circle of blue
where water speaks

Is Agrochemical Contamination Killing Nebraska's Children?

The harrowing trail of toxic nutrients in farm country water

This is the first of a two-part series. Read part two here.

By Brett Walton, Circle of Blue – February 2, 2022

Photography and videography by J. Carl Ganter

AURORA, Neb. — In the final, frantic hours Jacob Peters's body gave out. As nurses worked to stabilize his vitals, his

blood pressure dropped. Fluid built up in his abdomen and brain. He vomited. His words were slurred.

A ventilator kept the 17-year-old alive long enough for his younger brothers, Jerod and Dalton, and other family members to make the two-hour drive to the Omaha hospital where his parents stood vigil. On November 16, 2011, at 6:12 p.m., Jacob died, nine months after he was diagnosed with a rare and aggressive form of lymphoma.

A decade later, Jacob Peters's death turns out to be much more than a dreadful heartbreak for a small town, farm country family. His parents, Gary and Shari Peters, documented six more kids in Aurora diagnosed with cancer from 2005 to 2013. Of the seven, including Jacob, Circle of Blue confirmed that five died and two survived.

There are others across Nebraska. The Centers for Disease Control and Prevention counts 1,921 pediatric cancer cases in the state between 1999 and 2018, about 100 per year.

An investigation by Circle of Blue uncovered compelling evidence for why — agrochemical contamination in Nebraska's surface, ground, and drinking water. The reporting found:

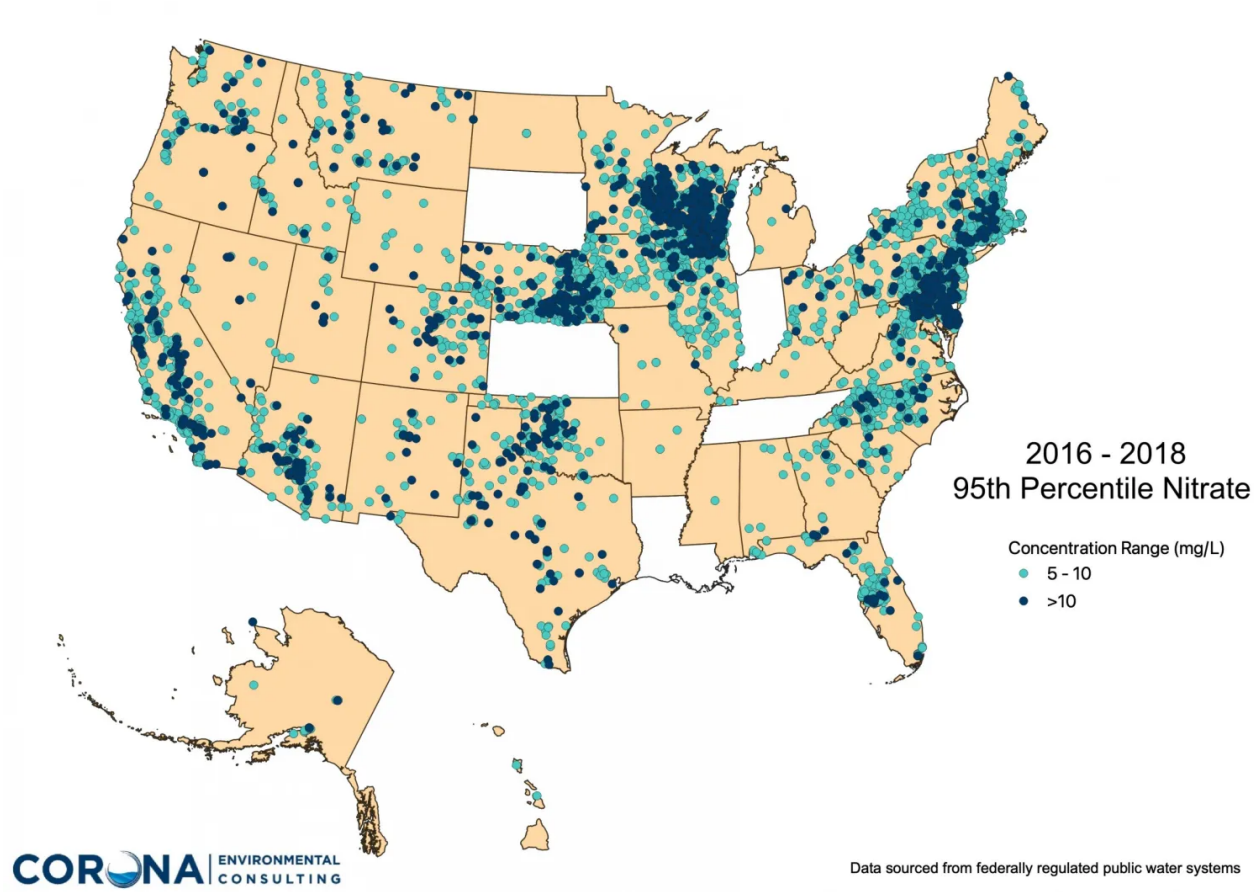
- Pediatric cancer is more common in Nebraska than anywhere in the United States outside of the Northeast. The state's pediatric cancer rate is seventh-highest in the country.

- High numbers of pediatric cancer cases, especially central nervous system tumors, leukemia, and lymphoma, are associated with Nebraska watersheds that have high levels of nitrate (a fertilizer) or atrazine (a weed killer) in surface and groundwater, according to a University of Nebraska Medical Center research team.

- Statistical analysis points to agrochemical pollutants in streams and groundwater as a potential source of Nebraska’s outsized pediatric cancer caseload.

- Nitrate is one of the most violated federal drinking water standards, with EPA data showing 458 systems in violation in the fourth quarter of 2021. Twenty-three are in Nebraska.

- Farms collectively are the largest source of nitrate pollution in rivers and groundwater, and the penalty for contaminated water — meaning stricter and more costly standards in order to protect public health — is paid by the people who drink it.



