1999 Project Abstract
For the Period Ending June 30, 2002

TITLE: 012f: Potential for Infant Risk from Nitrate Contamination
PROJECT MANAGER: Rita B. Messing
ORGANIZATION: Minnesota Department of Health, Division of Environmental Health
ADDRESS: P.O. Box 64975, St. Paul, MN 55164-0975
WEB SITE ADDRESS: www.health.state.mn.us/divs/eh/hazardous/healthed.html
FUND: Future Resources Fund
LEGAL CITATION: ML 1999, [Chap._231_], Sec. [_16__], Subd._012f.
(f) Potential for Infant Risk from Nitrate Contamination
APPROPRIATION AMOUNT: $200,000

Overall Project Outcome and Results

Researchers conducted interviews and measured nitrate and bacteria for 381 randomly selected suburban households with private wells (Dakota and Washington counties, Region I; approximately 27,000 household private wells) and 329 rural households (Murray and Nobles counties, Region II; approximately 3,200 household private wells).

In Region I, 24% of wells had nitrate-nitrogen levels above 3 ppm, with 5.6% above 10 ppm (representing1,500 households). In Region II, 37% of wells were above 3 ppm nitrate-nitrogen, with 23% above 10 ppm (representing 730 households). In Region I, 19% of wells were positive for coliform (less than 1% had fecal coliform); in Region II, 66% of wells were positive for coliform (17% positive had fecal coliform). Nitrate and coliform were correlated in Region II, but not Region I. Nitrate contamination was more likely in both regions in wells drilled before the 1974 Minnesota Well Code.

Most sampled households (both regions) reported using wells for over 10 years. In both regions, 30% of household members were children, 6% under age 6. Twenty households provided childcare. In Region I, 67% of children drank tap water during the first year of life versus 31% in Region II. Thirty-four of 65 child caregivers in Region I and 10 of 49 in Region II were unaware of concern about nitrates. Ninety percent of caregivers in Region I and 55% in Region II said that health care providers never discussed nitrates.

Nitrate and bacterial contamination is worse in the rural area but more people may be at risk in the suburbs. There is less knowledge in the suburbs.

Project Results Use and Dissemination

Presentations have been made to state and local government staff to inform decision-making, and to scientific groups. Information for physicians and a paper for publication are planned. Activities will increase awareness of physicians, private well owners and government officials about nitrate and bacterial contamination and potential health effects.

Date of Report: July 1,2002
LCMR Final Work Program Report
Project Completion Date: June 30, 2002

LCMR Final Work Program Report, July 2002

I. PROJECT TITLE: 012f: Potential for Infant Risk from Nitrate Contamination

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Total Biennial Project Budget:
$ LCMR: $200,000 **$ Match:** not applicable

- $ LCMR Amount
Spent: $198,428

= **$LCMR Balance:** $1,572 (*See Attachment B*)

A. Legal Citation: ML 1999, [Chap._231_], Sec. [_16__], Subd._012f.
(f) Potential for Infant Risk from Nitrate Contamination $200,000

Appropriation Language
Carryforward Language: ML 2001, 1st Special Session, Ch. 2, Sec. 14, subd. 18, paragraph (a), The availability of the appropriations for the following project is extended to June 30, 2002: ML 1999, [Chap._231_], Sec. [_16__], Subd._012f.

(f) Potential for Infant Risk from Nitrate Contamination
$200,000 is from the future resources fund to the commissioner of health to study nitrate and bacteria-contaminated drinking water of infants and families at risk.
B. Status of Match Requirement: not applicable

II. and III. FINAL PROJECT SUMMARY:

Overall Project Outcome and Results

Researchers conducted interviews and measured nitrate and bacteria for 381 randomly selected suburban households with private wells (Dakota and Washington counties, Region I; approximately 27,000 household private wells) and 329 rural households (Murray and Nobles counties, Region II; approximately 3,200 household private wells).

In Region I, 24% of wells had nitrate-nitrogen levels above 3 ppm, with 5.6% above 10 ppm (representing1,500 households). In Region II, 37% of wells were above 3 ppm nitrate-nitrogen, with 23% above 10 ppm (representing 730 households). In Region I, 19% of wells were positive for coliform (less than 1% had fecal coliform); in Region II, 66% of wells were positive for coliform (17% positive had fecal coliform). Nitrate and coliform were correlated in Region II, but not Region I. Nitrate contamination was more likely in both regions in wells drilled before the 1974 Minnesota Well Code.

Most sampled households (both regions) reported using wells for over 10 years. In both regions, 30% of household members were children, 6% under age 6. Twenty households provided childcare. In Region I, 67% of children drank tap water during the first year of life versus 31% in Region II. Thirty-four of 65 child caregivers in Region I and 10 of 49 in Region II were unaware of concern about nitrates. Ninety percent of caregivers in Region I and 55% in Region II said that health care providers never discussed nitrates.

Nitrate and bacterial contamination is worse in the rural area but more people may be at risk in the suburbs. There is less knowledge in the suburbs.

Project Results Use and Dissemination

Presentations have been made to state and local government staff to inform decision-making, and to scientific groups. Information for physicians and a paper for publication are planned. Activities will increase awareness of physicians, private well owners and government officials about nitrate and bacterial contamination and potential health effects.

IV. OUTLINE OF PROJECT RESULTS:

- Result 1: Determination of nitrate and coliform bacteria in drinking water in a population based survey of 710 households. Included in this result is the writing of a detailed protocol including criteria for selection of participant households, selection of households for visits, database design, design of forms for recording data, scheduling participants, correspondence, and data entry. Also included is writing a training manual for field researchers. Locational data were recorded with a GPS unit.

Budget:

LCMR Budget:	$105,850
Balance:	$0,000

This result is completed.

- Result 2: Administration of household survey questionnaires. These questionnaires determined the composition of exposed households and the potential at risk population (number of infants, children under age 6 exposed as infants, and women of child-bearing age), the length of exposure, prevalence of breast-feeding, bottle-feeding from tap water, bottle-feeding from other water supplies, known occurrence of methemoglobinemia in members of the household while living at the same address. Included in this result are database design, design of forms, correspondence, and data entry. Parts of the protocol and training manual relevant to this result are also included.

Budget:

LCMR Budget:	$58,750
Balance:	$0,000

This result is completed.

- Result 3: Analysis of drinking water and survey questionnaire results. This will be completed using appropriate statistical techniques and GIS; distribution of results to health professionals, planners, local government officials and risk managers. Included in this result are writing of reports, fact sheets, press releases, and presentations.

Budget:

LCMR Budget:	$35,400
Balance:	$1,572

Analysis is completed. Communication of results is ongoing. To date, study results have been presented at 2 national meetings and numerous presentations have been made to state and local government staff. Work in progress includes advice to physicians, a peer-reviewed publication, and other communications as needed. The web site will also continue to be updated. We are also working with the CDC to design a follow-up study.

Attachment C contains a copy of a Powerpoint presentation of study results and a copy of a fact sheet explaining our study and advice to project participants.

Based on randomly selected wells out of a population of about 57,000, and eligibility of wells selected for the study (must not have access to public water), we estimate that there are about 27,000 residential wells in Region 1 (Washington and Dakota Counties) used more than 1 month per year that are represented by 381 water samples and household visits, and and 3,200 households in Region 2 (Murray and Nobles Counties) represented by 329 water samples and household visits. In Region 1, 24% of wells had nitrate-nitrogen levels above 3 ppm, with 5.6% above 10 ppm (representing about 1,500 households). In Region 2, 37% of wells were above 3 ppm nitrate-nitrogen, with 23% above 10 ppm (representing about 730 households. In Region 1, 19% of the wells were positive for total coliform (less than 1% were positive for fecal coliform); in Region 2, 66% of the wells were positive for total coliform (17% were positive for fecal coliform). There was a positive relationship between nitrate and bacteria contamination in Region 2 but not in Region 1. Nitrate contamination was more likely in both regions in wells drilled before promulgation of the Minnesota Well Code in 1974.

Sampled households reported using the current well for a median of 10 years in Region 1 (Q3 = 20 years) and 15 years in Region 2 (Q3 =28 years). In both regions, households averaged 3 members; 30% of household members were children, with 6% of members under age 6. Twenty households provided childcare. In Region 1, 96% of household members drank the tap water versus 77% in Region 2. In both regions, well water was used for drinking in 98% of children during the first year of life. Thirty-four of 65 childcare givers in Region 1 and 10 of 49 in Region 2 reported being unaware of any concern about nitrates. Ninety percent of caregivers in Region 1 and 55% in Region 2 said that their health care provider never discussed nitrates.

The results indicate that nitrate and bacterial contamination of drinking water are common in both rural and suburban areas; contamination is considerably worse in the rural area but more people may be at risk in the suburban area. There is also less knowledge about nitrate and bacterial contamination in the suburban area.

We are currently working with the Centers for Disease Control and Prevention to design a study of methemoglobin in pregnant women, and its possible relationship to nitrates in drinking water.

V. DISSEMINATION

We have communicated results of testing to participant households, with appropriate fact sheets and advisories about what steps to take if drinking water nitrate is above 10 mg/L nitrate-nitrogen or between 3 and 10 mg/L. Households also received information about well decontamination if bacteria were observed. The information from this project is being organized into reports for peer review and publication, presented in fact sheets and press releases, and presented orally to interested parties. Specifically, the information is being disseminated to health care providers, local governmental decision-makers in residential planning, state and local officials responsible for drinking water protection and agricultural management, and to federal governmental officials concerned with drinking water regulations. The information may be used to improve awareness, diagnosis and reporting of methemoglobinemia, in residential planning and in decision-making for drinking water protection and agricultural management. A list of presentations follows:

International Society for Exposure Analysis, Charleston, November 2001.
State Agency Staff (Health, Agriculture), Minneapolis, December 2001
Minnesota Dept. of Health Well Management Section, St. Paul, January 2002
Well Inspector Training Course, St. Cloud, February 2002
Minnesota Environmental Health Association, Nisswa, April 2002
National Environmental Health Association, Minneapolis, July 2002
Local Government staff in western Minnesota, Slayton, July 2002
Local Government staff (Dakota County), Apple Valley, July 30, 2002
Local Government staff (Washington County), Stillwater, August 28 2002

VI. CONTEXT

A. Significance: Nitrate is the most commonly detected groundwater contaminant in Minnesota. High levels of nitrate are known to occur in drinking water in southern Minnesota; some data indicate that as many as 1/4 to 1/2 of wells in selected areas may have levels above health-based criteria. However, the public health impact of high levels of nitrate and nitrite is unknown.

The legislature (Groundwater Protection Act of 1989) directed the Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Agriculture (MDA) to study nitrate contamination. Subsequent studies by the Minnesota Department of Health (MDH), as well as MPCA and MDA and other state agencies have re-confirmed the extent of the problem in both public water supplies and private wells. These efforts have found high numbers of contaminated wells. However, they have emphasized voluntary testing of wells assumed to be the most vulnerable, and therefore provide no information about the actual proportion of contaminated wells. Furthermore, there has hitherto been no effort to determine the size and characteristics of the population served by contaminated wells.

The MDA and the University of Minnesota Extension Service have assembled Best Management Practices for nitrogen use. However, remediation and consumptive uses of groundwater are increasingly in conflict, and obtaining alternative water supplies (e.g. by drilling new wells in unimpacted aquifers) is often impractical and expensive. Therefore, an accurate determination of the actual prevalence of contamination and of the population affected is needed to facilitate planning, decision-making and education.

The U.S. Environmental Protection Agency (EPA) has determined a Maximum Contaminant Level for nitrate-nitrogen in public drinking water of 10 mg/L (or 44 mg/L of nitrate); similarly, based on authority granted in the Groundwater Protection Act, the MDH has promulgated a Health Risk Limit of 10 mg/L of nitrate-nitrogen, and advises private well owners not to drink water over this limit. These limits protect formula-fed infants less than 6 months of age from methemoglobinemia. Risk factors for methemoglobinemia (beyond exposures to nitrate or nitrite) are largely unknown, although infants who have diarrhea may be more susceptible. Thus, co-occurrence of nitrate or nitrite and coliform bacteria may be significant.

Methemoglobinemia is not a reportable disease; prevalence and incidence in the exposed and vulnerable population, are undetermined. Furthermore, while surveys of wells have also measured coliform bacteria, the correlation of the two measurements has not been emphasized, even though the most vulnerable wells for both contaminants are shallow. Infants drinking water with both contaminants may be at the greatest risk.

B. Time: The bulk of the project took two years to complete. However, significant aspects of Result 3, communication and distribution of results, were done during a third year (through June 30, 2002) to obtain the maximum benefit from the project. Some effort will be ongoing past June 30, 2002 (see above), and the appropriate acknowledgments will be made as more materials (e.g. peer reviewed papers, fact sheets) are produced in the future.

C. Budget Context: The U.S. Centers for Disease Control provided MDH with $154,000 in 1994 to conduct a statewide private well survey. Among other contaminants, nitrates and fecal coliform were measured in private wells. Wells were selected at the vertices of a 10 mile square grid placed over the state.

