Executive Summary

This report compiles and synthesizes research related to the conditions and standards that affect potable water quality in Truro and in areas with similar geophysical and water use profiles in the Outer Cape area.[1] It does not analyze well water data and relies on extant reports to establish these levels.

In presenting the scientific evidence available we have relied upon three sources of data:

- Scientific data drawn from research reported in legitimate, peer-reviewed journals and publications
- Regulatory data where official agencies at various levels of government set regulations and, in many instances, maintain data related to same
- Consultative and Policy reports, usually prepared by experts, who may collect original data but who all interpret scientific and empirical evidence for policy- and decision-makers.

A lead indicator of water quality and water supply contamination is the levels of nitrates found in well water, the predominant source of domestic and commercial water in Truro. Drinking water contamination takes the form of nitrates and other organic wastewater compounds and chemicals that are mostly undetectable by taste and smell; nitrates are both easier and less costly to measure than other compounds and chemicals. Additionally, nitrates are found to be an "early detection" marker for other contaminants and serve as an effective warning sign of additional contaminants in drinking water supplies. Nitrate levels are measured in terms of milligrams per liter of water (mg/L) interchangeably with parts per million (ppm). This report uses "mg/L" but both metrics are referenced below.

Truro's Water Supply Sources

Most of Truro's drinking water comes from private wells drilled from the Cape Cod aquifer which consists of two "lenses" - or underground pools of ground water - that float between the ground and the saltwater beneath the aquifer. The Pamet River, flowing from Ballston Beach to Cape Cod Bay, divides the lens into the **Pamet Lens** to the north and the **Chequesset Lens** to the south.

Because the aquifer is fairly close to the surface in many parts of Truro and thus easily reachable by drilling, these groundwater lenses can and do provide potable water resources. Ponds throughout Truro provide a good indication of the top of the aquifer, which at its highest is about 5 feet above sea level and is generally about 200 feet deep.

Groundwater in the aquifer is mostly the result of rainfall that slowly filters down to the aquifer with every rain. Other contributors to groundwater include **runoff from hard surfaces such as roofs and paved areas** which contribute salts, petrochemicals and other solvents in the runoff; **on-ground open-air storage of toxic materials** such as asphalt, brick, concrete and pressure-treated wood; and **wastewater from septic tanks and cesspools and their overflow**, which "leach" into the soil and likewise filter into groundwater over time, contributing organic (human) and chemical waste mixed in residential and commercial effluence and wastewater. Cesspool leaching finds its way easily into the aquifer and at proportionately greater densities. It is estimated that 10% of Truro homes still have outdated cesspools or otherwise failed septic systems.

Standards and Regulations for Truro's Water Supply

Eighty-five percent (85%) of Truro's homes get their water from private wells. Yet private wells are not regulated by the Cape-wide, state or federal authorities, including the EPA. The Cape Cod Commission issues policy guidelines and recommendations, but the local Board of Health determines acceptable levels of drinking water contamination.

According to Truro's Board of Health, water quality in certain areas in the Town of Truro is degraded. Excessive nitrogen loading in our watersheds has been identified as a major cause of this degradation. The primary source of excess nitrogen is reported to be wastewater from on-site septic systems.

Although the federal EPA does not regulate private wells and Truro's largest supply of potable water is obtained through private wells, **Truro's Board of Health currently relies on the EPA standard of 10 mg/L for municipal water**

[1] The Outer Cape includes the towns of Provincetown, Truro, Wellfleet, and Eastham.

systems (not wells) as the safe upper limit of nitrates in drinking water. The EPA standard was adopted in 1962 based on a federal study of nitrates and other contaminants in reliance on data from 1951 to determine nitrate level contribution to methemoglobinemia ("blue baby syndrome"). This standard, unchanged since 1962, **cited10 mg/L as the threshold for blue baby syndrome; at no time has the EPA stated that this level is safe for private wells.**

Extensive research, most notably since 1996, **shows serious health consequences at levels of 5 mg/L - half the EPA's 10 mg/L - and less**. To illustrate but not exhaust the known impact, research associates levels of 5 mg/L with non-Hodgkins lymphoma, bladder and thyroid cancer, and birth defects, and some of these consequences are associated with nitrate levels as low as 0.9 to 3.87 mg/L; other cancers (e.g., colorectal cancer) have been found at and around a nitrate loading level of 1 mg/L. Many other serious health impacts have been identified in the research. The evolution in the scientific understanding of the adverse effects of nitrate contamination has significantly advanced since 1962, with notable changes **since 1996: the trend is clear that low levels of nitrates in groundwater have adverse effects on health and that nitrate levels above 5mg/L present unacceptable and multiple challenges to public health.**

In the intervening almost 60 years since the EPA adopted its 10 mg/L standard, numerous entities and studies, including by the University of Massachusetts, have recommended that standard be reduced to 5 mg/L. More recent research has looked at the long-term effect of nitrates and related contaminants and found significantly more risks to health. In the most recent decade, non-profit research firms including the *Environmental Work Group* and *Silent Spring Institute*, **have recommended nitrate standards be reduced to 1 mg/L**. Other than the EPA and those who adhere to its high tolerance level, **no longer do studies recommend levels as high as 10 mg/L.**

Truro's current Local Comprehensive Plan calls for continuing review by the Board of Health of nitrate concentration standards to ensure they adequately address potential groundwater pollution problems. As recently as 2014 and 2018, the Town of Truro hired the consulting firm of Weston & Sampson to study Truro's water and to understand the cumulative effects of nitrogen (nitrate) loading on groundwater quality. Sampling data obtained in 2010-2011 shows that 1181 samples were taken identifying 45 lots with nitrate concentrations above 5 mg/L and 2 lots revealing concentrations above 10 mg/L. In 2012-17 another 1400 samples were tested, generally corroborating earlier findings and trends. As a result, W&S identified parts of North Truro and the Pamet River basin as particular areas of concern. Their results, guidance on safety and mitigation, and recommendations are summarized later in this paper.

Other Effects of Excessive Nitrate Levels

Once drinking water is contaminated by excess levels of nitrates or other health-harming agents, **the remedies are costly and irreversible: to construct a public water supply system**, including large wells for supply, water filtration plants, water towers, underground water mains, and wastewater treatment facilities.

As expensive as a city-like water infrastructure is to build and maintain, and as much as it needs to be funded by significantly increased taxes, another economically devastating consequence is the **decrease in property values due to polluted drinking water.** Per the Cape Cod Commission, **a 1% increase in nitrogen is associated with a decrease in home prices of 0.6% on average.** In Truro's case, the total value of its homes is on the order of $2.3 billion. A mere 2% increase in nitrogen would then, according to this model, reduce home values by about $28 million. Allowing the **current Board of Health standard of 10 mg/L doubles the level science now establishes as a threshold for multiple health impacts: 5 mg/L**. The corresponding rise in allowable nitrate levels could have adverse economic impacts of considerable magnitude.

Conclusion

Since 1996, increasing evidence of harmful effects of nitrate concentrations on human health are found at ever lower levels; the arc of this trend has been consistent and irrefutable, finding significant health consequences at and below nitrate levels of 5 mg/L. Well below current EPA and Truro Board of Health standard of 10mg/L, these findings warrant consideration and possible revision to reset local standards consistently with current scientific evaluations for nitrate and nitrate loading levels at or under 5 mg/L as a pressing local matter. In addition, it is now evident that nitrates serve as a marker for human activity, the source of other harmful organic and chemical contaminants, many of which are not easily reducible and pose serious risks of cancer and other health problems to residents.

Abstract

This paper reviews and presents a compilation of 75 years of scientific research collected on private well water and its safety, primarily focused on evolving standards and new research on the health effects of nitrates in drinking water. It has been undertaken by *Docs for Truro Safe Water*[2] to present and highlight the scientific evidence available to residents and decision makers in the Town of Truro, MA who are concerned with drinking water safety in a variety of settings. To the extent that current standards rely on geo-specific and/or historic data, consideration has been given to circumstances particular to the Outer Cape, as well as to more recent research conducted and reported in the past two decades.

Introduction

Most of Truro's drinking water comes from private wells which are drilled down into the Cape Cod Aquifer in order to pump up groundwater, providing water for domestic use. Most importantly well water is the predominant source of drinking water, serving more that 85% of current residential properties in Truro. The majority of public-serving commercial entities also rely on well-water to serve their clients. Unlike other systems and appliances that can be maintained for optimum performance, private wells are passive, delivering whatever exists in the aquifer, regardless of how safe it is for human consumption. Thus, the quality of Truro's drinking water is largely dependent on the quality of its groundwater.

A primary and indicative contaminant in Truro's drinking and groundwater is nitrates. Currently, no explicit standards exist at federal, state or local levels to establish safe levels on nitrate contamination in well water. Federal standards apply to municipal water systems and environmentally sensitive areas and states and local governments have generally adopted these or developed regulations consistent with Federal standards. In the case of well water - passive systems that have none of the source protections (e.g., reservoir controls) or the supply protections (e.g., water treatment systems), the standards are not comparable.

In addition, the level of nitrate concentration considered to be safe in these public and natural systems is evolving – and decreasing – rapidly and most notably in the past 20 years based upon multiple scientific studies. Similarly, the variety and types of health conditions adversely impacted by low levels of nitrates in water is also expanding. This report attempts to look at evolving standards for safe nitrate concentrations and appropriate standards for safe well water in a rural community largely dependent upon this source of drinking water.

Truro's Water Supply Sources

The Cape Cod aquifer consists of two "lenses" - or underground pools of ground water - that float between the ground and the saltwater beneath the aquifer. The Pamet River, flowing from Ballston Beach to Cape Cod Bay, divides the lens

[2] ***Docs for Truro Safe Water*** is a group of medical and scientific professionals - all holding M.D. or Ph.D. degrees - who reside in Truro, MA and the Outer Cape region who bring their expertise and scientific perspective to the evaluation of data related to specific issues affecting the region. In this case, the focus is on local drinking water safety. Brief bios of affiliates can be found at **https://docstruro.org**.

into the **Pamet Lens** to the north and the **Chequesset Lens** to the south, as depicted below in **Figure 1** and in **Appendix A**.

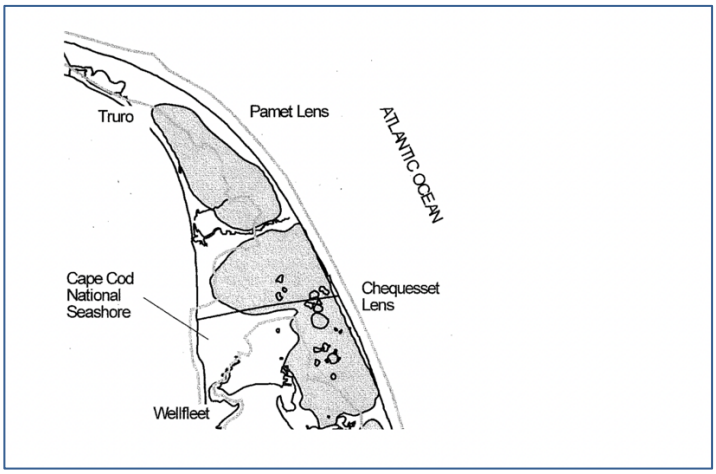


Figure 1: Aquifer Lenses in Truro, MA

Because the aquifer is fairly close to the surface in many parts of Truro and thus easily reachable by drilling, these groundwater lenses can and do provide potable water resources to the large majority of residents and businesses – as well as their visitors – throughout Truro. Ponds throughout Truro provide a good indication of the top of the aquifer, which at its highest is about 5 feet above sea level and is generally about 200 feet deep.

Groundwater in the aquifer is mostly the result of rainfall that slowly filters down to the aquifer with every rain. Other contributors to groundwater include:

- **Runoff from hard surfaces such as roofs and paved areas** which contribute salts, petrochemicals and other solvents in the runoff. This includes paved surfaces in roadways, driveways, sidewalks and all types of impermeable surfaces such as non-porous patios and decks
- **On-ground open-air storage of toxic materials** such as asphalt, brick, concrete, pressure-treated wood, aggregated construction debris, as well as any storage containers holding toxic materials (e.g., salts, petrochemicals, engine oils and other solvents) that leak or drip
- **Wastewater from septic tanks and cesspools and their overflow**, which "leach" into the soil and likewise filter into groundwater over time, contributing organic (human) and chemical waste mixed in residential and commercial effluence and wastewater. Cesspool leaching finds its way easily into the aquifer and at proportionately greater densities. It is estimated that 10% of Truro homes still have outdated cesspools.

Truro's water supply is plentiful on the one hand and fragile on the other, highly susceptible to the expanding use of toxic and environmentally sensitive chemicals introduced into the aquifer by human activity and products. In this respect nitrates pose a direct challenge to water quality and human health and serve as a barometer and catalyst for the presence of other contaminants that can also be harmful. According to the **Cape Cod Commission**:

> *The Cape Cod Aquifer is extremely susceptible to contamination from various land uses and activities.*
>
> *Nitrate, a major component of human wastewater, passes through septic systems virtually untreated and is introduced to the underlying groundwater.*

Nitrate can serve as an indicator of other wastewater contaminants, such as disease-causing organisms, solvents, cleaners, petroleum compounds, pharmaceuticals and personal care products and other emerging contaminants.

- *Water Quality Management Plan* (2015)

Access to clean water is first and foremost a public health issue, but it is also an economic and environmental issue as well. The US Geological Survey cautions us about the centrality of adequate water supply to our future well-being.

Population growth and increasing demands for water make the availability of that water, measured in terms of quantity and quality, even more essential to the long-term sustainability of our communities and ecosystems.

- National Water Quality Assessment Program (2010)

Standards and Regulations for Truro's Water Supply

All drinking water for Truro homes and businesses comes from the Cape Cod aquifer lenses located in whole or in part under the Town of Truro. The vast majority of these users rely on private wells for their water supply for home and business uses.

