

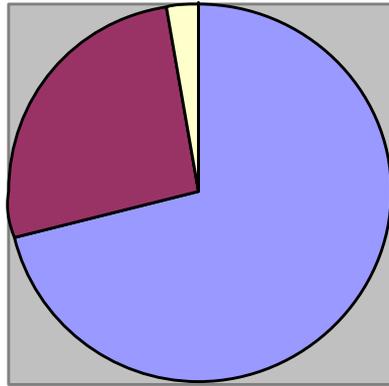
Groundwater Quality and Public Health in Areas of New Mexico Utilizing Onsite Wells and Septic Systems



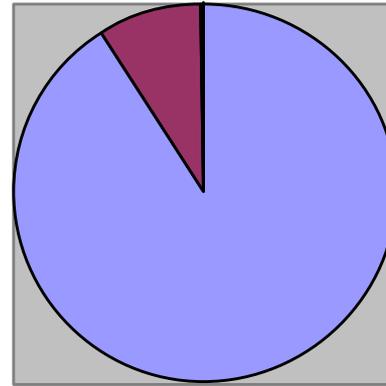
Dennis McQuillan, New Mexico Environment Department
January 2012

Sewage Management in New Mexico

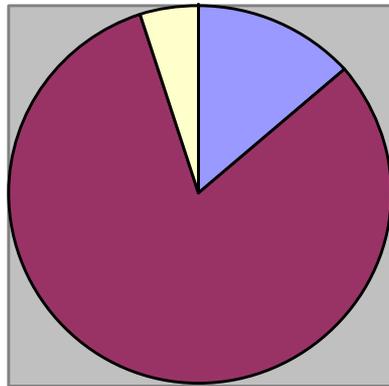
Statewide



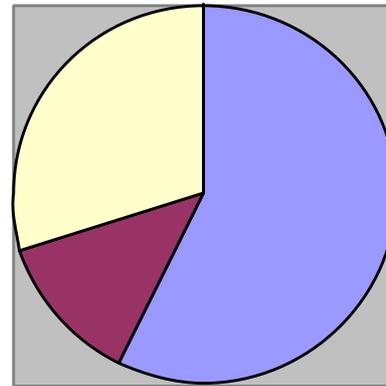
Bernalillo County



Catron County



McKinley County



On-Site Systems in NM

- ~235,000 household septic systems (septic tanks and cesspools), with ~4000 new systems/year
- ~88 million gallons per day of wastewater discharged to the subsurface
- most of this wastewater eventually percolates to ground water
- many areas using septic systems also rely on private wells for domestic supply

Septic System Suitability

- Septic systems are a suitable means of on-site waste disposal when site conditions are favorable for natural attenuation, however,

