

WATER TREATMENT ASSESSMENTS AND GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER DETERMINATIONS FOR GWA WELLS LOCATED IN THE NORTHERN AQUIFER OF GUAM

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Cooperators

U.S. ENVIRONMENTAL PROTECTION AGENCY GUAM ENVIRONMENTAL PROTECTION AGENCY GUAM WATERWORKS AUTHORITY US NAVY US AIR FORCE UNIVERSITY OF GUAM WERI

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ABSTRACT

In March of 2008 the Guam Environmental Protection Agency (GEPA) and the University of Guam, Water and Environmental Institute of the Western Pacific (WERI) signed a Memorandum of Understanding that established WERI as the study coordinator for a study to make treatment requirement and Groundwater Under The Direct Influence Of Surface Water (GWUDI) recommendations for wells located in the Northern Guam Aquifer. One year's worth of data was analyzed in the first phase of this study. The study was later extended to cover data that was gathered in 2011. This report is the completion report for the 2011 data interpretation project. Because of contractual delays, only the results for the GWA wells are presented in this report. The military wells will be analyzed in a follow-up study. Turbidity, bacteriological, and Microscopic Particle Analyses (MPA) data was analyzed to make the treatment and GWUDI determinations.

The turbidity treatment recommendations made are based on interpretations of the studies Quality Assurance Project Plan (QAPP) as applied to the frequency analysis of the continuous turbidity data. In making these turbidity treatment recommendations, it was suggested that a three period median averaging technique be applied to the raw turbidity data gathered at the well sites. It was also recommended that, in light of the vast amounts of 15 minute turbidity data gathered, the criteria recommended in the QAPP for the various treatment requirements be relaxed somewhat. Suggested treatment options varied from well to well and ranged from retaining single disinfection only to membrane filtration or well shut down during high turbidity times. It is now up to the regulators and the utilities to determine whether or not to use the smoothed data, whether or not to relax the QAPP criteria, and if the QAPP criteria is relaxed what relaxed values should apply.

A second study was carried out to determine the status of the wells as outlined by the GWUDI determination rules suggested in the QAPP. Certain adjustments were made to the QAPP GWUDI criteria to make it compatible with the frequency and regressions analyses that were used. Three sets of GWUDI determinations were presented. The least conservative of these recommendations declared all wells studied to be "NOT GWUDI". The most conservative of the three would require that nine of the wells be re-tested. In light of past MPA analyses that were performed, it is likely that the wells would test low and be declared "NOT GWUDI". The regulators and utilities must agree on which QAPP interpretations for GWUDI status should apply.

When making determinations about the GWUDI status and the treatment requirements it is important that these decisions be based on adequate and reliable data. A review of data availability showed that all of the GWA GWUDI wells were not serviced during the period of June through October 2011 leading to data reliability issues. Also, seven of the wells had no data recorded during the highest rainfall times of the study period. Lastly six of the wells had less than ½ of a year of data days available. These are all serious concerns that must be addressed by the regulatory agencies.

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INTRODUCTION

In March of 2008 the Guam Environmental Protection Agency (GEPA) and the University of Guam, Water and Environmental Institute of the Western Pacific (WERI) signed a Memorandum of Understanding that established WERI as the study coordinator for a study titled "Water Treatment Assessments And Groundwater Under The Direct Influence Of Surface Water Determinations For Wells In The Northern Aquifer Of Guam". Since this study involved the evaluation of Groundwater Under the Direct Influence of Surface Water, the study is more commonly known as the Guam GWUDI study. One year's worth of data was analyzed in the first phase of this study. The study was later extended to cover the 2011 period. The following report serves as the completion report for the 2011 data interpretation project. Because of contractual delays, only the results for the GWA wells will be presented in this report. The military wells will be analyzed in a follow up study

The following is taken from the planning document titled "Quality Assurance Project Plan" (QAPP) dated 10/15/08 which was used to set the scope of this GWUDI study. The complete QAPP for this project is provided in Appendix 1 of this report.

BACKGROUND AND SCOPE

A primary goal for drinking water is that it be microbiologically safe. Drinking water sources should be free of microbial pathogens, if possible. Otherwise, adequate treatment to remove and inactivate these pathogens is necessary. Filtration can remove pathogens directly and can control materials that can inhibit disinfection. Disinfection inactivates or destroys the pathogens. Current United States Environmental Protection Agency (USEPA) drinking water goals are to reduce the risk of waterborne disease to less than one infection per 10,000 people per year.

Water sources are generally either surface water (lakes, streams, rivers) or groundwater. Because surface water sources are directly open to fecal contamination from runoff or deposition, they are usually considered to be so contaminated. They are also subject to contamination with particulate matter, yielding turbidity. True groundwaters are considered to be free of larger pathogens (protozoa) and particulate matter due to natural filtration in the vadose zone or aquifer, or because of a confining layer that prevents surface contamination from reaching the aquifer. However, there is a class of groundwaters for which these barriers are not present. If an aquifer consists of fractured rock, or large-diameter material, or tubes and fissures, materials may move with minimal interference from surface source to groundwater. The term "groundwater under the direct influence of surface water" (GWUDI) is used for this type of groundwater.

The aquifer encompassing the northern half of Guam consists primarily of uplifted fractured limestone that has been substantially altered through dissolution. This hydrogeological setting is thought to be unique to Guam, Saipan and other islands in the Northern Marianas group. Fractured, chemically-altered limestone ("karst") aquifers are generally regarded as sensitive to surface contamination.

The following is the definition of a karst aquifer taken from Lohman and others (1972): A karst aquifer is an aquifer containing soluble rocks with a permeability structure dominated by interconnected conduits dissolved from the host rock which are organized to facilitate the circulation of fluid in the down gradient direction wherein the permeability structure evolved as a consequence of dissolution by the fluid.

Many surface-related sources of contamination are found in the northern part of Guam. Raw sewage can run directly into recharge wells and basins. Small-scale animal husbandry is wide-spread. There is a long history of microbial and chemical contamination of the groundwater. As a result, mandatory disinfection has been required for all wells.

It has been suggested that the entire aquifer be designated as GWUDI, because of the hydrogeology and contamination, and because groundwater contamination could rapidly follow major rain events. A recent study performed by GEPA, United States Geological Survey (USGS), and WERI estimated the time-lag between the heavy rain associated with Tropical Storm Tingting in June, 2004 and the subsequent rapid rise of the water table at 15 hours. This rapid infiltration occurred through an unsaturated zone of approximately 200 feet.

Unfortunately, current USEPA guidance for the determination of GWUDI does not adequately address this hydrogeological setting. This guidance was developed primarily for aquifers in unconsolidated soils and for aquifer recharge from surface water bodies such as lakes and rivers. The purpose was to identify situations where inadequate barriers, natural filtration, or time for pathogen inactivation existed between these surface waters and the groundwater reaching a well. In these cases, additional treatment in the form of filtration and enhanced disinfection might be required. The guidance was not designed for rainfall-induced infiltration of contaminants from the surface, nor for deep aquifers.

In addition, specific data normally used for this determination are limited or lacking. These include water quality information to quantitatively demonstrate relatedness, and microscopic particulate analysis results that can indicate the presence of materials not normally associated with true groundwater. A recently completed treatability study of PCB-contaminated sediment by Anderson Air Force Base (AAFB) implied that fine-grained sediment could be transported by infiltrating rain through voids in the limestone. Results from this study may be helpful in the GWUDI determination for Guam's Northern Aquifer. Additionally, while some wells show frequent and/or persistent contamination, many have no history of contamination. The depth to groundwater is generally large (300' is common), allowing for some physical and temporal barriers in some cases. This means that, while concern for direct influence is warranted, whether all or the majority of the ~150 public water supply wells should be so designated is unclear. Because of these reasons, classification of the wells and/or aquifer remains controversial.

The implications of a GWUDI designation are clear, however. These wells would be regulated under the Surface Water Treatment Rule (SWTR) as "Subpart H" surface water systems, would have to be appropriately monitored and disinfected, and would either have to install and operate filtration systems, or meet filtration avoidance criteria. In addition, Long-term 2 Enhanced Surface Water Treatment Rule (LT2 ESWTR) requirements would mean *Cryptosporidium*, *E. coli* and turbidity monitoring for each well. This would be an expensive and problematical burden for Guam, and would not obviously provide commensurate additional public health protection. Guam Water Authority (GWA) has 111 drinking water wells in the northern aquifer. US Navy and US Air Force have about 40 wells between them. A recent cost estimate for complete GWUDI compliance is \$145 million.

There is agreement between all parties that data need to be acquired to make the GWUDI determination and to help select appropriate water treatment. Several planning meetings have been held over more than a year to develop a feasible study that will provide the necessary information.

EPA Region 9 has taken enforcement actions against Guam Water Authority, resulting in a stipulated agreement to provide suitable treatment for the provision of drinking water. The GWUDI determinations by Guam EPA are necessary for GWA to address this agreement element. Additionally, this determination will impact wells in this aquifer under control of United States Nave (USN), United States Air Force (USAF), Foremost Foods and the Guam Plaza Hotel. Deadlines under the agreement and mandated by LT2 ESWTR require a determination as soon as possible.

Legal and Regulatory Authority

The authority for the study comes from the Safe Drinking Water Act (SDWA). State drinking water primacy agencies (such as Guam EPA) make GWUDI determinations and can require information from regulated utilities. They also make determinations with respect to treatment requirements, including filtration avoidance. The information from this study will be used by Guam EPA to make GWUDI, filtration avoidance, and treatment determinations. Therefore, Guam EPA is the primary end recipient of the study results. However, the utilities will benefit from the new information for planning and compliance purposes.

Study Objectives

The objectives of this water quality study on northern aquifer wells are 1) to determine whether specific wells are GWUDI, 2) to inform a decision on general classification of the aquifer and/or sub-basins as GWUDI, and 3) to suggest appropriate treatment for GWUDI and non-GWUDI wells.

Approach

The approach to achieving the study objectives will include these components:

1) A full GWUDI analysis on a statistically-representative subset of Guam drinking water wells using water quality data collected over a period of one year. (Conduct microscopic particulate analyses (MPAs) for these wells. Collect turbidity and

conductivity data on a continuous basis for each well. Collect microbial indicator data and other water quality information on a regular basis for each well. Collect corresponding meteorological (rainfall) data on a continuous basis. Conduct water quality studies associated with any incidental contamination events.)

- 2) Evaluation of these specific wells, the northern aquifer and its sub-basins as units for general GWUDI classification.
- 3) Collection of data to assist with decisions about what types of treatment would be most appropriate for the particular hydrogeological settings and contaminant threats found in Guam. This will include source water contamination assessments.

General study elements

- 1. A statistically-representative subset (approximately five per sub-basin) of wells will be initially tested. Wells with a history of significant fecal contamination will be considered as the highest priority for the study. This study set will also include wells with a history of no microbial problems as controls. To the extent possible (some sub-basins have few wells), geographical representation across the entire aquifer will be sought. This will be done collectively by the participants.
- 2. Continuous recording turbidimeters and conductivity meters will be installed and monitored on these designated wells. Monitoring will be done by the utilities: Guam Water Authority, US Navy, US Air Force, Guam Airport Authority, Guam Plaza Hotel.
- 3. Rain gauges will be installed and monitored at or adjacent to each site. Monitoring will be done by WERI/ UOG.
- 4. The designated wells will be tested weekly for total coliform bacteria, *E. coli* and enterococci. Coliphage will also be monitored weekly, if the method allows for this. Monitoring will be done by the utilities.
- 5. A minimum of two microscopic particulate analyses will be done on each of these designated wells. One will be done during the dry season. One will be done associated with storm events. Others will be done associated with positive *E. coli* or enterococci results. This will be done by the utilities.
- 6. If not already available, field surveys for potential sources of microbial and other contamination will be conducted in the recharge areas of each well. This will be done by GEPA.
- 7. Additional meteorological and hydrogeological data will be acquired to support correlations between storm events and contamination. This will be done by WERI and Guam EPA.
- 8. Data will be collected for a period of one year, compiled, and used by Guam EPA to classify wells as GWUDI or groundwater (GW). Data collection and analysis will be done collectively by the participants. Formal classification will be done by GEPA.
- 9. Water quality data (nitrate, hardness, calcium, magnesium and chloride) will be collected monthly and used to select candidate SWTR treatment approaches. This will be done collectively by the participants.

AREA OF STUDY

Figure 1 shows the area of Guam under investigation along with the location of the 15 GWA well sites where continuous water quality data was gathered. Figure 2 shows the Guam Waterworks Authority (GWA) well sites that are part of the investigation along with the groundwater sub-basin boundaries. Figure 3 shows the US Navy and US Air Force well sites that were monitored for the study. The analysis for the Air Force and Navy wells are not provided in this report. The contract to analyze the military data was not finalized until October of 2012 and the study results will be contained in a subsequent report.



Figure 1. Satellite imagery of study area with GWA study well sites

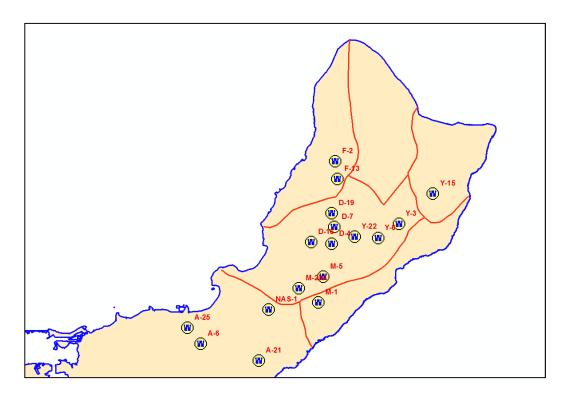


Figure 2. GWA well sites and groundwater sub-basins

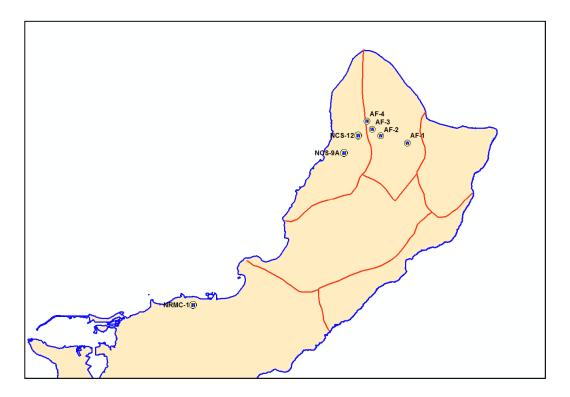


Figure 3. Air Force and Navy well sites

DATA GATHERED

The data that was gathered for the study is shown in Table 1. All of the data that was gathered by the cooperators was sent to WERI where it was catalogued and stored.

Following is a discussion of each of the parameters that were gathered:

RAINFALL

Tipping bucket rain gages were located throughout the study area. Figure 6 on page 24 of Appendix 1 shows a picture of a typical tipping bucket rain gage. The location and identifying name of the gages are show in Figure 4. Two rain gages were assigned to each of the wells being monitored. To assist in assigning rain gage stations to the nearest wells we used a GIS technique called Euclidian allocation. A map of this Euclidian allocation is shown in Figure 5. Two gages were assigned to each well by first evaluating which rainfall gage was closest to the well and secondly by trying to use at least one rain gage that was up gradient in the average flow of groundwater in the aquifer in the vicinity of the well. Table 2 contains a listing of which rainfall monitoring stations were assigned to which well.

- **❖** RAINFALL
 - ❖ TIPPING BUCKET RAIN GAGES 1/100 INCH RESOLUTION
- **❖** CONTINUOUS WATER QUALITY PARAMETERS
 - **❖** TURBIDITY
 - **❖** CONDUCTIVITY
 - **♦** pH
 - Temperature
- ❖ INTERMITTENT WATER QUALITY PARAMETERS (weekly basis)
 - **❖** Total Coliform
 - E. coli
 - Enterococci
 - Nitrates
 - Chloride
 - Calcium Hardness
 - **❖** Magnesium Hardness
 - **❖** Total Hardness
- ❖ MPA ANALYSIS (linked to Storm events)

Table 1. Parameters gathered for the GWUDI study

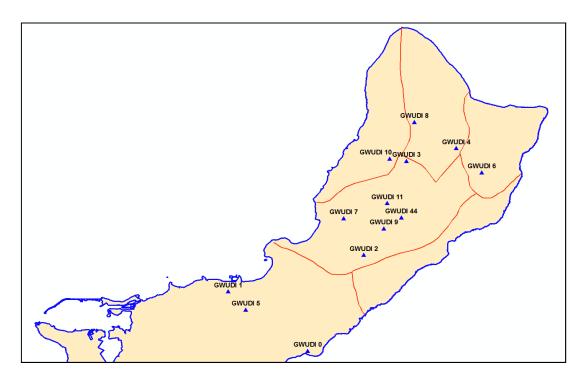


Figure 4. Location of project rainfall monitoring stations

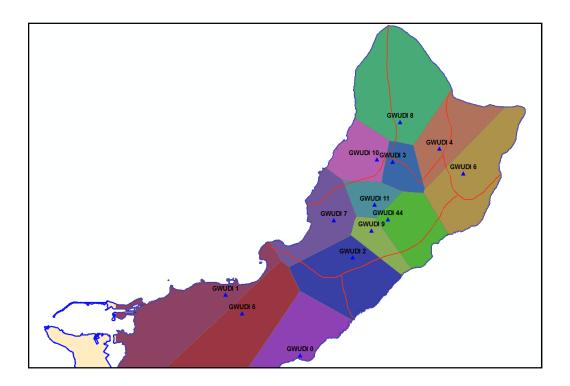


Figure 5. Euclidean allocation of rainfall monitoring sites

WELL	RAIN GAGE	RAIN GAGE 2
A6	5	1
A-21	0	5
A-25	5	1
D-4	44	9
D-16	5	1
D-19	3	11
F-2	44	10
M1	2	9
M5	2	9
M20-A	2	9
NAS1	1	5
Y-3	44	6
Y-6	44	6
Y-15	6	4
Y-22	44	11
NRMC-1	5	1
NCS-9A	8	10
NCS-12	8	10

Table 2. Rainfall monitoring stations assigned to well sites

A complete listing of the availability of data from the rainfall monitoring sites is shown in Figure 6. The raw data from the rain gages is simply a time-stamped data point for each time the tipping bucket is tripped. The rain gages that were used had 0.01 inch resolution which means that the gage tripped with each 1/100 of an inch of rainfall. An example of the raw data from a gage and the processing program that was applied to the data is shown in Figure 7. The rainfall data was processed to produce a complete listing of hourly data which was used in this study plus rainfall intensity data and listings for rainfall amounts for various other time durations. The processing program also produced charts of rainfall for various durations. An example of the output is shown in Figure 8. A detailed graph of the rainfall recorded at rain gage GWUDI 44 is shown in Figure 9.

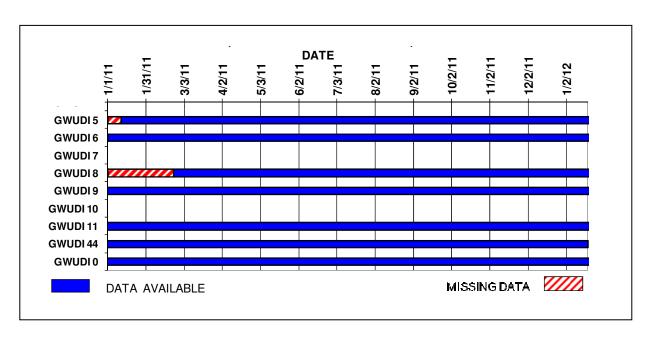


Figure 6. Availability of rainfall data

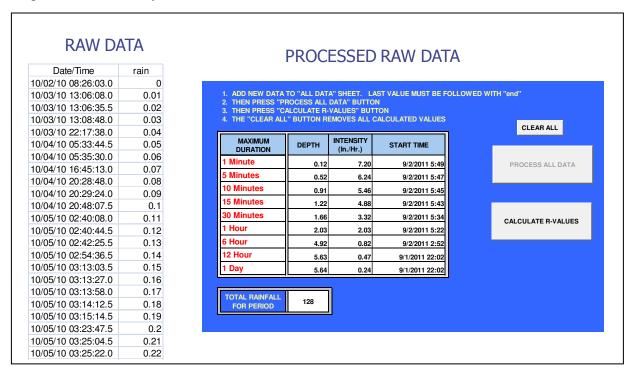


Figure 7. Raw rainfall data and rainfall data processing program

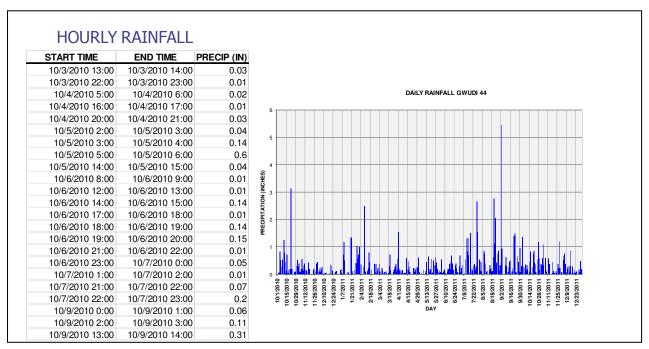


Figure 8. Processed rainfall data

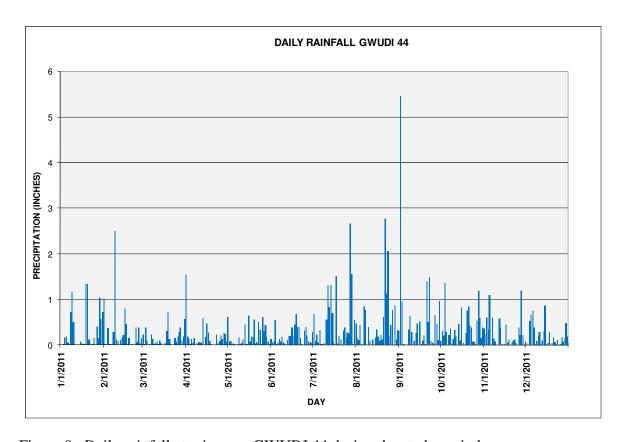


Figure 9. Daily rainfall at rain gage GWUDI 44 during the study period

CONTINUOUS WATER QUALITY PARAMETERS

As shown in Table 1, continuous readings of water quality were made at all of the project wells. The data was gathered at 15 minute increments using Hach continuous sampling equipment. Figure 4 on page 22 of Appendix 1 shows a picture of a typical water quality sampling installation. The same equipment was installed at all of the project wells. The controller is a model SC 1000. The turbidimeter is a model 1720E low range. The conductivity meter is a model 3700 series and the pH meter is a model PC3K.

Turbidity, conductivity, pH and temperature were measured. Because of the way the piping was routed to the sampling instruments, the temperatures recorded did not reflect the actual temperatures of water in the aquifer. What was actually recorded is the temperature of the water after it had been transported up the well and been exposed to outside temperatures before going into the sampler. For the most part the temperature data was not used. A sample of the processed water quality data is shown in Figure 10.

TURB	SIDITY	CONDU	CTIVI	TY		рН	
SC1000		SC1000			SC1000		
	MW1	FACILITY	MW1		FACILITY	MW1	
LOCATION		LOCATION			LOCATION		
SERIAL NUMBER	1245476	SERIAL NUMBER	1245476		SERIAL NUMBER	1245476	
SOFTWARE VERSI		SOFTWARE VERS	2.01		SOFTWARE VERSI	1 2.01	
		37xx sc			pH sc		
1720E		LOCATION	4E2F68F57	71E1	LOCATION	803530527	
LOCATION	1720E0070642	SERIAL NUMBER	4E2F68F57	71E1	SERIAL NUMBER	803530527	
SERIAL NUMBER	80300070642	DEVICE ID	20		DEVICE ID	21	_
DEVICE ID	13	MANUFACTURER			MANUFACTURER		
MANUFACTURER	0	SOFTWARE VERS)	SOFTWARE VERSI	1.04 (0 1 3)	
SOFTWARE VERSI	(2.10 (0 3 1)		. (-				
		DATE	CONDUCT	TEMP	DATE	pH	TEMP °C
DATE	TURBIDITY		ÂμS/cm	°C		pН	A·C
	NTU		, .		9/1/2009 0:00	7.006648	27.2
		9/1/2009 0:00	897.4248	28.10778	9/1/2009 0:15		
9/1/2009 0:00	0.068539	9/1/2009 0:15	897.5224	28.10901	9/1/2009 0:30	6.983233	27.3
9/1/2009 0:15	0.070266	9/1/2009 0:30	897.2056	28.0968	9/1/2009 0:45	6.982914	27.2
9/1/2009 0:30	0.075475	9/1/2009 0:45	898.708	28.10492	9/1/2009 1:00	6.982477	27.2
9/1/2009 0:45	0.065587	9/1/2009 1:00	895.1597	28.11194	9/1/2009 1:15	6.981637	27.2
9/1/2009 1:00	0.066543	9/1/2009 1:15	896.2479	28.10273	9/1/2009 1:30	6.979809	27.2
9/1/2009 1:15	0.066252	9/1/2009 1:30	896.9504	28.08909	9/1/2009 1:45		
9/1/2009 1:30	0.067725	9/1/2009 1:45	895.3859	28.10007	9/1/2009 2:00		27.2
9/1/2009 1:45		9/1/2009 2:00	896.6398	28.09673	9/1/2009 2:15		
9/1/2009 2:00		9/1/2009 2:15	896.4839	28.09912	9/1/2009 2:30	6.977323	27.

Figure 10. Sample of Turbidity, Conductivity and pH data from Hach SC 1000 sampler

The data files were sent via e-mail to WERI. Graphical time lines of the turbidity and rainfall data are shown in Figure 11. Please note that during the period June through October 2011 the automated sampling equipment was not serviced or calibrated. This makes the data gathered during that period suspect in terms of accuracy of the parameters measured. The suspect period is marked on Figure 11 along with the period of highest rainfall which falls within the period that the instrumentation was not serviced.

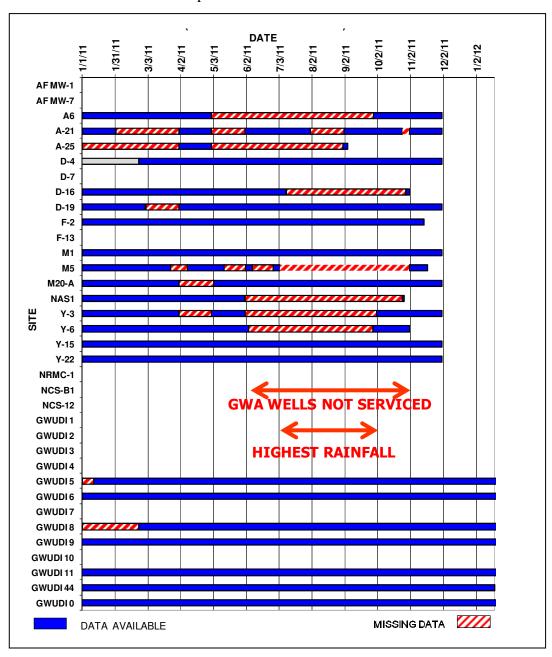


Figure 11. Timelines for data acquisition of turbidity and rainfall data

INTERMITTENT WATER QUALITY PARAMETERS

Laboratory water quality analyses were carried out on samples that were taken at weekly intervals and were analyzed for chemical and micro-biological constituents. These samples were gathered and analyzed by GWA's certified laboratory using US EPA Standard Methods and Procedures. A listing of sampling dates for the for GWA wells is shown in Table 3. A complete listing of all the chemical and bacteriological tests for each of the wells is contained on Table 2 located on page 4 of each of the Appendices 2 through16.

WELL NO.	STARTING DATE OF WEEKLY SAMPLING	ENDING DATE OF WEEKLY SAMPLING
A-6	07/27/09	03/14/11
A-21	07/27/09	03/14/11
A-25	07/10/08	03/14/11
D-4	02/18/09	03/14/11
D-16	02/18/09	03/14/11
D-19	03/24/09	03/02/11
F-2	06/30/09	03/14/11
M-1	07/14/09	03/14/11
M-5	07/20/09	03/14/11
M-20A	07/27/09	03/14/11
NAS-1	07/27/09	03/14/11
Y-3	07/07/09	03/14/11
Y-6	07/14/09	03/14/11
Y-15	07/14/09	03/14/11
Y-22	07/14/09	03/14/11

Table 3. Sampling periods for water quality analysis data for GWA GWUDI wells

MICROSCOPIC PARTICULATE ANALYSES

Microscopic Particulate Analyses (MPA) were carried out for waters sampled from the project wells. The samples were taken, for the most part, just after heavy rainfall events. Samples were gathered using US EPA Standard Methods procedures and the analyses were performed by off Guam laboratories certified for this type of analysis. A sample of the results sheets from one of the samples taken is shown in Table 4. The raw data from the MPA analysis is applied to the MPA risk assessment matrices shown in Table 5 to determine a final risk factor rating of high, medium or low. The bottom of Table 5 contains a listing of the analyses that were performed on the GWA GWUDI wells in 2011. Table 6 shows the results of MPA testing of GWA wells from 2007 through 2009. From these results and those shown in Table 5, we see that so far all samples taken from GWA GWUDI wells have returned as low risk. A complete listing of all the MPA tests for each of the wells is contained on Table 3 located on page 5 of each of the Appendices 2 through16.

Test:	Microscopic Particu	late Analysis	Method:	EPA 910/9-92-029 (600/R-	95/178) - Modi	ified
BioVir	Sample ID	Site		Parameter	Result	Unit
092066-001	200907300021	Air Force Well N	1W-1	Amoeba	0	# / 100 gal
092066-001	200907300021	Air Force Well M	fW-1	Amorphous Debris	0	
092066-001	200907300021	Air Force Well M	fW-1	Ciliates/Flagellates	0	# / 100 gal
092066-001	200907300021	Air Force Well M	fW-1	Crustacea	0	# / 100 gal
092066-001	200907300021	Air Force Well M	fW-1	Cryptosporidium	<0.0004	oocysts/L
092066-001	200907300021	Air Force Well M	fW-1	Diatoms	0	# / 100 gal
092066-001	200907300021	Air Force Well N	IW-1	Giardia	<0.0004	cysts/L
092066-001	200907300021	Air Force Well N	fW-1	Insect/Larvae	0	# / 100 gal
092066-001	200907300021	Air Force Well N	fW-1	Minerals	0	
092066-001	200907300021	Air Force Well M	fW-1	Nematodes	0	# / 100 gal
092066-001	200907300021	Air Force Well M	fW-1	Other Algae	0	# / 100 gal
092066-001	200907300021	Air Force Well M	fW-1	Other Organisms	0	# / 100 gal
092066-001	200907300021	Air Force Well N	IW-1	Plant Debris	0	# / 100 gal
092066-001	200907300021	Air Force Well N	IW-1	Plant Pollen	0	# / 100 gal
092066-001	200907300021	Air Force Well N	fW-1	Rotifers	0	# / 100 gal

Table 4. Sample MPA analysis for Air Force well MW-1

Indicators of					
surface water	EH	Н	М	R	NS
Giardia	>30	16-30	6-15	1-5	<1
Coccidia	>30	16-30	6-15	1-5	<1
Diatoms	>150	41-149	11-40	1-10	<1
Other Algae	>300	96-299	21-95	1-20	<1
Insects/Larvae	>100	31-99	16-30	1-15	<1
Rotifers	>150	61-149	21-60	1-20	<1
Plant Debris	>200	71-200	26-70	1-20	<1

key= EH - Extremely Heavy M - moderate NS - not significant H = heavy R = rare

2011 DATA

			MPA RESULT:
		WEATHER	RISK OF
WELL NO.	DATE SAMPLED	CONDITION	CONTAMINATION
A-21	9/6/2011	STORM	LOW
A-25	9/6/2011	STORM	LOW
Y-3	9/6/2011	STORM	LOW

Table 5. MPA scoring tables and results for GWA GWUDI wells

DATE	WELL	REL/RISK	PARTICULATES
1/6/2009	A-21	LOW	YES
5/8/2007	A-25	LOW	YES
12/9/2007	A-25	LOW	YES
1/5/2009	A-25	LOW	YES
1/6/2009	A-6	LOW	YES
3/23/2009	D-16	LOW	YES
8/23/2009	D-16	LOW	YES
3/23/2009	D-19	LOW	YES
8/23/2009	D-19	LOW	YES
3/23/2009	D-4	LOW	YES
8/23/2009	D-4	LOW	YES
9/28/2008	D7	LOW	YES
4/30/2007	D-7	LOW	YES
12/16/2007	D-7	LOW	YES
5/14/2007	F-13	LOW	YES
12/16/2007	F-13	LOW	YES
9/28/2008	F-13	LOW	YES
8/9/2009	F-2	LOW	YES
8/2/2009	M1	LOW	YES
8/2/2009	M-20A	LOW	YES
8/16/2009	M-5	LOW	YES
8/16/2009	NAS-1	LOW	YES
6/25/2009	Y-10	LOW	YES
8/16/2009	Y-15	LOW	YES
8/3/2009	Y-22	LOW	YES
6/25/2009	Y-3	LOW	YES
8/3/2009	Y-3	LOW	YES
8/9/2009	Y-3	LOW	YES
6/25/2009	Y-6	LOW	YES

Table 6. MPA testing results for GWA GWUDI wells in 2007-2009

TURBIDITY TREATMENT DETERMINATION

The continuous turbidly data gathered show high variability. Figure 12 shows a summary of data for the GWA wells under investigation. Please note that the turbidity scale on the graph is logarithmic.

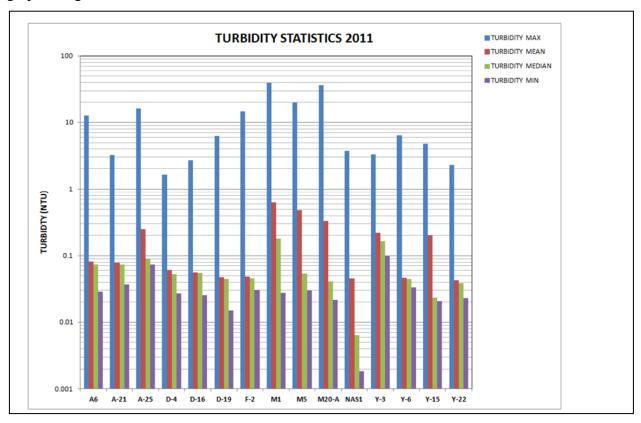


Figure 12. Turbidity statistics for GWA GWUDI well sites

The turbidity parameter is one of the key parameters in determining whether or not a well can truly be declared under the influence of surface water and for determining appropriate treatment options. The GWUDI Quality Assurance Project Plan (QAPP) planning document, which is contained in Appendix 1, set forth guidelines for declaration of ground water under the influence of surface water and also on what kind of treatment might be required. A general criteria suggested in the QAPP is "fluctuations of greater than 0.5-1 NTU over the course of a year, or associated with storm or spill events, may be indicative of surface water influence". This study used a criterion of 0.5 to 1 NTU "greater than the median value" to represent this criterion as an indicator of possible groundwater contamination. Table 7 summarizes the other treatment criteria that were shown in the QAPP. Please note that the QAPP used the word "Episodical" as a criterion. We suggest that this be defined as events happening more than 10% of the time. This makes it a more definitive and less ambiguous criteria. Figure 13 shows the Table 7 criteria in a usable decision tree format for determining treatment requirements. Comments from GWA suggested that the well shut down option is not really needed as membrane filtration can treat water to 30 NTU. To reflect this, the summary treatment tables have combined the membrane filtration and well shut down into one option.

- IF TURBIDITY<.3 NTU AND STABLE THEN DISINFECTION ONLY IS OK
- TURBIDITY FLUCTUATION GREATER THAN .5 TO 1 NTU UNITS ABOVE THE NORMAL MAY INDICATE SURFACE WATER INFLUENCE
- IF TURBIDITY >.3 NTU BUT ALWAYS BELOW 1 NTU THEN TREATMENT MAY REQUIRE 2 DISINFECTION PROCESSES e.g.. CHLORINATION AND ULTRAVIOLET TREATMENT
- IF TURBIDITY LEVELS EPISODICALLY > 0.3 (LESS THAN 10% > 0.3*) THEN CARTRIDGE FILTRATION MAY BE REQUIRED
- IF TURBIDITY REGULARLY > 0.3 (MORE THAN 10% > 0.3*) THEN MEMBRANE FILTRATION MAY BE REQUIRED
- IF TURBIDITY IS IN 3-5 RANGE EPISODICALLY (MORE THAN 10% > 3*)
 MAY CONSIDER WELL SHUTDOWN DURING THESE PERIODS
 * Authors Suggestion

Table 7. GWUDI declaration and treatment criteria summarized from QAPP

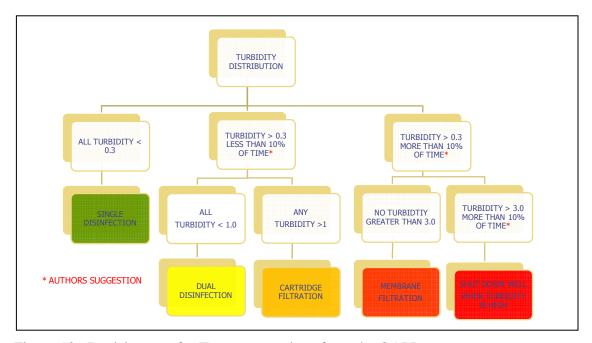


Figure 13. Decision tree for Treatment options from the QAPP

Figure 14 shows the statistics shown in Figure 12 with the criteria of Table 3 and Figure 13 overlaid. A quick examination of the graph along with the guidelines indicate that it is quite possible that at least some of the wells may very well require various levels of special treatment.

Figure 15 shows how many days of data were collected for each well site. It should be noted that six of the well sites had less than one half year's data.

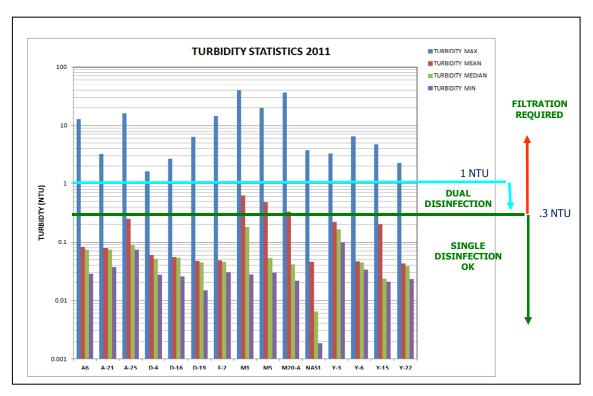


Figure 14. Turbidity summary statistics with GWUDI determination and treatment guidelines

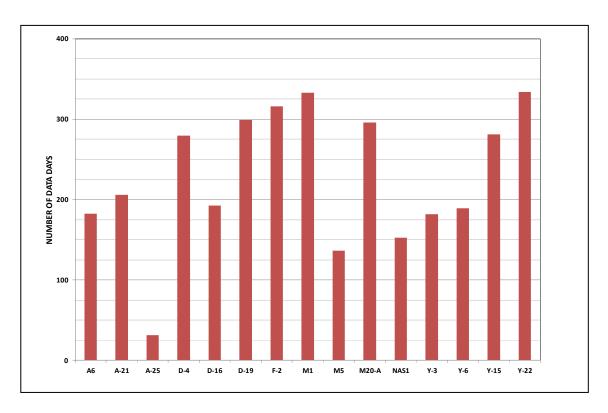


Figure 15. Number of data days of turbidity data at GWA GWUDI well sites

To better understand the affect of variable turbidity on treatment, a frequency analysis was carried out on the turbidly data for each of the 15 wells shown in Figure 14. We will use GWA GWUDI well D-4 to illustrate this frequency analysis technique. Figure 16 shows a frequency histogram of the turbidly data for Well D-4 along with a curve that shows the percentage of samples with higher turbidity values than the turbidity shown (turbidity percent exceedance or frequency curve). The data in the histogram table was developed using the Excel "Frequency" function which counts the number of data points falling within a certain turbidity interval referred to as a Bin. The total number of data points greater than the highest NTU value of the Bin and the percentage of points greater than the highest value in the Bin can then be calculated. The highest NTU value for the bin versus the number greater and percent greater are what is plotted in the frequency histogram and frequency curve shown in Figure 16.

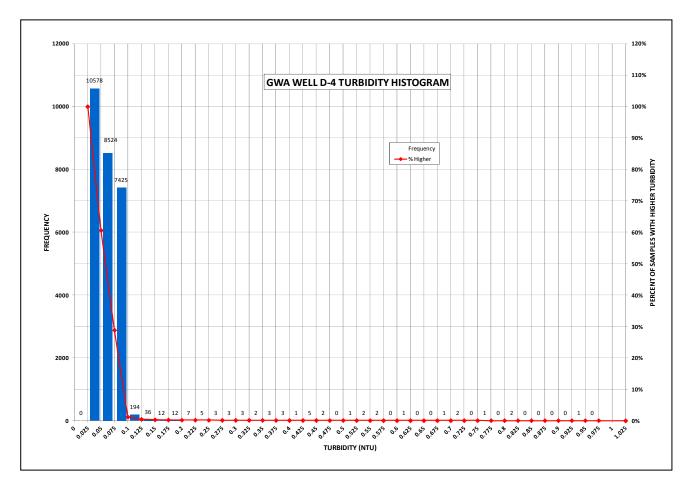


Figure 16. GWA well D-4 turbidity histogram and exceedance percentage frequency curve

If we add the turbidity criteria information shown in Table 7, we get the results that are shown in Figure 17. A close examination of the graph in Figure 17 shows that that the median value for 26,837 pieces or 280 data days of turbidly data is 0.053 NTU. Only 0.15% or 39 data points were higher than 0.3 NTU and only .03 % or seven samples were higher than 1 NTU. Only 13 samples or 0.05 % fell between .5 and 1 NTU of the median value of 0.053 leading to a fairly weak case for calling the water within the surface water influence limits under the general guideline. The data does fall in the range of the dual disinfection and cartridge filtration under strict interpretation of the guidelines. Only 39 data points or 0.15% of the data was greater than 0.3 NTU making a good case for single disinfection only. If a choice is to be made between dual disinfection or cartridge disinfection, we see that only a very small percentage of the data is greater than 1 NTU. Seven samples, or .03%, are in this range. Remember these determinations were made base solely on turbidity, leading to a strong case for dual disinfection over cartridge filtration. From this example it can be seen that the adoption of very strict standards when dealing with very large amount of data may lead to some amount of over cautiousness. This problem will be discussed later in the report. Later we also will examine the laboratory bacteriological analyses and MPA data to see if they support our GWUDI determinations. Lastly we will examine the correlation between rainfall events and changes in turbidity and bacterial water quality as part of the GWUDI determination process.

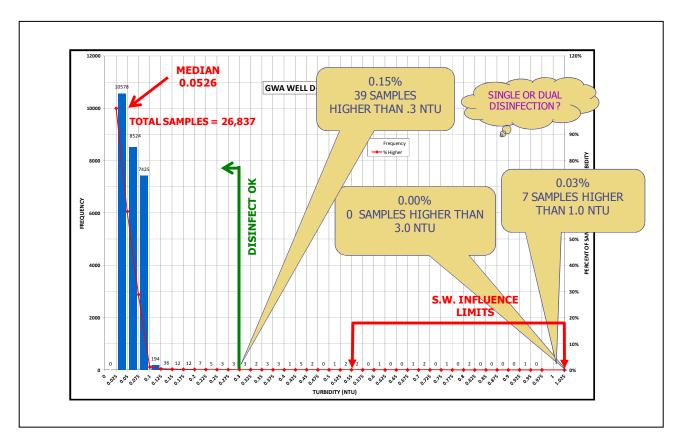


Figure 17. GWA well D-4 Turbidity histogram with GWUDI and turbidity treatment criteria

The process illustrated above for GWA GWUDI Well D-4 was repeated for all of the GWA wells under investigation. Table 8 shows the results of the turbidity analysis for all wells. A complete listing of the analysis results for each of the wells is contained in Appendices 2 through 16.

Table 9 compares the results of the data gathered in the 2011 study with results of the analysis of common wells in the 2009 data. The results of the two data sets led to very similar conclusions for the only well included in both studies (GWA GWUDI Well D-19). For this well both studies suggested either single or dual disinfection.

WELL	SAMPLES	MEDIAN	MEAN	SW INFLUENCE	SINGLE DIS	%>.3	DUAL DIS	%>1	CART FILTER	%>3	MEM FILTER	%>!
A-6 *	17,494	0.0744	0.0828	NO	YES	0.46	YES	0.07	YES	0.02	NO	0.02
A-21	19,997	0.0742	0.0795	NO	YES	0.2	YES	0.06	YES?	0	NO	0
A-25 **	3,006	0.0885	0.247	YES	NO	4.99	NO	4.49	YES	2	NO	1.1
D-4	26,837	0.0526	0.0611	NO	YES	0.15	YES	0.03	NO	0	NO	0
D-16 *	18,453	0.0547	0.0555	NO	YES	0.14	YES	0.04	NO	0	NO	0
D-19	28,717	0.0451	0.0477	NO	YES	0.05	YES	0.01	NO	0	NO	0
F-2	30,339	0.0459	0.0485	NO	YES	0.11	YES	0.02	NO	0	NO	0
F-13												
M-1	31,948	0.1806	0.6371	YES	NO	26.27	NO	13.58	NO	6.62	YES	2.98
M-5 *	13,110	0.0536	0.4883	YES	NO	15.48	NO	11.4	NO	3.84	YES	2.31
M20-A	28,403	0.0416	0.3342	YES	NO	4.96	NO	2.27	YES	1.85	NO	1.56
NAS-1 *	14,662	0.0064	0.0455	NO	YES	0.03	YES	0.01	NO	0.01	NO	0
Y-3 *	17,452	0.1638	0.223	YES	NO	14.71	NO	0.95	NO	0.01	YES	0
Y-6 *	18,131	0.0446	0.0467	NO	YES	0.24	YES	0.03	YES	0.01	NO	0.01
Y-15 *	27,008	0.0221	0.023	NO	YES	0.00	NO	0	NO	0	NO	NO
Y-22	32,039	0.0388	0.0429	NO	YES	0.06	YES	0.01	NO	0	NO	0
' NO DATA D	URING HIGH	EST RAINFAL		SH SKEW	** SMALL	. SAMPLE	SIZE, NO	DATA DI	JRING HIG	HEST R	AINFALL	PERIC

Table 8. Summary of turbidity treatment findings

WELL	SAMPLES	MEDIAN	MEAN	SW INFLUENCE	SINGLE DISINFECTION	%>.3	DUAL DISINFECTION	%>1	CART FILTER	%>3	MEM FILTER	%>5	WELL SHUT DOWN
AIR FORCE MW-1	48224	0.0261	0.0402	NO	х	0.15		0		0		0	
AIR FORCE MW-7	45329	0.0606	0.1831	YES		19.06		1.48		0	Х	0	
NAVY NMRC-1	33296	0.0683	0.4399	YES		11.00		10.1		5.26		3.23	Х
NAVY NCS-12	37701	0.063	1.5659	YES		39.01		23.52		11.06		7.39	Х
NAVY NCS B-1	11080	0.0711	0.1387	MAYBE		4.82		1.42	х	0.34		0.18	
GWA A-25	19974	0.0686	0.8564	MAYBE	Х	0.83	?	0.3		0.1		0.08	
GWA F-13	32896	0.0709	1.2159	YES		16.18		11.16		7.39		5.78	Х
GWA D-19	20961	0.0209	0.0229	NO	х	0.04		0		0		0	
D-19	28,717	0.0451	0.0477	NO	YES	0.05	YES 0.	01	NO	0	NO	0	NO
	20,7.27	0.0.01	010 177			0.05	0.	<u> </u>				-	

Table 9. Comparison of treatment recommendation resulting from the analysis of the turbidity data in 2009 and 2011

Figure 18, which shows the raw turbidity data for GWA GWUDI Well Y-22, illustrates a common problem with all of the 15 minute turbidity data. In all of this data there are numerous high values that last only a single time interval. It is possible that these occurred because of instrument malfunction or from short term passage of organic or inorganic material through the sensor. Because of the rather rigid restrictions in the treatment criteria it was felt that it would be worthwhile to explore the use of some kind of running average technique to filter out these very short time deviations of the data that could affect the predicted treatment requirements.

After examining various techniques, it was determined that a running three period median smoothing technique would be used. This method adequately filtered short term peaks but retained high values that lasted more than one sampling period. Illustration of how the technique functions is shown in Tables 10 and 11. Table 10 shows that there was a single peak of 1.2087 NTU in the turbidity data on 6/4/2011 14:15. The smoothed value calculated is the median of three values. The values used are the previous value, the present value, and the next value. For this case the three-period smoothed median is 0.2298 NTU. Table 11 illustrates the median smoothing calculation for the next time interval (on 6/4/2011 14:30). In this case the median value of the past present and future data values is again 0.2298. The smoothing affect has eliminated the one time very high fluctuation while retaining the lower fluctuation values and thus retaining any longer term indication of increases in turbidity.

Figure 19 shows the results of the smoothing process applied to all of the 2011 study data for GWA GWUDI Well Y-22. When comparing this graph too that shown in Figure 18, we see that there are no single event peaks in the data, but longer time higher values are left in place. The smoothed data seems to be a more realistic representation of the turbidity values that would be expected at the wells. Table 12 illustrates the changes in key NTU value frequencies that occur with application of the three value median smoothing technique. From Table 8 we see that GWA GWUDI well Y-22 was recommended for either single or dual disinfection due to the rather small value of the frequency of turbidity data greater than 0.3 NTU (0.6% or 18 samples). We can see in Table 12 that the smoothing of the Y-22 turbidity data resulted in 0.02 % or seven values greater than 0.3 NTU making a stronger case for only single disinfection. The smoothed data also resulting in no data values greater than 1 NTU removing the chance that cartridge filtration should be required.

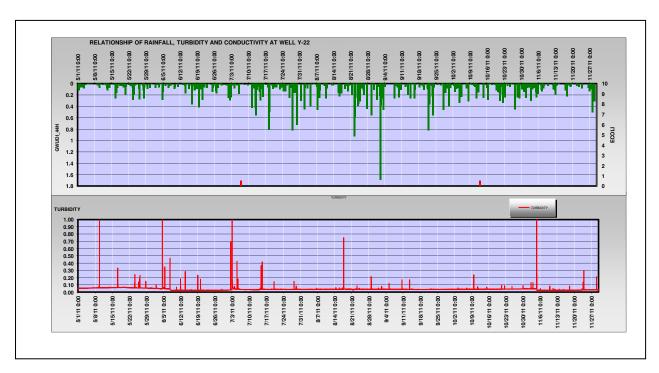


Figure 18. Short duration high turbidity values GWA GWUDI well Y-22 using raw data

DATE	SMOOTHED	DATE	TURBIDITY	
6/4/2011 13:45	0.0531	6/4/2011 13:45	0.0537	
6/4/2011 14:00	0.0537	6/4/2011 14:00	0.0522	
6/4/2011 14:15	0.2298	6/4/2011 14:15	1.2087	SINGLE HIGH
6/4/2011 14:30	0.2298	6/4/2011 14:30	0.2298	-
6/4/2011 14:45	0.0681	6/4/2011 14:45	0.0681	
6/4/2011 15:00	0.0593	6/4/2011 15:00	0.0593	
6/4/2011 15:15	0.0590	6/4/2011 15:15	0.0590	
FOR 6/4/200 SMOOTHED		98 = MEDIAN (OF 0.0522,	1.2087, AND <u>.2298</u>

Table 10. Illustration of three value median smoothing technique first time step

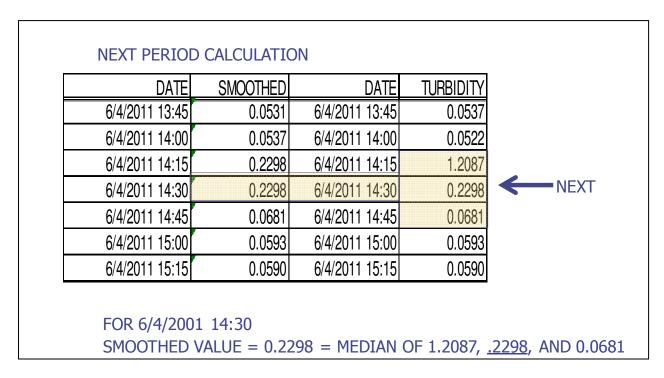


Table 11. Illustration of three value median smoothing technique next time step

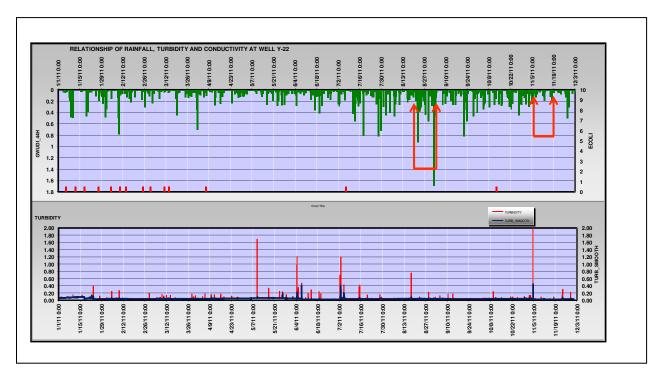


Figure 19. Short duration high turbidity values GWA GWUDI well Y-22 after smoothing

	RAW	TURBIDITY	SMOOTHED TURBIDIT		
NTU	%>	#>	%>	#>	
0.3	0.06	18	0.02	7	
1	0.01	4	0	0	
3	0	0	0	0	
5	0	0	0	0	

MAX 2.3051 MAX = 0.4510 MEDIAN = 0.0388 MEDIAN = 0.0388 MEAN = 0.0429 MEAN = 0.0424

Table 12. Comparison of key unsmoothed and smoothed frequency statistics for GWA GWUDI well Y-22

The adjustments to the original QAPP turbidity treatment recommendations revolved around developing a mathematical definition of what episodically means in terms of turbidity event frequency. We have defined "Episodical" as something that happens more than 10% of the time. Another concern that arises comes from using very specific criteria. For example, in order to recommend the use of single disinfection "all" turbidity data must be less than 0.3 NTU. The likely hood of this happening when we use our automated 15 minute data is nearly impossible.

A full year of 15 minute data is approximately 35,000 points and to not have any values greater than 0.3 due to instrument error or even an occasional passage of turbid matter is nearly impossible. We are suggesting possibly using a slightly more relaxed criterion of say, "TURBIDITY GREATER THAN 0.3 LESS THAN 0.5 % of the time". The actual value 0.5% is certainly debatable and we are open to suggestions of other possibilities from the regulators. We are proposing similar relaxations of criteria for the dual disinfection and cartridge disinfection criteria. Changing the dual disinfection criteria from "ALL TURBIDITY < 1.0" to "TURBIDITY GREATER THAN 1 LESS THAN 0.5% OF TIME". Similarly changing the cartridge filtration criteria from "ANY TURBIDITY > 1" to "TURBIDITY > 1 MORE THAN 0.5% OF THE TIME". These changes are shown in Figure 20. Again the percentage values in the changed criteria are debatable and open to suggestion from the regulators. Figure 21 shows all of the suggested changes.

