Second Lower Umatilla Basin Groundwater Management Area Local Action Plan

www.lubgwma.org

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Comment

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State of Oregon
Department of Environmental Quality

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Lower Umatilla Basin Groundwater Management Committee

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Acknowledgements

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Final Draft For Public Comment

ED_005296_00000290-00003

Table of Contents

Acronyms Related to the Lower Umatilla Basin Groundwater Management Area viii
1.0 Introduction 1
1.1 Purpose and Goal 2
1.1.1 Purpose 2
1.1.2 Goal 2
1.2 Authority and Approach 2
1.2.1 GWMA Declaration and Repeal 2
1.2.2 Second Local Action Plan Development and Regulatory Approval 6
1.2.3 Assessment of Voluntary Approach 7
1.2.4 Plan Organization 7
2.0 Background and Setting 8
2.1 Regional Setting 8
2.1.1 Geographic Setting 8
2.1.2 Residents 9
2.1.3 Geologic Setting 9
2.1.4 Hydrogeology Overview 10
2.1.5 Surface Water and Groundwater 10
2.1.6 Groundwater Quantity Limited Areas 11
2.1.7 Soils 11
2.1.8 Land Use 13
2.2 Health Concerns 14
2.2.1 What is nitrate? 14
2.2.2 Nitrate Health Risk 14
2.2.3 Actions to Take 15
2.2.4 Where do I look for more information? 15
2.3 Potential Sources of Nitrate Contamination 17
2.4 Previous Groundwater Sampling Studies and Results 18
2.4.1 Rationale For Well Networks 18
2.4.2 Scope of Initial Characterization – July 1990 through March 1993 20
2.4.3 Results of Reconnaissance Sampling 20
2.4.4 Results of LUBGWMA Well Network 20
2.4.5 Synoptic Sampling Event Results 29

Final Draft For Public Comment

ED_005296_00000290-00004

2.4.6 Summary and Conclusions of Previous Sampling Events 36
2.5 Statistical Approach 39
2.5.1 Complexities Affecting Interpretation of Groundwater Nitrate Data....39
2.5.2 Summary of Revised Statistical Approach....39
3.0 Sources and Solutions 40
3.1 Irrigated Agriculture 41
3.1.1 Overview....41
3.1.2 Potential Sources of Nitrate from Irrigated Agriculture 422
3.2 Land Application of Food Processing Industrial Process Wastewater 51
3.2.1 Overview....51
3.2.2 Inventory of Sources 51
3.2.3 Food Processing Wastewater Goals, Objectives, Strategies, and Actions....51
3.3 Rural, Open and Green Spaces (ROGs)....53
3.3.1 Overview 53
3.3.2 Sources of Nitrates from Residential, Open and Green Space 544
3.3.3 Goals, Objectives, Strategies, and Actions 56
3.3.4 Evaluation of Local Action Plan Progress and Success....62
3.4 Confined Animal Feeding Operations (CAFOs) 63
3.4.1 Overview....63
3.4.2 Potential Sources of Nitrate from CAFOs 63
3.4.3 Goals, Objectives, Strategies and Actions: 63
3.5 Livestock Operations 68
3.5.1 Overview:....68
3.5.2 Inventory of Livestock Operation Sources: 68
3.5.3 Livestock Goals, Objectives, Strategies, and Actions....69
3.6 Public Water Systems 72
3.6.1 Overview....72
3.6.2 Inventory of Potential Risks to Public Water Supplies....74
3.6.3 Public Water Supply Goals, Objectives, Strategies, and Actions 75
4.0 Implementation: Measuring Success Through Plan Implementation Performance (PIP) Indicators and Groundwater Monitoring 83
4.1 Implementation Participants 83
4.2 Plan Implementation Performance (PIP) Indicators 84
4.2.1 PIP Timeline and Benchmarks....84
4.2.2 Groundwater Monitoring 845
5.0 References and Appendix 87
Registered Professional Geologist Seal 88
Statistician's Comments and DEQ's Response....89

Final Draft For Public Comment

ED_005296_00000290-00005

List of Figures

Figure 2-1 Location and Boundaries of the Lower Umatilla Basin Groundwater Management Area
Figure 2-2 Overlap of DEQ's Lower Umatilla Basin Groundwater Management Area and OWRD's Critical Groundwater Areas
Figure 2-3 Nitrate Leaching Potential of the Lower Umatilla Basin Groundwater Management Area
Figure 2-4 Land Use in the Lower Umatilla Basin Groundwater Management Area
Figure 2-5 Estimation of Nitrogen Leached to Groundwater
Figure 2-6 Nitrate Trends through May 2016 at LUBGWMA Well Network
Figure 2-7 Average Nitrate Concentrations – LUBGWMA Well Network
Figure 2-8 LUBGWMA Well Network Area-Wide Trend Through May 2016
Figure 2-9 Fourth LUBGWMA Synoptic Sampling Event Nitrate Results
Figure 2-10 Box Plots of Fourth LUBGWMA Synoptic Sampling Event Nitrate Results by Well Type
Figure 2-11 Box Plots of Data from 85 Wells in Four LUBGWMA Synoptic Sampling Events
Figure 2-12 Composite of Available Nitrate Data in the LUBGWMA

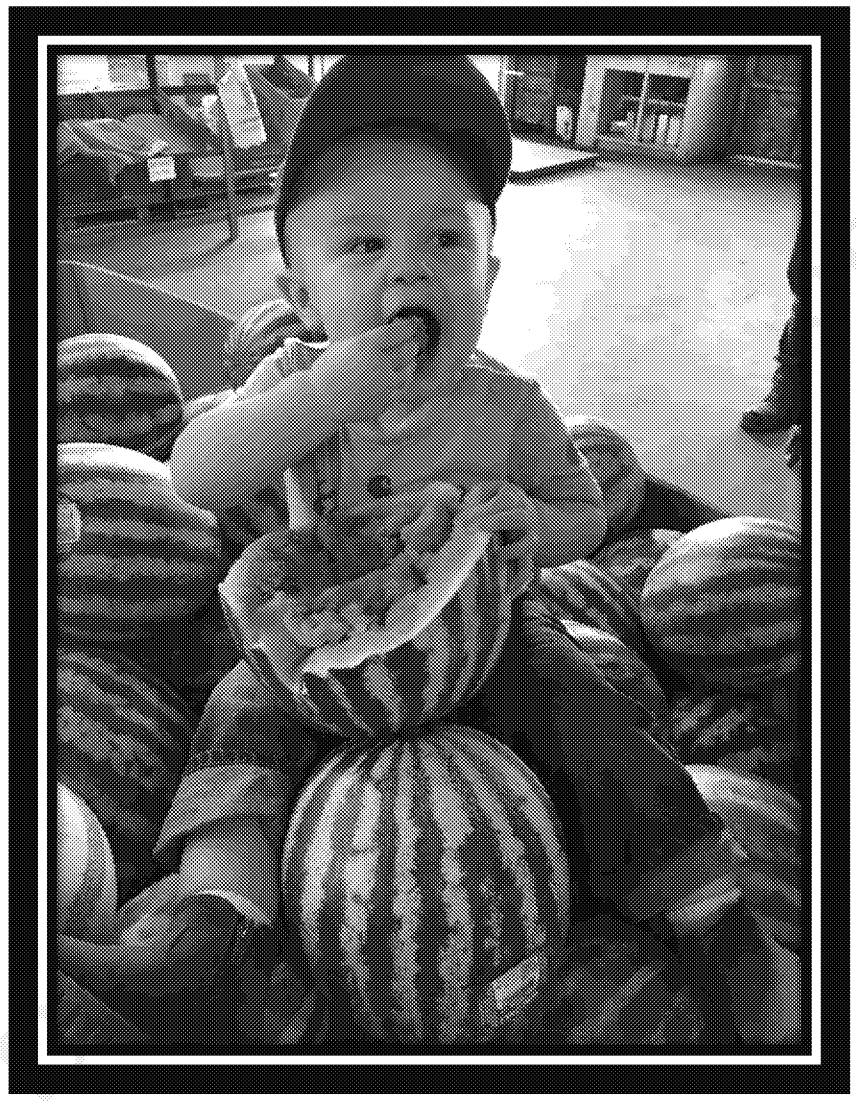
List of Tables

Table 2-1 Individual Well Nitrate Trends – LUBGWMA Well Network
Table 2-2 Summary of Individual LUBGWMA Well Nitrate Trends by Magnitude
Table 2-3 Indications of Improving and Worsening Water Quality
Table 2-4 Summary of Changes between LUBGWMA Synoptic Sampling Events
Table 2-5 Implied Trends at Wells Sampled in First and Fourth Synoptic Sampling Events

Final Draft For Public Comment

ED_005296_00000290-00006

Watermelon Festival
Irrigon, Oregon



Final Draft for Public Comment

ED_005296_00000290-00007

Acronyms Related to the Lower Umatilla Basin Groundwater Management Area

AWMP……Animal Waste Management Plan
BMP……Best Management Practice
CAFO ……Confined Animal Feeding Operation
CGA ……Critical Groundwater Area
DEQ ……Oregon Department of Environmental Quality
EPA ……United States Environmental Protection Agency
GPAF ……Groundwater Protection & Agronomic Factor
GWMA ……Groundwater Management Area
LUBGWMA ……Lower Umatilla Basin Groundwater Management Area
NPDES……National Pollution Discharge Elimination System
NRCS ……Natural Resource Conservation Service
ODA ……Oregon Department of Agriculture
OHA ……Oregon Health Authority
OMM……Operation, Monitoring and Management
OSU ……Oregon State University
OWRD ……Oregon Water Resources Department
PIP……Plan Implementation Performance
SWCD ……Soil & Water Conservation District
WPCF……Water Pollution Control Facility
UMCD ……U.S. Army Umatilla Chemical Depot
USGS ……United States Geological Survey

Final Draft For Public Comment

ED_005296_00000290-00008

Executive Summary

To protect the invaluable and finite resource of groundwater, Oregon has passed many laws, specifically the Oregon Groundwater Quality Protection Act of 1989 (Oregon Revised Statute 468B.150-190). In accordance with the Act, the Oregon Department of Environmental Quality (DEQ) declared the Lower Umatilla Basin (LUB), an area encompassing Morrow and Umatilla counties, a Groundwater Management Area (GWMA) in 1990 because regional nitrate- nitrogen concentrations exceeded 7 milligrams per liter (mg/L). Nitrate concentration in groundwater data has been compiled since the 1990s via bimonthly, quarterly and synoptic sampling events.

The LUBGWMA was established, as required by Oregon statute, to allow for the identification and implementation of practices that will reduce nitrate loading and reduce groundwater nitrate concentrations below 7 mg/L. To accomplish such tasks, the LUBGWMA Committee was formed and is composed of local area residents and governments representing a broad range of interests within the local area and basin. Under statute, several additional agencies are required to be involved, including Morrow & Umatilla County and city planning agencies, DEQ, the Oregon Health Authority (OHA), the Oregon Water Resources Department (OWRD), the Oregon Department of Agriculture (ODA), and Oregon State University's (OSU) agricultural research center. Umatilla and Morrow County Soil and Water Conservation Districts (SWCDs) are also involved and Morrow SWCD is designated the lead agency for developing and implementing the Second Local Action Plan.

The Second Local Action Plan identifies and encourages voluntary actions that will reduce groundwater nitrate concentrations while sustaining this reduction so that public and private drinking water remains safe to drink. In doing so, it also aims to repeal the GWMA declaration as allowed by Oregon statute. Chapter 1 of the plan offers an in-depth introduction of the GWMA and describes the approach to developing and implementing the Second Local Action Plan. Chapter 2 provides background information, describes the regional setting of the area and the sources of groundwater data. Chapter 3 identifies specific potential nitrate contamination sources within the GWMA that result from regional land use patterns (irrigated agriculture, land application of food processing industrial wastewater, rural and open green spaces, confined animal feeding operations (CAFOs), and livestock operations) as well as risks to public and private water supplies. This chapter also offers goals and specific management strategies and actions for land use that contribute to groundwater contamination and highlight the responsible entities for implementation. Chapter 4 describes the approach used in the evaluation of plan performance and groundwater quality and trends. Also included is a description of how the overall effectiveness of the plan will be measured.

The plan is subject to a 60-day period of public review and comment prior to final approval. The success of the voluntary nature of the plan will be assessed on an annual basis by the committee and the agencies involved. If progress in implementing strategies aimed at reducing groundwater nitrate levels is not accomplished at the time of these assessments, amendments to the plan may be warranted.

1.0 Introduction

Groundwater is an essential Oregon resource. It makes up 95 percent of available freshwater resources in Oregon. More than 70 percent of Oregon residents get their drinking water from groundwater, and over 90 percent of the state's public water systems get their drinking water from groundwater. To protect this valuable Oregon resource, Oregon passed laws to prevent groundwater contamination, conserve and restore groundwater, and maintain the high quality of Oregon's groundwater resource for present and future uses. Groundwater is the primary source of drinking water and its use is increasing.

