2014 Nebraska Groundwater Quality Monitoring Report

Prepared Pursuant
to Neb. Rev. Stat. §46-1304
(LB329 – 2001)

Nebraska Department of Environmental Quality
Water Quality Assessment Section
Groundwater Unit
December 2014

Photo on front cover:

University of Nebraska Conservation Survey Division (CSD) drilling test holes in the Lower Loup Natural Resources District for the design of groundwater monitoring network wells. Courtesy of Tylr Naprstek.

Acknowledgements:

This report would not be possible without the cooperation of the agencies and organizations contributing groundwater data to the "Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater", most notably the State's 23 Natural Resources Districts. The University of Nebraska must be thanked for their on-going work on the Database and attention to detail in assessing the quality of data presented for inclusion. Thanks to Sam Capps and Ryan Chapman, NDEQ, for most of the maps and data analysis for this report, while Marty Link and Rob Tobin, NDEQ, helped with editing. Most importantly, special thanks to Tom Lamberson for his leadership and guidance in making the expansion of the groundwater monitoring network possible. Direct any questions regarding this report to David Miesbach, Groundwater Unit, NDEQ, at (402) 471-4982.

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2014 Nebraska Groundwater Quality Monitoring Report

Introduction

The 2001 Nebraska Legislature passed LB329 (Neb. Rev. Stat. §46-1304) which, in part, directed the Nebraska Department of Environmental Quality (NDEQ) to report on groundwater quality monitoring in Nebraska. Reports have been issued annually since December 2001. The text of the statute applicable to this report follows:

> "The Department of Environmental Quality shall prepare a report outlining the extent of ground water quality monitoring conducted by natural resources districts during the preceding calendar year. The department shall analyze the data collected for the purpose of determining whether or not ground water quality is degrading or improving and shall present the results to the Natural Resources Committee of the Legislature beginning December 1, 2001, and each year thereafter. The districts shall submit in a timely manner all ground water quality monitoring data collected to the department or its designee. The department shall use the data submitted by the districts in conjunction with all other readily available and compatible data for the purpose of the annual ground water quality trend analysis."

The section following the statute quoted above (§ 46-1305), requires the State's Natural Resources Districts to submit an annual report to the legislature with information on their water quality programs, including financial data. That report has been prepared by the Nebraska Association of Resources Districts and is being issued concurrently with this groundwater quality report.

Groundwater in Nebraska

Groundwater can be defined as water that occurs in the open spaces below the surface of the earth (Figure 1). In Nebraska (as in many places worldwide), useable groundwater occurs in voids or pore spaces in various layers of geologic material such as sand, gravel, silt, sandstone, and limestone. These layers are referred to as aquifers where such geologic units yield sufficient water for human use. In parts of the state, groundwater may be encountered just a few feet below the surface, while in other areas, it may be a few hundred feet underground. This underground water "surface" is usually referred to as the water table, while water which soaks downward through overlying rocks and sediment to the water table is called recharge as shown in Figure 2. The amount of water that can be obtained from a given aquifer may range from a few gallons per minute (which is just enough to supply a typical household) to many hundreds or even thousands of gallons per minute (which is the yield of large irrigation, industrial or public water supply wells).

Public Water Supply well capable of pumping thousands of gallons per minute (Hastings, NE).

Depth & Velocity of Groundwater

The depth to groundwater plays a very important role in Nebraska's valuable water resource. Obviously, a shallow well is cheaper to drill, construct, and pump. Conversely, shallow groundwater is more at-risk from impacts from human activities. Surface spills, application of agricultural chemicals, effluent from septic tank leach fields, and other sources of contamination will impact shallow groundwater more quickly than groundwater found at depth. The map in Figure 3 shows the great variation of depth to water across the State.

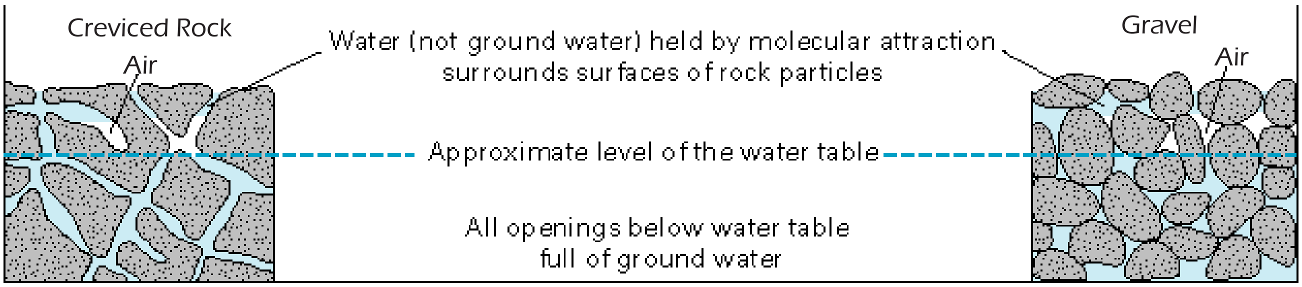


Figure 1. Basic aquifer concepts (U.S. Geological Survey).

In general, groundwater flows very slowly, especially when compared to the flow of water in streams and rivers. Many factors determine the speed of groundwater and most of these factors cannot be measured or observed directly. Basic groundwater features are shown in Figures 1 and 2. The most important geologic characteristics that impact groundwater movement are as follows:

- The sediment in the saturated zone of the aquifer. Groundwater generally flows faster through gravel sediments than clay sediments.
- The 'sorting' of the sediment. Groundwater in aquifers with a mix of clay, sand, and gravel (poor sorting) generally does not flow as fast as in aquifers that are composed of just one sediment, such as gravel (good sorting).
- The 'gradient' of the water table. Groundwater flows from higher elevations toward lower elevations under the force of gravity. In areas of high relief, groundwater flows faster. A typical groundwater gradient in Nebraska is 10 feet of drop over a mile (0.002 ft/ft).
- Well pumping influences. In areas of the State with numerous high capacity wells (mainly irrigation wells), groundwater velocity and direction can be changed seasonally as water is pumped.

Ultimately, groundwater scientists have determined that groundwater in Nebraska can flow as fast as one to two feet per day in areas like the Platte River valley and as slow as one to two inches per year in areas like the Pine Ridge in northwest Nebraska or the glacially deposited sediments in southeast Nebraska.

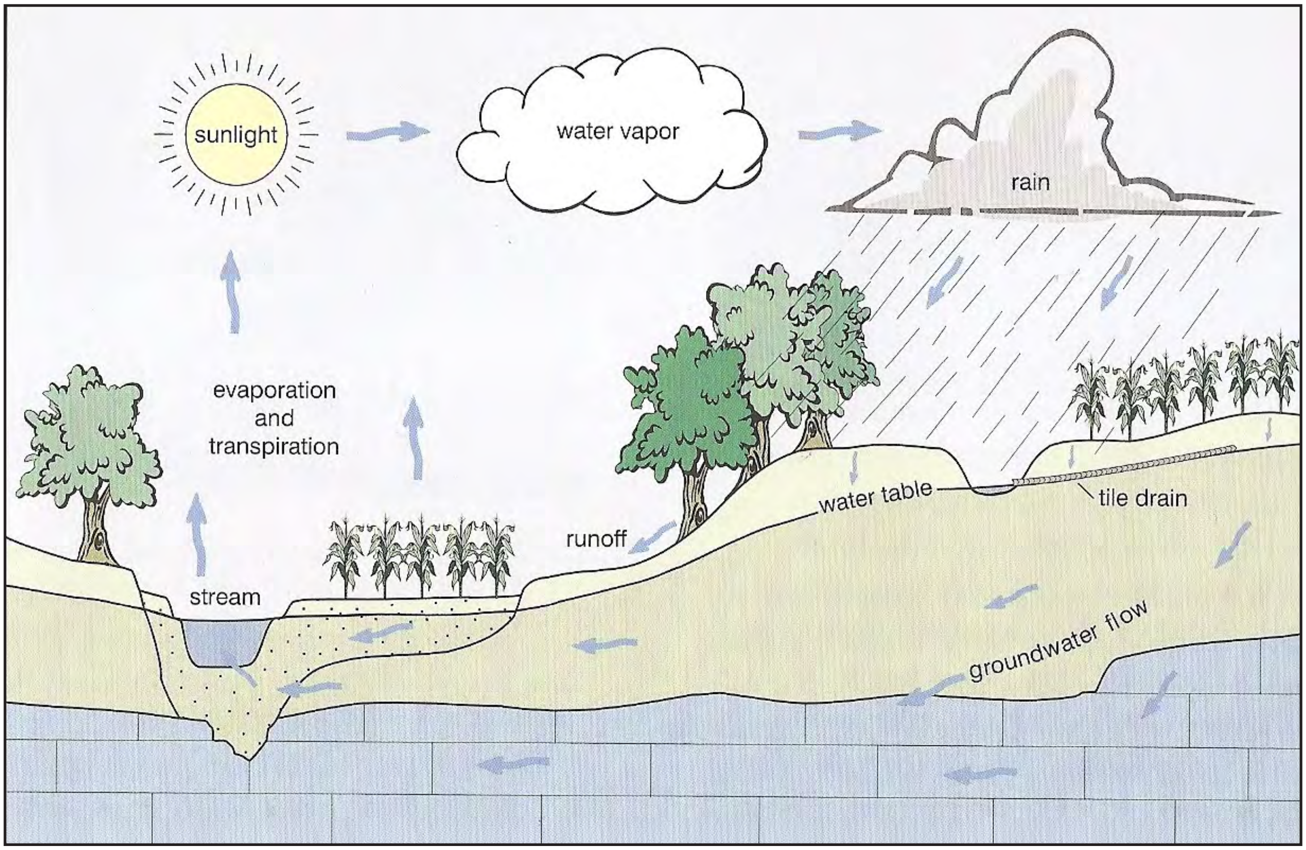


Figure 2. Generalized hydrologic cycle. (Prior, 2003).

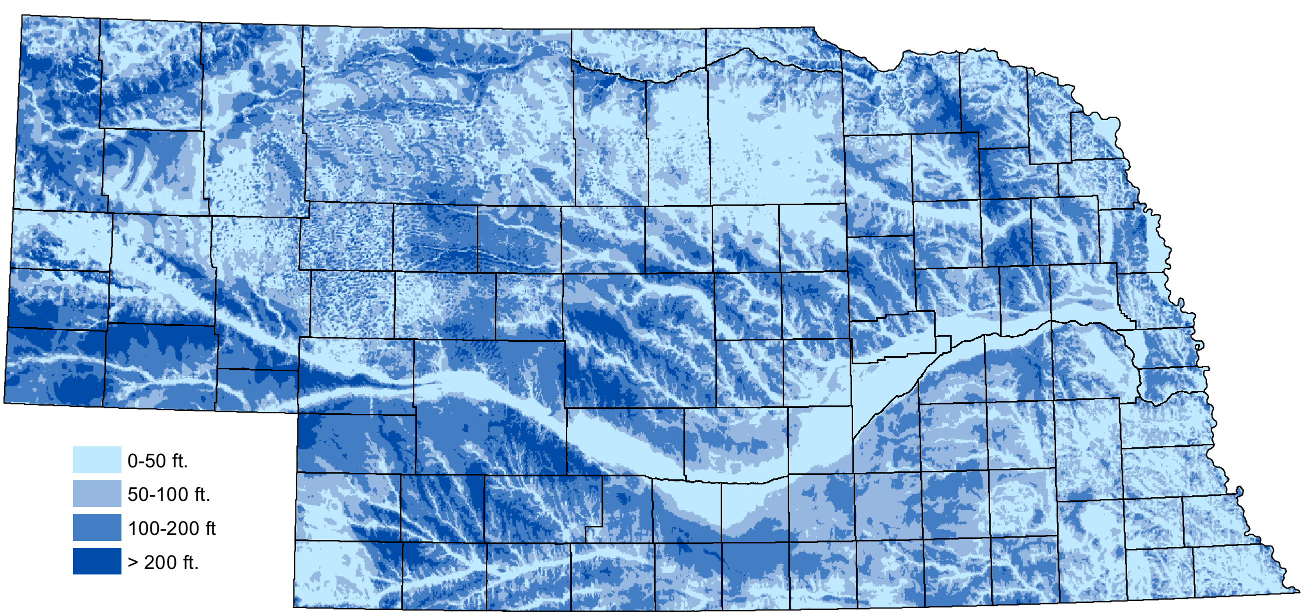


Figure 3. Generalized depth to groundwater. (Source: University of Nebraska, Conservation and Survey Division, 1998)

Geology and Groundwater

Nebraska has been "underwater" most of its history. Ancient seas deposited multiple layers of marine sediments that eventually formed sandstone, shale, and limestone. These units are now considered "bedrock" and have limited fresh water supplies, such as in portions of the Dakota and Niobrara. After the seas retreated, huge river systems deposited sand and gravel eroded from mountain building to the west to form groundwater bearing formations such as the lower Chadron, Ogallala (Figure 4 and 5) and Broadwater. Next, the combination of erosion (statewide) and glaciation in the east introduced new material that was deposited by wind, water and ice to form the remainder of the High Plains Aquifer (Figure 4 and 5).

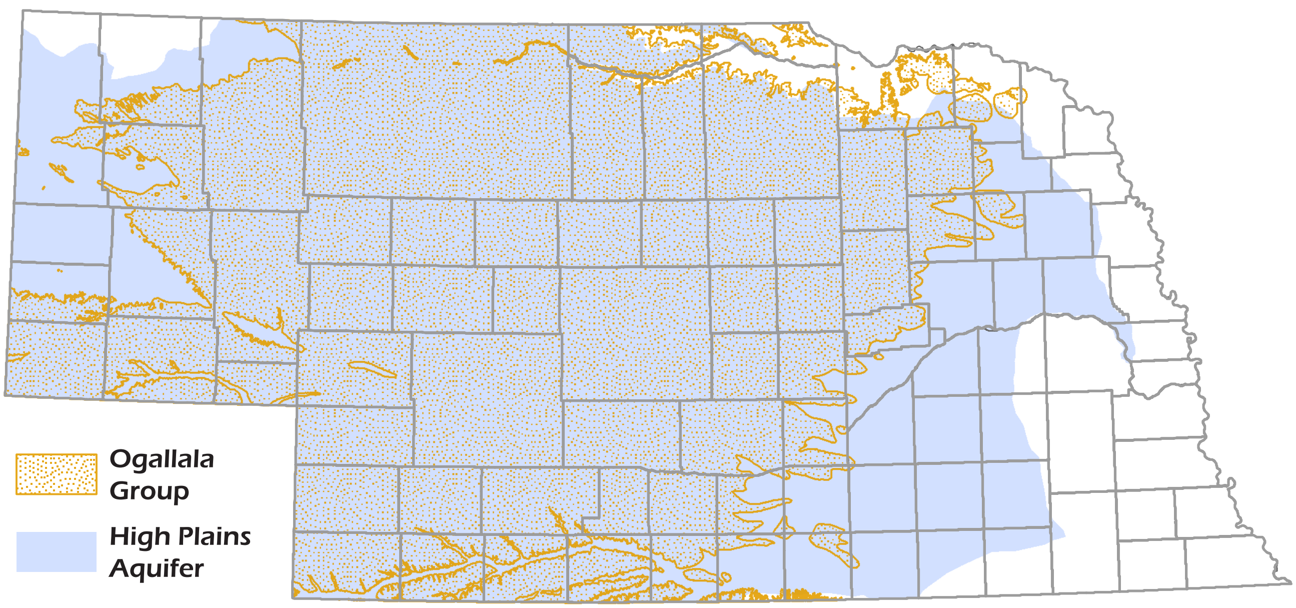


Figure 4. Map of the High Plains aquifer identifying the Ogallala Group. (Source: University of NE, Conservation and Survey Division, 2013)

The High Plains Aquifer is a conglomeration of many separate groundwater bearing formations such as the Brule, Arikaree, Ogallala, Broadwater, and many more recent unnamed deposits (including the Sand Hills). Many of the unnamed deposits are found mainly within the stream valleys (recent or ancient) and are a common source of groundwater (Figure 6, left pane). No single formation completely covers the entire state. However, when these numerous formations and deposits are combined, they form the High Plains Aquifer, covering almost 90% of Nebraska.