1.

BUDGET:

Personnel **$158,350**

The following Project Manager and Cooperators are all in the Site Assessment and Consultation (SAC) Unit, in the Division of Environmental Health MDH.

Rita B. Messing, Ph.D., Research Scientist Supervisor 2, Project Manager, Principal Investigator, 8%. Administration and scientific direction of project, supervisory responsibility for staff, assurance for quality of work and communications.

Jean Small-Johnson, Ph.D., Epidemiologist Senior, Co- Investigator, 10%. Specialized skills in epidemiology, survey research, biostatistics and evaluation.

Deborah Durkin, MPH, Research Scientist 2, Research Coordinator, 10%. Day-to-day oversight of collection of survey and water data; major responsibility for writing study protocol, forms, training manual; assistance with report writing and data analysis.

Melinda Salisbury, M.S., Hydrologist 2, Research Co-Coordinator, 4%. Major responsibility for collection of drinking water data; assist Research Coordinator with day-to-day project oversight, protocol and training manual; assistance with report writing and data analysis. Left project in July 2000.

The above personnel are classified employees in the SAC unit, whose expertise has been necessary for the successful completion of this project. The above comprise the project team that designed and directed the Minnesota Arsenic Study (MARS), a study of arsenic occurrence, geochemistry and effect, that was conducted by MDH in Western Minnesota. MARS was supported by supplemental funds to MDH from the U.S. Agency for Toxic Substances and Disease Registry (ATSDR), which funds most of the activities of the SAC unit. We used the expertise of this group to design and direct the present project.

Permanent funding of the SAC unit (and for these employees) is for investigation of site-specific uncontrolled contaminant releases and surveillance of hazardous substances emergency events. Permanent SAC unit funds come from ATSDR and from the Minnesota Solid Waste Fund. Thus, in order for these personnel to work on the present project, support for them had to be explicitly provided for in the LCMR workprogram. Other personnel are:

Project analysts (4, 75% each for 6 months. Collection of water samples, field

measurements, administration of survey instruments.
Project Specialist, 70%, Melissa Kemperman. Construct participant list, file maintenance, data analysis.
Clerical support, 25%. Participant scheduling, data entry, correspondence
Information Technology Specialist 3, $10,000 to EH Division Services (about 7%), Yuan-Ming Hsu. Computer and GIS support.

Other **$41,650**

In-state travel: $18,800. Includes mileage and per diem for project analysts, some in-state travel for senior personnel to oversee field activities.
Travel to scientific meetings (outstate): $1,900. Includes trips to two meetings to communicate results.
Supplies and tools: $14,550. Electrodes and reagents for field equipment, coolers, hoses, gloves, sample bottles, wipes, toolkits, office supplies.
Communication, printing and advertising: $6,400. Cell phones and pagers for project analysts, long distance phones, mailing expenses, printing and duplicating of materials, graphics production.

TOTAL **$200,000**

2. Submit a budget detail with all the specifics as attached as Attachment A.

VII. COOPERATION: **(See above for specific functions)**

Minnesota Department of Health:
Rita Messing (Project Manager)
Jean Small-Johnson
Deborah Durkin
Melinda Salisbury

VIII. LOCATION: We obtained data for 329 households in southwestern Minnesota (Nobles and Murray counties), and 381 households in two metro area suburban counties (Dakota and Washington counties) (see *Fig. 1*). We conducted 2 population-based surveys, one in each area. This plan was based on available information concerning occurrence of high nitrates and fecal coliform in Minnesota groundwater (MDH/CDC data, 1994; *Nitrogen in Minnesota Groundwater; Prepared for the Legislative Water Commission*, MPCA/MDA, 1991 and Clean Water Partnership 2000 proposals). This plan enabled us to compare nitrate/coliform contamination and its impact on populations in 2 areas of the state with different hydrogeological and population characteristics. Methemoglobinemia, voluntarily reported to MDH was found to be highest in southwestern Minnesota (Bosch et al, 1950). While these are old data, they are the largest data set available, and are an important source used by the U.S. Environmental Protection Agency for determination of the Maximum Contaminant Level (MCL) for nitrate-nitrogen.

IX. Research Projects (addendum)

POTENTIAL FOR INFANT RISK FROM NITRATE CONTAMINATION

I. Abstract

Levels of nitrate above health criteria are known to occur frequently in drinking water in southern Minnesota; some data indicate that as many as 1/4 to 1/2 of wells in highly impacted regions may have high levels. Criteria protect formula-fed infants less than 6 months of age from methemoglobinemia ("blue baby" syndrome). Infants with diarrhea may be more susceptible. Thus, co-occurrence of nitrate and coliform bacteria may be significant. Methemoglobinemia is not a reportable disease; thus its prevalence and the size of the potentially vulnerable population are unknown.

We have therefore determined the prevalence of drinking water contaminated with nitrate and coliform bacteria in 2 high nitrate areas of Minnesota in a population-based survey of about 710 households. The potential for "blue baby" syndrome in people exposed to contaminated drinking water was assessed by determining the number of exposed infants, children under 6 in surveyed households exposed as infants, and women of child-bearing age. Survey questionnaires also inquired about infants and young children who were likely exposed as infants who were breast fed, bottle-fed, and bottle-fed from tap water. Results were analyzed in a GIS, for simultaneous visualization of related data sets. Results are being distributed to health professionals, planners and risk managers for use in improving diagnosis and reporting of "blue baby" syndrome, residential planning, agricultural planning and drinking water protection.

II. Background and hypothesis

The link between cyanosis and ingestion of nitrates from well water used to make baby formula was discovered by Comly (1945). Comly reported two cases of Iowa infants who presented with diarrhea and cyanosis reminiscent of congenital heart disease. Cyanotic symptoms were eliminated by administration of methylene blue suggesting that methemoglobin was involved. Based on a report of infantile methemoglobinemia caused by bismuth subnitrate, Comly hypothesized that nitrate could be a causative agent. Very high nitrate-nitrogen was subsequently found in well water samples (90-140 ppm). Water samples were also found to be contaminated with bacteria.

Shortly afterward, the Minnesota Department of Health (MDH) analyzed 139 cases of methemoglobinemia voluntarily reported in Minnesota in 1947 and 1948 (Bosch et al, 1950). While it is old, this is still the largest single data set available. There were 129 wells connected with cases that were examined. Two wells had a nitrate-nitrogen concentration between 10-20 ppm; 25 wells were between 21 and 50 ppm; 53 wells were between 51 and 100 ppm; and 49 wells were over 100 ppm. The onset of cases was also examined. Fifty percent of cases had symptoms between two and four weeks of age, 70 percent between two and six weeks. The youngest case was 8 days old, and the oldest age of onset was in an infant 5 months old.

Walton (1953) reviewed 278 cases of methemoglobinemia, including 39 deaths for the American Public Health Association. Walton found that nitrate-nitrogen concentrations in well water ingested by cases was less than 20 ppm in 2.3% of cases. No cases were reported where nitrate-nitrogen was below 10 ppm. Most cases were associated with drinking water above 40 ppm.

Since 1953, reporting of cases of infantile methemoglobinemia has been sporadic. Most authors have noted, beginning with Comly (1945) that methemoglobinemia is not a reportable disease (unless there is a death), and that mild cases will likely go unnoticed. Thus, recent authors have expressed the opinion that most cases are neither reported nor published (e.g. Hegesh and Shiloah, 1982; Lukens, 1987; Meyer, 1996). Lukens, in his 1987 retrospective review (*Journal of the American Medical Association; JAMA)* of the Comly (1945) article, expressed the opinion that methemoglobinemia remains a potentially lethal problem for rural infants, underscored by a report in the same issue of *JAMA* of a 1986 death in South Dakota (Johnson, et al 1987). Other authors have expressed the opinion that milder forms of methemoglobinemia could result in subclinical, but nevertheless damaging effects (Hegesh and Shiloah, 1982).

Methemoglobin is formed by the *oxidation* of heme iron to Fe^{+++} from Fe^{++}. The resulting pigment is greenish brown, and is called methemoglobin. Oxidation of the heme iron prevents the *oxygenation* of hemoglobin, and causes hypoxia. Fe^{++} is oxidized to Fe^{+++} in the presence of nitrite (Smith, 1996). This is normally of no or limited consequence because methemoglobin can be metabolically reduced back to hemoglobin by reduced nicotinamide adenine dinucleotide (NADH)-cytochrome b_5 reductase. Another pathway for methemoglobin reduction is normally metabolically dormant, but can be activated by methylene blue or other electron acceptors. This is the reduced NAD phosphate (NADPH)-dependent cytochrome b_5 reductase.(Lukens, 1987; Smith, 1996).

While there are hereditary forms of methemoglobinemia (Lukens, 1987; Smith, 1996), and there are are rare adults who might be vulnerable to methemoglobinemia connected with drinking water, methemoglobinemia is almost entirely a disorder of infants and possibly of pregnancy (see below). This is due to several factors (ATSDR, 1991): 1) The infant gut is immature and has a higher pH than that in older people, which facilitates the reduction of nitrate to nitrite by nitrate reducing bacteria (see below). 2) Fetal hemoglobin is more readily oxidized by nitrite than is mature hemoglobin, and a large proportion of infant hemoglobin is fetal. 3) In infants NADH-cytochrome b_5 reductase has very low activity, so that methemoglobin formed in the presence of nitrite cannot be reduced back to hemoglobin as readily.

Many, if not most cases of methemoglobinemia co-occur with diarrhea (e.g. Comly, 1945; Walton, 1953). Shearer et al (1972) studied methemoglobin in blood in a high nitrate area of California, in which no cases of methemoglobinemia were diagnosed. They found that babies with diarrhea had the highest levels of methemoglobin. This is significant, because fecal microorganisms in the gut reduce nitrate to nitrite, and the higher (less acidic) gut pH of infants provides a milieu in which fecal microorganisms can more easily grow (Walton, 1953; ATSDR, 1991). Since many wells contaminated with nitrate are shallow, they are also at higher risk for contamination with fecal microorganisms. Minnesota data suggest that high nitrate and bacteria contamination occur in the same areas of the state, although no attempt has previously been made to systematically measure the co-occurrence of the two contaminants.

There are limited data suggesting that methemoglobin increases in women from the fourteenth to the fortieth week of pregnancy, reaching a peak at about the thirty-fifth week (Skrivan, 1971), although it is unknown whether this increase is related to nitrate ingestion from drinking water. An Australian study found a significant increase in the risk of birth defects associated with maternal drinking water nitrate concentrations (Dorsh et al, 1984). A Canadian study found a similar increase in risk of birth defects (although the increase was not significant). In the Canadian study, the increase in risk was seen only when nitrate was high and the maternal water supply was a private well, but not when the water supply was a municipal well. This could be because nitrate and bacterial contamination are more likely to co-occur in a private water supply. Based on these data, there is reason to suspect that pregnant women, possibly because of the increased metabolic stress of pregnancy, may be more at risk for methemoglobinemia than non-pregnant women, and that the developing fetus may therefore be at greater risk for congenital malformations when nitrate load to the mother is high. However, evidence on these points is still inconclusive.

Based on the above considerations, we collected population-based data on nitrate and fecal coliform co-occurrence in drinking water in areas at high risk for contamination, and systematically determined the characteristics of these high risk areas and of the population exposed. Data of this type are sorely lacking.

The results of this study can be used to inform awareness, diagnosis and reporting of methemoglobinemia, for residential planning and for decision-making for drinking water protection and agricultural management. These data may also be used to develop a population that could be used for prospective epidemiological studies of methemoglobinemia in pregnancy and infancy.

III. Description of the methodology to be employed to carry out the proposed research. Include sample design.

We performed two independent population-based surveys, one in southwestern Minnesota (Nobles and Murray counties), and one in east central Minnesota (Washington and Dakota counties). Population-based surveys of households that do NOT use municipal water were done (710 households in both regions). We randomly selected from a list of all households thought to be on private water in each region.

Selected households received a letter and fact sheet describing the study. About one week later, each household received a telephone call. The purpose of the telephone call was to determine eligibility. Eligible households were not served by municipal water. There was also a residency requirement (30 days). The telephone screener then scheduled an appointment.

Field researchers obtained written permission to sample water and to administer the survey instrument. Wells were purged, and water samples were collected and assayed for nitrate-nitrogen with a Hach spectrophotometer, courtesy of the Environmental Health Division Source Water Protection Unit. Fecal coliform in drinking water was analyzed by Colilert. Field staff also made a map of each property visited, indicating the proximity of the well-head to sources of contamination (fertilized fields, animal waste, septic system drainfields).

One adult from each household was interviewed using our survey instrument. General demographic characteristics were determined (e.g. age, gender, race/ethnicity, length of residence, occupation(s), family income, education). The survey instrument included questions about well depth and year of construction (if known), about infants and young children who were likely exposed as infants who were breast fed, bottle-fed, and bottle-fed from tap water. Participants were asked if any family members were ever diagnosed with methemoglobinemia or blue baby syndrome or cyanosis. There were also questions about diet, since some foods are high in nitrates. A more detailed questionnaire was administered to principal caregivers in households with children under 6 years of age.