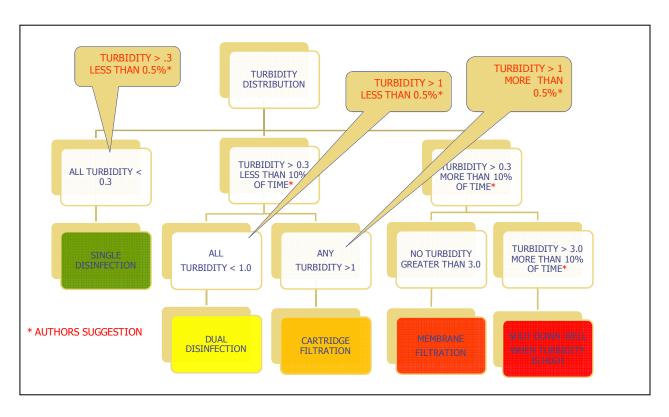


Figure 20. Relaxation of QAPP criteria for single or dual disinfection and cartridge treatment option

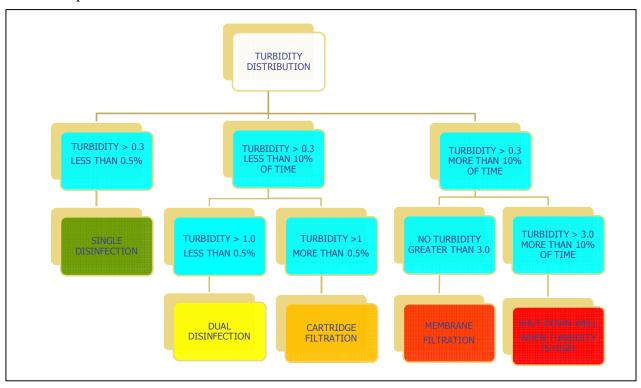


Figure 21. Final recommended turbidity treatment criteria

The question that now arises is what effect does using the median averaging and relaxation of the treatment criteria have on the final outcome of the suggested treatment for the wells. Table 13 compares the raw and smoothed data and the un-relaxed and relaxed criteria. The first column provides the treatment recommendations by applying the QAPP criteria directly to the raw data. The second column shows the treatment recommendations if all of the relaxed criteria discussed above are applied to the raw turbidity data. The third column shows the treatment requirement if the original QAPP criteria are applied to the median smoothed data. The last column shows the treatment requirements if the relaxed criteria area applied to the smoothed data.

Table 14 highlights the wells where treatment requirements changed between applying the original QAPP criteria and applying the relaxed criteria to the raw turbidity data. In this case nine of the wells that would have been required to use cartridge filtration were cleared for use of only single disinfection. Two wells retained the cartridge treatment requirements. All of the wells where membrane filtration or shut down during high turbidity were required remained the same when the original and relaxed criteria were applied.

Table 15 highlights the wells where treatment requirements changed between applying the original QAPP criteria to the raw turbidity data and applying original criteria to the median smoothed turbidity data. In this case one well that would have been required to use cartridge filtration was cleared for use of single disinfection. Five of the wells that would have been required to use cartridge filtration were cleared for use of dual disinfection. Five wells retained the cartridge treatment requirement. All of the wells where membrane filtration or shut down during high turbidity were required remained the same when the original and relaxed criteria were applied.

Table 16 highlights the wells where treatment requirements changed between applying the original QAPP criteria to the raw turbidity data and applying relaxed criteria to the median smoothed turbidity data. In this case nine of the wells that would have been required to use cartridge filtration were cleared for use of single disinfection. Two wells retained the cartridge treatment requirement. All of the wells where membrane filtration or shut down during high turbidity were required remained the same when the original and relaxed criteria were applied.

Table 17 highlights the wells where treatment requirements changed between applying the original QAPP criteria and the relaxed criteria to the median smoothed turbidity data. In this case three of the wells that would have been required to use cartridge filtration were cleared for use of single disinfection. Five of the wells that would have been required to use dual disinfection were cleared for use of single disinfection. One well retained the cartridge treatment requirement. All of the wells where membrane filtration or shut down during high turbidity were required remained the same when the original and relaxed criteria were applied.

	COMPARIS	ON OF TURBIDITY	REATMENT OPTION			
	RAV	V DATA	SMOOTH	SMOOTHED DTA		
WELL	RAW DATA STRICT RAW DAT RELAXED CRITERIA CRITERIA		SMOOOTHED DATA STRICT CRITERIA	SMOOTH DATA RELAXED CRITERIA		
A-6 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE		
A-21	CARTRIDGE	SINGLE	DUAL	SINGLE		
A-25 **	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE		
D-4	CARTRIDGE	SINGLE	DUAL	SINGLE		
D-16 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE		
D-19	CARTRIDGE	SINGLE	DUAL	SINGLE		
F-2	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE		
M-1	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN		
M-5 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN		
M20-A	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE		
NAS-1*	CARTRIDGE	SINGLE	SINGLE	SINGLE		
Y-3 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN		
Y-6 *	CARTRIDGE	SINGLE	DUAL	SINGLE		
Y-15 *	SINGLE	SINGLE	SINGLE	SINGLE		
Y-22	CARTRIDGE	SINGLE	DUAL	SINGLE		

Table 13. Comparison of the smoothed and un-smoothed data and the un-relaxed and relaxed criteria

	COMPARIS	ON OF TURBIDITY 1	REATMENT OPTION	IS		
	RAV	V DATA	SMOOTH	SMOOTHED DTA		
WELL	RAW DATA STRICT CRITERIA	RAW DAT RELAXED CRITERIA	SMOOOTHED DATA STRICT CRITERIA	SMOOTH DATA RELAXED CRITERIA		
A-6 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE		
A-21	CARTRIDGE	SINGLE	DUAL	SINGLE		
A-25 **	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE		
D-4	CARTRIDGE	SINGLE	DUAL	SINGLE		
D-16 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE		
D-19	CARTRIDGE	SINGLE	DUAL	SINGLE		
F-2	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE		
M-1	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN		
M-5 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN		
M20-A	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE		
NAS-1 *	CARTRIDGE	SINGLE	SINGLE	SINGLE		
Y-3 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN		
Y-6 *	CARTRIDGE	SINGLE	DUAL	SINGLE		
Y-15 *	SINGLE	SINGLE	SINGLE	SINGLE		
Y-22	CARTRIDGE	SINGLE	DUAL	SINGLE		

Table 14. Comparison of treatment options for raw data using relaxed and un-relaxed criteria

	RAV	V DATA	sмоотн		
WELL	RAW DATA STRICT CRITERIA	RAW DAT RELAXED CRITERIA	SMOOOTHED DATA STRICT CRITERIA	SMOOTH DATA RELAXED CRITERIA	
A-6 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE	
A-21	CARTRIDGE	SINGLE	DUAL	SINGLE	
A-25 **	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE	
D-4	CARTRIDGE	SINGLE	DUAL	SINGLE	
D-16 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE	
D-19	CARTRIDGE	SINGLE	DUAL	SINGLE	
F-2	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE	
M-1	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	
M-5 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	
M20-A	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE	
NAS-1 *	CARTRIDGE	SINGLE	SINGLE	SINGLE	
Y-3 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	
Y-6 *	CARTRIDGE	SINGLE	DUAL	SINGLE	
Y-15 *	SINGLE	SINGLE	SINGLE	SINGLE	
Y-22	CARTRIDGE	SINGLE	DUAL	SINGLE	

Table 15. Comparison of treatment options raw data to smoothed data using original QAPP criteria

	RAV	V DATA	SMOOTH		
WELL	RAW DATA STRICT	RAW DAT RELAXED CRITERIA	SMOOOTHED DATA STRICT CRITERIA	SMOOTH DATA RELAXED CRITERIA	
A-6 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE	
A-21	CARTRIDGE	SINGLE	DUAL	SINGLE	
A-25 **	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE	
D-4	CARTRIDGE	SINGLE	DUAL	SINGLE	
D-16 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE	
D-19	CARTRIDGE	SINGLE	DUAL	SINGLE	
F-2	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE	
M-1	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	
M-5 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	
M20-A	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE	
NAS-1 *	CARTRIDGE	SINGLE	SINGLE	SINGLE	
Y-3 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	
Y-6 *	CARTRIDGE	SINGLE	DUAL	SINGLE	
Y-15 *	SINGLE	SINGLE	SINGLE	SINGLE	
Y-22	CARTRIDGE	SINGLE	DUAL	SINGLE	

Table 16. Comparison of treatment options raw data using original QAPP criteria to smoothed data using relaxed criteria

	RAV	V DATA	SMOOTHED DTA		
WELL	RAW DATA STRICT CRITERIA	RAW DAT RELAXED CRITERIA	SMOOOTHED DATA STRICT CRITERIA	SMOOTH DATA RELAXED CRITERIA	
A-6 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE	
A-21	CARTRIDGE	SINGLE	DUAL	SINGLE	
A-25 **	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE	
D-4	CARTRIDGE	SINGLE	DUAL	SINGLE	
D-16 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE	
D-19	CARTRIDGE	SINGLE	DUAL	SINGLE	
F-2	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE	
M-1	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	
M-5 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	
M20-A	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE	
NAS-1 *	CARTRIDGE	SINGLE	SINGLE	SINGLE	
Y-3 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	
Y-6 *	CARTRIDGE	SINGLE	DUAL	SINGLE	
Y-15 *	SINGLE	SINGLE	SINGLE	SINGLE	
Y-22	CARTRIDGE	SINGLE	DUAL	SINGLE	

Table 17. Comparison of treatment options for median smoothed data used using unrelaxed and relaxed criteria

It is now up to the regulating agencies with the cooperation of the utilities to adopt the appropriate turbidity treatment criteria for Guam. We suggest that in all cases the smoothed turbidity data should be used instead of the raw data. It is felt that this data gives a more realistic representation of the water that is actually being pumped from the aquifer. The actual frequency values used to differentiate between treatment types are somewhat subjective. In any case, values must be determined that keep in mind both public health concerns and the costs of various treatment options. The values suggested by the authors are reasonable but are certainly open for discussion. One word of caution is that it is not practical to apply a fixed criteria for example "NO VALUES OF TURBIDITY GREATER THAN Y.Y NTU" when applied to the vast amount of data gathered for this study. A more reasonable criterion might be "XX.XX % OF TURBIDITY VALUES GREATER THAN Y.Y NTU" where regulators and utilities agree on the value of "XX.XX%" for each critical Y.Y NTU value. There must be some flexibility built in to account for instrumental error and other unforeseen data errors in the data sets. The values highlighted in blue on Figure 22 are the frequency values that need to be discussed thoroughly and for which recommended values should be adopted. The spreadsheet application shown in Figure 23 was developed to explore various turbidity treatment criteria. This program is available to regulators and utilities upon request.

Another caution is in order at this time. When making determinations about the GWUDI status and the treatment requirements it is important that these decisions be based on adequate and reliable data. A quick review of previous Figure 11 and Table 18 below shows that all of the GWA GWUDI wells were not serviced during the period of June through October. This leads to reliability issues in both the values recorded (since no calibration was done) and in the time stamps recorded for the data. Another issue is turbidity data during high rainfall periods. Seven of the wells had no data recorded during the highest rainfall times of the study period. A third concern comes in the amount of data available for each well. Previous Figure 15 shows that six of the wells had less than ½ of a year of data days available. These are all serious concerns that should be addressed by the regulatory agencies.

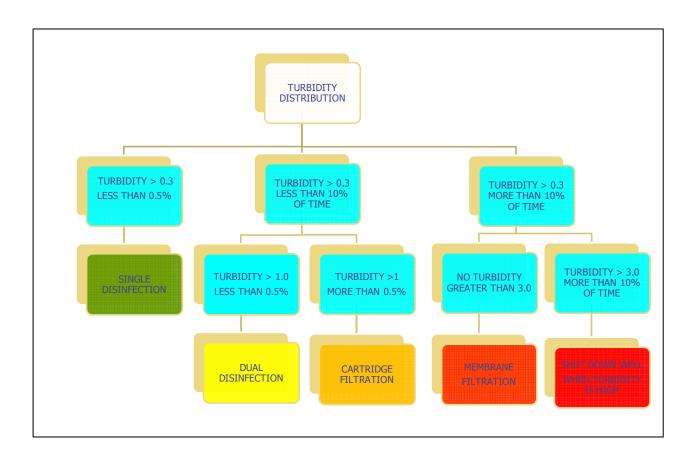


Figure 22. Turbidity treatment criteria requiring further discussion and final determination highlighted in blue

	TREATMENT OPTION	CRITERIA	ORIGIINAL %	RECCOMMENDED %
	SINGLE ONLY	% GREATER THAN .3 NTU MUST BE LESS THAN	0.000	0.500
	DUAL/CART	% GREATER THAN .3 NTU MUST BE LESS THAN	10.000	10.000
	DUAL ONLY	% GREATER THAN 1 NTU MUST BE LESS THAN	0.000	0.500
	MEMBRANE	% GREATER THAN 3 NTU MUST BE LESS THAN	0.000	0.000
	RECCOMENDED TREATMENT		RECCOMENDED TREATMENT	RECCOMENDED TREATMENT
	ORIGINAL DATA STRICT	RECCOMENDED TREATMENT ORIGINAL DATA	SMOOTHED DATA STRICT	SMOOTHED DATA RELAXED
WELL	ITERPRETATION	RELAXED ITERPRETATION	ITERPRETATION	ITERPRETATION
A-6 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE
A-21	CARTRIDGE	SINGLE	DUAL	SINGLE
A-25 **	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE
D-4	CARTRIDGE	SINGLE	DUAL	SINGLE
D-16 *	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE
D-19	CARTRIDGE	SINGLE	DUAL	SINGLE
F-2	CARTRIDGE	SINGLE	CARTRIDGE	SINGLE
M-1	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN
M-5 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN
M20-A	CARTRIDGE	CARTRIDGE	CARTRIDGE	CARTRIDGE
NAS-1*	CARTRIDGE	SINGLE	SINGLE	SINGLE
Y-3 *	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN	MEM/SHUT DOWN
Y-6 *	CARTRIDGE	SINGLE	DUAL	SINGLE
Y-15 *	SINGLE	SINGLE	SINGLE	SINGLE
Y-22	CARTRIDGE	SINGLE	DUAL	SINGLE

Figure 23. Spreadsheet application for evaluating the affect of changing turbidity treatment requirements

WELL	RAIN DATA	WELL GAGE MAINTENEANCE MISSING	TURBIDITY DATA (HIGH RAINFALL)	TURBIDTY DATA DAYS		
A6	YES	JUNE - OCTOBER	NO	182		
A-21	YES	JUNE - OCTOBER	YES	206		
A-25	YES	JUNE - OCTOBER	NO	31		
D-4	YES	JUNE - OCTOBER	YES	280		
D-16	YES	JUNE - OCTOBER	NO	192		
D-19	YES	JUNE - OCTOBER	YES	299		
F-2	YES	JUNE - OCTOBER	YES	316		
M1	YES	JUNE - OCTOBER	YES	333		
M5	YES	JUNE - OCTOBER	NO	137		
M20-A	YES	JUNE - OCTOBER	YES	296		
NAS1	YES	JUNE - OCTOBER	NO	153		
Y-3	YES	JUNE - OCTOBER	NO	182		
Y-6	YES	JUNE - OCTOBER	NO	189		
Y-15	YES	JUNE - OCTOBER	YES	281		
Y-22	YES	JUNE - OCTOBER	YES	334		
				TURBID	ITY DATA DAYS KEY	
		PROBLEMATIC			LESS THAN 6 MONTHS OF	DATA
		USE CAUTION			BETWEEN 6 AND 10 MONT	
		DATA OK			MORE THAN 10 MONTHS C	F DATA

Table 18. Summary of data availability and data quality concerns

GWUDI DETERMINATIONS

The background and scope section of this study discuss the reasoning behind the need to determine if the wells in the Northern Guam Lens Aquifer are truly Ground Water Under the Direct Influence of Surface water (GWUDI). The QAPP for this study, contained in Appendix 1, provides a written explanation of what criteria should be applied to data characterizing the various wells in order to determine whether they fall under the GWUDI classification. Figure 24 is a decision tree developed from the written criteria contained in the original QAPP.

The two deciding factors in this decision tree are the results of the Microscopic Particulate Analysis (MPA) and the risk factors listed in Figure 24. The number of risk factors for a well determines whether or not a well is to be classed as GWUDI or will further testing be required. The risk factor labeled "SUB-SURFACE PARTICULATES" was removed from consideration by mutual agreement between the regulators and the utilities. It was felt that this factor was already accounted for in the MPA analysis results. We will begin with a discussion of the MPA data followed by the risk factors.

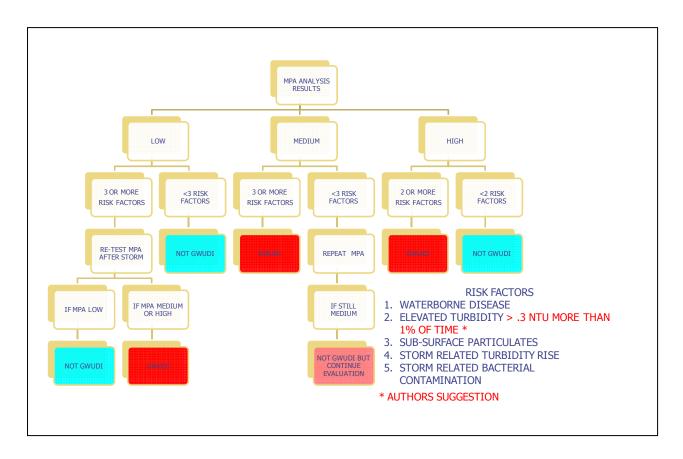


Figure 24. Decision tree for determining GWUDI status developed from QAPP

MICROSCOPIC PARTICLE ANALYSIS

The bottom of previous Table 5 contains a listing of the MPA analyses that were performed on the GWA GWUDI wells in 2011. Previous Table 6 shows the results of MPA testing of GWA wells from 2007 through 2009. From these results and those shown in Table 5, we see that so far all samples taken from GWA GWUDI wells have returned as low risk. The MPA testing results for each individual well are shown in Table 3 on page 5 of Appendices 2 through 16. Since all the test values for MPA were low only the left-most branch of the decision tree in Figure 24 applies.

RISK FACTORS

Waterborne Disease

This factor was used to identify if any water borne disease occurrences caused by Giardia lamblia or Cryptosporidium had resulted from contact with drinking water supplied by the wells. These two disease vectors were considered important as they do not respond to normal disinfection methods and require filtration. From discussions with Dr Haddock of Guam Public Health it was determined that no outbreaks of these diseases have ever been reported in Guam as a result of drinking well water. Therefore the Risk Factor "Waterborne Disease" was "NO" for all wells".

Elevated Turbidity

The Elevated Turbidity Risk Factor was not well defined in the QAPP. We decided to use the turbidity frequency analysis data for the wells to determine this Risk Factor. The authors assumed that if the turbidity of .3 NTU was exceeded more than 1% of the time then the Risk Factor would be "YES". The .3 NTU level and the 1% time value are certainly open for discussion. These two factors should be mutually agreed upon by the regulators and utilities. The results of application of the 1% criteria are shown in Table 19. Note that there is no difference in Risk Factor between the raw and smoothed turbidity data.

		T	URBIDITY STATISTICS	2011 SMOOTHE	DATA		
		MEDIAN	MEAN (TURBIDITY				
WELL	SAMPLES	TURBIDITY (NTU)	(NTU)	% of values >.3	% of values >1	% of vallues >3	% of values >5
A-6 *	17494	0.0744	0.0828	0.46	0.07	0.02	0.02
A-21	19776	0.0742	0.0795	0.2	0.06	0.01	0
A-25 **	3005	0.0885	0.2470	4.99	4.49	2	1.1
D-4	26837	0.0526	0.0611	0.15	0.03	0	0
D-16 *	18453	0.0547	0.0555	0.14	0.04	0	0
D-19	28718	0.0451	0.0477	0.05	0.01	0	0
F-2	30339	0.0459	0.0485	0.11	0.02	0	0
M-1	31949	0.1806	0.6371	26.27	13.58	6.62	2.98
M-5 *	13110	0.0536	0.4883	15.48	11.4	3.84	2.31
M20-A	28404	0.0416	0.3342	4.96	2.27	1.83	1.56
NAS-1 *	14662	0.0064	0.0455	0.03	0.01	0.01	0
Y-3 *	17452	0.1638	0.2223	14.71	0.95	0.01	0
Y-6 *	18131	0.0446	0.0467	0.24	0.03	0.01	0.01
Y-15 *	27008	0.0221	0.0230	0	0	0	0
Y-22	32039	0.0388	0.0429	0.06	0.01	0	0
			TURBIDITY STATIST	ICS 2011 RAW DA	TA		
		MEDIAN	MEAN (TURBIDITY				
WELL	SAMPLES	TURBIDITY (NTU)	(NTU)	% of values >.3	% of values >1		% of values >5
A-6 *	17494	0.0743	0.0816	0.32	0.04	0.02	0.02
A-21	19776	0.0741	0.0777	0.03	0	0	0
A-25 **	3005	0.0885	0.2380	4.92	4.36	1.93	1.1
D-4	26837	0.0526	0.0603	0.04	0	0	0
D-16 *	18453	0.0545	0.0544	0.03	0.02	0	0
D-19	28718	0.0451	0.0472	0.01	0	0	0
F-2	30339	0.0459	0.0477	0.06	0.01	0	0
M-1	13110	0.0535	0.4834	26.10	13.53	3.81	2.93
M-5 *	28404	0.0415	0.3304	15.38	11.42	1.82	2.27
M20-A	14662	0.0064	0.0451	4.84	2.25	0	1.55
NAS-1 *	17452	0.1638	0.2206	0.00	0	0	0
Y-3 *	18131	0.0445	0.0451	14.61	0.86	0	0
Y-6 *	27008	0.0220	0.0229	0.07	0	0	0
Y-15 *	32039	0.0388	0.0424	0.00	0	0	0
Y-22	32,039	0.0388	0.0424	0.02	0	0	0
	32,000	0.0300	0.0121			TA DURING HIGH	
* N	O DATA DURI	NG HIGHEST RAINF	ALL PERIOD		PER		

Table 19. GWA GWUDI wells identified as being at risk due to elevated turbidity

Storm Related Turbidity Rise

In order to evaluate the storm related turbidity rise risk factor a series of least squares regression studies were carried out. In these studies the daily rainfall at or near the well site was assumed to be the independent X variable and the daily geometric mean of the 3 period median smoothed 15 minute turbidity data was assumed to be the dependent Y variable. The turbidity was time lagged behind the rainfall by periods of 0, 1, 2, 5, 15, and 30 days. Analysis was performed on the 2009, 2011 and combined 2009 and 2011 data. One such scatter plot showing the regression equation and R Squared value is shown in Figure 25. A listing of a the highest significance regressions for the combined 2009-2011 data for each of the wells is shown on Figure 4 page 6 of each of the Appendices 2 through 16.

In no way are these regressions meant to model the extremely complex non-linear contaminant transfer processes that could occur as rain water containing turbidity causing particles moves from the ground surface through the aquifer and into the wells. The purpose is only to help in identifying if there is a statistical link between rainfall and turbidity levels in the pumped well water. Please note that the regressions do not identify the sources and the physical and chemical makeup of the turbidity causing particles only how the turbidity they cause is statistically related to rainfall.

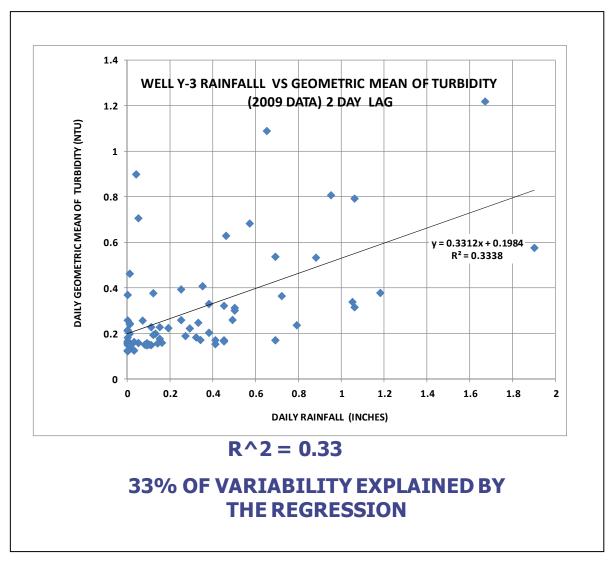


Figure 25. Example rainfall versus turbidity regression analysis for GWA GWUDI well Y-3 based on 2009 data

A summary of the results of rainfall turbidity studies applied to the 2009 data is shown in Table 20. The R Squared factors shown provide us with a measure of the fraction of the variation between rainfall and turbidity that can be explained by the computed regression equation. Table 21 shows more detailed factors that define the statistical significance of the R Squared values of the 2009 rainfall versus turbidity regressions. This table shows only the regression statistics for the lag times that had the highest R Squared values. From this table, we see that GWA GWUDI wells Y-3 and Y-6 have R Squared values of 0.33 and 0.34 respectively. This means that 33% and 34% of the variability between the lagged turbidity with rainfall is explained by the regression. Both of these R values are shown to be statistically significant at the 99% level. This implies that we are confident, at the 99% level, that the correlation is better than would be predicted from turbidity values drawn from a random sampling. This test for significance is described in "Basic Statistical Methods for Engineers" (Neville and Kennedy, 1964). The required "t" values were found using the

Excel "TINV" function adjusted for sample size and number of variables. The critical test R value was computed using the equation for "t", found in appendix E page 298 of the Neville and Kennedy text referenced above, solved for R.

Regression R Squared values can range from 0 to 1. A value of 0 means that none of the variability between dependent and independent variables is explained by the regression whereas a value of 1 means that all of the variability is explained by the regression. Values at the 30% level are not particularly high, but the statistics do show that the prediction is better than if the turbidity values had been drawn from a random sample. The highest R Squared values for well Y-3 came with a lag of only two days. The highest value for Y-6 came with a lag of 30 days. It should be noted that in many cases the sample sizes are smaller than the one year's worth of data goal specified by the QAPP.

The procedure described above was repeated for the 2011 data. The results are shown in Tables 22 and 23. Next the procedure described above was repeated for the combined 2009 and 2011 data. The results are shown in Tables 24 and 25. Table 26 summarizes the results of all the regression analyses that were carried out.

There were no specific data requirements or levels of statistical significance identified in the QAPP for the Risk Factor "Storm Related Turbidity Rise" Since neither the 2009 nor the 2011 data was for a complete year, we feel that the combined 2009 and 2011 data should be used for the determination of this Risk Factor. If we look at the combined data in Table 26, Well Y-3 has the highest R Squared value (0.25) meaning 25% of the variability between rainfall and turbidity is explained by the regression. None of the other wells showed R Squared values greater than 0.05 or 5%. While the 25% R Squared value for Well Y-3 is not particularly impressive it does show that there is a weak relationship between rainfall and turbidity and the significance test shows that it is better (at the 99% level) than if we used random samples for turbidity. Therefore we would suggest that from regression analysis alone well Y-3 exhibits the Risk Factor "Storm Related Turbidity Rise". Our application of required R Squared and percent significance over a random sample are subjective and should be agreed upon by the regulators and the utilities. Note that more than 50% of the items in Table 24 had negative slopes. The regressions coefficients for the negative slope regressions were all very small and were not significant even at the 95% level over what would be expected from drawing the turbidity values from a random sample and thus not considered to support any kind of storm related turbidity conclusions.

We also did a visual scan of the rainfall and turbidity data for all of the wells to see if we could detect any visual indications of storm related turbid rise. Only wells M-1, M-5, and Y-3 indicated storm related turbidly rise by visual inspection. The visual scan graphs of rainfall vs turbidly for these three wells are shown in Figures 26 through 28. Visual turbidity scans for all the wells are shown on Figure 5 page 6 of each of the Appendices 2 through 16. With these results we would suggest that three wells M-1, M-5 and Y-3 indicate storm related turbidity rise.

MELL 0 1 2 5 15 30 A6 0.0035 0.0039 0.029 0.152 0.0132 0.0063 A-21 0.0011 A-25 0.004 0.045 0.0070 D-16 0.0140 0.0827 0.0074 0.0032 M1 M5 0.0169 0.0004 0.0362 0.0048 0.0178 M20-A 0.1293 0.1614 0.0269 0.0008 0.0001 NAS1 0.1176 0.0393 Y-3 0.1179 0.2752 0.3338 0.0247 0.0535 Y-15 0.0129 0.00478 0.3357				R	R^2		
A6 0.0035 0.0039 0.029 0.152 0.0132 0.0063 A-21 0.0011 0.0011 0.0011 0.0011 0.0011 0.0011 0.0012 0.0070 0.0070 0.0070 0.0045 0.0070 0.0070 0.0070 0.0070 0.0070 0.0070 0.0070 0.0070 0.0070 0.0070 0.0070 0.0032 0.0074 0.0032 0.0032 0.0074 0.0032 0.0074 0.0032 0.0078 0.0078 0.0001 0.0001 0.0078 0.0001 0.0078 0.0001 0.0078 0.				LAG PERIO	OD IN DAYS	5	
A6 0.0035 0.0039 0.029 0.152 0.0132 0.0063 A-21 0.0011 A-25 0.001 D-16 0.001 F-2 0.0140 0.0827 0.0074 0.0032 M1 M5 0.0169 0.0004 0.0362 0.0048 0.0178 M20-A 0.1293 0.1614 0.0269 0.0008 0.0001 NAS1 0.1176 0.0393 Y-3 0.1179 0.2752 0.3338 0.0247 0.0355 Y-6 0.0047 0.0129 0.00478 0.3357							
A6 0.0035 0.0039 0.029 0.152 0.0132 0.0063 A-21 0.0011 A-25 0.001 D-16 0.001 F-2 0.0140 0.0827 0.0074 0.0032 M1 M5 0.0169 0.0004 0.0362 0.0048 0.0178 M20-A 0.1293 0.1614 0.0269 0.0008 0.0001 NAS1 0.1176 0.0393 Y-3 0.1179 0.2752 0.3338 0.0247 0.0355 Y-6 0.0047 0.0129 0.00478 0.3357							
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A-21	WELL	0	1	2	5	15	30
A-25 D-4 D-16 D-19 F-2 0.0140 0.0827 0.0074 0.0032 M1 M5 0.0169 0.0004 0.0362 0.0048 0.0178 M20-A 0.1293 0.1614 0.0269 0.0008 0.0001 NAS1 V-3 0.1176 0.2752 0.3338 0.0247 0.0535 V-6 V-15	A6	0.0035	0.0039	0.029	0.152	0.0132	0.0063
D-4 0.045 0.0070 D-16 0.019 0.0045 0.0070 F-2 0.0140 0.0827 0.0074 0.0032 M1 0.0169 0.0004 0.0362 0.0048 0.0178 M20-A 0.1293 0.1614 0.0269 0.0008 0.0001 NAS1 0.1176 0.0393 0.0247 0.0535 Y-3 0.1179 0.2752 0.3338 0.0247 0.0535 Y-6 0.0129 0.00478 0.3357 Y-15 0.00478 0.00478 0.00478	A-21						0.0011
D-16 D-19 O.0140 O.0827 O.0074 O.0032 M1 O.0169 O.0004 O.0362 O.0048 O.0178 M20-A O.1293 O.1614 O.0269 O.0008 O.0001 NAS1 O.1176 O.0393 Y-3 O.1179 O.2752 O.3338 O.0247 O.0535 Y-6 Y-15 O.0129 O.00478 O.3357	A-25						
D-19 0.0140 0.0827 0.0074 0.0032 M1 0.0140 0.0827 0.0074 0.0032 M5 0.0169 0.0004 0.0362 0.0048 0.0178 M20-A 0.1293 0.1614 0.0269 0.0008 0.0001 NAS1 0.1176 0.0393 0.0247 0.0535 Y-3 0.1179 0.2752 0.3338 0.0247 0.0535 Y-6 0.0129 0.00478 0.3357 Y-15 0.00478 0.00478	D-4					0.045	0.0070
F-2							
M1 0.0169 0.0004 0.0362 0.0048 0.0178 M20-A 0.1293 0.1614 0.0269 0.0008 0.0001 NAS1 0.1176 0.0393 0.0247 0.0535 Y-3 0.1179 0.2752 0.3338 0.0247 0.0535 Y-6 0.0129 0.00478 0.3357 Y-15 0.00478 0.00478 0.00478							
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M20-A 0.1293 0.1614 0.0269 0.0008 0.0001 NAS1 0.1176 0.0393 0.0247 0.0535 Y-3 0.1179 0.2752 0.3338 0.0247 0.0535 Y-6 0.0129 0.00478 0.3357 Y-15 0.0129 0.00478 0.00478							
NAS1 0.1176 0.0393 0.0247 0.0535 Y-3 0.1179 0.2752 0.3338 0.0247 0.0535 Y-6 0.0129 0.00478 0.3357 Y-15 0.0129 0.00478 0.00478						0.0048	
Y-3 0.1179 0.2752 0.3338 0.0247 0.0535 Y-6 0.0129 0.00478 0.3357 Y-15 0.0129 0.00478 0.3357				0.0269	0.0008		0.0001
Y-6 0.0129 0.00478 0.3357 Y-15 0.00129 0.00478 0.3357				0.2220		0.0047	0.0505
Y-15		0.1179	0.2752	0.3338			
					0.0129	0.00478	0.3337
	Y-22						
	GATIV	E SLO	PE TU	JRBID:	ITY D	ECREAS	SES W
NEGATIVE SLOPE TURBIDITY DECREASES W			. –				

Table 20. Summary of 2009 rainfall versus turbidity regressions

WELL	BEST FIT LAG	R	N	% OF VARIABILITY EXPLAINED BY REGRESSION	95% RANDOM CHANCE R	99% RANDOM CHANCE R	NOT RANDOM AT 95%	NOT RANDOM AT 99%
A6	5	0.390	74	15%	0.229	0.298	YES	YES
A-21	30	0.033	42	0%	0.304	0.393	NO	NO
A-25	ALL NEGA	TIVE SLOPE	213					
D-4	15	0.212	218	5%	0.133	0.174	YES	YES
D-16	ALL NEGA	TIVE SLOPE	199					
D-19	ALL NEGA	TIVE SLOPE	221					
F-2	5	0.288	42	8%	0.304	0.393	NO	NO
M1	ALL NEGA	TIVE SLOPE	74					
M5	5	0.190	69	4%	0.237	0.308	NO	NO
M20-A	1	0.402	58	16%	0.259	0.336	YES	YES
NAS1	0	0.198	75	4%	0.227	0.296	NO	NO
Y-3	2	0.578	73	33%	0.230	0.300	YES	YES
Y-6	30	0.579	74	34%	0.229	0.298	YES	YES
Y-15	ALL NEGA	TIVE SLOPE	54					
Y-22	ALL NEGA	TIVE SLOPE	74	0%	0.229	0.298	NO	NO

Table 21. Statistical significance of the highest R Squared values of the 2009 rainfall versus turbidity regressions

			(2011 DAT	A)						
			-	R^2						
	LAG PERIOD IN DAYS									
WELL	0	1	2	5	15	30				
A6	0.0199	0.0652	0.0820	0.0734	0.0065	0.0403				
A-21	0.0440	0.0291	0.0271	0.0139	0.0265	0.0050				
A-25										
D-4										
D-16										
D-19	0.0682	0.0442	0.0216	0.0565	0.0165	0.0121				
F-2	0.0026	0.0024	0.0009	0.000006	0.000006	0.0103				
M1	0.0550	0.0637	0.0583	0.0145	0.0024	0.0046				
M5										
M20-A										
NAS1	0.0005	0.0012	0.0013	0.0002	0.0007	0.0005				
Y-3	0.0008	0.1370	0.1891	0.0065	0.0296	0.0075				
Y-6	0.0332	0.0107	0.0072	0.0047	0.018	0.0308				
Y-15	0.0173	0.0178	0.0212	0.0243	0.0347	0.0514				
Y-22										

Table 22. Summary of 2011 rainfall versus turbidity regressions

	BEST FIT			% OF VARIABIITY EXPLAINED BY	95% RANDOM	99% RANDOM	NOT RANDOM	NOT RANDOM
WELL	LAG	R	N	REGRESSION	CHANCE R	CHANCE R	AT 95%	AT 99%
A6	2	0.286	172	8.2%	0.150	0.196	YES	YES
A-21	0	0.210	207	4.4%	0.136	0.179	YES	YES
A-25	NEGATIVE	SLOPE						
D-4	NEGATIVE	SLOPE						
D-16	NEGATIVE	SLOPE						
D-19	0	0.261	303	6.8%	0.113	0.148	YES	YES
F-2	30	0.010	318	0.01%	0.110	0.144	NO	NO
M1	30	0.252	334	6.4%	0.107	0.141	YES	YES
M5	NEGATIVE	SLOPE						
M20-A	NEGATIVE	SLOPE						
NAS1	2	0.036	141	0.1%	0.165	0.216	NO	NO
Y-3	2	0.435	182	18.9%	0.146	0.190	YES	YES
Y-6	0	0.182	190	3.3%	0.142	0.186	YES	NO
Y-15	30	0.227	285	5.1%	0.116	0.152	YES	YES
Y-22	NEGATIVE	SLOPE						

Table 23. Statistical significance of the highest R Squared values of the 2011 rainfall versus turbidity regressions

			R	<u>1^2</u>		
			LAG PERIO	OD IN DAYS	5	
WELL	0	1	2	5	15	30
A6		0.0046	0.0172	0.0482	0.0011	0.0045
A-21		0.00	0.0015	0.0028	0.0009	0.0190
A-25						
D-4						
D-16						
D-19	0.0071	0.0031	0.0007	0.0041	0.00002	0.0013
F-2		0.0002	0.0070	0.0109	0.0131	0.0247
M1	0.0433	0.0506	0.0464	0.0104	0.0011	0.0017
M5						
M20-A						
NAS1	0.0532	0.0234	0.0005			
Y-3	0.0167	0.1894	0.2459	0.0005	0.0366	0.0336
Y-6						0.0028
Y-15	0.0046	0.0042	0.0068	0.0054	0.0011	0.0031
Y-22						

NEGATIVE SLOPE TURBIDITY DECREASES WITH RAINFALL

R^2 = FRACTION OF VARIATION EXPLAINED BY REGRESSION

Table 24. Summary of 2009 and 2011 combined rainfall versus turbidity regressions

WELL	BEST FIT LAG	R	N	% OF VARIABILITY EXPLAINED BY REGRESSION	95% RANDOM CHANCE R	99% RANDOM CHANCE R	NOT RANDOM AT 95%	NOT RANDOM A' 99%
A6	5	0.220	243	5%	0.126	0.165	YES	YES
A-21	30	0.138	243	2%	0.126	0.165	YES	NO
A-25	ALL NEGA	TIVE SLOPE	244					
D-4	ALL NEGA	TIVE SLOPE	500					
D-16	ALL NEGA	TIVE SLOPE	370					
D-19	0	0.084	243	1%	0.126	0.165	NO	NO
F-2	30	0.157	418	2%	0.096	0.126	YES	YES
M1	1	0.225	399	5%	0.098	0.129	YES	YES
M5	ALL NEGA	TIVE SLOPE	219					
M20-A	ALL NEGA	TIVE SLOPE	366					
NAS1	0	0.231	217	5%	0.133	0.175	YES	YES
Y-3	2	0.496	255	25%	0.123	0.161	YES	YES
Y-6	30	0.053	264	0%	0.121	0.158	NO	NO
Y-15	2	0.082	255	1%	0.123	0.161	NO	NO
Y-22	ALL NEGA	TIVE SLOPE	408					

Table 25. Statistical significance of the highest R Squared values of the 2009 and 2011 combined rainfall versus turbidity regressions

		BEST FIT	BEST FIT	% OF VARIABILITY EXPLAINED BY	% OF VARIABILITY EXPLAINED BY	% OF VARIABILITY EXPLAINED BY	NOT RANDOM	NOT RANDOM	NOT
	BEST FIT LAG -	LAG	LAG	REGRESSION	REGRESSION	REGRESSION	AT 95%	AT 95%	AT 95%
WELL	2009	2011	ALL	2009	2011	ALL	2009	2011	ALL
A6	5	2	5	15%	8%	5%	YES	YES	YES
A-21	30	0	30	0%	4%	2%	NO	YES	YES
A-25									
D-4	15			5%			YES		
D-16									
D-19		0	0		7%	1%		YES	NO
F-2	5	30	30	8%	1%	2%	NO	NO	YES
M1		1	1		6%	5%		YES	YES
M5	5			4%			NO		
M20-A	1			16%			YES		
NAS1	0	2	0	4%	0%	5%	NO	NO	YES
Y-3	2	2	2	33%	19%	25%	YES	YES	YES
Y-6	30	0	30	34%	3%	0%	YES	YES	NO
Y-15		30	2		5%	1%		YES	NO
Y-22				0%			NO		

Table 26. Summary of highest significance rainfall versus turbidity regressions

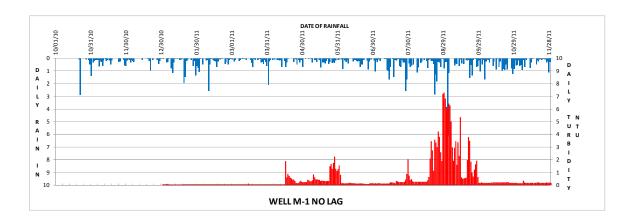


Figure 26. Well M-1 visual scan indicating storm related turbidity rise

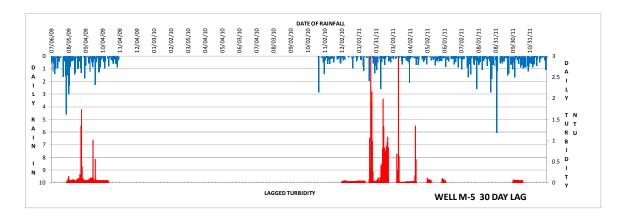


Figure 27. Well M-5 visual scan indicating storm related turbidity rise

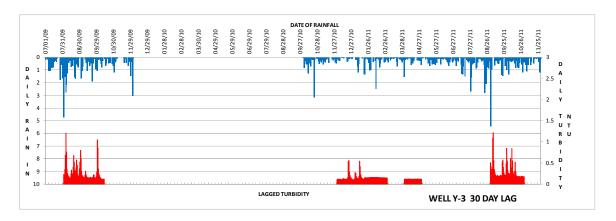


Figure 28. Well Y-3 visual scan indicating storm related turbidity rise

Storm Related Bacterial Contamination

Laboratory water quality analyses were carried out on samples taken at weekly intervals. These samples were analyzed for chemical and micro-biological constituents. Table 3 on page 14 contains a complete list of the weekly sampling dates for each of the wells. A complete listing of all the chemical and bacteriological test results for each of the wells is contained in Table 2 on page 4 of each of the Appendices 2 through 16.

In order to evaluate the Risk Factor "Storm Related Bacterial Contamination", a series of correlation studies were carried out. In these studies the daily rainfall at or near the well site was assumed to be the independent X variable and the measured bacteria levels were assumed to be the dependant Y variable. The bacteria counts were time-lagged behind the rainfall by periods of 0, 1, 2, 5, 15, and 30 days. Because of the small number of data samples available, analyses were performed on the combined 2009 and 2011 data. One such scatter plot showing the regression equation and R squared value is shown for well Y-3 in Figure 29.

A complete listing of all the highest significance regressions for Total, E. coli and Enterococci bacteria for each of the wells is contained in Figures 6 through 9 in each of the Appendices 2 through 16. In no way are these regressions meant to model the extremely complex non-linear contaminant transfer processes that could occur as rain water containing bacterial contaminants moves from the ground surface through the aquifer and into the wells. The purpose is only to help in identifying if there is a statistical link between bacteria surface sources and pumped well water beyond what would exists in normal non-GWUDI groundwater sources. Another point that should be made is that at no time were any of the bacteria data identified as "outliers" and removed from the analysis. In some instances this may very well be the case considering sampling error, false positives and free living enterococci in the soil and water. Since these conditions are very difficult to identify, we maintained a neutral position and left all the data as provided.

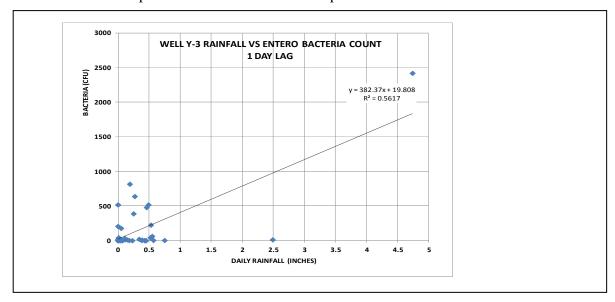


Figure 29. Example rainfall versus Enterococci correlation analysis for GWA GWUDI well Y-3 based on combine 2009 and 2011 data

A summary of the results of the rainfall versus total coliform count regression studies applied to the combined 2009 and 2011 data is shown in Table 27. The R Squared values shown provide us with a measure of the fraction of the variation between rainfall and bacteria count that can be explained by the computed regression equation. The statistical significance of the best R Squared values for any given lag time are further defined in Table 28. It can be seen that GWA GWUDI wells D-4 and F-2 have the highest R Squared values of 0.35 and 0.70 respectively.

This means that 35% and 70 % of the variability between the lagged bacterial levels with rainfall is explained by the regression. Both of these R values were shown to be statistically significant at the 99% level using the same statistical tests described earlier in the Rainfall versus Turbidity regression subsection. Thus it is 99% certain that the correlation is not simply a random outcome. Regression R Squared values range from 0 to 1. A value of 0 means that none of the variability between dependent and independent variables is explained by the regression, whereas a value of 1 means that all of the variability is explained by the regression. Values at the 35% level are not particularly high, but the statistics show that they are better than if the total coliform values had been drawn from a random sample. Values at the 70% level show a fairly strong correlation between rainfall and total bacteria levels and also support the hypothesis that the measured values are statistically different from expected from random total coliform counts. The highest R Squared values for well D-4 came with a lag of five days. The highest value for F-2 came with a lag of only 1 day. Note that the nearly 50% of items in Table 27 had negative slopes. The regressions coefficients for the negative slope regressions were all very small and were not significant even at the 95% level over what would be expected from drawing bacterial counts from a random sample and thus not considered to support any kind of bacterial contamination conclusions. Please note that these regressions do not identify the source of the total coliform only their statistical relationship with rainfall.

The procedure described above was repeated for the E. coli and enterococci data. The results are shown in Tables 29 and 30. Table 31 summarizes the results of all the regression analyses that were carried out.

There were no data requirements or specific levels of statistical significance identified for the Risk Factor "Storm Related Bacterial Contamination" in the QAPP. Well F-2 had the highest R Squared values for both total coliform and enterococci (70% and 72% respectively) showing a strong relationship between rainfall and these sources of bacterial contamination. Well Y-3 had high R Squared values for total coliform, E. coli, and enterococci (18% and 25% and 56% respectively). The 56% R Squared value for enterococci shows a fairly strong relationship between rainfall and bacterial contamination. Well Y-15 had a R Squared values for E. coli of 35% showing a somewhat weak but statistically significant relationship between rainfall and bacterial contamination. Well A-6 had R Squared values for total coliform, E. coli, and enterococci of 16%, 15%, and 17% respectively. The significance here is that all three regressions showed some correlation and all were highest for the same five day lag time. None of the other 10 wells showed R Squared values greater than 0.08 or 8%.

While the 25% R Squared value for the E. coli regression for Well Y-3 shows some significance in the relationship between rainfall and bacteria count, it should be noted that the highest R Squared value for this regression came with a lag time of 15 days which in all probability is beyond the survival time of enteric E. coli washed into the aquifer in surface water recharge. From the above considerations, it is suggest that wells A-6, F-2, Y-3, and Y-15 exhibit the Risk Factor "Storm Related Bacterial Contamination". Again, the R Squared value cut-off point and percent significance used here over a random sample are subjective and require further validation by the regulators and the utilities. Again note that these regressions do not identify the source of the bacterial contaminants only their statistical relationship with rainfall.

				<u>1^2</u>			
			LAG PERIO	OD IN DAYS	i		
WELL	0	1	2	5	15	30	
A6				0.1592	0.0016	0.0005	
A-21				0.0496			
A-25	0.0080	0.0381	0.0096				
D-4				0.3496	0.0171		
D-16							
D-19							
F-2		0.6986	0.2482				
M1	ALL TOTAL	BACT= ZEF	RO				
M5			0.0001			0.0002	
M20-A	0.0001	0.0483	0.0011		0.0483	0.0017	
NAS1				0.0006			
Y-3		0.1370	0.1777	0.0065	0.0296	0.0075	
Y-6	0.0001	0.0010	0.0409			0.0007	
Y-15	0.0001	0.0855			0.0034		
Y-22	ALL TOTAL	L BACT= ZEF	RO				
_		NE	GATIV	E SLOP	E (BAC	TERIA	DECREASES WITH RAINFA

Table 27. Summary of combined 2009 and 2011 rainfall versus total coliform regressions

WELL	BEST FIT	R	N	% OF VARIABILITY EXPLAINED BY REGRESSION	95% RANDOM CHANCE R	99% RANDOM CHANCE R	NOT RANDOM AT 95%	NOT RANDOM AT 99%
A6	5	0.399	26	16%	0.388	0.496	YES	NO
A-21	5	0.223	29	5%	0.367	0.471	NO	NO
A-25	1	0.195	67	4%	0.240	0.313	NO	NO
D-4	5	0.591	64	35%	0.246	0.320	YES	YES
D-16	ALL NEGATIV	/E SLOPE	45					
D-19	ALL NEGATIV	VE SLOPE	56					
F-2	1	0.836	49	70%	0.282	0.365	YES	YES
M1	ALL TOTAL B	ACT= ZERO	38					
M5	30	0.014	37	0%	0.325	0.418	NO	NO
M20-A	1	0.220	37	5%	0.325	0.418	NO	NO
NAS1	5	0.024	26	0%	0.388	0.496	NO	NO
Y-3	2	0.422	43	18%	0.301	0.389	YES	YES
Y-6	2	0.202	44	4%	0.297	0.384	NO	NO
Y-15	1	0.292	53	9%	0.271	0.351	YES	NO
Y-22	ALL TOTAL B	ACT= ZERO	44					

Table 28. Statistical significance of the R Squared values of the combined 2009 and 2011 rainfall versus total coliform regressions

WELL	BEST FIT LAG	R	N	% OF VARIABILITY EXPLAINED BY REGRESSION	95% RANDOM CHANCE R	99% RANDOM CHANCE R	NOT RANDOM AT 95%	NOT RANDON AT 99%
A6	5	0.390	29	15%	0.367	0.471	YES	NO
A-21	ALL ECOLI BA	ACT= ZERO	29					
A-25	15	0.136	67	2%	0.240	0.313	NO	NO
D-4	ALL ECOLI BA	ACT= ZERO	64					
D-16	ALL ECOLI BA	ACT= ZERO	45					
D-19	ALL ECOLI BA	ACT= ZERO	56					
F-2	ALL ECOLI BA	ACT= ZERO	49					
M1	ALL ECOLI BA	ACT= ZERO	38					
M5	ALL ECOLI BA	ACT= ZERO	37					
M20-A	ALL ECOLI BA	ACT= ZERO	37					
NAS1	ALL ECOLI BA	ACT= ZERO	26					
Y-3	15	0.500	42	25%	0.304	0.393	YES	YES
Y-6	ALL ECOLI BA	ACT= ZERO	44					
Y-15	0	0.595	53	35%	0.271	0.351	YES	YES
Y-22	ALL TOTAL B	ACT= ZERO	44					

Table 29. Statistical significance of the R Squared values of the combined 2009 and 2011 rainfall versus E. coli bacteria regressions

WELL	BEST FIT	R	N	% OF VARIABILITY EXPLAINED BY REGRESSION	95% RANDOM CHANCE R	99% RANDOM CHANCE R	NOT RANDOM AT 95%	NOT RANDOM AT 99%
A6	5	0.410	24	17%	0.404	0.515	YES	NO
A-21	ALL NEGATIV	/E SLOPE	29					
A-25	2	0.168	64	3%	0.246	0.320	NO	NO
D-4	0	0.120	62	1%	0.250	0.325	NO	NO
D-16	ALL NEGATIV	/E SLOPE	43					
D-19	30	0.265	54	7%	0.268	0.348	NO	NO
F-2	1	0.847	49	72%	0.282	0.365	YES	YES
M1			38	ALL ENTERO BACT	= ZERO OR NEG	SATIVE SLOPE		
M5	1	0.122	32	1%	0.349	0.449	NO	NO
M20-A	30	0.287	34	8%	0.339	0.436	NO	NO
NAS1			26	ALL ENTERO BACT	= ZERO OR NEG	SATIVE SLOPE		
Y-3	1	0.749	42	56%	0.304	0.393	YES	YES
Y-6	2	0.193	42	4%	0.304	0.393	NO	NO
Y-15	1	0.185	51	3%	0.276	0.358	NO	NO
Y-22	0	0.198	54	4%	0.263	0.342	NO	NO

Table 30. Statistical significance of the R Squared values of the combined 2009 and 2011 rainfall versus Enterococci bacteria regressions

				% OF VARIABILITY	% OF VARIABILITY	% OF VARIABILITY	NOT	NOT	NO
			BEST FIT	EXPLAINED BY	EXPLAINED BY	EXPLAINED BY	RANDOM	RANDOM	RAND
	BEST FIT LAG	BEST FIT LAG	LAG	REGRESSION	REGRESSION	REGRESSION	AT 95%	AT 95%	AT 95
WELL	TOTAL	ECOLI	ENTERO	TOTAL	ECOLI	ENTERO	TOTAL	ECOLI	ENTE
A6	5	5	5	16%	15%	17%	YES	YES	YES
A-21	5			5%			NO		
A-25	1	15	2	4%	2%	3%	NO	NO	NO
D-4	5		0	35%		1%	YES		NO
D-16									
D-19			30			7%			NO
F-2	1		1	70%		72%	YES		YES
M1									
M5	30		1	0%		1%	NO		NO
M20-A	1		30	5%		8%	NO		NO
NAS1	5			0%			NO		
Y-3	2	15	1	18%	25%	56%	YES	YES	YES
Y-6	2		2	4%		4%	NO		NO
Y-15	1	0	1	9%	35%	3%	YES	YES	NO
Y-22			0			4%			NO

Table 31. Summary of highest significance rainfall versus bacteria count regressions

To verify the results of the regression analysis, we developed a set of visual scans of each of the bacteria levels data sets. Examples of these scans are shown in Figures 30 and 31. A complete listing of the visual scans of bacterial levels for all of the wells is contained in Figures 7, 9 and 11 in Appendices 2 through 16. The scans contain all the laboratory data available from 2009 through 2011. The rainfall data for rain gage GWUDI 44 was used to represent rainfall for all the wells. First because of all the rain gages it had the most complete record overlapping the bacteria data sets, and secondly it was centrally located for a vast majority of the wells. Determining the visual correlation between rainfall and bacteria rise is somewhat subjective. Figure 30 shows the relationship of Enterococci values with rainfall for Well A-6. It is relatively easy to see a positive relationship between rainfall and bacterial rise at this well. Figure 31 shows the relationship of Enterococci values with rainfall for Well D-4. Here it is relatively easy to see that there is a poor relationship between rainfall and bacterial rise at this well. Table 32 is a repeat of Table 31 with the results of the visual scan correlation studies added to the regression equation results.

The visual correlation considerations shown in Table 32 support the regression equation considerations that wells A-6, F-2, and Y-3 exhibit the Risk Factor "Storm Related Bacterial Contamination". The visual correlation considerations do not support the regression equation considerations that well Y-15 exhibit the Risk Factor "Storm Related Bacterial Contamination". The visual correlation considerations support the regression equation considerations that well A-25, exhibits the Risk Factor "Storm Related Bacterial Contamination" for all three bacteria tests. The results of this analysis suggest that wells A-6, A-25, F-2, and Y-3 exhibit the Risk Factor "Storm Related Bacterial Contamination". Again, the application during data analysis of the R Squared cut-off point and percent significance over a random sample, and whether a visual correlation is exhibited are subjective and should be agreed upon by the regulators and the utilities.

