate that the sites with detections of E. coli and enterococci (Figure 4A) are associated with Barrier Indexes of less than -1, indicating sites identified as pathogen sensitive. Figure 4B exhibits similar relationships for total coliform. The limited results do not exhibit increasingly higher bacteria concentrations with more negative barrier indexes (pathogen-sensitive sites), but the sites with positive barrier indexes (pathogen non- sensitive sites) generally exhibit low bacteria

concentrations. Figure 4 documents that GWR Pilot sites with low Barrier Indexes are more likely to be impacted by pathogen contamination than GWR Pilot sites with high Barrier Indexes.



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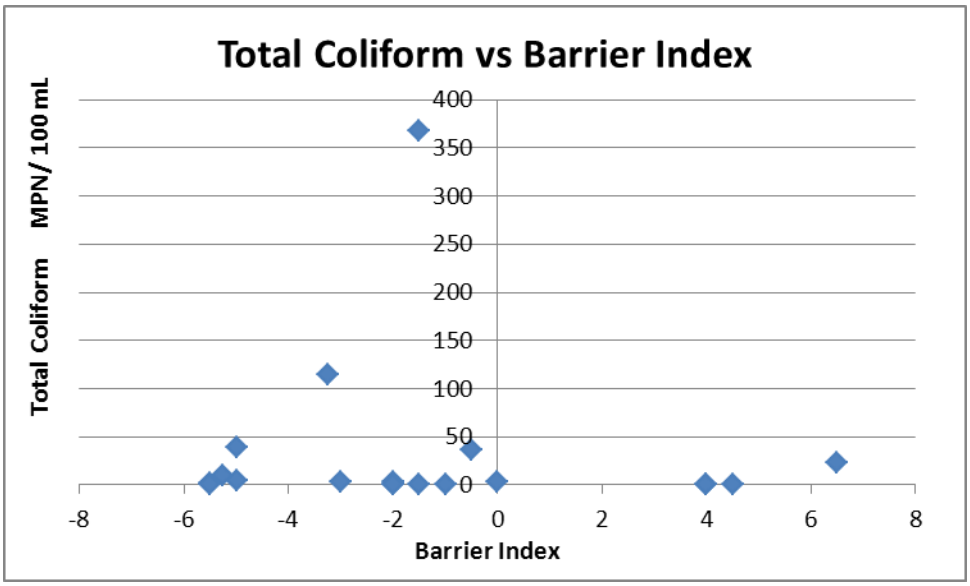


B

Figure 4. E. coli and enterococci Quantitray results (A) and total coliform Quantitray results (B) plotted against the Barrier Index for the GW Rule Pilot sites.

The concentration of pathogen sources around a well is a critical factor that may influence the concentration of pathogen indicators in well samples. A well sensitive to pathogen contamination with few pathogen sources in the wellhead area may not report elevated levels of pathogen indicators, but the same well with abundant pathogen sources is likely to exhibit

elevated pathogen concentrations. Thus, the variability of pathogen concentration around each well is another factor that influences pathogen concentration, but not one that is accounted for in Figure 4.

Since we targeted PWSs that were considered sensitive, there are not many sites with the HSA Barrier Index of 0 or greater. There are three points in the Barrier Index range of 4.0 to 6.5 in Figure 4, but they represent four pilot sites. All four sites are considered to be confined aquifers and have at least 18 feet of saturated glacial till and/or sand and gravel overlying the aquifer, which provide effective hydrogeologic barriers. These PWSs did not detect pathogen indicators except Makoy. The Makoy Center detected minor E. coli (average 0.15 MPN/100 mL; 2 of 13 samples with detections) and enterococci (average 0.77 MPN/100 mL, 3 of 13 samples with detections) and it has the highest Barrier Index of the GW Rule Pilot sites (6.5). Total coliform was detected in 6 of 13 samples with an average of 23.4 MPN/100 mL. Considering the Makoy Center's hydrogeologic setting with a confined aquifer under 36 feet of saturated till (unpumped conditions) and reduced water quality parameters, it appears that there must be some well construction deficiency providing a rapid recharge pathway along the casing. The Makoy Center is close to a small lake and there are several large drains in the parking lot. The most likely explanation for a rapid recharge pathway for surface water recharge is the parking lot drains are connected to gravel filled ditches that intersect the well or the water lines running from the well into the building (through footer drains?). Thus, when the parking lot drains are full, hydrostatic pressure builds up that is greater than the confining pressure and drives surface water into the well along the casing annular space or through broken or corroded casing. Considering the reduced nature of the Makoy water, the water volume transported is apparently not large enough to influence the redox conditions significantly.

Another way to evaluate the microbiologic data is to evaluate the frequency of detections. Figure 5 plots the detection frequency (samples with detections divided by total number of samples as percentage) against the Barrier Index for the Quantitray data presented in Figure 4. The sites considered sensitive to pathogen contamination have higher frequencies of detection for total coliform, E. coli and enterococci than the sites considered non-sensitive to pathogens.

Generally, the detection frequency for total coliform is significantly higher than for E. coli and enterococci. The elevated detection frequencies for the Makoy Center, with a Barrier Index of 6.5, are attributed to the rapid recharge pathway described in the previous paragraph. Camp Luz also detected total coliform at low concentrations (average of 0.31 MPN/100 mL, 1 of 13 samples) in spite of a barrier index of 4.5 (not obvious in Figure 4 due to vertical scale). If Quantitray data is not available and multiple samples have been collected, plotting the detection frequency is a viable option to illustrate pathogen sensitivity, but numeric data is preferred.

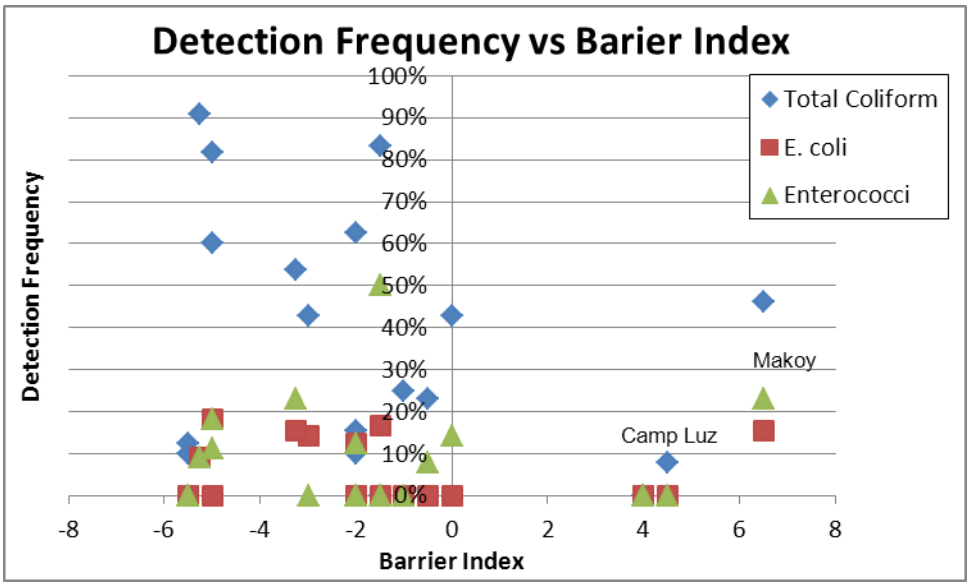


Figure 5. Detection frequencies of total coliform, E. coli and enterococci plotted against Barrier Index.

Figures 4 and 5 illustrate elevated concentrations and detection frequencies in pilot sites identified as pathogen-sensitive for all microbiologic parameters. This provides significant support for the Barrier Index. However, the use of MMO-MUG total coliform detections as an indicator for enteric bacteria is questionable. The MMO-MUG enzyme-based analysis for total coliform generates a positive indication for a much larger group of environmental total coliforms than the older media growth methods. Consequently, the MMO-MUG result for total coliform is not a good indicator of enteric bacteria (Standridge, 2008; Stevens, Ashbolt, and Cunliffe 2003). Fortunately, the MMO-MUG analysis for E. coli is a reasonably good indicator for enteric bacteria. A plot of the average concentrations of E. coli against the average concentrations of total coliform from the GWR Pilot sites does not exhibit strong correlations. The concentration of pathogen sources around the well head is an additional factor that can strongly influence the total bacteria concentrations at any location. This bacteria source factor is not utilized in determining the Barrier Index but can certainly influence the bacteria concentrations and frequency of detection exhibited in Figures 4 and 5.

Inorganic Parameters as Redox Indicators

As described in the summary of the ASWM sampling, inorganic parameters are used to support the determination of pathogen-sensitive settings on the basis of isolation from the atmosphere. Inorganic parameters are used as indirect measures of redox conditions with the interpretation that more reduced ground water is more isolated from the atmosphere. Oxidized ground water is exchanging oxygen with the atmosphere and is more likely to be receiving rapid recharge of oxidized surface water, and associated surface contaminants. The GW Rule Pilot data are used in this section to illustrate that the rationale for using specific inorganic parameters as independent indicators of redox conditions works.

Redox conditions in ground water are generally controlled by the transfer of electrons between electron donors and receptors in processes referred to as Terminal Electron Accepting Processes (TEAPS - McMahon and Chapelle, 2008). In ground water, organic carbon is usually

the electron donor with the result that the organic carbon is oxidized in these reactions. The electron acceptors are various inorganic constituents that are reduced during reactions. The reactions are mediated by microbial metabolism based on energies required for microbial reduction. This is an orderly process. As ground water is reduced, the following constituents are progressively consumed by the TEAPS reactions:

$O_2 > NO_3 > Mn(IV) > Fe(III) > SO_4^{2-} > CO_2$.

Thus, redox conditions can be identified by the presence and absence of the reactants and products. For example, if ground water exhibits detectable nitrate, it indicates that the water is at least slightly oxidized; however, if the water includes dissolved iron (Fe^{2+}) it suggests that the ground water is reduced and that iron oxide (Fe^{3+}) has been reduced. Figure 6 plots dissolved iron against dissolved nitrate for the GW Rule Pilot data and illustrates the mutually exclusive relationship between nitrate and iron imposed by the microbial mediated redox reactions. Oxidized ground water, as indicated by the presence of dissolved nitrate (NO_3), carries no dissolved iron and suggests some recent connection with the atmosphere and thus potential sensitivity to pathogen contamination. If the ground water is reduced, as indicated by the presence of elevated dissolved iron, it suggests that the ground water is isolated from the atmosphere, and suggests low sensitivity to pathogen contamination.

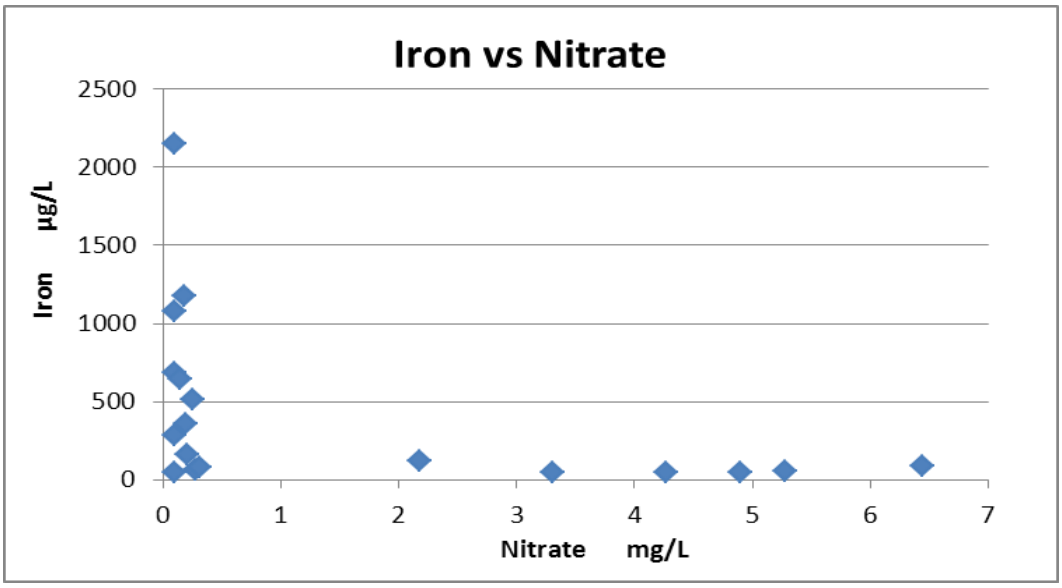
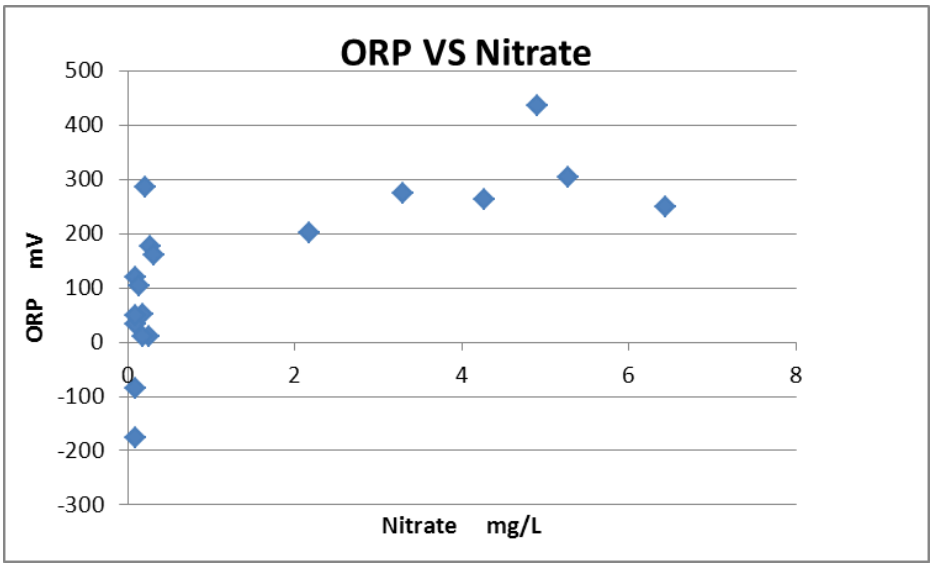


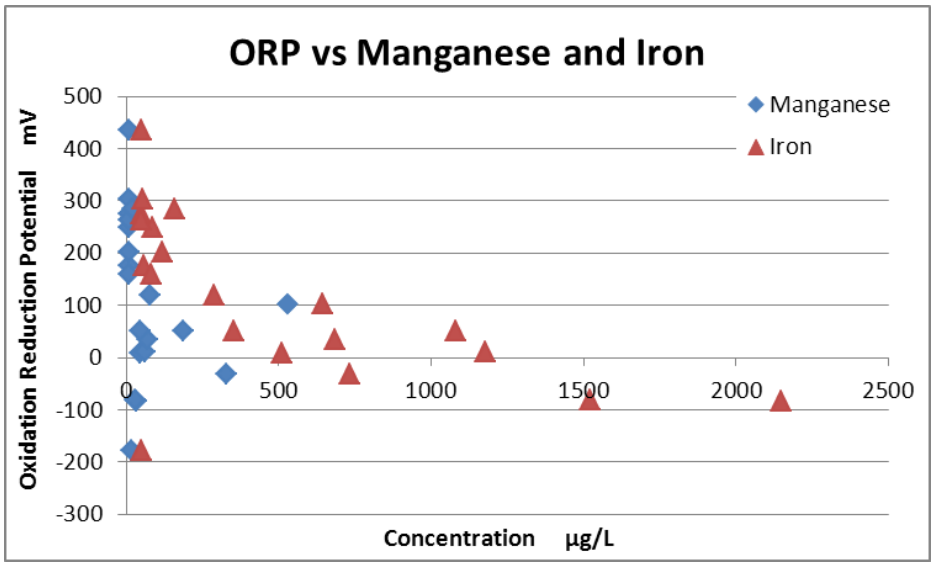
Figure 6. Iron concentrations plotted against nitrate concentrations in GW Rule Pilot data.

Another measure of redox state is the oxidation reduction potential (ORP) which is a measure of the affinity to acquire electrons (be reduced) and is measured in millivolts (mV). Ground water with lower ORP is more reduced. ORP is best collected in the field under controlled conditions since exposure to the atmosphere can quickly invalidate the measured value. Figure 7A indicates the association between ORP and nitrate, which delineates the oxidized systems with elevated nitrate (nitrate values > 2 mg/L with ORP > +200 mV). Systems with the highest ORP are considered to be in contact with the atmosphere and are likely to contain shallow, young ground waters. ORP is plotted against dissolved concentrations of manganese and iron in Figure 7B. As expected from the microbial mediated sequence listed above, both manganese

and iron exhibit low concentrations in oxidized ground water but as ground becomes more reduced, manganese and iron concentrations increase - the mirror image of nitrate.



A



B

Figure 7. ORP vs. nitrate to show elevated nitrate in oxidized settings (A) and ORP vs. manganese & iron to illustrate elevated metals in reduced sites (B).

Interestingly, at the lowest ORP recorded (-177 mV), manganese concentrations are again low. Figure 8 plots manganese concentrations against ORP for the Ambient Ground Water Quality Monitoring Program to explore the suggestion of low manganese concentrations in strongly reduced ground water. There is some variability, but it is clear that the manganese concentration decreases below ORP of -100 mV (precipitates, as reduced manganese oxide). Thus, elevated iron without dissolved manganese suggests more reduced ground water than elevated iron and manganese together.

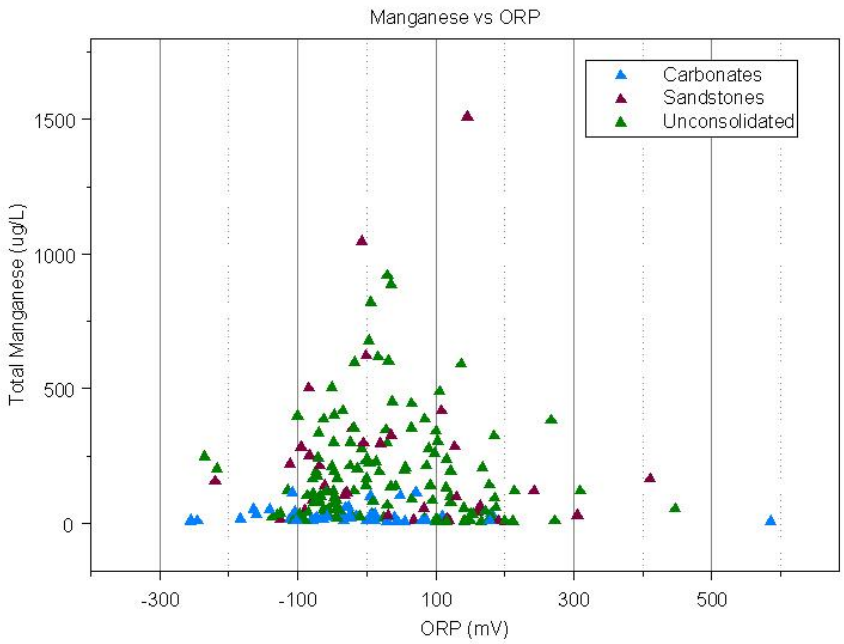


Figure 8. AGWQMP data for manganese plotted against ORP.

Figure 9 shows iron plotted against ammonia. Dissolved iron as Fe^{2+} and ammonia as NH_4^+, are both stable in reducing conditions. Consequently, no correlation is obvious in contrast to Figure 6, where the presence of dissolved nitrate excludes the presence of dissolved iron and visa-versa. Ammonia can be elevated or not when iron is elevated, but the concentration depends on the presence of local nitrogen sources. Ammonia can be used as an indicator of reduced conditions, but since ammonia is not included in the TEAPS sequence, it is not as precise an indicator as the products and reactants of the microbial mediated reactions.

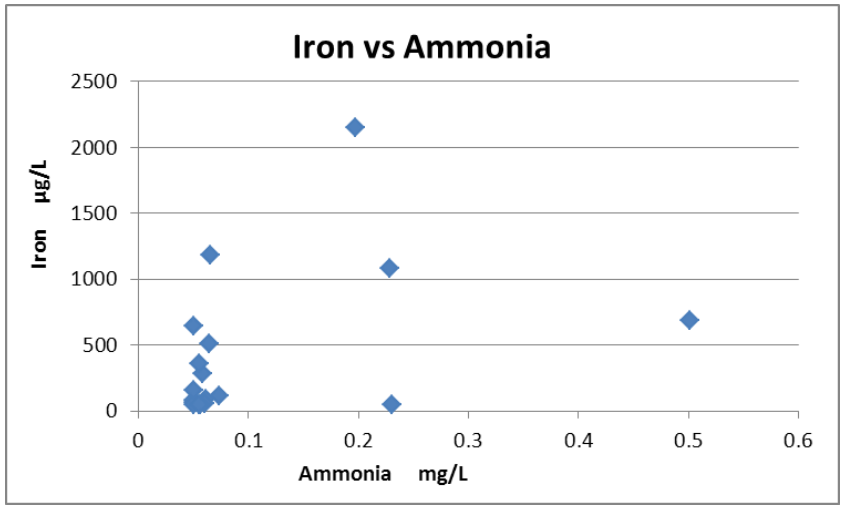


Figure 9. Plot of iron concentrations against ammonia concentrations.