IV. Description of the results and products produced from the proposed research.

The following results and products were produced:

1. Research protocol.
2. Databases for survey and well data.
3. Training manual for field researchers.
4. Forms, including letters to participants, factsheets, permissions, telephone screening and scheduling forms, well data forms and survey forms.
5. Newsletters to stakeholders, including state and local governmental public health, planning and environmental officials, university faculty, environmental and public health groups.
6. News releases.
7. Household addresses of participants were matched with information in the County Well Index to determine if there is any information about well depth and construction.
8. Data were analyzed to determine the range of nitrate concentrations, and whether or not presence of fecal coliform is more likely when nitrate-nitrogen is above the Maximum Contaminant Level (MCL) of 10 ppm.
9. Data were analyzed to determine if contamination is related to well depth and construction, and proximity to sources of contamination.
10. Data were analyzed to determine the general characteristics of the rural and suburban populations. They were also analyzed to determine if some population characteristics

differ as a function of nitrate level in drinking water (above or below the MCL).

11. Results were analyzed to determine if risk factors for methemoglobinemia (e.g. consumption of tap water versus bottled water in infant formula) vary as a function of demographic characteristics such as income and education. There were no reports of methemoglobinemia.
12. Individual well sampling results were communicated to study participants, and drinking water advice was given to participants with contaminated drinking water.
13. Results were presented at professional meetings. An abstract was submitted to the International Society for Exposure Analysis for presentation at the annual meeting in Charleston, SC in November 2001. Results were also presented at the National Environmental Health Association meeting and the Minnesota Environmental Health Association meeting.
14. Results are being described in a paper to be submitted for peer review and publication.
15. More informal reports of results in summary form will be done in factsheets and news releases.
16 Results are being communicated to health care providers, local and state public health, planning and environmental officials by means of informal reports and meetings.

V. Timetable for completing the proposed research.

By February 2000 we completed:

Databases containing households thought to be on private wells in our four target counties.
Research Protocol
First Drafts of all forms, for testing with volunteers acting as participants

By the end of March, 2000 we completed:

Databases for survey and well data
Training manual for field researchers
Final drafts of all forms, news releases, a first news letter and factsheet
Meetings with local officials in regions that we will be sampling
Hiring of field researchers and office staff
Selection of participants, or if we are sampling randomly selected clusters (e.g. census tracts), selection of all participants in the first 1/4 of tracts to be sampled

By the end of October, 2000 we completed:

All well sampling and participant surveys
Matching of household addresses with information in the County Well Index

By the end of January 2001 we completed:

Communication of results to study participants

By June 30, 2001 we completed:
Most of the data analyses.

By August 31, 2001 we completed:
All remaining data analyses.

By June 30, 2002 completed:
Presentation(s) at professional meetings
Several reports of results for lay audiences
Communication of results to health care providers, local and state officials

VI. Budget requirements to conduct the proposed research, including an identification of any in-kind and/or leveraged resources provided to support the research.

Budget requirements are described above and in Attachment A.

VII. Identification and brief background (resumes acceptable) of the principal investigators and cooperators who will carry out the proposed research and selected publications. Included in previous Work programs. Not included here.

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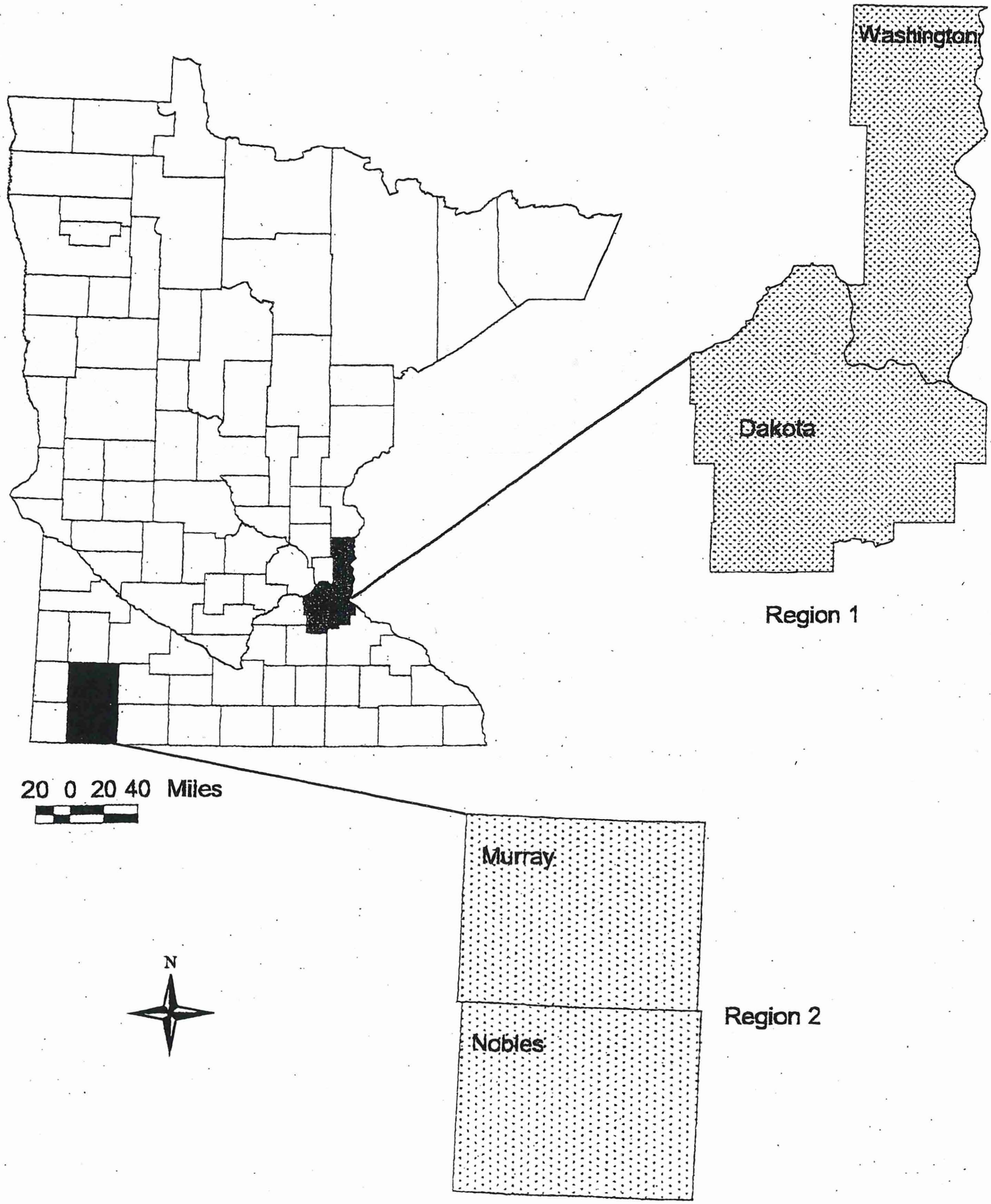
Fig.1. Nitrate Exposure and Infant Risk Study (NEXIR) Study Regions



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Attachment A Deliverable Products and Related Budget				
LCMR Project Biennial Budget		Objective / Result		
	Result 1	**Result 2**	**Result 3**	
Budget Item:	Determination of nitrate and coliform bacteria in drinking water in a population based survey of 800 households.	Administration of household survey questionnaires.	Analysis of drinking water and survey questionnaire results; distribution of results.	**ROW TOTAL**
Wages, salaries & benefits-Be Specific on who is paid $	R Messing $4,000 J Johnson $2,800 D Durkin $3,500 M Salisbury $ 3,850 Y-M Hsu $5,000 MKemp $27,600 Proj Anal, Field Staff $28,000 Clerical $5,000	R Messing $4,000 J Johnson $5,000 D Durkin $3,500 Y-M Hsu $ 2,000 MKemp $14,450 Proj Anal, Field Staff $15,500 Clerical $4,200	R Messing $4,300 J Johnson $4,100 D Durkin $4,500 Y-M Hsu $ 3,000 MKemp $10,050 Clerical $4,000	R Messing $12,300 J Johnson $ 11,900 D Durkin $11,500 MSalisbury $3,850 Y-M Hsu $10,000 MKemp $53,050 Proj Anal, Field Staff $43,500 Clerical $13,200
Printing and advertising	$200	$200	$1,500	$1,900
Communi-cations, tele-phone, mail,etc.	$1,900	$1,900	$700	$4,500
Other travel expenses in Minnesota	$10,000	$7,800	$1,000	$18,800

Travel outside Minnesota			$1,900	$1,900
Office supplies	$400	$200	$350	$950
Tools and equipment	$13,600			$13,600
COLUMN TOTAL	$105,850	$58,750	$35,400	$200,000

MINNESOTA DEPARTMENT OF HEALTH
BUDGET (MFR) FOR STATE YEAR ORG
STATE FISCAL YEAR 2002
SUMMMARY BY ORGANIZATION
FOR ORG's WITHOUT A REPORTING CATEGORY (ACTIVITY CODE)

FUND/ORG/ UNIT NAME AS OF Jul 26, 2002 Salary thru PPE on or before Jul 16, 2002

FUND/ORG/ UNIT	NAME	OBJ CLASS	BUDGET	ENCUMBERED	EXPENDED	BALANCE	%EXP
130 2740 130	LCMR-INFANT RISK						
	FULL TIME	1A0	11,289	0	10,817	472	96%
	PART-TIME, SEASONAL, LABOR SE	1B0	2,051	0	2,051	0	100%
	OTHER BENEFITS	1E0	0	0	0	0	0%
	PRINTING AND ADVERTISING	2C0	500	0	0	500	0%
	COMPUTER & SYSTEMS SERVICES	2E0	300	0	810	-510	270%
	COMMUNICATIONS	2F0	100	10	18	72	18%
	TRAVEL & SUBSISTANCE -INSTATI	2G0	500	0	46	454	9%
	TRAVEL & SUBSISTANCE -OUTSTA	2H0	1,300	0	744	556	57%
	SUPPLIES	2J0	30	0	0	30	0%
	EMPLOYEE DEVELOPMENT	2L0	470	0	470	0	100%
	OTHER OPERATING COSTS	2M0	0	0	11	-11	0%
TOTAL ALLOT	LCMR-INFANT RISK		$ 16,541	$ 10	$ 14,968	$ 1,562	90%

ATTACHMENT B
EXPENDITURES

SORT: ORG LEVEL=5 / ALLOT-ORG / OBJ-CLASS

ATTACHMENT C
POWERPOINT PRESENTATION

Minnesota Department of Health Nitrate Exposure and Infant Risk (NEXIR)

Rita Messing, Jean Small-Johnson, Deborah Durkin, Melinda Erickson, Melissa Kemperman, Yuan-Ming Hsu

Conducted from April to November, 2000. Supported by the Minnesota Future Resources Fund/Legislative Commission on Minnesota Resources (LCMR)

Methemoglobinemia - 1

- 1945: Comly reports two Iowa infants with diarrhea and cyanosis reminiscent of congenital heart disease
- Cyanosis eliminated with administration of methylene blue, suggesting methemoglobin responsible
- Well water samples show 90-140 ppm nitrate-nitrogen.

