



SPOKANE COUNTY



Draft
Spokane County
Critical Aquifer Recharge Areas Review
Technical Memorandum #2

Prepared for:
Spokane County
Division of Utilities
1026 West Broadway Avenue
Spokane, WA 99260

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Prepared by:



412 East Parkcenter Blvd.
Suite 100
Boise, ID 83706
(208) 387-7000

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Attachments

Attachment A – Level 1 Nitrate Balance

Acronyms

AKART	All known, available, and reasonable methods of prevention, control, and treatment)
CARA	Critical aquifer recharge area
GMA	Growth Management Act
HDR	HDR Engineering, Inc.
LOSS	Large on-site sewage system
SCC	Spokane County Code
UGA	Urban growth area
WDOE	Washington Department of Ecology
WDOH	Washington Department of Health
WAC	Washington Administrative Code

Introduction

Study Objectives and Approach

The objective of this study is to review and, if necessary, recommend updates to the Critical Aquifer Recharge Area (CARA) wastewater disposal standards for non-residential uses and activities outside the Urban Growth Areas (UGA) boundary (Spokane County Code (SCC) 11.20.075). HDR Engineering, Inc. (HDR) is working with Spokane County to review the current standard and to evaluate the need for standard revisions. An important component of this project is stakeholder participation, which includes a series of meetings and document review. Stakeholder engagement is being supported by Sarah Hubbard-Gray of Hubbard Gray Consulting.

This study involves an assessment of non-residential sanitary wastewater loadings to soils (typically through septic system drainfields) that are protective of groundwater in susceptible aquifer areas outside the UGA boundary. Understanding loadings that are protective of groundwater allows for recommendations for revised standards. In addition, surface water protection associated with groundwater-to-surface water discharge will be considered in this analysis. Acceptable constituent loadings to soil that lead to loadings to groundwater are dependent upon several factors, including wastewater constituent type, soil properties, groundwater properties, surface water properties, hydraulic loadings, and attenuation factors.

To meet project objectives, the following tasks are being conducted:

- a. Define area of study.
- b. Define non-residential uses.
- c. Define non-residential sanitary wastewater characteristics.
- d. Define environmental/resource properties for the area of study.
- e. Define groundwater quality criteria.
- f. Analyze the aquifer mixing zone.
- g. Determine soil loadings.
- h. Determine sanitary wastewater loadings.
- i. Develop a predictive model.
- j. Recommendations and final report.

Four technical memoranda (drafts and finals) are being developed that describes the above listed tasks and findings, along with supporting documentation:

- i. Technical Memorandum # 1 – Introduction of regulations and description of current standards and summary of tasks a through d (listed above).
- ii. Technical Memorandum # 2 – Documentation for task e.
- iii. Technical Memorandum # 3 – Documentation for tasks f through h.
- iv. Technical Memorandum # 4 – Documentation for task i.

Draft Technical Memorandum #1 was completed in October 2012 and was provided with the CARA Review Committee on October 24, 2012. This draft, along with the other draft technical memoranda will be combined into a final document with recommendations.

This document, Technical Memorandum #2, focuses on the objectives of task e – define groundwater quality criteria.



Background

The reader is referred to Technical Memorandum #1 for background information on the implementation of CARA in Spokane County, definition of non-residential areas outside the UGA, and characteristics of non-residential sanitary wastewater.

Under Washington's Growth Management Act (GMA), the county has designated areas and adopted development regulations for the purpose of protecting areas within the unincorporated areas of Spokane County critical to maintaining groundwater recharge and quality. SCC 11.20.075 specifies the requirements to be enacted when regulated development within these areas is proposed to occur. CARA goals as defined in the code are:

1. Prevent degradation of groundwater quality in Spokane County and improve water quality of aquifers that do not meet state standards.
2. Protect groundwater quality from development impacts.
3. Secure adequate water quantity for the residents of Spokane County.
4. Provide public information programs for land users to demonstrate how to protect critical aquifer recharge areas from degradation.
5. Consistently enforce regulations, effectively monitor compliance, and provide incentives to protect critical aquifer recharge areas.
6. Regularly update critical aquifer recharge area protection measures so they are effective, enforceable, and equitable.

Technical Memorandum #2 focuses on the interpretation and application of the *Water Quality Standards for Groundwater of the State of Washington* (Chapter 173-200 WAC) to meet CARA goals 1 and 2 listed above.