There are parts of eastern Nebraska where the High Plains Aquifer is not present. These areas rely heavily on groundwater from buried ancient river channels or recent alluvial valleys (Missouri, Platte, and Nemaha Rivers) (Figure 6, right pane).

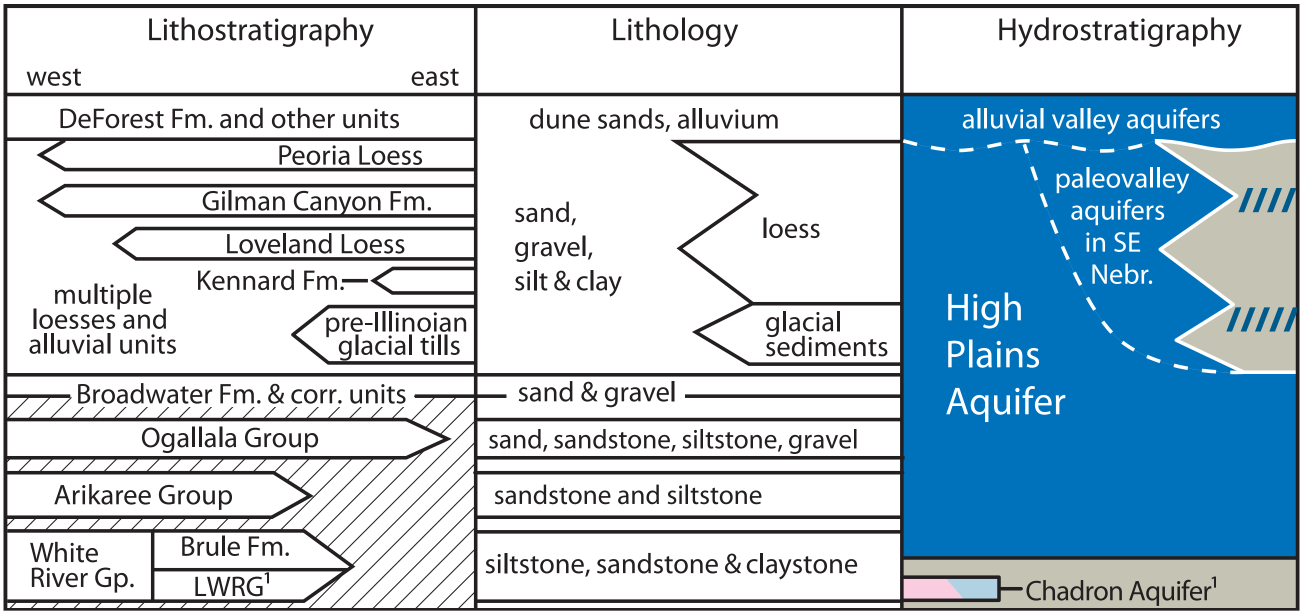


Figure 5. Excerpts from the generalized geologic and hydrostratigraphic framework of Nebraska. (Source: University of NE, Conservation and Survey Division, 2013)

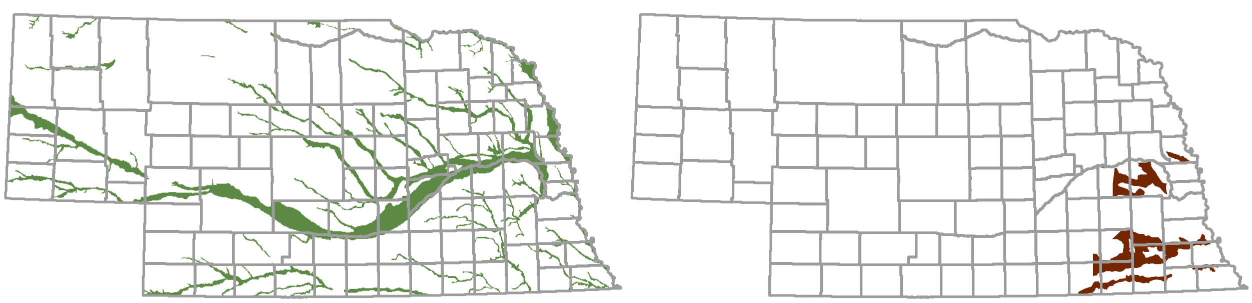


Figure 6. Map of valleys topographic region (left) and paleovalley aquifers (right). (Source: University of Nebraska, Conservation and Survey Division, 2013)

Importance of Groundwater

Nebraska is one of the most groundwater-rich places in the United States. Approximately 88% of the state's residents rely on groundwater as their source of drinking water. If the public water supply for the Omaha metropolitan area (which gets about a third of its water supply from the Missouri River) isn't counted, this rises to nearly 99%. Essentially all of the rural residents of the state use groundwater for their domestic supply. Not only does Nebraska depend on groundwater for its drinking water supply, the state's agricultural industry utilizes vast amounts of groundwater to irrigate crops. Most of Nebraska experiences variable amounts of precipitation throughout the year, so irrigation is used, where possible, to ensure adequate amounts of moisture for raising such crops as corn, soybeans, alfalfa, and edible beans. As of November 2014, the Nebraska Department of Natural Resources (NDNR) listed 95,786 active irrigation wells and 27,588 active domestic wells registered in the state. Domestic wells were not required to be registered with the state prior to September 1993, therefore thousands of domestic wells exist that are not registered with the NDNR. Figures 7 and 8 and information shown in Table 1 help illustrate this.

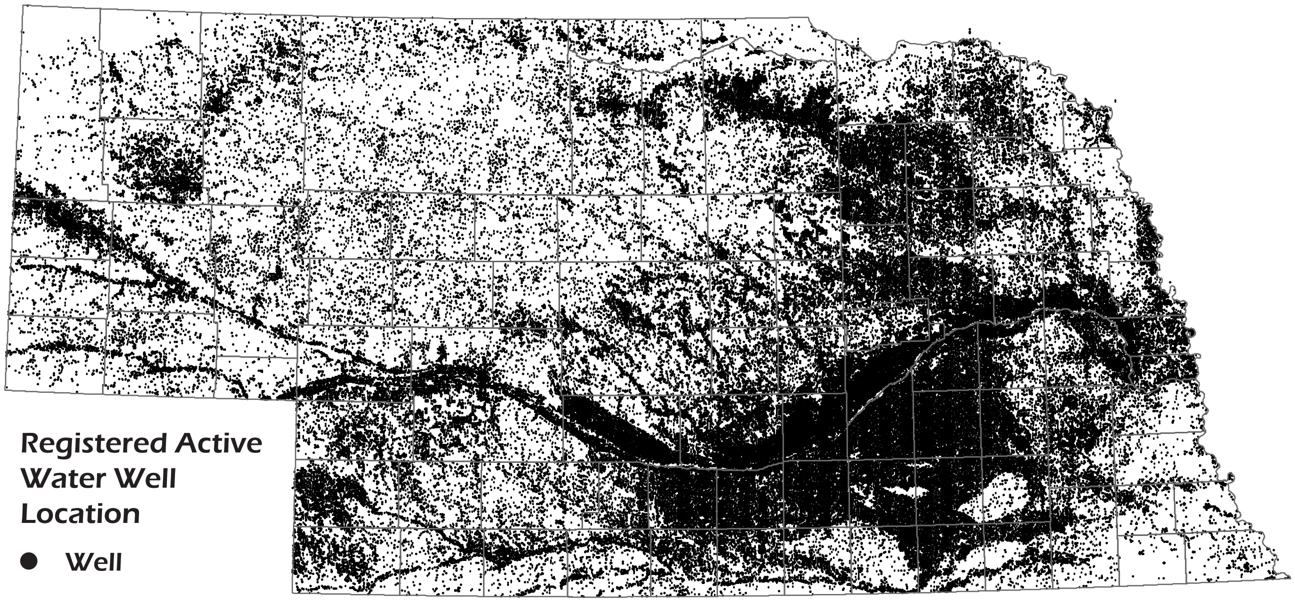


Figure 7. Active registered water wells as of November 2014. (Source: Nebraska Department of Natural Resources Registered Well Database, 2014)

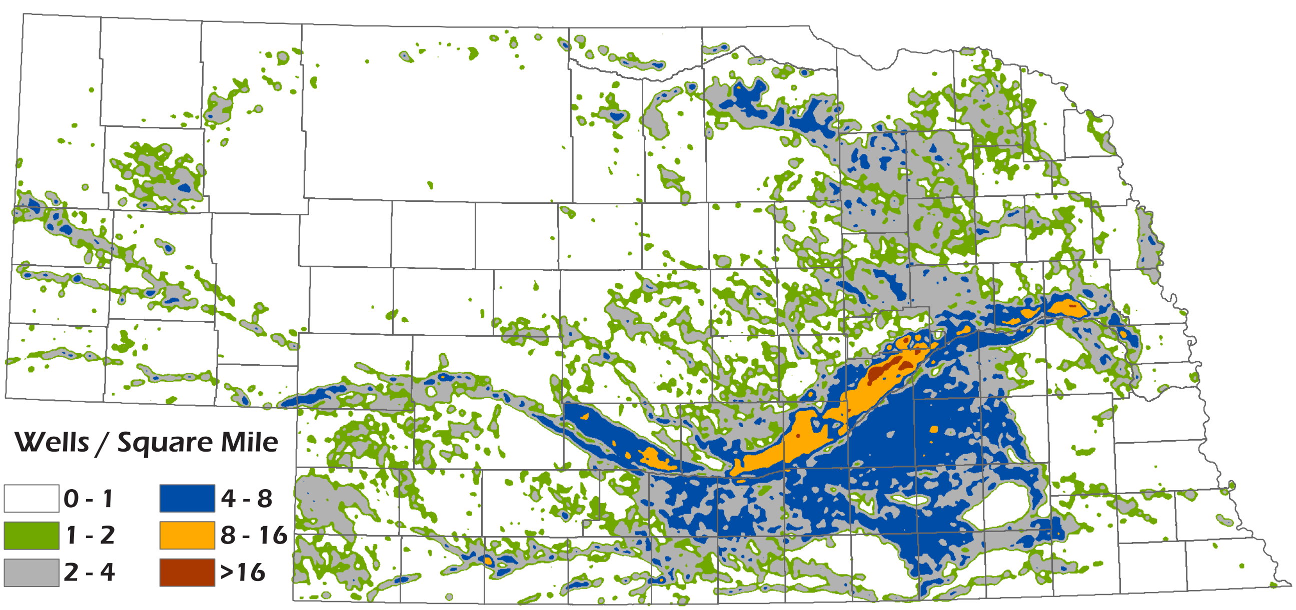
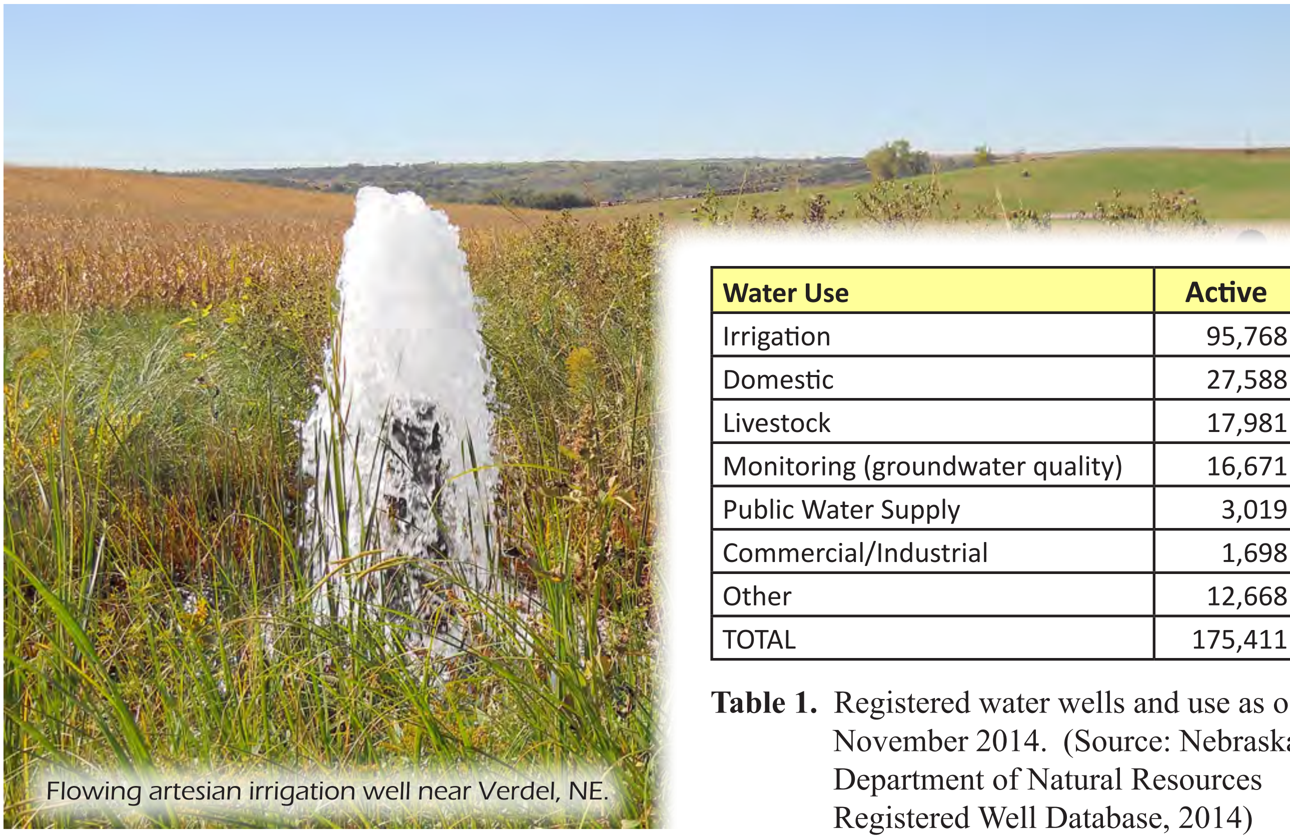


Figure 8. Density of active registered irrigation wells as of November 2013. (Source: Nebraska Department of Natural Resources Registered Well Database, 2013)



Flowing artesian irrigation well near Verdel, NE.

