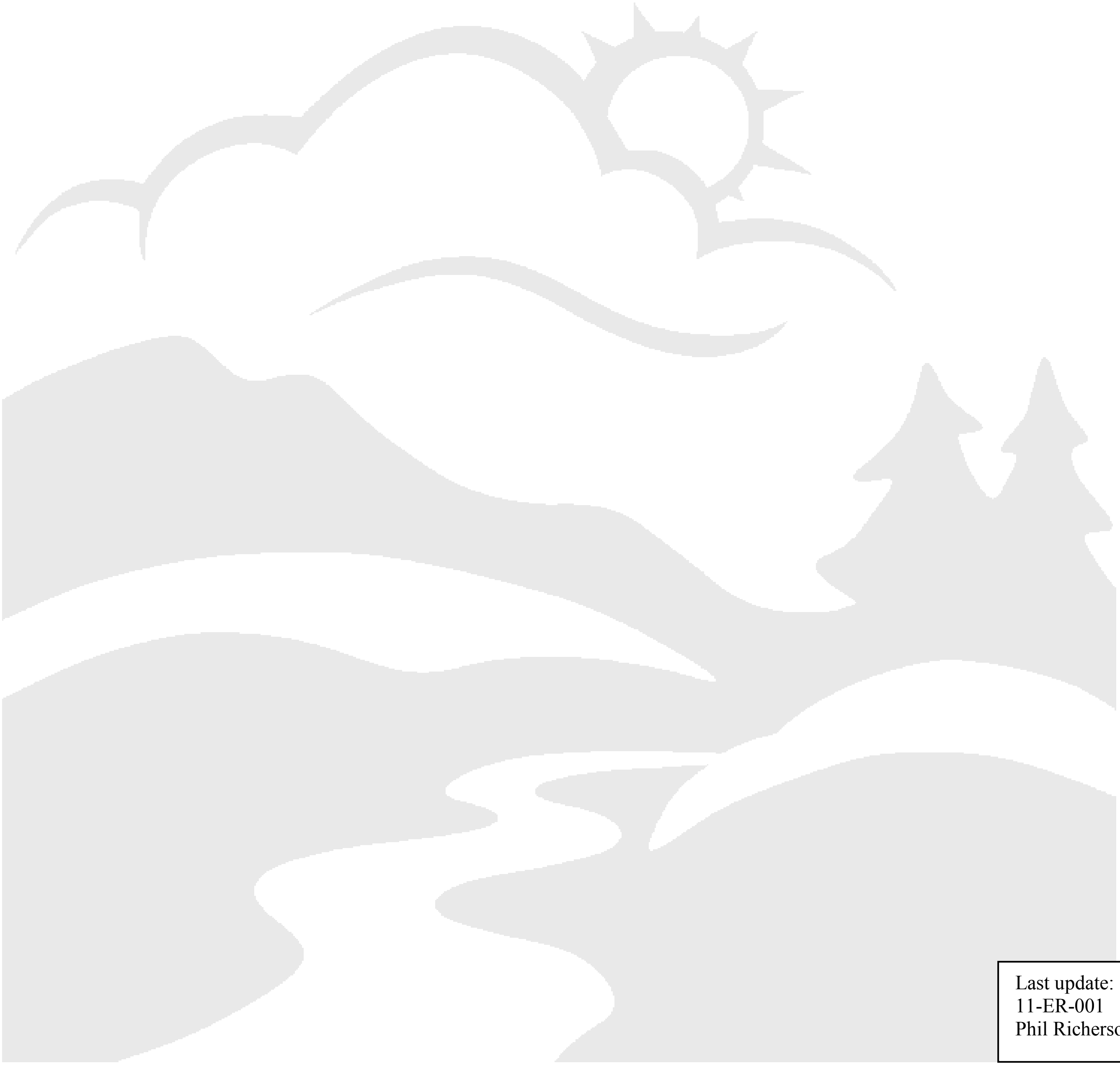
DEQ Water Quality Division

State of Oregon
Department of Environmental Quality

Estimation of Nitrogen Sources, Nitrogen Applied, And Nitrogen Leached to Groundwater in the Lower Umatilla Basin Groundwater Management Area

June 13, 2011



Last update: 6/13/11
11-ER-001
Phil Richerson

This report prepared by:

Oregon Department of Environmental Quality
700 SE Emigrant, Suite 330
Pendleton, OR 97801
1-800-452-4011

Contact:
Phil Richerson
(541) 278-4604

This, as well as other LUB GWMA documents, can be found on the Department's web site at:

http://www.deq.state.or.us/wq/groundwater/lubgwma.htm

For printed copies, please contact the DEQ Eastern Region Office in Pendleton at (541) 276-4063.

Table of Contents

Figures

Tables

Executive Summary

Introduction

This report describes an estimate of the sources of nitrogen, the amount of nitrogen introduced into the environment, and nitrogen leached to groundwater within the Lower Umatilla Basin Groundwater Management Area (LUB GWMA). Data used to assemble estimates of nitrogen available for leaching are just that, estimates. This document is not meant to give exact pounds of nitrogen contributed by any one group, but rather to give the relative importance of each group's nitrogen contribution.

Methodology

Estimates were made of the average loading rate and volume, the nitrogen imported or produced, the nitrogen applied, and the nitrogen leached to groundwater from each source of nitrate. Different methods were used to estimate the nitrogen loading from the following sources: irrigated agriculture, food processing wastewater, Confined Animal Feeding Operations (CAFOs), lawns and gardens, pastures, onsite septic systems, and the Umatilla Chemical Depot washout lagoon.

Discussion

CAFOs (at 46%) and irrigated agriculture (at 36%) are the two largest sources of nitrogen imported or produced in the GWMA and contribute approximately 82% of the total. The largest source of nitrogen applied is from irrigated agriculture, which contributed 74% of the total nitrogen introduced into the environment. The high percentage is, in part, due to the Oregon Department of Agriculture's estimate that 90% of CAFO waste is used by the irrigated agriculture community while 10% is used on dry land crops. The amount of nitrogen leached to groundwater was estimated by multiplying the amount applied by an assumed efficiency. Assumed efficiencies ranged from 0% (i.e., leaching 100%) for the Umatilla Depot Bomb Washout Lagoon to 98% (i.e., leaching 2%) for lawns and CAFO waste applied to dry land crops

Conclusions

- The sources of nitrate identified in the LUB GWMA Action Plan contribute significantly different amounts of nitrogen to groundwater, and can be classified into three tiers differing by approximately an order of magnitude:
    - *Tier One* – Irrigated Agriculture (81.6%)
    - *Tier Two* – Pastures (8.1%), food processors (4.6%), and on-site septic systems (3.9%).
    - *Tier Three* - Lawns (0.9%), CAFO waste applied to dry land crops (0.7%), vegetable gardens (0.3%), and the Depot Washout Lagoon (0.09%)
- Even though it is generally believed that the agricultural community is very efficient with nitrogen usage, the high percentage of land used to grow crops makes irrigated agriculture the largest percentage of nitrogen imported into the GWMA, introduced into the environment, and leached to groundwater.
- Changes in management practices within the irrigated agriculture community have the greatest potential to improve groundwater quality on a regional scale. For example, a 5% reduction in the amount of nitrate leached to groundwater from irrigated agriculture would offset approximately one-half the impact of pastures, 100% of impacts from on-site systems, or 90% of impacts from food processor wastewater application. All of the Tier Three sources combined equal about 2% of the total N leached.
- Even though irrigated agriculture is by far the largest contributor to groundwater nitrate, every source of nitrate should do what they can to reduce their contribution.

Recommendations

- The LUB GWMA Committee and sub-committees should review and update the practices identified in the Action Plan that would likely improve groundwater nitrate concentrations.
- The LUB GWMA Committee and sub-committees should consider this report when drafting the next Action Plan.

1.0 Introduction

This report describes an estimate of the sources of nitrogen, the amount of nitrogen introduced into the environment, and nitrogen leached to groundwater within the Lower Umatilla Basin Groundwater Management Area (LUB GWMA). Little if anything is know about the fate of any given nitrogen molecule in the LUB GWMA. Nitrogen is an elusive element constantly changing form and moving between the air, crop land and groundwater. Nitrogen is mobile in the soil as nitrate and relatively immobile as ammonium or as soil organic matter. Data used to assemble estimates of nitrogen available for leaching are just that, estimates. This document is not meant to give exact pounds of nitrogen contributed by any one group, but rather to give the relative importance of each group's nitrogen contribution.

1.1 Establishment of the Lower Umatilla Basin Groundwater Management Area

Oregon's Groundwater Protection Act of 1989 requires the Oregon Department of Environmental Quality (DEQ) to declare a Groundwater Management Area (GWMA) if area-wide groundwater contamination, caused primarily by nonpoint source pollution, exceeds certain trigger levels. In the case of nitrate, the trigger level is 7 mg/l. Nonpoint source pollution of groundwater results from contaminants coming from diffuse land use practices, rather than from discrete sources such as a pipe or ditch. The contaminants of nonpoint source pollution can be the same as from point source pollution, and can include sediment, nutrients, pesticides, metals, and petroleum products. The sources of nonpoint source pollution can include construction sites, agricultural areas, forests, stream banks, roads, and residential areas.

The Groundwater Protection Act also requires the establishment of a local Groundwater Management Area Committee composed of affected and interested parties. The Committee works with and advises the state agencies that are required to develop an action plan that will reduce groundwater contamination in the area.