Conceptual Model

Figure 1 provides a general conceptual model of an on-site treatment system for non-residential use. For this system, sanitary wastewater is discharged from a non-residential facility (influent wastewater) and enters into a septic tank where it receives primary biological treatment. This treatment involves the digestion of wastewater into liquid, fats and grease, and insoluble particles. The fine insoluble particles settle to the bottom of the septic tank forming sludge. Greases and fats float to the top forming a scum layer. The liquid (effluent) flows through the outlet pipe into the drainfield piping and then into the soil. Once in the soil system, some constituents in the effluent can undergo secondary biological and chemical interactions (treatment). For example, phosphorus can be adsorbed by soil clays while organic nitrogen can undergo biological mineralization and nitrification processes (microbial process of converting organic nitrogen to ammonium and then to nitrate). The hydraulic loading of the drainfield effluent to soils typically exceeds the ability of the soil to retain this water; thus the effluent, with its dissolved constituents (leachate), can move by gravity downward and enter the groundwater system.

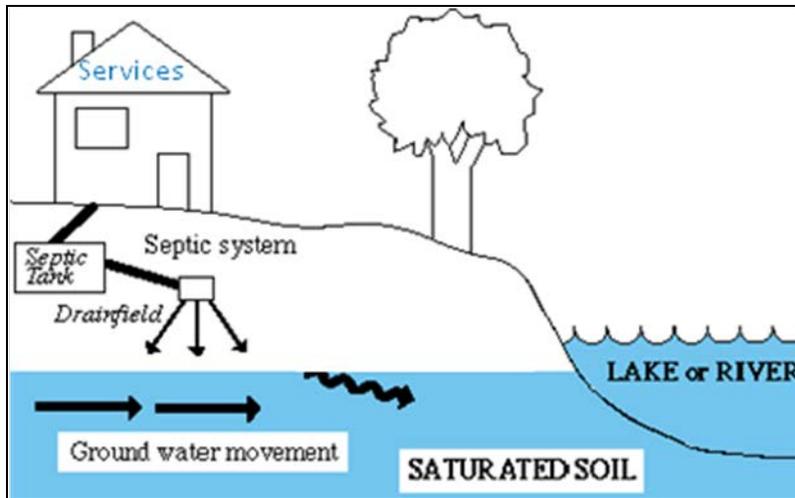


Figure 1. Conceptual On-Site Sanitary Treatment System

Technical Memorandum #1 provides a list of typical on-site treatment system effluent constituents and concentration ranges. Effluent entering the drainfield often has constituents at elevated concentrations (compared to typical ambient groundwater concentrations). Such constituents include: chloride, sulfate, nitrate, organic nitrogen, phosphorus, fecal coliform and fecal streptococci bacteria, and total organic carbon (Canter and Knox, 1985). In addition, trace organic compounds (e.g. caffeine) may be present. As described above, many of these constituents may undergo additional treatment in the soils system. Much of the regulatory focus for groundwater protection from on-site treatment systems has been on nitrate. This compound is very mobile in soil and groundwater systems, is at relatively high concentrations in effluent (e.g. typically in the 40 to 60 mg/L range compared to a groundwater quality standard of 10.0 mg/L), and is a “primary contaminant” under the groundwater quality standards (e.g. it can be harmful to human health when ingested at elevated concentrations).

In order to assess non-residential on-site wastewater disposal standards under CARA, it is necessary to quantify the following steps (**Figure 2**):

1. Influent wastewater loading to the septic tank.
2. Effluent wastewater loading to the drainfield.
3. Leachate moving into and through the soil system after discharge from the drainfield.
4. Leachate loading into groundwater.
5. Groundwater to surface water (only for some constituents such as phosphorus and only where there is a groundwater to surface water pathway).