Water Use	Active
Irrigation	95,768
Domestic	27,588
Livestock	17,981
Monitoring (groundwater quality)	16,671
Public Water Supply	3,019
Commercial/Industrial	1,698
Other	12,668
TOTAL	175,411

Table 1. Registered water wells and use as of November 2014. (Source: Nebraska Department of Natural Resources Registered Well Database, 2014)

Groundwater Monitoring

The previous information clearly shows that groundwater is vital to the well-being of all Nebraskans. Fortunately, our state has a long tradition of progressive action in monitoring, managing, and protecting this most precious resource. Several agencies perform monitoring of groundwater for a variety of purposes.

Those entities include:

- Natural Resources Districts (23)
- Nebraska Department of Agriculture
- Nebraska Department of Environmental Quality
- Nebraska Department of Health and Human Services
- University of Nebraska-Lincoln
- United States Geological Survey

Groundwater monitoring performed by these organizations meets a variety of needs, and therefore is not always directly comparable. For instance, the state's 23 Natural Resources Districts (NRDs) perform groundwater monitoring primarily to address contaminants over which they have some jurisdiction; mainly nitrates and agricultural chemicals. In contrast, the state's 1306 public water suppliers monitor groundwater for a large number of possible pollutants which could impact human health. These include basic field parameters, agricultural compounds, and industrial chemicals. Not only are these samples analyzed for many different parameters, the methods used for sampling and analysis vary widely as well.

Lower Platte South Natural Resources District sampling an irrigation well.

Partly in response to this situation, the Nebraska Departments of Agriculture (NDA) and Environmental Quality and the University of Nebraska - Lincoln (UNL) began a project in 1996 to develop a centralized data repository for groundwater quality information that would allow comparison of data obtained at different times and for different purposes. The result of this project is the Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater (referred to as the Database in this publication). The Database brings together groundwater data from many different sources and provides public access to this data.

The Database serves two primary functions. First, it provides to the public the results of groundwater monitoring for agricultural compounds in Nebraska as performed by a variety of entities. At present, agricultural contaminants (mainly nitrate and pesticides) are the focus of the Database because of their widespread use, and also because historical data suggests that these compounds pose the greatest threat to the quality of groundwater across Nebraska. Second, the Database provides an indicator of the methodologies that were used in sampling and analysis for each of the results. UNL staff examine the methods used for sampling and analysis to assign a quality "flag" consisting of a number from 1 to 5 to each of the sample results. The flag depends upon the amount and type of quality assurance/quality control (QA/QC) that was identified in obtaining each of the results. The higher the "flag" number, the better the QA/QC, and the higher the confidence in that particular result.

During the past several years, UNL staff have worked vigorously to establish contact with all the entities performing groundwater monitoring of agricultural chemicals (nitrates and pesticides) in Nebraska. Groundwater data is submitted to UNL by these entities each year, where it is assigned a quality "flag" and entered into the Database. The updated information is then forwarded to the Nebraska Department of Natural Resources (NDNR), which places the data on its website (http://www.dnr.ne.gov/ or more specifically http://dnrdata.dnr.ne.gov/clearinghouse/). The Database can be accessed and searched at NDNR's website for numerous subsets of data, sorted by county, type of well, Natural Resources District, etc.

Groundwater Quality Data

Groundwater quality data presented in the remainder of this report reflect the data present in the Database as of October 1, 2014. The dates for these data range from mid-1974 to 2013. Groundwater results from some of the agencies working in Nebraska have not been submitted to UNL to be entered into the Database, but NDEQ is confident that the information presented represents the majority of sample results available. Table 2 lists each agency producing groundwater quality data for this report.

Agency	
Central Platte NRD	Nebraska Department of Health and Human Services
Hastings Utilities	
Lewis & Clark NRD	Nemaha NRD
Little Blue NRD	North Platte NRD
Lower Big Blue NRD	Papio-Missouri River NRD
Lower Elkhorn NRD	South Platte NRD
Lower Loup NRD	Tri-Basin NRD
Lower Niobrara NRD	Twin Platte NRD
Lower Platte North NRD	U.S. Geological Survey
Lower Platte South NRD	University of Nebraska
Lower Republican NRD	Upper Big Blue NRD
Middle Niobrara NRD	Upper Elkhorn NRD
Middle Republican NRD	Upper Loup NRD
Nebraska Department of Agriculture	Upper Niobrara-White NRD
Nebraska Department of Environmental Quality	Upper Republican NRD

Table 2. Various agencies providing groundwater analyses in Nebraska to be used in the Database. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2014)

Types of Wells Sampled

The data summarized in Table 3 represent the quantity of water samples analyzed from a variety of well types. Historically, most wells that have been sampled are irrigation or domestic supply wells. Irrigation and domestic wells are constructed to yield adequate supplies of water, not to provide water quality samples (longer screens across large portions of the aquifer). However, in recent years, monitoring agencies have been installing increasing numbers of dedicated groundwater monitoring wells designed and located specifically to produce samples (shorter screens in distinct portions of the aquifer). By utilizing such varied sources, groundwater data from a wide range of geologic conditions can be obtained.

Well Type	Number of Analyses
Monitoring	252,048
Irrigation	103,313
Domestic	74,785
Public Water Supply	30,917
Commercial/Industrial	2,360
Livestock/Other	1,846
Total	465,269

Table 3. Total number of groundwater analyses by well type. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2014)

Lower Loup Natural Resources District utilizing a passive diffusion sampler to sample a monitoring well near Duncan, NE.

Monitoring Parameters

As already mentioned, numerous entities across Nebraska have been monitoring groundwater quality for many years, for a wide variety of possible contaminants. However, much of this monitoring has been for area-specific (part of an NRD), or at most, regional purposes (entire NRDs), and it has been difficult to assess data on a statewide basis for more than a short period of time. Creation of the Database has provided an important tool for such analysis. Appendix A lists the compounds for which groundwater has been sampled and analyzed since 1974. Table 4 lists the compounds from Appendix A for which at least 50 samples exceeded the **Reporting Limit***. This gives an indication of which compounds are most commonly detected in Nebraska's groundwater. Only 12 of the 241 compounds sampled met the criteria.

****Reporting Limit*** *refers to the concentration a laboratory has indicated their analysis method can be validated. For example, if a contaminant were at a level below the reporting limit, the laboratory's analysis method could not detect it and the concentration would be reported as "below the reporting limit".*

Throughout this report, the number of sample analyses for any one contaminant refers only to the number of analyses as reported **in the Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater**, and not for the total number of analyses for that contaminant taken in the state. As already mentioned, data which are currently in the process of being submitted to UNL to be entered into the database are not reflected in this report. In addition, there are undoubtedly samples for various contaminants taken by entities other than the agencies referred to in this report (for instance, private consulting firms, or other programs within some of the reporting agencies), which are not included in the Database.

The table in Appendix A shows a wide variety of compounds for which groundwater samples have been analyzed, all of which are used in agricultural production. As mentioned previously, there is also a significant effort in monitoring groundwater for other, non-agricultural contaminants. Examples of such compounds include petroleum products and additives, industrial chemicals, hazardous wastes, contaminants associated with landfills and other waste disposal sites, and effluent from wastewater treatment facilities. Such issues are beyond the scope of §46-1304, and information about such monitoring data is not contained in any centralized database at present.

Compound	Total Samples Collected	Number of Samples that exceed the Reporting Limit	Percent of Samples that exceed the Reporting Limit
nitrate-N	102,387	94,667	92.46%
alachlor ethane sulfonic acid	127	66	51.97%
deethylatrazine	5,375	1,567	29.15%
atrazine	10,260	2,273	22.15%
metolachlor	9,329	1,062	11.38%
deisopropylatrazine	4,799	378	7.88%
cyanazine	9,803	422	4.30%
alachlor	9,838	305	3.10%
propazine	5,267	119	2.26%
simazine	5,812	125	2.15%
prometon	5,621	54	0.96%
metribuzin	9,704	59	0.61%

Table 4. Compounds more commonly found in wells monitored in Nebraska. More than 50 samples analyzed for each compound were greater than the reporting limit. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2014)

Discussion and Analysis

The information presented previously in this report shows that a considerable amount of effort has gone into monitoring groundwater quality in Nebraska since the mid-1970s, especially in areas that are heavily farmed. **The majority of samples taken show that groundwater in the State is of very high quality.** A comparison of Appendix A and Table 4 shows that only a small percentage of parameters analyzed have been detected above the Reporting Limit (12 of 241). However, these same data show that several contaminants have been detected in numerous samples throughout the monitoring period. Levels and distribution of these compounds are issues of concern to Nebraskans.

As Table 4 shows, the compounds that have been detected above the Reporting Limit more than 50 times throughout the monitoring period include nitrate-nitrogen (nitrate-N), atrazine, metolachlor, and degradation products of atrazine, alachlor, and metolachlor. Nitrate is a form of nitrogen common in human and animal waste, plant residue, and commercial fertilizers. Atrazine, alachlor, and metolachlor are herbicides used for weed control in crops such as corn and sorghum while deethylatrazine, deisopropylatrazine, and metolachlor ethane sulfonic acid are degradation products, or metabolites of atrazine and metolachlor. Cyanazine is a trizine herbicide similar to atrazine, but its use has been discontinued. In addition to atrazine and metolachor, the Nebraska Department of Agriculture identified two other priority compounds (alachlor and simazine) for development of pesticide State Management Plans, following guidance produced by the U.S. Environmental Protection Agency.

Occurrence of elevated levels of nitrate and herbicides in groundwater has been associated with the practice of irrigated agriculture, especially corn production (Exner and Spalding 1990).

Installing a monitoring well near Clearwater, NE.

Dedicated monitoring wells in the Lower Loup Natural Resources District.

The Natural Resources Districts have instituted Groundwater Management Areas (GWMAs) over all or parts of nearly all of the 23 districts based on NRD and NDEQ groundwater sampling. The NRDs' institution of these GWMAs indicates a concern and recognition of nonpoint source groundwater contamination. Additionally, NDEQ's Groundwater Management Area program (Title 196, 2002) has completed 20 studies across the state since 1988 identifying areas of nonpoint source contamination mainly from the widespread application of commercial fertilizer and animal waste.

The State of Nebraska has a geographic area of over 77,000 square miles. Accurately characterizing the quality of Nebraska's groundwater in a complex aquifer system has always been difficult. The acquisition of more data is increasing the validity of a trend analysis. However, practices of sampling the "problem" areas still skew the data and make it very difficult to show the areas in Nebraska where the contaminant levels are decreasing through better management and farming practices.

Another difficulty is obtaining the resources and the logistics of collecting groundwater samples. There are approximately 175,000 active registered wells in Nebraska and there have been only enough resources to collect samples from 3,100 (1.8%) to 4,500 (2.6%) annually (since 2000). Also, not all samples collected are evenly distributed throughout the state (Appendix B).

Nitrate Trends Utilizing the Database

Nitrate monitoring data have been collected from wells for many years, and the purpose of collection has varied by the agency or organization performing the work. For instance, public water supply operators sample their drinking water wells to ensure that the public is offered good quality water through the municipal system. NRDs have been tasked by the Nebraska legislature to manage groundwater quality and quantity in order to preserve its usefulness into the future. Additionally, shallow groundwater may have different natural chemical characteristics than deep groundwater and is more easily and quickly affected by activities on the surface than deeper groundwater.

The Database makes accessing and reviewing data relatively simple. One must use caution, though, when utilizing the vast Database because differences in wells may result in incorrect assumptions. Data may be collected from:

- deep wells (bottom of the aquifer) vs. shallow wells (top of the aquifer) or
- irrigation wells (potentially screened across multiple aquifers) vs. dedicated monitoring wells (with perhaps only 10 feet of screen) or
- wells used for measuring water levels (piezometers) vs. wells used for water quality.

Several different methods have been used to present and interpret the nitrate data collected since the early 70s. The median (center of the data set) of the data is presented in tables (Figures 9 and 10) for the entire data set (1974-2013) and for the years with consistent sample events and locations (1994-2013). Maps were generated using the entire Database data set in an attempt to show "current" statewide groundwater quality (see Figure 11) from the most recent time the well had been sampled (aiming to show the most current water quality at that location). Unfortunately, there are numerous wells that haven't been sampled for 10 or more years but represent the most recent sample collected in those locations. As an example, there are four wells in Adams County that were only sampled once in 1991. These wells show up as green dots (<7.5 mg/L) on the statewide map (Figure 11) and it reflects that after 21 years, the groundwater quality is still the same. There is no recent data to verify this assumption.

One of the best ways to use the entire data set is to refer to the maps found in Appendix B, which show the results of sampling done each year, and compare the monitoring data over time. The 2013 map is also presented below as Figure 12. This gives the reader an idea of where there are reoccurring "problem" areas. For example, the reader is directed to look at the samples collected over the years in parts of Phelps, Kearney, Merrick, Nance, Platte, Holt, and Antelope Counties. These are all locations with sandy soils, shallow groundwater, and high nitrate.

In 2002, the NRDs and NDEQ began discussing a Statewide Monitoring Network (a defined subset of wells from the Database) with regularly sampled wells to help better assess Nebraska's groundwater quality and better develop and analyze trends for this report. The first data for this network were assessed in the 2005 Groundwater Quality Monitoring Report using 1280 wells that were sampled in 2004. The 2006 report used 1437 network wells, followed by 1427 wells in 2007, 1404 wells in 2008 and 2009, and 1386 wells from 2010 through present for the Statewide Network trend analysis. A current map of the network wells is presented in Figure 13.

