Description of Water Analysis Parameters

T. L. Provin and J. L. Pitt
Extension Soil Chemist and Extension Associate, Soil and Crop Sciences Department

Water analysis reports from a number of laboratories often lack basic descriptions for terminology, potential sources of contaminates or parameters, and/or fail to provide the end user an idea of potential concerns over the use of the water. The following discussion, while developed for the Texas Cooperative Extension Soil, Water and Forage Testing Laboratory water analysis report, should assist the reader in understanding basic inorganic water analyses reports.

Calcium (Ca)

Source
Calcium in water is from dissolved rock, limestone, gypsum, salts and soil.
Issues
Calcium is a component of water hardness and can combine with bicarbonate and carbonates resulting in "lime deposits," scale, extremely hard water and salinity (see Hardness).
Treatment/Practices
Reduction in Ca levels is normally performed through use of water softeners or similar ion exchange methods.
Target Concentrations
Domestic water: No EPA drinking water standard set, see TDS section.
Irrigation water: Current limit not established, see TDS section.
Livestock water: Current limit not established, see TDS section, potential problems with dairy cattle > 500 ppm.

Magnesium (Mg)

Source
Magnesium is dissolved from rock, dolomite, salts and soil.
Issues
Magnesium is a component of water hardness and can combine with bicarbonate and carbonates resulting in "lime deposits," scale, extremely hard water and salinity (see Hardness).
Treatment/Practices
Reduction in Mg levels is normally accomplished through use of water softeners or similar ion exchange methods.
Target Concentrations
Domestic water: No EPA drinking water standard set, see TDS section.
Irrigation water: Current limit not established, see TDS section.
Livestock water: Current limit not established, see TDS section, potential problems with dairy cattle >125 ppm.

Sodium (Na)

Source
Sodium is dissolved from rock, salts, and soil. It is also found in oil-field brine, sea water, industrial brine, and reclaimed effluent water, etc.
Issues
Moderate amounts of sodium have little effect on the usefulness of water; however persons on low sodium diets should consult their physician for levels above 20 ppm. (See SAR for information on sodium's role in water and soil quality).
Treatment/Practices
Reverse osmosis treatment is considered the only economical method for sodium removal for household uses. Reverse osmosis is more often used for drinking water rather than the whole household due to costs.
Target Concentrations
Domestic water: Secondary Water Standard is 20 ppm limit. Persons on restricted sodium diets may be limited to 20 ppm. High sodium may contribute to corrosion of copper plumbing and metal fixtures.
Irrigation water: Use of water containing greater than 400 ppm Na may create significant foliar burn. High levels of Na in irrigation water may cause Na to build up in soils, resulting in poor soil structure.
Livestock water: Current limit not established, see TDS section.

Potassium (K)

Source
Potassium is dissolved from rock, fertilizer, salt, and soil.
Issues
High potassium levels in irrigation water may significantly increase potassium concentrations in forage grasses, thus potentially creating concerns with lactating livestock.
Treatment/Practices
Limited treatment practices for reducing K levels. Consider distillation, reverse osmosis or ion exchange methods.
Target Concentrations
Domestic water: No EPA drinking water standard set, see TDS section.
Irrigation water: Current limit not established, see TDS section.
Livestock water: Current limit not established, see TDS section.

Boron (B)

Source
Boron may be naturally found in ground water, in surface water as an industrial pollutant or as a product of agricultural runoff and decaying plant materials.
Issues
Sensitive crops may be affected at levels of 0.33 ppm; semi-tolerant crops may be affected at levels of 0.33 – 0.67 ppm; and tolerant crops may be affected at levels above 0.67 ppm. Boron can become toxic to some plants when the soil-water concentration exceeds that required for optimum plant growth. Generally, toxic boron concentrations in the soil are found only in arid regions of Texas. Crops vary to tolerance of boron, therefore, water that is marginal for sensitive plants may still be used for more tolerant crops.

Note: If the boron level in your water exceeds 1.0 ppm, then boron levels may increase in your soil. Clay soils accumulate boron faster than sandy soils.
Treatment/Practices
Reverse osmosis and distillation.
Target Concentrations
Domestic water: No EPA drinking water standard set, see TDS section.
Irrigation water: Toxicity to many sensitive plants may occur at 1 ppm. Most perennial grasses are relatively tolerant at 2-10 ppm. (Rowe and Abdel-Mazid, 1995).
Livestock water: CAST levels established at 5.0 ppm.

