GROUND WATER QUALITY DATA ASSESSMENTS

DATA SOURCES

The Department established a ground water quality monitoring network in 1984 under the authority and direction of the Water Quality Assurance Act, passed by the Florida Legislature in 1983. From 1984-1999 the network was maintained to establish the background and baseline ground water quality of major aquifer systems in Florida. In 1999, the Department initiated a probabilistic sampling network to assess the water quality over a basin area. These two networks, and the additional sources described below, were the primary data sources used in the ground water quality assessment for the basin.

Florida DEP Status Network (1999-Present)

The Status Network is a statewide probabilistic sampling network that collects surface and ground water quality data over a 5-year rotating basin cycle. The ground water sampling groups are unconfined and confined aquifers. Sample locations are randomly selected by a computer program from a compiled list frame of existing wells. Within a defined watershed basin, 30 unconfined aquifer locations and 30 confined aquifer locations are sampled.

Florida DEP Ambient Background Network (1985-1999)

The Background Network is a network of over 1600 water wells and monitor wells designed to spatially monitor the general background water quality of the local aquifers (surficial, intermediate and Floridan aquifer) across the state. A well in the Background Network is selected to monitor an area of an aquifer that is representative of the general water quality of a region. These wells were not intended to indicate changes in aquifer chemistry associated with specific contaminant sources.

Florida DEP VISA (Very Intense Study Areas)

The DEP Very Intense Study Area monitoring was implemented to monitor the effects of specific land uses on ground water quality within specific aquifers in selected areas.

Florida DOH/DEP Private Water Well Sampling

These data are maintained in a DEP Water Supply Restoration Program database. Potential or suspected contaminantion, and well owner complaints, are investigated and water use samples are analyzed. The parameter list can be very limited, or extensive, and the evaluation purpose is to protect public health of citizens drinking the water. The results are useful in assessing water quality issues in an area, but the wells are not routinely and consistently monitored and do not represent a monitor network.

Florida Department of Health 1986-97 Private Water Well Quality Survey

This survey consisted of sampling and analyses for 50 private wells in each county located away from known aquifer contamination.

The Florida DEP Ground Water Temporal Variability Network

The current Ground Water Temporal Variability (TV) Network consists of 46 wells statewide, located in all of Florida's major potable aquifer systems. It is designed to 1) help correlate Status Network results with seasonal hydrological variations, and to 2) help estimate temporal variance of sampled analytes. In most cases, one well completed into a confined aquifer, and another well completed into an unconfined aquifer are located in each of the Status Network's original twenty reporting units. Only field analytes are collected from GWTV Network wells, except for those sites located in a Status Network reporting unit currently being sampled. Those Trend Network wells are sampled for Status Network lab analytes, during the calendar year that the Status Network sampling takes place.

Data Limitations

The evaluation of ground water quality is mainly based on available data from the Department's two major state-wide ground water sampling programs, the Background Network and the Status Network (Maddox, et al, 1992; Copeland, 2001). Although they differ in purpose, design, number of stations, period of sampling and bias toward contamination, these two sampling programs are the only available DEP data with representative state-wide coverage. The Status Network Cycle 1 Data Quality Assessment Guidelines and Analysis Protocols were applied to both the Background and Status Network data (Harrington, 2003a; Harrington, 2003b).

The Background Network was not based on a randomized selection process and was specifically designed to target ground water wells that should not have contamination from nearby sources as a way to determine background or baseline ground water quality. However, the inclusion of a well in the Background Network was not based on all analytes of concern. This is particularly relevant with coliform contamination where private wells, included in the Background Network, may have a higher incidence of coliform exceedances due to failed septic systems or poor well construction.

In contrast, the Status Network is based on a probabilistic design that randomly selects wells from a list frame that incorporates many different types of ground water wells, including those that are in close proximity to potentially contaminated sites such as upgradient facility wells. This randomized selection process allows the Department to draw conclusions about the typical range of values and general water quality of the sampled aquifer on a basin wide scale, providing it is appropriate to assume that the ground water in wells is representative of the resource. This assumption can be problematic for some contaminant groups where the well conditions promote biological growth or increase metal concentrations due to well casing materials. This will be addressed in each subsection where relevant.

DATA ANALYSES AND ISSUES OF INTEREST

The Department's ground water data was assessed using a comprehensive approach that evaluated five major groups of contaminants. For each analyte group, the assessment text includes introductory information on specific issues related to ground water contaminants and the results of the Ground Water Resource Index (GRI) comprehensive assessment, which is explained in detail below and in **Appendix 5.A**.

The first step of the GRI and interpretation of the data is focused on determining whether the potential for a basin-wide ground water issue exists based on the Status and Background Network data. When a potential basin-wide issue is identified for a particular contaminant group, the Department conducts a more intensive assessment designed to answer the following questions:

1. Are there any basin-wide ground water issues identified in the probabilistic Status Network and confirmed by other data sources?
2. What is the spatial distribution of wells that have exceeded a ground water standard and what are the associated microlanduses?
3. What are the typical range of values found in the basin and natural background level? Are ground water quality basin wide issues related to a natural abundance or contaminant transport?
4. Do the data suggest that the ground water resource has improved or degraded over time?

Analytical Approach

To assess whether ground water quality has been impacted on a basin-wide scale, a GRI was designed to effectively reveal basin wide ground water issues that can be readily understood by a wide audience. The Background and Status Network data are first examined to identify appropriate ground water monitoring analytes (with a ground water standard) and the dates of sampling in the basin. The data are then placed into main contaminant indicator groups that are comprised of biological, nutrient, inorganic-saltwater intrusion, inorganic-metals, and organic analytes. The percent of well samples that exceed the applicable ground water standard or Maximum Contaminant Limit (MCL) at individual wells in the basin is then calculated. Indicator groups with a greater than 10 percent exceedance frequency are determined to reflect a potential basin-wide issue that is confirmed with a more intensive assessment.