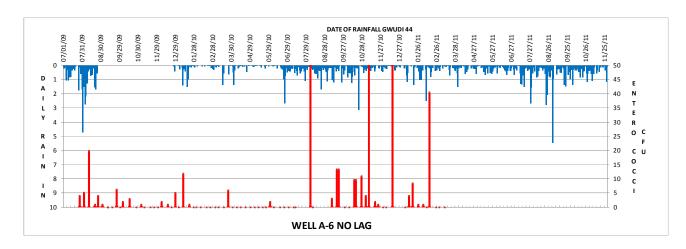


Figure 30. Well A-6 visual scan indicating storm related bacteria rise

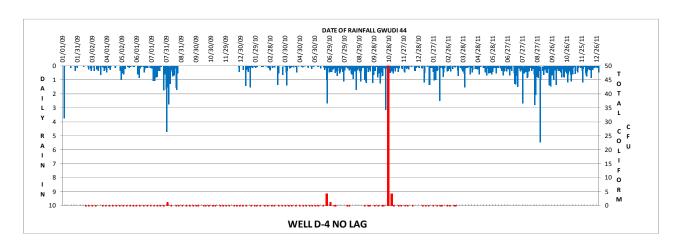


Figure 31. Well D-4 visual scan indicating no storm related bacteria rise

				% OF VARIABILITY	CORRELATION BY	% OF VARIABILITY	CORRELATION BY	% OF VARIABILITY	CORRELATION BY	NOT	NOT	NOT
			BEST FIT	EXPLAINED BY	VISIBLE	EXPLAINED BY	VISIBLE	EXPLAINED BY	VISIBLE	RANDOM	RANDOM	RANDOM
	BEST FIT LAG	BEST FIT LAG	LAG	REGRESSION	INTERPRETATION	REGRESSION	INTERPRETATION	REGRESSION	INTERPRETATION	AT 95%	AT 95%	AT 95%
WELL	TOTAL	ECOLI	ENTERO	TOTAL	TOTAL	ECOLI	ECOLI	ENTERO	ENTERO	TOTAL	ECOLI	ENTERO
A6	5	5	5	16%	YES	15%	YES	17%	YES	YES	YES	YES
A-21	5			5%						NO		
A-25	1	15	2	4%	YES	2%	YES	3%	YES	NO	NO	NO
D-4	5		0	35%				1%		YES		NO
D-16					YES							
D-19			30					7%				NO
F-2	1		1	70%	YES			72%		YES		YES
M1												
M5	30		1	0%				1%		NO		NO
M20-A	1		30	5%				8%		NO		NO
NAS1	5			0%						NO		
Y-3	2	15	1	18%	YES	25%	YES	56%	YES	YES	YES	YES
Y-6	2		2	4%				4%		NO		NO
Y-15	1	0	1	9%		35%		3%		YES	YES	NO

Table 32. Summary of highest significance rainfall versus bacteria count regressions including visual scans

GWUDI STATUS DETERMINATION

Next we applied the results of the previously described Risk Factor studies to the GWUDI decision tree that was developed from the QAPP and later modified to better match the actual measured MPA data. The original decision tree was previously shown in Figure 24 and the modified version is shown in Figure 32 for easy reference.

The first branch of the decision tree is dependent on the results of the MPA analyses that were performed as part of the study. As shown in previous Table 5, only 3 MPA tests were done in 2011. Extensive MPA testing was done as part of 2009 GWUDI study. The results of this testing is shown in previous Table 6. All MPA results from the 2009 and 2011 testing were low. Because of these low results we feel that all wells should follow the upper-left "LOW" branch on the decision tree.

The next branch on the decision tree involves the Risk Factors shown in Figure 32. The evaluation of these Risk Factors was described above, and a summary of the results of these studies is shown in Table 33 below. The Table shows, with the exception of one well (Y-3), all wells had less than three Risk Factors and therefore were classified as Not-GWUDI. According to the decision tree Well Y-3 should be re-tested. Since it had already been tested 4 times with low results, the re-test low branch was considered to be more applicable in this instance. Hence well Y-3 should also perhaps be classified as Not-GWUDI along with all the other 'GWA wells considered in this study...

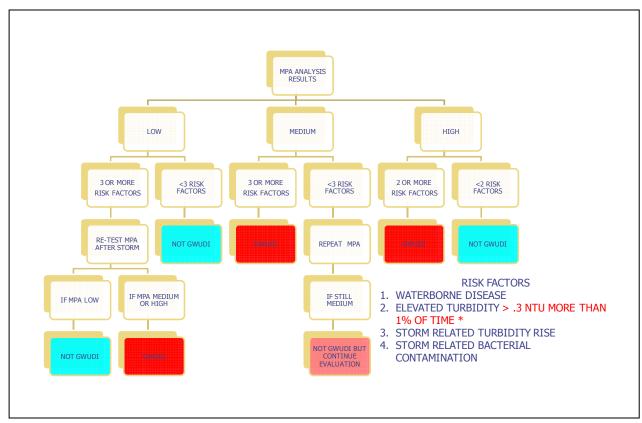


Figure 32. Decision tree for determining GWUDI status

WELL	WATERBORNE DISEASE	ELEVATED TURBIDTY *	STORM RELATED TURBIDITY RISE	STORM RELATED BACTERIAL CONTAMINATION	TOTAL RISK FACTORS	MPA TESTS	GWUDI STATUS
A6	NO	NO	NO	YES	1	LOW	NOT GWUDI
A-21	NO	NO	NO	NO	0	LOW	NOT GWUDI
A-25	NO	YES	NO	YES	2	LOW	NOT GWUDI
D-4	NO	NO	NO	NO	0	LOW	NOT GWUDI
D-16	NO	NO	NO	NO	0	LOW	NOT GWUDI
D-19	NO	NO	NO	NO	0	LOW	NOT GWUDI
F-2	NO	NO	NO	YES	1	LOW	NOT GWUDI
M1	NO	YES	YES	NO	2	LOW	NOT GWUDI
M5	NO	YES	YES	NO	2	LOW	NOT GWUDI
M20-A	NO	YES	NO	NO	1	LOW	NOT GWUDI
NAS1	NO	NO	NO	NO	0	LOW	NOT GWUDI
Y-3	NO	YES	YES	YES	3	LOW	RETEST /NOT GWUDI *
Y-6	NO	NO	NO	NO	0	LOW	NOT GWUDI
Y-15	NO	NO	NO	NO	0	LOW	NOT GWUDI
Y-22	NO	NO	NO	NO	0	LOW	NOT GWUDI
	* SMOOTHED TURBIDITY > 0.3 MORE THAN 1 % OF THE TIME						

Table 33. Summary of Risk Factors and GWUDI Status

It is very important to re-emphasize the assumptions that were used to reach the final GWUDI or NOT-GWUDI decision for the wells. The assumptions were necessary to take the broad suggested criteria made in the QAPP to concrete decision factors based on the analysis of the data gathered for the GWUDI studies. Following is a list of the assumptions that were made:

- 1. MPA testing done for the 2007, 2008, 2009 and 2011 studies were all valid for use in this study.
- 2. The Risk Factor "Waterborne Disease" was assumed to be low for all wells. Guam Public Health reported that no water borne diseases occurrences caused by Giardia Lamblia or Cryptosporidium had resulted from contact with drinking water supplied by the wells.
- 3. The Risk Factor "Elevated Turbidity" was determined from a frequency analysis of the 2011 automated turbidity data. The criteria for a positive risk factor was if the turbidity level was greater than 0.3 NTU more than 1% the time. Both the median smoothed and the unsmoothed turbidity values were examined and there was no difference in the risk factor determinations between the two methods.
- 4. The Risk Factor "Storm Related Turbidity Rise" was based on regression analysis and visual scans of the combined 2009 and 2011 rainfall and turbidity data. The turbidity data was based on the daily geometric mean of the 3 day moving median of the 15 minute turbidity data. An R Squared value greater than 20% with a level of significance greater than 99% was required in order for this Risk Factor to be positive. Visual scans were used to verify the results of the regression studies.
- 5. The Risk Factor "Storm Related Bacterial Contamination" was based on regression analysis and visual scans of the combined 2009 and 2011 rainfall and bacteria data. Separate regression studies were made for Total Coliform, E. coli and Enterococci. An R Squared value of greater than 20% for any one bacteria type or an R Squared level of greater than 10% for all three Bacteria with a level of significance greater than 99% was required in order for this Risk Factor to be positive. Visual scans were used to verify the results of the regression studies.

It is important that Guam EPA, US EPA and the involved utilities are in agreement that the above criteria are the correct interpretation of the intent of the original QAPP and thus result in valid GWUDI determination for the wells in this study.

Another important factor that must be considered when evaluating the GWUDI determination results is the reliability of the 15 minute turbidity data that was used as the basis for Risk Factors 3 and 4 mentioned above. Table 34, below, shows that the wells in this study were not provided maintenance for the period of June through October 2011. The data during this time frame does look reasonable and the total data set was used in this study. That being said, there is no way to determine with any certainty if all of the turbidity data during the un-serviced period reflects the actual turbidity levels experience by the wells. A second consideration is that seven of the wells sampled (A-6, A-25, D-16, M-5, NAS-1, Y-3 and Y-6) were not active during the highest rainfall period in 2011. A third consideration is the total data days of turbidity data available in 2011. Three of the well gages (A-25, M-5, and NAS-1) had less than 6 months worth of total data

available in 2011. These three factors all affect the Risk Factor "Elevated Turbidity levels". The Risk Factor "Storm Related Turbidity rise" was determined by regression analysis of daily rainfall versus average daily turbidity. The 2011 turbidity data used for this analysis was supplemented by that gathered for the earlier GWUDI study. While this helped to increase the number of data days available, it did not help with the problem of not having any data for seven of the wells during the highest rainfall period of 2011.

The above three considerations make the turbidity related Risk Factors somewhat suspect. If we modify the data in Table 32 by changing the Turbidity Risk factors (both Elevated Turbidity and Storm Related Turbidity Rise) all to Yes we get the data that is shown in Table 35. With these changes the status for wells A-6 and F-2 change from Not GWUDI to Retest and A-25 changes to Retest/Not GWUDI. More than likely if these wells are re-tested the results will be low and we will be back to all wells being Not GWUDI.

If we apply the same conservative concept to the Storm Related Bacterial Contamination Risk Factor, we get the results shown in Table 36. In this case all of the wells have three risk factors and require re-test. Six of the wells have already been re-tested as low for more than one time and therefore will be declared NOT GWUDI. According to the GWUDI decision tree, the remaining nine would require re-testing. More than likely if these wells are re-tested the results will be low and we will be back to all wells being NOT GWUDI.

It is important that Guam EPA, US EPA and the involved utilities are in agreement on which analysis considerations to use when declaring the wells GWUDI or NON GWUDI.

WELL	RAIN DATA	2011 WELL GAGE MAINTENANCE MISSING	2011 TURBIDITY DATA (HIGH RAINFALL)	2011 TURBIDITY DATA DAYS FOR TURBIDITY FREQUENCY STUDIES	TURBIDITY DATA DAYS FOR TURBIDITY VS RAINFALL REGRESSION	2007-2010 MPA DATA	2011 MPA DATA	TOTAL MPA	LAB BACTERIA DATA DATES	LAB BACTERIA DATA DAYS FOR RAINFALL VS BACTERIA LEVEL REGRESSION
A6	YES	JUNE - OCTOBER	NO	182	243	1 (STORM,LOW)	NO	1	7-27-09 TO 3-14-11	26
A-21	YES	JUNE - OCTOBER	YES	206	243	1 (STORM,LOW)	1 (STORM,LOW)	2	7-27-09 TO 3-14-11	29
A-25	YES	JUNE - OCTOBER	NO	31	244	3 (STORM,LOW)	1 (STORM,LOW)	4	7-10-09 TO 3-14-11	67
D-4	YES	JUNE - OCTOBER	YES	280	500	2 (STORM,LOW)	NO	2	2-18-09 TO 3-14-11	64
D-16	YES	JUNE - OCTOBER	NO	192	370	2 (STORM,LOW)	NO	2	2-18-09 TO 3-14-11	45
D-19	YES	JUNE - OCTOBER	YES	299	243	2 (STORM,LOW)	NO	2	3-24-09 TO 3-02-11	56
F-2	YES	JUNE - OCTOBER	YES	316	418	1 (STORM,LOW)	NO	1	6-30-09 TO 3-14-11	49
M1	YES	JUNE - OCTOBER	YES	333	399	1 (STORM,LOW)	NO	1	7-20-09 TO 3-14-11	38
M5	YES	JUNE - OCTOBER	NO	137	219	1 (STORM,LOW)	NO	1	7-20-09 TO 3-14-11	37
M20-A	YES	JUNE - OCTOBER	YES	296	366	1 (STORM,LOW)	NO	1	7-27-09 TO 3-14-11	37
NAS1	YES	JUNE - OCTOBER	NO	153	217	1 (STORM,LOW)	NO	1	7-27-09 TO 3-14-11	26
Y-3	YES	JUNE - OCTOBER	NO	182	255	3 (STORM,LOW)	1 (STORM,LOW)	4	7-7-09 TO 3-14-11	43
Y-6	YES	JUNE - OCTOBER	NO	189	264	1 (STORM,LOW)	NO	1	7-14-09 TO 3-14-11	44
Y-15	YES	JUNE - OCTOBER	YES	281	255	1 (STORM,LOW)	NO	1	7-14-09 TO 3-14-11	53
Y-22	YES	JUNE - OCTOBER	YES	334	408	1 (STORM,LOW)	NO	1	7-14-09 TO 3-14-11	44
		PROBLEMATIC USE CAUTION		TURBIDITY DATA DAYS KEY LESS THAN 6 MONTHS OF DATA BETWEEN 6 AND 10 MONTHS OF DATA						
		DATA OK			MORE THAN 10 MONTHS OF	DATA				

Table 34. Availability and adequacy of data for GWUDI determination

			STORM RELATED	STORM RELATED			
	WATERBORNE	ELEVATED	TURBIDITY	BACTERIAL	TOTAL RISK		
WELL	DISEASE	TURBIDTY *	RISE	CONTAMINATION	FACTORS	MPA TESTS	GWUDI STATUS
A6	NO	YES	YES	YES	3	1	RETEST
A-21	NO	YES	YES	NO	2	2	NOT GWUDI
A-25	NO	YES	YES	YES	3	4	RETEST /NOT GWUDI ***
D-4	NO	YES	YES	NO	2	2	NOT GWUDI
D-16	NO	YES	YES	NO	2	2	NOT GWUDI
D-19	NO	YES	YES	NO	2	2	NOT GWUDI
F-2	NO	YES	YES	YES	3	1	RETEST
M1	NO	YES	YES	NO	2	1	NOT GWUDI
M5	NO	YES	YES	NO	2	1	NOT GWUDI
M20-A	NO	YES	YES	NO	2	1	NOT GWUDI
NAS1	NO	YES	YES	NO	2	1	NOT GWUDI
Y-3	NO	YES	YES	YES	3	4	RETEST /NOT GWUDI **
Y-6	NO	YES	YES	NO	2	1	NOT GWUDI
Y-15	NO	YES	YES	NO	2	1	NOT GWUDI
Y-22	NO	YES	YES	NO	2	1	NOT GWUDI
	* SMOOTHED T	URBIDITY > 0.3	MORE THAN 1				
	** Y-3 TESTED I	OW MPA ONCE	IN 2011 AND T	HREE TIMES IN 2009			
	*** A-25 TESTE	D LOW MPA ON	ICE IN 2011 ANI	D THREE TIMES IN 20	07-2009		

Table 35. GWUDI determination using modified risk factors for elevated turbidity and storm related turbidity rise

WELL	WATERBORNE DISEASE	ELEVATED TURBIDTY *	STORM RELATED TURBIDITY RISE	STORM RELATED BACTERIAL CONTAMINATION	TOTAL RISK FACTORS	MPA TESTS	GWUDI STATUS
A6	NO	YES	YES	YES	3	1	RETEST
A-21	NO	YES	YES	YES	3	2	RETEST /NOT GWUDI **
A-25	NO	YES	YES	YES	3	4	RETEST /NOT GWUDI **
D-4	NO	YES	YES	YES	3	2	RETEST /NOT GWUDI **
D-16	NO	YES	YES	YES	3	2	RETEST /NOT GWUDI **
D-19	NO	YES	YES	YES	3	2	RETEST /NOT GWUDI **
F-2	NO	YES	YES	YES	3	1	RETEST
M1	NO	YES	YES	YES	3	1	RETEST
M5	NO	YES	YES	YES	3	1	RETEST
M20-A	NO	YES	YES	YES	3	1	RETEST
NAS1	NO	YES	YES	YES	3	1	RETEST
Y-3	NO	YES	YES	YES	3	4	RETEST /NOT GWUDI **
Y-6	NO	YES	YES	YES	3	1	RETEST
Y-15	NO	YES	YES	YES	3	1	RETEST
Y-22	NO	YES	YES	YES	3	1	RETEST
	* SMOOTHED TURBIDITY > 0.3 MORE THAN 1 % OF THE TIME ** TESTED LOW MPA MORE THAN ONCE						

Table 36. GWUDI determination using modified risk factors for elevated turbidity, storm related turbidity rise, and storm related bacterial contamination

MULTI-VARIABLE DATA DISPLAY

The risk factors shown in Figure 36 include storm related turbidity rise and storm related bacterial contamination. The Risk Factors Section presented previously described a statistical means of determining the various risk factors in making the GWUDI determination. It is also helpful to see a time plot of all of the data gathered in order to help visualize the relationships involved. In order to accomplish these visualizations efficiently an Excel spreadsheet multi-variable plotting application was developed. The application not only allows for the rapid visualization of data streams, but also serves as a single excel workbook to store all of the rainfall, turbidity, lab water quality and MPA data. One data scanner workbook was developed for each of the project wells.

The interface for the multi-variable data scanner is shown in Figure 33. The two graphs in the upper part of the scanner are synchronized so that the same period of time is shown on each graph. The top graph shows rainfall and laboratory analysis data. The bottom graph shows turbidity and smoothed turbidity data. The bottom area shown in blue is the control panel area of the application. This part of the graph contains various buttons, check boxes and input cells to control what variables are shown on the graph and how that data is shown. The VCR type buttons controls the time scale on both of the graph axies simultaneously. The total time scale of the graph can be changed to the user's preference along with what time increment that is applied each time the VCR buttons are pressed. The user has complete and convenient control of the axies scales used on the laboratory data and turbidity data. These values are changed by simply entering the desired range values in the appropriate spreadsheet cells. One of these multi-variable data scanners is shown for each of the GWUDI wells studied on Figure 3, page 5 of Appendices 2 through 16.

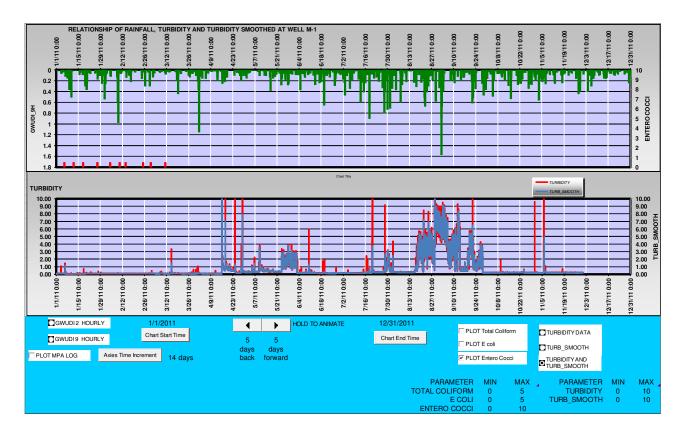


Figure 33. Multi-variable data scanner

RESULTS AND CONCLUSIONS

The purpose of this study was to make treatment requirement recommendations and GWUDI determination for 15 GWA wells. Turbidity, Bacteriological, and MPA data were analyzed to make these determinations.

The turbidity treatment recommendations made are based on interpretations of the QAPP presented in Appendix 1 as applied to the frequency analysis of the turbidity data. In making these turbidity treatment recommendations, we suggest using a three period median averaging technique applied to the raw turbidity data gathered at the well sites. We also recommend a relaxation of the criteria recommended in the QAPP for the various treatment requirements. This recommendation is made because of the vast amount of data available in the 15 minute turbidity data and the short time variability that can occur in this turbidity data. Several recommended treatment options were presented. We favor the two options that use the smoothed turbidity data over the raw data. Table 37 shows these two options. Of these two, we prefer some relaxation of the QAPP

recommendations. The result of our suggested relaxations is shown in Table 37. It is up to the regulators and the utilities to determine whether or not to use the smoothed data, whether or not to relax the QAPP criteria, and if the QAPP criteria is relaxed what relaxed values should apply.

	SMOOTH	D DATA	
WELL	SMOOTHED DATA STRICT CRITERIA	SMOOTHED DATA RELAXED CRITERIA	
A-6 *	CARTRIDGE	SINGLE	
A-21	DUAL	SINGLE	
A-25 **	CARTRIDGE	CARTRIDGE	
D-4	DUAL	SINGLE	
D-16 *	CARTRIDGE	SINGLE	
D-19	DUAL	SINGLE	
F-2	CARTRIDGE	SINGLE	
M-1	MEM/SHUT DOWN	MEM/SHUT DOWN	
M-5 *	MEM/SHUT DOWN	MEM/SHUT DOWN	
M20-A	CARTRIDGE	CARTRIDGE	
NAS-1 *	SINGLE	SINGLE	
Y-3 *	MEM/SHUT DOWN	MEM/SHUT DOWN	
Y-6 *	DUAL	SINGLE	
Y-15 *	SINGLE	SINGLE	
Y-22	DUAL	SINGLE	
	* NO DATA DURING HIG	HEST RAINFALL PERIOD	
	** SMALL SAMPLE SIZE		

Table 37. Suggested turbidity treatment recommendations

A second study was carried out to determine the status of the wells as outlined by the GWUDI determination rules of the QAPP. These recommendations were made based on interpretations of the QAPP as applied to: 1) MPA data gathered for 2007-2011, 2) Public health information concerning water borne disease on Guam, 3) Frequency analysis of the turbidity data, 4) Regression analysis and visual scans the of turbidity versus rainfall, and 5) Regression analysis and visual scans of the bacterial counts versus rainfall. Certain adjustments were made to the QAPP GWUDI criteria to make it compatible with the frequency and regressions analysis that were used. Three sets of GWUDI determinations were presented. The least conservative of these recommendations declared all wells studied to be "NOT GWUDI". The most conservative of the three would require that nine of the wells be re-tested. In light of past MPA analyses that were performed, it is likely that the wells would test low and be

declared "NOT GWUDI". The regulators and utilities must agree on the QAPP interpretations for GWUDI status made by this study if the results are to be deemed valid.

When making determinations about the GWUDI status and the treatment requirements it is important that these decisions be based on adequate and reliable data. A quick review of previous Figure 11 and Table 34 show that all of the GWA GWUDI well samplers were not serviced during the period of June through October 2011. This leads to reliability issues in the values recorded (since no calibration was done). Another issue is turbidity data during high rainfall periods. Seven of the wells had no data recorded during the highest rainfall times of the study period. A third concern come in amount of data available for each well. Previous Figure 15 shows that six of the wells had less than ½ year of data days available. These are all serious concerns that should be addressed by the regulatory agencies.

RECOMMENDATIONS

Many of the conclusions that come out of this study are based on the 15-minute interval turbidity data. In order for these conclusions to be valid, the turbidity data-sets have to be free of methodological artifacts and representative of real-time events. In this regard, uncertainties associated with equipment malfunction, calibration errors, and missing data associated with intermittent well operations, need to be accounted for in any final decision making process associated with this study. The variable nature of turbidity is also a grey area that requires further consideration. The methodology used in this study does not differentiate between surface water derived turbidity transported into the aquifer by recharge and that generated within the aquifer itself by ongoing geochemical processes. The chemical and biological characteristics of turbidity from each of these sources are very different and need to be considered separately in terms of chlorine demand and potential health risks. Internally generated turbidity is of little consequence on both accounts.

One of the goals of the QAPP was to come up with a continuous record of reliable turbidity data. Clearly this has not happened for all wells considered. Continuing the study for yet another year is unlikely to resolve the missing data issue in light of current pumping practices and the inevitability of equipment failure. Stitching data-sets together from intermittently operated wells is also not a recommend practice especially when high risk wells are being considered. We have an over abundance of relatively good turbidity data for dry season conditions and comparatively little for wetter months. Continuing the study only makes sense, therefore, if we focus exclusively on a suit of high risk wells during wet weather conditions.

Because of the overriding importance of the MPA findings in making GWUDI determinations, it is highly recommended that all future resources and effort be primarily channeled towards supplementing the current MPA data-base for high risk wells during wet weather conditions. Sample collections made 2-7 days after an initial 2 inches in a 24 hour rainfall event seems a reasonable criterion to adopt and is line with that adopted during the current study.

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- Neville, A.M. and Kennedy J.B. (1964). Basic Statistical Methods for Engineers and Scientists. Scranton, Pennsylvania: International Textbook Company.

APPENDIX 1

Water treatment assessments and groundwater under the direct influence of surface water determinations for wells in the northern aquifer of Guam

QUALITY ASSURANCE PROJECT PLAN

Version 10/15/08

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1.0 Project Management

1.1 Responsible Parties

The Groundwater under Direct Influence (GWUDI) of surface water is a joint study between the three largest water developers on Guam; the Guam Waterworks Authority (GWA), US Air Force and US Navy, regulatory agencies; Guam Environmental Protection Agency and US Environmental Protection Agency and the Water and Environmental Research Institute of the University of Guam and the Guam Airport Authority. Table 1 shows contact information of Key Personnel for the GWUDI Project. Figure 1 shows the project organization chart.

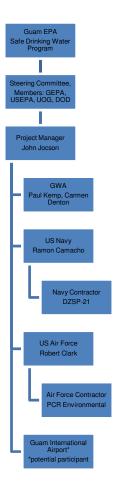
Table 1. Key Personnel for the GWUDI Project

Table 1: Rey Tersonner for the GW ODI Froject						
Team Member	Title and Organization	Overall Project Involvement	Specific Involvement			
Bruce Macler, PhD	USEPA Macler.bruce@epa.gov 972-3569	Project Advisor	Steering Committee/Planning			
Barry Pollock	USEPA Pollock.barry@epa.gov 972-3563	Project Advisor	Steering Committee/Planning			
John Jocson	WERI, University of Guam jjocson@uguam.uog.edu 735-2693	Project Manager	Planning/ Project Coordination/ Data organization			
Angel Marquez	GEPA Angel.Marquez@guamepa.net 475-1638	Regulatory Advisor	Steering Committee/Planning			
Carmen Denton	Guam Waterworks Authority cdenton@ite.net 632-9697	Steering Committee/GWA water quality analysis	GWA Quality Assurance Manager/Sampling/ Analysis			
Paul Kemp	Guam Waterworks Authority paulkemp@guamwaterworks.org 647-2605	Steering Committee GWA point of contact	GWA Quality Assurance /Site work			
Gary Denton, Ph.D.	WERI, University of Guam gdenton@uguam.uog.edu 735-2690	Steering Committee Project Advisor	Steering Committee			
Mark Lander, PhD,	WERI, University of Guam mlander@uguam.uog.edu 735-2695	Rain gage network and rainfall data collection	Rainfall data collection/Analysis			
Leroy Heitz, PhD	WERI, University of Guam lheitz@uguam.uog.edu	Data Management Specialist	All logger data/rainfall analysis			

John Salas	USAF	Steering Committee	Steering Committee
Robert Clark	USAF Robert.clark@andersen.af.mil 366-5071	Steering Committee	Steering Committee
Ramon Camacho	USN Ramon.Camacho@navfacmar.navy.mil 339-3711	Steering Committee Navy point of Contact	Steering Committee
Lucrina C. Jones	USN Water Quality Lab Lucrina.Jones.CTR@navfacmar.navy. mil	USN Water Laboratory Contractor	USN water quality analysis
Alejandro Soto	USN Consultant Alejandro.Soto.CTR@navfacmar.navy. mil 339-4415	Navy Contractor	Navy Quality Assurance
ТВА	Guam International Airport Authority*	TBA	TBA

^{*} Potential new participants

Figure 1. Organization Structure for the GWUDI Project.



1.2 Documentation

This Quality Assurance Project Plan (QAPP) will be distributed to the six (6) participating organization of the GWUDI Project.

2.0 Study Design

2.1 Problem Definition

A primary goal for drinking water is that it be microbiologically safe. Drinking water sources should be free of microbial pathogens, if possible. Otherwise, adequate treatment to remove and inactivate these pathogens is necessary. Filtration can remove pathogens directly and can control materials that can inhibit disinfection. Disinfection inactivates or destroys the pathogens. Current USEPA drinking water goals are to reduce the risk of waterborne disease to less than one infection per 10,000 people per year.

Water sources are generally either surface water (lakes, streams, rivers) or groundwater. Because surface water sources are directly open to fecal contamination from runoff or deposition, they are usually considered to be so contaminated. They are also subject to contamination with particulate matter, yielding turbidity. True groundwaters are considered to be free of larger pathogens (protozoa) and particulate matter due to natural filtration in the vadose zone or aquifer, or because of a confining layer that prevents surface contamination from reaching the aquifer. However, there is a class of groundwaters for which these barriers are not present. If an aquifer consists of fractured rock, or large-diameter material, or tubes and fissures, materials may move with minimal interference from surface source to groundwater. The term "groundwater under the direct influence of surface water" (GWUDI) is used for this type of groundwater.

The aquifer encompassing the northern half of Guam consists primarily of uplifted fractured limestone that has been substantially altered through dissolution (Figure 2). This hydrogeological setting is thought to be unique to Guam, Saipan and other islands in the Northern Marianas group. Fractured, chemically-altered limestone ("karst") aquifers are generally regarded as sensitive to surface contamination.



Figure 2. Northern Guam Plateau showing production well locations.

The following is the definition of a karst aquifer taken from Lohman and others (1972): A karst aquifer is an aquifer containing soluble rocks with a permeability structure dominated by interconnected conduits dissolved from the host rock which are organized to facilitate the circulation of fluid in the down-gradient direction wherein the permeability structure evolved as a consequence of dissolution by the fluid.

Many surface-related sources of contamination are found in this part of Guam. Raw sewage can run directly into recharge wells and basins. Small-scale animal husbandry is wide-spread. There is a long history of microbial and chemical contamination of the groundwater. As a result, mandatory disinfection has been required for all wells.

It has been suggested that the entire aquifer be designated as GWUDI, because of the hydrogeology and contamination, and because groundwater contamination can rapidly follow major rain events. A recent study performed by GEPA, USGS, and WERI

estimated the time-lag between the heavy rain associated with Tropical Storm Tingting in June, 2004 and the subsequent rapid rise of the water table at 15 hours. This rapid infiltration occurred through an unsaturated zone of approximately 200 feet.

Unfortunately, current USEPA guidance for the determination of GWUDI does not adequately address this hydrogeological setting. This guidance was developed primarily for aquifers in unconsolidated soils and for aquifer recharge from surface water bodies such as lakes and rivers. The purpose was to identify situations where inadequate barriers, natural filtration, or time for pathogen inactivation existed between these surface waters and the groundwater reaching a well. In these cases, additional treatment in the form of filtration and enhanced disinfection might be required. The guidance was not designed for rainfall-induced infiltration of contaminants from the surface, or for deep karstic aquifers.

In addition, specific data normally used for this determination are limited or lacking for Guam. These include water quality information to quantitatively demonstrate relatedness, and microscopic particulate analysis results that can indicate the presence of materials not normally associated with true groundwater. A recently completed treatability study of PCB-contaminated sediment by AAFB implied that fine-grained sediment could be transported by infiltrating rain through voids in the limestone. Results from this study may be helpful in the GWUDI determination for Guam's Northern Aquifer. Additionally, while some wells show frequent and/or persistent contamination, many have no history of contamination. The depth to groundwater is generally large (300' is common), allowing for some physical and temporal barriers in some cases. This means that, while concern for direct influence is warranted, whether all or the majority of the ~150 public water supply wells should be so designated is unclear. Because of these reasons, classification of the wells and/or aquifer remains controversial.

The implications of a GWUDI designation are clear, however. These wells would be regulated under the Surface Water Treatment Rule (SWTR) as "Subpart H" surface water systems, would have to be appropriately monitored and disinfected, and would either have to install and operate filtration systems, or meet filtration avoidance criteria. In addition, Long-term 2 Enhanced Surface Water Treatment Rule (LT2 ESWTR) requirements would mean *Cryptosporidium*, *E.coli* and turbidity monitoring for each well. This would be an expensive and problematical burden for Guam, and would not obviously provide commensurate additional public health protection. Guam Water Authority (GWA) has 121 drinking water wells in the northern aquifer. US Navy and US Air Force have about 30 wells between them. A recent cost estimate for complete GWUDI compliance is \$145 million.

There is agreement between all parties that data need to be acquired to make the GWUDI determination and to help select appropriate water treatment. Several planning meetings have been held over more than a year to develop a feasible study that will provide the necessary information.

EPA Region 9 has taken enforcement actions against Guam Water Authority, resulting in a stipulated agreement to provide suitable treatment for the provision of drinking water.

The GWUDI determinations by Guam EPA are necessary for GWA to address this agreement element. Additionally, this determination will impact wells in this aquifer under control of USN, USAF. Deadlines under the agreement and mandated by LT2 ESWTR require a determination as soon as possible.

2.2 Project Description and Objective

The objectives of this water quality study on northern aquifer wells are:

- Determine whether specific wells are GWUDI
- Inform a decision on general classification of the aquifer and/or sub-basins as GWUDI
- Suggest appropriate treatment for GWUDI and non-GWUDI wells.

Specific tasks are as follows:

- Collect turbidity, conductivity, ph, and temperature data on a continuous basis for each well.
- Collect corresponding meteorological (rainfall) data on a continuous basis.
- Collect microbial indicator data, hardness, nitrate as NOX, calcium, magnesium and chloride on a regular basis for each well.
- Conduct microscopic particulate analyses (MPAs) for these wells.
- Collect NEXRAD data on storm events
- Conduct water quality studies associated with any incidental contamination events.)

2.3 GWUDI determination criteria and data quality objectives

2.3.1 Establish GWUDI determination criteria and data quality objectives (ongoing) Criteria for the determination of GWUDI for individual wells in the Northern Aquifer have been agreed upon by Guam EPA and the participants. These criteria are derived from USEPA guidance documents for the Surface Water Treatment Rule, from subsequent guidance revisions and field evaluations, and from extensive on-island discussions by participants and WERI faculty.

Criteria

- Historical data showing waterborne microbial disease outbreak problems. A history of known or suspected waterborne disease outbreaks from organisms associated with surface water (for example, *Giardia, Chryptosporidium*, coccidia) attributed to that source will be evidence of GWUDI. No such outbreaks are known for Guam. However, leptospirosis is not uncommon from surface water exposures, so that leptospirosis associated with well water exposures would be evidence of GWUDI.
- <u>Data indicating elevated turbidities</u>.

True groundwaters are defined as having low turbidities, even following storm events. This is because many hydrogeological settings, such as unconsolidated soils, can provide adequate filtration to physically remove particulate matter. Confining layers, when present, can prevent downward flow of surface water containing particulates. Therefore, a history of elevated turbidity associated with the source is considered evidence of GWUDI. A history of low turbidity (<0.3 ntu) is indicative of true groundwater.

- Presence of surface-associated particulate matter. True groundwaters are characterized by a lack of microbial pathogens, especially larger pathogens such as *Giardia* or *Cryptosporidium*. This is because many hydrogeological settings, such as unconsolidated soils, can provide adequate filtration to physically remove these organisms and other materials of similar size. They may also provide sufficient retention time during travel from fecal source to well that pathogens become non-infective. Confining layers, when present, can prevent downward flow of surface water containing particulate matter. For these reasons, true groundwaters should not have materials or organisms found in surface waters or at the soil surface. These include microalgae (including diatoms), insect parts, pollen, rotifers, *Giardia* cysts, *Cryptosporidium* oocysts, coccidia and other, larger (>5-10 um) microorganisms. Identification of these and like materials in wellwater samples, done by microscopic particulate analysis (MPAs) to determine their presence or absence, will be evidence of GWUDI.
- <u>Temporal correlations of water quality changes associated with storm or spill</u> events.
 - Storm events can substantially change groundwater quality due to contributions from runoff, storm drains and increased water flow rates. Demonstration of rapid water quality changes in well water temporally associated with storm events or other events at the surface (sewage or chemical spills) will be evidence of possible GWUDI. "Rapid" in this sense means within hours or a day of the event. Longer time frames for storm-related changes may not indicate direct influence through unattenuated flow. Storm event (meteorological) data should be compared with turbidity and other water quality data to assess temporal associations.
- Recurrent or episodic presence of indicator organisms especially associated with storm or spill events. Bacteria and viruses may or may not be filtered out by soils in true groundwaters, therefore the presence of fecal indicator bacteria or viruses is not necessarily indicative of GWUDI. Studies have shown that about 10% of true groundwaters have evidence of fecal contamination at least episodically. Their presence may result from too-close proximity to a fecal source or from improper well construction. However, for karstic aquifers with little opportunity for natural filtration, recurrent presence of indicator organisms such as *E. coli*, enterococci, or coliphage (bacterial viruses) in wellwater, especially if associated with storm or spill events, is, in the absence of other

obvious causes, evidence of possible GWUDI. If there is no historical evidence of fecal contamination of a well, this is evidence that the well is not GWUDI

• Improper well construction, including defects in surface seal or casing. An improperly constructed well without adequate casing or surface seal can allow surface contamination to flow down the borehole. The system files should be reviewed for the well construction and results of sanitary surveys for each well. Evidence of defects in the surface seal or other surface features, or in the casing, indicate the potential for GWUDI.

While properly cased and sealed wells will minimize opportunities for direct surface water contamination, the prevailing hydrogeological structure of fractured limestone in Guam does not allow that proper construction alone provides adequate protection.

These criteria will be considered together to make a judgment of GWUDI. These should be reviewed by GEPA and discussed with participating agencies.

A review of the data indicates that wells on Guam are properly sealed, and cased down into the aquifer, so that this should not be a criterion of general concern.

2.3.2 Determinations from criteria

These criteria are not being considered independently. The drinking water regulatory community has considered these criteria, somewhat subjectively, as a whole, giving substantial weight to the MPA. This is discussed at some length in EPA guidance (Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis.)

If the MPA analysis shows high risk, and at least two other indicators are consistent with GWUDI, consider the well as GWUDI.

If the MPA analysis shows medium risk, and at least three other indicators are consistent with GWUDI, consider the well as GWUDI. If only one or two other indicators show positive, repeat the MPA. If still a medium risk, consider the well not GWUDI, but subject to continued evaluation.

If the MPA analysis shows low risk, consider the well to not be GWUDI, unless at least three other indicators are consistent with GWUDI, in which case, repeat the MPA after a storm event. If the repeat MPA indicates low risk, consider the well to not be GWUDI. If the risk is medium or high, consider the well to be GWUDI.

2.3.3 Aguifer, subbasin and adjacent well determinations

The above criteria are for the GWUDI determination of an individual well. A goal of the study is, if possible, to classify aquifer sub-basins and basins using the data from a limited number of representative wells. Variations in vadose flow within a subbasin make it impossible to predict flow from surface sources into the aquifer. However,

episodic high flows associated with storm events are thought less likely to impact water quality at the well screen, which is well below the aquifer surface. Provisionally, collected data will be interpreted to judge whether GWUDI determinations for wells adjacent to test wells can be done.

2.4 Data quality objectives for GWUDI determinations

Data quality objectives appropriate to making the GWUDI determinations will be specified. USEPA has provided guidance on some of these factors.

Presence of surface-associated particulate matter. Microscopic particulate analyses are sufficiently specialized that data quality objectives are available from the contract laboratory. Presence of microalgae (including green algae, blue-green algae (cyanobacteria), and diatoms), insect parts, pollen, rotifers, *Giardia* cysts, *Cryptosporidium* oocysts, coccidia and other microorganisms larger than 5-10 um may be indicative of surface water influence. The contract laboratory should provide its evaluation of high, medium or low risk. For this project, MWH is the primary contract laboratory for all the participants, so there will be consistency in results.

Over the years, general criteria based on subjective experience have been agreed upon by the water industry. Quantitative MPAs for the above constituents have been collected and statistically evaluated. Classifications of high, medium and low risk, based on the number of specific constituents identified in MPAs, are now accepted by USEPA. (ref Tables 1 and 2, Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis). In general, presence of protozoa (*Giardia* and *Cryptosporidium*) and coccidia rank higher than diatoms and other microalgae, which are ranked higher than insects, larvae, rotifers and plant debris. If *Giardia* cysts and/or *Cryptosporidium* oocysts are detected and confirmed, a high risk of GWUDI would be considered. In the absence of *Cryptosporidium* and *Giardia* detections, presence of other particulates can indicate other levels of risk.

<u>Data indicating elevated turbidities</u>. Turbidity levels consistently below 0.1-0.2 NTU are indicative of true groundwaters. Fluctuations of greater than 0.5-1 NTU over the course of a year, or associated with storm or spill events, may be indicative of surface water influence. However, caution in interpretation is warranted, since these changes may be only indirectly associated with surface events (i.e., resuspension of particulate carbonate in the aquifer itself). Because earthquakes can cause resuspension of particulates, seismic activity should be monitored and considered in interpreting data.

Data indicating temporal changes associated with storm events

Rainwater is somewhat colder than groundwater. Temperature decreases associated with rainfall events would be indicative of rapid recharge. However, measured temperature change may not tell us anything, since it may be more influenced by pump motor heating or surface heating. We cannot use this as a criterion at this time.

Water quality changes of greater than 50% associated with storm or spill events, are consistent with GWUDI.

2.4.1 Water quality, operational criteria and data quality objectives for treatment selection

Information that will inform selection and design of appropriate treatment will be collected as part of this project. Some data on a well-specific basis are already available. Work to identify more-promising technologies will be conducted concurrently.

Filtration

For wells that are considered GWUDI, a further determination is for whether or not filtration will be required. The role of filtration is to remove particulate material (and in some cases, organic material) that would affect chemical disinfection. If turbidities do not exceed 1 NTU, even during storm event fluxes, then the well can qualify for filtration avoidance. Two disinfectants will then be required, such as UV light and chlorine.

If turbidities are generally low, but episodically >0.3 NTU, filtration will be required to comply with SWTR. Because the water is generally low in turbidity, the treatment approach should consider a system that will be protective during a turbidity spike, but otherwise low-maintenance. Cartridge filters may be the best choice, but alternative filtration techniques are available.

If turbidities exceed 0.3 NTU on a regular basis filtration will be required. Membrane filtration may be appropriate, especially if high turbidities occur from time-to-time. However, if turbidities of 3-5 NTU or higher are only associated with major storm events or flooding, it may be prudent to shut down the well and issue a boil water notice instead of maintaining extensive treatment. As noted before, turbidity may consist of calcium carbonate particulates, which may not pose a chlorine demand or otherwise affect chemical disinfection (it may affect UV disinfection because of shading).

Besides turbidity data, information will be gathered for water hardness, nitrate, calcium, magnesium, chloride and pH.

2.5 Quantitative Quality Control Objectives

This section presents the calculations necessary to obtain the main data quality indicators that are used during this project. During all the intermediate calculations (for both data and indicators), all digits are kept and rounded off for final result.

2.5.1 Precision

The precision of duplicate samples is assessed by calculating the relative percent difference (RPD) according to:

$$RPD = \frac{\left|S - D\right|}{\frac{(S + D)}{2}} * 100\%$$

Where S: Sample Concentration

D: Duplicate sample concentration

If calculated from three or more replicates, the precision is determined using the relative standard deviation (RSD):

$$RSD = \frac{SD}{Average} *100\%$$

Where SD: Standard deviation for the replicate samples

Average: Average Value

2.5.2 Accuracy

For measurements where matrix spikes are used, accuracy is evaluated by calculating the percent recovery (R):

$$R(\%) = \frac{S - U}{C_{sq}} * 100\%$$

Where S: Measured concentration in spike sample

U: Measured concentration in unspiked sample

 C_{sq} : Calculated concentration of spike in sample

When a standard reference material (SRM) is used, the percent recovery is determined by:

$$R(\%) = \frac{C_m}{C_{srm}} * 100\%$$

Where C_m : Measured concentration of SRM

 C_{SRM} : Actual concentration of SRM

2.5.3 Method Detection Limit (MDL)

To determine the MDL, at least even replicates of a laboratory fortified blank at a concentration of three to five times the estimated instrument detection limit is analyzed through the entire analytical method. The MDL is calculated using the following equation:

$$MDL = (t)*(SD)$$

Where t: Student's t value for 999 percent (t for 7 replicates = 3.14)

2.5.4 Completeness

Completeness is a measure of the amount of valid data obtained compared to the amount of samples collected. The degree of completeness is the number of acceptable analyzed samples divided by the number of samples collected, multiplied by 100. Completeness is defined by the following equation:

$$\%C = 100\% * \left(\frac{V}{T}\right)$$

Where %C: percent completeness

V: number of measurements judged valid

T: total number of measurements

A summary of acceptable QC objectives for a precision, accuracy, and MDLs for all applicable water quality parameters is provided in Table 2. Further information from the individual laboratories is also presented in the SOPs shown in the appendices. This table also contains a summary of critical and secondary parameters for this study. Critical parameters are those that allow accomplishment of the primary goals of this research and determine the success or failure of a particular task. Secondary parameters are supplied are supplemental for data analysis in determining trends.

Table 2 Summary of Acceptable QC Objectives for Precision, Accuracy, MDLs, and Completeness of Data

					Accuracy	
		Reporting	MDL	Precision	(%Recovery or %	Completenes
Measurement	Classification	Units	Goal	(%RPD)	Bias)	S
calcium	Secondary	mg/L CaCO₃	1	±10	90-110	90
chloride	Secondary	mg/L	1	±10	90-110	90
conductivity	Secondary	μs/cm	1	±10	90-110	90
hardness	Secondary	mg/L CaCO ₃	1	±10	90-110	90
nitrate as NOX	Critical	μg/L-N	10	±20	80-120	90
magnesium	Secondary	mg/L CaCO ₃	2	±20	80-120	90
рН	Secondary	pH units	0.1	±0.05 unit	90-110	90
temperature	Secondary	C°	0.1	±10	90-110	90
turbidity	Secondary	NTU	0.01 NTU	±10	90-110	90
total coliform bacteria	Critical	MPN/100mL	1	±10	90	90
E. coli	Critical	MPN/100mL	1	±10	90	90
enterococci	Critical	MPN/100mL	1	±10	90	90
microscopic particulate analyses (MPA's)	Critical	Relative Risk Factor per MWH	Per MWH	Per MWH	Per MWH	Per MWH

2.6 Qualitative Quality Control Objective

2.6.1 Comparability

Comparability is the degree to which one data set can be compared with another, or degree of consistency between two data sets. It is achieved by use of consistent methods and materials through the use of SOP. Comparability of data is promoted by strict adherence to the analytical methods, and the use of SOPs. For parameters that are measured at more than one laboratory, inter-laboratory comparison experiments are conducted between both laboratories at the beginning of the project, and on a quarterly basis thereafter (further information regarding the inter laboratory comparison experiments is presented below.

2.6.2 Representativeness

Representativeness is a measure of the degree to which a group of sampled is indicative of an entire population being studied. Representativeness is achieved in this study by:

- Properly selecting the sampling locations
- Following appropriate and consistent sampling procedures through the use of an SOP
- Selecting the number or volume of samples according to the conditions being analyzed.
- Collect samples during typical or representative operation and conditions.

2.7 Impact of not meeting the quality objectives

There is no reason for not meeting the quality objectives of this project. If needed the SOPs will be revised and the method adapted in order to obtain data that meet the goals and objectives of this project, as well as all QC requirements. In the unfortunate event that the quality objectives were not met, we will discuss the issue(s) with the Steering Committee as appropriate, and propose remediation actions.

3.0 Data Acquisition

3.1 Experimental Approach

The approach to achieving the study objectives will include these components:

1) A full GWIDI analysis on a statistically-representative subset of Guam drives.

1) A full GWUDI analysis on a statistically-representative subset of Guam drinking water wells using water quality data collected over a period of *one* (1) year that includes:

- Conduct microscopic particulate analyses (MPAs) for these wells.
- Collect turbidity and conductivity data on a continuous basis for each well.
- Collect microbial indicator data and other water quality information on a regular basis for each well.
- Collect corresponding meteorological (rainfall) data on a continuous basis.

- Conduct water quality studies associated with any incidental contamination events.)
- Collect Seismic data from the USGS website that may influence turbidity measurement at the well. The database web address is http://earthquake.usgs.gov
- 2) Evaluation of these specific wells, the northern aquifer and its sub-basins as units for general GWUDI classification.
- 3) Collection of data to assist with decisions about what types of treatment would be most appropriate for the particular hydrogeological settings and contaminant threats found in Guam. This will include source water contamination assessments.
- 4) Well selected for the project are:
 - GWA wells are A6, A21, A25, D4, D7, D16, D19, D22, Y3, Y6, Y10, Y15, M1, M5, M20A, F2, F13
 - USN wells are NRMC-1, NCS-B1, and NCS-12
 - USAF wells are MW-1, AF-1, AF-5, and MW-7

Selection of the project wells were based on the following reasons. First a statistical representation of each sub-basin of the Aquifer was desired. Second, the history of the water quality at each well was considered. Wells with a history of contamination were selected as well as those that have little to no history of problems were selected. Along with their existing wells the Air Force will have two newly developed wells (AF-5 and AF-1) participating in this project.

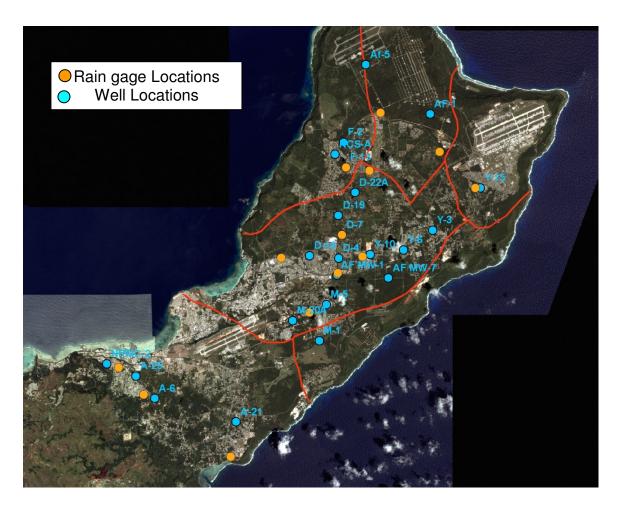


Figure 3. Production Wells selected for the GWUDI Project and rain gage locations. * Note not all wells currently instrumented.

3.2 Instrumentation and Calibration

Field data to be collected includes turbidity, pH, temperature, conductivity and rainfall. All wells that are monitored will be monitored using a common instrument. The Hach system with turbidity meter (1720E), pH probe and inductive conductivity probe will be the standard for this project. This equipment will also include a data logger and equipment for visual display of the data (SC 1000 w/ display). Tipping bucket rain gages from HoboWare will be deployed at strategic locations that would best represent recharge to a specific well(s) over the study area.

Calibration for the Hach system will be done according to the manufactures recommendations and methods. During the initial months of the project calibration can be done more frequently than recommended by the manufacturer.

A log book will be maintained at each well to record any events at the well that may affect the readings of the sensors on the instruments. See Appendix 1 for manual.

3.3 Instrument Setup and Schematics

Although a common data logging instrument was chosen to monitor the well turbidity. The setups differ slightly between the participating agencies. Figure 4 is the setup used by GWA and figure 5 is a schematic of the setup utilized by the Navy. The main difference is that GWA utilizes a feeder pipe to sample the water while Navy sample directly from the well discharge pipe.



Figure 4. shows the setup of the Hach instrumentation set up by GWA at well F-13.

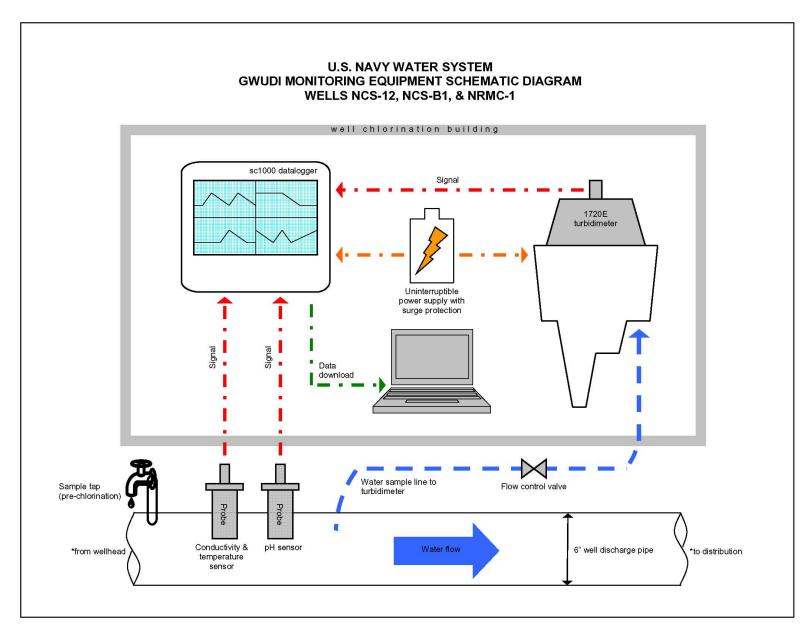


Figure 5. Schematic of the instrument setup used by the Navy for their project wells.

The data logger deployed by the Water and Environmental Research Institute for is from Onset Application called the Hobo weather station rain gage. The design is of the tipping bucket with an internal event logger model RG3.(Figure 6)



Figure 6. Hobo tipping bucket rain gage.

3.4 Sampling/Monitoring Frequency

- Each well will be monitored continuously for turbidity and conductivity for 12 months. Data download to be set at 15 minute intervals. The raw ascii format data files will be sent to WERI for processing every first week of the month.
- Each well will be sampled weekly (preferably on Mondays) for microbial indicators (*E. coli*, total coliform bacteria, and enterococci) for 12 months. Enterococci were chosen, since GWA has a history of detection of these after sewage discharges. *E.coli* and enterococci positive results will trigger daily repeat sampling until results are negative for 2 consecutive days. Analyses will be done using enumeration methods.
- Each well will be sampled once for MPA during the dry season (January-June) and once for MPA during the rainy season (July-December), associated as best as possible with storm events. One additional MPA sample will be triggered by two consecutive positive results for *E. coli* or enterococci and increased turbidity. Increased turbidity defined as being over 1 NTU or 10X background NTU for 2 days. If there is a positive *E. coli* or enterococci result, operators to check the turbidity meters at the well concerned for trending over past two days.