Bicarbonate and Carbonate (HCO_3^- and CO_3^{2-})

Source
Dissolution of limestone, dolomite, and atmospheric carbon dioxide.
Issues
Bicarbonate and carbonate serve as charge balancing anions (negatively charged ions) for calcium, magnesium, sodium and other cations (positively charged ions). High bicarbonate and carbonate levels in the presence of calcium and magnesium may lead to formation of lime deposits in plumbing and irrigation systems.
Treatment/Practices
Carbonate and bicarbonates can be reduced by lowering the pH of water through acid injection.
Target Concentrations
Domestic water: No EPA drinking water standard set, see TDS section.
Irrigation water: $CaCO_3$ may form on equipment or plants. Levels of 180-600 ppm can present a severe hazard (Camberato, 2001). Refer to alkalinity section.
Livestock water: Current limit not established, see TDS section.

Sulfate (SO_4)

Source
Sulfates are dissolved from rock and soil containing gypsum, iron sulfides, and other sulfur compounds. They may be found in surface water as an industrial pollutant commonly from coal mining, industrial wastes and sewage, and streams draining from coal or metal-sulfide mines.
Issues
Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfates can result in bitter, medicinal tastes, laxative effects or "rotten egg" odor from hydrogen sulfide gas formation (see TCE L-5312).

Treatment/Practices
Reverse osmosis is considered the best overall method for sulfate reduction.
Target Concentrations
Domestic water: > 250 ppm can cause diarrhea (Secondary Drinking Water Standard).
Irrigation water: Moderate concentration of sulfate can reduce growth or cause specific injury. Refer to salinity section.
Livestock water: > 2000 ppm can cause diarrhea in most livestock.

Chloride (Cl)

Source
Naturally occurring chloride is caused by dissolving minerals. It may be found in large amounts in oil-field brine, sea water and industrial brine. Chlorides may also be found in surface water from road salt, fertilizers, industrial wastes, or sewage.
Issues
When combined with sodium, chloride gives a salty taste to drinking water and may increase the corrosiveness of water. Chlorides may also result in blackening or pitting of stainless steel.
Treatment/Practices
Reverse osmosis is considered the best overall method for chloride reduction.
Target Concentrations
Domestic water: > 250 ppm may cause salty taste in water. (Secondary Drinking Water Standard).
Irrigation water: > 900 ppm is considered non-suitable for all agronomic crops.
Livestock water: Current limit not established, see TDS section.

Nitrate (NO_3-N)

Source
Decaying organic matter, sewage, fertilizers, manures, and nitrates in the soil result in soluble nitrates.
Issues
Water with high nitrate content may cause methemoglobinemia (blue-baby syndrome) and should not be used by pregnant women or for infant feeding. High concentrations of nitrate in rivers, streams, and lakes encourage the growth of algae and other organisms that may produce undesirable tastes and odors in water.
Treatment/Practices
Reverse osmosis is considered the best overall method for nitrate reduction.
Target Concentrations
Domestic water: < 10 ppm (EPA Primary drinking water standard)
Irrigation water: Levels > 40 ppm may be very limiting for some plants, while only 10-20 ppm may be limiting for others.
Livestock water: < 100 ppm (NAS), 300 ppm (CAST).

Phosphorus (P)

Source
Phosphorus may be found naturally in ground water and in surface water from landscape runoff or discharges from sewage treatment facilities.
Issues
Elevated phosphorus in surface water can lead to algal blooms and lower dissolved oxygen content, thereby reducing desired aquatic life and creating water taste issues.
Treatment/Practices
Reverse osmosis is considered the best overall method for phosphorus reduction.
Target Concentrations
Domestic water: No EPA drinking water standard set, see TDS section. Levels above 0.1 ppm in still waters may give rise to algal blooms.
Irrigation water: Current limit not established, see TDS section.
Livestock water: Current limit not established, see TDS section.

pH

Issues
Acids, acid-generating salts, and free carbon dioxide lower pH. Carbonates, bicarbonates, hydroxides, phosphates, silicates and borates raise pH. Water with high acidity may dissolve iron from pumping facilities and mains and produce a “red water” problem. Fabrics may be stained from the action of acid water on plumbing and appliances. Detergents do not perform as well in acid water as in neutral or alkaline water. To remove rust-colored stains from white or colorfast fabrics, use a commercial rust remover. Follow product directions, but avoid use in the washing machine.