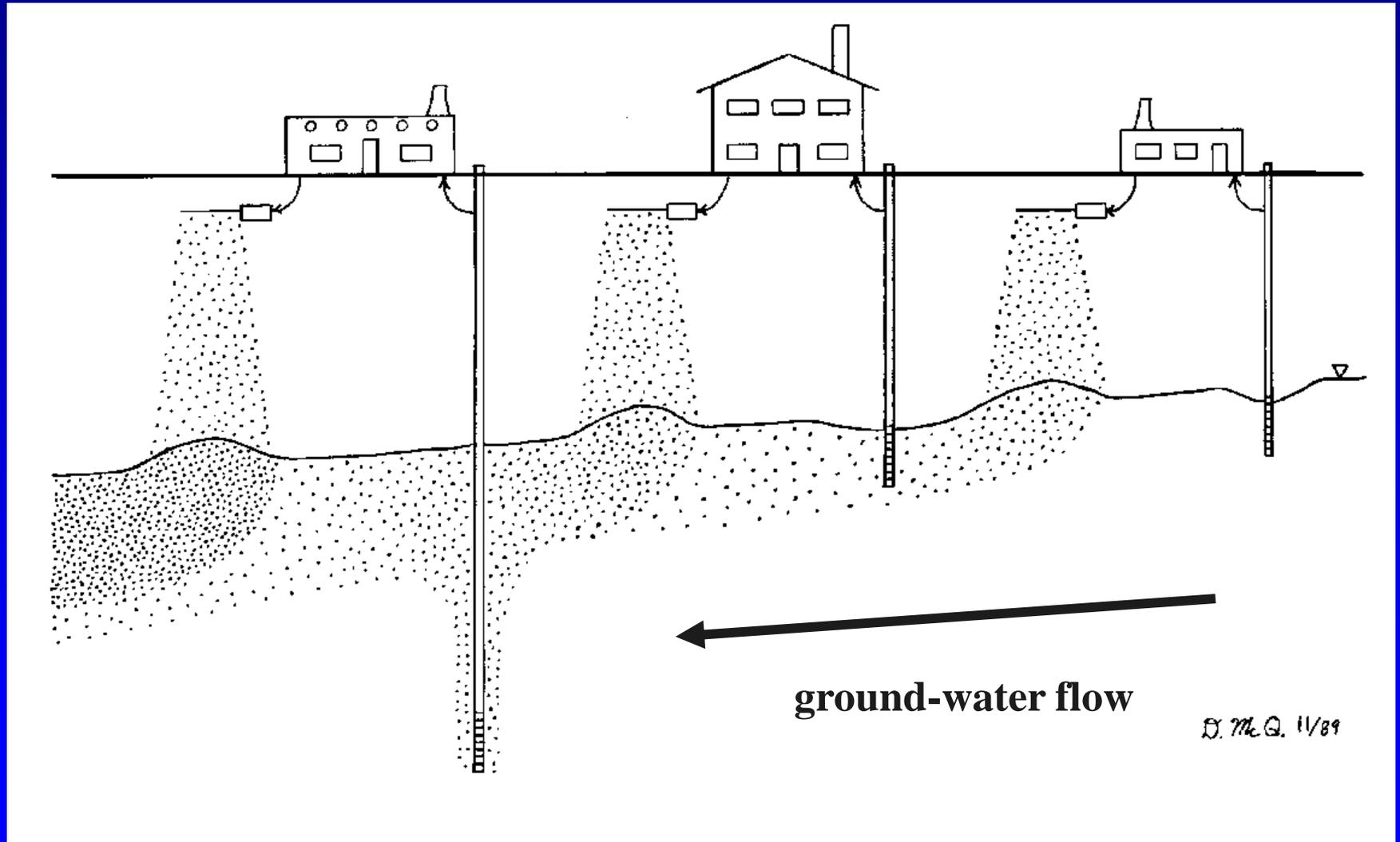
Septic System Suitability

- **"The development of fringe areas and subdivisions that do not have access to municipal water and sewage facilities is creating a continuously growing problem in proper protection of the public health in these areas. ... Septic tanks and leaching systems were never intended for use in closely built-up areas." (NM Board of Public Health, 1959)**

Potential Problems

- Hazards to public health and safety
- Entrapment, drowning, and asphyxiation in illegal cesspools or substandard septic tanks
- Pollution of water supply wells
- Surfacing sewage
- Degradation of surface water quality
- Interference with public welfare and property rights