- SOP on MPA and schedule, holding times, timing of sampling to delivery to lab (MW) Dr. Mark Lander will give the alert when potential storms events will be coming via email to the respective parties.
- Each well will be sampled for hardness, nitrate as NOX, calcium, magnesium and chloride monthly (first week of every month) for 12 months.
- Rain gages will be installed in the vicinity of each test well or up-gradient of the well, and rainfall data will be monitored continuously for the 12 months. Other meteorological data, including temporal and spatial information on rainfall and other storm events, will be accessed from UOG/WERI and other weather services.
- Standard Methods or EPA methods will be used in all cases. Certified labs (or equivalent labs using proper QA/QC) will be used. QA/QC requirements are to be met as established by the method. Standard methods are listed in the Appendix.
- NEXRAD data must be collected for each target event. WERI investigators will coordinate with National Weather Service personnel to gather the relevant NEXRAD products (e.g., base reflectivity, one-hour precipitation, and storm-total precipitation products) for target rainfall events.
- After at least the passage of the heart of one rainy season (July through October), the WERI investigators will begin to analyze the rainfall data to produce a comprehensive set of statistics on the character of extreme rainstorms on Guam
- Ancillary benefits include calibration by the rain-gage network of the NEXRAD reflectivity-rainfall algorithms. Many NEXRAD sites in the mainland are automatically calibrated on a storm-by-storm basis by rain gage networks. Also, the information gathered in the study may help researchers to evaluate the level of treatment that is needed for the northern well water.

Table 3 summarizes sampling constituents and schedules for the project. Analytical results to be turned into WERI every first week of the month for the previous month's samples.

Table 3. Sampling constituents and schedule.

Constituents	Sampling Schedule
microscopic particulate analyses (MPAs)	Once in Dry season and Once in Wet Season*
hardness nitrate as NOX calcium magnesium chloride	Monthly (First week of the month)
E. coli total coliform bacteria	Weekly (Mondays) Weekly (Mondays)(quantified)

enterococci Weekly (Mondays)

Rainfall continuous

conductivity continuous (15 minute intervals) ph continuous (15 minute intervals) temperature continuous (15 minute intervals) turbidity continuous (15 minute intervals)

^{*} Based on opportunity of storm events

		Preservative or dechlor(am)inating		
Parameter	Collection container	agent	Replicate frequency	Maximum sample holding time
Calcium	125-mL acid-rinsed polyethylene bottle	1 mL HNO ₃ (18%) (pH<2)	All samples analyzed in duplicate	6 months at 4℃
	20-mL amber glass vials,	Head-space free, 2		
Chloride	Teflon-lined septa and screw caps	mg ammonium chloride	1/10 samples analyzed in duplicate	Store at 4 ℃, analyze within 1 days
Total Hardness	125-mL acid-rinsed polyethylene bottle	1 mL HNO₃ (18%) (pH<2)	All samples analyzed in duplicate	6 months at 4℃
Nitrate as N	125-mL polyethylene bottle	none	1/10 samples analyzed in duplicate	48 hours at 4℃
рН	Not applicable	none	single	Store at 4℃, analyze within 1 day
Temperature	Not applicable	none	single	Analyzed immediately
•			-	Store at 4°C, analyze within 1
Turbidity	Not applicable	none	single	day
microscopic articulate analyses			-	
(MPA's)	Filter	none	single	96 hours at < 10 ℃
	125-mL acid-rinsed	1 mL HNO ₃ (18%)	All samples analyzed in	
Magnesium	polyethylene bottle	(pH<2)	duplicate	6 months at 4℃
E 1.	120-mL sterile	0 " "	1/10 samples analyzed in	
E. coli	polyethylene bottle	Sodium Thiosulfate	duplicate	8 hours at < 10 °C
total caliform	120-mL sterile	Codium Thiogulfota	1/10 samples analyzed in	8 hours at < 10 °C
total coliform	polyethylene bottle 120-mL sterile	Sodium Thiosulfate	duplicate 1/10 samples analyzed in	8 hours at < 10 ℃
Enterococci	polyethylene bottle	Sodium Thiosulfate	duplicate	o nouis at < 10 G
conductivity	Not applicable	none	single	28 days at 4°C

				Cor	ntrols	
	Investigating					
Parameter	Authority	Method/reference	Instrument	Negative	Positive	Calibration
Calcium	GWA/Navy/ AF	SM-3500-Ca-B	none	none	none	none
Chloride	GWA/Navy/ AF	SM-4500-CI	none	none	none	none
Hardness	GWA/Navy/ AF	SM-2340-C	none	none	none	none
		SM-4500-NO ₃	Lachat Flow	none	none	5 point
Nitrate as N	GWA/Navy/ AF	F/EPA 353.2	Injection Analyzer			Calibration
			Digital PC sc and	none	none	
			RC sc 3/4in			
.11	O)A/A/AI- / AF	01450011	Combination			
рН	GWA/Navy/ AF	SM4500 H	pH/ORP sensor Digital PC sc and	none	nono	
			RC sc 3/4in	none	none	
			Combination			
emperature	GWA/Navy/ AF	SM2550 B	pH/ORP sensor			none
	,		1720E Low	none	none	
			Range			
Turbidity	GWA/Navy/ AF	SM2130B	Turbidimeter			
			none	none	none	
microscopic						
particulate						
analyses						
(MPA's)	GWA/Navy/ AF	EPA 1992				none
nagnesium	GWA/Navy/ AF	SM-3500-Mg B	none			none
_			none	Klebsiella		
E. coli	GWA/Navy/ AF	SM9223 B		pneumoniae	E. coli	none
	GWA/Navy/ AF		none	Pseudomonas		
otal coliform	-	SM9223 B		aureaus	E. coli	none
_				Serratia	Enterococcus	
Interococci	GWA/Navy/ AF	SM9230-B		mecencens	faecium	none
			3700 sc Digital	none	none	
	C)A/ A /N c> ::/ A =	CM0E10D	Conductivity			
conductivity	GWA/Navy/ AF	SM2510B	sensor			

3.5 Data Storage Requirements

The data collection plan must provide a consistent approach and system for acquiring and storing study data, since several agencies and multiple teams will be providing separate data streams. The data must ultimately be available in usable form to Guam EPA, so a centralized data base and consistent protocols are essential. A GIS format for data storage is recommended.

WERI will utilize ESRI GIS-based data systems and Microsoft Excel for this project. Geographic layers of the study wells will be created and overlaid on a 2005 Quickbird® satellite image of Guam. Collected data for each well will be incorporated into the GIS database for the respective wells. Rain gage locations will also be plotted into a GIS layer to allow for ease of spatial analysis of the data.

4.0 Data Analysis

4.1 Turbidity Trends

As mentioned earlier the overall goal of the GWUDI project is to establish whether or not there are adequate pathways available so that contaminates in water that is on the ground surface above the Northern Aquifer can be detected in groundwater being pumped from the aquifer. In order to establish this connection a correlation of measurable increases in aquifer turbidity or other water quality parameters with significant rain storm events must be shown.

4.1.1 Develop GIS Maps showing Water Quality and Rainfall sampling locations and previously identified ground water head gradients.

Using GIS analysis and presentation techniques, we will develop maps to spatially visualize the locations of the sampled wells and rain gages and how these sampling locations correspond spatially with the groundwater gradients that have been identified in previous hydraulic modeling studies of the Northern Guam Lens. These maps will be used to help identify and define relationships between the water quality and rain fall data. A simple example of this sort of GIS map is shown in Figure 7.

4.1.2 Visually examine the relationships between water quality data gathered at the various wells and between the water quality data and rainfall data.

The data gathered from the wells and rain gages will be loaded into a multi parameter quick view Excel spreadsheet that was developed for a previous project. An example of the spreadsheet is shown in Figure 7. In Figure 7 the parameters of rainfall, turbidly and stream flow are shown plotted simultaneously. The VCR like buttons on the bottom of the frame can be used to rapidly move thought the data looking for relationships between the various parameters being plotted. This allows for both long term and short term trends to be examined. By using duel independent variable axis with multiple variables

on each axis several different parameters can be plotted and visualize with time as a common independent axis variable. The first visualizations that will be carried out will be comparisons of the well water quality data. This will be used to examine the similarity of the timing of turbidity peaks that might be moving through the well system. This wills give investigators an idea which wells are most responsive and if there are temporal differences in how the wells respond. The next step will be to plot the turbidity levels of the responsive wells against rainfall data from rain gages located in areas up the groundwater flow gradient from the wells.

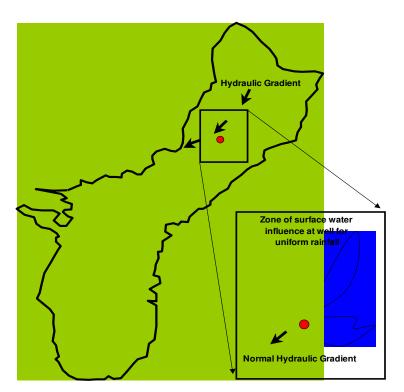


Figure 7. Simple map showing hydraulic Gradient in Groundwater Aquifer.

The Final GIS Maps for this project will include more detailed groundwater flow maps and the data sampling locations for water quality and rainfall.

After a thorough examination of the time relationship between the various water quality sampling sites and the time relationships between the various water quality sampling and rainfall sampling sites, it should become apparent where relationship among and between the data are appearing.

4.1.3 Statistical analyses between data sets identified

Statistical analyses of all data sets will be conducted to establish the validity of the trends and relationships that may exist between them. We will carry out multiple and two variable correlation analysis to determine the statistical validity of the visual relationships that were identified. The timing of the rainfall and water quality data sets will be adjusted to help determine the magnitude of time lags between the rainfall events and the water quality changes that are observed at the well sites.

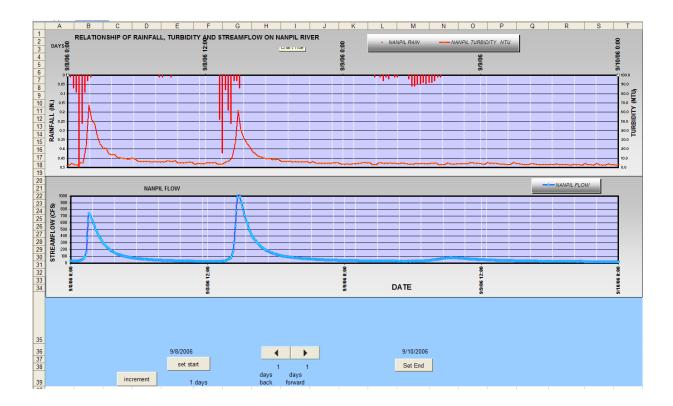


Figure 8. Example of Excel Spreadsheet Multi-Parameter Quick View Software that will be used on this project.

5.0 Data Management

5.1 Data Handling

Both automated data acquisition systems and manual recording of experimental data are used in this project. Typically, the automated systems are associated with continuous monitoring devices attached to the pilot- or demonstration-plant processes used in this project. Manual recording refers to data that are entered into a laboratory notebook or computer spreadsheet by an analyst. In either case, the data are downloaded to or entered into Microsoft Excel spreadsheets for subsequent transformation or reduction.

5.1.1 Automated Data Acquisition

Data that will be acquired with an automated system during this pilot study include water quality data (e.g., pH and temperature), flow rates, and pressures. Data will typically be recorded by a data logger, which will require regular downloads by an operator (typically every 1 to 2 weeks). All data recorded in computer spreadsheets will be backed up on CD or backup drive.

The automated systems will have any necessary virus and password protection as possible. During a task, only authorized personnel will be given the password for data entry or acquisition.

5.1.2 Manual Data recording

The following are guidelines are followed in conjunction with manual data recording:

- Data that are collected and the condition of data generation are recorded in the laboratory notebooks or in computer spreadsheets ad a primary record. Laboratory notebooks are signed and dated by the person that generated the data.
- A secondary record or data summary sheet is created using computer a
 spreadsheet in which the primary data are entered and manipulated if necessary.
 Each datum entered is verified by the person that generated that datum. Also,
 verification from the primary source is performed on an "as needed" basis in
 addition to periodic spot checks by the respective persons. Data requiring "as
 needed" verification include any of the data that do not conform to anticipated
 trends or those deemed suspicious based on the experience of the QC managers.

The Laboratory QC Managers ensure that all SOPs are followed, and any deviations documented. Any problems or unforeseen circumstances that may affect the quality of the data or integrity of the study, ad well as all corrective actions, are accurately discussed, documented and reported.

5.2 Data Review and Verification Methods

Data review, verification, and validation are judged against the project Scope of Work and the data quality objective, methods, and procedures discussed in this QAPP. The protocol for these activities is discussed below.

5.2.1 Data Review and Verification Methods

Data review and verification apply to logs (i.e. field logs, sample logs, etc) and data packages compiles from field and/or laboratory activities. This process is conducted at

various levels, resulting in verified data, accompanied by the appropriate verification records.

Each investigator is responsible for the data obtained at his/her facility and serves as QC manager in his/her laboratory. These individuals are responsible for ensuring that all data collected in the laboratory, including the unexpected and the conditions of data generation, are recorded in data recording form or laboratory notebooks as a primary record. As part of this responsibility, each laboratory QC manager performs random spot checks on a weekly basis.

Data generated during field activities are the responsibility of several people during this particular task, including field personnel, analytical laboratory personnel, and Project QC manager. The field personnel are responsible for ensuring that all data collected in the field, including the unexpected and the conditions of data generation, are recorded in the data recording form or laboratory notebooks as a primary record and done according to the appropriate procedure. This is completed for analysis done on onsite, as well as data obtained via a data acquisition system (logger). All QC checks necessary to ensure proper equipment operation, including meter calibration gage checks, etc are included in these laboratory notebooks.

Any samples collected during field activities and shipped to an analytical laboratory are documented using the chain of custody forms as presented in the appendices. Throughout processing of these field samples, a data package is generated by each laboratory. Laboratory personnel including the Laboratory QC Manager are responsible for reviewing the data packages to ensure that the data have been recorded appropriately (including any deviations).

5.2.2 Errors in Data and Deviations from SOPs

Any deviation from an SOP for sample collection, analysis, data reduction, or others are documented and explained by the analyst and Laboratory QC Manager. Errors in data may require correction action to be taken, in which case the description of the applied correction action is included with the verification records.

5.2.3 Data validation Methods

A QA Officer is responsible for data validation for each laboratory or agency. The QA Officer has access to a complete set of verified data and verification records. Due to the size a complexity of this project, the QA Officer conducts random checks of these documents on a monthly basis. Data validation includes:

- An evaluation of the laboratory and field records for consistency
- A review of QC information, including instrument calibration and control samples
- A summary of deviations and discrepancies in experimental activities and documentation with an evaluation of the impact on the data quality.

5.3 Reconciliation with User Requirements

During the execution of this study, all activities are validated by comparison with the project scope of work and this QAPP. The need for corrective actions is identified in the QC evaluation activities. The sample collection, handling, transportation and analysis are conducted described in previous sections, and any deviations are documented with the reasons for such deviations as well as the corrective actions undertaken. Any issues that may impair the team's ability to use the set of data are discussed and reported. The data obtained are also evaluated based on the QC requirements presented earlier.

6.0 Documents and Records

The key documents records to be produced during this project include numerous data packages, project assessments, reports to management, and GIS projects.

6.1 Assessment and Response Actions

Oversight and assessment of this project are conducted by a number of different participants and stakeholders. However, the primary body is the Project Steering Committee. The Project Steering Committee members have been previously established for this project and their duties include the selection of the contractor(s) and oversight of the project.

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APPENDIX 2 WELL A-6 DATA AND ANALYSIS

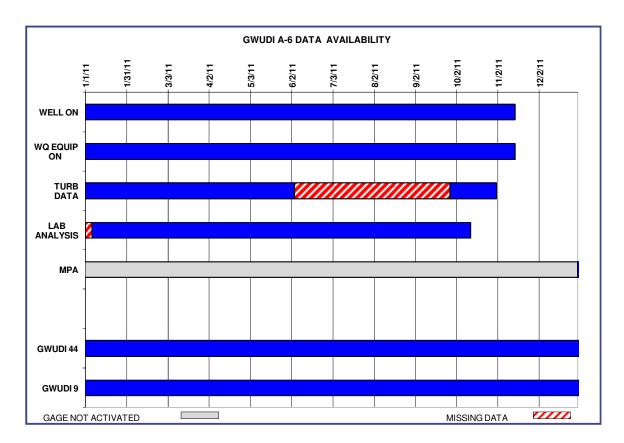


Figure 1. Well A-6 data availability

BIN	FREQUENCY	CUMMULTIVE %	% HIGHER	NUMBER HIGHER	INVERSE CUMULATIVE %	BIN AVG
0.025	0	0.00%	100.00%	17494	100.00%	0.0125
0.05	1936	11.07%	88.93%	15558	88.93%	0.0375
0.075	7250	52.51%	47.49%	8308	47.49%	0.0625
0.1	5780	85.55%	14.45%	2528	14.45%	0.0875
0.125	1790	95.78%	4.22%	738	4.22%	0.1125
0.15	368	97.88%	2.12%	370	2.12%	0.1375
0.175	148	98.73%	1.27%	222	1.27%	0.1625
0.2	49	99.01%	0.99%	173	0.99%	0.1875
0.225	47	99.28%	0.72%	126	0.72%	0.2125
0.25	42	99.52%	0.48%	84	0.48%	0.2375
0.275	13	99.59%	0.41%	71	0.41%	0.2625
0.3	15	99.68%	0.32%	56	0.32%	0.2875
0.325	5	99.71%	0.29%	51	0.29%	0.3125
0.35	4	99.73%	0.27%	47	0.27%	0.3375
0.375	6	99.77%	0.23%	41	0.23%	0.3625
0.4	0	99.77%	0.23%	41	0.23%	0.3875
0.425	4	99.79%	0.21%	37	0.21%	0.4125
0.45	4	99.81%	0.19%	33	0.19%	0.4375
0.475	3	99.83%	0.17%	30	0.17%	0.4625
0.5	3	99.85%	0.15%	27	0.15%	0.4875
0.525	2	99.86%	0.14%	25	0.14%	0.5125
0.55	7	99.90%	0.10%	18	0.10%	0.5375
0.575	0	99.90%	0.10%	18	0.10%	0.5625
0.6	0	99.90%	0.10%	18	0.10%	0.5875
0.625	0	99.90%	0.10%	18	0.10%	0.6125
0.65	0	99.90%	0.10%	18	0.10%	0.6375
0.675	2	99.91%	0.09%	16	0.09%	0.6625
0.7	3	99.93%	0.07%	13	0.07%	0.6875
0.725	0	99.93%	0.07%	13	0.07%	0.7125
0.75	1	99.93%	0.07%	12	0.07%	0.7375
0.775	0	99.93%	0.07%	12	0.07%	0.7625
0.8	0	99.93%	0.07%	12	0.07%	0.7875
0.825	0	99.93%	0.07%	12	0.07%	0.8125
0.85	0	99.93%	0.07%	12	0.07%	0.8375
0.875	0	99.93%	0.07%	12	0.07%	0.8625
0.9	3	99.95%	0.05%	9	0.05%	0.8875
0.925	0	99.95%	0.05%	9	0.05%	0.9125
0.95	2	99.96%	0.04%	7	0.04%	0.9375
0.975	0	99.96%	0.04%	7	0.04%	0.9625
1	0	99.96%	0.04%	7	0.04%	0.9875
1.025	7	100.00%	0.00%	0	0.00%	1.0125
sum	17494					

Table 1. Well A-6 smoothed turbidity frequency histogram

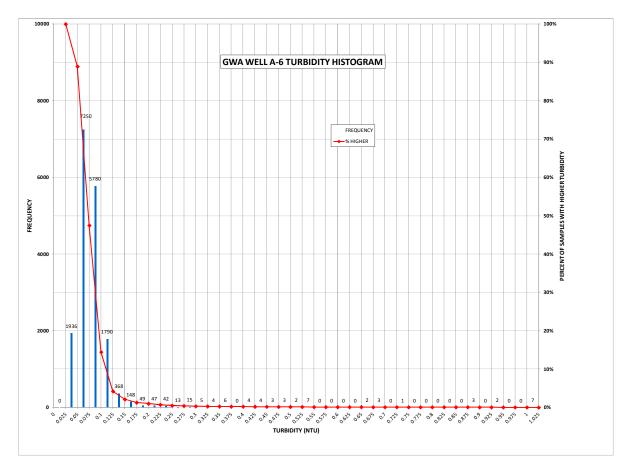


Figure 2. Well A-6 smoothed turbidity frequency curve

WELL NO.	DATE SAMPLED	TOTAL HARDNESS (mg/L as CaCO3)	CALCIUM (mg/L as CaCO3)	MAGNESIUM (mg/L as CaCO3)	CHLORIDES (mg/L)	TOTAL COLIFORM (MPN/100 ML)	E. COLI (MPN/100 ML)	ENTERO COCCI (MPN/100 ML)	NITRATES (MG/L)
A-6	07/27/09					98.5	<1	4.1	
A-6	08/03/09	318	306	12	34	18.7	<1	5.2	2.2
A-6	08/11/09					613.1	129.1	19.9	
A-6	08/21/09					44.8	1.0	1.0	
A-6	08/26/09					65.7	2.0	4.1	
A-6	09/02/09	324	304	20	55	14.6	<1	1.0	
A-6	09/11/09					1.0	<1	<1	2.3
A-6	09/11/09					1.0	<1	<1	
A-6	09/18/09					2.0	<1	<1	
A-6	09/25/09					20.3	<1	6.3	
A-6	10/01/09	302	290	12	24	5.2	<1	<1	
A-6	10/05/09					21.6	<1	2.0	2.2
A-6	10/16/09					<1	<1	3.0	
A-6	10/20/09					<1	<1	nd	
A-6	10/27/09					6.3	<1	<1	
A-6	11/04/09					<1	<1	1.0	
A-6	11/09/09	334	300	34	26	<1	<1	<1	2.3
A-6	11/19/09	001	000	0,		<1	<1	<1	2.0
A-6	11/25/09					<1	<1	<1	
A-6	12/01/09					3.1	<1	<1	
A-6	12/07/09	312	290	22	21	34.5	1.0	2.0	2.2
A-6	12/17/09					45.0	<1	1.0	
A-6	12/23/09					<1	<1	<1	
A-6	12/29/09					29.5	2.0	5.1	
A-6	01/04/10					1.0	<1	<1	
A-6	01/11/10	384	296	88	29	435.2	80.9	11.9	2.3
A-6	01/21/10					38.4	9.8	1.0	
A-6	01/28/10					5.2	<1	<1	
A-6	02/01/10					<1	<1	<1	
A-6	02/08/10	310	290	20	37	1.0	<1	<1	2.2
A-6	02/18/10	0.0	200		0,	<1	<1	<1	
A-6	02/24/10					<1	<1	<1	
A-6	03/04/10					<1	<1	<1	
A-6	03/09/10	294	288	6	52	<1	<1	<1	2.3
A-6	03/18/10					3.1	<1	<1	
A-6	03/25/10					9.6	<1	6.0	
A-6	04/01/10					<1	<1	<1	
A-6	04/08/10	326	310	16	68	<1	<1	<1	2.1
A-6	04/14/10					1.0	<1	<1	
A-6	04/22/10					<1	<1	<1	
A-6	04/30/10					<1	<1	<1	
A-6	05/07/10					1.0	<1	<1	
A-6	05/13/10					<1	<1	<1	
A-6	05/20/10					<1	<1	<1	
A-6	05/25/10	310	266	44	40	<1	<1	<1	2.4
A-6	06/01/10					<1	<1	2.0	
A-6	06/07/10	286	286	0	49	<1	<1	<1	2.2
A-6	06/17/10					<1	<1	<1	
A-6	06/24/10					<1	<1	<1	
A-6	07/01/10					<1	<1	<1	
A-6	07/09/10					<1	<1	<1	
A-6	07/12/10	304	296	8	32	<1	<1	<1	2.3
A-6	08/05/10					214.3	36.4	119.8	
A-6	08/09/10	258	240	18	48	<1	<1	<1	2.3
A-6	09/09/10	316	308	8	53	72.2	<1	3.1	
A-6	09/17/10	010	500	Ů	30	133.3	1.0	13.4	
			 						0.0
A-6	09/20/10					248.9	6.3	13.4	2.2
A-6	09/30/10		-			67.6	4.1	<1	
A-6	10/07/10					7.4	30.5	<1	2.0
A-6	10/15/10					55.4	<1	9.7	
A-6	10/18/10	320	304	16	60	178.2	3.0	9.7	2.0
A-6	10/27/10					105.0	4.1	11.0	
A-6	11/03/10					83.9	4.1	4.1	
A-6	11/08/10	310	266	44	62	689.3	184.2	77.6	2.2
A-6	11/18/10					48.8	17.6	2.0	
A-6	11/23/10		İ			7.4	2.0	1.0	
A-6	12/01/10					<1	<1	<1	
A-6	12/06/10	292	260	32	32	2.0	1.0	<1	2.3
		LJL	200	JE.	32				2.0
A-6	12/16/10					1553.0	435.0	472.0	
A-6	01/06/11		-			6.3	2.0	<1	
A-6	01/12/11					27.2	2.0	4.1	
A-6	01/18/11	306	296	10	53	13.5	<1	8.5	2.2
A-6	01/27/11					14.6	<1	1.0	
A-6	02/04/11					23.8	1.0	1.0	
A-6	02/10/11					20.1	<1	<1	
A-6	02/14/11	314	300	14	23	316.9	135.4	40.5	3.9
A-6	02/25/11					24.9	6.3	<1	3.0
A-6	03/02/11					7.4	2.0	<1	
A-6	03/11/11		<u> </u>			1.0	<1	<1	
A-6	03/14/11	296	288	8	35	3.1	<1	NA	2.2

Table 2. Well A-6 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	LOW =.1 MEDIUM = .5 HIGH = 1
A-6	1/5/2009	STORM	LOW	0.1

Table 3. Well A-6 MPA data

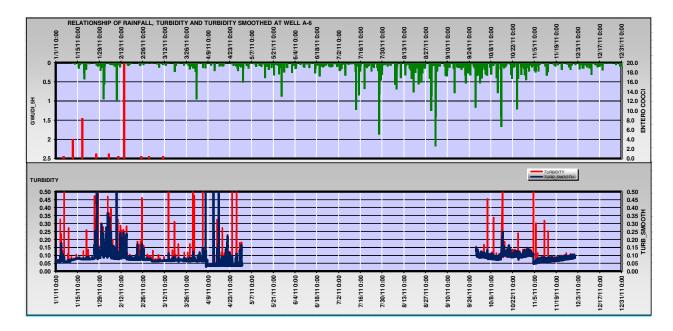


Figure 3. Well A-6 multi-variable scanner

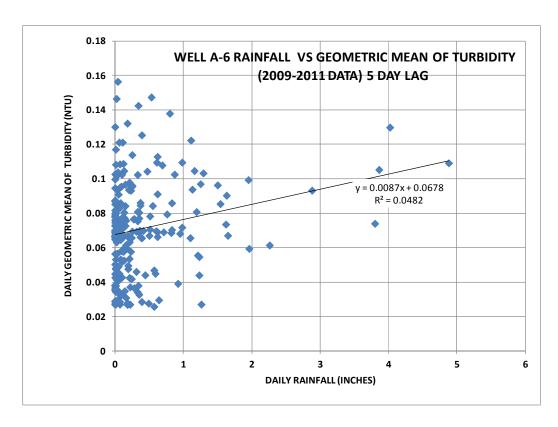


Figure 4. Well A-6 smoothed turbidity vs. rainfall regression analysis for 5 day lag

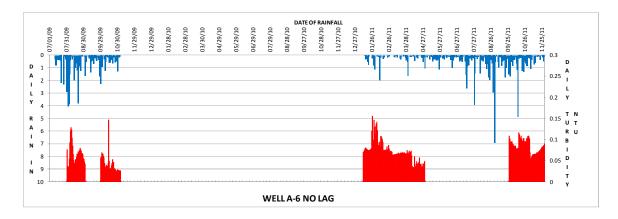


Figure 5. Well A-6 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

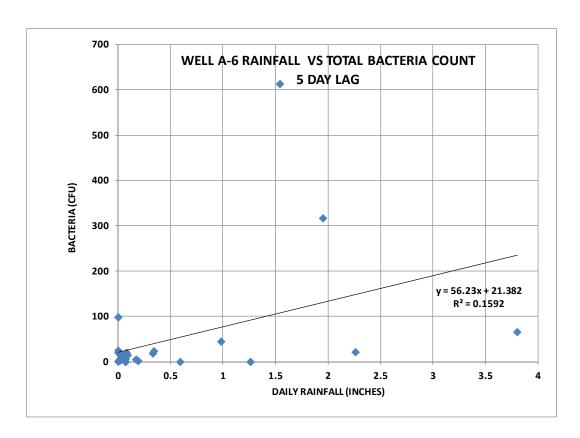


Figure 6. Well A-6 total coliform vs. rainfall regression analysis for 5 day lag

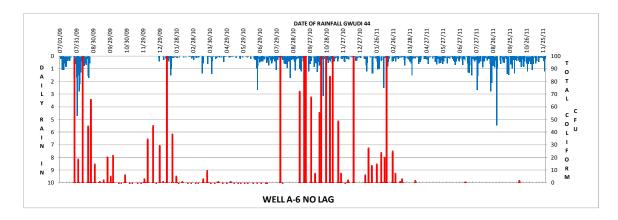


Figure 7. Well A-6 visual scan of daily rainfall versus total coliform

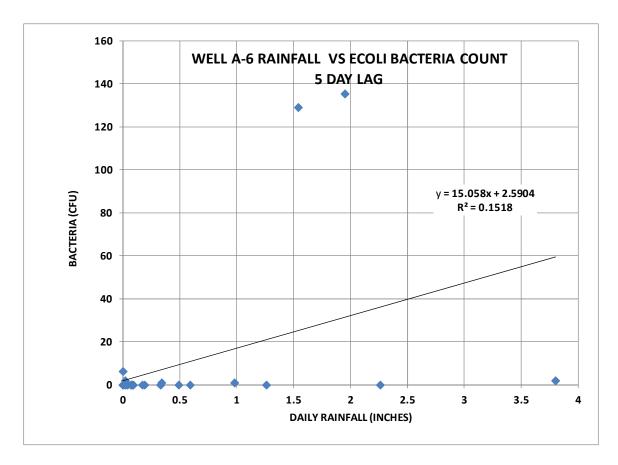


Figure 8. Well A-6 E. coli vs. rainfall regression analysis for 5 day lag

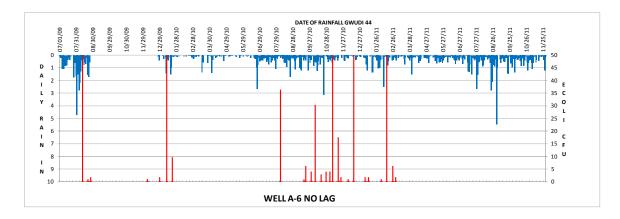


Figure 9. Well A-6 visual scan of daily rainfall versus E. Coli

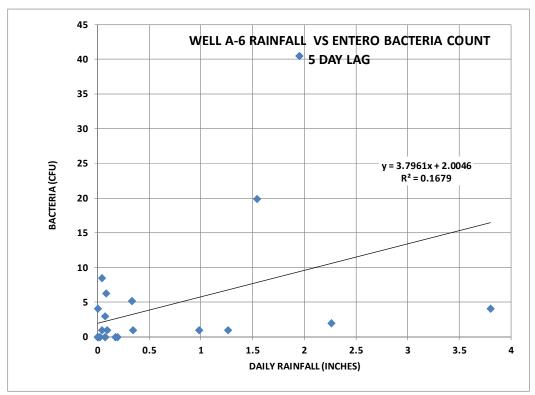


Figure 10. Well A-6 enterococci vs. rainfall regression analysis for 5 day lag

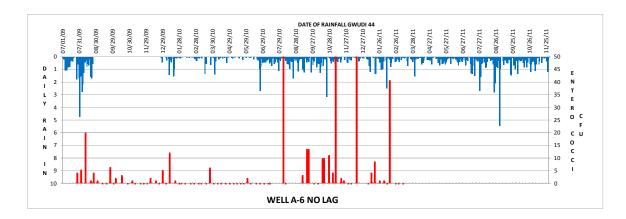


Figure 11. Well A-6 visual scan of daily rainfall versus enterococci

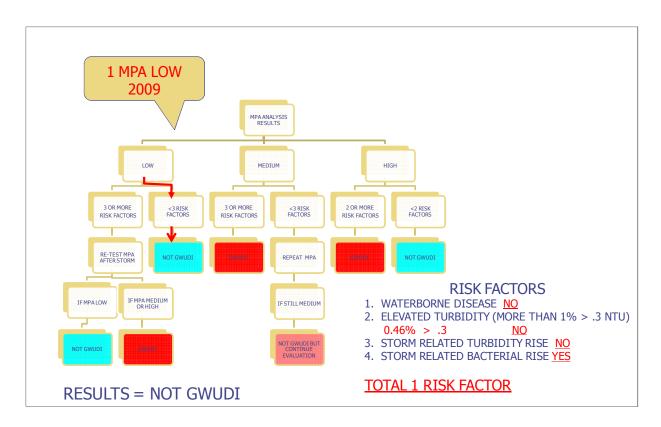


Figure 12. Well A-6 GWUDI determination decision tree

APPENDIX 3 WELL A-21 DATA AND ANALYSIS

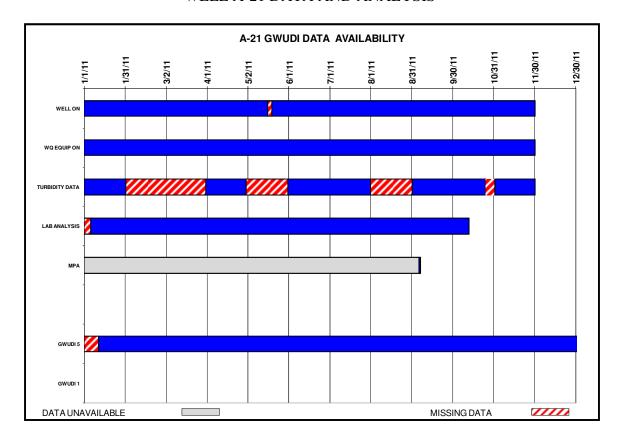


Figure 1. Well A-21 data availability

Bin	Frequency	Cumulative %	% Higher	Number Higher	Inverse Cummulative %	Bin Avg
0.025	0	0.00%	100.00%	19776	100.00%	0.0125
0.05	2401	12.14%	87.86%	17375	87.86%	0.0375
0.075	8089	53.04%	46.96%	9286	46.96%	0.0625
0.1	5679	81.76%	18.24%	3607	18.24%	0.0875
0.125	2325	93.52%	6.48%	1282	6.48%	0.1125
0.15	1148	99.32%	0.68%	134	0.68%	0.1375
0.175	58	99.62%	0.38%	76	0.38%	0.1625
0.2	62	99.93%	0.07%	14	0.07%	0.1875
0.225	8	99.97%	0.03%	6	0.03%	0.2125
0.25	0	99.97%	0.03%	6	0.03%	0.2375
0.275	0	99.97%	0.03%	6	0.03%	0.2625
0.3	0	99.97%	0.03%	6	0.03%	0.2875
0.325	0	99.97%	0.03%	6	0.03%	0.3125
0.35	0	99.97%	0.03%	6	0.03%	0.3375
0.375	0	99.97%	0.03%	6	0.03%	0.3625
0.4	4	99.99%	0.01%	2	0.01%	0.3875
0.425	2	100.00%	0.00%	0	0.00%	0.4125
0.45	0	100.00%	0.00%	0	0.00%	0.4375
0.475	0	100.00%	0.00%	0	0.00%	0.4625
0.5	0	100.00%	0.00%	0	0.00%	0.4875
0.525	0	100.00%	0.00%	0	0.00%	0.5125
0.55	0	100.00%	0.00%	0	0.00%	0.5375
0.575	0	100.00%	0.00%	0	0.00%	0.5625
0.6	0	100.00%	0.00%	0	0.00%	0.5875
0.625	0	100.00%	0.00%	0	0.00%	0.6125
0.65	0	100.00%	0.00%	0	0.00%	0.6375
0.675	0	100.00%	0.00%	0	0.00%	0.6625
0.7	0	100.00%	0.00%	0	0.00%	0.6875
0.725	0	100.00%	0.00%	0	0.00%	0.7125
0.75	0	100.00%	0.00%	0	0.00%	0.7375
0.775	0	100.00%	0.00%	0	0.00%	0.7625
0.8	0	100.00%	0.00%	0	0.00%	0.7875
0.825	0	100.00%	0.00%	0	0.00%	0.8125
0.85	0	100.00%	0.00%	0	0.00%	0.8375
0.875	0	100.00%	0.00%	0	0.00%	0.8625
0.9	0	100.00%	0.00%	0	0.00%	0.8875
0.925	0	100.00%	0.00%	0	0.00%	0.9125
1	0	100.00%	0.00%	0	0.00%	0.9625
3	0	100.00%	0.00%	0	0.00%	2
5	0	100.00%	0.00%	0	0.00%	4
1.025	0	100.00%	0.00%	0	0.00%	3.0125
sum	19776					

Table 1. Well A-21 smoothed turbidity frequency histogram

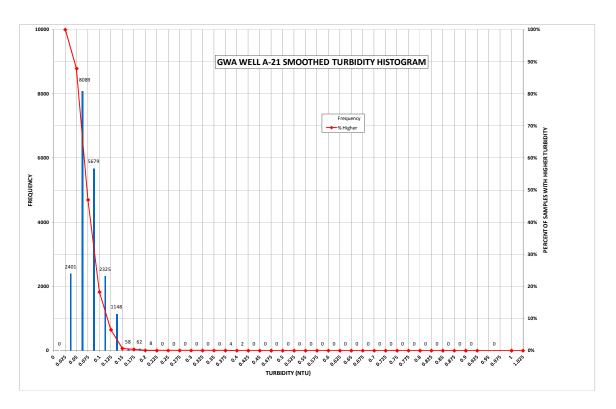


Figure 2. Well A-21 smoothed turbidity frequency curve

			CALCIUM	MAGNESIUM	CHLORIDES				
WELL NO.	DATE SAMPLED	TOTAL HARDNESS (mg/L as CaCO3)	(mg/L as CaCO3)	(mg/L as CaCO3)	(mg/L)	TOTAL COLIFORM (MPN/100 ML)	E. COLI (MPN/100 ML)	ENTERO COCCI (MPN/100 ML)	NITRATES (MG/L)
A-21	07/27/09	(IIIg/L as Cacos)	Caccos	Cacos	1 - 1	(MF100 ML)	<1	(WFN/100 WL)	(WG/L)
A-21	08/03/09	440	330	110	468	<1	<1	<1	
A-21	08/11/09	440	550	110	400	<1	<1	<1	
A-21	08/21/09					<1	<1	<1	
A-21	08/26/09					11.0	<1	<1	
A-21	09/02/09	396	312	84	44	<1	<1	<1	
A-21	09/11/09	330	512	- 04		<1	<1	<1	
A-21	09/11/09					<1	<1	<1	
A-21	09/18/09					<1	<1	<1	
A-21	09/25/09					<1	<1	<1	
A-21	10/01/09	328	306	22	415	1.0	<1	<1	
A-21	10/01/09	320	300	- 22	415	<1	<1	<1	
A-21	10/16/09					8.5	<1	3.0	
A-21	10/16/09					6.5 <1	<1	nd	
A-21	10/20/09					<1	<1	2.0	
A-21	11/04/09					<1	<1	<1	
A-21	11/09/09	410	334	76	410	<1	<1	<1	
A-21	11/19/09	410	554	70	410	<1	<1	<1	
A-21	11/25/09					<1	<1	<1	
A-21	12/01/09					307.6	<1	17.7	
A-21		412	326	96	433	17.3		14.5	
	12/07/09	716	326	86	433		<1		
A-21 A-21	12/17/09 12/23/09					<1 <1	<1 <1	<1 <1	
A-21	12/23/09					<1	<1	25.6	
A-21	01/04/10					<1	<1	12.0	
A-21	01/04/10	410	314	96	436	<1	<1	4.0	
		710	514	30	730				
A-21 A-21	01/21/10					<1 <1	<1 <1	4.1 <1	
A-21 A-21	01/28/10 02/01/10					<1	<1	<1	
A-21 A-21	02/01/10	416	310	106	415	2.0	<1	1.0	
A-21	02/08/10	410	310	106	415	<1	<1	4.0	
A-21 A-21	02/24/10					<1 <1	<1 <1	<1 <1	
	03/04/10	400	210	00	470			7.4	
A-21 A-21	03/09/10	406	310	96	476	<1 <1	<1 <1		
	03/18/10							1.0	
A-21	03/25/10 04/01/10					<1	<1	3.0	
A-21		440	250	00	400	<1	<1	2.0	
A-21	04/08/10	440	350	90	486	<1	<1	<1	
A-21	04/14/10 04/22/10					2.1	<1	8.6	
A-21						6.3	<1	<1	
A-21	04/30/10					<1	<1	1.0	
A-21	05/07/10					<1	<1	4.1	
A-21	05/13/10					<1	<1	<1	
A-21	05/20/10	400		400	507	<1	<1	1.0	
A-21	05/25/10	420	288	132	527	2.0	<1	<1	
A-21	06/01/10					1.0	<1	1.0	
A-21	06/07/10	424	310	114	490	2.0	<1	<1	
A-21	06/17/10					<1	<1	<1	
A-21	06/24/10					<1	<1	<1	
A-21	07/01/10					5.2	<1	<1	
A-21	07/09/10					5.2	<1	<1	
A-21	07/12/10	450	326	124	474	<1	<1	1.0	
A-21	08/05/10					4.1	<1	2.0	
A-21	08/09/10	426	360	66	505	<1	<1	<1	
A-21	09/09/10	434	376	58	518	4.1	<1	<1	
A-21	09/17/10					<1	<1	<1	
A-21	09/20/10					1.0	<1	<1	
A-21	09/30/10			 		24.9	<1	<1	
A-21	10/07/10					<1	<1	<1	
A-21	10/15/10					12.1	<1	5.1	
A-21	10/18/10	428	310	118	506	<1	<1	2.0	
A-21	10/27/10			 		<1	<1	<1	
A-21	11/03/10			l		165.8	<1	<1	
A-21	11/08/10	424	296	128	429	<1	<1	<1	
A-21	11/18/10			 		<1	<1	<1	
A-21	11/23/10			ļ		<1	<1	<1	
A-21	12/01/10			ļ		<1	<1	<1	
A-21	12/06/10	448	330	118	433	<1	<1	<1	
A-21	12/16/10			ļ		1.0	<1	<1	
A-21	01/06/11					<1	<1	<1	
A-21	01/12/11					1.0	<1	<1	
A-21	01/18/11	454	348	106	531	<1	<1	<1	
A-21	01/27/11					<1	<1	2.0	
A-21	02/04/11					<1	<1	<1	
A-21	02/10/11			ļ		<1	<1	<1	
A-21	02/14/11	444	370	74	439	<1	<1	<1	
A-21	02/25/11					<1	<1	<1	
A-21	03/02/11					<1	<1	<1	
A-21	03/11/11					16.1	<1	<1	
A-ZI									

Table 2. Well A-21 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF	LOW =.1 MEDIUM = .5 HIGH = 1
A-21	1/5/2009	STORM	LOW	0.1
A-21	9/6/2011	STORM	LOW	0.1
	_			

Table 3. Well A-21 MPA data

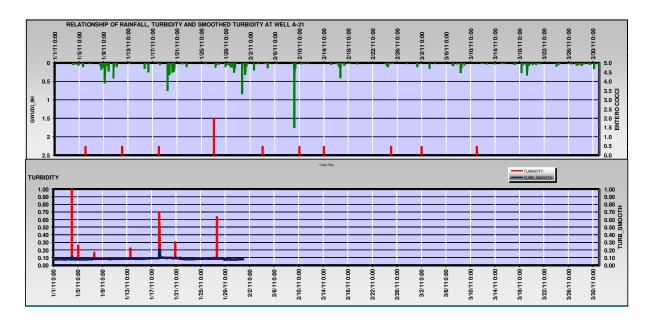


Figure 3. Well A-21 multi-variable scanner

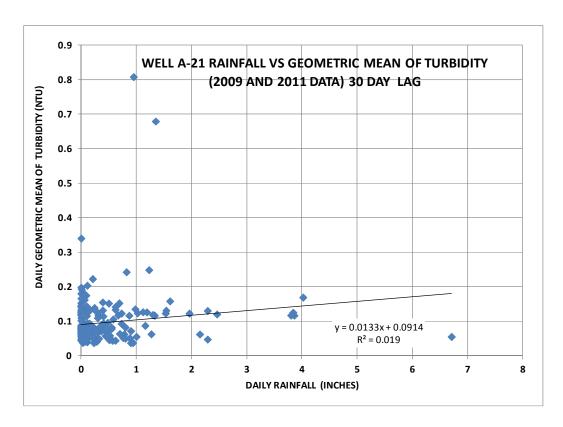


Figure 4. Well A-21 smoothed turbidity vs. rainfall regression analysis for 30 day lag

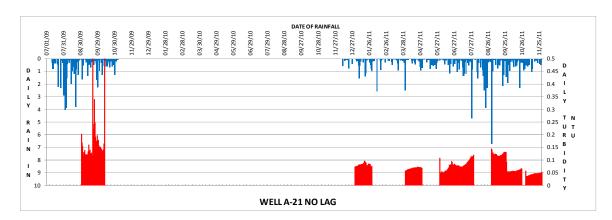


Figure 5. Well A-21 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

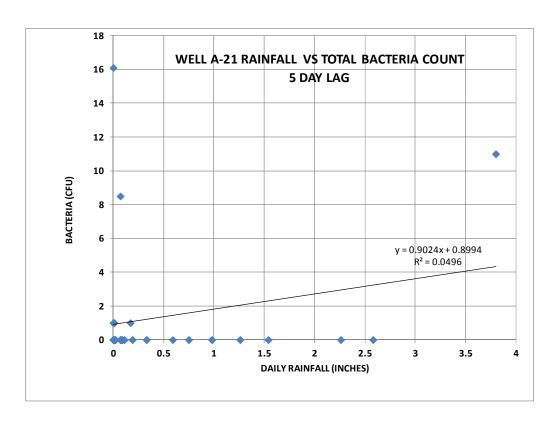


Figure 6. Well A-21 total coliform vs. rainfall regression analysis for 5 day lag

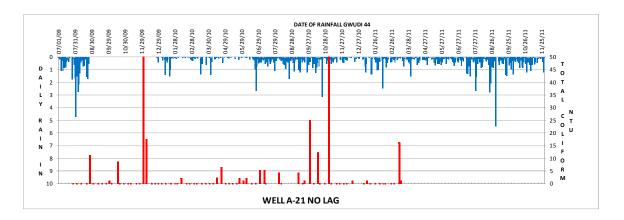


Figure 7. Well A-21 visual scan of daily rainfall versus total coliform

(ALL E. COLI DATA = ZERO)

Figure 8. Well A-21 E. coli vs. rainfall regression analysis for 5 day lag (E. coli values all zero)

(ALL E. COLI DATA = ZERO)

Figure 9. Well A-21 visual scan of daily rainfall versus E. Coli

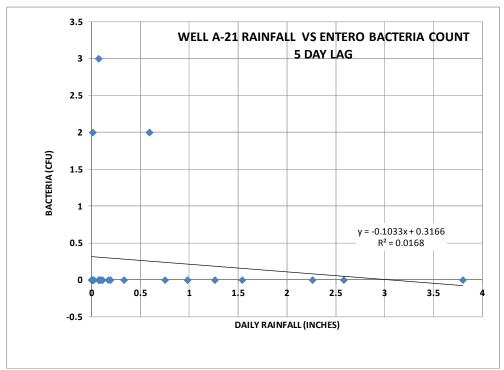


Figure 10. Well A-21enterococci vs. rainfall regression analysis for 5 day lag (all enterococci regressions yielded negative slopes)

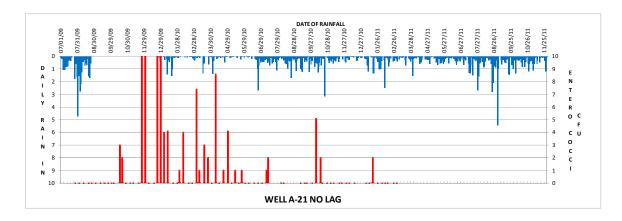


Figure 11. Well A-21 visual scan of daily rainfall versus enterococci

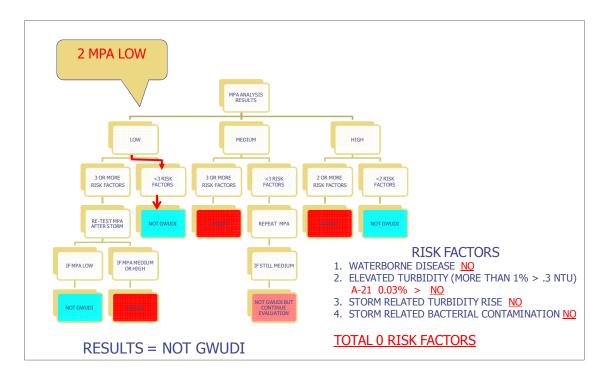


Figure 12. Well A-21 GWUDI determination decision tree

APPENDIX 4 WELL A-25 DATA AND ANALYSIS

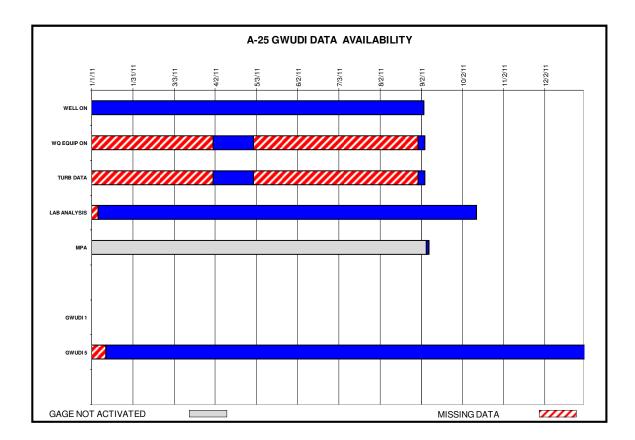


Figure 1. Well A-25 data availability

Bin	FREQUENCY	Cumulative %	% HIGHER	Number Higher	INVERSE CUMULATIVE %	BIN AVG
0.025	0	0.00%	100.00%	3006	100.00%	0.0125
0.05	0	0.00%	100.00%	3006	100.00%	0.0375
0.075	61	2.03%	97.97%	2945	97.97%	0.0625
0.1	2667	90.75%	9.25%	278	9.25%	0.0875
0.125	115	94.58%	5.42%	163	5.42%	0.1125
0.15	6	94.78%	5.22%	157	5.22%	0.1375
0.175	1	94.81%	5.19%	156	5.19%	0.1625
0.2	1	94.84%	5.16%	155	5.16%	0.1875
0.225	4	94.98%	5.02%	151	5.02%	0.2125
0.25	1	95.01%	4.99%	150	4.99%	0.2375
0.275	0	95.01%	4.99%	150	4.99%	0.2625
0.3	2	95.08%	4.92%	148	4.92%	0.2875
0.325	0	95.08%	4.92%	148	4.92%	0.3125
0.35	0	95.08%	4.92%	148	4.92%	0.3375
0.375	0	95.08%	4.92%	148	4.92%	0.3625
0.4	0	95.08%	4.92%	148	4.92%	0.3875
0.425	0	95.08%	4.92%	148	4.92%	0.4125
0.45	2	95.14%	4.86%	146	4.86%	0.4375
0.475	0	95.14%	4.86%	146	4.86%	0.4625
0.5	3	95.24%	4.76%	143	4.76%	0.4875
0.525	0	95.24%	4.76%	143	4.76%	0.5125
0.55	4	95.38%	4.62%	139	4.62%	0.5375
0.575	0	95.38%	4.62%	139	4.62%	0.5625
0.6	4	95.51%	4.49%	135	4.49%	0.5875
0.625	0	95.51%	4.49%	135	4.49%	0.6125
0.65	0	95.51%	4.49%	135	4.49%	0.6375
0.675	0	95.51%	4.49%	135	4.49%	0.6625
0.7	2	95.58%	4.42%	133	4.42%	0.6875
0.725	2	95.64%	4.36%	131	4.36%	0.7125
0.75	0	95.64%	4.36%	131	4.36%	0.7375
0.775	0	95.64%	4.36%	131	4.36%	0.7625
0.8	0	95.64%	4.36%	131	4.36%	0.7875
0.825	0	95.64%	4.36%	131	4.36%	0.8125
0.85	0	95.64%	4.36%	131	4.36%	0.8375
0.875	0	95.64%	4.36%	131	4.36%	0.8625
0.9	0	95.64%	4.36%	131	4.36%	0.8875
0.925	0	95.64%	4.36%	131	4.36%	0.9125
0.95	0	95.64%	4.36%	131	4.36%	0.9375
0.975	0	95.64%	4.36%	131	4.36%	0.9625
1	0	95.64%	4.36%	131	4.36%	0.9875
1.025	131	100.00%	0.00%	0	0.00%	1.0125
sum	3006					