Rating	pH Range
High Acidity	< 6.5
Moderate Acidity	6.5 - 7.0
Moderate Alkalinity	7.0 - 8 .5
High Alkalinity	> 8.5

Treatment/Practices
Water pH is adjusted using acid feeders (lower pH) or by use of soda ash feeders (raise pH).
Target Concentrations
Domestic water: EPA secondary drinking water standards of 6.5-8.5.
Irrigation water: pH can greatly affect the solubility/availability of many trace elements in the soil. Exceedingly low (< 5.5) or high (> 8.5) pH may result in corrosion of equipment. High pH values (> 8.5) indicate alkalinity and may pose a sodicity (excess sodium) hazard.
Livestock water: 5.5 – 8.5 Levels outside of this range may cause problems for dairy cattle.

Conductivity

Source
Conductivity is an indicator of salinity. Salinity (or salts) often originate from the earth’s crust, although the additions of fertilizers and organic matter may also contribute salts. Through weathering, small amounts of rock and other deposits are dissolved and carried away by water. This slow weathering may cause an accumulation of salts in both surface and subsurface waters. Surface runoff of these dissolved salts has caused the salt concentrations in oceans and lakes. The term salt and salinity are often used interchangeably, and sometimes incorrectly. A salt is simply an inorganic mineral that is subject to dissolving in water. Many individuals often associate salt with sodium chloride, common table salt. In reality, the salts which affect both surface and ground-waters often are a combination of sodium, calcium, potassium, and magnesium, with chloride, nitrate, sulfate, bicarbonate, and carbonate.
Issues
High conductivity is an indication of (TDS) total dissolved salts. This value should only be used as an initial screening parameter. Other individual characteristics should be evaluated when conductivity levels are high.
Treatment/Practices
Steam distillation, ion exchange (H^+ and OH^- saturated resin only) and reverse osmosis are common treatment methods for reducing TDS and conductivity levels.
Target Concentrations
Domestic water: Current limit not established, see TDS section.
Irrigation water: Concern over soil salinity is greatest when irrigating with water high in salts, where soils are poorly drained and allow for excessive surface evaporation, or where soils are naturally high in salts due to limited leaching and shallow water tables. As soluble salt levels increase, plant utilization of soil water often declines. This is because plant roots contain varying concentrations of ions (salts) that cause a natural gradient for water to flow from the soil into the plant roots. As the soil salt levels approach the concentration of salts in the plant roots, water becomes less likely to enter the root. Naturally, each plant species contains varying levels of root salts, thus some plants continue to thrive when others die. The buildup of salts in soils may result in soils that are termed saline, saline-sodic or sodic. Each of these types of soils has unique properties that require special management. Conductivity is an indication of the amount of salinity, or TDS in water. Water can be classified according to its conductivity. Permissible limits for classes of irrigation water are listed in the following table.
Livestock water: Current limit not established, see TDS section.

Classes of Water	EC, dSm^{-1} mmho cm^{-1}*	TDS, ppm	Comments
Class 1, Excellent	0-0.250	175	No damage expected, no additional management needed
Class 2, Good	0.250-0.750	175-525	Damage to sensitive plants will occur; use of low salinity water may be required periodically.
Class 3, Permissible	0.750-2.0	525-1400	Damage to plants with low salinity tolerance will likely occur. Plant growth and quality will be improved with excess irrigation for leaching and/or periodic use of low salinity water.
Class 4, Doubtful	2.0-3.0	1400-2100	Damage to plants with high tolerance to salinity may occur. Successful use as irrigation source requires salt tolerant plants, good soil drainage, excess irrigation for leaching, and/or periodic utilization of low salinity water.
Class 5, Unsuitable	>3.0	>2100	Same as above.

**To convert to umhos cm^{-1} multiply by 1000.*

Hardness (expressed as $CaCO_3$)

Source
Total hardness is caused by the presence of calcium and magnesium.
Issues
Hard water consumes soap before lather will form and interferes with almost every cleaning and cooking task. It deposits film on surfaces, causing spots and dingy clothes. It creates scale in boilers, water heaters and pipes. It forms white flakes in ice that are visible after the ice melts. Check the Water Hardness Rating Scale to evaluate the relative hardness of your water.