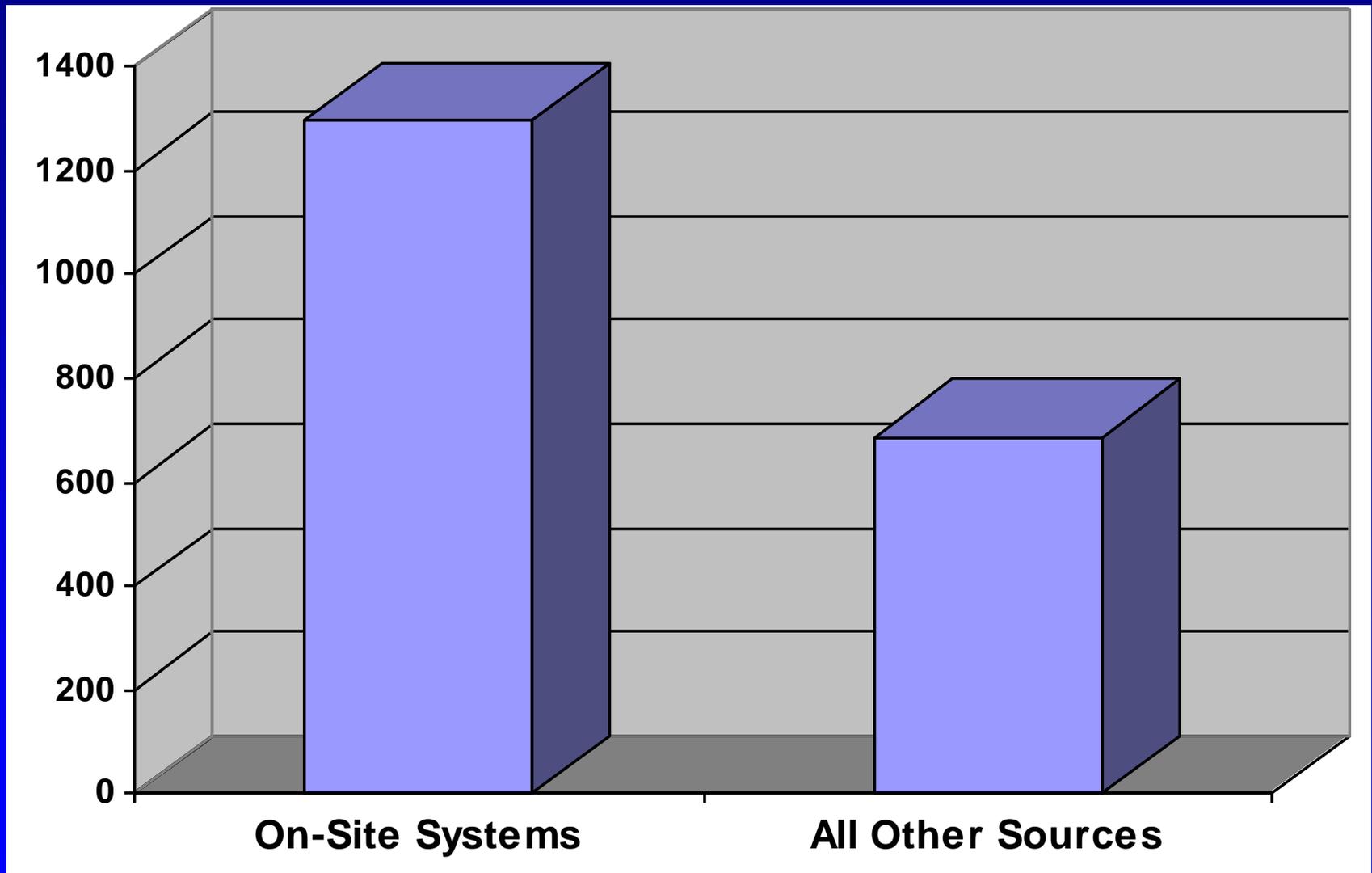
The Capacity for Natural Attenuation is Finite



N.M. Water Quality Control Commission

“Household septic tanks and cesspools constitute the single largest source of ground water contamination in the state.”

Contaminated* Wells in N.M.



*Chemical constituent above numerical standard or fecal coliform detection.

Potential Groundwater Contamination

Onsite wastewater systems can contaminate groundwater with:

- Pathogens*
- Nitrate*
- Anaerobic respiration byproducts
 - Iron,
 - Manganese,
 - Hydrogen sulfide
- Organic compounds
 - Aromatic and chlorinated VOCs
 - Ethers, ketones
 - Pharmaceuticals

*Subject of health-related field investigations in N.M.

Waterborne Disease

- **Notifiable diseases or conditions.**
- **Acute Disease Response Team investigates outbreaks of food or water-borne illness.**
- **Cause of illness is not always determined.**
- **Potential exposure sources include drinking water, food, recreational water, poor hygiene.**
- **Groundwater studies in 1985 and 2008-09.**

1985 Study

- **Albuquerque South Valley, high percentage of homes served by onsite wells and septic systems.**
- **Allegations of epidemic of giardiasis.**
- **State Health/Environment Dept. study funded by legislature.**
- **Gallaher et al., 1987.**
- **Active surveillance system for diarrheal disease.**

1985 Study – Case Definition

- Patients seeking health care for diarrheal disease, May to September 1985, were asked to submit stool specimen.
- Case defined as patient with positive stool detection of amebiasis, campylobacteriosis, cryptosporidiosis, giardiasis, salmonellosis, or shigellosis.