The EPA is often cited as the standard setter for water quality in public water systems and natural environments, but since its inception **the EPA has not regulated private wells. Federal authorities instruct well owners to be responsible for water quality in their own wells.**

Figure 2: Current EPA Message to Private Well Owners

EPA does not regulate private wells nor does it provide recommended criteria or standards for individual wells. EPA offers information regarding the importance of testing private wells and guidance on technologies that may be used to treat or remove any contaminants. Private well owners are responsible for the safety of their water.
https://www.epa.gov/sites/production/files/2018-02/documents/epa-ogwdw-private-wells-v4.pdf

While Federal authorities often establish thresholds on water safety for use by other levels of government, in the absence of EPA standards for private wells it is notable that **private wells are also not regulated by the Massachusetts Department of Environmental Protection (Mass DEP)**. The Commonwealth points to local Boards of Health to act as regulators, as stated on their Mass DEP website:

> *MassDEP does not regulate private wells. Your local board of health or health department regulates them….The local BOH is empowered to adopt a Private Well Regulation that establishes criteria for ...water quality.*
>
> *https://www.mass.gov/orgs/massachusetts-department-of-environmental/-protection*

The Truro Board of Health has expressed concern about degradation of drinking water quality in Truro:

> *Water quality in certain areas in the Town of Truro is degraded and excessive nitrogen loading in our watersheds has been identified as a major cause of this degradation. The primary source of excess nitrogen is wastewater from on-site septic systems.* - *Truro Board of Health Regulations*

Sources of Drinking Water Contaminants in Well Water

Contaminants in well water come primarily from septic systems. Those septic systems contain both **organic nitrogen (nitrates) from human waste as well as organic wastewater compounds (OWCs)** and may contain other toxins that are flushed or washed into septic systems or dropped on the ground to leach into groundwater. OWCs are ingredients and by-products of common agricultural, industrial, and household substances that can contaminate our groundwater through sources like hard surface runoff and septic systems, as noted above. **Appendix B** gives more examples, such as **solvents, disinfectants, detergent, and human drugs**. To a lesser degree, nitrates also come from the use of **fertilizer applied to plants, including animal waste**. An illustration of the Environmental Nitrogen Cycle is found in **Appendix C**.

In a residential community such as Truro, nitrates and OWCs both primarily originate from human activity. Because it is much simpler and less expensive to test for nitrate than it is to test for chemical compounds, actual OWC levels are less frequently reported - but that does not mean they are absent. To determine nitrate levels, water tests are available through the Barnstable County testing laboratory. An example test result is shown in **Appendix D**.

As regulators analyze water safety, a high correlation has been shown to exist between nitrate levels and OWC levels. This means that health risks exist at lower nitrate levels than previously understood, in part due to the co-presence of OWC contaminants. This is in part due to lower levels of tolerance for OWC contamination and to the cumulative effect of these in combination.

Researchers are also giving more attention to longer duration exposures at reduced levels of nitrate concentrations. Originally, pursuant to the EPA formulating its standards in the early 1960s, nitrate toxicity in infants was based on exposure of just a few months duration. High levels would be needed to show impact in a short time span. But exposure to a reduced nitrate level over several years, when that cumulative exposure also includes OWCs present as well, has been increasingly linked to health risks in humans of all ages. This exposure has been coined by Kevin Kuechler, former chair of Truro's Water Resource Oversight Committee, as the ***nitrogen footprint*** **which, like a carbon footprint, can benefit from substantial reduction in concentration and volume.**

"Safe" Levels of Contamination

A "safe level of contamination" is an oxymoron; contamination is never safe, but it is sometimes tolerable if contaminants have a negligible impact on human, animal or environmental health. In this respect, there is agreement about the sources of well water contamination. Consensus as to what levels of contaminants are safe in drinking water, and especially well water, is evolving. In recent years, research and scientific evidence has mounted that shows "safe" levels - that is, the level at which no known adverse consequences to health are triggered - are lower than originally understood.

The first known report of potential effects of nitrate poisoning in infants was made in 1945. In 1962, the EPA adopted a **standard of 10 mg/L originally as the threshold for blue baby syndrome** based on a federal study of nitrates and other contaminants in reliance on data from 1951 to determine nitrate level contribution to methemoglobinemia ("blue baby syndrome"). This standard, **unchanged since 1962, currently applies an MCL (maximum contamination level) of 10 mg/L for municipal water systems (not wells) as the safe upper limit of nitrates in drinking water; at no time has the EPA stated that this level is safe for private wells.**[3] Yet, in the face of growing and consistent research which indicate this standard may be too high, the EPA has begun to re-assess its recommendation. For example:

- In 2017, **the EPA** acknowledged (a) a growing body of literature indicating potential associations between nitrate/nitrite exposure and other serious noncancer health effects, and (b) epidemiological studies also suggesting an increased risk of cancer, the EPA began undertaking a reassessment of the health effects of nitrate and nitrite.

Based on their own independent research:

- **University of Massachusetts Dartmouth** recommends **a nitrate level no higher than 5 mg/L**. Its seminal study states, inter alia:

  Ingestion of drinking water with nitrate concentrations in excess of 10 mg/L may be fatal to infants. Concentrations in excess of 5 mg/L indicate a severe degradation of groundwater quality. In order to guard against nitrate concentrations reaching danger levels, if you have a nitrate concentration exceeding 5 mg/L in your well, you should monitor the nitrate for a trend of increasing concentrations.

  A potential cancer risk from nitrate in drinking water and food has been reported. The possibility exists that nitrate can form nitrosamine, which is known to cause cancer.

  Nitrate-nitrogen concentrations above 1.0 mg/L indicate potential land use impacts to water quality. You should try to identify the potential land use source that is causing the elevated levels in your drinking water. Drinking water with nitrate-nitrogen concentrations greater than 5.0 mg/L should not be used to prepare infant formula.

- The **Cape Cod Commission** recommends **a nitrate level no higher than 5 mg/L** Further to this, it has published some minimum guidelines as to level of discharge from septic systems to protect the aquifer in general and the private wells that pump from it. More follows below on the Commission's insights.

- The **Environmental Working Group,** a nationally recognized non-profit, non-partisan organization dedicated to protecting human health and the environment, **recommends a nitrate level "10 times lower" than EPA 10 mg/L, that is, 1 mg/L,** stating inter alia:

  Private drinking water wells in the vicinity of animal farms and intensively fertilized fields, or in locations where septic tanks are commonly used, can also have unsafe levels of nitrate.

  The federal limit of 10 milligrams per liter, or mg/L, equivalent to parts per million, for nitrate in drinking water was set in 1962 and has never been updated. This standard was developed to prevent acute cases of methemoglobinemia, known as blue baby syndrome, which can occur when an infant's excessive ingestion of nitrate leads to oxygen deprivation in the blood.

  Epidemiological research suggests that the federal nitrate limit does not sufficiently protect public health. Studies conducted in the U.S. and in other countries found greater incidence of colorectal, ovarian, thyroid, kidney and bladder cancers among people exposed to nitrate in drinking water. Researchers in Europe have found elevated risk of colorectal cancer associated with drinking water concentrations more than 10 times lower than the federal limit. Epidemiological studies also report that nitrate contamination of tap water can harm the developing fetus.

[3] At recent public meetings in Truro, it has been reported that the Board of Health currently relies on the EPA standard of 10 mg/L.

The federal legal limit for nitrate in drinking water fails to address the growing concerns about chronic, low-level exposure to nitrate and potential cancer risk.

- The **Silent Spring Institute**, a non-profit research institute, recommends **a nitrate level no higher than 1mg/L.** Silent Spring's mission is preventing cancer by reducing people's exposure to harmful chemicals. It is explicit and firm, inter alia, that based on the current EPA standard of 10 mg/L of nitrates in drinking water:

  Our results suggest that current regulations to protect domestic wells from pathogens in septic system discharges do not prevent OWCs [organic wastewater compounds] from reaching domestic wells.

  We found that nitrate concentrations of 1 mg/L NO3-N, which are tenfold higher than local background and tenfold lower than the US federal drinking water standard, were associated with wastewater impacts from OWCs. Since nitrate is a commonly measured drinking water contaminant, it is a useful screening tool for OWCs in domestic wells.

- **Cape Cod's** Area Wide Water Quality Management Plan Update, developed pursuant to Section 208 of the Clean Water Act, was certified by Governor Charlie Baker in June 2015 and approved by the U.S. Environmental Protection Agency on September 15, 2015. It states, inter alia:

  Cape Cod has a water problem. The saltwater border that has defined our peninsula is being poisoned by nitrogen. The rapid decrease in the water quality of Cape Cod's marine ecosystems is plain to see. The problem is nitrogen and the largest controllable source is the septic systems used every day.

  Nitrogen is impacting coastal water quality. About 80% of the nitrogen that enters Cape Cod's watersheds is from septic systems.

  The Cape Cod seasonal economy relies on the water that surrounds the region and the degraded water quality is negatively impacting important economic drivers including coastal property values.

- The **Cape Cod Regional Policy Plan** established a nitrogen loading concentration of 5 ppm (i.e., 5 mg/L) to ensure that nitrate levels in drinking water will not approach the 10 mg/L federal standard for public water supplies.

  Five-ppm Nitrogen Loading Standard: All development and redevelopment shall not exceed a 5-parts per million (ppm) nitrogen loading standard for impact on groundwater…

The Evolution of Safe Drinking Water Standards Over Time (1945 to now)

In order to understand how nitrate safety standards have evolved over the past 75 years, **Figure 3** depicts the main moments in time where "safe levels" of nitrates changed over time. This allows us to get a perspective on how long it has taken policy to catch up with science on water contamination and at the same time, to see how rapidly consensus and revised policy recommendations are being developed more recently. Starting with the first query in 1945 about "blue-baby syndrome" and the few small sample studies that followed on this topic in the 1950s to the early establishment of the EPA standard in 1962 that resulted, and on to more recent research focusing on various diseases resulting from well-water nitrates and other contaminants.

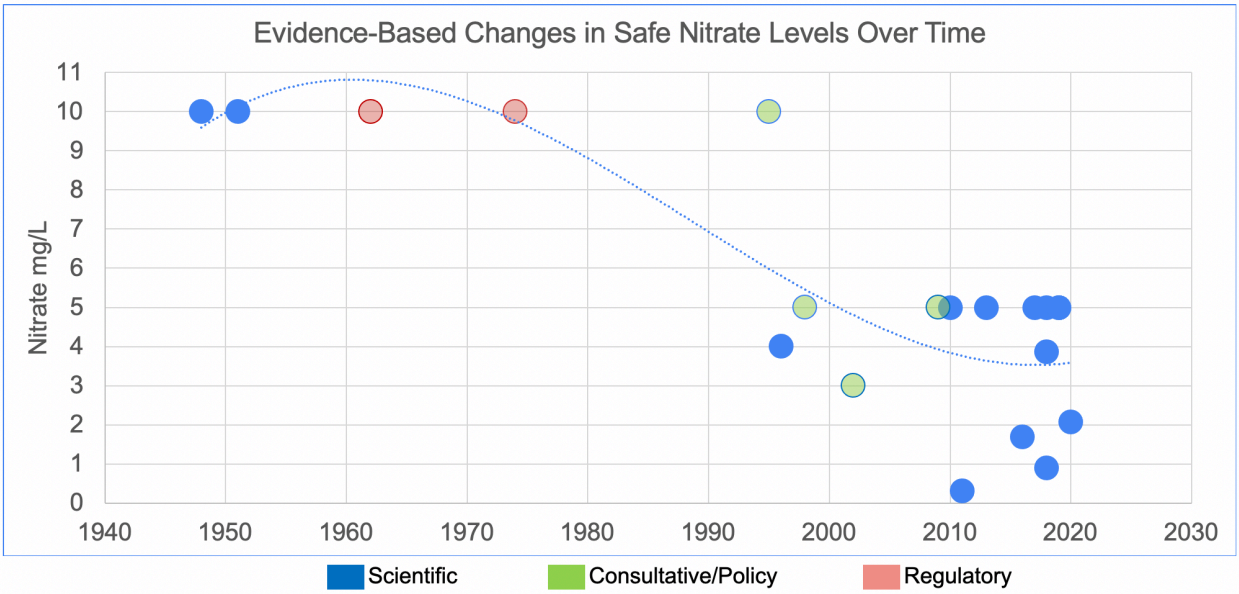


Figure 3: Evidence-Based Decreases in Safe Nitrate Levels (1945-2020)

Snapshot of Key Findings on Determinants of Health-Compromising Nitrate Levels Over Time

- 1945 (year 1)

  Dr. Hunter Comly of Iowa reported on two cases of a "previously unrecognized" condition that "may occur anywhere in rural areas where well-water is used in infant feeding." Dr. Comly suspected that the nitrates in the family's well-water were at fault.

- 1947-1950 (years 2-5)

  Journal of the American Water Works Association

  The first scientific reported study is conducted in 1947-49 by clinical and sanitary experts of 139 cases of methemoglobinemia ("blue baby syndrome") resulting from the consumption of well-water reported in Minnesota between January 1947 and September 1949 in infants under five months of age.

- 1951 (year 6)

  American Journal of Public Health and the Nation's Health

  "Water used in preparing infant's feeding formula should contain no more than 10 (possibly 20) ppm nitrate N."

- 1962 (year 17)

  The **U.S. Public Health Service** recommended a national nitrate standard of 10 ppm.

- 1974 (year 30)

  The **Safe Drinking Water Act (SDWA)** was passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The EPA endorsed a 10 mg/L (ppm) nitrate limit in public drinking water.

- 1996 (year 52)

  Epidemiology

  "Long term consumption of community water with average nitrate levels in the highest quartile (> or = 4 mg[4] per liter nitrate-nitrogen) was positively associated with health risk [citing non-Hodgkin's lymphoma]."

  "These findings indicate that long term exposure to elevated nitrate levels in drinking water may contribute to the risk of NHL [non-Hodgkin's lymphoma]."

- 1998 (year 54)

  Lower Cape Water Management Task Force

  "Descriptions of water quality are typically expressed by using an acceptable standard value. In this study, we report the number of wells that exceed 5 mg/L as a measure of water quality."

- 2002 (year 58)

  The Journal of Preventive Medicine

  "By mandating a safety factor of two, which would reduce the current MCL and HAL for nitrate to 5.0 mg/L NO3- N, and by promulgating a MCLG of 3.0 mg/L of NO3-N; the United States regulatory approach for nitrate in drinking water would become consistent with other European countries and would encourage the prudent public health strategy of limiting human nitrate exposure."

