IDAHO
CONSERVATION
LEAGUE

THE 2021
GROUNDWATER REPORT

Groundwater Quality in the Magic Valley

Josh Johnson, Central Idaho Conservation Associate
jjohnson@idahoconservation.org or 208-345-6933 x301.
Idaho Conservation League
PO Box 844
Boise, ID 83701

www.idahoconservation.org
208.345.6933

EXECUTIVE SUMMARY

Groundwater quality in the Magic Valley continues to be degraded as a result of contamination, primarily from the overapplication of fertilizers and animal waste across the Snake River Plain. The groundwater in this region is stored in the Eastern Snake Plain Aquifer (ESPA) – southern Idaho's most important source of drinking water. The ESPA supplies drinking water to over 300,000 Idahoans and is particularly susceptible to contamination because of geologic factors and human activities – including the rapid growth of the industrialized dairy and cattle industries in recent decades, which collectively account for 1.2 million cows and calves in the Magic Valley. The nitrogen and phosphorus from synthetic fertilizer, animal manure, and other sources far exceeds what typical crops can uptake, with the remainder susceptible to leaching into the groundwater.

Since the inaugural Groundwater Report in 2019, the Idaho Conservation League has continued to aggregate new groundwater data collected by state and federal agencies, review the latest peer-reviewed literature pertaining to agricultural pollution, and engage in discussions with local stakeholders and water quality and agricultural professionals in the region. This 2021 Groundwater Report incorporates and synthesizes the latest information available regarding groundwater quality in the Magic Valley.

Our key findings since the last groundwater report:

1. For the third straight year, agencies detected elevated total phosphorus concentrations at a number of springs fed by the Eastern Snake Plain Aquifer, continuing a troubling trend of worsening water quality.
2. County-level analysis of groundwater data for the Magic Valley reveals that the highest and most harmful nitrate concentrations are typically found in Twin Falls, Cassia, and Minidoka counties.
3. A growing body of evidence indicates that long-term ingestion of nitrate in drinking water increases the risk of a myriad of adverse health effects, particularly colorectal cancer. This increased risk is tied to nitrate levels below regulatory limits, suggesting that the current drinking water standard likely does not adequately protect the public from nitrate-related health conditions.
4. 19% of public water systems in the Magic Valley have average nitrate concentrations >5 mg/L based on samples collected in the last five years, a concern given the potential health effects of nitrate in drinking water.

Stricter regulation of fertilizer and animal manure application by the appropriate state agencies along with significant funding to assist and incentivize industry-wide implementation of best management practices are necessary to prevent further groundwater contamination. This issue affects everyone who relies on groundwater in the Magic Valley so we all share a responsibility to address the issue in accordance with our respective impacts, from the dairy operation with 50,000 cows to individual homeowners who fertilize their front yards.

INTRODUCTION

Clean water is important to Idahoans who fish and recreate in our lakes and streams. / Scott Knickerbocker photo.

The Idaho Conservation League is Idaho's leading voice for conservation. With offices in Boise, Ketchum, Sandpoint, and McCall, we work to protect the air you breathe, the water you drink, and the wild places you and your family love.

The Idaho Conservation League (ICL) has been engaged in a multi-year campaign to restore the Snake River in southern Idaho to a swimmable and fishable condition. For decades, water in the Snake River, its tributaries, and its aquifer has been polluted and overdrawn, resulting in poor water quality and declining flows. A river system that begins as a blue-ribbon trout stream in eastern Idaho and western Wyoming morphs into a polluted waterway that at times is unsafe to touch by the time it empties into Hells Canyon near the Oregon border. The massive scale of the problem will require an equally extensive basin-wide restoration plan involving a significant state-federal-Tribal partnership.

A key objective of ICL's Snake River campaign is to improve groundwater quality in the Magic Valley region. An integral part of the Snake River system, the Eastern Snake Plain Aquifer (ESPA) supplies drinking water to over 300,000 Idahoans and supports a large swath of irrigated agriculture in high desert. This report provides an overview of the main threats to groundwater quality in the Magic Valley, examines trends in the available water quality data, and highlights public health concerns stemming from aquifer contamination – in short, a snapshot of the current health of the aquifer.

The motivation for ICL's initial groundwater report in 2019 stemmed from the recognition of declining water quality in the aquifer. Studies clearly identify the sources of pollutants that impact groundwater quality in the Magic Valley (e.g. Frans et al., 2012; Skinner and Rupert, 2012; Rupert et al., 2014). Proliferation of irrigated agriculture and the rapid growth of the industrialized dairy industry have significantly increased the quantities of contaminants (primarily nitrogen and phosphorus) introduced to the landscape and subsequently transported to the underlying aquifer. Nitrate concentrations, already elevated in much of the Magic Valley's groundwater, continue to be a persistent problem (Mahler and Keith, 2002; Skinner, 2017). Based on available data, phosphorus seems to be a growing problem with increasing concentrations found at many ESPA-fed springs along the Snake River. Degraded groundwater quality can lead to a host of health problems and presents a serious threat to one of the most important drinking water sources in Idaho.

Peter Lovera photo.

THE EASTERN SNAKE PLAIN AQUIFER

Geography & Geology

The Eastern Snake Plain Aquifer covers approximately 10,800 square miles in southern Idaho, spanning from St. Anthony to Hagerman (Figure 1). The underground aquifer generally mimics the surface geology of the Snake River Plain, a broad ground depression formed by repeated volcanic activity in the last 12 million years. The northern boundary of the ESPA generally coincides with the southern terminus of mountain ranges in Central and eastern Idaho, while the southern boundary closely mirrors the course of the Snake River. The overall groundwater flow from northeast to southwest parallels a gentle regional elevation gradient in that direction. This flow pattern results in two main areas of discharge from the aquifer to the Snake River – a series of springs near American Falls and the Thousand Springs area near Hagerman (Link and Phoenix, 1996).

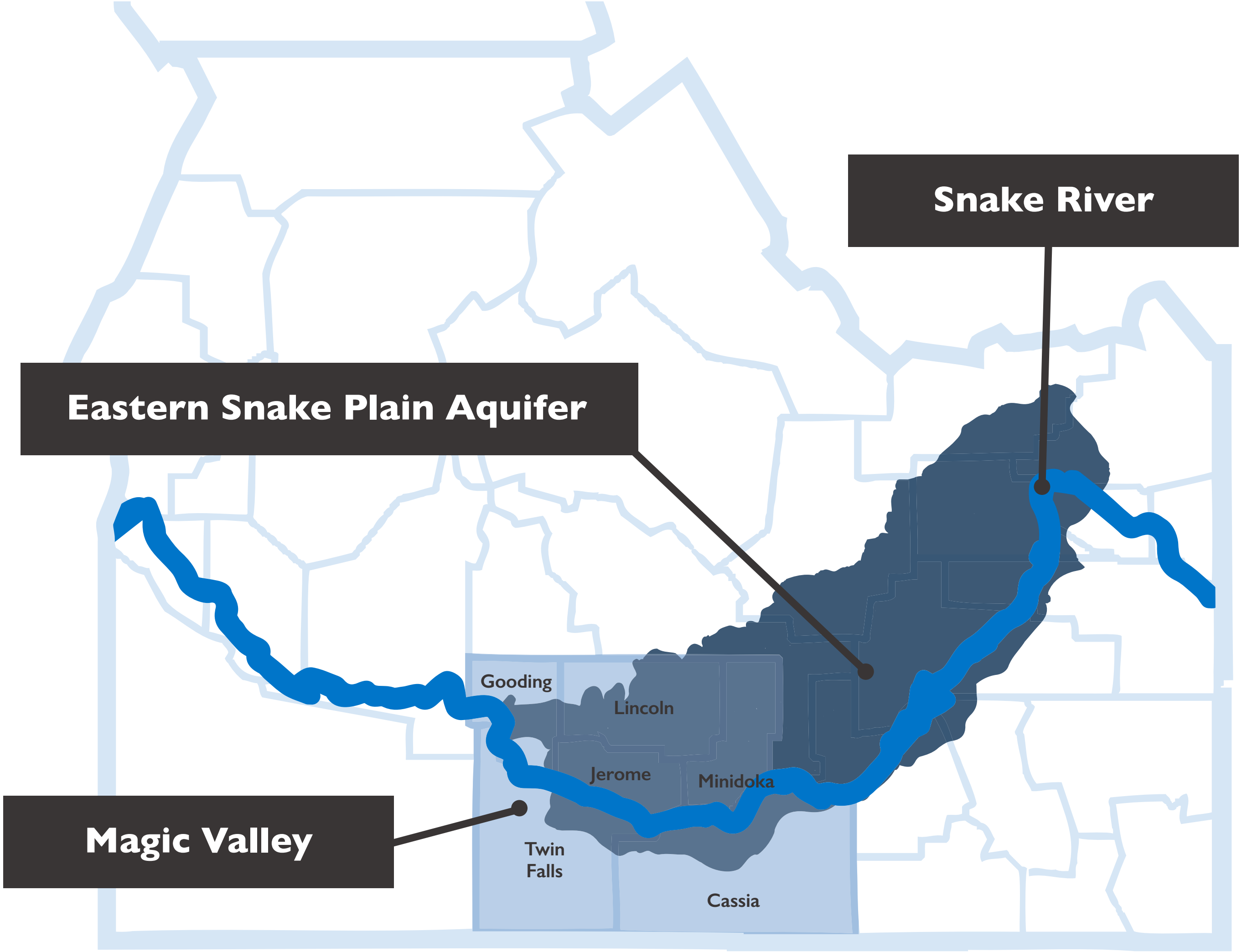


Figure 1. Map of the Eastern Snake Plain Aquifer in southern Idaho.

The ESPA's importance as a high-yielding, productive water supply for Idahoans derives directly from its geology. Beneath the Snake River Plain lies a very thick (~5,000 feet) stack of layered basalts formed during volcanism associated with the passage of the North American plate over the stationary Yellowstone hotspot. This highly fractured basalt allows surface water to easily enter the aquifer through interconnected pore spaces in rubbly lava flows. The upper 300 to 500 feet of the aquifer stores most of the groundwater, but the total storage capacity roughly equals that of Lake Erie (200 to 300 million acre-feet) (IDEQ). Snowpack runoff from Idaho's Central and eastern mountains naturally recharges the aquifer, supplemented by excess irrigation water and managed aquifer recharge.

Importance

The ESPA is the largest aquifer in Idaho and a truly priceless resource. The Environmental Protection Agency has designated the ESPA as a sole source aquifer that supplies drinking water to nearly 300,000 people in south-central and eastern Idaho, including the fast-growing I-86/84 corridor from Twin Falls to Rexburg.

This aquifer enables land in high desert sagebrush to produce the bulk of Idaho's agricultural products and support extensive dairies and feedlots. In total, 2.1 million irrigated acres lie on the ESPA, about 60% of Idaho's total irrigated acres (IDWR, 2009). The generally high-quality, aquifer-fed springs along the Snake River also support a robust aquaculture industry that earned the region the moniker "Trout Capital of the World." In total, the ESPA region produces an estimated 33% of all goods and services in Idaho, valued at $14.9 billion annually (IDWR, 2015).

Snake River in southern Idaho

GROUNDWATER CONTAMINATION

Clean groundwater is vitally important for Idaho given the significance of the ESPA for drinking water and other uses. This section provides an overview of current contamination issues in the Magic Valley and how they affect groundwater quality.