One concern with using inorganic parameters as proxies for ground water redox conditions is the mixed nature of the water samples from some wells. A well with a long screen or extensive open hole section is collecting water over a significant vertical section of the saturated zone. Consequently, the water collected may represents a mixture of redox conditions. The consistency in the previous graphs, presented to illustrate the rationale for using inorganic parameter proxies of redox conditions, indicates that this is not a major problem, but it is a concern that needs to be evaluated. The USGS has documented that public water system production wells frequently produce water of a mixture of waters with varying age. Large production wells collect water from multiple stratigraphic levels and consequently produce water with a mix of travel times and redox conditions (USGS NAWQA Transport of Anthropogenic and Natural Contaminants to Supply Wells - TANC Program). Wells that produce water from multiple stratigraphic levels require careful interpretation of redox conditions.

Figure 10 illustrates the relationship between ORP and the Barrier Index developed for each GW Rule Pilot site. The trend line indicates that ORP generally increases as the sensitivity to pathogen contamination increases (lower Barrier Index). This relationship supports the premise for using redox conditions to confirm the HSA determination. Sites with more oxidized redox conditions are more likely to be pathogen-sensitive. ORP and other chemical parameters are not used in generating the HSA Barrier Index, so the association of more oxidized settings with pathogen-sensitive sites exhibited in Figure 10 independently supports the logic used to develop the HSA Barrier Index.

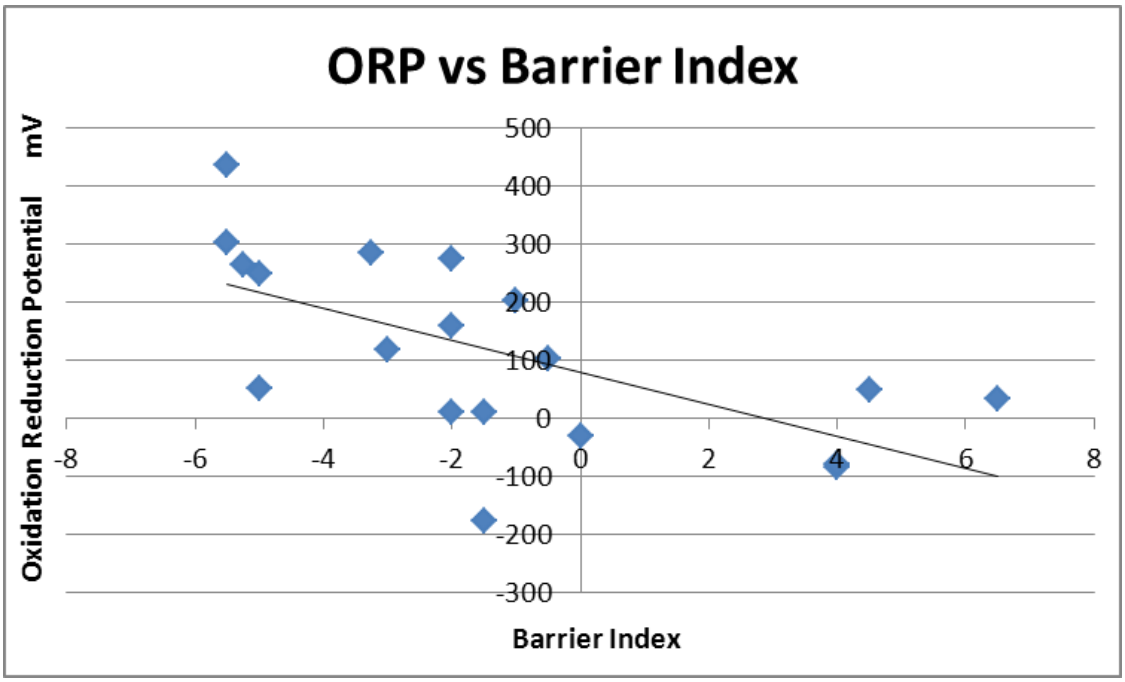
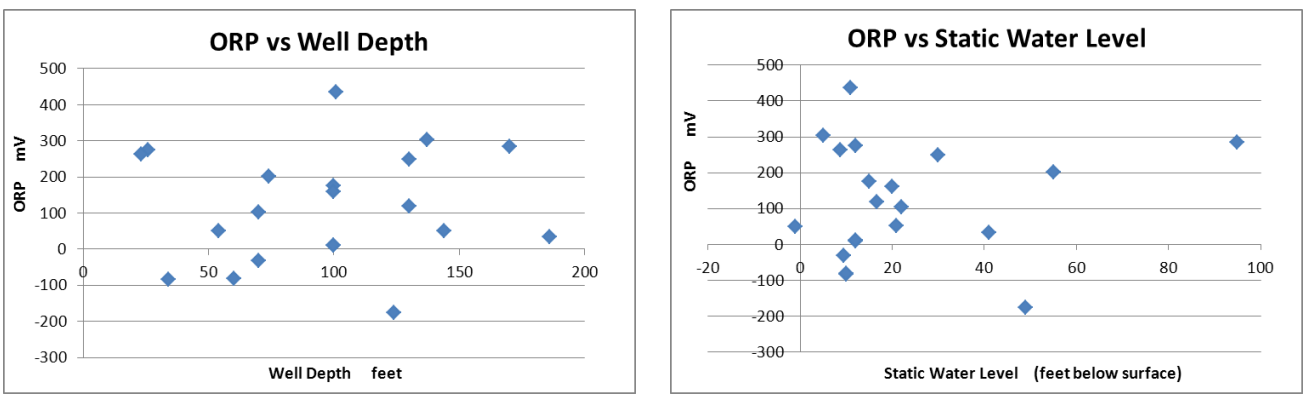


Figure 10. Association of ORP and the Barrier Index with trend line.

Well Attributes and Barrier Index Correlations

This section presents data correlations between characteristics of the geologic setting and well attributes with the Barrier Index. The data plotted illustrate the importance of various attributes that control the Barrier Index. These attributes can also be plotted against microbiologic results and chemical parameters to illustrate critical relationships. The purpose of this analysis is to identify important factors that provide hydrogeologic barriers to the migration of bacteria to aquifers. The analysis follows the general recharge flow paths and considers the common hydrogeologic barriers that are present from the vadose zone, to the saturated zone, to the aquifer. The goal is to use the GW Rule Pilot results to illustrate and evaluate hydrogeologic barriers commonly present and to continue the evaluation of the Barrier Index.

Figure 11 exhibits the relationship between ORP and total well depth (A) and the relationship between ORP and the depth of the static water (feet below surface, B). Neither of these graphs demonstrates strong correlations. The ORP exhibits the range of normal redox conditions in all well depths and in wells with shallow and deep static water levels. The isolation of an aquifer is generally controlled by the depth of water production below the water table. Figure 12, a plot of static water against well depth, indicates deep wells are usually associated with deep water tables and shallow wells with shallower water tables. It makes sense that a well is not drilled too far below the static water table unless the yield is low, the well is tapping multiple aquifers, the well is deep to provide well bore storage, or it is tapping a confined aquifer.



A B

Figure 11. Oxidation reduction potential plotted against well depth (A) and static water level (B).

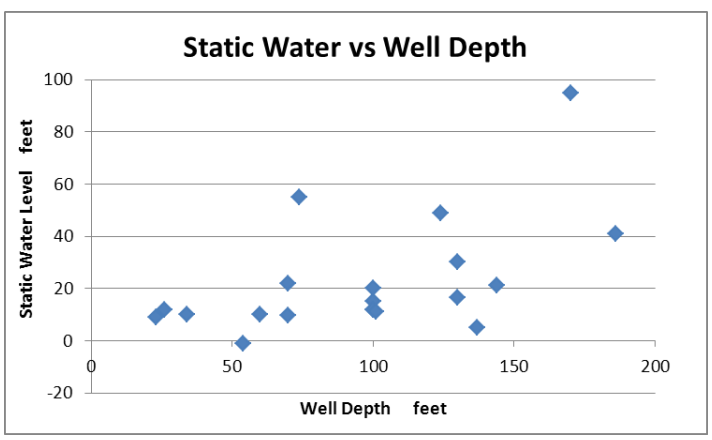


Figure 12. Graph of static water against well depth.

PWSs that detected E. coli in 2010 and 2011 and for which HSAs were generated suggest a deep water table or thick vadose zone is not a good hydrogeologic barrier to pathogen migration. In the vadose zone, vertical transport of recharge and associated contamination can move from the surface to the water table rapidly. This is especially true if the till overlying the bedrock is thin, as documented in the Unsafe Water Supply Investigation - Wooster Township, Wayne County (Ohio EPA, 2006).

Thick tills are considered hydrogeologic barriers; however, the presence of fractures in tills provide recharge pathways. Fractures play a larger role in rapid recharge within thin, unsaturated tills. The HSA guidance gives unsaturated tills less than 25 feet thick no credit as a hydrogeologic barrier. Figure 13 plots the average concentration of the Quantitray analysis for E. coli and enterococci against overburden thickness. The overburden thickness for the bedrock wells is the thickness of till overlying the bedrock, whether saturated or not. For wells producing from sand and gravel aquifers in buried valleys, the overburden thickness is the depth to the top of the screen and is usually dominated by sand and gravel but may include some till. For the GW Rule Pilot sites, Figure 13 documents that the average concentration of E. coli and enterococci are low if the till overburden is greater than 20 feet and that significant concentrations may be present where the overburden is less than 20 feet thick as illustrated for the Wayne Lanes and Heritage Fellowship sites. These results support the risk assessment that thick tills provide effective hydrogeologic barriers to pathogens.

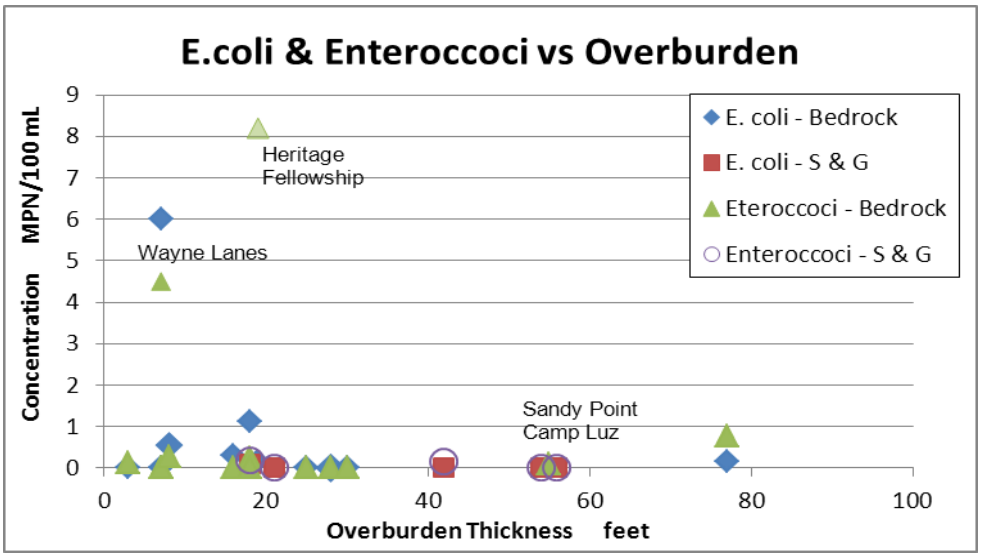


Figure 13. Pathogen indicator concentrations plotted against overburden thickness.

In thicker tills, some portion of the till is usually saturated, which increases their effectiveness as a hydrogeologic barrier. The sand and gravel wells in the GW Rule Pilot did not exhibit elevated pathogen indicators, as indicated in Figure 13. This suggests the poorly sorted sand and gravel aquifers in Ohio's buried valleys provide slower ground water flow for natural filtration and time for inactivation of pathogens than gravels identified as sensitive in the GWR. Although this is a small sampling of sand and gravel aquifers, the conclusion is consistent with historical data on PWSs with no treatment (S&G aquifers) and studies on riverbank filtration (Chapter 4, LT2ESWTR Toolbox Guidance, 2009; Gollnitz et,al. 2004).

The GWR Pilot includes two sites, Camp Luz and Sandy Point, that have well screens set in gravel and are drawing water from confined glacial aquifers. These sites detected no E. coli or enterococci. Other factors that restrict the recharge pathways to gravel aquifers within the buried valley glacial sediments is the heterogeneity of the depositional settings and lithofacies within the aggrading, braided stream valley deposits and the distribution of isolated remnants of tills acting as aquitards (Ritzi, Dominic and Kausch, 1996; Dominic, Ritzi and Kausch, 1996).

Figure 14 illustrates a consistent trend of decreasing ORP as the overburden thickness increases for till over bedrock and sand and gravel deposits. The weighting of the HSA identifies greater vadose zone thickness and especially greater thickness of the saturated zone as providing more effective hydrogeologic barriers to pathogen transport. Thus, the decrease in ORP associated with thicker overburden supports the approach used to generate the Barrier Index. Figure 15 illustrates the relationship between the Barrier Index and overburden thickness. The strong correlation for till and sand and gravel deposits is no surprise and reflects the importance placed on the relative thickness of the vadose zone material and particularly the thickness of the saturated zone above the aquifer in generating the Barrier Index.

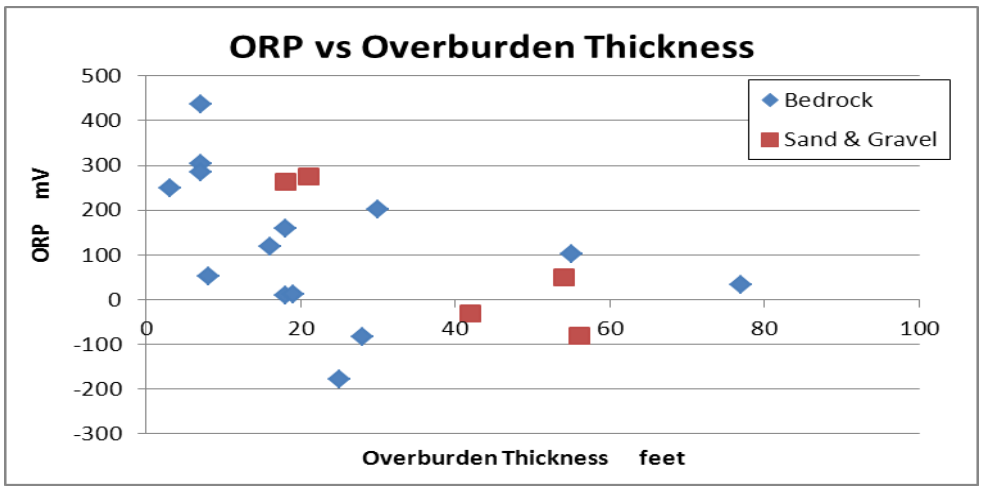


Figure 14. Graph of ORP against overburden thickness.

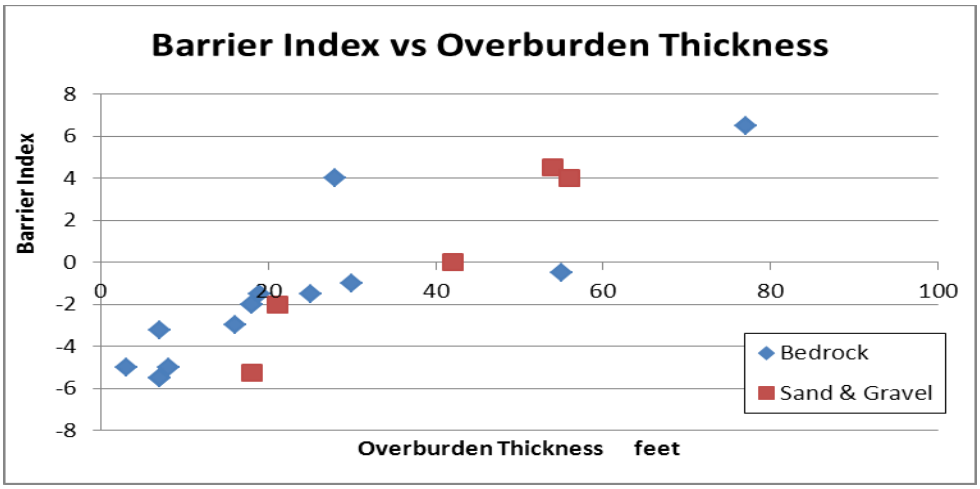


Figure 15. Plot of barrier index against overburden thickness.

Saturated material is a better hydrogeologic barrier than unsaturated material because the vertical driving force is reduced below the surface of the saturated zone and horizontal flow components dominate over vertical flow components. The attribute of saturated condition is used to illustrate the influence of saturated thickness within the overburden. Saturated material is weighted more heavily in the HSA process than unsaturated material, so thicker sections of saturated overburden lead to higher Barrier Indices reflecting more effective hydrogeologic barriers to pathogen migration in saturated materials.

The saturated condition is defined as the static water level minus the depth of unconsolidated overburden above the aquifer multiplied by minus one. In locations with thick overburden and shallow water tables, the saturated condition is the thickness of saturated, unconsolidated material. This is the vertical section of saturated, unconsolidated material that recharge flows through to recharge the aquifer. There are three general cases for determining the saturated condition as illustrated in Figure 16. Each example has an equation to determine a numerical description of the saturated condition and the values produced provide a continuous numeric value to describe the saturated condition. Figure 16 illustrates the physical meaning of the three saturated conditions. Each example is described below.

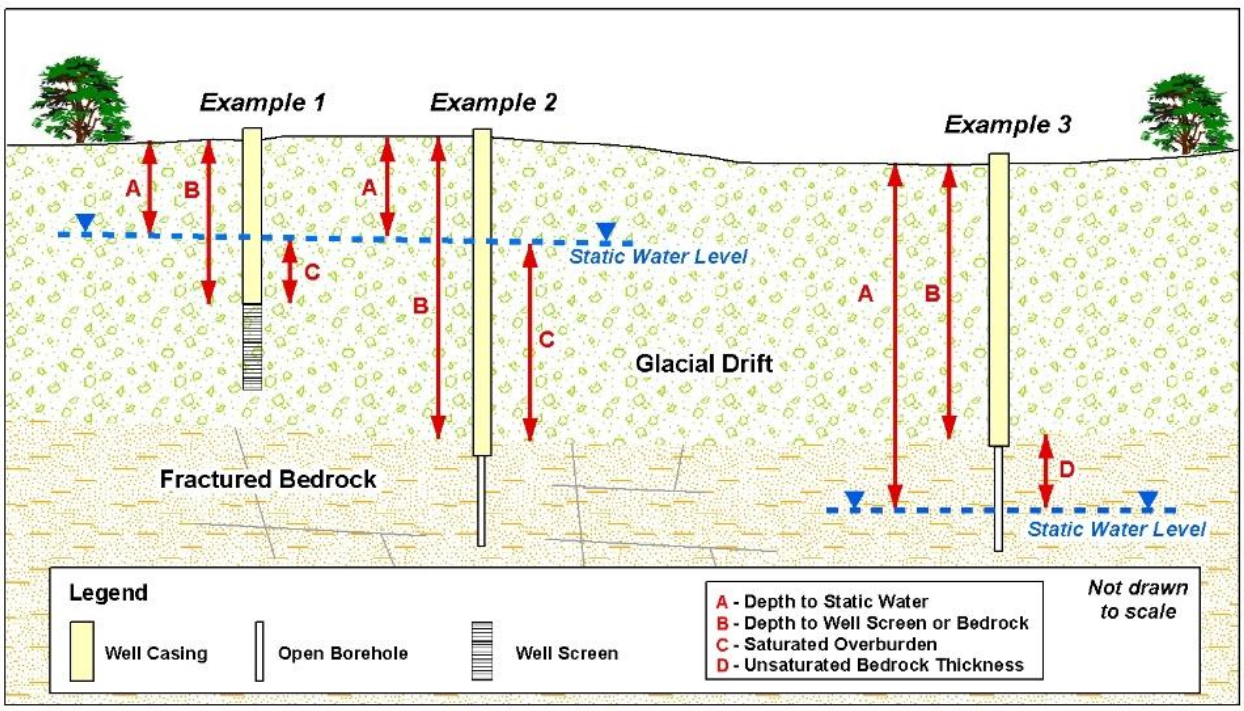


Figure 16. Three examples to illustrate the physical meaning of saturated conditions

Example 1 – Well in unconsolidated material:

Saturated condition = (-1 (static water depth – depth to top of screen)) = (-1(A-B)) = C_1

The first example is the situation for a well producing from a sand and gravel aquifer within the unconsolidated material where the static water level lies above the screen. Here, the saturated condition identifies the thickness of saturated, unconsolidated material above the top of the

screen. This is the portion of the saturated material that recharge must pass through to contribute to well production.

Example 2 - Bedrock well with static water level in unconsolidated material:

Saturated Condition = (-1 (static water depth – depth to top of bedrock)) = (-1(A-B)) = C_2

The second example is the case of bedrock wells cased through the unconsolidated material with the static water level within the unconsolidated sediments. The equation produces positive values that are the thickness of saturated unconsolidated material (arrow C). The thicker the saturated overburden, whether it is till or sand and gravel, the more effective this hydrogeologic barrier is for restricting the migration of pathogens. The Barrier Index incorporates this logic by providing higher barrier values for thicker sections of saturated, unconsolidated material.

