Typical Costs of Most Common Water Samples

Nitrate Only	**FREE**
Nitrate & Bacteria	**$12.52**
Household Complete & Bacteria (Hardness, pH, Nitrate, etc.)	**$26.65**

Other, Less Common Water Test Costs

Irrigation Water Quality	**$10.57**
Livestock Water Quality	**$13.65**
Household Mineral & Bacteria	**$22.59**

The following information pertains only to those contaminants for which the Lower Big Blue NRD commonly submits water samples to area laboratories. This document is meant to provide information that can help you make decisions based upon your specific analysis report, but does not necessarily carry any regulatory or punitive weight.

pH: used to determine how acidic or basic a substance is, the pH scale ranges from 0 to 14, 0-6.9 indicating a more acidic substance, 7.0 being completely neutral (neither acidic or basic) and 7.1-14 indicating a more basic substance. The primary sources of groundwater (rain and snow) typically have a pH around 5.6. While there is great variability in how that will translate to groundwater pH levels, the following are general rules: passing through carbonate-rich rock (i.e. limestone and marble) will usually result in pH values > 7.0 as the acidic water is neutralized; passing through fewer carbonate rocks (i.e. sandstone, volcanic rock) will usually result in the groundwater remaining more acidic. The United States EPA has determined that **drinking water should have pH levels between 6.5 and 8.5** in order to limit the concentration of dissolved contaminants from acidic waters or the build-up of scale deposits from alkaline water. **Source:** American Ground Water Trust. 2003. Acid Rain and Ground Water pH. The American Well Owner, Number 3

Sodium Adsorption Ratio (SAR): the ratio of sodium to the square root of calcium plus magnesium. When the concentration of sodium becomes excessive in proportion to calcium plus magnesium in a soil, that soil is said to be sodic. Excessive sodium causes soil mineral particles to disperse and water penetration to decrease. High sodium concentrations become a problem when the infiltration rate is reduced to the extent the crop is not adequately supplied with water or when the hydraulic conductivity of the soil profile is too low to provide adequate drainage. Excessive sodium may also add to cropping difficulties through crusting seed beds, temporary saturation of the surface soil, high pH and the increased potential for disease, weeds, soil erosion, lack of oxygen and inadequate nutrient availability. If calcium and magnesium are the dominant cations, absorbed on the soil exchange complex, the soil tends to be easily tilled and have a readily permeable granular structure. Generally speaking, **a SAR between 0 and 15 will have a higher infiltration rate** than a SAR between 16 and 30. **Source:** Hoffman, Glenn J. 2010. Water Quality Criteria for Irrigation. UNL Extension, EC782: 4

Adjusted SAR: The sodium adsorption ratio (SAR) is commonly used as an index for evaluating the sodium hazard associated with an irrigation water supply. Irrigation waters having high SAR levels can lead to the build-up of high soil Na (Sodium) levels over time, which in turn can adversely affect soil infiltration and percolation rates (due to soil dispersion). The standard SAR formula represents a suitable sodium hazard index for typical irrigation waters, but **an adjusted SAR index is required for irrigation waters having appreciable concentrations of calcium (Ca) and/or bicarbonates (HCO3).** **Source:** Lesch, S.M., Suarez, D.L. 2009. A short note on calculating the adjusted SAR index. Transactions of the ASABE. 52(2):493-496

Total Dissolved Solids (TDS) Est, ppm: Total Dissolved Solids (TDS) are the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water, expressed in units of mg per unit volume of water (mg/L), also referred to as parts per million (ppm). TDS is directly related to the purity of water and the quality of water purification systems and affects everything that consumes, lives in, or uses water, whether organic or inorganic, whether for better or for worse. The EPA Secondary Regulations advise a **maximum contamination level (MCL) of 500mg/liter (500 parts per million (ppm))** for TDS. Numerous water supplies exceed this level. When TDS levels exceed 1000mg/L it is generally considered unfit for human consumption. A high level of TDS is an indicator of potential concerns, and warrants further investigation. Most often, high levels of TDS are caused by the presence of potassium, chlorides and sodium. These ions have little or no short-term effects, but toxic ions (lead arsenic, cadmium, nitrate and others) may also be dissolved in the water. **Source:** HM Digital, Inc. (manufacturers of water testing instruments), 2008-2012