1985 Study – Control Definition

- **Patients seeking health care at same clinic for condition other than diarrheal illness.**
- **Three controls selected for each case identified.**

1985 Study – Questionnaire

Questionnaire administered to all study participants regarding:

- demographic info;
- time of residence at current address;
- whether patient had experienced vomiting and/or diarrhea; and
- 23 questions about risk factors for diarrheal illness.

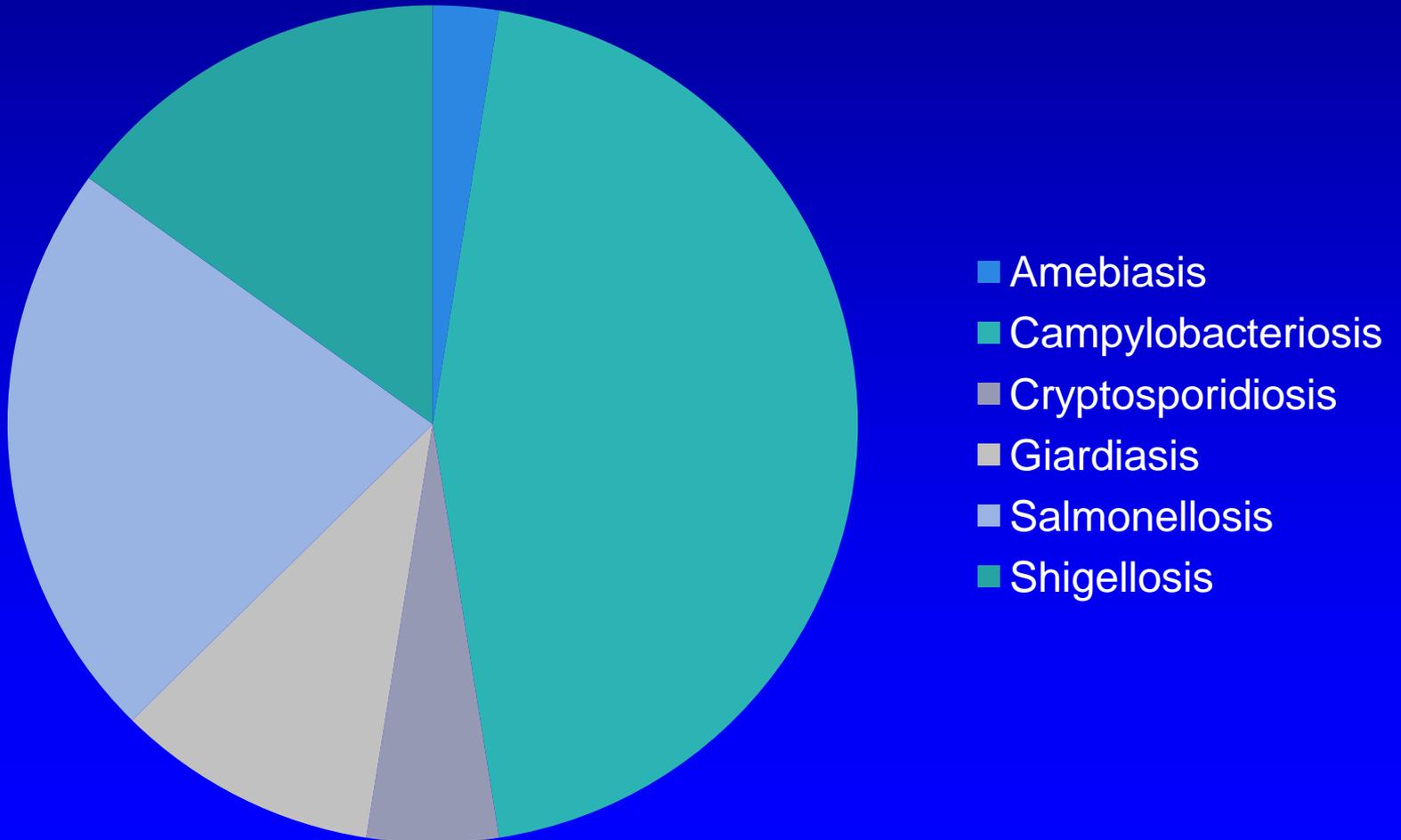
1985 Study – Water Testing

For each case and control served by a private well, water samples were collected for:

- fecal coliform;
- general chemistry;
- trace elements; and
- nitrogen species.