Susceptibility to Contamination

Compared to other aquifers, the ESPA is especially susceptible to contamination due to geologic and human factors (Rupert et al., 2014):

1. ***Geologic Characteristics.*** The same characteristics that make the ESPA such a productive aquifer – well-drained soils and permeable volcanic rock – also make it susceptible to contamination. The high permeability of the aquifer, which stems from the fractured and porous nature of the basaltic rock, gives contaminants easy pathways into the groundwater system.
2. ***Oxic Conditions.*** Groundwater in the ESPA typically displays oxic conditions, meaning it contains at least 0.5 mg/L dissolved oxygen (Rupert et al., 2014). In oxic conditions, nitrate is unlikely to break down into inert nitrogen gas and can therefore persist for decades as a contaminant in the groundwater system (Dubrovsky et al., 2012).
3. ***Irrigation Techniques.*** Excess irrigation water applied to fields seeps into the groundwater, carrying pollutants and other chemicals with it. Users often withdraw shallow groundwater and reapply it to fields, which further concentrates nitrates and other dissolved constituents.

Contaminants of Concern

The primary contaminants of concern affecting groundwater in the Magic Valley are nitrogen and phosphorus. These elements play an important role in plant growth, but in excess quantities can become harmful to human health and the environment. Also, pesticides applied on agricultural fields are a relatively smaller but growing concern for groundwater in the Magic Valley.

Human activities on the Snake River Plain lead to groundwater contamination in the Magic Valley – waste generated by large concentrated animal feeding operations, overapplication of fertilizer on agricultural fields, and, to a much lesser extent, household lawn fertilizer application and leaking septic systems. Unfortunately, current groundwater data in Idaho is not sufficient to provide a specific attribution of nitrogen, phosphorus, and pesticide inputs from different sources. However, for context, researchers in other agriculturally-dominated regions have found that artificial fertilizers and manure accounted for 90% of the nitrogen inputs to groundwater; septic systems and lawn care contributed 9% and 1% of the nitrogen inputs, respectively (Shaw, 1994).

Synthetic Fertilizer

Synthetic fertilizers are one of the largest sources of excess nitrogen and phosphorus in the Snake River Plain. Although crops uptake much of the agriculturally applied synthetic fertilizer, a fraction of it leaches through the soil with rain and excess irrigation water, ultimately reaching the groundwater. Fertilizer use for agricultural purposes on the Snake River Plain increased dramatically after 1950 and accounts for roughly 160,000 tons of nitrogen input annually (Frans et al., 2012).

Animal Manure

Since 1980, the number of dairy cows in Idaho has increased substantially, from 148,000 head in 1980 to 646,000 in 2021 (USDA, 2021). Roughly 470,000 of these dairy cows are located in the Magic Valley region (USDA, 2021). In one year, a dairy cow generates manure that contains an average of 58 pounds of phosphorus and 336 pounds of total nitrogen (ASAE, 2005). For comparison, in one year, the average human produces excrement containing 1.3 pounds of phosphorus and 10 pounds of total nitrogen (Del Porto and Steinfeld, 1999). Thus, the 469,200 dairy cows in the Magic Valley produce manure resulting in a total annual nitrogen input of roughly 79,000 tons – equivalent to the amount of nitrogen produced by the waste of nearly 16 million people. Also, 77,200 beef cattle in the Magic Valley produce additional amounts of nitrogen and phosphorus from their waste (USDA, 2021). The 1.2 million total cows in the Magic Valley (dairy cows + beef cattle + all calves) remain a significant contributor of nitrogen and phosphorus pollution to the Magic Valley's groundwater.

Various state and federal regulations pertaining to fertilizer and waste management apply to dairies, feedlots, and other agricultural operations. But these efforts have not prevented growing contamination of groundwater in the Magic Valley. Despite regular environmental inspections of Idaho dairies and feedlots, a glaring loophole still exists where dairies can "export" their waste to third-party fields that avoid waste management requirements. Irrespective of existing industry regulations, the sheer volume of manure produced every day in the Magic Valley ultimately hinders efforts to disperse and properly dispose of that massive amount of waste. In many areas of the Magic Valley, the combined nitrogen and phosphorus input from fertilizer and animal waste far exceeds what typical crops can uptake, with the remaining nitrogen and phosphorus available to leach into surface and groundwater (e.g. Hirsh and Weil, 2019).

Aerial view of a large dairy in the Magic Valley. EcoFlight Photo.

Pesticides

According to the U.S. Geological Survey (USGS), commercial pesticide applicators, farmers, and homeowners apply about one billion pounds of pesticides annually to agricultural land, non-crop land, and urban areas throughout the United States. Pesticides can reach water-bearing aquifers below ground from application onto crop fields, seepage of contaminated surface water, accidental spills and leaks, improper disposal, and through injection of waste material into wells. Specific information on overall pesticide use in the Magic Valley does not exist.

Other Sources

The State of Idaho has an ongoing aquifer recharge program in the ESPA, which diverts surface water to designated sites with high groundwater connectivity. The Idaho Water Resource Board (IWRB) has set a goal of adding at least 250,000 acre-feet of water per year to the ESPA, a target that has been exceeded in recent years. At a fundamental level, any source of water entering the aquifer in large quantities has the potential to contaminate the groundwater. However, groundwater quality data obtained from IWRB monitoring wells at recharge sites since 2014 indicate relatively low levels of nitrogen (<0.1 mg/L) and phosphorus (<0.05 mg/L) post-recharge. Also, as most recharge sites are located in the upper reaches of the aquifer, recharge water generally mixes with the very clean, deeper groundwater in that part of the aquifer. Thus, aquifer recharge is likely not a major source of the nitrogen and phosphorus contamination currently identified in the ESPA. Nonetheless, the IWRB should continue to ensure that clean water is used to recharge the aquifer to prevent further pollution in the ESPA.

Depending on the age of the system, geologic conditions, and the number of septic tanks in proximity to one another, household septic tanks can also release nitrogen and phosphorus into groundwater. The Idaho Department of Environmental Quality (IDEQ) requires a nutrient-pathogen evaluation for proposed septic systems located in nitrate priority areas, over sensitive resource aquifers, and for all proposed large soil absorption septic systems. No data currently exists for the amount of nitrogen and phosphorus that can be attributed to septic systems in the Magic Valley.

Nitrogen and Phosphorus Leaching

The ability of nitrogen and phosphorus to leach into groundwater depends on how these elements behave in soils. Due to its chemistry, nitrogen – specifically in nitrate form (NO3) – is very mobile in soils and leaches relatively easily into the water (Jury and Nielsen, 1989). About half of all applied nitrogen on agricultural fields contaminates surface and groundwater (Davidson et al., 2012). On the other hand, soils largely retain phosphorus via a process called adsorption. Phosphorus also does not leach easily into water (Sharpley et al., 1993; Sharpley, 1995). This marked difference in mobility helps explain why nitrate has been a more prevalent and severe problem in the ESPA as compared to phosphorus thus far. However, recent research has shown that once a soil reaches its capacity to adsorb phosphorus, the soil can no longer retain phosphorus and the excess will leach into the subsurface (Domagalski and Johnson, 2012). Recent soil studies in the region indicate that some soils have become saturated with phosphorus and that leaching occurs in portions of the Snake River Plain (Lentz et al., 2018). Additional study is needed to confirm the extent of this phenomenon.

Groundwater Flow

Groundwater flow in the aquifer, and not the spatial distribution of nitrogen and phosphorus inputs to the land surface, primarily drive the pattern of groundwater contamination in the ESPA. As shown in Figure 2, regional groundwater typically flows from northeast to southwest due to the geologic shape of the aquifer. Generally high-quality, snowmelt-derived water naturally recharges the aquifer, eventually mixing with lower quality groundwater closer to the Snake River. This reduced-quality groundwater (indicated in pink on Figure 2) derives mainly from human-recharged, agriculturally-impacted water with elevated concentrations of nitrogen. North of the Snake River, mixing of the shallow, high-nitrate groundwater with the deeper, low-nitrate groundwater occurs as the aquifer thins with increasing proximity to the river (Rupert et al., 2014). Without this mixing which forces the higher quality groundwater to the surface, nitrate concentrations would be even higher than are currently observed in the ESPA (Skinner and Rupert, 2012).

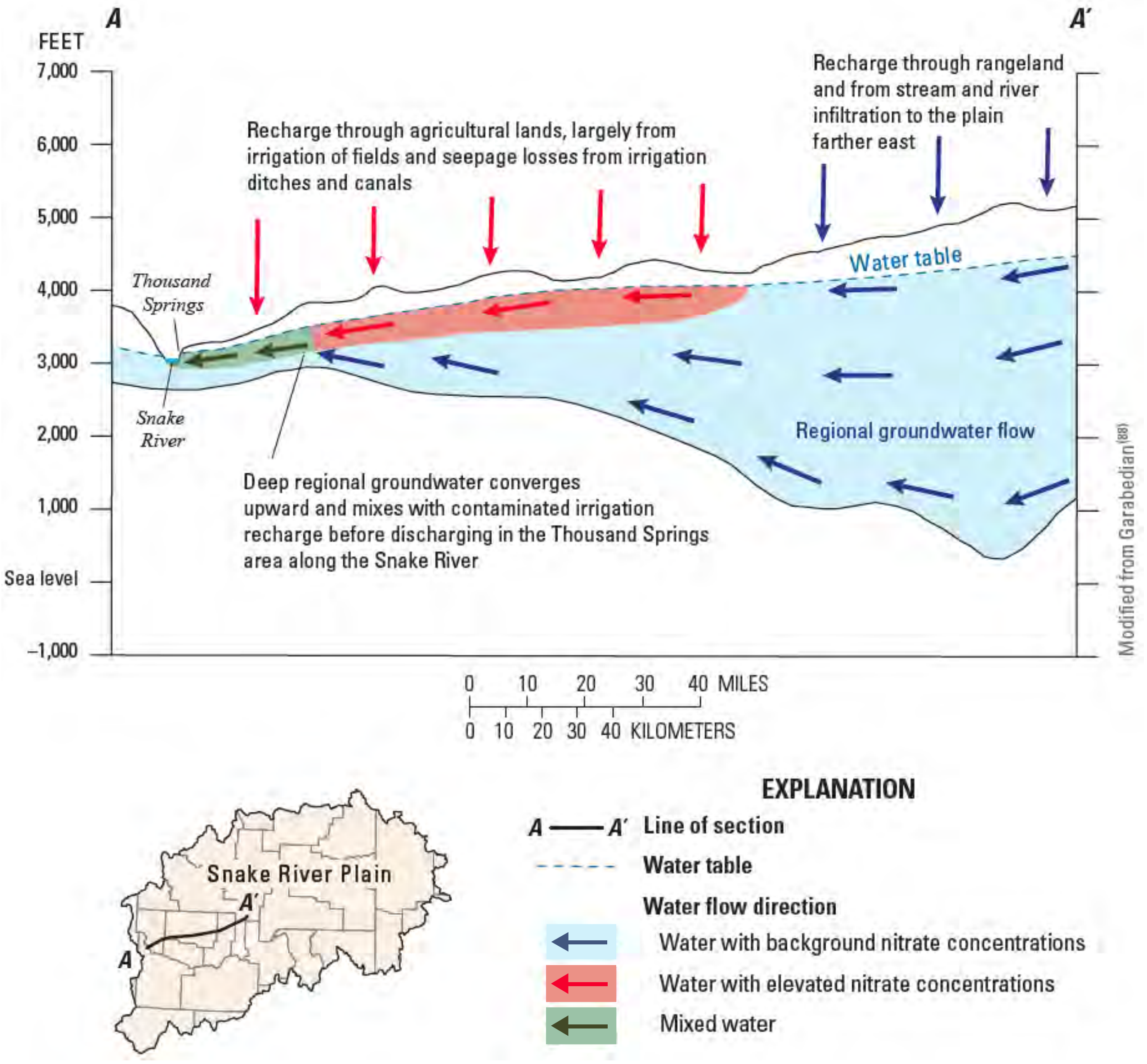


Figure 2. Diagram from Rupert et al., 2014 (Figure 6-9, pg. 49 in that report) showing how groundwater flow patterns in the ESPA influence observed nitrate concentrations.