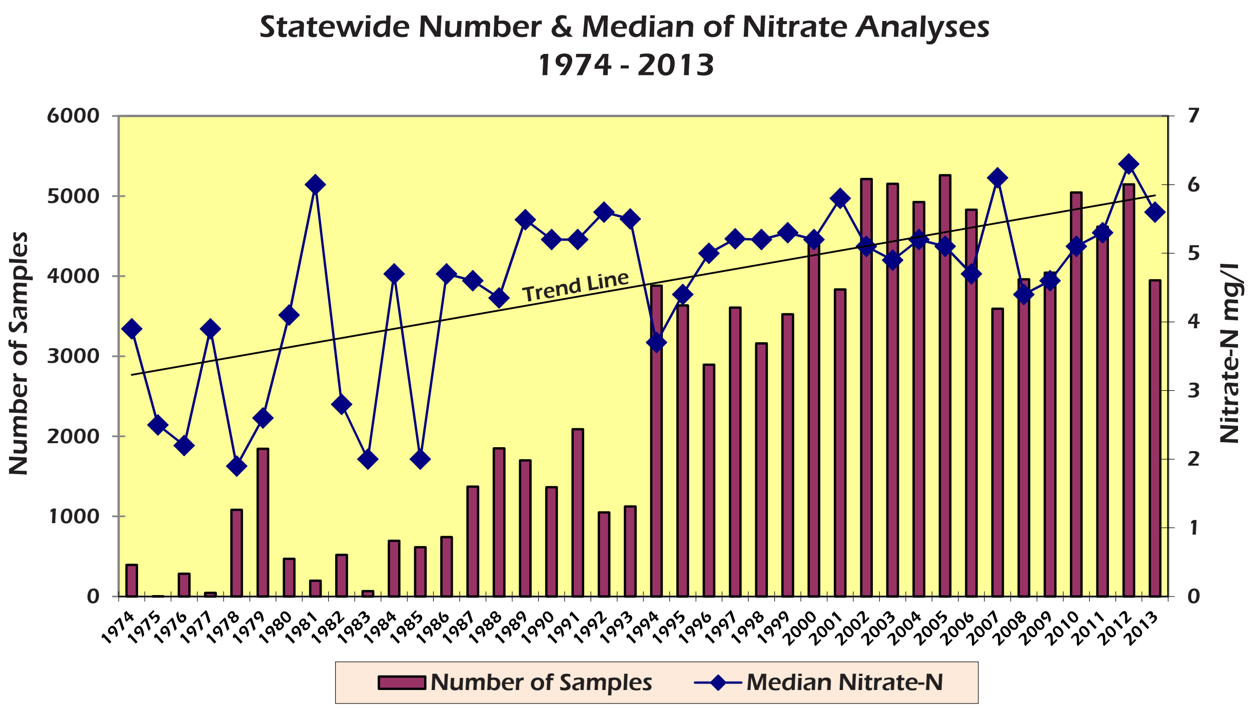


Figure 9. All 102,386 analyses and median nitrate-nitrogen levels for Nebraska, 1974-2013. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2014)

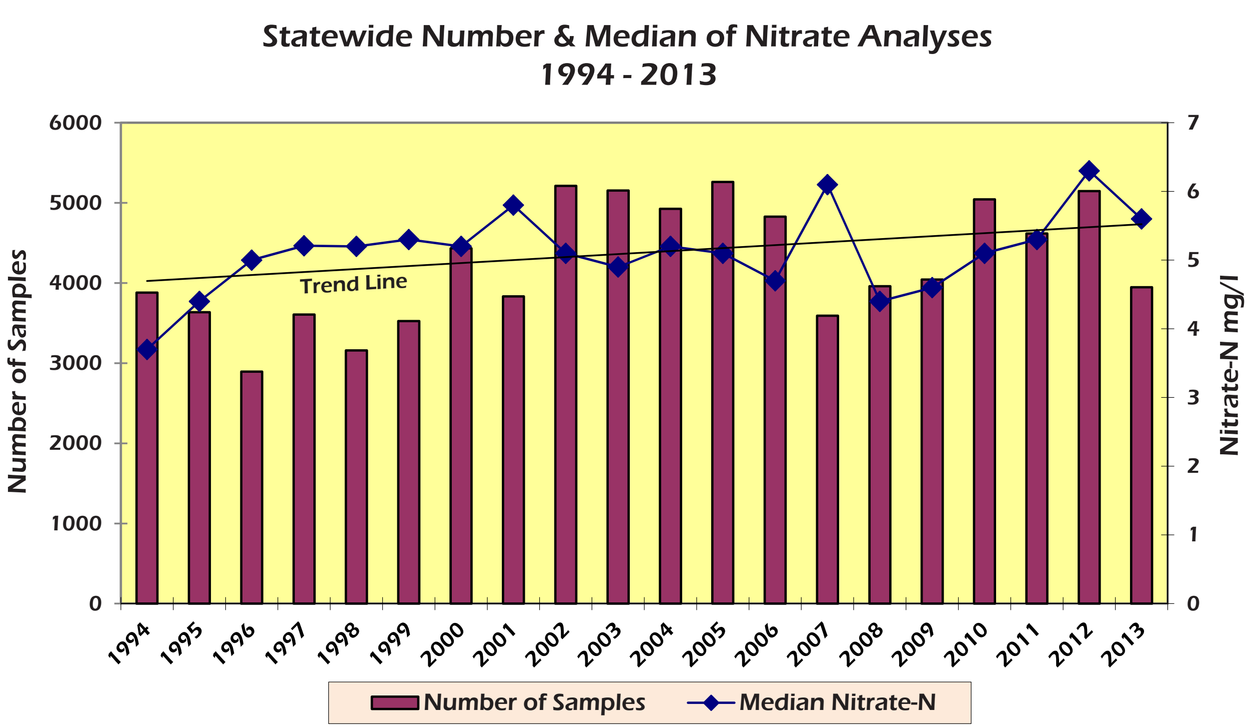


Figure 10. All 84,885 analyses and median nitrate-nitrogen levels for Nebraska, 1994-2013. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2014)

Most Recent Nitrate-N Concentrations

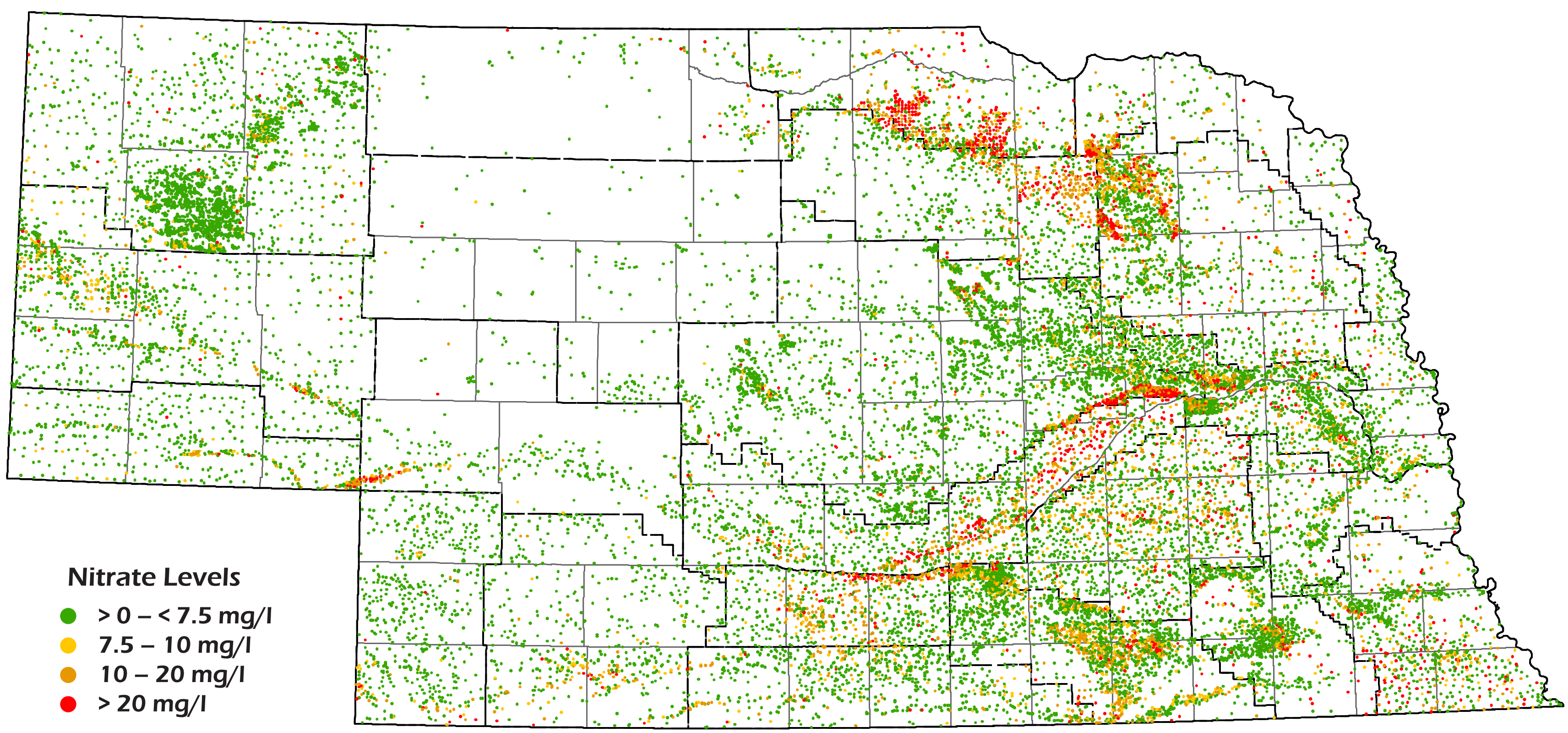


Figure 11. Most recent recorded Nitrate-N concentrations of 25,014 wells from 1974-2013.
(Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2014)
Empty areas indicate no data reported, not the absence of nitrate in groundwater.

Nitrate-N Concentrations of Wells Sampled in 2013

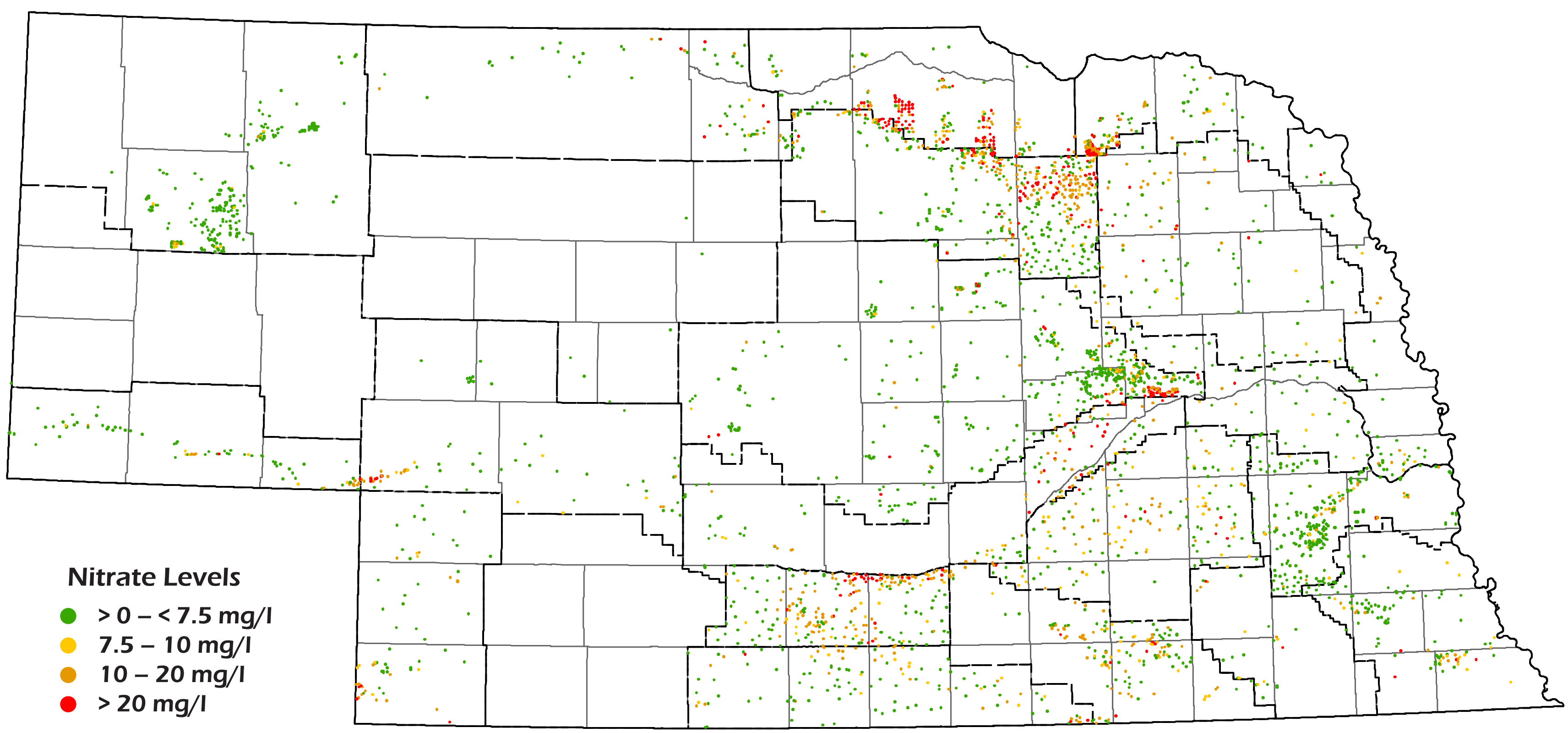


Figure 12. Most recent recorded Nitrate-N concentrations of 3,415 wells sampled in 2013.
(Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2014)
Empty areas indicate no data reported, not the absence of nitrate in groundwater.

University of Nebraska Conservation and Survey Division drilling test holes in the Lower Loup Natural Resources District.

The Network wells were set up to be sampled on an annual basis to make data assessment more reliable and to complete trend analyses. Unfortunately, resources are not always available to the NRDs and not all of the wells are sampled on an annual basis. The data that are collected are still very useful and can still be used for trend analysis. Data from 618 network wells sampled in 2013 are presented in Figure 14.

This year, the NDEQ had the opportunity to expand the Network utilizing federal and state funds. General locations for new Network wells were determined utilizing a Geographic Information System (GIS) computer model to analyze the locations of NRD dedicated monitoring wells, Wellhead Protection (WHP) areas, and Conservation and Survey Division (CSD) test holes (Figure 15). The map generated by this model was distributed to the NRDs and CSD to refine drilling/well locations. Using this method, NDEQ was able to place monitoring wells in areas that would benefit not only the Network, but also CSD for geologic information, NRD for management issues, and local communities. Since a majority of the wells were placed in or close to WHP areas, local communities will be able to use the information gathered from these wells to monitor any groundwater quality issue associated with their system.

NDEQ contracted with CSD to drill and log a test hole at each proposed monitoring location. Test holes were drilled in 37 locations (in 13 NRDs) and representative samples of the sediments were collected and archived (Figure 16). Also, CSD developed a lithological and geophysical log for each test hole. Most of the test holes were drilled through the entire depth of the aquifer. In one case, the test hole was drilled to a depth of over 1,720 feet below ground level. After the test holes were completed, CSD provided NDEQ with a recommended monitoring well design. Two to three monitoring wells were recommended in a majority of the new locations. In these instances, each of the wells were screened in different portions of the aquifer instead of one long screen across the entire aquifer (typical in production wells). This method will allow making a distinction in water quality throughout the aquifer.

NDEQ contracted with a water well driller to construct 31 dedicated monitoring wells at 18 locations (Figure 17). The NRDs secured access to the drill locations and committed to signing agreements to assume ownership, sample annually, and submit to the Database the sample results of each well. The new monitoring wells will become part of the Network and dedicated pumping equipment will enable regular sampling. In addition to the wells the NDEQ funded, several NRDs took it upon themselves to contract the drilling of additional monitoring wells in locations where CSD drilled test holes.

The most important aspect of the current Network is the ability to sample the wells on regular basis. Some of the gaps in the Network actually have existing monitoring wells, but these wells may not get sampled because of access issues, time commitment, or poor data quality involved in manually bailing each well for samples. Equipping these wells with dedicated pumps for sampling allows Nebraska to greatly expand the Network without the cost of drilling new wells. These existing wells will receive dedicated sampling equipment in order to quickly sample groundwater without disturbing the water column and affecting the accuracy and precision of the data. Pump controls and electric generators were also purchased so that multiple sampling crews can operate statewide. Altogether, the equipment, pumps, controls, and generators allow for the collection of physical and chemical data on groundwater in locations where monitoring does not exist or is inadequate. Utilizing irrigation wells requires the well to be running at the time the sampler arrives. If the well is not running the sampler must return another time which in turn uses more resources. Monitoring wells with dedicated sampling equipment can be sampled anytime which reduces personnel costs. Therefore, NDEQ provided funds to 15 NRDs to purchase dedicated sampling equipment to be placed in over 100 active Network monitoring wells and the 31 new monitoring wells added this year.