1985 Study – Results

40 cases of confirmed illness



1985 Study – Results

Diarrheal Illness Rate

- **74 per 100,000 in ABQ South Valley**
- **66 per 100,000 statewide**

1985 Study – Results

Risk Factors for Diarrheal Illness

- **Instate travel**
- **Eating at restaurant, party or banquet**
- **Consumption of raw milk**
- **Consumption of raw meat or poultry**
- **Swimming in river, lake or ditch**

1985 Study – Results

Risk Factors for Diarrheal Illness

- Consumption of private domestic well water was not found to be a risk factor.

1985 Study – Results

Water Testing

Fecal coliform not detected in any private well.

Logistic regression analysis found that no water chemistry parameter served as a predictor for diarrheal illness.

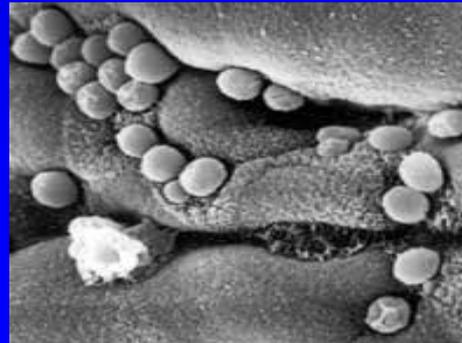
Regional groundwater geochemistry and redox conditions, including influences from onsite wastewater discharges, were defined.

2008-09 Study

- **Communities in Albuquerque area served by onsite wells and septic systems: basin fill sediment and fractured/weathered bedrock.**
- ***Cryptosporidium* antibodies used as an indicator of an immune response that may be caused by contaminated water.**
- **University of New Mexico and Lovelace Institute study funded by Association for Prevention Teaching and Research.**
- **Jackson, 2009.**

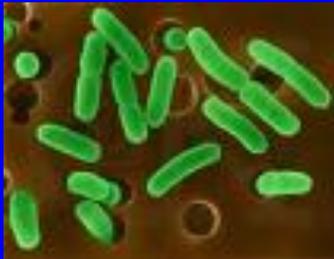
Cryptosporidium

- Common waterborne protozoan parasite.
- Cause of infectious gastroenteritis characterized by watery diarrhea.
- Some 403,000 people were sickened in Milwaukee in 1993 when *Cryptosporidium* oocysts in water from Lake Michigan passed thru the drinking water treatment works.
- Cryptosporidiosis is believed to be an underreported condition.



2008-09 Study - Methods

- Blood testing for *Cryptosporidium* antibody.
- Well water testing for: total coliforms, *E. coli*, *Enterococcus*, and somatic coliphage.
- Questionnaire



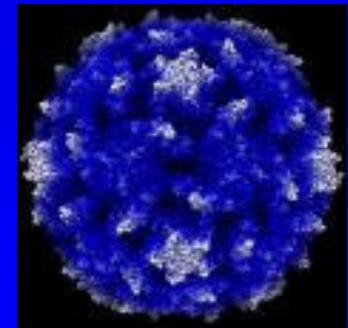
coliform



Enterococcus



E. coli



somatic coliphage

2008-09 Study – Phase 1

Cross-Sectional Study

- People with wells/septics on basin-fill site had more intense serological response to *Cryptosporidium* antigen, after controlling for other risk factors, than the users of city water and sewer.

2008-09 Study – Phase 2

Repeat Water Sample Study

Look at individuals with high levels of *Cryptosporidium* antibodies in regards to:

- water contamination indicators,
- diarrheal and gastro-intestinal illness,
- risk factors for *Cryptosporidium* infection.