An estimated 350,000 private drinking water wells exist in Oregon today. Oregon's businesses require clean groundwater for industries such as food processing, dairies, manufacturing and computer chip production. Groundwater provides irrigation water for Oregon agriculture and water for livestock and supplies base flow for most of the state's rivers, lakes, streams and wetlands. (Tarnow, et. al., 2017)

ED_005296_00000290-00009

The Oregon Groundwater Quality Protection Act of 1989 (Oregon Revised Statute 468B.150-190) set a broad goal for the state of Oregon – to prevent contamination of Oregon's groundwater resource, to conserve and restore this resource, and to maintain the high quality of this resource for present and future uses. The act established a policy that all state agencies' rules and programs are to be consistent with the goal of protecting drinking water resources and public health.

In accordance with Oregon's Groundwater Quality Protection Act (ORS 468B.180), DEQ declared the GWMA in 1990 because regional nitrate-nitrogen concentrations exceeded 7 milligrams per liter (mg/ l[1]). The intent of declaring a GWMA is to allow the identification and implementation of practices that will reduce nitrate loading and ultimately reduce regional groundwater nitrate concentrations to below 7 mg/L.

The Lower Umatilla Basin Groundwater Management Area Committee adopted the first LUBGWMA Action Plan in December 1997. The first Action Plan was finalized in December 1997, and included goals through December of 2009. This Second Local Action Plan replaces the First Action Plan.

Throughout this document this Action Plan is interchangeably referred to as the "Second Action Plan", the "Local Action Plan" and the "Second Local Action Plan".

For more information go to: http://lubgwma.org/

The following section describes the purpose and goal of the Second Local Action Plan, the regulatory authority and voluntary approach to implementing the Second Local Action Plan, and describes the organization of the Second Local Action Plan.

1.1 Purpose and Goal

1.1.1 Purpose

The purpose of this Second Local Action Plan is to identify and encourage voluntary actions that will reduce the groundwater nitrate concentrations in the LUBGWMA. *This Second Local Action Plan will be reviewed annually by the Committee to identify any necessary amendments that will further reduce groundwater nitrate concentration in the LUBGWMA.*

1.1.2 Goals

The goals of this Second Local Action Plan is to reduce groundwater nitrate concentrations to less than 7 mg/L throughout the region. In addition, the Local Action Plan aims to sustain this reduction so that public and private drinking waters remain safe to drink and the GWMA declaration can be repealed via ORS 468B.188.

1.2 Authority and Approach

1.2.1 GWMA Declaration and Repeal

The goals of the Oregon Groundwater Quality Protection Act is to prevent contamination of groundwater and to conserve, restore, and maintain Oregon's groundwater resources for present and future beneficial uses.

[1] Seven milligrams per liter (mg/L) nitrate-nitrogen is essentially equivalent to 7 parts per million (ppm) nitrate-nitrogen. The units mg/L and ppm are used interchangeably in this document. Nitrate-nitrogen refers to a common way of reporting nitrate as nitrogen rather than nitrate as nitrate. State and Federal drinking water standards use the unit nitrate-nitrogen. The term nitrate-nitrogen is shorted to nitrate in this document.

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ED_005296_00000290-00010

Oregon Groundwater Quality Protection Act Statute [ORS 468B.160] states the following: Groundwater contamination levels shall be used to trigger specific governmental actions designed to prevent those levels from being exceeded or to restore groundwater quality to at least those levels. All groundwater of the state shall be protected for both existing and future beneficial uses so that the state may continue to provide for whatever beneficial uses the natural water quality allows.

Oregon Statute (ORS 468B.165) also states the following: The adoption or failure to adopt a rule establishing a maximum measurable level for a contaminant under subsection (1) of this section shall not alone be construed to require the imposition of restrictions on the use of fertilizers under ORS 633.311 to 633.479 and 633 or the use of pesticides under ORS chapter 634.

In accordance with the requirements of the Groundwater Quality Protection Act of 1989, Oregon Statute (ORS 468B.180) requires Oregon's DEQ to declare a GWMA if groundwater contamination, resulting at least in part from nonpoint source activities, exceeds certain threshold levels. For most contaminants, the threshold level is 50% of a federal drinking water standard. In the case of nitrate, the threshold level is 70% of the 10 milligrams per liter (mg/L) federal drinking water standard (i.e., 7 mg/L). For more information: https://www.oregonlaws.org/ors/468B.180

DEQ declared the Lower Umatilla Basin a Groundwater Management Area in 1990 because nitrate concentrations exceeded 7 mg/L in many area groundwater samples. After the GWMA was declared, a 4-year interagency hydrogeological investigation was conducted to determine the extent of contamination and to identify the potential sources of that contamination (Grondin, et. al., 1995).

Regarding regulatory background: the 1987 amendments to the Federal Clean Water Act (CWA) established the Section 319 Nonpoint Source (NPS) Management Program. The United States Congress chose not to address nonpoint sources through a regulatory approach, unlike its actions with "point" sources. Rather, when it added Section 319 to the CWA in 1987, it created a federal grant program that provides money to states, tribes, and territories for developing and implementing NPS management programs (EPA.gov).

Section 319 attempts to address the need for greater federal leadership to help focus state and local nonpoint source efforts. Under Section 319; states, territories and tribes receive grant money that supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific NPS implementation projects (EPA.gov).

Federal Code of Federal Regulations (CFR) Title 33, Chapter 26 Subchapter II, Section § 1329 allows for prioritization of grants to states which have implemented or are proposing to implement NPS management programs which will carry out groundwater quality protection activities.

Federal grants to states advance the state toward implementation of a comprehensive nonpoint source pollution control program including, but not be limited to, research, planning, groundwater assessments, demonstration programs, enforcement, technical assistance, education, and training to protect the quality of groundwater, and to prevent contamination of groundwater from nonpoint sources of pollution (Govinfo.gov).

There is no federal regulatory authority over nonpoint sources of pollution and the CWA does not require states to develop their own regulatory programs to obtain 319 grants. Under the Clean Water Act Section 319, states, territories, and delegated tribes are required to develop NPS pollution management programs, if they receive 319 funds. Once EPA has approved a state's nonpoint source program, EPA provides grants to implement NPS management programs under Section 319 (EPA.gov).

Once EPA has approved a state's nonpoint source program, EPA provides funding that is used as "pass through" monies to stakeholders working on local pollution issues. Funds from 319 can be used to conduct activities to ensure the use of Best Management Practices, develop strategies for collaborating with other agencies and draft monitoring and evaluation plans. States, territories and tribes, at their discretion, may use 319 funds to develop their own NPS regulatory programs. Section 319 funds can also be used for developing and implementing total

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maximum daily loads (TMDLs) in watersheds where nonpoint sources are a substantial contributor of loadings of the pollutant(s) causing impairment (EPA.gov).

Recipients of Section 319 grant funds must provide a percent match, either in dollars or in-kind services. Each grantee must provide 40% of the total project funding in match dollars – either in-kind or cash contributions. A state, tribe, or territory receiving section 319 funds must complete and update an NPS management plan every five years. States and territories "pass on" a substantial fraction of the 319 funds they receive from EPA to support local NPS pollution management efforts. Depending on the state or territory, a "local match" may also be required. Section 319 is a significant source of funding for implementing NPS management programs, but there are other federal (e.g., Farm Bill), state, local and private funding mechanisms (EPA.gov).

The Coastal Zone Act Reauthorization Amendments (CZARA) is a 1990 federal law that prevents states that fail to establish enforceable controls on nonpoint source pollution from receiving federal funds. In a 2010 lawsuit brought by Northwest Environmental Advocates, it was decided that Oregon DEQ must mitigate logging impacts to coastal waters or lose federal funds, in part through budget cuts to the Section 319 program. Since that time, the funding for the Section 319 program in Oregon has been reduced substantially.

Section 319 of the CWA also requires states to identify water bodies that cannot meet water quality standards without control of nonpoint sources. The states must then identify best management practices and measures for those impaired sources, along with an implementation plan. Section 319 does not place enforceable limits on nonpoint source pollution, and there is no enforcement mechanism. Section 319 Nonpoint Source Program identifies "best management practices and measures to control each category and subcategory of nonpoint sources and….to reduce, to the maximum extent practicable, the level of pollution resulting from such category, subcategory, or source."

Oregon's Section 319 program is documented in the Oregon Nonpoint Source Program Plan, which is periodically updated by DEQ and approved by EPA. The nonpoint source program's long-term goal (as identified in the 2014 Nonpoint Source Program Management Plan) is to develop and implement strategies to protect, prevent, control, and eliminate water pollution from nonpoint sources in waters of the state to meet water quality standards and TMDL load allocations. Protecting water quality also protects beneficial uses, the environment and Oregon's economy by reducing capital costs for water treatment infrastructure and flood mitigation (Oregon.gov).

DEQ's Clean Water State Revolving Fund loans finance a variety of nonpoint source water quality plans and projects. Planning loans can finance the establishment of watershed partnerships, local ordinances to implement a stormwater management plan, engineering and development standards for new and redevelopment, permanent riparian buffers, floodplains, wetlands and other natural features. Loans can also finance protecting and restoring streamside areas, wetlands and floodplains, and acquisition of riparian land, wetlands and conservation easements (Oregon.gov).

In Oregon, Agricultural Water Quality Management Area Plans (area plans) and Agricultural Water Quality Management Area Rules (area rules) are intended to be the implementation measures for Nonpoint Sources with respect to agriculture. The Agricultural Water Quality Management Act (ORS 568.900 to 568.933) authorizes the Oregon Department of Agriculture (ODA) to develop Agricultural Water Quality Management (AGWQMP) Area Plans (area plans) and rules throughout the state. The statute authorizes the development of area rules to serve as a regulatory backstop to the voluntary efforts described in the area plans. ORS 561.191 states that ODA shall develop and implement any program or rules that directly regulates farming practices to protect water quality. The Agricultural Water Quality Management Program is the main regulatory tool to prevent and control nonpoint source pollution from agricultural lands. The area plans and rules are reviewed every two years for each management area. DEQ provides review and comment on the area plans and rules during these biennial reviews. Water quality standards and TMDL load allocations for agricultural lands should be met through implementation of area plans and enforcement of area rules (Oregon.gov).

The ODA Area Plan identifies strategies to prevent and control water pollution from agricultural lands through a combination of outreach programs, suggested land treatments, management activities, compliance, and

ED_005296_00000290-00012

monitoring. The Area Plan is neither regulatory, nor enforceable and the provisions of the Area Plan do not establish legal requirements or prohibitions (ORS 568.912(1)).

Each Area Plan is accompanied by Area Rules that describe local agricultural water quality regulatory requirements. ODA will exercise its regulatory authority for the prevention and control of water pollution from agricultural activities under the Ag Water Quality Program's general regulations (OAR 603-090- 0000 to 603-090-0120) and under the Area Rules for the Umatilla Management Area (OAR 603-095-3200). The Ag Water Quality Program's general rules guide the Ag Water Quality Program, and the Area Rules for the Management Area are the regulations that landowners are required to follow (Oregon.gov).

Section 303(d) of the Clean Water Act authorizes EPA to assist states, territories and authorized tribes in listing impaired waters and developing Total Maximum Daily Loads (TMDLs) for these waterbodies. A TMDL establishes the maximum amount of a pollutant allowed in a waterbody and serves as the starting point or planning tool for restoring water quality (EPA.gov).

Section 303(d) of the CWA requires states to identify waterbodies that do not meet water quality standards after application of the technology-based standards for point source pollution. States must then establish a TMDL for those impaired water bodies to bring them into compliance with water quality standards. The standards are submitted to the EPA for approval. TMDLs address the total amount of loading, which includes nonpoint sources. If nonpoint sources are impairing a body of water, the TMDL addresses reductions to those nonpoint sources (EPA.gov)

Oregon Administrative Rules Division 42, Total Maximum Daily Loads (TMDLs), describe the TMDL process including establishing and implementing Load Allocations for nonpoint sources. Division 42 and DEQ's TMDL internal Management Directive provides details on load allocation development and implementation. When developing or revising a TMDL, DEQ will form a local TMDL stakeholder committee and work with ODA to ensure appropriate load allocations for agricultural nonpoint source sectors are established.

In 2001, Oregon's Department of Environmental Quality released the Nitrate TMDL for the Umatilla Basin. The Sensitive Beneficial Use for nitrate is listed as drinking water. The TMDL set the goal for instream nitrate levels to the state water quality standard of 10 mg/L. While the TMDL focuses on surface water quality, it acknowledges the relationship between surface water and groundwater.

Groundwater is the source of summer base flow in some creeks, and thus a potential source for surface water contamination. The Water Quality Management Plan section of the TMDL was prepared through the Basin's TMDL process, primarily by land-use or water-resource workgroups, who worked closely with and were supported by the two principal committees: the Umatilla Basin TMDL Stakeholders Committee and the Umatilla Basin TMDL Technical Committee. All committees were sponsored by a core stakeholder partnership: the Umatilla Basin Watershed Council, the Confederated Tribes of the Umatilla Indian Reservation and the Oregon Department of Environmental Quality.