The GRI is calculated with and without stratification by aquifer type to also include the largest possible number of observations. This inucreases the robustness of the result by decreasing the uncertainty. The GRI was designed so that it can be used for individual analytes and for grouped analytes when appropriate (i.e., nitrate and nitrite; cumulative statistics for organic analytes). Specific treatments may differ for each contaminant group and are detailed in each of the respective assessment subsections. While the GRI is used to initially identify possible basin-wide ground water issues, confirmation is sought from additional

discretionary data sources for a comprehensive and integrated approach. The technical reader is referred to the Status Network Cycle 1 report for the detailed statistical analyses of the data.

Biological Contaminants

Introduction to Bacteria and Ground Water Quality

Ground water microbiology is a relatively new field of study. Research has shown that most of the bacteria found in soils and surface water have also been found in shallow unconfined and confined aquifers. Leaking or substandard septic systems and runoff are the most important sources of bacterial contamination. Trest et al, (2002) found that airborne coliform bacteria commonly exist near well-heads and are associated with genera in the well water, indicating an additional transport mechanism. The contamination of ground water from pathogens is dependent on the pathogen survival and transport rates within the system, which are in turn influenced by the physical and chemical properties of water and soil, hydrology of the system, and microbial characteristics (Teutsch, 1991; Abu-Shour, 1994). Water can transport pathogens quickly and over long distances depending on survival rates and environmental conditions (Woessner, et al., 2001; OSRAS, 2001). Oliphant et al. (2002) monitored wells for six months and found there is considerable temporal variation in total and fecal coliforms levels. The individual wells intermittently met and exceeded ground water standards for coliforms, indicating annual sampling was insufficient.

It is difficult to differentiate between the presence of organisms and their relative concentration in the aquifer and those trapped and growing in the actual well environment. It is not uncommon for microorganisms to propagate after entering a ground water well where there are suitable environmental conditions and where they can attach to biofilms. Biofilms form ubiquitously on substrata in ground water wells, whereby they constitute the predominant mode of bacterial growth. The variability in ground water microbial data may be related to these biofilms that commonly detach, erode or slough from surfaces in the well and are released into the ground water in the well (EPA, 2001). Identifying the difference between in-situ growth and ground water transport from a contaminant source can be difficult and requires intensive monitoring. Oliphant (2002) indicated a relatively fast and similar rate of recovery of total heterotrophic bacteria, suggesting they are related to biofilm formation in the wells and not to ground water contamination.

Although bacteria generally perform beneficial processes, some bacteria or other microorganisms such as protozoa and viruses are pathogenic and may cause adverse health effects in humans. Coliform bacteria may not directly cause disease, but are often found with other pathogenic organisms that could cause intestinal infections, vomiting, dysentery, hepatitis, typhoid fever, cholera, meningitis, myocarditis, ulcers and other illnesses. Intestinal infections and dysentery are generally considered minor health problems, but they could prove fatal to infants, the elderly, and those who are already ill. Because it is impractical to analyze for the many pathogens that could be present, indicator organisms have been used to determine

whether ground water is contaminated and therefore unsuitable for potable drinking water.

The indicator organisms most frequently used for ground water monitoring are total and fecal coliforms. Detections of total coliforms in ground water typically indicate exposure to surface water run-off that can include fecal associated pathogenic species that live in the gastrointestinal tract of warm-blooded mammals. In karst areas, total coliforms may remain elevated for six months after significant storm events (such as hurricanes) due to surface water entering ground water from sink holes.

Fecal Indicator Microorganisms

Total coliforms are a broad category of bacteria that incorporates both harmless and pathogenic species. The ground water standard or MCL for total coliforms is 4 colonies per 100 mL. Occasionally the same ground water standard for total coliforms is informally applied to fecal coliform results, however, research has shown that a lower value may be more appropriate. There are three general fecal indicator analytes, including **fecal coliforms** (subset of total coliforms), *Escherichia coli* (subset of fecal coliforms), and **enterococci** (subset of fecal streptococci) (EPA, 2001). There are no ground water standards for *Escherichia coli* or enterococci, however the Department of Health uses fecal coliforms and enterococci as indicators of bacterial contamination and posts swimming advisories when thresholds are exceeded in recreational waters and beaches.

Coliform survival rates in ground water are being investigated, however, in applying the Total Coliforms standard for ground water, we are assuming that other pathogens have the same survival rate as fecal indicator bacteria. This may not always be the case since enterococci have been shown to be better predictors of gastrointestinal illness in saline water than fecal coliforms because enterococci have a slower die-off rate when compared to fecal coliform bacteria (EPA, 2001). Fecal indicator bacteria can survive from a few hours (surface water) up to months (lake sediments) (USGS web, 2003). There is less information on the presence and survival rates of bacteria in ground water since this field of study is so recent.

Other Pathogenic Microorganisms

Ground water free of fecal indicator bacteria can have other pathogenic bacteria, viruses, protozoans and helminths with special survival mechanisms including dormancy (USGS web, 2003). When these pathogens are dormant they are not detectable by the fecal indicator methods currently used. The two protozoans of major concern are *Giardia lamblia* and *Cryptosporidium*. Pathogenic protozoans exist as cysts that hatch, grow and multiply after ingestion by an appropriate host. The encystations enable protozoans to survive in harsh conditions such as high temperature and salinity. Enteric viruses are a group of infectious agents that are excreted in feces and include hepatitis. While chlorination and ultrafiltration methods have proven an effective treatment for some of these pathogens in ground water, concerns about biological contamination still persist.