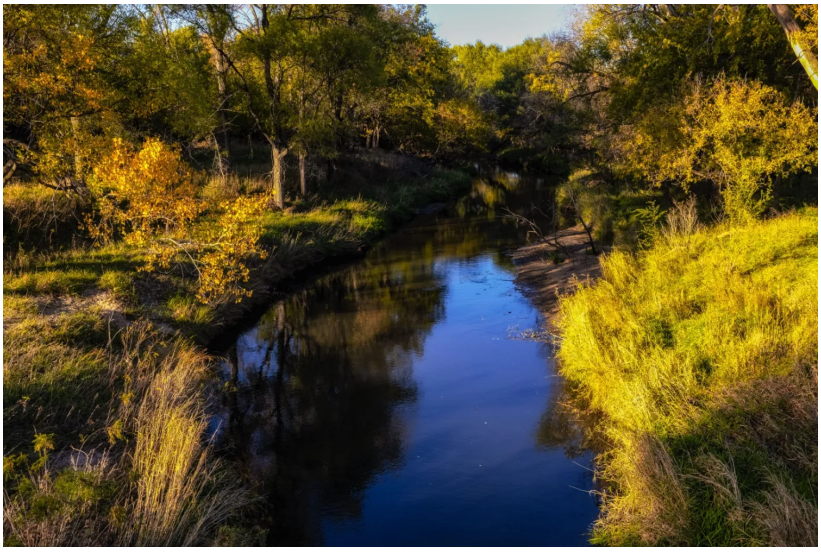
This map shows nitrate concentrations in drinking water between 2016 and 2018 for federally regulated water systems. Dark blue dots indicate water systems that exceeded the federal nitrate standard of 10 parts per million. Light blue dots show systems just under the standard, where concentrations were between 5 ppm and 10 ppm. The areas with high nitrate concentrations generally correspond to areas with intensive agriculture where groundwater is a major water source. States shaded white did not provide or have data. The map shows a combination of nitrate and nitrate-nitrite data from state and federal sources. The map was produced by Corona Environmental Consulting based on a data-collection project funded by the Water Quality Research Foundation.

Nebraska agriculture is a behemoth. More than nine out of every 10 acres in the 49.5 million-acre state is given over to farms and ranches.

In the annals of toxic chemical contamination in the U.S. and globally, agrochemicals used to increase crop production, kill insects and weeds, and prevent plant and animal diseases are well-recognized hazards. In weighing the documented risks to health and the environment against the benefits of an ample food supply at reasonable prices regulatory authorities have been reluctant to exert strong safeguards except in the most egregious instances — like banning DDT in 1972 because it prevented birds from reproducing.

Even with that record of risk nitrate pollution is in a category to itself. The chemical fertilizers that farmers insist are needed to assure high crop production, and the nitrogen-rich manure produced by contemporary animal agriculture, are largely unregulated. The result is nitrates are causing health and ecological trauma in farming regions across the country and around the world as farmers and governments intensify their efforts to produce more food from each acre of land.

Purging nitrate from groundwater will not be a quick fix. Nitrate is water soluble and soils are loaded with excess fertilizer that could take decades to expunge, even if new nitrogen application on farmland is curtailed. The long memory of this legacy nitrate is likely to be rattled by a changing climate. One recent study found that more intense precipitation, as is expected in the Midwest and Great Plains in the coming decades, could flush more nitrate from soils to groundwater, especially from fields that are tilled.



A small but growing body of research suggests that agrochemical pollutants in groundwater and streams, like Bazile Creek, shown here, play a role in Nebraska's outsized pediatric cancer caseload.

In the United States, excess nutrients build up in waterways from Lake Erie to the Gulf of Mexico, precipitating algae outbreaks that kill fish, close public drinking water utilities, and pollute water. Politically powerful farm lobbies, preferring voluntary measures to curb nutrient pollution, have held off oversight under the Clean Water Act and other statutes. Fertilizer runoff from farm fields is not federally regulated, so the EPA's announcement on January 26 that it would step up enforcement of polluting facilities has little resonance for nitrate contamination.

What's happened in Nebraska to kids and their families may help change the official indifference. A small but growing body of research suggests that agrochemical pollutants in streams and groundwater play a role in Nebraska's outsized pediatric cancer caseload. That line of inquiry points at the heart of the Nebraska economy: its $21.4 billion farm industry.

Nebraska agriculture is a behemoth. More than nine out of every 10 acres in the 49.5 million-acre state is given over to farms and ranches. Collectively they produced 294 million bushels of soybeans in 2020, ranking fifth nationally. Grain corn was even better, third nationally with 1.79 billion bushels. The state produced nearly 8 billion pounds of red meat.

Such prodigious output requires enormous inputs, especially of nitrogen fertilizers.

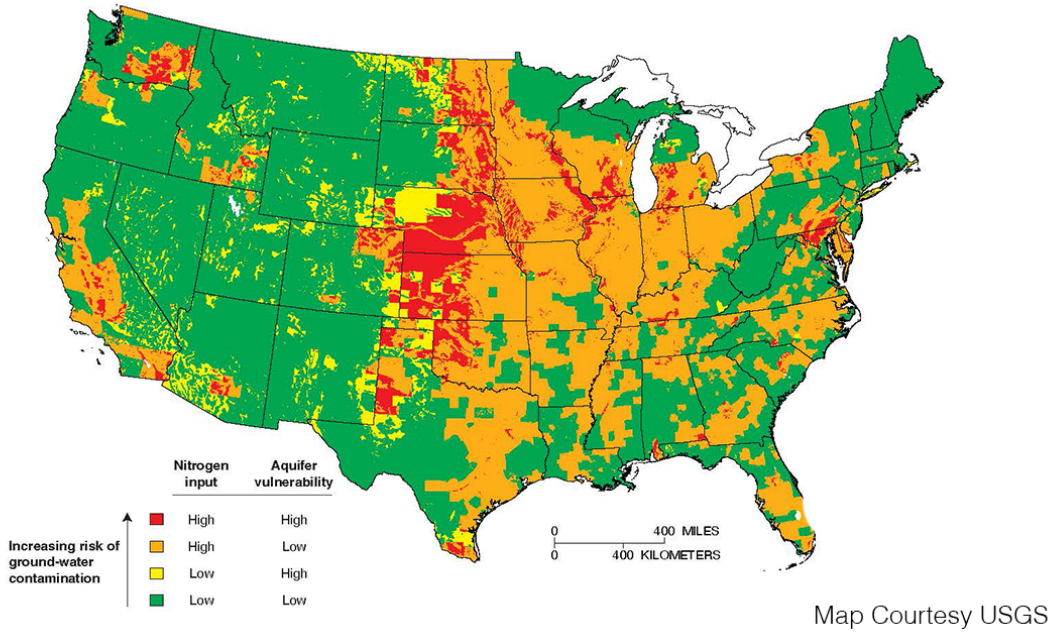
Fertilizers developed to produce huge harvests across the Corn Belt have also been found to wreak havoc on human bodies. So have farm chemicals like atrazine, a weed killer.

Don Coulter, center, speaks with Jesse Bell, right, and Eleanor Rogan. The three University of Nebraska Medical Center researchers are part of a collaborative project investigating the links between water pollution and pediatric cancer in Nebraska.