South of the Snake River, the aquifer thins out with little to no upwelling of high-quality groundwater, as is often the case in the aquifer north of the Snake (Skinner and Rupert, 2012). Thus, areas south of the river (which include the Twin Falls metro area) are particularly at risk from groundwater contamination because they do not have the benefit of dilution with deeper, cleaner groundwater. The velocity of groundwater also factors into groundwater contamination. The groundwater north of the Snake River increases in velocity as it nears the end of the aquifer and discharges from springs, which minimizes time for mixing between poor-quality recharge closer to the surface and the upwelling of cleaner regional groundwater from deeper below. South of the Snake River near Twin Falls, the groundwater does not upwell or accelerate so any poor-quality surface recharge has more time to mix with and degrade the deeper, cleaner groundwater.

GROUNDWATER QUALITY

Phosphorus

Phosphorus data for the ESPA remains limited compared to available nitrate data. Beginning in 2019, IDWR added phosphorus to the list of constituents sampled at wells as part of their statewide monitoring program. Also, the Idaho Department of Fish and Game (IDFG) collects data at ESPA spring sources for the hatcheries they operate along the Snake River. In addition, numerous aquaculture facilities along the Snake River measure phosphorus concentrations in their incoming water (typically spring water), and we recently gained access to this data through their publicly available Discharge Monitoring Reports (DMRs).

Summary of Available Data

Beginning in the 2019 sampling season (and continuing for the foreseeable future), IDWR added total phosphorus to the list of constituents they analyze when sampling wells as part of the Statewide Ambient Groundwater Quality Monitoring Program. Over time, as they collect more years of data, IDWR sampling will significantly enhance our collective understanding of the scope and magnitude of phosphorus contamination in the ESPA.

IDWR regularly samples 33 sites in the Magic Valley as part of the statewide program. In the 2019 and 2020 sampling cycles, they measured a mean phosphorus concentration of 0.042 mg/L, with a median concentration of 0.030 mg/L. Although only two years of total phosphorus sampling has been completed, this dataset will eventually prove invaluable for identifying and tracking trends in phosphorus concentrations over time.

IDFG maintains phosphorus data for the four fish hatchery facilities they operate along the Snake River that rely on spring water from the ESPA: Hagerman State, Hagerman National, Niagara Springs, and Magic Valley. IDFG has devised complicated plumbing systems for the springs feeding these hatcheries These hatcheries use groundwater from the ESPA, but their systems also respond to surface water flows.

IDFG’s data demonstrate a consistent, notable increase in influent, or spring-fed, phosphorus concentrations since late 2017 at all four facilities (Figure 3). Analysis further shows statistically significant increases in phosphorus concentrations since 2011-12 ($p<0.001$). Across all sites, the average influent phosphorus

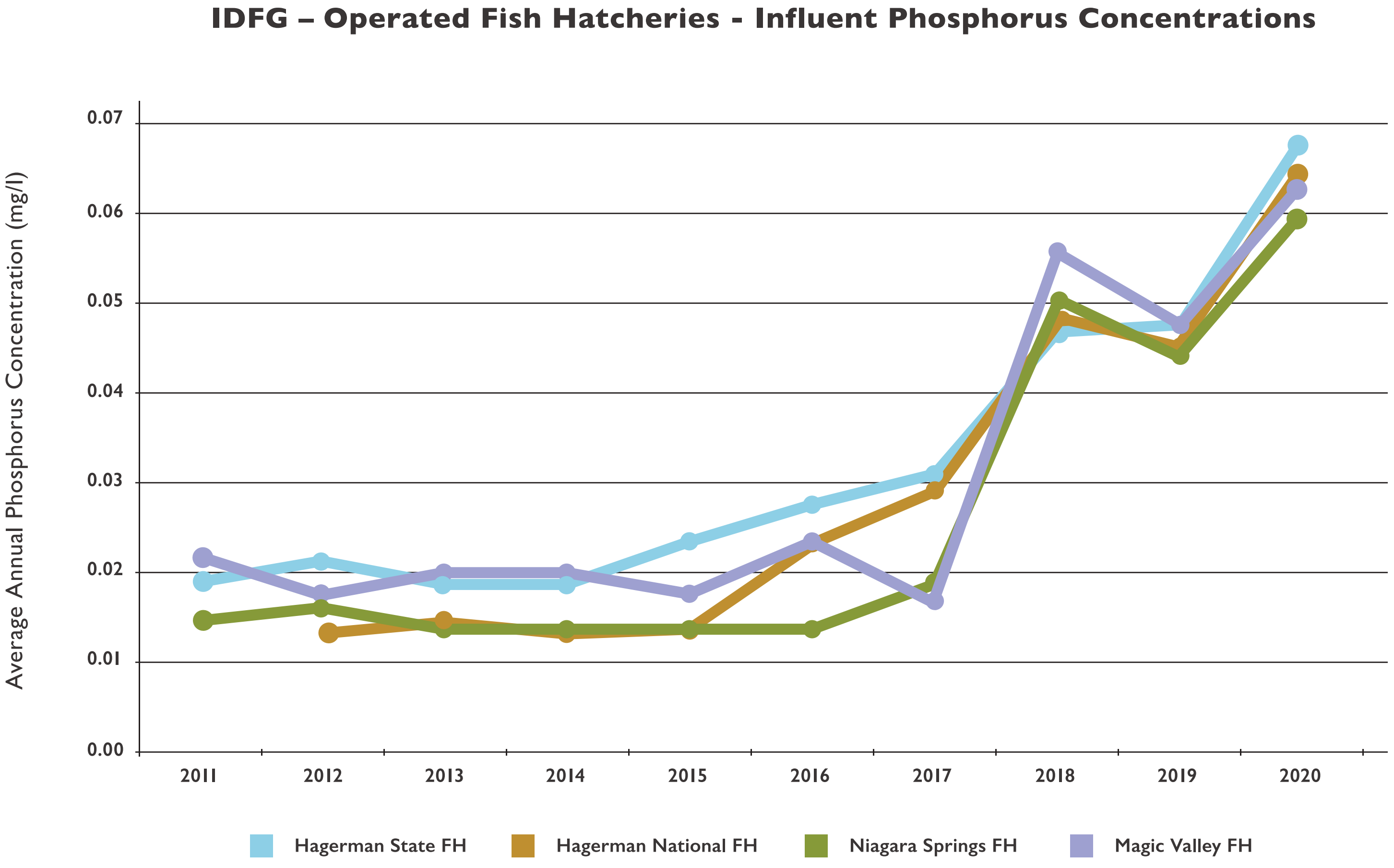


Figure 3. Graph showing increasing phosphorus concentrations in springs fed by the ESPA that flow into Idaho Department of Fish and Game hatcheries along the Snake River. Data obtained from IDFG via public records request.

concentrations have at least doubled from the most recent three-year period (2018-2020) compared to prior three-year periods (2012-2014, 2015-2017). Increasing phosphorus concentrations at each of the four hatchery spring sources starting in Q4 2017 demonstrate that the increase does not originate from an isolated, single spring source. The maximum single-sample influent phosphorus concentration measured from this collection of springs was 0.098 mg/L at the influent spring for the Magic Valley Fish Hatchery (Q2 2020), which is higher than the target instream total phosphorus concentration in that section of the Snake River (0.075 mg/L). Please refer to Appendix I for the full hatchery dataset and additional graphs.

IDEQ requires aquaculture facilities along the Snake River or its tributaries within the upper Snake Rock subbasin to measure phosphorus concentrations of their incoming water (typically from aquifer-fed springs) as part of their discharge permits. This data is publicly available through the facilities' monthly Discharge Monitoring Reports (DMRs). We obtained these DMRs from aquaculture facilities where the majority of ESPA-fed springs are located. We then whittled down this large dataset specifically to focus on aquaculture facilities that get their influent water from a single spring and not from other sources like creeks and canals. This approach left us with about 25 aquaculture facilities in the area with data from October 2008 to December 2019.

For this analysis, we chose to use a total phosphorus (TP) concentration of 0.02 mg/L as a reference point; the target groundwater concentration in the Mid-Snake Total Daily Maximum Load (TMDL) plan to reduce phosphorus pollution. Because phosphorus does not tend to easily leach into water due to its chemical properties, groundwater concentrations above background levels are significant. From analysis of 2008 to 2019 data, we found statistically significant increases in phosphorus levels:

- Since 2008, phosphorus concentrations have significantly increased ($p<0.001$) in Magic Valley springs.
- 56% of the analyzed springs had a majority of samples measure >0.02 mg/L TP, which is the typical maximum natural background concentration of phosphorus in groundwater.
- The average of all 2,728 TP samples from 11 years of data from these 25 springs was 0.0275 mg/L, with 51% of samples >0.02 mg/L TP and 15% of samples >0.04 mg/L TP.

Several data charts from the analyzed springs can be found in Appendix II.

Past Studies

In the USGS study on groundwater quality in Jerome and Gooding counties referenced in the "Nitrate" section, their scientists also collected orthophosphate (the dissolved component of total phosphorus) data from a total of 36 wells, which showed elevated concentrations ranging from 0.014 mg/L to 0.081 mg/L (Skinner, 2017).

Projected Trends

Phosphorus concentrations have shown a notable upward trend during the last three years in various ESPA-sourced springs. Although too early to tell if this is a long-term trend, we reasonably expect these increases to continue given ongoing land-use practices. In addition, more evidence suggests that continued phosphorus loading from animal waste and other sources could be saturating soils in isolated areas of the Magic Valley. Soil saturation prevents phosphorus adsorption and leads to increased leaching of dissolved phosphorus into the groundwater (Lentz et al., 2018). Previous studies have shown that once phosphorus leaching zones develop, they can have long-term, negative effects on groundwater quality. And that it can take several decades to return to compliant water quality standard levels (Schoumans and Groenendijk, 2000; Sharpley et al., 2013).

Nitrate

Compared to phosphorus, more robust data exists for nitrate concentrations in the Magic Valley's groundwater. We analysed the majority of the available data from IDWR's Environmental Data Management System (EDMS) database. We also received a subset of more recent nitrate data from the IDEQ via a public records request. In the past, the USGS has also conducted several nitrate studies relevant to the ESPA.

Low levels of nitrate naturally occur in groundwater, but concentrations above 2 mg/L indicate that human activities have put nitrate into groundwater (Mahler and Keith, 2002). The federal drinking water standard for nitrate is 10 mg/L, but recent studies have shown that adverse health effects can occur at nitrate concentrations below regulatory levels (Ward et al., 2018). Many of the epidemiological studies cited in Ward et al. used 5 mg/L as a marker for "high nitrate drinking water." For that reason, we have chosen 5 mg/L nitrate as a general threshold of concern for health effects related to nitrate rather than the drinking water standard of 10 mg/L (which was developed specifically for infants and blue-baby syndrome). Please refer to the "Public Health Concerns" section of this report for more information.

Summary of Available Data

The available groundwater data for the ESPA clearly indicate that nitrate contamination continues to be a significant, widespread issue affecting the drinking water of Idahoans. In our analysis of all publicly available nitrate monitoring well data for the Magic Valley (Gooding, Twin Falls, Lincoln, Minidoka, Jerome, and Cassia counties) going back to 2001, 73% of all well samples had nitrate concentrations greater than background levels (>2 mg/L), including 38% of samples above 5 mg/L. IDWR data did not show a substantive difference in the percentage of samples with elevated nitrate levels when compared with the full dataset from across all relevant agencies, or data from just the last five years.