2008-09 Study – Phase 2

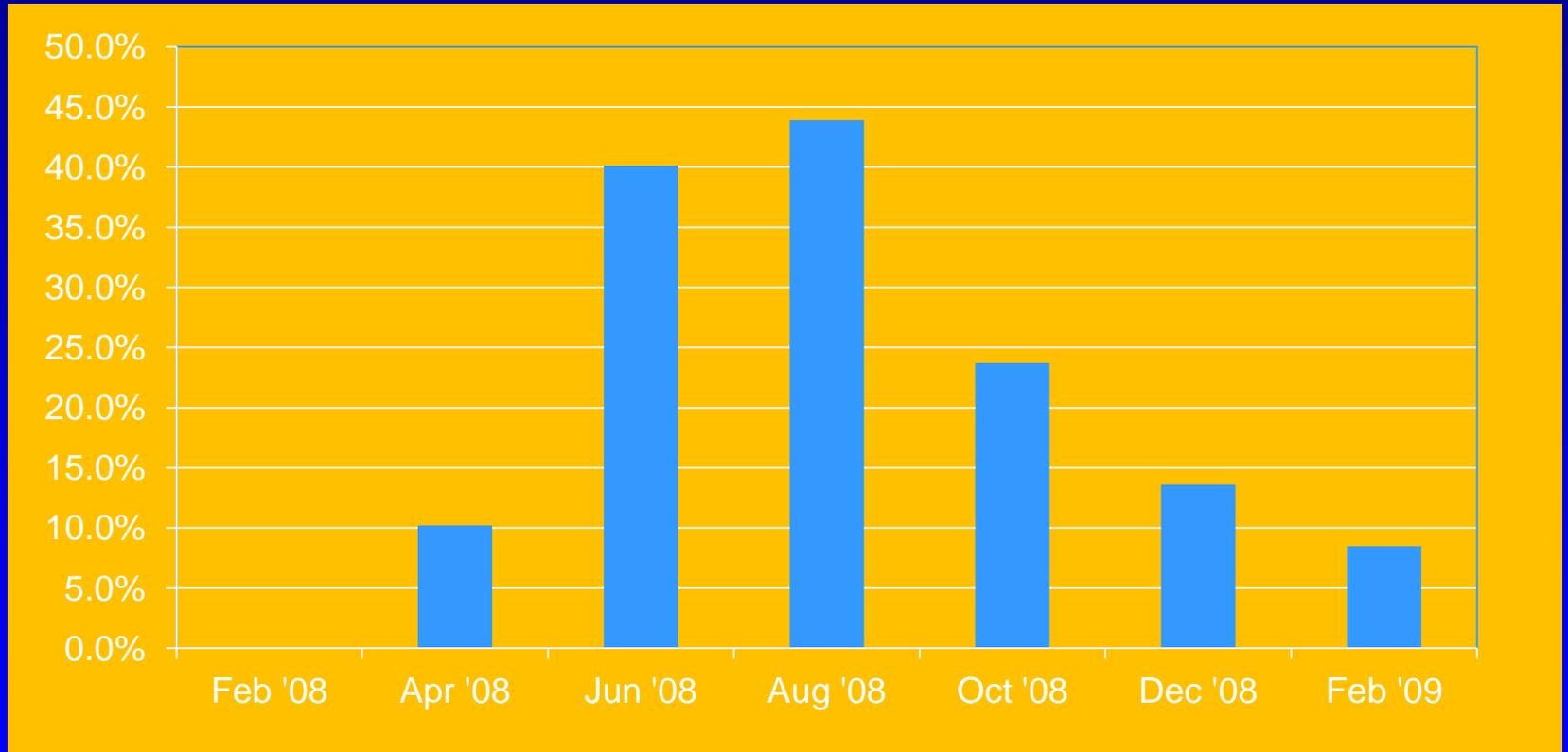
- Data collected Feb. 2008 to Feb. 2009.
- 7 well water samples – once every other month.
- 5 blood samples – once every 3 months.
- 5 questionnaires – once every 3 months.

		Month Following Enrollment											
	Enrollment	2	3	4	5	6	7	8	9	10	11	12	13
Water	x		x		x		x		x		x		x
Blood	x			x			x			x			x
Questionnaire	x			x			x			x			x

2008-09 Participants

- Recruitment pool: Phase I participants who had a septic system and well, and who had a serological response $\geq 20\%$ of the positive control.
- 60 participants selected from exposed group of Phase I.

2008-09 Positive Water Tests by Month



2008-09 Well Test Results

- In a 13 month cycle, 80% of the wells had microbiological contamination at some point.
- It was common for samples to have multiple microbiological detections, and for wells to test positive more than once.

