Guidance Document

Nitrate Treatment and Remediation for Small Water Systems

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Environmental Public Health
Office of Drinking Water

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Foreword

This guidance document is for small water system owners and board members of water systems who found elevated nitrate concentrations in one or more of their sources. It may also serve as guidance for engineers who work with small water systems. This document summarizes the options available for water systems to take action if a source nitrate sample exceeds the drinking water standard of 10.0 milligrams per liter of nitrate-nitrogen or 1.0 milligram per liter of nitrite-nitrogen. The information presented is intended to be general. You can find specific information on alternatives for source protection and nitrate treatment in the references cited at the end of each chapter or by contacting the agencies listed in the appendices.

Chapter 1 Introduction

Nitrate Contamination

Nitrate and nitrite contamination of drinking water supplies are a health concern for many people throughout the country, including Washington State. The Maximum Contaminant Level (MCL) for nitrate in drinking water is 10.0 milligrams per liter (mg/L) and the MCL for nitrite is 1.0 mg/L.

Nitrate and nitrite concern health professionals because, when ingested, they interfere with the production of red blood cells capable of carrying oxygen. Instead of hemoglobin, excessive nitrate/nitrite ingestion causes the production of methemoglobin (metHb). MetHb is unable to release oxygen in the cells, leading to methemoglobinemia, also known as "blue baby syndrome" because it occurs predominantly in infants. Left untreated, this condition may lead to cyanosis, brain damage, and death by asphyxiation. For more health information about nitrate please refer to DOH 331-214.

Throughout the rest of this document, the term nitrate implies both nitrate and nitrite, unless otherwise noted. In groundwater sources, nitrite usually occurs at concentrations above the MCL only when nitrate concentrations are also above the MCL.

Nitrate in Groundwater

Nitrate is a stable and highly soluble ion with a low potential for precipitation or adsorption. It moves through soil over long distances with ease, following the course of groundwater movement.

Nitrate is a naturally occurring inorganic chemical. Background nitrate (NO_3-N) concentrations in groundwater less than 100 feet deep tend to occur at about 1.0 mg/L. Nitrate concentrations that exceed the MCL of 10.0 mg/L are often present as a result of several contributing factors. The most significant factors are land use, well depth (to first open interval), and soil type (Burow, 2010). Think of these factors as activity, opportunity, and susceptibility.

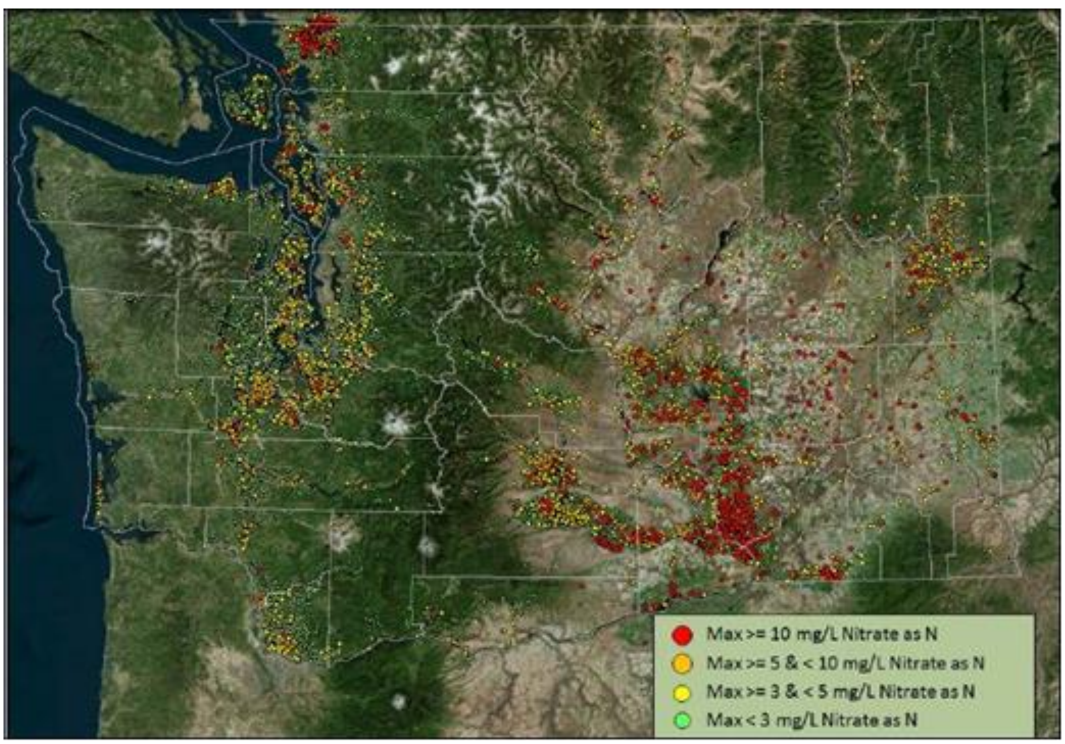
Land Use—Activity

Agricultural activities are the most significant source of nitrate in groundwater (Ryker and Jones, 1995). Nitrogen-rich inorganic fertilizers, manure, plant decomposition, and other sources contain nitrate that may leach into groundwater. In many cases, agricultural processes have adapted to mitigate excess nitrate, reducing the amount available to leach into groundwater. In addition, septic systems, lawn fertilizers, and other non-agricultural factors also contribute to nitrate occurrence in sources (Ryker and Jones, 1995; Anderson, 2003; Risinit, 2003; Tesoriero and Voss, 1997). Contributions of excess nitrate to an aquifer, while an important factor, is not sufficient to predict nitrate contamination in a drinking water well.

Well Depth—Opportunity

In order for excess nitrate to reach hazardous levels in a drinking water well, the nitrate must move past the root zone, driven downward through the soil column by precipitation or irrigation in excess of plant uptake. Where soils like fine-grained silts and clay form a confining layer, the downward movement of water is reduced or essentially stopped. Wells in unconfined aquifers are more likely to have nitrate contamination than deeper wells developed in an aquifer confined by an impermeable soil layer above. For high risk sources evaluated throughout the United States, the risk of exceeding the nitrate MCL dropped from 24 percent for wells less than 100 feet deep, to almost 0 percent for wells greater than 200 feet deep (Nolan, 2002).

Figure 1-1 Distribution of Historical Nitrate Maximums in Groundwater (WSDOH 2000 to 2011, Ecology 1982 to 2013, USGS 1970 to 2013.) Source: Washington State Department of Ecology.



Soil Type—Susceptibility

In addition to depth, soil type plays an important part in the ability of nitrate to reach groundwater sources. Soils with conditions favorable to reduction oxidation reactions are less susceptible to nitrate contamination. This is because biochemical reactions reduce the nitrate to harmless nitrogen gas through the metabolic activities of certain microorganisms. The microorganisms capable of reducing nitrate are most prevalent in saturated soils with low dissolved oxygen and high organic carbon (Burow, 2010). Conversely, water sources in highly permeable soils with oxic (i.e., oxygen is available) conditions are more susceptible to elevated nitrate concentrations. USGS reports show support for this conclusion in fractured bedrock and coarse-grained glacial deposits that are associated with higher concentrations of nitrate in groundwater (Tesoriero and Voss, 1997; Frans, 2000). These same reports indicate high concentrations of nitrate are less likely to occur where fine-grained silts and clays are present.

Nitrate Occurrence in Washington

In Washington, nitrate contamination occurs most frequently in agricultural areas in Eastern Washington and in Whatcom County. These areas are characterized by wells developed in unconfined aquifers, coarse-grained soils, and agricultural land use (Erwin and Tesoriero, 1997; Frans, 2000). The U.S. Geological Survey (USGS) aquifer vulnerability assessments agree with data collected from wells across the state by the Washington State Department of Ecology.

The nitrate concentration in a particular aquifer at a particular location is subject to change over time due to precipitation patterns, seasonal irrigation and fertilization practices, and changes in land use such as modified or increased agricultural activities, deforestation, and installation of septic systems. Sometimes these changes in nitrate groundwater concentration are abrupt, as shown in Figure 1-2, and sometimes these changes are gradual, over a long period of time, as shown in Figure 1-3, next page.

Figure 1-2 Nitrate sampling results for Washington State Patrol-Kennewick system, Benton County WA. 1994-2016 (Source: WADOH.)