Don Coulter, the director of the University of Nebraska Medical Center's Pediatric Cancer Research Group, is one of the medical specialists taking a close look at the links between farm chemicals and Nebraska's pediatric cancers. He is part of a research team that mapped three decades of pediatric cancer cases in Nebraska not according to political boundaries, such as counties or towns, but instead by watersheds. Coulter has a particularly keen interest. He was one of the doctors on Jacob Peters's care team.

The mapping project shows that cancer cases are associated with watersheds that have high levels of nitrate or atrazine in groundwater. The Upper Big Blue watershed in south-central Nebraska, where the Peters family lives, is one of the basins with a high cancer incidence.

Besides Jacob Peters, four of the Aurora kids died from their cancers. Tyler Larson was diagnosed in 2010 with neurofibroma sarcoma, which resulted in tumors on nerve endings. He was 19 when he died. Sydnee Owens, who contracted non-Hodgkin's lymphoma in 2006, died six years later at age 14. Alyssa Sandmeier died at age 10 from leukemia. And Madalyn Spellman died at age 13 after being diagnosed with leukemia and bone cancer. Two kids survived and they or their parents did not respond to interview requests.



Map Courtesy USGS

This U.S. Geological Survey map shows areas at risk of nitrate contamination in shallow groundwater. Areas shaded red have the highest risk, meaning high nitrogen use from agriculture and aquifers that are vulnerable to contamination – typically those in sandy soils.

Studies and Questions

The complexity of the nitrate problem, unknotting its social, economic, medical, political, and practical threads, is part of the appeal for Coulter.

With fresh eyes, Coulter came to the issue after caring for Jacob and another pediatric cancer patient in 2011. It was three years after he arrived at the University of Nebraska Medical Center following medical school at the University of Arizona and residency in North Carolina. It was a career shift. Before becoming a doctor he worked at Charles Schwab.

Teamwork was a big part of the finance job, and that is what Coulter, with the aid of $1.8 million annually from the state Legislature, has helped create at the University of Nebraska Medical Center. The collaborators on the water and cancer research project include, among others, Eleanor Rogan, chair of the Department of Environmental,

Agricultural, and Occupational Health, and Jesse Bell, director of the Water, Climate and Health Program. The group has also elicited the help of two natural resources districts — the Lower Elkhorn and Upper Big Blue — which have a regulatory role in Nebraska over issues like water quality and soil erosion.

Eleanor Rogan, chair of the Department of Environmental, Agricultural, and Occupational Health.

The team's approach appeals to Rogan because she is far more interested in disease prevention than disease treatment. "For me, once you have a tumor cell I'm not interested anymore because I didn't want you to have a tumor cell," she told Circle of Blue.

Coulter said that he sees his role to be that of a facilitator, connecting across disciplines and identifying new lines of questioning. "Science in a silo doesn't work," he says. The work on environmental factors has prompted many questions. Why does Nebraska have higher pediatric cancer rates than its neighbors Iowa and Kansas, even when they share similar agricultural risks? What is the interaction between nitrate and uranium, which is naturally present in Nebraska groundwater? And should the U.S. regulatory system, when looking at the variety of chemical

pollutants in drinking water, continue to assess the toxicity of contaminants individually?

"Sure, you can do that," Coulter said about considering contaminants one by one. "But another way to think about it is that when something grabs a glass of water, and it has all those different compounds within it, what are those compounds doing within a glass of water to allow one to be more bioavailable or problematic than it would be if it was just in isolation? And so we have to provide that data and not try to necessarily interpret it for people, but sort of show them, 'Hey, this is what we found in this watershed. These are the compounds that are all playing in this person's well. This could be an issue.'"

Coulter added: "We know these compounds are problematic. We may not be able to find something definitive for cancer, but at least it's helping people to identify that this is something we need to be thinking about."

Nighttime harvest, east of Creighton, in north-central Nebraska.

The work seems to be moving minds. In Nebraska, at least, Coulter has seen a more intense focus in the last five years on water pollution. "I think for a long period of time, it was always about the quantity of water. Do we have enough? Now I think people are also looking at the other side of that coin and saying what are we doing to our water supply? And what sort of impacts is that having?"

The findings from the University of Nebraska team contribute to a larger body of research investigating the health consequences of one of the country's most pervasive drinking water contaminants. Research on nitrate is generating limited but compelling evidence of acute and chronic health damage when the chemical is present in drinking water at concentrations above and below the current federal standard of 10 parts per million. It comes at a time when the U.S. Environmental Protection Agency is undertaking a mandatory review of federal drinking water standards, due in 2023.

A Standard Under Scrutiny

The federal nitrate standard was set three decades ago to protect infants from a disease called blue baby syndrome. Now there are new worries. Recent studies in the United States and Denmark on nitrate exposure indicate a higher risk of preterm birth, low birth weight, birth defects, and infant brain tumors. In adults, there is a higher risk of colorectal cancer and some associations with thyroid disease. These associations are present when nitrate is above and, in some cases, below the federal drinking water standard.

"There seems to be quite a growing literature that suggests that the standard that was really based on blue baby syndrome is not sufficiently stringent to protect children from other adverse birth outcomes," Leslie Stayner, a professor emeritus of epidemiology at the University of Illinois at Chicago, School of Public Health, told Circle of Blue. Stayner currently lives in Denmark, where he is using that country's meticulous data registries to investigate the health damage from nitrate.

Researchers who specialize in the health effects of nitrate say that more work needs to be done to establish cause-and-effect relationships. In the field of epidemiology, and especially in drinking water assessments, no single study is ever definitive.

"Taken together these studies add to the evidence for adverse health effects related to nitrate ingestion at levels below the current regulatory standards in the U.S. and E.U.," said Mary Ward, a senior investigator at the National Cancer Institute. "However, the number of studies is still too few to draw conclusions about risk."

If the U.S. Environmental Protection Agency were to lower the nitrate standard — something the agency rejected in 2016, in its last review of federal drinking water regulations — the consequences would be enormous. The risk of disease would likely decrease. But more communities would violate the standard and would be required to upgrade their treatment works or find new water sources with lower levels of nitrate. That is a difficult proposition in farm country, where a town may be surrounded by high-nitrate groundwater. In deciding whether to lower the standard, the EPA would weigh the reduction in health risks against these community financial liabilities.

Soybean harvest in late October.

Nitrate is already one of the most violated federal drinking water standards, with EPA data showing 458 systems in violation in the fourth quarter of 2021. Yet, it remains overlooked. Spurred by public outrage after high-profile health crises in the last decade, other drinking water contaminants have taken center stage in the federal response to dirty water.