We also analyzed the full nitrate monitoring well dataset on the county level for the Magic Valley. This breakdown, shown in Figure 4, clearly highlights Cassia, Minidoka, and Twin Falls counties as regional hot spots of elevated nitrate levels, each with about 40% of their well samples showing concentrations above 5 mg/L. These county-by-county differences in nitrate levels were statistically significant ($p<0.001$). This data corresponds with groundwater flow modeling predictions for the ESPA (Rupert et al., 2014), as these three counties lie above portions of the aquifer that pinch out and thin closer to the Snake River. This geology means these wells contain a higher proportion of shallow, dirtier groundwater versus deeper, cleaner groundwater.

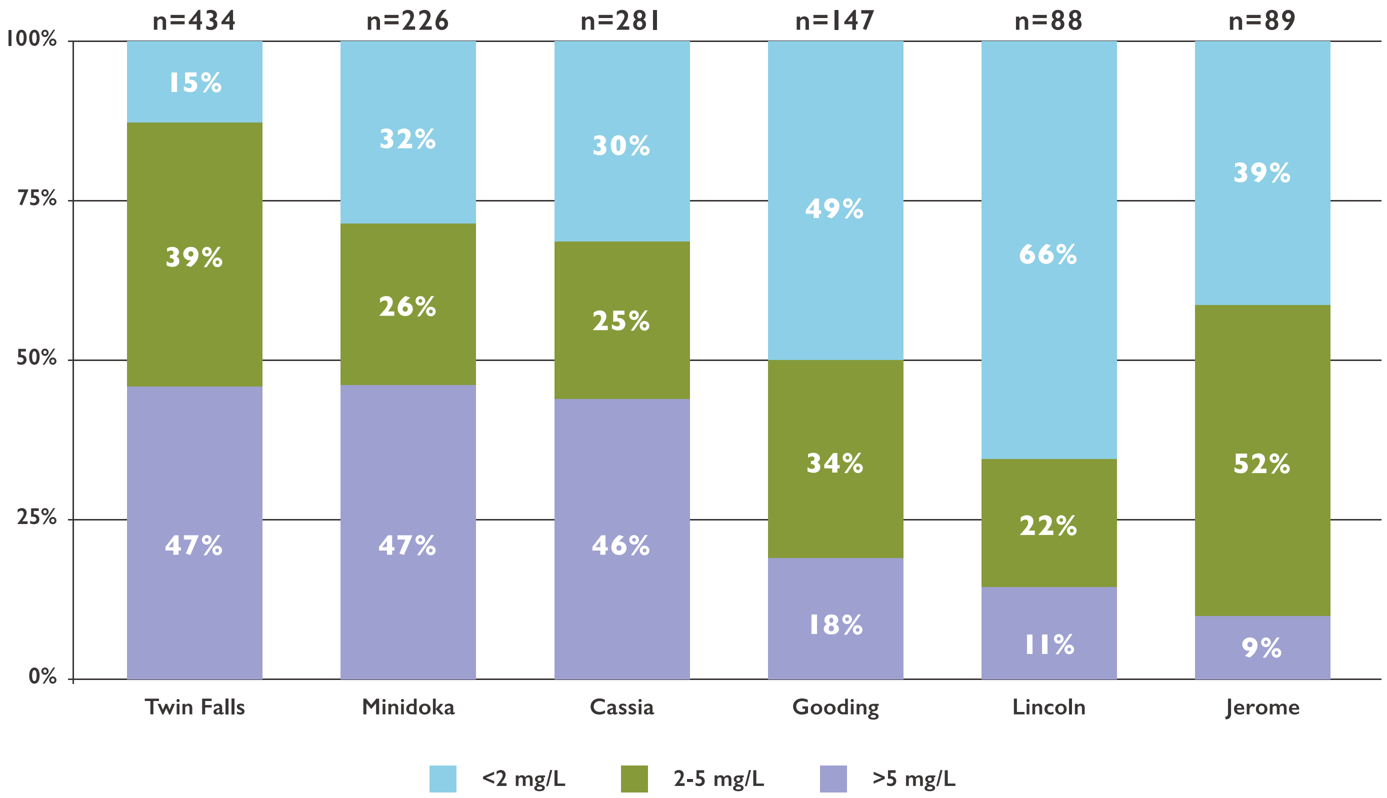

NITRATE CONCENTRATIONS IN THE MAGIC VALLEY

Figure 4. Graph showing the percentage of nitrate samples by concentration for each of the six counties in the Magic Valley. Monitoring well data obtained from IDWR, IDEQ, and ISDA (2001-2020).

---

[2] These well samples are predominantly from the ESPA, but a small percentage come from a perched aquifer in the southern Minidoka County/northern Cassia County area that is only influenced by human-related recharge.

Through a public records request to IDEQ, we obtained a dataset containing 1,560 water samples from all of the public water systems (PWS) in the Magic Valley from the last five years. 40% of these individual well samples had measured nitrate concentrations above 5 mg/L. Thirty-one of the PWS (18% of the total in the Magic Valley) averaged >5 mg/L over the last five years of sampling. The City of Twin Falls PWS, which serves a population of approximately 50,000, had an average nitrate concentration of 4.8 mg/L over the last five years. Similar to the county-level analysis we did for the monitoring well dataset, the PWS dataset also highlights Cassia, Minidoka, and Twin Falls counties as regional hot spots of elevated nitrate levels, each with about 40% of their PWS samples showing concentrations above 5 mg/L.

Past Studies

A 2012 USGS study analyzed existing nitrate data from the ESPA and found that most wells with numerous samples collected over time showed increasing trends in nitrate concentration (Frans et al., 2012). In 2017, the USGS published a report on groundwater quality in Jerome and Gooding counties. USGS researchers took groundwater samples from 36 wells and analyzed for a number of constituents, including nitrate. The data showed generally increasing concentrations with increasing proximity to the Snake River (Figure 4 in Skinner, 2017), consistent with expected concentration patterns based on groundwater flow dynamics. Nitrate concentrations above 2 mg/L were widespread in southern Jerome County and southeastern Gooding County, with an isolated maximum of 9.93 mg/L (Skinner, 2017).

IDEQ identified 35 "nitrate priority areas" (NPAs) throughout the state during its last assessment in 2020. In these NPAs, at least 25% of wells sampled have nitrate concentrations of 5 mg/L or greater. Five of the 35 NPAs in Idaho lie within the Magic Valley, including two of the five top priority areas (Minidoka and Marsh Creek NPAs). Wells sampled within the Marsh Creek NPA had an average nitrate concentration of 6.8 mg/L and a maximum concentration of 40 mg/L, an increasing trend from previous assessments (IDEQ, 2020). 88% of samples from Marsh Creek had nitrate concentrations above background levels (>2 mg/L), with 20% of samples in excess of the drinking water standard of 10 mg/L (IDEQ, 2020).

Projected Trends

Based on numerical modeling simulations, a 2012 USGS report concluded that current hotspots of high nitrate concentrations (8-12 mg/L), such as southwest Minidoka County and northern Twin Falls and Cassia counties, will continue to increase in severity (Skinner and Rupert, 2012). Paradoxically, areas of high nitrogen input, such as western Jerome County and southern Gooding County, will continue to have relatively low nitrate concentrations (<2 mg/L) because of consistent upwelling of low-nitrate groundwater in these areas (Skinner and Rupert, 2012). USGS numerical model simulations of nitrate in the ESPA indicate that it will take 40 to 50 years for concentrations to fully respond to the effects of drastically increased nitrogen inputs in recent decades (Skinner and Rupert, 2012). Thus, even if nitrogen inputs were held constant for the next several decades, concentrations would continue to increase for a significant amount of time before eventually leveling off (Skinner and Rupert, 2012). This same study also showed that if all agricultural nitrogen input was stopped immediately, nitrate concentrations would begin to decline in five to 10 years. This phenomenon highlights the notable lag time between land use activities and changes in groundwater quality (Rupert et al., 2014).

Pesticides

Summary of Available Data

The latest data published by ISDA, in their 2019 technical summary, indicate mostly low-level detections of 26 different types of pesticides across the 255 monitoring wells surveyed in Idaho. In the Magic Valley, detectable pesticides were most likely in the shallow aquifers in Twin Falls, Cassia, and Minidoka counties. This finding correlates with the higher risk areas for nitrate and phosphorus pollution based on groundwater flow and mixing dynamics. The most widespread pesticide detected in the Magic Valley's groundwater is atrazine, a common herbicide.

Projected Trends

Pesticide use remains widespread across the Snake River Plain. We expect increased detection in groundwater of certain widely-used pesticides in the Magic Valley as long as their use remains steady or goes up. Elevated concentrations are most likely to occur in the general contaminant hotspots of Twin Falls, Cassia, and Minidoka counties.

South Fork Snake River

IMPLICATIONS

Morley Nelson photo.

Public Health Concerns

The ESPA provides drinking water – from private wells and public systems (where water is generally treated to some degree) – to over 300,000 Idahoans so its quality matters.

Nitrate

Nitrate causes human health problems when found above certain concentrations in drinking water (Mahler et al., 2007; Ward et al., 2018). Colorless, odorless, and tasteless in water, nitrate can only be detected by laboratory testing. The U.S. drinking water standard for nitrate is 10 mg/L; a standard developed in 1962 in order to protect against methemoglobinemia (also known as blue-baby syndrome). This condition affects infants younger than six months old. Bacteria in the digestive tracts of infants change nitrate into nitrite, which then enters the infant's bloodstream and reacts with hemoglobin (the molecule that carries oxygen in the bloodstream). This reaction produces a new compound called methemoglobin, which interferes with the blood's ability to carry oxygen. In the worst-case scenario, this process results in decreasing oxygen levels leading to rare infant deaths (Mahler et al., 2007).

For decades, blue-baby syndrome was the primary health concern associated with nitrate in drinking water, and it remains a serious concern now as commonly reflected in regulatory health guidance (Temkin et al., 2019). Prior to 2010, a scant few studies dealt with nitrate levels; studies that did established possible links between long-term exposure to nitrate concentrations greater than 2 mg/L and increased risk of bladder and ovarian cancer (Weyer et al., 2001), as well as non-Hodgkin's lymphoma (Ward et al., 1996).

The growing body of epidemiological evidence linking nitrate in drinking water with a myriad of human health problems, other than blue-baby syndrome, raises troubling questions about whether the current drinking water standard protects the general population (Temkin et al., 2019). A comprehensive 2018 review of drinking water nitrate and human health found that a large body of epidemiological research supports a connection between the presence of nitrate in drinking water and an elevated risk of colorectal cancer, adverse birth outcomes, and other health impacts, such as thyroid disease (Ward et al., 2018). Many cancer risks do not have an absolute threshold value, but the risk rises as the carcinogen level (in this case, nitrate concentrations) rises.

Crucially, many of these studies observed increased risk of health conditions with nitrate levels below the regulatory level of 10 mg/L (Ward et al., 2018). Given that the nitrate drinking water standard of 10 mg/L was developed in 1962 specifically for blue-baby syndrome, this standard should not be viewed as any sort of "magic number" by the general public or by the regulatory agencies. Quite often, we find that health officials downplay elevated nitrate levels in the Magic Valley because they do not exceed the 10 mg/L standard.

Justin Hayes photo.

For state or federal health officials to assure the rest of the population that their drinking water is safe as long as nitrate levels are below 10 mg/L is misguided and not based on current, relevant science. As noted above, nitrate levels below regulatory limits likely still increase the risk for adverse health effects among adults. In the absence of specific information, the goal should be to reduce nitrate levels as much as possible, not just below the outdated and incomplete regulatory standard.

In 2019, the first study of its kind attempted to quantify the health and economic impacts due to nitrate in drinking water in the United States (Temkin et al., 2019). Using a meta-analysis of several existing epidemiological studies of drinking water nitrate and cancer risk, this study found an average of 6,500 nitrate-attributable cancer cases annually with an economic cost of hundreds of millions of dollars for medical expenses alone (Temkin et al., 2019). That same study also observed a statistically significant positive association for nitrate exposure and colorectal cancer risk. Ultimately, the study concluded that lowering nitrate levels in drinking water would not only lower the risk of related adverse health effects, but would also bring economic benefits by reducing the medical expenses associated with the treatment of health conditions.