Rating	Grains per Gallon	Total Hardness (ppm)
Soft	0-1	0.0-17.17
Slightly hard	1-3.5	17.18-60
Moderately hard	3.5-7	61-120
Hard	7.1-10.5	121-180
Very hard	>10.5	>180

Treatment/Practices
Hardness can be reduced through use of water softener, or distillation methods.
Target Concentrations
Domestic water: No EPA drinking water standard set, see sections on alkalinity and/or TDS.
Irrigation water: See alkalinity, Ca, and Mg sections.
Livestock water: Current limit not established, see TDS section.

Alkalinity (expressed as $CaCO_3$)

Source
Alkalinity is a buffering property caused by the presence of bicarbonates and carbonates, but calculated based on the concentration of calcium and magnesium.
Issues
Alkalinity is an estimate of the ability of water to resist change in pH upon addition of acid.
Treatment/Practices
The acidification of the water will lower water pH and reduce actual alkalinity; however, only the reduction in calcium + magnesium levels through water softening or distillation will reduce calculated numbers.
Target Concentrations
Domestic water: No EPA drinking water standard set, see TDS section. Water with low alkalinity is more likely to be corrosive and cause deterioration of plumbing.
Irrigation water: Current limit not established, see TDS section. Water with low alkalinity is more likely to be corrosive and cause deterioration of plumbing.
Livestock water: Levels above 500 ppm may pose problems for dairy cattle.

Total Dissolved Salts (TDS)

Source
Total dissolved salts are determined by the summation of all measured ions (cations and anions).
Issues
Total dissolved salts may be used interchangeably with total dissolved solids in clear non-turbid waters. See conductivity and SAR for more information.
Treatment/Practices
See conductivity section.
Target Concentrations
Domestic water: EPA secondary drinking water standard of 500 ppm.
Irrigation water: Refer to conductivity section regarding classification of waters based on TDS.
Livestock water: Levels above 3000 ppm should be avoided for lactating animals; levels above 7000 ppm may pose significant risks for many animals. Refer to TCE publication L-2374.

Sodium Adsorption Ratio (SAR)

The SAR is a measure of the sodium concentration in relation to the calcium and magnesium charge concentrations in meq/L or eq/L.

SAR	Rating/Comments
<10	No sodium hazard. May be used on all sensitive crops.
10 - 18	Medium sodium hazard. Gypsum and leaching needed.
18 - 26	High sodium hazard. Generally unsuitable for continued use.
>26	Very high sodium hazard. Generally unsuitable for use.

Treatment/Practices
See TCE publication E-60 “Managing Soil Salinity”.
Target Concentrations
Domestic water: No EPA drinking water standard, refer to salinity section.
Irrigation water: Current limit not established, see TDS section.
Livestock water: Current limit not established, see TDS section.

Iron (Fe)

Source
Iron may be dissolved from rock and soil. It may also come from iron pipes, pumps and other equipment if low pH water is present.
Issues
On exposure to air, iron in ground water oxidizes to reddish-brown (or rust) water that may stain laundry and utensils. Large quantities can cause unpleasant taste and encourage the growth of iron bacteria.
Treatment/Practices
1) Continuous chlorination followed by sediment filter and carbon filter.
2) Aerate water in storage tank or use potassium permanganate ($KMnO_4$) feeder, then sediment filter.
3) Use sediment filter and water softener.
4) Adjust pH to 7.0 or more, then treat with manganese oxidizing green sand filter.
5) Trickle over crushed limestone bed.
Target Concentrations
Domestic water: Secondary EPA drinking water standard of 0.3 ppm. Laundry Practices: Avoid the use of chlorine bleach. Iron reacts with bleach in the water to cause permanent stains. To remove rust discoloration from white and colorfast washable fabric, use a commercial rust remover. Follow product directions. Do not use in the washing machine.
Irrigation water: 5 ppm. High iron (greater than 5 ppm) may significantly reduce photosynthesis as films form on leaf surfaces.
Livestock water: Levels above 0.3 ppm may reduce consumption quantities due to taste issues.