The $1.2 trillion infrastructure package that President Joe Biden signed into law in November included $15 billion to remove lead pipes and $10 billion for dealing with toxic PFAS chemicals. But there was no specific earmark for utilities to address nitrate.

Chad Seidel, who works on drinking water treatment and policy, says he is frustrated with the lack of attention to such a deeply rooted, widespread problem. "If we were addressing nitrate with the fervor we're currently addressing PFAS, we would have solved the problem a decade ago," said Seidel, president of Corona Environmental Consulting. "But we haven't. We've accepted the fact that hundreds and hundreds of water systems across the U.S. can be out of compliance. And we're okay with it."

Nitrogen Fixation

Though notorious as a water polluter, nitrate is regarded by farmers as absolutely necessary and by industrialists as one of the great discoveries of the 20th century. By combining inert nitrogen gas with hydrogen sourced from fossil fuels, two German scientists at the start of the century learned they could "fix" nitrogen from natural gas to produce fertilizers whose provenance previously had been the domain of lightning, legumes, and manure.

The Haber-Bosch process "changed the world," according to one scientific retrospective. The widespread availability of manufactured nitrogen fertilizers caused crop yields to soar. Nitrogen use rose exponentially after World War Two before leveling off in the 1980s and growing more slowly thereafter.

Environmental problems developed in tandem with nitrate's swift ascent. Corn and soybeans couldn't consume all of the nitrogen they were fed. Some residual nitrogen was lodged in soils where microbes converted it into nitrous oxide, a significant greenhouse gas. The rest was flushed from fields into rivers, or it leached into shallow groundwater. The nutrient-laden runoff fed the growth of algae in lakes and estuaries. Oxygen-deprived "dead zones" developed in the Gulf of Mexico and Chesapeake Bay, key waterways downstream of intensive farming.

For people who consumed water high in nitrates health problems emerged starting in the 1940s. The pathway is indirect. In the body, nitrate is converted into nitrite by bacteria in saliva. Nitrite then reacts with ferrous hemoglobin, a compound in blood that transports oxygen from the lungs to cells and tissues. From this interaction comes methemoglobin, which cannot carry oxygen. Starved of a critical element of life, methemoglobinemia patients begin to suffocate from within, their skin drained of color, sometimes acquiring a blue tint.

Gary Peters, left, sits at his dining room table, talking with Nick Owens, right. Owens's daughter, Sydnee, contracted non-Hodgkin's lymphoma and died six years later at age 14.

Adults are not at risk, but bottle-fed infants are particularly defenseless, thus the common name for the disease: blue baby syndrome. Once infants in farm communities began to die, researchers snapped into action. They found that reducing nitrate in drinking water substantially reduces the risk of infant death. For that reason, in 1991, the EPA established a federal nitrate standard of 10 parts per million in drinking water, roughly in line with World Health Organization guidance. Utilities developed methods to reduce or remove nitrates. Health officials warned household well owners, whose water is not regulated, about the dangers. Deaths of blue-tinted infants almost disappeared by the late 1990s. The standard has not been changed since.

New research is starting to call that standard into question. One area of concern is cancer. Nitrate converts to nitrite in the mouth, which can interfere with oxygen transport in the blood. Thus methemoglobinemia. But nitrite has another indirect route for damaging the body. It interacts with acids in the stomach to produce carcinogenic N-nitroso compounds.

N-nitroso compounds can cross the placenta and expose a child in utero. Leslie Stayner, the University of Illinois at Chicago epidemiologist, said that his research has led him to the conclusion that pregnant women should be cautious about their drinking water, not only for nitrates but for other chemicals in low concentrations that could pass to the fetus.

For newborns, four out of six studies showed communities prevalence of birth defects of the central nervous system at nitrate levels below the EPA standard of 10 parts per million. The evidence of harm is growing, but it is far short of the amount of study needed for scientific consensus. "In the epidemiology field, these are not a lot of studies," said Mary Ward of the National Cancer Institute.

Ward said that diseases related to drinking water nitrate are probably due to a combination of two factors: nitrate ingestion and the body's production of N-nitroso compounds. Factors that would increase N-nitroso production include a person's diet. Eating more steaks and hamburgers increases the risk. Eating more foods rich in antioxidants, like fruits and most vegetables, lowers it. Joseph Cotruvo, a former director of the EPA drinking water standards division, said more work needs to be done to account for dietary nitrate when assessing health risk.

Decades of exposure to nitrate for high-risk people can also lead to chronic ailments like cancer. Ward, one of the country's foremost nitrate researchers, pointed out that the strongest associations between nitrate and cancer are with colorectal cancer (four studies out of five total showing a link for at least one group of people) and childhood brain tumors (three studies out of three).

Every six years, the U.S. Environmental Protection Agency is supposed to review national drinking water standards to consider whether updates are needed. The agency considers new information on health effects, treatment capabilities, and how often contaminants occur in drinking water. In the most recent review, completed in December 2016, the agency concluded that eight standards were candidates for revision.

The nitrate standard was not one of them. Reviewers had already recommended that the EPA's health risk division, known as IRIS, complete a new hazard assessment for

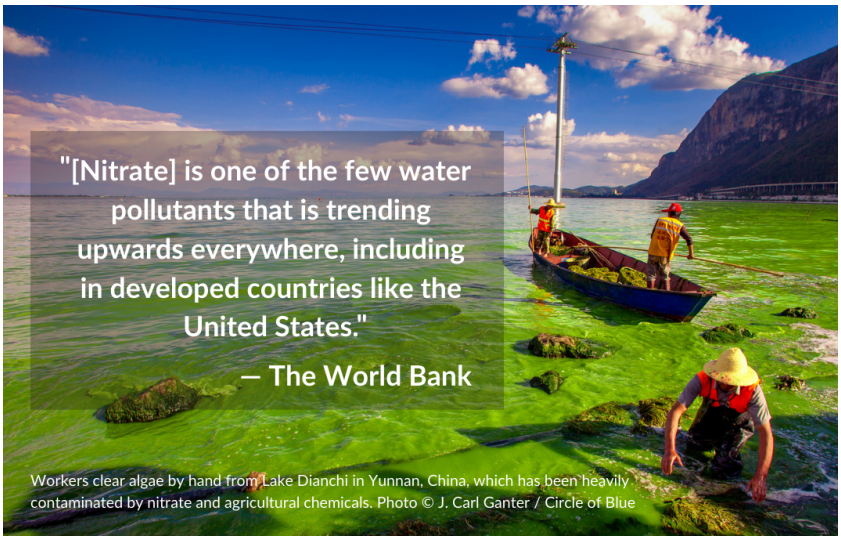
nitrate. It did not get very far. IRIS suspended the assessment in 2019 because it "was not identified as a priority by Agency partners," an EPA spokesperson wrote in a statement to Circle of Blue.