The DEQ declared the LUB GWMA in 1990 after nitrate contamination was identified in a 352,000-acre area in the northern portions of Umatilla and Morrow counties. Groundwater samples from private wells had nitrate contamination above the federal safe drinking water standard in many samples collected from the area. DEQ, the Oregon Water Resources Department, and the Oregon Health Division conducted a four-year comprehensive study of the area in the early 1990s. This study resulted in a 1995 report titled "Hydrogeology, Groundwater Chemistry, & Land Use in the Lower Umatilla Basin Groundwater Management Area". The study identified five potential sources of nitrate loading to groundwater:

1. Confined Animal Feeding Operations (i.e., dairies and feed lots),
2. Irrigated Agriculture,
3. Land Application of Food Processing Wastewater,
4. Septic Systems (rural residential areas), and
5. The Umatilla Chemical Depot Washout Lagoons

DEQ and the Committee finalized the LUB GWMA Action Plan in December 1997. The Action Plan details the activities to be conducted by the various agencies and organizations involved. The Umatilla and Morrow County Soil and Water Conservation Districts are the local agencies leading implementation of the Action Plan. DEQ and the Oregon Department of Agriculture (ODA) have oversight responsibility. Local governments, private industry, and the US Army are also involved in implementation of the Action Plan.

DEQ and the Committee decided to implement the Action Plan on a voluntary basis recognizing that individuals, businesses, organizations, and governments will, if given adequate information and encouragement, take positive actions to adopt or modify practices and activities to reduce contaminant loading to groundwater.

The Action Plan recommends general activities and specific tasks to be conducted by involved agencies and groups representing the five sources of nitrate loading. The Action Plan also identifies methods and a schedule for evaluating progress in implementing the Action Plan.

The Action Plan requires an evaluation of Action Plan Success every four years. The continued voluntary nature of the Action Plan is assessed as part of each four-year evaluation.

1.2 Purpose of this Report

Despite eleven years of Action Plan implementation, regional nitrate concentrations are not yet declining. For details, see previous progress reports at http://www.deq.state.or.us/wq/groundwater/lubgwma.htm). The intent of producing this estimate is to identify areas in which changes in management practices have the greatest potential to improve groundwater quality on a regional scale. Conclusions and a recommendation based on the estimate are provided.

1.3 Scope of this Report

This document describes an estimate of the sources of nitrogen (N), the amount of nitrogen applied (i.e., introduced into the environment), and nitrogen leached to groundwater within the Lower Umatilla Basin Groundwater Management Area (LUB GWMA).

This estimate provides an assessment of the relative contributions of each of the five sources of nitrate identified in the LUB GWMA Action Plan: irrigated agriculture, confined animal feeding operations (CAFOs), rural residential development (including septic systems, landscaping, and pastures), food processor wastewater application, and the Umatilla Depot bomb washout lagoon. In addition, the contribution from lawns and vegetable gardens within city limits is also included in the estimate. Irrigated agriculture and food processor data are from 2004, on-site system data is from 2005, and CAFO data are from 2007. Other data are estimates based on local knowledge or literature values.

Although the time frames of data used in this estimate are several years old, we anticipate that estimates using more recent information would produce similar results and conclusions.

2.0 Methodology

This section describes the methods used to evaluate each nitrogen source. Table 1 is a summary of the estimate. For each nitrogen source, the table includes an estimate of the average loading rate and volume, the nitrogen imported or produced, the nitrogen applied, and the nitrogen leached to groundwater. Tables 2 through 7 illustrate the method used to calculate the load from each source. The method used to estimate the percentage of applied fertilizer that leaches to groundwater is described below.

2.1 Percentage of Applied Fertilizer Leaching to Groundwater

The estimate of the amount of fertilizer that leaches to groundwater beneath commercial crops and private lawns was based on a review of journal articles and books on the topic written over the past 20 years. The consensus of the articles was that leaching nitrogen from lawns is less than that from irrigated crops and, under most circumstances, poses little risk to the environment. On the other hand, several articles identified nitrate lost through leaching beneath cropland to be significant. Several studies quantified the nitrate concentration in leachate from crops and/or lawns. These studies consistently showed lower concentrations leaching from lawns than from crops.

Results from these studies include:

1. Raciti, et. al., (2008) concluded lawns under low to moderate management intensities are an important *sink* for atmospheric N deposition rather than a source of N leaching to groundwater.
2. Quiroga-Garza, et. al., (2001) concluded leaching N losses from lawns represented a minimal fraction (<1%) of the total applied N.
3. Miltner et. al., (1996) studied the fate of urea applied to a 1 year old Kentucky bluegrass turf and collected 0.23% of the fertilizer applied in leachate.
4. Frank et. al., (2006) reported mature turf grass produced a leachate of 1.2% of applied N for an 87 lb/acre application or 11% for a 219 lb/acre application.
5. Guillard and Kopp (2004) investigated leaching of four different fertilizer scenarios (ammonium nitrate, polymer-coated sulfur-coated urea, organic product, and non-fertilized control) applied at 131 lb/acre. Average NO3 leaching losses (as a percentage of N applied) were 16.8% for ammonium nitrate, 1.7% for PCSCU, and 0.6% for organic.
6. Gold, et. al., (1990) quantified and compared nitrate losses to groundwater from septic systems, forests, home lawns, and urea- and manure-fertilized silage corn during a two-year study. Their results showed fertilizing lawns (at 218 lb/acre) produced nitrate concentrations in leachate ranging from 0.2 to 1.6 mg/l and averaged 0.6 mg/l. In contrast, their results showed fertilizing corn (at 180 to 211 lb/acre) produced nitrate concentrations in leachate ranging from 4.2 to 17.5 mg/l and averaged 12.6 mg/l. Their results also showed the septic system averaged 68.1 mg/l while forests averaged 0.2 mg/l nitrate.
7. Gold and Groffman (1993) compared nitrate leaching from four different land uses over a two-year period. The four land uses were a home lawn, corn grown for silage, a mature oak-pine forest, and a septic system. Nitrogen was applied to the lawn at an annual rate of 307 lb/acre divided into five applications. Nitrogen was applied to corn at an annual rate of 180 lb/acre. Leachate concentrations from the lawn ranged from 0.2 to 5 mg/l while the leachate from the silage corn ranged from 3 to 50 mg/l. Leachate from the septic system contained an average of 59 mg/l nitrate-nitrogen. Nitrate-nitrogen concentrations from the mature forest were consistently near 0.2 mg/l. A significant observation from this study is that although approximately half as much nitrogen was applied to the corn, leachate concentrations beneath the corn were 10 times higher than beneath the lawn.
8. The Encyclopedia of Soil Science includes a two-page chapter titled “Nitrate Leaching Management” (Meisinger, et.al, 2006) which includes the statement “Leaching losses in modern agriculture commonly account for 10-30% of the nitrogen (N) additions”.
9. Hartz (2006) discusses five best management practices to reduce nitrogen and phosphorus loss from vegetable fields. He points out that irrigation water must be distributed evenly to maximize irrigation efficiency and concludes that appropriately designed drip irrigation systems can realistically reach a distribution uniformity of greater than 90%, and when managed with care can achieve an irrigation

efficiency of near 90%. Dr. Hartz told DEQ that, due to the nature of drip irrigation systems, the potential 90% irrigation efficiency would result in very little water loss to evaporation. The 10% loss would be to leaching. Dr. Hartz also indicated that sprinkler and flood irrigation systems are almost always less efficient than drip irrigation systems (Hartz, 2011).

10. The Lane Council of Governments prepared a Nitrogen/Nitrate Budget Report in June 2008 for the Southern Willamette Valley Groundwater Management Area. They conducted an analysis of available literature and used data from ODA to generate estimates for both poor utilization and good utilization values for nitrogen in applied fertilizer. Their estimates of poor utilization ranged from 10% (for beans/peas and grains) to 60% (for orchards and irrigated perennials) and averaged 36%. Their estimates of good utilization ranged from 50% (for irrigated annual rotation) to 90% (for orchards and irrigated perennials) and averaged 74%.
11. Feaga, et.al, (2004) describes results of several studies undertaken to understand the process of nitrate leaching. Nitrate leaching studies were completed throughout Lane County and at OSU's North Willamette Research and Extension Center (NWREC). These long-term studies show that "Oregon agriculture contributes large amounts of nutrients to groundwater, but very effective methods exist to treat the problem".

    Data from the Lane County study were collected for four years at vegetable crop fields and for five years at mint fields. Annual average nitrate leaching rates from vegetable fields ranged from 18% to 75% and averaged 47%. Similarly, annual average nitrate leaching rates from mint fields ranged from 14% to 52% and averaged 32%.

    Data from the NWREC study were collected for eight years at vegetable crop fields using cereal cover crops. The study made a clear case for the effectiveness of cover crops to reduce groundwater contamination. With no fertilizer added, fallow fields lost 21lb/acre nitrate while cover-cropped fields lost 13 lb/acre nitrate. At half the recommended fertilization rate, fallow fields lost 35 lb/acre (30% of applied) while cover-cropped fields lost 25 lb/acre (21% of applied). At the recommended fertilization rate, fallow fields lost 68 lb/acre (29% of applied) while cover-cropped fields lost 39 lb/acre (17% of applied).