Methemoglobinemia - 2

- 1947-48: MDH analyzes 139 cases; linked to data from 129 wells.
- Largest single data set to date
- Most cases in southwestern Minnesota
  - 2 wells had 10-20 ppm nitrate-N
  - 25 wells 21-50 ppm nitrate-N
  - 53 wells 51-100 ppm nitrate-N
  - 49 wells >100 ppm nitrate-N
- Onset: 50% between 2-4 wks of age
  70% between 2-6 weeks
  range: 8 days to 5 months

Methemoglobinemia - 3

- Methemoglobinemia not a reportable disease
- Most cases probably unreported
- Symptoms:
  - 10-20% MeHb: asymptomatic cyanosis of limbs and trunk
  - 20-45%: CNS depression, dyspnea
  - 45-55%: coma, arrhythmias, shock, convulsion
  - >70%: High risk of mortality

Methemoglobinemia – 4

- Methemoglobin *formed* by *oxidation* of heme iron to Fe^{+++} from Fe^{++}
  - *Oxidation* of heme iron prevents *oxygenation* of hemoglobin -- causes hypoxia
  - Fe^{++} is oxidized to Fe^{+++} in the presence of nitrite
- Methemoglobin metabolically reduced to hemoglobin
  - Reduced nicotinamide adenine dinucleotide (NADH)-cytochrome b_5 reductase
- Normally dormant reduction pathway - activated by methylene blue or other electron acceptors
  - Reduced NAD phosphate (NADPH)-dependent cytochrome b_5 reductase

Methemoglobinemia – 5

Disease of infants … possibly pregnancy

- Infant gut: immature; higher pH
  - facilitates the reduction of nitrate to nitrite by nitrate reducing bacteria
  - exacerbated by diarrhea-causing bacteria
- Fetal hemoglobin more readily oxidized than mature hemoglobin
  - large proportion of infant hemoglobin is fetal
- In infants **NADH-cytochrome b_5 reductase** has very low activity
  - methemoglobin formed in the presence of nitrite cannot easily be reduced back to hemoglobin

NEXIR Objectives-1

- Determine prevalence of high nitrate and bacteria in private wells in a rural area and a suburban area of Minnesota
- Determine the relationship between nitrates and bacteria in drinking water and well construction
- Describe the population living in households using private wells

NEXIR Objectives- 2

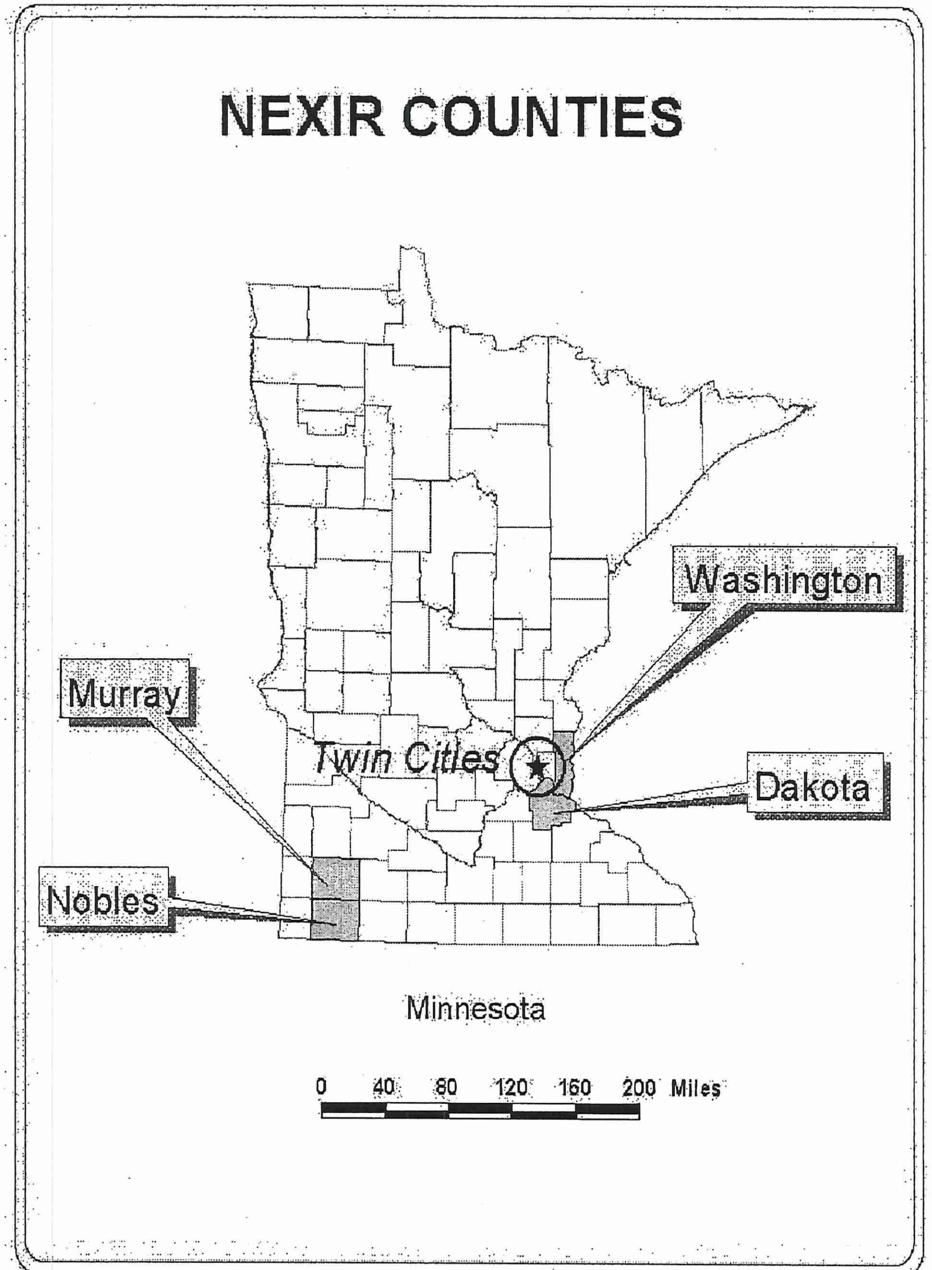
- Determine the proportion of children < age 6 living in these households, and potentially exposed to nitrates and bacteria in infancy
- Measure frequency of reported symptoms, physician visits, diagnoses for diarrhea, methemoglobinemia during infancy
- Describe primary care givers' (of children < 6) knowledge of nitrate risk, exposure prevention methods, and available sources of information

NEXIR Objectives- 3

- Compare well findings and demographic findings in the two study areas
- Report results and implications for health education and policy planning

NEXIR Methods:

I: Identify two study regions with known risk of nitrate and bacterial contamination in private wells



NEXIR Methods:

II. Household Selection, Screening and Recruitment

- Select areas not served by public water
- Use tax records to identify property pool
- Screen owner or resident for eligibility:
  - Lived in residence>30 days/year
  - Not connected to city or rural water
  - Have an operable private well

II. Household Selection and Screening

AREA	ALL PROPERTIES (1999 Tax Records)	PROPERTIES WITH HIGH PROBABILITY OF PRIVATE WELLS	RANDOMLY SELECTED PROPERTIES	ELIGIBLE NEXIR PROPERTIES		EXTRAPOLATED ELIGIBLE PROPERTIES	
		Number	Number	Number	*Percent Randomly Selected*	Number	*Percent of All Properties*
Dakota	127,116	19,838	326	133	*40.8*	8,093	*6.4*
Washington	82,550	30,038	474	298	*62.9*	18,885	*22.9*
REGION 1	**209,666**	**49,876**	**800**	**431**	***54.1***	**26,978**	***12.9***
Murray	2,295	1,610	192	121	*63.0*	1,015	*44.2*
Nobles	6,247	6,093	752	266	*35.4*	2,155	*34.5*
REGION 2	**8,542**	**7,703**	**944**	**387**	***41.1***	**3,170**	***37.1***
ALL COUNTIES	***218,208***	***57,579***	***1744***	***818***	**52.4**	***30,148***	**13.8**

NEXIR Methods:

III. Data Collection and Sampling

- A. Household questionnaire:

  well water use
  use of water treatment
  prior well testing
  length of residence
  well characteristics
  household demographics

- B. Water samples

  outdoor nitrate and coliform
  indoor (kitchen tap) nitrate

- C. Child exposure questionnaire for caregivers

  frequency of diarrhea
  methemoglobinemia
  well water consumption in infancy

- D. Caregiver's questionnaire

  knowledge of risk, prevention

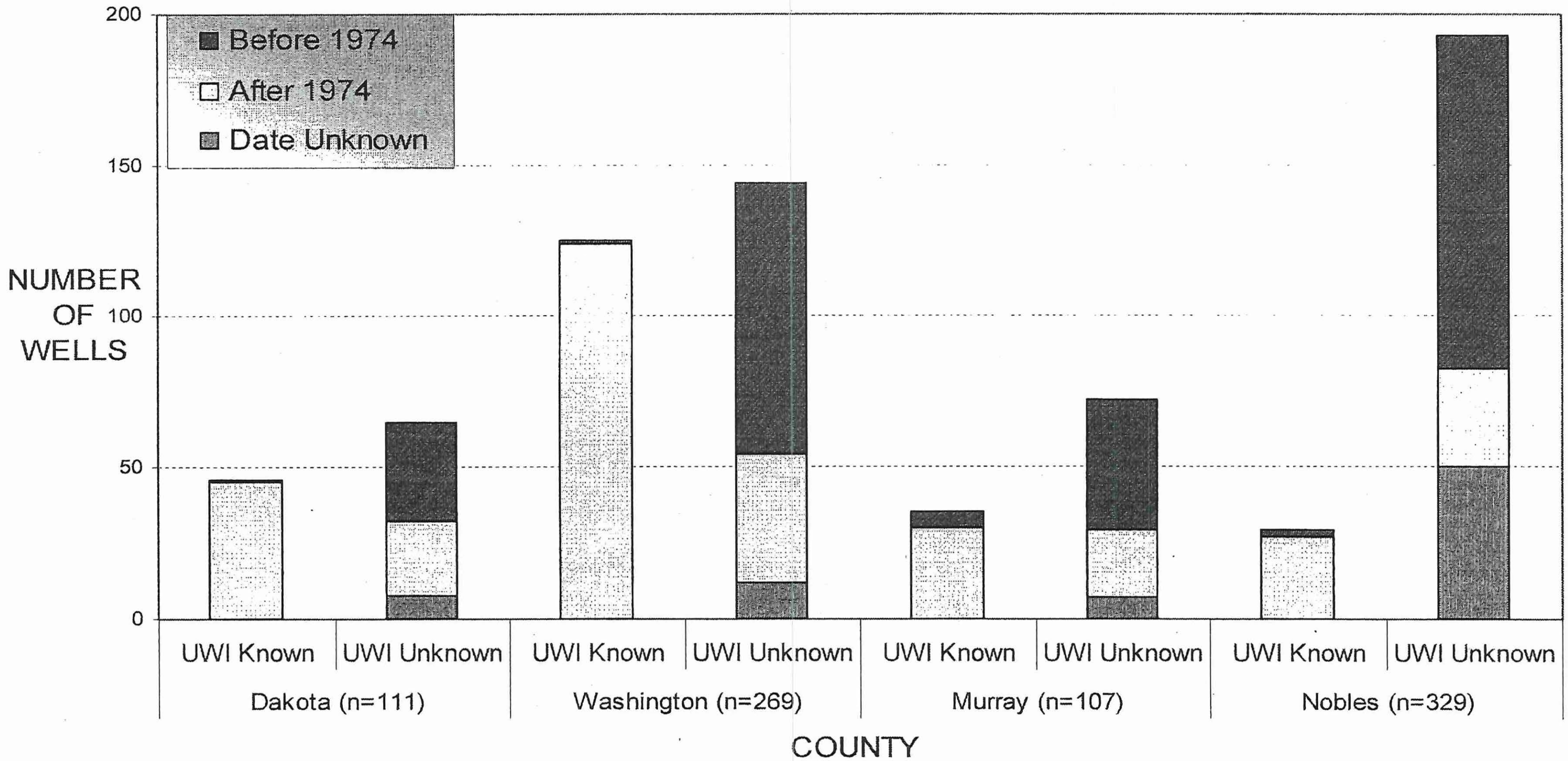
- E. Advice to participants

NEXIR Results:

710 households: 381 Region 1; 329 Region 2

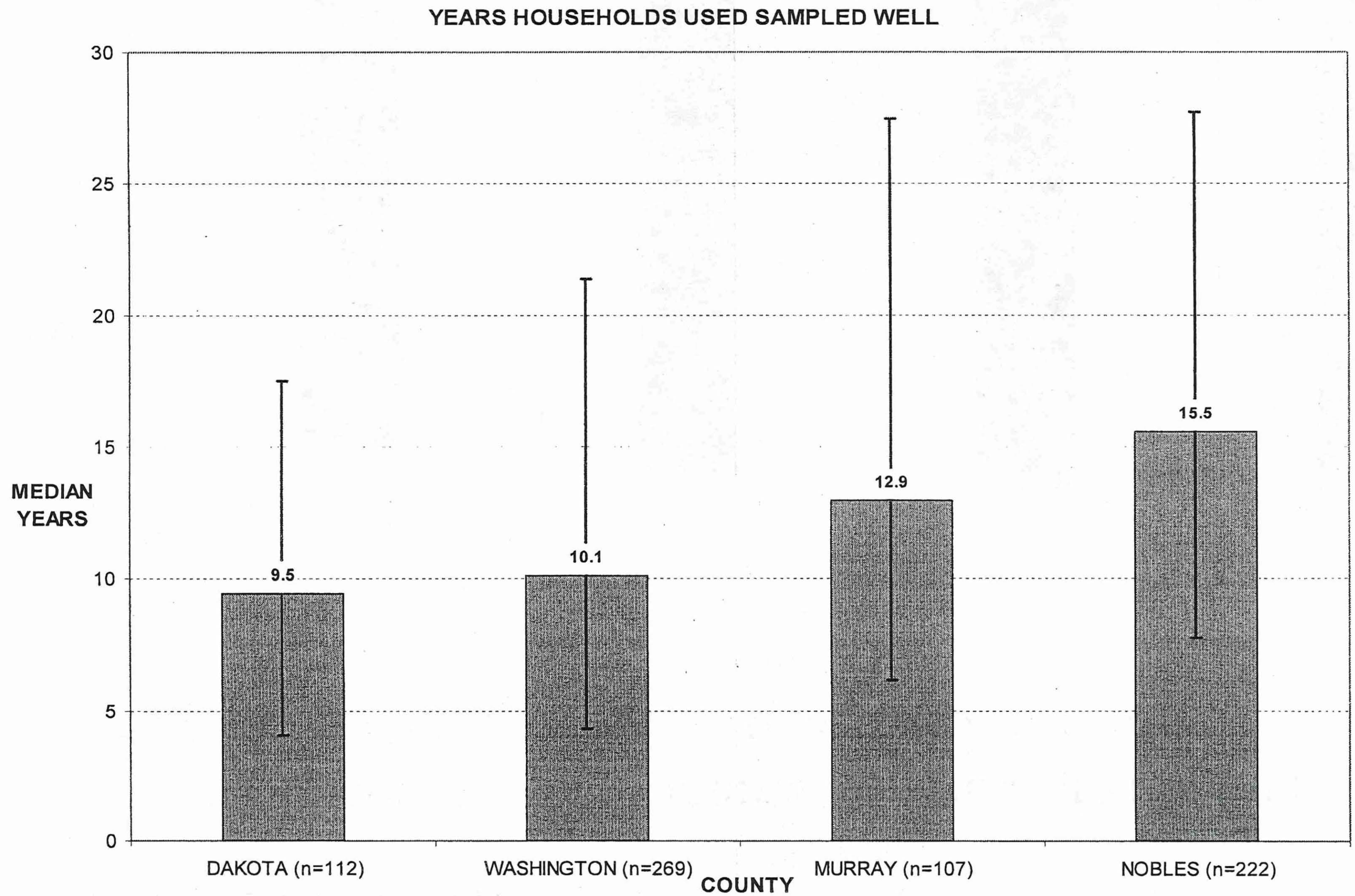
109 of 818 eligible refused (12%)