Electrical Conductivity, mmho/cm: the property of a substance which enables it to serve as a channel or medium for electricity. Salty water conducts electricity more readily than purer water. Therefore, electrical conductivity is routinely used to measure salinity. The types of salts (ions) causing the salinity usually are chlorides, sulphates, carbonates, sodium, magnesium, calcium and potassium. Combined with Sodium Adsorption Ratio (SAR), electrical conductivity can assist in determining if there will be a reduction in infiltration rate. Regardless of sodium content, **water with low electrical conductivity (≤0.2 mmho/cm) causes degradation of the soil structure, promotes crusting and reduces water penetration.** Rainfall and snow melt are prime examples of low-salinity waters which reduce water penetration into soils. **Source:** Environment Australia, July 2002. ISBN 0642548560, and Hoffman, Glenn J. 2010. Water Quality Criteria for Irrigation. UNL Extension, EC782: 4

Cations/Anions, me/L: major cations and major anions in groundwater are detected in concentrations **ranging generally from 1 to 1,000 milligrams per liter (mg/L).** The major cations include calcium, magnesium, sodium, and potassium; the major anions include bicarbonate, chloride, and sulfate. These two numbers should be relatively close to equal as all aqueous solutions must be stable and ionically balanced. **Source:** Abbott, David W., P.G., C. Hg., Todd Engineers. Wells and Words: Some simple and helpful observations on basic inorganic groundwater chemistry

Sodium, Na: a highly soluble chemical element naturally found in groundwater. It has no smell, but can be tasted by most people at 200 mg/L (milligrams per liter are the same as parts per million). **The Nebraska Safe Drinking Water Act Maximum Contaminant Level (MCL) for sodium is 500 mg/L.** Refer to description of Sodium Adsorption Ratio (SAR) for potential concerns regarding high concentrations of sodium. **Sources:** Water Stewardship Information Series: Sodium in Groundwater. The British Columbia Groundwater Association. 2007. Nebraska Safe Drinking Water Act Maximum Contaminant Levels (MCLs). Nebraska Department of Health and Human Services. 3/2008

Potassium, K: potassium is commonly found in soils and rocks. Sodium and potassium are often associated with chloride and bromide. In these forms, they readily dissolve in water. In soils containing appreciable amounts of clay, these metals are not mobile. Sodium and potassium are released slowly upon dissolution of rocks. Consequently, concentrations increase as residence time in ground water increases. Potassium, an important fertilizer, is strongly held by clay particles in soil. Therefore, leaching of potassium through the soil profile and into ground water is important only on coarse-textured soils. Sodium is more mobile in soil than potassium and so it is often used as an indicator of human impacts to shallow ground water. There are no health-based drinking water standards for potassium in Nebraska. **Potassium concentrations in groundwater are generally between 2.0 and 4.0 parts per million.** **Sources:** Sodium and Potassium in Minnesota's Groundwater. Minnesota Pollution Control Agency. May, 1999. Potassium and water. Lenntech Water Treatment Solutions. 1998-2011

Calcium, Ca; Magnesium, Mg; Total Hardness, $CaCO_3$: calcium and magnesium are both abundant in soil and rocks. The most common source of calcium and magnesium in groundwater is through the erosion of rocks, such as limestone and dolomite, and minerals, such as calcite and magnesite. Calcium and Magnesium are major contributors to water hardness. If well water is found to be excessively hard (greater than 180 mg/L of CaCO3), get a second test to confirm the original results. Although hardness does not pose a health risk at levels normally found in well water, it can affect the function and lifetime of the plumbing system and appliances. Water hardness is measured by adding up the concentrations of calcium and magnesium and converting this value to an equivalent concentration of calcium carbonate (CaCO3). **The optimum range of hardness in drinking water is from 80 to 100 mg/L.** **Source:** The Drop on Water: Calcium and Magnesium. Nova Scotia Environment. 3/2008