Last year's analysis of all the data indicated that there were no clear trends and that the deeper the well, the lower the nitrate concentration. With the addition of more dedicated monitoring wells screened in different portions of the aquifer, future analysis may be used to assess water quality in distinct aquifers. This information could be vital in the location of new drinking water wells, both public and private, or manage groundwater through voluntary actions.

NDEQ sampling monitoring wells near Clearwater NE.

Most Recent Nitrate-N Concentrations of Network Wells

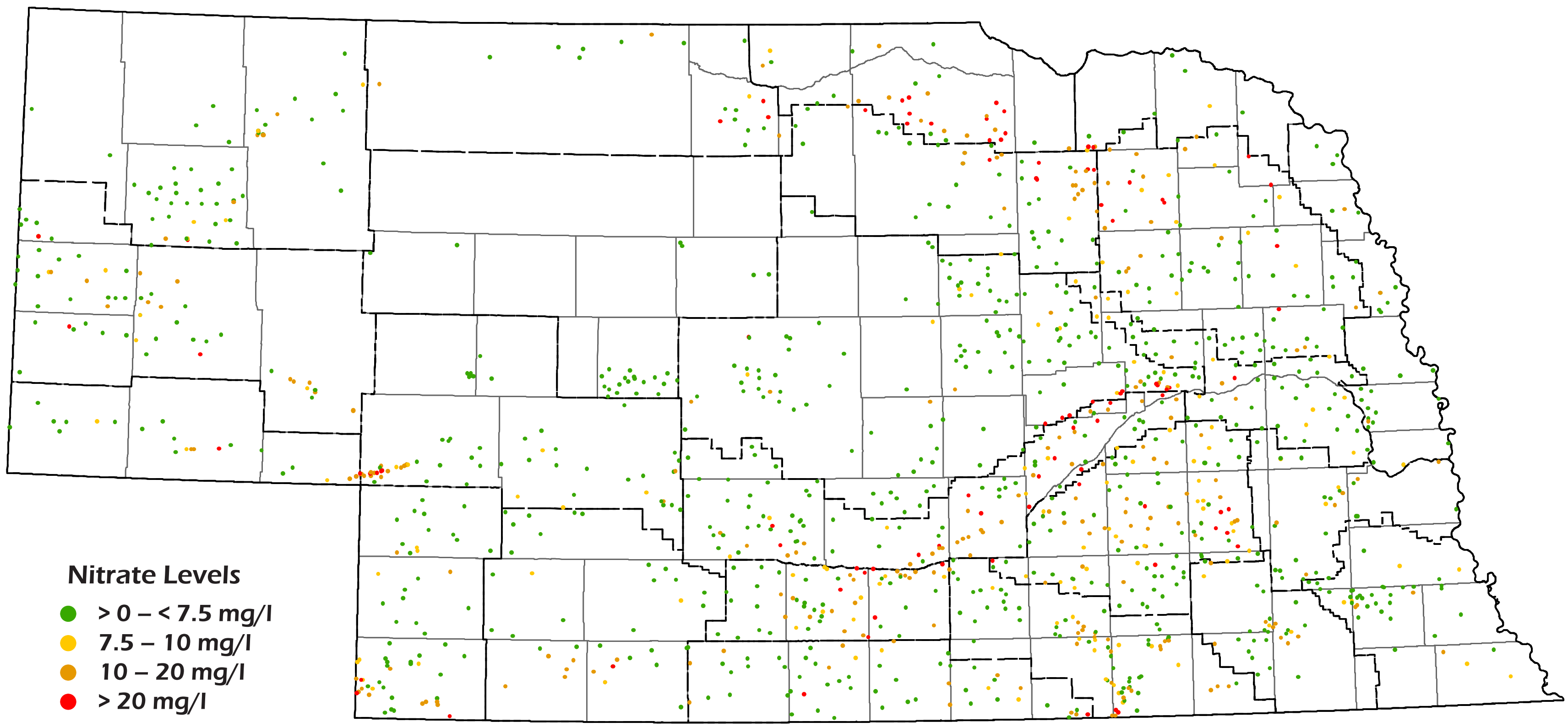


Figure 13. Most recent recorded Nitrate-N concentrations of all 1386 statewide groundwater monitoring wells.
(Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2014)
Empty areas indicate no data reported, not the absence of nitrate in groundwater.

Nitrate-N Concentrations of Network Wells Sampled in 2013

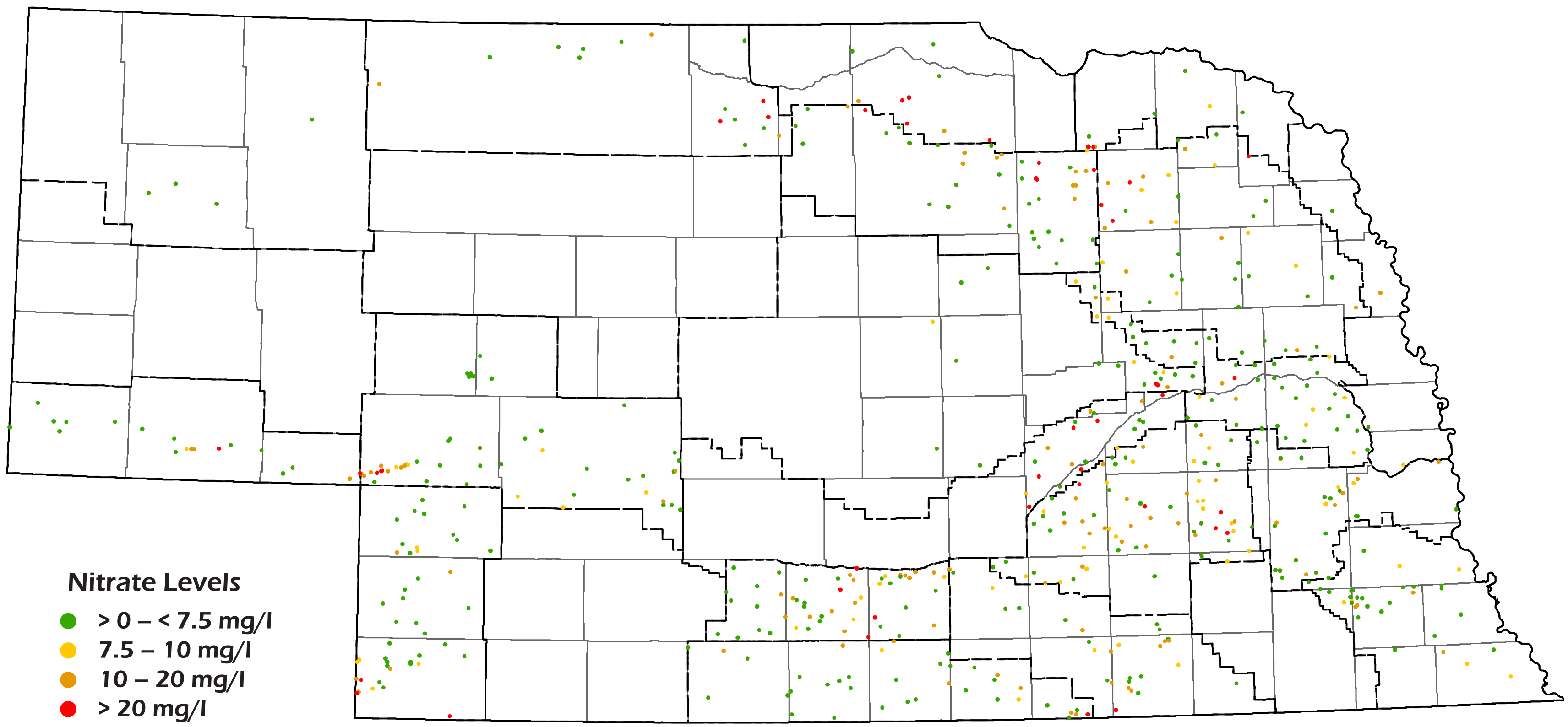


Figure 14. Most recent recorded Nitrate-N concentrations of 618 statewide groundwater monitoring network wells sampled in 2013.
(Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2014)
Empty areas indicate no data reported, not the absence of nitrate in groundwater.

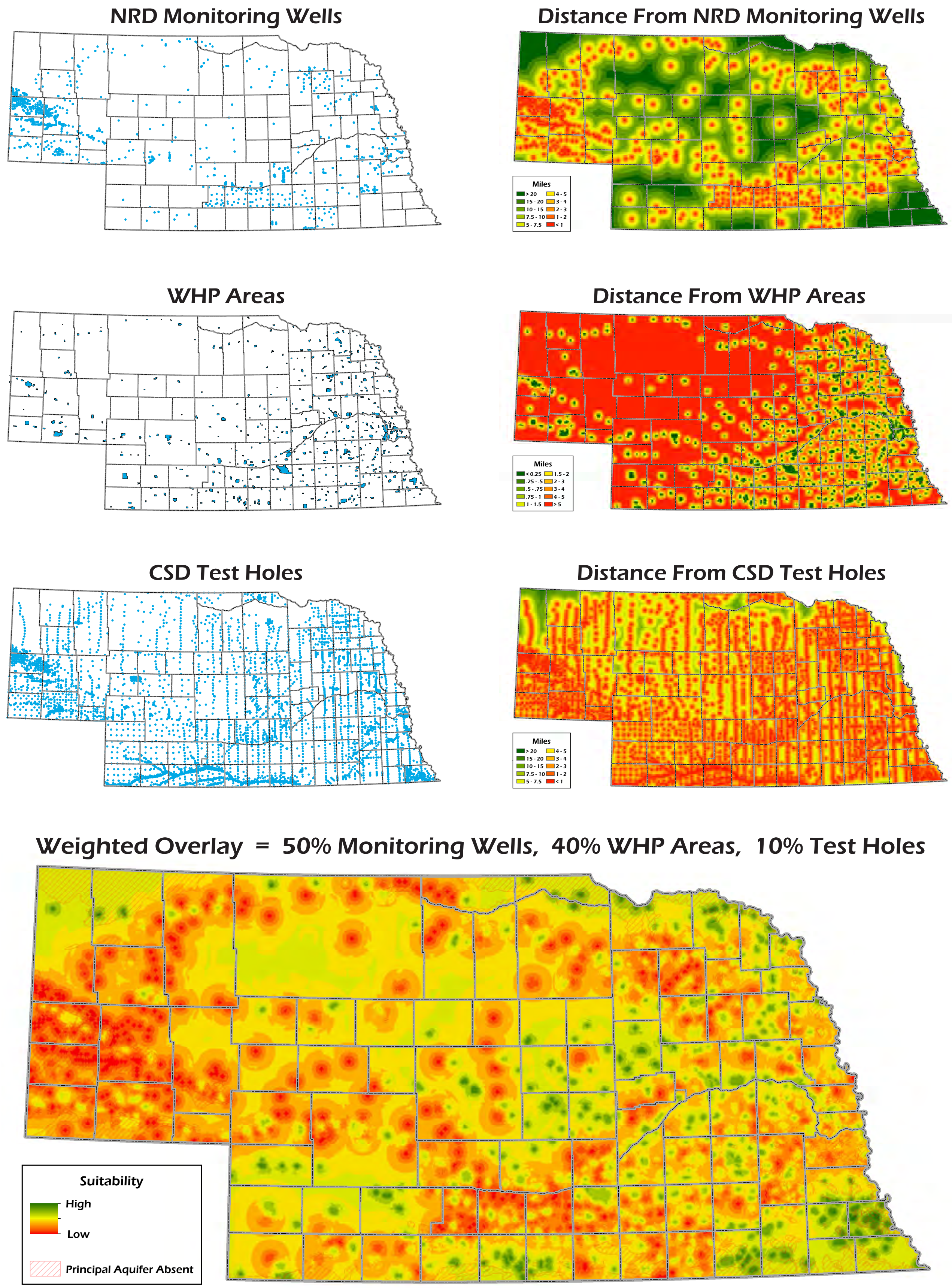


Figure 15. Modeling used to determine locations of test holes and new network wells.

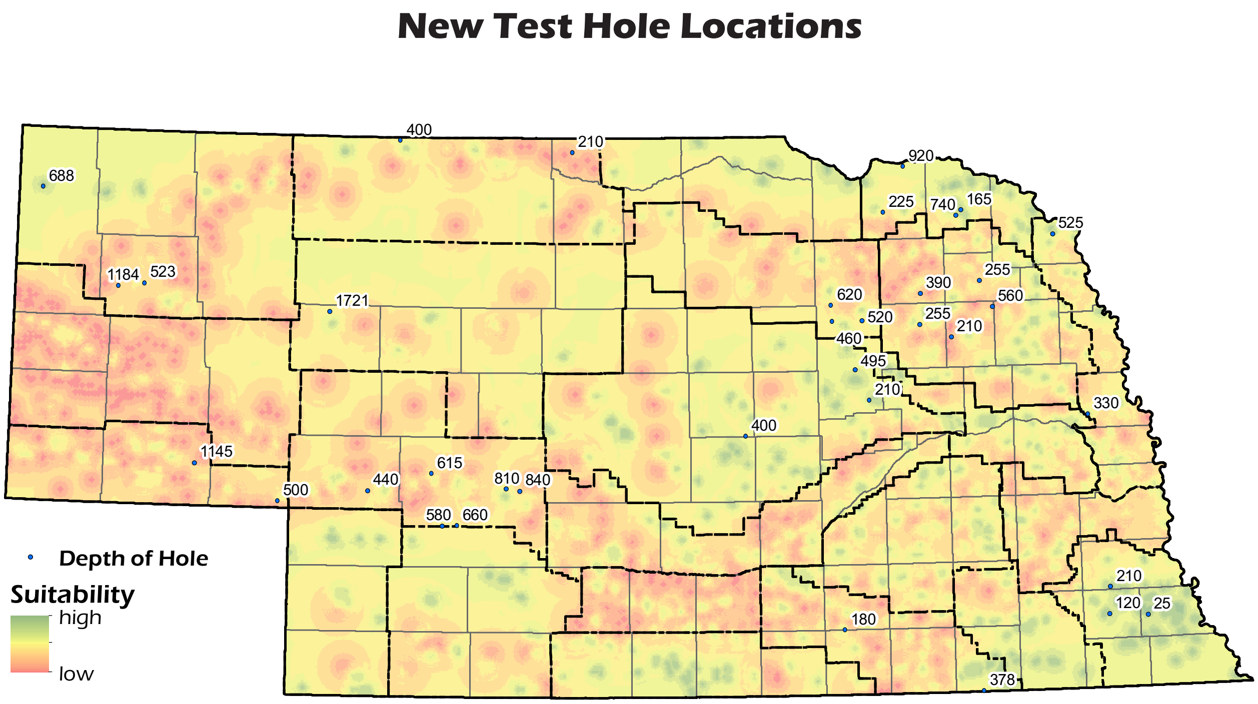


Figure 16. Location of 37 test holes drilled by Conservation Survey Division (CSD) for new monitoring well network.