  Cape Cod Commission

  "This Regional Policy Plan continues to support the 5-ppm limit on nitrogen loading."

  "The maximum nitrogen loading standard for Potential Public Water Supply Areas shall be 1 ppm for development."

- 2005 (year 61)

  Truro Local Comprehensive Planning Committee

  "The Board of Health is asked to: Continually review the Board of Health nitrogen loading standards to ensure that such standards adequately address potential groundwater pollution problems."

- 2009 (year 65)

  Cape Cod Commission

  "Five-ppm Nitrogen Loading Standard: The maximum nitrogen loading standard for impact on groundwater shall be 5 ppm for development and redevelopment unless a cumulative impact analysis indicates a more stringent loading standard is necessary."

- 2010 (year 66)

  Epidemiology

  "We found an increased risk of thyroid cancer with higher average nitrate levels in public water supplies and with longer consumption of water exceeding 5 mg/L nitrate-N (for > or = 5 years at >5 mg/L."

[4] The symbols (> or =) and (≥) mean "greater than or equal to" the stated number. The symbol (< or =) and (≤) mean "less than or equal to" the stated number.

- 2013 (year 69)

  Environmental Health Perspectives

  "Women who had babies with NTDs [neural tube defects], limb deficiencies, and oral cleft defects were significantly more likely than control mothers to ingest >= 5 mg of nitrate per day from drinking water."

- 2017 (year 73)

  EPA – The Integrated Risk Information System (IRIS) Program

  "Since 1987, a growing body of literature indicates potential associations between nitrate/nitrite exposure and other non-cancer health effects."

- 2018 (year 74)

  International Journal of Cancer

  "We found statistically significant increased risks [of cancer] at drinking water levels above 3.87 mg/L."

  Environmental Health Perspectives

  "Mothers of babies with spina bifida were 2.0 times more likely to ingest ≥ 5 mg nitrate daily from drinking water."

  "During one month preconception through the first trimester, mothers of limb deficiency, cleft palate, and cleft lip cases were, respectively, 1.8, 1.9, and 1.8 times more likely than control mothers to ingest ≥ 5.42 mg of nitrate daily."

  International Journal of Public Health/MPDI

  "Risk of specific cancers and birth defects may be increased when nitrate is ingested under conditions that increase formation of N-nitroso compounds. We previously reviewed epidemiologic studies before 2005 of nitrate intake from drinking water and cancer, adverse reproductive outcomes and other health effects. Since that review, more than 30 epidemiologic studies have evaluated drinking water nitrate and these outcomes. The most common endpoints studied were colorectal cancer, bladder, and breast cancer (three studies each), and thyroid disease (four studies). Considering all studies, the strongest evidence for a relationship between drinking water nitrate ingestion and adverse health outcomes (besides methemoglobinemia) is for colorectal cancer, thyroid disease, and neural tube defects. Many studies observed increased risk with ingestion of water nitrate levels that were below regulatory limits."

  "Four of the five published studies of colorectal cancer found evidence of an increased risk of colorectal cancer or colon cancer associated with water nitrate levels that were mostly below the respective regulatory limits."

  "Four of the five studies of thyroid disease found evidence for an increased prevalence of subclinical hypothyroidism with higher ingestion of drinking water nitrate among children, pregnant women, or women only. Positive associations with drinking water nitrate were observed at nitrate concentrations close to or above the MCL (maximum contaminant level).[5]"

  "To date, five of six studies of neural tube defects showed increased risk with exposure to drinking water nitrate below the MCL. Thus, the evidence continues to accumulate that higher nitrate intake during the pregnancy is a risk factor for this group of birth defects."

[5] This same study reported "the maximum contaminant level (MCL) for nitrate in public drinking water supplies in the United States (U.S.) is 10 mg/L as nitrate-nitrogen (NO_3-N)."

- 2019 (year 75)

  Silent Spring Institute

  "…recent studies suggest exposure at levels as low as 5 ppm is also associated with several cancers and birth defects, raising the possibility that EPA's water standard is not sufficiently protective of health."

  Cape Cod Commission

  "The Cape Cod Commission has a long standing policy that aims to limit project site-wide nitrogen loading to a concentration of 5 mg/L or less in order to protect and preserve the drinking water quality of supply wells and areas that contribute to them: these areas include public drinking water supplies, private wells, and the sole source Cape Cod Aquifer in general. Included in the concentration limit are those controllable sources of nitrogen typically associated with development: wastewater, stormwater and turf fertilization."[6]

- 2020 (year 76)

  Epidemiology

  "Average drinking water nitrate concentration above the 95th percentile (>2.07 mg/L) compared with the lowest quartile (≤0.21 mg/L) was associated with bladder cancer."

While this survey of the scientific literature concerning key findings about nitrate concentrations over time is illustrative but not exhaustive, it is substantially representative of the extant research. This research shows that:

- From 1945-1996 the focus on one disease ("blue baby syndrome") without consideration of other conditions was associated with an MCL of 10 mg/L for nitrates in public water systems.
- From 1996 to today **the recommended MCL for nitrates has consistently been cited at or below 5 mg/L.**
- **Further, research confirms that nitrate levels below 5 mg/L are associated with an increasing number of health consequences.**
- These include numerous forms of cancer **- thyroid, bladder, colorectal, non-Hodgkins' lymphoma, and childhood brain tumors - as well as non-cancer health conditions, including birth defects.**

Figure 4 presents a brief summary in chart form of the evolution of the basis for changes in the recommended MCL (maximum contamination level) associated with serious cancer- and non-cancer-related health consequences in humans.[7] Key findings with some additional narrative are also presented here in the interest of clarity and brevity. Additional details and supportive citations are provided in **Appendix E**.

[6] Map contained in **Water Resources of Outer Cape Cod**, *Final Report of the Lower Cape Water Management Task Force,* May 1998, Figure 1

[7] Neither this survey of the scientific literature or this report addresses the adverse impact of nitrogen and OWCs, alone and in combination, on the health of flora, fauna or natural waters and related environmental conditions. That is beyond the scope of this report. However, that research is consistent with this report.

Timeline Summary | Level of Nitrates in Water and Serious Health Risks

Year	Nitrate	Reference Source	Type	Health Risk
1948	10	Minnesota Department of Health	S	methemoglobinemia
1951	10	Graham Walton, PhD	S	methemoglobinemia
1962	10	US Public Health Service	R	methemoglobinemia
1974	10	US Safe Water Drinking Act	R	methemoglobinemia
1995	10	US Environmental Protection Agency	C/P	methemoglobinemia
1996	4	Epidemiology/National Cancer Institute	S	non-Hodgkin's lymphoma
1998	5	Lower Cape Water Management Task Force	C/P	general
2002	3	The Journal of Preventive Medicine	C/P	Max Contam Limit Goal
2009	5	Cape Cod Commission Regional Policy Plan	C/P	Nitrogen loading standard
2010	5	Epidemiology	S	thyroid cancer
2011	0.31	Journal of Toxicology and Environmental Health	S	childhood brain tumors
2013	5	Environmental Health Perspectives	S	birth defects
2016	1.7	Spain and Italy	S	colorectal cancer
2017	5	Environmental Health Perspectives	S	bladder cancer
2018	3.87	International Journal of Cancer	S	colorectal cancer
2018	5	Environmental Health Perspectives	S	birth defects
2018	0.9	Denmark	S	colorectal cancer
2019	5	Silent Spring Institute	S	cancers and birth defects
2019	5	Environmental Research	S	colorectal cancer
2020	2.07	Epidemiology	S	bladder cancer

Scientific Consultative/Policy Regulatory

Figure 4: Timeline Summary of Changes in Nitrate Levels Associated with Serious Health Risks

Current Well Safety and Contamination Prevention in Truro

The safety of private well water in Truro depends on where you live. It also depends on well owners' personal vigilance, attention, and where needed, mitigation. As Weston & Sampson noted (see **Appendix F**), some neighborhoods, most notably **Pond Village and other areas in North Truro, have more contaminants in their drinking water than other areas**. Older "pre-Title V" neighborhoods, such as **the Pamet River Valley basin, are also of concern**. Other areas in Truro have lower levels on average but increasing human activity trends toward increasing nitrates wherever it occurs.

The **Truro Board of Health** controls nitrogen loading[8] by setting limits on the density of human activity by limiting development to one bedroom per 10,000 square feet of land up to the limits of total acreage (Section VI, Article 14 of the Board of Health Local Septic Regulations). See **Appendix G** for a summary of Truro's Board of Health regulations.

[8] Nitrogen loading is related to but different from nitrate concentration levels. Where nitrate levels can be assessed in drinking water directly, nitrogen loading is determined through multi-factor calculations. The load (aka, the flux) is the amount (or mass) that passes a given point in groundwater over a given period of time. In Truro, this is determined by gallons per day per bedroom per 10,000 sf for residential applications. More simply, it is the load per unit of drainage area. For a helpful link, see https://buzzardsbay.org/buzzards-bay-pollution/nitrogen-pollution/nitrogen-tools/bbpnitro-interactive/. **The Cape Cod Commission recommends 5mg/L as a safe nitrogen loading limit.**

The **Truro Housing Production Plan**, accepted by the Commonwealth's Department of Housing and Community Development, states:

> "... the town's resources for absorbing growth are extremely limited ...Truro has limited water and no sewer services, making denser development more costly and difficult. Consequently, residents must rely largely on wells and on-site septic systems. This raises concerns among residents about water supply and quality impacts of any development."

As seen in **Figure 5**, the EPA advises private well owners to monitor their own wells, ask questions, and understand mitigation options to protect the safety of their well water:

Figure 5: EPA Advisory to Self-Monitor Private Wells

The **Truro Water Resources Oversight Committee** (WROC) and the town's water consultant **Weston & Sampson** have provided information in this regard, and highlighted areas of concern. It is generally accepted that nitrate levels in excess of 1.0 ppm (i.e., 1 mg/L) are indicative of human activity. The more human activity and waste, the higher the nitrate level. **Figure 6** informs us that on average nitrate levels in Truro based upon voluntary sampling from 2007-2011 that the average nitrate concentration in Truro is 1 mg/L (ppm), while certain areas have levels $\geq$ 5 mg/L, generating designation as areas of concern with regard to drinking water safety.

As recently as 2014 and 2018, the Town of Truro hired the consulting firm of **Weston & Sampson** to study Truro's groundwater and to understand the cumulative effects of nitrogen (nitrate) loading on groundwater quality. Sampling data obtained in 2007-2011 shows that 1181 samples were taken identifying 45 lots with nitrate concentrations above 5 mg/L and 2 lots revealing concentrations above 10 mg/L. From 2012-2017 another 1400 samples were tested, generally corroborating earlier findings and trends. As a result, W&S **identified parts of North Truro and the Pamet River basin as particular areas of concern.** Local water sample tests provided voluntarily to the **Town's WROC and Board of Health** showed consistent results.

A summary of Weston & Sampson's two reports can be found in **Appendix G**.

Figure 7 shows where well monitoring took place in Phase 1 of the W&S study (2007-2011). Phase 2 (2012-2017) focused on identified areas of concern.