Oregon's 1989 Groundwater Quality Protection Act (Act) [ORS 468B.188] requires DEQ to repeal a GWMA designation if groundwater contamination improves so that the levels of contaminants no longer exceed the levels established under ORS 468B.180. ORS 468B.188 repeal of declaration of groundwater management area states the following:

(1) If, after implementation of the action plan developed by affected agencies under ORS 468B.184 (Designation of lead agency for development of action plan) to 468B.187 (Acceptance or rejection of action plan), the groundwater improves so that the levels of contaminants no longer exceed the levels established under ORS 468B.180 (Declaration of ground water management area), the Department of Environmental Quality shall determine whether to repeal the groundwater management area declaration and to establish an area of groundwater concern.
(2) Before the declaration of a groundwater management area is repealed under subsection (1) of this section, the Department of Environmental Quality must find that, according to the best information available, a new or revised

ED_005296_00000290-00013

local action plan exists that will continue to improve the ground water in the area. In addition, the findings can be implemented at the local level without the necessity of state enforcement authority.
(3) Before the Department of Environmental Quality terminates any mandatory controls imposed under the action plan created under ORS 468B.184 (Designation of lead agency for development of action plan) to 468B.187 (Acceptance or rejection of action plan), the groundwater management committee must produce a local action plan that includes provisions necessary to improve groundwater in the area and that the department finds can be implemented at the local level without the necessity of state enforcement authority.

For more information: https://www.oregonlaws.org/0ors/468B.188

1.2.2 Second Local Action Plan Development and Regulatory Approval

Oregon's 1989 Groundwater Quality Protection Act (Act) [ORS 468B.162] requires DEQ to conduct interagency management of groundwater to achieve the goal of preventing groundwater contamination. ORS 468B.184 requires DEQ to designate a lead agency for development of a local action plan and to request other agencies to assume responsibilities for drafting and implementing a local action plan.

ORS 468B.184 and ORS 468B.160 requires certain items be included in the action plan including, but not limited to the following: **1.)** Recommendations of mandatory actions that, when implemented, will reduce the contamination to a level below that level requiring the declaration of groundwater management area, **2.)** Public review of the action plan and **3.)** Required amendments of affected city or county comprehensive plans and land use regulations to address the identified groundwater protection and management concerns. **4.)** Establishment of programs to prevent groundwater quality degradation through the use of best practicable management practices (BMPs).

As required by statute, DEQ's current recommendations for mandatory action is implementation of the Agricultural Water Quality Management Program by Oregon Department of Agriculture, (as supported in an inter-agency memorandum of understanding relating to agricultural non-point source pollution), to achieve protection of groundwater for beneficial drinking water use.

DEQ also recommends that this Second Local Action Plan be funded, resourced and implemented in its entirety by all stakeholders and entities in Oregon and the Lower Umatilla Basin region, including the following Oregon state & local agencies: ODEQ, ODA, OSU, OHA, OWRD, Morrow & Umatilla County SWCDs, and city and county planning agencies.

The Act also requires DEQ to convene a Groundwater Management Area Committee (Committee) and produce a Local Action Plan. The Committee, comprised of various stakeholders, works with and advises state agencies in the development of an action plan that will reduce existing groundwater contamination and prevent further contamination of the impacted aquifer.

The lead agency is the primary entity responsible for developing and implementing the Second Local Action Plan. DEQ designated the Morrow and Umatilla County Soil and Water Conservation Districts (SWCDs) as the lead agencies for developing and implementing the first Action Plan. The original Committee finalized the first Action Plan in December 1997 (LUBGWMA Committee, 1997). DEQ designated the Morrow SWCD as the lead agency for developing and implementing this Second Local Action Plan. A list of the current Committee members is included in the acknowledgments section of this report.

If a GWMA is located on agricultural lands or in an area designated as an exclusive farm use zone, the Act makes the Oregon Department of Agriculture (ODA) responsible for developing the portion of the Second Local Action Plan that addresses farming practices.

The Act further requires that the lead agency provide a 60-day period of public comment prior to final approval. After consideration of the public comments, the lead agency finalizes the plan and forwards it to DEQ for

ED_005296_00000290-00014

acceptance or rejection. DEQ then has 30 days to accept the final plan or remand the plan back to the lead agency for revision in accordance with participating agency recommendations.

Morrow SWCD will conduct a 60-day public review of this Second Local Action Plan and consider public comment in finalizing this Second Local Action Plan. Required amendments of city and county comprehensive plans and land use regulations are addressed in Section 3.3. Establishment of BMP programs are addressed in Section 3.1.3.

This Second Local Action Plan follows the procedure outlined above.

1.2.3 Assessment of Voluntary Approach

The Committee, ODA and DEQ have agreed to implement a voluntary approach for addressing the groundwater contamination, which will complement the implementation of DEQ and ODA-issued water quality permits for point sources. The success of the voluntary nature of this Local Action Plan will be assessed every year by the GWMA Committee and the state agencies. If progress in implementing the strategies (that lead to reductions the groundwater nitrate levels) is not accomplished at the time of these assessments, then amendments to the Local Action Plan may be warranted or changes may include mandatory actions or regulatory changes to address protection of groundwater as required in Oregon statute. It is ultimately DEQ's responsibility to determine if mandatory actions or regulatory changes are necessary to achieve the goal of groundwater protection.

If additional mandatory requirements are deemed necessary, DEQ will work with the Committee to develop rulemaking and implement requirements for those sources over which they have jurisdictional authority. Similarly, if mandatory requirements are deemed necessary, ODA will work with the Committee to develop and implement additional mandatory requirements for agricultural and rural lands.

1.2.4 Plan Organization

This plan is organized into four chapters:

Chapter One – Introduction describes the Local Action Plan purpose and goal and: 1.) the authority to declare a GWMA and require a Local Action Plan, 2.) the approach to developing and implementing the Local Action Plan, 3.) and the Local Action Plan's organization.

Chapter Two – Background and Setting describes the regional setting such as land use and local jurisdictions. This chapter also provides an overview of: 1.) the health concerns related to nitrate, 2.) a broad overview of potential nitrate sources in the region, 3.) previous sampling studies conducted in the area, 4.) and a discussion of the statistical approach used to evaluate groundwater nitrate concentrations in the GWMA.

Chapter Three – Sources and Solutions identifies specific potential nitrate contamination sources within the GWMA that result from regional land use patterns. This chapter includes the goals and specific management strategies and actions for land use that contribute to groundwater contamination. Chapter Three also examines contamination risk to public and private water supplies and strategies to prevent contamination.

Chapter Four – Implementation: Measuring Success through Plan Implementation Performance (PIP) Indicators and Groundwater Monitoring provides a description of how the overall effectiveness of the plan will be measured through Plan Implementation Performance (PIP) indicators. This chapter also describes the sources of groundwater data and the approach used in the evaluation of groundwater quality concentrations and trends.

Chapter Five – References provides citations for referenced documents.

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2.0 Background and Setting

This section describes the regional setting, nitrate health concerns, potential sources of nitrate contamination, previous groundwater sampling studies and results, and the statistical approach to evaluate data in the past and in the future.

2.1 Regional Setting

This section describes some general characteristics of the Lower Umatilla basin region including its geographic setting, its residents, the geologic and hydrogeologic setting, surface water and groundwater resources, soils, and land use.

2.1.1 Geographic Setting

The LUBGWMA is located within the Snake/Columbia Shrub Steppe ecoregion, which is the largest grassland in North America. It extends from eastern Oregon and southeastern Washington through Idaho, Nevada, Utah, and into western Wyoming and Colorado. Shrub refers to the most abundant plant species in the region. Steppe is a Russian word that means a vast treeless plain. In the Mid-Columbia Basin, shrub-steppe winters are cold and wet with strong winds. Summers are hot and dry during the day, then cool at night (PNNL, 2016). Annual average rainfall in the LUBGWMA is about 9 inches.

The Snake/Columbia Shrub Steppe is a vast, mostly arid ecoregion. Its easternmost limit is the Continental Divide in eastern Idaho. From there, the ecoregion follows the arc of the Snake River Plain as far as Hells Canyon. The ecoregion then spreads throughout southeastern Oregon, extending along the Deschutes River basin to the Columbia River. It also includes, following hydrographic lines, parts of northern Nevada and the extreme northeast of California. To the north, the ecoregion dominates the western portion of the Columbia Basin in Washington.

The ecoregion is largely in the rain shadow of the Cascade Mountains and thus receives little precipitation. Grazing by domestic livestock, fire suppression, irrigated agriculture, and invasive grasses are recent changes to the ecoregion. Latitude and physiography are influential factors in distinguishing this ecoregion from other similar ecoregions, such as the Wyoming Basin and Great Basin Shrub Steppes. The Snake/Columbia Shrub Steppe is lower in elevation than the Wyoming Basin, and the two are separated by mountainous areas.

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The LUBGWMA encompasses approximately 562 square miles of land in northern Umatilla and Morrow Counties (Figure 2-1). It includes the communities of Echo, Stanfield, Hermiston, Umatilla, Irrigon, and Boardman.

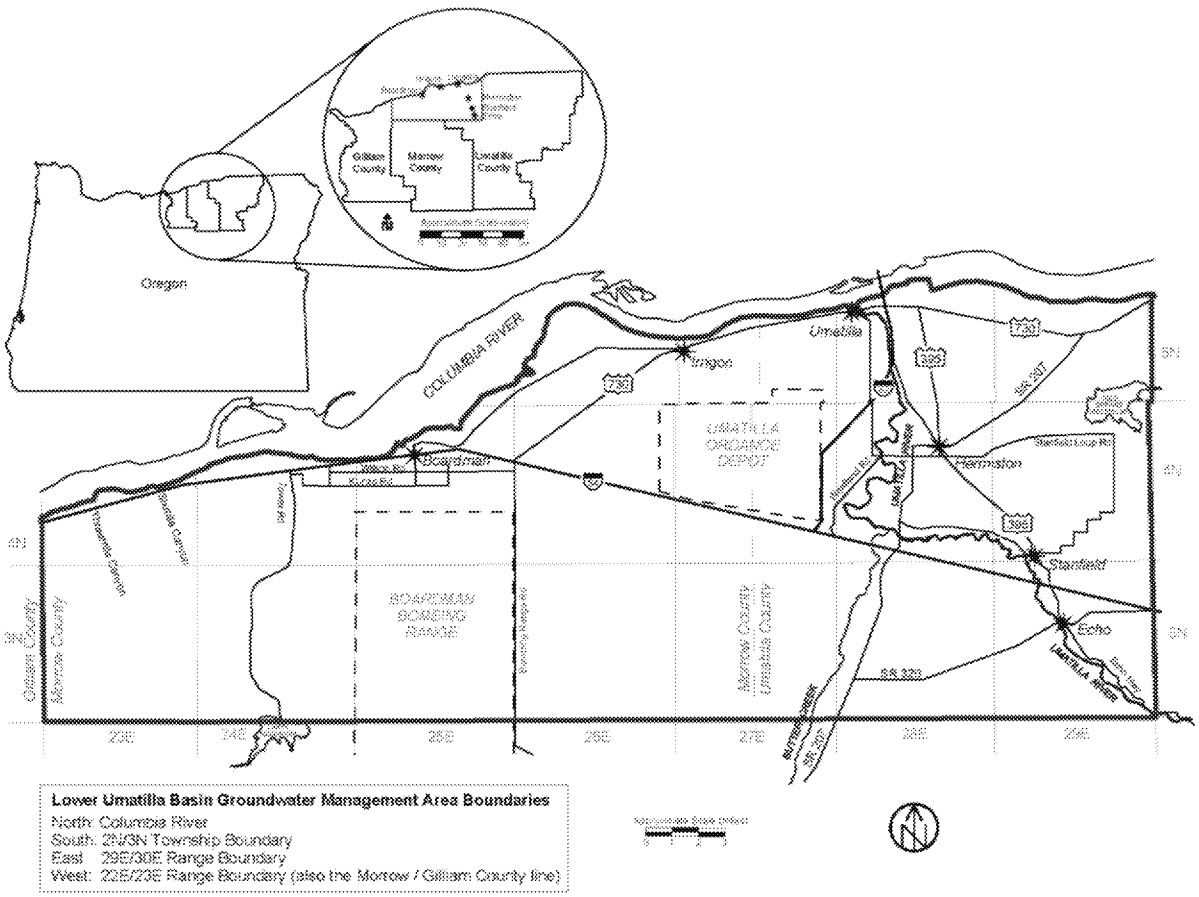
2.1.2 Residents

The 2010 census indicated that there were 87,062 people living in Umatilla and Morrow Counties. Using 2010 census data, the population within the six urban growth boundaries (UGBs) around the six cities in the LUBGWMA is estimated to be 31,490. The rural population of the LUBGWMA (i.e., the people outside UGBs

Figure 2-1

Location and Boundaries of the Lower Umatilla Basin Groundwater Management Area

Second LUBGWMA Action Plan



but within the GWMA) is estimated to be 14,830 people. As of the 2015 census, there were 87,721 people living in Umatilla and Morrow Counties.