A similar study done for the State of Wisconsin showed roughly 100 to 300 annual cases of various cancers that could be attributed to nitrate contamination of drinking water (Mathewson et al., 2020). The direct medical costs attributable to all adverse health outcomes from nitrate-laden drinking water in Wisconsin were estimated to be between $23 million and $80 million annually (Mathewson et al., 2020). While a similar targeted study has not yet been completed for Idaho, we would expect the attributable medical costs here to be of the same order of magnitude.

Phosphorus

The presence of phosphorus in drinking water is not known to have direct human health effects. However, phosphorus in the ESPA contributes to the overall rise of phosphorus concentrations in the Snake River. The overabundance of phosphorus in the Snake has contributed to the formation of harmful algal outbreaks, particularly in the numerous slow-moving reservoirs along the length of the river. (Higgins et al., 2017). In some circumstances, harmful algal outbreaks can produce toxins that cause a variety of illnesses in humans (Fleming et al., 2002). Outbreaks of harmful algae on the Snake River and its reservoirs regularly result in closures of swimming areas and present dangers to humans, animals, livestock, and pets.

Pesticides

Pesticides refer to a large group of chemicals used to kill or control pests. Whether these contaminants pose a health risk depends on pesticide toxicity, the amount in water, and how much exposure occurs on a daily basis. The most common pesticide detected in southern Idaho by the ISDA's groundwater pesticide monitoring program is a herbicide called atrazine (ISDA, 2020). The EPA notes that atrazine causes numerous adverse health effects and the European Union bans use of this chemical due to its toxicity. Additionally, atrazine contamination of drinking water is known to cause adverse birth outcomes at contaminant levels below the federal drinking water standard (Almberg et al., 2018). At present, the groundwater data from the Magic Valley does not indicate the presence of widespread atrazine contamination, but this pesticide is worth monitoring into the future.

Failure to Meet Water Quality Standards

If current trends continue, it is increasingly likely that nitrate levels in drinking water will exceed the 10 mg/L standard in areas near the communities of Twin Falls, Buhl, and Paul. A recent EPA nationwide nitrate modeling study identified the Snake River Plain as one of the standout regions nationally to have a high predicted probability of potential nitrate violations (Pennino et al., 2020). Based on USGS numerical modeling and existing groundwater data, northern Twin Falls County, northwest Cassia County, and southwest Minidoka County are at higher risk of violating federal/state standards than other areas in the Snake River Plain (Skinner and Rupert, 2012).

Idaho does not have a groundwater quality standard for phosphorus because it is not directly linked to human health effects in drinking water. However, the aquifer feeds numerous springs that discharge into the Snake River, which is listed as impaired for phosphorus for its entire length along the ESPA. Excessive levels of phosphorus contribute to elevated levels of aquatic plant growth that reduce oxygen levels; this leads to fish kills and reduced habitat quality. It also contributes to outbreaks of toxic algae, which poses a serious human health risk. If the springs that recharge the Snake River carry increasingly significant phosphorus loads, it will exacerbate contaminant-related problems and lead to continued violation of surface water quality standards in the Snake River.

Snake River

NEXT STEPS

South Fork Snake River / BLM Photo.

Rising nitrate, phosphorus, and pesticide concentrations in the Magic Valley's groundwater continue to have serious implications for public health and the state's ability to meet its water quality standards. The available groundwater quality data, while still somewhat limited, clearly indicate nitrate and phosphorus concentrations well above natural background levels in significant portions of the ESPA. These concentrations are projected to continue to rise for the foreseeable future and, as recent medical research identifies potential links between long-term nitrate ingestion and cancer risk, human health risks likely will increase.

Groundwater contamination in the Magic Valley is unequivocally linked to human activities on the Snake River Plain – waste generated by large concentrated animal feeding operations, overapplication of fertilizer on agricultural fields, and to a much lesser extent, household lawn fertilizers and leaking septic systems. To meaningfully address this growing problem and substantially curtail groundwater pollution, we provide the following recommendations:

1. Better characterize and publicize the problem. The existing groundwater quality data for the ESPA is only sufficient to highlight a growing problem, not to fully characterize the issue. The state should continue to develop a widespread monitoring well network across the Magic Valley, with the data compiled in a user-friendly, publicly accessible database. Pairing groundwater data with demographic information would allow a better assessment of whether certain communities are particularly at risk from groundwater contamination. First and foremost, Idahoans deserve to know what is in their drinking water and if their health is at risk.

2. Infusion of federal funding. A significant investment of federal funds is needed to address non-point source pollution that contaminates the Magic Valley's groundwater. These funds should incentivize the adoption of better manure management and best management practices on agricultural fields. The recent Columbia Basin Initiative proposal from Rep. Mike Simpson, if passed through congress, would provide new funding for protection and restoration of water resources in the Magic Valley. The proposal currently includes $700 million for watershed partnerships in the basin, along with $1.6 billion for research and development associated with animal water management. Major investments at a similar scale will be required to protect southern Idaho's critically important groundwater resources.

3. Implement best management practices industry-wide. Widespread adoption of practices such as cover crops, residue management, and conservation tillage can help reduce leaching and runoff from agricultural fields and lessen nitrogen and phosphorus inputs to the aquifer below. One promising approach comes from an Ohio-based coalition group called H2Ohio, who have identified the 10 most effective and cost-efficient practices proven to reduce agricultural phosphorus runoff and then provide economic incentives to farmers who develop management plans that incorporate these best management practices.

4. Implement more effective and transparent management of animal waste. Existing management regulations are not sufficient to prevent the overapplication of animal waste. A publicly-accessible inventory of concentrated animal feeding operations should be created to increase transparency and accountability among some of the biggest contributors of nitrogen and phosphorus. Additionally, the third-party manure application loophole must be closed; currently, dairies can send large quantities of manure to external fields to be land applied outside their nutrient management plans. Innovative approaches that extract pollutants from manure should also be explored.

5. Centralize oversight responsibility. The current regulatory structure as defined by the *Idaho Ground Water Protection Interagency Cooperative Agreement* splits the responsibility of groundwater quality protection and sampling among five different state agencies, a disjointed and ineffectual approach. Centralizing this responsibility under a single regulatory agency would improve the effectiveness and accountability of the state in dealing with matters of groundwater protection.

It is paramount to protect the quality of our drinking water in the Magic Valley. Groundwater contamination affects everyone in the Magic Valley, and we all have a responsibility to help fix the problem. ICL will continue to work with the relevant stakeholders and state and federal agencies to address this issue head-on.

Please contact Josh Johnson, Central Idaho Conservation Associate,
for more information at jjohnson@idahoconservation.org or 208-345-6933 x301.

REFERENCES CITED

Almberg, K. S., Turyk, M. E., Jones, R. M., Rankin, K., Freels, S., & Stayner, L. T. (2018). Atrazine Contamination of Drinking Water and Adverse Birth Outcomes in Community Water Systems with Elevated Atrazine in Ohio, 2006□2008. International journal of environmental research and public health, 15(9), 1889.

(ASAE) American Society of Agricultural Engineers (2005). Manure Production and Characteristics. In: A.S.o.A. Engineers (eds.). St. Joseph, MI: American Society of Agricultural and Biological Engineers.

Davidson E.A., David M.B., Galloway J.N., Goodale C.L., Haeuber R., Harrison J.A., Howarth R.W., Jaynes D.B., Lowrance R.R., Nolan B.T., et al. (2012). Excess nitrogen in the U.S. environment: Trends, risks, and solutions. In Issues in Ecology. Washington, DC: Ecological Society of America.

Del Porto, D. and Steinfeld, C. (1999). The Composting Toilet System Book. Concord, Mass.: Center for Ecological Pollution Prevention, 234 p.

Domagalski, J. and Johnson, H. (2012). Phosphorus and Groundwater: Establishing Links Between Agricultural Use and Transport to Streams. U.S. Geological Survey Fact Sheet 2012–3004.

Fleming, L., Backer, L., and Rowan, A. (2002). The epidemiology of human illnesses associated with harmful algal blooms. In E. Massaro (Ed.), Handbook of Neurotoxicology (pp. 363-381). New York, NY: Humana Press.

Frans, L.M., Rupert, M.G., Hunt, C.D., Jr., and Skinner, K.D. (2012). Groundwater quality in the Columbia Plateau, Snake River Plain, and Oahu basaltic-rock and basin-fill aquifers in the northwestern United States and Hawaii, 1992-2010. U.S. Geological Survey Scientific Investigations Report, 5123.

Higgins, S.N., Paterson, M.J., Hecky, R.E., Schindler, D.W., Venkiteswaran, J.J., and Findlay, D.L. (2017). Biological nitrogen fixation prevents the response of a eutrophic lake to reduced loading of nitrogen: Evidence from a 46-year whole-lake experiment. Ecosystems, 21, 1088-1100.

Hirsh, S.M., and Weil, R.R. (2019). Deep Soil Cores Reveal Large End-of-Season Residual Mineral Nitrogen Pool. Agricultural & Environmental Letters, 4(1).

(IDA) Idaho Dairymen's Association (2021). IDA Presentation to the Idaho House Agricultural Affairs Committee on 2/8/21. Accessed at: https://legislature.idaho.gov/wp-content/uploads/sessioninfo/ 2021/standingcommittees/210218_saga_0800AM-Minutes_Attachment_1.pdf.

(IDEQ) Idaho Department of Environmental Quality (2020). 2020 Nitrate Priority Area Delineation and Ranking Process. Accessed at: https://www2.deq.idaho.gov/admin/LEIA/api/document/ download/15259.

(IDEQ) Idaho Department of Environmental Quality. Sole Source Aquifers. Accessed at: http://www.deq.idaho.gov/water-quality/ground-water/sole-source-aquifers/.

(IDWR) Idaho Department of Water Resources (2009). Eastern Snake Plain Aquifer (ESPA): Comprehensive Management Plan.

(IDWR) Idaho Department of Water Resources (2015). Addressing a history of ESPA declines: Aquifer history, delivery calls, and settlement. Presented to Natural Resources Interim Committee on October 16, 2015.

(ISDA) Idaho State Department of Agriculture (2017). Active Producers with Inspections dated 10/25/2016 – 10/25/2017, Estimated Mature Animal Summary. Idaho Department of Agriculture – Bureau of Dairying.

(ISDA) Idaho State Department of Agriculture (2020). Regional and Local Pesticide and Ground Water Monitoring Results, 2019. ISDA Technical Summary #60. Authored by: Curtis Cooper, PhD.

Jury, W.A., and Nielsen, D.R. (1989). Nitrate transport and leaching mechanisms. In R.F. Follett (Ed.), Developments in Agricultural and Managed-Forest Ecology (pp. 139-157). Amsterdam, Netherlands: Elsevier.

Lentz, R.D., Carver, D.L., Haye, S.V. (2018). Changes in groundwater quality and agriculture in forty years on the Twin Falls irrigation tract in southern Idaho. Journal of Soil and Water Conservation, 73(2), 107-119.

Link, P.K. and Phoenix, E.C. (1996). Rocks, Rail, & Trails (2nd ed.). Pocatello, ID: Idaho Museum of Natural History.

(LPELC) Livestock and Poultry Environmental Learning Community, 2019. Liquid manure storage ponds, pits, and tanks. Accessed at: https://lpelc.org/liquid-manure-storage-ponds-pits-and-tanks/.

Mahler, R.L., Colter, A., and Hirnyck, R. (2007). Nitrate and Groundwater. University of Idaho Extension, CIS 872. Accessed at: https://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS0872.pdf.

Mahler, R.L. and Keith, K.E. (2002). Idaho's Nitrate Areas of Concern. University of Idaho Extension, CIS 1099. Accessed at: https://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS1099.pdf.