Identifying Basin Wide Ground Water Quality Issues

The Status Network randomly selected and sampled fifty-nine wells and one spring within the St. Marks/Ochlockonee Basin in 2000 (**Appendix 5.B**). There were one spring and 29 wells in the unconfined aquifer group and 30 wells in the confined aquifer group. In this basin, the unconfined aquifer group consists of the surficial and the unconfined Floridan aquifers, and the confined aquifer group consists of the intermediate and confined Floridan aquifers. The intermediate aquifer is rarely used as a supply for ground water in the basin, and there were only two surficial wells randomly selected for sampling within the 30 confined aquifer wells. There was insufficient data to assess the intermediate aquifer wells.The Status Network biological analytes sampled for this basin included **total coliforms** and three more specific fecal indicators - **fecal coliforms ,** *Escherichia coli and* **enterococci.** Descriptive statistics of the Status Network data for the basin are provided in **Appendix 5.C** and discussed later in this assessment.

The Background Network included 44 wells from this basin sampled from 1985-1987, with 10 wells in unconfined aquifers and 34 in confined aquifers (**Appendix 5.D**). The Background Network biological analytes included only **total and fecal coliforms**, and descriptive statistics for these data are provided in **Appendix 5.D**.

To assess ground water quality for biological contaminants, the GRI for the basin was calculated based on total coliform data, the only biological analyte with a ground water standard.

Met GW Standards for Biological Contaminants
Values below the method detection limit (BDL) * and detections at or below the MCL.

Exceeded GW Standards for Biological Contaminants
Values that exceeded the MCL of 4 colonies/100 mL.

[* The lowest coliform method detection limit (MDL) reported for the Status Network is 1 colony/100 mL and for the Background Network 0 colonies/100 mL.]

Status Network Total Coliform GRI Analyses (2000)

The majority of confined and unconfined wells randomly selected were not significantly impacted by total coliforms, with 68% of the wells meeting the ground water standard for total coliforms (**Figure 5.1**). However, there were 19 Status Network wells that exceeded the ground water standard for total coliforms in this basin. **The Status Network GRI threshold of 10% was exceeded for coliforms in this basin, and this high incidence of exceedances may indicate there is a concern on a basin scale.**

Background Network Total Coliform GRI Analyses (1985-1987)

The Background Network GRI indicates that the majority of confined and unconfined wells in the basin were not significantly impacted by total coliforms, with 80% of the well samples meeting the ground water standard

(**Figure 5.2**). However, there were nine Background Network wells that exceeded the ground water standard for total coliforms, and the **Background Network GRI threshold of 10% was exceeded for coliforms in this basin, indicating coliforms are a significant issue.**

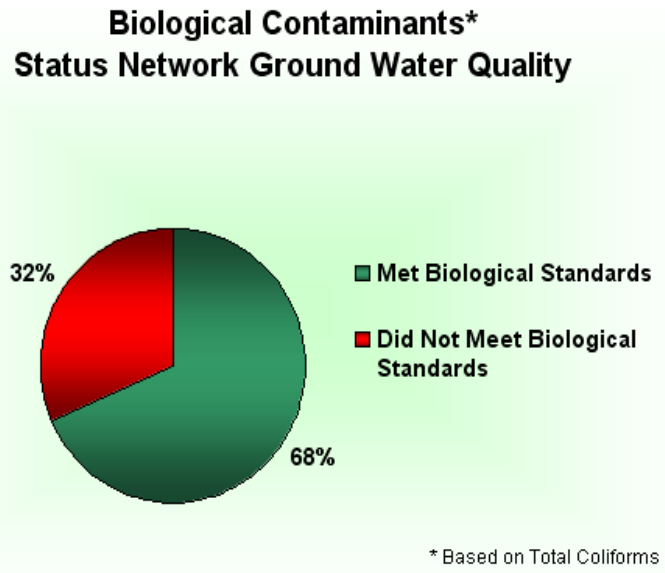

Figure 5.1. Biological Contaminants Status Network Ground Water Quality

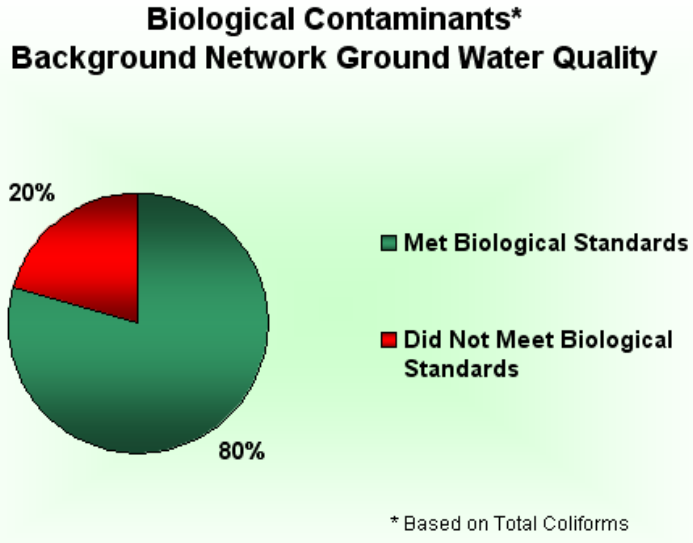

Figure 5.2. Biological Contaminants Background Network Ground Water Quality

Comparing the Background and Status Network

The GRI for both the Status and Background Network indicated a potential basin-wide issue exists. Status and Background Network data falls within two response categories – either total coliforms were not detected

or they exceeded the ground water maximum contaminant limit (MCL) of 4 colonies/100 mL. The descriptive statistics for the Background and Status Network wells are compared to further explore these issues. The variance, standard deviation and relative standard deviation (also known as the coefficient of variation) for total coliforms in both Background and Status Network wells are extremely high (Appendix 5.C and 5.D; Tables 5.1 and 5.2).