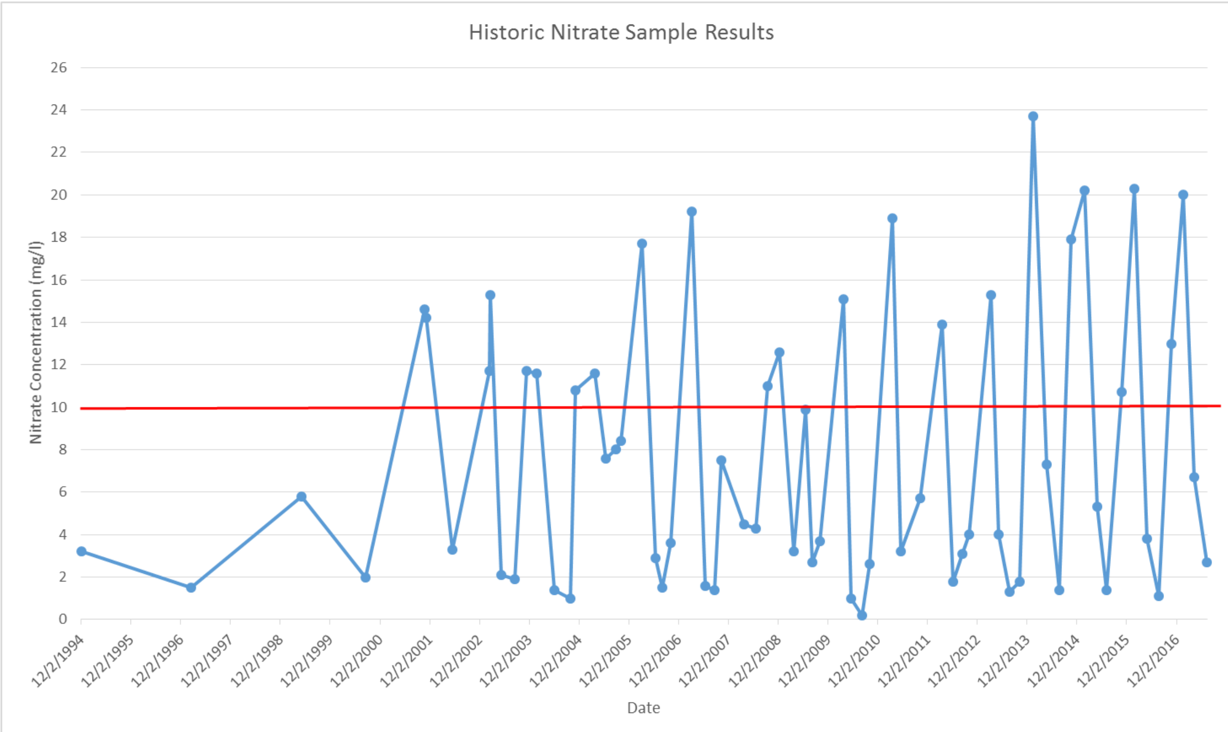
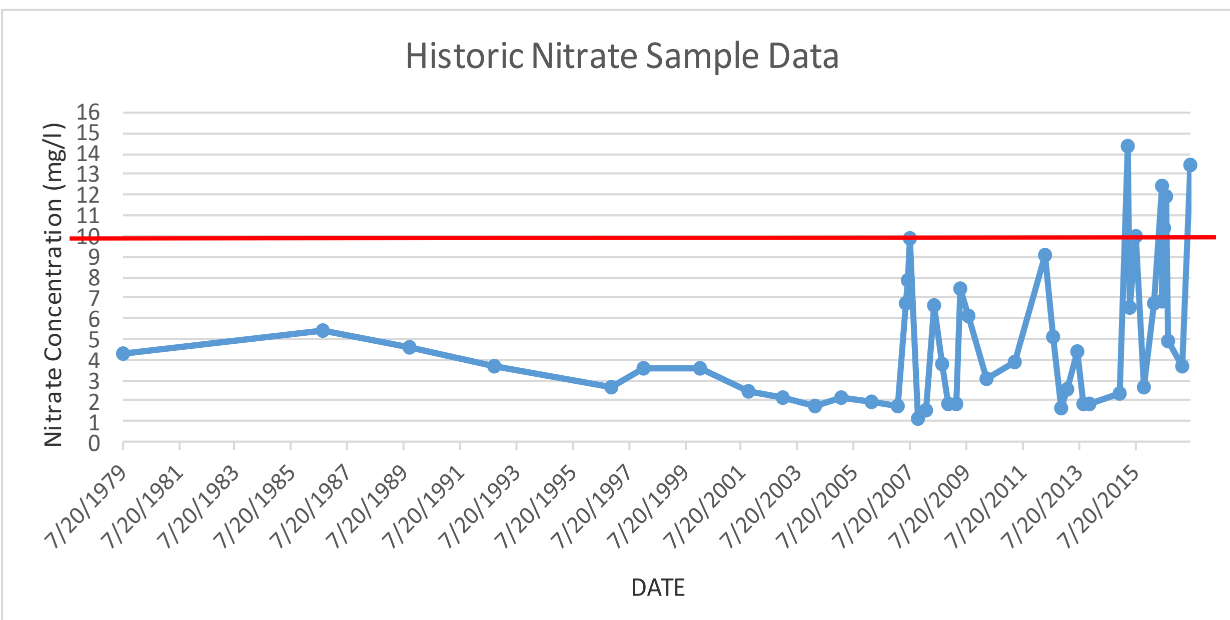


Figure 1-3 Nitrate sampling results for the Parker Spring Acres water system, Grant County, WA. 1979-2016. (Source: WADOH.)



Nitrate contamination is the most common chemical contaminant found in Washington's public water systems. Between 2006 and 2016, 216 Group A public water systems violated the nitrate MCL at least once. Water systems reported more nitrate MCL violations than all other chemical MCL violations combined.

Conclusions

Elevated nitrate levels are a serious and acute health concern, especially for vulnerable populations. Also, water quality data tell us that nitrate MCL violations occur frequently in many areas. The cause of the elevated concentrations is the result of several factors including land use, source depth and construction, and soil conditions. Additionally, the occurrence of an elevated nitrate concentration can vary over time, in some instances tied to seasonal variations and in others tied to more long-term trends. The following chapters will explore how individual systems can assess and effectively respond to elevated nitrate in their sources.

References

Anderson, T., "USGS Says Carson Groundwater Nitrate Levels Increasing," *Reno Gazette-Journal*, December 5, 2003.

Burow, K. R., Nolan, B. T., Rupert, M. G., & Dubrovsky, N. M. (2010). Nitrate in groundwater of the United States, 1991– 2003. Environmental science & technology, 44(13), 4988-4997.

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Risinit, M., "State Makes Recommendations on Putnam Lake Water," *The Journal News*, White Plains, New York, December 22, 2003.

Ryker, S. J., and J.L. Jones, "Nitrate Concentrations in Ground Water of the Central Columbia Plateau," U.S. Geological Survey Open File Report, 95-445, 1995.

Tesoriero, A.J., and F.D. Voss, "Predicting the Probability of Elevated Nitrate Concentrations in the Puget Sound Basin: Implications for Aquifer Susceptibility and Vulnerability," *Ground Water,* 1997, Vol. 35(6).

Chapter 2 Nitrate Compliance Options

This chapter summarizes options available for water systems to take action if a source exceeds the nitrate MCL. When the nitrate MCL is exceeded, short-term and longer-term actions must be taken.

In the short-term, water systems must provide public notification to all their customers within 24 hours of exceeding the MCL. Water system owners must also provide bottled water or another alternate supply of safe drinking water for as long as consumers' drinking water exceeds the nitrate standard. For more information on public notification requirements visit the DOH nitrate web page.

Long-term solutions depend on the characteristics of individual water sources and the financial, managerial, and technical capacity of the water systems to effectively implement them.

The following checklist provides concise information, in sequence from an initial MCL exceedance through nitrate remediation project implementation.

Nitrate Checklist

- ☐ **Collect Confirmation Sample**
  Sampling and analytical mistakes are rare, but possible. Nitrate is an acute contaminant, so you must collect a repeat sample for confirmation within 24 hours if an initial sample exceeds the MCL. If you do not take a repeat sample, you must take follow-up action based on the initial sample.

- ☐ **Public Notification**
  Conduct public notification as outlined in Appendix A. Public notification is required within 24 hours of an MCL violation, because nitrate is an acute contaminant.

- ☐ **Enter into a Compliance Schedule with DOH**
  Usually, the first step in evaluating long-term alternatives is to develop a compliance schedule with DOH.

- ☐ **Prepare a Project Report and Evaluate Alternatives**
  A professional engineer is required to submit a project report that identifies alternative solutions, evaluates them based on cost, effectiveness, reliability, and technical capacity of the water system. Alternative options include treatment and non-treatment.

☐ **Conduct a Pilot Test (for treatment alternatives)**
Upon completion of the pilot test, submit a pre-design/pilot test report to DOH. Pilot testing is not required for non-treatment alternatives and blending.