Mathewson, P.D., Evans, S., Byrnes, T., Joos, A., and Naidenko, O.V. (2020). Health and economic impact of nitrate pollution in drinking water: a Wisconsin case study. Environmental Monitoring and Assessment, 192(724)

Pennino, M.J., Leibowitz, S.G., Compton, J.E., Hill, R.A., and Sabo, R.D. (2020). Patterns and predictions of drinking water nitrate violations across the conterminous United States. Science of the Total Environment, 722.

Plummer, L.N., Rupert, M.G., Busenberg, E., and Schlosser, P. (2000). Age of irrigation water in ground water from the Eastern Snake River Plain Aquifer, south-central Idaho. Ground Water, 38(2), 264-283.

Rupert, M.G., Hunt, C.D., Jr., Skinner, K.D., Frans, L.M., and Mahler, B.J. (2014). The quality of our Nation's waters—Groundwater quality in the Columbia Plateau and Snake River Plain basin-fill and basaltic-rock aquifers and the Hawaiian volcanic-rock aquifers, Washington, Idaho, and Hawaii, 1993–2005. U.S. Geological Survey Circular, 1359.

Schoumans, O.F., and P. Groenendijk (2000). Modeling soil phosphorus levels and phosphorus leaching from agricultural land in the Netherlands. Journal of Environmental Quality, 29(1), 111-116.

Sharpley, A.N., Daniel, T.C., and Edwards, D.R. (1993). Phosphorus Movement in the Landscape. Journal of Production Agriculture, 6, 492-500.

Sharpley, A.N. (1995). RCA III, fate and transport of nutrients: phosphorus. Working Paper No. 8. U.S. Dept. of Agriculture, Natural Resources Conservation Service.

Sharpley, A., Jarvie, H.P., Buda, A., May, L., Spears, B., and Kleinman P. (2013). Phosphorus legacy: Overcoming the effects of past management practices to mitigate future water quality impairment. Journal of Environmental Quality, 42(5), 1308-1326.

Shaw, B. (1994). Nitrogen Contamination Sources: A Look at Relative Contributions. In Conference Proceedings: Nitrate in Wisconsin's Groundwater: Strategies and Challenges, May 10, 1994.

Skinner, K.D. (2017). Groundwater-quality data from the Eastern Snake River Plain Aquifer, Jerome and Gooding Counties, South-Central Idaho. U.S. Geological Survey Data Series, 1085.

Skinner, K.D., and Rupert, M.G. (2012). Numerical model simulations of nitrate concentrations in groundwater using various nitrogen input scenarios, mid-Snake region, south-central Idaho. U.S. Geological Survey Scientific Investigations Report, 5237.

Temkin, A., Evans, S., Manidis, T., Campbell, C., and Naidenko, O. (2019). Exposure-based assessment and economic valuation of adverse birth outcomes and cancer risk due to nitrate in United States drinking water. Environmental research, 176.

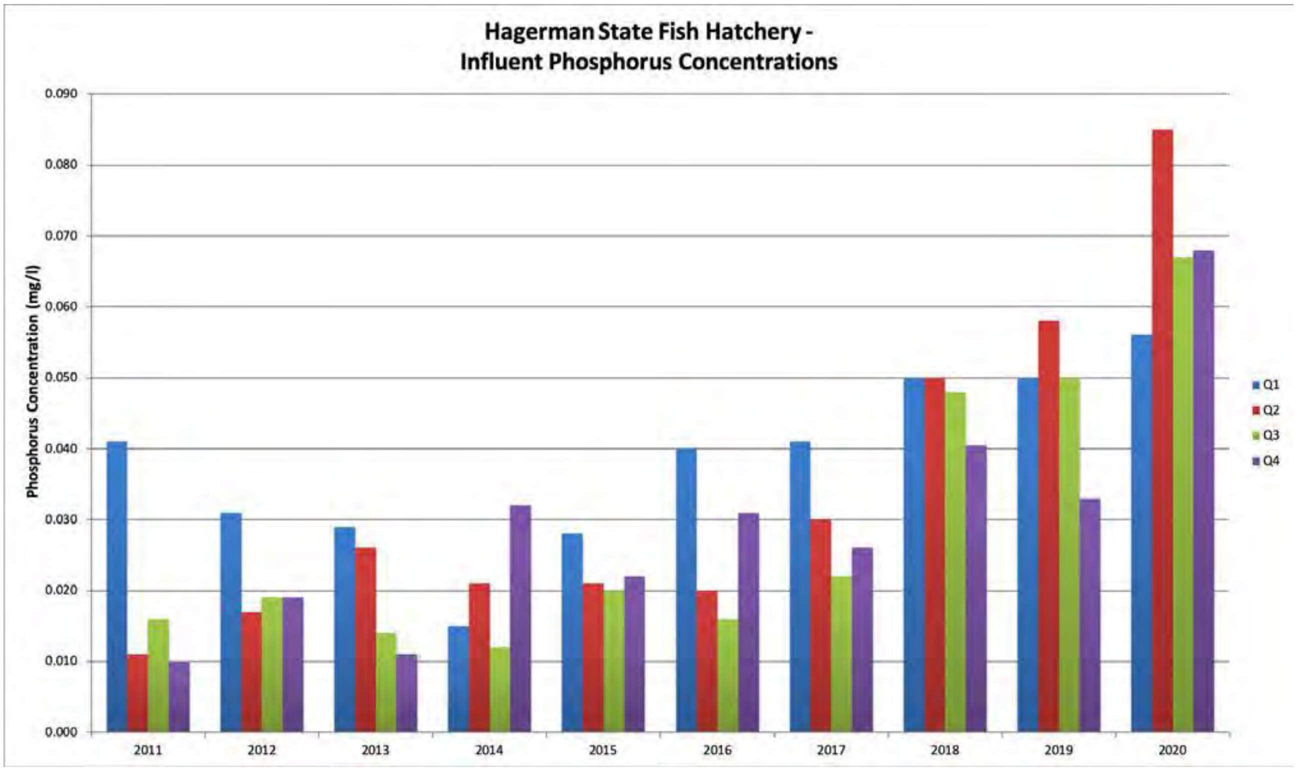
(USDA) U.S. Department of Agriculture (2021). Press Release: January 1 Cattle Inventory in the Northwest Region Down 1 Percent from Last Year. Natural Agricultural Statistics Service, released January 29, 2021.

Ward, M.H., Mark, S.D., Cantor, K.P., Weisenburger, D.D., Correa-Villaseñor, A., and Zahm, S.H. (1996). Drinking water nitrate and the risk of non-Hodgkin's lymphoma. Epidemiology, 7(5), 465-471.

Ward, M. H., Jones, R. R., Brender, J. D., de Kok, T. M., Weyer, P. J., Nolan, B. T., Villanueva, C. M., and van Breda, S. G. (2018). Drinking Water Nitrate and Human Health: An Updated Review. International journal of environmental research and public health, 15(7), 1557.

Weyer, P.J., Cerhan, J.R., Kross, B.C., Hallberg, G.R., Kantamneni, J., Breuer, G., Jones, M.P., Zheng, W., and Lynch, C.F. (2001). Municipal drinking water nitrate level and cancer risk in older women— The Iowa women's health study. Epidemiology, 11(3), 327-338.

APPENDIX I - FISH HATCHERY INFLUENT PHOSPHORUS DATA[2]



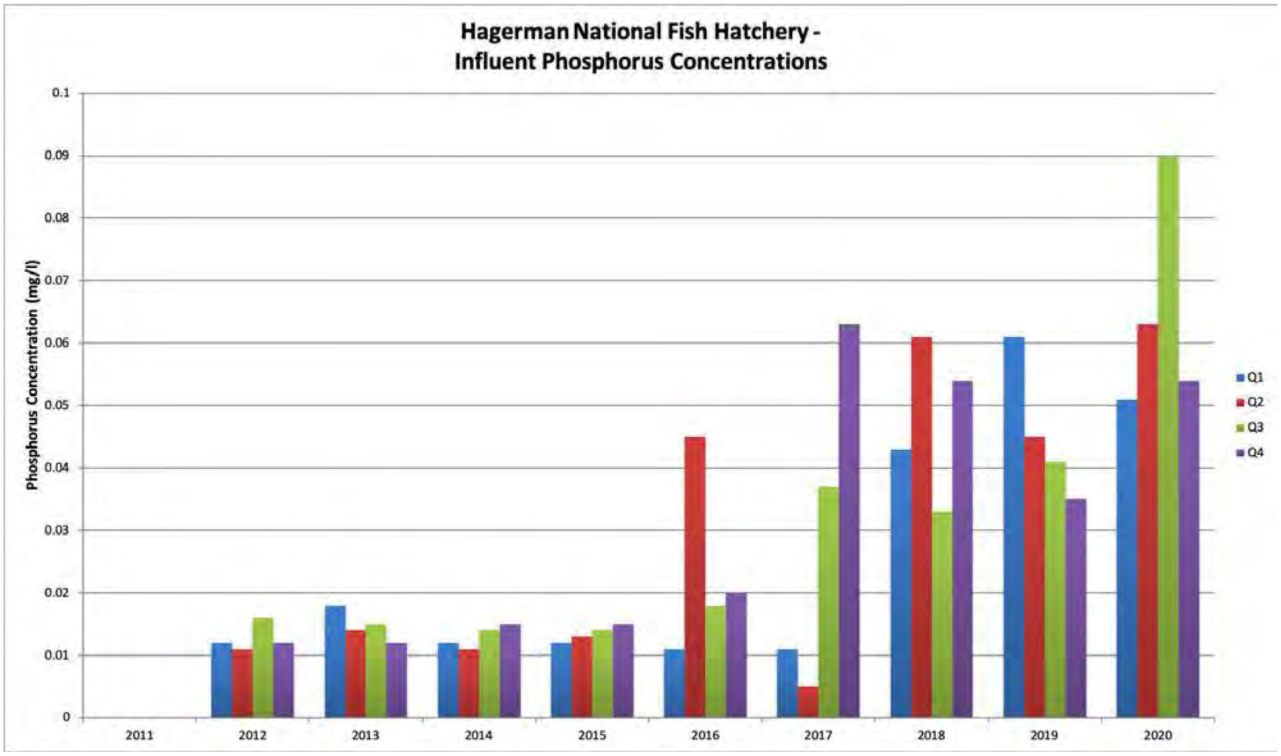
Hagerman State Fish Hatchery
Phosphorus

Switched labs in Feb 2017

	Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average 2011-2017	Average 2018-2020
Quarter 1	**Influent**	**0.041**	**0.031**	**0.029**	**0.015**	**0.028**	**0.040**	**0.041**	**0.050**	**0.050**	**0.056**	0.032	0.052
	Gross	0.051	0.038	0.076	0.051	0.053	0.066	0.031	0.060	0.098	0.069		
	Net	0.010	0.007	0.047	0.036	0.025	0.026	-0.010	0.010	0.048	0.013		
Quarter 2	**Influent**	**0.011**	**0.017**	**0.026**	**0.021**	**0.021**	**0.020**	**0.030**	**0.050**	**0.058**	**0.085**	0.021	0.064
	Gross	0.020	0.028	0.041	0.056	0.048	0.058	0.050	0.059	0.074	0.093		
	Net	0.009	0.011	0.015	0.035	0.027	0.038	0.020	0.009	0.016	0.008		
Quarter 3	**Influent**	**0.016**	**0.019**	**0.014**	**0.012**	**0.020**	**0.016**	**0.022**	**0.048**	**0.050**	**0.067**	0.017	0.055
	Gross	0.022	0.026	0.036	0.039	0.046	0.030	0.042	0.056	0.072	0.071		
	Net	0.006	0.007	0.022	0.027	0.026	0.014	0.020	0.008	0.022	0.004		
Quarter 4	**Influent**	**0.010**	**0.019**	**0.011**	**0.032**	**0.022**	**0.031**	**0.026**	**0.041**	**0.033**	**0.068**	0.022	0.047
	Gross	0.044	0.052	0.035	0.033	0.038	0.037	0.030	0.072	0.053	0.101		
	Net	0.034	0.033	0.024	0.001	0.016	0.006	0.004	0.031	0.020	0.033		
	Average	*0.020*	*0.022*	*0.020*	*0.020*	*0.023*	*0.027*	*0.030*	*0.047*	*0.048*	*0.069*	**0.023**	**0.055**

