# Challenges for Water Quality Policy in Nebraska: Short- and Long-Term

Peter Calow, Office of Research and Economic Development
Daniel Snow, Water Sciences Lab, Nebraska Water Center
Shannon Bartelt-Hunt, Department of Civil Engineering
Valery Forbes, School of Biological Sciences
University of Nebraska - Lincoln
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Water is the most important natural resource for Nebraska and the Great Plains. It falls as rain and snow on the land, collects into rivers, streams, ponds, lakes and reservoirs (surface waters) and it seeps into the ground and ultimately into the subsurface to replenish shallow aquifers where it is stored as ground water. We use it in a multitude of ways: as drinking water; in the home; to support agriculture and food production; to support a range of other industries; and as a source of pleasure and recreation. Given pressures from drought, climate change and an increasing demand for food to meet the needs of an expanding world population, much attention is being paid to the amounts of available water. However, also of importance is the quality of available water. Most human uses in some way add contamination to water; and yet most uses also depend on having a supply of water that is not critically contaminated. Much of the High Plains Aquifer System, including the critically important Ogallala Aquifer, lies relatively close to the land surface in Nebraska and so is vulnerable to contamination. The cleanup of contaminated water can be costly; and those bearing the costs are often not those causing the contamination.

The aim of this briefing paper will be to draw attention to policy challenges in attending to the quality of water, recognizing the delicate balance between human use and contamination of this key resource.

**Need for integrated management**

The interconnections between surface waters and ground water and human interactions with them call for an integrated management approach. This is fundamental to the law (LB 962, 198$^{th}$ Legislature, 2004) governing the quantity of water extracted for irrigation and other major uses; but also needs to be taken into account in assessing and managing water quality (Fig. 1). Thus contamination of surface water can affect ground water and ultimately drinking water quality.

Effective management requires sound understanding of what chemical contaminants are in water and of their effects on the ecological systems and humans that are exposed to the waters, and this depends, in turn, on sound monitoring programs.

Since the early 1970s management and monitoring programs of waters have been driven by federal legislation overseen by the US Environmental Protection Agency (USEPA). There are two main legal instruments: the Safe Drinking Water Act (1974) and the Clean Water Act (1972) both of which have been subject to complex amendments. Responding to this legislation and local requirements, the State of Nebraska has established its own monitoring and management programs. These programs center on the Nebraska Department of Environmental Quality (NDEQ) for management of ground and surface waters and the Nebraska Department of Health and Human Services (NDHHS) for drinking water. The

Nebraska Department of Natural Resources (NDNR), the 23 Natural Resource Districts (NRDs), the Nebraska Department of Agriculture, US Geological Survey, and the Army Corps of Engineers also play critical roles in management of the quality of Nebraska's water resources. There is a range of databases available on a variety of chemical and biological quality measurements undertaken in Nebraska. Coverage is comprehensive in terms of what is monitored and geographical extent; but the data are scattered and in general are not easily accessed. ***Better integration of databases could lead to better management and it would be in the best interests of the State for this to be encouraged by the Legislature.*** Some attempt has been made to bring specific data together for ground water in a *quality-assessed agrichemical database*, and this so-called Clearinghouse database could provide a model for a more integrated approach to water in general. There are clear benefits to more integrated water quality data collection and assessment. At the national scale, the U.S. Geological Survey is already engaged in a project compiling forms of historic and current monitoring data from all sources (local, state, and federal) for addressing regional, multi-state, and national scale water-resources issues as part of the NAWQA (National Water-Quality Assessment) Program (Rowe et al 2013). At both the national and state level, readily available water-quality data from multiple sources can clearly be used more effectively to address environmental issues, such as energy development, nutrient enrichment, land use, and climate change.