☐ **Secure Funding**
Prepare a cost estimate and evaluate funding options, such as a Drinking Water State Revolving Fund (DWSRF) loan. See the DOH DWSRF web page for more information. Learn about other potential sources of funding at the Infrastructure Assistance Coordinating Council website.

☐ **Implement the Selected Alternative**

- ✓ Have a professional engineer prepare construction documents and operations and maintenance plans, including a treatment plant monitoring plan and submit to DOH for approval. A treatment monitoring plan is not required for non-treatment alternatives.
- ✓ Employ a certified operator. A certified treatment plant operator is not required for non-treatment alternatives and blending.
- ✓ Start construction.
- ✓ Submit certification of construction completion to DOH.
- ✓ Initiate start-up activities.

For more detailed guidance on submittal requirements and design of nitrate water treatment facilities please refer to DOH Water System Design Manual (331-123).

We developed the Water System Design Manual to establish uniform concepts for water system design. The manual is intended for Group A public water systems, which are regulated under the federal Safe Drinking Water Act and Chapter 246-290 WAC. We have separate Design Guidelines for Group B Public Water Systems (331-467). Group B systems are so small that they are regulated only under Washington State law (Chapter 246-291 WAC).

This manual provides guidelines and criteria for design engineers to use in preparing portions of planning documents (WAC 246-290-100), project reports (WAC 246-290-110), construction documents (WAC 246-290-120), and source approval documents (WAC 246-290-135). This manual also clarifies engineering document submittal and review requirements.

Returning to Compliance

You cannot achieve compliance using a one-size-fits-all approach. As with any water treatment process there are unique variables for each individual system. This guidance document addresses general approaches to remedy nitrate contamination. We encourage water systems with complex or unusual situations to seek the advice of water professionals early in the planning process. A brief summary of compliance options is below. Chapters 3 and 4 describe each alternative in more detail.

Non-Treatment Alternatives

We encourage water systems seeking to remedy nitrate contamination in their drinking water supply to exhaust all non-treatment alternatives before considering treatment. Non-treatment alternatives include:

- Developing a new well.
- Modifying the existing well.
- Connecting to a nearby system.

Wherever feasible, a non-treatment alternative is typically easier to operate, less costly over the life of the water system, and is more reliable than treatment in delivering safe drinking water every day, year after year.

Treatment Alternatives

Maintaining consistent and reliably effective nitrate treatment, especially mechanical treatment (e.g., ion exchange, reverse osmosis), can be challenging for small systems. Nitrate is an acute contaminant, which means that an undetected failure of the nitrate treatment process can present an immediate risk to public health. We know of many instances when small system nitrate treatment processes have failed.

East of the Cascade Crest there are currently 45 small water systems operating a nitrate treatment process. During the period 2014-2016, there were 32 separate treatment plant failures. Treatment may be relatively easy to construct, but it is challenging to operate below the nitrate MCL every day, year after year. We believe non-treatment alternatives, wherever feasible, are a better long-term solution to nitrate contamination.

We know in some cases it is just not feasible to implement a non-treatment alternative. Reasons include impractical distances between water systems that eliminates the possibility of connecting to another system, and widespread nitrate contamination that eliminates the option to modify or develop a new source.

The chemical properties of nitrate make it difficult to remove from water using conventional processes such as filtration or activated carbon adsorption. As a result, more complex treatment processes must be considered.

- Blending sources (to achieve a nitrate concentration below 10.0 mg/L at or before entry to the distribution system).
- Ion exchange (a majority of treatment plant failures described above occur at aging ion exchange nitrate treatment plants).
- Reverse osmosis.
- Electrodialysis.
- Engineered biological treatment.

Point-of-Use (POU) and Point-of-Entry (POE) treatment is not a viable option to comply with drinking water standards in Washington State. ODW limits the use of POU and POE treatment because their application is incompatible with existing regulatory requirements (WSDOH 2007). A limited exception to this restriction applies to non-community water systems using a POE treatment device to treat all the water entering a single-building water system.

Bottled water is often used as a necessary, but temporary, measure to protect public health until a permanent remedial option is implemented according to an established compliance schedule. Federal law prohibits public water systems from using bottled water to achieve compliance. As long as the water system exposes consumers to tap water used for human consumptive purposes above 10.0 mg/L, the system owner is responsible for providing potable water (usually by providing bottled water produced by a Washington-licensed bottled water producer) to all customers who request it.

Summary of Treatment Alternatives

Blending, ion exchange, reverse osmosis, electrodialysis, and biological denitrification have all been applied at full-scale for the removal of nitrate from drinking water. Table 2-1 summarizes the advantages, disadvantages, and limitations of each treatment process.

Conclusions

Responding to a nitrate MCL exceedance requires both short-term action and long-term planning. The checklist provided in this chapter provides a sequential process designed to confirm the problem; evaluate, select, and implement measures to restore safe and reliable drinking water. Part of the process is the analysis of alternatives. This analysis likely contains many components including available options, system characteristics, and both capital and lifetime operation and maintenance costs. Although there are treatment processes we know that remove nitrate from water, a non-treatment alternative is a more reliable solution. In either case, you must have a professional engineer licensed in Washington State prepare the project report and construction documents.

References

WSDOH. 2007. *Point-of-Use or Point-of-Entry Treatment Strategy*, DOH 331-358, Washington State Department of Health, Olympia, WA.

Table 2-1 Summary of Nitrate Treatment Alternatives

	Treatment				
Factor	**Blending**	**Ion Exchange**	**Reverse Osmosis**	**Electrodialysis**	**Engineered Biological Treatment**
Installations	Many	Many	Few	None is U.S. Several in Europe	Few
Pretreatment Required	None	Sometimes	Significant	Sometimes	None
Total Life Cycle Cost	Variable	Moderate	High	High	Moderate
Performance-Limiting Raw Water Quality Parameters[1]	Mass-balance flow from blended sources so that nitrate at entry point to dist. system is less than MCL	Iron, manganese, , sulfate, bicarbonate hardness, alkalinity, organic carbon, turbidity, and total dissolved solids	Total dissolved solids, turbidity, silt density index, total hardness, pH, iron, manganese, organic carbon, sulfate and hydrogen sulfide, chlorine	Iron, manganese, turbidity, total dissolved solids, hydrogen sulfide, total hardness, pH, alkalinity, chlorine	Optimum pH 7-8.5. Temperature: 5-30°C
Post Treatment	None	pH adjustment may be required	pH and alkalinity adjustment may be required	pH adjustment may be required	Filtration, disinfection, and taste and odor control
Waste Disposal	None	Salt brine and rinse water	Concentrate	Concentrate	Biological solids
Feasibility of Automation	Good	Good	Good	Good	Good
Process Start-up Time	Short	Short	Short	Short	Long

[1]Consult with the manufacturer on recommended water quality parameter testing and acceptable water quality values for their equipment and process.

Chapter 3 Non-Treatment Alternatives

This chapter discusses alternatives that do not involve the treatment of water pumped from the affected well. When feasible, non-treatment alternatives are usually less burdensome, less costly, and more reliable than treatment. Non-treatment alternatives include developing an alternate source such as:

- Developing a new well.
- Modifying the existing well.
- Connecting to a nearby system (intertie).

The non-treatment alternatives, described below, should be investigated before treatment alternatives.

New Well

Developing a new well requires sufficient information to determine the location and depth needed in order to increase the likelihood of having nitrate below 10.0 mg/L. In general, wells constructed with the first open interval located within a confined aquifer and a surface seal constructed into the top of the first confining layer are not vulnerable to surface-generated contamination such as nitrate.

Consulting the Department of Ecology well log and DOH water quality data on our Sentry Internet helps establish a three-dimensional picture of water quality in the project area.

Redevelop the Existing Well

It may be possible to redevelop the existing well to tap into a low nitrate strata of groundwater. This approach requires similar knowledge to developing a new well to estimate the feasibility of obtaining groundwater from an aquifer low in nitrate. In North Carolina, one well in fractured bedrock was reconstructed after it was determined that shallow rock fractures produced water with high nitrate concentrations (Mitchell and Campbell, 2003). In Washington State, USGS developed maps showing the lower risk of nitrate from deep groundwater (Frans, 2000, Tesoriero and Voss, 1997).

Construct an Intertie

An intertie with a nearby water system is another way to obtain drinking water low in nitrate. To implement this approach, the water systems must be close enough to make construction of an intertie economically feasible. Both DOH and the Department of Ecology regulate interties. These regulations include specific intertie requirements to ensure that the neighboring system has the capacity to provide service to the water system in need. If an intertie results in consolidation of two or more systems into a single water system, the Drinking Water State Revolving Fund may waive repayment of up to half the loan amount (known as loan forgiveness).