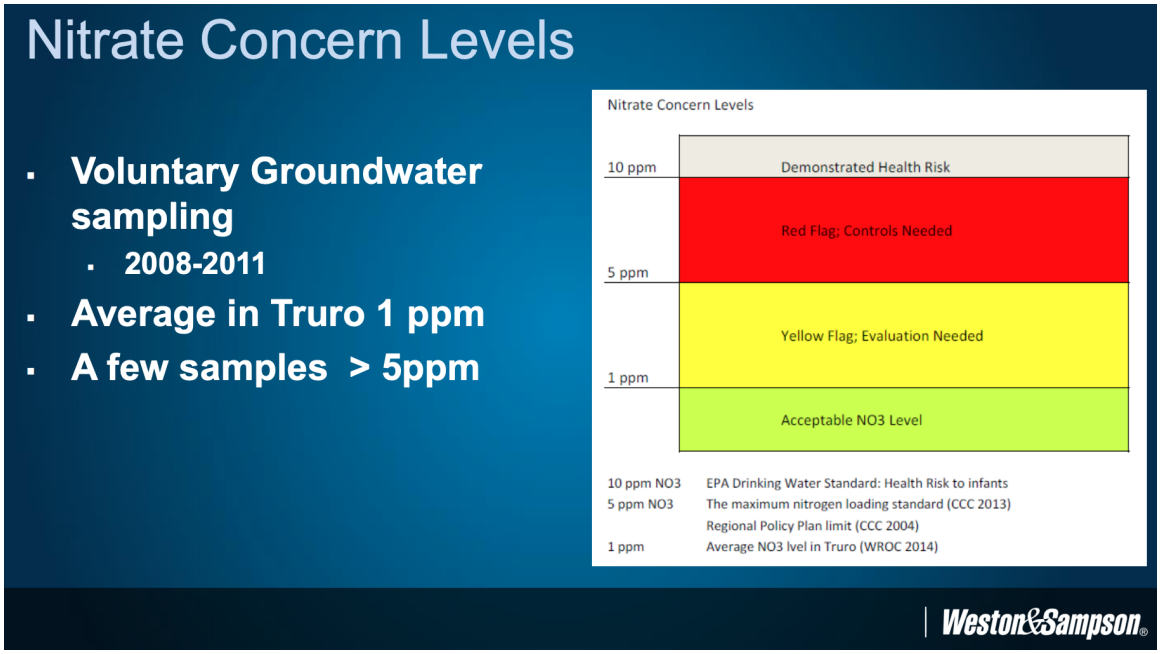


Figure 6: W&S Water Sampling Results and Impact 2008-2011

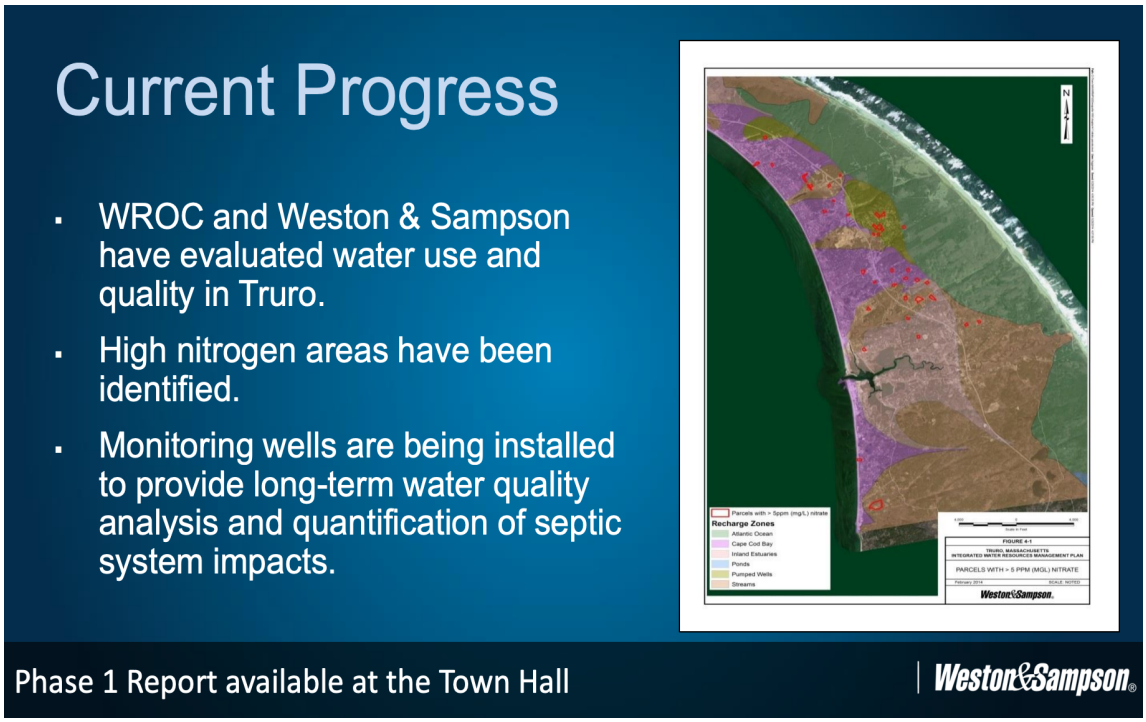


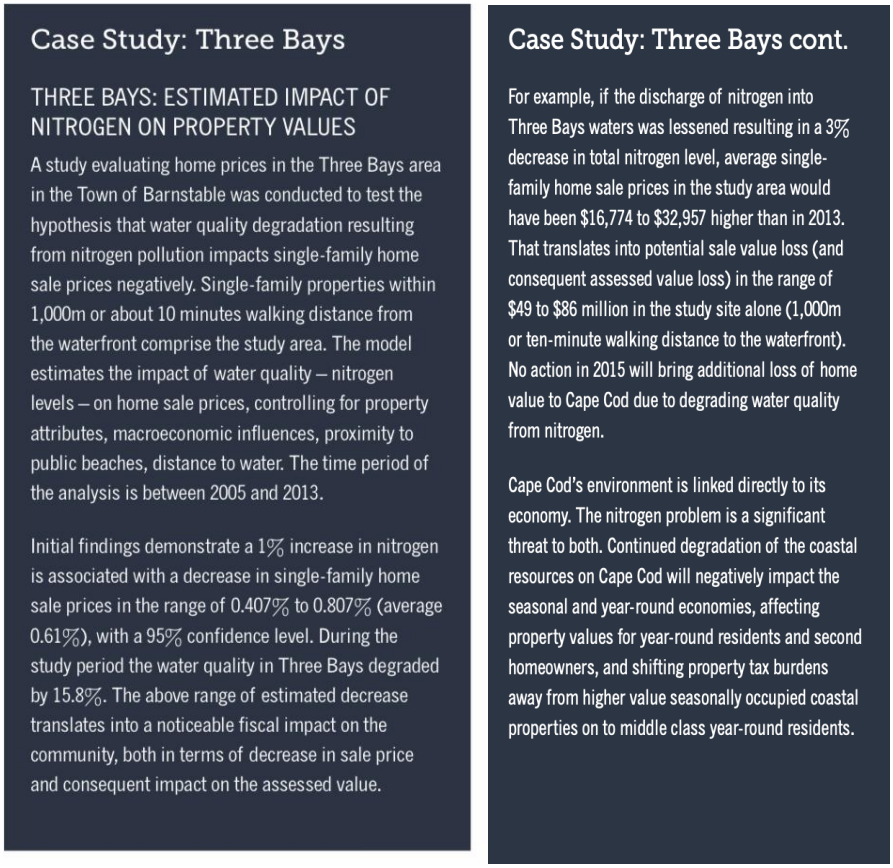
Figure 7: W&S Water Sampling Areas and Status 2008-2011

Other Effects of Excessive Nitrate Levels

- Property Values

Once drinking water is contaminated by excess levels of nitrates or other health-harming agents, the remedies are **costly and irreversible: to construct a public water supply system**, including large wells for supply, water filtration plants, water towers, underground water mains, and wastewater treatment facilities.

As expensive as a city-like water infrastructure is to build and maintain, and as much as it would be funded by significantly increased taxes, another economically devastating consequence is the **decrease in property values due to polluted drinking water.** Per the Cape Cod Commission, **a 1% increase in nitrogen is associated with a decrease in home prices of 0.6% on average.** In Truro's case, the total value of its homes is on the order of $2.3 billion. A mere 2% increase in nitrogen - below the rate of increase observed by the Inner Pamet Harbor monitoring project - would then reduce home values by about $28 million per year. Allowing the **current Board of Health standard of 10 mg/L doubles the level science now establishes as a threshold for multiple health impacts: 5 mg/L**. The corresponding rise in allowable nitrate levels could have adverse economic impacts of considerable magnitude.



Case Study: Three Bays

THREE BAYS: ESTIMATED IMPACT OF NITROGEN ON PROPERTY VALUES

A study evaluating home prices in the Three Bays area in the Town of Barnstable was conducted to test the hypothesis that water quality degradation resulting from nitrogen pollution impacts single-family home sale prices negatively. Single-family properties within 1,000m or about 10 minutes walking distance from the waterfront comprise the study area. The model estimates the impact of water quality – nitrogen levels – on home sale prices, controlling for property attributes, macroeconomic influences, proximity to public beaches, distance to water. The time period of the analysis is between 2005 and 2013.

Initial findings demonstrate a 1% increase in nitrogen is associated with a decrease in single-family home sale prices in the range of 0.407% to 0.807% (average 0.61%), with a 95% confidence level. During the study period the water quality in Three Bays degraded by 15.8%. The above range of estimated decrease translates into a noticeable fiscal impact on the community, both in terms of decrease in sale price and consequent impact on the assessed value.

Case Study: Three Bays cont.

For example, if the discharge of nitrogen into Three Bays waters was lessened resulting in a 3% decrease in total nitrogen level, average single-family home sale prices in the study area would have been $16,774 to $32,957 higher than in 2013. That translates into potential sale value loss (and consequent assessed value loss) in the range of $49 to $86 million in the study site alone (1,000m or ten-minute walking distance to the waterfront). No action in 2015 will bring additional loss of home value to Cape Cod due to degrading water quality from nitrogen.

Cape Cod's environment is linked directly to its economy. The nitrogen problem is a significant threat to both. Continued degradation of the coastal resources on Cape Cod will negatively impact the seasonal and year-round economies, affecting property values for year-round residents and second homeowners, and shifting property tax burdens away from higher value seasonally occupied coastal properties on to middle class year-round residents.

Figure 8: Case Study | Estimated Impact of Nitrates on Cape Cod Property Values

- **Commercial Safety Concerns**

The potential impact of contaminated water is not limited to residential property owners. Commercial operations, and especially those who serve the tourists and seasonal visitors who drive business success in Truro, must also rely on

safe groundwater supplies. Contamination comes from human activity. If there is increased human activity, of the same or expanded scale as we see now, then we will experience increased contaminants and safety and health of the tourist and seasonal clientele will accordingly be at risk. All of the potential effects on property values as well as the impact on consumer-serving business could proportionately affect Truro's limited retail and restaurant businesses that serve or rely on safe drinking water.

- **The Challenge of Density**

The Town of Truro has not consistently obtained, documented and published water quality test results over time to enable a trend to be determined in Truro. However, the **Center for Coastal Studies** has been monitoring the nitrogen levels at the Inner Pamet Harbor for over 10 years. The data is presently being analyzed by **Docs for Truro Safe Water** and a report is forthcoming. Preliminary results indicate an increasing nitrogen level over time, consistent with the increasing density of septic systems in Truro in general and in the Pamet watershed in particular. This is consistent with the Weston & Sampson study which concluded based on sampling that gradual increases would result absent well mitigation or more stringent regulation.

The more densely populated areas of Truro, including Pond Village, North Truro and the Pamet River basin in central Truro could experience an increase due to high density development up gradient. Other neighborhoods could experience increases due to added people and/or occupancy and deteriorating septic systems.

- **The Challenge of Mitigation**

There are at least three ways in which mitigation can pose challenges to property owners relying on well water for domestic or commercial consumer use:

- **Cesspool Replacement.** Truro is estimated to still have about 210 cesspools in operation. A cesspool is a pit lined with cement or stone. Cesspools lack the ability to filter waste and the sewage eventually contaminates the surrounding soil. For this reason, **cesspools are outdated and illegal**. However, when the Commonwealth enacted Title V in 1975, it mandated that cesspools be upgraded to septic systems upon the sale of the property. Since some properties have not sold or have been passed inter-generationally, these cesspools have in effect become "grandfathered" until a sale happens. In the meantime, these cesspools have been contributing a significant amount of contamination to the aquifer for the 45 years since Title V became law and will for the foreseeable future until some plan to upgrade them is formulated.
- **Nitrate reduction.** Once nitrates have entered groundwater, it is a difficult, uncertain and lengthy process to reduce nitrates concentrations and nitrogen loading. It is by far better to avoid the contamination if at all possible, avoiding the cost and health risks of attempted nitrate reduction efforts. Septic system improvements (e.g., cesspool replacement) through tax incentives, policy and regulations to limit nitrates in drinking water, building regulations that conform with adjusted lower limits, discouragement of residential lawns (and thus nitrogen) and other nitrate-reducing actions undertaken prophylactically are worth consideration.
- **Be proactive.** It is possible to take steps to prevent nitrate concentrations from reaching levels where health and safety are in danger. This requires personal vigilance and monitoring by individual well owners. But equally, it requires community planning, scientifically based decision-making, and regulations that reflect both of these.

A common solution for communities that neglect their private well water safety until it becomes too contaminated is to build expensive water treatment plant(s) and water department infrastructures, as mentioned above. We have expensive examples of this surrounding Truro in both Provincetown and Eastham. For example, Eastham faced the same issue over a decade ago, but failed to take sufficient measures early enough. (See **Appendix H** for a brief re-cap of Eastham's initial timeline.) That resulted in the necessity of replacing private wells with a town water system, at a projected cost of over $100 million.

Truro need not suffer this fate.

Conclusions

As more research has emerged from the first question in 1945 about nitrates in well water as a possible cause of "blue baby syndrome" to this day, the scientific evidence shows consistently and incontrovertibly that:

- The harmful effects of nitrate on human health are found at lower and lower levels of concentration.
- The trend of lower threshold levels has been consistent for more than 25 years, finding significant health consequences **at and below nitrate concentrations of 5 mg/L.**
- At levels below 5mg/L the list of cancer and non-cancer health conditions triggered by lower levels of nitrates expands continuously, to include, among other conditions, **non-Hodgkin's lymphoma, thyroid, bladder, colorectal and ovarian cancers, brain tumors in children, and multiple birth defects.**
- **Many experts and organizations domestically and internationally have called for the maximum contaminant level for nitrate to be set between 1 mg/L and 5 mg/L.**
- **Nitrate concentrations of 5 mg/L** are well below current EPA and Truro Board of Health standards.
- **Nitrate in private wells – serving 85% of Truro's households - is not regulated. In Truro, only the Board of Health has the authority to do so.**
- Nitrates combine with and catalyze action of OWCs (organic wastewater compounds) to induce adverse health effects **at lower levels of concentration and over longer periods of time**.
- Mitigation of excessive nitrate concentrations or nitrate loading is uncertain, expensive, and prolonged once it enters groundwater.
- With prior planning and sound regulation, the worst effects of water contamination can be avoided, as can the adverse effects associated with excess nitrates on human health, property values, the local economy and the surrounding natural environment.

Recommendations

It is clear that nitrate levels once thought to be safe in the 1960's – set at 10mg/L - are considered to be too high and are no longer viewed as safe by the great majority of scientific evaluations, and today's level of safety should reflect the evolution in science and science-based policy and regulation.

These extensive scientific evaluations propound that safe levels fall within the range of 1 to 5 mg/L.

Accordingly, as a pressing local matter this research warrants consideration and possible revision by the Truro Board of Health to reset local standards in conformity with current scientific evaluations for nitrate concentrations and nitrate loading at a level at or under 5 mg/L.