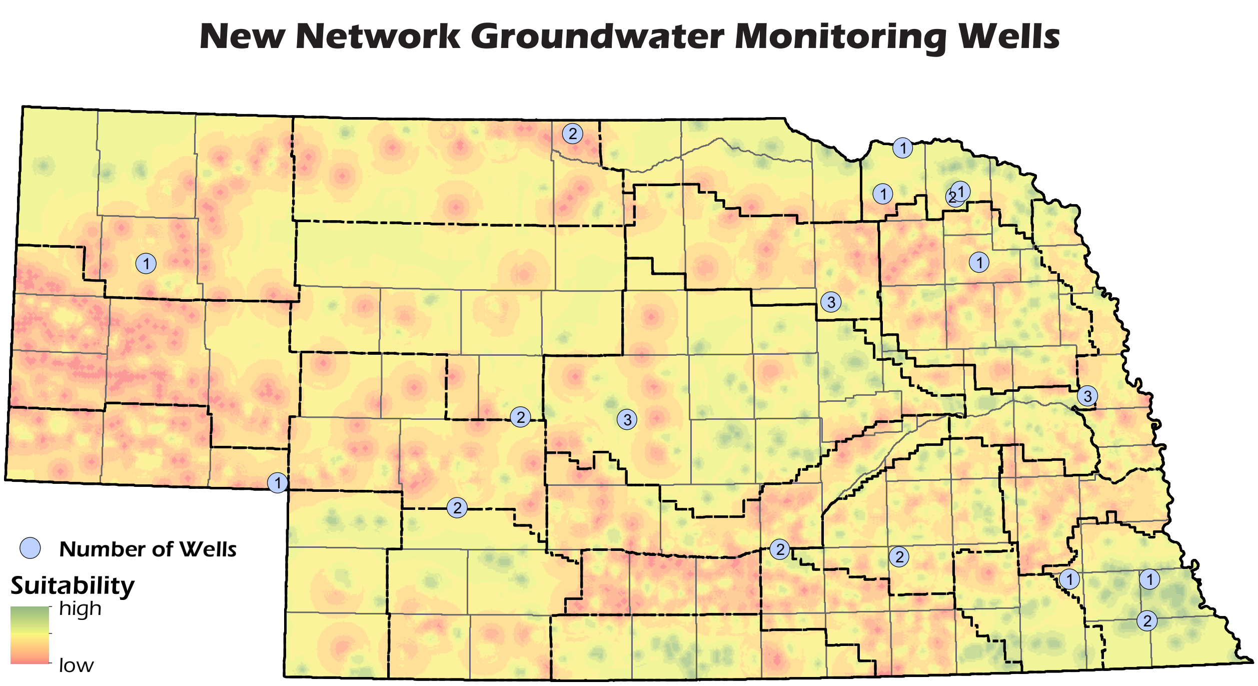


Figure 17. 18 new locations of 31 new monitoring wells to be utilized in the statewide groundwater monitoring network.

Nitrate in Public Water Supplies

Reverse Osmosis treatment plant to remove nitrate (Seward, NE).

Public water supply systems are required to test for a variety of potential contaminants in the drinking water that they provide to the public. When a contaminant in the drinking water is above the federal Safe Drinking Water Act limit (also known as the maximum contaminant level [MCL]), the water system will receive an Administrative Order concerning that contaminant from the Nebraska Department of Health and Human Services (DHHS) and must resolve the problem. The MCL for nitrate-nitrogen is 10 mg/l, but public water supply systems with wells or intakes testing over 5 mg/l may be required to perform quarterly sampling. Of the nearly 550 groundwater based community public water supply systems in Nebraska that supply their own water, 66 of those must perform quarterly sampling for nitrate. Common methods to resolve a nitrate Administrative Order include drilling a new or deeper well, hooking on to a neighboring water system, or building a water treatment plant. Figure 18 shows the location of active community public water supply systems that have their own wells. Colors indicate if there is an administrative order for nitrate, systems required to perform quarterly sampling, and systems treating water because of high levels of nitrate. Administrative Orders due to high levels of nitrate do not necessarily fall in the areas of highest nitrate problems, as indicated in Figures 11 and 12 and the figures in Appendix B.

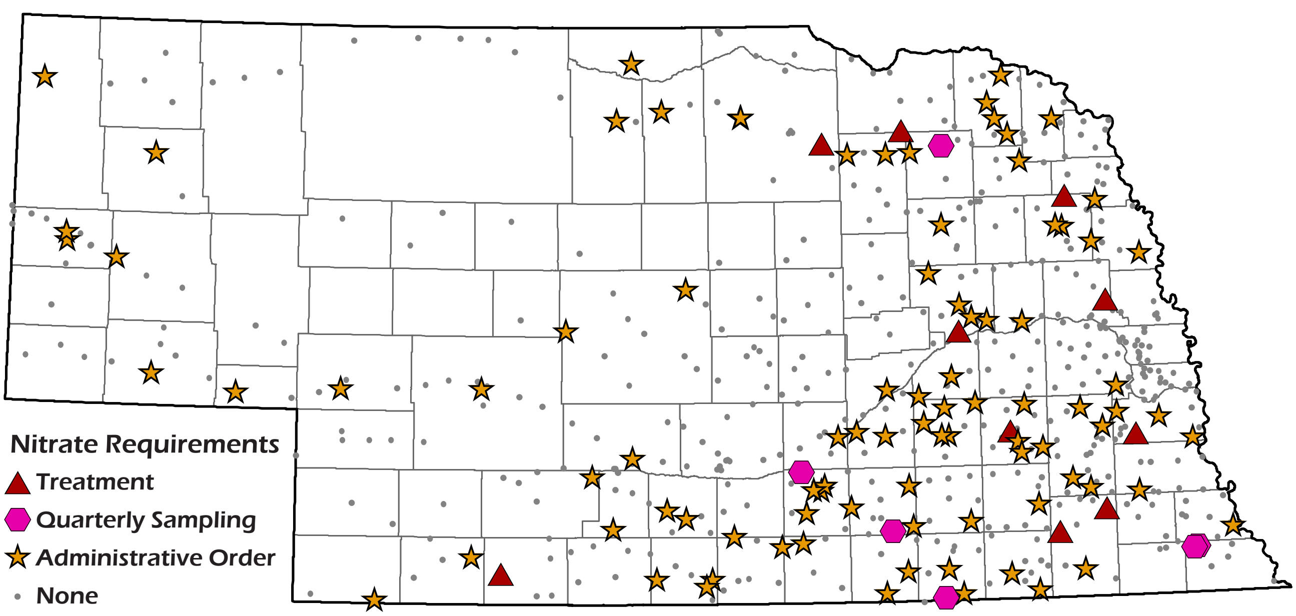


Figure 18. Community public water supply systems with requirements for nitrate. (Source: DHHS, November 2014)

Several recent studies considered the relationship of nitrate leaching into the subsurface and uranium concentrations found in groundwater. Research indicates that natural uranium in the subsurface may be oxidized and mobilized as the nitrate (in many forms) moves through the root zone and eventually to groundwater. Uranium is found naturally in sediment deposited mainly by streams and rivers.

Some public water supply systems treat not only nitrate, but also uranium. The MCL for uranium is 0.030 mg/L. Figure 19 shows the location of active community public water systems treating for uranium.

Ion Exchange plant to remove uranium (McCook, NE).

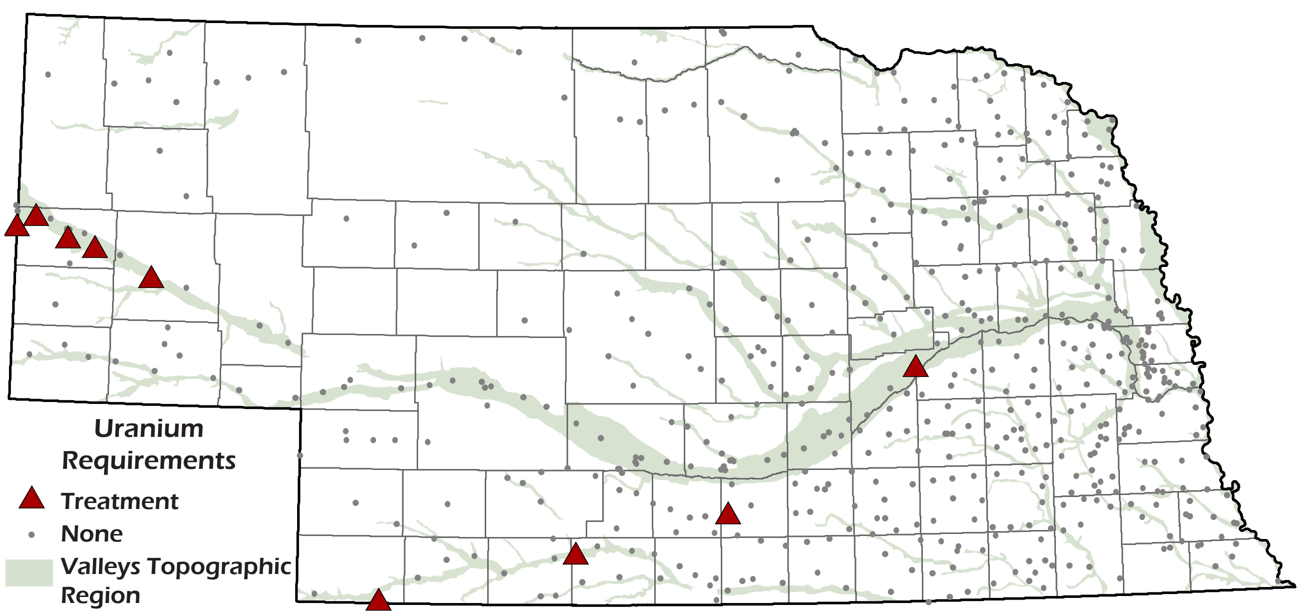


Figure 19. Community public water supply systems treating for uranium. (Source: DHHS, November 2014)

Herbicides

Atrazine

Atrazine is used as an herbicide to eradicate broad leaf weeds. Commercial trademark names include Aatrex and Bicep. There have been 19,179 samples collected for Atrazine since 1974. There was an average concentration of 0.004 µg/L for the 86 samples collected in 2013.

Then mean atrazine concentration calculated from the Database for the entire record since 1974 is 0.81 µg/L, compared to the USEPAs MCL of 3 µg/L.

Alachlor

Alachor is used as an herbicide to eradicate broad leaf weeds and grasses. Commercial trademark names include Lasso, Bullet, and Lariat. There have been 18,753 samples collected since 1974 and only one sample with a concentration above the reporting limit for Alachlor in the 1,637 samples collected since 2004.

The mean alachlor concentration calculated from the Database for the entire record since 1974 is 0.008 µg/L, compared to the USEPAs MCL of 6 µg/L.

Metolachlor

Metoloachlor is used as an herbicide to eradicate broad leaf weeds. Commercial trademark names include Bicep and Dual. There have been 18,248 samples collected since 1974 and an average concentration of 0.006 µg/L for the 1,014 samples collected since 2007.

The mean metolachlor concentration calculated from the Database for the entire record since 1974 is 0.16 µg/L. There is no USEPA MCL for metolachlor.

Simazine

Simazine is used as an herbicide to eradicate broad leaf weeds. Commercial trademark names include Princep and Aladdin. There have been 14,281 samples collected and only one sample with a concentration above the reporting limit for Simazine in the 1,636 samples collected since 2004.

The mean simazine concentration calculated from the Database for the entire record since 1974 is 0.004 µg/L, compared to the USEPAs MCL of 4 µg/L.

Alternative Laboratory Methods

In mid-2004, the NRDs, working with NDEQ and the Nebraska Department of Agriculture (NDA), began new monitoring efforts. Using funding from USEPA Region 7, NDEQ, and NDA placed in-house equipment for the analysis of priority herbicides (atrazine and metolachlor) in several NRD offices. In 2005, NDEQ obtained additional funding from USEPA to place herbicide units in other NRD offices for a total of 14.

Monitoring for these parameters using these in-house methods continues as resources allow. The herbicide data received from this project can be considered qualitative or semi-quantitative, and the results have been roughly similar to the pattern of detections from the Database.

The herbicide data has been compiled by the NDA and is available at: http://data.dnr.nebraska.gov/Clearinghouse/ClearinghouseELISA.aspx

Herbicide Trends

An in-depth analysis of statewide trends for any of the herbicides has not been attempted this year because the number of detections in separate wells for these compounds is too small to permit a reliable trend analysis. Many of the detections for these compounds are in the same wells or a series of closely spaced wells. Therefore, an analysis for trends in these parameters would not be valid. In general, the greater numbers of detections of herbicides in groundwater follows the same overall pattern of higher nitrate in groundwater.

As mentioned previously in this report, 14 of the 23 NRDs continue to sample for atrazine, metolachlor, and acetochlor and analyze on a case-by-case basis using the in-house technology described above. The Nebraska Department of Agriculture (NDA) has authority to manage pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The NDA can be contacted at (402) 471-2351 and their annual report can be found at http://www.nda.nebraska.gov/pesticide/ .

Twin Platte Natural Resources District

CONCLUSIONS

Groundwater is a valuable Nebraska resource. The majority of Nebraska's residents rely on groundwater for drinking water, as does agriculture, and industry. Most public water supplies that utilize groundwater do not require any form of treatment for drinking water before serving it to the public. There are some limited areas in Nebraska where the nitrate concentration is greater than the drinking water standard of 10 mg/L. The state's reliance on groundwater suggests that it is important to continue to monitor groundwater quality and to coordinate and share monitoring techniques. This will enable decision makers to make more informed management decisions.

The Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater has been invaluable to decision makers in managing Nebraska's groundwater resource. This report authorized by Neb. Rev. Stat. § 46-1304 (LB 329, 2001) would be impossible to prepare without the Database. The Database has made it possible to quickly and confidently retrieve both recent and historic groundwater quality data for the entire State. These data are utilized to make regulatory decisions to protect groundwater quality, and are used by the private sector to identify alternate sources of groundwater for drinking water purposes. Most of the 23 NRDs and several state and federal agencies are conducting groundwater monitoring, resulting in a large number of analyses spread across the entire state. The Database must continue to be implemented and updated for the foreseeable future.

Nebraska's Natural Resources Districts are conducting extensive groundwater quality monitoring, focusing on nitrate and pesticides, and have instituted many Groundwater Management Areas (GWMAs). Most of the NRDs have submitted groundwater quality monitoring data to the Database. The other NRDs are submitting data through a cooperative agreement with USGS. The NRDs have also developed a Statewide Groundwater Monitoring Network that has been sampled for nine years. The NRDs data is vital to the Database, and their implementation of GWMAs is essential in the protection of groundwater quality in Nebraska. NRDs with GWMAs have encouraged and in some places, required farm operator certification, soil testing for nitrogen, irrigation water management, and other best management practices. It will be through these GWMAs and related practices that Nebraskans will see a decrease in contaminants such as nitrate over the next several decades.