Table 1. Well A-25 smoothed turbidity frequency histogram

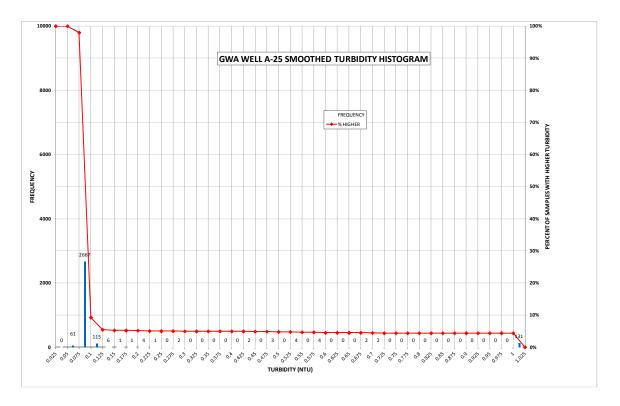


Figure 2. Well A-25 smoothed turbidity frequency curve

WELL NO	DATE OAMO: 50	TOTAL HARDNESS (mg/L as CaCO3)	CALCIUM (mg/L as	MAGNESIUM (mg/L as CaCO3)	CHLORIDES (mg/L)	TOTAL COLIFORM	E. COLI (MPN/100	ENTERO COCCI (MPN/100 ML)	NITRATES
A-25	10/07/08	as CaCO3)	CaCO3)	(mg/L as CaCO3)	(9-)	(MPN/100 ML) 17.1	ML) 15.8	2.0	(MG/L)
A-25 A-25	10/15/08					25.9 32.7	1.0	<1 2.0	
A-25 A-25	10/27/08 11/05/08	344	342	2		28.5 37.9	<1 <1	1.0	
A-25	11/11/08					31.3	<1	8.6	
A-25 A-25	11/17/08 11/25/08					44.1 44.1	<1 <1	<1 1.0	
A-25 A-25	12/01/08 12/09/08	276	260	16		6.3 69.7	<1 <1	<1 <1	
A-25 A-25	12/15/08 12/22/08					37.9 23.1	<1 <1	<1 <1	
A-25	12/29/08					31.8	<1	1.0	
A-25 A-25	01/05/09	296	270	26		64.4 17.3	<1	2 <1	
A-25 A-25	01/19/09					11.9 379	<1	<1	
A-25 A-25	02/02/09	290	272	18	85	13.2 8.5	<1	3.1	
A-25	02/18/09					3.1	<1	<1	
A-25 A-25	02/24/09 03/03/09	300	270	30	103	<1 1.0	<1 <1	<1 1.0	
A-25 A-25	03/10/09					2.0	<1 <1	<1	
A-25	03/30/09					13.4	<1	<1	
A-25 A-25	04/07/09 04/14/09	314	310	4	120	21.6 6.3	<1 <1	<1 <1	
A-25 A-25	04/21/09 04/28/09					4.1 5.2	<1 <1	<1 1.0	
A-25 A-25	05/05/09 05/12/09	376	346	30	119	97.1 150.0	1.0	41.1	
A-25	05/19/09	376	340	30	119	37.3	<1	<1	
A-25 A-25	05/26/09 06/01/09	356	334	22	108	60.5 83.3	<1 <1	<1 <1	
A-25 A-25	06/08/09 06/16/09					75.4 15.6	1.0	2.0	
A-25	06/23/09					48.4	<1	<1	
A-25 A-25	06/30/09 07/07/09	344	308	36	129	26.2 7.4	<1 <1	<1 <1	
A-25 A-25	07/14/09 07/20/09					107.1 36.9	<1 <1	5.2 <1	
A-25 A-25	07/27/09	940	9**		107	160.7	<1	20.9	
A-25	08/03/09 08/11/09	310	310	0	107	75.9 31.8	1.0 <1	4.1 <1	
A-25 A-25	08/21/09 08/26/09					52.1 12.1	2.0	2.0	
A-25 A-25	09/02/09	320	286	34	76	9.8 22.8	<1 <1	<1 3.1	
A-25	09/11/09					22.8	<1	3.1	
A-25 A-25	09/18/09					19.7 36.8	3.1 5.2	1.0 9.7	
A-25 A-25	10/01/09 10/05/09	272	264	8	66	34.5 10.9	<1 <1	<1 2.0	
A-25	10/16/09					23.1	<1	<1	
A-25 A-25	10/20/09 10/27/09					8.8 17.3	<1 <1	nd 8.2	
A-25 A-25	11/04/09 11/09/09	290	222	68	63	32.7 6.3	<1 <1	<1 <1	
A-25 A-25	11/19/09 11/25/09					11.0 63.1	<1 <1	6.3 <1	
A-25	12/01/09					159.7	1.0	13.5	
A-25 A-25	12/07/09 12/17/09	286	260	26	55	68.9 21.1	<1 <1	<1	
A-25 A-25	12/23/09 12/29/09					47.2 21.6	1.0	<1 2.0	
A-25	01/04/10					8.6	<1	<1	
A-25 A-25	01/11/10 01/21/10	310	254	56	63	7.4	<1 <1	<1 2.0	
A-25 A-25	01/28/10 02/01/10					5.2 5.2	<1 <1	<1	
A-25 A-25	02/08/10	278	264	14	60	3.1	<1	<1	
A-25	02/24/10					<1 1.0	<1 <1	<1 7.1	
A-25 A-25	03/04/10	292	268	24	79	2.0	<1 <1	<1 <1	
A-25 A-25	03/18/10					67.7 9.6	<1 <1	2.0	
A-25	04/08/10	292	274	18	89	24.6	<1	6.3	
A-25 A-25	04/14/10 04/22/10					35.5 28.8	<1 <1	<1 <1	
A-25 A-25	04/30/10 05/07/10					3.0	<1 <1	<1 <1	
A-25	05/13/10					<1	41	1.0	
A-25 A-25	05/25/10	296	252	44	115	6.3 17.5	<1	2.0	
A-25 A-25	06/01/10 06/07/10	298	268	30	106	12.1 7.4	<1 <1	<1 <1	
A-25 A-25	06/17/10 06/24/10					22.8 98.7	<1 <1	<1 14.6	
A-25	07/01/10					90.7	<1	11.0	
A-25 A-25	07/09/10 07/12/10	316	300	16	104	15.8 30.5	<1 <1	<1 1.0	
A-25 A-25	08/05/10 08/09/10	113.5	310	288	114	63.1 <1	<1 <1	1.0	
A-25 A-25	09/09/10 09/17/10	304	286	18	120	5.2 88.4	<1 1.0	<1 8.5	
A-25	09/20/10					64.4	2.0	<1	
A-25 A-25	09/30/10 10/07/10					58.3 <1	<1 <1	4.1 <1	
A-25 A-25	10/15/10	288	270	18	98	45.7 34.1	<1 2.0	13.4 5.2	
A-25	10/27/10	200	270	-10	39	17.1	<1	2.0	
A-25 A-25	11/03/10 11/08/10	290	260	30	81	35.0 14.6	<1 <1	9.6 2.0	
A-25 A-25	11/18/10 11/23/10					32.3 9.7	<1 <1	<1 1.0	
A-25	12/01/10	074	00.5	**		34.5	<1	<1	
A-25 A-25	12/06/10 12/16/10	274	264	10	64	28.2 35.5	<1 <1	<1 2.0	
A-25 A-25	01/06/11 01/12/11					16.8 34.1	1.0	<1 11.0	
A-25	01/18/11	288	276	12	93	24.0 24.0	2.0	3.1	
A-25 A-25	01/27/11 02/04/11					62.4	<1 4.1	1.0 17.3	
A-25 A-25	02/10/11	298	274	24	65	37.4 104.6	<1 <1	3.1 1.0	
A-25 A-25	02/25/11 03/02/11					8.6 3.1	1.0	<1	
A-25	03/11/11					6.3	<1	<1	
A-25	03/14/11	288	266	22	75	3.1	<1	NA .	ш

Table 2. Well A-25 laboratory water quality data

				LOW =.1
			MPA RESULT: RISK OF	MEDIUM = .5
WELL NO.	DATE SAMPLED	WEATHER CONDITION	CONTAMINATION	HIGH = 1
A-25	5/5/2007	DRY	LOW	0.1
A-25	12/10/2007	WET	LOW	0.1
A-25	1/5/2009 0:00	STORM	LOW	0.1
A-25	9/6/2011	STORM	LOW	0.1

Table 3. Well A-25 MPA data

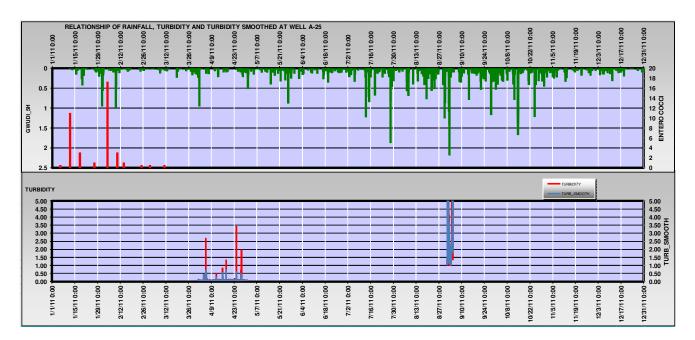


Figure 3. Well A-25 multi-variable scanner

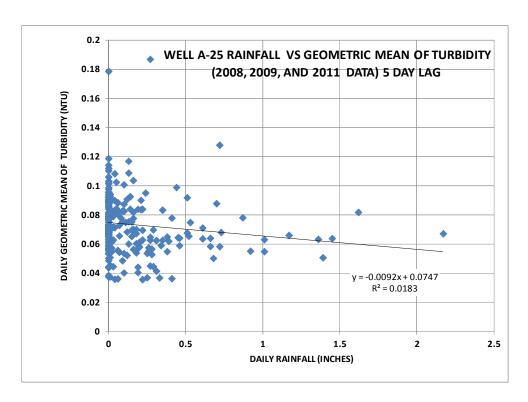


Figure 4. Well A-25 smoothed turbidity vs. rainfall regression analysis for 5 day lag (all lags yielded negative slopes)

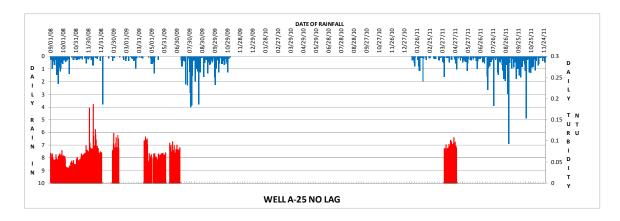


Figure 5. Well A-25 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

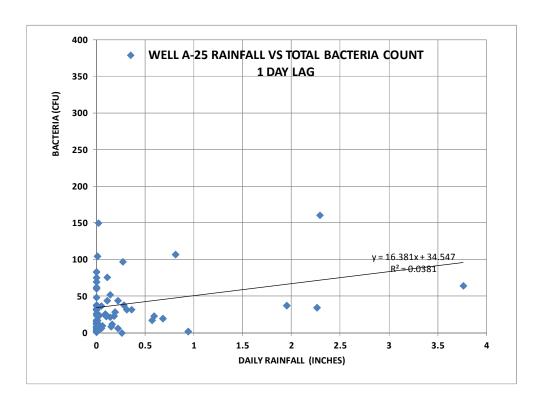


Figure 6. Well A-25 total coliform vs. rainfall regression analysis for 1 day lag

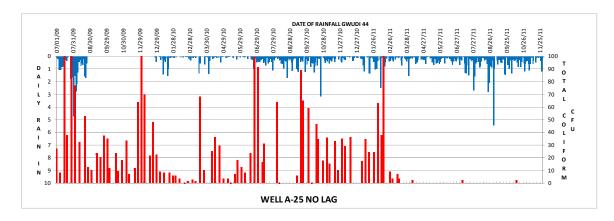


Figure 7. Well A-25 visual scan of daily rainfall versus total coliform

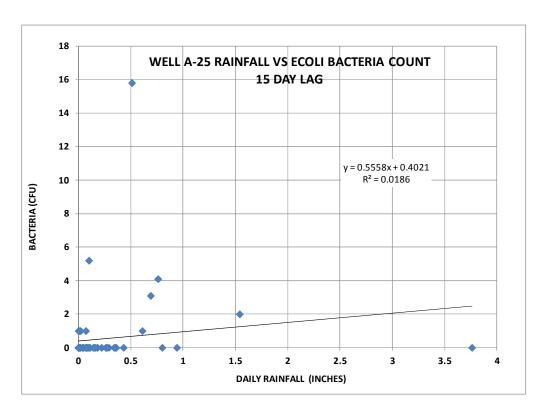


Figure 8. Well A-25 E. coli vs. rainfall regression analysis for 15 day lag

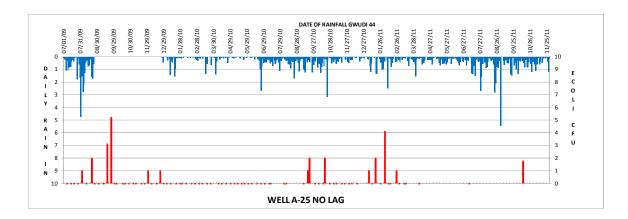


Figure 9. Well A-25 visual scan of daily rainfall versus E. Coli

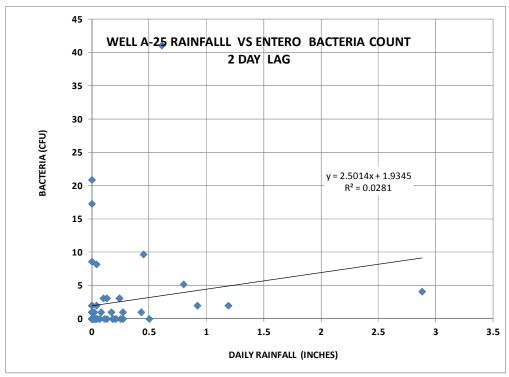


Figure 10. Well A-25 enterococci vs. rainfall regression analysis for 2 day lag

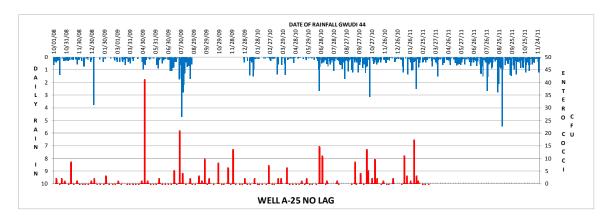


Figure 11. Well A-25 visual scan of daily rainfall versus enterococci

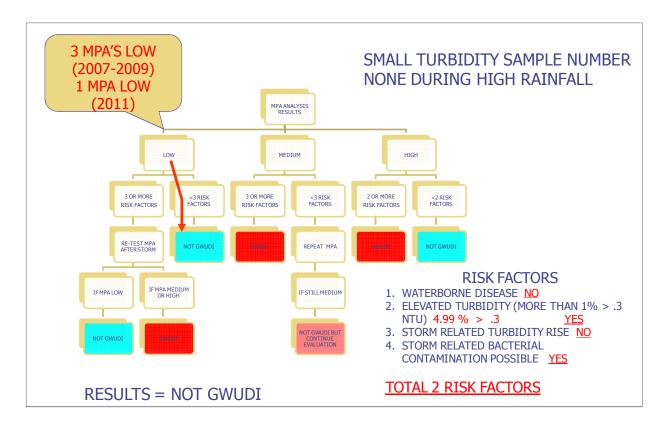


Figure 12. Well A-25 GWUDI determination decision tree

APPENDIX 5 WELL D-4 DATA AND ANALYSIS

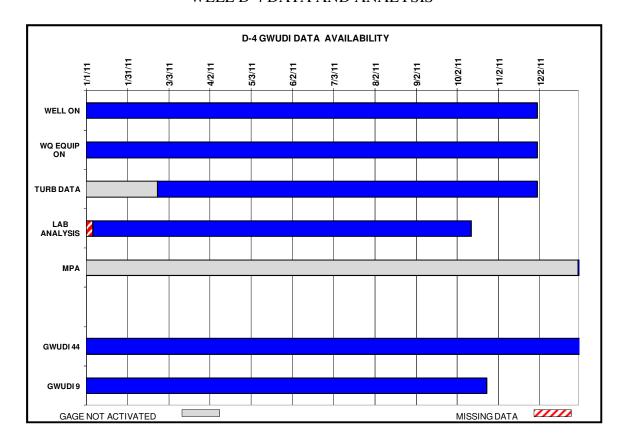


Figure 1. Well D-4 data availability

0.025 0 0.00% 100.00% 0.05 10656 39.70% 60.30% 0.075 8474 71.28% 28.72% 0.1 7438 98.99% 1.01% 0.125 181 99.67% 0.33% 0.15 44 99.83% 0.17% 0.175 9 99.87% 0.13% 0.2 8 99.90% 0.10% 0.25 0 99.94% 0.06% 0.25 0 99.94% 0.06% 0.275 2 99.94% 0.06% 0.33 3 99.96% 0.04% 0.35 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.44 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.04% 0.425 2 99.97% 0.04%	Number Higher	Inverse Cumulative %	Bin Avg
0.05 10656 39.70% 60.30% 0.075 8474 71.28% 28.72% 0.1 7438 98.99% 1.01% 0.125 181 99.67% 0.33% 0.15 44 99.83% 0.17% 0.175 9 99.87% 0.13% 0.2 8 99.90% 0.10% 0.255 0 99.94% 0.06% 0.255 0 99.94% 0.06% 0.275 2 99.94% 0.06% 0.3 3 99.96% 0.04% 0.325 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.44 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.525 0 99.99% 0.01%			
0.075 8474 71.28% 28.72% 0.1 7438 98.99% 1.01% 0.125 181 99.67% 0.33% 0.15 44 99.83% 0.17% 0.175 9 99.87% 0.13% 0.2 8 99.90% 0.10% 0.255 0 99.94% 0.06% 0.255 0 99.94% 0.06% 0.275 2 99.94% 0.06% 0.3 3 99.96% 0.04% 0.355 0 99.96% 0.04% 0.355 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.44 1 99.96% 0.04% 0.455 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.55 0 99.99% 0.01% 0.555 1 99.99% 0.01%	26838	100.00%	0.0125
0.1 7438 98.99% 1.01% 0.125 181 99.67% 0.33% 0.15 44 99.83% 0.17% 0.175 9 99.87% 0.13% 0.2 8 99.90% 0.10% 0.225 11 99.94% 0.06% 0.25 0 99.94% 0.06% 0.275 2 99.94% 0.06% 0.3 3 99.96% 0.04% 0.325 0 99.96% 0.04% 0.355 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.44 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.44 1 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.55 0 99.99% 0.01% 0.555 1 99.99% 0.01% <td>16182</td> <td>60.30%</td> <td>0.0375</td>	16182	60.30%	0.0375
0.125 181 99.67% 0.33% 0.15 444 99.83% 0.17% 0.175 9 99.87% 0.13% 0.2 8 99.90% 0.10% 0.255 0 99.94% 0.06% 0.25 0 99.94% 0.06% 0.275 2 99.94% 0.06% 0.3 3 99.96% 0.04% 0.325 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.425 2 99.97% 0.03% 0.44 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.55 1 99.99% 0.01% 0.555 1 99.99% 0.01%	7708	28.72%	0.0625
0.15 44 99.83% 0.17% 0.175 9 99.87% 0.13% 0.2 8 99.90% 0.10% 0.255 11 99.94% 0.06% 0.25 0 99.94% 0.06% 0.275 2 99.94% 0.06% 0.3 3 99.96% 0.04% 0.325 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.4 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 1 99.98% 0.02% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.55 0 99.99% 0.01% 0.55 1 99.99% 0.01% 0.555 1 99.99% 0.01% 0.66 0 99.99% 0.01%<	270	1.01%	0.0875
0.175 9 99.87% 0.13% 0.2 8 99.90% 0.10% 0.255 11 99.94% 0.06% 0.275 2 99.94% 0.06% 0.3 3 99.96% 0.04% 0.325 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.4 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.55 1 99.99% 0.01% 0.555 1 99.99% 0.01% 0.66 0 99.99% 0.01% 0.655 1 99.99% 0.01% 0.655 0 99.99% 0.01% 0.655 0 99.99% 0.01%	89	0.33%	0.1125
0.2 8 99.90% 0.10% 0.225 11 99.94% 0.06% 0.25 0 99.94% 0.06% 0.275 2 99.94% 0.06% 0.3 3 99.96% 0.04% 0.325 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.44 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.55 0 99.99% 0.01% 0.55 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.625 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.655 0 99.99% 0.01%	45	0.17%	0.1375
0.225 11 99.94% 0.06% 0.25 0 99.94% 0.06% 0.275 2 99.94% 0.06% 0.3 3 99.96% 0.04% 0.325 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.4 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.55 0 99.99% 0.01% 0.555 1 99.99% 0.01% 0.66 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.675 0 99.99% 0.01%	36	0.13%	0.1625
0.25 0 99.94% 0.06% 0.275 2 99.94% 0.06% 0.3 3 99.96% 0.04% 0.325 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.4 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.55 0 99.99% 0.01% 0.555 1 99.99% 0.01% 0.65 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.655 0 99.99% 0.01%	28	0.10%	0.1875
0.275 2 99.94% 0.06% 0.3 3 99.96% 0.04% 0.325 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.4 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.55 0 99.99% 0.01% 0.555 1 99.99% 0.01% 0.55 1 99.99% 0.01% 0.60 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.675 0 99.99% 0.01%	17	0.06%	0.2125
0.3 3 99.96% 0.04% 0.325 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.4 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.555 0 99.99% 0.01% 0.555 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.60 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.675 0 99.99% 0.01%	17	0.06%	0.2375
0.325 0 99.96% 0.04% 0.35 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.4 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.555 1 99.99% 0.01% 0.555 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.725 2 100.00% 0.00%	15	0.06%	0.2625
0.35 0 99.96% 0.04% 0.375 0 99.96% 0.04% 0.4 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.525 0 99.99% 0.01% 0.555 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.6575 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.75 0 100.00% 0.00%	12	0.04%	0.2875
0.375 0 99.96% 0.04% 0.4 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.525 0 99.99% 0.01% 0.555 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.725 0 99.99% 0.01% 0.725 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.75 0 100.00% 0.00%	12	0.04%	0.3125
0.4 1 99.96% 0.04% 0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.525 0 99.99% 0.01% 0.555 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.75 0 100.00% 0.00% 0.75 0 100.00% 0.00% 0.75 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.85 0 100.00% 0.00%	12	0.04%	0.3375
0.425 2 99.97% 0.03% 0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.525 0 99.99% 0.01% 0.55 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.75 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% <td>12</td> <td>0.04%</td> <td>0.3625</td>	12	0.04%	0.3625
0.45 4 99.98% 0.02% 0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.525 0 99.99% 0.01% 0.55 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.755 0 100.00% 0.00% 0.755 0 100.00% 0.00% 0.755 0 100.00% 0.00% 0.88 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00%	11	0.04%	0.3875
0.475 1 99.99% 0.01% 0.5 0 99.99% 0.01% 0.525 0 99.99% 0.01% 0.55 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.655 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.775 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.85 0 100.00% 0.00% </td <td>9</td> <td>0.03%</td> <td>0.4125</td>	9	0.03%	0.4125
0.5 0 99.99% 0.01% 0.525 0 99.99% 0.01% 0.55 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.775 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.99 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.995 0 100.00% 0.00% </td <td>5</td> <td>0.02%</td> <td>0.4375</td>	5	0.02%	0.4375
0.525 0 99.99% 0.01% 0.55 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.775 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.99 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.955 0 100.00% 0.00% 0.975 0 100.00% 0.00%	4	0.01%	0.4625
0.55 1 99.99% 0.01% 0.575 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.775 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.99 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.955 0 100.00% 0.00% 0.975 0 100.00% 0.00% 0.975 0 100.00% 0.00%	4	0.01%	0.4875
0.575 1 99.99% 0.01% 0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.775 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.955 0 100.00% 0.00% 0.975 0 100.00% 0.00% 0.975 0 100.00% 0.00% 0.975 0 100.00% 0.00%	4	0.01%	0.5125
0.6 0 99.99% 0.01% 0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 0.975 0 100.00% 0.00% 0.975 0 100.00% 0.00% 0.975 0 100.00% 0.00%	3	0.01%	0.5375
0.625 0 99.99% 0.01% 0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 0.975 0 100.00% 0.00% 0.975 0 100.00% 0.00%	2	0.01%	0.5625
0.65 0 99.99% 0.01% 0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.955 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	2	0.01%	0.5875
0.675 0 99.99% 0.01% 0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.775 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	2	0.01%	0.6125
0.7 0 99.99% 0.01% 0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.775 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	2	0.01%	0.6375
0.725 2 100.00% 0.00% 0.75 0 100.00% 0.00% 0.775 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	2	0.01%	0.6625
0.75 0 100.00% 0.00% 0.775 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	2	0.01%	0.6875
0.775 0 100.00% 0.00% 0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	0	0.00%	0.7125
0.8 0 100.00% 0.00% 0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	0	0.00%	0.7375
0.825 0 100.00% 0.00% 0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	0	0.00%	0.7625
0.85 0 100.00% 0.00% 0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	0	0.00%	0.7875
0.875 0 100.00% 0.00% 0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	0	0.00%	0.8125
0.9 0 100.00% 0.00% 0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	0	0.00%	0.8375
0.925 0 100.00% 0.00% 0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	0	0.00%	0.8625
0.95 0 100.00% 0.00% 0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	0	0.00%	0.8875
0.975 0 100.00% 0.00% 1 0 100.00% 0.00%	0	0.00%	0.9125
1 0 100.00% 0.00%	0	0.00%	0.9375
	0	0.00%	0.9625
1.025 0 100.00% 0.00%	0	0.00%	0.9875
	0	0.00%	1.0125
sum 26838			

Table 1. Well D-4 smoothed turbidity frequency histogram

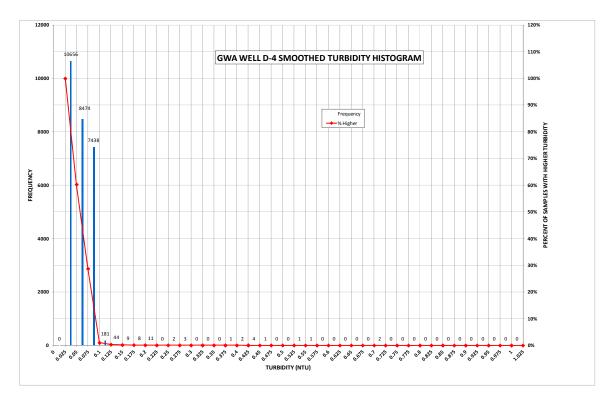


Figure 2. Well D-4 smoothed turbidity frequency curve

WELL NO.	DATE SAMPLED	TOTAL HARDNESS	CALCIUM (mg/L as	(mg/L as	CHLORIDES (mg/L)	TOTAL COLIFORM	E. COLI (MPN/100	ENTERO COCCI	NITRATES (MG/L)
D-4	02/18/09	(mg/L as CaCO3) 236	Ca CO3) 204	CaCO3) 32	50	(MPN/100 ML) <1	ML) <1	(MPN/100 ML) <1	(MG/L)
D-4	02/24/09			-		<1	<1	3.1	
D-4	03/03/09	248	210	38	61	<1	<1	<1	2.7
D-4	03/10/09					<1	<1	<1	
D-4	03/24/09					<1	<1	<1	
D-4 D-4	03/30/09 04/07/09	256	226	30	66	<1 <1	<1 <1	<1 <1	2.8
D-4	04/14/09	230	220	30	- 00	<1	<1	<1	2.0
D-4	04/21/09					<1	<1	<1	
D-4	04/28/09					<1	<1	<1	
D-4	05/05/09					<1	<1	<1	2.7
D-4	05/12/09	284	236	48	45	<1	<1	<1	
D-4	05/19/09					<1	<1	<1	
D-4 D-4	05/26/09 06/01/09	296	230	66	42	<1 <1	<1 <1	<1 <1	2.8
D-4	06/08/09	200	200	55	72	<1	<1	<1	2.0
D-4	06/16/09					<1	<1	<1	
D-4	06/23/09					<1	<1	<1	
D-4	06/30/09					<1	<1	<1	
D-4	07/07/09	258	192	66	57	<1	<1	<1	2.7
D-4	07/14/09					<1	<1	<1	
D-4 D-4	07/20/09 07/27/09					<1 <1	<1 <1	<1 <1	
D-4	08/03/09	254	250	4	62	1.0	<1	<1	2.8
D-4	08/11/09					<1	<1	<1	
D-4	08/21/09					<1	<1	<1	
D-4	08/26/09		-			<1	<1	<1	
D-4	09/02/09	260	230	30	63	<1	<1	<1	
D-4	09/11/09					<1	<1	<1	0.7
D-4 D-4	09/11/09 09/18/09					<1 <1	<1 <1	<1 7.4	
D-4 D-4	09/18/09					<1	<1	7.4 <1	
D-4	10/01/09	260	210	50	90	<1	7	<1	
D-4	10/05/09					<1	<1	<1	2.8
D-4	10/16/09					<1	<1	<1	
D-4	10/20/09					<1	<1	nd	
D-4 D-4	10/27/09 11/04/09					<1	<1	16.0	
D-4	11/04/09	284	278	6	54	<1 <1	<1 <1	<1 3.0	2.9
D-4	11/19/09			_	-	<1	<1	<1	
D-4	11/25/09					<1	<1	<1	
D-4	12/01/09					<1	<1	<1	
D-4	12/07/09	270	232	38	61	<1	<1	<1	2.8
D-4	12/17/09					<1	<1	<1	
D-4 D-4	12/23/09 12/29/09					<1 <1	<1 <1	<1 <1	
D-4	01/04/10					<1	<1	<1	
D-4	01/11/10	276	252	24	61	<1	<1	<1	2.9
D-4	01/21/10					<1	<1	<1	
D-4	01/28/10					<1	<1	<1	
D-4	02/01/10					<1	<1	<1	
D-4 D-4	02/08/10 02/18/10	260	214	46	58	<1	<1	<1	2.8
D-4	02/14/10					<1 <1	<1 <1	<1 <1	
D-4	03/04/10					<1	<1	39.3	
D-4	03/09/10	260	232	28	75	<1	<1	<1	2.9
D-4	03/18/10					<1	<1	2.0	
D-4	03/25/10					<1	<1	<1	
D-4	04/01/10					<1	<1	3.0	
D-4 D-4	04/08/10 04/14/10	290	230	60	65	<1 <1	<1 <1	<1 <1	2.8
D-4	04/22/10					<1	<1	<1	
D-4	04/30/10					<1	<1	<1	
D-4	05/07/10					<1	<1	<1	
D-4	05/13/10					<1	<1	<1	
D-4	05/20/10					<1	<1	<1	<u> </u>
D-4	05/25/10	250	204	46	74	<1	<1	<1	2.9
D-4 D-4	06/01/10 06/07/10	246	204	42	57	<1 <1	<1 <1	<1 <1	2.7
D-4	06/17/10	240	2.04	-12	31	<1	<1	<1	2.7
D-4	06/24/10					4.1	<1	<1	
D-4	07/01/10					1.0	<1	<1	
D-4	07/09/10					<1	<1	<1	
D-4	07/12/10	260	240	20	63	<1	<1	<1	2.9
D-4 D-4	08/05/10 08/09/10	264	246	18	58	<1 <1	<1 <1	<1 <1	2.9
D-4	09/09/10	250	230	20	71	<1	<1	<1	2.9
D-4	09/17/10					<1	, ₁	<1	
D-4	09/20/10					<1	<1	<1	3.0
D-4	09/30/10					<1	<1	<1	
D-4	10/07/10					<1	<1	<1	
D-4	10/15/10 10/18/10	044	174	70	20	<1	<1	<1	0.0
D-4 D-4	10/18/10	244	174	70	69	<1 129.6	<1 <1	<1 <1	2.9
D-4	11/03/10					4.1	<1	<1	
D-4	11/08/10	244	220	24	59	<1	<1	<1	3.0
D-4	11/18/10					<1	<1	<1	
D-4	11/23/10					<1	<1	<1	
D-4	12/01/10	070	011		F0	<1	<1	<1	
D-4	12/06/10	276	214	62	53	<1	<1	<1	3.0
D-4 D-4	12/16/10 01/06/11	 				<1	<1	<1	
D-4 D-4	01/06/11	 				<1 <1	<1 <1	<1 <1	
D-4	01/18/11	244	230	14	91	<1	<1	<1	3.0
D-4	01/27/11					<1	<1	<1	
	02/04/11					<1	<1	<1	
D-4	02/10/11					<1	<1	<1	
D-4			240	10	53	<1	<1	<1	3.0
D-4 D-4	02/14/11	250							
D-4 D-4 D-4	02/14/11 02/25/11	290				<1	<1	<1	
D-4 D-4	02/14/11	250					<1 <1 <1	<1 <1 <1	

Table 2. Well D-4 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	LOW =.1 MEDIUM = .5 HIGH = 1
D-4	3/24/2009	DRY	LOW	0.1
D-4	8/24/2009	STORM	LOW	0.1

NO 2011 MPA DATA

Table 3. Well D-4 MPA data

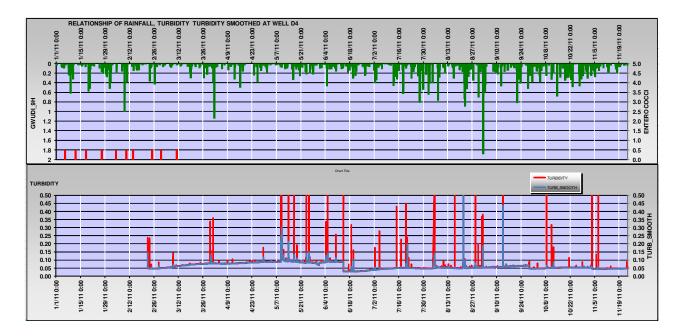


Figure 3. Well D-4 multi-variable scanner

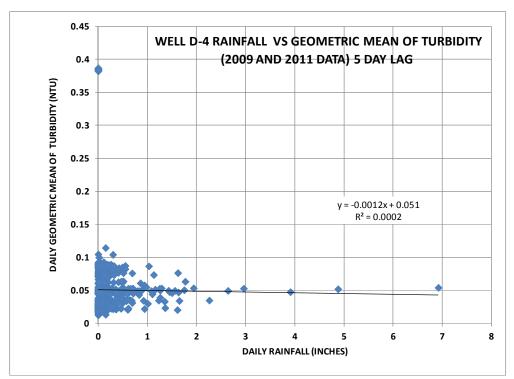


Figure 4. Well D-4 smoothed turbidity vs. rainfall regression analysis for 5 day lag (all lags yielded negative slopes)

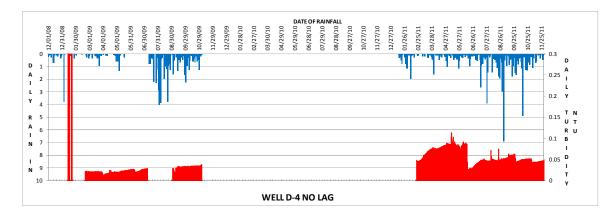


Figure 5. Well D-4 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

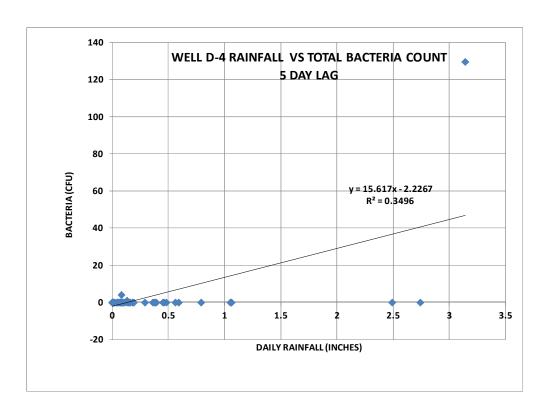


Figure 6. Well D-4 total coliform vs. rainfall regression analysis for 5 day lag

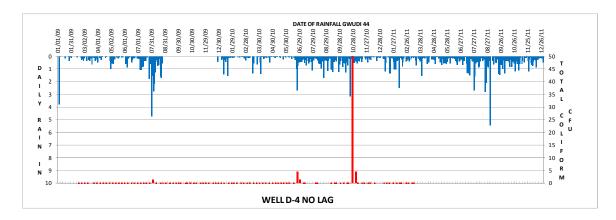


Figure 7. Well D-4 visual scan of daily rainfall versus total coliform

(ALL E. COLI DATA = ZERO)

Figure 8. Well D-4 E. coli vs. rainfall regression analysis

(ALL E. COLI DATA = ZERO)

Figure 9. Well D-4 visual scan of daily rainfall versus E. Coli

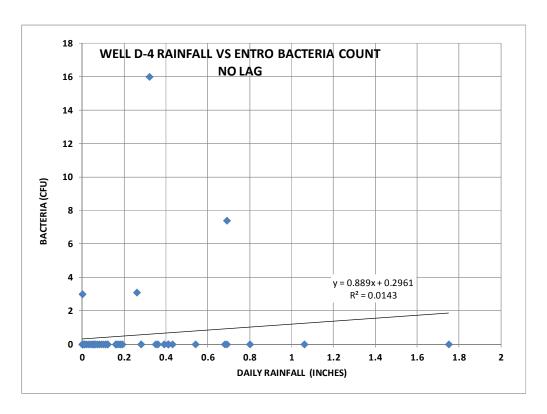


Figure 10. Well D-4 enterococci vs. rainfall regression analysis for 0 day lag

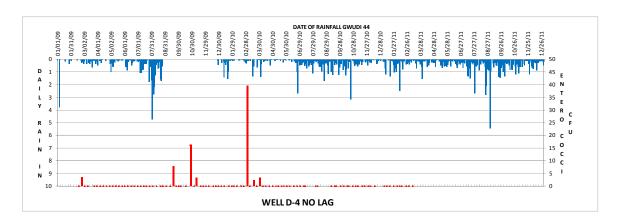


Figure 11. Well D-4 visual scan of daily rainfall versus enterococci

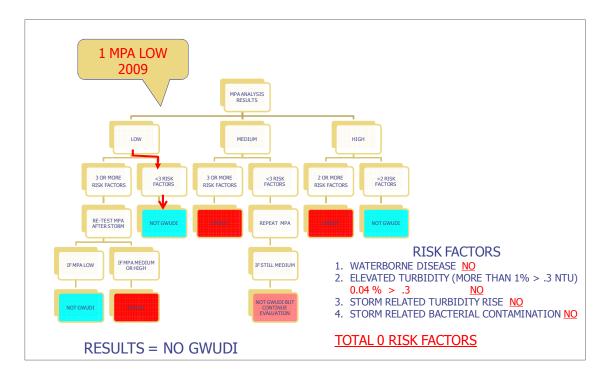


Figure 12. Well D-4 GWUDI determination decision tree

APPENDIX 6 WELL D-16 DATA AND ANALYSIS

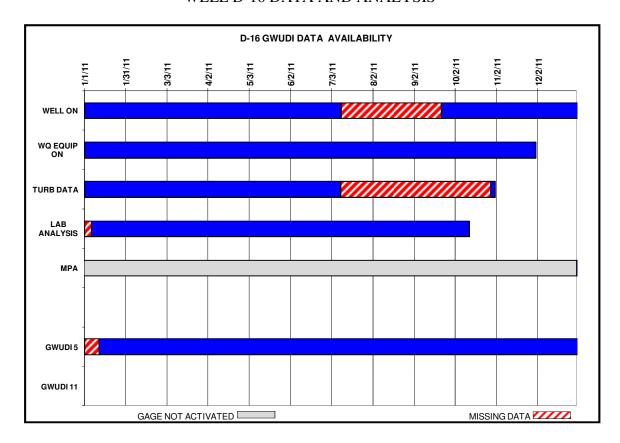


Figure 1. Well D-16 data availability

Bin	FREQUENCY	Cumulative %	% HIGHER	Number Higher	INVERSE CUMULATIVE %	BIN A
0.025	0	0.00%	100.00%	18454	100.00%	0.012
0.05	3992	21.63%	78.37%	14462	78.37%	0.037
0.075	14175	98.44%	1.56%	287	1.56%	0.062
0.1	193	99.49%	0.51%	94	0.51%	0.087
0.125	42	99.72%	0.28%	52	0.28%	0.112
0.15	16	99.80%	0.20%	36	0.20%	0.13
0.175	11	99.86%	0.14%	25	0.14%	0.16
0.2	9	99.91%	0.09%	16	0.09%	0.18
0.225	5	99.94%	0.06%	11	0.06%	0.21
0.25	1	99.95%	0.05%	10	0.05%	0.23
0.275	4	99.97%	0.03%	6	0.03%	0.262
0.3	0	99.97%	0.03%	6	0.03%	0.287
0.325	0	99.97%	0.03%	6	0.03%	0.312
0.35	0	99.97%	0.03%	6	0.03%	0.337
0.375	0	99.97%	0.03%	6	0.03%	0.36
0.4	1	99.97%	0.03%	5	0.03%	0.38
0.425	0	99.97%	0.03%	5	0.03%	0.41
0.45	0	99.97%	0.03%	5	0.03%	0.43
0.475	0	99.97%	0.03%	5	0.03%	0.46
0.5	0	99.97%	0.03%	5	0.03%	0.48
0.525	0	99.97%	0.03%	5	0.03%	0.51
0.55	0	99.97%	0.03%	5	0.03%	0.53
0.575	1	99.98%	0.02%	4	0.02%	0.56
0.6	0	99.98%	0.02%	4	0.02%	0.58
0.625	0	99.98%	0.02%	4	0.02%	0.612
0.65	0	99.98%	0.02%	4	0.02%	0.63
0.675	0	99.98%	0.02%	4	0.02%	0.66
0.073	0	99.98%	0.02%	4	0.02%	0.68
0.725	0	99.98%	0.02%	4	0.02%	0.71
0.725	0	99.98%	0.02%	4	0.02%	0.73
0.775	0	99.98%	0.02%	4	0.02%	0.76
0.773	0	99.98%	0.02%	4	0.02%	0.78
0.825	0	99.98%	0.02%	4	0.02%	0.78
0.85	0	99.98%	0.02%	4	0.02%	0.83
0.875	0	99.98%	0.02%	4	0.02%	0.86
0.9	0	99.98%	0.02%	4	0.02%	0.88
0.925	0	99.98%	0.02%	4	0.02%	0.91
0.95	0	99.98%	0.02%	4	0.02%	0.93
0.975	0	99.98%	0.02%	4	0.02%	0.96
1	0	99.98%	0.02%	4	0.02%	0.98
1.025	4	100.00%	0.00%	0	0.00%	1.012

Table 1. Well D-16 smoothed turbidity frequency histogram

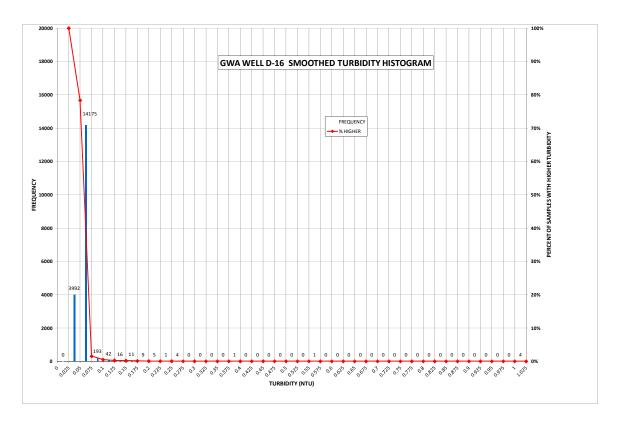


Figure 2. Well D-16 smoothed turbidity frequency curve

		TOTAL HARDNESS	CALCIUM (mg/L as	MAGNESIUM (mg/L as	CHLORIDES	TOTAL COLIFORM	E COLL/MPN/100	ENTERO COCCI	NITRATES
WELL NO.	DATE SAMPLED	(mg/L as CaCO3)	CaCO3)	CaCO3)	(mg/L)	(MPN/100 ML)	ML)	(MPN/100 ML)	(MG/L)
D-16 D-16	02/18/09 02/24/09	250	220	30	87	<1 <1	<1 <1	<1 1.0	
D-16	03/03/09	258	220	38	116	1.0	<1	<1	3.2
D-16	03/10/09					<1	<1	<1	
D-16 D-16	03/24/09 03/30/09					1.0	<1 <1	<1 <1	
D-16	04/07/09	256	230	26	124	<1	<1	<1	3.4
D-16 D-16	04/14/09					<1 1.0	<1 <1	<1	
D-16	04/28/09					<1	<1	<1	
D-16 D-16	05/05/09 05/12/09	304	262	42	127	<1 <1	<1 <1	<1 <1	3.2
D-16	05/19/09	304	202	42	121	<1	<1	<1	
D-16	05/26/09	242	050	04	407	<1	<1	<1	0.5
D-16 D-16	06/01/09 06/08/09	316	252	64	107	<1 <1	<1 <1	<1 <1	3.5
D-16	06/16/09					<1	<1	<1	
D-16 D-16	06/23/09 06/30/09					<1 <1	<1 <1	<1	
D-16	07/07/09	314	228	86	122	<1	<1	<1	3.4
D-16	07/14/09					<1	<1	<1	
D-16 D-16	07/20/09 07/27/09					<1 <1	<1 <1	<1 <1	
D-16	08/03/09	266	240	26	117	<1	<1	<1	3.4
D-16 D-16	08/11/09					<1 2.0	<1 <1	<1 <1	
D-16	08/26/09					2.1	<1	<1	
D-16	09/02/09	264	240	20	118	<1	<1	<1	
D-16 D-16	09/11/09 09/11/09					<1 <1	<1 <1	<1	0.7
D-16	09/18/09					<1	<1	<1	
D-16 D-16	09/25/09 10/01/09	266	220	46	87	<1 <1	<1 <1	<1 <1	
D-16 D-16	10/01/09	200	250	40	01	2.0	<1	<1	3.4
D-16	10/16/09					<1	<1	<1	
D-16 D-16	10/20/09 10/27/09					<1 1.0	<1 <1	nd <1	
D-16	11/04/09					<1	<1	<1	
D-16 D-16	11/09/09 11/19/09	260	230	30	118	<1 <1	<1 <1	1.0	3.7
D-16	11/25/09					<1	<1	<1	
D-16	12/01/09					<1	<1	<1	
D-16 D-16	12/07/09 12/17/09	286	256	30	113	<1 <1	<1 <1	<1 2.0	3.5
D-16	12/23/09					<1	<1	<1	
D-16 D-16	12/29/09 01/04/10					9.6	<1 <1	<1 <1	
D-16	01/11/10	272	234	38	123	<1	<1	<1	3.4
D-16	01/21/10					<1	<1	<1	
D-16 D-16	01/28/10 02/01/10					<1 <1	<1 <1	<1	
D-16	02/08/10	270	236	34	122	<1	<1	<1	3.6
D-16 D-16	02/18/10 02/24/10					<1 <1	<1 <1	<1 2.0	
D-16	03/04/10					<1	<1	<1	
D-16	03/09/10	216	186	30	104	<1	<1	<1	3.3
D-16 D-16	03/18/10 03/25/10					<1 <1	<1 <1	1.0 4.0	
D-16	04/01/10					1.0	<1	3.0	
D-16 D-16	04/08/10 04/14/10	264	230	34	95	4.1 1.0	<1 <1	<1	3.4
D-16	04/22/10					1.0	<1	<1	
D-16	04/30/10					<1	<1	<1	
D-16 D-16	05/07/10 05/13/10					<1 <1	<1 <1	<1	
D-16	05/20/10					<1	<1	<1	
D-16 D-16	05/25/10 06/01/10	280	224	56	136	6.3 <1	<1 <1	<1	3.7
D-16	06/07/10	252	222	30	131	<1	<1	<1	3.4
D-16	06/17/10					<1	<1	<1	
D-16 D-16	06/24/10 07/01/10					1.0	<1 <1	<1	
D-16	07/09/10					<1	<1	<1	
D-16 D-16	07/12/10 08/05/10	266	210	82	120	<1 <1	<1 <1	<1 2.0	3.5
D-16	08/09/10	274	240	34	124	<1	<1	<1	3.5
D-16	09/09/10 09/17/10	260	234	26	136	<1 4.1	<1 <1	<1 <1	
D-16 D-16	09/17/10 09/20/10					4.1 9.7	<1 <1	<1 <1	3.7
D-16	09/30/10					3.1	<1	<1	
D-16 D-16	10/07/10 10/15/10					<1 <1	<1 <1	<1 <1	
D-16	10/18/10	256	224	32	132	<1	<1	<1	3.5
D-16	10/27/10					<1	<1	<1	
D-16 D-16	11/03/10 11/08/10	266	224	42	124	15.6 5.2	<1 <1	7.0 <1	3.5
D-16	11/18/10					<1	<1	<1	
D-16 D-16	11/23/10 12/01/10					<1 <1	<1 <1	<1 <1	
D-16	12/06/10	262	202	60	111	<1	<1	<1	3.5
D-16	12/16/10					<1	<1	<1	
D-16 D-16	01/06/11					<1 <1	<1 <1	<1 <1	
D-16	01/18/11	260	230	30	131	<1	<1	<1	3.5
D-16 D-16	01/27/11					4.1 <1	<1 <1	4.1 <1	
D-16 D-16	02/04/11					<1	<1	V 7	
D-16	02/14/11	270	250	20	111	1.0	<1	<1	3.6
D-16 D-16	02/25/11					69.1 1.0	<1 <1	<1 <1	
D-16	03/11/11					<1	<1	<1	
D-16	03/14/11	268	234	34	118	<1	<1	NA	3.4

Table 2. Well D-16 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	
D-16	3/24/2009	DRY	LOW	0.1
D-16	8/24/2009	STORM	LOW	0.1
			•	1

Table 3. Well D-16 MPA data

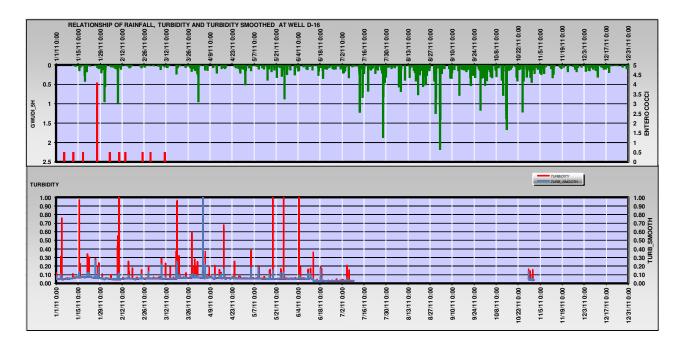


Figure 3. Well D-16 multi-variable scanner

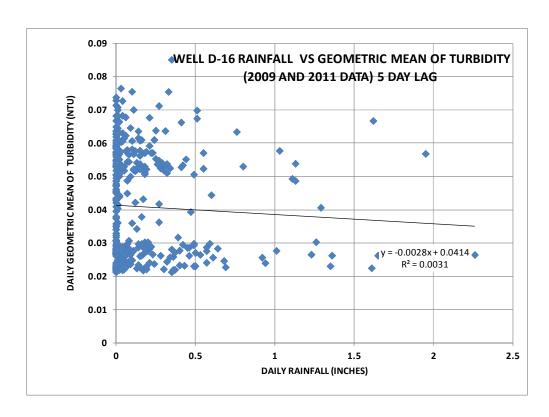


Figure 4. Well D-16 smoothed turbidity vs. rainfall regression analysis for 5 day lag (all lags yielded negative slopes)

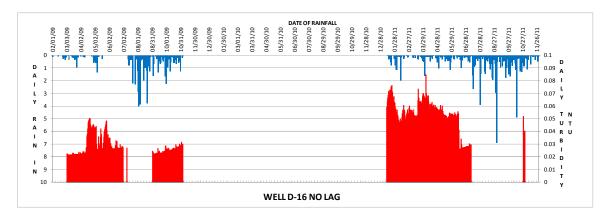


Figure 5. Well D-16 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

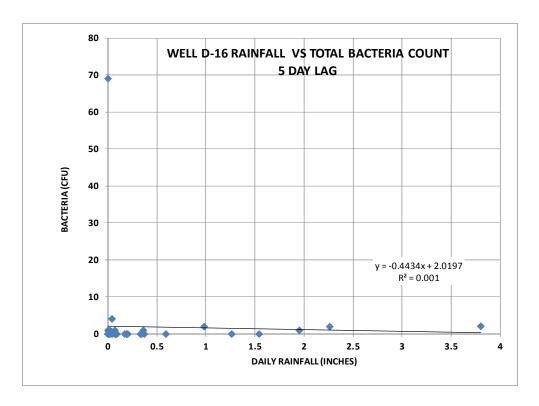


Figure 6. Well D-16 total coliform vs. rainfall regression analysis for 5 day lag (all lags yielded negative slopes)

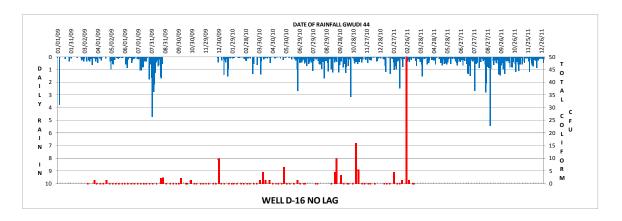


Figure 7. Well D-16 visual scan of daily rainfall versus total coliform

(ALL E. COLI DATA = ZERO)

Figure 8. Well D-16 E. coli vs. rainfall regression analysis

(ALL E. COLI DATA = ZERO)

Figure 9. Well D-16 visual scan of daily rainfall versus E. Coli

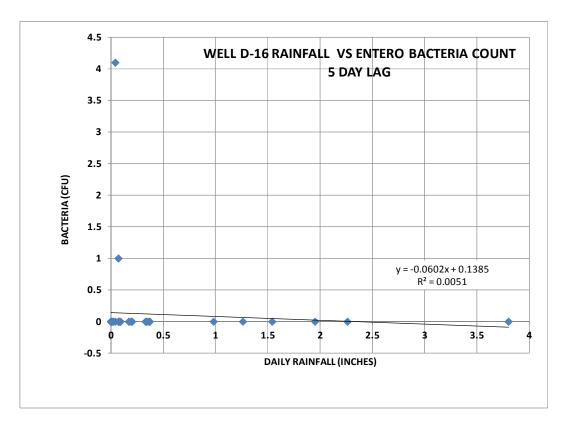


Figure 10. Well D-16 enterococci vs. rainfall regression analysis for 5 day lag (all lags yielded negative slopes)

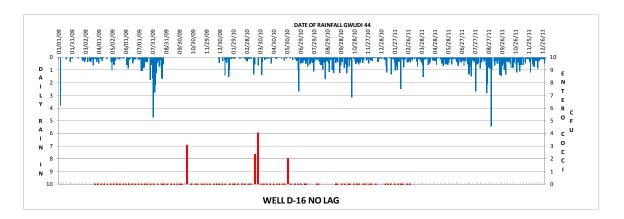


Figure 11. Well D-16 visual scan of daily rainfall versus enterococci

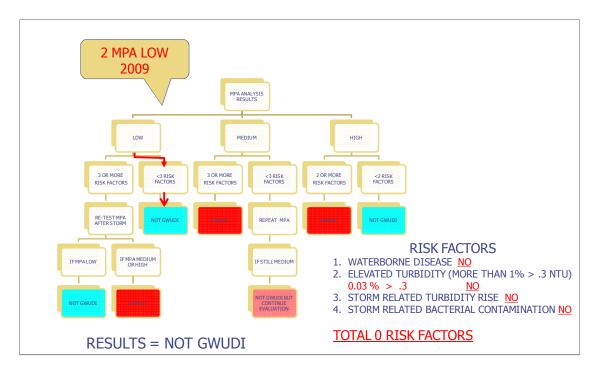


Figure 12. Well D-16 GWUDI determination decision tree

APPENDIX 7 WELL D-19 DATA AND ANALYSIS

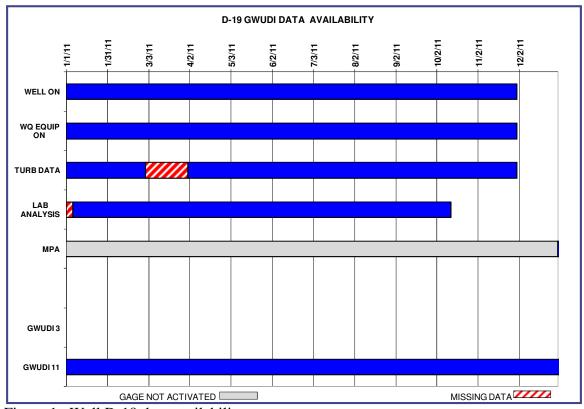


Figure 1. Well D-19 data availability

Bin	FREQUENCY	Cumulative %	% HIGHER	Number Higher	INVERSE CUMULATIVE %	BIN AVG
0.025	6	0.02%	99.98%	28712	99.98%	0.0125
0.05	19896	69.30%	30.70%	8816	30.70%	0.0375
0.075	7849	96.63%	3.37%	967	3.37%	0.0625
0.1	385	97.97%	2.03%	582	2.03%	0.0875
0.125	381	99.30%	0.70%	201	0.70%	0.1125
0.15	177	99.92%	0.08%	24	0.08%	0.1375
0.175	22	99.99%	0.01%	2	0.01%	0.1625
0.2	0	99.99%	0.01%	2	0.01%	0.1875
0.225	0	99.99%	0.01%	2	0.01%	0.2125
0.25	0	99.99%	0.01%	2	0.01%	0.2375
0.275	0	99.99%	0.01%	2	0.01%	0.2625
0.3	0	99.99%	0.01%	2	0.01%	0.2875
0.325	0	99.99%	0.01%	2	0.01%	0.3125
0.35	0	99.99%	0.01%	2	0.01%	0.3375
0.375	0	99.99%	0.01%	2	0.01%	0.3625
0.4	0	99.99%	0.01%	2	0.01%	0.3875
0.425	0	99.99%	0.01%	2	0.01%	0.4125
0.45	0	99.99%	0.01%	2	0.01%	0.4375
0.475	0	99.99%	0.01%	2	0.01%	0.4625
0.5	0	99.99%	0.01%	2	0.01%	0.4875
0.525	0	99.99%	0.01%	2	0.01%	0.5125
0.55	2	100.00%	0.00%	0	0.00%	0.5375
0.575	0	100.00%	0.00%	0	0.00%	0.5625
0.6	0	100.00%	0.00%	0	0.00%	0.5875
0.625	0	100.00%	0.00%	0	0.00%	0.6125
0.65	0	100.00%	0.00%	0	0.00%	0.6375
0.675	0	100.00%	0.00%	0	0.00%	0.6625
0.7	0	100.00%	0.00%	0	0.00%	0.6875
0.725	0	100.00%	0.00%	0	0.00%	0.7125
0.75	0	100.00%	0.00%	0	0.00%	0.7375
0.775	0	100.00%	0.00%	0	0.00%	0.7625
0.8	0	100.00%	0.00%	0	0.00%	0.7875
0.825	0	100.00%	0.00%	0	0.00%	0.8125
0.85	0	100.00%	0.00%	0	0.00%	0.8375
0.875	0	100.00%	0.00%	0	0.00%	0.8625
0.9	0	100.00%	0.00%	0	0.00%	0.8875
0.925	0	100.00%	0.00%	0	0.00%	0.9125
0.95	0	100.00%	0.00%	0	0.00%	0.9375
0.975	0	100.00%	0.00%	0	0.00%	0.9625
1	0	100.00%	0.00%	0	0.00%	0.9875
1.025	0	100.00%	0.00%	0	0.00%	1.0125
sum	28718					