Case Study: Clark Addition Water Association

At the beginning of 2007, three water systems in Franklin County faced the problem of elevated concentrations of nitrate in their wells. Clarktown's well had a nitrate concentration of 23.4 mg/L. Nearby, the Beneficial and Dixon Community Water Systems had nitrate concentrations of 22.3 mg/L and 23.1 mg/L, respectively. The population of the three systems combined totaled less than 200 residents.

All three systems had shallow wells constructed into the unconfined aquifer. Rather than pursue individual treatment solutions or individual new (deep) sources, they determined that a consolidated system, supplied by a new deep source, would best meet all their needs. So the systems pursued a consolidation process. The new Clark Addition Water Association formed in April 2007. The new system includes a reservoir and distribution system in addition to a new deep well drilled with the first open interval at 500 feet below ground surface. Since the new well was placed into service in April 2007, all nitrate samples have been below 0.5 mg/L.

Conclusions

When feasible, non-treatment alternatives are typically less complicated, less costly, and more reliable than treatment. They should be investigated before treatment alternatives. Typical non-treatment alternatives to consider are developing a new well, modifying the existing well, and constructing an intertie with a nearby system. The feasibility of each alternative is determined by the individual system characteristics.

References

Frans, L.M, "Estimating the Probability of Elevated Nitrate (NO_2+NO_3-N) Concentrations in Ground Water in the Columbia Basin Ground Water Management Area, Washington," U.S. Geological Survey Water Resources Investigation Report, 00-4110, 2000.

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Chapter 4 Treatment Alternatives

Nitrate is a stable and highly soluble ion with a low potential for precipitation or adsorption. These properties make it difficult to remove nitrate from water using treatment processes such as filtration or activated carbon adsorption. As a result, you must consider more complex treatment processes. Many of these treatment processes have been evaluated for applicability (Clifford and Liu, 1995; Kapoor and Viraraghavan, 1997; U.S. Bureau of Reclamation, 2001; Jensen et al. 2012).

This chapter reviews widely used and novel treatment processes. Established processes such as blending, ion exchange, reverse osmosis, and electrodialysis are widely used to reduce exposure to nitrate from contaminated drinking water sources. These processes reduce nitrate prior to entry to the distribution system by either dilution or by physical or chemical removal from the source water. Experimental treatment techniques rely on biological processes to convert nitrate to nitrogen gas, which is then released to the atmosphere. These biological processes offer some advantages over conventional treatment techniques, especially in terms of waste disposal.

The quantity of water treated significantly affects the cost of any treatment process. Therefore, the design should consider the feasibility of separating non-potable uses such as irrigation water and industrial process from potable water requiring treatment.

Blending

Some water systems use blending to combine wells with high concentrations of nitrate with low nitrate wells to meet the MCL. Blending must occur before the water enters the distribution system. This option requires an adequate source of low nitrate water. Because nitrate is an acute contaminant, it is important to make sure the low nitrate source is the primary source of drinking water. Rising or significantly fluctuating source water nitrate concentrations could decrease the reliability of this option.

Maintenance and Monitoring

No maintenance beyond routine well pump maintenance will typically be required for blending. Daily nitrate field monitoring of the blended water and a monthly nitrate sample analyzed by a state-certified drinking water laboratory are required to assure blending is effective in reducing nitrate concentration reliably below the MCL before entry to the distribution system.

Advantages

- Easier to implement than other treatment if low nitrate water is readily available.

- Operation by a certified water treatment plant operator is not required.
- No waste disposal issues.

Disadvantages

- Capital costs can be significant to plumb the low and high nitrate sources together before entry to the distribution system.
- Fluctuating nitrate concentrations in either source may require adjustment to flow from one or both wells.
- Daily and monthly blending treatment monitoring and reporting to DOH is required.

Case Study: Country Villa Mobile Park

Country Villa Mobile Park, a community water system in Stevens County with a population of around 145 people, including a school, blends two sources prior to entry to the distribution system to remain in compliance with the nitrate standard of 10.0 mg/L.

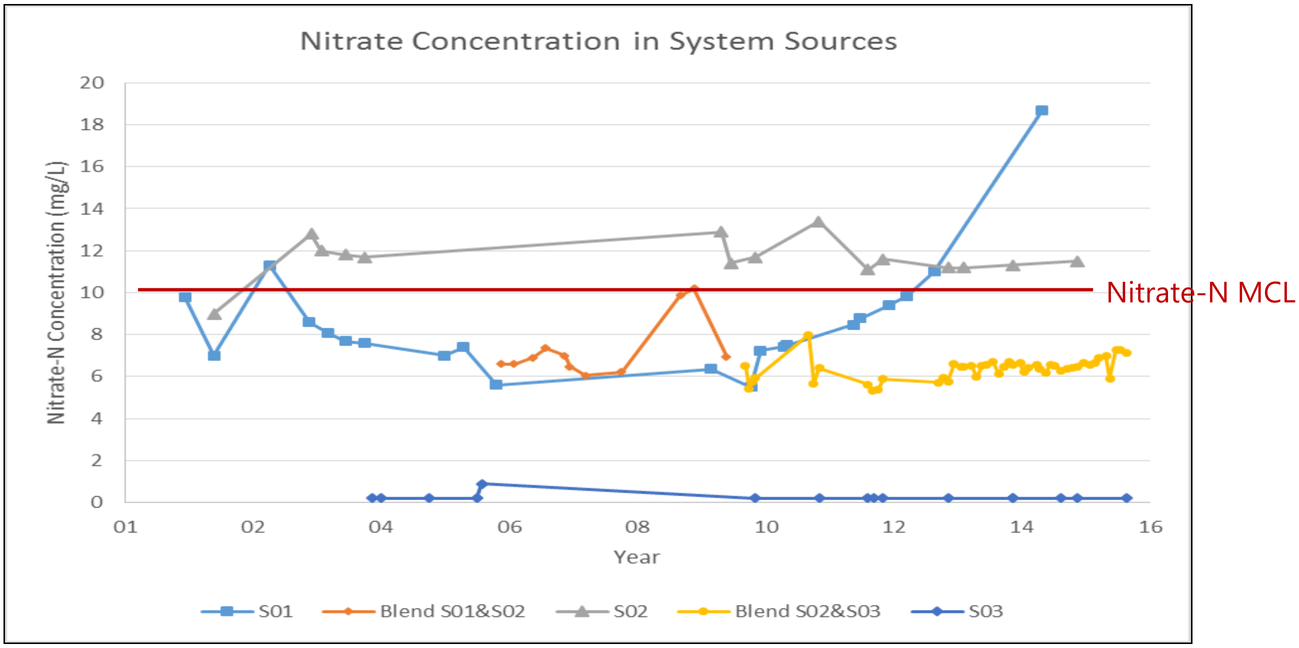
Sources 01 and 02 are both shallow wells. In the early 2000s, S02 began exceeding the nitrate MCL and was shut off because S01 had enough capacity to supply the system. By 2005, this was no longer the case and the system began blending S01 and S02 and developed a third source. S03 has very little nitrate but too much arsenic, so it wasn't used at the time. Increasing nitrate concentration in the S01/S02 blended water caused the system to bring S03 online. S01 was taken offline and blending operations shifted to S02 and S03. S02 has very little arsenic. The current blending scheme remedies the high nitrate in S02 and the high arsenic in S03, achieving compliance with both MCLs at the point of entry to the distribution system.

Table 4-1 Country Villa Mobile Park Source Data

	Well 01	Well 02	Well 03
Source Number	S01	S02	S03
Surface Seal Depth	None	20	18
Depth to First Open Interval (ft)	45	37	436
Capacity (gpm)	70	70	220
Nitrate Range (mg/L)*	5.5—18.7	9.0—13.4	< 0.5—0.9

**For the period 2001-2016.*

Figure 4-2 Country Villa Mobile Park Nitrate Concentrations



Ion Exchange

In the ion exchange process, nitrate ions bind to an ion exchange resin and, in the process, displace chloride ions. The resin is contained within a pressure vessel and is periodically regenerated with new chloride ions by introducing a concentrated salt solution. The process is identical to a water softener, which gives up sodium in exchange for calcium and magnesium, thus removing these hardness components from the water supply.

The frequency of regeneration will depend on the raw water quality and type of resin used. With non-selective resins, common ions in drinking water such as sulfate can compete with nitrate for binding sites on the ion exchange resin. Nitrate-selective resins have a higher affinity for nitrate than for sulfate. The performance of the ion exchange process is sensitive to the type of resin used to treat the water.

Resins used to treat water must meet the American National Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 61 for contact with potable water. Design engineers should plan to pilot-test with one or more resins prior to design of a full-scale system in order to establish which resin is most efficient and economical in removal of nitrate from the contaminated well. Figure 4-4 depicts two different ion exchange treatment plants.