Zinc (Zn)

Source
Zinc occurs naturally, but it may also result from industrial pollution. Additionally, low water pH can result in release of zinc from corrosion of copper-zinc alloys commonly used in plumbing systems.
Issues
Zinc can produce a chalky appearance in water and produce a disagreeable taste.
Treatment/Practices
Treatment practices are dependent on zinc source. Treatment of water naturally high in zinc includes ion exchange, reverse osmosis and distillation. Elevated zinc levels due to contact of low pH water with metal alloys is treated by use of soda ash feeder.
Target Concentrations
Domestic water: 5.0 ppm (Secondary EPA drinking water standard)
Irrigation water: 2.0 ppm (See Other Terms section)
Livestock water: 25 ppm established by CAST

Copper (Cu)

Source
Copper is sometimes caused by contamination from mining operations, acid waters and corrosion in copper plumbing.

Issues
Copper poisoning symptoms include jaundice and anemia. High levels may cause staining and bad tastes in addition to producing a corrosive effect.

Treatment/Practices
Increase pH using soda ash (sodium carbonate). Corrosion created by high dissolved oxygen or total salts can be prevented using a polyphosphate feeder system.

Target Concentrations
Domestic water: 1.3 ppm. (Primary EPA drinking water standard, 1.0 ppm secondary EPA drinking water standard.
Irrigation water: 0.2 ppm (See Other Terms section)
Livestock water: 0.5 ppm level established by CAST

Manganese (Mn)

Source
Manganese is dissolved from shale, sandstone or river basin material and may be found in surface water in swampy areas.

Issues
Excessive manganese gives water a grayish/black appearance and may stain plumbing fixtures and laundry. Manganese can also produce taste problems.
Treatment/Practices
1) Oxidizing treatments convert reduced manganese to oxidized manganese followed by precipitate filtration (air spray system and $KMnO_4$ feeders).
2) Low levels can be removed through ion-exchange water softeners.
Target Concentrations
Domestic water: 0.05 ppm. (Secondary EPA drinking water standard)
Irrigation water: 0.2 ppm. High manganese concentrations can reduce photosynthesis by coating leaf surfaces, thus limiting sunlight adsorption by chlorophyll.
Livestock water: Levels above 0.05 ppm may cause taste issue reducing livestock consumption; 0.1 ppm has been established by CAST

Arsenic (As)

Source
Arsenic may be found in ground water naturally and in surface water as an industrial pollutant or as a product of agricultural runoff from previously used pesticides.

Issues
The high toxicity of arsenic is cumulative in the body with symptoms ranging from fatigue to coma and death.
Treatment/Practices
Reduction of As levels is best performed by use of reverse osmosis.
Target Concentrations
Domestic water: Primary EPA drinking water standard. 0.05 ppm, may change to 0.01 ppm.
Irrigation water: 0.10 ppm for long term use; 2.0 ppm for short-term use (Rowe and Abdel-Mazid 1995).
Livestock water: Reported problems with dairy cows at levels > 0.2 ppm; CAST has established level of 0.5 ppm.

Barium (Ba)

Source
Barium may be found in ground water naturally or in surface water as an industrial pollutant often related to oil and gas.
Issues
Barium may have a toxic effect on the heart, blood vessels, nerves and kidneys.
Treatment/Practices
Reverse osmosis is considered the best overall method for Ba concentration reduction.
Target Concentrations
Domestic water: Primary EPA drinking water standard 2.0 ppm
Irrigation water: Drinking water standard 2.0 ppm.
Livestock water: Reported health issues with dairy cattle at levels > 10 ppm; CAST has not established any limits.

Nickel (Ni)

Source
Nickel may be found in ground water naturally or in surface water as a mining or an industrial pollutant.
Issues
Chronic exposure to nickel may decrease body weight, induce heart and liver damage, and dermatitis problems.
Treatment/Practices
Reverse osmosis is considered best overall method for Ni concentration reduction.
Target Concentrations
Domestic water: Primary EPA drinking water standard 0.1 ppm
Irrigation water: 0.2 ppm for long-term use; 2.0 for short-term use (Rowe and Abdel-Mazid, 1995).
Livestock water: NAS established recommended limit of 1.0 ppm.

Cadmium (Cd)

Source
Cadmium is primarily found in surface water as a pollutant from industries such as electroplating.
Issues
Potential damage from cadmium may take the form of anemia, retarded growth and increased hypertension.
Treatment/Practices
Reverse osmosis is considered best overall method for Cd concentration reduction.
Target Concentrations
Domestic water: Primary drinking water standard 0.05 ppm
Irrigation water: 0.01 ppm for long-term use.; 0.5 for short-term use (Rowe and Abdel-Mazid, 1995).
Livestock water: 0.05 ppm – limit recommended NAS; CAST established limits at 0.5 ppm.