Most of 709 wells sampled previously unidentified in dbases



NEXIR Results:

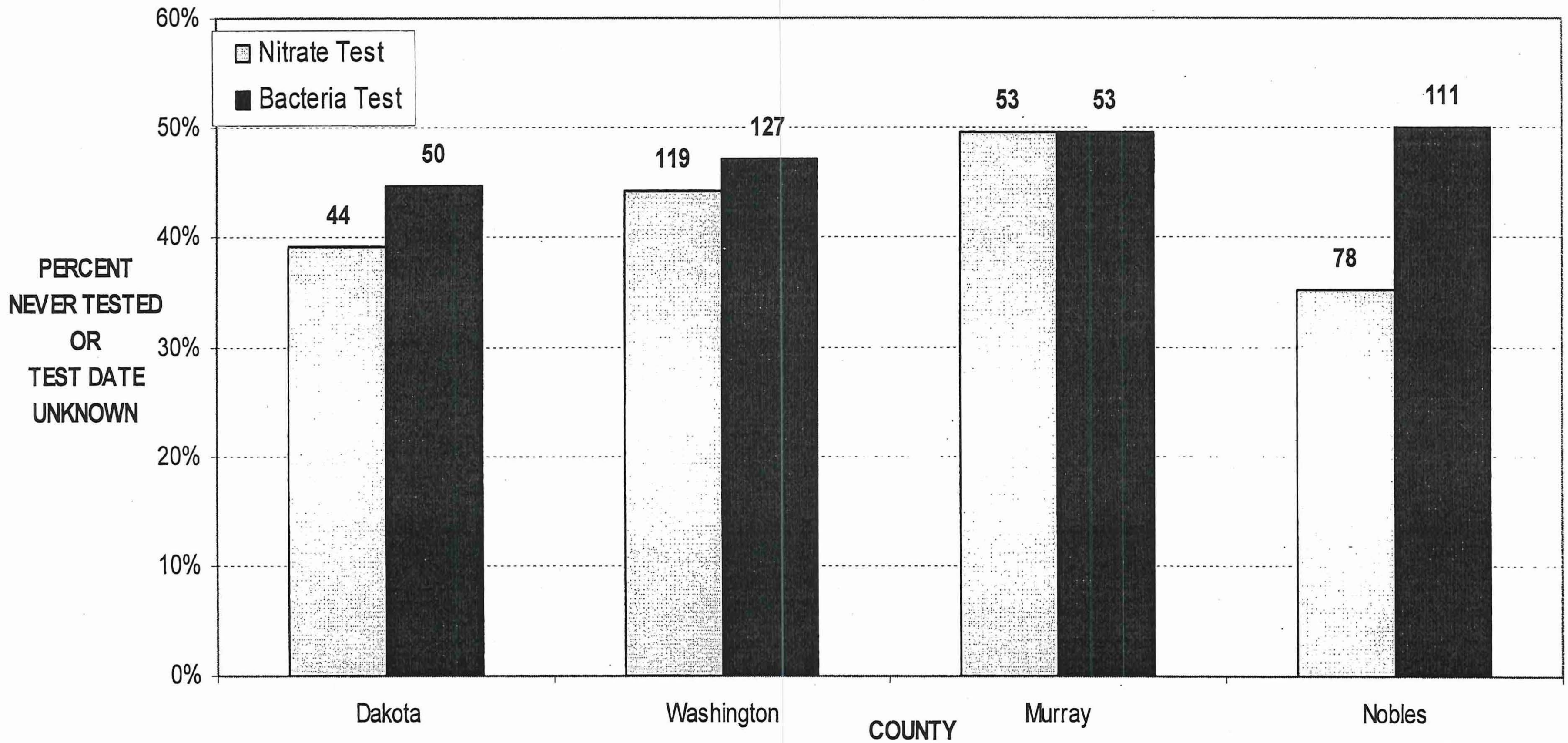
Most households had used sampled well > 10 years



Years using well were known for all 710 sampled households. Bars show median years using well, with 25th and 75th percentiles.

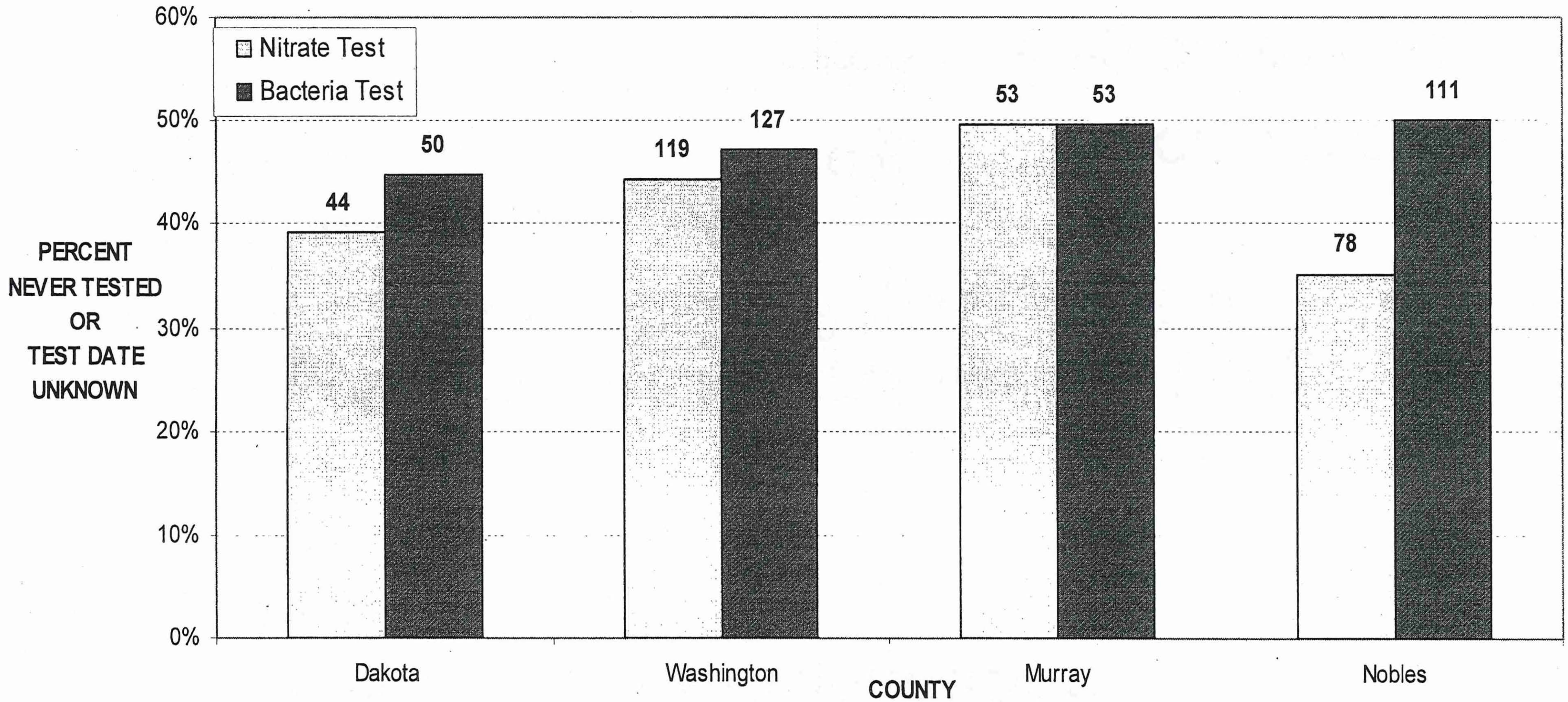
NEXIR Results:

40% of household respondents unaware of previous nitrate or coliform test or said well never tested



NEXIR Results:

Half of the remaining 60% had no test in past 5 years



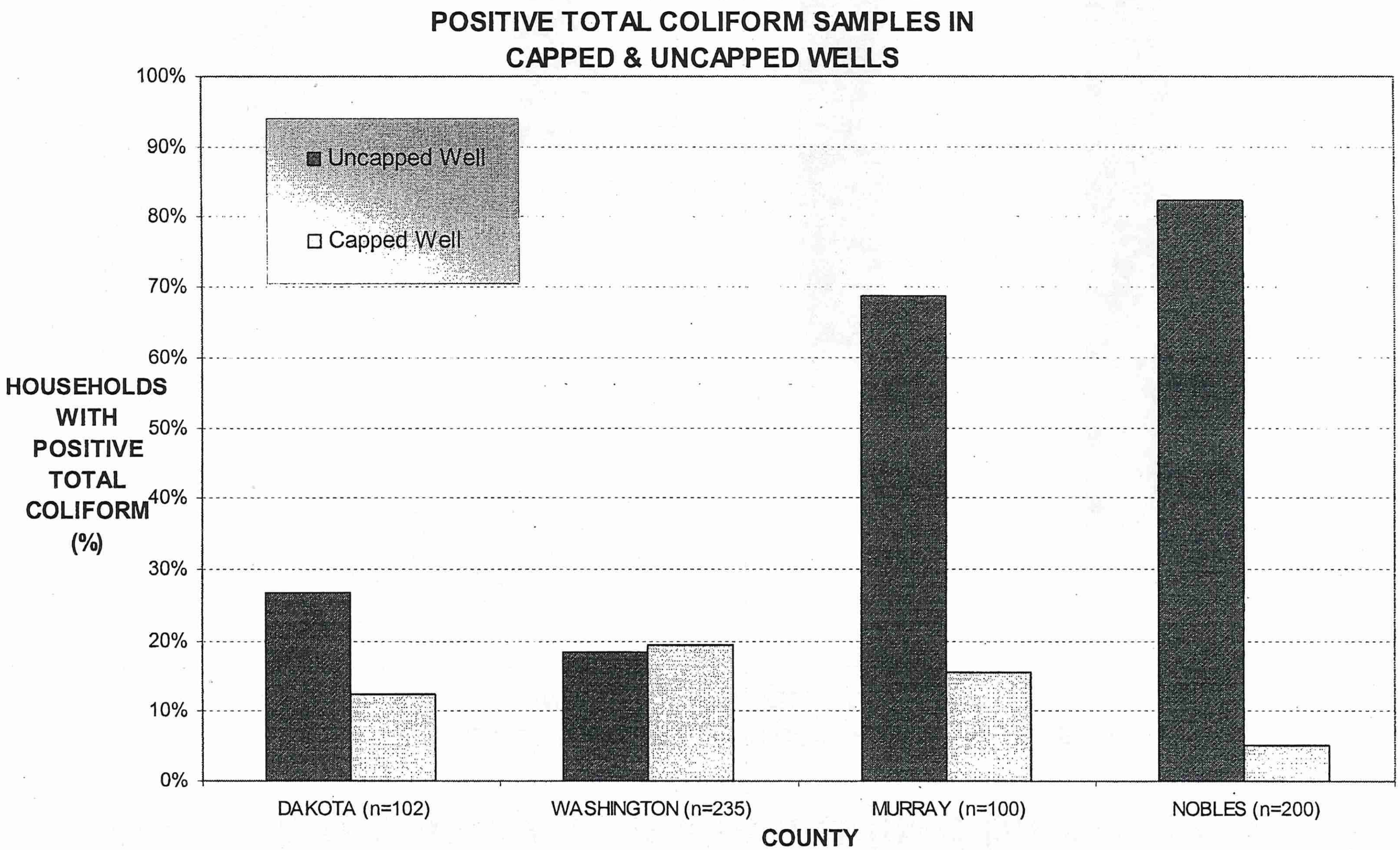
NEXIR Results:

Prevalence of Contamination in Private Wells

- Region 2 wells older, shallower and larger diameter than wells in Region 1 (particularly in Nobles Co.)
- Coliform found: 19% of Region 1 wells
  66% of Region 2 wells
- Fecal coliform found: <1% of Region 1 wells
  17% of Region 2 wells

NEXIR Results:

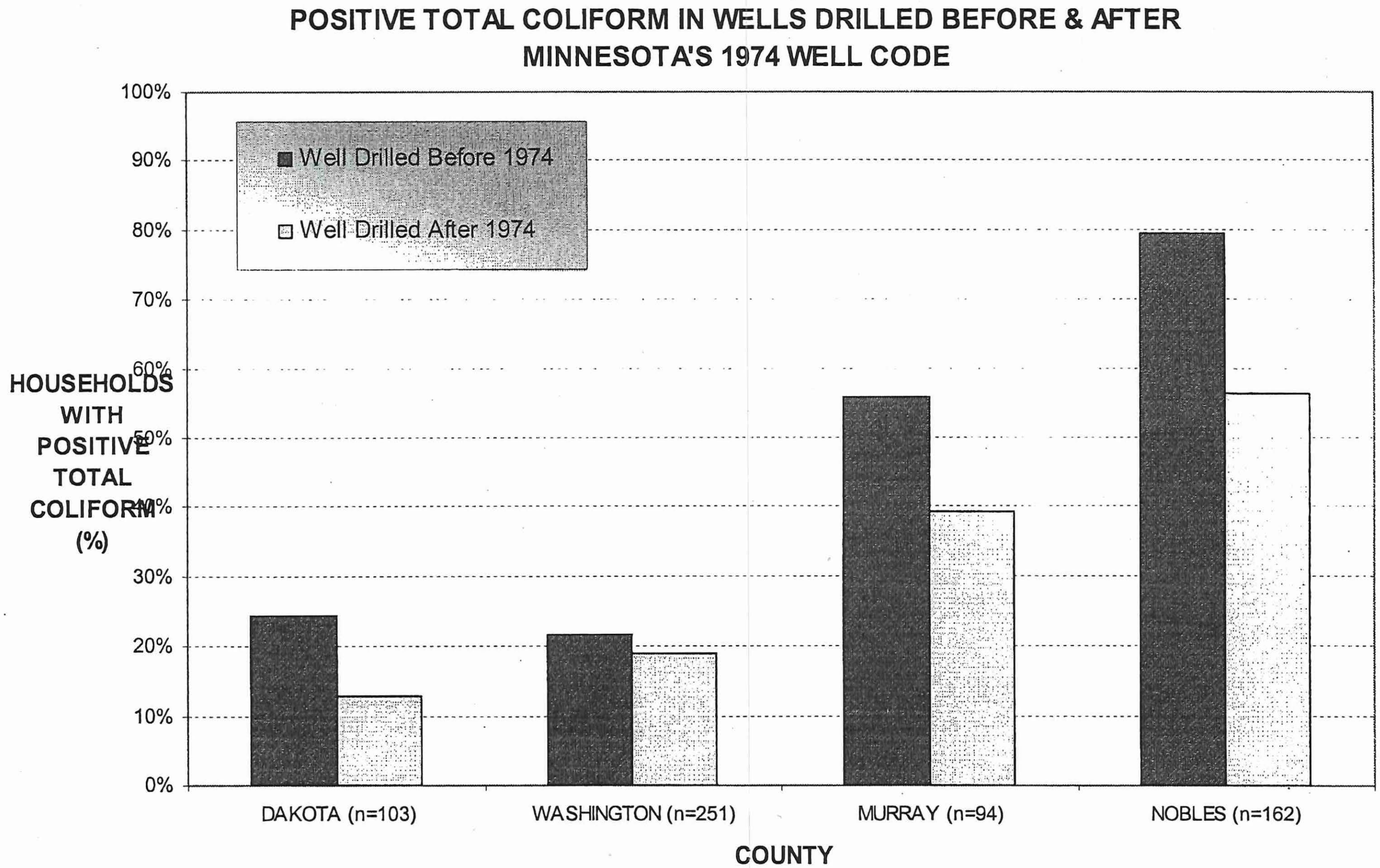
Coliform more likely in uncapped wells



Well cap coverage was known and an untreated, outdoor total coliform sample was collected at 637 households (636 wells - 2 households shared 1 well). In Murray and Nobles counties, proportions of households whose wells tested positive for total coliform bacteria were significantly higher in uncapped than in capped wells ($p < 0.01$, $\alpha = 0.05$). In Dakota and Washington counties, proportions were not significantly different.

NEXIR Results:

Coliform more likely in in wells drilled before 1974



Well age was known and an untreated total coliform sample was collected at 610 households (609 wells - 2 households shared 1 well). In Nobles county, the proportion of positive coliform samples was significantly higher in wells drilled before 1974 than in wells drilled after 1974 ($p < 0.01$, $\alpha = 0.05$). In Dakota, Washington, and Murray counties, proportions of positive total coliform were not significantly different between pre- and post-1974 wells.

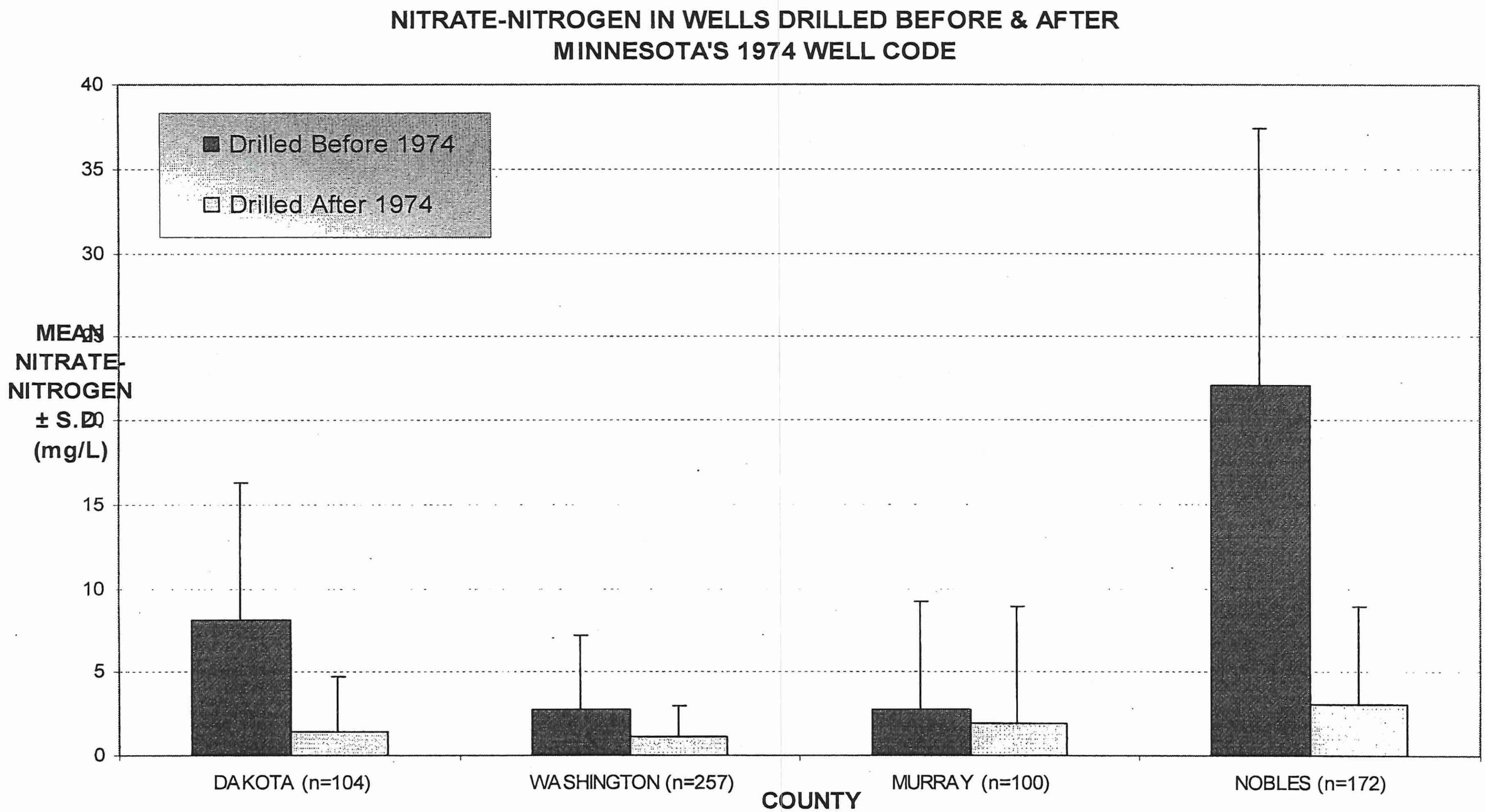
NEXIR Results:

Prevalence of High Nitrate

- Nitrate-N >10 ppm
  - Region 1 wells: 6%
  - Region 2 wells: 23%
- However, we estimate that more households in Region 1 (1,500) had wells with high nitrate, versus Region 2 (730).

NEXIR Results:

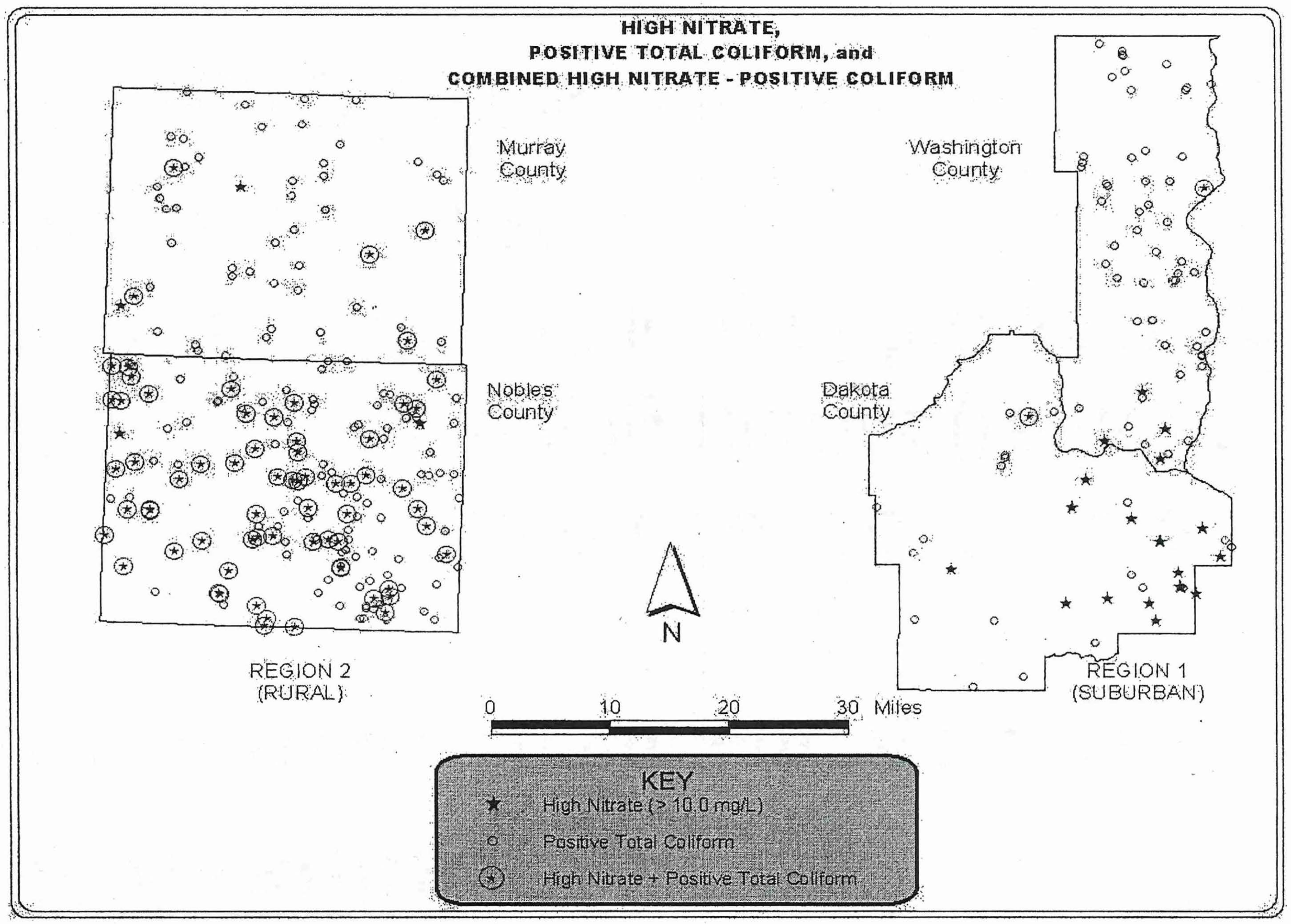
Nitrate contamination more likely in pre-Well Code wells



Well age was known and an untreated outside nitrate sample was collected at 633 total households. Mean nitrate-nitrogen concentrations were significantly higher in wells drilled before 1974 than in wells drilled after 1974 in Dakota, Washington, and Nobles counties ($p < 0.01$, $\alpha = 0.05$), but were not significantly different in Murray county.