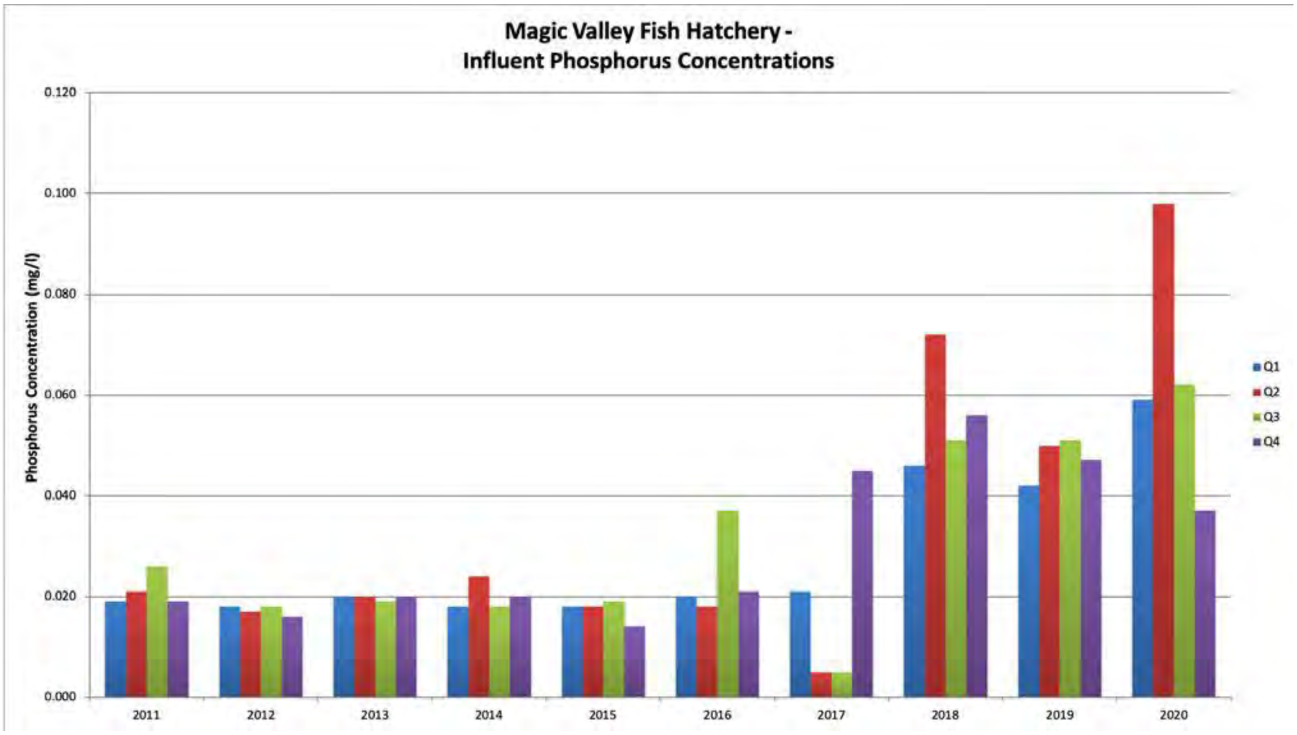
---

[2] Data obtained from IDFG via public records request



Hagerman National Fish Hatchery
Phosphorus

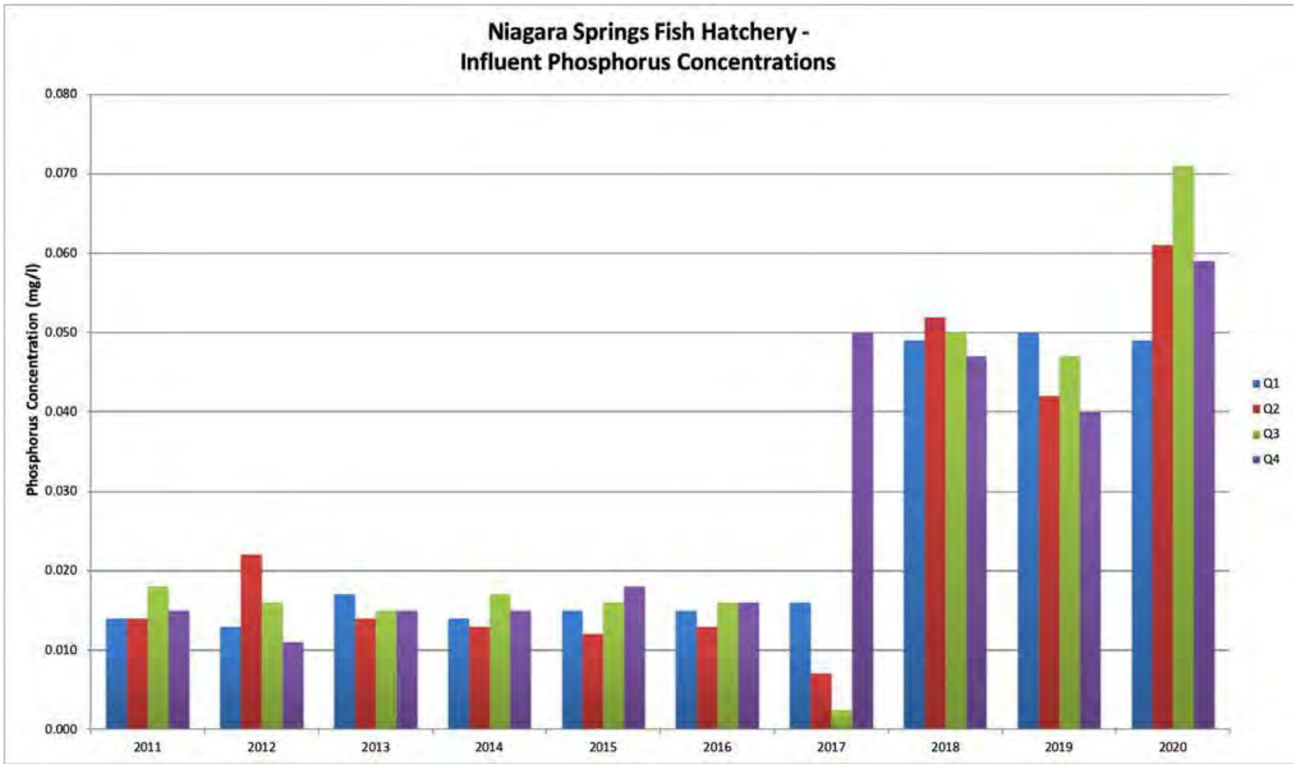
	Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average 2011-2017	Average 2018-2020
Quarter 1	**Influent**		**0.012**	**0.018**	**0.012**	**0.012**	**0.011**	**0.011**	**0.043**	**0.061**	**0.051**	0.013	0.052
	Gross		0.039	0.058	0.053	0.027	0.041	0.031	0.063	0.063	0.066		
	Net		0.027	0.040	0.041	0.015	0.030	0.002	0.020	0.002	0.015		
Quarter 2	**Influent**		**0.011**	**0.014**	**0.011**	**0.013**	**0.045**	**0.005**	**0.061**	**0.045**	**0.063**	0.017	0.056
	Gross		0.032	0.035	0.022	0.184	0.032	0.011	0.066	0.048	0.062		
	Net		0.021	0.021	0.011	0.171	-0.013	0.006	0.005	0.003	-0.001		
Quarter 3	**Influent**		**0.016**	**0.015**	**0.014**	**0.014**	**0.018**	**0.037**	**0.033**	**0.041**	**0.090**	0.019	0.055
	Gross		0.030	0.021	0.024	0.025	0.023	0.032	0.044	0.042	0.070		
	Net		0.014	0.006	0.010	0.011	0.005	-0.005	0.011	0.001	-0.020		
Quarter 4	**Influent**		**0.012**	**0.012**	**0.015**	**0.015**	**0.02**	**0.063**	**0.054**	**0.035**	**0.054**	0.023	0.048
	Gross		0.028	0.022	0.025	0.030	0.035	0.071	0.054	0.053	0.059		
	Net		0.016	0.010	0.010	0.015	0.015	0.008	0.000	0.018	0.005		
	Average		*0.013*	*0.015*	*0.013*	*0.014*	*0.024*	*0.029*	*0.048*	*0.046*	*0.065*	**0.018**	**0.053**



Magic Valley Fish Hatchery
Phosphorus

Switched labs in Feb 2017

	Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Average 2011-2017**	**Average 2018-2020**
Quarter 1	**Influent**	**0.019**	**0.018**	**0.020**	**0.018**	**0.018**	**0.020**	**0.021**	**0.046**	**0.042**	**0.059**	0.019	0.049
	Gross	0.030	0.034	0.026	0.038	0.031	0.041	0.031	0.053	0.049	0.084		
	Net	0.011	0.016	0.006	0.020	0.013	0.021	0.010	0.007	0.007	0.025		
Quarter 2	**Influent**	**0.021**	**0.017**	**0.020**	**0.024**	**0.018**	**0.018**	**0.005**	**0.072**	**0.050**	**0.098**	0.018	0.073
	Gross	0.077	0.048	0.047	0.054	0.037	0.056	0.005	0.087	0.068	0.151		
	Net	0.056	0.031	0.027	0.020	0.019	0.038	0.000	0.015	0.002	0.053		
Quarter 3	**Influent**	**0.026**	**0.018**	**0.019**	**0.018**	**0.019**	**0.037**	**0.005**	**0.051**	**0.051**	**0.062**	0.020	0.055
	Gross	0.025	0.023	0.025	0.022	0.030	0.050	0.038	0.061	0.052	0.079		
	Net	0.000	0.005	0.006	0.004	0.011	0.013	0.036	0.010	0.001	0.017		
Quarter 4	**Influent**	**0.019**	**0.016**	**0.020**	**0.020**	**0.014**	**0.021**	**0.045**	**0.056**	**0.047**	**0.037**	0.022	0.047
	Gross	0.033	0.036	0.034	0.036	0.039	0.031	0.065	0.060	0.051	0.074		
	Net	0.014	0.020	0.014	0.016	0.025	0.010	0.020	0.004	0.004	0.037		
	Average	*0.021*	*0.017*	*0.020*	*0.020*	*0.017*	*0.024*	*0.019*	*0.056*	*0.048*	*0.064*	**0.020**	**0.056**