Table 5.1. Unconfined Aquifer Wells in the Background Network (1985-1987) and Status Network (2000)

TOTAL COLIFORMS	*Surficial*	*Surficial*	*Unconfined Floridan*	*Unconfined Floridan*
Sampling Years	*1985-1987*	*2000*	*1985-1986*	*2000*
Minimum*	1	0	0	0
1st Quartile*	2	0	1	11
Median	**2**	**0**	**30**	**20**
3rd Quartile	26	28	55	30
Maximum	50	1200	300	2000
Relative Standard Deviation	159%	269%	171%	250%
Total Wells	3	23	7	7
Number BDLs	1	15	3	1
Number MCL Exceedances	1	8	4	6
Percent MCL Exceedances	33%	35%	57%	86%

Table 5.2. Confined Aquifer Wells in the Background Network (1985-1987) and Status Network (2000)

TOTAL COLIFORMS	*Confined Intermediate*	*Confined Intermediate*	*Confined Floridan*	*Confined Floridan*
Sampling Years	*1985-1987*	*2000*	*1985-1987*	*2000*
Minimum*	0	0	0	0
1st Quartile*	0	0	1	0
Median	**1**	**0**	**1**	**0**
3rd Quartile	3	0	2	0
Maximum	70	0	31	40
Relative Standard Deviation	263%	NSD	231%	269%
Total Wells	11	2	23	28
Number BDLs	8	2	17	23
Number MCL Exceedances	2	0	2	5
Percent MCL Exceedances	18%	0%	9%	18%

[* NOTE: The lower range of data for both Status and Background Network datasets are censored, but with different method detection limits – 1 colony/100 mL for the Status Network and either 0 or 2 colonies/100 mL for the Background Network. Therefore densities of 1 colony/100 mL could be a BDL for the Background Network and a detection for the Status Network. For values reported as below the MDL, ½ the reported MDL is typically used in the dataset. However, for samples reported as below an MDL of 1 colony/100 mL, the values were set at 0 in the statistical analyses because there cannot be half a bacteria colony.]

Comparatively, the relative standard deviation and variance is higher for Status Network wells, which is an expected result since Background Wells should not be located near known point sources. The variance for Status Network wells compared to Background Network wells was over 100 times higher for the surficial aquifer, 48 times higher for the unconfined Floridan, and 2 times higher for the confined Floridan. Although high variance in the data is not unusual for coliforms, this greater variation in Status Network unconfined wells could be associated with the higher percent of monitoring wells randomly selected from the list frame of wells. This high variance in the data is important since it may suggest there is an insufficient number of samples to characterize the basin and it is inappropriate to apply particular statistical tests that assume homogeneity of variance (**Appendix 5E**).

To understand and interprete the differences in the variance and other descriptive statistics, impacted wells were evaluated with respect to the aquifer source and type of well they represent (**Table 5.3**). Status Network wells with elevated coliforms represented 8 private wells and 10 monitoring wells. Background Network wells with elevated coliforms represented 5 private wells and 6 monitor wells. It is notable that both networks have an almost equal amount of private and monitoring wells represented by the data. It is apparent the proportion of unconfined versus confined wells were not equal for the Background Network as they were for the Status Network and the unconfined aquifers were under-sampled by comparison in the Background Network. The Background Network's lower overall statistics (percent of all MCL exceedances) could simply be due to the inclusion of fewer monitoring wells in the population and twice as many wells in confined aquifers, which are less vulnerable than unconfined aquifers. Consistent with the Status Network results, the unconfined Floridan wells in the Background Network demonstrate a particular susceptibility, with a higher incidence of MCL exceedances than the surficial or confined Floridan wells.

Table 5.3. Well Type and Exceedance of GW Standards*

[* Based on total coliforms >4 colonies/100 mL.]

Establishing the Natural Background or Typical Levels of Coliforms

Establishing the natural background of coliforms for ground water is complex due to the issues and data limitations previously discussed. The Status Network was designed to provide the typical range of values on a basin wide scale while the Background Network was designed to provide a baseline representing the natural background levels for local areas of interest throughout the basin (**Tables 5.1** and **5.2**). As previously discussed, the natural background or typical values for coliforms may not reflect aquifer conditions. The distribution of the data indicates the median values are a better approximation of the central tendency than the mean (**Appendix 5.E**).

The **Unconfined Aquifers' Natural Background Range of Values** (Background Network) for total coliforms ranged from not detected to 300 colonies/100mL, with a mean value of 49.5 and a median of 16 colonies/100mL. The **Confined Aquifers' Natural Background Range of Values** (Background Network) for total coliforms ranged from not detected to 31 colonies/100mL, with a mean value of 2.7 and a median value of 1 colony/100mL. .

The **Unconfined Aquifers' Typical Range of Values** (Status Network) for total coliforms ranged from not detected to 2000 colonies/100mL, with a mean value of 150.5 colonies/100mL and a median value below detection. The **Confined Aquifers' Typical Range of Values** (Status Network) for total coliforms ranged from not detected to 40 colonies/100mL, with a mean value of 3.0 colonies/100mL and a median value of below detection.

Associations Between Water Quality and Hydrogeology

The typical range and median values established by the Status Network for total coliforms illustrate the magnitude of dissimilarity between the unconfined and confined aquifers (**Figure 5.3**). The unconfined Floridan aquifer had the highest maximum total coliform value of 2000 colonies/100 mL and a median value of 20 colonies/100 mL. The surficial aquifer had a maximum total coliform value of 1200 and a median of 0 colonies/ 100 mL. In contrast, the confined Floridan aquifer had a maximum total coliform value of 40 colonies/100 mL and a median value of 0 colonies/100mL.

The Status and Background Network data indicate The occurrence of total coliform exceedances in Status Network wells with different confining conditions and aquifer types shows that an association between hydrogeology and water quality. Overall, the unconfined Floridan wells in both the Background Network and Status Network demonstrate a particular susceptibility and have the highest percentage of MCL exceedances and median values for total coliforms (**Tables 5.1** and **5.2**). Confined Floridan wells appear similar for both networks. The confined intermediate wells did not have an adequate representation in the Status Network for evaluation.