The methodology used to generate the rural population estimate involved first calculating the population for all census block groups within the GWMA. Then the total population for the different urban boundaries for the towns of Echo, Stanfield, Hermiston, Umatilla, Irrigon and Boardman was determined based on the estimates from *Portland State University's Population Research Center* for the year 2010. The 2010 estimates were used because the census tract data is based on the 2010 Census. The US Census Bureau defines rural as what is not urban. The population for the urban areas was subtracted from the total population for block groups within the GWMA boundaries to arrive at the rural population for the GWMA area.

2.1.3 Geologic Setting

Large areas of eastern Washington and northeastern Oregon are underlain by a thick sequence of basalt lava flows, which are collectively known as the Columbia River Basalt Group. In the Umatilla Basin, the lavas have

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been folded into a prominent east-west trough (the Dalles-Umatilla Syncline) which is roughly coincident with the Columbia River between Arlington and Hermiston. Up to 250 feet of alluvial sediments have accumulated in the trough. Some of the sediments (the Alkali Canyon Formation) were deposited by streams which drained the Blue Mountains to the south, but most sediments were deposited by catastrophic floods (glacial Lake Missoula) which swept down the Columbia River drainage during the Pleistocene Epoch (ice age).

Since the end of the Pleistocene (about 12,000 years ago), thin deposits of micaceous silt, sand, and gravel have accumulated in portions of the Butter Creek and Umatilla River drainages. These modern alluvial deposits (Holocene Alluvium) are less than 30 feet thick and are largely composed of reworked catastrophic flood sediments.

2.1.4 Hydrogeology Overview

The principal aquifers of the Lower Umatilla Basin occur in alluvial sands and gravels, which overlie the Columbia River Basalt Group, and in porous breccia zones between the basalt flows. The alluvial aquifer and the upper two or three basalt aquifers are the principal sources of domestic groundwater in the basin. The alluvial aquifer is also a source of irrigation water for local farms, and a source of municipal water for the cities of Hermiston, Irrigon, and Boardman. Deeper basalt aquifers are a major source of irrigation water in the basin. The shallow alluvial aquifer is the focus of this Local Action Plan.

Groundwater recharge comes from precipitation, deep percolation of irrigation water past the root zone, and leakage from canals, streams, and reservoirs. The recharge area for the alluvial aquifer is very broad because porous and permeable sediments overlie the aquifer throughout most of its extent. Recharge areas for the basalt aquifers are narrow because porous and permeable breccia zones in the basalts are generally restricted to the top or bottom of flows (inter-flow zones). Because these breccias typically constitute less than 10 percent of a flow's thickness, their exposed surface area is relatively small where the flow margin is exposed at land surface or beneath a cover of sediments.

2.1.5 Surface Water and Groundwater

The main flowing surface water features in the LUBGWMA are the Columbia River (which forms the northern boundary of the GWMA), the Umatilla River (located in the eastern portion of the GWMA), and its tributary Butter Creek. Smaller intermittent streams are in the western portion of the GWMA within Sixmile Canyon and Threemile Canyon. In addition to the natural flowing surface water bodies, there are also six irrigation districts within the GWMA that typically have water flow during irrigation season. Two large reservoirs are also located within the GWMA: Cold Springs Reservoir in the northeast corner of the GWMA, and Carty Reservoir in the southwest portion of the GWMA.

In the Umatilla Basin, there is a good communication between the groundwater and surface water. Groundwater in the shallow aquifer flows towards the Columbia and Umatilla rivers where it is discharged from the groundwater system to become stream flow. As groundwater flows closer to a stream or river, it starts to move in the same direction as the river and groundwater is incorporated into the river (gaining reach). Under certain circumstances, especially during wetter times of the year, water can change directions and flow into the groundwater aquifer from the river (losing reach). During the drier months, groundwater will often flow from the aquifer into the river and help sustain river flows as baseflow contribution.

Some alluvial groundwater is discharged to underlying basalt aquifers where updip margins of lava flows are exposed at the base of the alluvial aquifer. Large volumes of groundwater are discharged from the shallow aquifers by wells. Groundwater can also migrate between aquifers in well bores that are open to more than one aquifer or in the annular space behind ungrouted casing.

The alluvial aquifer includes all saturated sediments, which overlie the Columbia River Basalt Group and saturated breccia zones at the top of the uppermost flow. Water bearing units include the Alkali Canyon Formation, Pleistocene catastrophic flood deposits, and Holocene Alluvium. The principal water bearing zones occur in the flood deposits. The upper surface of the Columbia River Basalt Group defines the approximate base

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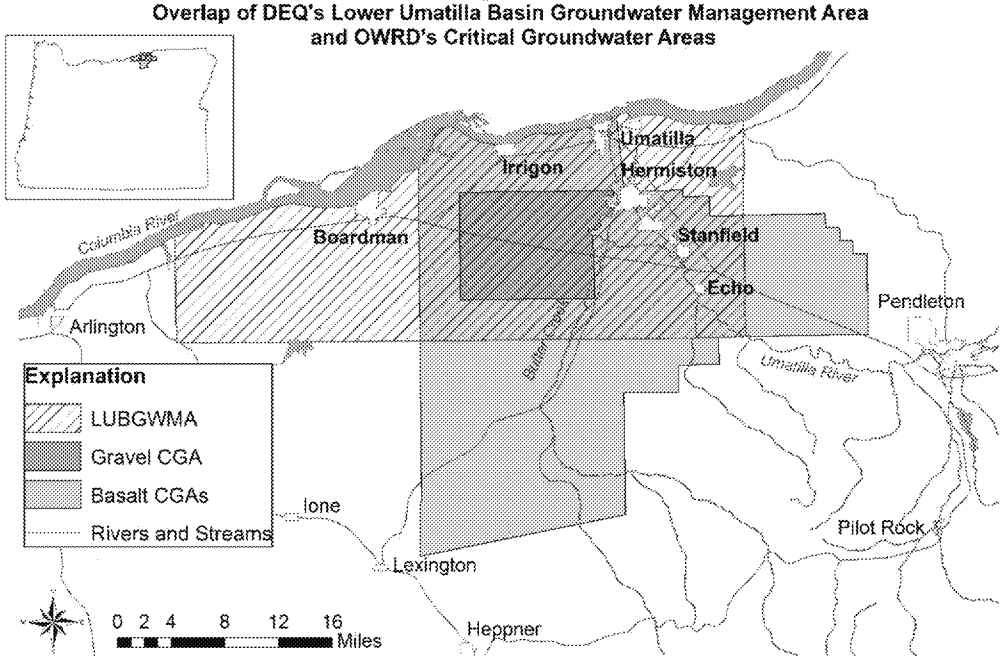
of the alluvial aquifer. The subsurface topography of the basalt bedrock is the primary factor, which controls the thickness of the alluvial aquifer. The aquifer thins above local bedrock highs and thickens above bedrock lows. The aquifer also thins to the south and east as the basalt surface rises to higher elevations.

2.1.6 Groundwater Quantity Limited Areas

In addition to impacted groundwater quality, this portion of Oregon also has groundwater quantity shortages. In general, water *quality* problems are in the shallow sand and gravel aquifer while water *quantity* problems are in the deeper basalt aquifers.

Between 1976 and 1991, the Oregon Water Resources Department (OWRD) declared four Critical Groundwater Areas (CGAs) in the region due to groundwater level declines of up to 500 feet. Three of the CGAs are in deep basalt aquifers and one is in the shallow gravel aquifer. Figure 2-2 shows the overlap of the LUBGWMA and the CGAs.

Figure 2-2
Overlap of DEQ's Lower Umatilla Basin Groundwater Management Area and OWRD's Critical Groundwater Areas



Because of groundwater level declines, groundwater pumping for irrigation has been significantly reduced. In addition to the management of the CGAs by OWRD, cities with current Water Management and Conservation Plans approved by OWRD have, in effect, a moratorium on future permitted groundwater development within a 4-mile radius of each municipal well.

2.1.7 Soils

Soil surveys for Umatilla and Morrow Counties indicate that Lower Umatilla basin soils consist of well-drained, fine sand, and sandy loams. The soils are low in clay content and nutrients, contain little organic matter, with a pH range from 6.5 to 7.8 in near surface and up to 9.0 in deeper soil. The soil permeability rates from moderate to high, and the available water holding capacity ranges from approximately 0.7 to 3 inches of water per foot of soil.

The Natural Resources Conservation Service (NRCS) has an online tool that allows the calculation of a simplified Nitrate Leaching Potential (for about 100,000 acres at a time) based on inherent soil and climate properties that affect nitrate leaching. The tool does not account for management practices such as fertilizer application rates and timing, crop rotation, and irrigation water management. The following soil and climate factors are used in the calculation:

1. Mean annual precipitation minus potential evapotranspiration,
2. Water travel time through the entire soil profile,
3. Available water capacity,

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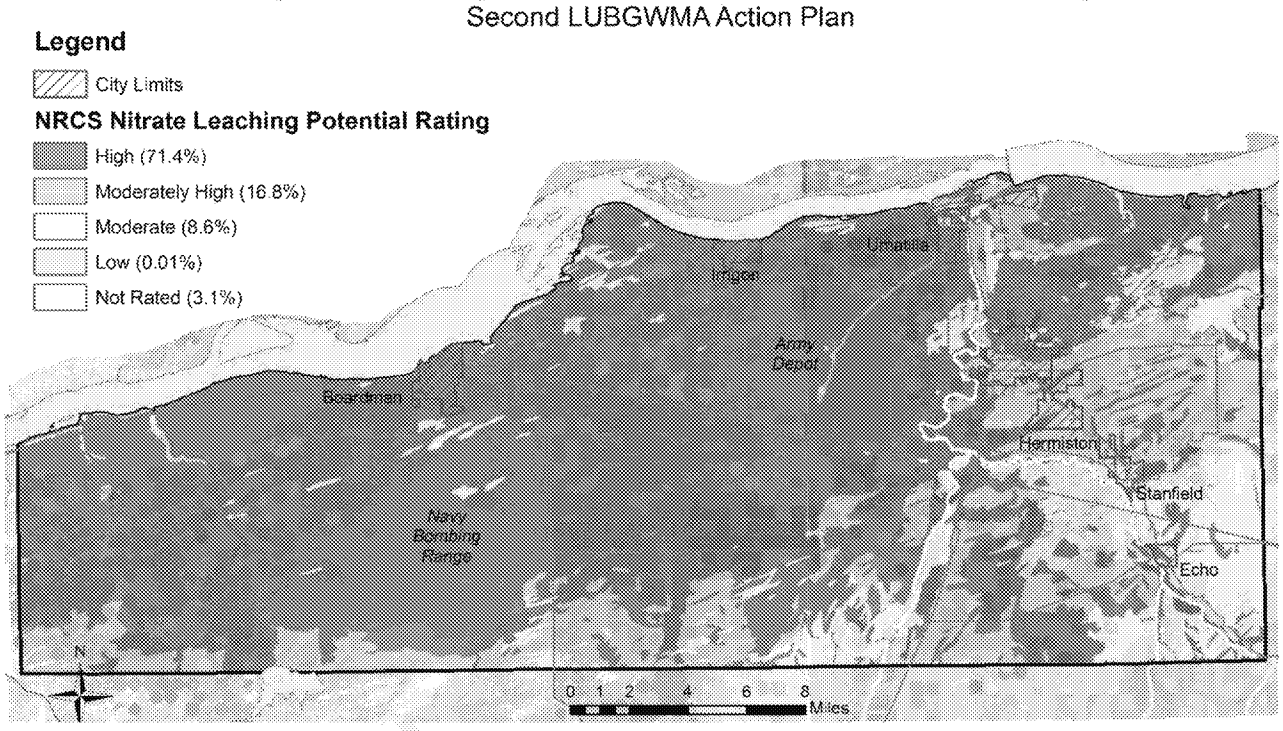
4. Depth and duration of water table and
5. Slope gradient adjusted for hydrologic soil group.

The NRCS calculated Nitrate Leaching Potential for Irrigated Condition Rating Classes are both textual and numeric. The textual classes are termed Low, Moderate, Moderately High, and High. The NRCS tool was used to produce reports of the Nitrate Leaching Potential for Irrigated Conditions for the entire LUBGWMA. Results are presented in Figure 2-3 and indicate that 71.4% of the area has a High potential, 16.8% has a Moderately High potential, 8.6% has a Moderate potential, 3.1% are not rated, and 0.01% has a Low potential. In general, the nitrate leaching potential increases from east to west across the GWMA. The fact that 88% of the area has a moderately high or high potential for nitrate leaching highlights the vulnerability of the shallow aquifer to contamination.