Example 3 - Bedrock well with static water level in bedrock material:

Saturated Condition = (-1 (static water depth – depth to top of bedrock)) = (-1(A-B)) = D

The third example illustrates the situation of bedrock wells cased through the unconsolidated material with the static water level within the bedrock, below any unconsolidated sediments that are present. In this example, the equation for the saturated condition produces a negative number, which indicates there is no saturated, unconsolidated overburden and the absolute value of the number is the thickness of unsaturated bedrock above the water table (arrow D, Figure 16). The negative value indicates the lack of saturated overburden and the value documents the thickness of unsaturated bedrock.

These equations provide a continuous series of values that reflect physical settings relevant to pathogen sensitivity. Figure 17 presents the relationship between ORP and saturated conditions.

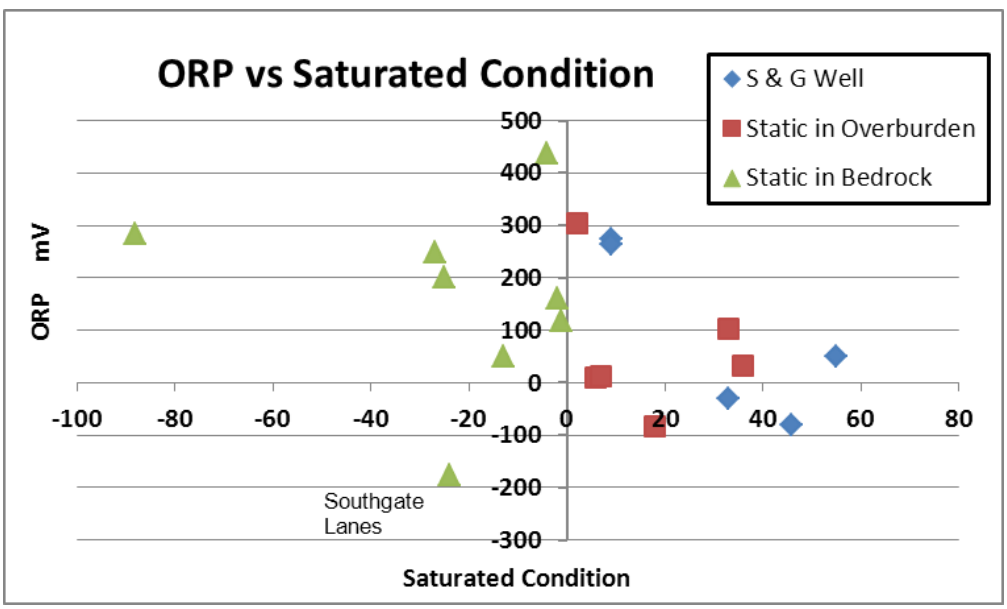


Figure 17. ORP plotted against saturated condition - three situations identified.

Figure 17 documents that ORP generally decreases as the value of the saturated condition increases. The higher the saturated condition (thicker the saturated overburden), the more isolated the aquifer is from the atmosphere (low ORP). This is consistent with the concept that thicker saturated overburden restricts recharge, leading to longer travel times, more natural predation of bacteria, and increased natural filtration processes along recharge pathways. On the other hand, the sites with negative saturated conditions (deep water tables in bedrock) have high ORP and no unconsolidated material that is saturated above the bedrock. Thus, the atmosphere interacts with the water table surface in fractured bedrock and recharge can move rapidly through the overburden macropores and along fractures in the bedrock to the water table. Unsaturated till may provide a hydrogeologic barrier if it is fairly thick and the fracture density is low, but saturated till is a better hydrogeologic barrier.

The site with the lowest ORP recorded in the pilot study (Southgate Lanes, -177 mV) plots below the broad trend of data in Figure 17. Samples from this site are significantly reduced (probable H_2S based on “rotten egg” smell) and the operator uses peroxide to remove sulfur. This well at Southgate Lanes in Allen County was deepened in 1998 (from 73 feet to 124 feet) due to drawdown associated with a local quarry’s pumping to dewater the quarry area. The local till is considered unsaturated, but a pond within 75 feet of the well may produce local saturation of the till. This may reduce the interaction of the atmosphere with the static water level, which occurs at 49 feet, 24 feet below the top of bedrock (saturated condition = -24 feet). There are numerous areas in NW Ohio where reduced ground water is associated with the reduction of sulfate, and it is suspected that this is the situation at Southgate Lanes.

The Barrier Index is plotted against saturated condition in Figure 18. The barrier index decreases as the saturated condition decreases. This reflects the effectiveness of saturated unconsolidated material to act as a hydrogeologic barrier and the weight saturated material is given in generating the HSA Barrier Index. Sites with negative saturated condition (sites with the static water levels within bedrock) are pathogen-sensitive because the unsaturated overburden and fractured bedrock above the static water level are not effective hydrogeologic barriers to pathogen migration compared to saturated material.

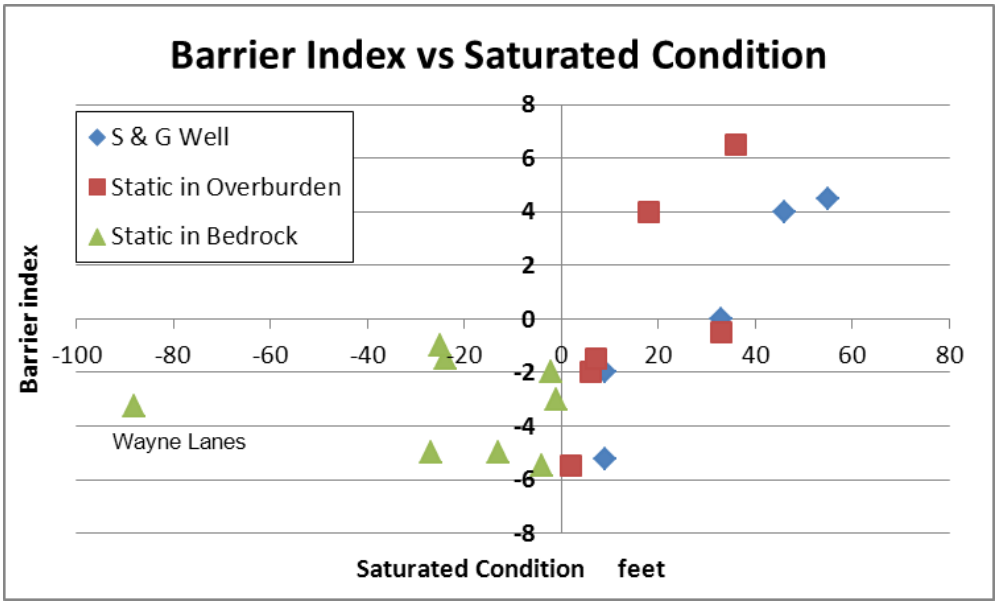


Figure 18. Plot of Barrier Index against saturated condition with three conditions identified.

The GW Rule Pilot site with the deepest water table (95 feet bgs) is Wayne Lanes in Holmes County. It has a saturated condition of -88 feet and is considered pathogen sensitive (Barrier Index = -3.25). This site has 7 feet of till over fractured bedrock with a well that is 170 feet deep. The water produced exhibits high ORP and detections of nitrate at low concentrations (<0.36 mg/L). This site recorded some of the highest average concentrations of E. coli and enterococci (E. coli = 6 MPN/100mL; enterococci = 4.5 MPN/100mL), which documents the potential for pathogen sensitive settings in bedrock wells with deep water tables and thin, unsaturated overburden.

Figure 19 plots the Quantitray results for E. coli and enterococci against saturated condition. The presence of higher concentrations of pathogen indicators associated with sites exhibiting thin saturated overburden (Heritage Fellowship with 7 feet of saturated till) and sites with static water within the bedrock (Wayne Lanes) supports the logic used for weighting saturated overburden as an effective hydrogeologic barrier in the generation of Barrier Indexes. The Heritage Fellowship well is located in carbonate bedrock with thin glacial drift overlying the bedrock. This is a karst area and karst settings are known for rapid pathogen migration. The data points for Makoy Center document the detections of pathogen indicators in a site with 36 feet of saturated overburden - a situation that has been discussed previously and is considered anomalous (see page 9 for explanation).

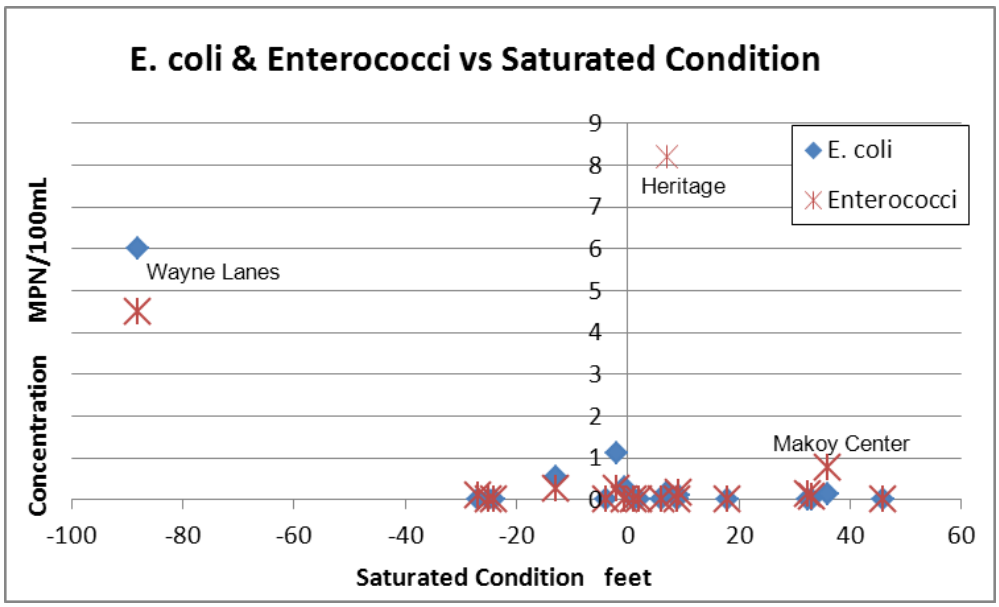


Figure 19. E. coli and enterococci concentrations plotted against saturated conditions.

Overall, the relationships exhibited in Figures 17-19 highlight the importance of saturated conditions for providing effective natural filtration of surface recharge infiltrating to an aquifer. These relationships exhibit more complexity if we plot the microbiologic data in terms of frequency of detection (number of samples with detection/total number of samples) rather than the average of the results (MPN/100 mL) as in Figure 19. This approach does not use the Quantitray results to their full advantage, but frequently DDAGW staff only have presence-absence microbial data. Presenting the Quantitray data in terms of detection frequency closely resembles presence-absence data.

Figure 20 exhibits the frequency of detection for the microbial data plotted against the saturated condition. The same relationships shown in Figure 19 are illustrated in Figure 20, but the frequency of detections measure expands the sensitivity of the vertical scale and allows the inclusion of total coliform. This plot dilutes the Quantitray data to presence–absence data, typical for the standard MMO-MUG test. The higher detection rates for total coliform compared to E. coli and enterococci are immediately obvious. This is not surprising considering these sites were selected because of a history of detections associated with the Total Coliform Rule. As discussed previously, total coliform detections using the MMO-MUG methodology is not a good indicator of enteric bacteria (discussed in the Barrier Index and Quantitray Correlation section, page 10). The bulk of the elevated detections rates are associated with saturated overburden thicknesses that are 10 feet thick or less, which is consistent with the HSA weighting procedures. However, there are several sites with saturated overburden thicknesses around 35 feet that would be expected to provide significant hydrogeologic barriers to pathogen migration but do not.

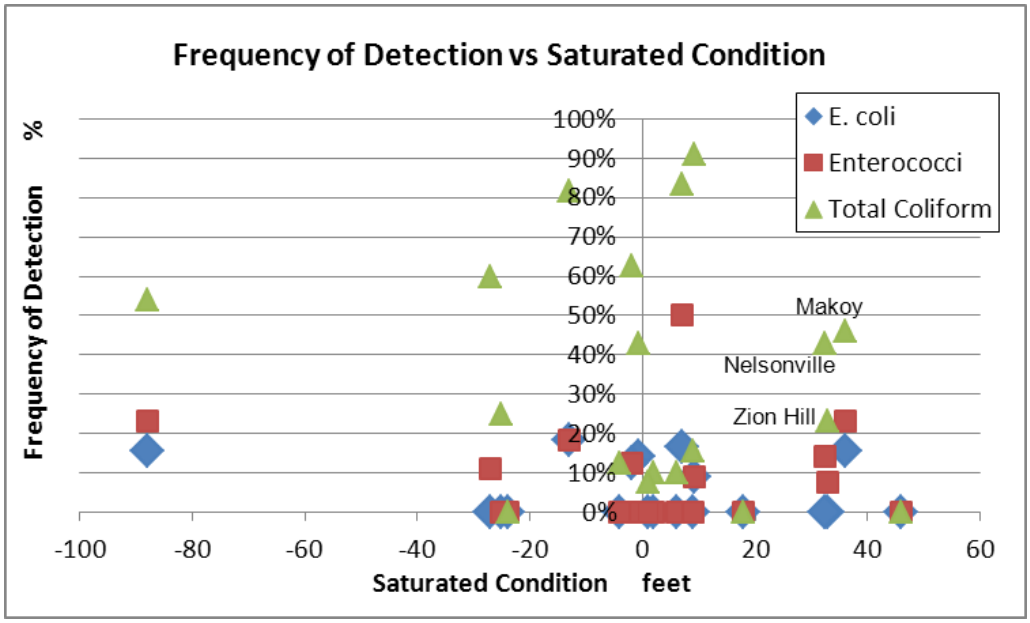


Figure 20. Relationships between frequency of detection and saturated condition

The sites of concern include Makoy Center, Zion Hill, and Nelsonville. Reasonable explanations need to be provided for the detection of pathogen indicators at these sites if the current HSA procedures and weighting for barrier values are to be trusted. It is important to note that the GW Rule Pilot selected PWSs considered sensitive to pathogens so it is not surprising to see detections at these sites. The question is: are there additional flow paths that are transporting pathogens to these wells that the HSA procedures did not include? Makoy Center has been discussed previously as anomalous and the suspected pathway is migration of surface drainage along gravel filled ditches migrating to the well casing and then moving down the casing.

Zion Hill Church of the Brethren is a 70 foot well drilled through 55 feet of sand and gravel and into sandstone and shale bedrock. The well is cased to 61 feet, set into bedrock. Static water is at 22 feet with 15 feet of drawdown during a 4 hour pump test run at 23 gallons per minute.

This hydrogeologic setting appears to be well protected with the deep casing requiring vertical recharge to flow through 55 feet of sand and gravel, of which 33 feet is usually saturated. The problem, however, is the possibility of horizontal flow paths. The Zion Hill well is 300-350 feet to the southwest of a stream and the wellhead is approximately 20 feet above this stream (based on topographic map). Numerous fractures are exposed in outcrop in the stream bed, so horizontal flow paths from the stream to the well along fractured bedrock is certainly possible and even likely when the well is being pumped hard and the stream level is high. The frequency of detection at Zion Hill is not high and no E. coli were detected; one enterococci (MPN/100 mL) was detected in 1 of 13 samples; and 3 of 13 samples detected total coliform with the highest concentration of 308 MPN/100 mL.

Nelsonville was selected for the GW Rule Pilot as an example of a well that is located close to a river in a buried valley, with the purpose of testing wells in which induced recharge is active. At less than 50 feet from the Hocking River, Nelsonville well 1 was the closest to a river of the four GW Rule pilot sites in buried valley sand and gravel aquifers close to rivers or streams. The Nelsonville well is 70 feet deep with 42 feet of casing. The static water level is 9.5 feet so the saturated condition is about 33 feet. Generally, it is assumed that the horizontal permeability in sediments is greater than vertical permeability. Considering the short distance between the river and well and the significant pump rates for a community well (750 gpm pump), induced recharge contributes significantly to the production of Nelsonville Well 1. Although natural filtration is certainly occurring along river to well flow paths, it appears that it is not sufficient to remove all the bacteria all the time. Only seven samples were collected at Nelsonville and none detected E. coli, only one detected enterococci (1 MPN/100 mL), and three detected total coliform, with the highest recording 19 MPN/100 mL. Thus, the natural filtration is somewhat effective, but the horizontal flow paths provide additional pathways for pathogen migration to production wells, independent of the vertical saturated thickness.

The Zion Hill and Nelsonville examples illustrate why it is important to consider horizontal pathways as well as vertical recharge flow paths in evaluating pathogen sensitivity. The HSA procedure includes a section for the inclusion of horizontal pathways but it is difficult to weight the importance of horizontal recharge as documented by these examples. It is also important to note that the GWR Pilot sampling was random and was not planned to follow large rain fall events or high flood stage events. Major recharge events will increase the rate and volume of recharge processes and consequently the likelihood of pathogen contamination.

Saturated casing is the length of casing that is below the static water level. The concept of saturated casing is closely associated with saturated condition. A significant thickness of saturated casing restricts movement of contaminated water concentrated at the surface of the water table from flowing or cascading into a pumping well. Figure 21 illustrates the correlation between saturated casing and saturated conditions. Both static and pumped saturated casing lengths are plotted. If there is no drawdown during pumping, the static and pumped saturated casing lengths are the same. If there is drawdown during pumping, then the pumped saturated casing length is less than the static saturated casing. If the static water level lies below the bottom of the casing the saturated casing length is negative and the absolute value is the distance from the bottom of the casing to the water level. Negative saturated casing lengths are not unusual in bedrock wells and increase the vulnerability of wells to the migration of pathogens due to cascading of water into the well bore.

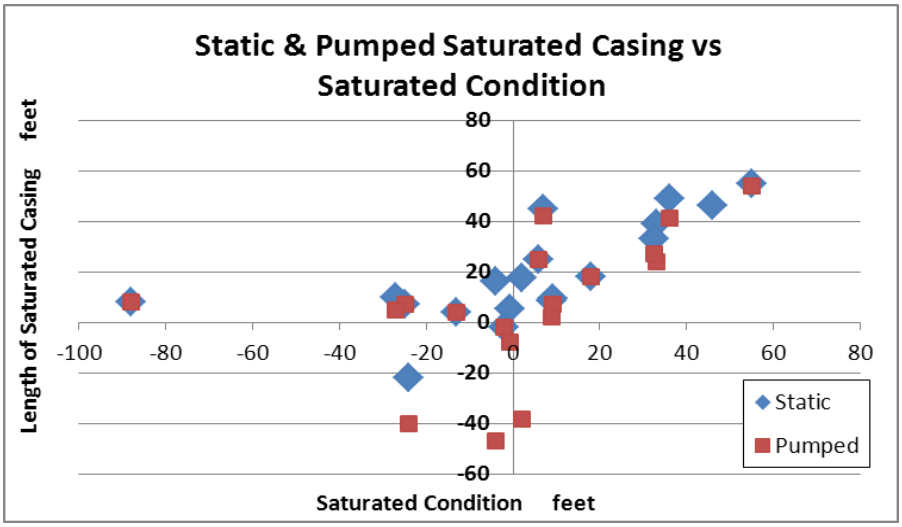


Figure 21. Relationship between saturated casing and saturated condition.

Figure 21 plots saturated casing against saturated condition. In the positive saturated conditions of Figure 21, where the water table occurs within the unconsolidated overburden, there is a strong correlation between saturated casing and saturated condition. The trend indicates that the saturated casing length is generally equal to the thickness of the saturated overburden. This occurs because in most bedrock wells the casing is set into the top of bedrock. Wells that plot above this trend have casing that extends some distance into bedrock. In negative saturated conditions (left half of Figure 21) where the water table is within the bedrock, wells are generally open holes without casing. Many bedrock wells are susceptible to cascading of water into the well during pumping, particularly if there is significant drawdown.

Figure 22 illustrates the relationship between the Barrier Index and saturated casing. A similar correlation is exhibited as in Figure 21. Generally, as the length of saturated casing is reduced, the Barrier Index is lower. The correlation is not as good as in Figure 21 because the Barrier Index takes multiple factors into consideration, not just the thickness of the saturated casing.

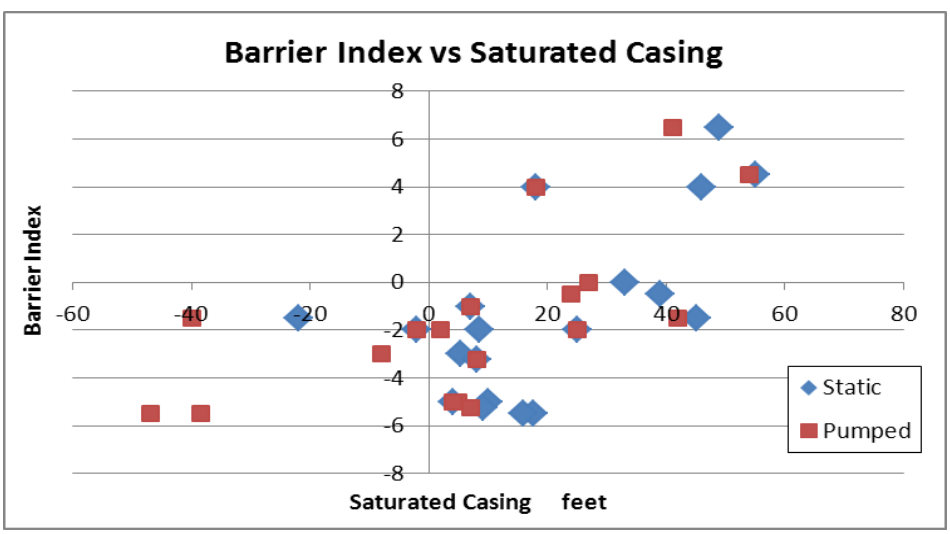


Figure 22. Barrier Index plotted against length of saturated casing.