As it now stands, the EPA does not allow any room for improvement for nitrate. Under the Safe Drinking Water Act, the law that regulates public water systems, the agency sets two standards for contaminants. One is the maximum contaminant level goal (MCLG), which is the level at which no health risks are anticipated. The other is the maximum contaminant level (MCL), a standard that utilities — but not household well owners — are required to meet.

The MCL takes into account treatment technology and the cost of treatment. It is supposed to be as close to the MCLG as possible. For nitrate, the MCLG and MCL are both 10 parts per million.

The EPA, in effect, asserts that the nitrate standard is as protective as it needs to be. Of course, that could change. The EPA is again in the middle of a six-year review of drinking water regulations. This one is slated to be completed in 2023. The agency is not willing to discuss the process. The agency did not allow staff to be interviewed about the six-year review or about nitrate in drinking water for this article.

The reporting and photography for this project were funded by a Kozik Environmental Justice Reporting Grant from the National Press Foundation and the National Press Club Journalism Institute.



Workers clear algae by hand from Lake Dianchi in Yunnan, China, which has been heavily contaminated by nitrate and agricultural chemicals. Photo © J. Carl Ganter / Circle of Blue

Photos and video

Opening video:

Families in Aurora, Nebraska stand at the gravestones of their children who died from cancer. Left to right, Gary and Shari Peters, Nick Owens and Nicole Broman, Tammy and Corey Spellman. Video © J. Carl Ganter/ Circle of Blue

Banner images from top to bottom:

Creighton, Nebraska. Photo © J. Carl Ganter/ Circle of Blue

Platte River, north of Aurora, Nebraska. Photo © J. Carl Ganter/ Circle of Blue

Nebraska generated $21.4 billion in farm sales in 2019. It is the country's third-largest corn producer. Photo Brett Walton / Circle of Blue

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U.S. Food Trade Using Unsustainable Groundwater Supplies

Pacific Institute

Nitrates – Central Valley study

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Drinking Water Nitrate and Human Health: An Updated Review

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University of Nebraska Systems

Examining the Effects of Agrichemical Contaminants on Pediatric Cancers

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Brett Walton

Brett writes about agriculture, energy, infrastructure, and the politics and economics of water in the United States. He also writes the Federal Water Tap, Circle of Blue's weekly digest of U.S. government water news. He is the winner of two Society of Environmental Journalists reporting awards, one of the top honors in American environmental journalism: first place for explanatory reporting for a series on septic system pollution in the United States(2016) and third place for beat reporting in a small market (2014). He received the Sierra Club's Distinguished Service Award in 2018. Brett lives in Seattle, where he hikes the mountains and bakes pies. Contact Brett Walton

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Moonrise over Creighton, Nebraska.

Nebraska Agrochemical Contamination Throws Families, Communities, Water Providers into Turmoil

The harrowing trail of toxic nutrients in farm country water

This is the second of a two-part series. Read part one here.

By Brett Walton, Circle of Blue – February 9, 2022

Photography by J. Carl Ganter, Circle of Blue

AURORA, Neb. — Last October, a decade after their son Jacob died of a rare and aggressive form of lymphoma, Gary and Shari Peters reflected on an ordeal that produced unbounded pain, and unexpected clarity and purpose.

“There’s two ways to handle losing your child to cancer,” Gary said. “Get involved and do something or just disappear. There’s nothing in the middle.”

The Peterses took the first path. Gary, a construction project manager and volunteer assistant with the Aurora High School football team, turned his journals into a book-length chronicle of the family’s cancer year. He and Shari are active in the Pediatric Cancer Action Network, a grassroots advocacy and support group in Nebraska. Their work has revealed to them one of the darker sides of rural life in Nebraska. Six kids in town besides Jacob were diagnosed with cancer from 2005 to 2013.

Madalyn “Maddy” Spellman lived in Aurora and died from cancer in September 2016, at age 13. Her parents, Corey and

Tammy Spellman, stand over her grave.

An investigation by Circle of Blue uncovered compelling evidence for why — agrochemical contamination in Nebraska's surface, ground, and drinking water. Pediatric cancer is more common in Nebraska than anywhere in the United States outside of the Northeast. And elevated numbers of pediatric cancer cases are associated with Nebraska watersheds that have high levels of nitrate (a fertilizer) or atrazine (a weed killer) in surface and groundwater, according to a University of Nebraska Medical Center research team.

Drinking water in rural Nebraska has become so prominent an issue that two state senators introduced bills this legislative session that target nitrate contamination. LB 1160 would use $10 million in federal coronavirus relief funds to assist rural communities in removing nitrate from their water. LB 925, meanwhile, would allocate $250,000 annually over five years to develop farmer-led educational programs on soil health and water quality.

Fresh attention to a persistent drinking water problem in farm country did not happen overnight. The University of Nebraska Medical Center research project traces its roots to Jacob's cancer diagnosis a decade ago, a year of struggle that started innocently enough: with a bad game.

The evening of January 14, 2011, Jacob, then a 16-year-old sophomore at Aurora High School, entered a basketball game against Central City. In most contests for the Huskies, Jacob was a physical force. But that mid-winter day he faltered on the court. To Gary and Shari, the uncharacteristically sloppy performance and lack of effort were clear signs that their oldest son was ill.

Gary Peters observes football practice at Aurora High School, where he is a volunteer assistant coach.

Confirming their intuition, Jacob awoke the next morning congested with cold symptoms that developed into what Gary described as a “deep, heavy, hard, whole body cough.” A week of rest and antibiotics did not subdue the sickness. A different antibiotic didn’t either.

Two weeks later, Jacob was still having trouble breathing. At a January 31, 2011, appointment the doctor ordered blood tests and chest X-rays, to check for infection. The X-ray seemed off. A CT scan did, too. Medical staff shared worried glances. Biopsies the next day of Jacob’s lymph nodes and bone marrow resulted in the diagnosis the family had feared: lymphoma.

More specifically, it was T-cell lymphoblastic lymphoma, a rare and typically aggressive cancer that attacks the organs and tissues that rally the body’s defenses against disease. Within the week — and just three weeks after starting to feel ill — Jacob began chemotherapy in Omaha at the University of Nebraska Medical Center, a two-hour

drive from the brick-paved streets of his 4,600-person hometown.