Table 1. Well D-19 smoothed turbidity frequency histogram

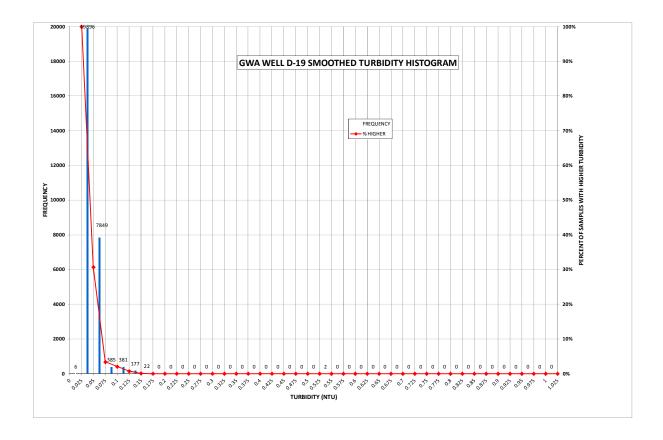


Figure 2. Well D-19 smoothed turbidity frequency curve

		TOTAL HARDNESS	CALCIUM (mg/L as	MAGNESIUM (mg/L as	CHLORIDES	TOTAL COLIFORM	E. COLI (MPN/100	ENTERO COCCI	NITRATES
	DATE SAMPLED	(mg/L as CaCO3)	CaCO3)	CaCO3)	(mg/L)	(MPN/100 ML)	ML)	(MPN/100 ML)	(MG/L)
D-19 D-19	03/24/09 03/30/09	220	190	30	83	<1 <1	<1 <1	<1 <1	
D-19	04/07/09	298	240	58	113	<1	<1	<1	2.5
D-19	04/14/09					<1	<1	<1	
D-19 D-19	04/21/09 04/28/09					<1 <1	<1 <1	<1 <1	
D-19	05/05/09					1.0	<1	<1	2.5
D-19	05/12/09	260	234	26	81	<1	<1	<1	
D-19	05/19/09					<1	<1	<1	
D-19 D-19	05/26/09	270	228	42	76	1.0	<1 <1	<1	2.6
D-19	06/08/09					1.0	<1	<1	
D-19	06/16/09					<1	<1	<1	
D-19	06/23/09					2.0	<1	<1	
D-19 D-19	06/30/09 07/07/09	300	208	92	92	1.0	<1 <1	<1 <1	2.5
D-19	07/14/09				-	<1	<1	<1	
D-19	07/20/09					1.0	<1	<1	
D-19	07/27/09	014	204	10	07	<1	<1	<1	0.6
D-19 D-19	08/03/09 08/11/09	214	204	10	87	<1 <1	<1 <1	<1 <1	2.6
D-19	08/21/09					<1	<1	<1	
D-19	08/26/09					<1	<1	<1	
D-19	09/02/09	276	234	42	92	<1	<1	<1	0.
D-19 D-19	09/11/09 09/11/09					<1 <1	<1 <1	<1 <1	0.4
D-19 D-19	09/11/09					<1	<1	<1	
D-19	09/25/09					<1	<1	<1	
D-19	10/01/09	268	220	48	250	<1	<1	<1	
D-19 D-19	10/05/09 10/16/09					<1 <1	<1 <1	<1 3.0	2.7
D-19	10/20/09					<1	<1	nd nd	
D-19	10/27/09					<1	<1	<1	
D-19	11/04/09					<1	<1	<1	
D-19	11/09/09	220	206	14	80	<1	<1	<1	2.8
D-19 D-19	11/19/09 11/25/09					<1 <1	<1 <1	<1 <1	
D-19	12/01/09					<1	<1	<1	
D-19	12/07/09	272	212	60	79	<1	<1	<1	1.8
D-19	12/17/09					<1	<1	<1	
D-19 D-19	12/23/09 12/29/09					<1 <1	<1 <1	<1 <1	
D-19	01/04/10					<1	<1	<1	
D-19	01/11/10	270	192	78	85	<1	<1	<1	2.7
D-19	01/21/10					<1	<1	<1	
D-19	01/28/10					<1	<1	<1	
D-19 D-19	02/01/10 02/08/10	234	210	24	81	<1 <1	<1 <1	<1 <1	1.4
D-19	02/18/10	204	2.10	2.4	0.	<1	<1	<1	1.4
D-19	02/24/10					<1	<1	<1	
D-19	03/04/10	040	100		404	<1	<1	<1	0.7
D-19 D-19	03/09/10	216	186	30	104	<1 <1	<1 <1	<1 2.3	2.7
D-19	03/25/10					<1	<1	4.0	
D-19	04/01/10					<1	<1	<1	
D-19	04/08/10	224	198	26	90	41.9	<1	<1	2.7
D-19 D-19	04/14/10 04/22/10					10.9 3.1	<1 <1	<1 <1	
D-19	04/30/10					1.0	<1	<1	
D-19	05/07/10					6.3	<1	<1	
D-19	05/13/10					4.1	<1	<1	
D-19 D-19	05/20/10 05/25/10	220	182	38	94	<1 <1	<1 <1	<1	2.8
D-19 D-19	06/01/10	220	132	30	34	3.1	<1	2.0	2.0
D-19	06/07/10	210	188	22	99	3.1	<1	<1	2.6
D-19	06/17/10					1.0	<1	<1	
D-19 D-19	06/24/10 07/01/10					3.1 <1	<1 <1	<1 <1	
D-19 D-19	07/01/10					<1	<1	<1	
D-19	07/12/10	216	184	32	81	<1	<1	<1	2.7
D-19	08/05/10					<1	<1	<1	
D-19 D-19	08/09/10 09/09/10	240 220	210	30 16	88 98	<1 <1	<1 <1	<1 na	2.7
D-19 D-19	09/09/10	220	204	16	98	<1 <1	<1	na <1	
D-19	09/20/10					<1	<1	<1	2.8
D-19	09/30/10					<1	<1	<1	
D-19	10/07/10					<1	<1	<1	
D-19 D-19	10/15/10 10/18/10	210	192	18	99	<1 <1	<1 <1	<1 <1	2.8
D-19	10/27/10				- 33	<1	<1	<1	
D-19	11/03/10					<1	<1	<1	
D-19	11/08/10	210	180	30	94	<1	<1	<1	2.9
D-19 D-19	11/18/10 11/23/10					<1 <1	<1 <1	<1 <1	
D-19 D-19	11/23/10					1.0	<1	<1	
D-19	12/06/10	216	184	32	39	<1	<1	<1	2.8
D-19	12/16/10					1.0	<1	<1	
D-19	01/06/11					<1	<1	<1	
D-19 D-19	01/12/11	224	204	20	110	<1	<1	<1	3.0
D-19 D-19	01/18/11	234	204	30	112	<1 <1	<1 <1	<1 <1	2.5
D-19	02/04/11					<1	<1	<1	
D-19	02/10/11					<1	<1	<1	
D-19 D-19	02/14/11 02/25/11	230	216	14	72	<1 <1	<1 <1	<1 <1	2.8
פו-ט	11/62/20				1	<1	×1	81	

Table 2. Well D-19 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	MEDIUM = .5
D-19	3/24/2009	DRY	LOW	0.1
D-19	8/24/2009	STORM	LOW	0.1

NO 2011 MPA DATA

Table 3. Well D-19 MPA data

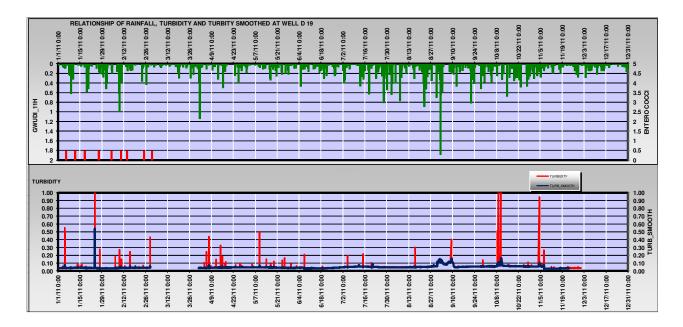


Figure 3. Well D-19 multi-variable scanner

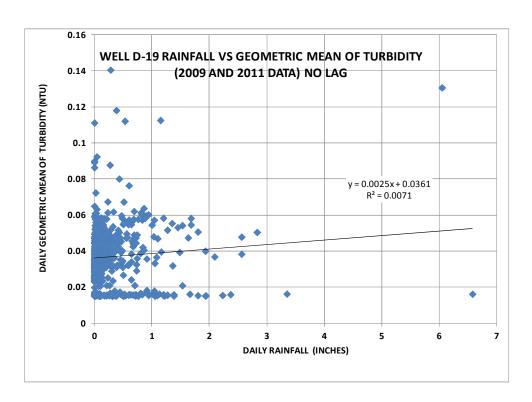


Figure 4. Well D-19 smoothed turbidity vs. rainfall regression analysis for 0 day lag

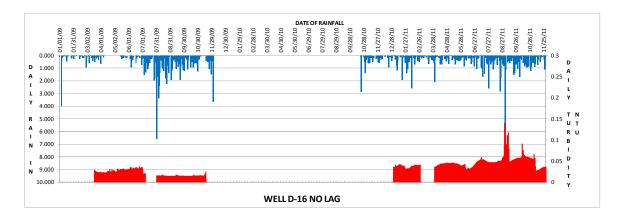


Figure 5. Well D-19 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

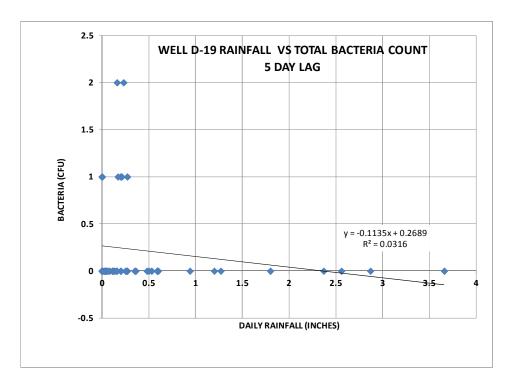


Figure 6. Well D-19 total coliform vs. rainfall regression analysis for 5 day lag (all lags yielded negative slopes)

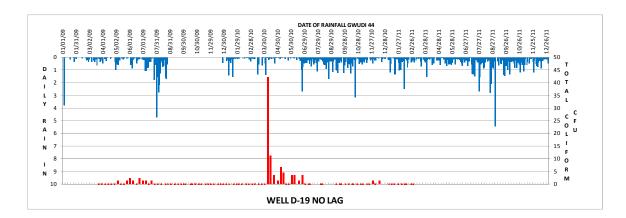


Figure 7. Well D-19 visual scan of daily rainfall versus total coliform

(ALL E. COLI DATA = ZERO)

Figure 8. Well D-19 E. coli vs. rainfall regression analysis

(ALL E. COLI DATA = ZERO)

Figure 9. Well D-19 visual scan of daily rainfall versus E. Coli

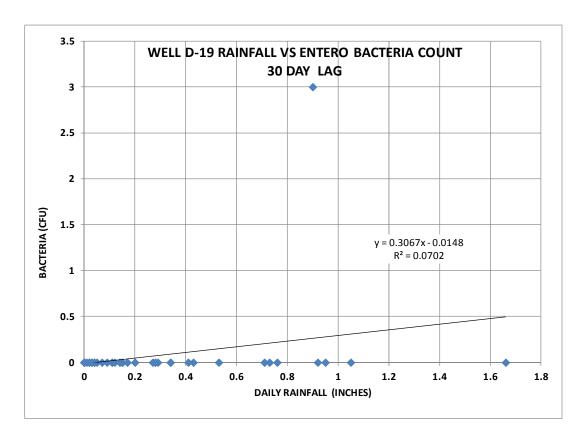


Figure 10. Well D-19 enterococci vs. rainfall regression analysis for 30 day lag

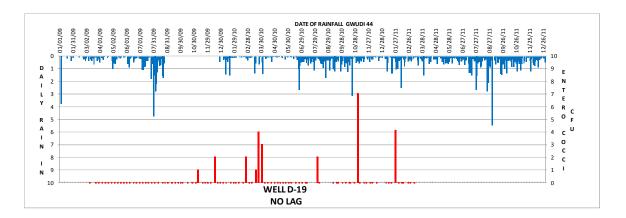


Figure 11. Well D-19 visual scan of daily rainfall versus enterococci

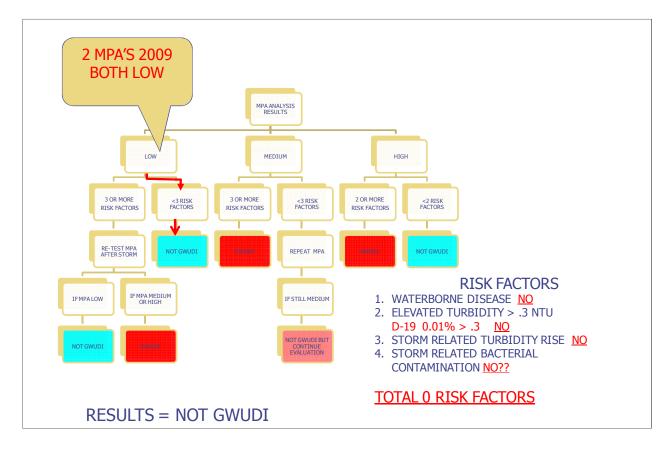
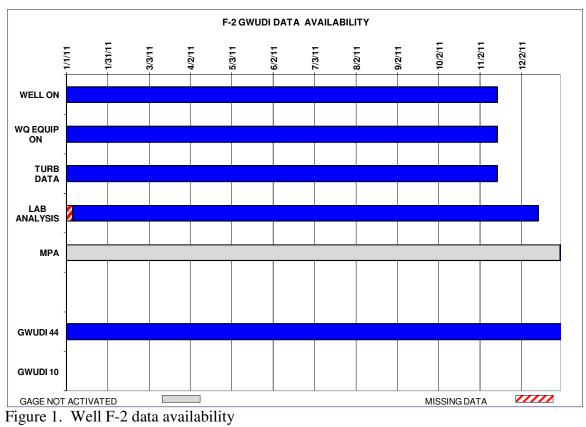


Figure 12. Well D-19 GWUDI determination decision tree

APPENDIX 8 WELL F-2 DATA AND ANALYSIS



Page 1 APPENDIX 8

Bin	Frequency	Cumulative %	% Higher	Number Higher	Inverse Cumulative %	Bin Avg AVG
0.025	0	0.00%	100.00%	30340	100.00%	0.0125
0.05	21250	70.04%	29.96%	9090	29.96%	0.0375
0.075	8893	99.35%	0.65%	197	0.65%	0.0625
0.1	137	99.80%	0.20%	60	0.20%	0.0875
0.125	25	99.88%	0.12%	35	0.12%	0.1125
0.15	7	99.91%	0.09%	28	0.09%	0.1375
0.175	1	99.91%	0.09%	27	0.09%	0.1625
0.2	5	99.93%	0.07%	22	0.07%	0.1875
0.225	3	99.94%	0.06%	19	0.06%	0.2125
0.25	1	99.94%	0.06%	18	0.06%	0.2375
0.275	0	99.94%	0.06%	18	0.06%	0.2625
0.3	1	99.94%	0.06%	17	0.06%	0.2875
0.325	1	99.95%	0.05%	16	0.05%	0.3125
0.35	5	99.96%	0.04%	11	0.04%	0.3375
0.375	1	99.97%	0.03%	10	0.03%	0.3625
0.4	2	99.97%	0.03%	8	0.03%	0.3875
0.425	0	99.97%	0.03%	8	0.03%	0.4125
0.45	0	99.97%	0.03%	8	0.03%	0.4375
0.475	0	99.97%	0.03%	8	0.03%	0.4625
0.5	2	99.98%	0.02%	6	0.02%	0.4875
0.525	0	99.98%	0.02%	6	0.02%	0.5125
0.55	0	99.98%	0.02%	6	0.02%	0.5375
0.575	1	99.98%	0.02%	5	0.02%	0.5625
0.6	0	99.98%	0.02%	5	0.02%	0.5875
0.625	2	99.99%	0.01%	3	0.01%	0.6125
0.65	0	99.99%	0.01%	3	0.01%	0.6375
0.675	0	99.99%	0.01%	3	0.01%	0.6625
0.7	0	99.99%	0.01%	3	0.01%	0.6875
0.725	0	99.99%	0.01%	3	0.01%	0.7125
0.75	0	99.99%	0.01%	3	0.01%	0.7375
0.775	0	99.99%	0.01%	3	0.01%	0.7625
0.8	0	99.99%	0.01%	3	0.01%	0.7875
0.825	0	99.99%	0.01%	3	0.01%	0.8125
0.85	0	99.99%	0.01%	3	0.01%	0.8375
0.875	0	99.99%	0.01%	3	0.01%	0.8625
0.9	0	99.99%	0.01%	3	0.01%	0.8875
0.925	0	99.99%	0.01%	3	0.01%	0.9125
0.95	0	99.99%	0.01%	3	0.01%	0.9375
0.975	0	99.99%	0.01%	3	0.01%	0.9625
1	0	99.99%	0.01%	3	0.01%	0.9875
1.025	3	100.00%	0.00%	0	0.00%	1.0125
01:22	20240					
sum	30340					

Table 1. Well F-2 smoothed turbidity frequency histogram

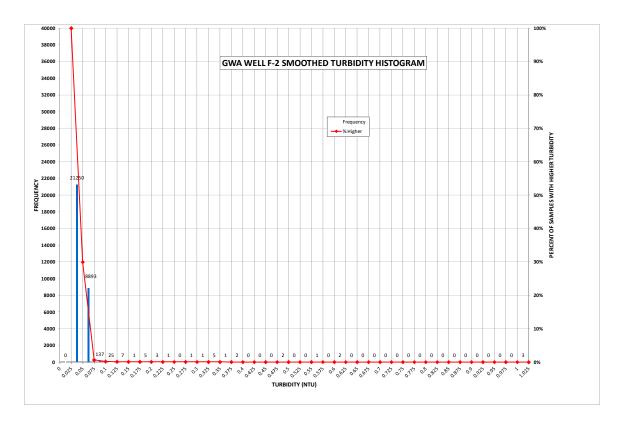


Figure 2. Well F-2 smoothed turbidity frequency curve

WELL NO.	DATE SAMPLED	TOTAL HARDNESS (mg/L as CaCO3)	CALCIUM (mg/L as CaCO3)	MAGNESIUM (mg/L as CaCO3)	CHLORIDES (mg/L)	TOTAL COLIFORM (MPN/100 ML)	E. COLI (MPN/100 ML)	ENTERO COCCI (MPN/100 ML)	NITRATES (MG/L)
F-2	06/30/09					<1	<1	<1	
F-2	07/07/09	272	236	36	169	<1	<1	<1	1.9
F-2	07/14/09					<1	<1	<1	
F-2	07/20/09					<1	<1	<1	
F-2	07/27/09					<1	<1	<1	
F-2	08/03/09	250	220	30	153	121.0	<1	1553.1	1.9
F-2	08/11/09					<1	<1	<1	
F-2	08/21/09					<1	<1	<1	
F-2	08/26/09					1.0	<1	<1	
F-2	09/02/09	264	220	44	143	<1	<1	<1	
F-2	09/11/09					<1	<1	<1	2.1
F-2	09/11/09					<1	<1	<1	
F-2	09/18/09					<1	<1	<1	
F-2	09/25/09					<1	<1	<1	
F-2	10/01/09	250	204	46	296	<1	<1	<1	
F-2	10/05/09					<1	<1	<1	2.1
F-2	10/16/09					<1	<1	1.0	
F-2	10/20/09					<1	<1	nd	
F-2	10/27/09					<1	<1	<1	
F-2	11/04/09					<1	<1	<1	
F-2	11/09/09	300	210	90	136	<1	<1	<1	2.1
F-2	11/19/09	300	210	30	100				2.1
F-2	11/19/09					<1	<1	<1	
F-2	12/01/09			 	 	<1	<1	<1	
		001	000	00	440	<1	<1	<1	
F-2	12/07/09	264	226	38	146	<1	<1	<1	2.1
F-2	12/17/09			1	ļ	<1	<1	1.0	
F-2	12/23/09			-	ļ	<1	<1	<1	
F-2	12/29/09			1		<1	<1	<1	
F-2	01/04/10					<1	<1	<1	
F-2	01/11/10	284	206	78	323	<1	<1	<1	2.1
F-2	01/21/10					<1	<1	<1	
F-2	01/28/10					<1	<1	<1	
F-2	02/01/10					<1	<1	<1	
F-2	02/08/10	274	268	6	150	<1	<1	<1	1.7
F-2	02/18/10					<1	<1	<1	
F-2	02/24/10					<1	<1	<1	
F-2	03/04/10					<1	<1	<1	
F-2		270	214	EC	161				2.2
	03/09/10	270	214	56	161	<1	<1	<1	2.2
F-2	03/18/10					<1	<1	<1	
F-2	03/25/10					<1	<1	1.0	
F-2	04/01/10					<1	<1	<1	
F-2	04/08/10	258	250	8	161	<1	<1	<1	1.9
F-2	04/14/10					<1	<1	<1	
F-2	04/22/10					<1	<1	<1	
F-2	04/30/10					<1	<1	<1	
F-2	05/07/10					<1	<1	<1	
F-2	05/13/10					<1	<1	<1	
F-2	05/20/10					<1	<1	<1	
F-2	05/25/10	250	204	46	151	<1	<1	<1	2.2
F-2	06/01/10					<1	<1	<1	
F-2	06/07/10	248	206	42	163	<1	<1	<1	2.1
F-2	06/17/10					<1	<1	<1	
F-2	06/24/10					<1	<1	<1	
F-2	07/01/10				1	<1	<1	<1	
F-2	07/09/10					14.8	<1	<1	
F-2		264	220	44	151	2.0	1.0		2.1
F-2	07/12/10 08/05/10	264	220	44	151	4.1	1.0	<1	2.1
	08/05/10	250	990	00	145				0.0
F-2		256	236	20	145	<1	<1	<1	2.2
F-2	09/09/10	256	236	20	174	<1	<1	<1	
F-2	09/17/10			1		<1	<1	<1	
F-2	09/20/10			-	ļ	<1	<1	<1	2.1
F-2	09/30/10					<1	<1	<1	
F-2	10/07/10					<1	<1	<1	
F-2	10/15/10					<1	<1	<1	
F-2	10/18/10	256	212	44	147	<1	<1	<1	2.1
F-2	10/27/10					<1	<1	<1	
F-2	11/03/10					<1	<1	<1	
F-2	11/18/10					25.6	<1	<1	
F-2	12/01/10					6.3	<1	<1	
F-2	12/06/10	262	144	118	139	1.0	<1	<1	2.2
F-2	12/16/10					<1	<1	<1	
F-2	01/06/11			1		<1	<1	<1	
				1					
F-2 F-2	01/12/11	246	220	26	153	<1	<1	<1	2.0
	01/18/11	240	220	20	100	<1	<1	<1	2.0
F-2	01/27/11			+	1	<1	<1	<1	
F-2	02/04/11					<1	<1	<1	
F-2	02/10/11					<1	<1	<1	
F-2	02/14/11	264	246	18	148	<1	<1	<1	2.2
F-2	02/25/11					<1	<1	<1	
F-2	03/02/11					<1	<1	<1	
	03/11/11					<1	<1	<1	
F-2									

Table 2. Well F-2 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	LOW =.1 MEDIUM = .5 HIGH = 1
F-2	8/10/2009	STORM	LOW	0.1
				1
		NO 2011 MPA DATA		

Table 3. Well F-2 MPA data

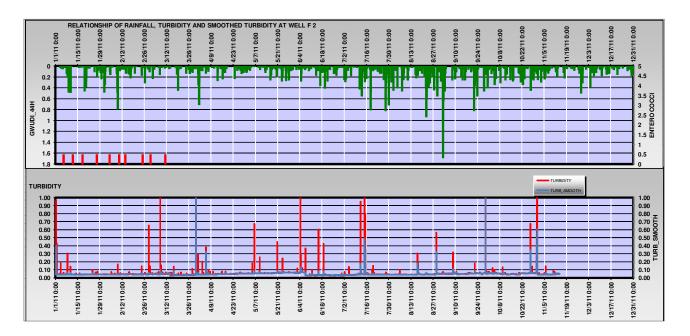


Figure 3. Well F-2 multi-variable scanner

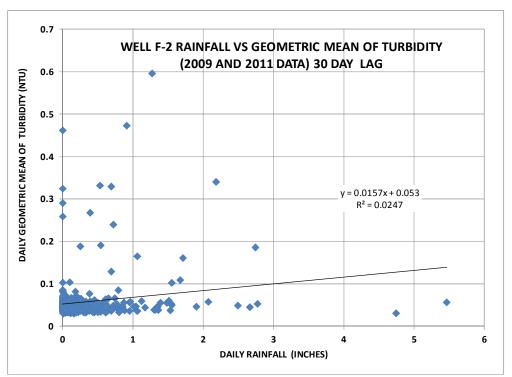


Figure 4. Well F-2 smoothed turbidity vs. rainfall regression analysis for 30 day lag

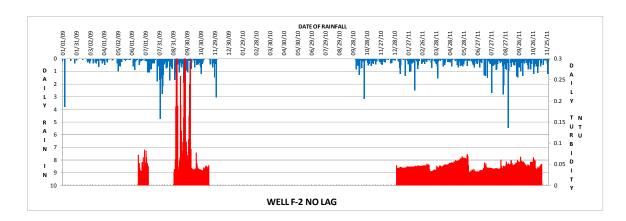


Figure 5. Well F-2 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

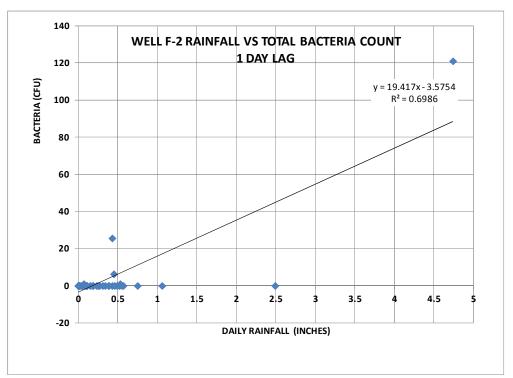


Figure 6. Well F-2 total coliform vs. rainfall regression analysis for 1 day lag

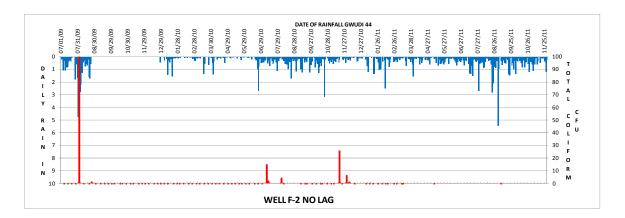


Figure 7. Well F-2 visual scan of daily rainfall versus total coliform

(ALL E. COLI DATA = ZERO)

Figure 8. Well F-2 E. coli vs. rainfall regression analysis

(ALL E. COLI DATA = ZERO)

Figure 9. Well F-2 visual scan of daily rainfall versus E. Coli

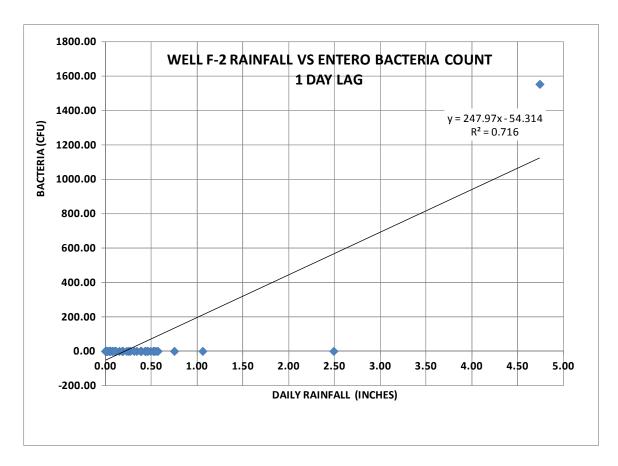


Figure 10. Well F-2 enterococci vs. rainfall regression analysis for 1 day lag

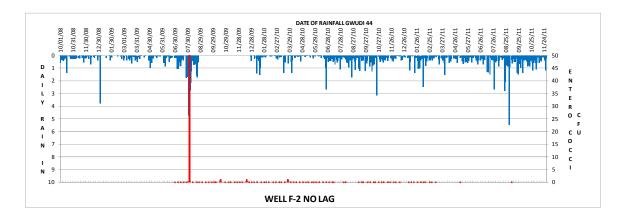


Figure 11. Well F-2 visual scan of daily rainfall versus enterococci

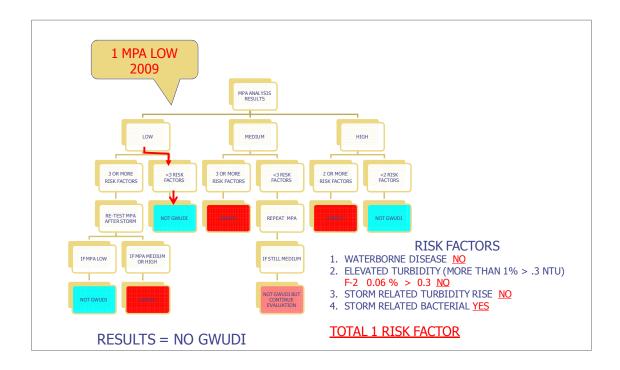


Figure 12. Well F-2 GWUDI determination decision tree

APPENDIX 9 WELL M-1 DATA AND ANALYSIS

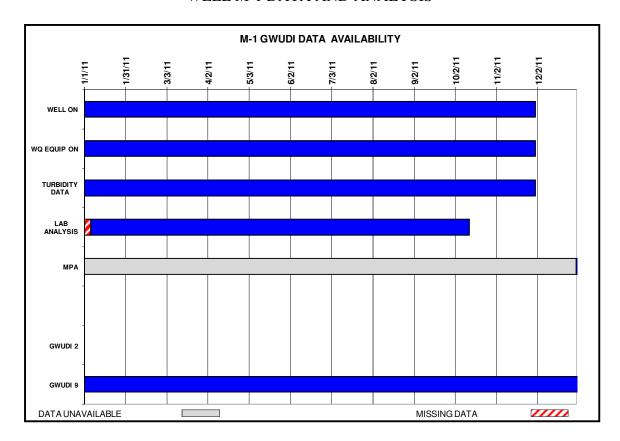


Figure 1. Well M-1 data availability

Bin	Frequency	Cumulative %	% Higher	Number Higher	Inverse Cumulative %	Bin Avg
0.200	18292	57.25%	42.75%	13657	42.75%	0.15
0.300	5318	73.90%	26.10%	8339	26.10%	0.25
0.600	3030	83.38%	16.62%	5309	16.62%	0.45
0.800	633	85.36%	14.64%	4676	14.64%	0.7
1.000	353	86.47%	13.53%	4323	13.53%	0.9
1.200	307	87.43%	12.57%	4016	12.57%	1.1
1.400	279	88.30%	11.70%	3737	11.70%	1.3
1.600	192	88.90%	11.10%	3545	11.10%	1.5
1.800	265	89.73%	10.27%	3280	10.27%	1.7
2.000	255	90.53%	9.47%	3025	9.47%	1.9
2.200	256	91.33%	8.67%	2769	8.67%	2.1
2.400	142	91.78%	8.22%	2627	8.22%	2.3
2.600	175	92.33%	7.67%	2452	7.67%	2.5
2.800	162	92.83%	7.17%	2290	7.17%	2.7
3.000	188	93.42%	6.58%	2102	6.58%	2.9
3.200	173	93.96%	6.04%	1929	6.04%	3.1
3.400	154	94.44%	5.56%	1775	5.56%	3.3
3.600	144	94.89%	5.11%	1631	5.11%	3.5
3.800	147	95.36%	4.64%	1484	4.64%	3.7
4.000	117	95.72%	4.28%	1367	4.28%	3.9
4.200	73	95.95%	4.05%	1294	4.05%	4.1
4.400	120	96.33%	3.67%	1174	3.67%	4.3
4.600	90	96.61%	3.39%	1084	3.39%	4.5
4.800	79	96.85%	3.15%	1005	3.15%	4.7
5.000	68	97.07%	2.93%	937	2.93%	4.9
5.200	65	97.27%	2.73%	872	2.73%	5.1
5.400	79	97.52%	2.48%	793	2.48%	5.3
5.600	54	97.69%	2.31%	739	2.31%	5.5
5.800	50	97.84%	2.16%	689	2.16%	5.7
6.000	93	98.13%	1.87%	596	1.87%	5.9
6.200	78	98.38%	1.62%	518	1.62%	6.1
6.400	42	98.51%	1.49%	476	1.49%	6.3
6.600	57	98.69%	1.31%	419	1.31%	6.5
6.800	60	98.88%	1.12%	359	1.12%	6.7
7.000	61	99.07%	0.93%	298	0.93%	6.9
7.200	43	99.20%	0.80%	255	0.80%	7.1
7.400	46	99.35%	0.65%	209	0.65%	7.3
7.600	41	99.47%	0.53%	168	0.53%	7.5
7.800	37	99.59%	0.41%	131	0.41%	7.7
8.000	40	99.72%	0.28%	91	0.28%	7.9
8.200	91	100.00%	0.00%	0	0.00%	8.1
sum	31949			history		

Table 1. Well M-1 smoothed turbidity frequency histogram

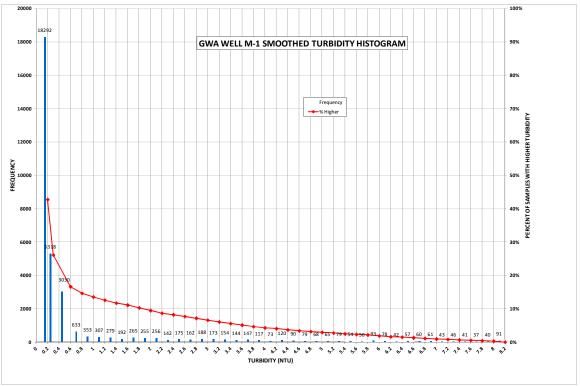


Figure 2. Well M-1 smoothed turbidity frequency curve

		TOTAL HARDNESS	CALCIUM (mg/L as	MAGNESIUM (mg/L as	CHLORIDES	TOTAL COLIFORM	F COLL (MPN/100	ENTERO COCCI	NITRATES
WELL NO.	DATE SAMPLED	(mg/L as CaCO3)	CaCO3)	CaCO3)	(mg/L)	(MPN/100 ML)	ML)	(MPN/100 ML)	(MG/L)
M-1	07/14/09		-			<1	<1	<1	
M-1	07/20/09					<1	<1	<1	
M-1	07/27/09					<1	<1	<1	
M-1	08/03/09	268	206	62	164	<1	<1	<1	3.1
M-1	08/11/09					<1	<1	<1	
M-1	08/21/09					<1	<1	<1	
M-1	08/26/09					<1	<1	<1	
M-1	09/02/09	274	180	94	183	<1	<1	<1	
M-1	09/11/09	2/7	100	34	100	<1	<1	<1	3.2
									3.2
M-1	09/11/09					<1	<1	<1	
M-1	09/18/09					<1	<1	<1	
M-1	09/25/09					<1	<1	<1	
M-1	10/01/09	268	180	88	193	<1	<1	<1	
M-1	10/05/09					<1	<1	<1	3.4
M-1	10/16/09					<1	<1	<1	
M-1	10/20/09					<1	<1	nd	
M-1	10/27/09					<1	<1	<1	
M-1	11/04/09					<1	<1	<1	
M-1	11/09/09	270	176	6	187	<1	<1	3.0	3.3
M-1	11/19/09					<1	<1	<1	
M-1	11/25/09					<1	<1	<1	
M-1	12/01/09					<1	<1	<1	
M-1	12/07/09	240	216	24	201	<1	<1	<1	3.3
M-1	12/17/09	2.40	210		201	<1	<1	<1	5.5
M-1	12/17/09			 		<1	<1	<1	
M-1	12/23/09			 		<1	<1	<1	
				 					
M-1	01/04/10	05-			0	<1	<1	<1	
M-1	01/11/10	286	216	70	204	<1	<1	<1	1.7
M-1	01/21/10			-		<1	<1	<1	
M-1	01/28/10					<1	<1	<1	
M-1	02/01/10					1.0	<1	<1	
M-1	02/08/10	274	174	100	208	<1	<1	<1	3.3
M-1	02/18/10					1.0	<1	<1	
M-1	02/24/10					<1	<1	<1	
M-1	03/04/10					<1	<1	<1	
M-1	03/09/10	278	164	114	220	<1	<1	<1	3.3
M-1	03/18/10					<1	<1	4.0	0.0
M-1	03/25/10					<1	<1	<1	
						t			
M-1	04/01/10	070	100	70	000	<1	<1	1.0	
M-1	04/08/10	270	192	78	228	<1	<1	<1	3.2
M-1	04/14/10					<1	<1	<1	
M-1	04/22/10					<1	<1	<1	
M-1	04/30/10					<1	<1	1.0	
M-1	05/07/10					<1	<1	<1	
M-1	05/13/10					<1	<1	<1	
M-1	05/20/10					<1	<1	<1	
M-1	05/25/10	260	180	80	236	<1	<1	<1	3.4
M-1	06/01/10					<1	<1	<1	
M-1	06/07/10	278	180	98	214	<1	<1	<1	3.1
M-1	06/17/10					<1	<1	<1	
M-1	06/24/10					<1	<1	<1	
M-1	07/01/10					<1	<1	<1	
M-1	07/09/10			İ		<1	<1	<1	
M-1	07/12/10	290	200	90	222	<1	<1	<1	3.3
M-1	08/05/10	230	200	30		43.5	<1	<1	5.5
M-1	08/09/10	280	210	70	226	Check bacti results!	1	<1	3.3
									3.3
M-1 M-1	09/09/10	308	186	122	252	1.0	<1	<1	
	09/17/10			 		<1	<1	<1	
M-1	09/20/10			 		<1	<1	<1	3.3
M-1	09/30/10			-		<1	<1	<1	
M-1	10/07/10					<1	<1	<1	ļ
M-1	10/15/10					<1	<1	<1	1
M-1	10/18/10	246	196	50	200	<1	<1	<1	3.2
M-1	10/27/10					<1	<1	<1	
M-1	11/03/10					<1	<1	<1	
M-1	11/08/10	278	178	100	222	<1	<1	<1	3.5
M-1	11/18/10					<1	<1	<1	
M-1	11/23/10					<1	<1	<1	1
M-1	12/01/10					<1	<1	<1	
M-1	12/06/10	298	202	96	215	<1	<1	<1	3.4
M-1	12/16/10		-	İ		<1	<1	<1	
M-1	01/06/11					<1	<1	<1	
M-1	01/12/11			 		<1	<1	<1	
		004	004	00	040				
M-1	01/18/11	284	204	80	243	<1	<1	<1	3.2
M-1	01/27/11			1		<1	<1	<1	——
M-1	02/04/11					<1	<1	<1	
M-1	02/10/11					<1	<1	<1	
M-1	02/14/11	292	194	98	189	<1	<1	<1	3.3
M-1	02/25/11					<1	<1	<1	
M-1	03/02/11					<1	<1	<1	
M-1	03/11/11					<1	<1	<1	
	03/14/11	296	190	106	230	<1	<1	NA	3.1

Table 2. Well M-1 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF	LOW =.1 MEDIUM = .5 HIGH = 1
M-1	8/3/2009	STORM	LOW	0.1

NO 2011 MPA DATA

Table 3. Well M-1 MPA data

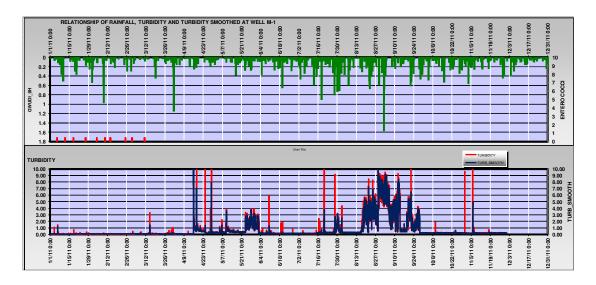


Figure 3. Well M-1 multi-variable scanner

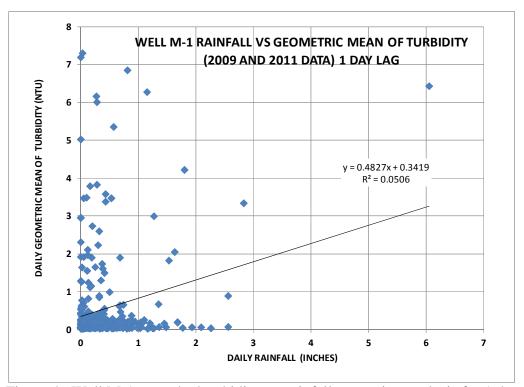


Figure 4. Well M-1 smoothed turbidity vs. rainfall regression analysis for 1 day lag

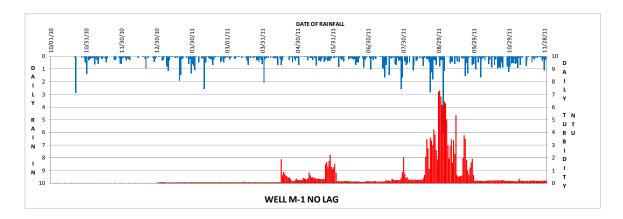


Figure 5. Well M-1 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

(ALL TOTAL COLIFORM DATA WITH MATCHING RAINFALL = ZERO)

Figure 6. Well M-1 total coliform vs. rainfall regression analysis

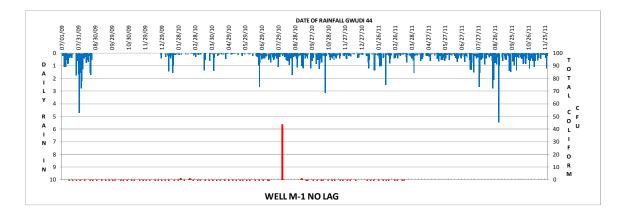


Figure 7. Well M-1 visual scan of daily rainfall versus total coliform

(ALL E. COLI DATA = ZERO)

Figure 8. Well M-1 E. coli vs. rainfall regression analysis

(ALL E. COLI DATA = ZERO)

Figure 9. Well M-1 visual scan of daily rainfall versus E. Coli

(ALL ENTEROCOCCI DATA WITH MATCHING RAINFALL = ZERO)

Figure 10. Well M-1 enterococci vs. rainfall regression analysis

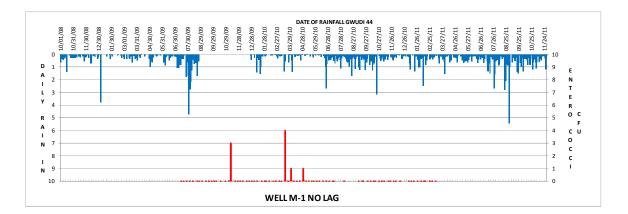


Figure 11. Well M-1 visual scan of daily rainfall versus enterococci

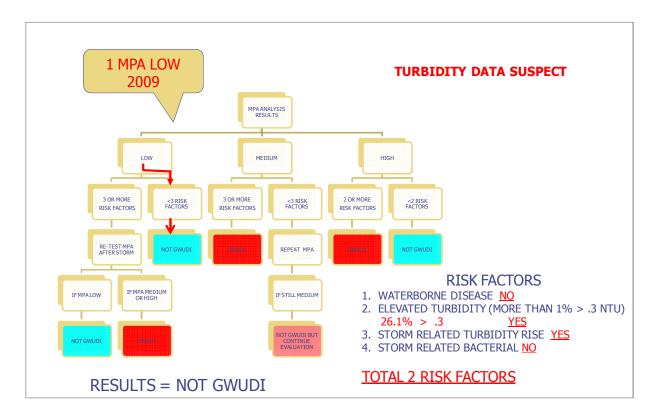


Figure 12. Well M-1 GWUDI determination decision tree

APPENDIX 10 WELL M-5 DATA AND ANALYSIS

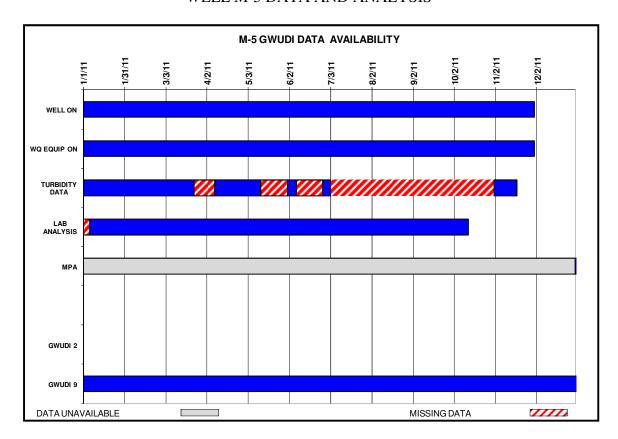


Figure 1. Well M-5 data availability

Bin	FREQUENCY	Cumulative %	% HIGHER	Number Higher	INVERSE CUMULATIVE %	BIN AVG
0.200	10933	83.38%	16.62%	2179	16.62%	0.15
0.300	163	84.62%	15.38%	2016	15.38%	0.25
0.600	295	86.87%	13.13%	1721	13.13%	0.45
0.800	111	87.72%	12.28%	1610	12.28%	0.7
1.000	113	88.58%	11.42%	1497	11.42%	0.9
1.200	126	89.54%	10.46%	1371	10.46%	1.1
1.400	168	90.83%	9.17%	1203	9.17%	1.3
1.600	137	91.87%	8.13%	1066	8.13%	1.5
1.800	170	93.17%	6.83%	896	6.83%	1.7
2.000	112	94.02%	5.98%	784	5.98%	1.9
2.200	101	94.79%	5.21%	683	5.21%	2.1
2.400	69	95.32%	4.68%	614	4.68%	2.3
2.600	42	95.64%	4.36%	572	4.36%	2.5
2.800	45	95.98%	4.02%	527	4.02%	2.7
3.000	27	96.19%	3.81%	500	3.81%	2.9
3.200	26	96.38%	3.62%	474	3.62%	3.1
3.400	21	96.55%	3.45%	453	3.45%	3.3
3.600	22	96.71%	3.29%	431	3.29%	3.5
3.800	15	96.83%	3.17%	416	3.17%	3.7
4.000	19	96.97%	3.03%	397	3.03%	3.9
4.200	21	97.13%	2.87%	376	2.87%	4.1
4.400	25	97.32%	2.68%	351	2.68%	4.3
4.600	22	97.49%	2.51%	329	2.51%	4.5
4.800	17	97.62%	2.38%	312	2.38%	4.7
5.000	14	97.73%	2.27%	298	2.27%	4.9
5.200	17	97.86%	2.14%	281	2.14%	5.1
5.400	6	97.90%	2.10%	275	2.10%	5.3
5.600	16	98.02%	1.98%	259	1.98%	5.5
5.800	10	98.10%	1.90%	249	1.90%	5.7
6.000	21	98.26%	1.74%	228	1.74%	5.9
6.200	16	98.38%	1.62%	212	1.62%	6.1
6.400	11	98.47%	1.53%	201	1.53%	6.3
6.600	14	98.57%	1.43%	187	1.43%	6.5
6.800	16	98.70%	1.30%	171	1.30%	6.7
7.000	15	98.81%	1.19%	156	1.19%	6.9
7.200	9	98.88%	1.12%	147	1.12%	7.1
7.400	8	98.94%	1.06%	139	1.06%	7.3
7.600	8	99.00%	1.00%	131	1.00%	7.5
7.800	12	99.09%	0.91%	119	0.91%	7.7
8.000	15	99.21%	0.79%	104	0.79%	7.9
8.200	104	100.00%	0.00%	0	0.00%	8.1
sum	13112					

Table 1. Well M-5 smoothed turbidity frequency histogram

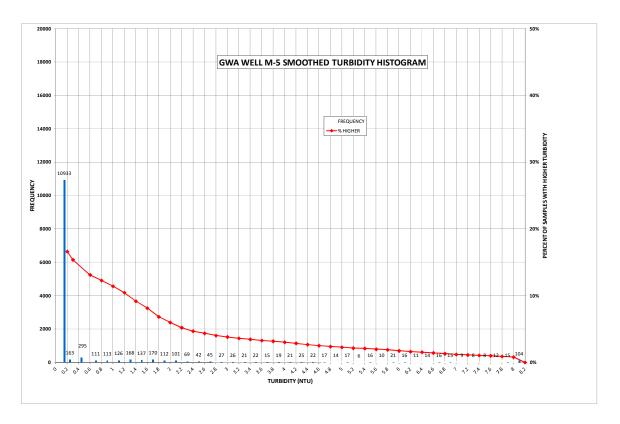


Figure 2. Well M-5 smoothed turbidity frequency curve

WELL NO.	DATE SAMPLED	TOTAL HARDNESS (mg/L as CaCO3)	CALCIUM (mg/L as CaCO3)	MAGNESIUM (mg/L as CaCO3)	CHLORIDES (mg/L)	TOTAL COLIFORM (MPN/100 ML)	E. COLI (MPN/100 ML)	ENTERO COCCI (MPN/100 ML)	NITRATES (MG/L)
M-5	07/20/09	(g, 2 23 02003)	00000	3.300)	1	(MF14/100 ML)	<1	<1 <1	(G/L)
M-5	07/27/09					<1	<1	<1	
M-5	08/03/09	258	220	38	87	<1	<1	<1	1.7
M-5	08/11/09				-	<1	<1	<1	
M-5	08/21/09					<1	<1	<1	
M-5	08/26/09					2.0	<1	<1	
M-5	09/02/09	264	228	36	88	<1	<1	<1	
M-5	09/11/09	201	220	- 55		<1	<1	<1	1.0
M-5	09/11/09					<1	<1	<1	1.0
M-5	09/18/09					<1	<1	<1	
M-5	09/25/09					<1	<1	<1	
M-5	10/01/09	200	no.		no.				
		ns	ns	ns	ns	ns	ns	ns	1.7
M-5	10/05/09					<1	<1	<1	1.7
M-5	10/16/09					<1	<1	<1	
M-5	10/20/09					<1	<1	nd	
M-5	10/27/09					<1	<1	<1	
M-5	11/04/09					<1	<1	<1	
M-5	11/09/09	266	210	56	90	<1	<1	<1	1.7
M-5	11/19/09					<1	<1	<1	
M-5	11/25/09					<1	<1	<1	
M-5	12/01/09					<1	<1	<1	
M-5	12/07/09	250	226	24	93	<1	<1	<1	2.0
M-5	12/17/09					1.0	<1	<1	
M-5	12/23/09					<1	<1	<1	
M-5	12/29/09					<1	<1	<1	
M-5	01/04/10					<1	<1	<1	
M-5	01/11/10	292	214	78	194	<1	<1	<1	3.2
M-5	01/21/10					<1	<1	<1	
M-5	01/28/10					<1	<1	<1	
M-5	02/01/10					<1	<1	<1	
M-5	02/08/10	266	230	36	77	<1	<1	1.0	1.8
M-5	02/18/10					1.0	<1	<1	
M-5	02/24/10					<1	<1	<1	
M-5	03/04/10					<1	<1	<1	
M-5	03/09/10	256	200	56	94	<1	<1	<1	1.8
M-5	03/18/10	230	200	30	34	2.0	<1	5	1.0
M-5	03/25/10					1.0	<1	<1	
M-5	04/01/10	050	000	20	00	<1	<1	<1	1.0
M-5	04/08/10	252	220	32	99	<1	<1	<1	1.8
M-5	04/14/10					<1	<1	<1	
M-5	04/22/10					<1	<1	<1	
M-5	04/30/10					1.0	<1	1.0	
M-5	05/07/10					4.1	<1	<1	
M-5	05/13/10					<1	<1	<1	
M-5	05/20/10					2.0	<1	<1	
M-5	05/25/10	250	202	48	97	2.0	<1	<1	1.9
M-5	06/01/10					<1	<1	<1	
M-5	06/07/10	250	208	42	86	<1	<1	<1	1.7
M-5	06/17/10					<1	<1	<1	
M-5	06/24/10					<1	<1	<1	
M-5	07/01/10					<1	<1	5.2	
M-5	07/09/10					<1	<1	<1	
M-5	07/12/10	300	224	76	80	<1	<1	<1	1.8
M-5	08/05/10					112.6	<1	1.0	
M-5	08/09/10	292	258	34	80	<1	<1	<1	1.8
M-5	09/09/10	276	232	44	104	<1	<1	<1	
M-5	09/17/10					<1	<1	<1	
M-5	09/20/10					<1	<1	<1	1.8
M-5	09/30/10					<1	<1	<1	
M-5	10/07/10					<1	<1	<1	
M-5	10/15/10					<1	<1	<1	
M-5	10/18/10	250	212	38	80	<1	<1	<1	1.7
M-5	10/27/10					<1	<1	<1	
M-5	11/03/10			İ	İ	<1	<1	<1	
M-5	11/08/10	256	200	56	87	<1	<1	1.0	1.8
M-5	11/18/10			T	T	2.0	<1	<1	
M-5	11/23/10			l	1	<1	<1	<1	
M-5	12/01/10				 	<1	<1	1.0	
M-5	12/01/10	252	204	48	74	<1	<1	<1	1.8
M-5	12/16/10	LJE	204	+0	/+	1.0	<1	<1	1.0
				l	1				
M-5	01/06/11			 	 	<1	<1	<1	
M-5	01/12/11	050	040	 ,,	F2	1.0	<1	<1	1.0
M-5	01/18/11	256	212	44	53	<1	<1	<1	1.8
M-5	01/27/11				-	<1	<1	<1	
M-5	02/04/11				 	<1	<1	<1	
M-5	02/10/11			ļ		<1	<1	<1	
M-5	02/14/11	250	218	32	76	<1	<1	<1	1.8
M-5	02/25/11					7.4	<1	<1	
M-5	03/02/11					<1	<1	<1	
		1		I		2.0	<1	<1	l
M-5 M-5	03/11/11						<1	NA	