Conclusions

Overall, the correlations between the microbiologic and inorganic results and the barrier index presented in this report document that the HSA procedures provide a reasonable, relative measure of the sensitivity of pathogen migration in a range of hydrogeologic settings. The pilot study focused on a small group of PWSs that were considered sensitive to pathogen contamination and the data analysis indicates that:

- The barrier index exhibits indirect relationships with pathogen indicator concentrations - negative Barrier Indices are associated with higher concentrations of pathogen indicators;

- Selected inorganic parameters can be used effectively as proxies for redox conditions, This was demonstrated by correlations with ORP and relationships between concentrations of TEAPS parameters;

- ORP exhibits an indirect correlation with the barrier index - high ORP correlates with low barrier index values, indicating that sites with rapid recharge are not isolated from the atmosphere;

- ORP exhibits an inverse relationship with overburden thickness and saturated conditions – higher ORP is associated with thin overburden, thin saturated overburden and the lack of overburden;

- Barrier Index exhibits a direct relationship with overburden thickness and saturated conditions - high Barrier Indices are associated with thick overburden and larger values of saturated conditions.

These conclusions support the general logic utilized to generate the HSA barrier index and indirectly support the utility of microbiologic data and the inorganic parameters for evaluating the sensitivity of hydrogeologic settings. Microbiological and inorganic results are not utilized in the HSA procedures that generate the Barrier Index, so correlations between the geochemical results and the Barrier Index or inorganic TEAPS parameters provide significant documentation that the HSA procedures are accomplishing the goal of providing a reliable indicator of relative pathogen sensitivity.

The data presented here confirms the HSA provides a relative ranking of PWS sensitivity to pathogens that can be correlated to geochemical parameters. Thus, t**he HSA procedures are a reasonable starting point, but it is an imperfect tool to identify gradational boundaries on a continuum of sensitivity**. There is no question that additional data needs to be collected to confirm these conclusions and to refine the processes. All of the sites selected for the GW Rule Pilot were considered to be sensitive to pathogen migration. It would have been useful to include several sites that were not sensitive to pathogen migration to provide a wider range of hydrogeologic settings to evaluate. This could be done for some of the less sensitive sites sampled for the “Identification of Hydrogeologic Barriers to Pathogens Movement in Sensitive Aquifers” study (MDH & OEPA, 2006). Unfortunately, we do not have Quantitray data for these sites.

Steps to refine the HSA procedures

1) GWR-triggered source water monitoring and ASWM will provide additional, independent data to evaluate HSA results. Quantitray samples should be encouraged because the results provide a numeric value that can be correlated to the continuum of pathogen sensitivity.

2) Set up an Excel spread sheet to promote uniform HSA determinations. Procedure could be organized into a question and answer format using Table 1 & 2 of the guidance as the framework of the spreadsheet, which would:

- Promote more uniform HSA across the state;
- Preserve a uniform data set for each HSA generated; and
- Promote analysis of data to help refine HSA procedures.

3) With sufficient data and some mathematical sophistication, a mathematical model for calculating the Barrier Index could be generated. Application of multivariate analysis to evaluate which factors exert the most influence on the Barrier Index would allow significant refinement of the Barrier Index equation. Independent data, including geochemistry and microbiologic results from ASWM, could be used to confirm the analysis. Identifying the individual factors that are the most important hydrogeologic barriers would improve the primitive weighting scheme currently used in the HSA for generating the Barrier Index. Ultimately this analysis will help to improve the HSA procedure and increase the division's ability to identify small PWSs at risk for pathogen contamination

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Appendix A - GWR Pilot Location and Well Attribute Data.

LOCATION	Red Canery	Southgate Lanes	Carrollton 2	Carrollton 4	Carrollton 5	Carmichael Machine	Heritage Fellowship	Makoy	Greenfield 8	Living Word	Zion Hill	Elizabeth Township
PWSID	OH0232612	OH0249812	OH1000012	OH1000012	OH1000012	OH1230412	OH1247412	OH2557212	OH3600312	OH3841512	OH5048112	OH5537712
Well-ID	WL78024	WL78311	WL80646	WL80650	WL80654	WL81783	WL82309	WL133834	WL92229	WL93165	WL98465	WL100804
Latitude	40.695239	40.880264	40.623303	40.626528	40.619506	39.921117	39.925583	40.037004	39.354175	40.652928	40.906264	39.999239
Longitude	-83.982261	-83.908967	-81.089836	-81.091014	-81.089964	-83.914697	-83.91485	-83.163723	-83.377333	-81.856311	-80.706144	-84.101756
ODNR Well Log	279870	665056	192454	UNK	103402	753572	842447	856885	Const.	306312	378680	351127
Well Depth (ft)	34	124	130	100	100	100	100	186	26	74	70	130
Well Casing Length (ft)	28	27	22	30	18	37	57	90	20.5	62	61	40
Static Water Level (FBG)*	10	49	17	15	20	12	12	41	12	55	22	30
Pumped Static Water (FBG)*	10	67	30		?	12	15	49	18.5	55	37	35?
Saturated Casing (ft) Static	18	-22	5		-2	25	45	49	9	7	39	10
Saturated Casing (ft) Pumped	18	-40	-8		-2	25	42	41	2	7	24	5
Length of Screen or Production (ft)	28-34	49-124	22-110		20-60	37-98	57-100	90-186	21-26	62-74	61-70	40-130
Well Yield (GPM)	20?	?	250	250	UN	UN	UN	28?	200	UN	6.5	10
Overburden Thickness** Bedrock	28	25	16		18	18	19	77		30	55	3
Overburden Thickness** Unconsolidated									21			

Appendix A - GWR Pilot Location and Well Attribute Data.

LOCATION	Red Canery	Southgate Lanes	Carrollton 2	Carrollton 4	Carrollton 5	Carmichael Machine	Heritage Fellowship	Makoy	Greenfield 8	Living Word	Zion Hill	Elizabeth Township
Saturated Condition #	0	-2	-6		0	-19	-38	-13	1	-32	-6	-37
Example 1 Unconsolidated Well									9			
Example 2 Static in Overburden	18					6	7	36			33	
Example 3 Static in Bedrock		-24	-1		-2					-25		-27
SWAP Susceptibility	Low	Low	High	High	High	High	High	Moderate	High	Low	High	High
Primary Overburden Material	Clay	Clay	Clay;S&G		Clay	Clay	Clay	Clay; S&G	Clay; S&G	Clay	S&G	Clay
Bedrock Lithology	LS	LS	SS/SH		SS/SH	LS	LS	LS	NA	SH	SS	LS/SH
Aquifer Lithology	LS	LS	SS		SS	LS	LS	LS	S&G	SH	SS	LS
Confined Aquifer ?	Yes	No	No		No	No	No	Yes	No	No	no	No
Barrier Index	4	-1.5	-3		-2	-2	-1.5	6.5	-2	-1	-0.5	-5
Lithology Unconsolidated-VADOSE ZONE	Till	Till	Colluvium		Colluvium	Till	Till	Till& S&G	Till	Till & S&G	S&G	Thin Till
Lithology Consolidated-VADOSE ZONE		LS	SS/Sh		SS/Sh					Shale		20+ ' LS

Appendix A - GWR Pilot Location and Well Attribute Data.

LOCATION	Red Canery	Southgate Lanes	Carrollton 2	Carrollton 4	Carrollton 5	Carmichael Machine	Heritage Fellowship	Makoy	Greenfield 8	Living Word	Zion Hill	Elizabeth Township
Lithology Unconsolidated-SATURATED ZONE	Till					Till	Till	Till	S&G		S&G	
Lithology Consolidated-SATURATED ZONE						LS	LS	LS			SS/SH	LS
Aquifer Lithology	DOL	DOL	SS		SS	DOL	DOL	LS	S&G	Shale	SS	DOL
Induced Recharge	SW-70 '	Pond			stream-100'			Pond	SW-190'		SW-350'	
Well Construction Concern	18' Saturated Casing	<10' saturated casing	<10' saturated casing		12' saturated casing	25 ' saturated casing	42' saturated casing	51' saturated casing	< 10 ft saturated casing	<10' saturated casing	24 ' saturated casing	<10' Saturated Casing

* FBG - Feet Below Ground Surface

Aquifer Lithology: S&G, SS, LS

Overburden Material: Till, Lacustrine, Sand, Sand & Gravel, Colluvium

Bedrock Lithology: NA (not appliciple), SS (sandstone), LS (limestone)

** Overburden Thickness for bedrock wells = thickness of unconsolidated cover

** Overburden Thickness for unconsolidated wells = thickness of sediments to top of screen

\# Saturated Condition = (-1(static water - depth to bedrock));

Example 1, unconsolidated well = saturated zone above screen

Example 2, bedrock well with static water in unconsolidated material = thickness of saturated unconsolidated

Example 3, static water in bedrock gives negative value = thickness of **unsaturated** bedrock

Appendix A - GWR Pilot Location and Well Attribute Data (continued)

LOCATION	Phillipsburg 2	Phillipsburg 3	Gratis Well 2	C M Schermerhorn	Camp Luz	Wayne Lanes	Sandy Point	Nelsonville
PWSID	OH5702112	OH5702112	OH6800612	OH7258812	OH8532912	OH8554112	OH0239412	OH0501214
Well-ID	WL101587	WL101589	WL113475	WL149439	WL125435	WL126050	WL78199	WL79551
Latitude	39.907667	39.903111	39.656719	41.341389	40.793397	40.794806	40.832939	39.462464
Longitude	-84.399614	-84.40525	-84.511564	-83.152222	-81.741483	-81.909003	-84.165642	-82.249317
ODNR Well Log	UNK	114945	137357	953203	382306	676552	Const.	450808
Well Depth (ft)	137	101	23	144	54	170	60	70
Well Casing Length (ft)	22.5	27	18	25	54	103	56	42.5
Static Water Level (FBG)*	5	11	9	21	-1	95	10	10
Pumped Static Water (FBG)*	61	74	11.4	?	-1	95?		15
Saturated Casing (ft) Static	18	16	9	4	55	8	46	33
Saturated Casing (ft) Pumped	-38.5	-47	7	4	54	8		27
Length of Screen or Production (ft)	22.5-137	27-101	18-23	25-144	0	103-170	56-60	42-62
Well Yield (GPM)	50	32.5	60	UN	?	10		750
Overburden Thickness** Bedrock	7	7		8	54	7		
Overburden Thickness** Unconsolidated			18				56	42

Appendix A - GWR Pilot Location and Well Attribute Data (continued)

LOCATION	Phillipsburg 2	Phillipsburg 3	Gratis Well 2	C M Schermerhorn	Camp Luz	Wayne Lanes	Sandy Point	Nelsonville
Saturated Condition #	-16	-20	0	-17	0	-96	0	-1
Example 1 Unconsolidated Well			9				46	33
Example 2 Static in Overburden	2				55			
Example 3 Static in Bedrock		-4		-13		-88		
SWAP Susceptibility	High	High	High	High	High	Moderate	Low	High
Primary Overburden Material	Clay	Clay	S&G	Clay	Clay & S&G	Clay	Clay; S&G	Clay; S&G
Bedrock Lithology	LS	LS	NA	LS	SS	SS/SH	NA	NA
Aquifer Lithology	LS	LS	S&G	LS	Gravel	SS	Gravel	S&G
Confined Aquifer ?	No	No	No	No	Yes	No	Yes	No
Barrier Index	-5.5	-5.5	-5.25	-5	4.5	-3.25	4	0
Lithology Unconsolidated-VADOSE ZONE	Thin Till	Thin Till	Till + Gravel	Thin Till	Till & S&G	Thin Till	Till & S&G	Clay & S&G
Lithology Consolidated-VADOSE ZONE			NA	13' LS		90 ' SS/SH		

Appendix A - GWR Pilot Location and Well Attribute Data (continued)

LOCATION	Phillipsburg 2	Phillipsburg 3	Gratis Well 2	C M Schermerhorn	Camp Luz	Wayne Lanes	Sandy Point	Nelsonville
Lithology Unconsolidated-SATURATED ZONE			Till		Till		Till & S&G	Clay & S&G
Lithology Consolidated-SATURATED ZONE	LS	LS	NA					
Aquifer Lithology	DOL	DOL	Gravel	DOL	Gravel	SS	Gravel	S&G
Induced Recharge	NA	NA	SW-150'	NA	Pond		Pond	river
Well Construction Concern	<10' Saturated Casing	<10' Saturated Casing	<10' Saturated Casing	<10' Saturated Casing	26 ' Saturated casing	<10' Saturated Casing	10-25' saturated casing	Floodplain

* FBG - Feet Below Ground Surface

Aquifer Lithology: S&G, SS, LS

Overburden Material: Till, Lacustrine, Sand, Sand & Gravel, Colluvium

Bedrock Lithology: NA (not appliciple), SS (sandstone), LS (limestone)

** Overburden Thickness for bedrock wells = thickness of unconsolidated cover

** Overburden Thickness for unconsolidated wells = thickness of sediments to top of screen

Saturated Condition = (-1(static water - depth to bedrock));

Example 1, unconsolidated well = saturated zone above screen

Example 2, bedrock well with static water in unconsolidated material = thickness of saturated unconsolidated

Example 3, static water in bedrock gives negative value = tickness of **unsaturated** bedrock

Appendix B
Protocol for GW Rule Pilot Sampling
August 2009

The purpose of this Protocol is to outline the sampling procedures for the GW Rule Pilot in detail, in order that all the Districts and Central Office are collecting the GW Rule Pilot samples in the same manner. Generally the sampling protocol is similar to the AGWQMP sampling for raw water samples except that for the GW Rule Pilot we are also collecting bacteria samples so the sample tap needs to be disinfected. The scope and purpose of the GW Rule Pilot project are outlined in the Ground Water Rule Source Water Review - Pilot Project Sample Plan.

Raw water samples to be collected.

On a monthly basis: Quantitray Analysis - 2 100 mL sterile plastic bottles (pre-preserved with Sodium Thiosulfate)
Sampling requires disinfection of sampling tap

Two 100 Ml Bottles – fill to just above fill line

On a quarterly basis: Inorganic analysis – 3 one quart cubitainer (Non preserved, H_2SO_4, and HNO_3)
Sampling procedure similar to AGWQMP sampling, but sample tap is disinfected for bacteria samples.

Non Preserved H_2SO_4 HNO_3

Notes for small system sampling:

- Running water in sinks or flushing toilets will help reduce pressure and trigger pumping which is important for collecting high quality raw water GW Rule samples.
- The location of the sample tap may be good or bad; many pressure tank taps are close to the floor level which makes sampling difficult.
- Transporting water flushed from the tap is a significant activity for some of the small systems where no good drains are close to sample tap - bring some buckets.
- Take some paper towels along with you to clean up after sampling. Please leave the areas in the same of better condition than when you arrived.
- Districts should be able to get chlorine tester from DW staff.

Sampling Protocol – GW Rule Pilot

Steps are listed in sequence

1) Prior to sampling:
   - In the week before sampling contact the PWSs that you are sampling to arrange a sampling time. Request that they do not chlorinate the well.
   - Contact Kathie Haas to let her know when the samples will be delivered.
   - Arrange for courier service if needed.
   - Organize the sampling equipment and supplies - Equipment List in Appendix 1.

2) Upon arriving at the site, meet with local contact and gain access to the well or the well to be sampled.

3) Fill out the GWR Pilot - Sample Log as sampling progresses, one sheet per sample (or sample and duplicate).

4) Locate and record details of location and condition of sample tap. The GW Rule Pilot is collecting **raw water** samples, so the tap should be upstream of any treatment, generally as close to the pressure tank as possible for the small systems and at the wellheads for the larger systems.
   - If the only available tap is post softening this is acceptable for small systems;

5) Prepare sample tap area and flush sample tap:
   - Clear area around sample tap of clutter and dirt to help assure a good sample.
   - Remove tap aerator (if present) and clear/clean tap of debris, cobwebs, etc.
   - Flush the tap to clean out any debris

6) Collect water for **total chlorine** test – follow instrument directions.
   - Rinse vials with raw water - Fill two vials with 10 ml of water from sample tap - Zero machine with one vial, add reagent to second vial and wait three minutes to read second vial. **If chlorine is present do not collect GW Rule samples**. Record total chlorine reading on sample log.
   - If chlorine is detected try to sample closer to the raw water inflow into the system and/or increase water usage to increase raw water input and measure chlorine again. Inquire when the well was chlorinated?

7) Turn off the sample tap.

8) Disinfect the sample tap (can be done while total chlorine reagent reacts).
   - Use a Clorox solution (one ounce of bleach to one gallon of water or 1 tablespoon per half-gallon) in a spray bottle and a toothbrush (cleaned and disinfected, and stored in a Clorox solution) to clean the sample tap. Spray the outside surface of the tap and point several sprays into the nozzle of the sample tap. With the tooth brush freshly sprayed with Clorox solution, scrub the outside surface and threads as well as scrubbing the interior of the tap while applying Clorox solution.
   - Wait at least 3 minutes for Clorox solution to disinfect sample tap.

   Disinfection time can be use to run total chlorine test and if no chlorine is detected to start labeling sample containers.

9) Flush sample tap for at least 5 minutes.

10) Label containers (location, sample date and time, sampler, and preservative if needed) or if containers already labeled add the sample time - all containers from a sampling site should have the same sample time (identical time on SSF).
    - Label before filling - Wet labels or containers are difficult to label.
    - Some staff choose to pre-label and pre-preserve. Labeling containers on site avoids labeled containers and no sample in case total chlorine is detected.

11) Collect field parameters and record on GWR Pilot - Sample Log
    - Towards the end of the post disinfection flushing the field parameters should have stabilized. Confirm that the parameters have stabilized and record the stabilized results for Temperature, Conductivity, TDS, ORP, and pH on the sample log.

12) Systematically fill sample containers.
    - Gloves are to be worn **at all times** when filling sample containers.
    - Fill cubitainers first if inorganic sample is being collected then bacterial samples, in order to maximize flush time for bacteria samples.
    - Do not rinse sample container.
    - Avoid touching the inside of the bottle of cap. If you accidently touch any of these surfaces a new bottle needs to be used.
    - Watch out for back splash, resample if this occurs.
    - Headspace is fine in sample containers, make sure bacteria containers are filled to or above the fill line.

13) Turn off the tap and clean up the area. Collect samples, meters, and sampling materials.

14) Preservation – if sample containers were not pre-preserved, preserve the samples at the vehicle.
    - Glasses/safety glasses are required for preservation steps.
    - No preservation needed for bacteria samples (sodium thiosulfate in vials).
    - If an inorganic sample is collected one cubitainer needs to be preserved with H_2SO_4, and one cubitainer needs to be preserved with HNO_3. The third cubitainer is not preserved. All cubitainers should be labeled with preservative.

15) Place all the DES samples in a cooler on ice (bacteria samples and the 3 quart cubitainers if an inorganic sample was collected).
    - Bacteria samples should be secured in a ziplock bag.

16) Sample Documentation – paper work
    - Review the GWR Pilot - Sample Log to confirm that the sheet is completed and any unusual circumstances that occurred while sampling are recorded.
    - Record any information gained about timing and frequency for well chlorination.

17) **Sample Submission Forms and Chain of Custody – Templates in Appendix 2**
    - Complete a Sample Submission Form (SSF) for each site using the SSF templates provided. Project Identy – GWR Pilot; GWR Pilot templat has been set up for the Inorganic samples.
    - Chain of Custody sheet for each sampling run needs to be completed

Appendix 1
GW Rule Pilot Sampling - Equipment List

Containers

1 quart Cubitainers (inorganic samples)
100 mL Sterile Vials (bacteria samples)

Buckets for water transport (5 gallon and 2.5 gallon)
Coolers for transporting samples on ice

Preservatives/Disinfectant

Sulfuric Acid ampules (2 ml)
Nitric Acid ampules (5 ml)
Sodium Thiosulfate (power in 100 ml sterile vials)

Bleach solution in spray bottle (1 table spoon/ half gallon minimum concentration)
Toothbrushes (disinfected with and stored in bleach solution)

Field Meters (with instructions and necessary reagents)

Myron 6P ultrameter
Hatch chlorine meter or equivalent (available from DW staff)

Miscellaneous Equipment

Masking tape
Duct tape
Cellular Phone
Flashlight & batteries
Tool Box – Pliers, screwdriver, and adjustable wrench at minimum.
Clipboard

Expendables

Ice (bagged, loose only)
Sampling Gloves
Paper towels
Kimwipes
Extra batteries
Trash bags
Baggies (good quality)
DI and Nanopure™ wash bottles
Sharpies, pens, pencils

Documentation

Sampling site folders (including contact information)
GWR Pilot - Sample Log
GW Rule Pilot Sampling Protocol
Equipment List
DES Inorganic Sample Submission Forms and Templates
Chain-of-Custody Forms and Template
Sample Labels if using

Appendix 2
GW Rule Pilot Sampling
Parameters Analyzed and Sample Submission Forms

Quantitray Analysis
The quantitray analysis uses the enzyme based MMO-MUG method in a tray with multiple depressions. Thus the presence-absence test is run in each depression to provide a sense for the number of bacteria in the sample. This does not provide an absolute number like membrane filtration but it gives a better sense for the number of bacteria by providing the presense or absence of bacteria in each depression. The quantitray result is reported as a most probable number (MPN). For the GW Rule Pilot we are analyzing the bacteria samples for:

- Total coliform
- E. coli, and
- Enterococci

In the microbiologic section of the Sample Submission Form, check the MMO-MUG oval and write Qtray after it, then list TC (for total coliform), EC (for E. coli), and enterococci.