From the start he faced decisions few teenagers have to make. Did he want to participate in a clinical trial for an experimental cancer drug? Did he want to freeze his sperm, in case the cancer treatment robbed him of his ability to father children?

These were unexpected trials. All he wanted was to be in the weight room, preparing himself for his pivotal junior season of football, the year that college scouts would be assessing his potential and making scholarship offers.

In short time the rituals of Jacob's life shifted. No more basketball practice and off-season football workouts. Instead, a buffet of medications, a tube inserted into his chest, and weekly trips to Omaha for treatment.

The University of Nebraska Medical Center is the only pediatric cancer care center in the state. The Peters family repeated the journey over and over and over. Gary and Shari estimated that they drove 12,000 miles during the course of Jacob's treatment. They had to. Omaha was their closest option. Families in the western half of Nebraska, located unreasonably far from Omaha, turn in a different direction for care. They drive west, across the state line, to Denver.

The burdens for families extend far beyond geography. Coulter cited data from Utah, which also has only one pediatric cancer center. A survey of 254 families that experienced a pediatric cancer found that one-third of adult caregivers quit work or changed jobs. Rural residents reported financial burdens due to the lengthy travel demands for hospital visits.

During Jacob's treatment both Gary and Shari lost their jobs. Shari's layoff arrived out of the blue, a result of her employer closing the local office. Gary, who owned a construction company, fell behind on bills that stemmed from an apartment project three years prior that went over budget. He said that Jacob's illness did not cause his company to collapse, but it might have accelerated the downfall. "I may have lost my will to fight two fronts during that time, but I believe now that it was inevitable."

Many cancers, like tumors in the lungs due to smoking, have clear pathways for exposure. That is not the case for pediatric cancers like Jacob's lymphoma. His doctors don't know how he got it or what exactly he was exposed to. Don Coulter, the director of the University of Nebraska Medical Center's Pediatric Cancer Research Group and

one of the doctors on Jacob's care team, said that pediatric cancer is a relatively rare occurrence compared to adult cancers. There is not a wealth of data to sift through. Jacob's exposure could have taken place early in life or in the womb. It could have stemmed from epigenetic changes passed through the family. It could have resulted from the interplay between a basket of chemicals that are present in farm country.

The sun sets behind the Aurora Ethanol East LLC plant as a tractor harvests corn near Aurora, Nebraska.

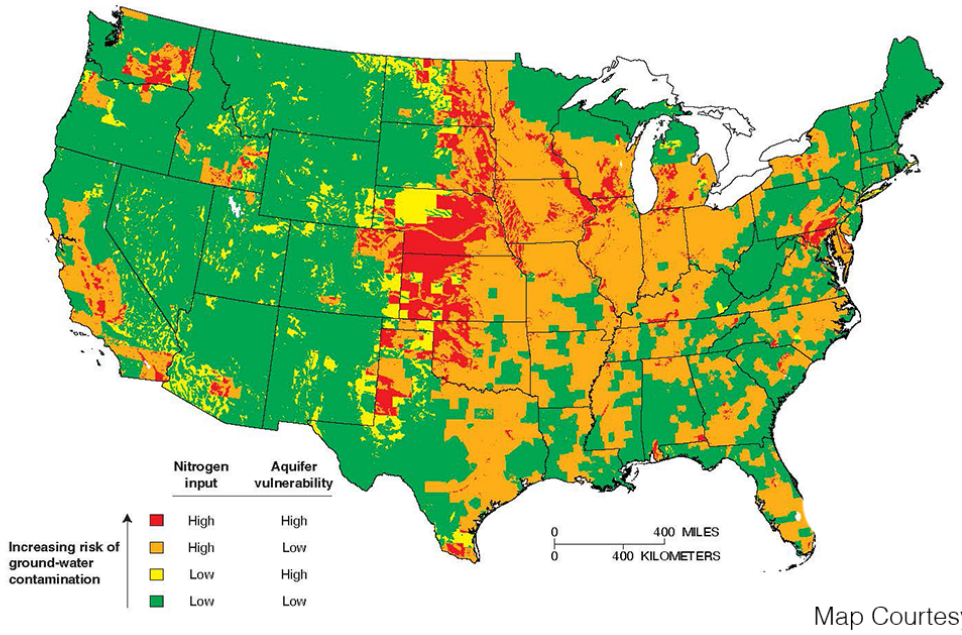
Besides Jacob Peters, four of the Aurora kids died from their cancers. Tyler Larson was diagnosed in 2010 with neurofibroma sarcoma, which resulted in tumors on nerve endings. He was 19 when he died. Sydnee Owens, who contracted non-Hodgkin's lymphoma in 2006, died six years later at age 14. Alyssa Sandmeier died at age 10 from leukemia. And Madalyn Spellman died at age 13 after being diagnosed with leukemia and bone cancer. Two kids

survived and they or their parents did not want personal details published.

Even with the uncertainty around any individual's disease, risk factors for nitrate contamination are not difficult to identify collectively. Septic systems, wastewater treatment plants, and lawns play a role. So does fossil fuel combustion. In countries without proper waste disposal, untreated sewage is a factor. And natural hazards like wildfire can elevate nitrate in streams. But the main source of nitrate is not the forest but the field. Where intensive, industrial-scale agriculture flourishes, nitrate is a menace.