    Cover-cropped plots reduced nitrate contribution to groundwater by 40% over the fallow fields. They point out that in the Willamette Valley, long-term groundwater concentrations can be expected to exceed the 10 mg/l drinking water standard. They also point out that drier climates east of the Cascades would expect much higher long-term concentrations.

For the purposes of this estimate, it is assumed that irrigated agriculture is 90% efficient (i.e., 10% of N leaches to groundwater). This value likely underestimates the amount of nitrogen leached to groundwater, but estimates for crops grown in Eastern Oregon were not available.

Food processors operate under DEQ permits that require water applied to crops be monitored and limited. The goal of the DEQ permit is to protect groundwater quality. This is primarily done by limiting nitrogen and water application. Therefore, it is assumed that less leaching occurs at food processing wastewater sites than at traditional irrigated agriculture sites. Because irrigated agriculture was assumed to leach 10%, it was assumed that 5% of the nitrogen applied at food processing wastewater application sites ends up leaching to groundwater. This value also likely underestimates the amount of nitrogen leached to groundwater beneath these fields, but estimates for crops grown this way in Eastern Oregon could not be found.

Since Eastern Oregon receives less winter precipitation, and irrigation control is likely tighter than in the Willamette Valley, average efficiency values for Eastern Oregon agriculture should be higher than for the Willamette Valley.

We assumed irrigated agriculture to be 90% efficient, food processing facilities were assumed to be 95% efficient, and lawns were assumed to be 98% efficient (i.e., 2% of N leaches to groundwater).

No literature citations were found which quantified nitrogen use efficiency for vegetable gardens. Based on local knowledge and experience, OSU Extension staff estimated the nitrogen use efficiency of gardens to be 50% (i.e., 50% of N leaches to groundwater).

It is worth noting that due to the large percentage of land use associated with irrigated agriculture, altering efficiencies for irrigated agriculture and food processors to 80% and 90% efficiency respectively still produce similar proportional contributions for these sources.

2.2 Irrigated Agriculture

OSU Extension staff in Hermiston collected the crop acreage data used to estimate the annual nitrogen loading from the irrigated agriculture sector. These data come from the Oregon Agricultural Information Network (OAIN). Data are input into the OAIN by OSU representatives throughout the state but are retrievable only on a countywide basis. The data used in this estimate (included in Table 2) represent only the crops grown within the irrigated acres of northern Umatilla and Morrow Counties during 2004. This area is slightly larger than the LUB GWMA.

As shown in Table 2, an average nitrogen application rate and the number of acres of each crop harvested were used to estimate nitrogen loading. Based on local knowledge and experience, OSU Extension staff estimated the average nitrogen application rate for 30 of the crops representing approximately 99% of the acres harvested. An assumed application rate of 100 pounds per acre was used for the remaining 15 crops.

The estimated average nitrogen application rate of a particular crop (in pounds per acre) was multiplied by the number of acres of that crop to obtain the pounds of nitrogen applied to that crop throughout the GWMA (Table 2).

Some crops are grown using the land application of food processing wastewater. The number of acres of each crop grown by the six permitted food processors was subtracted from the data used to estimate the irrigated agriculture loading to avoid double counting acres. The food processor acres are discussed in Section 2.2.

Alfalfa is a multi-year crop that, under traditional practices, typically receives a small amount of fertilizer during its first year but none in subsequent years. Alfalfa is capable of utilizing nitrogen from the atmosphere. To estimate the annual average nitrogen loading from alfalfa grown under traditional practices, it was assumed that 33% of the acres of alfalfa received starter fertilizer while the remaining 67% of the acres received no fertilizer. These percentages correspond to an assumed three-year crop cycle.

OSU Extension staff estimate that 80% of these acres are within the GWMA and 20% of the acres are adjacent to the GWMA. Therefore, 80% of the total acres and total nitrogen were used in this estimate.

The number of pounds and acres per crop were summed to produce GWMA-wide figures. The total number of pounds applied was divided by the total number of acres to calculate the average application rate for the irrigated agriculture sector.

As explained in Section 2.1, the nitrogen use efficiency (i.e., the amount of nitrate applied that leaches to groundwater) was based on a comparison of several leaching studies. For the purposes of this estimate, it is assumed that irrigated agriculture is on average 90% efficient. In other words, irrigated agriculture is assumed to leach 10% of the nitrogen applied. As discussed in Section 2.1, the actual percentage of leaching is likely higher.

2.3 Food Processing Wastewater

Food processing facilities in the GWMA generate large volumes of nutrient-rich wastewater as part of their daily operations. These facilities are required to have a National Pollutant Discharge Elimination System (NPDES) or Water Pollution Control Facility (WPCF) permit from the State to discharge wastewater to waters of the State or to land apply wastewater.

There are six facilities that land-apply food processing wastewater in the GWMA. The wastewater is used in conjunction with other sources of water to irrigate crops. Each facility provides quarterly and annual reports that detail the crops being grown as well as the amount of nitrogen and water applied to each field. The 2004 information from these facilities was compiled to quantify the annual nitrogen loading rate for each facility (Table 3a) as well as the total loading rate for all food processors (Table 3b). Because the Simplot facility closed in November 2004, estimates from subsequent years would have much smaller volumes and lower nitrogen concentrations in Simplot wastewater.

Alfalfa grown using food processing wastewater receives more nitrogen than under traditional practices, and is fertilized every year. Alfalfa will use nitrogen provided in the soil before fixing it from the atmosphere.

Since the Simplot facility closed in November 2004, nutrient and hydraulic loading has remained in accordance with their permit, and generally consistent with previous years. The form of nutrients applied has changed from wastewater plus commercial fertilizer to only commercial fertilizer. Because food processing wastewater is no longer used at the Simplot sites, the Simplot acres would be better described in loading estimates using data more recent than 2004 as irrigated agriculture acres.

2.4 CAFOs

The LUB GWMA Action Plan defines a Confined Animal Feeding Operation (CAFO) as the holding of animals including cattle, sheep, and other animals in buildings, pens or lots where the surface has been treated to support animals in wet weather. Activities discussed in the Action Plan apply to all CAFOs, whether permitted or not.

Thirteen permitted CAFOs are located within the GWMA. These CAFOs have either a General or Individual National Pollutant Discharge Elimination System (NPDES) permit jointly issued by ODA and DEQ. Table 4 summarizes the nitrogen generated at each of these facilities. The amount of nitrogen excreted was calculated using the maximum permitted number of animals, which is about 15% more animals than are typically onsite. This waste volatilizes nitrogen upon excretion. The waste continues to lose nitrogen to the atmosphere through further mineralization and volatilization during storage and handling.

The amount of nitrogen available for crop use (i.e., the amount after mineralization in the soil) for each facility was used in the loading calculation. For this estimate, ODA CAFO Program staff assumed 50% of the total N as excreted is lost by the time the manure is applied to cropland as fertilizer.

The pie chart of total pounds produced (Figure 1) reflects the amount of CAFO waste produced. Most of the waste is used as fertilizer within the LUB GWMA. However, three facilities do not export their waste. Instead, it is stockpiled within animal holding pens. It is not known how much of the nitrogen in this waste volatilizes or how much enters groundwater.

ODA CAFO Program staff estimate that 90% of CAFO waste produced in the LUB GWMA is used on irrigated crops within the LUB GWMA, while 10% is used on dry land crops within the GWMA. To avoid double counting, the 90% of CAFO waste assumed to be used on irrigated crops is not carried forward to other calculations. The proportion of nitrogen applied by CAFOs reflects the 10% of the plant available nitrogen estimated to be used on dry land crops within the LUB GWMA.

Dry land crops receive less irrigation than irrigated crops. Therefore, we estimated that 2% of the nitrogen in CAFO waste applied to dry land crops ends up leaching to groundwater.

Sources Not Included

Several potential sources of nitrate associated with CAFOs are not included in this estimate because they are too difficult to estimate with existing data. It is likely that the contribution from CAFOs would be larger if the following sources were included:

- An unknown number of non-permitted CAFOs exist within the LUB GWMA. Nitrogen loading from non-permitted CAFOs was not included in this estimate.
- As explained above, approximately 50% of the N excreted by CAFO animals is lost to the atmosphere during handling and storage. Redeposition of this N was not included in this estimate.
- Although permitted CAFOs are built with the goal of being zero discharge facilities, spills and leaks do sometimes occur. Spills and leaks from CAFOs were not included in this estimate.
- As explained above, the waste generated at three CAFOs is kept onsite. The amount leached to groundwater from these sites is not included in this estimate.

2.5 Residential Development (Lawns and Vegetable Gardens)

The annual nitrate applied to and leached from lawns and vegetable gardens was calculated using estimates of the area covered by lawns and gardens, the nitrogen application rates, and the percentage of applied fertilizer that leaches to groundwater. An estimate was made for within city limits as well as within Urban Growth Areas[1]. Table 5a summarizes the nitrogen loading from lawns and gardens inside city limits within the GWMA. Table 5b summarizes the nitrogen loading from lawns and gardens inside the urban growth areas within the GWMA.

Area Covered by Grass

The area within each city limit covered by grass was estimated by taking the total acreage within each city limit and subtracting estimates of the percentage covered by buildings, roads, and driveways. ODA GIS staff generated estimates of the total acreage within each city limit. Hermiston's City Planner provided estimates of percentages covered by buildings, roads, and driveways for Hermiston. These estimates were used for all cities within the GWMA (Table 5a).