Inorganic Analysis
The primary purpose for the inorganic analysis is to collect some water quality parameters that can be used to suggest oxidation state of the water and the presence of common sewage components. The inorganic analysis includes:

- Nitrate/TKN/Ammonia (nutrient input, oxidation proxy);
- TOC (measure of organic carbon level in ground water);
- Fe, Mn, As (oxidation/reduction proxy);
- Cl, TDS (indicator of septic input relative to background);
- Br (Br/Cl ratio has been used to ID characteristic groups); and
- Phosphate (as septic input indicator).

A GWR Pilot Template for these paramenters was set up for the GW Rule Pilot inorganic samples. Consequently, for the quarterly inorganic samples you do not need to mark all of the inorganic parameters on the Sample Submission Form, but rather, write “GWR Pilot” on the Template line in the parameter section of the Sample Submission Form.

Sample Submission Form Examples
On the following pages example of SSFs are provided:

- The first example is for a **quarterly sample**, for which both inorganic and bacteria samples were collected; and
- The second example is for a **monthly sample** for which just the bacteria sample was collected.

A Chain of Custody Report must be completed for the GW Rule pilot samples sent to DES.

SSF for site where inorganic and bacteria samples are collected

OhioEPA *Division of Environmental Services*

Inorganic Sample Submission Form

DW Certification #4105

DES Use Only

Sample #_____

MM DD YY

Date Received ___ / ___ / ___

Sample Information (INSTRUCTIONS ON BACK) **Parameters**

Client (Bill to) DDAGW

Project Identity GWR PILOT

(project identity **requires prior approval**)

No Folder ○

Division(check one)

DAPC	○
DDAGW	☒
DERR	○
DHWM	○
DSW	○
DSIWM	○
Other	

OEPA District(check one)

CO	☒
CDO	○
NEDO	○
NWDO	○
SEDO	○
SWDO	○
Other	

Sample Type(check one)

Ambient	○	
Complaint	○	
Compliance	○	
Litigation	○	
Survey	☒	
Raw	○	DW only
Plant	○	DW only
Distribution	○	DW only
Other		

Matrix(check one)

Air Filter	○
Drinking water	○
Ground water	☒
Sediment	○
Surface water	○
Waste water	○
Reagent Water	○
Other	

Collection Date

	MM	DD	YY	HH	MM
Grab ☒	08	04	09	09	45
(or) Composite ○ Begin	/	/		/	
End	/	/		/	

Frequency & Duration of Composite Sample:

Container Information

Qty.	Type	Pres.
	Air Filter	
	Cubitainer	NaOH
1	Cubitainer	HNO_3
	Cubitainer	HNO_3_Filt
1	Cubitainer	H_2SO_4
	Cubitainer	H_2SO_4_Filt
1	Cubitainer	N/P
	Cubitainer	N/P_Filt
	Jar	H_2SO_4_Phenol
	Jar	H_2SO_4_O&G
	Sed	Frozen
	Sed	
2	Bacteria	Sterile

Field QC (Check one)

Field Duplicate	○
Field/Equip/Acid Blank	○
MSD	○

Collected By C. KENAH

Customer ID # _____

Station ID # OH7258812

Sample Location

SCHERMERHORN

County: SANDUSKY

Template GWR PILOT

Demand

- ○ ------ % Solids, *Sed only*
- ○ ------ BOD-20 day
- ○ ------ BOD-5 day
- ○ ------ CBOD-20 day
- ○ ------ CBOD-5 day
- ○ ------ Oil&Grease
- ○ ------ Particle Size, *Sed only*
- ○ ------ pH
- ○ ------ Solids_Diss(filt)
- ○ ------ Solids_Suspd(nonfilt)
- ○ ------ Solids_Total
- ○ ------ Solids_Total Volatile
- ○ ------ TOC

Nutrients

- ○ ------ Acidity,Total $CaCO_3$
- ○ ------ AlkalinityTotal $CaCO_3$
- ○ ------ Ammonia
- ○ ------ Bicarbonate
- ○ ------ Chloride
- ○ ------ COD
- ○ ------ Conductivity
- ○ ------ Cyanide_Free (WAD)
- ○ ------ Cyanide_Total
- ○ ------ Fluoride
- ○ ------ Nitrite
- ○ ------ Nitrate+nitrite
- ○ ------ Orthophosphate, Dissolved
- ○ ------ Phenolics, Total w/man dist.
- ○ ------ Phosphorus, Dissolved (Filt)
- ○ ------ Phosphorous, Total
- ○ ------ Sulfate
- ○ ------ TKN

Microbiology

- ○ ------ E. coli
- ○ ------ Fecal Coliform
- ○ ------ Fecal Streptococcus
- ☒ ------ MMO-MUG QTRAY
  - TC
  - EC
  - ENTEROCOCCI

Misc.

- ○ ------ Turbidity
- ○ ------ Chlorophyll_a (see back #5)
- ○ ------ _____
- ○ ------ _____

Metals (Please select one ICP AND one ICPMS package if needed)

- ○ ------ **ICP 1**, *Water only*(Al,Ba,Ca,Fe,Mg,Mn,Na,K,Sr,Zn,Hardness)
- ○ ------ **ICP 2**, *Water only*(Ca,Mg,Hardness)
- ○ ------ **ICP 3**, *Sediment only*(Al,Ba,Ca,Fe,Mg,Mn,Na,K,Sr,Zn)
- ○ ------ **ICP 4**, *SW846 only*(Al,Ba,Ca,Fe,Mg,Mn,Na,K,Sr,Zn,V,Ti,Hardness)
- ○ ------ **ICP 5**, *SW846 SED only*(Al,Ba,Ca,Fe,Mg,Mn,Na,K,Sr,Zn,V,Ti)
- ○ ------ **ICP 6**, *Air Filters only*(Zn,Mn)

- ○ ------ **ICPMS 1**, *Water only*(As,Cd,Cr,Cu,Ni,Pb,Se)
- ○ ------ **ICPMS 2**, *Sediment only*(As,Cd,Cr,Cu,Ni,Pb,Se)
- ○ ------ **ICPMS 3**, *Air Filter only*(As,Cd,Cr,Ni,Pb,Be)
- ○ ------ **ICPMS 4**, *SW846 Water* only (As,Be,Cd,Co,Cr,Cu,Ni,Pb,Se)
- ○ ------ **ICPMS 5**, *SW846 Sediment* only (As,Be,Cd,Co,Cr,Cu,Ni,Pb,Se)

Single element metals - please list only if NOT using Metals packages

- ○ ------ Antimony
- ○ ------ Beryllium
- ○ ------ Cobalt
- ○ ------ Silver
- ○ ------ _____
- ○ ------ _____
- ○ ------ Thallium
- ○ ------ Tin
- ○ ------ Titanium
- ○ ------ Vanadium
- ○ ------ _____
- ○ ------ _____

○ ------ **SW846 (Check this box if single elements require SW846 method)**

The following require prior notification to DES before submittal:

- ○ ------ Mercury
- ○ ------ Chromium, Hexavalent (N/P_Filt)

Other tests are available; please check current price list

Field Comments

Lab Comments

Chlorine,mg/l	Cond,umho/cm	DO,mg/l	ORP	Flow,cfs	Gage Ht, ft	pH, su	% Sat	Temp,oC	TDS	Corr.Cond, umho/cm
P50060	P94	P299		P61	P65	P400		P10		P94

EPA 4709 (1/08) White-Original(DES) Green-DES Yellow-Field Records

Remove yellow copy of form for your records prior to submitting form to DES

All Rush Samples require prior approval

SSF for site where just bacteria samples are collected

OhioEPA *Division of Environmental Services*

Inorganic Sample Submission Form

DW Certification #4105

DES Use Only

Sample # _____

Date Received MM / DD / YY

Sample Information (INSTRUCTIONS ON BACK) **Parameters**

Client (Bill to) DDAGW

Project Identity GWR PILOT (project identity **requires prior approval**)

No Folder ○

Division(check one)		**OEPA District**(check one)	
DAPC	○	CO	☒
DDAGW	☒	CDO	○
DERR	○	NEDO	○
DHWM	○	NWDO	○
DSW	○	SEDO	○
DSIWM	○	SWDO	○
Other		Other	

Sample Type(check one)		**Matrix**(check one)	
Ambient	○	Air Filter	○
Complaint	○	Drinking water	○
Compliance	○	Ground water	☒
Litigation	○	Sediment	○
Survey	☒	Surface water	○
Raw	○	Waste water	○
Plant	○ DW only	Reagent Water	○
Distribution	○	Other	
Other			

Collection Date

	MM	DD	YY	HH	MM
Grab ☒	08	04	09	15	15
(or)					
Composite ○ Begin	/	/		/	
End	/	/		/	

Frequency & Duration of Composite Sample:

Container Information

Qty.	Type	Pres.
	Air Filter	
	Cubitainer	NaOH
	Cubitainer	HNO_3
	Cubitainer	HNO_3_Filt
	Cubitainer	H_2SO_4
	Cubitainer	H_2SO_4_Filt
	Cubitainer	N/P
	Cubitainer	N/P_Filt
	Jar	H_2SO_4_Phenol
	Jar	H_2SO_4_O&G
	Sed	Frozen
	Sed	
2	Bacteria	Sterile

Field QC (Check one)

Field Duplicate ○

Field/Equip/Acid Blank ○

MSD ○

Collected By C. KENAH

Customer ID # _____

Station ID # OH0232612

Sample Location RED CANERY

County: ALLEN

Template _____

Demand

- ○ ------ % Solids, *Sed only*
- ○ ------ BOD-20 day
- ○ ------ BOD-5 day
- ○ ------ CBOD-20 day
- ○ ------ CBOD-5 day
- ○ ------ Oil&Grease
- ○ ------ Particle Size, *Sed only*
- ○ ------ pH
- ○ ------ Solids_Diss(filt)
- ○ ------ Solids_Suspd(nonfilt)
- ○ ------ Solids_Total
- ○ ------ Solids_Total Volatile
- ○ ------ TOC

Nutrients

- ○ ------ Acidity,Total $CaCO_3$
- ○ ------ AlkalinityTotal $CaCO_3$
- ○ ------ Ammonia
- ○ ------ Bicarbonate
- ○ ------ Chloride
- ○ ------ COD
- ○ ------ Conductivity
- ○ ------ Cyanide_Free (WAD)
- ○ ------ Cyanide_Total
- ○ ------ Fluoride
- ○ ------ Nitrite
- ○ ------ Nitrate+nitrite
- ○ ------ Orthophosphate, Dissolved
- ○ ------ Phenolics, Total w/man dist.
- ○ ------ Phosphorus, Dissolved (Filt)
- ○ ------ Phosphorous, Total
- ○ ------ Sulfate
- ○ ------ TKN

Microbiology

- ○ ------ E. coli
- ○ ------ Fecal Coliform
- ○ ------ Fecal Streptococcus
- ☒ ------ MMO-MUG QTRAY TC EC ENTEROCOCCI

Misc.

- ○ ------ Turbidity
- ○ ------ Chlorophyll_a (see back #5)
- ○ ------ _____
- ○ ------ _____

Metals (Please select one ICP AND one ICPMS package if needed)

- ○ ------ **ICP 1**, *Water only*(Al,Ba,Ca,Fe,Mg,Mn,Na,K,Sr,Zn,Hardness)
- ○ ------ **ICP 2**, *Water only*(Ca,Mg,Hardness)
- ○ ------ **ICP 3**, *Sediment only*(Al,Ba,Ca,Fe,Mg,Mn,Na,K,Sr,Zn)
- ○ ------ **ICP 4**, *SW846 only*(Al,Ba,Ca,Fe,Mg,Mn,Na,K,Sr,Zn,V,Ti,Hardness)
- ○ ------ **ICP 5**, *SW846 SED only*(Al,Ba,Ca,Fe,Mg,Mn,Na,K,Sr,Zn,V,Ti)
- ○ ------ **ICP 6**, *Air Filters only*(Zn,Mn)
- ○ ------ **ICPMS 1**, *Water only*(As,Cd,Cr,Cu,Ni,Pb,Se)
- ○ ------ **ICPMS 2**, *Sediment only*(As,Cd,Cr,Cu,Ni,Pb,Se)
- ○ ------ **ICPMS 3**, *Air Filter only*(As,Cd,Cr,Ni,Pb,Be)
- ○ ------ **ICPMS 4**, *SW846 Water* only (As,Be,Cd,Co,Cr,Cu,Ni,Pb,Se)
- ○ ------ **ICPMS 5**, *SW846 Sediment* only (As,Be,Cd,Co,Cr,Cu,Ni,Pb,Se)

Single element metals - please list only if NOT using Metals packages

- ○ ------ Antimony
- ○ ------ Beryllium
- ○ ------ Cobalt
- ○ ------ Silver
- ○ ------ _____
- ○ ------ _____
- ○ ------ Thallium
- ○ ------ Tin
- ○ ------ Titanium
- ○ ------ Vanadium
- ○ ------ _____
- ○ ------ _____

○ ------ **SW846 (Check this box if single elements require SW846 method)**

The following require prior notification to DES before submittal:

- ○ ------ Mercury
- ○ ------ Chromium, Hexavalent (N/P_Filt)

Other tests are available; please check current price list

Field Comments

Chlorine,mg/l	Cond,umho/cm	DO,mg/l	ORP	Flow,cfs	Gage Ht, ft	pH, su	% Sat	Temp,oC	TDS	Corr.Cond, umho/cm
P50060	P94	P299		P61	P65	P400		P10		P94

Lab Comments

EPA 4709 (1/08) White-Original(DES) Green-DES Yellow-Field Records

Remove yellow copy of form for your records prior to submitting form to DES

All Rush Samples require prior approval

Appendix 3
GW Rule Pilot Sampling

The procedure for collecting total coliform samples is included because it defines the minimum concentration of the Clorox solution (section 1 e) and provides disinfection options. The GW Rule Pilot adds the use of a disinfected toothbrush to help clean debris and bioslimes from the sample tap.

Collection of Drinking Water Samples for Total Coliform Bacteria Analyses

The following is the approved procedure for the collection of drinking water samples for analysis of total coliform, as detailed in the methods approved in Ohio Administrative Code rule 3745-81-27. The following procedure should be followed **in detail** to ensure a valid laboratory analysis.

1) Select the sampling tap.
   a) A tap, such as faucet or small valve, is preferable. Do not sample from hoses or drinking water fountains.
   b) Avoid taps with a leak at the stem or taps with a swivel joint.
   c) Aerated or screened nozzles may harbor bacteria. The aerator or screen must be removed before collection of the sample.
   d) Place all carbon filters, sediment filters and water softeners on bypass unless operated by the public water system.
   e) Sanitize the nozzle of the tap with a chlorine solution.
      i) Use a 6% sodium hypochlorite solution, such as household liquid bleach. **Do not use chlorine solutions with special scents**. To prepare a sanitizing solution, add one ounce of bleach to one gallon of water (or 1 tablespoon per half-gallon). Store the mixed solution in a tightly closed screw-capped container. The solution should be discarded and remade 6 months after preparation. Stronger solutions can be used, however, some faucet discoloration may result.
      ii) Flush the sample tap to waste for 1 minute. Close the valve.
      iii) Apply the sanitizing solution prepared in step (i) above to the nozzle. This can be accomplished by either using a spray bottle or a plastic bag.
         (1) Using a spray bottle, saturate the tap opening with sanitizing solution then wait at least 2 minutes before proceeding.
         or
         (2) Place a bag over the nozzle and hold the top of the bag tightly on the tap. Alternately squeeze and release the bag to flush the solution in and out of the tap. Do this for 2 minutes. A fresh solution and bag must be used to sanitize each tap.
2) Flush the tap.
   The sample to be collected is intended to be representative of the water in the main. The tap must be opened fully and the water run to waste for at least 3-5 minutes to allow for adequate flushing of the piping between the tap and water main.
3) Reduce the flow from the tap to allow the sample bottle to be filled without splashing.
4) Open the sample bottle.

   a) Grasp the bottom of the sample bottle.
   b) Remove the cap and hold the exterior of the cap between your fingers while filling the sample bottle. Do not lay the cap down. Take care to not touch the mouth of the sample bottle or the inside of the cap with fingers as the sample could become contaminated.
   c) The sample bottle must be open only during the collection of the sample.
5) Fill the sample bottle.
   a) Do not rinse out the sample bottle before collecting the sample. Do not remove any pills, powder, or liquid from the sample bottle. The sample bottle contains a small amount of sodium thiosulfate to neutralize any chlorine in the water.
   b) Do not touch the rim or mouth of the sample bottle during collection of the sample.
   c) Do not overflow the sample bottle. Fill the sample bottle to within ½” - 1" of the top or to the indicator line on the sample bottle.
6) Immediately recap the sample bottle tightly.
   If there is any question as to whether a sample has become contaminated during collection of the sample, the sample must be discarded and a new sample collected in a new sample bottle.
7) Deliver the sample to the laboratory as soon as possible.
   The laboratory must receive the sample so that analysis can be initiated within 30 hours after collection. Allow the laboratory adequate time to analyze the sample. Certified laboratories will not test samples greater than 30 hours old because the results will be invalid.
8) Additional information.
   a) A bacteriological sample report form is supplied with each sample bottle. The top half of the form is to be filled out in a legible manner using either indelible pen, rubber stamp, or typewriter. Do not use a fountain pen or other pens having water soluble ink.
   b) Samples must be collected in sample bottles supplied by the certified laboratory.
   c) Bacteriological sample report forms that have not been properly completed as to name of water system, PWS ID#, address, date and time of collection, and signature of collector will not be accepted for bacteriological examination.