Addenda

Glossary

Appendices A-I

Addendum 1 - Glossary

Scientific Acronyms Used in This Report

BOD	biochemical oxygen demand
gal	gallons
L or l	liter; 1.06 quarts
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg/L	milligrams per liter; a measure of concentration; the weight in milligrams of any specific substance or substances contained in one liter of solution
N2	Nitrogen gas naturally present in the atmosphere
NO3-N	Nitrate as Nitrogen
NO2	Nitrite
NH3	Ammonia
OWC	organic wastewater compound
pH	below 7.0 = acidic / above 7.0 = alkaline
ppm	parts per million
SF	square feet

Conversion Factors

mg/L to ppm =	1 (mg/L and ppm are equivalent at the density of water of 1 kg/L)
Liters to gal =	3.7854 liters to a gallon
SF per acre =	40,000 sf in a "builder's acre" (43,560 actual sf in one acre)

Constants

SF per parking space =	350 SF
Allowable Effluent / 1 bedroom per 10,000SF =	110 gals/day
Title V septic effluent concentration =	23.63 mg/L
Average household size in Truro =	2.03 people per house (per 2010 Truro Census data)

Symbols

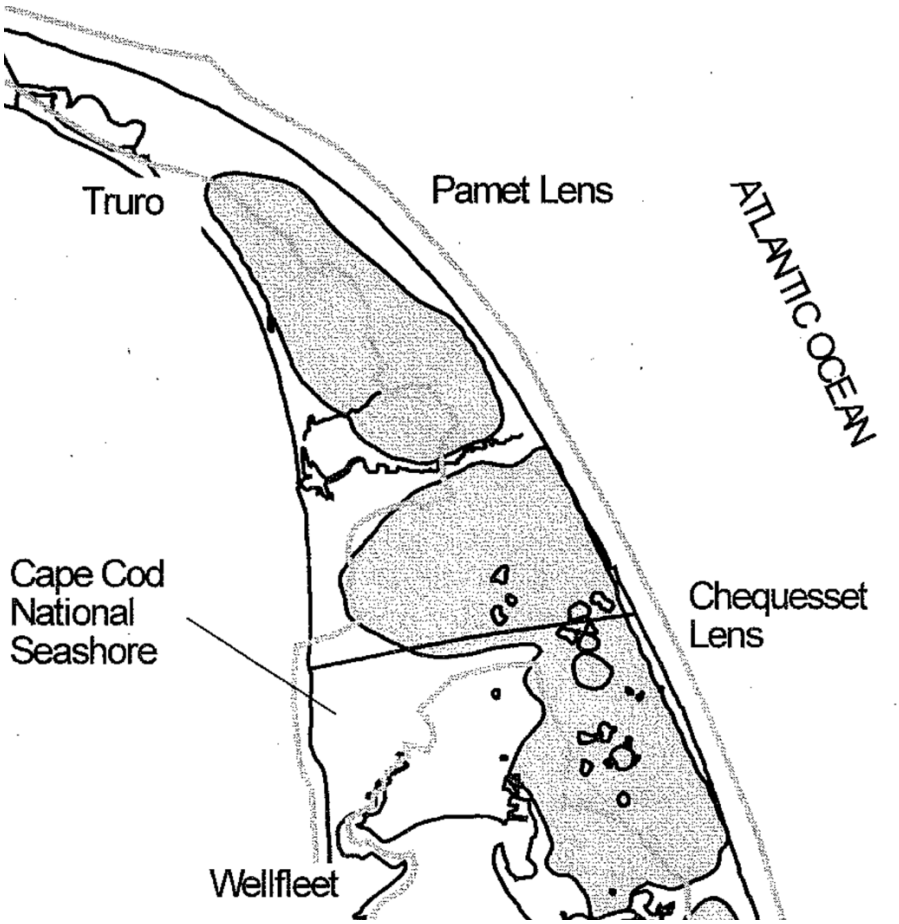
(>=) and (≥)	"greater than or equal to" the stated number
(<=) and (≤)	"less than or equal to" the stated number
~	"approximately"

Appendix A– Pamet Lens, Chequesset Lens, and Nitrate Levels from 1984-1995

Truro's groundwater, and thus well water, comes from the sections of the Cape Cod aquifer located under Truro known as the:

- **Pamet Lens** (north of the Pamet River) - The Pamet Lens exhibited a significant number of private wells which exceeded nitrate levels of 5 mg/L in the 1984 to 1994 timeframe.
- **Chequesset Lens** (south of the Pamet River)

These "lenses" are designated where ground water levels rise up to 5 feet above sea level. They float over sediments saturated with denser saltwater and have been studied extensively by the USGS, Cape Cod Commission, private consultants and municipal entities. The maps here are found in **Water Resources of Outer Cape Cod, Final Report of the Lower Cape Water Management Task Force, May 1998, Figures 1 and 6, respectively**



Appendix A – continued

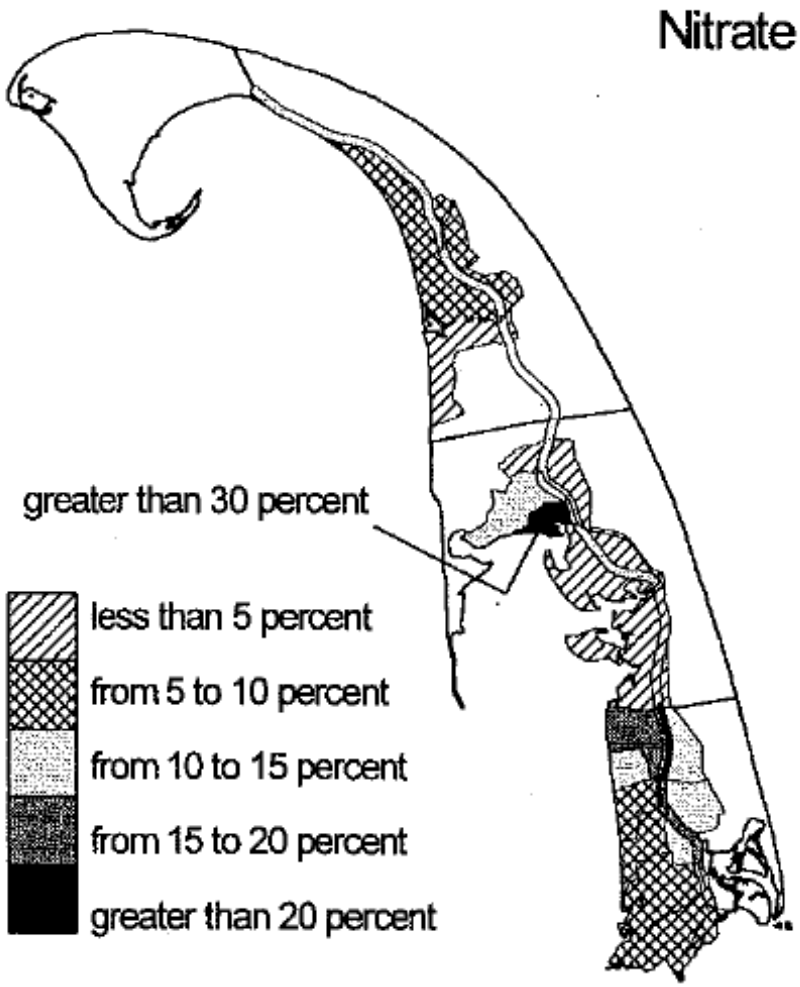


Figure 6. Percentage of private wells which exceeded nitrate levels of 5 mg/L from 1985 to 1994.

Appendix B – Organic Waste Compounds

What Are Organic Waste Compounds (OWCs)?

OWCs are ingredients and by-products of common agricultural, industrial, and household substances. For this study, 69 individual compounds were aggregated into 15 classes:

- Antioxidants
- Dyes/pigments
- Fire retardants
- Polycyclic aromatic hydrocarbons (PAHs)
- Plasticizers
- Fuels
- Solvents
- Herbicides
- Insecticides
- Antimicrobial disinfectants
- Detergent metabolites
- Flavors and fragrances
- Human drugs (nonprescription)
- Sterols
- Miscellaneous

OWCs enter the environment in many ways, including runoff from urban and agricultural areas, industrial discharges into the air or water, leaching into the groundwater from unlined landfills, discharges from wastewater-treatment plants, combined sewer overflows, leaking septic systems, and leaking municipal sanitary and storm sewer systems.

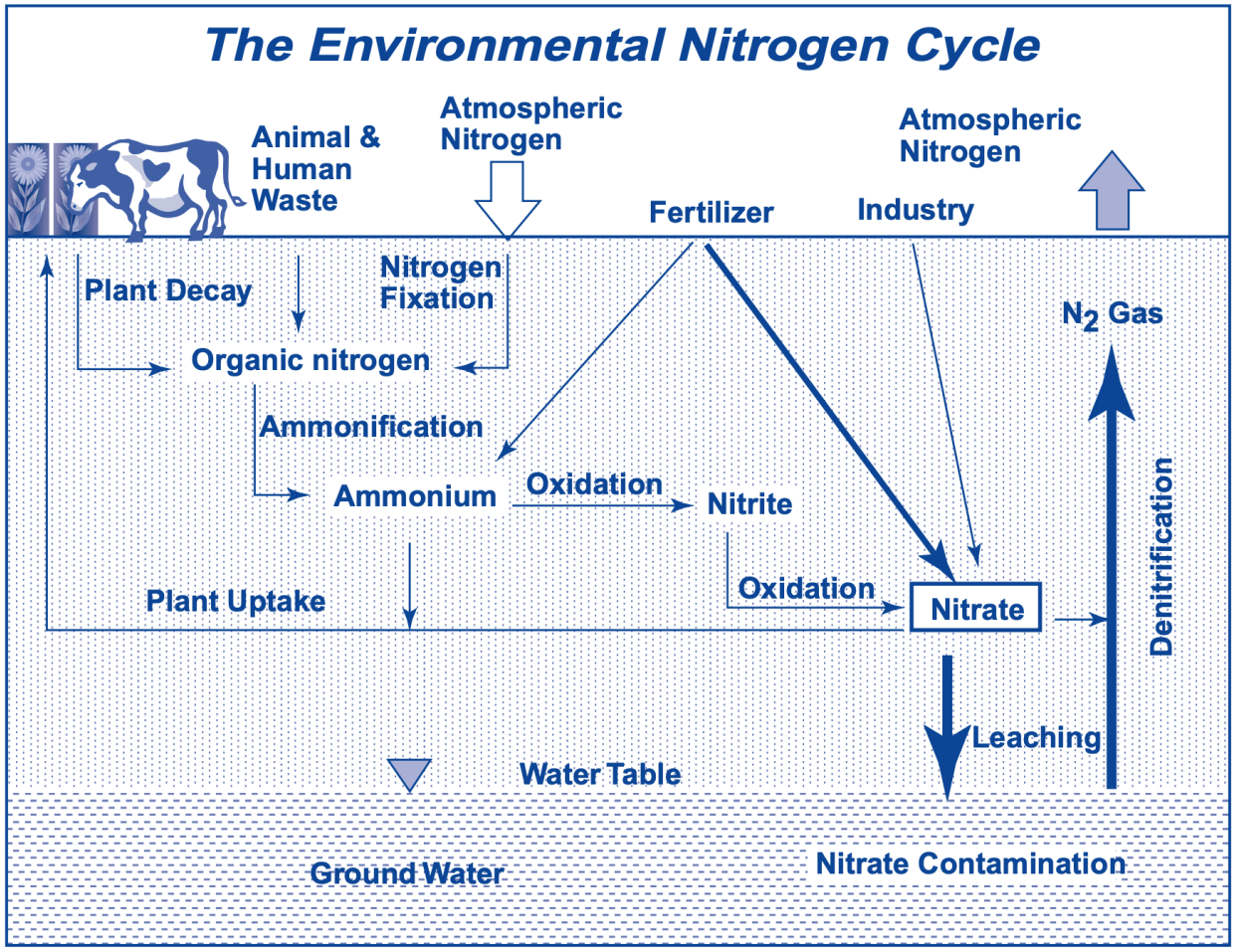
Many of these compounds are toxic at elevated concentrations and (or) are known to have endocrine-disrupting potential. Even low concentrations can impact aquatic organisms because exposure is often chronic, spanning entire life cycles and multiple generations. Furthermore, OWCs often occur as mixtures of multiple compounds, which can strengthen their effects.

https://pubs.usgs.gov/fs/2015/3056/fs20153056.pdf

OWCs are present in wastewater. They were not studied at the time when the original Safe Water Drinking Act was enacted in 1974, 46 years ago.

Appendix C – The Environmental Nitrogen Cycle

The graphic below illustrates the flow of nitrogen into and out of the ground water table.



Appendix D - Sample Water Testing Results Report

The **Barnstable County Health Laboratory** conducts drinking water analysis from samples collected and sent to them.

Below is a result from a randomly collected well-water sample from Pond Road in North Truro, analyzed in 2019. The nitrate level is outlined in red, having a very high nitrate level of 4.7 mg/L. The pH of 6.1 indicates acidic water, and the sodium level of 58 is also high.

CERTIFICATE OF ANALYSIS

Barnstable County Health Laboratory (M-MA009)

Recipient: [redacted]
[redacted] Pond Road
North Truro, MA 02652

Order No.: G19114801
Report Dated: 07/29/2019
Submitter: [redacted]
Description: rtn - [redacted] Pond Road

Laboratory ID#: 19114801-01
Sample #:
Collection Address: [redacted] Pond Road, North Truro, MA 02652
Sample Location:

Matrix: Water - Drinking Water
Sampled: 07/11/2019 By: Customer
Received: 07/11/2019 11:37 By: SamirB
Turn Around: Standard

Routine

ITEM	RESULT	UNITS	RL	MCL	METHOD #	ANALYST	TESTED	TIME
Nitrate as Nitrogen	4.7	mg/L	0.10	10	EPA 300.0	CL	07/11/2019	14:03
Copper	0.12	mg/L	0.10	1.3	EPA 200.8	CL	07/12/2019	13:09
Iron	0.13	mg/L	0.10	0.3	EPA 200.8	CL	07/12/2019	13:09
pH	6.1	PH AT 25C	NA	6.5-8.5	SM 4500-H-B	CL	07/11/2019	14:23
Sodium	58	mg/L	2.5	20	EPA 200.8	CL	07/12/2019	13:09
Total Coliform	Absent	P/A	0	0	SM 9223B	RG	07/11/2019	16:26
Conductance	410	umohs/cm	2.0		EPA 120.1	DCB	07/11/2019	14:23

Sodium level is above the maximum contaminant level. Those on a low sodium diet may wish to consult a physician.

Attached please find the laboratory certified parameter list.

Approved By: [signature]
(Lab Manager) 30JUL19

Appendix E – Timeline of Research on Water Safety | Additional Details

This appendix summarizes the evolution over time of research into drinking water safety. The science has evolved considerably over the last 75 years since the end of World War II. It shows a period of accepting a 10 mg/L nitrate standard from 1962 (based on results from the 15 years prior) until today.

After the year 2000, studies began to appear questioning the appropriateness of the standard, especially as it relates to carcinogens and cancer. By 2010, more studies appear and confirm the relationship of nitrates and cancer and other illnesses. Some studies argue for a reduction in the standard to 5 mg/L or below. The last five years have seen an accelerating number of studies supporting similar conclusions.