Lead (Pb)

Source
Lead is normally found in surface water from industrial pollution, but some Texas groundwater naturally contains elevated levels.
Issues
Lead symptoms range from gastrointestinal disturbances to inflammation of the brain and spinal cord. Brain damage is common among children exposed to high levels of lead.
Treatment/Practices
Reverse osmosis methods are considered best overall method for Pb concentration reduction. Some point source Pb precipitation filters are currently on the market.
Target Concentrations
Domestic water: Primary drinking water standard 0.015 ppm
Irrigation water: 5.0 ppm for long-term use; 10.0 for short-term use (Rowe and Abdel-Mazid, 1995). Elevated levels may cause plumbing corrosion problems.
Livestock water: 0.10 ppm established by both NAS and CAST.

Chromium (Cr)

Source
Chromium may be found in ground water as a natural occurrence and in surface water as an industrial pollutant commonly from the plating industry.
Issues
Chromium can be toxic to humans and produce skin irritations when external exposures occur. Liver and kidney damage may result from internal exposure.
Treatment/Practices
Reverse osmosis methods are considered best overall method for Cr concentration reduction.
Target Concentrations
Domestic water: Primary drinking water standard 0.10 ppm.
Irrigation water: 0.1 ppm for long-term use; 1.0 for short-term use (Rowe and Abdel-Mazid, 1995).
Livestock water: 1.00 ppm established by CAST.

Fluoride (F)

Source
Fluoride may be found naturally by dissolving small quantities of rock and soil in the water. Fluoride is also added to drinking water by some water utilities.
Issues
Fluoride concentrations of 1 ppm are desirable in drinking water for protection against dental cavities. However, excessive levels may cause brownish discoloration of the teeth. The maximum recommended fluoride concentration depends on the quantity and temperature average per year:

Temperature °F	ppm
63.9 – 70.6	1.8
70.7 – 79.2	1.6
79.3 – 90.5	1.4

Treatment/Practices
Reverse osmosis methods are considered best overall method for F concentration reduction.
Target Concentrations
Domestic water: Primary drinking water standard, 4.0 ppm. Elevated levels may cause skeletal damage, bone disease.
Irrigation water: 1.0 for long-term use; 15.0 for short-term use (Rowe and Abdel-Mazid, 1995).
Livestock water: NAS recommended limit of 2.0 ppm; CAST limit established at 3.0 ppm.

Charge Balance

Charge balance is a calculated term used to express the recovery of anions and cations. Ideally, this term will equal 100, thus indicating the amount of negative charges (anions) equals the amount of positive charges (cations). This number may differ significantly from 100 if sediment, organics or other non-analyzed substances are present.

Other Terms

V. Limiting - This term indicates that such significant management or treatment is required that the water may not be economically or technically feasible for the intended use.
Limiting - Limiting indicates that a higher than normal level of management or treatment is needed to utilize the water for a given application.
Acceptable - Under normal management, an acceptable rating suggests the water should not pose any long-term problem for the intended use.
ppm - parts per million.
EPA Primary drinking water standard - Legally enforceable standards that apply to public water systems.
EPA Secondary drinking water standard - Nonenforceable guidelines regulating contaminates that may cause cosmetic affects or aesthetic effects in the drinking water. This standard may be lower than primary standards due to plant phytotoxicity issues.

Additional information can be found on the following websites and references: http://soiltesting.tamu.edu or http://soilcrop.tamu.edu .

Managing Soil Salinity. TCE E-60.
Water Quality Guide for Livestock and Poultry. TCE E-8.
Water Quality: It's Relationship to Livestock. TCE L-2374.
Hydrogen Sulfide in Drinking Water. TCE L-5312.

Water Quality and Requirements for Dairy Cattle. Cooperative Extension of Nebraska-Lincoln. G93-1138-A.

NAS – National Academy of Science.
CAST – Council for Agricultural Science and Technology.

Camberato, James. 2001. Irrigation Water Quality. Clemson University. (http://virtual.clemson.edu/groups/utrfornamental/tmi/irrigation).

Rowe, D.R. and I.M. Abdel-Mazid. 1995. Handbook of Wastewater Reclamation and Reuse. CRC Press, Inc. 550 pp.