Appendix C - GWR Pilot - Microbial and Inorganic Results – Annual Average

Location	PWSID	Well-ID	Latitude	Longitude	Well Depth	Well Casing Length	QUANTITRAY								
							Total Coliform	E. coli	Entero-cocci	#enteroc+/ #samples	Enterococci Frequency	#EC+/ #samples	EC Frequency	#TC+/ #samples	TC Frequency
Units (Reporting					feet	feet	MPN	MPN	MPN						
Red Canery	OH0232612	WL78024	40.6952	-83.982261	34	28	0	0	0	0/10	0%	0/10	0%	0/10	0%
Southgate Lanes	OH0249812	WL78311	40.8803	-83.908967	124	27	0	0	0	0/12	0%	0/12	0%	0/12	0%
Carrollton 2	OH1000012	WL80646	40.6233	-81.089836	130	22	3.64	0.29	0	0/14	0%	2/14	14%	6/14	43%
Carrollton 4	OH1000012	WL80650	40.6265	-81.091014	100	30	195	0.29	0.87	2/15	13%	4/15	27%	13/15	87%
Carrollton 5	OH1000012	WL80654	40.6195	-81.089964	100	18	2.75	1.12	0.25	1/8	13%	1/8	13%	5/8	63%
Carmichael Machine	OH1230412	WL81783	39.9211	-83.914697	100	37	0.3	0	0	0/10	0%	0/10	0%	1/10	10%
Heritage Fellowship	OH1247412	WL82309	39.9256	-83.91485	100	57	368	0.16	8.2	3/6	50%	1/6	17%	5/6	83%
Makoy	OH2557212	WL133834	40.037	-83.163723	186	90	23.4	0.15	0.77	3/13	23%	2/13	15%	6/13	46%
Greenfield 8	OH3600312	WL92229	39.3542	-83.377333	26	20.5	0.15	0	0	0/13	0%	0/13	0%	2/13	15%
Living Word	OH3841512	WL93165	40.6529	-81.856311	74	62	0.58	0	0	0/12	0%	0/12	0%	3/12	25%
Zion Hill	OH5048112	WL98465	40.9063	-80.706144	70	61	36.5	0	0.08	1/13	8%	0/13	0%	3/13	23%
Elizabeth Township	OH5537712	WL100804	39.9992	-84.101756	130	40	4.1	0	0.11	1/9	11%	0/10	0%	6/10	60%
Phillipsburg 2	OH5702112	WL101587	39.9077	-84.399614	137	22.5	2.4	0	0	0/10	0%	0/10	0%	1/10	10%
Phillipsburg 3	OH5702112	WL101589	39.9031	-84.40525	101	27	0.63	0	0	0/8	0%	0/8	0%	1/8	13%
Gratis Well 2	OH6800612	WL113475	39.6567	-84.511564	23	18	10.1	0.09	0.18	1/11	9%	1/11	9%	10/11	91%
C M Schermerhorn	OH7258812	WL149439	41.3414	-83.152222	144	25	39.5	0.55	0.27	2/11	18%	2/11	18%	9/11	82%
Camp Luz	OH8532912	WL125435	40.7934	-81.741483	54	54	0.31	0	0	0/13	0%	0/13	0%	1/13	8%
Wayne Lanes	OH8554112	WL126050	40.7948	-81.909003	170	103	114	6	4.5	3/13	23%	2/13	15%	7/13	54%
Sandy Point	OH0239412	WL78199	40.8329	-84.165642	60	56	0	0	0	0/4	0%	0/4	0%	0/4	0%
Nelsonville	OH0501214	WL79551	39.4625	-82.249317	70	42.5	3	0	0.14	1/7	14%	0/7	0%	3/7	43%

Appendix C - GWR Pilot - Microbial and Inorganic Results – Annual Average

Location	INORGANIC												
	Nitrate	Ammonia	TKN	Total Phosphorus	Chloride	Bromide	Cl/Br	Sulfate	Iron	Arsenic	Manganese	TOC	TDS
Units (Reporting	mg/L (0.10)	mg/L (0.05)	mg/L (0.2)	mg/L (0.01)	mg/L (5)	µg/L (20)		mg/L (10)	µg/L (50)	µg/L (2)	µg/L (10)	mg/L (2)	mg/L (10)
Red Canery	0.1	0.197	0.4	0.01	71.8	64.5	1113	127	2148	2.28	34	2	697
Southgate Lanes	0.1	0.231	0.43	0.01	37	68.6	539	229	50	2	16.8	2	765
Carrollton 2	0.1	0.058	0.22	0.125	20.3	25.5	796	28.5	287	2	80.5	2	311
Carrollton 4	0.27	0.05	0.2	0.022	16.7	36.2	461	19.9	60	2	10	2	286
Carrollton 5	0.31	0.05	0.27	0.01	30.7	21.2	1448	36.5	82	2	10	2	233
Carmichael Machine	0.25	0.064	0.31	0.01	59	37.8	1561	38.3	513	12.28	48.2	2	493
Heritage Fellowship	0.18	0.065	0.21	0.01	12	22.4	536	24.5	1179	15.2	62.5	2	391
Makoy	0.1	0.501	0.46	0.011	5	33.5	149	123.6	686	21	70.7	2	580
Greenfield 8	3.3	0.05	0.26	0.025	29.8	29.5	1010	28.1	50	2	10	2	421
Living Word	2.18	0.073	0.2	0.01	10.5	43	244	50.2	118	2	10	2	381
Zion Hill	0.14	0.05	0.32	0.021	22.4	32.8	683	125	645	2	529	2	523
Elizabeth Township	6.44	0.061	0.24	0.097	47.1	48.5	971	48.9	87.7	2.2	10	2	496
Phillipsburg 2	5.28	0.06	0.22	0.01	70	58.9	1188	24.6	53.4	2	10	2.02	529
Phillipsburg 3	4.9	0.056	0.22	0.01	53.7	51.2	1049	29.6	50	2	10	2	491
Gratis Well 2	4.27	0.055	0.21	0.01	30.9	27.7	1116	22.1	50	2	10	2	386
C M Schermerhorn	0.19	0.055	1.23	0.01	41.8	48.8	857	76.1	355	2	47	2.4	520
Camp Luz	0.1	0.229	0.368	0.0115	20.9	32.4	645	21.1	1080	2	187	2	257
Wayne Lanes	0.21	0.05	0.21	0.01	42.3	84.9	498	36	160	2	20.8	2	296
Sandy Point	0.1	0.353	0.43	0.02	18	136	132	158	1523	2	32	2	595
Nelsonville	0.1	0.097	0.31	0.01	90.2	306	295		734	2.75	328	2	462

Appendix C - GWR Pilot - Microbial and Inorganic Results – Annual Average

Location	FIELD PARAMETERS					
	pH	Temperature	Specific Conductivity	ORP	TDS	Total Chlorine
Units (Reporting	SU	^{o}C	umhos/ cm	mV	mg/L	mg/L
Red Canery	7.17	14.2	1016	-84	716	0.006
Southgate Lanes	7.09	13	1051	-177	744	0.013
Carrollton 2	7.2	12	503	119	346	0
Carrollton 4	726	11.7	486	176	334	0
Carrollton 5	7.07	11.7	403	160	278	0
Carmichael Machine	7.29	13.9	841	9.5	585	0
Heritage Fellowship	7.34	13.1	666	11	459	0
Makoy	7.09	13.6	894	33.4	618	0
Greenfield 8	7.13	11.8	722	275	494	0.04
Living Word	6.92	13.6	612	202	423	0
Zion Hill	7.01	12.8	792	103	550	0
Elizabeth Township	7.14	13.7	838	249	581	0
Phillipsburg 2	6.93	12.4	912	303	633	0
Phillipsburg 3	678	13.2	831	436	578	0
Gratis Well 2	7.13	12.7	659	263	454	0
C M Schermerhorn	7.13	13.1	767	51	536	0.032
Camp Luz	7.24	12.6	429	49.9	291	0
Wayne Lanes	7	14	507	285	346	0
Sandy Point	7.25	15.2	930	-80.5	649	0.015
Nelsonville	7.34	18.7	752	-31.7	494	0

Appendix D - Individual Sample Results

Site Name	PWSID	Well_ID	Sample	Date Collected	Collected By	Ammonia	Arsenic	Bromide	Chloride	Iron	Manganese	Nitrate	Enterococci ND= 0	Enterococci 1= ND or 1	E. coli ND=0	E. coli 1= ND or 1
Units						mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	mg/L	MPN	MPN	MPN	MPN
C M Schermerhorn	OH7258812	WL149439	113937	08/04/2009 09:45	KENAH, CHRIS	0.05	2	47.9	28.7	338	47	0.45	0	1	0	1
C M Schermerhorn	OH7258812	WL149439	115370	09/02/2009 09:35	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
C M Schermerhorn	OH7258812	WL149439	116760	10/07/2009 09:30	ZAJKOWSKI, CHAD	0.067	2	56.6	56.5	300	50	0.1	0	1	1	1
C M Schermerhorn	OH7258812	WL149439	117777	11/04/2009 09:30	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
C M Schermerhorn	OH7258812	WL149439	118362	12/09/2009 09:20	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	1	1	0	1
C M Schermerhorn	OH7258812	WL149439	118600	01/11/2010 09:30	ZAJKOWSKI, CHAD	0.055	2	45.2	42.5	473	49	0.1	0	1	0	1
C M Schermerhorn	OH7258812	WL149439	118780	02/16/2010 09:25	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
C M Schermerhorn	OH7258812	WL149439	119180	03/22/2010 10:05	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
C M Schermerhorn	OH7258812	WL149439	119570	04/14/2010 09:30	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
C M Schermerhorn	OH7258812	WL149439	120281	05/12/2010 09:30	ZAJKOWSKI, CHAD	0.05	2	45.4	39.6	308	42	0.1	0	1	0	1
C M Schermerhorn	OH7258812	WL149439	120859	06/09/2010 09:30	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	2	2	5	5
Site Average						0.0555	2	48.775	41.825	354.75	47	0.1875	0.27272727	1.09090909	0.545454545	1.363636364
Camp Luz	OH8532912	WL125435	112341	06/29/2009 13:00	KENAH, CHRIS	0.255	2	29.6	19.9	1030	189	0.1	0	1	0	1
Camp Luz	OH8532912	WL125435	113470	07/28/2009 13:45	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Camp Luz	OH8532912	WL125435	115315	09/01/2009 16:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Camp Luz	OH8532912	WL125435	116492	09/30/2009 16:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Camp Luz	OH8532912	WL125435	117588	10/27/2009 16:30	KOCHER, RUSS	0.227	2	30.4	21	1050	184	0.1	0	1	0	1
Camp Luz	OH8532912	WL125435	118036	11/18/2009 16:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Camp Luz	OH8532912	WL125435	118457	12/16/2009 16:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Camp Luz	OH8532912	WL125435	118680	01/26/2010 16:30	KOCHER, RUSS	0.214	2	40	21.6	1160	194	0.1	0	1	0	1
Camp Luz	OH8532912	WL125435	118818	02/24/2010 16:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Camp Luz	OH8532912	WL125435	119338	03/31/2010 16:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Camp Luz	OH8532912	WL125435	120026	05/05/2010 16:30	KOCHER, RUSS	0.22	2	29.4	21.2	1080	180	0.1	0	1	0	1
Camp Luz	OH8532912	WL125435	120607	05/26/2010 16:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Camp Luz	OH8532912	WL125435	121665	06/30/2010 16:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Site Average						0.229	2	32.35	20.925	1080	186.75	0.1	0	1	0	1
Carmichael Machine	OH1230412	WL81783	113192	07/20/2009 13:30	KENAH, CHRIS	0.05	12.7	40.7	57.3	512	46	0.1	0	1	0	1
Carmichael Machine	OH1230412	WL81783	115002	08/26/2009 15:15	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Carmichael Machine	OH1230412	WL81783	116177	09/23/2009 16:30	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Carmichael Machine	OH1230412	WL81783	117251	10/20/2009 14:50	MCGINNIS, JOHN	0.05	13.5	40.3	53.7	552	45	0.1	0	1	0	1
Carmichael Machine	OH1230412	WL81783	118356	12/08/2009 15:10	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Carmichael Machine	OH1230412	WL81783	118645	01/19/2010 15:15	MCGINNIS, JOHN	0.05	12.6	39	57.2	529	42	0.24	0	1	0	1
Carmichael Machine	OH1230412	WL81783	118938	03/09/2010 15:45	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Carmichael Machine	OH1230412	WL81783	119919	04/28/2010 15:40	MCGINNIS, JOHN	0.119	10.7	38	66.2	491	56	0.1	0	1	0	1
Carmichael Machine	OH1230412	WL81783	120722	06/02/2010 14:45	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Carmichael Machine	OH1230412	WL81783	122703	07/21/2010 14:45	MCGINNIS, JOHN	0.05	11.9	30.8	60.7	481	52	0.72	0	1	0	1
Site Average						0.0638	12.28	37.76	59.02	513	48.2	0.252	0	1	0	1
Carrollton 2	OH1000012	WL80646	113467	07/28/2009 09:30	KENAH, CHRIS	0.06	2	25.9	18.4	247	84	0.1	0	1	0	1
Carrollton 2	OH1000012	WL80646	115310	09/01/2009 10:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	2	2
Carrollton 2	OH1000012	WL80646	116489	09/30/2009 10:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 2	OH1000012	WL80646	117590	10/27/2009 10:30	KOCHER, RUSS	0.07	2	24.9	17.7	291	85	0.1	0	1	0	1
Carrollton 2	OH1000012	WL80646	118032	11/18/2009 10:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 2	OH1000012	WL80646	118452	12/16/2009 10:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 2	OH1000012	WL80646	118683	01/26/2010 10:00	KOCHER, RUSS	0.05	2	24.6	21.6	377	83	0.1	0	1	0	1
Carrollton 2	OH1000012	WL80646	118815	02/24/2010 10:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 2	OH1000012	WL80646	119333	03/31/2010 10:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 2	OH1000012	WL80646	120030	05/05/2010 10:30	KOCHER, RUSS	0.053	2	26.6	23.4	235	70	0.1	0	1	0	1
Carrollton 2	OH1000012	WL80646	120603	05/26/2010 10:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1

Appendix D - Individual Sample Results Continued

Total Coliform ND= 0 MPN	Total Coliform 1 = ND or 1 MPN	Sulfate mg/L	TKN mg/L	TOC mg/L	TDS mg/L	Total Phosphorus mg/L	QC		pH SU	Temperature C°	Specific Conductivity umhos/cm	ORP mV	TDS mg/L	Total Chlorine mg/l
40	40	0	0.44	2.4	516	0.01	N		7.31	18.7	749	102	513	0
23	23	0	0	0	0	0	N		7.04	16	760	24	522	0
74	74	0	0.28	2.5	552	0.01	N		7.11	14.9	810	44	567	0
5	5	0	0	0	0	0	N		7.14	14.1	768	44	537	0.06
6	6	0	0	0	0	0	N		7.13	12.2	799	4	562	0.04
0	1	0	0.2	2.7	496	0.01	N		7.14	10.7	769	44	542	0
0	1	0	0	0	0	0	N		7.15	8.1	789	99	558	0.03
1	1	0	0	0	0	0	N		7.1	10	755	56	533	0.04
6	6	0	0	0	0	0	N		7.14	11.5	742	87	521	0.05
60	60	76.1	3.99	2.1	516	0.01	N		7.12	12.6	752	57	527	0
219	219	0	0	0	0	0	N		7.02	15	742	0	517	0.13
39.45454545	39.63636364	76.1	1.2275	2.425	520	0.01			7.127273	13.07272727	766.818182	51	536.2727	0.031818
0	1	0	0.2	2	264	0.01	N		7.15	13.6	438	48	295	
0	1	0	0	0	0	0	N		7.13	12.4	428	43	288	0
0	1	0	0	0	0	0	N			14.9	436	9	289	0
0	1	0	0	0	0	0	N		7.01	13	441	151	299	0
0	1	0	0.65	2	262	0.016	N		7.32	12.8	434	32	292	0
0	1	0	0	0	0	0	N		7.36	11.9	438	77	295	0
0	1	0	0	0	0	0	N		7.15	11.1	441	65	297	0
0	1	20.9	0.39	2	248	0.01	N		7.26	11.2	434	14	293	0
0	1	0	0	0	0	0	N		7.13	11.1	430	60	289	0
0	1	0	0	0	0	0	N		7.39	11.8	414	29	288	0
0	1	21.3	0.23	2	254	0.01	N		7.41	13.4	421	7	288	0
0	1	0	0	0	0	0	N		7.5	13.9	418	39	290	0
4	4	0	0	0	0	0	N		7.03	12.9	403	75	286	0
0.307692308	1.230769231	21.1	0.3675	2	257	0.0115		0	7.236667	12.61538462	428.923077	49.92308	291.4615	0
0	1	0	0.2	2	484	0.01	N		7.06	14.3	850	40	586	0
3	3	0	0	0	0	0	N		7.08	14.4	841	54	580	0
0	1	0	0	0	0	0	N		7.37	14.6	823	20	580	0
0	1	0	0.2	2	500	0.01	N		7.37	13.7	835	-7	580	0
0	1	0	0	0	0	0	N		7.21	13.6	835	-4	582	0
0	1	0	0.73	2	498	0.01	N		7.28	13.1	843	6	588	0
0	1	0	0	0	0	0	N		7.36	12.2	840	-2	586	0
0	1	37.9	0.2	2	492	0.01	N		7.4	13.7	855	-5	590	0
0	1	0	0	0	0	0	N		7.45	15.5	851	-16	592	0
0	1	38.7	0.2	2	492	0.01	N							0
0.3	1.2	38.3	0.306	2	493.2	0.01			7.286667	13.9	841.444444	9.555556	584.8889	0
0	1	35.6	0.2	2	300	0.468	N		7.1	11.9	535	82	363	0
12	12	0	0	0	0	0	N		6.9	11.9	543	86	368	0
0	1	0	0	0	0	0	N		7.2	11.6	542	134	370	0
0	1	0	0.2	2	322	0.013	N		7.22	12.1	533	84	362	0
0	1	0	0	0	0	0	N		7.38	11.7	547	40	372	0
7	7	0	0	0	0	0	N		7.15	10.8	549	115	372	0
0	1	39.9	0.27	2	298	0.01	N		7.26	12.2	507	76	343	0
0	1	0	0	0	0	0	N		7.16	12.3	491	85	331	0
0	1	0	0	0	0	0	N		7.4	11.9	458	126	319	0
0	1	38.4	0.2	2	326	0.01	N		7.35	12.5	502	95	348	0
3	3	0	0	0	0	0	N		7.48	12.4	481	193	336	0

Site Name	PWSID	Well_ID	Sample	Date Collected	Collected By	Ammonia	Arsenic	Bromide	Chloride	Iron	Manganese	Nitrate	Enterococci ND= 0	Enterococci 1= ND or 1	E. coli ND=0	E. coli 1= ND or 1
Units						mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	mg/L	MPN	MPN	MPN	MPN
Carrollton 2	OH1000012	WL80646	120604	05/26/2010 11:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 2	OH1000012	WL80646	121660	06/30/2010 10:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 2	OH1000012	WL80646	123197	07/28/2010 10:30	KOCH, TOM	0	0	0	0	0	0	0	0	1	2	2
Site Average						0.05825	2	25.5	20.275	287.5	80.5	0.1	0	1	0.285714286	1.142857143
Carrollton 4	OH1000012	WL80650	113465	07/28/2009 08:45	KENAH, CHRIS	0.05	2	39	14.5	64	10	0.24	0	1	0	1
Carrollton 4	OH1000012	WL80650	113466	07/28/2009 08:45	KENAH, CHRIS	0.05	2	39.2	14.3	58	10	0.26	0	1	0	1
Carrollton 4	OH1000012	WL80650	115314	09/01/2009 11:50	KOCHER, RUSS	0	0	0	0	0	0	0	11	11	10	10
Carrollton 4	OH1000012	WL80650	116490	09/30/2009 11:00	KOCHER, RUSS	0	0	0	0	0	0	0	2	2	16	16
Carrollton 4	OH1000012	WL80650	117585	10/27/2009 11:30	KOCHER, RUSS	0.05	2	37.8	19.3	50	10	0.2	0	1	1	1
Carrollton 4	OH1000012	WL80650	118033	11/18/2009 11:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 4	OH1000012	WL80650	118454	12/16/2009 11:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	3	3
Carrollton 4	OH1000012	WL80650	118679	01/26/2010 11:30	KOCHER, RUSS	0.05	2	33.3	22	50	10	0.32	0	1	0	1
Carrollton 4	OH1000012	WL80650	118819	02/24/2010 12:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 4	OH1000012	WL80650	119335	03/31/2010 12:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 4	OH1000012	WL80650	120031	05/05/2010 12:00	KOCHER, RUSS	0.05	2	31.6	13.3	78	10	0.33	0	1	0	1
Carrollton 4	OH1000012	WL80650	120605	05/26/2010 12:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 4	OH1000012	WL80650	121662	06/30/2010 12:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 4	OH1000012	WL80650	123199	07/28/2010 12:30	KOCH, TOM	0	0	0	0	0	0	0	0	1	0	1
Carrollton 4	OH1000012	WL80650	123200	07/28/2010 12:30	KOCH, TOM	0	0	0	0	0	0	0	0	1	0	1
Site Average						0.05	2	36.18	16.68	60	10	0.27	0.86666667	1.73333333	2	2.733333333
Carrollton 5	OH1000012	WL80654	118453	12/16/2009 10:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 5	OH1000012	WL80654	118682	01/26/2010 10:30	KOCHER, RUSS	0.05	2	20	23.5	64	10	0.38	0	1	0	1
Carrollton 5	OH1000012	WL80654	118814	02/24/2010 11:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 5	OH1000012	WL80654	119334	03/31/2010 11:00	KOCHER, RUSS	0	0	0	0	0	0	0	2	2	9	9
Carrollton 5	OH1000012	WL80654	120032	05/05/2010 11:00	KOCHER, RUSS	0.05	2	22.4	37.9	100	10	0.23	0	1	0	1
Carrollton 5	OH1000012	WL80654	120604	5/26/2010 11:00	KOCHER, RUSS								0	1	0	1
Carrollton 5	OH1000012	WL80654	121661	06/30/2010 11:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Carrollton 5	OH1000012	WL80654	123198	07/28/2010 11:30	KOCH, TOM	0	0	0	0	0	0	0	0	1	0	1
Site Average						0.05	2	21.2	30.7	82	10	0.305	0.25	1.125	1.125	2
Danville Church	OH4243012	WL240951	112344	06/29/2009 17:45	KENAH, CHRIS	0.09	2	43	17.7	50	60	0.1	0	1	0	1
Danville Church	OH4243012	WL240951	116765	10/07/2009 08:30	KENAH, CHRIS	0.092	2	40.8	18.1	50	204	0.1	0	1	0	1
Danville Church	OH4243012	WL240951	117778	11/04/2009 08:30	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	1	1
Danville Church	OH4243012	WL240951	118243	12/02/2009 08:15	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Double J	OH2350912	WL255383	112810	07/14/2009 17:30	KENAH, CHRIS	0.05	2	20	5	15900	212	0.63	0	1	0	1
Double J	OH2350912	WL255383	115318	09/01/2009 11:30	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Double J	OH2350912	WL255383	116767	10/07/2009 13:45	KENAH, CHRIS	0.05	2	22.8	5.9	12200	75	1.28	0	1	0	1
Double J	OH2350912	WL255383	117780	11/04/2009 13:25	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Double J	OH2350912	WL255383	118245	12/02/2009 12:45	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Elizabeth Township	OH5537712	WL100804	113193	07/20/2009 15:00	KENAH, CHRIS	0.05	2	31.9	46.7	50	10	6.86	0	1	0	1
Elizabeth Township	OH5537712	WL100804	115001	08/26/2009 13:30	KENAH, CHRIS	0	0	0	0	0	0	0	1	1	0	1
Elizabeth Township	OH5537712	WL100804	116178	09/23/2009 15:30	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Elizabeth Township	OH5537712	WL100804	117250	10/20/2009 13:40	MCGINNIS, JOHN	0.05	3.1	49.5	45.1	239	10	5.72	0	1	0	1
Elizabeth Township	OH5537712	WL100804	118355	12/08/2009 15:55	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Elizabeth Township	OH5537712	WL100804	118642	01/19/2010 14:05	MCGINNIS, JOHN	0.05	2	27.3	45.4	50	10	6.22			0	1
Elizabeth Township	OH5537712	WL100804	118937	03/09/2010 14:25	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Elizabeth Township	OH5537712	WL100804	119920	04/28/2010 14:20	MCGINNIS, JOHN	0.105	2	100	48.9	50	10	6.65	0	1	0	1
Elizabeth Township	OH5537712	WL100804	120721	06/02/2010 13:40	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Elizabeth Township	OH5537712	WL100804	122704	07/21/2010 13:40	MCGINNIS, JOHN	0.05	2	34	49.4	50	10	6.73	0	1	0	1
Site Average						0.061	2.22	48.54	47.1	87.8	10	6.436	0.11111111	1	0	1
Gratis Well 2	OH6800612	WL113475	113190	07/20/2009 09:45	KENAH, CHRIS	0.05	2	25	19	50	10	5.32	2	2	1	1
Gratis Well 2	OH6800612	WL113475	114999	08/26/2009 09:45	KENAH, CHRIS	0.05	2	29.1	22.6	50	10	5.16	0	1	0	1