Figure 2-3
Nitrate Leaching Potential Rating of the Lower Umatilla Basin Groundwater Management Area
Second LUBGWMA Action Plan



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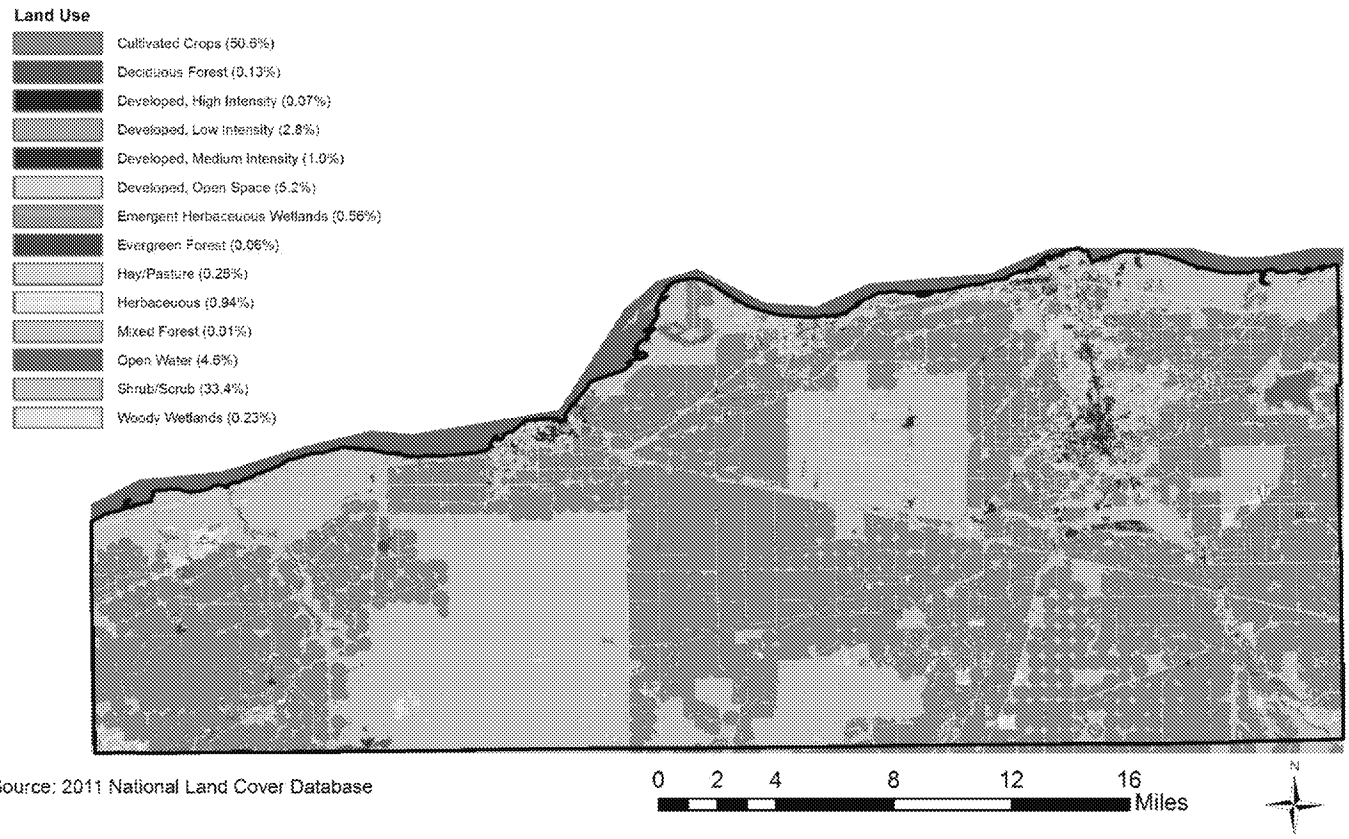
2.1.8 Land Use

Figure 2-4 shows the land use in the LUBGWMA as of 2011. Data used to create this image is from the National Land Cover Database created by the multi-agency effort known as the Multi-Resolution Land Characteristics Consortium.

Figure 2-4
Land Use in the Lower Umatilla Basin Groundwater Management Area
Second LUBGWMA Action Plan



Source: 2011 National Land Cover Database

As shown in Figure 2-4, cultivated crops occupy the largest percentage of land (50.6%) in the LUBGWMA. This category includes areas used for the production of annual crops such as vegetables, and also perennial woody crops such as orchards and vineyards. This category also includes all land being actively tilled. The second largest land use category is shrub/scrub at 33.4%. This land use category includes areas dominated by shrubs less than 5 meters tall. The largest contiguous areas of this land use category in the LUBGWMA include the Umatilla Depot and the Navy Bombing Range. The third largest land use category in the LUBGWMA is Developed Open Space. This land use category includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes. Development of all types (i.e., high intensity, medium intensity, low intensity, and open space) account for 9.1% of the area.

The high percentage of land being used for cultivated crops illustrates the potential for widespread groundwater nitrate contamination from agricultural activities. The potential for groundwater nitrate contamination from other land uses is more geographically limited than agricultural activities.

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2.2 Health Concerns

2.2.1 What is nitrate?

Nitrate is a naturally occurring oxide of nitrogen and is an essential component of all living things. It is the primary source of nitrogen for plants, and it occurs naturally in soil and water. If the concentrations of nitrate get too high, it can pose a potential health risk. Sources of excess nitrate in water include fertilizers, septic systems, wastewater treatment effluent, animal wastes, industrial wastes, and food processing wastes. By applying nitrogen fertilizers, burning fossil fuels, and replacing natural vegetation with nitrogen-fixing crops, humans have doubled the rate of nitrogen deposition onto land over the past 50 years. Nitrate levels can be high in streams and rivers due to runoff of nitrogen fertilizer from agricultural fields and urban lawns.

Groundwater is susceptible to contamination from many different chemicals, including nitrate fertilizers, especially where the water table is shallow and there are no confining units to reduce migration downward. Most of these contaminated groundwaters flow into streams and rivers, causing elevated nitrate levels in those water bodies downstream. Water samples collected from both private and public wells in Oregon over the past twenty years show that nitrate levels in some wells may approach or exceed the historic level considered safe for drinking water. The U.S. Geological Survey (USGS) has studies that indicate that about 20 percent of the wells in agricultural areas of the U.S. exceed the maximum contaminant level set by the U.S. Environmental Protection Agency (EPA).

Oregon has designated three Groundwater Management Areas because of elevated nitrate concentrations in groundwater. These include the Lower Umatilla Basin GWMA, the Northern Malheur County GWMA, and the Southern Willamette Valley GWMA. Each one has developed a voluntary action plan to reduce nitrate concentrations in groundwater. High nitrate levels in surface water contribute to algae blooms and may result in elevated levels of disinfection by-products in treated drinking water. Disinfection byproducts have been linked to increased cancer and reproductive health risks in humans as well as liver, kidney and central nervous system problems.

2.2.2 Nitrate Health Risk

U.S. EPA has set a maximum contaminant level of 10 mg/L or ppm for nitrate for drinking water. Nitrate levels above 10 ppm may present a serious health concern for infants and pregnant or nursing women. Adults receive more nitrate exposure from food than from water. Infants, however, receive the greatest exposure from drinking water because most of their food is in liquid form. This is especially true for bottle-fed infants whose formula is reconstituted with drinking water with high nitrate concentrations. Nitrate can interfere with the ability of the blood to carry oxygen to vital tissues of the body in infants of six months old or younger. The resulting illness is called methemoglobinemia, or "blue baby syndrome".

Pregnant women may be less able to tolerate nitrate, and nitrate in the milk of nursing mothers may affect infants directly. These persons should not consume water containing more than 10 mg/L nitrate directly, added to food products, or beverages (especially in baby formula).

Little is known about the long-term effects of drinking water with elevated nitrate levels. Some research has suggested that nitrate may play a role in spontaneous miscarriages, thyroid disorders, birth defects, and in the development of some cancers in adults. Recent human epidemiologic studies have shown that nitrate ingestion may be linked to gastric or bladder cancer. The most likely mechanism for human cancer related to nitrate is the body's formation of N-nitroso compounds or NOCs , which have been shown to cause tumors at multiple organ sites in every animal species tested, including neurological system cancers following transplacental exposure. Nitrite, the reduced form of nitrate, reacts in the acidic stomach to form nitrosating agents that then react with certain compounds from protein or other sources such as medications to form NOCs. In humans, it is the nitrosamines and NOCs that are suspected brain and central nervous system carcinogens. Additional epidemiologic and research studies are needed to verify these links and identify any other potential nitrate-related cancer risks. Links to supporting information are provided at the end of this section. One associated human health

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concern is that water supplies showing nitrate contamination have the potential for other contaminants, such as bacteria and pesticides, to reach groundwater along with the nitrate. In a 2009 report on the quality of water in domestic wells, the USGS found that contaminants such as nitrate (nutrients) co-occurred with other contaminants in 73 percent of wells tested in the study.

2.2.3 Actions to Take

- The following actions are recommended for wells contaminated by high levels of nitrate (10 ppm or above):
  - Infants, pregnant/nursing women, and other sensitive individuals should stop drinking well water.
  - If you are using infant formula, make sure that it is prepared with bottled water, or use pre-mixed formula.
- The following actions are recommended if you choose to treat your water to remove nitrate:
  - Use systems with reverse osmosis, distillation, or ion exchange. Remember that these treatment systems require careful maintenance for effective operation.
  - Use a treatment system with National Sanitation Foundation (NSF) certification. For additional information on these options, contact the Drinking Water Section of the Oregon Health Authority at 971-673-0405 or at the website http://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/DRINKINGWATER/SOURCEWATER/DOMESTICWELLSAFETY/pages/index.aspx .
  - Boiling water does not help because it actually concentrates the nitrate, as the water boils away. Charcoal filters, water softeners, or use of chlorine does nothing to remove nitrate from water.
- The following actions are recommended for all well owners.
  - Monitor your well water nitrate levels at least once per year (in the spring or summer) and keep records. To protect the health of your family, annual well water tests should also be made for bacteria. For more information on laboratories in Oregon that can test your water, contact the Drinking Water Section of the Oregon Health Authority at 971-673- 0405.
  - Water containing high nitrate levels can be safely used for bathing, cleaning dishes, washing laundry, or other uses where water is not ingested.
  - Identify any potential sources of nitrate on your property and find ways to manage those sources.

Levels of nitrate in your well above 3 ppm indicate that shallow groundwater drawn by your well may be vulnerable to other types of contaminants moving through the soil, including pesticides. Examine your property and the surrounding area for sources of other contaminants. Consider testing for these chemicals if you think your water may be at risk.

2.2.4 Where do I look for more information?

For more information on nitrate and groundwater protection, consult these websites.

For general information on groundwater quality protection:
http://www.oregon.gov/deq/wq/programs/Pages/GWP.aspx

For information on private wells and well water treatment:
http://www.oregon.gov/deq/wq/programs/Pages/DWP-Private-Well-Owners.aspx

For information on septic systems and groundwater contamination:
https://www3.epa.gov/npdes/pubs/homeowner_guide_long.pdf

For information on drinking water and maximum contaminant levels:
https://www.epa.gov/dwstandardsregulations

For information on Oregon's Groundwater Management Areas:
http://www.oregon.gov/deq/wq/programs/Pages/GWP-Management-Areas.aspx

Final Draft for Public Comment

ED_005296_00000290-00023

For information on federal efforts to evaluate nutrient pollution:
https://www.epa.gov/nutrient-policy-data/what-epa-doing-reduce-nutrient-pollution

For information on the most recent cancer related research:
https://progressreport.cancer.gov/node/95

For information on national USGS research on nutrients:
http://water.usgs.gov/nawqa/nutrients/

Final Draft For Public Comment

ED_005296_00000290-00024

2.3 Potential Sources of Nitrate Contamination

The technical investigation which lead to the first LUBGWMA Action Plan in 1997 identified five activities contributing to nitrate contamination:

1. Irrigated agriculture,
2. Land application of food processing wastewater,
3. Confined animal feeding operations (all dairies and feedlots),
4. Domestic sewage where septic systems occur in high densities and
5. The U.S. Army Umatilla Chemical Depot's (UMCD) washout lagoons.

In 2011, DEQ, OSU Extension and ODA prepared a document titled *Estimation of Nitrogen Sources, Nitrogen Applied, and Nitrogen Leached to Groundwater in the Lower Umatilla Basin Groundwater Management Area* (DEQ, 2011) that estimates the relative contributions of each of the five sources of nitrate identified in the LUBGWMA Action Plan: irrigated agriculture, confined animal feeding operations (CAFOs), rural residential development (including septic systems, landscaping, and pastures), food processor wastewater application, and the UMCD bomb washout lagoon. In addition, the contribution from lawns and vegetable gardens within city limits is also included in the estimate. Figures 1, 2, and 3 of the 2011 document show the results of the estimate, and indicates irrigated agriculture is the largest contributor.