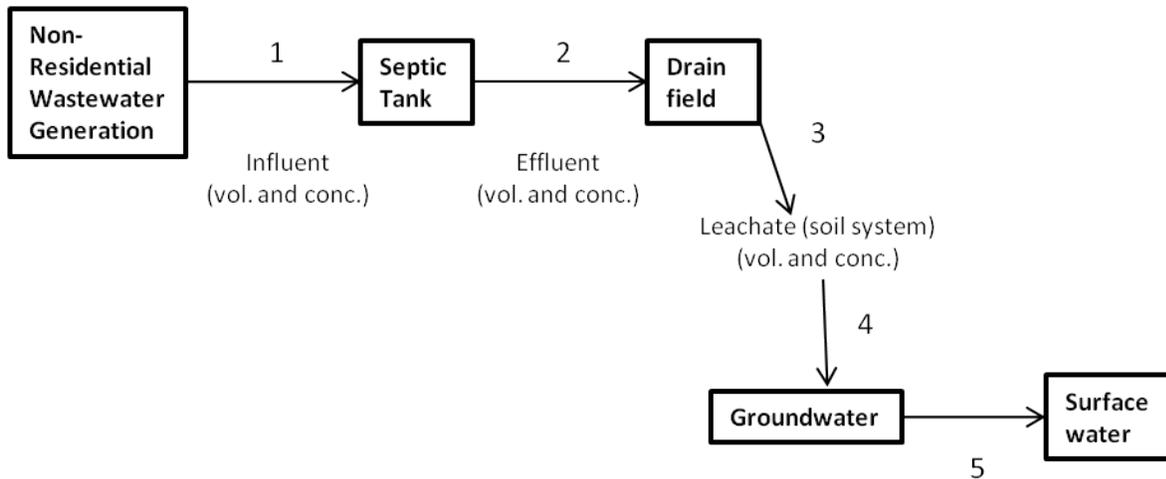


Figure 2. Process Flow Model

The regulatory driver for determining “acceptable” loadings to groundwater is the groundwater quality standards. The remainder of this technical memorandum focuses on the *Water Quality Standard for Ground Water of the State of Washington* (Chapter 173-200 WAC) (referred to as the groundwater quality standards). The document, *Implementation Guidance for the Ground Water Quality Standard* (WDOE 2005) is relied upon for this evaluation. Furthermore, the focus of this evaluation is nitrate, as this is the most common groundwater pollutant associated with on-site treatment systems. Phosphorus is also being evaluated, not as a groundwater pollutant, but as a potential pollutant to surface water (drainfield to groundwater to surface water pathway). The need for evaluating other constituents will be considered once protocols are established for nitrate and phosphorus.

Groundwater Quality Standards (WAC 173-200)

Washington’s groundwater quality standards apply to any activity which has the potential to contaminate groundwater quality, including on-site sanitary waste treatment systems. Furthermore, the standards apply to all groundwater in the saturated zone, statewide. All groundwater is classified as a potential drinking water source; the standard does not distinguish groundwater that may be perched, seasonal, or artificial.

Regulatory Authority for On-Site Sewage Systems and the Groundwater Quality Standards

The following agencies have responsibilities for regulating wastewater treatment systems in Spokane County:

Spokane Regional Health District – Authority and approval over individual and small (up to 3,499 gallons/day) on-site sewage systems.

Washington State Department of Health (WDOH) – Authority and approval over on-site sewage systems designed to handle domestic strength sewage at design flows from 3,500 to 100,000 gallons/ day (may include mechanical treatment). Staff also reviews and approves all septic tanks, pump chambers, and other tanks used as part of small and large systems in Washington State.

Washington Department of Ecology (WDOE) – has authority and approval over:

- Domestic or industrial wastewater treatment under Chapter 173-240 WAC (wastewater facilities).
- Wastewater treatment systems with subsurface disposal and design flows above 100,000 gallons per day.
- Wastewater treatment systems with subsurface disposal that treat industrial waste.
- Wastewater treatment systems with subsurface disposal where the groundwater receiving effluent is in hydraulic continuity with surface water.
- Wastewater treatment systems with evaporative lagoons.
- Wastewater treatment systems receiving storm water discharges, including combined sanitary sewer and storm water systems.

Implementation and enforcement of groundwater quality standards (Chapter 173-200 WAC) for on-site sewage systems is the responsibility of the permitting agencies which are the Department of Health and the Spokane Regional Health District.

Standard Outline and Intent

The goal of the groundwater quality standards is to maintain existing high quality groundwater and to protect existing and future beneficial uses. This goal is achieved through three basic mechanisms:

1. Antidegradation - The antidegradation policy mandates the protection of background water quality and prevents degradation of water quality which would harm a beneficial use or violate the groundwater quality standards.
2. AKART - All discharges of pollutants to groundwater must be treated at a minimum with AKART (all known, available, and reasonable methods of prevention, control and treatment), or best management practices (BMPs) implemented through permits or agreements with other agencies.
3. Standards - The human health and welfare based standards which include numeric and narrative standards.

Antidegradation

The antidegradation policy as described in the groundwater quality standards has a two tiered approach (WDOE 2005):

- *Existing and future beneficial uses shall be maintained and protected. Degradation of groundwater quality that would interfere with or become injurious to beneficial uses shall not be allowed, [WAC 173-200-030 (2) (a)].* At a minimum all groundwater should be protected as a potential source of drinking water. Not all groundwater is presently used for drinking water, nor do the standards presume that all groundwater is suitable as a drinking water source. However, the groundwater quality standards recognize the

potential for these sources to be used for drinking water purposes in the future if other sources become diminished or the demand for water increases.

- *Whenever groundwaters are of a higher quality than the criteria (see **Box 1**) assigned for said waters, the existing water quality shall be protected, and contaminants that will reduce the existing quality thereof shall not be allowed to enter such waters, except in those instances where it can be demonstrated to the department's satisfaction that:*

- An overriding public interest will be served.*
- All contaminants proposed for entry into said waters shall be provided with all known, available, and reasonable methods of prevention, control, and treatment prior to entry, [WAC 173-200-030 2(c)].*

Box 1: "Criteria" - The term as used in the groundwater quality standards refers to numeric values and narrative standards that represent contaminant concentrations which are not to be exceeded in groundwater (e.g. the numeric criterion for nitrate-N in groundwater is 10 mg/L).