If an ion exchange column is not regenerated frequently enough, the concentration of nitrate in the treatment effluent could spike to levels well above 10 mg/L, and well above the untreated nitrate concentration. This is because of certain resin's preference for exchanging sulfate over nitrate, thus displacing the nitrate already captured by the resin and introducing additional nitrate (above the influent concentration) to the treatment effluent stream. Figure 4-3 depicts the ion exchange treatment process.

Water Quality Issues

The effectiveness of the ion exchange process depends on the raw water quality. Pretreatment may be required with raw water containing elevated levels of iron, manganese, sulfate, chloride, and/or turbidity to avoid fouling the resins thereby decreasing treatment performance. Pretreatment may be required if the combination of iron, manganese, and other metals exceeds 0.1 mg/L. Similarly, elevated raw water hardness and high pH promote scaling on the resins. You may need to pretreat to remove hardness or acid-wash the resins to maintain acceptable treatment plant performance.

The ion exchange process initially removes some bicarbonate or carbonate ions following regeneration. As a result, the pH of the finished water may fluctuate unless controlled. The magnitude of this pH fluctuation depends on the raw water quality and the resin selected. In addition, ion exchange increases the concentration of chloride in the finished water, which can make it more corrosive to lead. As a result of these changes in corrosiveness of the treated water, installation of an ion exchange treatment process will trigger renewed initial monitoring under the Lead and Copper Rule (except for transient non-community water systems). Design engineers for all types of water systems should plan on providing post-treatment pH adjustment to reduce corrosivity.

Maintenance and Monitoring

The ion exchange column regeneration frequency will vary depending on the raw water quality, flow rate, and the resin material and design. Regeneration requires the preparation and disposal of significant quantities of salt brine. You may need to replace the resin every few years due to degradation in performance over time.

Ion exchange treatment plant effluent should be equipped with continuous nitrate monitoring and recording equipment (Health Research, Inc., 2012). If continuous monitoring and recording equipment is not provided, daily nitrate field monitoring of the treated water just prior to regeneration and a monthly nitrate sample analyzed by a state-certified drinking water laboratory are required to assure ion exchange is effective in reducing nitrate concentration reliably below the MCL.

Figure 4-3 Ion Exchange Treatment Schematic

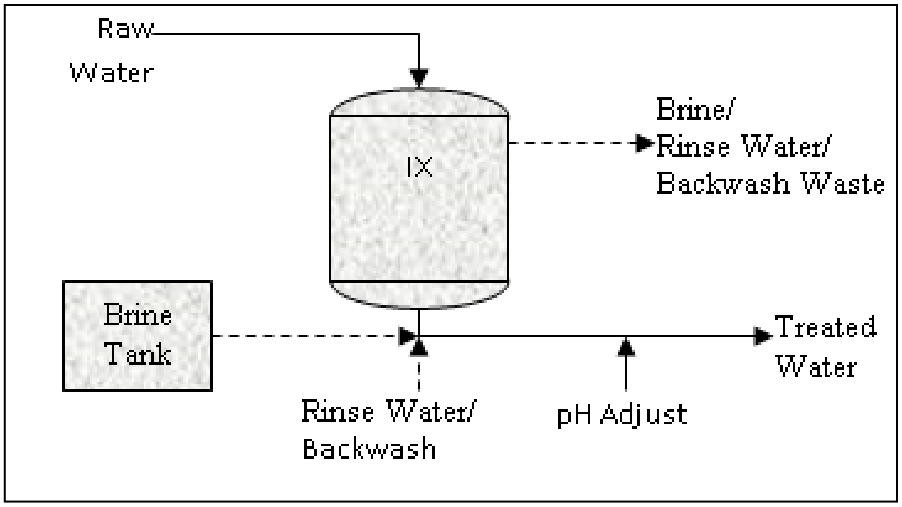


Figure 4-4a Ion Exchange Treatment Equipment (single exchange vessel)

Figure 4-4b Ion Exchange Treatment Equipment (multiple exchange vessels)

Waste Disposal

The ion exchange process generates a salt brine waste following column regeneration. The Washington State Department of Ecology implements the state's Wastewater Discharge Permit program. Brine waste discharge may need an individual state waste discharge permit. The feasibility of installing a brine waste denitrification step should be considered. See Appendix C for more information.

Key Design Parameters

In evaluating the feasibility of ion exchange, the single-most important factor to consider is the volume of water that can be treated before regeneration (sometimes referred to as the number of empty bed volumes, or the volume of the resin tank[s]). Frequent regeneration reduces the efficiency of the treatment process (gallons of drinking water produced per pound of salt and per volume of waste generated), increases operating costs, and increases the cost and complication of waste disposal. Parameters affecting how much water can be treated before regeneration are:

- Raw water quality parameters (see discussion above).
- Resin type (see discussion above).
- Resin volume.
- Influent flow rate (gpm/cubic foot of resin).

Provide the ion exchange manufacturer with the following information.

- Your raw water quality data.
- Peak hourly demand (gallons per minute, or gpm), maximum daily demand (gallons per day, or gpd), and average daily demand (gpd).

In return, the manufacturer will be able to tell you:

- The type of resin (must be NSF 61 listed for contact with drinking water).
- The size and number of vessels needed.
- The maximum and average daily salt consumption.
- The need for pretreatment.
- The volume of waste generated by backwash and rinse.
- Rinse volume (gallons/cubic foot of resin).
- Backwash volume (gpm/square foot of resin bed cross section and backwash time).
- Regenerant dose of salt (lbs per cubic foot of resin per regeneration cycle).
- Frequency of regeneration.

Advantages

- Automated operation.
- Low initial cost.
- More widely used than other forms of treatment.
- Most suited to small installations (<10,000 gallons per day supply capacity).

Disadvantages

- Requires frequent monitoring for nitrate removal.
- Requires storing large volumes of salt.
- Resins are susceptible to organic fouling.
- May "dump" nitrate captured in the exchange vessel when regeneration is not performed before all the resin exchange sites are full, resulting in high concentrations of nitrate in the treated water.
- Changes in finished water pH potentially requiring pH adjustment.
- Salt brine disposal can be difficult.

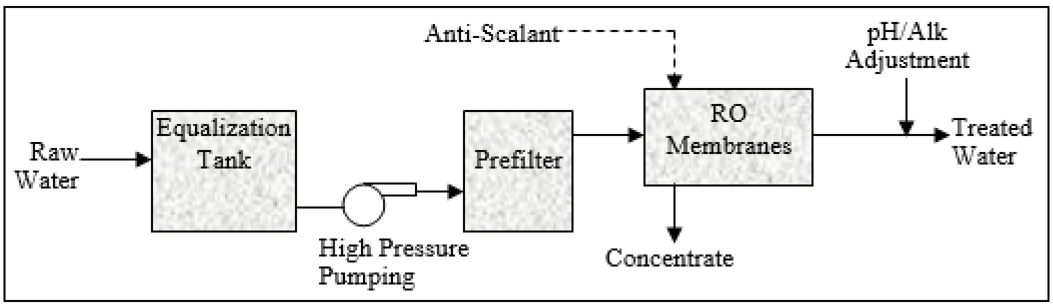
Reverse Osmosis

Reverse Osmosis (RO) is a physical process in which contaminants are removed by applying pressure to move raw water through a semi-permeable membrane allowing water molecules to pass through while retaining most of the dissolved minerals. In low pressure (<100 psi) applications, only 10 to 25 percent of the raw water is produced as finished water. High-pressure systems can achieve water efficiencies greater than 85 percent, but require specialized pumps and significant energy to achieve this level of efficiency. RO is one of the most expensive forms of centralized treatment and will likely not be cost effective unless multiple contaminants require removal or potable water demand is very low.

Point-of-Use (POU) and Point-of-Entry (POE) treatment is not a viable option to comply with drinking water standards in Washington. ODW limits the use of POU and POE treatment because their application is incompatible with existing regulatory requirements (WSDOH 2007). A limited exception to this restriction applies to non-community water systems that use a POE treatment device to treat all the water entering a single-building water system.

The American Water Works Association created a manual of practice on reverse osmosis (AWWA, 2007). Figure 4-5 depicts the reserve osmosis treatment process.

Figure 4-5 Reverse Osmosis System Schematic



Water Quality

RO requires careful review of raw water characteristics and pretreatment needs to prevent membranes from fouling, scaling, or degrading. Removal of suspended solids is necessary to prevent membrane fouling, while the removal of dissolved solids is necessary to prevent scaling and chemical degradation of the membrane. Pretreatment usually involves passing the water through a series of progressively finer filters prior to the RO membrane. Figure 4-6 depicts an RO membrane treatment skid.