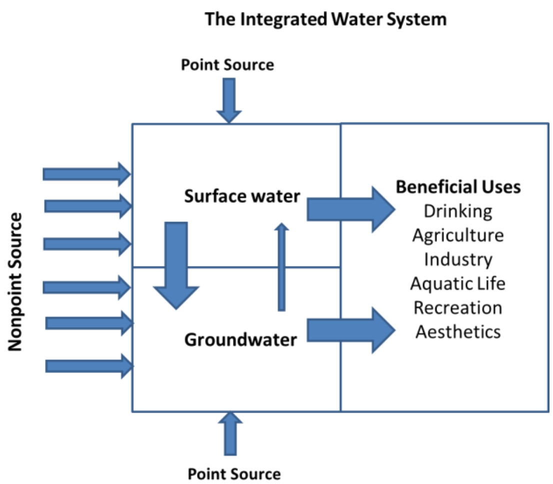


Fig. 1. The interconnected water system. The blue arrows represent the inputs and flows of contaminants.

**Current state of ground water and surface waters in Nebraska**

The NDEQ organizes a ground water cooperative monitoring program that involves data collected from the numerous Nebraska Natural Resource Districts and other agencies from thousands of samples. ***Nitrate has been found in more than 90% of these samples and the herbicide atrazine and its degradation products in around 10% of the samples.*** There is a recognized bias in that samples are often taken from presumed problem areas. Data for nitrate show little trend over time (Fig. 2). The measured concentrations of nitrate range from one-third to two-thirds the standard (10 milligrams per liter, abbreviated as mg/l) required in the State of Nebraska (this being equivalent to the standard required by USEPA for safe drinking water). The data shown in Fig. 2 are mid-range (median) values that may obscure local hot spots. Moreover, once contaminated, ground water may take years to become clean. Most other substances contained in the Clearinghouse database are either below detection limits or within recommended water quality guidelines, suggesting that widespread contamination of ground water by the majority of these well-characterized chemicals is not a statewide issue.

The NDEQ also carries out a comprehensive and extensive surface water monitoring program that involves physical, chemical and biological assessments at both fixed and randomly selected sites, primarily to meet Clean Water Act regulatory requirements. Amongst other things, the Clean Water Act requires NDEQ to prepare a list of impaired waters that do not support the assigned beneficial uses for: primary contact recreation; aquatic life; drinking, agriculture and industrial uses; and aesthetic pleasure. The assessments summarized in the database demonstrate that many of the sites monitored are impaired according to this definition. ***For rivers and streams the most common impairments are: (1) for primary contact recreation from bacteria potentially due to inadequate domestic sewage treatment and runoff from organic wastes applied to land as fertilizers; and (2) for aquatic life from high levels of nutrients and chemicals.*** Selenium, a natural contaminant related to the geology of the drainage areas, but which may also be derived from agricultural sources, can be a cause of impairment for aquatic life in Nebraska. The herbicide, atrazine is another cause of impairment for aquatic life and is regularly

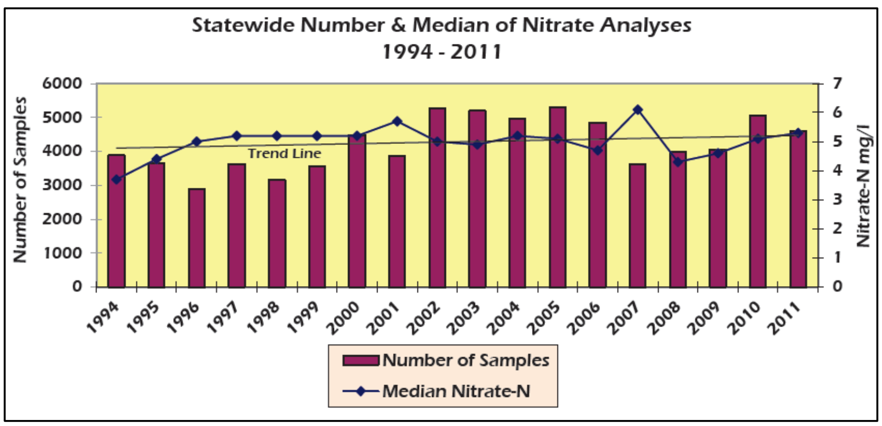


Fig. 2. All 76,004 analyses and median nitrate-nitrogen levels for Nebraska, 1994-2011.
(Source: Quality-Assessed Agrichemical Database for Nebraska Ground Water, 2012)