Antidegradation applies to both permitted and non-permitted activities.

Nondegradation

The standards also include a nondegradation clause that prohibits a measurable increase of contaminant concentrations in groundwater and applies in the following situations:

- *High quality groundwater constituting an outstanding national or state resource, such as waters of national and state parks, wildlife refuges, and waters of exceptional recreational or ecological significance, [WAC 173-200-030 (2)(b)].*
- Waters designated as outstanding resource waters through the provisions of Chapter 34.05 RCW, Administrative Procedures Act.
- Designated Special Protection Areas which have been classified as nondegradation areas, (WAC 173-200-090).
- Those areas where groundwater has been degraded to levels greater than the criteria, a nondegradation policy will be in effect for those constituents which exceed the criteria in ground water.

No groundwater in Spokane County has been designated or classified for nondegradation (first three bullets above). If groundwater is found to exceed a criteria (see **Box 1** for definition), then non-degradation applies.

Beneficial Uses

The antidegradation policy requires that beneficial uses be maintained and protected. Beneficial uses of groundwater include drinking water (the main premise for CARA), domestic, stock watering, industrial, commercial, agricultural, irrigation, mining, fish/wildlife maintenance and enhancement, recreation, generation of electrical power, preservation of environmental and aesthetic values, and all other uses compatible with the enjoyment of the public waters of the state, [WAC 173-200-020 (4)].

Groundwater that is hydraulically connected to a surface water body must maintain the water quality standards established in Chapter 173-201A WAC (Water Quality Standards for Surface Water of the State of Washington).

AKART (all known, available, and reasonable methods of prevention, control and treatment)

The antidegradation policy and AKART form the primary mechanisms for protecting groundwater quality. All discharges of pollutants to groundwater must be treated at a minimum with AKART or BMPs implemented through permits or agreements with other agencies. On-site treatment system design requirements are defined in Chapter 246-272A WAC – *On-Site Sewage Systems* and Chapter 246-272C WAC – *On-Site Sewage System Tanks Regulations*, and are regulated and permitted through the Spokane County Regional Health District and the Washington State Department of Health. The requirements set forth in on-site sewage systems regulations represent AKART. Thus, for purposes of this CARA evaluation, it is assumed that non-residential sanitary disposal that are permitted through the Spokane County Regional Health District and that follow the on-site sewage systems standards meet the AKART criteria as set forth in the groundwater quality standards.

Point of Compliance

The point of compliance is the location where the facility must be in compliance with the groundwater quality standards. The point of compliance assures the protection of all current and reasonable future uses of the groundwater. The point of compliance should be located in accordance with *WAC 173-200-060(1) in the groundwater as near and directly downgradient from the pollutant source as technically, hydrogeologically, and geographically feasible*. For this evaluation, therefore, the point of compliance is assumed to be directly downgradient of the drainfield.

Applying Groundwater Quality Standards to CARA Study

Based on the summary of the groundwater quality standards presented above, the question becomes what is an acceptable loading of leachate from a non-residential on-site treatment system to groundwater? **Table 1** summarizes how the groundwater quality standards are to be applied to this study for nitrate. Protocol has been established by the WDOH for large on-site sewage systems (LOSS) for assessing treatment system impacts to groundwater for nitrate. The agency has developed a Level 1 Nitrate Balance as a screening tool to identify LOSS that may have potential impacts to an unconfined or semi-confined surface aquifer (the aquifer nearest the surface and connected to the soil column above). The agency provides an Excel spreadsheet that calculates the estimated nitrate concentration in the groundwater at the point of compliance. The default point of compliance is the downgradient edge of the drainfield, which is consistent with the groundwater quality standards. The WDOH also uses an alternative point of compliance that is the edge of property. An increase of greater than 2.0 mg/L nitrate-N in groundwater above background is considered to be a moderate impact. Thus, the agency has defined up to 2.0 mg/L as being acceptable; and therefore, meets the groundwater quality standard requirements. Furthermore, the WDOH's policy restricts increases in the groundwater nitrate concentration above 5.0 mg/L. In practice, when the groundwater concentration is less than or equal to 3.0 mg/L then a 2.0 mg/L increase is possible, when the groundwater concentration is between 3.0 and 5.0 mg/L then an increase between 0 and 2.0 mg/L is allowed

that results in downgradient groundwater concentration of no more than 5.0 mg/L. When the upgradient groundwater concentration is greater than 5.0 mg/L then a minimal increase in nitrate-N such as 0.1 mg/L is used.