Nitrate, NO_3-N: nitrate levels in groundwater are generally very low (typically <10 mg/L), but concentrations grow due to human activities, such as agriculture, industry, domestic effluents and emissions from combustion engines. **The Nebraska Safe Drinking Water Act Maximum Contaminant Level (MCL) for nitrates is 10 mg/L.** Consuming water with nitrate levels greater than 10 mg/L can pose health risks, particularly to infants. **Sources:** Lenntech Water Treatment Solutions, 1998-2011. Nebraska Safe Drinking Water Act Maximum Contaminant Levels (MCLs). Nebraska Department of Health and Human Services. 3/2008

Sulfate, SO_4-S: commonly found in air, soil and water. Sulfate is soluble (easily dissolved) in water, and is found at high concentrations in many aquifers and surface waters. Oxidized from sulfur in the atmosphere and deposited with precipitation or through dry deposition, sulfate occurs as a dissolved ion and is mobile in water. Sources of sulfate include gypsum, the decomposition of organic matter, fertilizers and other natural sources. **EPA National Secondary Drinking Water Regulations recommend a maximum standard of 250 mg/L**. **Sources:** Sulfate in Minnesota's Groundwater. Minnesota Pollution Control Agency. May, 1999. Drinking Water Contaminants. US EPA. June 5, 2012

Chloride, Cl: every water supply contains some chloride as it is common in nature, generally as a salt. Water with **levels of chloride above 250 mg/L** may cause corrosion in distribution systems, and can begin to decrease agricultural yields. **Source:** Chloride. Government of Saskatchewan. March 2010.

Carbonate, CO_3; Bicarbonate, HCO_3: because carbonate and bicarbonate are on opposite ends of the equilibrium equation they are **NOT often detected in the same groundwater sample,** but they can occur simultaneously at defined temperatures, pressures and pH levels. These conditions can be caused in the same vicinity of wells by contamination and leaching from high-pH materials, including cement surface seals, cement backfill and some types of drilling mud. **Source:** Abbott, David W., P.G., C. Hg., Todd Engineers. Wells and Words: Some simple and helpful observations on basic inorganic groundwater chemistry

Total Alkalinity, $CaCO_3$: alkalinity may be defined for water as the capacity to neutralize acids. **EPA Secondary Drinking Water Regulations recommend a maximum standard of 500 mg/L**. **Source:** Alkalinity of Drinking Water Explained. APEC.

Boron, B: waterborne boron may be adsorbed by soils and sediments, the extent to which depends upon the pH of the water and the concentration of boron in solution (greatest adsorption occurs in solutions between 7.5 and 9.0 pH). **The EPA Recommended Water Quality Criterion for protection of sensitive crops under long-term irrigation in regards to boron is 0.75 mg/L.** **Sources:** Boron in Drinking Water. Guidelines for drinking-water quality, 2nd ed. Addendum to Vol. 2. *Health criteria and other supporting information.* World Health Organization, Geneva, 1998 and Recommended Water Quality Criteria. US EPA. May 1, 1986.

WARDGUIDE (WARD LABORATORIES KEARNEY, NE)

WATER

IRRIGATION WATER QUALITY AND INTERPRETATION

Irrigation water quality is dependent on its chemical composition. The concentration of mineral constituents in the water varies depending on the amount of soluble materials encountered by the water. These soluble constituents are called soluble salts. If soluble salts are high they may be detrimental to plants. The most common soluble salts are the cations, sodium (Na), calcium (Ca), magnesium (Mg) and potassium (K), and the anions, carbonate (CO3), bicarbonate (HCO3), chloride (Cl), sulfate (SO4) and nitrate (NO3).

The total soluble salt level is determined by the electrical conductivity reading. Since cations are positively charged and anions are negatively charged, they will conduct an electric current. The more ions present the more readily it will conduct an electric current which is calibrated to give soluble salt readings in milliohms per centimeter.

The higher the electrical conductivity reading is the higher the salinity hazard. The salinity hazard interpretation is:

Electrical Conductivity, mmho/cm	Interpretation
less than 0.75	No problems - little chance for increased salinity.
0.76 - 1.50	There may be some detrimental affects on crops such as field beans, lettuce, bell pepper, onion and carrots
1.51 - 3.00	Water may have adverse effects on many crops. Salinity will increase without adequate leaching.
3.00 - 7.50	Water can be used for salt tolerant crops on permeable soils. High leaching requirement is necessary.