2008-09 Variations in Questionnaire Answers

Risk Factor	Percentage giving variable answers out of 5 questionnaires
Diarrhea in the last 2 months	35.6 %
Episodes of GI illness in past year	40.7 %
Used daycare for child in home	8.5 %
Handled child in diapers	20.3 %
Cared for someone with diarrhea	25.4 %
Visited someone in the hospital	57.6 %
Handled pets	15.3 %
Handled young pets	35.6 %
Handled livestock or wild animals	13.6 %
Drank untreated water	1.7 %
Swam or waded in lake or stream	18.6 %
Used pool, hot tub or water park	35.6 %
Plumbing work done in home	39.0 %
Traveled outside United States	37.2 %
Have pets in home	8.5 %
Diagnosed with Hepatitis A	3.4 %
Vaccinated for Hepatitis A	15.3 %
Eat fresh food or vegetables	8.5 %
Eat organic vegetables	54.2 %
Wash produce before eating	35.6 %
Eat fruit and vegetable peels	79.7 %
Eat outer leaves	57.6 %

2008-09 Study – Results

Relationship between 27-kDa antibody level \geq 75% of positive control and a positive water test for total coliforms

Variable	N	Adjusted odds ratio and 95% confidence interval	p-value
Positive total coliform test	59	2.5 (0.7-8.5)	0.14
Traveled outside the US	59	.18 (0.0-0.8)	0.02

Relationship between 27-kDa antibody level \geq 75% of positive control and a positive water test for *E. coli* (risk factor: most often positive)

Variable	N	Adjusted odds ratio and 95% confidence interval	p-value
Positive <i>E. coli</i> test	59	2.9 (.96-8.7)	0.06

2008-09 Discussion

- Despite the high number of contaminated well-water samples, there were no associations between positive water tests and diarrhea or GI illness.
- Protective immunity may be occurring.
- Visitors may be susceptible to illness or deposit foreign bacteria, virus or parasite into the septic tank.