The 2.0 mg/L groundwater nitrate-N increase was also utilized by the WDOE when that agency had primacy for permitting of LOSS. A copy of the Level 1 Nitrate Balance instructions and example spreadsheet is provided in Attachment A. Details on the mixing zone model and implementation of this approach for the CARA study is described in Technical Memorandum #3.

Table 1. Application of the Groundwater Quality Standards to the CARA Study for Nitrate

Implementation Mechanism	CARA Study
Antidegradation Policy	<p>Upgradient nitrate-N ≤ 3.0 mg/L; then allow a 2.0 mg/L increase at point of compliance.</p> <p>Upgradient nitrate > 3.0 to ≤ 5.0 mg/L; then allow an increase up to 5.0 mg/L at point of compliance (e.g. if upgradient is 3.5 mg/L then allow an increase of 1.5 mg/L at point of compliance).</p> <p>Upgradient nitrate-N > 5.0 mg/L; then allow a 0.1 mg/L increase at point of compliance.</p> <p>Upgradient nitrate-N > 10.0 mg/L; then no measureable increase allowed.</p>
AKART	On-site sewage treatment systems meet AKART by being permitted and meeting the design requirements outlined in Chapter 246-272A WAC – <i>On-Site Sewage Systems</i> and Chapter 246-272C WAC – <i>On-Site Sewage System Tanks Regulations</i> .
Criteria	The on-site treatment system shall not result in groundwater nitrate-N exceeding 10.0 mg/L (in addition the antidegradation policy and AKART must be met).
Point of Compliance	Point of compliance is directly downgradient of the drainfield with an alternative at the edge of property.

References

Canter, L.W. and R. C. Knox. 1985. Septic tank system effects on ground water quality. Lewis Publications. 336p.

Washington Department of Ecology. 2005. *Implementation Guidance for the Ground Water Quality Standard*. Publication 96-02

Attachment A – Level 1 Nitrate Balance



Level 1 Nitrate Balance Instructions for Large On-site Sewage Systems

Instructions for Department of Health (DOH) Level 1 Nitrate Balance

DOH uses the Level 1 Nitrate Balance as a screening tool to identify LOSS which may have potential impacts to an unconfined or semi-confined surface aquifer. DOH may require a more comprehensive Nitrate Balance at sites where the Level 1 analysis indicates a potential moderate or significant impact to ground water. In general, a moderate impact is an increase greater than 2 mg/L above background. You can use the nitrate balance as a tool to understand the sensitivity of your LOSS on groundwater quality by varying values for effluent quality, effluent volume, and drainfield orientation. The equation used to build the Level 1 Nitrate Balance Excel spreadsheet is shown in [Appendix A](#).

When you fill out the Nitrate Balance Excel spreadsheet use the most reliable site specific information you can find. Always list your information source on the spreadsheet or on a separate reference sheet if you need more room. Provide a copy of the information source or an on-line link to the source. Sources of information can include field measurements, pump test data, well logs, literature reviews, a local or regional study, and state or local databases. DOH will generally consider a nitrate balance supported by field measurements to be more reliable than one completed with literature values.

Based on the parameters you provide, the spread sheet will calculate the estimated nitrate concentration in the groundwater at the point of compliance. The default point of compliance is the downgradient edge of the drainfield. DOH may approve an alternative point of compliance up to but not exceeding the property boundary.

In your supporting information, identify and include all drainfields associated with the project or located on the property in the nitrate balance. One nitrate balance must be performed that includes all active drainfields unless the drainfields are separated by a groundwater boundary condition that would result in different points of compliance. For those cases, a separate nitrate balance should be performed for each drainfield.

As explained below, several parameters must be shown on a topographic map of 1:7200 scale or less. The parameters are drainfield area, point of compliance, alternative point of compliance (if applicable), aquifer width, hydraulic gradient, and the property boundary. The map MUST be readable at a printable size of 11"x17" or smaller. An example map is shown in [Appendix B](#).

The nitrate balance(s) and supporting information can be submitted as a hard copy or electronically submitted as a PDF file.

For more information call 360.236.3040 or email Nancy.Darling@doh.wa.gov.

Level 1 Nitrate Balance Instructions for Large On-site Sewage Systems

Input values

Nitrate Concentration in Precipitation: Precipitation in Washington State contains a small amount of nitrates from both natural and man-made sources.

Instructions: Use the default value of 0.24 mg/L

Total Nitrogen Concentration in Wastewater: This is the concentration of total nitrogen in the effluent measured at the end of the pipe before it enters the drainfield. Residential strength effluent can range from 30 to 100 mg/L. High strength effluent, such as RV waste, can have total nitrogen concentrations greater than 500 mg/L.