Morrow County Planning estimated the percentage of grassy areas within the Urban Growth Areas of Irrigon (28%) and Boardman (14%). The larger of these estimates (28%) was used to estimate the percentage of grassy areas within the Urban Growth Areas of Echo, Hermiston, Stanfield, and Umatilla (Table 5b).

OSU Extension's Master Gardener for Umatilla County estimated that no more than 20% of area homeowners have vegetable gardens. The typical vegetable garden is 100 to 200 square feet, which equates to approximately 2% of the grassy area for typical lot sizes (see Table 5 footnote 8).

Nitrogen Application Rate for Lawns

The OSU Extension Service Publication EC 1278 "Fertilizing Lawns" advises the following application rates:

- For functional turf, apply 1 to 2 pounds N per 1,000 square feet per year
- For medium quality turf, apply 3 to 4 lbs N per 1,000 ft^2/year
- For top quality turf, apply up to 6 lb N per 1,000 ft^2/year

In order to approximate the anticipated variability in fertilizer application rates by homeowners, an application rate of 3.5 pounds N per 1,000 square feet per year (152 lb/acre/year) was assumed for grassy areas within each city limit and within each Urban Growth Area (see Table 5 footnotes 2 and 3).

---

[1] The Urban Growth Area is the area outside the City Limits but within the Urban Growth Boundary.

Nitrogen Application Rate for Gardens

The OSU Extension Service Publication EC1503 "Fertilizing Your Garden" recommends (depending on soil phosphorus levels) fertilizer application rates for Eastern Oregon gardens that equate to 98 to 139 lb/acre (and averaging 118 lb/acre) of N before planting. If needed during the growing season, another 229 lb/acre of N is recommended making the maximum recommended rate 368 lb/acre (Table 5 footnote 9). However, based on local knowledge and experience, OSU Extension staff estimate the average nitrogen application rate for LUB GWMA gardens to be 500 lb/acre. This application rate would include all sources such as manure, compost, commercial fertilizer, etc.

2.6 Rural Residential Development (Pastures)

The annual nitrate applied to and leached from pastures was calculated using estimates of the area covered by pasture, the nitrogen application rate, and the percentage of applied fertilizer that leaches to groundwater. Table 5c illustrates these calculations.

The area covered by pasture was estimated from a recent aerial photograph interpretation by ODA GIS staff that classified 21,141 acres as "< 40 acre non-irrigation circle" agricultural land use, and is assumed to be pasture.

Pasture Quality

One question in the "2007 LUB GWMA Animal Feeding Operation Survey" asked participants to rate the condition of their pasture. Of the 334 respondents to this question, 22.2% answered "excellent", 64.4% answered "good", and 13.5% answered "poor". As explained below, these percentages were used to estimate the commercial nitrogen application rate for pastures, as well as the nitrogen use efficiency.

Nitrogen Application Rate

Based on local knowledge and experience, OSU Extension staff estimate the following commercial nitrogen application rates:

- poor quality pastures receive zero to 50 lb/acre (average 25),
- good quality pastures receive 50 to 150 lb/acre (average 100), and
- excellent quality pastures receive an average of 225 lb/acre.

The average commercial nitrogen application rates for each pasture quality type are used in the calculations.

In addition to commercial fertilizer, pastures receive nitrogen from excreted manure. The Oregon Agricultural Information Network (OAIN) database indicates there were 184,300 cows and 6,600 horses and mules in Morrow and Umatilla Counties in 2007. There were 156,200 cows permitted to be at the 13 CAFOs within the LUB GWMA in 2007, but only 135,143 animals reported to be onsite. There are 47,060 animals permitted to be at 13 additional CAFOs outside the LUB GWMA but within Umatilla and Morrow Counties. The actual number of animals at these 13 additional CAFOs is likely around 42,000. That leaves approximately 7,000 cows in pasture and open range within the two counties. Given 21,141 acres of pasture inside the LUB GWMA, a density of 0.3 cows per acre of pasture was assumed.

If all 6,600 horses and mules within the two counties were in pastures within the LUB GWMA, that would equate to 0.3 horses or mules per acre. The actual animal density within the LUB GWMA is likely less. Therefore, a total animal density of 0.5 animals per acre was used for this estimate. The average value of N excreted per head of cattle (119 lb/hd) as well as the 50% loss of N through mineralization and volatilization used in the CAFO calculations was used in the pasture calculations. The assumed manure application rate is therefore 29.75 lb/acre (Table 5c).

It was assumed that pastures rated excellent or good quality are well managed while pastures rated poor quality are poorly managed. Poorly managed pastures are typically overgrazed and are likely to be less efficient (i.e., leach a greater percentage of applied nitrogen) than well-managed pastures. As discussed below, differing efficiency values were used for well managed versus poorly managed pastures to account for the difference in nitrate leaching potential.

Nitrogen Use Efficiency

Well-managed pasture grass is a perennial crop with an established root mass. It is assumed to be more efficient than the 90% assumed for irrigated agriculture and the 95% assumed for land application of food processing wastewater, which are typically annual crops. It is also assumed that pastures are irrigated less frequently but with higher volumes than lawns, and would therefore be less efficient than the 98% assumed for lawns. Therefore, it is assumed that well managed pastures are 96.5% efficient in nitrogen uptake. In other words, it is assumed that 3.5% of the nitrogen applied to well managed pastures leaches to groundwater. Pastures rated excellent or good by survey respondents were assumed to be well-managed pastures.

Pastures rated poor by survey respondents were assumed to be poorly managed pastures. Poorly managed pastures are typically overgrazed and, therefore, have a much lower ability to uptake and retain nitrogen. We assumed that poorly managed pastures are 20% efficient in nitrogen uptake. In other words, 80% of nitrogen applied to poorly managed pastures leaches to groundwater.

2.7 Rural Residential Development (Onsite Septic Systems)

Two pieces of information were used to calculate the annual nitrate loading from onsite septic systems: the number of septic systems in the GWMA and the annual average loading rate per system. Table 6 illustrates this calculation.

The number of septic systems was obtained from the DEQ Eastern Region Office Onsite Application Database. DEQ began construction of a database to document and track onsite wastewater treatment system (i.e., septic system) applications in 1990. The information entered into the database included some limited information on historical systems such as owner and location but little information regarding the type of system. Information entered into the database starting in 1990 includes such things as owner, location, system type, inspection dates, installer, and fees. The version of the database used to generate the information used in this evaluation includes information through December 2005.

The annual nitrogen loading rate (21 lb/system) used in these calculations was obtained from the USGS Scientific Investigations Report 2007-5237 “Evaluation of Approaches for Managing Nitrate Loading from On-Site Wastewater Systems near La Pine, Oregon” available at http://pubs.usgs.gov/sir/2007/5237/.

Table 3-19 of the USEPA Onsite Wastewater Treatment Systems Manual (available at http://www.epa.gov/nrmrl/pubs/625r00008/html/625R00008.htm) estimates septic systems remove 10 to 20% of the nitrogen in the effluent. A treatment value of 15% was used in this estimate, which results in a leaching percentage of 85%.

2.8 Umatilla Chemical Depot Washout Lagoon

Table 7 illustrates the nitrogen loading from the washout lagoon. The source of nitrate at the washout lagoon is soil containing explosive compounds and nitrate. The washout lagoon operated from approximately 1950 to 1965. The uppermost 15 feet of this soil (down to the water table) was removed during cleanup efforts in 1996. Soil sampling in 2007 showed explosive residue as high as 300 mg/kg 1,3,5-trinitroperhydro-1,3,5-triazine (RDX) to a depth of at least 35 feet below ground surface beneath the lagoon.

A groundwater pump and treat system has been operating since 1997 to remove the explosive compounds. The explosive compounds 2,4,6-trinitrotoluene (TNT), RDX, and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) can degrade to nitrate, so the site could still be a source of nitrate to groundwater.

The amount of nitrogen added to groundwater from the washout lagoon was estimated by multiplying the maximum nitrate concentration ever observed in the bomb washout lagoon (52 mg/l) by the volume of explosive washout water discharged to the lagoon between the early 1950s to the mid-1960s (approximately 85 million gallons or 322 billion liters).

Because the washout lagoon operated for approximately 15 years, an annual loading rate of one-fifteenth of the total loading was used as the estimate of an annual nitrate loading rate. This annual loading rate seems appropriate considering the saturated soils contained approximately 340 mg/kg RDX prior to source removal (early 1990s) and contained as much as 300 mg/kg RDX in 2007. It was assumed that 100% of the annual nitrogen loading leaches to groundwater.

3.0 Discussion

This section discusses the results of the estimate of nitrogen sources. Figures 1 through 3 are pie charts that illustrate estimates of (1) the sources of nitrogen imported into or produced within the GWMA, (2) the amount of nitrogen applied, and (3) the amount of nitrogen leached to the groundwater. The values illustrated by the pie charts are presented in Table 1.

3.1 Nitrogen Imported or Produced

Table 1 indicates whether each N source is imported into the GWMA, produced within the GWMA, or both. Figure 1 shows the percentage of nitrogen imported or produced by each source. Table 1 and Figure 1 indicate the largest producer of nitrogen is CAFOs (18.7 million lbs or 46.4% of total N) while the largest importer of nitrogen in the GWMA is irrigated agriculture (14.5 million lbs or 36.0%). Other producers of nitrogen include onsite septic systems (0.3%) and the Umatilla Chemical Depot Bomb Washout Lagoon (0.1%). Other importers of nitrogen include lawn fertilizer (3.0%) and garden fertilizer (0.04%). Sources that are both imported and produced in the GWMA include pastures (7.7%) and food processors (6.4%).