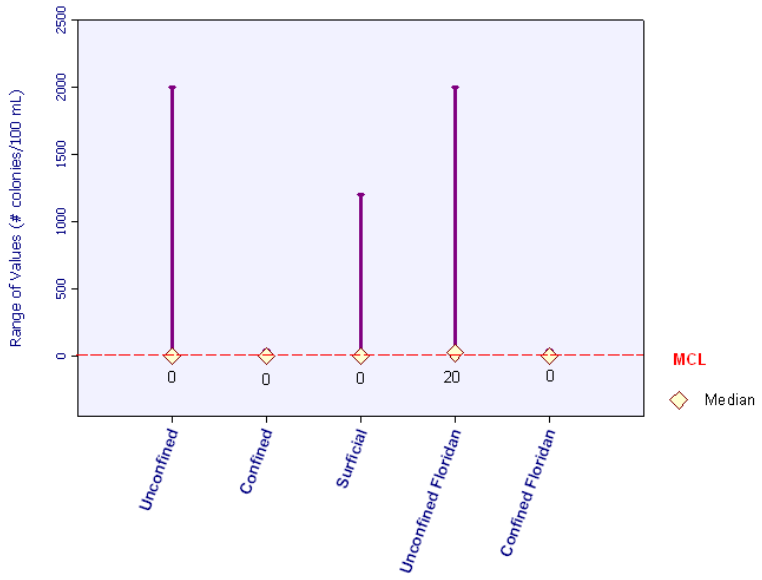

Figure 5.3. Range of Values for Total Coliforms Status Network Wells

Detailed statistical analyses (Fisher's Exact and Yates Chi-Square Tests) on Status Network data confirm that the unconfined Floridan has the greatest vulnerability to coliform contamination and is significantly more vulnerable than the surficial aquifer (**Table 5.4**). This is attributed to the unconfined Floridan's proximity to land surface and/or presence of karst features that result in a higher vulnerability to contamination. Further analyses indicate that coliform contamination is controlled by both the type of aquifer and confining conditions (**Appendix 5.F**).

Table 5.4. Total Coliforms Relate to Confinement and Aquifers

Aquifer	Surficial	Intermediate	Unconfined Floridan	Confined Floridan	Total Wells
Nondetections	15	2	1	23	41
Detections < = MCL	0	0	0	0	0
Exceedances MCL	8	0	6	5	19
Total Wells	23	2	7	28	60
Percent MCL Exceedances	35%	0%	86%	18%	32%

Integrating Other Data Sources

Other sources of data were also assessed to determine if they support the initial findings based on the Status and Background Network data. Another source of ground water data for the basin was from Public Water Supply (PWS) systems, which must report monitoring results for total coliforms on a regular basis for untreated source water. The compliance data for PWS wells near Status Network stations with MCL exceedances were helpful in determining the spatial extent of the contamination and whether improper

maintenance of private wells could be a factor. Five out of eighteen Status Network wells (Station Numbers 33, 6324, 6341, 9267, 9271 and 9272) and one Temporal Variability Network (Station Number 91) well were located in close proximity to a PWS well. Results from Status Network Station number 33 was actually from a PWS well.

Monitoring data from the past 5 years (1998-2003) from untreated source water for these six PWS wells were analyzed. The MCL exceedance frequency could not be calculated for PWS wells because drinking water facilities use drinking water standards with presence/absence categories and do not report actual coliform values (Rule 62-550.310 F.A.C.). There were 342 well samples with only 2 detections of total coliforms, representing 0.6% detections. This is a very low occurrence when compared to Status and Background Network wells. These data indicate the coliform exceedances in the basin are limited in extent to the local conditions near the network wells and could be related to aquifer vulnerability, depth of wells, well construction, siting of wells near septic tanks, and less frequent well testing and/or maintenance of Status and Background Network wells promoting coliform growth. These data also imply that the coliform contamination could be a condition within the well and not necessarily related to conditions in the aquifer.

The VISA and HRS wells were not sampled for biological contaminants in this basin. The State and County Health Department officials sample for suspected occurrences of bacteria in private wells, but the data are not retained in a database by either FDEP or DOH.

Spatial Distribution of Status Network Exceedances (2000)

Coliform exceedances from Status Network results are spatially distributed throughout the basin, but occur more frequently in the southeastern portion below the Cody Scarp and where the Floridan aquifer is unconfined (**Figure 5.4**). The location of wells with exceedances in the Background Network also followed this pattern (**Appendix 5.D**). The characteristics of the unconfined Floridan aquifer with karst features exemplify the most vulnerable conditions for pathogen transport to ground water. In the southeastern portion of the basin, the unconfined Floridan is at the land surface, contains little organic matter and clays, and has a higher pH that results in a lower rate of pathogen adsorption to soil particles.

Microlanduse and Sources of Coliforms

Fecal indicator bacteria (fecal coliforms, *Escherichia coli* and enterococci) are typically used to indicate ground water contamination from septic systems, waste treatment plants, water reuse or sprayfields (waste land application), landfills, domestic pet and wildlife excrement, or animal feeding operations. Young and Thackston (1999) found an association between fecal bacteria densities and the density of housing, population, development, percent impervious area, and domestic animal density.