Instructions: Use the default value of 60 mg/L for residential strength effluent. This value is for systems that do not have advanced treatment and are not treating high strength waste. Any value other than 60 mg/L must be supported by sampling data or a supporting reference.

Soil Denitrification: Denitrification in the soil can reduce the amount of nitrates that reach groundwater. Denitrification occurs when soil oxygen is depleted and the microbes must obtain oxygen from another source. Microbes obtain oxygen from soil compounds in the following general order: $O_2 > NO_3^- > Mn^{+4} > Fe^{+3} > SO_4^{-2} > CO_2$. The amount of denitrification is difficult to quantify and depends on several variables including soil carbon, soil moisture, soil temperature, and soil pH. In general, a coarse well drained soil will have less denitrification than a fine poorly drained soil.

Instructions: Use the default value of 10% denitrification. If you use a denitrification rate greater than 10%, you must provide site specific data or a supporting reference.

NOTE: The nitrate balance does not have a specific value for plant uptake. Some LOSS using shallow drip systems may qualify for an additional percent reduction in soil nitrates due to plant uptake. To qualify, your site must have a nutrient management plan that includes soil sampling and vegetation management. If you are taking a nitrate reduction for plant uptake, add the reduction to your denitrification value. Clearly identify which portion of the reduction is for plant uptake.

Aquifer Thickness: This value is used to calculate nitrate dilution in the upper-most aquifer through vertical mixing of the nitrate and groundwater.

Instructions: Use the default value of 20 feet or the actual aquifer thickness, whichever is less. Aquifer thickness can be estimated from a well log.

Level 1 Nitrate Balance Instructions for Large On-site Sewage Systems

Drainfield Area: This is the area of the primary drainfield and does not include the reserve area except when part of the reserve area is being used. The area of the drainfield is used to calculate how much dilution is received from infiltrating precipitation (recharge). The down gradient edge of the drainfield is the default point of compliance (POC) for the nitrate concentration in groundwater.

Instructions: For a new LOSS, calculate the area of the primary drainfield based on the estimated drainfield size including the area between trenches. For an existing LOSS, field measure the area of the existing drainfield. Be sure to take credit if you use or plan to use 50% of the reserve area in addition to the primary (“150% of the primary”). Show the drainfield area on the nitrate balance map.

Distance from the drainfield to the property boundary: The LOSS owner may request an alternative POC and DOH may approve an alternative POC up to but not exceeding the property boundary. An alternative POC can sometimes help dilute the nitrate in the groundwater to an acceptable level. If there is a well, spring, or surface water before the property boundary, then use that point for the distance instead of the property boundary for the alternative POC.

Instructions: The nitrate balance must first always be calculated with a zero value for the distance to the property boundary. This allows the spreadsheet to calculate the POC at the downgradient edge of the drainfield. A second nitrate balance can then be completed for an alternative POC (if applicable) using the distance between the down gradient edge of the drainfield and the property boundary or other receptor such as a well, spring or surface water. Measure the distance in the direction of the groundwater flow. Show both the default POC at the edge of the drainfield and the alternate POC on the nitrate balance map.

Aquifer Width: The width of the aquifer is the width of the gross area of the drainfield (not the width of the property) perpendicular to the groundwater flow.

Instructions: Measure the primary drainfield perpendicular to the direction of groundwater flow. Similar to measuring the drainfield area, be sure to consider the additional width if you use or plan to use 50% of the reserve area. Place a dotted line on the nitrate balance map to show where you measured the drainfield width.

Hydraulic conductivity of aquifer (K): Hydraulic conductivity is a measurement of an aquifer’s ability to transmit water. Hydraulic conductivities can range from greater than 10,000 ft/day to less than 1 ft/day. A well sorted gravel aquifer has high conductivity, whereas a poorly sorted sand aquifer has a lower conductivity. A high conductivity results in greater dilution and lower nitrate concentrations.

Instructions: Use the most site specific value available. Pump test or slug test data from a nearby well is preferred. Many public supply wells will have a pump test on record with the county that will contain a value for hydraulic conductivity. Other options include drawdown data on well logs from nearby wells, values in a technical report for the local area, or literature values for hydraulic conductivity based on

Level 1 Nitrate Balance Instructions for Large On-site Sewage Systems

aquifer materials. The table below shows typical literature values. If you are using the table, follow these steps:

1. Based on a geotechnical report or the nearest well logs, determine the materials of the uppermost aquifer (this may not be the aquifer where the well is completed).
2. Find the materials on the table that best matches the well log description and select a K value in the mid to lower range for that material. **Input K using ft/day.**