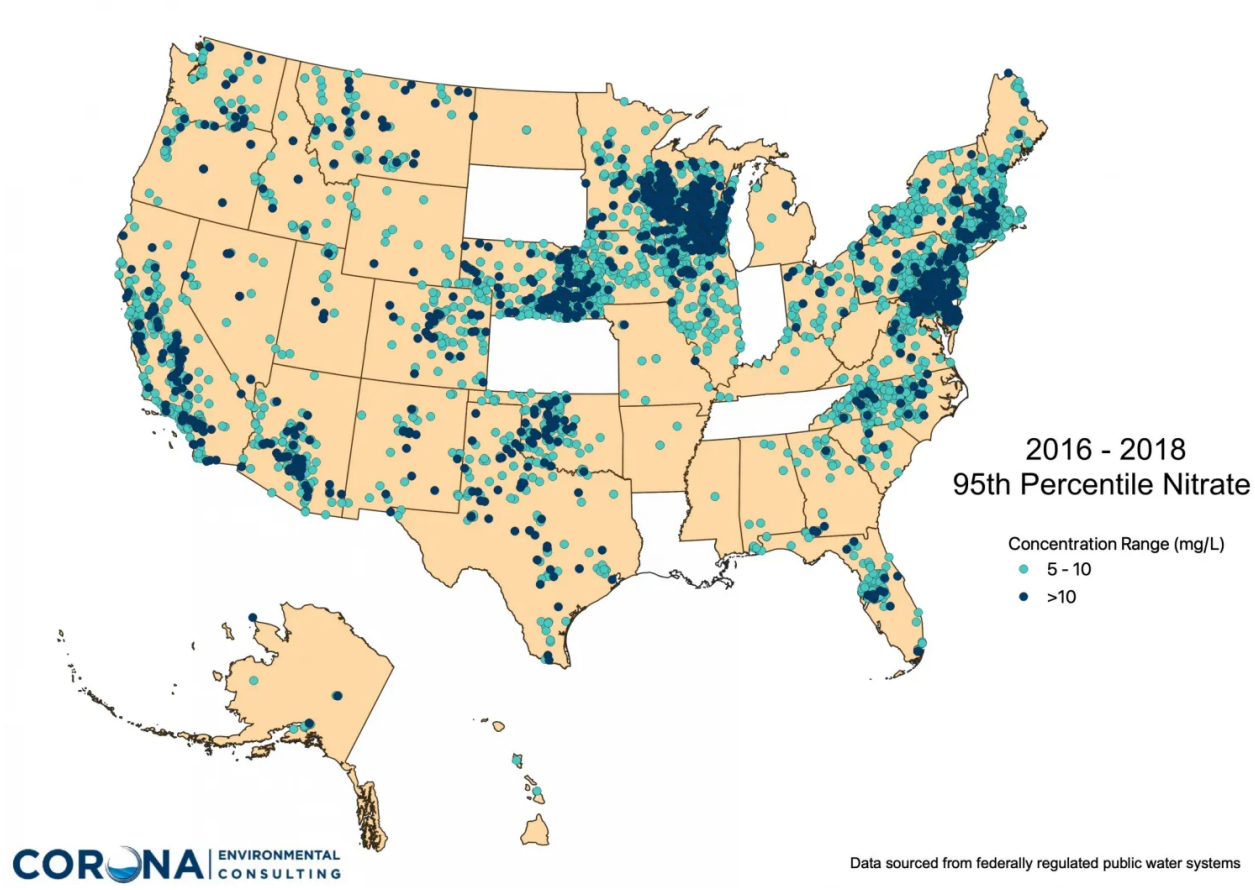
A map of drinking water nitrate violations resembles a map of America's high-value farm regions: California's Central Valley and Washington's Yakima Valley; the Corn Belt from eastern Nebraska through Iowa to Illinois; the Texas Panhandle; nearly all of Wisconsin dairy land; eastern Pennsylvania extending into the tri-state Delmarva region, where poultry operations dominate.

The towns at risk for nitrate in these areas share many characteristics. They are neighbors to the ag industry. They typically use groundwater. Groundwater systems account for nearly 95 percent of nitrate violations, according to the U.S. Environmental Protection Agency. And they are small. Almost all nitrate violations occur in systems that serve fewer than 3,300 people. Especially vulnerable are the very small systems that have a population below 500. In other words, these at-risk towns look a lot like Creighton.



Map Courtesy USGS

This U.S. Geological Survey map shows areas at risk of nitrate contamination in shallow groundwater. Areas shaded red have the highest risk, meaning high nitrogen use from agriculture and aquifers that are vulnerable to contamination – typically those in sandy soils.



This map shows nitrate concentrations in drinking water between 2016 and 2018 for federally regulated water systems. Dark blue dots indicate water systems that exceeded the federal nitrate standard of 10 parts per million. Light blue dots show systems just under the standard, where concentrations were between 5 ppm and 10 ppm. The areas with high nitrate concentrations generally correspond to areas with intensive agriculture where groundwater is a major water source.

States shaded white did not provide or have data. The map shows a combination of nitrate and nitrate-nitrite data from state and federal sources. The map was produced by Corona Environmental Consulting based on a data-collection project funded by the Water Quality Research Foundation.

Kevin Sonnichsen, water commissioner, right, and Alan Novacek, backup operator and sewer commissioner, left, gaze into the Creighton water treatment facility. Built in 1993, the facility uses reverse osmosis to remove nitrate. Creighton was the first community in Nebraska to use reverse osmosis to remove nitrate in drinking water.

First in Line

Creighton, like hundreds of small Nebraska communities, is surrounded by an expanse of corn and soybeans that ripples to the horizon, seemingly without end.

A small, tan building less than a mile east of Main Street has become a pilgrimage site of sorts. Not for religious seekers, but for town administrators and water professionals. The one-story structure at the intersection of state highways 59 and 13 houses the town's nitrate removal facility.

Home to 1,147 people, Creighton was the first town in Nebraska to install reverse osmosis treatment for nitrate, opening the facility in 1991 at a cost of $1.3 million. It needs the facility in order to meet federal drinking water standards. Other communities do, too. Today, the Nebraska Department of Environment and Energy counts 49 public water systems in the state that have reverse osmosis systems for removing nitrate.

Kevin Sonnichsen is the water commissioner for Creighton, Nebraska. Part of this role is operating the machinery that removes nitrate from the town's drinking water.

Kevin Sonnichsen, the town's water commissioner, is responsible for running the facility. The annual operating cost, including electricity and cleaning the filters, is about $550,000. "It's a money pit," Sonnichsen told Circle of Blue.

Creighton's present could be its neighbor's future.

Plainview, another small farm town, is a 15-minute drive southeast of Creighton. The town has two wells, one of which began exceeding the federal nitrate standard in 2020.

Plainview has been down this road before. Town officials had to shutter two other wells because of high nitrate levels. When that happened they drilled new wells. Drilling yet another well will be a challenge. There are few nearby places where the groundwater isn't already contaminated. If a new well doesn't work out, then a reverse osmosis system like Creighton's is a possibility.

Plainview is working with an engineer to determine the better option. Jeremy Tarr, the town administrator, is

preparing to spend a lot. “We know it’s coming,” Tarr said. “We know it’s going to be a big number.”

Tarr worked in other small towns in Nebraska before taking the Plainview job in August 2020. None had nitrate problems, so Tarr is learning the ropes as he goes. He reckons a new well could cost $2 million. “That’s high for a small community,” Tarr said. If a new well is a high cost, a reverse osmosis system would be an astronomical outlay. Tarr will know more in the spring when the engineering reports are filed, but he’s anticipating maybe $8 million or more. “I’m not wanting to go down that road,” he said.