CAFOs (at 46.4%) and irrigated agriculture (at 36.0%) are the two largest sources of nitrogen imported or produced in the GWMA and contribute approximately 82% of the total.

3.2 Nitrogen Applied

Figure 2 and Table 1 illustrate the percentage of nitrogen applied by each source. The largest difference between Figure 1 and Figure 2 is the amount of N attributed to CAFOs (46.4 % in Figure 1 vs. 3.0% in Figure 2). The difference is due to the following items:

- 50% of the 18.7 million lbs total N excreted by cattle is assumed to be lost to the atmosphere during handling and storage.
- Three CAFOs stockpile all their waste (610,048 lbs) onsite with none of it applied to cropland.
- ODA estimates that 90% of the CAFO waste available for crops in the LUB GWMA is used by the irrigated agriculture community, with 10% being used on dry land crops. Therefore, Table 1 and Figure 2 attribute approximately 0.9 million lbs (or 3.0% of the total N applied in the GWMA) to CAFOs.

The largest source of nitrogen applied is from irrigated agriculture (CAFO waste and fertilizer applied to irrigated crops), which contributes 74.2% of the total N introduced into the environment. The remaining 25.8% comes from pastures (10.1%), food processors (8.3%), lawns (3.9%), CAFO waste applied to dry land crops (3.0%), on-site systems (0.4%), vegetable gardens (0.05%), and the Depot (0.008%).

3.3 Nitrogen Leached to Groundwater

Figure 3 illustrates the estimated percentage of nitrogen leached to groundwater by each source. The differences between Figure 2 and Figure 3 are caused by the differing assumptions for the “efficiency” of the various sources. For example, the most efficient sources (i.e., those that leach the least) are lawns and CAFO waste applied to dry land crops, which are assumed to be 98% efficient and therefore leach 2% of their total volume applied. The next most efficient source is good and excellent quality pastures, which are assumed to be less efficient than dry land crops and lawns but more efficient than irrigated agriculture and food processor sites. It was assumed that good and excellent quality pastures are 96.5% efficient. Food processors are assumed to be 95% efficient. Irrigated agriculture is assumed to be 90% efficient. Gardens are assumed to be 50% efficient. Poor quality pastures are assumed to be 20% efficient. On-site septic systems are assumed to be 15% efficient (i.e., leaching 85%). The Depot Bomb Washout Lagoon was assumed to be 0% efficient (i.e., leaching 100%).

These differing assumptions regarding efficiency cause the percentages of total N applied versus total N leached to groundwater (Figure 3) to increase dramatically for the Depot, on-site systems, and gardens while they increase slightly for irrigated agriculture. The percentages are slightly lower for food processors and pastures while they decrease significantly for CAFO waste applied to dry land crops and lawns.

4.0 Conclusions and Recommendation

4.1 Conclusions

Based on the discussion above and the goals of the LUB GWMA Action Plan, the following conclusions are made:

- The sources of nitrate identified in the LUB GWMA Action Plan contribute significantly different amounts of nitrogen to groundwater, and can be classified into three tiers differing by approximately an order of magnitude:
  - *Tier One* – Irrigated Agriculture (81.6%)
  - *Tier Two* – Pastures (8.1%), food processors (4.6%), and on-site septic systems (3.9%).
  - *Tier Three* - Lawns (0.9%), CAFO waste applied to dry land crops (0.7%), vegetable gardens (0.3%), and the Depot Washout Lagoon (0.09%)
- Even though it is generally believed that the agricultural community is very efficient with nitrogen usage, the high percentage of land used to grow crops makes irrigated agriculture the largest percentage of nitrogen imported into the GWMA, introduced into the environment, and leached to groundwater.
- Changes in management practices within the irrigated agriculture community have the greatest potential to improve groundwater quality on a regional scale. For example, a 5% reduction in the amount of nitrate leached to groundwater from irrigated agriculture would offset approximately one-half the impact of pastures, 100% of impacts from on-site systems, or 90% of impacts from food processor wastewater application. All of the Tier Three sources combined equal about 2% of the total N leached.
- Even though irrigated agriculture is by far the largest contributor to groundwater nitrate, every source of nitrate should do what they can to reduce their contribution.

4.2 Recommendation

Based on the above conclusions, the following recommendations are made.

- The LUB GWMA Committee and sub-committees should review and update the practices identified in the Action Plan that would likely improve groundwater nitrate concentrations.
- The LUB GWMA Committee and sub-committees should consider this report when drafting the next Action Plan.

5.0 References

Cook, T. and B. McDonald. 2005. “Fertilizing Lawns”. OSU Extension Service Publication EC 1278. Revised January 2005.

Feaga, J., R. Dick, M. Louie, and J. Selker. 2004. “Nitrates and Groundwater: Why Should We Be Concerned with Our Current Fertilizer Practices?”. OSU Agricultural Experiment Station Special Report 1050. January 2004.

Frank, K. W., K. M. O’Reilly, J. R. Crum, and R. N. Calhoun. 2006. The Fate of Nitrogen Applied to a Mature Kentucky Bluegrass Turf. *Crop Sciences* Vol 46. pp. 209-215.

Gold, A. J., W.R. DeRagon, W. M. Sullivan, and J. L. Lemunyon. 1990. *Journal of Soil and Water Conservation.* 45(2). pp. 305-310

Gold, A.J., and P.M. Groffman. 1993. Leaching of agrichemicals from suburban areas. p. 182-190. *In* K.D. Rache and A.R. Leslie (ed.) Pesticides in urban environments: fate and significance. ACS symposium series 522. ACS, Washington, DC.

Guillard, K. and K. L. Kopp. 2004. Nitrogen Fertilizer Form and Associated Nitrate Leaching from Cool-Season Lawn Turf. *Journal of Environmental Quality* Vol 33. pp. 1822-1827.

Hart, J. and R. McNeilan. 2000. “Fertilizing Your Garden”. OSU Extension Service Publication EC1503. April 2000

Hartz, T.K. “Vegetable Production Best Management Practices to Minimize Nutrient Loss”. HortTechnology, v16, no. 3, July-September 2006.

Hartz, T.K., Personal Communication with Phil Richerson of Oregon DEQ. March 28, 2011.

LCOG, 2008. Southern Willamette Valley Groundwater Management Area Nitrogen/Nitrate Budget Report. Prepared by Lane Council of Governments. June, 2008.

Mangiafico, S. S. and K. Guillard. 2006. Fall Fertilization Timing Effects on Nitrate Leaching and Turfgrass Color and Growth. *Journal of Environmental Quality* Vol 35. pp. 163-171.

Mangiafico, S. S. and K. Guillard. 2007. Nitrate Leaching from Kentucky Bluegrass Soil Columns predicted with Anion Exchange Membranes. *Soil Sci. Soc. Am. Journal* Vol 71. pp. 219-224.

Meisinger, J.J., J.A. Delgado, and A. Alva. Nitrate Leaching Management, *Encyclopedia of Soil Science*. Taylor & Francis, 2006.

Miltner, E.D., B.E. Branhan, E.A. Paul, and P.E. Rieke. 1996. Leaching and mass balance of ^{15}N-labeled urea applied to Kentucky bluegrass turf. *Crop Sci.* Vol. 36. pp. 1427-1433.

Quiroga-Garza, J. M., G. A. Picchioni, and M. D. Remmenga. 2001. Bermudagrass Fertilized with Slow-Release nitrogen Sources. I. Nitrogen Uptake and Potential Leaching Losses. Journal of Environmental Quality. Vol 30. pp. 440-448.

Raciti, S.M., P.M. Groffman, and T.J. Fahey. 2008. Nitrogen Retention in Urban Lawns and Forests. *Ecological Applications* 18(7). pp. 1615-1626

Umatilla County Soil and Water Conservation District. 2007 Lower Umatilla Basin Groundwater Management Area Animal Feeding Operation Survey. (available at http://www.deq.state.or.us/wq/groundwater/docs/lubgwma/AnnualReportAppendices20052006.pdf)

USEPA 2002 Onsite Wastewater Treatment Systems Manual. EPA/625/R-00/008
February 2002. Office of Water, Office of Research and Development, U.S. Environmental Protection Agency (available at http://www.epa.gov/nrmrl/pubs/625r00008/html/625R00008.htm)

USGS 2007 Scientific Investigations Report 2007-5237 "Evaluation of Approaches for Managing Nitrate Loading from On-Site Wastewater Systems near La Pine, Oregon" available at http://pubs.usgs.gov/sir/2007/5237/.