Total Coliform ND= 0 MPN	Total Coliform 1 = ND or 1 MPN	Sulfate mg/L	TKN mg/L	TOC mg/L	TDS mg/L	Total Phosphorus mg/L	QC	pH SU	Temperature C°	Specific Conductivity umhos/cm	ORP mV	TDS mg/L	Total Chlorine mg/l
4	4	0	0	0	0	0	N	7.42	11.8	406	198	281	0
1	1	0	0	0	0	0	N	7.68	11.8	484	155	348	0
16	16	0	0	0	0	0	N	6.19	13	457	190	325	0
3.071428571	3.642857143	28.475	0.2175	2	311.5	0.12525		7.206429	11.99285714	502.5	118.5	345.5714	0
1	1	22.9	0.2	2	272	0.028	Y	7.14	11.4	483	125	327	0
0	1	23.5	0.2	2	274	0.027	Y	7.14	11.4	483	125	327	0
2419	2419	0	0	0	0	0	N		13	502	67	338	0
345	345	0	0	0	0	0	N	7.15	11.5	525	136	358	0
26	26	0	0.2	2	316	0.026	N	7.21	11.5	529	115	359	0
5	5	0	0	0	0	0	N	7.3	11.8	532	117	361	0
62	62	0	0	0	0	0	N	7.22	10.3	531	129	360	0
19	19	28.1	0.21	2	300	0.016	N	7.26	11.1	510	129	346	0
0	1	0	0	0	0	0	N	7.15	11.8	501	191	339	0
1	1	0	0	0	0	0	N	7.4	12.1	462	173	322	0
6	6	25	0.2	2	270	0.014	N	7.44	12	447	159	311	0
16	16	0	0	0	0	0	N	7.47	11.9	471	212	328	0
2	2	0	0	0	0	0	N	7.38	12	482	158	345	0
15	15	0	0	0	0	0	Y	7.21	12.2	420	175	297	0
7	7	0	0	0	0	0	Y	7.21	12.2	420	175	297	0
194.9333333	195.0666667	19.9	0.202	2	286.4	0.0222		7.262857	11.74666667	486.533333	145.7333	334.3333	0
1	1	0	0	0	0	0	N	6.92	10.5	384	115	257	0
0	1	35.8	0.33	2	210	0.01	N	7.11	11.7	350	90	233	0
0	1	0	0	0	0	0	N	6.8	11.7	388	153	260	
14	14	0	0	0	0	0	N	7.15	11.3	390	195	272	0
0	1	37.3	0.2	2	256	0.01	N	7.24	11.6	423	109	293	0
4	4							7.42	11.8	406	198	281	0
2	2	0	0	0	0	0	N	7.32	11.9	427	176	307	0
1	1	0	0	0	0	0	N	6.63	13.1	458	248	325	0
2.75	3.125	36.55	0.265	2	233	0.01	N	7.07375	11.7	403.25	160.5	278.5	0
0	1	0	0.2	2	278	0.01	N	7.15	13.3	459	260	309	
0	1	0	0.2	2	268	0.01	N	7.52	12.1	479	252	324	0.11
82	82	0	0	0	0	0	N	7.34	12	423	338	285	0.05
4	4	0	0	0	0	0	N	7.1	12	384	495	257	0
111	111	0	0.2	2	88	0.123	N	6.55	13.9	109	189	70	0
11	11	0	0	0	0	0	N	6.6	14.2	123	202	79	0
81	81	0	0.2	2	62	0.086	N	6.07	14.1	127	175	81	0
18	18	0	0	0	0	0	N	6.11	14	127	202	82	0
5	5	0	0	0	0	0	N	5.94	13.6	123	198	79	0
0	1	0	0.2	2	488	0.446	N	7.21	14	849	250	585	0
3	3	0	0	0	0	0	N	7.18	14.1	845	316	583	0
32	32	0	0	0	0	0	N	7.28	13.9	837	148	573	0
3	3	0	0.2	2	514	0.01	N	7.22	13.7	836	239	583	0
1	1	0	0	0	0	0	N	7.09	13.1	848	227	592	0
1	1	0	0.4	2	494	0.01	N	7.16	13.2	831	180	580	0
0	1	0	0	0	0	0	N	6.93	13.4	817	246	569	0
0	1	49.4	0.2	2	492	0.01	N	7.13	13.6	833	226	581	0
0	1	0	0	0	0	0	N	7.1	13.7	840	230	584	0
1	1	48.5	0.2	2	494	0.01	N	7.12	14.2	841	425	577	0
4.1	4.5	48.95	0.24	2	496.4	0.0972		7.142	13.69	837.7	248.7	580.7	0
4	4	0	0.2	2	372	0.01	N	7.3	13.1	644	243	439	0
2	2	0	0.2	2	376	0.01	N	7.34	13.1	660	200	450	0

Site Name	PWSID	Well_ID	Sample	Date Collected	Collected By	Ammonia	Arsenic	Bromide	Chloride	Iron	Manganese	Nitrate	Enterococci ND= 0	Enterococci 1= ND or 1	E. coli ND=0	E. coli 1= ND or 1
Units						mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	mg/L	MPN	MPN	MPN	MPN
Gratis Well 2	OH6800612	WL113475	116174	09/23/2009 10:20	MCGINNIS, JOHN	0.05	2	27.2	27.8	50	10	2.93	0	1	0	1
Gratis Well 2	OH6800612	WL113475	117248	10/20/2009 10:00	MCGINNIS, JOHN	0.05	2	29.9	29.6	50	10	1.89	0	1	0	1
Gratis Well 2	OH6800612	WL113475	118352	12/08/2009 10:00	MCGINNIS, JOHN	0.05	2	30.6	99.9	50	10	2.17	0	1	0	1
Gratis Well 2	OH6800612	WL113475	118646	01/19/2010 10:30	MCGINNIS, JOHN	0.05	2	27.3	21.6	50	10	3.86	0	1	0	1
Gratis Well 2	OH6800612	WL113475	118934	03/09/2010 10:25	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Gratis Well 2	OH6800612	WL113475	119923	04/28/2010 10:15	MCGINNIS, JOHN	0.093	2	25.5	13.6	50	10	7.15	0	1	0	1
Gratis Well 2	OH6800612	WL113475	120719	06/02/2010 10:25	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Gratis Well 2	OH6800612	WL113475	122699	07/21/2010 10:00	MCGINNIS, JOHN	0.05	2	26.6	13.2	50	10	5.69	0	1	0	1
Gratis Well 2	OH6800612	WL113475	122700	07/21/2010 10:00	MCGINNIS, JOHN	0.05	2	26.8	13.2	50	10	5.64	0	1	0	1
Site Average						0.055375	2	27.65	30.9125	50	10	4.27125	0.18181818	1.09090909	0.090909091	1
Greenfield 10	OH3600312	WL92233	122378	07/14/2010 14:30	KENAH, CHRIS	0.05	2	20	22.7	50	10	7.32	0	1	0	1
Greenfield 8	OH3600312	WL92229	112807	07/14/2009 09:45	KENAH, CHRIS	0.05	2	27.7	31.1	50	10	4.12	0	1	0	1
Greenfield 8	OH3600312	WL92229	115316	09/01/2009 09:15	KENAH, CHRIS	0.05	2	32.6	32	50	10	3	0	1	0	1
Greenfield 8	OH3600312	WL92229	116768	10/07/2009 16:00	KENAH, CHRIS	0.05	2	28.9	34.9	50	10	4.61	0	1	0	1
Greenfield 8	OH3600312	WL92229	117781	11/04/2009 15:40	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Greenfield 8	OH3600312	WL92229	118246	12/02/2009 14:30	KENAH, CHRIS	0.05	2	32	33	50	10	3.04	0	1	0	1
Greenfield 8	OH3600312	WL92229	118661	01/20/2010 14:45	KENAH, CHRIS	0.05	2	28.2	30.2	50	10	3.32	0	1	0	1
Greenfield 8	OH3600312	WL92229	118662	01/20/2010 14:45	KENAH, CHRIS	0.05	2	27.5	29.4	50	10	3.52	0	1	0	1
Greenfield 8	OH3600312	WL92229	118782	02/17/2010 15:00	KENAH, CHRIS	0.05	2	40	30	50	10	2.7	0	1	0	1
Greenfield 8	OH3600312	WL92229	118929	03/09/2010 14:30	KENAH, CHRIS	0.05	2	40	32.3	50	10	3.22	0	1	0	1
Greenfield 8	OH3600312	WL92229	119381	04/06/2010 14:15	KENAH, CHRIS	0.05	2	20	23.5	50	10	2.38	0	1	0	1
Greenfield 8	OH3600312	WL92229	120417	05/19/2010 12:00	KENAH, CHRIS	0.05	2	23.3	25.6	50	10	3.14	0	1	0	1
Greenfield 8	OH3600312	WL92229	120997	06/15/2010 14:45	KENAH, CHRIS	0.05	2	24.4	25.3	50	10	3.25	0	1	0	1
Site Average						0.05	2	29.50909	29.75455	50	10	3.3	0	1	0	1
Greenfield SW	OH3600312	Surface2	119382	04/06/2010 14:50	KENAH, CHRIS	0.05	2	20.9	36.7	318	11	4.4		46		261
Greenfield SW	OH3600312	Surface2	120416	05/19/2010 12:40	KENAH, CHRIS	0.05	2	21.6	33.6	169	10	7.87		56		435
Greenfield SW	OH3600312	Surface2	120998	06/15/2010 15:30	KENAH, CHRIS	0.05	2	20	17.5	2910	65	6.39		2419		1986
Greenfield SW	OH3600312	Surface2	122379	07/14/2010 15:40	KENAH, CHRIS	0.05	2	20	28.6	696	32	2.72		291		361
Heritage Fellowship	OH1247412	WL82309	117252	10/20/2009 15:55	MCGINNIS, JOHN	0.05	11.3	20.6	12.3	824	65	0.41	0	1	0	1
Heritage Fellowship	OH1247412	WL82309	118357	12/08/2009 14:55	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Heritage Fellowship	OH1247412	WL82309	118644	01/19/2010 14:55	MCGINNIS, JOHN	0.05	7.5	24.2	9.6	671	55	0.1	0	1	0	1
Heritage Fellowship	OH1247412	WL82309	119918	04/28/2010 16:25	MCGINNIS, JOHN	0.108	13.3	23.3	13	1000	61	0.1	4	4	1	1
Heritage Fellowship	OH1247412	WL82309	120720	06/02/2010 15:20	MCGINNIS, JOHN	0	0	0	0	0	0	0	44	44	0	1
Heritage Fellowship	OH1247412	WL82309	122705	07/21/2010 15:25	MCGINNIS, JOHN	0.05	28.8	21.5	13.2	2220	69	0.1	1	1	0	1
Site Average						0.0645	15.225	22.4	12.025	1178.75	62.5	0.1775	8.16666667	8.66666667	0.166666667	1
Living Word	OH3841512	WL93165	112343	06/29/2009 16:00	KENAH, CHRIS	0.05	2	37.8	8.8	299	10	0.37	0	1	0	1
Living Word	OH3841512	WL93165	113471	07/28/2009 16:00	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Living Word	OH3841512	WL93165	115311	09/01/2009 13:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Living Word	OH3841512	WL93165	116694	10/06/2009 12:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Living Word	OH3841512	WL93165	117586	10/27/2009 13:30	KOCHER, RUSS	0.05	2	33.7	7.6	73	10	0.28	0	1	0	1
Living Word	OH3841512	WL93165	118034	11/18/2009 13:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Living Word	OH3841512	WL93165	118455	12/16/2009 14:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Living Word	OH3841512	WL93165	118820	02/24/2010 14:30	KOCHER, RUSS	0.141	2	61.6	13.6	50	10	6.31	0	1	0	1
Living Word	OH3841512	WL93165	119336	03/31/2010 14:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Living Word	OH3841512	WL93165	120028	05/05/2010 14:30	KOCHER, RUSS	0.05	2	38.7	11.9	50	10	1.77	0	1	0	1
Living Word	OH3841512	WL93165	121663	06/30/2010 14:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Living Word	OH3841512	WL93165	123185	07/28/2010 15:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Site Average						0.07275	2	42.95	10.475	118	10	2.1825	0	1	0	1
Makoy	OH2557212	WL133834	112523	07/07/2009 18:30	KENAH, CHRIS	0.476	20.5	36	5	671	88	0.1	0	1	0	1
Makoy	OH2557212	WL133834	115319	09/01/2009 14:00	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Makoy	OH2557212	WL133834	116766	10/07/2009 11:00	KENAH, CHRIS	0.513	24.1	32.7	5	728	74	0.1	5	5	0	1

Total Coliform ND= 0 MPN	Total Coliform 1 = ND or 1 MPN	Sulfate mg/L	TKN mg/L	TOC mg/L	TDS mg/L	Total Phosphorus mg/L	QC		pH SU	Temperature C°	Specific Conductivity umhos/cm	ORP mV	TDS mg/L	Total Chlorine mg/l
2	2	0	0.2	2	396	0.01	N		6.99	13.6	668	246	460	0
0	1	0	0.2	2	412	0.01	N		7.13	13.3	670	275	463	0
11	11	0	0.2	2	382	0.01	N		7.14	11.1	683	235	482	0
2	2	0	0.31	2	404	0.01	N		7.03	12.5	663	335	458	0
70	70	0	0	0	0	0	N		6.98	12	674	220	465	0
1	1	22.1	0.2	2	376	0.01	N		7.02	11.8	641	347	443	0
6	6	0	0	0	0	0	N		7.1	12.3	642	190	443	0
4	4	22.1	0.2	2	368	0.01	Y		7.25	13.8	642	340	437	0
9	9	22.2	0.2	2	378	0.01	Y		7.25	13.8	642	340	437	0
10.09090909	10.18181818	22.1	0.21375	2	385.75	0.01			7.128	12.66	658.7	263.1	454	0
1	1	20.8	0.2	2	426	0.01	N		7.24	12.4	685	252	467	0.01
0	1	0	0.29	2	414	0.039	N		6.77	12	707	216	483	0
0	1	0	0.29	2	424	0.043	N		7.02	14	714	215	488	0
0	1	0	0.53	2	418	0.018	N		7.13	14.8	731	196	500	0
0	1	0	0	0	0	0	N		7.33	14.2	724	301	495	0
0	1	0	0.2	2	416	0.029	N		7.2	13.4	733	247	502	0.03
0	1	29.9	0.23	2	422	0.03	Y		7.29	11.3	741	276	505	0
0	1	29.5	0.3	2	434	0.021	Y		7.29	11.3	741	276	505	0
0	1	30.4	0.2	2	426	0.02	N		7.11	10.4	732	438	500	0
0	1	30.6	0.2	2	436	0.01	N		7.12	9.7	736	214	505	0.02
0	1	24.8	0.2	2	398	0.019	N		7.17	9.2	689	202	470	0.04
0	1	24.8	0.2	2	416	0.019	N		7.06	9.7	716	314	489	0.09
1	1	26.9	0.2	2	430	0.023	N		7.07	11.2	705	405	483	0.06
0.153846154	1	28.12857	0.258182	2	421.2727	0.02463636			7.13	11.76666667	722.416667	275	493.75	0.04
	2419	33.6	0.34	3	352	0.082	N							
	2419	31.7	0.35	2.1	388	0.077	N							
	2419	20.8	0.64	8.5	296	0.201	N		7.76	22.8	412	193	277	0.11
	2419	31	0.36	4.7	350	0.066	N		8.29	24.8	556	188	377	0.1
0	1	0	0.2	2	408	0.01	N		7.34	13.5	679	36	467	
1	1	0	0	0	0	0	N		7.24	12.8	665	9	458	0
15	15	0	0.23	2	390	0.01	N		7.22	11.1	660	11	456	0
276	276	24.1	0.2	2	380	0.01	N		7.39	12.8	664	12	459	0
1553	1553	0	0	0	0	0	N		7.52	15.3	663	-13	456	0
365	365	24.8	0.2	2	386	0.01	N							0
368.3333333	368.5	24.45	0.2075	2	391	0.01			7.342	13.1	666.2	11	459.2	0
0	1	0	0.2	2	376	0.01	N							
0	1	0	0	0	0	0	N		7.01	13.4	647	244	441	0
0	1	0	0	0	0	0	N		6.5	15.8	638	115	435	0
0	1	0	0	0	0	0	N		6.28	13.2	700	156	478	0
0	1	0	0.2	2	392	0.01	N		7.01	13	636	194	434	0
0	1	0	0	0	0	0	N		7	13.1	629	210	429	0
0	1	0	0	0	0	0	N		6.94	13.1	580	191	395	0
1	1	47.6	0.2	2	364	0.01	N		6.85	13.4	580	169	394	0
0	1	0	0	0	0	0	N		7.12	13.4	531	244	371	0
0	1	52.8	0.2	2	390	0.01	N		7.11	13	601	235	418	0
1	1	0	0	0	0	0	N		7.2	14	615	222	441	0
5	5	0	0	0	0	0	N		7.12	14	580	248	412	0
0.583333333	1.333333333	50.2	0.2	2	380.5	0.01		0	6.921818	13.58181818	612.454545	202.5455	422.5455	0
0	1	0	0.42	2	586	0.012	N		7.02	14.8	896	4	621	0
14	14	0	0	0	0	0	N		7.05	14.7	889	43	616	0
0	1	118	0.54	2	572	0.012	N		7.1	13.6	902	33	624	0.03