detected, especially in areas prone to surface water run-off such as the Elkhorn, Lower Platte, and Big Blue watersheds of eastern Nebraska. ***For lakes the commonest impairments are due to bacteria and artificial enrichment, for example by nitrates and phosphates from agricultural sources.*** Artificial enrichment can lead to poor water clarity and low oxygen causing “suffocation” of aquatic organisms including fish. For rivers and streams there has not been any sign of improvement over the past 10 years, and for lakes and ponds the situation seems to have gotten worse with time. For both kinds of systems Nebraska performs poorly as compared with neighboring states.

**Agriculture is a major source of contamination of waters in Nebraska**

Given the extent and intensity of agriculture in Nebraska, it is inevitable that chemicals used in agricultural production are likely to be a major source of contamination of waters in the state. Of major concern are the nitrates and phosphates from fertilizers. Residues of pesticides and even traces of pharmaceuticals can also be of concern. Bacteria from organic wastes applied as fertilizer are also found in both surface- and ground water. ***The challenge for management is not just understanding and controlling the quantitative magnitude of these sources but that they are spatially spread – diffuse - and hence the activities behind them are not easily identified, monitored or managed.***

That said there are controls associated with the use of pesticides and fertilizers designed to limit applications to the extent that concentrations of these contaminants do not reach levels in water that will cause harm to humans or ecosystems. For example, the Nebraska Department of Agriculture Pesticide Program is responsible for regulating the distribution, storage, and use of pesticides in Nebraska. This program was created by statute to protect citizens and the environment from the harmful effects of pesticides by ensuring these products are handled, stored, and used properly, safely, and effectively. Its functions are primarily to provide education and training combined with a vigorous inspection and enforcement program. The Pesticide Program works in close cooperation with the U.S. Environmental Protection Agency (EPA) in enforcing the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as well as the Nebraska Pesticide Act, in addition to implementing national and regional programs related to pesticide sale and use.

Interestingly, ***veterinary pharmaceuticals are not subject to the same level of assessments and controls for impacts on the environment***, and potentially for impacts to human health. Hence they are currently not regularly monitored in surface or ground water. This is despite the fact that, being biologically active, they may have impacts at low concentrations. In contrast, environmental exposures and occurrence of human and veterinary pharmaceuticals are increasingly subject to regulation in other jurisdictions around the world.

Proactively, NDEQ has identified several ground water management areas in the state (see Fig. 3) which are particularly susceptible to nonpoint ground water contamination primarily determined from increasing nitrate concentrations. Management occurs by working with the Natural Resource Districts to characterize the extent of contamination and help control additional inputs to prevent further contamination in these areas. However, as will be discussed below, this kind of management, that seeks to achieve better balance between inputs of fertilizer to crops and yields, is not without some costs and these tend to militate against widespread application of these programs.