To facilitate the evaluation of possible sources of contamination, microlanduse, defined as features observed within 300 feet surrounding the well, is recorded at the time of sampling for both the Status and Background Networks. The station numbers on **Table 5.5** correlate to locations shown on **Figure 5.4** and station

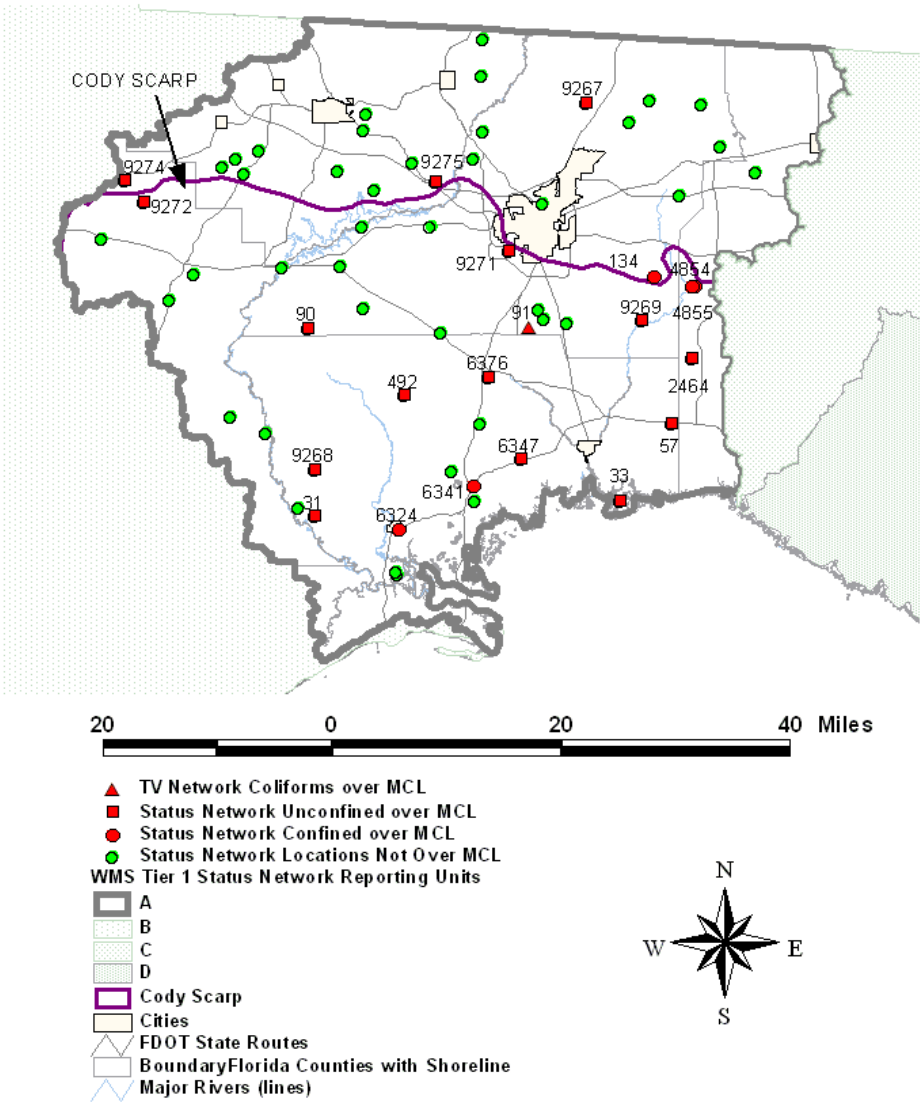

Figure 5.4. Spatial Distribution of Status Network Exceedances (2000)

descriptions are provided in **Appendix 5.B**. The microlanduse data for all wells with elevated coliforms was evaluated. In every instance of elevated coliforms, potential sources of coliforms such as residences, septic tanks, animal waste, and sewage treatment sprayfields were noted.

The highest coliform exceedances are located in the basin's southern unconfined aquifers. MCL exceedances in both the historic and the more recent sampling periods, which potentially represent a continuing concern, were observed in two Status Network stations (Station 90 and 57) and one Temporal Variability Network (91) station. The microlanduse for both of the Status Network stations involve hunting and camping recreational activities, while the Temporal Variability Network station is a private well. Coliform contamination is not unusual near campgrounds with recreational vehicles and sewage holding tanks or near hunting camps with kennels. However, this data assessment identified both camping and hunting activities as potential new microlanduse categories of interest through the benefit of the Status Network's probabilistic approach.

Table 5.5. Status Network Wells and Microlanduse

STATUS NETWORK WELLS AND MICROLANDUSE				
Station #	Aquifer	Parameter	Value	Associated Microlanduse
31	S	Total Coliform	15	Low Density Residential
31	S	Fecal Coliform	14	Low Density Residential
33	UF	Total Coliform	20	Refuge Headquarters, Wetlands
57	UF	Total Coliform	2000	Game Check Station, Kennels, Wetlands & Highway
57	UF	Fecal Coliform	10	Game Check Station, Kennels, Wetlands & Highway
90	S	Total Coliform	700	Otter Camp, Kennels, Roads
91	UF	Total Coliform	10	Septic Tanks, Residential, Roads, Streams, Private Wells
91	UF	Fecal Coliform	4	Septic Tanks, Residential, Roads, Streams, Private Wells
134	CF	Total Coliform	40	Low Density Residential, Septic Tanks, Junk Yard
492	S	Total Coliform	1200	Hunt Camp, Roads, Wetlands, PWS Well(s)
492	S	Fecal Coliform	900	Hunt Camp, Roads, Wetlands, PWS Well(s)
2464	UF	Total Coliform	12	Septic Tank(s), Animal Feeding, Low Density Residential
4854	CF	Total Coliform	10	Septic Tank(s), Animal Feeding, Low Density Residential
4854	CF	Fecal Coliform	8	Septic Tank(s), Animal Feeding, Low Density Residential
6324	CF	Total Coliform	10	Septic Tank(s), Ditch, Parking Lot, Residence, Wetlands
6324	CF	Fecal Coliform	8	Septic Tank(s), Ditch, Parking Lot, Residence, Wetlands
6341	CF	Total Coliform	20	Septic Tank(s), Residential, Major Roads
6347	UF	Total Coliform	10	Septic Tank(s), Animal Feeding, Kennel, Residential, Roads
6376	UF	Total Coliform	10	Septic Tank(s), Animal Feeding, Residential, Roads
9267	S	Total Coliform	40	Talquin Sewage Treatment Sprayfield
9267	S	Fecal Coliform	40	Talquin Sewage Treatment Sprayfield
9268	S	Total Coliform	50	Ditch-drainage, Storage Tanks, Lakes, Roads-Other
9268	S	Fecal Coliform	25	Ditch-drainage, Storage Tanks, Lakes, Roads-Other
9269	Spring	Total Coliform	20	Septic Tank(s), Ditch, Residence, Storage Tank, PWS Well(s)
9269	Spring	Fecal Coliform	20	Septic Tank(s), Ditch, Residence, Storage Tank, PWS Well(s)
9271	S	Total Coliform	10	Sewage Treatment Sprayfield, High Density Residential, Wetlands
9272	S	Nitrate+Nitrite	19	Liberty Correctional Facility - Sewage Treatment Plant, Septic Tank(s)
9274	S	Total Coliform	200	Liberty County Landfill, Grove - Other
9274	S	Fecal Coliform	60	Liberty County Landfill, Grove - Other
9275	S	Total Coliform	200	Residential/Commercial - Septic Tank(s), Ditch-drainage, Repair Shops