Figures and Tables

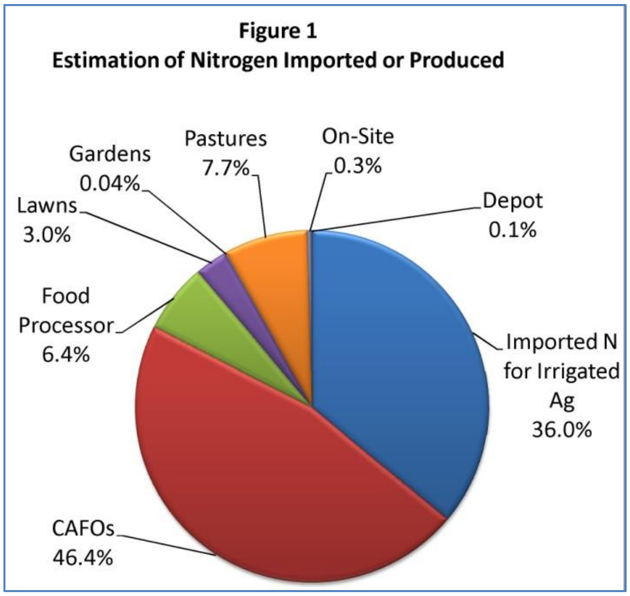


Figure 1
Estimation of Nitrogen Imported or Produced

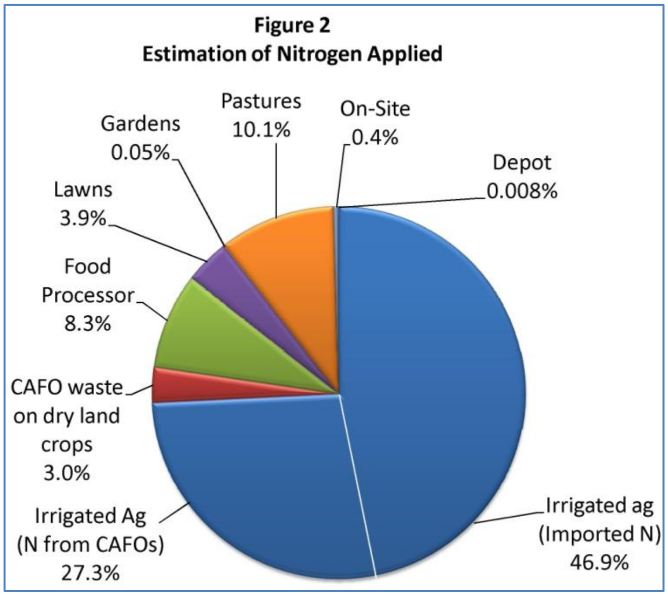


Figure 2
Estimation of Nitrogen Applied

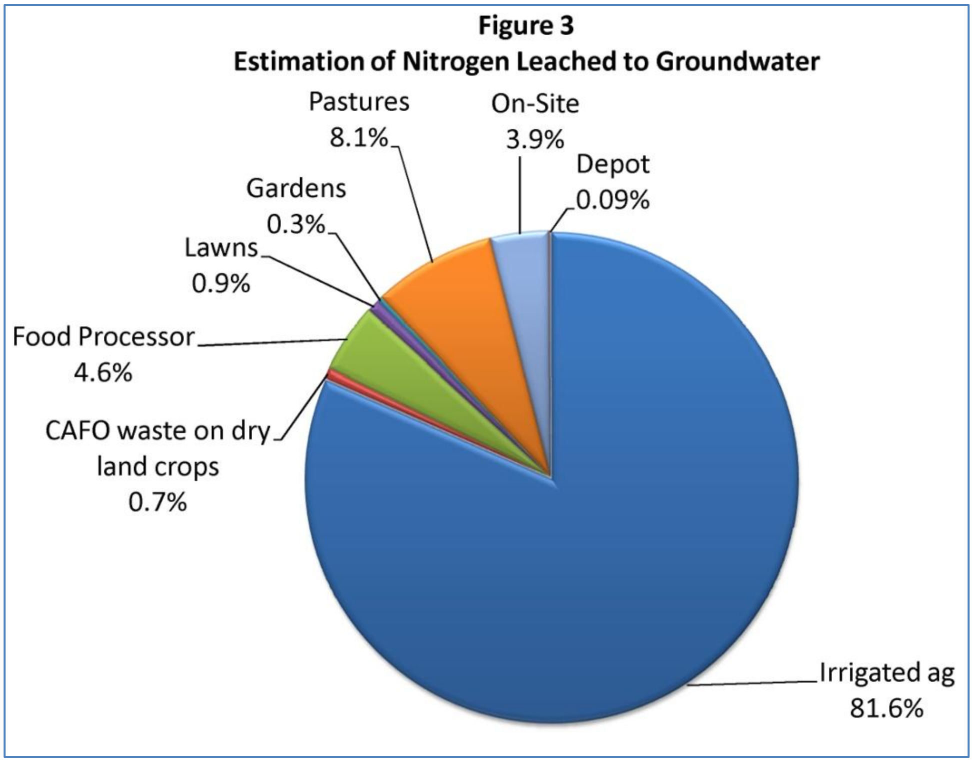


Figure 3
Estimation of Nitrogen Leached to Groundwater

Table 1
Summary of Nitrogen Sources, Nitrogen Applied, and Nitrogen Leached to Groundwater
Lower Umatilla Basin Groundwater Management Area

Nitrogen Source	**Loading Rate**		**Loading Volume**		**Nitrogen Imported or Produced**			**Nitrogen Applied**		**Nitrogen Leached to Groundwater**		**Summary of Process**
	Quantity	***Units***	***Quantity***	***Units***	***Total***	***Percentage***	***Source***	***Total Pounds***	***Percentage***	***Total Pounds***	***Percentage***	
Irrigated Agriculture	141	lb/acre	162,601	acres	14,517,798	36.0%	imported	22,984,758	74.2%	2,298,476	81.6%	OSU Extension's 2004 crop acreage estimates are used along with their estimates of typical application rates to estimate Total Pounds Produced. It is assumed that 10% of the nitrogen applied leaches to groundwater.
CAFOs	60	lb/head	157,406	head	18,701,354	46.4%	produced	940,773	3.0%	18,815	0.7%	ODA CAFO Program staff estimated the total pounds produced in 2007. Some waste is exported out of state while other waste is stockpiled onsite. The remaining waste was then reduced by 50% to account for losses to the atmosphere. This value represents the "crop available" nitrogen. ODA then estimated that 90% of the crop available nitrogen was used on irrigated crops within the LUB GWMA (and therefore attributable to Irrigated Ag). The remaining 10% of the total pounds produced are attributed to permitted CAFOs. It is assumed that 2% of the nitrogen applied leaches to groundwater.
Food Processor Wastewater	142	lb/acre	18,031	acres	2,568,971	6.4%	imported & produced	2,568,971	8.3%	128,449	4.6%	Nitrogen loading estimates were taken directly from 2004 Annual Reports from the Food Processors. It was assumed that 5% of the nitrogen applied leaches to groundwater
Rural Residential Development (lawns)	152	lb/acre	7,539	acres	1,205,089	3.0%	imported	1,205,089	3.9%	24,102	0.9%	Estimates of "grassy" acreage inside city limits and within the Urban Growth Area were made for some areas by County Planners, and assumed for other areas. 98 to 100% of the grassy area was assumed to be lawn. The recommended lawn fertilization rate for medium quality turf (3.5 lb/1,000 sqft) was assumed for these grassy acres. 2% of the applied fertilizer is assumed to leach.
Rural Residential Development (gardens)	500	lb/acre	397	acres	15,872	0.04%	imported	15,872	0.05%	7,936	0.3%	Estimates of "grassy" acreage inside city limits and within the Urban Growth Area were made for some areas by County Planners, and assumed for other areas. OSU Extension's estimates of garden frequency (up to 20% of households) size (up to 200 sqft), average application rate (500 lb/acre) and efficiency (50%) were used.
Rural Residential Development (pastures)	118	lb/acre	21,141	acres	3,114,848	7.7%	imported & produced	3,114,848	10.1%	228,316	8.1%	ODA used aerial photographs to estimate pasture acres. Estimates of pasture quality are from the 2007 LUB GWMA Animal Feeding Operations Survey. Commercial nitrogen application rates are variable (higher quality pastures receive more), but based on an OSU Fertilizer Guide. A manure application rate from 0.5 cow per acre was assumed for all pastures. It was assumed that 3.5% of the nitrogen applied to well managed pastures, and 80% of nitrogen applied to poorly managed pastures, leaches to groundwater.
Rural Residential Development (on-site systems)	21	lb/system	6,091	systems	127,911	0.3%	produced	127,911	0.4%	108,724	3.9%	The number of on-site systems in 2005 was calculated from a DEQ on-site system database. The nitrogen loading rate from the USGS La Pine modeling project was used. Using an EPA estimate, it was assumed that 85% of the nitrogen applied leaches to groundwater.
Umatilla Chemical Depot Bomb Washout Lagoon	52	mg/l	321,760,020	liters	36,887	0.1%	produced	2,459	0.008%	2,459	0.09%	The maximum nitrate concentration observed was multiplied by the total volume of wastewater to estimate total loading. One-fifteenth of the total loading since the 1950s was used as an annual loading estimate. 100% of this annual loading is assumed to leach to groundwater.
TOTAL					40,288,730	100%		30,960,682	100%	2,817,277	100%	

E:\LUB\Loading Estimates\[LUB GWMA Nitrate Loading Estimate 15.xlsx]Table

Notes:
The average loading rates for irrigated ag, CAFOs, and food processor wastewater are back calculated from site specific data, and are therefore included in this table for comparison purposes only.
The average loading rates for on-site systems and the Umatilla Chemical Depot Bomb Washout Lagoon are used to calculate the nitrogen loading.