Hydraulic Conductivity Table

K (cm/s)	10 ²	10 ¹	10 ⁰ =1	10 ⁻¹	10 ⁻²	10 ⁻³	10 ⁻⁴	10 ⁻⁵	10 ⁻⁶	10 ⁻⁷	10 ⁻⁸	10 ⁻⁹	10 ⁻¹⁰
K (ft/day)	10⁵	10,000	1,000	100	10	1	0.1	0.01	0.001	0.0001	10⁻⁵	10⁻⁶	10⁻⁷
Relative Permeability	Pervious			Semi-Pervious				Impervious					
Aquifer	Good				Poor				None				
Unconsolidated Sand & Gravel	Well Sorted Gravel	Well Sorted Sand or Sand & Gravel		Very Fine Sand, Silt, Loess, Loam									
Unconsolidated Clay & Organic				Peat	Layered Clay			Unweathered Clay					
Consolidated Rocks	Highly Fractured Rocks			Oil Reservoir Rocks		Fresh Sandstone		Fresh Limestone, Dolomite		Fresh Granite			

Modified from J. Bear, 1972

Hydraulic gradient: This is the “slope” of the groundwater. Hydraulic gradients are generally less than three percent. The gradient, hydraulic conductivity, width of the aquifer, and depth of the mixing zone determine the aquifer flow under the drainfield.

Instructions: Water table elevations may be found on a water table map if one is available or can be calculated using water table elevations from nearby wells. Use a default value of 0.01 (1%) if the gradient is unknown. Place an arrow on the nitrate balance map to show the direction of groundwater flow.

Level 1 Nitrate Balance Instructions for Large On-site Sewage Systems

Recharge: The rate of recharge is the amount of inches per year of rainfall that infiltrate into the ground surface. Recharge is a percentage of the annual precipitation. This value is converted to gallons per day (gpd) in the nitrate balance equation.

Instructions: Some counties have groundwater recharge rates available. Where recharge is unknown, use a default is 35% of annual rainfall in western Washington and 20% of annual rainfall in eastern Washington.

Nitrate concentration of up-gradient groundwater: This is the nitrate concentration upgradient of the primary drainfield.

Instructions: Use site specific groundwater quality data for this value. Provide two or more sample results from nearby wells preferably on or upgradient of the project property. The sample must come from the surface aquifer. If you are unable to get a sample, you may use recent data from nearby public drinking water wells, county records, or hydrogeology reports in the local area. If you know the name or location of the public water system you can find sample data at <http://www.doh.wa.gov/ehp/dw/sentry.htm>. If you use well data, show the location of the wells on the nitrate balance map.

Wastewater Volume: For a new LOSS, the volume of wastewater is the daily operating capacity of the LOSS. The operating capacity is the design flow without a peaking factor. Use actual flow volumes if you have an existing LOSS with a reliable history of flow monitoring.

Instructions: For a new LOSS, determine the daily operating capacity from the pre-design report. For an existing LOSS use flow data if available or estimate the flow using information in Section-06150 of WAC 246-272B (the LOSS rule).

Level 1 Nitrate Balance Instructions for Large On-site Sewage Systems

Appendix A - Nitrogen Balance Equation

$$N_{GW} = \frac{\text{Upgradient } (Q \times N_B) + \text{Effluent } (V_W \times N_W(1-d)) + \text{Recharge } (V_R \times N_r)}{Q + V_W + V_r}$$

N_{GW} = nitrate concentration in groundwater (mg/L) at the selected point of compliance

$$Q = KibW_A (7.48)$$

Q = aquifer flow (gallons/day)

i = gradient (ft/ft)

b = depth of mixing in Aquifer (feet)

W_A = width of aquifer (measured as width of drainfield) (feet)

N_B = background (upgradient) ground water nitrate concentration (mg/L)

V_W = volume of wastewater (gallons/day)

N_W = nitrogen concentration in wastewater (mg/L)

d = denitrification rate in soil and vadose zone (unitless)