Figure 2-5
Estimation of Nitrogen Leached to Groundwater
Second LUBGWMA Action Plan

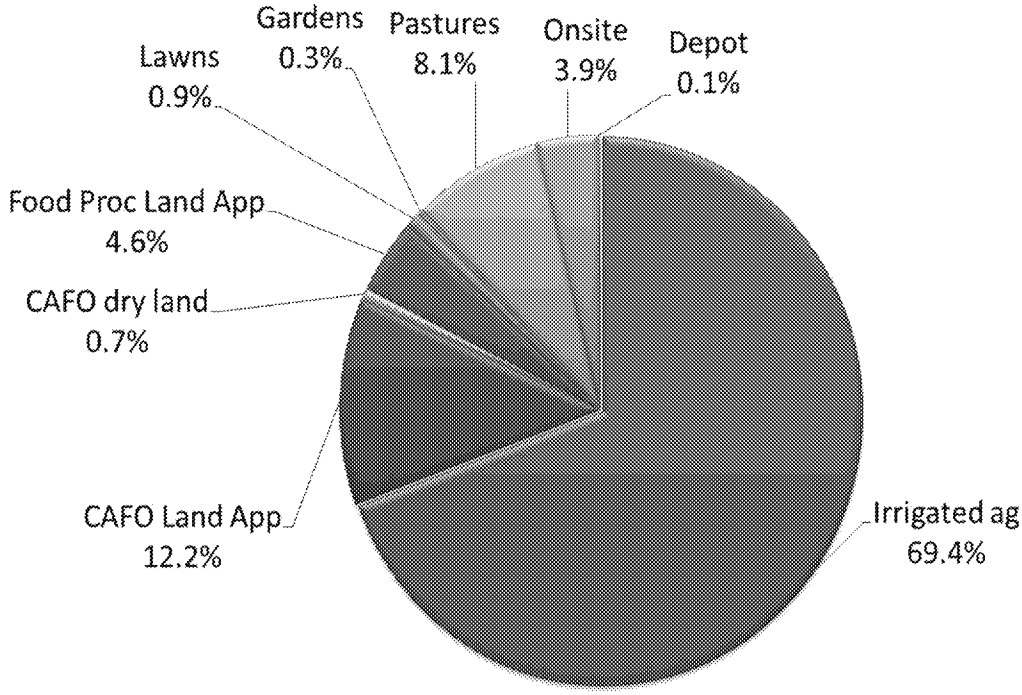

Figure 2-5 is an updated version of the final pie chart from the 2011 document. It shows the 2011 loading estimate of CAFO waste that was land applied subtracted from the irrigated agriculture. It is worth noting that the 2011 estimate also uses the data from 2004 through 2007. Updated information (e.g., number of animals at CAFOs, number of acres of various crops) could result in differing percentages being attributed to the various sources.

During preparation of this LUBGWMA Local Action Plan, the Committee decided not to focus on the UMCD as a significant source of nitrate contamination, as it is being addressed under federal and state cleanup authorities and regulations by EPA and DEQ. It is currently remediated and contained by a groundwater pump & treat system and represents an estimated contribution of only about 0.1%.

Supporting rationale for this decision includes the fact that the existing groundwater pump and treat system has substantially reduced groundwater nitrate concentrations in the area, is effectively containing the residual

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contaminant plume, and the relatively small impacted area (but relatively concentrated impact prior to remediation) of the bomb washout lagoon on the regional scale of the LUBGWMA.

2.4 Previous Groundwater Sampling Studies and Results

This section describes the supporting rationale and results of various groundwater sampling studies that have been conducted in the LUBGWMA. The referenced reports are available upon request for those readers interested in reading them.

2.4.1 Rationale for Well Networks

This section provides the rationale for the various well networks and sampling programs used by DEQ to evaluate groundwater nitrate concentrations and trends in the LUBGWMA.

2.4.1.1 Reconnaissance Sampling

The groundwater quality assessment project characterizing Lower Umatilla Basin groundwater quality began with reconnaissance sampling conducted from July 1990 through September 1991. A total of 198 wells were sampled during the 15-month period. The intent of the sampling was to preliminarily:

- Understand the general chemistry of local groundwater,
- Identify the contaminant list and concentration range of contaminants present in local groundwater,
- Identify the extent of groundwater contamination, and
- Help establish the project boundaries.

Final Draft For Public Comment

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2.4.1.2 LUBGWMA Well Network

Bi-monthly (i.e. every other month) groundwater sampling at a specific group of 38 wells began in September 1991. For budgetary reasons, DEQ reduced the sampling frequency from six times per year to four times per year in 2011. An analysis was conducted to identify which months could be dropped from the sampling program with the least impact on the ability to detect trends. It was determined that the January and July events would be dropped. Because the wells are no longer sampled bimonthly, it is now called the LUBGWMA well network.

The intent of the LUBGWMA well network was to determine seasonal variability and trends over time. The network was established after reviewing water chemistry and well construction data collected from the 198 wells sampled during the reconnaissance phase. The network wells were chosen for their hydrogeological placement, geographic location and groundwater chemistry characteristics. The selection process involved two steps.
Step one involved:

- DEQ and/or OWRD staff locating and observing the wells during the reconnaissance sampling,
- Confirming the well was completed in alluvium only or completed in a single basalt water-bearing zone, and
- Confirming the well would be accessible throughout the year for sampling.

Step two involved selecting wells if they met one or more of the following criteria:

- The well is a member of a group of wells positioned along a groundwater flow path,
- The well provides data for an isolated geographic location,
- Groundwater from the well had moderate to high levels of nitrate, and
- Wells that had confirmed levels of pesticide or volatile organic compound detections.

The selection process resulted in most wells in the network being private domestic wells. The data from this network is intended to provide information about seasonal and long-term nitrate trends at different locations and along selected groundwater flow paths. The first LUBGWMA Action Plan and this Local Action Plan identifies this well network as the primary source of information utilized to evaluate nitrate trends in the GWMA.

2.4.1.3 Synoptic Sampling Events

Synoptic means "conditions as they exist *simultaneously* over a broad area". The first synoptic sampling event was conducted in 1992, and involved approximately 250 samples. The intent of the synoptic event was to give a "point in time" area-wide snap shot of groundwater quality. The goals of the synoptic sampling event were to:

- Establish regional concentrations and distribution of nitrate and other chemicals in alluvial groundwater illustrated by iso-chemical maps,
- Establish the chemical identification of recharge water carrying nitrate to groundwater,
- Identify source(s)/surface activity contaminating alluvial groundwater with nitrate,
- Identify and quantify the transport of nitrate in alluvial groundwater, and
- Identify and quantify the chemical fate/evolution of nitrate in the groundwater.

Subsequent synoptic sampling events have been conducted in 2003, 2009, and 2015. The goal of the subsequent sampling events was to provide additional snapshots of groundwater quality. This also allows a comparison of sampling events that contained a large amount of wells sampled infrequently to events that contained a small amount of wells sampled frequently. Wells were selected for inclusion in subsequent synoptic sampling events if they were included in previous synoptic sampling events and/or if they provided data for an isolated geographic location not previously sampled.

2.4.1.4 Permitted Facility Well Networks

Oregon's Groundwater Quality Protection Rules [OAR 340-040-0030(2)] require a groundwater quality protection program for permitted facilities that have the potential for adverse impacts to groundwater quality. Given the vulnerability of the aquifer in the LUBGWMA and waste and wastewater characteristics and volume, many of the sites that land apply waste from food processing facilities and CAFOs have the potential for adverse impacts to groundwater quality. As part of their groundwater quality protection program, these facilities are required to operate a groundwater monitoring well network that is capable of determining rate and direction of

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groundwater movement, and monitoring the groundwater quality immediately upgradient and downgradient from the waste management area. If downgradient concentrations exceed concentration limits based on site-specific upgradient concentrations for any contaminant not listed in Table 3 of the Rules[2], the facility is then required to conduct a remedial investigation and feasibility study, and implement the appropriate remedial actions.

Many of these permitted facility well networks are located in largely or wholly agricultural areas. Given the general scarcity of alluvial aquifer wells in agricultural areas, the upgradient wells at these land application sites are often the best available gauge of the groundwater quality in agricultural areas.

2.4.2 Scope of Initial Characterization – July 1990 through March 1993

The first large scale study of the region's groundwater quality was conducted shortly after Oregon's Groundwater Quality Protection Act was passed in 1989 and the Lower Umatilla Basin Groundwater Management Area was declared. Five state agencies (DEQ, OWRD, OHA, ODA, and OSU) began coordinating a groundwater quality investigation in July 1990. Groundwater quality sampling included reconnaissance sampling, bimonthly sampling, synoptic sampling, and nitrogen isotope sampling, with each type serving a different purpose. Results of the initial characterization are described in the 1995 Report called *Hydrogeology, Groundwater Chemistry, and Land Uses in the Lower Umatilla Basin Groundwater Management Area* (Grondin, et. al., 1995).

2.4.3 Results of Reconnaissance Sampling

As discussed above, characterizing Lower Umatilla Basin groundwater quality began with reconnaissance sampling conducted from July 1990 through September 1991. DEQ staff collected 206 samples, including well waters, surface waters and QA/QC samples. The sampling effort provided a basic understanding of the nature, extent, and concentration range of contaminants in the basin. That understanding informed decisions about subsequent groundwater sampling events, laboratory analyses, and data analysis. Results of the reconnaissance sampling are fully described in Grondin et. al., (1995). A brief summary of the results follows.

The reconnaissance sampling indicated area-wide nitrate contamination, elevated levels of total dissolved solids, and scattered pesticide/industrial chemical detections. The highest nitrate concentration detected was 76 mg/L from an irrigation well located within a center pivot field[3]. About 25% of samples contained more than 10 mg/L nitrate, and 37% exceed the 7 mg/L GWMA trigger level. The median nitrate concentration was 4.25 mg/L.

2.4.4 Results of LUBGWMA Well Network

The rationale for the LUBGWMA network is described in Section 2.4.1.2. The first LUBGWMA Action Plan identified this well network as the primary source of information to be used to evaluate nitrate trends in the GWMA. The Action Plan also included a goal of a downward trend in nitrate levels throughout most of the GWMA by 2009.

For a variety of reasons (including failed pumps and changing property ownership), some of the original wells have been dropped from the well network. As of the date of this report, 31 of the original 38 wells are still being sampled. Two additional wells were added to the well network in 2012.

The following sections describe nitrate trends at individual wells, average nitrate concentrations at individual wells, the area-wide trend, seasonal trends, and concludes with a discussion of indications of improving and worsening water quality in the LUBGWMA.

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[2] Table 3 includes chloride, color, copper, foaming agents, iron, manganese, odor, pH, sulfate, total dissolved solids, and zinc.
[3] A nitrate concentration of 160 mg/L was reported from a sample collected from a 200-foot deep industrial well near Hermiston in October 1990. However, this well was sampled the next month and reportedly contained 22 mg/L. This well was also included in the bimonthly sampling program, and was sampled 76 more times over the next 14 years. The well averaged about 15 mg/L over that time and was never more than 30 mg/L. The initial result of 160 mg/L appears to be an anomaly. It may be a sampling error, a laboratory analysis error, a transcription error, or even a real value representing a short term event.

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Trend Analyses

The 2012 document titled *Analysis of Groundwater Nitrate Concentrations in the LUBGWMA* (DEQ, 2012) included an evaluation of nitrate trends through 2009[4] at 201 wells, including the 38-well LUBGWMA network specifically designed for evaluating this goal. The LUBGWMA well network exhibited 55% increasing trends, 21% decreasing trends, 3% flat trends, and 21% statistically insignificant trends (i.e., the direction and magnitude of the trend is uncertain). When this data set was used to calculate an area-wide trend, results indicate the regional nitrate trend had been increasing since at least 1997 and continued to increase, although generally at slower and slower rates.

A second evaluation of nitrate trends in the LUBGWMA well network was conducted using data from September 1991 through May 2016. Table 2-1 shows summary statistics and the trend for each network well. Table 2-2 shows a comparison of these nitrate trends by magnitude. Figure 2-6 illustrates the nitrate trends at the LUBGWMA Well Network wells while Figure 2-7 illustrates the average nitrate concentrations at those wells over the same time frame.

Final Draft For Public Comment

[4] The earliest data available for analysis varied from well to well (from June 1987 to June 2000) but typically was from the early 1990s.

ED_005296_00000290-00029

Trends at Individual Wells

As indicated in Table 2-1, there are more increasing trends than decreasing trends within the network. Of the 31 wells that have been sampled since 1991, 16 (52%) exhibit increasing trends, 10 (32%) exhibit decreasing trends, 1 (3%) exhibit a flat trend, and 4 (13%) exhibit statistically insignificant trends. The average slope of all trends is increasing.