RO will remove almost all ions from the water, including ions that supply needed alkalinity to buffer the water against plumbing corrosion. As a result, the pH of the finished water will fluctuate unless controlled. Consequently, installation of RO will trigger renewed initial monitoring under the Lead and Copper Rule (except for transient non-community water systems). Design engineers for all types of water systems should plan on providing post-treatment pH and alkalinity adjustment to stabilize the treated water and reduce its corrosivity.

Figure 4-6 Reverse Osmosis Membrane Skid

Maintenance and Monitoring

The frequency of membrane and prefilter replacement depends on the raw water characteristics, pretreatment provided, and membrane maintenance. Periodically, it is necessary to clean the membranes with acid or caustic solutions to remove deposits and scales. After a sequential cleaning of the membranes, they usually are flushed with finished water and returned to service.

Monitoring is required to assure RO treatment is effective in reducing nitrate concentration reliably below the MCL. Monitoring includes a daily grab sample or continuous nitrate monitoring, or continuous analysis of a surrogate such as conductivity. In addition, a monthly nitrate sample must be collected and analyzed by a state-certified drinking water laboratory. The production flow rate and differential pressure across the membrane and the prefilters should also be monitored to track membrane performance, identify fouling, and the need for cleaning or membrane replacement.

Waste Disposal

RO generates a concentrate waste stream during normal operations, and a waste stream of chemicals and byproducts following periodic membrane cleaning. The Washington State Department of Ecology implements the state's Wastewater Discharge Permit program. RO waste discharge may need an individual state waste discharge permit. See Appendix C for more details.

Advantages

- Produces high quality water.
- Low pressure (<100 psi), compact units are available for small installations.

- Most suited to very small installations (<5,000 gallons per day supply capacity).

Disadvantages

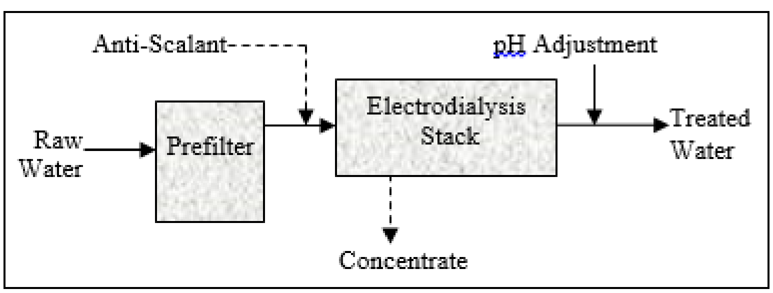
- Expensive to install and maintain.
- Disposal of concentrate and pretreatment waste streams may be difficult.
- Membranes are prone to fouling.
- Pre- and post-treatment can make the process complex.
- Changes in finished water pH potentially requiring pH adjustment.
- Frequent membrane monitoring and maintenance is required.
- Low water efficiency (10-25 percent) for low pressure applications.

Electrodialysis/Electrodialysis Reversal

In the Electrodialysis (ED) process, ions migrate through ion-selective semipermeable membranes as a result of electrically charged membrane surfaces. A positive electrode (cathode) and a negative electrode (anode) are used to charge the membrane surfaces and attract oppositely charged ions. Through this process, ions such as nitrate are removed from the raw water. In Electrodialysis Reversal (EDR), the charge on the membranes is reversed periodically to minimize scale development.

The American Water Works Association created a manual of practice on ED (AWWA, 1995). Figure 4-7 depicts the EDR treatment process.

Figure 4-7 ED Process Schematic



Water Quality

ED normally requires less pretreatment than other membrane processes. The only pretreatment normally used with groundwater systems is prefiltration with a 10-micron cartridge filter to remove solids. Pretreatment to remove iron and manganese should be provided if iron is greater than 0.3 mg/L or manganese is more than 0.1 mg/L. Hydrogen sulfide can be tolerated up to 0.3 mg/L and turbidity up to 2 NTU. For most groundwater, turbidity is due to the presence of iron and manganese, so removing these minerals will remove the turbidity.

Precipitation of solids on the membrane surfaces can be an operational concern. As water passes through the equipment, minerals are removed and concentrated in the brine stream, which can lead to the build-up of scales on process equipment. The potential for scale formation increases when water is high in total dissolved solids and the process operates at high water-recovery rates. ED process membranes can be cleaned in place using a dilute acid solution to restore system performance.

As with ion exchange and RO, ED treatment increases corrosivity of the water, triggering renewed initial Lead and Copper monitoring and provisions for pH adjustment. Figure 4-8 depicts an EDR packaged treatment plant.

Figure 4-8 Electrodialysis Reversal Package Plant

Maintenance and Monitoring

Chemical cleaning of the accumulated solids from the stack should be performed at least weekly. Byproducts from the process include small quantities of hydrogen gas formed at the cathode and oxygen and chlorine gas from the anode spacer. These gases should be vented above the building to avoid potential safety concerns associated with their build-up.

Monitoring is required to assure ED treatment is effective in reducing nitrate concentration reliably below the MCL. Monitoring includes a daily grab sample or continuous nitrate monitoring of the ED treated water, or continuous monitoring of a surrogate such as conductivity. In addition, a monthly nitrate sample must be collected and analyzed by a state-certified drinking water laboratory. Daily monitoring of differential pressure across the membrane, and other key operational parameters should be performed.

Waste Disposal

ED/EDR generates a concentrate waste stream during normal operations, and a waste stream of chemicals and byproducts following periodic membrane cleaning. The Washington State Department of Ecology implements the state's Wastewater Discharge Permit program. ED/EDR waste discharge may need an individual state waste discharge permit. See Appendix C for more details.

Advantages

- Low pressure requirements.
- Typically quieter than RO.
- Long membrane life expectancy.
- May be scaled to suit any size system.

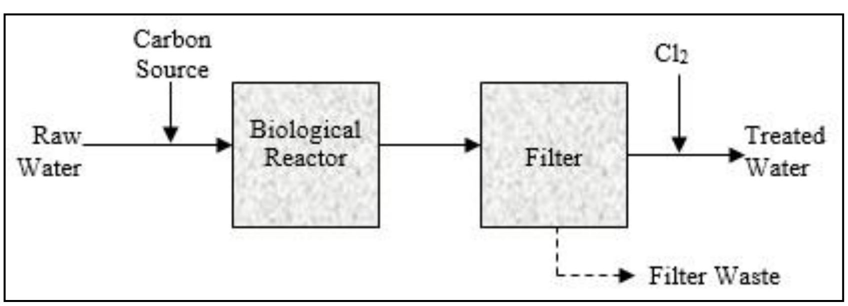
Disadvantages

- Pretreatment required for high levels of Fe, Mn, H_2S, chlorine, or hardness.
- Changes in finished water pH potentially requiring pH adjustment.
- Concentrate may require special disposal.

Biological Treatment (Engineered)

Biological denitrification is a process through which bacteria convert nitrate to nitrogen gas under anoxic (oxygen free) conditions. The nitrogen gas and bacteria are removed from the water before it enters the distribution system. Ethanol, methanol, acetate, and other chemicals are used to facilitate the biological denitrification process. Although this process is used in Europe to remove nitrate from drinking water, a limited number of water system in the United States use this technology. Figure 4-9 depicts an engineered biological denitrification treatment process.

Figure 4-9 Engineered Biological Denitrification Schematic



Water Quality

Because denitrification takes place under anoxic conditions, it is important to ensure there is no oxygen in the reactor. As little as 0.1 mg/L of oxygen inhibits the denitrification process (Rittman and Huck, 1989). The optimal process pH is between 7 and 8.5, and the alkalinity produced by the denitrification process will cause a slight increase in pH (Metcalf and Eddy, 1991). Temperature also has a strong effect on the treatment process with an approximate doubling of the denitrification rate with a 10ºC (18ºF) increase in temperature. Temperatures less than 5ºC (41ºF) make the process impractical.

Maintenance and Monitoring

Biological denitrification requires daily, or more frequent, monitoring to ensure the process operates reliably. In addition to monitoring for nitrate, the pH, temperature, oxidation-reduction potential, and concentration of organic carbon in the finished water should be checked daily. A monthly nitrate sample analyzed by a state-certified drinking water laboratory is also required to assure validation of daily monitoring and to comply with state monitoring requirements designed to ensure treatment is effective in reducing nitrate concentration reliably below the MCL.

Waste Disposal

Biological treatment generates a filter backwash/filter-to-waste discharge. The Washington State Department of Ecology implements the state's Wastewater Discharge Permit program. Biological treatment filter waste discharge may be covered under the state's waste discharge general permit. See Appendix C for more details.