1945

Dr. Hunter Comly of Iowa reported on two cases of a "previously unrecognized" condition that "may occur anywhere in rural areas where well-water is used in infant feeding." Dr. Comly suspected that the nitrates in the family's well-water were at fault. Before publishing his report, Dr. Comly collected from colleagues' anecdotal accounts of 17 more cases, including one that had resulted in death. It appeared to him that "the condition was not rare."

https://dartmed.dartmouth.edu/summer00/html/what_makes_my_baby_blue.shtml
https://jamanetwork.com/journals/jama/article-abstract/275699

1947-1950

Methemoglobinemia and Minnesota well supplies
Journal of the American Water Works Association

A study is conducted in 1947-49 by clinical and sanitary experts of 139 cases of methaemoglobinaemia, due to the consumption of well-water, reported in Minnesota between January 1947, and September 1949, in infants under five months of age.

Based on the study, in 1950 the Journal of the American Water Works Association publishes a journal article Methemoglobinemia and Minnesota well supplies, reporting on the association of this condition with a high nitrate content of water.

https://hero.epa.gov/hero/index.cfm/reference/details/reference_id/3841331

1951

Survey of literature relating to infant methemoglobinemia due to nitrate-contaminated water - G. Walton
American Journal of Public Health and the Nation's Health

The literature on methemoglobinemia in new-born infants due to ingestion of high-nitrate water is reviewed, the historical background leading to Comly's hypothesis is presented, and medical aspects, including cause, susceptibility, physiol. effects, diagnosis, and treatment, are briefly covered. Water used in preparing the infant's feeding formula should contain not more than 10 or possibly 20 ppm nitrate N.

https://hero.epa.gov/hero/index.cfm/reference/details/reference_id/3002705

1962

The U.S. Public Health Service recommended a national nitrate standard of 10 ppm.

1970

President Richard Nixon decided in July of 1970 to create a single agency to deal with environmental issues, and the EPA was born.

1974

The Safe Drinking Water Act (SDWA) was passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The EPA endorsed the 10 ppm nitrate limit to protect against "blue-baby syndrome."

https://www.epa.gov/sites/production/files/2015-04/documents/epa816f04030.pdf

1995

The SDWA also authorized the EPA to seek the expertise of the National Research Council (NRC) to identify the health effects of specific contaminants. A 1995 NRC document, ***Nitrate and Nitrite in Drinking Water***, was then the most recent of the required periodic reviews and again upheld the 10 ppm nitrate limit, based on no other data or research being available since 1951.

> "When EPA evaluated the toxicity of nitrate and nitrite for the purpose of establishing drinking-water criteria, it did not assign a weight-of-evidence classification for their carcinogenic potential (EPA 1990a). EPA concluded that there are no convincing data to suggest that nitrate or nitrite is associated with any adverse effect other than methemoglobinemia, and it identified a no-observed-adverse-effect level (NOAEL) for nitrate of 10 mg of nitrate nitrogen per liter (1.6 mg/kg-day) on the basis of epidemiologic studies (Walton 1951). That value is equivalent to nitrate at 44 mg/L. To obtain a reference dose (RfD) from the NOAEL, an uncertainty factor of 1 was used because the NOAEL was derived from studies in humans of the most sensitive subpopulation. For nitrite, EPA assumed that the conversion rate of nitrate to nitrite by gastrointestinal tract bacteria in infants is about 10%, from which an RfD of 1 mg of nitrite nitrogen per liter (0.16 mg/kg-day) was calculated. That value is equivalent to nitrite at 3.3 mg/L. The MCLGs for nitrate and nitrite are based on these RfDs: nitrate nitrogen at 10 mg/L and nitrite nitrogen at 1 mg/L (EPA 1991)."
>
> "Available data are inadequate to support an association between nitrate and nitrite exposure from drinking water and any noncancer effects except for methemoglobinemia in infants."
>
> "The subcommittee concludes that EPA's current MCLGs and MCLs of nitrate at 44 mg/L (nitrate nitrogen at 10 mg/L) and nitrite at 3.3 mg/L (nitrite nitrogen at 1 mg/L) are adequate to protect human health."
>
> https://pubmed.ncbi.nlm.nih.gov/25101396/

1996

Drinking water nitrate and the risk of non-Hodgkin's lymphoma - Mary H. Ward et al
Epidemiology

> Long term consumption of community water with average nitrate levels in the highest quartile (> or = 4 mg per liter nitrate-nitrogen) was positively associated with risk.
>
> These findings indicate that long term exposure to elevated nitrate levels in drinking water may contribute to the risk of NHL [non-Hodgkin's lymphoma].
>
> https://pubmed.ncbi.nlm.nih.gov/8862975/

1998

Water Resources of Outer Cape Cod
Lower Cape Water Management Task Force

From 1985 to 1994, 3 of every 4 wells did not exceed nitrate levels of 1.4 mg/L in Truro.

Descriptions of water quality are typically expressed by using an acceptable standard value. In this study, we report the number of wells that exceed 5 mg/L as a measure of water quality… movement from sparse to dense development is accompanied by increasing variation of sampled nitrate levels and a general decrease in water quality. The importance of this trend is that it challenges the misconception that degrading water quality touches only a small minority of wells that already have "higher" nitrate levels. In fact, increasing development density is shown to affect the entire range of private wells on the Outer Cape.

A private well water quality monitoring program should be established in order to track water quality conditions into the future.

The absence of central wastewater treatment has meant that all households and businesses on the Outer Cape rely on onsite septic systems to dispose of their wastewater. Other than removing solids and reducing dissolved solids, conventional onsite systems do little to remove many other contaminants of household sewage.

The gradual accumulation of nitrate in groundwater as it flows towards coastal discharge areas and municipal wells has both environmental and public health implications on Cape Cod.

https://sp.barnstablecounty.org/ccc/public/Documents/Provincetown%20Harbor/1998%20Water%20Resources%20of%20Outer%20Cape%20Cod.pdf

2002

Nitrate Toxicity and Drinking Water Standards: A Review - B.C. Kross
The Journal of Preventive Medicine

"The current US EPA maximum contaminant level (MCL) for public drinking water supplies and the health advisory level (HAL) for other private water supplies is 10 mg/L, expressed as NO3-N. Unlike other drinking water standards, the nitrate standard has no safety factor, which typically is about a 10-fold safety factor to account for differences in human susceptibility. Guidance, action, or advisory levels for nitrate in drinking water are lower in several countries, including Germany (4.4 mg/L), South Africa (4.4 mg/L), and Denmark (5.6 mg/L). Clearly health and regulatory officials in other countries believe that the current WHO and USA drinking water standard for nitrate is not adequate."

"The regulatory authorities should establish a safety factor of two, which would reduce the current MCL and HAL for nitrate to 5.0 mg/L NO3-N. This regulatory mandate would encourage a prudent public health strategy of limiting human nitrate exposure."

"The current nitrate standard established in 1987 is based on a literature review of 278 cases of methemoglobinemia reported in the United States between 1945 and 1950. The study reported that none of these cases occurred when nitrate concentrations in drinking water were below 10 mg/L (18). Unlike other drinking water standards, the nitrate standard has no safety factor, which typically is about a 10-fold safety factor to account for differences in human susceptibility."

"By mandating a safety factor of two, which would reduce the current MCL and HAL for nitrate to 5.0 mg/L NO3-N, and by promulgating a MCLG of 3.0 mg/L of NO3-N; the United States regulatory approach for nitrate in drinking water would become consistent with other European countries and would encourage the prudent public health strategy of limiting human nitrate exposure."

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.490.9053&rep=rep1&type=pdf

2005

2005 Truro Local Comprehensive Plan
Truro Local Comprehensive Planning Committee

Truro's greatest treasure is the rural character it has preserved.

The pressures for change are relentless, however -- and likely to accelerate. How can we balance economic growth with the need to protect limited resources?

This local comprehensive plan suggests a response to those questions. Developed over almost a year, representing the thought and work of scores of town citizens, employees, and officials…

Land Use. Town policies codified into the zoning bylaws are Truro's most effective planning tool.

Water Resources. The critical issues involving the Outer Cape's limited water resources were brought dramatically into the public eye by the 2004 agreement between Truro and Provincetown over how to share the water pumped from the Pamet Lens.

Board of Health is asked to: Continually review the Board of Health nitrogen loading standards to ensure that such standards adequately address potential groundwater pollution problems.

2009

Cape Cod Regional Policy Plan
Cape Cod Commission

Five-ppm Nitrogen Loading Standard: The maximum nitrogen loading standard for impact on groundwater shall be 5 ppm for development and redevelopment unless a cumulative impact analysis indicates a more stringent loading standard is necessary.

https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/Website_Resources/RPP/030411RPP_forweb.pdf

2010

Nitrate intake and the risk of thyroid cancer and thyroid disease – Mary H. Ward et al
Epidemiology

"We found an increased risk of thyroid cancer with higher average nitrate levels in public water supplies and with longer consumption of water exceeding 5 mg/L nitrate-N (for >or=5 years at >5 mg/L."

https://pubmed.ncbi.nlm.nih.gov/20335813/

2012

Cape Cod Environmental Summit Consensus Statement
Association for the Protection of Cape Cod

On September 27, 2012 representatives from thirty-six Cape Cod-based 501(c)3 nonprofit environmental organizations gathered to discuss and agree upon a set of core principles related to wastewater and nutrient loading of Cape Cod's waters.

Excess nutrients from wastewater and other sources are contributing to the decline of water quality.

Nutrient loading of Cape Cod's groundwater, ponds, and coastal waters caused by human activity and waste is the region's number one environmental priority. Immediate action on the part of government, business, and every citizen across Cape Cod is necessary.

Delay will add to the environmental damage, the cost of remediation and the cost of necessary infrastructure.

Long-term management of nutrients/wastewater requires an integrated approach. Integrated approach is "a holistic approach to water resources management that takes into account land use practices, open space preservation, growth management, zoning, stormwater management, drinking water protection, wastewater management, and water quality enhancement."

It is necessary to use appropriate zoning, natural resource protection regulations, and land use regulations to protect our water resources and facilitate the goal of no net increase above each watershed's TMDL for nutrients.

Sound land use planning, including zoning, can be used to manage growth, facilitate growth in areas with adequate infrastructure and control the generation of nutrients/wastewater.

https://apcc.org/wp-content/uploads/2020/05/Consensus-Statement-final-ratified.pdf

2013

Prenatal nitrate intake from drinking water and selected birth defects in offspring of participants in the national birth defects prevention study
Environmental Health Perspectives

"Women who had babies with NTDs [neural tube defects], limb deficiencies, and oral cleft defects were significantly more likely than control mothers to ingest >= 5 mg of nitrate per day from drinking water."

https://pubmed.ncbi.nlm.nih.gov/23771435/#:~:text=Higher%20water%20nitrate%20intake%20did,nitrosatable%20drugs%20and%20birth%20defects.

2017

Nitrate from Drinking Water and Diet and Bladder Cancer Among Postmenopausal Women in Iowa
Environmental Health Perspectives

"We found significant associations among those exposed ≥ 4 years to drinking water with > 5 mg/L NO3-N. "

"Long-term ingestion of elevated nitrate in drinking water was associated with an increased risk of bladder cancer among postmenopausal women."

https://pubmed.ncbi.nlm.nih.gov/27258851/

EPA

"The Integrated Risk Information System (IRIS) Program is undertaking a reassessment of the health effects of nitrate and nitrite."

The IRIS Program previously evaluated the oral health effects of nitrate and nitrite; oral reference doses (RfDs) for nitrite and nitrate2 were posted to the IRIS database in 1987 and 1991, respectively. EPA based these RfDs on surveys of clinical cases of methemoglobinemia in infants associated with ingestion of nitrate-containing drinking water conducted in the early 1950s (Walton, 1951; Bosch et al., 1950). Since 1987, a growing body of literature indicates potential associations between nitrate/nitrite exposure and other noncancer health effects. Some epidemiological studies also suggest an increased risk of cancer, especially gastric cancer, associated with dietary nitrite exposure (ATSDR, 2017). Cancer risk associated with nitrate or nitrite exposure is complicated by the fact that, under conditions of concurrent exposure to amines or amides or low levels of antioxidants, endogenous nitrosation can occur, leading to the formation of carcinogenic nitroso compounds (ATSDR, 2017; IARC, 2010). IARC (2010) concluded that ingested nitrate or nitrite under conditions that result in endogenous nitrosation is probably carcinogenic to humans.

https://yosemite.epa.gov/sab/sabproduct.nsf/8AF41B299F1C342C852581980075D17D/$File/Nitrate-Nitrite_IAP_draft_plan+9.8.17.pdf

2018

Nitrate in drinking water and colorectal cancer risk: A nationwide population-based cohort study.
International Journal of Cancer

"We found statistically significant increased risks at drinking water levels above 3.87 mg/L."

https://onlinelibrary.wiley.com/doi/full/10.1002/ijc.31306

Prenatal nitrate intake from drinking water and selected birth defects in offspring of participants in the national birth defects prevention study
Environmental Health Perspectives

"Mothers of babies with spina bifida were 2.0 times more likely (95% CI: 1.3, 3.2) to ingest ≥ 5 mg nitrate daily from drinking water."

"During 1 month preconception through the first trimester, mothers of limb deficiency, cleft palate, and cleft lip cases were, respectively, 1.8 (95% CI: 1.1, 3.1), 1.9 (95% CI: 1.2, 3.1), and 1.8 (95% CI: 1.1, 3.1) times more likely than control mothers to ingest ≥ 5.42 mg of nitrate daily."

https://ehp.niehs.nih.gov/doi/10.1289/ehp.1206249

Drinking Water Nitrate and Human Health: An Updated Review – Mary H. Ward et al
Int J Environ Res Public Health

"Risk of specific cancers and birth defects may be increased when nitrate is ingested under conditions that increase formation of N-nitroso compounds. We previously reviewed epidemiologic studies before 2005 of nitrate intake from drinking water and cancer, adverse reproductive outcomes and other health effects. Since that review, more than 30 epidemiologic studies have evaluated drinking water nitrate and these outcomes. The most common endpoints studied were colorectal cancer, bladder, and breast cancer (three studies each), and thyroid disease (four studies). Considering all studies, the strongest evidence for a relationship between drinking water nitrate ingestion and adverse health outcomes (besides methemoglobinemia) is for colorectal cancer, thyroid disease, and neural tube defects. Many studies observed increased risk with ingestion of water nitrate levels that were below regulatory limits."