In addition to the soluble salts, one must analyze the sodium level in the water. The presence of high sodium can reduce permeability of the soil. The sodium hazard of irrigation water is estimated by calculating the sodium adsorption ratio (SAR).

If sodium is the predominant cation in the irrigation water, continual use of the water will adversely affect the physical condition of the soil. Sodium replaces exchangeable calcium and magnesium, which causes dispersion of the clay. This dispersion destroys soil aggregates so the soil appears slick when wet and very hard when dry. In addition to reduced permeability other problems are slow seed germination, less soil aeration and more difficult disease and weed control due to surface water ponding and stagnation.

Permeability problems are also related to the carbonate and bicarbonate content of the irrigation water. When soils dry, part of the calcium and magnesium is precipitated as Ca-Mg carbonates (lime). This removes Ca and Mg from the soil water and increases the sodium hazard. Recent research has developed a method for evaluating the carbonate-bicarbonate effect on the sodium hazard. The new procedure employs a modification of the SAR and is called the adjusted SAR (adj SAR).

The interpretation of the adj SAR is:

Soil Clay Type	adj SAR	Permeability Interpretation
Montmorillonite Illite - Vermiculite	less than 6 less than 8	No problem
Montmorillonite Illite - Vermiculite	6 - 9 8 - 16	Increasing problem. Special cropping practices may be necessary for long term production. Sodium levels in soil should be monitored by soil test.
Montmorillonite Illite - Vermiculite	greater than 9 greater than 16	Severe problem. Special cropping practices will have to be followed for long term productivity. Soil amendments may have to be used or water supply changed.

In addition to the salinity and sodium hazards of irrigation water, chloride, bicarbonate and boron are potential hazards.
The interpretation of these constituents are shown below for plants sensitive to the constituent:

Constituent	Content	Interpretation
Chloride (ppm Cl)	less than 140 140 - 350 greater than 350	No Problem Increasing problem Severe problem
Bicarbonate (ppm HCO_3)	less than 180 180 - 520 greater than 520	No Problem Increasing problem Severe problem
Boron (ppm B)	less than 0.75 0.75 - 2.0 greater than 2.0	No Problem Increasing problem Severe problem

LIVESTOCK WATER QUALITY

A clean, plentiful supply of livestock water is as important to optimum animal performance as is a balanced ration. When a water shortage occurs, it is easy to see the problem. However, the quality of water is much more difficult to visualize and laboratory analysis is usually required. Poor water quality is often caused by excessive salinity or total dissolved solids in the water. Sometimes nitrate contributes to the problem. Occasionally, alkalinity or another factor may be the cause of the problem.

INTERPRETING A WATER ANALYSIS

A guide to the use of saline water for livestock is presented in Table 1. General guidelines for use of water containing nitrate are shown in Table 2. Waters with alkalinities of less than 1000 ppm are satisfactory for most livestock.

Table 1 - A Guide to the Use of Water Containing Salts:

Total Dissolved Solids	Comments
<1000 ppm	Excellent for all livestock classes.
1000 - 2999 ppm	Satisfactory for most livestock, may cause decreased gain or death with poultry.
3000 - 4999 ppm	Satisfactory for some livestock, may cause decreased gain or death with poultry.
5000 - 6999 ppm	Acceptable. Do not use for pregnant or lactating livestock. Unacceptable for poultry.
>7000 ppm	Unacceptable for all livestock use.

Table 2- A Guide to the Use of Water Containing Nitrate:

ppm NO_3-N	Comments
<100	No harm to livestock and poultry.
100 - 300	No harm when used alone on livestock and poultry. Use caution when feeds also contain nitrates.
>300	Nitrate poisoning occurs.

SALINITY

Highly mineralized or salty water can cause physiological disturbances in animals including gastrointestinal disturbances, poor rate of gain, and sometimes death. The dissolved minerals that contribute to high salt content are inorganic salts; calcium, magnesium, sodium, chloride, sulfate and bicarbonate.

Animals are more susceptible to salts when a physical stress, such as pregnancy, lactation, or rapid growth occurs. Anything causing an increase in water consumption, such as lactation, high temperature, or exertion increases the danger. When livestock are fed a salt limiting ration, special care needs to be taken to supply water low in salt because ration salt will increase total water consumed by the livestock. Poultry is least tolerant to excess salt; cattle and sheep are most tolerant. Salt in water is measured in parts per million (ppm) as total dissolved solids (TDS).