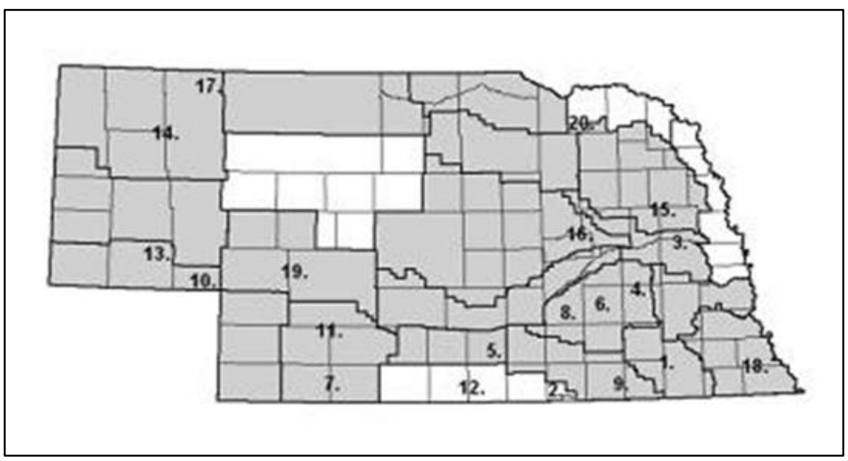


Fig 3. Location of Ground Water Management Areas in the State. Source: http://www.deq.state.ne.us/GroundW.nsf/Pages/GWMA-2

**Point sources of contamination are more easily managed**

Industrial effluents typically enter surface waters in pipes as point sources (cf. with the diffuse/nonpoint contamination from agricultural sources). USEPA requires the reporting of the annual release of certain potentially toxic contaminants to freshwater, and these are compiled into toxic release inventories (TRIs) from these point sources. Data from the TRI program are summarized in the database reports. They show that ***Nebraska has the highest toxic releases to surface waters as compared with neighboring states.*** However, most of the problems in Nebraska can be attributed to release of nitrates in food processing effluents from a few dischargers.

In principle these point sources may be readily managed by the application of end-of-pipe treatment technology. There is a natural tendency to want to apply controls given the tractability of end-of-pipe solutions. However some caution is needed because they may not be the main source of contamination in a watershed; and only requiring clean-up of point sources may not always be a cost-effective way of achieving reductions in total environmental loads. Regional comparison of the magnitude of these releases with the previously discussed non-point source contamination may help in determining which sources provide the most economical and effective management solutions at particular sites.

**Drinking water quality will come under increasing pressure**

Much of the drinking water in Nebraska is from ground water and hence the quality of drinking water is intimately related to the quality of ground water. Drinking water derived from surface sources, and ground water directly influenced by surface water, is similarly influenced by changes in quality of the source water.

The challenges associated with the quality of these public water supplies are dealt with in a separate policy brief (*Policy Challenges for Drinking Water Quality in Nebraska*, 2013). ***The immediate, recurring concerns involve bacteria in distribution systems and nitrate contamination of source water.*** There are a number of reasons for expecting the quality of drinking water to come under even greater pressure on the longer term. First, global food shortages are likely to encourage ever-more intensification of agriculture, with the potential consequence of increasing release of associated contaminants into the ground water unless steps are taken to minimize losses. Second, global climate change, leading to more variable rainfall may exacerbate this release. For example, residual levels of soil nutrients from fertilizers used in crop production may increase during dry conditions and so be lost to run-off and leaching in greater extents when wet conditions return. Already this has very likely caused problems in terms of nitrate spikes in drinking water in Iowa (Pitt, 2013). Finally there is a possibility that nitrates, a predominant contaminant in waters in Nebraska, may have chemical effects (oxidization) on other naturally occurring but toxic chemicals, such as arsenic and uranium, and so cause them to more easily dissolve with the increased risk of them turning up in drinking water. These kinds of problems have already been recorded in California (Jurgens et al, 2010; Landon et al 2011) and the developing world (Buschmann et al 2007; Harvey et al, 2002).

**Costs and benefits of management**

Under Executive Order 13563, *Improving Regulation and Regulatory Review* (supplementing Executive Order 12866) the USEPA is required to consider the costs and benefits of any provisions under the Safe Drinking Water Act and the Clean Water Act.