Advantages

- No concentrated salt brine or nitrate for disposal.
- Hydraulically efficient (low volume waste stream).
- No impact on corrosivity and no need for pH adjustment.
- Low energy demand.
- Most suited for systems with higher treatment flow requirements (>100 gpm).

Disadvantages

- Little operating experience in the United States.
- Extensive piloting likely required (at least one-year of continuous operation).
- Several weeks required from start-up to stable operation for new systems.
- Post treatment filtration and disinfection required.

- Process is temperature sensitive.
- Taste and odor problems may require additional treatment.

Pilot Testing of Source Treatment Alternatives

The best overall alternative must be pilot tested (WAC 246-290-250(3)). Pilot testing consists of setting up and operating a small-scale system to determine its performance using the actual field conditions and raw water that will be treated at full-scale.
In some cases, where the cost of pilot testing would approach the cost of installing the full-scale equipment, the pilot-testing phase could be included in the start-up process for the technology. The water from the full-scale pilot cannot be used for potable water supply.

Due to the complexity and importance of treatment, pilot testing must involve an engineer. Properly conducted pilot testing can provide valuable information to avoid significant mistakes in the final design. For a pilot study to be useful, the pilot study should be conducted for long enough to obtain meaningful data. The length of time required will vary depending on the process selected and the raw water quality.

DOH must review and approve the pilot study protocol prepared by a licensed engineer. Upon completion of the pilot study fieldwork, a report summarizing the data and results must be submitted for approval.

Conclusions

There are a number of treatment processes to consider. These range from processes widely used for drinking water treatment to more novel technologies relying on biological processes to remove nitrate from groundwater. The best approach may combine land use management practices with some treatment process. Land use management practices can decrease the concentration of nitrate in groundwater over the long-term. Some treatment process will be necessary until the nitrate in the groundwater is reliably and consistently below the MCL.

References

American Water Works Association, "Electrodialysis and Electrodialysis Reversal," *Manual of Water Supply Practices – M38,* First Edition, AWWA, Denver, Colorado, 1995.

American Water Works Association, "Reverse Osmosis and Nanofiltration," *Manual of Water Supply Practices – M46,* Second Edition, AWWA, Denver, Colorado, 2007.

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Clifford, D. and C.X. Liu, "A Review of Processes for Removing Nitrate from Drinking Water," AWWA Annual Conf., Anaheim, California, 1995.

Health Research, Inc., Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. 2012. Ten State Standards - *Recommended Standards for Water Works.* Health Education Service, Albany, NY, Section 2.9.

Jensen, V.B., Darby, J.L., Seidel, C. & Gorman, C. Drinking Water Treatment for Nitrate. Technical Report 6 in: *Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater. Report for the State Water Resources Control Board Report to the Legislature.* Center for Watershed Sciences, University of California, Davis, 2012.

Metcalf and Eddy (Edited by G. Tchobanoglous and Burton), *Wastewater Engineering, Treatment, Disposal, and Reuse,* 3rd ed., 1991, pp. 432-433.

Rittman, B.E. and P.M. Huck, "Biological Treatment of Public Water," *CRC Critical Review Environmental Control,* 1989, Vol. 19(2), pp.119-184.

WSDOH. 2007. *Point-of-Use or Point-of-Entry Treatment Strategy*, DOH 331-358, Washington State Department of Health, Olympia, WA.

Chapter 5 Source Protection

Source water protection activities can be an important preventative measure, and helpful in slowing or preventing nitrate contamination in the first place. However, developing and implementing a source water protection plan will not take the place of implementing a treatment or non-treatment alternative to address nitrate contamination (above the nitrate MCL) of a drinking water source within the timeframe needed to protect public health.

Since one of the factors contributing to nitrate contamination of drinking water sources is land use activities that provide excess nitrate and other nitrogen-based compounds to enter water supplies, good management of these compounds can minimize nitrate leaching into the groundwater. Long-term source protection activities are recommended regardless of other actions taken because improved source protection may eliminate the need for treatment in the future, or at least reduce the level of nitrate reduction required to achieve compliance.

A Wellhead Protection Program is a required part of every public water system's planning documents (WAC 246-290-135(3)). Part of that program is the identification and notification of potential groundwater contamination sources within a ten-year time of travel boundary (a travel boundary represents a distance that it will take water to reach your well over a specific amount of time). Source protection activities involve working with the owners of the potential contamination sources in this area of influence to reduce their impact and are important to protect the source from contamination.

Source protection includes land management activities intended to decrease nitrate concentrations over the long-term. Agricultural fertilizers, septic systems, and dairy facilities are all potential sources of significant nitrate contamination. USGS also found high concentrations of nitrate associated with the detection of pesticides in groundwater (Ryker, 1995). Removal of the source(s) of nitrate contamination will typically result in decreased nitrate contamination over a period, ranging from months to several years.

High nitrate levels are common in agricultural regions where the use of inorganic nitrogen based fertilizers is widespread. The U.S. Department of Agriculture (USDA) developed several programs used to protect drinking water sources, including the Conservation Reserve Program, Environmental Quality Initiative Program, and Conservation Security Program. Appendix B describes these programs in more detail.

Non-agricultural sources of nitrate contamination include septic systems and lawn fertilizers. These sources of nitrate may cause a localized increase in nitrate. Appropriate actions include relocating the source of contamination and changes in landscaping practices. Regardless of the source of contamination, it is important to support activities leading to a decrease in nitrate contamination of groundwater. Source protection activities may prevent an increase in nitrate contamination, preserving compliance options such as blending and developing a new source.

References

Ryker, S. J., and J.L. Jones, “Nitrate Concentrations in Ground Water of the Central Columbia Plateau,” U.S. Geological Survey Fact Sheet, FS-061-97, 1995.

Appendix A: USDA Watershed Protection Programs

The following programs can be used to decrease nitrate contamination of groundwater and implement other source water quality protection activities.

- Conservation Reserve Program (CRP).
- Environmental Quality Incentive Program (EQIP).
- Conservation Technical Assistance (CTA).

These programs are briefly summarized below. You may obtain more information on these programs by contacting the Farm Services Agency or Natural Resource Conservation Service in Spokane, or from local conservation district offices. Contact information for these agencies and the Washington State Conservation Commission is in Appendix B.

Conservation Reserve Program

The Conservation Reserve Program (CRP) is a voluntary program that retires environmentally sensitive cropland under protective vegetative cover for a 10- to 15-year contract period in exchange for annual per acre rental payment. Producers can offer land for enrollment under a competitive process during periodic signups or automatically enroll more limited acreages in conservation buffer practices. Land within 2,000 feet of a public water system well can be enrolled in a continuous CRP sign-up. The boundaries of these circular shaped areas can be adjusted to simplify farming practices.

Environmental Quality Incentive Program

The Environmental Quality Incentive Program (EQIP) is a voluntary conservation program that promotes agricultural production and environmental quality as compatible goals. Through EQIP, farmers and ranchers receive financial and technical help to install or implement structural and management conservation practices on eligible agricultural land. Reduction of groundwater contamination is one of the national priorities of the program. Incentive payments encourage producers to implement nutrient management and manure management activities designed to decrease groundwater nitrate concentrations. The EQIP cost share rate may be up to 90 percent of the conservation practices for new farmers and those with limited resources, and 75 percent for most others that employ accepted groundwater protection practices.

Conservation Technical Assistance

Conservation Technical Assistance (CTA) is a program that provides assistance to land-users, communities, and others to plan and implement conservation systems. The purpose of the conservation systems includes efforts to, improve soil and water quality, enhance fish and wildlife habitat, improve air quality, improve pasture and range condition, reduce upstream flooding and improve woodlands.