NITRATE

Nitrate is found in most all forages and occasionally in water. Nitrate itself is not toxic, but during digestion bacteria reduce nitrate to nitrite, which then gets into the blood stream. There, the nitrite converts the red pigment hemoglobin, which carries oxygen from lungs to tissue, to methemoglobin, a dark brown pigment which cannot carry oxygen. Nitrate poisoning is usually more of a problem in young, especially newborn animals. Older animals seem able to tolerate higher nitrate levels. High nitrate water levels are often caused by shallow water tables, leaching of nitrate from sandy soils, or under heavy N fertilization.

OTHER FACTORS

Natural waters rarely contain or become contaminated with toxic substances such as boron, iron, copper, magnesium, manganese, and zinc. Analysis needs to be made for these when excess levels are suspected.

Drinking Water Standards

pH	5.0 - 9.0	Safe
Total Dissolved Solids	30 - 900 ppm	Safe
Electrical Conductivity	0.05 - 1.5 mmho/cm	Safe
Magnesium	Less than 400 ppm Mg	Safe
Total Hardness	0 - 75 ppm $CaCO_3$ 75 - 150 ppm $CaCO_3$ 150 - 300 ppm $CaCO_3$ 300 + ppm $CaCO_3$	Soft Water Moderately Hard Water Hard Water Very Hard Water
Chloride	Less than 250 ppm Cl	Safe
Total Alkalinity	Less than 400 ppm $CaCO_3$	No Problem
Coliform Bacteria	No Colonies per 100 ml	Safe
Iron	Less than 0.3 ppm Fe	Safe
Manganese	Less than 0.05 ppm Mn	Safe
Copper	Less than 1.0 ppm Cu	Safe
Lead	Less than 0.05 ppm Pb	Safe
Cadmium	Less than 0.02 ppm Cd	Safe
Fluoride	0.75 - 1.50 ppm F	Optimum Level for Proper Dental Care
Sulfate - Sulfur	Less than 83 ppm SO_4-S	Desirable
Nitrate - Nitrogen	Less than 10 ppm NO_3-N	Safe

If the nitrate level is above 10 ppm there is a cause for concern. A safe alternate source of water should be found for infants under six months of age and pregnant mothers, because of the danger of prenatal methemoglobinemia.

A nitrate-nitrogen level over 10 ppm is less critical if only adults and older children will be drinking the water. You may wish to consult with your personal physician or a health professional before deciding on a course of action.

Boiling will not reduce the nitrate levels in water.

(ppm is the same as mg/L)

DRINKING WATER BACTERIOLOGICAL TESTING

Total coliform analysis is the test most widely accepted for the acceptance of drinking water purity. Coliforms are used to assess water quality because their detection is more reliable. Coliform bacteria are indicator organisms in water microbiological analysis. Coliforms are a group of bacteria that are readily found in soil, decaying vegetation, animal feces, and raw surface water. They are not normally present in deep groundwater and treated surface water. These indicator organisms may be accompanied by pathogens (i.e., disease-causing organisms), but do not normally cause disease in healthy individuals. However, individuals with compromised immune systems should be considered at risk. Pathogens appear in smaller numbers than coliforms, so are less likely to be isolated. Drinking water found to contain coliforms is considered biologically contaminated.
Coliform or other bacteria in drinking or swimming water will not necessarily make you ill. However, since these organisms are present, other disease-causing organisms are more likely to be present. Health symptoms related to drinking or swallowing water contaminated with bacteria generally range from no ill effects to cramps and diarrhea (gastrointestinal distress).