NEXIR Results:

Positive relationship between nitrate and bacteria in Region 2 but not in Region 1



NEXIR Results:

Use of Water Treatment Systems

- Households using treatment systems capable of reducing nitrate (reverse osmosis or distillation) at the kitchen tap
  - Region 1: 6%
  - Region 2: 22%

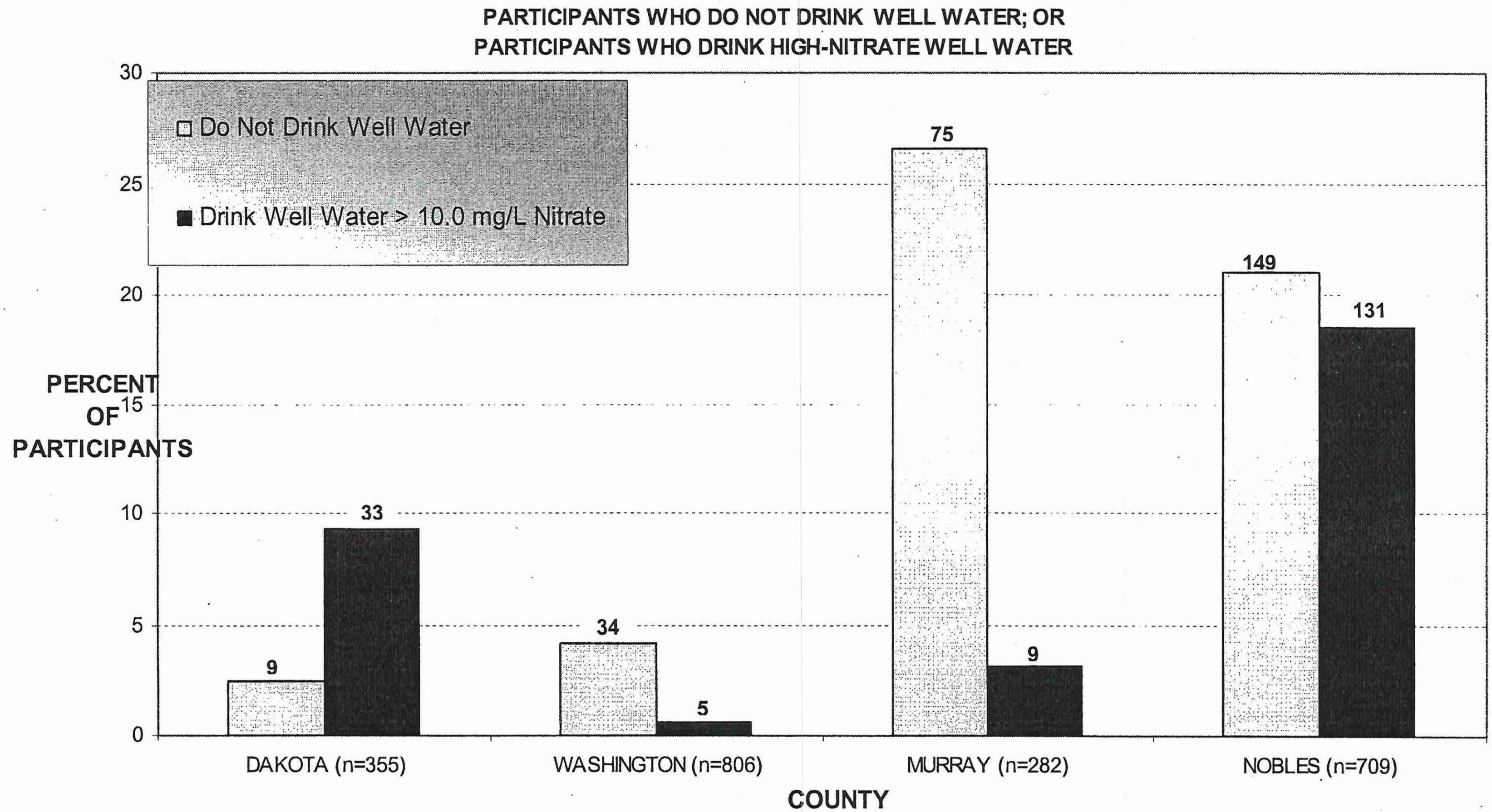
NEXIR Results:

Exposure to Nitrate and Bacteria

- 1,523 adults and 633 children < 6, in 710 households: % using well water for drinking:
  - Region 1: 96%
  - Region 2: 77%
- 178 (9%) of participants exposed to high nitrate

NEXIR Results:

Exposure to Nitrate and Bacteria



A total of 2152 (out of 2156) participants answered whether or not they drink their well water, which included use for cooking. Nitrate-nitrogen concentrations over 10.0 mg/L are from inside sampling results, including taps undergoing water treatment, or are from outside results if no inside sample was collected. Values for categories in each county are shown above bars.

NEXIR Results:
Children's Exposure to Nitrate and Bacteria

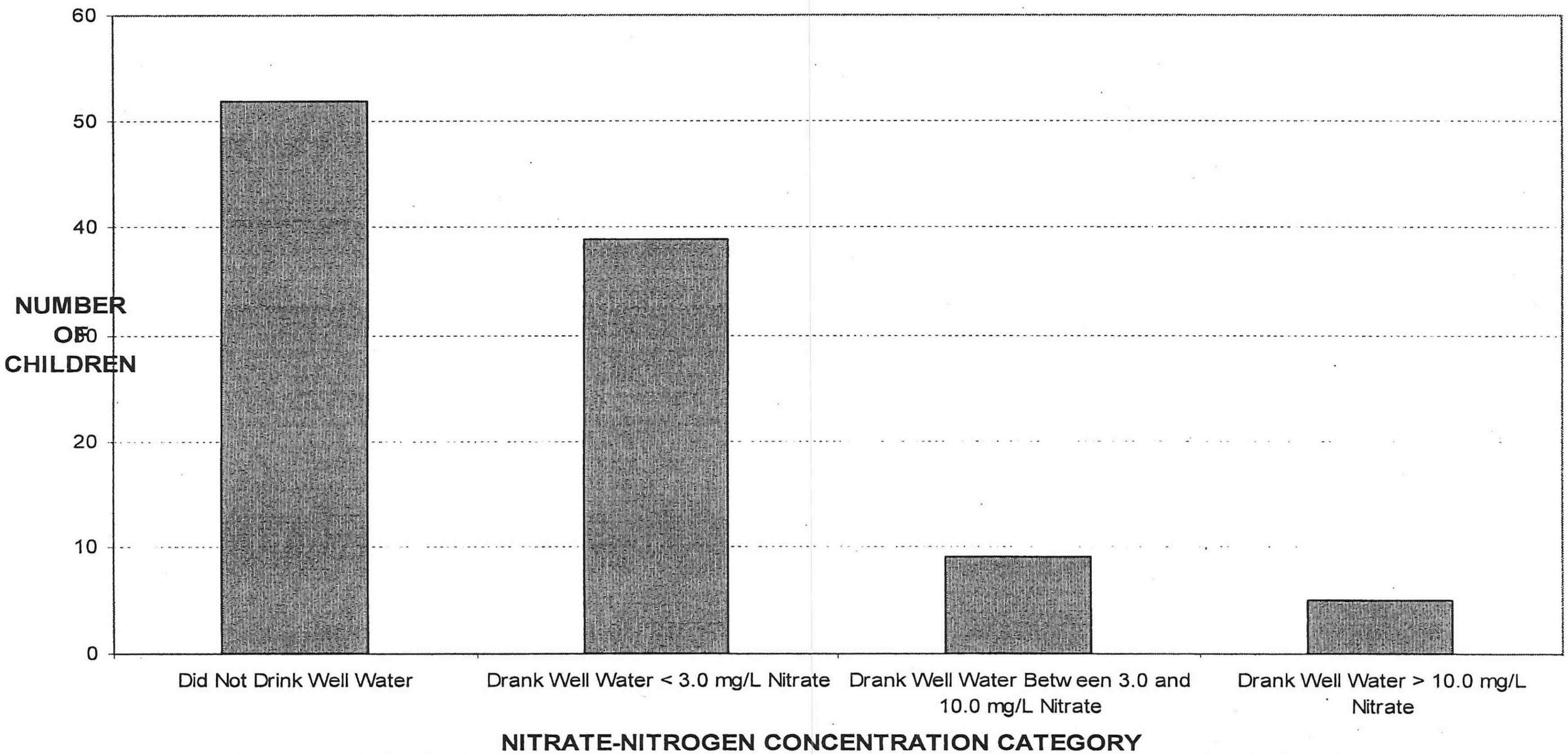
- Children < 6 using well water first year of life
  - Region 1: 67% of children
  - Region 2: 31% of children

- Of 51 who drank well water in first year,
  5 exposed to >10 ppm nitrate-N
  (range 15-62)
  - 4 of 5 wells had coliform bacteria
  - 1 had fecal coliform

NEXIR Results:

Consumption of Nitrate by Infants

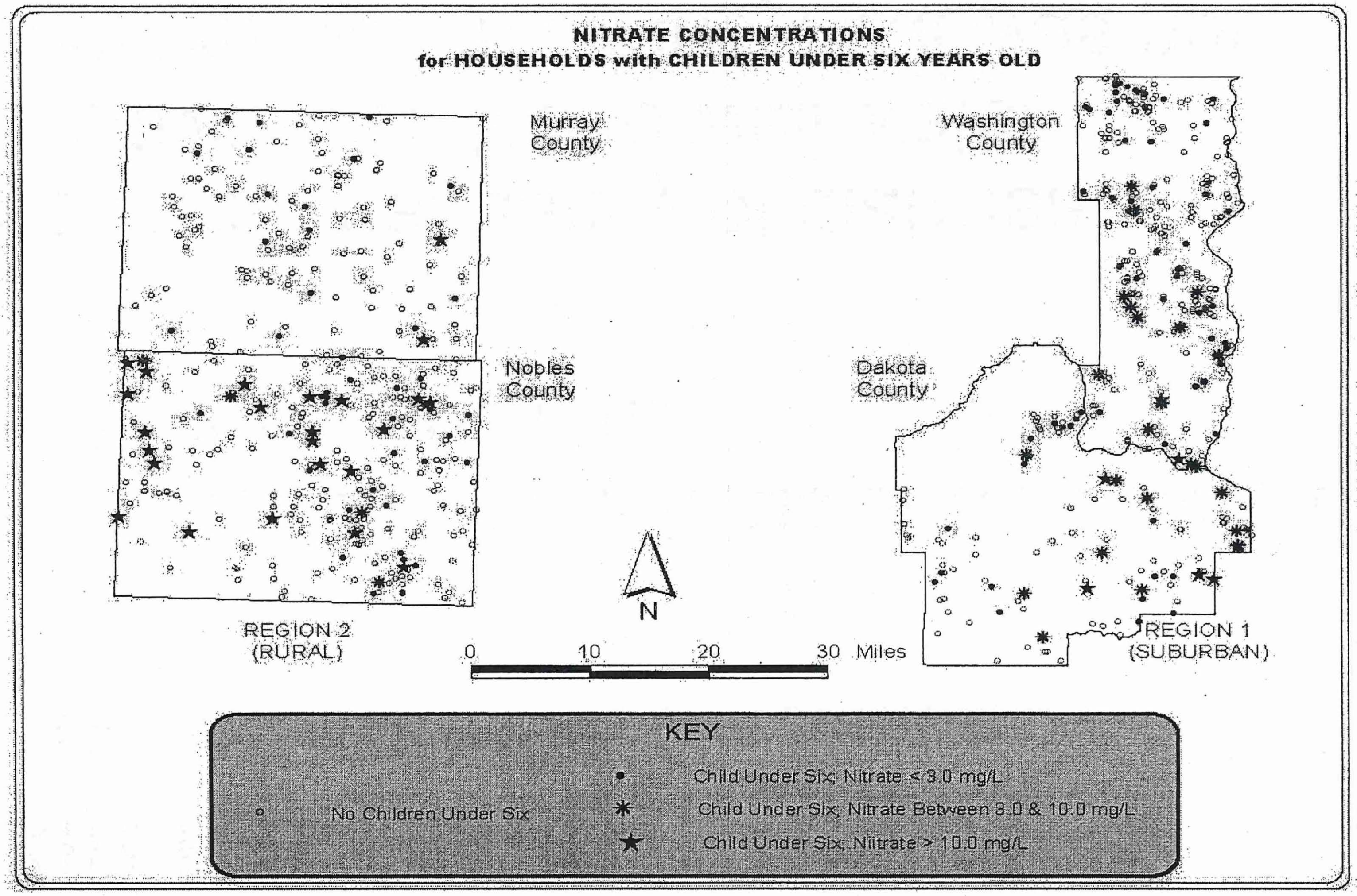
CONSUMPTION OF NITRATE BY INFANTS DURING FIRST YEAR OF LIFE



Well water consumption history during the first year of life was collected for 105 children who were under six years old at the time of survey. Nitrate-nitrogen concentration categories are based on inside nitrate results, including any undergoing water treatment. The majority of children either did not drink their well water, or drank water with low nitrate levels, during the first year of life; however, 14 children did consume water with elevated nitrate concentration (greater than 3.0 mg/L nitrate-nitrogen). These 14 children were from households in all 4 counties. Five children from Dakota, Murray, and Nobles counties drank water with over 10 mg/L nitrate-nitrogen (range = 15-62). Additionally, off the 52 children who did not drink their well water, 15 had potential exposure to water over 10 mg/L nitrate-nitrogen.