Table 2
Estimation of 2004 Nitrogen Applied By Irrigated Agriculture
Lower Umatilla Basin Groundwater Management Area

Crop	Irrigated Acres	% of Total Acreage	Cumulative %	OSU Estimate of Average Nitrogen Application (lb/acre)	Default loading rate (lb/acre)	Annual Nitrogen Load (lb)	% of Annual Loading
Alfalfa	47,862	23.5%	23.5%	See below		947,668	3.3%
Potato	26,315	12.9%	36.5%	275		7,236,625	25.2%
Poplar Trees	25,784	12.7%	49.2%	50		1,289,200	4.5%
Wheat	14,881	7.3%	56.5%	175		2,604,175	9.1%
Green Peas	14,259	7.0%	63.5%	50		712,950	2.5%
Corn (field)	8,601	4.2%	67.7%	325		2,795,325	9.7%
Hay Silage ???	8,410	4.1%	71.9%	275		2,312,750	8.0%
Sweet corn, processed	7,705	3.8%	75.7%	275		2,118,875	7.4%
Dry Onions	5,698	2.8%	78.5%	175		997,150	3.5%
K. Bluegrass	5,098	2.5%	81.0%	175		892,150	3.1%
Perennial Ryegrass	4,943	2.4%	83.4%	225		1,112,175	3.9%
Other Hay	4,571	2.2%	85.7%	225		1,028,475	3.6%
Wheat (cereals)	4,380	2.2%	87.8%	175		766,500	2.7%
Tall Fescue	3,810	1.9%	89.7%	225		857,250	3.0%
Misc field crops	3,277	1.6%	91.3%	100		327,700	1.1%
Corn Silage	2,900	1.4%	92.7%	275		797,500	2.8%
Lima Beans	2,700	1.3%	94.1%	90		243,000	0.8%
Pepperment for oil	2,307	1.1%	95.2%	225		519,075	1.8%
Dry Field Peas	1,132	0.56%	95.8%	75		84,900	0.3%
Snap Beans	1,045	0.51%	96.3%	80		83,600	0.3%
Carrots	980	0.48%	96.8%	175		171,500	0.6%
Asparagus	960	0.47%	97.2%	100		96,000	0.3%
Grapes	851	0.42%	97.6%	60		51,060	0.2%
Barley	750	0.37%	98.0%	90		67,500	0.2%
Carrots, fresh	610	0.30%	98.3%	175		106,750	0.4%
Asst Fescue	518	0.25%	98.6%	175		90,650	0.3%
Alfalfa seed	401	0.20%	98.8%	20		8,020	0.03%
Watermellon	400	0.20%	99.0%	250		100,000	0.3%
Spearment for oil	375	0.18%	99.1%	225		84,375	0.3%
Oats	350	0.172%	99.32%		100	35,000	0.12%
Other oil (dill)	300	0.148%	99.47%		100	30,000	0.10%
Sweet corn	230	0.113%	99.58%	275		63,250	0.22%
other grasses	113	0.056%	99.64%		100	11,300	0.039%
Apples	110	0.054%	99.69%		100	11,000	0.038%
Cants & Muskmellon	100	0.049%	99.74%		100	10,000	0.035%
Plums & Prunes	100	0.049%	99.79%	250		25,000	0.087%
Canola oil	140	0.069%	99.86%		100	14,000	0.049%
Chewing Fescue	79	0.039%	99.90%		100	7,900	0.027%
Cherry	60	0.030%	99.93%		100	6,000	0.021%
Squash & Pumpkins	45	0.022%	99.95%		100	4,500	0.016%
Red Raspberries	30	0.015%	99.97%		100	3,000	0.010%
Apricots & other	25	0.012%	99.98%		100	2,500	0.009%
Other Vege (truck)	21	0.010%	99.988%		100	2,100	0.01%
Strawberries	15	0.007%	99.995%		100	1,500	0.005%
Tomatoes	10	0.005%	100.000%		100	1,000	0.0035%
TOTAL NON FP ACRES IN AREA	**203,251**				Sub-total	**28,730,948**	**100%**

Division of 54,000 alfalfa acres

Alfalfa acres at Food Proc. Facilities	6,138	acres		Avg loading rate (lb/acre)		Annual Nitrogen Load (lb)	
Non FP alfalfa acres receiving fertilizer	15,794	acres		60		947,668	
Non FP alfalfa acres receiving no fertilizer	32,068	acres		0		0	
TOTAL Non FP alfalfa acres	47,862	acres		**Non FP Alfalfa sub-total**		**947,668**	
TOTAL alfalfa acres	54,000	acres					

TOTAL NON FP ACRES IN AREA	**203,251**
TOTAL NON FP ACRES IN GWMA (3)	**162,601**

TOTAL N IMPORTED INTO AREA (1)	**14,517,798**
TOTAL N APPLIED IN AREA (2)	**28,730,948**
TOTAL N APPLIED IN GWMA (3)	**22,984,758**
Average Loading Rate	141

Notes:

(1) The amount of N imported into the GWMA is estimated to be the amount of N applied by irrigated agriculture in the GWMA minus the amount of CAFO waste produced in the GWMA that is applied to irrigated crops.

(2) The amount of N applied in the area is the amount applied to all non-food processor irrigated acres in northern Umatilla and Morrow Counties.

(3) Approximately 80% of the total irrigated acres in the area are within the LUBGWMA boundary. Therefore, the total amount of acres and nitrogen applied in the area is multiplied by 0.8 to estimate the amount in the GWMA.

Table 3
2004 Nitrogen Loading Rates from Food Processors
Lower Umatilla Basin Groundwater Management Area

Table 3a

Facility Specific Information				
Facility	**Crop**	**Total Acres Harvested**	**Total lbs**	**Avg loading rate (lb/acre)**
ConAgra	Potatoes	866	245,409	283
ConAgra	Grass	124	27,367	221
ConAgra	Canola	308	44,142	143
ConAgra	Winter Wheat	1193	163,438	137
ConAgra	Vol. Wheat Pasture	136	17,138	126
ConAgra	Alfalfa	1585	172,418	109
ConAgra	Corn	786	80,330	102
ConAgra	Bluegrass Seed	129	5,289	41
ConAgra	Peas	154	5,723	37
Hermiston Foods	Poplar Trees	15	6,419	440
Hermiston Foods	Alfalfa	250	73,470	294
POM	Mint	375	125,622	335
POM	Field Corn	1236	345,404	279
POM	Sorghum	12	3,088	262
POM	Potato	210	48,761	232
POM	Onions	582	114,343	197
POM	Sweet Corn	485	86,328	178
POM	Sugar Beets	95	15,567	164
POM	Triticale	24	2,657	128
POM	Peas	500	58,788	118
POM	Alfalfa	1587	208,977	109
POM	Garlic	288	19,510	68
POM	Winter Wheat	41	5,601	44
Simplot	Mint	242	74,028	306
Simplot	Potato	609	81,741	134
Simplot	Wheat/Straw	1627	199,290	123
Simplot	Alfalfa	2427	194,349	80
Simplot	Field Corn	377	27,147	72
Simplot	Pasture	212	14,595	69
Simplot	Grass Seed/Hay	738	40,131	54
Simplot	Tritacale	93	3,813	41
Simplot	Peas	247	4,439	18
Simplot	Wheat	123	123	1
Snack Alliance	Alfalfa?	289	39,615	137
Tate & Lyle	Grass & Alfalfa hay	67	13,912	206
		18,031	**2,568,971**	**142**

Table 3b

GWMA Wide Information			
Crop	**Total lbs**	**Total Acres Harvested**	**Avg loading rate (lb/acre)**
Poplar Trees	6,419	15	440
Mint	199,650	617	324
Sorghum	3,088	12	262
Potatoes	375,910	1685	223
Onions	114,343	582	197
Field Corn	452,882	2399	189
Sweet Corn	86,328	485	178
Sugar Beets	15,567	95	164
Canola	44,142	308	143
Winter Wheat	385,590	3119	124
Alfalfa	688,829	6138	112
Grass Seed/Hay	81,410	929	88
Peas	68,950	901	77
Pasture	14,595	212	69
Garlic	19,510	288	68
Triticale	6,470	117	55
Bluegrass Seed	5,289	129	41

Table 4
Estimation of Nitrogen Produced by CAFOs in 2007
Lower Umatilla Basin Groundwater Management Area

Business Name	City	County	Animal Type	Total Adults	Total Adolescent	Total Animals	Total N as Excreted (lbs)	Total N Stockpiled Onsite (lbs)	Total N Available for Crops in LUB GWMA (lbs)
Beef Northwest Feeders. Inc.	Boardman	Morrow	Beef, Feedlot Fattening	38206	0	38,206	3,765,201		1,882,601
Fox Cattle **(A1;B1)**	Irrigon	Morrow	Beef, Feedlot Fattening	300	0	300	54,372	54,372	
Meenderinck, Pete & Tressa Dairy **(C1)**	Boardman	Morrow	Dairy Milking	0	0	-			
Sage Hollow Ranch llc	Sunnyside	Morrow	Dairy Milking	8700	0	8,700	1,991,039		995,520
TMCF Columbia River Dairy	Boardman	Morrow	Dairy, Milking	19100	0	19,100	4,371,131		2,185,566
TMCF Heifer Facility	Boardman	Morrow	Dairy Heifer Replace	0	32000	32,000	2,715,600		1,357,800
TMCF Willow Creek Dairy	Boardman	Morrow	Dairy Milking	8000	28100	36,100	3,568,240		1,784,120
Beef City Feed Lot llc **(A1;B1)**	Hermiston	Umatilla	Beef, Feedlot Fattening	0	1300	1,300	117,676	117,676	
Columbia Feeders **(A1;B1)**	Echo	Umatilla	Beef, Feedlot Fattening	4000	0	4,000	438,000	438,000	
Double M Ranch Inc.	Echo	Umatilla	Beef, Feedlot Fattening	0	6000	6,000	591,300		295,650
H4 Farms Inc. **(C1)**	Hermiston	Umatilla	Dairy Milking	0	0	-			-
Reata Ranches llc	Hermiston	Umatilla	Beef, Feedlot Fattening	0	8000	8,000	724,160		724,160
Wolfe Feedlot	Hermiston	Umatilla	Beef, Feedlot Fattening	3700	0	3,700	364,635		182,318
Total				**82,006**	**75,400**	**157,406**	**18,701,354**	**610,048**	**9,407,733**

Loading Rate (lb/hd) = *60*

8,466,960 pounds used on irrigated crops (90%)

940,773 pounds used on dryland crops (10%)

Notes:

A1: No application of waste, all stored in lot

B1: No AWMP submitted; book value used for calculations

C1. Plan approved, but not yet in operation

To convert number of animals to total N excreted, actual values were used when known; NRCS values were used otherwise.