Table 2. Well M-5 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	LOW =.1 MEDIUM = .5 HIGH = 1
M-5	8/17/2009	STORM	LOW	0.1

NO 2011 MPA DATA

Table 3. Well M-5 MPA data

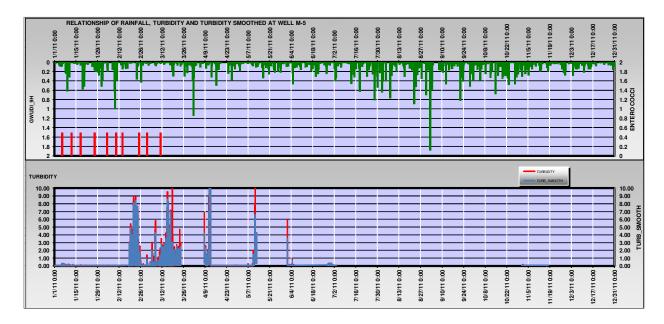


Figure 3. Well M-5 multi-variable scanner

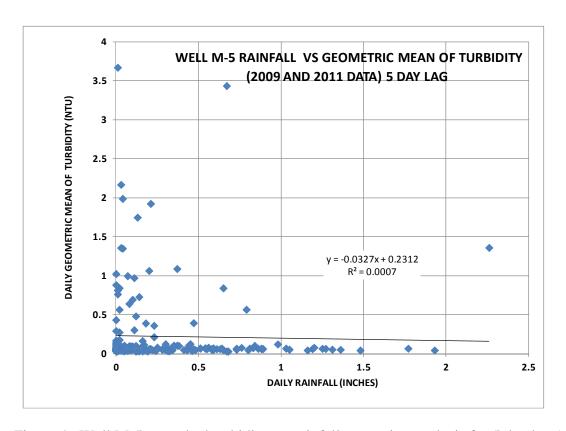


Figure 4. Well M-5 smoothed turbidity vs. rainfall regression analysis for 5 day lag (all lags yielded negative slopes)

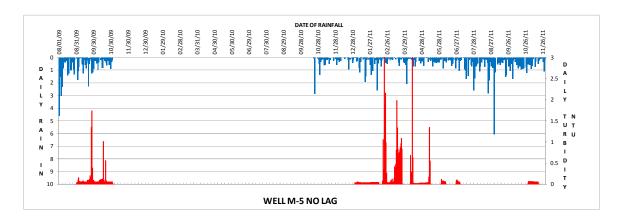


Figure 5. Well M-5 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

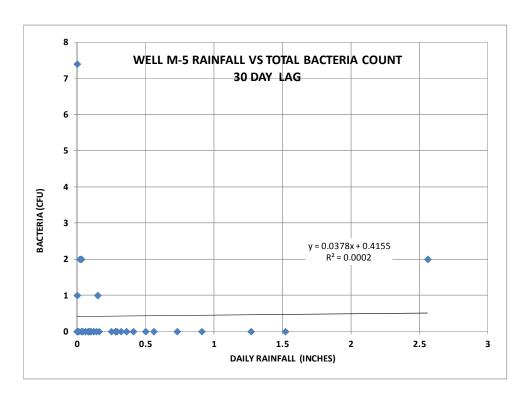


Figure 6. Well M-5 total coliform vs. rainfall regression analysis for 30 day lag

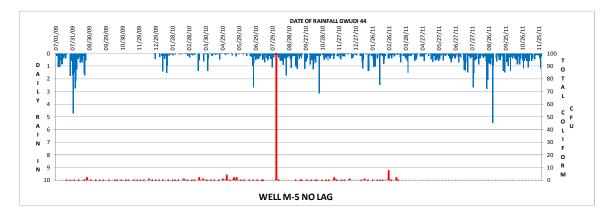


Figure 7. Well M-5 visual scan of daily rainfall versus total coliform

(ALL E. COLI DATA = ZERO)

Figure 8. Well M-5 E. coli vs. rainfall regression analysis

(ALL E. COLI DATA = ZERO)

Figure 9. Well M-5 visual scan of daily rainfall versus E. Coli

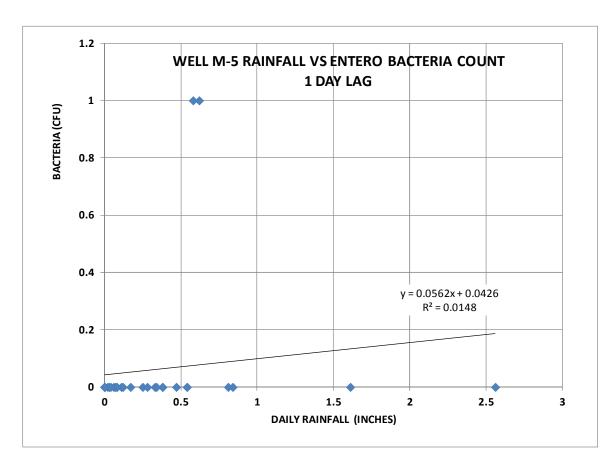


Figure 10. Well M-5 enterococci vs. rainfall regression analysis for 1 day lag

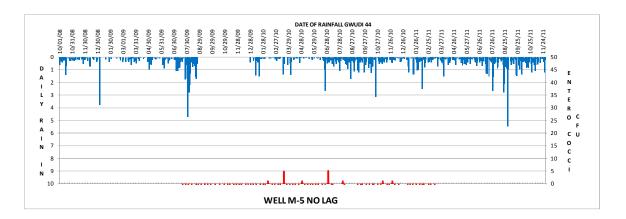


Figure 11. Well M-5 visual scan of daily rainfall versus enterococci

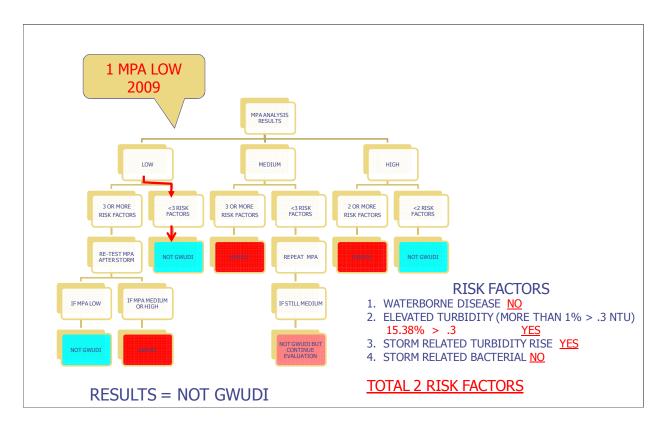


Figure 12. Well M-5 GWUDI determination decision tree

APPENDIX 11 WELL M-20A DATA AND ANALYSIS

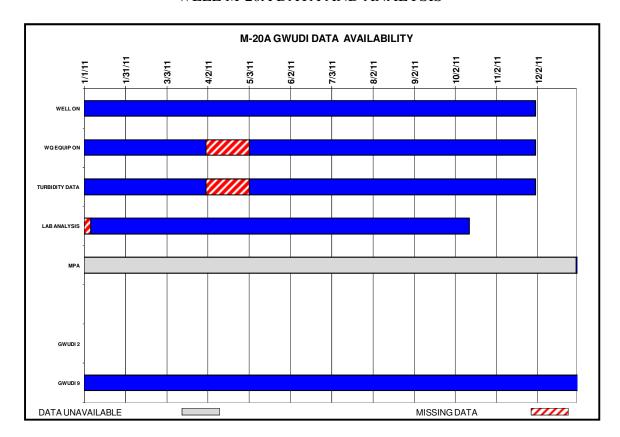


Figure 1. Well M-20A data availability

Bin	Frequency	Cumulative %	% Higher	Number Higher	Inverse Cumulative %	Bin Avg
0.100	25062	88.23%	11.77%	3342	11.77%	0.05
0.200	1336	92.94%	7.06%	2006	7.06%	0.15
0.300	631	95.16%	4.84%	1375	4.84%	0.25
0.400	458	96.77%	3.23%	917	3.23%	0.35
0.500	107	97.15%	2.85%	810	2.85%	0.45
0.600	80	97.43%	2.57%	730	2.57%	0.55
0.700	32	97.54%	2.46%	698	2.46%	0.65
0.800	21	97.62%	2.38%	677	2.38%	0.75
0.900	23	97.70%	2.30%	654	2.30%	0.85
1.000	14	97.75%	2.25%	640	2.25%	0.95
1.100	18	97.81%	2.19%	622	2.19%	1.05
1.200	16	97.87%	2.13%	606	2.13%	1.15
1.300	15	97.92%	2.08%	591	2.08%	1.25
1.400	9	97.95%	2.05%	582	2.05%	1.35
1.500	7	97.98%	2.02%	575	2.02%	1.45
1.600	6	98.00%	2.00%	569	2.00%	1.55
1.700	5	98.01%	1.99%	564	1.99%	1.65
1.800	4	98.03%	1.97%	560	1.97%	1.75
1.900	8	98.06%	1.94%	552	1.94%	1.85
2.000	3	98.07%	1.93%	549	1.93%	1.95
2.100	3	98.08%	1.92%	546	1.92%	2.05
2.200	4	98.09%	1.91%	542	1.91%	2.15
2.300	8	98.12%	1.88%	534	1.88%	2.25
2.400	2	98.13%	1.87%	532	1.87%	2.35
2.500	5	98.14%	1.86%	527	1.86%	2.45
2.600	1	98.15%	1.85%	526	1.85%	2.55
2.700	3	98.16%	1.84%	523	1.84%	2.65
2.800	1	98.16%	1.84%	522	1.84%	2.75
2.900	2	98.17%	1.83%	520	1.83%	2.85
3.000	2	98.18%	1.82%	518	1.82%	2.95
3.100	3	98.19%	1.81%	515	1.81%	3.05
3.200	1	98.19%	1.81%	514	1.81%	3.15
3.300	7	98.22%	1.78%	507	1.78%	3.25
3.400	5	98.23%	1.77%	502	1.77%	3.35
3.500	2	98.24%	1.76%	500	1.76%	3.45
3.600	4	98.25%	1.75%	496	1.75%	3.55
3.700	7	98.28%	1.72%	489	1.72%	3.65
3.800	2	98.29%	1.71%	487	1.71%	3.75
3.900	3	98.30%	1.70%	484	1.70%	3.85
5.000	43	98.45%	1.55%	441	1.55%	4.45
4.100	441	100.00%	0.00%	0	0.00%	4.55
sum	28404					

Table 1. Well M-20A smoothed turbidity frequency histogram

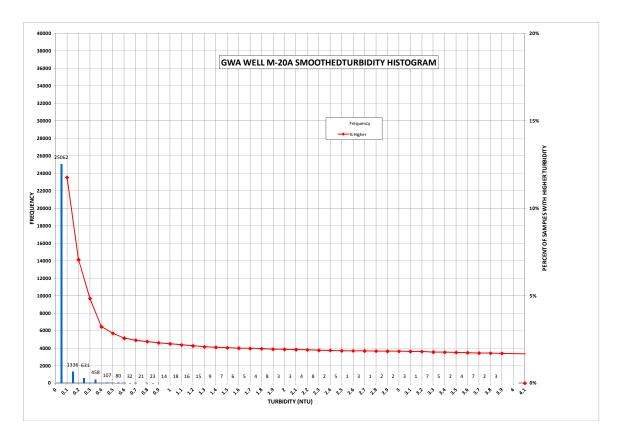


Figure 2. Well M-20A smoothed turbidity frequency curve

M-20A 08// M-20A 08// M-20A 08// M-20A 08// M-20A 09// M-20A 09// M-20A 09// M-20A 09// M-20A 09// M-20A 10// M-20A 10// M-20A 10// M-20A 10// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 12//	7/27/09 8/03/09 8/03/09 8/11/09 8/21/09 8/26/09 9/02/09 9/11/09 9/18/09 9/18/09 9/16/09 0/26/09 0/27/09	254	226	28	74	1.0 <1 <1 <1 <1 <1	41 41 41 41 41	<1 <1 <1 <1 <1 <1 <1 <1 <1 <1 <1 <1 <1 <	3.0
M-20A 08/ M-20A 08/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 12/	8/11/09 8/21/09 8/21/09 8/26/09 8/26/09 9/11/09 9/11/09 9/18/09 9/18/09 9/18/09 0/05/09 0/16/09 0/20/09	270				<1 <1 <1	<1 <1 <1	<1 <1 <1	3.0
M-20A 08/ M-20A 08/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/	8/21/09 8/26/09 9/02/09 9/11/09 9/11/09 9/11/09 9/18/09 9/25/09 0/01/09 0/05/09 0/16/09		244	26	84	<1 <1	<1 <1	<1 <1	
M-20A 08/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/	8/26/09 9/02/09 9/11/09 9/11/09 9/11/09 9/18/09 9/25/09 0/01/09 0/05/09 0/16/09		244	26	84	<1	<1	<1	
M-20A 08/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/	8/26/09 9/02/09 9/11/09 9/11/09 9/11/09 9/18/09 9/25/09 0/01/09 0/05/09 0/16/09		244	26	84	<1	<1	<1	
M-20A 09/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/	9/02/09 9/11/09 9/11/09 9/18/09 9/25/09 0/01/09 0/05/09 0/16/09 0/20/09		244	26	84				
M-20A 09/ M-20A 09/ M-20A 09/ M-20A 09/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 12/	9/11/09 9/11/09 9/18/09 9/25/09 0/01/09 0/05/09 0/16/09 0/20/09		244	20	04				1
M-20A 09/ M-20A 09/ M-20A 09/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/	9/11/09 9/18/09 9/25/09 0/01/09 0/05/09 0/16/09 0/20/09	296							4.5
M-20A 09/ M-20A 09/ M-20A 09/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/	9/18/09 9/25/09 0/01/09 0/05/09 0/16/09 0/20/09	296				<1	<1	<1	1.5
M-20A 09/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 10/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/	9/25/09 0/01/09 0/05/09 0/16/09 0/20/09	296				<1	<1	<1	ļ
M-20A 10// M-20A 10// M-20A 10// M-20A 10// M-20A 10// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12//	0/01/09 0/05/09 0/16/09 0/20/09	296				5.1	<1	<1	
M-20A 10// M-20A 10// M-20A 10// M-20A 10// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12//	0/05/09 0/16/09 0/20/09	296				<1	<1	<1	
M-20A 10// M-20A 10// M-20A 10// M-20A 10// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12//	0/05/09 0/16/09 0/20/09		224	72	121	<1	<1	<1	
M-20A 10/ M-20A 100/ M-20A 100/ M-20A 110/ M-20A 111/ M-20A 111/ M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/	0/16/09 0/20/09					<1	<1	<1	3.0
M-20A 10// M-20A 10// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12//	0/20/09								0.0
M-20A 10// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12//						<1	<1	<1	+
M-20A 11// M-20A 11// M-20A 11// M-20A 11// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12//	0/27/09					<1	<1	nd	ļ
M-20A 11/ M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/						<1	<1	3.1	
M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/	1/04/09					<1	<1	<1	
M-20A 11/ M-20A 11/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/	1/09/09	260	246	14	73	<1	<1	<1	3.2
M-20A 11// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12// M-20A 12//	1/19/09					<1	<1	<1	
M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/	1/25/09					<1	<1	1.0	+
M-20A 12/ M-20A 12/ M-20A 12/ M-20A 12/									+
M-20A 12/ M-20A 12/ M-20A 12/	2/01/09					<1	<1	<1	
M-20A 12/3 M-20A 12/3	2/07/09	264	250	14	89	<1	<1	<1	3.1
M-20A 12/	2/17/09					2.0	<1	<1	<u></u>
M-20A 12/	2/23/09					<1	<1	<1	
	2/29/09					<1	<1	<1	1
IVITZUM UT/	1/04/10					<1	<1	<1	†
		004	004	00	OF.				
	1/11/10	294	234	60	25	<1	<1	<1	3.1
	1/21/10					<1	<1	<1	ļ
M-20A 01/3	1/28/10					<1	<1	<1	
M-20A 02/	2/01/10					<1	<1	<1	
	2/08/10	288	232	56	80	<1	<1	<1	3.0
	2/18/10			30		<1	<1	<1	
									
	2/24/10					<1	<1	<1	├
M-20A 03/	3/04/10					<1	<1	<1	
M-20A 03/	3/09/10	270	226	44	87	<1	<1	<1	3.0
M-20A 03/	3/18/10					<1	<1	<1	
	3/25/10					<1	<1	<1	
	4/01/10								†
						<1	<1	<1	
	4/08/10	260	226	34	108	<1	<1	<1	3.1
M-20A 04/	4/14/10					2.0	<1	<1	
M-20A 04/	4/22/10					2.0	<1	<1	
M-20A 04/	4/30/10					<1	<1	1.0	
	5/07/10					<1	<1	<1	
	5/13/10					<1	<1	<1	+
									+
	5/20/10					<1	<1	<1	
	5/25/10	260	220	40	113	<1	<1	<1	3.3
M-20A 06/	6/01/10					<1	<1	<1	
M-20A 06/	6/07/10	236	220	16	101	<1	<1	<1	3.2
M-20A 06/	6/17/10					<1	<1	<1	
	6/24/10					<1	<1	<1	
									-
	7/01/10					<1	<1	<1	+
	7/09/10					<1	<1	<1	
M-20A 07/	7/12/10	266	256	10	85	<1	<1	<1	3.3
M-20A 08/	8/05/10				<u> </u>	1.0	<1	<1	L
M-20A 08/	8/09/10	250	238	12	98	<1	<1	<1	3.4
	9/09/10	256	250	6	104	<1	<1	<1	1
	9/17/10			-	·	<1	<1	<1	†
					l				
	9/20/10					<1	<1	<1	3.3
	9/30/10				ļ	<1	<1	<1	
	0/07/10					<1	<1	<1	ļ
M-20A 10/	0/15/10					<1	<1	<1	
M-20A 10/	0/18/10	254	230	24	104	<1	<1	<1	3.2
	0/27/10					<1	<1	<1	
	1/03/10					<1	<1	<1	1
		250	010	00	105				2.0
	1/08/10	256	218	38	105	<1	<1	<1	3.3
	1/18/10					<1	<1	<1	
M-20A 11/	1/23/10					<1	<1	<1	
M-20A 12/	2/01/10					<1	<1	<1	
	2/06/10	272	254	18	92	<1	<1	<1	3.2
	2/16/10			-	·-	<1	<1	<1	†
									†
	1/06/11					<1	<1	<1	
	1/12/11					<1	<1	<1	
	1/18/11	270	234	36	103	<1	<1	<1	2.3
M-20A 01/2	1/27/11					<1	<1	<1	
	2/04/11					<1	<1	<1	
	2/10/11					<1	<1	<1	
		070	OE?	00	6.				
M-20A 02/	2/14/11	270	250	20	91	<1	<1	<1	3.3
M-20A 02/ M-20A 02/	2/25/11					<1	<1	<1	
M-20A 02/ M-20A 02/ M-20A 02/	3/02/11					<1	<1	<1	
M-20A 02/ M-20A 02/ M-20A 02/					1	1.0	<1	<1	
M-20A 02/ M-20A 02/ M-20A 02/ M-20A 03/	3/11/11				1				

Table 2. Well M-20A laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	LOW =.1 MEDIUM = . HIGH = 1
M-20A	8/3/2009	STORM	LOW	0.1
		NO 2011 MPA D	DATA	

Table 3. Well M-20A MPA data

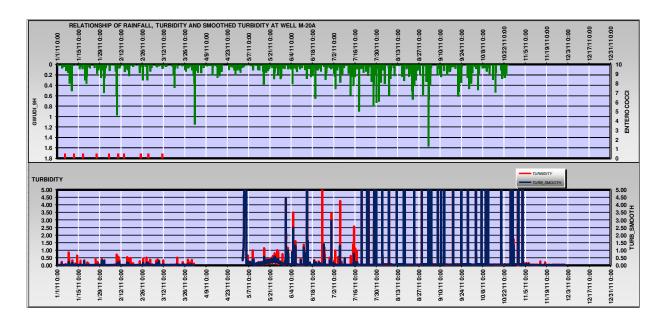


Figure 3. Well M-20A multi-variable scanner

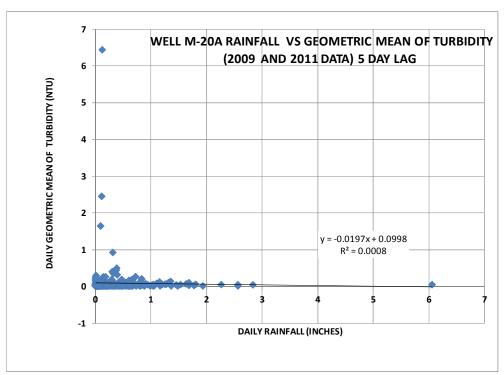


Figure 4. Well M-20A smoothed turbidity vs. rainfall regression analysis for 5 day lag (all lags yielded negative slopes)

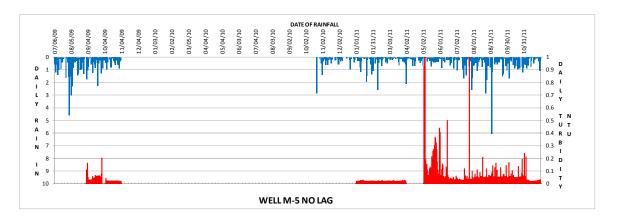


Figure 5. Well M-20A visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

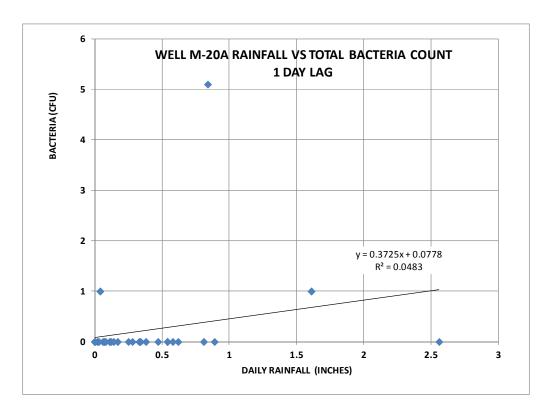


Figure 6. Well M-20A total coliform vs. rainfall regression analysis for 1 day lag

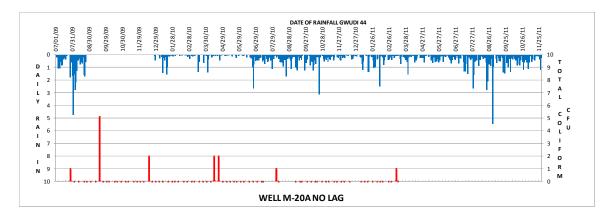


Figure 7. Well M-20A visual scan of daily rainfall versus total coliform

(ALL E. COLI DATA = ZERO)

Figure 8. Well M-20A E. coli vs. rainfall regression analysis

(ALL E. COLI DATA = ZERO)

Figure 9. Well M-20A visual scan of daily rainfall versus E. Coli

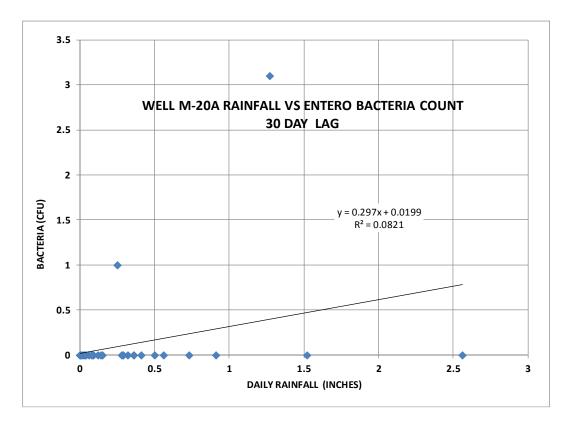


Figure 10. Well M-20A enterococci vs. rainfall regression analysis for 30 day lag

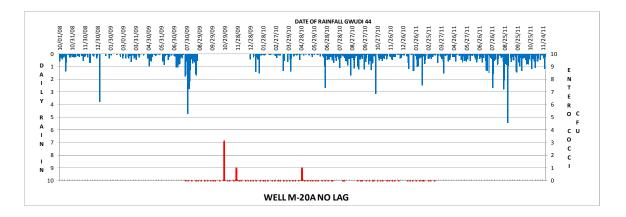


Figure 11. Well M-20A visual scan of daily rainfall versus enterococci

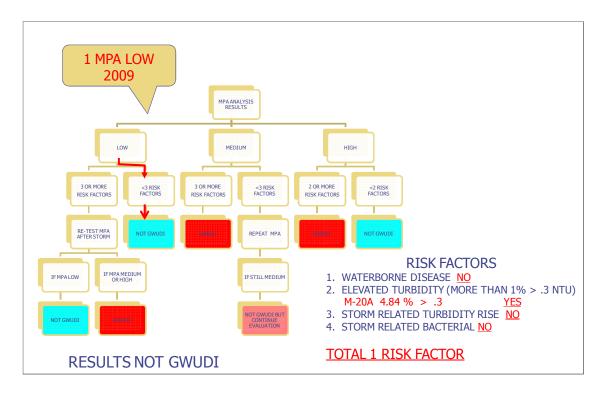
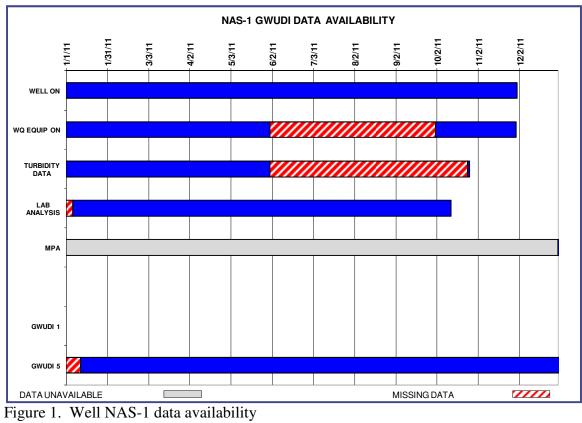


Figure 12. Well M-20A GWUDI determination decision tree

APPENDIX 12 WELL NAS-1 DATA AND ANALYSIS



Bin	FREQUENCY	Cumulative %	% HIGHER	Number Higher	INVERSE CUMULATIVE %	BIN AVG
0.0125	8959	61.60%	38.40%	5584	38.40%	0.00625
0.025	278	63.52%	36.48%	5306	36.48%	0.01875
0.0375	0	63.52%	36.48%	5306	36.48%	0.03125
0.05	0	63.52%	36.48%	5306	36.48%	0.04375
0.0625	0	63.52%	36.48%	5306	36.48%	0.05625
0.075	88	64.12%	35.88%	5218	35.88%	0.06875
0.0875	160	65.22%	34.78%	5058	34.78%	0.08125
0.1	653	69.71%	30.29%	4405	30.29%	0.09375
0.1125	1728	81.59%	18.41%	2677	18.41%	0.10625
0.125	1410	91.29%	8.71%	1267	8.71%	0.11875
0.1375	1252	99.90%	0.10%	15	0.10%	0.13125
0.15	9	99.96%	0.04%	6	0.04%	0.14375
0.1625	2	99.97%	0.03%	4	0.03%	0.15625
0.175	0	99.97%	0.03%	4	0.03%	0.16875
0.1875	2	99.99%	0.01%	2	0.01%	0.18125
0.2	0	99.99%	0.01%	2	0.01%	0.19375
0.2125	0	99.99%	0.01%	2	0.01%	0.20625
0.225	0	99.99%	0.01%	2	0.01%	0.21875
0.2375	0	99.99%	0.01%	2	0.01%	0.23125
0.25	2	100.00%	0.00%	0	0.00%	0.24375
0.2625	0	100.00%	0.00%	0	0.00%	0.25625
0.275	0	100.00%	0.00%	0	0.00%	0.26875
0.2875	0	100.00%	0.00%	0	0.00%	0.28125
0.3	0	100.00%	0.00%	0	0.00%	0.29375
0.3125	0	100.00%	0.00%	0	0.00%	0.30625
0.325	0	100.00%	0.00%	0	0.00%	0.31875
0.3375	0	100.00%	0.00%	0	0.00%	0.33125
0.35	0	100.00%	0.00%	0	0.00%	0.34375
0.3625	0	100.00%	0.00%	0	0.00%	0.35625
0.375	0	100.00%	0.00%	0	0.00%	0.36875
0.3875	0	100.00%	0.00%	0	0.00%	0.38125
0.4	0	100.00%	0.00%	0	0.00%	0.39375
0.4125	0	100.00%	0.00%	0	0.00%	0.40625
0.425	0	100.00%	0.00%	0	0.00%	0.41875
0.4375	0	100.00%	0.00%	0	0.00%	0.43125
0.45	0	100.00%	0.00%	0	0.00%	0.44375
0.4625	0	100.00%	0.00%	0	0.00%	0.45625
0.475	0	100.00%	0.00%	0	0.00%	0.46875
0.4875	0	100.00%	0.00%	0	0.00%	0.48125
0.5	0	100.00%	0.00%	0	0.00%	0.49375
0.5125	0	100.00%	0.00%	0	0.00%	0.50625
sum	14543					

Table 1. Well NAS-1 smoothed turbidity frequency histogram

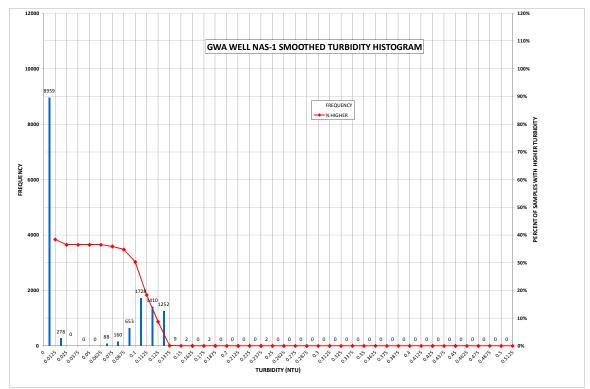


Figure 2. Well NAS-1 smoothed turbidity frequency curve

	1		CALCIUM	MAGNESIUM	1	1			
		TOTAL HARDNESS	(mg/L as	(mg/L as	CHLORIDES (mg/L)	TOTAL COLIFORM			NITRATES
WELL NO.	DATE SAMPLED	(mg/L as CaCO3)	CaCO3)	CaCO3)	(IIIg/L)	(MPN/100 ML)	ML)	(MPN/100 ML)	(MG/L)
NAS-1	07/27/09					<1	<1	<1	NAS-1
NAS-1	08/03/09	338	260	78	251	<1	<1	<1	NAS-1
NAS-1 NAS-1	08/11/09 08/21/09					<1 <1	<1 <1	<1 <1	NAS-1 NAS-1
NAS-1	08/26/09					<1	<1	<1	NAS-1
NAS-1	09/02/09	322	306	16	205	<1	<1	<1	NAS-1
NAS-1	09/11/09			-		<1	<1	<1	NAS-1
NAS-1	09/11/09					<1	<1	<1	NAS-1
NAS-1	09/18/09					<1	<1	<1	NAS-1
NAS-1	09/25/09					<1	<1	<1	NAS-1
NAS-1	10/01/09	304	276	28	188	<1	<1	<1	NAS-1
NAS-1	10/05/09					1.0	<1	<1	NAS-1
NAS-1	10/16/09					<1	<1	<1	NAS-1
NAS-1	10/20/09					<1	<1	nd	NAS-1
NAS-1	10/27/09					2.0	<1	<1	NAS-1
NAS-1	11/04/09					<1	<1	<1	NAS-1
NAS-1	11/09/09	304	260	44	179	<1	<1	<1	NAS-1
NAS-1	11/19/09					<1	<1	<1	NAS-1
NAS-1	11/25/09 12/01/09					<1 <1	<1 <1	<1 <1	NAS-1 NAS-1
NAS-1	12/07/09	290	272	18	169	<1	<1	<1	NAS-1
NAS-1	12/07/09	230	616	10	109	<1	<1	4.0	NAS-1
NAS-1	12/17/09					<1	<1	<1	NAS-1
NAS-1	12/29/09					<1	<1	<1	NAS-1
NAS-1	01/04/10					<1	<1	<1	NAS-1
NAS-1	01/11/10	324	234	90	177	<1	<1	<1	NAS-1
NAS-1	01/21/10					<1	<1	<1	NAS-1
NAS-1	01/28/10					<1	<1	<1	NAS-1
NAS-1	02/01/10					<1	<1	<1	NAS-1
NAS-1	02/08/10	350	310	40	172	<1	<1	<1	NAS-1
NAS-1	02/18/10					<1	<1	<1	NAS-1
NAS-1	02/24/10					<1	<1	<1	NAS-1
NAS-1	03/04/10					<1	<1	<1	NAS-1
NAS-1	03/09/10	270	236	34	197	<1	<1	<1	NAS-1
NAS-1	03/18/10					<1	<1	<1	NAS-1
NAS-1	03/25/10					<1	<1	4	NAS-1
NAS-1 NAS-1	04/01/10 04/08/10	318	274	44	208	<1 <1	<1 <1	1.0	NAS-1 NAS-1
NAS-1	04/06/10	310	2/4	44	200	<1	<1	<1	NAS-1
NAS-1	04/22/10					<1	<1	<1	NAS-1
NAS-1	04/30/10					<1	<1	1.0	NAS-1
NAS-1	05/07/10					<1	<1	<1	NAS-1
NAS-1	05/13/10					<1	<1	<1	NAS-1
NAS-1	05/20/10					<1	<1	<1	NAS-1
NAS-1	05/25/10	300	250	50	204	<1	<1	<1	NAS-1
NAS-1	06/01/10					<1	<1	41.9	NAS-1
NAS-1	06/07/10	308	250	58	210	<1	<1	<1	NAS-1
NAS-1	06/17/10					<1	<1	<1	NAS-1
NAS-1	06/24/10					<1	<1	<1	NAS-1
NAS-1	07/01/10					<1	<1	<1	NAS-1
NAS-1	07/09/10					<1	<1	<1	NAS-1
NAS-1	07/12/10	330	250	80	197	<1	<1	<1	NAS-1
NAS-1	08/05/10	914	200	14	200	1.0	<1	<1	NAS-1
NAS-1	08/09/10	314	300	14	209	<1	<1	<1	NAS-1
NAS-1 NAS-1	09/09/10 09/17/10	308	268	40	231	<1 <1	<1 <1	<1 <1	NAS-1 NAS-1
NAS-1	09/17/10					<1	<1	<1	NAS-1
NAS-1	09/30/10					<1	<1	<1	NAS-1
NAS-1	10/07/10					<1	<1	<1	NAS-1
NAS-1	10/15/10					<1	<1	<1	NAS-1
NAS-1	10/18/10	262	254	8	221	<1	<1	<1	NAS-1
NAS-1	11/03/10					9.7	2.0	1.0	NAS-1
NAS-1	11/08/10	310	248	62	192	<1	<1	<1	NAS-1
NAS-1	11/18/10					<1	<1	<1	NAS-1
NAS-1	11/23/10					<1	<1	1.0	NAS-1
NAS-1	12/01/10					<1	<1	<1	NAS-1
NAS-1	12/06/10	276	246	30	186	<1	<1	<1	NAS-1
NAS-1	12/16/10					2.0	<1	<1	NAS-1
NAS-1	01/06/11					<1	<1	1.0	NAS-1
NAS-1	01/12/11					4.1	<1	1.0	NAS-1
NAS-1	01/18/11	330	308	22	241	<1	<1	1.0	NAS-1
NAS-1	01/27/11					<1	<1	<1	NAS-1
NAS-1	02/04/11					<1	<1	<1	NAS-1
NAS-1	02/10/11	004	000	00	000	<1	<1	<1	NAS-1
NAS-1	02/14/11	304	266	38	238	<1	<1	<1	NAS-1
NAS-1 NAS-1	02/25/11 03/02/11					1 <1	<1 <1	<1 <1	NAS-1 NAS-1
NAS-1	03/02/11					<1	<1	<1	NAS-1 NAS-1
NAS-1	03/11/11	310	252	58	247	<1	<1	NA .	NAS-1
		0.0	LUL	~~	L				

Table 2. Well NAS-1 laboratory water quality data

MPA RESULT: RISK OF CONTAMINATION	MEDIUM = .5 HIGH = 1
LOW	0.
	CONTAMINATION

Table 3. Well NAS-1 MPA data

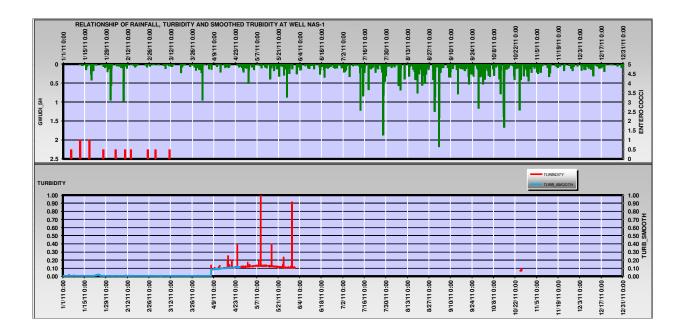


Figure 3. NAS-1 multi-variable scanner

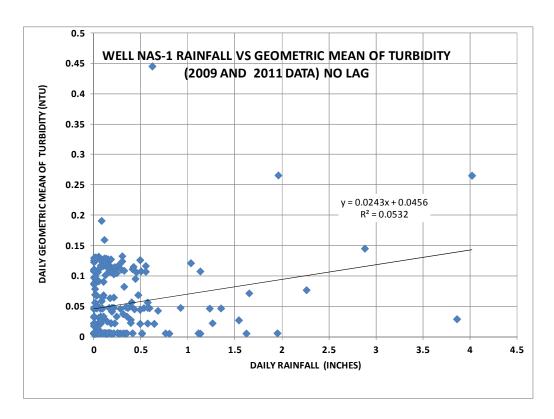


Figure 4. Well NAS-1 smoothed turbidity vs. rainfall regression analysis for 0 day lag

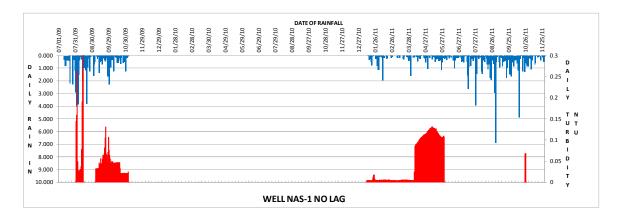


Figure 5. Well NAS-1 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

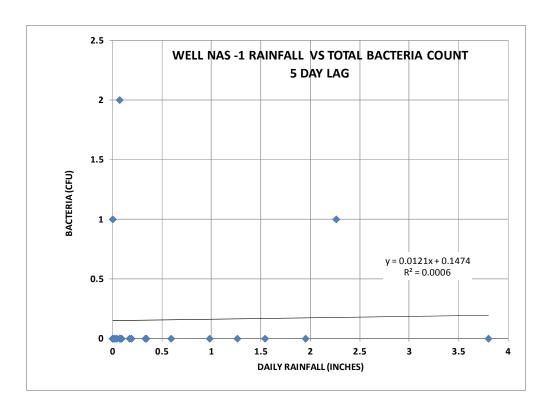


Figure 6. Well NAS-1 total coliform vs. rainfall regression analysis for 5 day lag

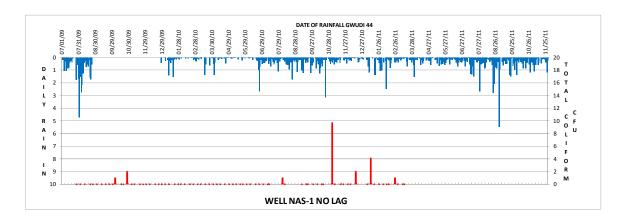


Figure 7. Well NAS-1 visual scan of daily rainfall versus total coliform

(ALL E. COLI DATA WITH MATCHING RAINFALL = 0)

Figure 8. Well NAS-1 E. coli vs. rainfall regression analysis

(ALL E. COLI DATA = ZERO)

Figure 9. Well NAS-1 visual scan of daily rainfall versus E. Coli

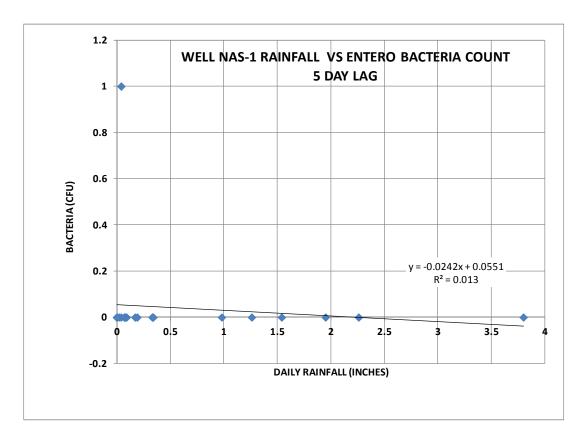


Figure 10. Well NAS-1 enterococci vs. rainfall regression analysis for 5 day lag (all lags yielded negative slopes)

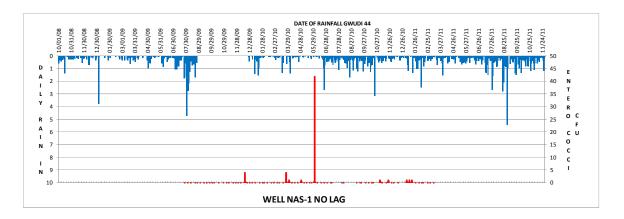


Figure 11. Well NAS-1 visual scan of daily rainfall versus enterococci

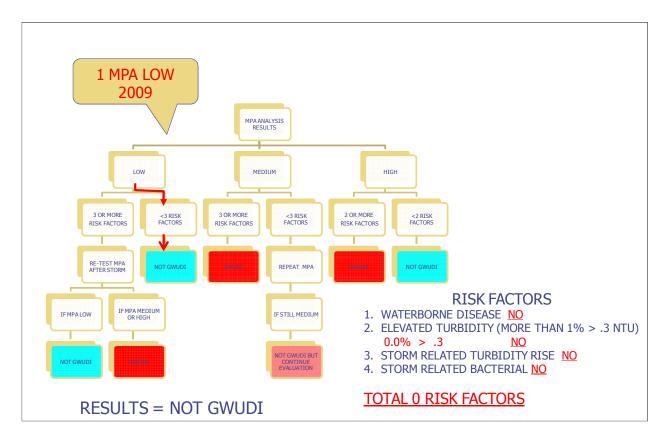


Figure 12. Well NAS-1 GWUDI determination decision tree

APPENDIX 13 WELL Y-3 DATA AND ANALYSIS

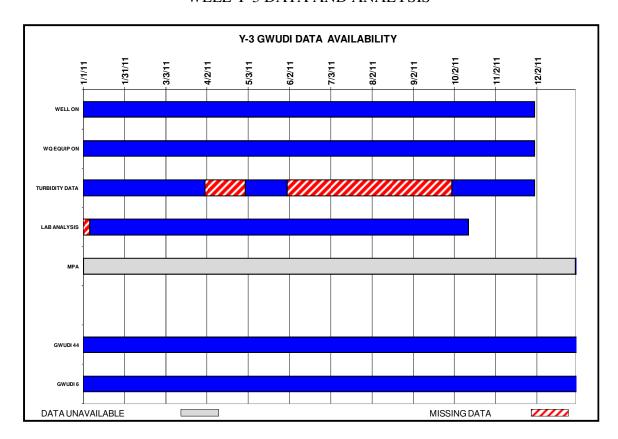


Figure 1. Well Y-3 data availability

Bin	FREQUENCY	Cumulative %	% HIGHER	Number Higher	INVERSE CUMULATIVE %	BIN AVG
0.125	2812	16.11%	83.89%	14640	83.89%	0.1125
0.15	3342	35.26%	64.74%	11298	64.74%	0.1375
0.175	4507	61.09%	38.91%	6791	38.91%	0.1625
0.2	1914	72.05%	27.95%	4877	27.95%	0.1875
0.225	1044	78.04%	21.96%	3833	21.96%	0.2125
0.25	539	81.13%	18.87%	3294	18.87%	0.2375
0.275	406	83.45%	16.55%	2888	16.55%	0.2625
0.3	338	85.39%	14.61%	2550	14.61%	0.2875
0.325	245	86.79%	13.21%	2305	13.21%	0.3125
0.35	248	88.21%	11.79%	2057	11.79%	0.3375
0.375	198	89.35%	10.65%	1859	10.65%	0.3625
0.4	151	90.21%	9.79%	1708	9.79%	0.3875
0.425	125	90.93%	9.07%	1583	9.07%	0.4125
0.45	106	91.54%	8.46%	1477	8.46%	0.4375
0.475	94	92.08%	7.92%	1383	7.92%	0.4625
0.5	109	92.70%	7.30%	1274	7.30%	0.4875
0.525	93	93.23%	6.77%	1181	6.77%	0.5125
0.55	104	93.83%	6.17%	1077	6.17%	0.5375
0.575	109	94.45%	5.55%	968	5.55%	0.5625
0.6	134	95.22%	4.78%	834	4.78%	0.5875
0.625	171	96.20%	3.80%	663	3.80%	0.6125
0.65	74	96.63%	3.37%	589	3.37%	0.6375
0.675	68	97.01%	2.99%	521	2.99%	0.6625
0.7	46	97.28%	2.72%	475	2.72%	0.6875
0.725	50	97.56%	2.44%	425	2.44%	0.7125
0.75	27	97.72%	2.28%	398	2.28%	0.7375
0.775	28	97.88%	2.12%	370	2.12%	0.7625
0.8	16	97.97%	2.03%	354	2.03%	0.7875
0.825	25	98.11%	1.89%	329	1.89%	0.8125
0.85	17	98.21%	1.79%	312	1.79%	0.8375
0.875	35	98.41%	1.59%	277	1.59%	0.8625
0.9	19	98.52%	1.48%	258	1.48%	0.8875
0.925	25	98.66%	1.34%	233	1.34%	0.9125
0.95	24	98.80%	1.20%	209	1.20%	0.9375
0.975	32	98.99%	1.01%	177	1.01%	0.9625
1	27	99.14%	0.86%	150	0.86%	0.9875
1.025	9	99.19%	0.81%	141	0.81%	1.0125
1.05	3	99.21%	0.79%	138	0.79%	1.0375
1.075	4	99.23%	0.77%	134	0.77%	1.0625
1.1	3	99.25%	0.75%	131	0.75%	1.0875
1.125	131	100.00%	0.00%	0	0.00%	1.1125
01:	17450					
sum	17452]

Table 1. Well Y-3 smoothed turbidity frequency histogram

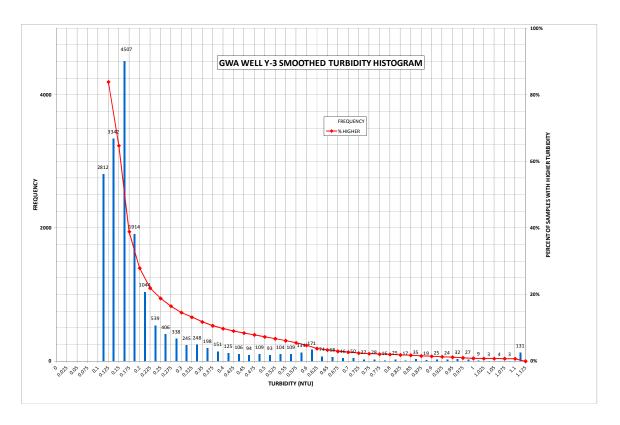


Figure 2. Well Y-3 smoothed turbidity frequency curve

WELL NO	DATE CAMDI ED	TOTAL HARDNESS	CALCIUM (mg/L as	MAGNESIUM (mg/L as	CHLORIDES (mg/L)	TOTAL COLIFORM	E. COLI (MPN/100	ENTERO COCCI	NITRATES
WELL NO.	DATE SAMPLED	(mg/L as CaCO3)	CaCO3)	CaCO3)		(MPN/100 ML)	ML)	(MPN/100 ML)	(MG/L)
Y-3	07/07/09	282	240	42	36	<1	<1	<1	3.1
Y-3	07/14/09					1.0	<1	3.1	
Y-3	07/20/09					<1	<1	<1	
Y-3	07/27/09					<1	<1	<1	
Y-3	08/03/09	268	252	16	31	>2419.2	<1	>2419.2	3.0
Y-3	08/11/09					>2419.2	21.3	387.3	
Y-3	08/21/09					>2419.2	214.2	816.4	
Y-3	08/26/09					547.5	51.2	224.7	
Y-3	09/02/09	296	280	16	47	137.4	10.8	19.7	
Y-3	09/11/09					106.7	6.3	13.0	3.1
Y-3	09/11/09					106.7	6.3	13.0	
Y-3	09/18/09					95.9	7.4	4.1	
Y-3	09/25/09					>2419.2	157.6	517.2	
		004	000	00	45				
Y-3	10/01/09	264	228	36	45	>2419.2	39.3	478.6	
Y-3	10/05/09					290.9	4.1	10.8	2.9
Y-3	10/16/09					67.0	1.0	2.0	
Y-3	10/20/09					82.0	1.0	nd	
Y-3	10/27/09					260.2	14.5	13.4	
Y-3	11/04/09					344.8	7.4	19.9	
Y-3	11/09/09	266	250	16	34	48.8	<1	<1	3.0
Y-3	11/19/09					14.5	<1	<1	
Y-3	11/25/09				i	6.3	<1	1.0	
Y-3	12/01/09				 	135.4	5.2	8.4	
Y-3	well down				-				
Y-3	12/17/09				1	74.9	<1	7.2	
Y-3	12/23/09					18.5	3.1	1.0	
Y-3	12/29/09					866.4	12.2	32.0	
Y-3	01/04/10					83.3	2.0	1.0	
Y-3	01/11/10	288	232	56	32	13.2	<1	1.0	3.3
Y-3	01/21/10					727.0	6.3	67.5	
Y-3	01/28/10					27.5	<1	<1	
Y-3	02/01/10					14.6	<1	<1	
Y-3	02/08/10	256	238	18	32	5.2	<1	<1	3.1
		230	230	10	32				3.1
Y-3	02/18/10					4.1	<1	<1	
Y-3	02/24/10					2.0	<1	<1	
Y-3	03/04/10					2.0	1.0	<1	
Y-3	03/09/10	270	244	26	46	5.2	<1	<1	3.2
Y-3	03/18/10					<1	<1	2.0	
Y-3	03/25/10					<1	<1	1.0	
Y-3	04/01/10					1.0	<1	3.0	
Y-3	04/08/10	268	242	26	51	<1	<1	1.0	3.2
Y-3	04/14/10					<1	<1	<1	
Y-3	04/22/10					<1	<1	<1	
						1			
Y-3	04/30/10					<1	<1	<1	
Y-3	05/07/10					<1	<1	<1	
Y-3	05/13/10					4.1	<1	<1	
Y-3	05/20/10					2.0	<1	<1	
Y-3	05/25/10	276	236	40	50	<1	<1	<1	3.6
Y-3	06/01/10					<1	<1	<1	
Y-3	06/07/10	260	222	38	63	1.0	<1	<1	3.1
Y-3	06/17/10					<1	<1	<1	
Y-3	06/24/10					13.5	<1	2.0	
Y-3	07/01/10					151.5	2.0	2.0	
					 				
Y-3	07/09/10	07:	0.7	6:		24.3	1.0	<1	
Y-3	07/12/10	270	246	24	46	16.1	1.0	<1	3.2
Y-3	08/05/10					43.5	<1	4.1	
Y-3	08/09/10	290	264	26	43	<1	<1	<1	3.4
Y-3	09/09/10	266	256	10	56	21.3	1.0	<1	
Y-3	09/17/10					461.1	6.3	44.8	
Y-3	09/20/10		-			120.1	12.0	12.0	3.3
Y-3	09/30/10					344.8	6.3	50.4	
Y-3	10/07/10			İ	İ	293.2	3.0	41.4	
Y-3	10/15/10				 				
		262	240	~~	45	90.4	37.3	178.2	0.4
Y-3	10/18/10	262	242	20	45	313.0	17.5	16.9	3.1
Y-3	10/27/10				1	164.3	9.6	41.9	
Y-3	11/03/10					478.6	37.3	638.8	
Y-3	11/08/10	278	226	52	60	122.3	2.0	63.1	3.3
Y-3	11/18/10					16.3	1.0	3.0	
Y-3	11/23/10					9.7	<1	<1	
Y-3	12/01/10					4.1	<1	<1	
Y-3	12/06/10	268	250	18	29	1.0	<1	<1	3.4
Y-3	12/16/10				i .	<1	<1	<1	
Y-3	01/06/11				I	<1	<1	1.0	
					 				
Y-3	01/12/11					198.9	9.8	29.5	
Y-3	01/18/11	260	248	12	42	26.2	2.0	1.0	3.2
Y-3	01/27/11					307.6	4.1	206.3	
Y-3	02/04/11					1203.3	14.6	517.2	
Y-3	02/10/11					52.0	2.0	13.1	
Y-3	02/14/11	276	256	20	35	488.4	11.0	30.5	3.3
Y-3	02/25/11		_50		T	9.8	1.0	2.0	3.0
				 	1				
Y-3	03/02/11				 	8.6	<1	<1	
110					i	1.0	<1	<1	
Y-3 Y-3	03/14/11	270	260	10	27	3.1	<1	NA ,	3.1

Table 2. Well Y-3 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	LOW =.1 MEDIUM = .5 HIGH = 1
Y-3	5/26/2009	DRY	LOW	0.1
Y-3	8/4/2009	STORM	LOW	0.1
Y-3	8/10/2009	STORM	LOW	0.1
Y-3	9/6/2011	STORM	LOW	0.1

Table 3. Well Y-3 MPA data

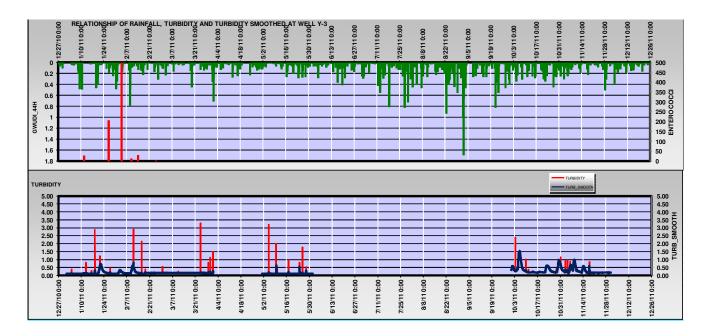


Figure 3. Y-3 multi-variable scanner

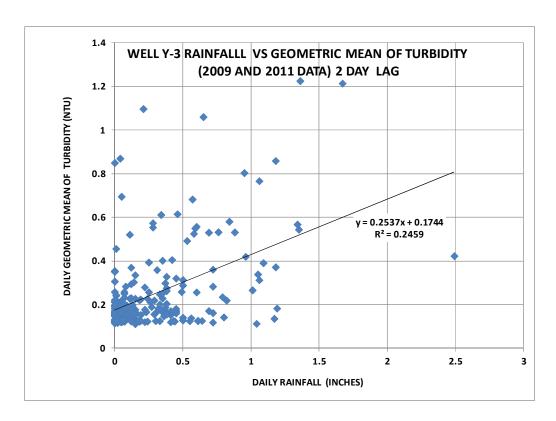


Figure 4. Well Y-3 smoothed turbidity vs. rainfall regression analysis for 2 day lag