Site Name	PWSID	Well_ID	Sample	Date Collected	Collected By	Ammonia	Arsenic	Bromide	Chloride	Iron	Manganese	Nitrate	Enterococci ND= 0	Enterococci 1= ND or 1	E. coli ND=0	E. coli 1= ND or 1
Units						mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	mg/L	MPN	MPN	MPN	MPN
Makoy	OH2557212	WL133834	117779	11/04/2009 11:25	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Makoy	OH2557212	WL133834	118244	12/02/2009 10:45	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Makoy	OH2557212	WL133834	118659	01/20/2010 11:00	KENAH, CHRIS	0.507	20.8	39.5	5	653	61	0.1	0	1	0	1
Makoy	OH2557212	WL133834	118783	02/17/2010 11:30	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Makoy	OH2557212	WL133834	118930	03/09/2010 11:15	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Makoy	OH2557212	WL133834	119380	04/06/2010 11:15	KENAH, CHRIS	0.514	20.4	32.7	5	701	66	0.1	0	1	0	1
Makoy	OH2557212	WL133834	120418	05/19/2010 15:30	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Makoy	OH2557212	WL133834	120996	06/15/2010 12:00	KENAH, CHRIS	0.514	19.7	34.6	5	661	67	0.1	0	1	0	1
Makoy	OH2557212	WL133834	122376	07/14/2010 11:55	KENAH, CHRIS	0.484	20.7	25.7	5	701	68	0.1	2	2	1	1
Makoy	OH2557212	WL133834	122377	07/14/2010 11:55	KENAH, CHRIS	0.483	20.6	26.2	5	676	70	0.1	3	3	1	1
Site Average						0.5013333	21.03333	33.53333	5	685.8333	70.66666667	0.1	0.76923077	1.53846154	0.153846154	1
Nelsonville 1	OH0501214	WL79551	112809	07/14/2009 15:15	KENAH, CHRIS	0.093	2.8	175	58.4	604	274	0.1	0	1	0	1
Nelsonville 1	OH0501214	WL79551	114718	08/19/2009 10:00	KENAH, CHRIS	0.097	4.1	138	57.2	883	332	0.1	0	1	0	1
Nelsonville 1	OH0501214	WL79551	116225	09/24/2009 09:00	REED, BEN	0.091	2.8	476	125	718	364	0.1	0	1	0	1
Nelsonville 1	OH0501214	WL79551	117187	10/20/2009 08:45	REED, BEN	0.104	2.7	518	135	693	363	0.1	0	1	0	1
Nelsonville 1	OH0501214	WL79551	118247	12/03/2009 09:00	REED, BEN	0.072	2.1	428	122	639	321	0.1	0	1	0	1
Nelsonville 1	OH0501214	WL79551	121316	06/23/2010 10:40	REED, BEN	0.122	2	105	43.7	867	314	0.1	1	1	0	1
Nelsonville 1	OH0501214	WL79551	125204	09/02/2010 10:00	REED, BEN	0	0	0	0	0	0	0	0	1	0	1
Site Average						0.0965	2.75	306.6667	90.21667	734	328	0.1	0.14285714	1	0	1
Nelsonville SW	OH0501214	Surface1	125205	09/02/2010 10:30	REED, BEN	0	0	0	0	0	0	0		45		61
Phillipsburg 2	OH5702112	WL101587	113191	07/20/2009 11:45	KENAH, CHRIS	0.05	2	45.5	74.1	50	10	6.13	0	1	0	1
Phillipsburg 2	OH5702112	WL101587	115000	08/26/2009 11:45	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Phillipsburg 2	OH5702112	WL101587	116176	09/23/2009 12:50	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Phillipsburg 2	OH5702112	WL101587	117247	10/20/2009 11:55	MCGINNIS, JOHN	0.05	2	58	57	50	10	5.3	0	1	0	1
Phillipsburg 2	OH5702112	WL101587	118354	12/08/2009 12:20	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Phillipsburg 2	OH5702112	WL101587	118647	01/19/2010 12:25	MCGINNIS, JOHN	0.05	2	43.1	65	67	10	5.08	0	1	0	1
Phillipsburg 2	OH5702112	WL101587	118936	03/09/2010 12:50	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Phillipsburg 2	OH5702112	WL101587	119921	04/28/2010 12:50	MCGINNIS, JOHN	0.098	2	100	76.5	50	10	5.38	0	1	0	1
Phillipsburg 2	OH5702112	WL101587	120723	06/02/2010 12:25	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Phillipsburg 2	OH5702112	WL101587	122702	07/21/2010 12:20	MCGINNIS, JOHN	0.05	2	47.8	72.8	50	10	4.53	0	1	0	1
Site Average						0.0596	2	58.88	69.08	53.4	10	5.284	0	1	0	1
Phillipsburg 3	OH5702112	WL101589	116175	09/23/2009 13:30	MCGINNIS, JOHN	0.05	2	39.3	54	50	10	5.11	0	1	0	1
Phillipsburg 3	OH5702112	WL101589	117249	10/20/2009 11:25	MCGINNIS, JOHN	0.05	2	38.9	53.1	50	10	5.27	0	1	0	1
Phillipsburg 3	OH5702112	WL101589	118353	12/08/2009 12:20	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Phillipsburg 3	OH5702112	WL101589	118643	01/19/2010 11:50	MCGINNIS, JOHN	0.05	2	38.5	54.3	50	10	4.77	0	1	0	1
Phillipsburg 3	OH5702112	WL101589	118935	03/09/2010 12:25	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Phillipsburg 3	OH5702112	WL101589	119922	04/28/2010 12:15	MCGINNIS, JOHN	0.082	2	100	53.7	50	10	4.61	0	1	0	1
Phillipsburg 3	OH5702112	WL101589	120724	06/02/2010 11:55	MCGINNIS, JOHN	0	0	0	0	0	0	0	0	1	0	1
Phillipsburg 3	OH5702112	WL101589	122701	07/21/2010 11:40	MCGINNIS, JOHN	0.05	2	39.1	53.3	50	10	4.74	0	1	0	1
Site Average						0.0564	2	51.16	53.68	50	10	4.9	0	1	0	1
Red Canery	OH0232612	WL78024	112522	07/07/2009 15:30	KENAH, CHRIS	0.193	2	65.3	62.9	1400	38	0.1	0	1	0	1
Red Canery	OH0232612	WL78024	113940	08/04/2009 15:15	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Red Canery	OH0232612	WL78024	115368	09/02/2009 14:00	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Red Canery	OH0232612	WL78024	116761	10/07/2009 13:30	ZAJKOWSKI, CHAD	0.22	2.6	83.3	76.6	2270	32	0.1	0	1	0	1
Red Canery	OH0232612	WL78024	117775	11/04/2009 12:40	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Red Canery	OH0232612	WL78024	118364	12/09/2009 12:10	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Red Canery	OH0232612	WL78024	119082	03/16/2010 12:10	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Red Canery	OH0232612	WL78024	119572	04/14/2010 12:40	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Red Canery	OH0232612	WL78024	120279	05/12/2010 12:55	ZAJKOWSKI, CHAD	0.18	2	60	76.1	2430	34	0.1	0	1	0	1
Red Canery	OH0232612	WL78024	122981	07/27/2010 14:05	ZAJKOWSKI, CHAD	0.196	2.5	49.2	71.6	2490	32	0.1	0	1	0	1
Red Canery	OH0232612	WL78024	122982	07/27/2010 14:05	ZAJKOWSKI, CHAD	0.201	2.5	54.4	69.3	2560	32	0.1	0	1	0	1

Total Coliform ND= 0 MPN	Total Coliform 1 = ND or 1 MPN	Sulfate mg/L	TKN mg/L	TOC mg/L	TDS mg/L	Total Phosphorus mg/L	QC		pH SU	Temperature C°	Specific Conductivity umhos/cm	ORP mV	TDS mg/L	Total Chlorine mg/l
0	1	0	0	0	0	0	N		7.22	13.4	900	39	622	0
1	1	0	0	0	0	0	N		7.07	13.2	901	44	623	0
0	1	124	0.67	2	572	0.01	N		6.98	13.1	897	40	621	0
0	1	0	0	0	0	0	N		7.16	13		45	619	0
0	1	0	0	0	0	0	N		7.19	13.4	895	21	619	0
0	1	125	0.42	2	580	0.01	N		7.07	13.5	884	47	612	0
1	1	0	0	0	0	0	N		7.2	13.4	898	30	622	0
22	22	125	0.47	2	574	0.013	N		7.03	13.8	890	16	616	0
131	131	126	0.25	2	600	0.01	N		7.04	13.8	885	39	612	0
135	135	125	0.33	2	616	0.01	Y		7.04	13.8	885	39	612	0
23.38461538	23.92307692	123.6	0.461667	2	580.6667	0.01116667		0	7.094167	13.64166667	894.272727	33.41667	618.9167	0.0025
0	1	0	0.5	2	346	0.01	N		7.44	17.8	605	-15	411	0
0	1	0	0.3	2	380	0.01	N		7.3	21.7	658	-44	448	0
1	1	0	0.2	2	518	0.01	N		7.37	20	753	-31	551	0
0	1	0	0.23	2	610	0.01	N		7.08	18	856	-42	525	0
0	1	0	0.42	2	522	0.01	N		7.45	15.6	821	-41	537	0
1	1	96.9	0.2	2	396	0.01	N		7.41	18.2	771	-28	465	0
19	19	0	0	0	0	0	N			19.7	803	-21	521	0
3	3.571428571		0.308333	2	462	0.01			7.341667	18.71428571	752.428571	-31.7143	494	0
	2419	0	0	0	0	0	N			23.7	753	310	516	0
0	1	0	0.2	2	526	0.01	N		7.03	12.1	938	223	648	0
0	1	0	0	0	0	0	N		7.02	12.7	920	175	636	0
0	1	0	0	0	0	0	N		6.96	13.2	904	167	593	0
0	1	0	0.28	2	536	0.01	N		7.24	13.1	891	216	624	0
0	1	0	0	0	0	0	N		6.93	12.8	884	401	618	0
0	1	0	0.2	2	534	0.01	N		6.97	12.8	908	239	636	0
24	24	0	0	0	0	0	N		6.84	11.8	923	284	649	0
0	1	24.2	0.2	2	524	0.01	N		6.58	11.6	924	535	649	0
0	1	0	0	0	0	0	N		6.56	11.8	917	432	644	0
0	1	25.1	0.2	2.1	526	0.01	N		7.13	12.1	915	361	634	0
2.4	3.3	24.65	0.216	2.02	529.2	0.01			6.926	12.4	912.4	303.3	633.1	0
0	1	0	0.2	2	500	0.01	N		6.75	13.8	834	243	580	0
0	1	0	0.3	2	506	0.01	N		7.07	13.5	849	344	592	0
0	1	0	0	0	0	0	N		6.81	13.5	834	590	581	0
0	1	0	0.21	2	500	0.01	N		6.83	13.2	846	487	590	0
0	1	0	0	0	0	0	N		6.84	13	832	604	580	0
0	1	27.8	0.2	2	470	0.01	N		6.42	12.4	818	483	570	0
5	5	0	0	0	0	0	N		6.53	12.7	813	457	565	0
0	1	31.5	0.2	2	480	0.01	N		6.97	13.7	825	285	567	0
0.625	1.5	29.65	0.222	2	491.2	0.01			6.7775	13.225	831.375	436.625	578.125	0
0	1	0	0.35	2	724	0.01	N		7.19	14.4	1013	42	705	0
0	1	0	0	0	0	0	N		7.14	15.2	1001	-21	696	0
0	1	0	0	0	0	0	N		7.08	14.2	1017	-126	711	0
0	1	0	0.39	2	750	0.01	N		7.22	14.1	1032	-135	731	0.02
0	1	0	0	0	0	0	N		7.17	14.6	1075	-145	764	0
0	1	0	0	0	0	0	N		7.18	14.2	1042	-155	739	0.01
0	1	0	0	0	0	0	N		7.24	13.7	996	-102	705	0.02
0	1	0	0	0	0	0	N		7.15	13.4	998	-14	707	0
0	1	124	0.56	2	674	0.01	N		7.2	13.3	999	-111	708	0.01
0	1	130	0.28	2	638	0.01	Y		7.08	14.9	985	-75	690	0
0	1	124	0.37	2	628	0.01	Y		7.08	14.9	985	-75	690	0

Site Name	PWSID	Well_ID	Sample	Date Collected	Collected By	Ammonia	Arsenic	Bromide	Chloride	Iron	Manganese	Nitrate	Enterococci ND= 0	Enterococci 1= ND or 1	E. coli ND=0	E. coli 1= ND or 1
Units						mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	mg/L	MPN	MPN	MPN	MPN
Site Average						0.19725	2.275	64.45	71.8	2147.5	34	0.1	0	1	0	1
Sandy Point	OH0239412	WL78199	112521	07/07/2009 14:00	KENAH, CHRIS	0.361	2	138	16.7	1570	31	0.1	0	1	0	1
Sandy Point	OH0239412	WL78199	113939	08/04/2009 14:00	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Sandy Point	OH0239412	WL78199	120856	06/09/2010 12:28	ZAJKOWSKI, CHAD	0.352	2	146	18.2	1480	33	0.1	0	1	0	1
Sandy Point	OH0239412	WL78199	122980	07/27/2010 12:45	ZAJKOWSKI, CHAD	0.348	2	124	19.1	1520	32	0.1	0	1	0	1
Site Average						0.3536667	2	136	18	1523.333	32	0.1	0		0	
Southgate Lanes	OH0249812	WL78311	112520	07/07/2009 12:00	KENAH, CHRIS	0.225	2	52.4	29.8	50	17	0.1	0	1	0	1
Southgate Lanes	OH0249812	WL78311	113938	08/04/2009 12:00	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Southgate Lanes	OH0249812	WL78311	115369	09/02/2009 11:45	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Southgate Lanes	OH0249812	WL78311	116762	10/07/2009 11:55	ZAJKOWSKI, CHAD	0.246	2	61.1	32.3	50	16	0.1	0	1	0	1
Southgate Lanes	OH0249812	WL78311	117776	11/04/2009 11:40	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Southgate Lanes	OH0249812	WL78311	118363	12/09/2009 11:10	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Southgate Lanes	OH0249812	WL78311	118599	01/11/2010 11:30	ZAJKOWSKI, CHAD	0.238	2	100	31.3	50	17	0.1	0	1	0	1
Southgate Lanes	OH0249812	WL78311	118781	02/16/2010 11:30	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Southgate Lanes	OH0249812	WL78311	119071	03/16/2010 10:45	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Southgate Lanes	OH0249812	WL78311	119571	04/14/2010 11:10	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Southgate Lanes	OH0249812	WL78311	120280	05/12/2010 11:15	ZAJKOWSKI, CHAD	0.215	2	61	54.4	50	17	0.1	0	1	0	1
Southgate Lanes	OH0249812	WL78311	120858	06/09/2010 11:20	ZAJKOWSKI, CHAD	0	0	0	0	0	0	0	0	1	0	1
Site Average						0.231	2	68.625	36.95	50	16.75	0.1	0	1	0	1
Sunoco 7613	OH8750412	WL127475	116982	10/14/2009 10:20	ZAJKOWSKI, CHAD	0.084	2	59.9	42.8	129	10	0.1		1		1
Wayne Lanes	OH8554112	WL126050	112342	06/29/2009 14:15	KENAH, CHRIS	0.05	2	38.9	26.6	387	13	0.1	0	1	0	1
Wayne Lanes	OH8554112	WL126050	113468	07/28/2009 14:45	KENAH, CHRIS	0.05	2	98.6	30.5	50	14	0.23	0	1	0	1
Wayne Lanes	OH8554112	WL126050	115312	09/01/2009 15:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Wayne Lanes	OH8554112	WL126050	116491	09/30/2009 15:30	KOCHER, RUSS	0	0	0	0	0	0	0	3	3	13	13
Wayne Lanes	OH8554112	WL126050	117587	10/27/2009 15:30	KOCHER, RUSS	0.05	2	106	25	50	21	0.14	0	1	0	1
Wayne Lanes	OH8554112	WL126050	118035	11/18/2009 15:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Wayne Lanes	OH8554112	WL126050	118456	12/16/2009 15:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Wayne Lanes	OH8554112	WL126050	118681	01/26/2010 15:30	KOCHER, RUSS	0.05	2	90.2	35.9	160	30	0.22	0	1	0	1
Wayne Lanes	OH8554112	WL126050	118816	02/24/2010 15:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Wayne Lanes	OH8554112	WL126050	119337	03/31/2010 15:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Wayne Lanes	OH8554112	WL126050	120027	05/05/2010 15:30	KOCHER, RUSS	0.05	2	90.7	93.3	155	26	0.36	0	1	0	1
Wayne Lanes	OH8554112	WL126050	120606	05/26/2010 15:30	KOCHER, RUSS	0	0	0	0	0	0	0	2	2	0	1
Wayne Lanes	OH8554112	WL126050	121664	06/30/2010 15:30	KOCHER, RUSS	0	0	0	0	0	0	0	53	53	65	65
Site Average						0.05	2	84.88	42.26	160.4	20.8	0.21	4.46153846	5.23076923	6	6.846153846
Zion Hill	OH5048112	WL98465	112340	06/29/2009 10:15	KENAH, CHRIS	0.05	2	33.6	20.4	391	469	0.1	0	1	0	1
Zion Hill	OH5048112	WL98465	113469	07/28/2009 11:00	KENAH, CHRIS	0	0	0	0	0	0	0	0	1	0	1
Zion Hill	OH5048112	WL98465	115313	09/01/2009 08:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Zion Hill	OH5048112	WL98465	116488	09/30/2009 08:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Zion Hill	OH5048112	WL98465	117589	10/27/2009 08:00	KOCHER, RUSS	0.05	2	30.8	21.9	451	532	0.16	0	1	0	1
Zion Hill	OH5048112	WL98465	118031	11/18/2009 08:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Zion Hill	OH5048112	WL98465	118458	12/16/2009 08:00	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Zion Hill	OH5048112	WL98465	118684	01/26/2010 08:00	KOCHER, RUSS	0.05	2	31.3	24	991	573	0.19	0	1	0	1
Zion Hill	OH5048112	WL98465	118817	02/24/2010 08:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Zion Hill	OH5048112	WL98465	119332	03/31/2010 08:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Zion Hill	OH5048112	WL98465	120029	05/05/2010 08:30	KOCHER, RUSS	0.05	2	35.6	23.4	748	541	0.1	0	1	0	1
Zion Hill	OH5048112	WL98465	120602	05/26/2010 08:30	KOCHER, RUSS	0	0	0	0	0	0	0	1	1	0	1
Zion Hill	OH5048112	WL98465	121659	06/30/2010 08:30	KOCHER, RUSS	0	0	0	0	0	0	0	0	1	0	1
Site Average						0.05	2	32.825	22.425	645.25	528.75	0.1375	0.07692308	1	0	1

Total Coliform ND= 0 MPN	Total Coliform 1 = ND or 1 MPN	Sulfate mg/L	TKN mg/L	TOC mg/L	TDS mg/L	Total Phosphorus mg/L	QC	pH SU	Temperature C°	Specific Conductivity umhos/cm	ORP mV	TDS mg/L	Total Chlorine mg/l
0	1	127	0.395	2	696.5	0.01		0 7.165	14.2	1015.8	-84.2	715.6	0.006
0	1	0	0.41	2	606	0.021	N	7.31	15.3	917	-27	636	0
0	1	0	0	0	0	0	N	7.26	14.5	916	-48	634	0
0	1	155	0.64	2	596	0.011	N	7.2	15	985	-151	691	0.06
0	1	161	0.23	2	582	0.027	N	7.24	16	900	-96	634	0
0		158	0.426667	2	594.6667	0.01966667		7.2525	15.2	929.5	-80.5	648.75	0.015
0	1	0	0.34	2	762	0.01	N	7.15	17.4	1036	-150	721	0
0	1	0	0	0	0	0	N	7.05	14	1041	-167	725	0
0	1	0	0	0	0	0	N	7.11	15	1030	-182	720	0.01
0	1	0	0.43	2	768	0.01	N	7.08	14.4	1044	-173	740	0
0	1	0	0	0	0	0	N	7.09	13.4	1053	-191	748	0
0	1	0	0	0	0	0	N	7.07	11.2	1061	-179	757	0.03
0	1	0	0.42	2	746	0.01	N	7.09	11.1	1069	-175	763	0.04
0	1	0	0	0	0	0	N	7.08	10.3	1066	-182	762	0
0	1	0	0	0	0	0	N	7.04	11.1	1054	-202	752	0
0	1	0	0	0	0	0	N	7.12	11.6	1055	-166	752	0.03
0	1	229	0.54	2	782	0.01	N	7.08	12.4	1058	-190	753	0.03
0	1	0	0	0	0	0	N	7.06	13.6	1039	-166	737	0.02
0	1	229	0.4325	2	764.5	0.01		0 7.085	12.95833333	1050.5	-176.917	744.1667	0.013333
	1	0	0.2	2	540	0.01	N	7.29	15.9	772	-106	535	0.03
0	1	0	0.2	2	280	0.01	N	7.07	16.5	491	682	333	
6	6	0	0.2	2	260	0.01	N	7.02	12.9	481	250	326	0
0	1	0	0	0	0	0	N	6.19	15.7	473	211	319	
222	222	0	0	0	0	0	N	7.36	13.3	468	181	317	0
0	1	0	0.2	2	292	0.01	N	7.29	14.2	486	350	328	0
1	1	0	0	0	0	0	N	7.3	13.5	491	263	332	0
0	1	0	0	0	0	0	N	7.18	12.6	489	202	331	0
0	1	26.3	0.2	2	290	0.01	N	7.23	13.1	482	189	326	0
1	1	0	0	0	0	0	N	6.99	12.8	486	353	329	0
48	48	0	0	0	0	0	N	6.3	14.8	633	257	442	0
0	1	45.6	0.25	2	356	0.01	N	7.02	14.8	580	239	397	0
5	5	0	0	0	0	0	N	7.45	13.8	555	249	387	0
1203	1203	0	0	0	0	0	N	6.58	14	472	279	337	0
114.3076923	114.7692308	35.95	0.21	2	295.6	0.01		0 6.998462	14	506.692308	285	346.4615	0
0	1	0	0.2	2	474	0.054	N	7.13	13.5	761	96	521	
0	1	0	0	0	0	0	N	7.11	15.5	780	40	535	0
0	1	0	0	0	0	0	N	6.04	14.1	780	-10	535	0
0	1	0	0	0	0	0	N	6.8	12.8	778	181	533	0
1	1	0	0.34	2	562	0.01	N	7.15	12.6	922	115	639	0
0	1	0	0	0	0	0	N	7.11	12.4	810	95	557	0
0	1	0	0	0	0	0	N	7.07	11.7	802	107	551	0
0	1	129	0.53	2	518	0.01	N	7.2	11.5	808	65	556	0
0	1	0	0	0	0	0	N	6.98	11.7	835	120	571	0
0	1	0	0	0	0	0	N	7.42	11.6	768	102	547	0
0	1	121	0.2	2	538	0.01	N	7.18	12.6	760	90	537	0
308	308	0	0	0	0	0	N	6.83	12.9	770	197	543	0
166	166	0	0	0	0	0	N	7.2	12.9	728	140	527	0
36.53846154	37.30769231	125	0.3175	2	523	0.021		0 7.016923	12.75384615	792.461538	102.9231	550.1538	0