Pollutant Source Indicators in Status Network Wells

As previously discussed, detections of total coliforms in ground water indicate an exposure to either biological contaminants. The presence of total coliforms indicates either surface water runoff (with or without harmful pathogens) or some type of fecal waste leachate (with harmful pathogens), either from the surface or within the aquifer, is reaching the ground water. Detections of more specific fecal indicators - fecal coliforms (subset of total coliforms), *Escherichia coli* (subset of fecal coliforms), and enterococci (subset of fecal streptococci) - provide a more definitive assessment since they are more directly related to human or animal waste and associated pathogenic species. The drinking water standard exceedances for microbiologicals include any detection of total coliforms or Escherichia coli (Rule 62-550.310 F.A.C.). Although there are no ground water standards for these three fecal indicators, their very presence in a well signifies a deterioration in ground water quality. If only total coliforms and none of the more specific fecal indicators are present in the well, then there is a greater chance that surface water with harmless naturally occurring bacteria rather than septic leachate is influencing the water quality in the well. If the source of total coliforms in ground

water is due to leached animal or human excrement, it is expected that some of the more specific fecal indicators would also be present.

The Status Network descriptive statistics for multiple fecal indicators are shown for the two broad categories of aquifers (**Tables 5.6** and **5.7**). The median value for all of the fecal indicators was zero for the categories of unconfined and confined wells in the basin, indicating that fecal indicators were not present in the majority of ground water wells in the basin. Upon review of the data from the 15 Status Network wells that exceeded the total coliforms standard, 80% of these exceedances (12) had detections in at least one of the other fecal indicators (**Appendix 5.C**, **Figures 5.C2** and **5.C3**). The total coliforms in the three unconfined wells that did not have detections of other fecal indicators (Stations 90, 6376 and 9275) could reflect an impact from surface water runoff without fecal excrement, although all three had microlanduses that could contribute fecal coliforms. The maximum values for unconfined aquifers are magnitudes higher than the confined aquifers and even exceed the surface water criteria (800 colonies per 100 ml). It is important to note that there are numerous surface water bodies that are potentially impaired for coliforms and other bacteria in this basin. Coliforms in ground and surface water will be explored further with the Ground Water/Surface Water Relational Assessment (SRA) in a later section of this report.

Is the Resource Improving or Degrading

If there is no significant difference between the historic Background and recent Status Network data, then the conclusion of no change is uncomplicated. However, if the two data sets are dissimilar, the cause could be due to previously stated differences in the network design and/or populations of wells selected for sampling. This assessment, however, identified significant differences between the historic Background and recent Status Network data. For example, the Status Network had a higher variance and percent of overall exceedances than the Background Network for total coliforms, with exceedance rates of 32% and 20% respectively **(Figures 5.1** and **5.2**). Descriptive statistics also show that in addition to the greater

Table 5.6. Fecal Indicator Analytes for Status Network Unconfined Aquifers

Parameter Name Units (#/100ml)	*Total Coliform*	*Fecal Coliform*	*E. Coli*	*Enterococci*
Sampling Years	*2000*	*2000*	*2000*	*2000*
Minimum *	0	0	0	0
1st Quartile *	0	0	0	0
Median	**0**	**0**	**0**	**0**
3rd Quartile	35	2	0	25
Maximum	2000	900	1000	1300
Interquartile Range *	35.0	1.5	0.0	25.0
Mean	150.6	35.2	34.8	64.1
Total Wells	30	30	30	30
Number BDLs	16	22	25	18
Number MCL Exceedances	14	N/A	N/A	N/A
Percent MCL Exceedances	**47%**	**N/A**	**N/A**	**N/A**

Table 5.7. Fecal Indicator Analytes for Status Network Confined Aquifers

Parameter Name Units (#/100ml)	*Total Coliform*	*Fecal Coliform*	*E. Coli*	*Enterococci*
Sampling Years	*2000*	*2000*	*2000*	*2000*
Minimum *	0	0	0	0
1st Quartile *	0	0	0	0
Median	**0**	**0**	**0**	**0**
3rd Quartile	0	0	0	0
Maximum	40	8	2	124
Interquartile Range *	0.0	0.0	0.0	0.0
Mean	3.0	0.7	0.1	4.6
Total Wells	30	30	30	30
Number BDLs	25	26	29	25
Number MCL Exceedances	5	N/A	N/A	N/A
Percent MCL Exceedances	**17%**	**N/A**	**N/A**	**N/A**

percentage of exceedances in the Status Network, there are higher maximum values in the more recent Status Network data.