Concentrations and trends of contaminants. Last year was the first year that the data from the Statewide Groundwater Monitoring Network was utilized to show trends of nitrate detected in the State's groundwater. These data indicated that nitrate concentrations tend to decrease with depth of the well. Also, there was no clear trend (up or down) in the nitrate concentrations in groundwater for the data gathered from 2000 to the present. Looking back at previous reports (Figures 9 and 10, page 15) in which the median nitrate concentration in groundwater for each year was utilized in a simple trend analysis, these data also indicated that there was no clear trend after 2000. However, there are still areas in Nebraska where the median nitrate concentration in groundwater is approaching the drinking water MCL of 10 mg/l. Another trend analysis for nitrates will be conducted in the 2016 report after three years of data have been collected from the new Network monitoring wells. There is not enough recent data statewide for atrazine, alachlor, metolachlor, or simazine to conduct any trend analyses.

The Future. There has been a significant amount of time and effort expended to populate the Database and the importance of its merits cannot be emphasized enough. The NRDs' Statewide Groundwater Monitoring Network has been very useful and consists of many dedicated monitoring wells. This year's efforts to improve the Statewide Groundwater Monitoring Network with new dedicated monitoring wells with carefully considered well construction and screen placement, and emphasizing standards for sample collection and reporting should facilitate a clearer picture of Nebraska's groundwater quality. Also, dedicated pumps added to current and newly constructed network monitoring wells will make sampling more efficient and therefore provide more data than was collected from the network in past years. Continued attention and resources (i.e. local and state staff time, and funding) directed toward groundwater monitoring and implementation of the Statewide Groundwater Monitoring Network will be crucial for the successful management of Nebraska's valuable natural resource, groundwater.

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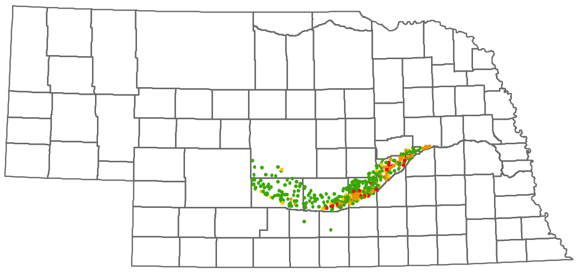
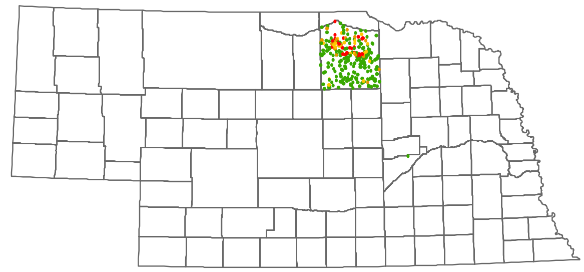
Compound	Compound	Compound
1,1,1-trichloroethane	aldicarb sulfoxide	dechloroacetochlor
1,2,4-trichlorobenzene	aldrin	dechloroalachlor
1,2-dibromo-3-chloropropane	alpha-HCH	dechlorodimethenamid
1,2-dibromoethane	ametryn	dechlorometolachlor
1,2-dichlorobenzene	atrazine	deethylatrazine
1,2-dichloroethane	azinphos-methyl	deethylcyanazine
1,2-dichloropropane	azinphos-methyl oxon	deethylcyanazine acid
1,3-dichloropropane	bendiocarb	deethylcyanazine amid
1,4-dichlorobenzene	benfluralin	deethylhydroxyatrazine
1-naphthol	benomyl	deisopropylatrazine
2,4,5-T	bensulfuron-methyl	deisopropylhydroxyatrazine
2,4,6-trichlorophenol	bentazon	delta-HCH
2,4-D	benzo(a)pyrene	demethylfluometuron
2,4-D methyl ester	beta-HCH	desulfinylfipronil
2,4-DB	bromacil	desulfinylfipronil amide
2,4-dinitrophenol	bromomethane	di(2-ethylhexyl)adipate
2,6-diethylaniline	bromoxynil	di(2-ethylhexyl)phthalate
2-[(2-ethyl-6-methylphenyl) amino]-1-propanol	butachlor	diazinon
	butylate	diazoxon
2-[(2-ethyl-6-methylphenyl) amino]-2-oxoethane sulfonic acid	carbaryl	dicamba
	carbofuran	dichlobenil
2-chloro-2',6'-diethylacetanilide	carbon disulfide	dichlorprop
2-ethyl-6-methlyaniline	carbon tetrachloride	dichlorvos
3,4-dichloroaniline	carboxin	dicrotophos
3,5-dichloroaniline	chloramben methyl ester	didealkyl atrazine
3-hydroxycarbofuran	chlordane	dieldrin
4,6-dinitro-o-cresol	chlorimuron-ethyl	dimethenamid
4-chloro-2-methylphenol	chloroform	dimethenamid ethane sulfonic acid
4-chloro-3-methylphenol	chlorothalonil	
4-nitrophenol	chlorpyrifos	dimethenamid oxalinic acid
acenaphthene	chlorpyrifos oxon	dimethoate
acetochlor	cis-1,3-dichloropropene	dinoseb
acetochlor ethane sulfonic acid	cis-permethrin	diphenamid
acetochlor oxanilic acid	clopyralid	disulfoton
acetochlor sulfynilacetic acid	cyanazine	disulfoton sulfone
acifluorfen	cyanazine acid	diuron
acrylonitrile	cyanazine amide	endosulfan I
alachlor	cycloate	endosulfan II
alachlor ethane sulfonic acid	cyfluthrin	endosulfan sulfate
alachlor ethane sulfonic acid, secondary amide	cypermethrin	endrin
	cyprazine	endrin aldehyde
alachlor oxanilic acid	DCPA	EPTC
alachlor sulfynilacetic acid	DCPA monoacid	esfenvalerate
aldicarb	DDD	ethalfluralin
aldicarb sulfone	DDT	ethion

Appendix A. Compounds for which groundwater samples have been analyzed

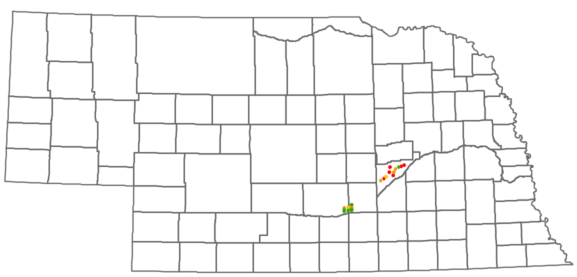
Compound	Compound	Compound
ethion monoxon	lindane	phorate
ethoprop	linuron	phorate oxon
ethyl parathion	malathion	phosmet
fenamiphos	malathion oxon	phosmet oxon
fenamiphos sulfone	MCPA	picloram
fenamiphos sulfoxide	MCPB	prometon
fenuron	metalaxyl	prometryn
fipronil	methidathion	propachlor
fipronil sulfide	methiocarb	propachlor ethane sulfonic acid
fipronil sulfone	methomyl	propachlor oxalinic acid
flufenacet	methoxychlor	propanil
flufenacet ethane sulfonic acid	methyl paraoxon	propargite
flufenacet oxalinic acid	methyl parathion	propazine
flumetsulam	methylene chloride	propham
fluometuron	metolachlor	propiconazole
fonofos	metolachlor ethane sulfonic acid	propoxur
fonofos oxon		propyzamide
heptachlor	metolachlor oxalinic acid	siduron
heptachlor epoxide	metribuzin	silvex
hexachlorobenzene	metsulfuron-methyl	simazine
hexachlorocyclopentadiene	molinate	simetryn
hexazinone	myclobutanil	sulfometuron-methyl
hydroxyacetochlor	naphthalene	tebuthiuron
hydroxyalachlor	napropamide	terbacil
hydroxyatrazine	neburon	terbufos
hydroxydimethenamid	nicosulfuron	terbufos oxon sulfone
hydroxymetolachlor	nitrate-N	terbuthylazine
hydroxysimazine	norflurazon	terbutryn
imazaquin	oryzalin	tetrachloroethene
imazethapyr	oxadiazon	thiobencarb
imidacloprid	oxamyl	toxaphene
iodomehtane	oxyfluorfen	trans-1,3-dichloropropene
iprodione	p,p'-DDE	triallate
isofenphos	pebulate	trichloroethene
isoxaflutole	pendimethalin	triclopyr
isoxaflutole benzoic acid	pentachlorophenol	trifluralin
isoxaflutole diketonitrile	permethrin	vernolate



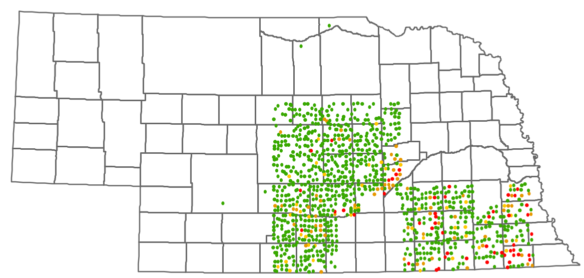
1974 - 1975 (397 wells, 397 analyses)



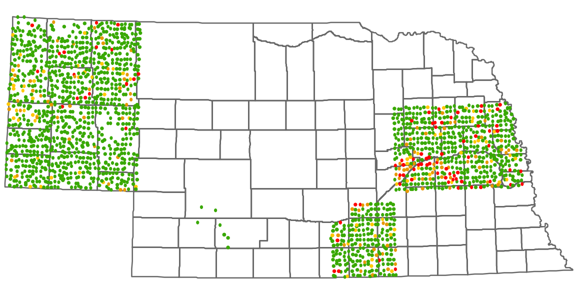
1976 (283 wells, 283 analyses)



1977 (45 wells, 45 analyses)



1978 (1057 wells, 1082 analyses)

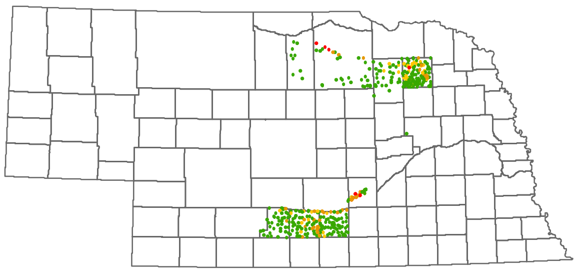


1979 (1843 wells, 1844 analyses)

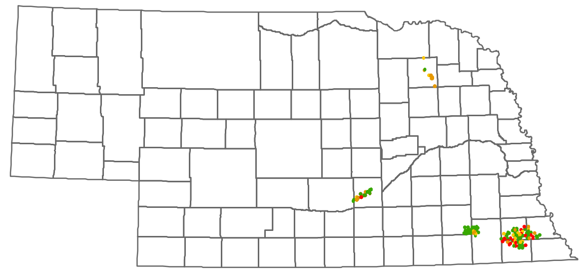
Figure B-1
Nitrate analyses for years 1974 - 1979
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- **< 7.5 mg/l**
- **7.5 – 10 mg/l**
- **10 – 20 mg/l**
- **> 20 mg/l**

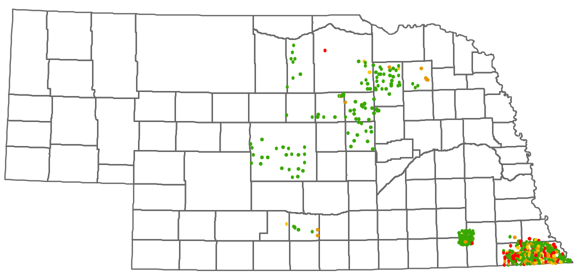
Empty areas indicate no data reported. These Maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (http://deq.ne.gov) and use your Adobe Acrobat reader to enlarge individual maps.



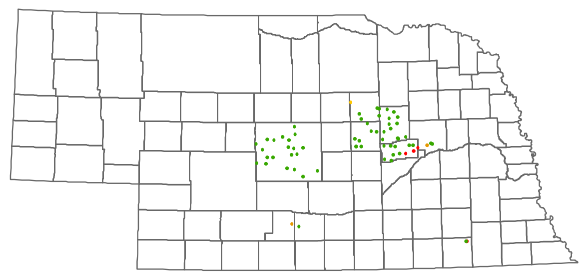
1980 (402 wells, 469 analyses)



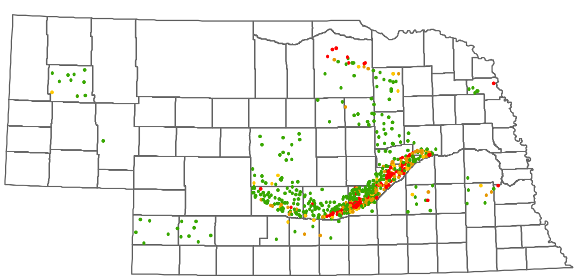
1981 (143 wells, 197 analyses)



1982 (506 wells, 519 analyses)



1983 (65 wells, 67 analyses)



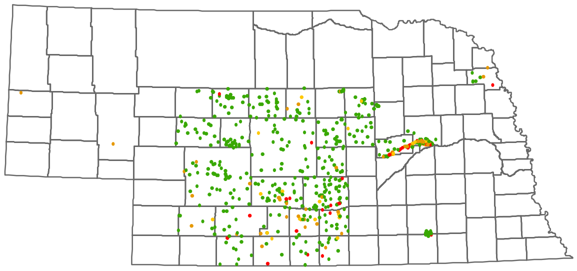
1984 (691 wells, 695 analyses)

Figure B-2
Nitrate analyses for years 1980 - 1984
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

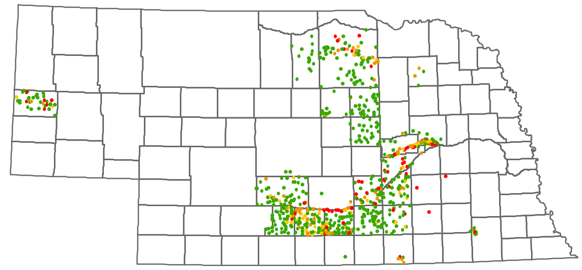
Nitrate Levels

- **< 7.5 mg/l**
- **7.5 – 10 mg/l**
- **10 – 20 mg/l**
- **> 20 mg/l**

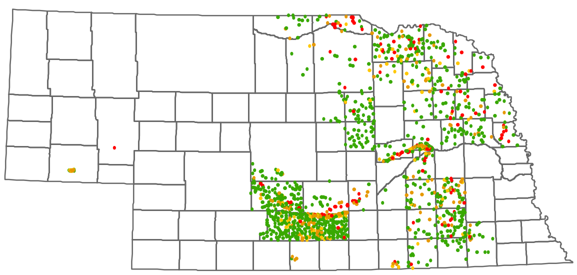
Empty areas indicate no data reported. These Maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (http://deq.ne.gov) and use your Adobe Acrobat reader to enlarge individual maps.