"Four of the five published studies of colorectal cancer found evidence of an increased risk of colorectal cancer or colon cancer associated with water nitrate levels that were mostly below the respective regulatory limits."

"Four of the five studies of thyroid disease found evidence for an increased prevalence of subclinical hypothyroidism with higher ingestion of drinking water nitrate among children, pregnant women, or women only [37,144,145,160]. Positive associations with drinking water nitrate were observed at nitrate concentrations close to or above the MCL."

"To date, five of six studies of neural tube defects showed increased risk with exposure to drinking water nitrate below the MCL. Thus, the evidence continues to accumulate that higher nitrate intake during the pregnancy is a risk factor for this group of birth defects."

"Estimating exposure for private well users is important because it allows assessment of risk over a greater range of nitrate exposures compared to studies focusing solely on populations using PWS [public water supplies]. Future health studies should focus on these populations, many of which may have been exposed to elevated nitrate in drinking water from early childhood into adulthood. A major challenge in conducting studies in these regions is the high prevalence of private well use with limited nitrate measurement data for exposure assessment. Recent efforts to model nitrate concentrations in private wells have shown that it is feasible to develop predictive models where sufficient measurement data are available."

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6068531/

2019

Millions of Americans Exposed to Elevated Nitrate Levels In Drinking Water
Silent Spring Institute

> "Currently, EPA's drinking water standard for nitrate is 10 ppm. That level is set in order to protect infants from a potentially fatal condition known as "blue baby syndrome," a decrease in the ability of blood to carry oxygen around the body. However, recent studies suggest exposure at levels as low as 5 ppm is also associated with several cancers and birth defects, raising the possibility that EPA's water standard is not sufficiently protective of health."
>
> https://silentspring.org/news/millions-americans-exposed-elevated-nitrate-levels-drinking-water

Exposure-based assessment and economic valuation of adverse birth outcomes and cancer risk due to nitrate in United States drinking water - Alexis Temkin et al
Environmental Research

> "Our data suggest that exposure to nitrate in drinking water could account for 1–8% of total colorectal cancer cases, which translates into 1233–10,379 cancer cases annually. Of these cases, 12–24% are due to nitrate exposure for private well users, especially for people whose well water has 5 mg/L or more nitrate."
>
> "The latest research has produced strengthened epidemiological evidence for the risk of colorectal cancer at nitrate levels below the regulatory standard of 10 mg/L of nitrate as nitrogen."
>
> https://reader.elsevier.com/reader/sd/pii/S001393511930218X?token=E6DB567D0A18C237359A21B313EF0AE2DE0F45986F253723721 7E221968B84D7AE9B0C022F545E65E4E6C59C8947CFCD

Nitrate in U.S tap water may cause more than 12,500 cancers a year
Environmental Working Group

> In 2018, a nationwide study in Denmark found a significant increase in colorectal cancer risk at nitrate levels above 0.9 ppm. And in 2016, a study conducted in Spain and Italy found an increase in colorectal cancer risk at approximately 1.7 ppm of nitrate. A long-running epidemiological research program based in Iowa has reported an association of nitrate in drinking water and increased risk of colorectal, ovarian, thyroid, and bladder cancers.
>
> https://www.ewg.org/research/nitrate-us-tap-water-may-cause-more-12500-cancers-year/

2020

Ingested Nitrate and Nitrite and Bladder Cancer in Northern New England - Kathryn Hughes Barry et al
Epidemiology

> "Average drinking water nitrate concentration above the 95th percentile (>2.07 mg/L) compared with the lowest quartile (≤ 0.21 mg/L) was associated with bladder cancer."
>
> "Our results suggest the importance of both drinking water and dietary nitrate sources as risk factors for bladder cancer."
>
> https://pubmed.ncbi.nlm.nih.gov/31577632/

New Hampshire Department of Environmental Services

> "EPA has not established an MCL [Maximum Contamination Limit] for a man-made contaminant since 1995."
>
> https://ebcne.org/wp-content/uploads/2020/03/Presentations-Emerging-Contaminants-Seminar-The-Life-Cycle-of-PFAS.pdf

Appendix F – Weston & Sampson Reports | Phases 1 and 2 | Relevant Excerpts

This appendix summarizes key findings in the reports by the Town of Truro's water consultant, Weston & Sampson (W&S), an employee-owned interdisciplinary design, engineering, and environmental services firm in Massachusetts with over 100 years of experience. https://www.westonandsampson.com/about-us/

The Truro **Integrated Water Resources Management Plan (IWRMP)** was prepared and delivered in two phases: Phase I in 2014, and Phase II in 2018. The report is summarized below by including selections from the text of the report at the pages indicated.

- **Truro Weston & Sampson Phase I Report - October 2014**

  https://www.truro-ma.gov/sites/g/files/vyhlif3936/f/u286/truro_phase_i_iwrmp.pdf

  by page:

1-1
Truro, like many Cape Cod communities is seeking to understand both current and potential future impacts to water resources and undertake a sensible and cost-effective approach to management. Maintaining the rural characteristics and natural beauty of Truro is of primary importance. Managing impacts due to summer population increases while not placing undue burden on year round residence is also important. While economic cycles may cause changes in the rate of development, future increases in population, tourist visits, and ageing infrastructure will most likely have increased water demand, additional wastewater management needs and increasing impervious cover dictating stormwater infrastructure improvements

One of the Outer Cape's greatest assets is the groundwater lenses that are capable of providing potable water resources.

1-4
The IWRMP was initiated to understand the cumulative effects of nutrient loading on groundwater quality and surface water resources.

1-5
Based on multiple working sessions with the Truro Water Resources Oversight Committee a rational approach to incremental change and methods to address data gaps was developed. The overarching goal of sustainable water resource stewardship for Truro is well served by the committee and their commitment to a long-term plan.

3-1 Stormwater
Ensuring that precipitation enters the ground where it falls (direct infiltration) is a critical component of improving stormwater management. The largest inhibitor of direct infiltration is impervious surfaces and therefore, the most important factor in minimizing the amount of stormwater is by reducing impervious surfaces or treating stormwater from impervious surfaces. The amount of existing impervious surface varies by community, but all communities must work diligently to minimize the amount of newly constructed impervious surface, and even reduce that already existing, through proper regulation of growth and development. This is particularly true for critical recharge zones within Truro. Recharge zones based on ground water flow patterns are shown in Figure 3-2. Essentially, Truro can be divided into nineteen (19) zones effecting wells, rivers, lakes or direct discharge to the ocean.

3-2
"Point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

3-7 Sampling
Although nitrogen concentrations can be modeled, empirical ground water sampling data is often used to compare

(Appendix F – p 2)

and contrast predicted concentrations from the model. Nitrogen sampling data from domestic wells was compared and plotted against modeled concentrations. Lots revealing > 5ppm (mg/l) of nitrogen are shown on Figure 3-2.

Sampling data suggests that over the sample period (2007-2009) over 1181 lots have been sampled with 45 showing concentrations above 5 ppm and 2 lots revealing concentrations above 10 ppm. Concentrations above 5 represent action levels for public drinking water supplies while concentrations above 10 exceed safe drinking water standards. Although, individual sample results require verification through sampling, the results suggest a variety of actions and management approaches are warranted.

A nitrogen loading rate of 13.5 pounds/acre/year was used for pavement loading and 6.76 pounds/acre/year was used for roof loading.

A nitrogen loading rate (0.45 pounds/acre/year) was applied to each recharge zone to calculate annual nitrogen loading for vegetative cover.

In lawn areas a loading rate of 1.08 pounds/5000sf/year was applied to each recharge zone to calculate annual nitrogen loading from the addition of fertilizers applied to lawn areas.

A nitrogen loading rate of 9.73 pounds/acre/year was used for open area loading.

3-9
The amount of open land and impervious area results in a total load of 13,065 lbs/year, or almost 37% of Truro's total annual nitrogen load for this analysis. [implies total annual nitrogen load ~ 35,000 lbs/yr]

3-12
The Town of Truro does not have a separate Stormwater Bylaw and associated Stormwater Regulations. In order to improve stormwater issues within Town, a public outreach program should be developed to make the population aware of the issue.

3-16
Figure 3-2, Map: Areas of Nitrate >5 ppm

3-18
Locally, the Board of Health rules and regulations govern subsurface disposal systems and the discharge of wastewater. Systems above a capacity of 10,000 GPD are required to obtain a Ground Water Discharge Permit (BRP WS-79, 85) and apply treatment technologies that limit the impacts to receptors and generally maintain groundwater quality at less than 10 ppb of Nitrogen (measured as Nitrate) at a property boundary. Although some inconsistency exists with these criteria and the drinking water action level of 5 ppb, most large systems in recent years have been achieving discharge concentrations between 4 and 7 ppb.

4-2

The initiation of a water quality sampling program in 2007 was a progressive move by concerned citizens. The program was designed to sample one-third of the private wells in Truro in every calendar year. The program is voluntary and response is neither mandatory nor punitive. Sample results above the safe drinking water level of 10mg/L (ppm) are asked to retest immediately. Sampling efforts have met with a high rate of response which has helped to establish baseline data throughout the town.

Sample bottles were directly distributed to 889 residences in 2007. Ten (10) sample results indicated concentrations between 5 and 10 ppm. No sample results revealed concentrations above 10 ppm.

No discernible pattern or clustering of the results between 5 and 10 ppm could be suggested. Instead results appeared scattered or random over the subject population.

4-5
Further work is necessary in densely developed areas and within the general locale of elevated concentrations.

(Appendix F – p 3)

4-6
Figure 4-1, Map: Areas with >5 ppm Nitrate

4-8
Figure 4-3, Map: Areas of Critical Interest

5-4
A loading rate of 26.23 mg/L of nitrogen was used for residential septic systems for the entire Town. This loading rate is consistent with current MassDEP assumptions for working septic systems. Additionally, this loading rate is consistent with values used in the Massachusetts Estuaries Program and ongoing studies for Cape Cod.

6-2
The time frame was restricted to a 10-year build-out analysis for nutrient loading purposes. The 10-year time frame was essentially chosen due to the relatively recent data sets available from the 2010 census and its comparison to 1990 and 2000 data. The analysis included nutrient loading using nitrogen as a key essential component of the challenges faced by most Cape Cod communities.

6-3
Table 1. Nitrogen Loading Summary (10-Year Build-Out)

6-6
110 gallons per day per bedroom was the assumed wastewater flow. This loading rate of 23.63 mg/L for wastewater flow is comparable to the loading rate used by the Buzzards Bay National Estuaries Program nitrogen loading studies.

6-9
The existing nutrient loading rate from residential use was then calculated using the nitrogen loading rate of 5.95 pounds per person per year, which is the loading rate per person used in the Buzzards Bay Project's Nitrogen Loading Model.

6-11
Developable parcels map. Shows large parcels in Pond Village/N Truro

7-1
The sampling data and nutrient loading models indicate that excessive water quality impacts or risks to human health and ecology are not evident. Instead, sampling programs indicate that further detailed evaluations in areas with elevated nitrate sampling results should help ascertain whether land use practices, septic system conditions, or simply well construction and hydrogeologic conditions have resulted in localized impacts to groundwater quality. In essence, Truro is fortunate in that the need to create extended municipal infrastructure is not necessary.

W&S Appendix C | Parcels with Septic Systems on Recharge Boundary Line

#####

End of **Weston & Sampson Phase I Report** excerpts

Truro Weston & Sampson Phase II Report excerpts follow below

(Appendix F – p 4)

- **Truro Weston & Sampson Phase II Report - February 2018**

  https://www.dropbox.com/s/8if11a9uhfu1xl6/IWRMP_FINAL_REPORT_8.16.19.pdf?dl=0

IWRMP 8/16/2019

> "…development shall generally meet a 5 parts per million nitrate/nitrogen loading standard for impact on groundwater, but may increase to 10 parts per million nitrate/nitrogen where it can be demonstrated to the permitting authority that such increase will cause no significant adverse impact on wetlands, water bodies, public or private drinking water supply wells and potential water supply wells."

[by page]
1
2005-2010 Local Comprehensive Plan, Ch. 3 Water Resources, Page 38 et al

2
2005-2010 Local Comprehensive Plan, Ch. 3 Water Resources Page 42 et al
https://septic.barnstablecountyhealth.org/
https://www.masstc.org/

3-7
Area 1 includes the intersection of Highland Road and Route 6 and the vicinity of the Pond Road commercial district, and including approximately 128 residences. This area has a significant amount of impervious surface. In addition, DOH records indicate replacement of 4 cesspools with Title 5 compliant systems since 2004. Village Pond is downgradient of this area.

3-9
...current Title 5 compliant systems are assumed to result in effluent containing 26.25 mg/L (ppm) NO3 while I/A systems may reduce loading to 13 to 19 mg/L.

3-9
MassDEP has approved I/A and enhanced I/A septic systems that are expected to achieve 19 and 13 mg/L, respectively in treated effluent. Other I/A system may be installed for nitrogen reduction, but the system must go through an approval process at the local level.

Barnstable County records indicate that 6 I/A systems have been installed in Truro.

3-11
The Town should establish one or more monitoring wells in the Pamet River drainage, Pond Road commercial district, Old Rt.6/Sylvan Lane area and South Highland road area. Monitoring wells in these areas should be monitored twice a year in spring and fall.

Reference to Local Comprehensive Plan 2005

page 41: In Fresh Water Recharge Areas surrounding ponds, when developments generate over 2,000 gallons per day of sewage effluent, Developments of Regional Impact may be required to delineate the groundwater recharge areas to potentially affected fresh water ponds in order to identify and mitigate adverse effects.
https://www.capecodcommission.org/our-work/developments-of-regional-impact

page 42: In Unimpaired Areas, (areas where groundwater may have been degraded by point and non-point sources of pollution, including but not limited to areas with unsewered residential developments where lots, on average, are less

(Appendix F – p 5)

than 20,000 sq ft; landfills, septage and wastewater treatment plant discharge sites; high density commercial and industrial areas and those down gradient areas where the groundwater may have been degraded by these sources) development shall generally meet a 5 parts per million nitrate/nitrogen loading standard for impact on groundwater, but may increase to 10 parts per million nitrate/nitrogen where it can be demonstrated to the permitting authority that such increase will cause no significant adverse impact on wetlands, water bodies, public or private drinking water supply wells and potential water supply wells.