Table 2-1
Individual Well Nitrate Trends - LUB GWMA Well Network
Second LUBGWMA Action Plan

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction
	Starting Date	Ending Date	Minimum	Maximum	Mean	Median	n	% BDL	Slope (ppm/yr)	Confidence Level	
JMA033	Sep-91	May-16	2.58	13.8	7.29	6.98	105	0%	0.002	30%	NS80
JMA034	Sep-91	May-16	0.186	7.37	3.82	3.5	97	0%	0.04	99%	Increasing
JMA038	Sep-91	May-16	1.09	9.68	3.93	2.7	92	0%	-0.08	99%	Decreasing
JMA046	Sep-91	May-16	0.19	4.9	0.85	0.6	98	0%	-0.02	99%	Decreasing
JMA048	Sep-91	May-16	1.90	3.82	2.08	1.9	97	0%	0.04	99%	Increasing
JMA066	Sep-91	May-16	0.58	7.32	6.13	6.2	89	0%	-0.05	99%	Decreasing
JMA084	Sep-91	May-16	3.61	22	10.2	10.45	90	0%	-0.18	99%	Decreasing
JMA094	Sep-91	May-16	4.62	13	8.54	8.2	97	0%	-0.08	99%	Decreasing
JMA096	Sep-91	May-16	12.8	42.8	31.7	32.8	101	0%	0.47	99%	Increasing
JMA103	Sep-91	May-16	9.1	30.5	21.2	21.7	91	0%	0.15	99%	Increasing
JMA109	Sep-91	May-16	1.3	7.22	4.21	4	93	0%	0.15	99%	Increasing
JMA110	Sep-91	May-16	1.89	21	8.31	6.850	98	0%	0.31	99%	Increasing
JMA112	Sep-91	May-16	0.97	5.5	2.66	2.60	100	0%	-0.14	99%	Decreasing
JMA116	Sep-91	May-16	2.3	5.15	3.95	3.98	97	0%	0.04	99%	Increasing
JMA119	Sep-91	May-16	3.5	22.4	13.0	13.3	102	0%	0.08	93%	Increasing
JMA133	Sep-91	May-16	1.8	35	16.6	16.7	101	0%	-0.59	99%	Decreasing
JMA144	Sep-91	May-16	1.46	42.3	13.9	12.3	97	0%	-0.12	96%	Decreasing
JMA156	Sep-91	May-16	2.86	32	18.6	18.6	96	0%	-0.10	99%	NS80
JMA160	Sep-91	May-16	<0.005	27.5	4.29	1.01	94	15%	0.14	99%	Increasing
JMA168	Sep-91	May-16	0.68	5.8	2.87	2.90	97	0%	-0.13	99%	Decreasing
JMA180	Sep-91	May-16	<0.02	29.2	7.44	5.41	80	1%	0.78	99%	Increasing
JMA185	Sep-91	May-16	0.006	0.184	0.14	0.14	88	0%	0.001	99%	Increasing
JMA187	Sep-91	May-16	<0.005	0.134	0.0056	<0.005	91	89%	0	nc	Flat
JMA190	Sep-91	May-16	<0.005	11	2.56	2.15	92	2%	0.038	91%	Increasing
JMA191	Sep-91	May-16	0.16	6.11	0.98	0.86	97	0%	-0.005	70%	NS80
JMA198	Sep-91	May-16	5.60	58.1	21.8	19.4	91	0%	0.85	99%	Increasing
JMA201	Sep-91	May-16	3.36	36.8	21.1	21.9	96	0%	0.81	99%	Increasing
JMA312	Mar-12	May-16	5.55	9.26	7.5	7.24	17	0%	0.74	99%	Increasing
JMA313	Mar-12	May-16	0.18	0.426	0.3	0.322	17	0%	-0.03	99%	Decreasing
JMA029	Sep-91	May-16	25.5	61.3	41.7	44	93	0%	-0.58	99%	Decreasing
JMA047	Sep-91	May-16	2.5	4.18	3.38	3.40	94	0%	0.06	99%	Increasing
JMA106	Sep-91	May-16	0.42	2.02	0.96	0.851	98	0%	0.003	70%	NS80
JMA164	Sep-91	May-16	<0.02	6.12	4.11	4.44	92	1%	0.12	99%	Increasing

Notes:
nc = not calculated
n = number of samples
BDL = below detection limit
NS80 = not significant at an 80% confidence level
[ ] = well only sampled since March 2012

	31 Long Term Wells	All 33 Wells
# of Increasing Trends ==>	16	17
# of Decreasing Trends ==>	10	11
# of Flat Trends ==>	1	1
# of Insignificant Trends ==>	4	4
Avg slope of significant trends at the wells ==>	0.08	0.10
Avg slope of all trends at the wells ==>	0.07	0.07

The trends summarized in Table 2-1 are grouped by magnitude in Table 2-2. Small trends are defined as up to 0.1 milligrams per liter per year (or parts per million per year (ppm/yr)). Medium trends are defined as between 0.1 and 0.5 ppm/yr. Large trends are defined as greater than 0.5 ppm/yr. As indicated in Table 2-2, there are more small, medium, and large increasing trends than small, medium, and large decreasing trends. When comparing trend *magnitudes*, the average slope of small decreasing trends is steeper than the average slope of small increasing trends, but the average slope of medium and large increasing trends is steeper than medium and large decreasing trends. In summary, comparing nitrate trends by magnitude indicates nitrate concentrations are going up more than they are going down.

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Table 2-2
Summary of Individual LUBGWMA Well Trends by Magnitude
Second LUBGWMA Action Plan

Sept 1991 through May 2016
31 Long Term Wells

Trend Magnitude	# of Wells with Increasing Trends	Average slope of Increasing Trends (ppm/yr)	# of Wells with Decreasing Trends	Average slope of Decreasing Trends (ppm/yr)	# of wells with Flat Trend	Slope of Flat Trend (ppm/yr)	# of Wells with Statistically insignificant Trends	Average slope of Statistically insignificant Trends (ppm/yr)
Small (up to 0.1 ppm/yr)	7	0.04	4	**-0.05**			4	-0.02
Medium (0.1 to 0.5 ppm/yr)	6	**0.22**	4	-0.14			0	
Large (greater than 0.5 ppm/yr)	3	**0.82**	2	-0.57			0	
TOTAL	16 (52%)		10 (32%)		1 (3%)	0.00	4 (13%)	
OVERALL AVERAGE		**0.26**		-0.19				

Sept 1991 through May 2016
All 33 Wells

Trend Magnitude	# of Wells with Increasing Trends	Average slope of Increasing Trends (ppm/yr)	# of Wells with Decreasing Trends	Average slope of Decreasing Trends (ppm/yr)	# of wells with Flat Trend	Slope of Flat Trend (ppm/yr)	# of Wells with Statistically insignificant Trends	Average slope of Statistically insignificant Trends (ppm/yr)
Small (up to 0.1 ppm/yr)	7	0.04	5	**-0.05**			4	-0.02
Medium (0.1 to 0.5 ppm/yr)	6	**0.22**	4	-0.14			0	
Large (greater than 0.5 ppm/yr)	4	**0.80**	2	-0.57			0	
TOTAL	17 (52%)		11 (33%)		1 (3%)	0.00	4 (12%)	
OVERALL AVERAGE		**0.28**		-0.17				
bold	= Larger number of wells or steeper trend							

33 Well Summary:

When viewed in total, there are more increasing trends than decreasing trends (52% vs 33%).

When viewed in total, average increasing trends are steeper than average decreasing trends (increasing at 0.28 ppm/yr vs Decreasing at 0.17 ppm/yr).

When viewed by magnitude, there are more increasing trends than decreasing trends in each category (7 vs 5 small, 6 vs 4 medium, and 4 vs 2 large).

When viewed by magnitude, average small decreasing trends are steeper than small increasing trends (0.05 ppm/yr vs 0.04 ppm/yr)

When viewed by magnitude, average medium increasing trends are steeper than medium decreasing trends (0.28 ppm vs 0.17 ppm/yr)

When viewed by magnitude, average large increasing trends are steeper than large decreasing trends (0.80 ppm vs 0.17 ppm/yr)

Figure 2-6 shows the location of the wells and the general magnitude of the nitrate trend (i.e., small, medium, or large) at that well from September 1991 through May 2016. Upward pointing red arrows represent increasing trends while downward pointing green arrows represent decreasing trends. Purple asterisks represent statistically insignificant trends. A blue double-sided horizontal arrow represents the flat trend.

As indicated in Figure 2-6, there does not appear to be a consistent geographic pattern to nitrate trends (i.e., both increasing trends and decreasing trends occur throughout the region). In addition to the lack of a regional geographic pattern, wells showing increasing trends can be relatively close to wells showing decreasing trends. These results reflect some of the complexities affecting the interpretation of groundwater nitrate results discussed later in Section 2.5.2.

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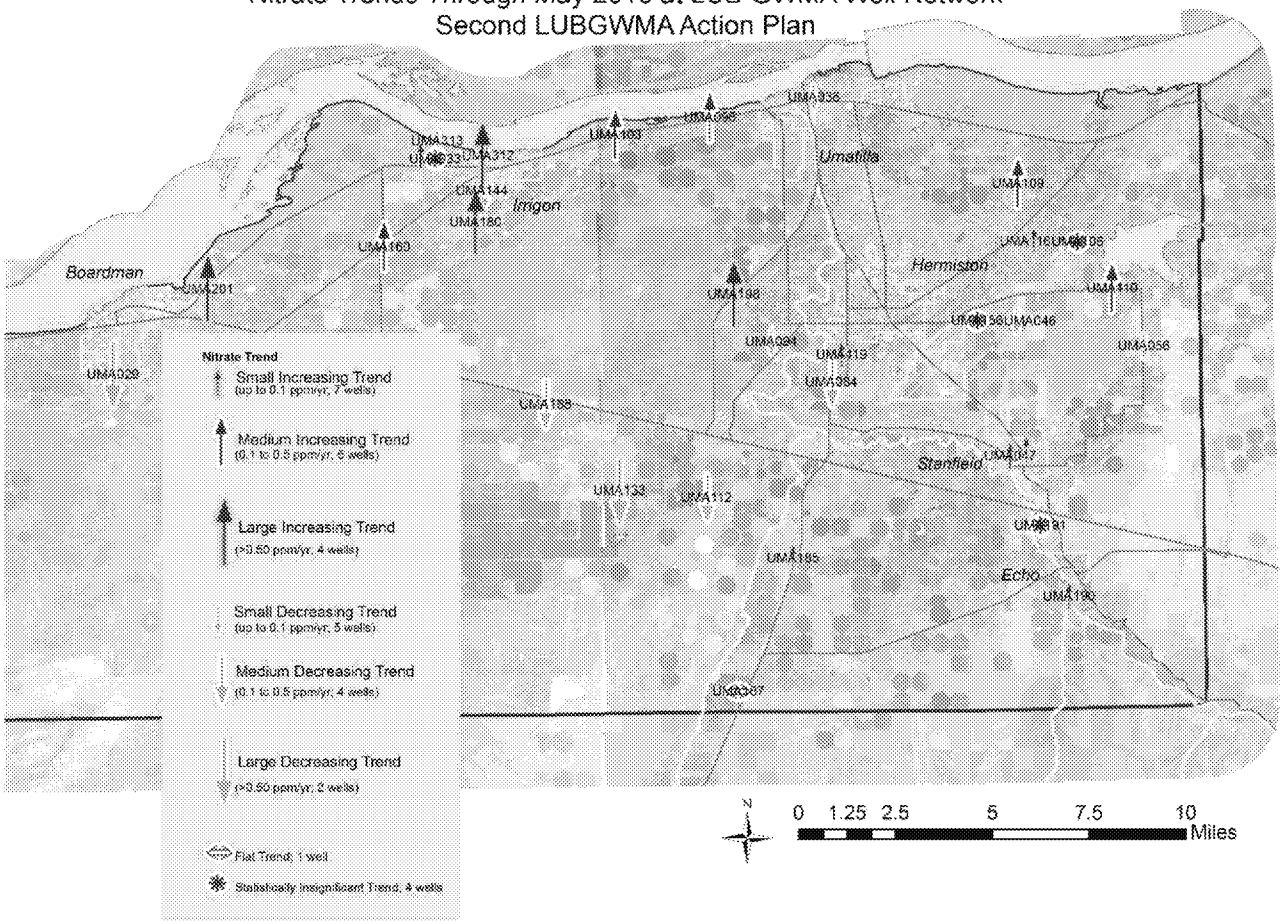
Figure 2-6
Nitrate Trends Through May 2016 at LUB GWMA Well Network
Second LUBGWMA Action Plan



Average Nitrate Concentrations

Figure 2-7 shows the location of the wells and the average nitrate concentration at that well from September 1991 through May 2016 as color-coded dots. Wells with low nitrate concentrations are represented by "cool" colors while wells with higher nitrate concentrations are represented by "warm" colors. As shown in Figure 2-7, wells with lower nitrate concentrations are generally in the southeast portion of the GWMA while wells with higher nitrate concentrations are generally in the north-northwest portion of the GWMA. This pattern is consistent with the generally higher nitrate leaching potential in the western portion of the GWMA as compared to the eastern portion (Section 2.1.7 and Figure 2-3). The long-term average nitrate concentration exceeds the 7 mg/L GWMA trigger level at 45% of the wells. The long-term average nitrate concentration exceeds the 10 mg/L drinking water standard at 30% of the wells.