Appendix B: Contacts and Resources

Interagency and Local Government

- Abbotsford-Sumas Aquifer International Task Force
- Columbia Basin Groundwater Management Agency
- Conservation Districts (Local)

Washington State

- Conservation Commission
  300 Desmond Drive
  Lacey, WA 98503
  Phone: 360-407-6200
  scc.wa.gov/

- Department of Agriculture
  Pesticide Management Division
  PO Box 42589
  Olympia, WA 98504-2589
  Phone: 360-902-1804
  agr.wa.gov/PestFert/

- Department of Ecology
  Water Quality
  PO Box 47600
  Olympia, WA 98504-7600
  Phone: 360-407-6483
  ecology.wa.gov/Water-Shorelines/Water-quality

- Department of Health
  Office of Drinking Water
  PO Box 47822
  Phone: 360-236-3100
  Olympia, WA 98504-7822
  doh.wa.gov/DrinkingWater

Federal

- Columbia Basin Groundwater Management Agency
  934 Broadway
  Suite 300
  Tacoma, WA 98402
  Phone: 253-552-1694
  wa.water.usgs.gov/projects/cbgwma/

- U.S. Department of Agriculture
  Washington State Farm Service Agency
  316 W. Boone Ave., Suite 568
  Spokane, WA 99201-2350
  Phone: 509-323-3000
  Fax: 509-323-3074
  fsa.usda.gov/state-offices/Washington/index

- USDA - Natural Resources Conservation Service
  316 W. Boone Ave., Suite 450
  Spokane, WA 99201-2348
  Phone: 509-323-2900
  Fax: 509-323-2909
  wa.nrcs.usda.gov/programs/

- Agricultural Research Service
  USDA-National Laboratory for Agriculture and the Environment
  2010 University Blvd.,
  Ames, IA 5011-3120
  Phone: 515-294-8243
  Fax: 515-294-8125
  ars.usda.gov/

- U.S. Environmental Protection Agency Region 10 (Seattle Office)
  1200 6th Ave.
  Seattle, WA 98101
  Main phone: 800-424-4372 or 206-553-1200
  epa.gov/aboutepa/epa-region-10-pacific-northwest

- U.S. Geological Survey
  934 Broadway, Suite 300
  Tacoma, WA 98402
  Phone: 253-552-1600
  wa.water.usgs.gov/water_issues/qual.htm

Appendix C: Water Treatment Plant Wastewater Disposal

Water treatment plants (WTPs) that discharge wastewater are considered industrial dischargers, no matter where they discharge their wastewater (to the land, surface water, or local public treatment works). The Department of Ecology (Ecology) is the lead agency in permitting discharges of wastewater from WTPs through either a general or individual permit.

Ecology permits discharges of wastewater produced from a water treatment filtration process (filter backwash, sedimentation or presedimentation basin washdown, sedimentation/clarification, or filter-to-waste) under its combined National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge General Permit ("General Permit"). Engineered biological treatment is an example of a facility likely eligible for the General Permit. All eligible facilities **must** apply for coverage.

Wastewater discharge from a WTP is covered under the General Permit if **all** the following criteria are met:

- The WTP is not covered by an NPDES waste discharge **individual** permit.
- The WTP produces water for potable or industrial use as its primary function.
- The WTP produces an average of 35,000 gallons per day or more of finished water, as determined on an average monthly basis.
- The WTP discharges its wastewater directly to surface water or to a settling pond or basin if an overflow from the pond or basin can flow to surface water. Surface waters include: lakes, rivers, ponds, streams, inland waters, wetlands, marine waters, estuaries, and all other fresh or brackish waters and water courses, plus drainages to those waterbodies.
- The discharged wastewater is produced from a water treatment filtration process (filter backwash, sedimentation/presedimentation basin washdown, sedimentation/clarification, or filter-to-waste).
- The discharged wastewater is **not** produced from ion exchange, reverse osmosis, or slow sand filtration.

Ecology considers WTPs producing an average of 35,000 gallons per day or more of finished water to be "conditionally exempt" from operating under the General Permit requirements for discharges of filter backwash wastewater if they meet **all** of the following conditions. This exemption is subject to periodic review by Ecology of WTP processes and discharge characteristics. Part of Ecology's review includes a determination of whether a “reasonable potential to pollute” exists, based on defined USEPA methods.

- The WTP discharges its filter backwash wastewater to the ground so that the majority of the liquid either evaporates or infiltrates to the subsurface, provided that the area receiving the discharge does not contain highly permeable soils; and does not lie directly above a shallow aquifer, above an aquifer with limited recharge, or in a location where groundwater quality appears to be threatened.
- Discharge to a drain field, infiltration pond, or trench should be utilized only when discharge via land application (irrigation) or into a grass-lined swale is not possible. Note: Discharge to a “dry well” is prohibited under the State Underground Injection Control Act.
- Infiltration ponds and trenches must have sufficient freeboard to prevent over-topping and must be managed so that no reasonable potential exists for discharge to surface water.
- The wastewater must be free of additives and any amounts greater than *de minimis* of toxic materials that have the potential to reach state waters.
- The volume of the discharge and the concentration of dissolved solids do not demonstrate a reasonable potential to contaminate groundwater.
- Discharge must not cause soil erosion or deterioration of land features.
- Residual solids that accumulate in infiltration ponds and trenches must be disposed of as necessary to avoid a build-up and concentration of these materials.
- Disposal of solids must be consistent with requirements of the local health jurisdiction.

WTPs discharging wastewater produced from a water treatment filtration process (filter backwash, sedimentation or presedimentation basin washdown, sedimentation/clarification, or filter-to-waste) that have an actual average production rate of less than 35,000 gpd of finished water generally do not require a permit to discharge filter backwash wastewater. Generally, such WTPs are assumed to have no reasonable potential to pollute. See Table C-1.

Ecology excludes from coverage under its General Permit wastewater discharges from WTPs that employ ion exchange, reverse osmosis, or slow sand filtration. Depending on site-specific circumstances, Ecology may require such WTPs to obtain coverage under an individual permit. Design engineers employing ion exchange or reverse osmosis to remove nitrate should evaluate waste generation issues early and consult with Ecology because waste discharge issues could significantly affect the cost or feasibility of the proposed treatment. See Table C-2.

Ecology’s web page on general permits for water treatment plants provides a link to the current general permit, and a link to the associated fact sheet. The fact sheet explains how the general permit conditions were developed, presents the legal basis for permit conditions, and provides background information on water treatment facilities.

Table C-1 Less than 35,000 gpd finished water production. Treatment is not IX, RO, or Slow Sand Filtration.

Waste Stream Characteristics (daily volume, content, etc.)	Disposal Method	Agency with Regulatory Oversight Authority
Wastewater (not the settled sludge) generated by filter backwash (including from microfiltration and ultrafiltration), sedimentation/presedimentation basin washdown, sedimentation/clarification, and filter-to-waste processes	Discharge to surface water	**Department of Ecology** No reasonable potential to pollute.
Wastewater (not the settled sludge) generated by filter backwash (including from microfiltration and ultrafiltration), sedimentation/presedimentation basin washdown, sedimentation/clarification, and filter-to-waste processes	Discharge to ground	**Department of Ecology** No reasonable potential to pollute.
Wastewater (not the settled sludge) generated by filter backwash (including from microfiltration and ultrafiltration), sedimentation/presedimentation basin washdown, sedimentation/clarification, and filter-to-waste processes	Discharge to POTW	**Local municipality**
Settled sludge (from wastewater) generated by filter backwash (including from microfiltration and ultrafiltration), sedimentation/presedimentation basin washdown, sedimentation/clarification, and filter-to-waste processes	Agronomic or silvicultural use	Land application: **Local health jurisdiction** Statewide Beneficial Use Determination: **Department of Ecology**
Settled sludge (from wastewater) generated by filter backwash (including from microfiltration and ultrafiltration), sedimentation/presedimentation basin washdown, sedimentation/clarification, and filter-to-waste processes	Landfill	**Local health jurisdiction**

Table C-2 Any treatment plant finished water production capacity. IX, RO, EER, Microfiltration, Ultrafiltration, or Nanofiltration.

Waste Stream Characteristics (daily volume, content, etc.)	Disposal Method	Agency with Regulatory Oversight Authority
IX or RO brine, or filter backwash that contains dissolved solids removed from the source water (consisting of regeneration liquid, ionic pollutants, and rinse water)	Discharge to surface water	**Department of Ecology** Individual NPDES permit, except for discharges from desalinization processes of up to 5,000 gpd to salt waters.
IX or RO brine, or filter backwash that contains dissolved solids removed from the source water (consisting of regeneration liquid, ionic pollutants, and rinse water)	Discharge to ground	**Department of Ecology** Site-specific: May need a NPDES individual permit or a state waste discharge permit.
IX or RO brine, or filter backwash that contains dissolved solids removed from the source water (consisting of regeneration liquid, ionic pollutants, and rinse water)	Discharge to POTW	**Local municipality** and **Department of Ecology** Site-specific: May need a state waste discharge permit.
IX or RO brine, or filter backwash that contains dissolved solids removed from the source water (consisting of regeneration liquid, ionic pollutants, and rinse water)	Agronomic or silvicultural use	**Department of Ecology** Site-specific: May need a state waste discharge permit.
Settled sludge (from wastewater) generated by filter backwash, sedimentation/presedimentation basin washdown, sedimentation/clarification, and filter-to-waste processes	Landfill or recycling	**Local health jurisdiction**

EER = Electrodialysis/electrodialysis reversal

IX = Ion exchange

RO = Reverse osmosis

The main assumption for Tables C-1 and C-2 is that wastes and discharges are "typical," i.e., they do not contain unusually large amounts of pollutants.

Single domestic or point-of-use IX or RO systems do not require a state waste discharge permit because they are considered to have no reasonable potential to pollute.