42-12. In Unimpaired Areas, where existing development exceeds the 10 parts per million nitrogen loading standard, redevelopment of that property shall not increase existing levels of nitrogen loading.

page 44: The certification, development and use of appropriate new innovative technologies designed to improve wastewater treatment by reducing nutrient loading is encouraged, although such technologies shall not be the basis upon which to increase building density or change uses from those defined by the Town Zoning By-Law.

page 45: Public & Private Wastewater Treatment Facilities: Truro will not actively encourage the use of these systems except in cases where groundwater quality is significantly deteriorated, the public health is threatened and public water supplies are not available, or where the use of such a system might advance a larger community goal identified in this Plan. In most such cases, private funding of such systems will be preferred. Under no circumstances will these systems alone be the basis upon which building densities are increased or land uses changed from those allowed in Truro's Zoning By-Law.

page 58: All forms of shellfishing have been experiencing unsatisfactory levels of productivity for many years. The brood stock for all species has fallen below the level where natural production of a bountiful annual harvest can be anticipated.

page 87: Truro's economy today depends almost completely on summer visitors and second homeowners. Almost 70% of its area is National Seashore, which, together with its beaches, is the primary attraction of what is perhaps the Cape's last rural town.

page 110: The Pamet Lens will reach output capacity by about 2020.

Appendix G - Truro's Board of Health Regulations | Summary on Nitrogen Loads

Article 3
Truro's Board of Health regulations, Article 3, applies to facilities with on-site sewage disposal systems located in the Town of Truro with a septic design flow greater than 600 gallons per day (gpd).

They must achieve/produce no greater than 19 mg/L total nitrogen concentration in the effluent by using the secondary treatment achieved with an approved innovative/alternative (I/A) septic system.

These systems shall be tested and reported on a quarterly basis.

Any application for a system proposing the use of I/A technology shall be submitted to the Truro Board of Health which shall hold a public hearing to consider its approval.

All applications shall include a copy of the Massachusetts Department of Environmental Protection approval letter appropriate to the I/A technology being used and the level of approval (i.e., General Use, Provisional Use, Remedial Use, Piloting Use, or site-specific Pilot Approval). All applications for Pilot Approval shall include all performance data from all piloting sites where the I/A technology has been similarly configured and utilized.

Article 14
Nitrogen Loading Limitations. The Truro Board of Health hereby requires that all properties within the Town of Truro meet the loading restrictions set forth in 310 CMR 15.214 and contain at least ten thousand (10,000) square feet of Buildable Upland (as defined in Article 1 hereunder) for every 110 gallons per day of design flow and that all systems designed to serve said facilities meet the same restrictions and requirements contained in Title 5 as the "Nitrogen Sensitive Areas" defined in 310 CMR 15.215 irrespective of whether the properties are located within "Nitrogen Sensitive Areas" as so defined.

In other words:

Each bedroom in a residential property in Truro is assumed to have two (2) human occupants who produce nitrogen-based waste. Each bedroom is assumed to contribute 110 gallons per day (gpd) on average. That nitrogen load must be spread over enough land so as not to create a "point load" which poses an added danger to the aquifer.

The Truro Board of Health has long required 10,000 square feet of land (or approx. ¼ acre) per bedroom. The more bedrooms, the more waste, and so the more land is needed to spread the nitrogen load. By limiting the nitrogen load per acre, Truro's aquifer is not subjected to high nitrogen loads from any one parcel, and the consequences down gradient of such a load are mitigated for abutters and neighbors in the down gradient area.

Four bedrooms would require almost 1 acre, 25 bedrooms would require about 5.7 acres, 70 bedrooms would require about 15.9 acres, and 100 bedrooms would require about 22.8 acres to meet Truro's nitrogen load requirements.

Appendix H – Eastham's Struggle with Water Safety

This Appendix compiles some findings and timeline about how the Town of Eastham has dealt with the increasing elevation of nitrogen load in groundwater. This has been a more than decade long journey for the town, from dealing with increasing nitrogen levels to eventually acknowledging the need for a town-wide public water system.

March 2013

After weeks of presentations about the need for town water, selectmen unveiled the price tag per household for a $114.8 million public water system that will be proposed at town meeting.

The cost — for the median priced home in Eastham — will be $17,875 over a 29-year payment schedule, which includes inflation. Depending on the bond payments, the cost will vary from about $300 a year to $966 at the top payment year. The annual cost averages out to $616 a year, or $52 a month, for the median home valued at $400,000, according to the town's presentation Tuesday night.

All homeowners, regardless of whether they hook up to the system, would pay for the town water with their annual tax bill.

https://www.capecodtimes.com/article/20130327/NEWS/303270322#:~:text=After%20weeks%20of%20presentations%20about,be%20proposed%20at%20town%20meeting.

April 2017

Eastham's waterworks continue to progress. Overall construction for Phase 1 is 92-percent complete and that portion of the work is $2.4 million under its eventual $45.8-million budget (including phase 2).

While the listed cost of Phase 1 alone is $28 million that doesn't include three decades of interest at a 2.4 percent rate. Nor did it include $2.1 million in loan forgiveness to Eastham from Massachusetts and a $400,000 grant from the U.S. Department of Agriculture to support the project.

https://eastham.wickedlocal.com/news/20170415/260-connected-to-eastham-water---next-17-million-to-be-spent

August 2020

Phase 2 of the program is currently underway and is anticipated to be completed by 2023. Construction consists of five phases, A through E, to expand water service and fire protection to secondary roadways and neighborhoods Town-wide. Phase 2A is under construction and includes three separate contracts to complete over 20 miles of water mains and associated water services and fire hydrants. Phase 2B, which includes additional water main construction, a water supply wellfield and control building, and a water storage tank, is currently scheduled to be online in late 2020.

https://www.envpartners.com/project/new-municipal-water-system-development/

Appendix I - Citations in Text and Additional Resources Organized by Source

EPA

https://www.epa.gov/privatewells

https://www3.epa.gov/region1/eco/drinkwater/private_well_owners.html

https://yosemite.epa.gov/sab/sabproduct.nsf/8AF41B299F1C342C852581980075D17D/$File/Nitrate-Nitrite_IAP_draft_plan+9.8.17.pdf

The IRIS [Integrated Risk Information System] Program previously evaluated the oral health effects of nitrate and nitrite; oral reference doses (RfDs) for nitrite and nitrate2 were posted to the IRIS database in 1987 and 1991, respectively. EPA based these RfDs on surveys of clinical cases of methemoglobinemia in infants associated with ingestion of nitrate-containing drinking water conducted in the early 1950s (Walton, 1951; Bosch et al., 1950). Since 1987, a growing body of literature indicates potential associations between nitrate/nitrite exposure and other noncancer health effects. Some epidemiological studies also suggest an increased risk of cancer, especially gastric cancer, associated with dietary nitrite exposure (ATSDR, 2017). Cancer risk associated with nitrate or nitrite exposure is complicated by the fact that, under conditions of concurrent exposure to amines or amides or low levels of antioxidants, endogenous nitrosation can occur, leading to the formation of carcinogenic nitroso compounds (ATSDR, 2017; IARC, 2010). IARC (2010) concluded that ingested nitrate or nitrite under conditions that result in endogenous nitrosation is probably carcinogenic to humans.

https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0078_summary.pdf

Primary research cited above by EPA

https://hero.epa.gov/hero/index.cfm/reference/details/reference_id/3841331

https://hero.epa.gov/hero/index.cfm/reference/details/reference_id/3002705

US Geological Survey

https://pubs.usgs.gov/sir/2012/5001/pdf/sir2012-5001_report_508.pdf

http://www.state.in.us/idem/cleanwater/files/gw_source_water_workshop_usgs_nitrates.pdf

Population growth and increasing demands for water make the availability of that water, measured in terms of quantity and quality, even more essential to the long-term sustainability of our communities and ecosystems.

Scientific Investigations Report 2010-5100

Examination of the 1.640-ft-radius area around a well can provide a broad characterization of local land use affecting the well, but it may not adequately characterize the land use in the entire capture area of the well, which may also affect the quality of the water in the well.

http://www.state.in.us/idem/cleanwater/files/gw_source_water_workshop_usgs_nitrates.pdf

Commonwealth of Massachusetts

https://www.mass.gov/private-wells

https://www.mass.gov/service-details/private-well-guidelines

https://www.mass.gov/service-details/faqs-private-wells

https://www.mass.gov/service-details/protect-your-family-a-guide-to-water-quality-testing-for-private-wells

https://www.mass.gov/regulations/310-CMR-1500-septic-systems-title-5

https://www.mass.gov/doc/310-cmr-15000-title-5-of-the-state-environmental-code/download

https://www.mass.gov/doc/private-well-guidelines/download

https://www.mass.gov/service-details/chapter-40-b-housing-production-plan

https://www.mass.gov/files/documents/2016/07/vt/truro.pdf

Cape Cod Commission

https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/Website_Resources/RPP/RPPrev2003illustrated.pdf

https://www.capecodcommission.org/our-work/208

https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/208/208%20Final/Cape_Cod_Area_Wide_Water_Quality_Management_Plan_Update_June_15_2015_Summary.pdf

https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/208/208%20Final/Cape_Cod_Area_Wide_Water_Quality_Management_Plan_Update_June_15_2015.pdf

Barnstable County

https://www.barnstablecountyhealth.org/resources/publications/compendium-of-information-on-alternative-onsite-septic-system-technology/basics-of-wastewater-treatment#:~:text=The%20amount%20of%20oxygen%20required,biochemical%20oxygen%20demand%20or%20BOD.&text=Some%20BOD%20is%20removed%20in,flows%20to%20the%20leaching%20field.

University of Massachusetts

https://ag.umass.edu/cafe/fact-sheets/nitrate-nitrite-in-private-drinking-water-wells

https://ag.umass.edu/sites/ag.umass.edu/files/fact-sheets/pdf/nitrate.pdf

https://ag.umass.edu/cafe/fact-sheets/well-water

Truro Board of Health

https://www.truro-ma.gov/board-of-health
https://www.truro-ma.gov/sites/g/files/vyhlif3936/f/uploads/board_of_health_regulations_rev_eff_2-2020.pdf

Truro Water Resources Oversight Committee

https://www.truro-ma.gov/sites/g/files/vyhlif3936/f/u286/wastewater_in_truro_august_13_2015.pdf

Environmental Work Group

https://www.ewg.org/tapwater/

https://www.ewg.org/tapwater/reviewed-nitrate.php#:~:text=According%20to%20the%20findings%20of,%2Done%2Dmillion%20cancer%20risk.

Environmental Working Group | Drinking Water Standards:

https://cdn3.ewg.org/sites/default/files/u352/EWG_TWDBStandards-Chart_PP01.pdf

Exposure-based assessment and economic valuation of adverse birth outcomes and cancer risk due to nitrate in United States drinking water

https://reader.elsevier.com/reader/sd/pii/S001393511930218X?token=E6DB567D0A18C237359A21B313EF0AE2DE0F45986F2537237217E221968B84D7AE9B0C022F545E65E4E6C59C8947CFCD

Silent Spring Institute

https://silentspring.org/our-science

https://www.youtube.com/watch?v=MV5Oc5Ml6-Y&feature=youtu.be

In general, shallower wells pull younger groundwater more recently in contact with the atmosphere (Plummer and Friedman, 1999) with shorter flow paths that allow less time for sorption and biodegradation processes. Shallower wells have previously been found to show the greatest impact from septic systems and other pollution sources.

https://www.sciencedirect.com/science/article/pii/S0048969715312353

Our results suggest that current regulations to protect domestic wells from pathogens in septic system discharges do not prevent OWCs from reaching domestic wells.

We found that nitrate concentrations of 1 mg/L NO3-N, which are tenfold higher than local background and tenfold lower than the US federal drinking water standard, were associated with wastewater impacts from OWCs. Since nitrate is a commonly measured drinking water contaminant, it is a useful screening tool for OWCs in domestic wells

https://privatewells.silentspring.org/faq

https://www.mendeley.com/catalogue/309b4ce1-901e-3985-a68a-6924f9713888/

Association for the Protection of Cape Cod (APCC)

A large portion (roughly 80 percent) of the excess nitrogen in our coastal waters comes from on-site septic systems. Title 5 septic systems were designed to remove bacteria and viruses, but not nutrients like nitrogen or phosphorous.

https://apcc.org/our-work/advocacy/water-quality/

New Hampshire Department of Environmental Services

"EPA has not established an MCL [Maximum Contamination Limit] for a manmade contaminant since 1995. EPA issued a preliminary regulatory determination for perchlorate in October 2008 – still no MCL."

https://ebcne.org/wp-content/uploads/2020/03/Presentations-Emerging-Contaminants-Seminar-The-Life-Cycle-of-PFAS.pdf

Interstate Technology and Regulatory Council (ITRC)

Per- and polyfluoroalkyl substances (PFAS) are a very large family of thousands of chemicals that vary widely in their chemical and physical properties, as well as their potential risks to human health and the environment.

PFAS have only recently come to the attention of investigators and the public in large part due to the fact that until the early 2000s analytical methods to detect low levels of PFAS in the environment were available only in a few select research institutions. It was not until the early 2010s that these methods became widely available and had detection limits in water low enough to be commensurate with levels of potential human health effects. Toxicological studies have raised concerns regarding the bio-accumulative nature and potential health concerns of some PFAS. As a result, our understanding of PFAS and the risks they may pose is rapidly evolving.

https://pfas-1.itrcweb.org/

https://pfas-1.itrcweb.org/wp-content/uploads/2020/04/ITRC_PFAS_TechReg_April2020.pdf

https://www.youtube.com/watch?v=Zm1C3vjvre8&feature=youtu.be

MassDEP 310 CMR: DEPARTMENT OF ENVIRONMENTAL PROTECTION

15.214: Nitrogen Loading Limitations (1) No system serving new construction in Nitrogen Sensitive Areas designated in 310 CMR 15.215 shall be designed to receive or shall receive more than 440 gallons of design flow per day per acre except as set forth at 310 CMR 15.216 (aggregate flows) or 15.217 (enhanced nitrogen removal).

Comments and Questions?

Comments and questions on this publication can be emailed to docsTruro@gmail.com