When the Background Network is compared to the Status Network by aquifer type, the upper distribution of data suggests that overall ground water conditions in unconfined and confined wells have degraded over the years (**Tables 5.1** and **5.2**) .

Upper Distribution (3rd Quartile and Maximum)

- **Surficial and unconfined Floridan** wells had an upper distribution that increased, as illustrated by the 3rd quartile and maximum values that both exceeded the MCL. There was also an increase in the percent MCL exceedances. **Unconfined Floridan wells** showed the most change in maximum values (from 300 to 2000) and a 29% increase in the percent of MCL exceedances (from 57% to 86%). **Surficial wells** also showed considerable change in maximum values (from 50 to 1200) and a 2% increase in the percent of MCL exceedances (from 33% to 35%).
- **Confined Floridan** wells had an upper distribution that remained relatively constant and exceeded the MCL. The **confined Floridan wells** had only a slight increase in maximums (from 31 to 40), with an increase in the percent of MCL exceedances of 9% (from 9% to 18%).

Median Values

- Values were low and exhibited little change for all aquifer types except the **unconfined Floridan** wells that had a decrease in the median value.

Lower Distribution (1st Quartile and Minimum)

- The lower distribution remained relatively constant for unconfined and confined wells.However, there is somewhat more dissimilarity for the **unconfined Floridan** wells.

Probability of Contamination in the Actual Ground Water Resource

Although the GRI assessment appears to indicate a slight decline in the overall ground water quality due to coliforms in wells, the Status and Background Network are based on sampling existing wells rather than the actual ground water in the aquifer. It is apparent the proportion of unconfined versus confined wells were not equal for the Background Network as they were for the Status Network and the unconfined aquifers were under-sampled by comparison in the Background Network (**Table 5.3**). The Background Network's lower overall statistics (percent of all MCL exceedances) could simply be due to the inclusion of fewer monitoring wells in the population and twice as many wells in confined aquifers, which are less vulnerable than unconfined aquifers.

Additionally, the large number of censored data points at the MDL may affect inferential statistics such as the commonly used cumulative distribution function (CDF) plot. Acknowledging these concerns, the Status Network wells were compared to the Background Network wells with a CDF plot and approximately thirty percent of all existing wells in the basin were inferentially estimated to have a high probability of total coliform MCL exceedances **(Appendix 5.E**, **Figure 5.E6**). Other coliform data from public water supply wells with a very low rate of detections suggest contamination is local in extent and not a widespread resource issue. Therefore, any inferences about the water quality in the actual ground water resource, based on the ground water sampled from wells for biological contaminants, is circumspect.

As this assessment has shown, there is no basis for the assumption that the densities of coliforms in wells accurately assess conditions in the aquifer. No definitive conclusion can be formulated based on the existing data as to whether the actual ground water resource has improved or degraded with respect to coliform contamination in this basin. As the new Status Network progresses, future cycles of random data will be compared to previous cycles from the same design. This refinement will improve our ability to evaluate and demonstrate whether changes have occurred in a basin's ground water resource.

CONCLUSIONS OF THE BIOLOGICAL ASSESSMENT

Although the majority of ground water in the St. Marks and Ochlockonee Basin meets the total coliform standard, **the percent of wells that exceed the coliform standard is of concern.** The GRI and assessment for biological contamination indicates a significant issue exists for coliforms in surficial, unconfined Floridan and Floridan aquifer wells. The data suggest a strong association between aquifer vulnerability, microlanduse and biological contamination. The most frequent occurrence of biological contamination was in the southern area of the basin, below the Cody Scarp, where the unconfined Floridan is at or near the land surface. Without stratifying the data, the Status Network wells with coliform MCL exceedances are comprised of an almost equal number of private and monitoring wells. The most frequent microlanduses near wells with a coliform exceedance are related to wastewater systems, including residential septic systems and municipal sprayfields. Hunting and camping activities were also identified by the Status Network random selection of sites as an unexpected microlanduse commonly associated with coliform contamination.

Although the GRI and assessment appears to indicate a slight decline in the overall ground water quality due to coliforms, conditions inside a well are not always representative of the aquifer resource. Inferences into the reason for the decline are complicated due the following:

(1) Coliforms are a living organism that can become established in a well and reproduce if an adequate substrate such as biofilms are present. If wells were contaminated in the Background Network (1985-1987) and not disinfected properly, the organisms could have multiplied and increased the MCL exceedances reported in the Status Network sampling (2000) without a simultaneous increase in the aquifer;

(2) Considerable changes have occurred in the basin during the thirteen years between the Status (2000) and Background Network (1985-1987) sampling periods. The basin has experienced increased land development in many vulnerable areas and areas that remained relatively rural could have an increase in biological contaminants due to inadequate maintenance of existing septic systems; and

(3) The increased number of wells that do not meet the standard could simply be an artifact of comparing two different sampling designs.

Monitoring data from public supply wells near Status Network wells with MCL exceedances were helpful in determining the extent of coliform contamination and whether frequent monitoring and proper maintenance of wells could be a factor. Using the past five years of monitoring data, public supply wells had few incidences of coliform detections. The type of well with coliform exceedances was represented almost equally by both private and monitoring wells (not associated with public water supply facilities). These data

indicate the coliform exceedances in the basin are limited in extent to the local conditions near wells and may be related to aquifer vulnerability, well construction, siting of wells near septic tanks, and less frequent well testing and/or maintenance promoting coliform growth.

With respect to addressing the coliform issues stated above, more targeted data will be needed to draw meaningful conclusions. As a result of this assessment, the GWPS recommends that Status and Background Network wells reported with coliform MCL exceedances be resampled for fecal contamination for those wells where the water is used for consumption. The GWPS may also recommend additional sampling of surrounding wells in the area once these data are available. When appropriate, the GWPS may design and execute intensive ground water studies to define the spatial extent and sources of persistent contamination.