A helping hand for places like Plainview might be on the horizon. A bill introduced on January 19 in the Nebraska Legislature would provide $10 million in grants to rural communities for reverse osmosis treatment systems to remove nitrate. The money would come from the state’s allotment of federal coronavirus relief funds. LB 1160 was introduced by Sen. Anna Wishart, who represents Legislative District 27, an area that includes part of Lincoln and its southwest suburbs. The bill is scheduled to be heard by the Legislature’s Appropriations Committee on March 3.

Nitrate levels in Aurora fluctuate throughout the year, rising and ebbing with fertilizer cycles. At the maximum, nitrate in Aurora is just below the federal standard, though the town did exceed the 10 parts per million (ppm) threshold in the summer of 2017, registering 11.4 ppm.

For utilities that do not meet the current nitrate standard, the treatment options unfortunately are “complicated, onerous to operate, and expensive,” said Chad Seidel of Corona Environmental Consulting. And there is little enthusiasm among town water managers and utility operators for lowering the nitrate standard because of the cost and difficulty of meeting it at 10 parts per million.

The most common treatment option is ion exchange, a process in which contaminated water passes through a filter that swaps out nitrate for another type of ion, like chloride. Ion exchange works, Seidel said, but it has problems. The process introduces salts into the waste stream, which are detrimental for downstream waters. And these systems require savvy, well-trained operators. Tiny communities might not have access to such personnel.

A second option is reverse osmosis, the type of system that Creighton uses. Even that has drawbacks, Seidel said. It produces more corrosive water that could strip lead from pipes. Trained operators are also a requirement. Sonnichsen, Creighton's water manager, wants to retire in a few years. Who, he wonders as the town's population shrinks and ages, will replace him?

Communities nationwide are facing similar financial questions regarding nitrate. Ted Corrigan is the CEO and general manager of Des Moines Water Works, which is the drinking water utility for Iowa's capital city. Des Moines is downstream from one of the most severe zones of agricultural water pollution in the country. Corrigan said

that the utility's $4 million nitrate removal facility, which was installed in 1992, costs $10,000 a day to operate.

It is turned on only when nitrate levels spike in the Raccoon River, one of its water sources. But the fact that the facility exists, Corrigan said, is an indictment of the state's pollution-control measures. "It's a cost that we shouldn't have," Corrigan said. "It's a cost that's inequitable, in my opinion."

Shari Peters displays a bracelet that spells Jacob's name.

Jacob's Road

Jacob's treatment for T-cell lymphoblastic lymphoma started well enough. In those early months the family expected Jacob to join the 80 percent of pediatric lymphoma patients who survive the disease. "Everything is going according to plan," Gary wrote in his journal on February 25, 2011. It was just before Jacob's fourth chemotherapy session.

Weeks stretched into months. Despite the frequent trips to Omaha, Jacob's schooling remained on track throughout the spring. He finished the semester with a 4.0 grade point average. Competitive sports, which, for Jacob, were the grand prize at the end of this dark tunnel, were a possibility again. At the end of May, his doctors allowed Jacob to begin summer football workouts. Gary joined him on that reintroduction to physical exertion.

"Bald, out of shape and of course wearing his mask, he still had spring in his step and an attitude that we have not seen since the diagnosis," Gary noted in his journal on May 31.

Then the disease shifted course and the mood darkened. Jacob relapsed in June. He acquired a staph infection in July. A second relapse came in August. His doctors were anxious, The cancer had spread to Jacob's blood and bone marrow. The best chance for survival, it seemed, was a stem cell transplant. It was scheduled for November, but Jacob kept relapsing, needing more chemotherapy. At that point, the disease broke him, his body no longer able to hold up.

Gary and Shari remain in touch with Don Coulter, Eleanor Rogan, and the rest of the University of Nebraska research team studying nitrates and childhood cancer. They plan to help collect water samples in Aurora for the next phase of research into the environmental factors of pediatric cancer. Anything they can do to find a cause or prevent other families from living their nightmare. "My long-term goal is to have it eliminated," Gary said. "Just find out why. And fix that."

The reporting and photography for this project were funded by a Kozik Environmental Justice Reporting Grant from the National Press Foundation and the National Press Club Journalism Institute.

Banner images from top to bottom:

- Moonrise over Creighton, Nebraska.

- Madalyn “Maddy” Spellman lived in Aurora and died from cancer in September 2016, at age 13. Her parents, Corey and Tammy Spellman, stand over her grave.

- Gary Peters observes football practice at Aurora High School, where he is a volunteer assistant coach.

- Agriculture is the dominant industry in Nebraska, generating $21.4 billion in farm sales in 2019. Rural Nebraska towns pulse with the seasonal rhythms of planting, irrigating, and harvesting.

- Kevin Sonnichsen, water commissioner, right, and Alan Novacek, backup operator and sewer commissioner, left, gaze into the Creighton water treatment facility. Built in 1993, the facility uses reverse osmosis to remove nitrate. Creighton was the first community in Nebraska to use reverse osmosis to remove nitrate in drinking water.

- Shari Peters displays a bracelet that spells Jacob’s name.

Resources and Links

Circle of Blue

Toxic Water, Toxic Crops

Michigan's Groundwater Emergency

U.S. Food Trade Using Unsustainable Groundwater Supplies

Pacific Institute

Nitrates – Central Valley study

The Nitrogen Legacy: The Long-Term Effects of Water Pollution on Human Capital

Peer-Reviewed Research

Drinking Water Nitrate and Human Health: An Updated Review

University of Nebraska Lincoln

Nitrate in Nebraska

Nebraska Nitrate Working Groups – Summary and Call for Action

University of Nebraska Systems

Examining the Effects of Agrichemical Contaminants on Pediatric Cancers

Association between Aqueous Atrazine and Pediatric Cancer in Nebraska

Wilson Center

Groundwater Scarcity, Pollution Set India on Perilous Course

World Bank

Quality Unknown

The Nitrogen Legacy: The Long-Term Effects of Water Pollution on Human Capital

World Water Week

Groundwater: Mapping a Global Story of Pollution, Scarcity and Survival

Additional coverage of agriculture and groundwater

Brett Walton

Brett writes about agriculture, energy, infrastructure, and the politics and economics of water in the United States. He also writes the Federal Water Tap, Circle of Blue's weekly

digest of U.S. government water news. He is the winner of two Society of Environmental Journalists reporting awards, one of the top honors in American environmental journalism: first place for explanatory reporting for a series on septic system pollution in the United States(2016) and third place for beat reporting in a small market (2014). He received the Sierra Club's Distinguished Service Award in 2018. Brett lives in Seattle, where he hikes the mountains and bakes pies. Contact Brett Walton

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