The costs of improved water quality come from those involved in changes in practices to reduce contamination at source (e.g. managing fertilizer application), the capital expenditure on clean-up technology (e.g. of contaminated drinking water) and their operating costs together with monitoring costs, all of which can be borne by both public and private sectors. But there may be broader costs; for example from jobs lost as a result of increasing pressures on business sectors affected. The benefits of improving water quality come from improved health and ecology, and economists have developed techniques for assessing the values that we put on these so that they can be expressed in dollars just like the costs. In principle, then, both costs and benefits can be compared. In practice this is not without difficulty and debate. Nationally USEPA has reported costs and benefits associated with the management of water quality in terms of tens of billions of US dollars per year and purported to show that benefits exceed costs (USEPA, 1997 & 2000) – but this is not without dispute (Johnson 2004). NDEQ follows this example of the USEPA and makes the presumption that the ecological and societal benefits of managing water quality are greater than costs. It expresses costs in a limited way in terms of the availability and use of grants and loans for improvement projects of various kinds (e.g. see NDEQ (2012)).

The likely complex interplay of pressures on agriculture to intensify while reducing ecological impact, the pressures on the drinking water supply, together with the costs of dealing with more complex contamination in all parts of the water system, argue for making the costs and benefits of decisions and policies more explicit. An interesting recent study in California on nitrate contamination has emphasized the integrated nature of the problem; linking farm practice in fertilizer use with the need for clean-up of drinking water sources (Harter & Lund, 2012). Changes in farm practice to ensure a better balance of application to yield and hence less contamination involved significant costs (up to 0.6% of net farm revenues) as did the installation of cleanup technologies to achieve appropriate nitrate standards (up to $1 million per year for small community public water systems). Cleanup of contaminated ground water was infeasible. It is difficult to generalize from this work since the solutions are so situation specific depending on such things as soil types and farming practices, so a similar study could be warranted for Nebraska given the critical importance of water quality for the state.

**Challenges for better policies**

- Recognize the importance of water quality as well as quantity for both human health and ecology.
- Encourage an integrated approach to management with the development of integrated databases.
- Note that nutrients (nitrates and phosphates), largely from agriculture, are the single most important cause for concern.
- Recognize that nonpoint pollution is going to be dominant but difficult to manage.
- Pay attention to point sources of pollution just because they can more easily be managed – but note that management here might bring costs without commensurate benefits in reducing total environmental loads.
- Realize that the quality of drinking water is likely to come under increasing pressure as agriculture intensifies and drought complicates the dynamics of the water system.
- Make decisions with a more explicit understanding of their costs and benefits.

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**Glossary of Terms**

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| arsenic | A chemical element that is highly toxic to humans and other animals |
| atrazine | A commonly used herbicide. It can have adverse effects on people and wildlife. For example it has been implicated as an endocrine disruptor – i.e. interfering with normal hormonal controls in a way that impairs sperm production. It is also said to cause cancer. |
| FIFRA | Federal Insecticide, Fungicide, and Rodenticide Act |
| mg/l | A way to express concentration; i.e. of milligrams of a substance in a liter of water. It is often represented as parts per million (ppm). |
| NAWQA | National Water-Quality Assessment Program |
| NDEQ | Nebraska Department of Environmental Quality |
| NDHHS | Nebraska Department of Health and Human Services |
| NDNR | Nebraska Department of Natural Resources |
| NRD | Natural Resource Districts |
| nitrates | Produced by microbial action on nitrogen products such as manure and nitrogen-based fertilizers. Nitrogen is essential to all life but at high concentrations can have negative effects on health such as "blue baby syndrome" and cancer. Can artificially enrich natural waters leading to excessive algal growth and fouling. |
| phosphates | Phosphorus, from which phosphates form, is essential to life and hence is often included in fertilizers. Can artificially enrich natural waters leading to excessive algal growth and fouling. |
| selenium | A chemical element essential to life; but at high concentration can be toxic to humans and wildlife. It occurs naturally but also may derive from agricultural sources. |
| uranium | Radioactive chemical and as such can have adverse effects on humans and wildlife. It occurs naturally and often in insoluble form so it does not enter water systems. However, oxidation can make it more soluble such that it does enter water systems. |
| TRI | Toxic Release Inventory |
| USEPA | US Environmental Protection Agency |
| USGS | US Geological Survey |