COLIFORM TEST REPORT METHODS

The IDEXX Quanti-Tray/2000 is a semi-automated quantification method based on the Standard Methods Most Probable Number (MPN) model. The Quanti-Tray® Sealer automatically distributes the sample/reagent mixture into separate wells. After incubation, the number of positive wells is converted to an MPN using a table. Quanti-Tray/2000 counts accurately from one to 2,419/100 mL.
A. Coliform Density per 100 ml
The density per 100 ml must be 0. Samples that contain any coliform bacteria per 100 ml do not meet the bacteriological standard for purity. Coliform bacteria must be absent in a 100 ml volume sample.
B. (TNTC) Too Numerous To Count
“Too Numerous to Count” may be reported if the calculated MPN (Most Probable Number) is greater than 2,419 MPN. A replacement sample may be requested if a more accurate count is required.
For a more detailed explanation and answers to specific questions regarding the analysis itself, test results or additional microbiological questions contact Ward Laboratories, Inc.
Source: US EPA 9221C Standard Methods for the Examination of water and wastewater Surface Water Treatment, 18th Edition. Rule (40 CFR 141.74 (a) (2))

PROPER DISINFECTION OF WATER WELLS

The well should first be cleaned of any foreign debris. The method for accomplishing this will vary with the type of well (dug, drilled, etc.). Upon cleaning, the well should be pumped until the water yielded appears clean; then the complete water system should be disinfected.
A universal disinfecting agent used in water works is chlorine. It is available in many forms; however, the two most commonly used forms are dry chlorine (calcium hypochlorite) and liquid sodium hypochlorite, commonly referred to as "household bleach", which contains approximately 5.25 percent available chlorine.
Ingenuity must be used in introducing the chlorine into the well, reservoir, and piping systems, to assure proper distribution and disinfection of all parts of the water system.
One convenient way of chlorinating the water supply is to add the chlorine directly into the well. An effective hypochlorite solution can be made by adding the required amount of bleaching liquid; refer to Table 1. This chlorinated water should be poured into the well, washing the walls, casing, drop pipe and other equipment in the process. A hose attached to a nearby faucet should be directed back into the well, and the pump started, thereby enabling the recirculated chlorine water to contact the casing, drop pipe, etc., to assure complete disinfection of the well itself. If after a reasonable period (approximately 10 minutes) a chlorine odor is not evident, repeat the procedure until a chlorine odor is present.
After the recirculation process, the components of the well should be reassembled and the well left idle for approximately two hours. The well pump should then be started and all taps opened and

flushed until a chlorine odor is evident, thus allowing for complete disinfection of the distribution system. The taps should then be closed and the remainder of the chlorinated water flushed to waste through an outdoor tap (to avoid any possible damage or overloading of the septic tank) until all traces of chlorine are gone. Once you are sure the water supply is chlorine-free, you may resample. Traces of chlorine residual will interfere with the laboratory results.

Shallow wells may remain contaminated for some time after flooding because of surface seepage; therefore, for at least two weeks after the ground has dried up, the water should be boiled or chlorinated before use. Boiling for three minutes or adding two drops of household bleach per quart to water has been found satisfactory.

Following are the quantities of liquid household bleach (5.25 percent sodium hypochlorite) or dry chlorine (65 percent calcium hypochlorite) required for water well disinfection.

For Each Ten Feet of Water Depth in Well:

Well Diameter	Ounces 65% Hypochlorite	Pints 5% Bleach
2" – 8"	1	1
10" – 14"	3	3
16" – 20"	7	7
22" – 26"	12	12
28" – 30"	16	16
36"	24	24

Source: Recommended Water Supply Practices. Nebraska Department of Health, Division of Drinking Water and Environmental Sanitation, Lincoln, NE.

DRINKING WATER SAMPLING PROCEDURES

Water samples should not be collected from outside hydrants, leaky faucets, or faucets with aerators or faucet filters still attached, since these may produce positive samples when the well water is actually safe.

"Flaming" of the water taps is not necessary but should be provided when practical, especially following the removal of an aerator or filter.

Containers for submitting water samples for bacterial and/or nitrate analysis and other minerals may be obtained from Ward Laboratories, Inc. Instructions for collecting water samples are included in each container.

A "satisfactory" bacteriological water analysis is not a guarantee that the water supply system will continue to be safe. Water quality depends on many variables: proper well construction and location, groundwater table, soil formation, flooding, etc. It is recommended that you have your water analyzed at least annually, when repairs or alterations are made to the water supply system, or if you suspect possible contaminations of your water well.

Source: Recommended Water Supply Practices. Nebraska Department of Health, Division of Drinking Water and Environmental Sanitation, Lincoln, NE.