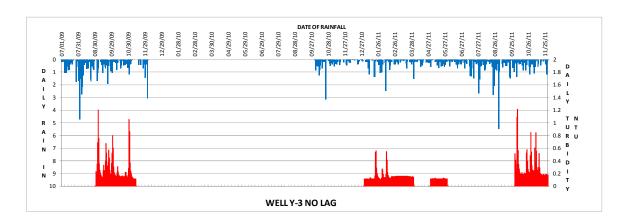


Figure 5. Well Y-3 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

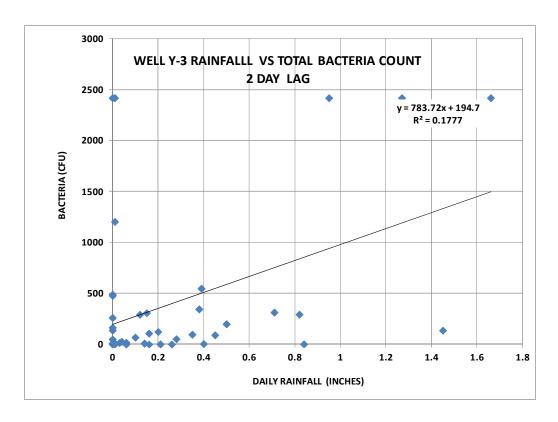


Figure 6. Well Y-3 total coliform vs. rainfall regression analysis for 2 day lag

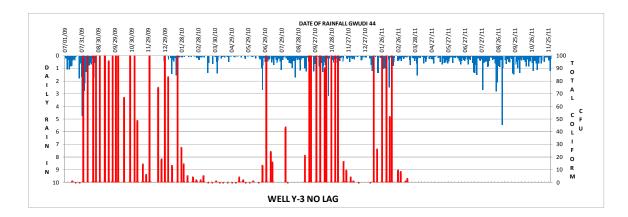


Figure 7. Well Y-3 visual scan of daily rainfall versus total coliform

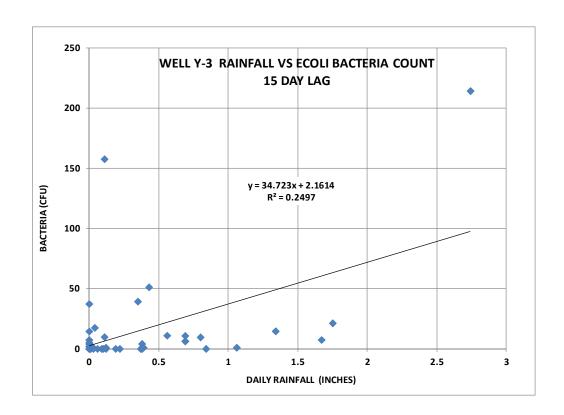


Figure 8. Well Y-3 E. coli vs. rainfall regression analysis for 15 day lag

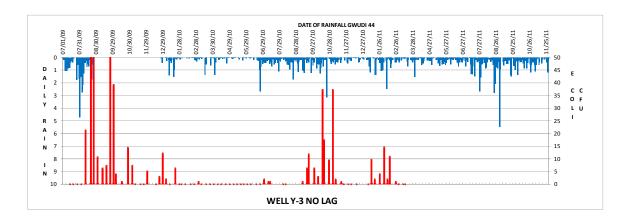


Figure 9. Well Y-3 visual scan of daily rainfall versus E. Coli

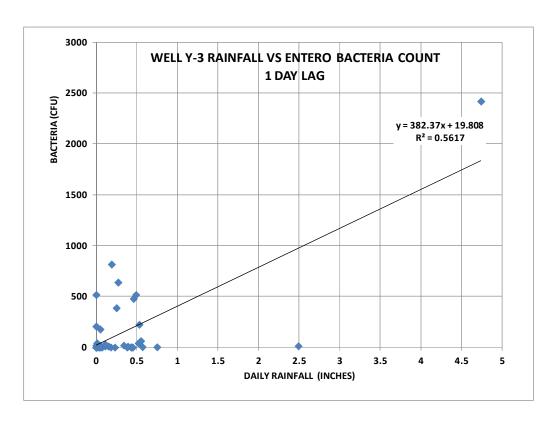


Figure 10. Well Y-3 enterococci vs. rainfall regression analysis for 1 day lag

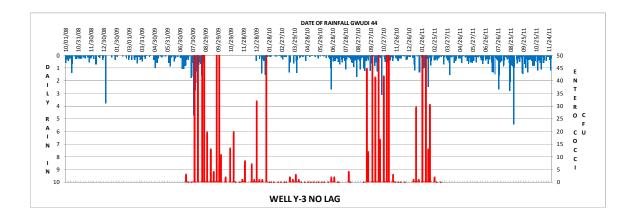


Figure 11. Well Y-3 visual scan of daily rainfall versus enterococci

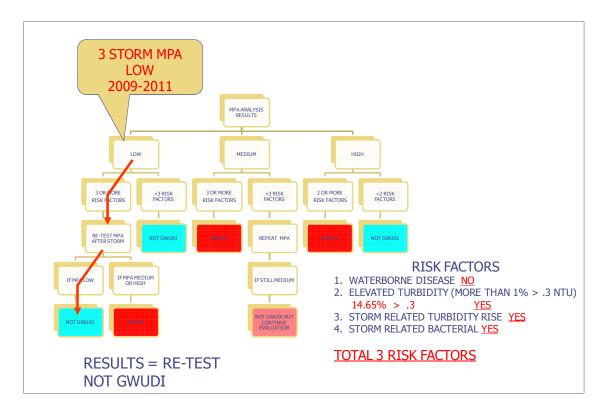


Figure 12. Well Y-3 GWUDI determination decision tree

APPENDIX 14 WELL Y-6 DATA AND ANALYSIS

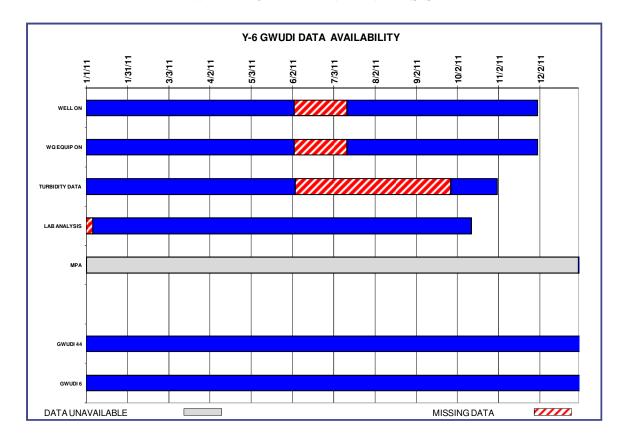


Figure 1. Well Y-6 data availability

Bin	FREQUENCY	Cumulative %	% HIGHER	Number Higher	INVERSE CUMULATIVE %	BIN AVG
0.05	15609	86.09%	13.91%	2522	13.91%	0.0375
0.075	2442	99.56%	0.44%	80	0.44%	0.0625
0.1	36	99.76%	0.24%	44	0.24%	0.0875
0.125	3	99.77%	0.23%	41	0.23%	0.1125
0.15	6	99.81%	0.19%	35	0.19%	0.1375
0.175	11	99.87%	0.13%	24	0.13%	0.1625
0.2	4	99.89%	0.11%	20	0.11%	0.1875
0.225	3	99.91%	0.09%	17	0.09%	0.2125
0.25	4	99.93%	0.07%	13	0.07%	0.2375
0.275	0	99.93%	0.07%	13	0.07%	0.2625
0.3	0	99.93%	0.07%	13	0.07%	0.2875
0.325	1	99.93%	0.07%	12	0.07%	0.3125
0.35	0	99.93%	0.07%	12	0.07%	0.3375
0.375	0	99.93%	0.07%	12	0.07%	0.3625
0.4	2	99.94%	0.06%	10	0.06%	0.3875
0.425	2	99.96%	0.04%	8	0.04%	0.4125
0.45	0	99.96%	0.04%	8	0.04%	0.4375
0.475	0	99.96%	0.04%	8	0.04%	0.4625
0.5	0	99.96%	0.04%	8	0.04%	0.4875
0.525	2	99.97%	0.03%	6	0.03%	0.5125
0.55	0	99.97%	0.03%	6	0.03%	0.5375
0.575	4	99.99%	0.01%	2	0.01%	0.5625
0.6	0	99.99%	0.01%	2	0.01%	0.5875
0.625	0	99.99%	0.01%	2	0.01%	0.6125
0.65	0	99.99%	0.01%	2	0.01%	0.6375
0.675	0	99.99%	0.01%	2	0.01%	0.6625
0.7	0	99.99%	0.01%	2	0.01%	0.6875
0.725	0	99.99%	0.01%	2	0.01%	0.7125
0.75	0	99.99%	0.01%	2	0.01%	0.7375
0.775	0	99.99%	0.01%	2	0.01%	0.7625
0.8	0	99.99%	0.01%	2	0.01%	0.7875
0.825	0	99.99%	0.01%	2	0.01%	0.8125
0.85	0	99.99%	0.01%	2	0.01%	0.8375
0.875	2	100.00%	0.00%	0	0.00%	0.8625
0.9	0	100.00%	0.00%	0	0.00%	0.8875
0.925	0	100.00%	0.00%	0	0.00%	0.9125
0.95	0	100.00%	0.00%	0	0.00%	0.9375
0.975	0	100.00%	0.00%	0	0.00%	0.9625
1	0	100.00%	0.00%	0	0.00%	0.9875
1.025	0	100.00%	0.00%	0	0.00%	1.0125
1.05	0	100.00%	0.00%	0	0.00%	1.0375
sum	18131					
Suiii	10131	1		I	I .	1

Table 1. Well Y-6 smoothed turbidity frequency histogram

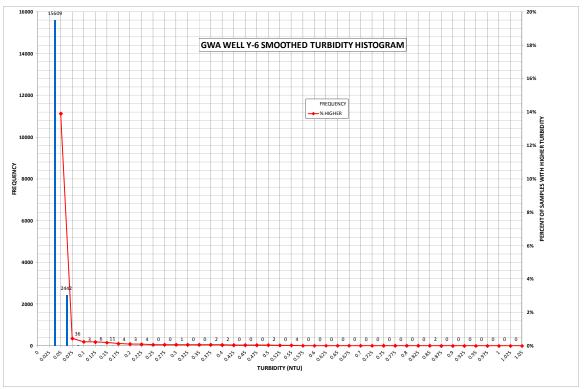


Figure 2. Well Y-6 smoothed turbidity frequency curve

		TOTAL HARDNESS	CALCIUM (mg/L as	MAGNESIUM (mg/L as	CHLORIDES	TOTAL COLIFORM	E. COLI (MPN/100	ENTERO COCCI	NITRATES
WELL NO.	DATE SAMPLED	(mg/L as CaCO3)	CaCO3)	CaCO3)	(mg/L)	(MPN/100 ML)	ML)	(MPN/100 ML)	(MG/L)
Y-6	07/14/09					<1	<1	<1	
Y-6	07/20/09					<1	<1	<1	
Y-6	07/27/09	050	040	- 10		<1	<1	<1	
Y-6	08/03/09	250	240	10	36	<1	<1	<1	3.8
Y-6 Y-6	08/11/09			-		<1	<1	<1	
Y-6	08/21/09 08/26/09					<1 <1	<1 <1	<1 <1	
Y-6	09/02/09	282	240	42	46	<1	<1	<1	
Y-6	09/11/09	202	240	42	40	<1	<1	<1	3.9
Y-6	09/11/09					<1	<1	<1	3.9
Y-6	09/18/09					<1	<1	<1	
Y-6	09/25/09			<u> </u>		<1	<1	<1	1
Y-6	10/01/09	250	216	34	35	<1	<1	<1	
Y-6	10/05/09	200	2.0		- 55	<1	<1	<1	3.6
Y-6	10/16/09			1		<1	<1	3.0	0.0
Y-6	10/20/09					<1	<1	nd	
Y-6	10/27/09					<1	<1	<1	
Y-6	11/04/09					<1	<1	<1	
Y-6	11/09/09	258	220	38	34	<1	<1	<1	4.0
Y-6	11/19/09					<1	<1	<1	
Y-6	11/25/09					<1	<1	<1	
Y-6	12/01/09					<1	<1	<1	
Y-6	12/07/09	270	244	26	44	<1	<1	<1	3.7
Y-6	12/17/09					<1	<1	3.0	
Y-6	12/23/09					<1	<1	<1	
Y-6	12/29/09					<1	<1	<1	
Y-6	01/04/10					<1	<1	<1	
Y-6	01/11/10	274	230	44	24	<1	<1	<1	3.6
Y-6	01/21/10					<1	<1	<1	
Y-6	01/28/10					<1	<1	<1	
Y-6	02/01/10					<1	<1	<1	
Y-6	02/08/10	244	220	24	38	<1	<1	<1	3.7
Y-6	02/18/10					<1	<1	<1	
Y-6	02/24/10					<1	<1	<1	
Y-6	03/04/10					<1	<1	<1	
Y-6	03/09/10	244	216	28	57	<1	<1	<1	3.5
Y-6	03/18/10					<1	<1	<1	
Y-6	03/25/10					<1	<1	<1	
Y-6	04/01/10					<1	<1	<1	
Y-6	04/08/10	260	242	18	56	<1	<1	<1	3.5
Y-6	04/14/10					<1	<1	<1	
Y-6	04/22/10					<1	<1	<1	
Y-6	04/30/10					<1	<1	<1	
Y-6	05/07/10					<1	<1	<1	
Y-6	05/13/10					<1	<1	<1	
Y-6	05/20/10					<1	<1	<1	
Y-6	05/25/10	250	212	38	47	<1	<1	<1	3.7
Y-6	06/01/10					<1	<1	<1	
Y-6	06/07/10	238	228	10	48	<1	<1	<1	3.5
Y-6	06/17/10					<1	<1	<1	
Y-6	06/24/10					<1	<1	<1	
Y-6	07/01/10					<1	<1	<1	
Y-6	07/09/10			-	ļ	<1	<1	<1	
Y-6	07/12/10	244	230	14	56	<1	<1	<1	3.5
Y-6	08/05/10	ļ <u> </u>		+	.	<1	<1	<1	-
Y-6	08/09/10	244	236	8	40	<1	<1	<1	3.5
Y-6	09/09/10	244	236	8	5305	<1	<1	<1	
Y-6	09/17/10			1		<1	<1	<1	
Y-6	09/20/10			+	-	<1 395.5	<1	<1	3.8
Y-6	09/30/10			1	 	020.0	<1	34.3	-
Y-6	10/07/10 10/15/10			1	 	266.7	<1	46.7	-
Y-6	10/15/10	240	900	10	40	<1	<1	<1	0.7
Y-6		242	226	16	40	<1	<1	<1	3.7
Y-6	10/27/10			1	 	<1	<1	<1	
Y-6	11/03/10	240	210	04	FO	<1	<1	<1	0.0
Y-6 Y-6	11/08/10	240	216	24	58	2.0	<1 <1	<1 <1	3.6
Y-6 Y-6	11/18/10 11/23/10			1	 	<1 <1	<1	<1 <1	
Y-6	12/01/10			1		<1	<1	1.0	
Y-6 Y-6	12/01/10	210	158	52	32	<1			3.6
Y-6 Y-6	12/06/10	210	138	32	32		<1 <1	<1	3.0
Y-6 Y-6	01/06/11			1	 	<1 <1	<1	<1 1.0	
				1					
Y-6 Y-6	01/12/11	250	200	20	44	<1 1.0	<1	<1	9.7
Y-6 Y-6	01/18/11	258	228	30	44		<1	<1	3.7
Y-6 Y-6	01/2//11			+		1.0	<1 <1	<1 1	-
				1	 				
Y-6	02/10/11	990	210	00	97	<1	<1	<1	
Y-6	02/14/11	236	216	20	37	<1	<1	<1	2.3
Y-6	02/25/11			+		<1	<1	<1	-
Y-6	03/02/11			+		<1	<1	<1	-
Y-6	03/11/11	240	228	12	26	<1 <1	<1 <1	<1 NA	
Y-6					. /b	<1	<1	ı INA .	3.5

Table 2. Well Y-6 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	LOW =.1 MEDIUM = .5 HIGH = 1
Y-6	5/26/2009	DRY	LOW	0.1

NO MPA'S 2011

Table 3. Well Y-6 MPA data

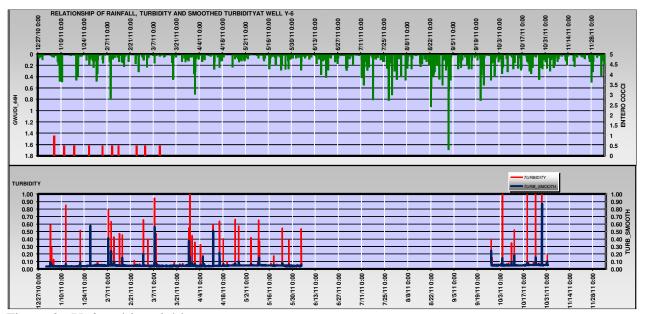


Figure 3. Y-6 multi-variable scanner

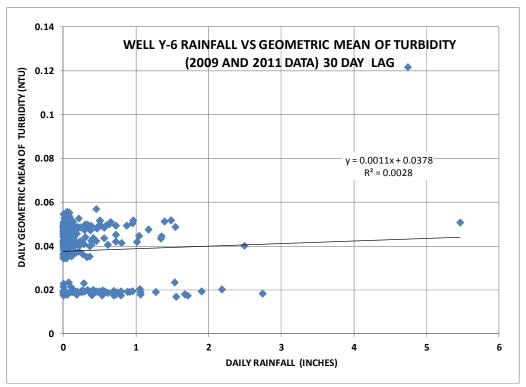


Figure 4. Well Y-6 smoothed turbidity vs. rainfall regression analysis for 30 day lag

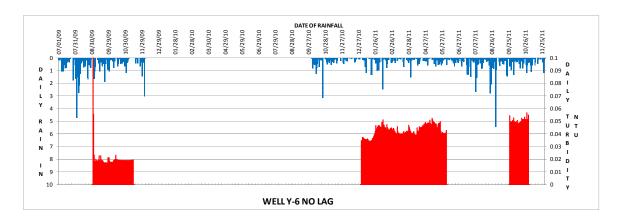


Figure 5. Well Y-6 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

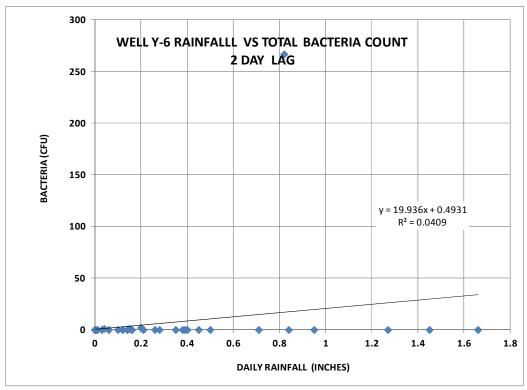


Figure 6. Well Y-6 total coliform vs. rainfall regression analysis for 2 day lag

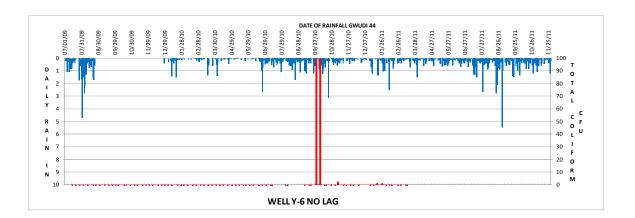


Figure 7. Well Y-6 visual scan of daily rainfall versus total coliform

(ALL E. COLI VALUES = 0)

Figure 8. Well Y-6 E. coli vs. rainfall regression analysis

(ALL E. COLI VALUES = 0)

Figure 9. Well Y-6 visual scan of daily rainfall versus E. Coli

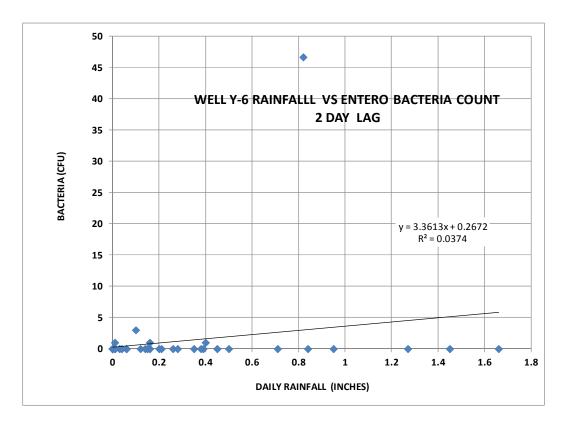


Figure 10. Well Y-6 enterococci vs. rainfall regression analysis for 2 day lag

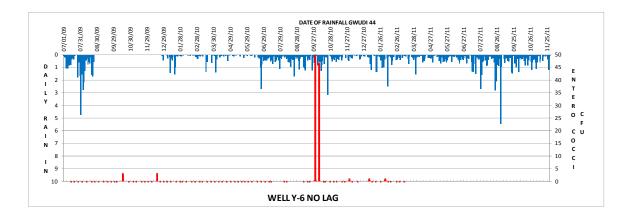


Figure 11. Well Y-6 visual scan of daily rainfall versus enterococci

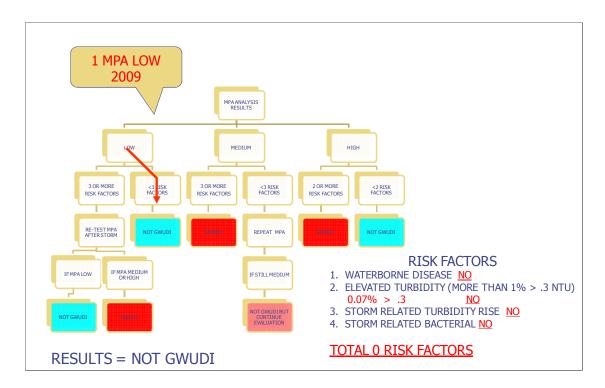


Figure 12. Well Y-6 GWUDI determination decision tree

APPENDIX 15 WELL Y-15 DATA AND ANALYSIS

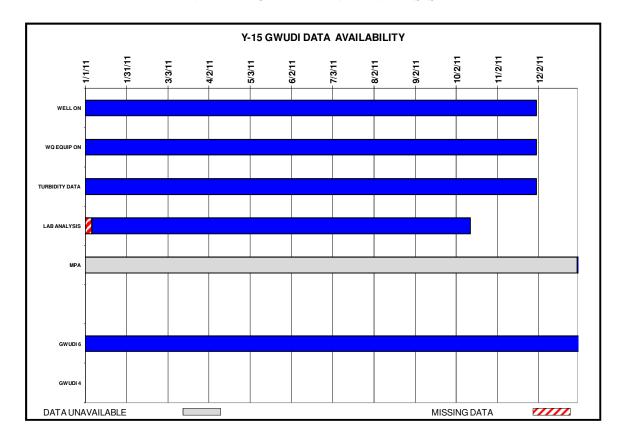


Figure 1. Well Y-15 data availability

Bin	Frequency	Cumulative %	% Higher	Number Higher	Inverse Cumulartive %	Bin Avg
0.025	23263	86.13%	13.87%	3745	13.87%	0.0125
0.05	3745	100.00%	0.00%	0	0.00%	0.0375
0.075	0	100.00%	0.00%	0	0.00%	0.0625
0.1	0	100.00%	0.00%	0	0.00%	0.0875
0.125	0	100.00%	0.00%	0	0.00%	0.1125
0.15	0	100.00%	0.00%	0	0.00%	0.1375
0.175	0	100.00%	0.00%	0	0.00%	0.1625
0.2	0	100.00%	0.00%	0	0.00%	0.1875
0.225	0	100.00%	0.00%	0	0.00%	0.2125
0.25	0	100.00%	0.00%	0	0.00%	0.2375
0.275	0	100.00%	0.00%	0	0.00%	0.2625
0.3	0	100.00%	0.00%	0	0.00%	0.2875
0.325	0	100.00%	0.00%	0	0.00%	0.3125
0.35	0	100.00%	0.00%	0	0.00%	0.3375
0.375	0	100.00%	0.00%	0	0.00%	0.3625
0.4	0	100.00%	0.00%	0	0.00%	0.3875
0.425	0	100.00%	0.00%	0	0.00%	0.4125
0.45	0	100.00%	0.00%	0	0.00%	0.4375
0.475	0	100.00%	0.00%	0	0.00%	0.4625
0.5	0	100.00%	0.00%	0	0.00%	0.4875
0.525	0	100.00%	0.00%	0	0.00%	0.5125
0.55	0	100.00%	0.00%	0	0.00%	0.5375
0.575	0	100.00%	0.00%	0	0.00%	0.5625
0.6	0	100.00%	0.00%	0	0.00%	0.5875
0.625	0	100.00%	0.00%	0	0.00%	0.6125
0.65	0	100.00%	0.00%	0	0.00%	0.6375
0.675	0	100.00%	0.00%	0	0.00%	0.6625
0.7	0	100.00%	0.00%	0	0.00%	0.6875
0.725	0	100.00%	0.00%	0	0.00%	0.7125
0.75	0	100.00%	0.00%	0	0.00%	0.7375
0.775	0	100.00%	0.00%	0	0.00%	0.7625
0.8	0	100.00%	0.00%	0	0.00%	0.7875
0.825	0	100.00%	0.00%	0	0.00%	0.8125
0.85	0	100.00%	0.00%	0	0.00%	0.8375
0.875	0	100.00%	0.00%	0	0.00%	0.8625
0.9	0	100.00%	0.00%	0	0.00%	0.8875
0.925	0	100.00%	0.00%	0	0.00%	0.9125
0.95	0	100.00%	0.00%	0	0.00%	0.9375
0.975	0	100.00%	0.00%	0	0.00%	0.9625
1	0	100.00%	0.00%	0	0.00%	0.9875
1.025	0	100.00%	0.00%	0	0.00%	1.0125
sum	27008					

Table 1. Well Y-15 smoothed turbidity frequency histogram

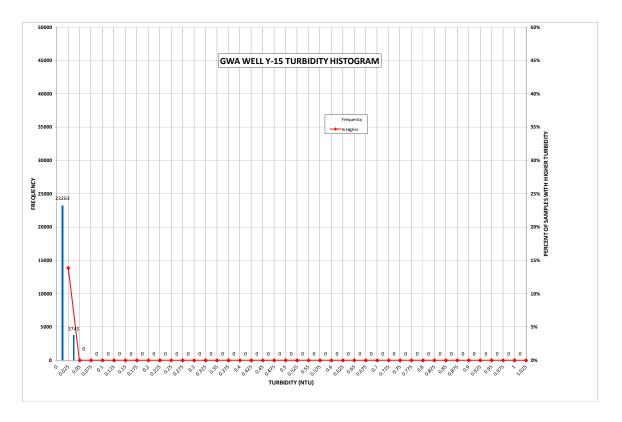


Figure 2. Well Y-15 smoothed turbidity frequency curve

			CALCIUM	MAGNESIUM	CHLORIDES				
WELL NO.	DATE SAMPLED	TOTAL HARDNESS (mg/L as CaCO3)	(mg/L as CaCO3)	(mg/L as CaCO3)	(mg/L)	TOTAL COLIFORM (MPN/100 ML)	E. COLI (MPN/100 ML)	ENTERO COCCI (MPN/100 ML)	NITRATES (MG/L)
Y-15	07/20/09	(mg/L as CaCOs)	CaCO3)	CaCO3)		(MPN/100 ML)	wiL) <1	1.0	(WG/L)
								5.2	
Y-15 Y-15	07/27/09 08/03/09	178	166	12	33	33.5 1.0	<1 <1	<1	3.2
Y-15	08/11/09	176	100	12	- 55	<1	<1	<1	3.2
Y-15	08/21/09					12.1	1.0	1.0	
Y-15	08/26/09					<1	<1	<1	
Y-15	09/02/09	216	196	80	41	<1	<1	<1	
Y-15	09/11/09	210	190	80	41	<1	<1	<1	2.4
Y-15	09/11/09					<1	<1	<1	2.4
Y-15	09/18/09					<1	<1	<1	
Y-15	09/25/09					<1	<1	<1	
Y-15	10/01/09	194	166	28	27	<1	<1	<1	
Y-15	10/05/09	134	100	20		<1	<1	<1	2.1
Y-15	10/16/09					<1	<1	4.0	2.1
Y-15	10/20/09					<1	<1	nd	
Y-15	10/27/09					<1	<1	<1	
Y-15	11/04/09					<1	<1	<1	
Y-15	11/09/09	186	172	14	35	<1	<1	2.0	2.2
Y-15	11/19/09	100	172		- 55	<1	<1	1.0	2.2
Y-15	11/15/09					52.1	<1	<1	
Y-15	12/01/09					<1	<1	<1	
Y-15	12/07/09	210	172	38	31	<1	<1	1.0	3.1
Y-15	12/17/09	2.0		30	3,	<1	<1	<1	5.1
Y-15	12/17/09					<1	<1	<1	
Y-15	12/23/09	+				<1	<1	<1	
Y-15	01/04/10				1	<1	<1	<1	
Y-15	01/11/10	236	166	70	27	<1	<1	<1	2.3
Y-15	01/21/10	_50	. 30			<1	<1	<1	
Y-15	01/28/10				1	<1	<1	<1	
Y-15	02/01/10				1	<1	<1	<1	
Y-15	02/08/10	208	172	36	32	<1	<1	<1	2.2
Y-15	02/18/10	200	.,,		- OL	<1	<1	<1	2.2
Y-15	02/24/10					<1	<1	<1	
Y-15	03/04/10					<1	<1	<1	
Y-15	03/09/10	184	164	20	41	<1	<1	<1	2.4
Y-15	03/18/10	104	104	20	41	<1	<1	2	2.4
Y-15	03/25/10					<1	<1	2.0	
Y-15	04/01/10					<1	<1	1.0	
Y-15	04/08/10	210	202	8	50	<1	<1	<1	2.4
Y-15	04/14/10	2.10	202	Ŭ	- 00	<1	<1	<1	2
Y-15	04/22/10					<1	<1	<1	
Y-15	04/30/10					<1	<1	<1	
Y-15	05/07/10					<1	<1	<1	
Y-15	05/13/10					<1	<1	<1	
Y-15	05/20/10					<1	<1	<1	
Y-15	05/25/10	180	170	10	44	<1	<1	<1	2.6
Y-15	06/01/10					<1	<1	<1	
Y-15	06/07/10	172	164	8	71	<1	<1	<1	2.4
Y-15	06/17/10			-		<1	<1	<1	
Y-15	06/24/10					<1	<1	<1	
Y-15	07/01/10					<1	<1	<1	
Y-15	07/09/10					<1	<1	<1	
Y-15	07/12/10	216	170	46	46	<1	<1	<1	2.5
Y-15	08/05/10	-	•	_	·	<1	<1	<1	
Y-15	08/09/10	190	172	18	38	<1	<1	<1	3.1
Y-15	09/09/10	178	170	8	39	<1	<1	<1	
Y-15	09/17/10	-		-		<1	<1	<1	
Y-15	09/20/10					<1	<1	<1	2.5
Y-15	09/30/10	1			İ	<1	<1	<1	
Y-15	10/07/10				1	<1	<1	<1	
Y-15	10/15/10					<1	<1	<1	
Y-15	10/18/10	182	166	16	38	<1	<1	<1	2.4
Y-15	10/27/10				i	<1	<1	<1	
Y-15	11/03/10					<1	<1	<1	
Y-15	11/08/10	180	164	16	55	<1	<1	<1	2.5
Y-15	11/18/10					<1	<1	<1	
Y-15	11/23/10	1				<1	<1	1.0	
Y-15	12/01/10				ĺ	<1	<1	<1	
Y-15	12/06/10	328	204	124	29	<1	<1	<1	2.6
Y-15	12/16/10					<1	<1	<1	
Y-15	01/06/11				l	<1	<1	<1	
Y-15	01/12/11					<1	<1	<1	
Y-15	01/12/11	240	212	28	33	<1	<1	<1	2.7
Y-15	01/27/11					<1	<1	<1	
Y-15	02/04/11	+				<1	<1	<1	
Y-15	02/04/11					<1	<1	<1	
Y-15	02/10/11	220	178	42	50	<1	<1	<1	2.7
		220	170	744	30				£./
Y-15 Y-15	02/25/11 03/02/11					<1 <1	<1 <1	<1 <1	
Y-15 Y-15									
1-10	03/11/11					<1	<1	<1	
Y-15	03/14/11	190	172	18	19	<1	<1	NA .	2.6

Table 2. Well Y-15 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	LOW =.1 MEDIUM = .5 HIGH = 1
Y-15	8/17/2009	STORM	LOW	0.
		1	ı	

Table 3. Well Y-15 MPA data

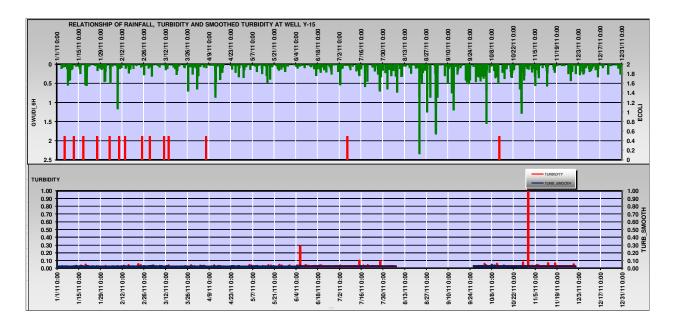


Figure 3. Y-15 multi-variable scanner

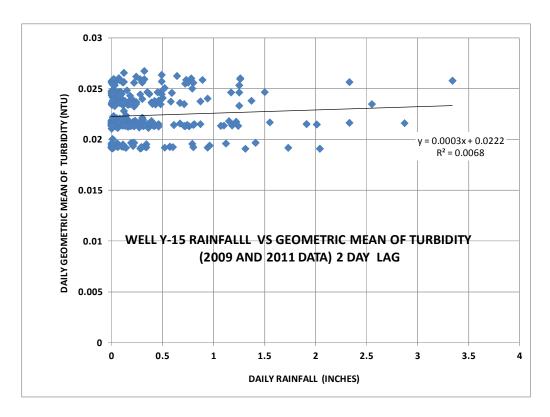


Figure 4. Well Y-15 smoothed turbidity vs. rainfall regression analysis for 2 day lag

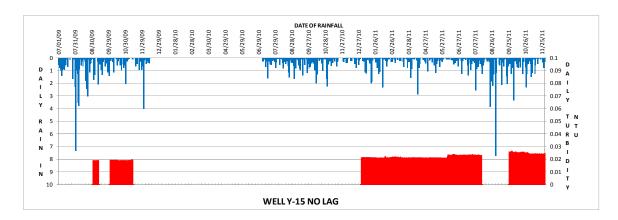


Figure 5. Well Y-15 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

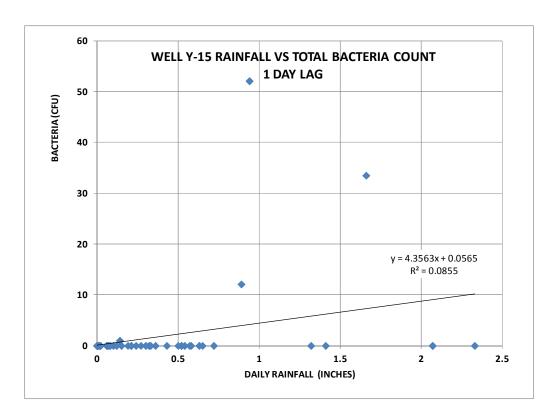


Figure 6. Well Y-15 total coliform vs. rainfall regression analysis for 1 day lag

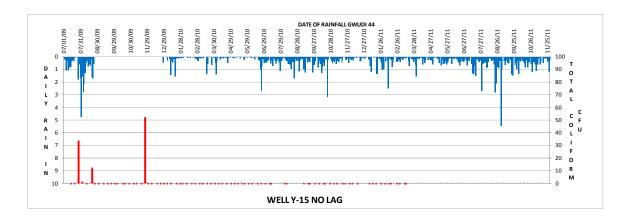


Figure 7. Well Y-15 visual scan of daily rainfall versus total coliform

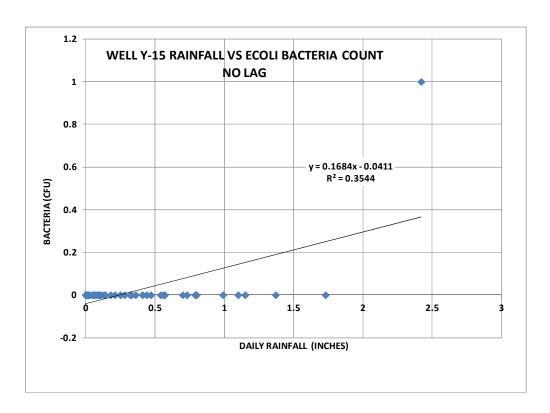


Figure 8. Well Y-15 E. coli vs. rainfall regression analysis for 0 day lag

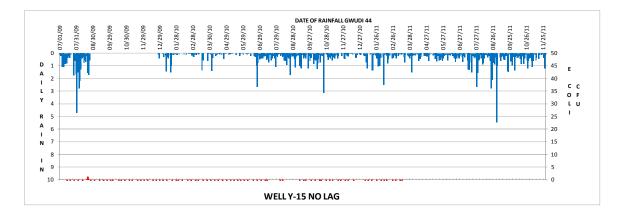


Figure 9. Well Y-15 visual scan of daily rainfall versus E. Coli

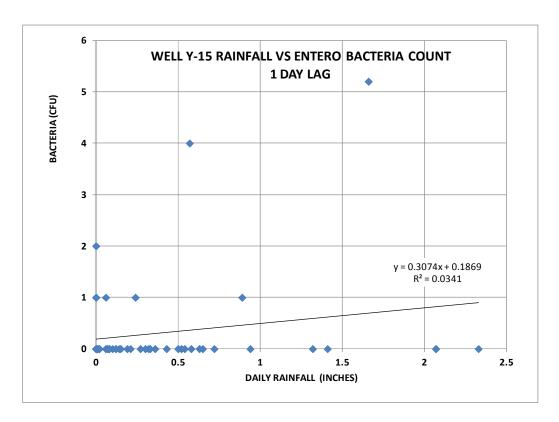


Figure 10. Well Y-15 enterococci vs. rainfall regression analysis for 1 day lag

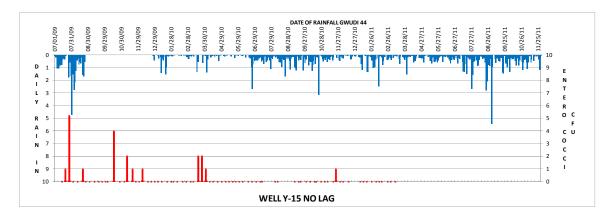


Figure 11. Well Y-15 visual scan of daily rainfall versus enterococci

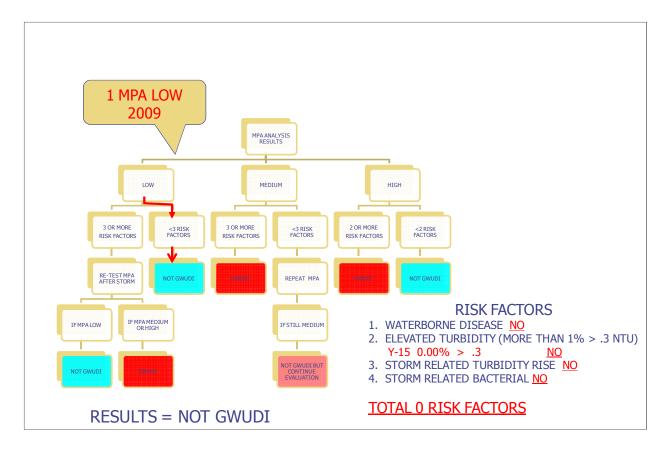


Figure 12. Well Y-15 GWUDI determination decision tree (bad data removed)

APPENDIX 16 WELL Y-22 DATA AND ANALYSIS

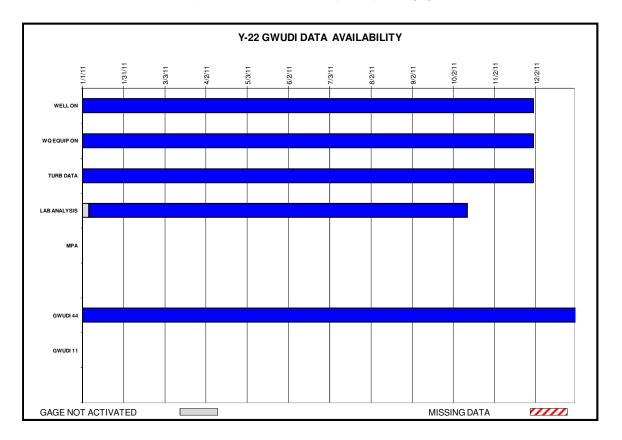


Figure 1. Well Y-22 data availability

Bin	Frequency	Cumulative %	% Higher	Number Higher	Inverse Cumulative %	Bin Avg
0.025	1881	5.87%	94.13%	30158	94.13%	0.0125
0.05	24022	80.85%	19.15%	6136	19.15%	0.0375
0.075	5120	96.83%	3.17%	1016	3.17%	0.0625
0.1	984	99.90%	0.10%	32	0.10%	0.0875
0.125	11	99.93%	0.07%	21	0.07%	0.1125
0.15	5	99.95%	0.05%	16	0.05%	0.1375
0.175	2	99.96%	0.04%	14	0.04%	0.1625
0.2	1	99.96%	0.04%	13	0.04%	0.1875
0.225	3	99.97%	0.03%	10	0.03%	0.2125
0.25	2	99.98%	0.02%	8	0.02%	0.2375
0.275	0	99.98%	0.02%	8	0.02%	0.2625
0.3	1	99.98%	0.02%	7	0.02%	0.2875
0.325	0	99.98%	0.02%	7	0.02%	0.3125
0.35	0	99.98%	0.02%	7	0.02%	0.3375
0.375	0	99.98%	0.02%	7	0.02%	0.3625
0.4	1	99.98%	0.02%	6	0.02%	0.3875
0.425	4	99.99%	0.01%	2	0.01%	0.4125
0.45	0	99.99%	0.01%	2	0.01%	0.4375
0.475	2	100.00%	0.00%	0	0.00%	0.4625
0.5	0	100.00%	0.00%	0	0.00%	0.4875
0.525	0	100.00%	0.00%	0	0.00%	0.5125
0.55	0	100.00%	0.00%	0	0.00%	0.5375
0.575	0	100.00%	0.00%	0	0.00%	0.5625
0.6	0	100.00%	0.00%	0	0.00%	0.5875
0.625	0	100.00%	0.00%	0	0.00%	0.6125
0.65	0	100.00%	0.00%	0	0.00%	0.6375
0.675	0	100.00%	0.00%	0	0.00%	0.6625
0.7	0	100.00%	0.00%	0	0.00%	0.6875
0.725	0	100.00%	0.00%	0	0.00%	0.7125
0.75	0	100.00%	0.00%	0	0.00%	0.7375
0.775	0	100.00%	0.00%	0	0.00%	0.7625
0.8	0	100.00%	0.00%	0	0.00%	0.7875
0.825	0	100.00%	0.00%	0	0.00%	0.8125
0.85	0	100.00%	0.00%	0	0.00%	0.8375
0.875	0	100.00%	0.00%	0	0.00%	0.8625
0.9	0	100.00%	0.00%	0	0.00%	0.8875
0.925	0	100.00%	0.00%	0	0.00%	0.9125
0.95	0	100.00%	0.00%	0	0.00%	0.9375
0.975	0	100.00%	0.00%	0	0.00%	0.9625
1	0	100.00%	0.00%	0	0.00%	0.9875
1.025	0	100.00%	0.00%	0	0.00%	1.0125
sum	32039					-
Juin	02000			LL		_1

Table 1. Well Y-22 smoothed turbidity frequency histogram

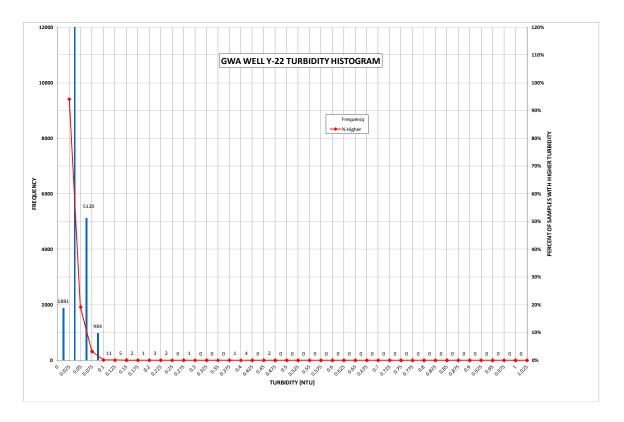


Figure 2. Well Y-22 smoothed turbidity frequency curve

WELL NO.	DATE SAMPLED	TOTAL HARDNESS (mg/L as CaCO3)	CALCIUM (mg/L as CaCO3)	MAGNESIUM (mg/L as CaCO3)	CHLORIDES (mg/L)	TOTAL COLIFORM (MPN/100 ML)	E. COLI (MPN/100 ML)	ENTERO COCCI (MPN/100 ML)	NITRATES (MG/L)
Y-22	07/14/09	,		,		<1	<1	<1	
Y-22	07/20/09					<1	<1	<1	
Y-22	07/27/09					<1	<1	<1	
Y-22	08/03/09	228	212	16	26	<1	<1	<1	2.4
Y-22	08/11/09					<1	<1	<1	
Y-22	08/21/09					<1	<1	<1	
Y-22	08/26/09					<1	<1	<1	
Y-22	09/02/09	236	214	22	47	<1	<1	<1	
		230	214	- 22	47				2.4
Y-22 Y-22	09/11/09				-	<1	<1	<1	3.4
	09/11/09					<1	<1	<1	1
Y-22	09/18/09					<1	<1	<1	
Y-22	09/25/09					<1	<1	<1	
Y-22	10/01/09	260	166	28	33	<1	<1	<1	
Y-22	10/05/09					<1	<1	1.0	3.2
Y-22	10/16/09					<1	<1	4.0	
Y-22	10/20/09					<1	<1	nd	
Y-22	10/27/09					<1	<1	<1	
Y-22	11/04/09					<1	<1	<1	
Y-22	11/09/09	230	212	18	30	<1	<1	<1	3.3
Y-22	11/19/09					<1	<1	<1	
Y-22	11/25/09					<1	<1	24.0	
Y-22	12/01/09	1		İ		<1	<1	<1	
Y-22	12/07/09	226	216	10	30	<1	<1	<1	2.3
Y-22	12/17/09			1		<1	<1	<1	
Y-22	12/17/09					<1	<1	<1	
Y-22	12/23/09					<1	<1	<1	
Y-22	01/04/10					<1	<1	<1	
		240	210	00	150				0.4
Y-22	01/11/10	242	216	26	153	<1	<1	<1	3.1
Y-22	01/21/10				-	<1	<1	<1	
Y-22	01/28/10					<1	<1	<1	
Y-22	02/01/10					<1	<1	<1	
Y-22	02/08/10	240	224	16	31	<1	<1	<1	3.2
Y-22	02/18/10					<1	<1	<1	
Y-22	02/24/10					<1	<1	<1	
Y-22	03/04/10					<1	<1	<1	
Y-22	03/09/10	218	188	30	58	<1	<1	<1	3.2
Y-22	03/18/10					<1	<1	2.0	
Y-22	03/25/10					<1	<1	5.0	
Y-22	04/01/10					<1	<1	<1	
Y-22	04/08/10	226	216	10	55	<1	<1	<1	3.2
		220	210	10	35				3.2
Y-22	04/14/10					<1	<1	<1	
Y-22	04/22/10					<1	<1	<1	-
Y-22	04/30/10					<1	<1	<1	-
Y-22	05/07/10					<1	<1	<1	
Y-22	05/13/10					<1	<1	<1	-
Y-22	05/20/10					<1	<1	<1	
Y-22	05/25/10	220	204	16	44	<1	<1	<1	3.2
Y-22	06/01/10					<1	<1	<1	
Y-22	06/07/10	216	202	14	52	<1	<1	<1	3.0
Y-22	06/17/10					<1	<1	<1	
Y-22	06/24/10					<1	<1	<1	l
Y-22	07/01/10					<1	<1	<1	
Y-22	07/09/10					<1	<1	<1	
Y-22	07/12/10	224	216	8	46	<1	<1	<1	3.1
Y-22	08/05/10	1	-			<1	<1	<1	
Y-22	08/09/10	220	210	10	31	<1	<1	<1	2.5
Y-22	09/09/10	224	220	4	45	<1	<1	<1	
Y-22	09/17/10			,	├ ~	<1	<1	<1	
Y-22	09/17/10					<1	<1	1.0	2.5
V-22	09/20/10					<1	<1	1.0	2.5
1 °CC					-	- 4	< I	< 1 .4	
Y-22	10/07/10					<1	<1	<1	
Y-22	10/15/10	05-		_	l	<1	<1	<1	
Y-22	10/18/10	220	214	6	43	<1	<1	6.1	3.1
Y-22	10/27/10					<1	<1	<1	—
Y-22	11/03/10					<1	<1	<1	
Y-22	11/08/10	230	208	22	56	<1	<1	<1	3.2
Y-22	11/18/10					<1	<1	<1	
Y-22	11/23/10					<1	<1	<1	
Y-22	12/01/10					<1	<1	<1	
Y-22	12/06/10	210	182	28	22	<1	<1	1.0	3.0
Y-22	12/16/10	· 1				<1	<1	<1	
Y-22	01/06/11					<1	<1	<1	
Y-22									
	01/12/11	240	210	00	00	<1	<1	<1	
Y-22	01/18/11	240	212	28	36	<1	<1	<1	3.0
Y-22	01/27/11				-	<1	<1	<1	—
Y-22	02/04/11					<1	<1	<1	—
Y-22	02/10/11					<1	<1	<1	
Y-22	02/14/11	254	236	18	26	<1	<1	<1	3.2
Y-22	02/25/11					<1	<1	<1	l
Y-22	03/02/11					<1	<1	<1	
Y-22	03/11/11					<1	<1	<1	
Y-22	03/14/11	240	216	24	20	<1	<1	NA	3.1

Table 2. Well Y-22 laboratory water quality data

WELL NO.	DATE SAMPLED	WEATHER CONDITION	MPA RESULT: RISK OF CONTAMINATION	LOW =.1 MEDIUM = .5 HIGH = 1
Y-22	8/4/2009	STORM	LOW	0.1

Table 3. Well Y-22 MPA data

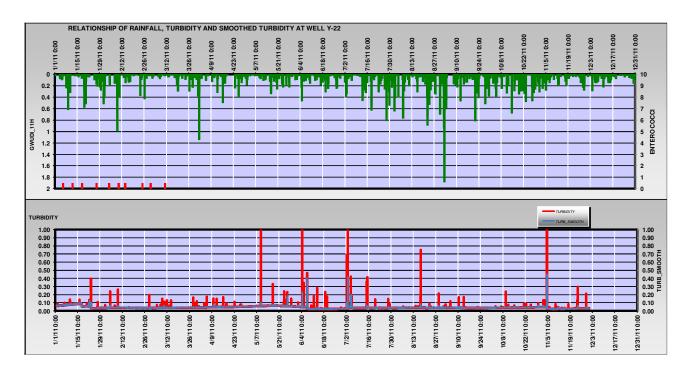


Figure 3. Y-22 multi-variable scanner

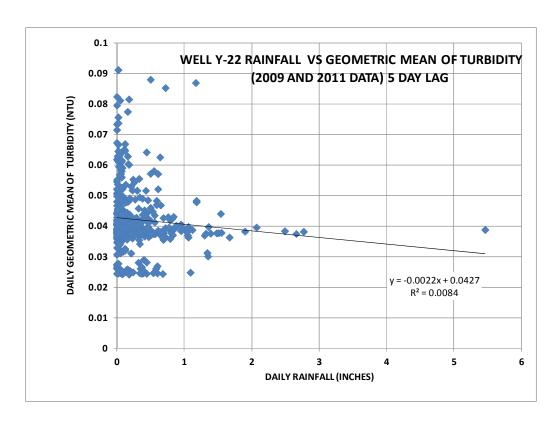


Figure 4. Well Y-22 smoothed turbidity vs. rainfall regression analysis for 5 day lag (all lags negative slope)

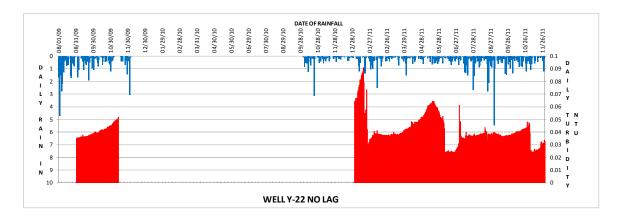


Figure 5. Well Y-22 visual scan of daily rainfall versus daily geometric mean of smoothed turbidity

(ALL TOTAL COLIFORM VALUES = 0)

Figure 6. Well Y-22 total coliform vs. rainfall regression analysis

(ALL TOTAL COLIFORM VALUES = 0)

Figure 7. Well Y-22 visual scan of daily rainfall versus total coliform

(ALL TOTAL E. COLI VALUES = 0)

Figure 8. Well Y-22 E. coli vs. rainfall regression analysis

(ALL TOTAL E. COLI VALUES = 0)

Figure 9. Well Y-22 visual scan of daily rainfall versus E. Coli

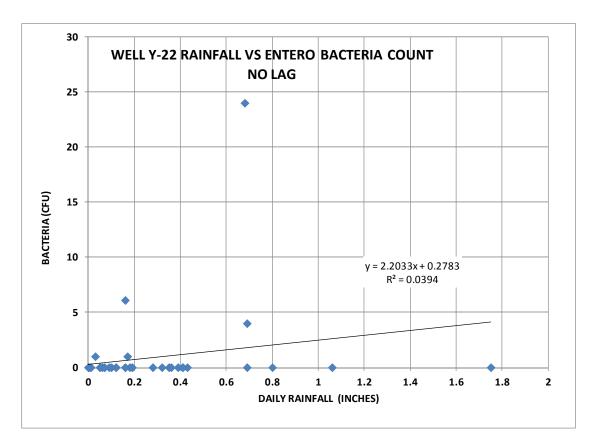


Figure 10. Well Y-22 enterococci vs. rainfall regression analysis for 0 day lag

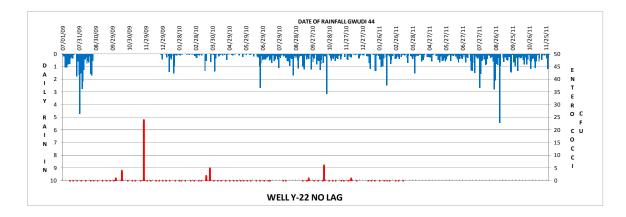


Figure 11. Well Y-22 visual scan of daily rainfall versus enterococci

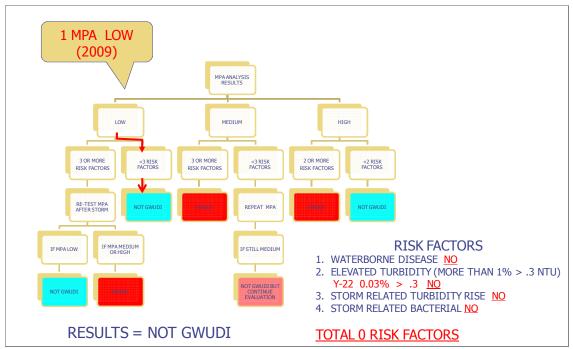


Figure 12. Well Y-22 GWUDI determination decision tree