$$V_R = A_D \times R \times 0.0017$$

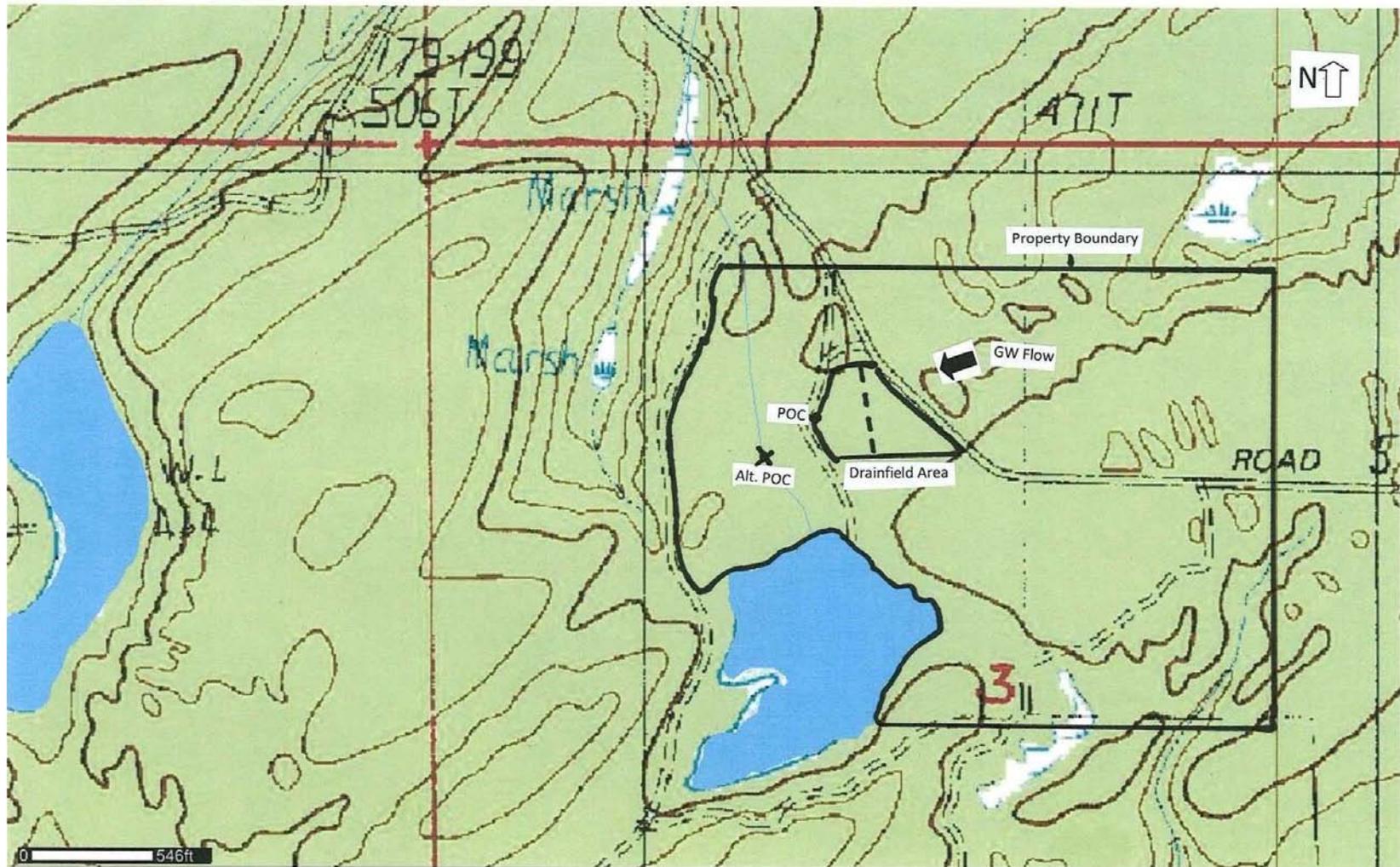
V_R = volume of recharge over drainfield (gallons/day)

A_D = area of drainfield (ft²)

R = recharge (in/yr)

N_r = nitrate concentration in precipitation (mg/L)

Appendix B - Level One Nitrate Balance Sample Map



Darling's Acres Proposed LOSS 2/5/2011

WASHINGTON DEPARTMENT OF HEALTH
 LEVEL 1 NITRATE BALANCE FOR LARGE ON-SITE SEWAGE SYSTEM

Project name:	
Address, city and county:	
Completed by (name and title):	
Date:	

Input Values	Factor	Units	Values	Instructions	Information Source
Nitrate concentration in precipitation	N _R	mg/l as N	0.24	Default	
Total nitrogen concentration in wastewater	N _W	mg/l	60	Default - residential strength	
Soil denitrification	d	unitless	0.1	Default	
Aquifer thickness	b	ft	20	Default or aquifer thickness if known	
Drainfield area	A _D	ft ²		Primary drainfield area	
Distance from drainfield to property boundary	D _{pb}	ft	0	Measure in direction of GW flow	
Aquifer width	W _A	ft	100	Perpendicular to GW flow	
Aquifer hydraulic conductivity	K	ft/day	100	Measured or literature value	
Hydraulic gradient	i	ft/ft	0.010	If unknown, use 0.010	
Recharge	R	in/yr	0.00	Recharge will be a % of ppt	
Nitrate concentration of upgradient ground water	N _B	mg/l	2	Prefer sampling data	
Wastewater volume	V _W	gpd	250	Design flows or measured volume	

Output Values					
Groundwater nitrate value	N _{GW}	mg/l as N	2.85	Point of Compliance (POC)	
Groundwater nitrate value	N _{GW ALT}	mg/l as N	2.85	Alternative POC	