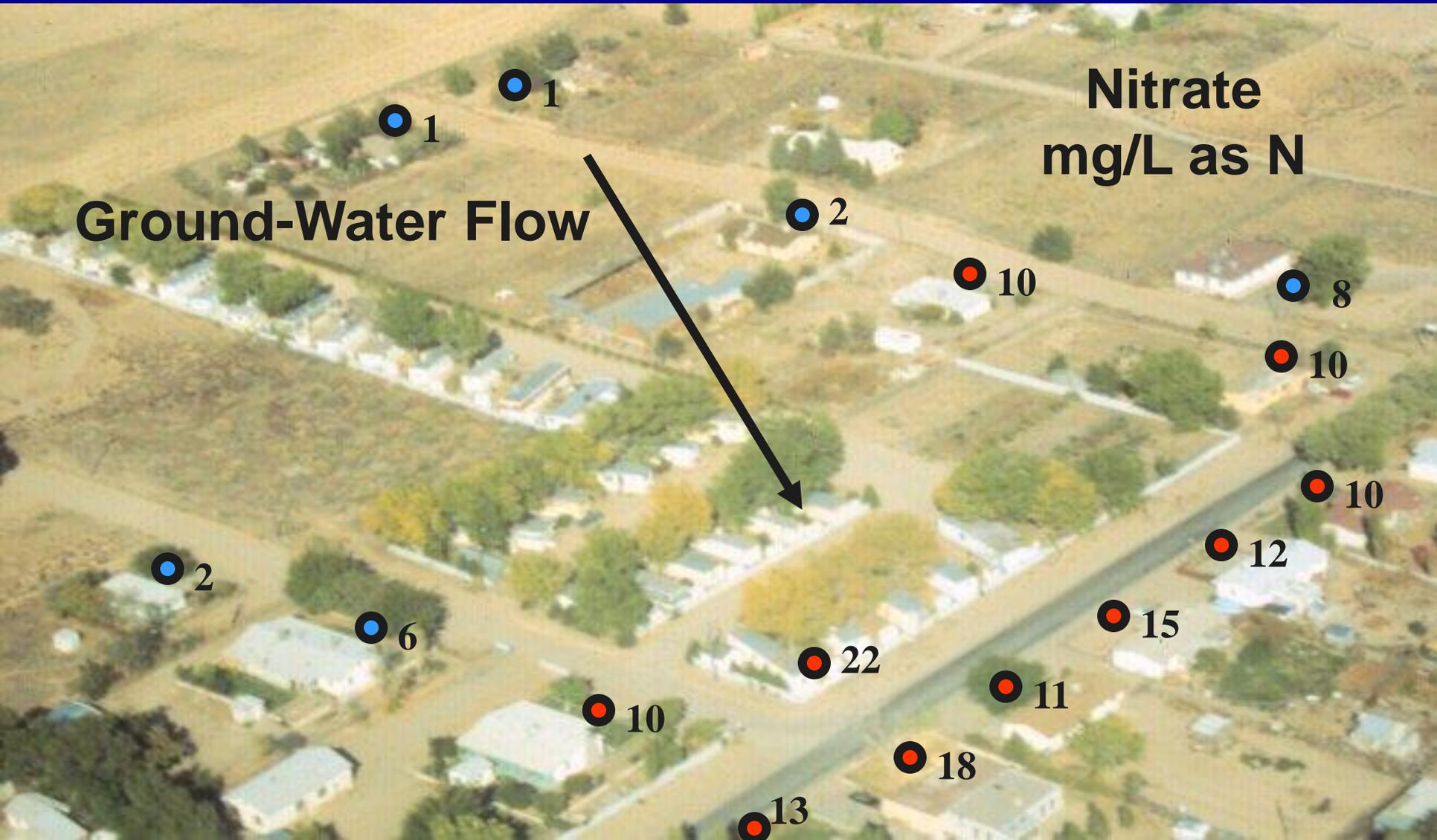
2008-09 Conclusions

- Study results suggest an association between contaminated water and infection from *Cryptosporidium*.
- After controlling for other risk factors, the most likely source of exposure is the underground septic system that exists in close proximity to the private wells.
- Having an on-site septic system and well may increase risk of *Cryptosporidium* infection.

Research On-Going

- UNM has tracer studies underway using wells and septics from some of the participants of the *Cryptosporidium* study.

Groundwater Nitrate Pollution from Septic Systems



Possible Infant Methemoglobinemia (MHG) Cases from Nitrate in Well Water in N.M.

<i>Date</i>	<i>Location</i>	<i>NO₃-N (mg/L) In Well Water</i>	<i>Potential Nitrate Sources</i>	<i>Remarks</i>
1960's-70's	Blue Water	unknown	Uranium mill tailings, septic systems	anecdotal
1960's-70's	Carlsbad	unknown	Septic systems	anecdotal
1961	Carnuel	132	Septic systems, black powder, marine rocks	Male infant recovered after hospitalization for MHG
1980	Albuquerque	47	Fertilizers, ET, septic systems	Male infant (5.5 mo. old) recovered after methylene blue treatment; 14.9% methemoglobin in blood
1996	Veguita	150-200	Fertilizers, ET, septic systems, dairy waste	Female infant (4 mo. old) died of cyanosis, post-mortem methemoglobin blood tests inconclusive

Of the 278+ cases of infant MHG reported by Walton (1951), none were in New Mexico. Infant MHG became a notifiable condition in the State of New Mexico in 2006.

Observations Regarding MHG

- At least 713 private domestic wells in N.M. are known to have been contaminated with high nitrate originating, at least in part, from onsite wastewater systems.
- I have personally visited 7 households where infants were ingesting well water with high nitrate (up to 105 mg/L as N), typically via baby formula or oatmeal, without developing visible symptoms of MHG.
- Blood samples drawn from 3 children at two such households contained normal levels of methemoglobin.

Observations Regarding MHG

- It has long been observed that gastrointestinal illness may be a risk factor in the development of MHG from high nitrate in drinking water.
 - “...methemoglobinemia may occur in an infant following ingestion of water high in nitrates, especially if the infant is suffering from gastrointestinal disturbances.” Walton (1951)
 - “An association between methemoglobinemia and acute gastroenteritis in infants has been noted in several studies and may be due to acidosis from stool bicarbonate loss impairing the already immature function of the methemoglobin reductase system in these young patients.” (Verive, 2011)

Conclusions Regarding MHG

- **MHG is a rare health condition in N.M.**
- **MHG, when it occurs, has caused life-threatening conditions that require emergency medical attention.**

Free Well Water Testing

The New Mexico Environment Department has, for 30 years, provided free nitrate tests to people who utilize private domestic wells.



Shannon and Aiden McQuillan measure specific conductance at a Water Fair in Pojoaque, NM, 2004.

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Questions?