NEXIR Results: Nitrate Exposure

Of 52 children who did not drink their well water in the 1st first year, 15 were served by wells > 10 ppm



NEXIR Results:

Children's Health Outcomes

- No reports of symptoms or diagnosis of methemoglobinemia
- Reported frequency of diarrhea positively related to well water consumption in infancy, but was not related to measurements of well contamination.

NEXIR Results: Awareness of Nitrate Risk

- Region 2 caregivers better informed of nitrate risks than Region 1 caregivers.
- Out of 83 caregivers reporting use of well water to feed an infant, 27 had used some treatment. Seven of these 27 from Region 1 reported boiling.

Prior to our letter and visit here today, were you aware of the problem of nitrates in drinking water?			
	TOTAL CARE-GIVERS ANSWERING	NO (Not Aware At All)	
		Number	*Percent*
Dakota	19	8	*42.1*
Washington	46	26	*56.5*
REGION 1	**65**	**34**	***52.3***
Murray	10	5	*50.0*
Nobles	38	5	*13.2*
REGION 2	**48**	**10**	***20.8***
ALL COUNTIES	***113***	***44***	***38.9***

NEXIR Results: Awareness of Nitrate Risk

- Most common source cited for information about nitrate was the news media.
- Most caregivers reported never discussing the problem with their health care provider.

Did your physician, pediatrician, or other health care provider ever discuss with you the problem of nitrates?			
	TOTAL CARE-GIVERS ANSWERING	NO (No Discussion with Health Care Provider)	
		Number	*Percent*
Dakota	19	16	*84.2*
Washington	46	41	*89.1*
REGION 1	**65**	**57**	***87.7***
Murray	10	8	*80.0*
Nobles	36	19	*52.8*
REGION 2	**46**	**27**	***58.7***
ALL COUNTIES	***111***	***84***	***75.7***

NEXIR Conclusions - 1

- Fewer than 10% of well users were exposed to > 10 ppm nitrate-N
- 15% were exposed to levels between 3 and 10 ppm.
- Most people either were exposed below 3 ppm or did not drink their well water.

NEXIR Conclusions - 2

- While the prevalence of contamination is higher in Region 2, more people, including infants, are likely exposed above health criteria in Region 1.
  - Region 1: 5.6% of wells (1,500 households) have levels of nitrate-N above 10 ppm;

    96% of household members drink the water.
  - Region 2: 23% of wells (730 households) have nitrate-N above 10 ppm;
    77% of household members drink their well water.

NEXIR Conclusions - 3

- In both regions, bacterial contamination (but not fecal contamination) is more common than nitrate-N contamination above 10 ppm.

NEXIR Conclusions - 4

- Ongoing educational efforts are needed in communities using private wells, particularly in suburban areas.

NEXIR Conclusions - 5

- Physicians, particularly in suburbs, should be informed of the risk and should be advising parents of newborns (and possibly pregnant mothers?) not to use private well water for their child in the first 6 months of life, unless the water was recently sampled and found to be safe.

Nitrate Exposure and Infant Risk Study (NEXIR)

2002 Update

The Nitrate Exposure and Infant Risk Study (NEXIR) was performed by the Minnesota Department of Health (MDH), Division of Environmental Health, with support from the Minnesota Future Resources Fund as recommended by the Legislative Commission on Minnesota Resources (LCMR). The study investigated the occurrence of nitrate and bacteria in private drinking water wells and the potential health impact that exposure may have on young children.

Background

Nitrate (NO_3) is a common groundwater contaminant throughout Minnesota. Nitrate occurs naturally in our environment and is important in natural processes such as decomposition and plant growth. Natural levels of nitrate in groundwater are rarely high enough to be dangerous to humans who drink the water. However, when it becomes highly concentrated in groundwater, nitrate can be toxic. Significant sources of nitrate contamination include fertilizers, animal wastes, and human sewage. Nitrate may contaminate a private drinking water well if the well is shallow, poorly maintained, old, and/or near a source of contamination. These situations also favor contamination by disease-causing bacteria. Disease-causing bacteria such as fecal coliform, or *E. coli*, may worsen the health effects of nitrate if ingested.

Infants under six months of age are at the most danger from elevated levels of nitrates in drinking water. A baby fed water high in nitrates (or fed formula made with high-nitrate water) may develop a condition called "methemeglobinemia" or "blue baby syndrome." In this condition, the baby's blood is unable to properly carry oxygen. As a result, the baby's skin turns a blue color, particularly around the eyes, nose, and mouth. Death may follow, if oxygen deprivation is severe and lengthy enough. Susceptibility to blue baby syndrome increases if fecal coliform bacteria are also present in the baby's drinking water. Fecal coliform bacteria cause diarrhea and interfere with digestion, intensifying nitrate's effects on the body.

Any water nitrate-nitrogen level over 10 mg/L is considered too high for safe drinking by babies under six months of age. This 10 mg/L nitrate-nitrogen limit is the Maximum Contaminant Level set up by the U.S. Environmental Protection Agency. Almost all adults may drink water with nitrate-nitrogen levels higher than 10 mg/L. However, some hereditary disorders render a few adults susceptible to methemeglobinemia. Also, women who are pregnant should not drink water high in nitrates.

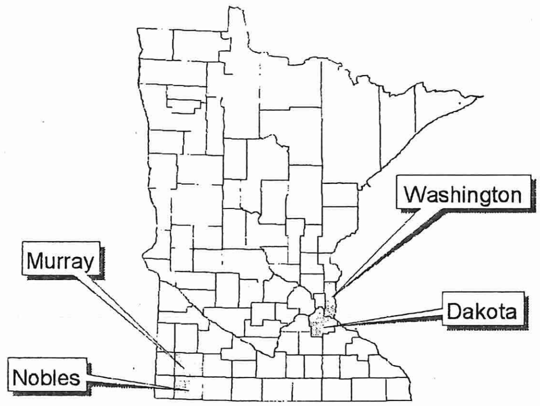
NEXIR was designed to examine how infants in Minnesota may be exposed to nitrate from private drinking water wells. NEXIR was a population-based study; that is, its findings characterize a cross-section of Minnesota residents who use private well water. The objectives of NEXIR were to:

- Investigate nitrate and bacteria occurrence in drinking water among private well users;
- Investigate history of water use, and exposure to nitrate and bacteria in young children, as related to indications of methemeglobinemia or diarrhea;
- Assess existing knowledge among caregivers of young children about risks of nitrate exposure; and
- Assess the need for further education for caregivers and physicians.

NEXIR Methodology

NEXIR took place in four counties in two different study areas (*see map, below*). Region I comprised Washington and Dakota counties in east-central Minnesota, representing the Twin Cities suburban area. Region II comprised Murray and Nobles counties in southwestern Minnesota, representing a rural, highly-agricultural area.

NEXIR households were randomly selected from lists of all properties not using public water. Property owners or residents were called, screened for eligibility, and invited to participate. A property was considered eligible for NEXIR if: (1) at least one person lived there more than 30 days per year; (2) the household had no access to a city or rural water supply; and (3) a private well was present, and was or could be used for drinking water.



NEXIR Counties

Field staff visited a total of 710 eligible properties throughout the two study areas. Nitrate samples were collected from well water both indoors and at the wellhead. Samples were also collected to test for presence of total and fecal coliform bacteria. Family members completed a household questionnaire with questions on well water use, drinking water habits, and demographics. Additional questionnaires for caregivers of children under the age of six inquired about children's water use, children's health, and caregivers' knowledge of nitrates.

NEXIR Results

Preliminary analysis of water samples shows that nitrate and bacterial contamination differed between regions. *Nitrate-nitrogen* levels from the wellhead were over 10 mg/L in about 6% of Region I samples, and in about 23% of Region II samples. *Total coliform bacteria* were present in 19% of Region I samples and in about 66% of Region II samples. *Fecal coliform bacteria* were present in just under 1% of Region I samples and in about 17% of Region II samples. In Region I, 96% of household members drank the tap water versus 77% in Region II. Thirty percent of household members were children, with 6% below the age of 6.

A final report of NEXIR results is expected in 2003, when results will be presented to the LCMR.

NEXIR Advice to Participants

All participants were sent a letter with individual nitrate and bacteria results, along with MDH recommendations, within two months of their household visit. MDH recommendations for nitrate and coliform bacteria are shown on the following pages.

NITRATE RESULT	MDH RECOMMENDATION
> 10 mg/L	The nitrate levels measured in a sample from your well water (outdoor tap) exceed the health limit of 10 mg/L. The presence of nitrate in the water indicates that surface contamination of the well is occurring. Do not give water from this well to any infant under six months of age, either directly or in formula. Do not boil to "treat" high nitrate water. Boiling actually concentrates the nitrate, due to evaporation of the water. Commercially bottled water is required to meet the nitrate standard, and can be given to infants. Pregnant women should avoid drinking well water known to contain high levels of nitrate. Our health recommendations are based on levels of nitrate found in the well (outdoor tap). Your indoor drinking water tap was also sampled and tested for nitrate. Levels of nitrate from the indoor tap may be lower than levels tested from the well outdoors, if the tap is being effectively treated with a treatment system in the home. Please be aware that treatment systems can and do fail over time, and they require ongoing maintenance. For that reason, home water treatment units are not recommended for treating high nitrate well water that will be given to infants.
≥ 3 and ≤ 10 mg/L	Nitrate has been measured in a sample collected from your well (outdoor tap) at a low level, between 3 and 10 mg/L, that does not exceed the health limit of 10 mg/L. Although this level of nitrate is considered safe for drinking, the presence of greater than 3 mg/L nitrate in the water indicates that surface contamination of the well is occurring. Frequent testing of the water, at least once per year, is recommended because nitrate levels can change over time, particularly in older wells. Our health recommendations are based on levels of nitrate found in the well (outdoor tap). Your indoor tap was also sampled and tested for nitrate. Levels of nitrate from the indoor tap may be different from nitrate levels found in the well outdoors, if the indoor tap is being effectively treated in the home. Please be aware that treatment systems can and do fail over time, and require ongoing maintenance. For that reason, home water treatment units are not recommended for treating high nitrate well water, which will be given to infants.
< 3 mg/L	Nitrate was not detected or is at very low levels (<3 mg/L) in the sample collected from your well (outdoor tap), indicating that the well water is safe from nitrate contamination. We do recommend that private well owners routinely test their drinking water every 2-3 years to ensure that the water remains safe from nitrate. Nitrate levels can change over time, particularly in older wells. Our health recommendations are based on levels of nitrate found in the well (outdoor tap). Your indoor tap was also sampled and tested for nitrate. Levels of nitrate from the indoor tap may be different from levels tested from the well outdoors, if the indoor tap is being effectively treated with a home water treatment system. Your indoor nitrate result also may be different from the well sample result if your indoor tap is connected to a different water source.

Advice to NEXIR Participants for Bacteria Results

BACTERIA TEST RESULT	MDH RECOMMENDATIONS
Total Coliform: Absent *and* Fecal Coliform: Absent	Your well tested negative for total coliform and for fecal coliform bacteria. This finding indicates that the water was safe from contamination by disease-causing bacteria at the time of the test. Because bacteria contamination can vary over time, it it recommended that you continue to test the well every 2-3 years for bacteria contamination. Spring is usually the best time to test.
Total Coliform: Present *and* Fecal Coliform: Absent	Your well tested positive for total coliform and negative for fecal coliform bacteria. This finding indicates that surface contamination has gotten into the water. There is potential for disease-causing bacteria to be present in the drinking water also. It is recommended that the well be tested at least once a year for bacterial safety. Spring is usually the best time to test.
Total Coliform: Present *and* Fecal Coliform: Present	Your well tested positive for total coliform and for fecal coliform bacteria. This finding indicates that surface contamination has gotten into your well water and that unsafe levels of disease-causing fecal bacteria are present. It is recommended that: the water not be used for drinking or for food preparation unless it is boiled for at least three minutes at a full, rolling boil; and the well be disinfected and retested clean (or uncontaminated) before drinking unboiled water.

Questions?

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