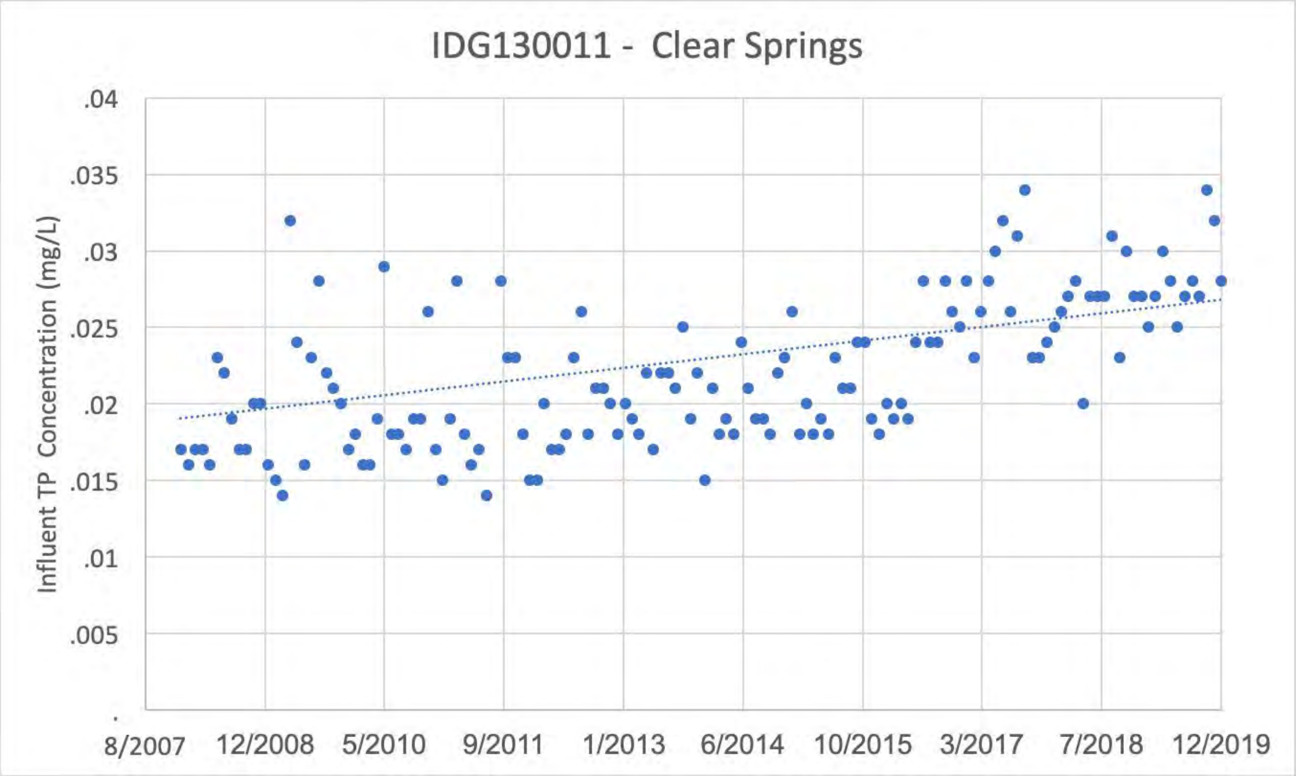
Niagara Springs Fish Hatchery
Phosphorus

Switched labs in Feb 2017

	Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average 2011-2017	Average 2018-2020
Quarter 1	**Influent**	**0.014**	**0.013**	**0.017**	**0.014**	**0.015**	**0.015**	**0.016**	**0.049**	**0.050**	**0.049**	0.015	0.049
	Gross	0.040	0.046	0.037	0.074	0.031	0.041	0.025	0.054	0.057	0.060		
	Net	0.026	0.034	0.020	0.060	0.016	0.026	0.009	0.005	0.007	0.011		
Quarter 2	**Influent**	**0.014**	**0.022**	**0.014**	**0.013**	**0.012**	**0.013**	**0.007**	**0.052**	**0.042**	**0.061**	0.014	0.052
	Gross	0.039	0.026	0.017	0.024	0.015	0.018	0.005	0.054	0.048	0.094		
	Net	0.025	0.004	0.003	0.011	0.003	0.005	-0.002	0.002	0.006	0.033		
Quarter 3	**Influent**	**0.018**	**0.016**	**0.015**	**0.017**	**0.016**	**0.016**	**0.003**	**0.050**	**0.047**	**0.071**	0.014	0.056
	Gross	0.027	0.022	0.025	0.024	0.021	0.023	0.008	0.056	0.039	0.070		
	Net	0.009	0.006	0.010	0.007	0.005	0.007	0.006	0.006	-0.008	-0.001		
Quarter 4	**Influent**	**0.015**	**0.011**	**0.015**	**0.015**	**0.018**	**0.016**	**0.050**	**0.047**	**0.040**	**0.059**	0.020	0.049
	Gross	0.034	0.030	0.042	0.029	0.038	0.023	0.070	0.051	0.046	0.080		
	Net	0.019	0.019	0.027	0.014	0.020	0.007	0.020	0.004	0.006	0.021		
	Average	*0.015*	*0.016*	*0.015*	*0.015*	*0.015*	*0.015*	*0.019*	*0.050*	*0.045*	*0.060*	**0.016**	**0.051**

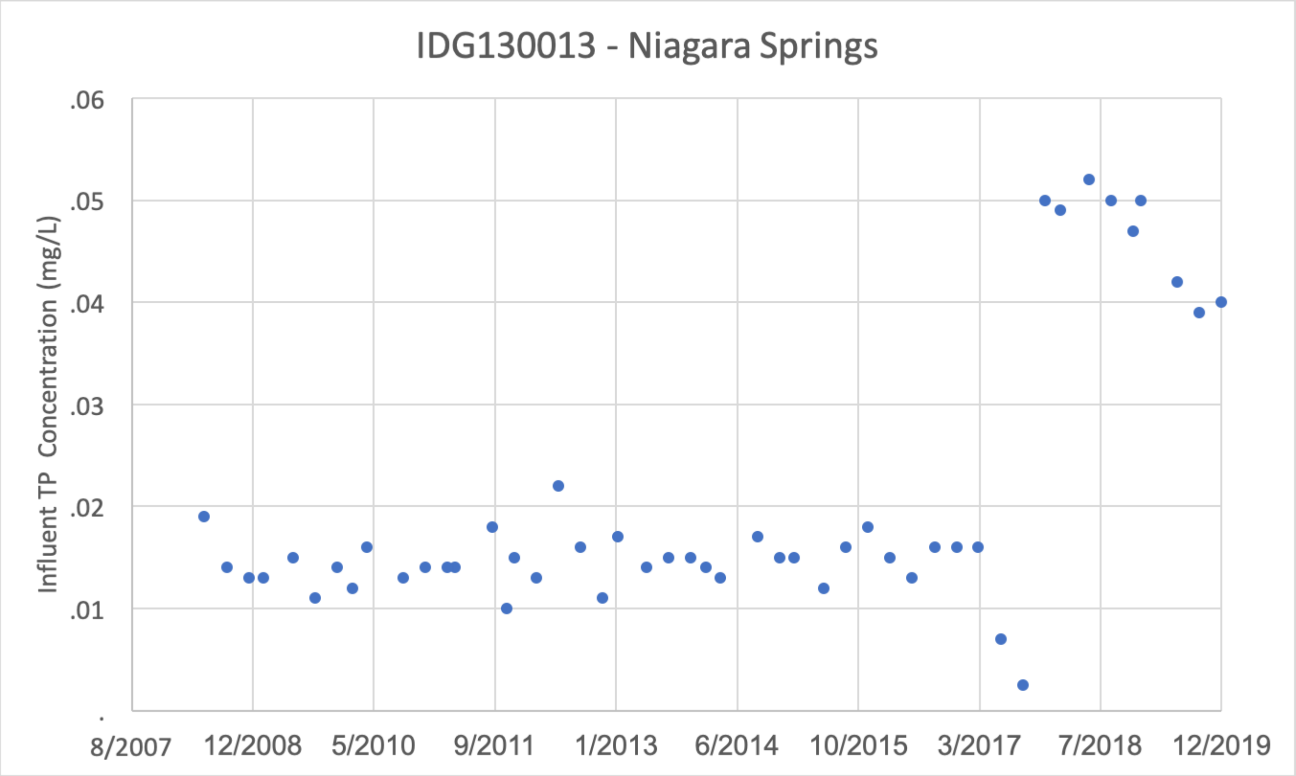
APPENDIX II - AQUACULTURE FACILITY INFLUENT PHOSPHORUS DATA[3]

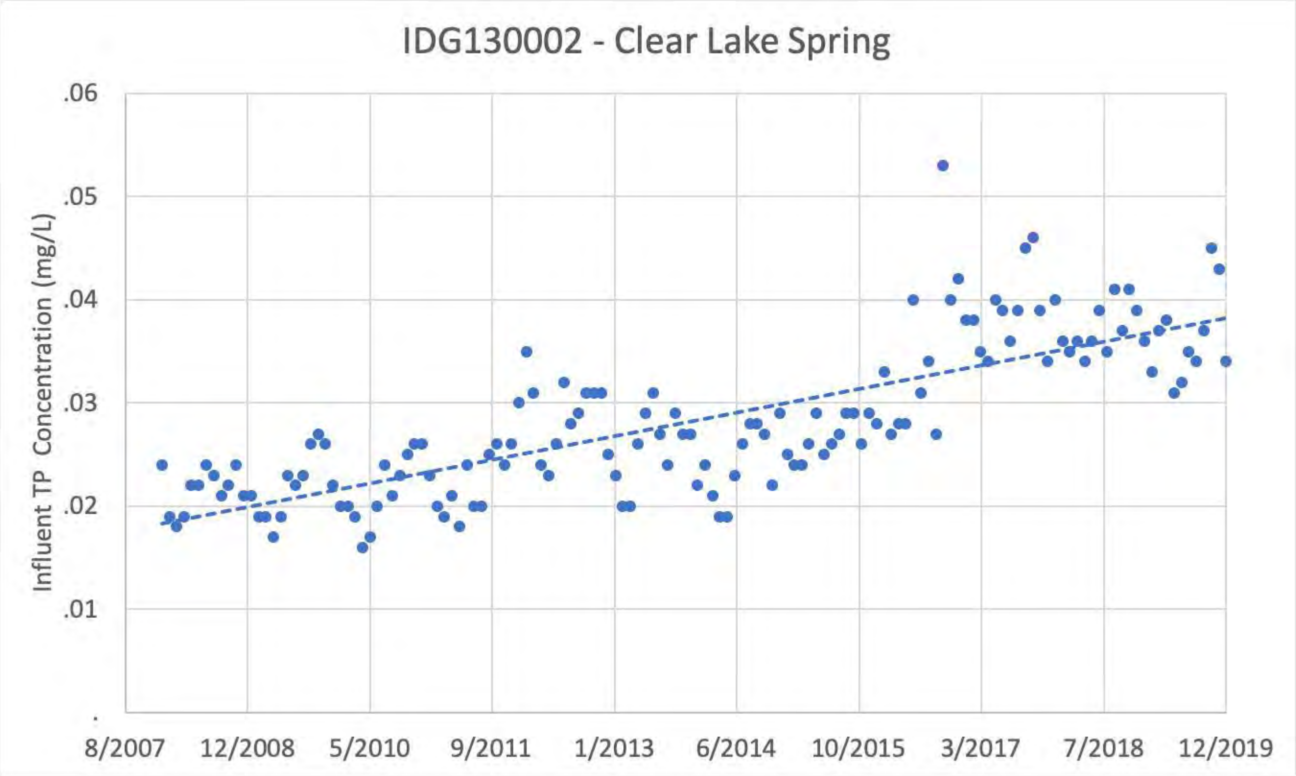
*We chose to show data from three different spring sources that show an increasing trend in phosphorus concentrations. Not every spring source shows a clear trend due to spatial variability among different springs, no springs showed decreasing trends over the same time period.



---

[3] Data is from publicly-available Discharge Monitoring Reports, obtained through IDEQ and EPA


IDG130013 - Niagara Springs
Influent TP Concentration (mg/L)
.06
.05
.04
.03
.02
.01
.
8/2007
12/2008
5/2010
9/2011
1/2013
6/2014
10/2015
3/2017
7/2018
12/2019


IDG130002 - Clear Lake Spring
Influent TP Concentration (mg/L)
.06
.05
.04
.03
.02
.01
.
8/2007
12/2008
5/2010
9/2011
1/2013
6/2014
10/2015
3/2017
7/2018
12/2019