A 50% reduction in Total N as excreted to Total N Available for Crop was assumed for all facilities.

ODA CAFO Program estimates that 90% of the waste generated is used on irrigated crops in the GWMA and 10% is used on dryland crops

Table 5
Estimation of Nitrogen Loading Rates from Lawns, Gardens, and Pastures
Lower Umatilla Basin Groundwater Management Area

Table 5a - Lawns & Gardens within City Limits

City	Acres in City Limits	% of city limits covered by buildings	% of city limits covered by roads & driveways	% of city limits covered by grass	Grassy acres within City limits	N Application Rate to Lawns (lb/acre)	Total N Applied to Lawns within CL (lb)	N Application Rate to Gardens (lb/acre)	Total N Applied to Gardens within CL (lb)	Comment
Boardman	2,584	35%	25%	40%	1,034	152	156,958	500	2,067	It is assumed that 20% of homeowners have a garden, and those gardens cover 2% of grassy area. See Note #8
Echo	371	35%	25%	40%	148	152	22,543	500	297	
Hermiston	4,854	35%	25%	40%	1,941	152	294,816	500	3,883	
Irrigon	1,028	35%	25%	40%	411	152	62,443	500	822	
Stanfield	997	35%	25%	40%	399	152	60,533	500	797	
Umatilla	2,965	35%	25%	40%	1,186	152	180,071	500	2,372	
TOTAL	***12,798***				***5,119***		**777,364**		**10,239**	

Table 5b - Lawns & Gardens within Urban Growth Area

City	Acres in City Limits	Acres in Urban Growth Boundary	Acres inside Urban Growth Area	% UGA Covered in Grass	Grassy acres in UGA	N Application Rate (lb/acre)	Total N Applied to Lawns within UGA (lb)	N Application Rate to Gardens (lb/acre)	Total N Applied to Gardens within CL (lb)	Comment
Boardman	2,584	3,555	971	14%	136	152	20,648	500	272	Morrow County Planning estimates 14% grassy area in Boardman and 28% in Irrigon. It was assumed that 28% of Umatilla County UGAs are grassy. It is assumed that 20% of homeowners have a garden, and those gardens cover 2% of grassy area.
Echo	371	1,011	639	28%	179	152	27,190	500	358	
Hermiston	4,854	9,013	4,159	28%	1,164	152	176,826	500	2,329	
Irrigon	1,028	1,453	425	28%	119	152	18,070	500	238	
Stanfield	997	1,875	879	28%	246	152	37,359	500	492	
Umatilla	2,965	6,437	3,472	28%	972	152	147,631	500	1,944	
TOTAL	***12,798***	***23,343***	***10,545***		***2,817***		**427,725**		**5,633**	

LAWN TOTAL	**7,539**	**152**	**1,205,089**		
GARDEN TOTAL	**397**	**500**			**15,872**

Table 5c - Pastures

	% of Acres	Acres	N Application Rate (lb/acre)	Total Commercial N Applied (lb)	Manure Application Rate (lb/acre)	Total Manure Applied (lb)	Total N Applied (lb)
Excellent Quality Pasture	22.2%	4,683.84	225	1,053,864	29.75	139,344	1,193,208
Good Quality Pasture	64.4%	13,608.45	100	1,360,845	29.75	404,851	1,765,697
Poor Quality Pasture	13.5%	2,848.28	25	71,207	29.75	84,736	155,943
TOTAL	100%	21,140.57		**2,485,916**		**628,932**	**3,114,848**
AVERAGE LOADING RATE			**118**				

Total N Applied to Well Managed Pastures = 2,958,905
Total N Applied to Poorly Managed Pastures = 155,943

PASTURE TOTAL	**3,114,848**

NOTES & ASSUMPTIONS

(1) Acreages are from OSU GIS dpt estimates from aerial photographs

(2) OSU Extension Service Publication EC 1278 "Fertilizing Lawns" says:
For functional turf, apply 1 to 2 lb N per 1,000 sq ft per year
For medium-quality, apply 3 to 4 lb N per 1,000 sq ft per year

For top quality turf, apply up to 6 lb N per 1,000 sq ft per year

(3) Given that: 1 acre = 43,560.17 sqft, the following lawn fertilization rates apply:

lb / 1,000 sqft	lb / acre
1	44
2	87
3	131
3.5	***152***
4	174
5	218
6	261

(4) Based on aerial photograph interpretation, ODA classified 21,141 acres as "< 40 acre non-irrigation circle" agricultural land use, as is assumed to be pasture

(5) OSUs estimates of fertilizer application rates on local pastures were used.
The average of the range of values cited was used in these calculations.

(9) OSU Extension Service Publication EC1503 "Fertilizing Your Garden" recommends (depending on the phosphorus levels), the following rates for Eastern Oregon (in lb fertilizer per 100 sqft).
They have been converted to lb N per acre.

Recommended Application Rate (prior to planting)

N	P	K	lb fertilizer per 100sqft	lb N per 100 sqft	lb N per acre
15	15	15	1.5	0.225	98
16	20	0	1.5	0.24	105
15	15	15	2	0.3	131
21	0	0	1.5	0.315	137
16	20	0	2	0.32	139
				average =	118

Recommended Application Rate (if needed during growing season)

N	cups per 10' of row	lb per 10' of row	lb fertilizer per 100sqft	lb N per 100 sqft	lb N per acre
21	0.5	0.25	2.5	0.525	229

Average Annual Recommendation (lb/acre) =	347
Maximum Annual Recommendation (lb/acre) =	368

(6) City of Salem, OR is 39% grass covered (lawns,parks, golf courses, cemeteries, etc.)

(7) Pasture quality estimates are from 2007 LUB GWMA Animal Feeding Operation Survey

(8) OSU Extension's Umatilla County Master Gardener estimated no more than 20% of area households have a garden, and typical gardens are 100 to 200 sq ft. (about 2% of the grassy area).

Lot size (acre)	Grassy area in sq ft (40% of lot size)	% of lot covered by 100 sq ft garden	% of lot covered by 150 sq ft garden	% of lot covered by 200 sq ft garden
0.25	4,356	2.3%	3.4%	4.6%
0.33	5,750	1.7%	2.6%	3.5%
0.5	8,712	1.1%	1.7%	2.3%
1	17,424	0.6%	0.9%	1.1%
4	69,696	0.1%	0.2%	0.3%

Table 6
Estimation of Nitrogen Loading Rates from On-Site Systems
Lower Umatilla Basin Groundwater Management Area

Estimation of total pounds of annual nitrogen loading

Source	Loading Rate	Quantity	Total Pounds	Comment
On-Site Systems	21 lb/system	6,091	**127,911**	Loading rate from USGS La Pine modeling project

Estimates of Treatment of Septic System Effluent

USEPA Onsite Wastewater Treatment System Manual says 10 to 20%

If 10% reduction, then	115,120	pounds are added annually
If 15% reduction, then	108,724	pounds are added annually
If 20% reduction, then	102,329	pounds are added annually

Table 7
Estimation of Nitrogen Lost to Groundwater from Depot Washout Lagoon
Lower Umatilla Basin Groundwater Management Area

TOTAL N LOADED

$$52\ \frac{\text{mg}}{\text{L}} \ * \ \frac{85{,}000{,}000}{1}\ \frac{\text{gal}}{1} \ * \ \frac{2.20\text{E-}06}{1}\ \frac{\text{lb}}{\text{mg}} \ * \ \frac{3.785412}{1}\ \frac{\text{L}}{\text{gal}} = \boxed{36{,}887}\ \text{lbs}$$

ANNUAL N LOADING

$$\frac{36{,}887}{15}\ \frac{\text{lbs}}{\text{years}} = \boxed{2{,}459}\ \text{lbs}$$

Assumptions / Input variables

(1) The maximum concentration observed in the bomb washout lagoon area was 52 mg/l.

(2) 85 million gallons of explosive washout water was discharged to the lagoon between the early-1950s to the mid-1960s.

(3) Because the washout lagoons operated for approximately 15 years, an annual loading rate of one-fifteenth the total loading is used to estimate annual loading.

(4) This annual loading rate seems appropriate considering saturated soils contained approximately 340 mg/kg RDX prior to source removal (early 1990s) and contained as much as 300 mg/kg RDX in 2007.

1 liter = 0.264 gal
1 mg = 2.204623 x 10^-6 lb
1 gal = 3.785412 liter