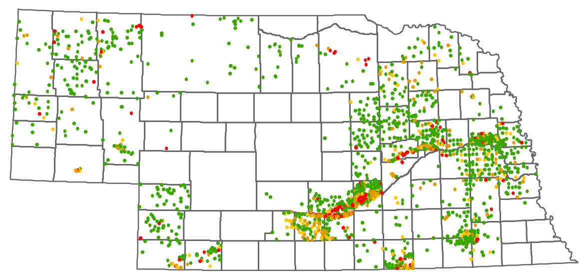
1985 (615 wells, 615 analyses)



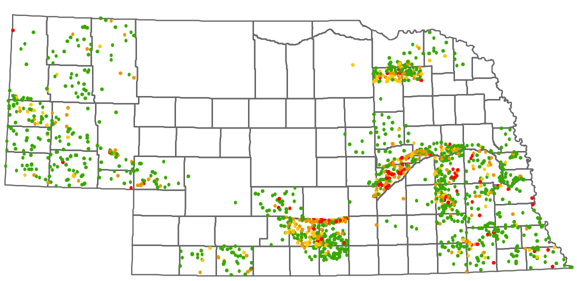
1986 (742 wells, 742 analyses)



1987 (1323 wells, 1371 analyses)



1988 (1794 wells, 1850 analyses)

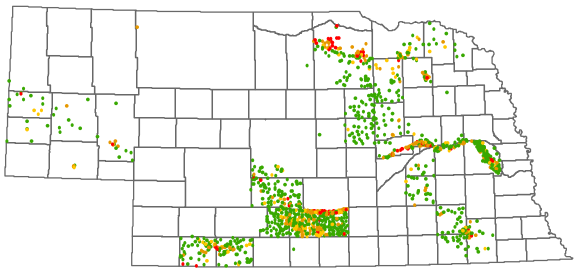


1989 (1664 wells, 1699 analyses)

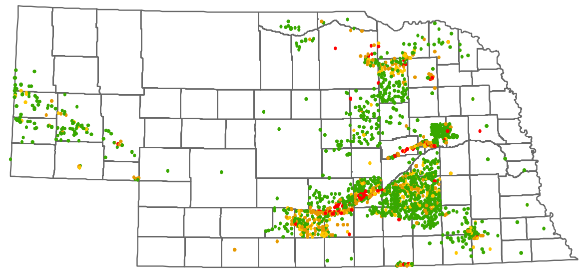
Figure B-3
Nitrate analyses for years 1985 - 1989
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

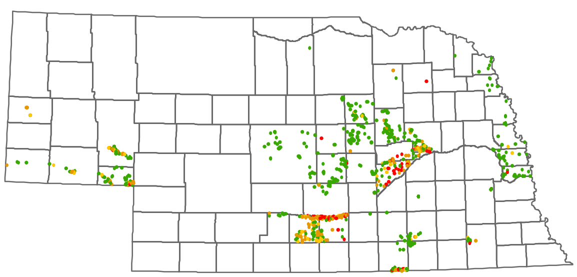
Empty areas indicate no data reported. These Maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (http://deq.ne.gov) and use your Adobe Acrobat reader to enlarge individual maps.



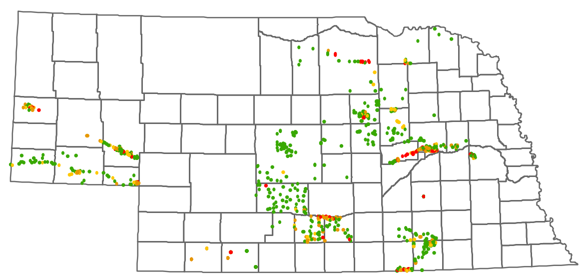
1990 (1335 wells, 1364 analyses)



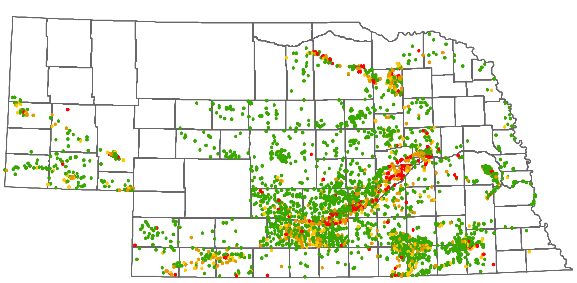
1991 (1918 wells, 2089 analyses)



1992 (803 wells, 1049 analyses)



1993 (809 wells, 1124 analyses)

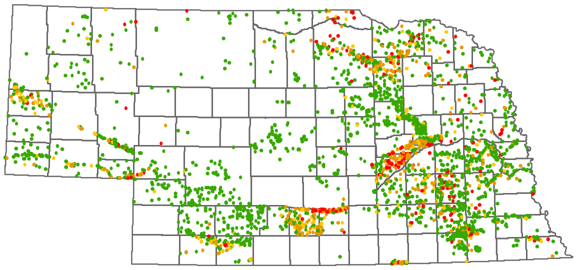


1994 (3149 wells, 3881 analyses)

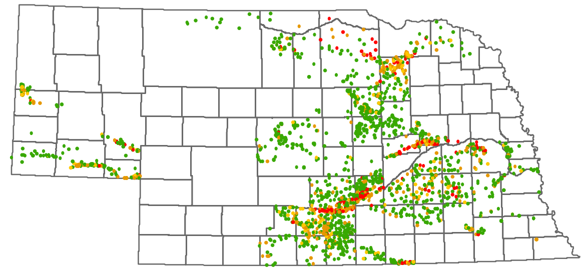
Figure B-4
Nitrate analyses for years 1990 - 1994
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- $<$ 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- $>$ 20 mg/l

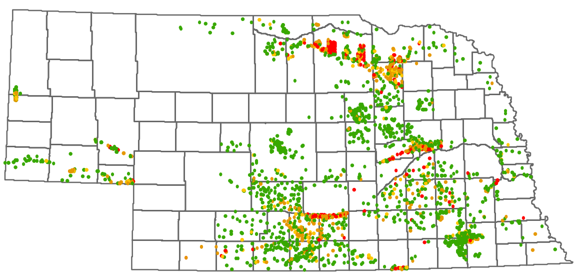
Empty areas indicate no data reported. These Maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (http://deq.ne.gov) and use your Adobe Acrobat reader to enlarge individual maps.



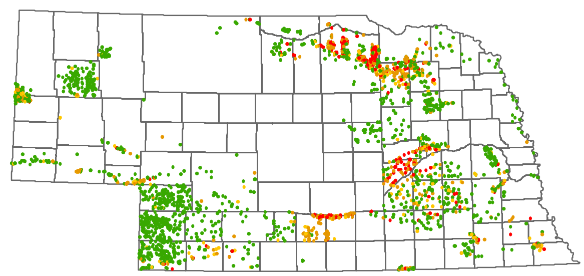
1995 (2938 wells, 3634 analyses)



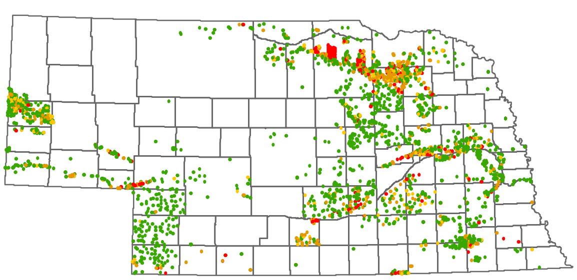
1996 (2112 wells, 2892 analyses)



1997 (2624 wells, 3605 analyses)



1998 (2427 wells, 3159 analyses)



1999 (2879 wells, 3521 analyses)

Figure B-5
Nitrate analyses for years 1995 - 1999
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

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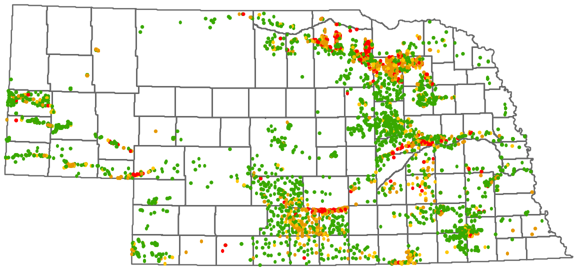
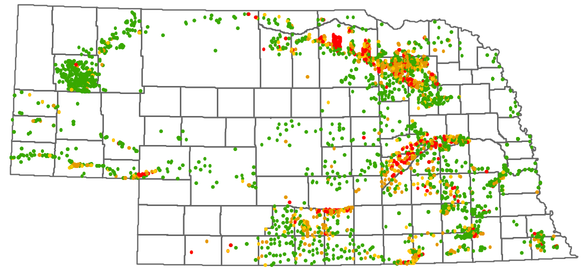
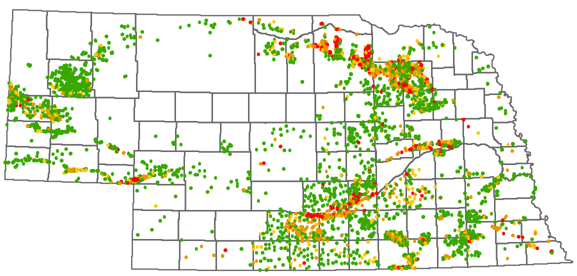


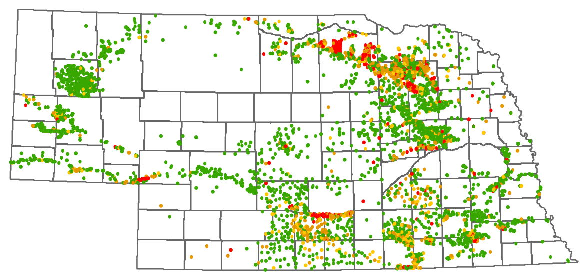
2000 (3501 wells, 4431 analyses)



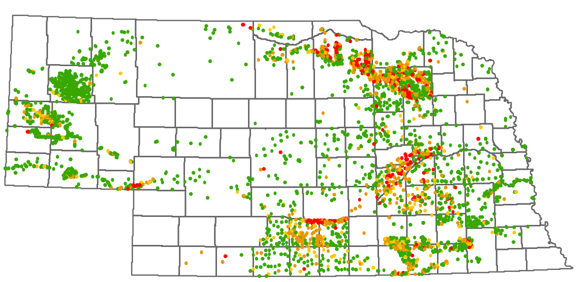
2001 (3240 wells, 3831 analyses)



2002 (4318 wells, 5213 analyses)



2003 (4417 wells, 5151 analyses)



2004 (3973 wells, 4923 analyses)

Figure B-6
Nitrate analyses for years 2000 - 2004
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

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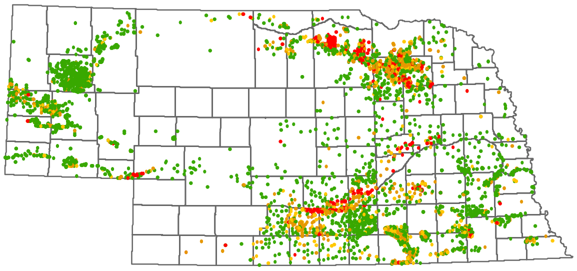
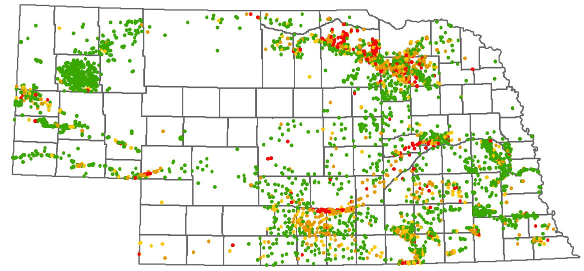
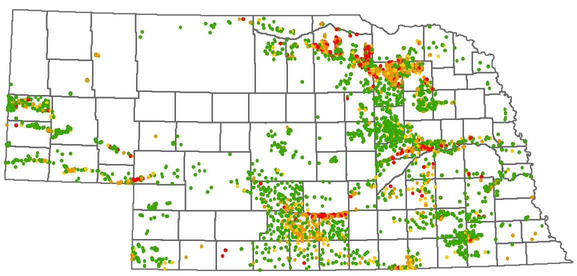


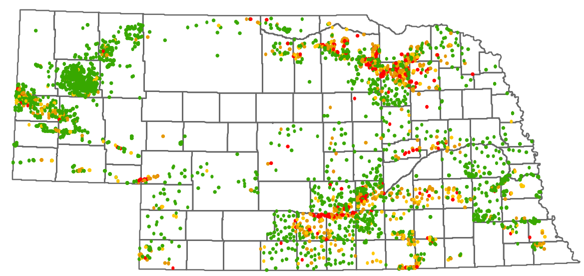
2005 (4271 wells, 5258 analyses)



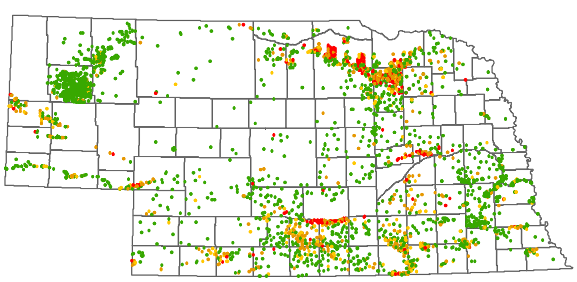
2006 (3889 wells, 4826 analyses)



2007 (3095 wells, 3590 analyses)



2008 (3458 wells, 3957 analyses)



2009 (3426 wells, 4041 analyses)

Figure B-7
Nitrate analyses for years 2005 - 2009
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

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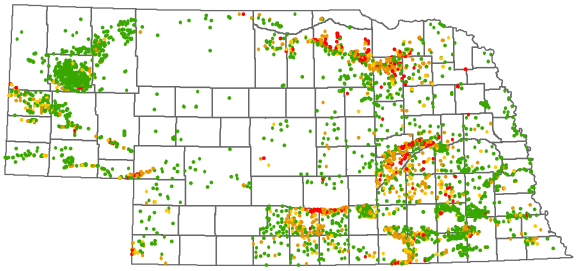
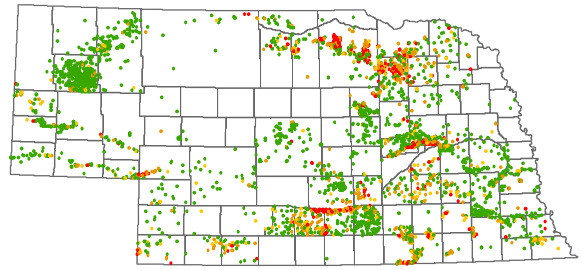
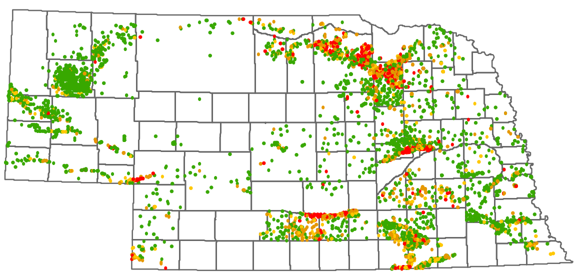


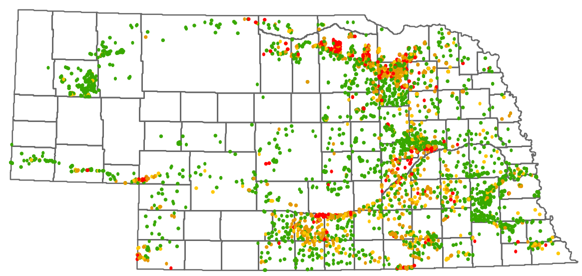
2010 (4490 wells, 5042 analyses)



2011 (4117 wells, 4615 analyses)



2012 (4482 wells, 5372 analyses)



2013 (3415 wells, 3943 analyses)

Figure B-8
Nitrate analyses for years 2010 - 2013
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- **< 7.5 mg/l**
- **7.5 – 10 mg/l**
- **10 – 20 mg/l**
- **> 20 mg/l**

Empty areas indicate no data reported. These Maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (http://deq.ne.gov) and use your Adobe Acrobat reader to enlarge individual maps.