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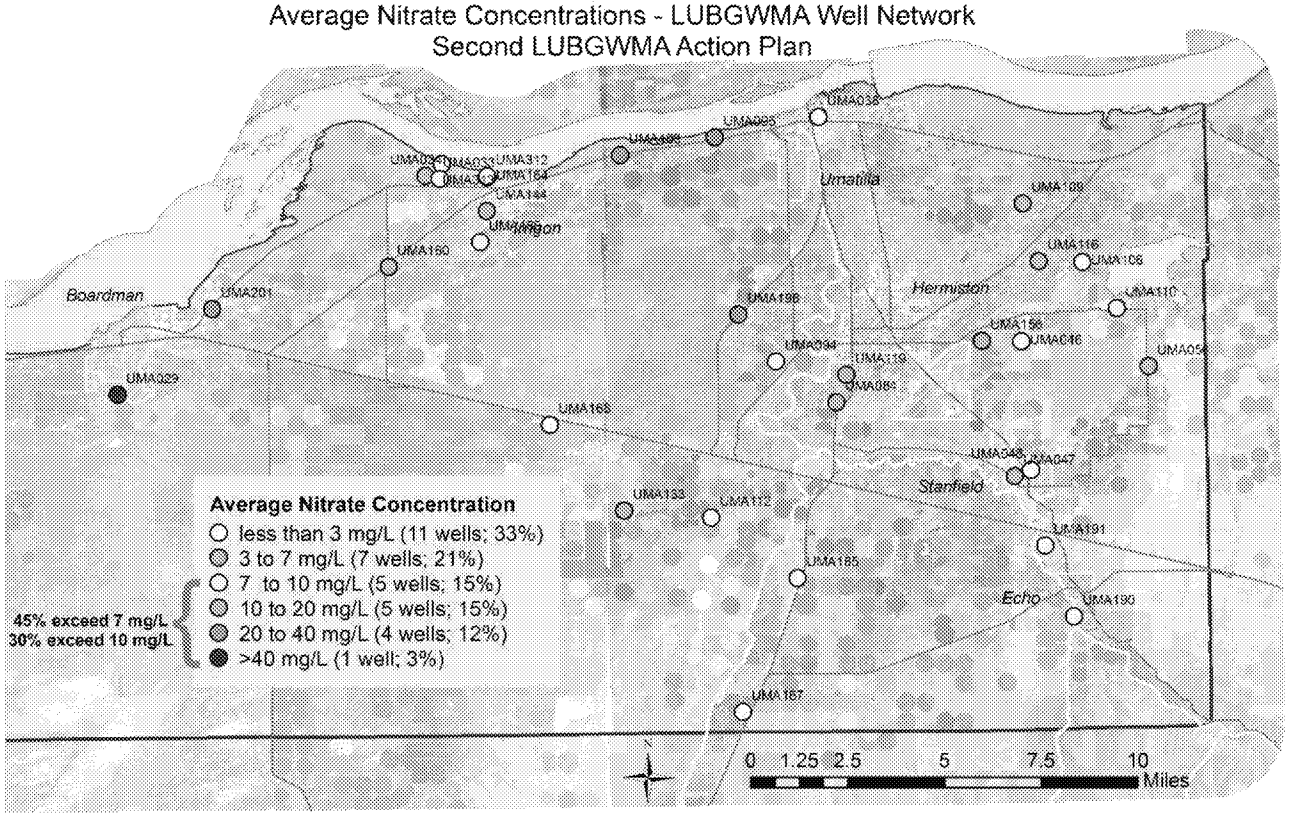
Figure 2-7
Average Nitrate Concentrations - LUBGWMA Well Network
Second LUBGWMA Action Plan



The mix of trends (dominated by increasing trends) discussed above is reflected in changes in average nitrate concentrations. For example, the most recent annual average nitrate concentration (i.e., May 2015 through May 2016; not shown in Table 2-1) is lower than the long-term average in more wells than it is higher. However, the increases in average nitrate concentrations are larger in magnitude than the decreases in average nitrate concentrations. This is reflected in the most recent annual average nitrate concentration (10.51 mg/L) being larger than the long-term average nitrate concentration (9.26 mg/L).

Area-Wide Nitrate Trend

Figure 2-8 shows all nitrate results from the LUBGWMA well network collected in September, November, March, and May as open circles. In addition to the individual data points, the figure also shows the area-wide Regional Kendall trend as a dashed red line and the LOWESS line (which is a data smoothing technique similar to a moving average) as a thick solid blue line. For reference, a thin purple line indicates the 10 mg/L drinking water standard. The figure shows the area-wide trend increases very slightly (0.0024 mg/L per year) over the timeframe of September 1991 through May 2016. The LOWESS line increased until about 2009 then began decreasing.

In order to see the change in trend over time, one year of data was removed from the dataset at a time and the area-wide trend recalculated. Results show the area-wide trend has been increasing since enough data was collected to calculate a trend. The slope of the trend line consistently decreased in magnitude (while remaining positive) from about 0.04 mg/L per year (in 1998) to about 0.005 mg/L per year in 2004. Since 2004, the trend line continues some reduction in slope while also fluctuating, but remains slightly increasing through May 2016 (0.0024 mg/L per year).

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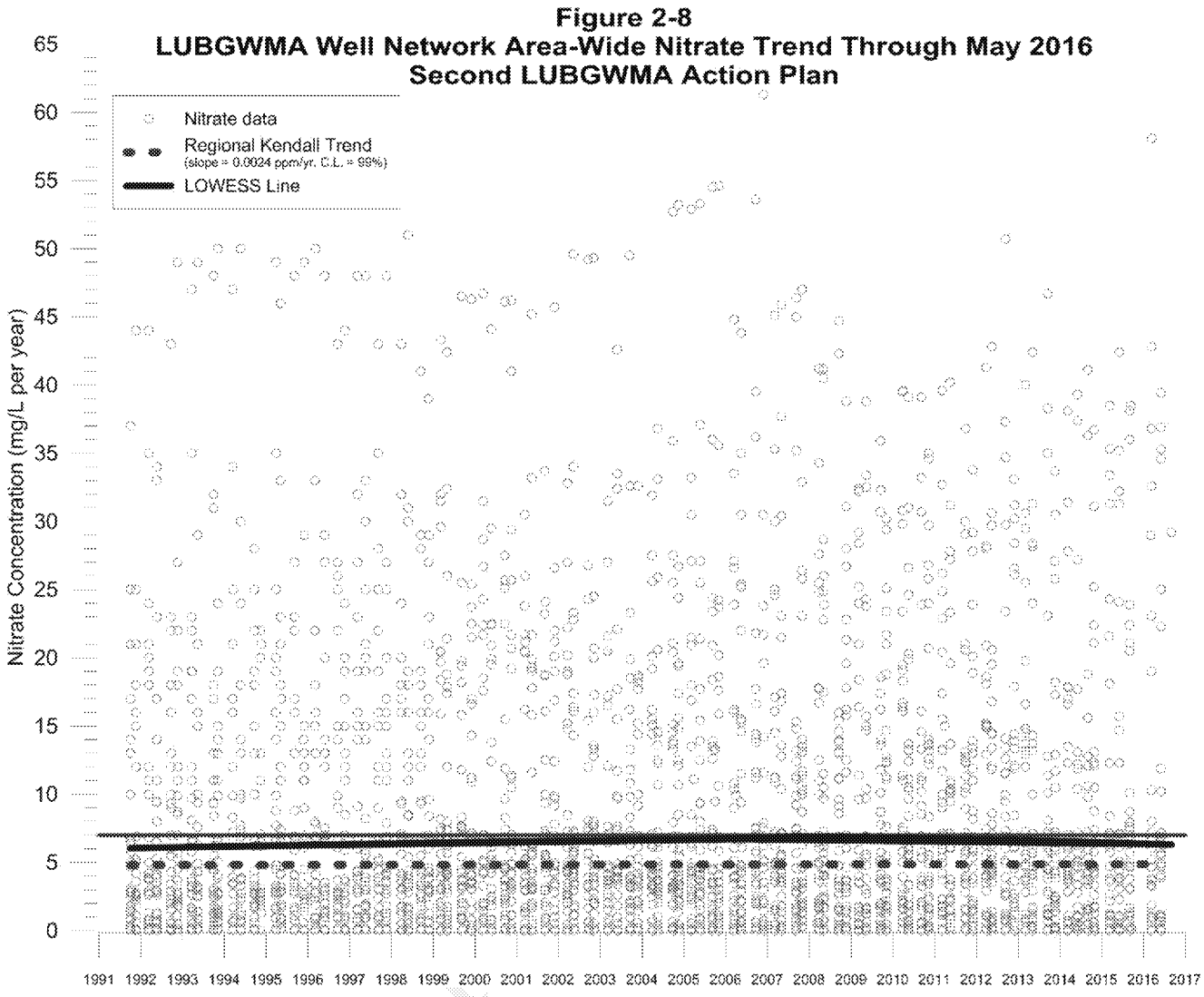

Seasonal Trends

As part of the area-wide trend calculation, the Regional Kendall test calculates individual "seasonal trends" that describe changes in nitrate concentrations at a particular well during a particular time of year (e.g., changes in nitrate concentrations at well #1 during March of every year). When those seasonal trends are examined in total, there are more increasing trends than decreasing trends. In addition, increasing trends are steeper than decreasing trends. When compared by month, there are more increasing trends than decreasing trends in all four months sampled. In addition, increasing trends are steeper than decreasing trends in all four months. Overall, seasonal nitrate trends indicate nitrate concentrations are increasing more than they are decreasing.

DEQ's experience in the Northern Malheur County GWMA shows that before the area-wide trend decreases, decreasing individual seasonal trends will start to dominate in number and magnitude. This is not yet happening in the Lower Umatilla Basin GWMA.

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Indications of Improving and Worsening Water Quality

Table 2-3 summarizes indications of improving and worsening water quality using the LUBGWMA well network data set. The table includes inferences from both the area-wide trend and from the 31 individual wells used to calculate the area-wide trend.

As shown in Table 2-3, there are both indications of improving water quality and worsening water quality. However, there are more indications of worsening water quality including the most important indicator, which is nitrate trends. For example, the area-wide trend continues to increase. Similarly, there are more small, medium, and large increasing trends than small, medium, and large decreasing trends. Medium and large increasing trends are also greater in magnitude than medium and large decreasing trends.

Based on data collected from the LUBGWMA well network, it is conclusive that nitrate concentrations are increasing more than they are decreasing, and that the goal of reducing nitrate concentrations below 7 mg/L has not been met.

Final Draft For Public Comment

ED_005296_00000290-00035

Table 2-3
Indications of Improving and Worsening Water Quality – LUBGWMA Well Network
Second LUBGWMA Local Action Plan

Data Set	Variable	Indications of Improving Water Quality	Indications of Worsening Water Quality
Area-Wide Trend calculated using 31 Long Term Wells *(Sept 1991 through May 2016)*	Overall area-wide nitrate trend	When comparing trends through 2009 to trends through May 2016, Increasing trend is increasing less steeply *(from 0.003 to 0.002 ppm/yr)*	Area-wide trend continues to increase
	Area-wide trends by month (or season)		Overall, there are more increasing trends than decreasing trends; and increasing trends are steeper than decreasing trends. By month, there are more increasing trends than decreasing trends in all four months; and increasing trends are steeper than decreasing trends in all four months
	LOWESS line through all data	Values rise from 1991 through 2008, then decrease through May 2016	Most recent values are higher than initial values
31 Individual Wells *(Sept 1991 through May 2016)*	Number of small, medium, and large trends *Small= up to 0.1 ppm/yr* *Med = 0.1 to 0.5 ppm/yr* *Large = > 0.5 ppm/yr*		All sizes of increasing trends are more frequent than all sizes of decreasing trends *(7 vs 4) Small* *(6 vs 4) Med* *(3 vs 2) Large* *16 increasing vs 10 decreasing*
	Magnitude of small, medium, and large trends	Small decreasing trends are steeper than small increasing trends *(-0.05 vs 0.04 ppm/yr)*	Medium and large increasing trends are steeper than medium and large decreasing trends *(0.22 vs -0.14 ppm/yr) Med* *(0.82 vs -0.57 ppm/yr) Large*
	Average slope of all trends		*Average slope is increasing at 0.07 ppm/yr*
	New minimum concentrations *	23% of wells (7 wells) exhibited new minimum concentrations	
	New maximum concentrations *		32% of wells (10 wells) exhibited new maximum concentrations
	Mean concentrations *	36% of wells (11 wells) exhibited lower mean concentrations	45% of wells (14 wells) exhibited higher mean concentrations
	Median concentrations *	29% of wells (9 wells) exhibited lower median concentrations	55% of wells (17 wells) exhibited higher median concentrations

* = These are not perfect comparisons because sampling frequency at these wells was changed from six times per year to four times per year in 2011. Sampling events occurring in January and July were dropped, and data from those months were not used in subsequent trend analysis calculations or data set summaries. This caused 7 previous minimums and 4 previous maximums to be culled from the data set.

Final Draft For Public Comment

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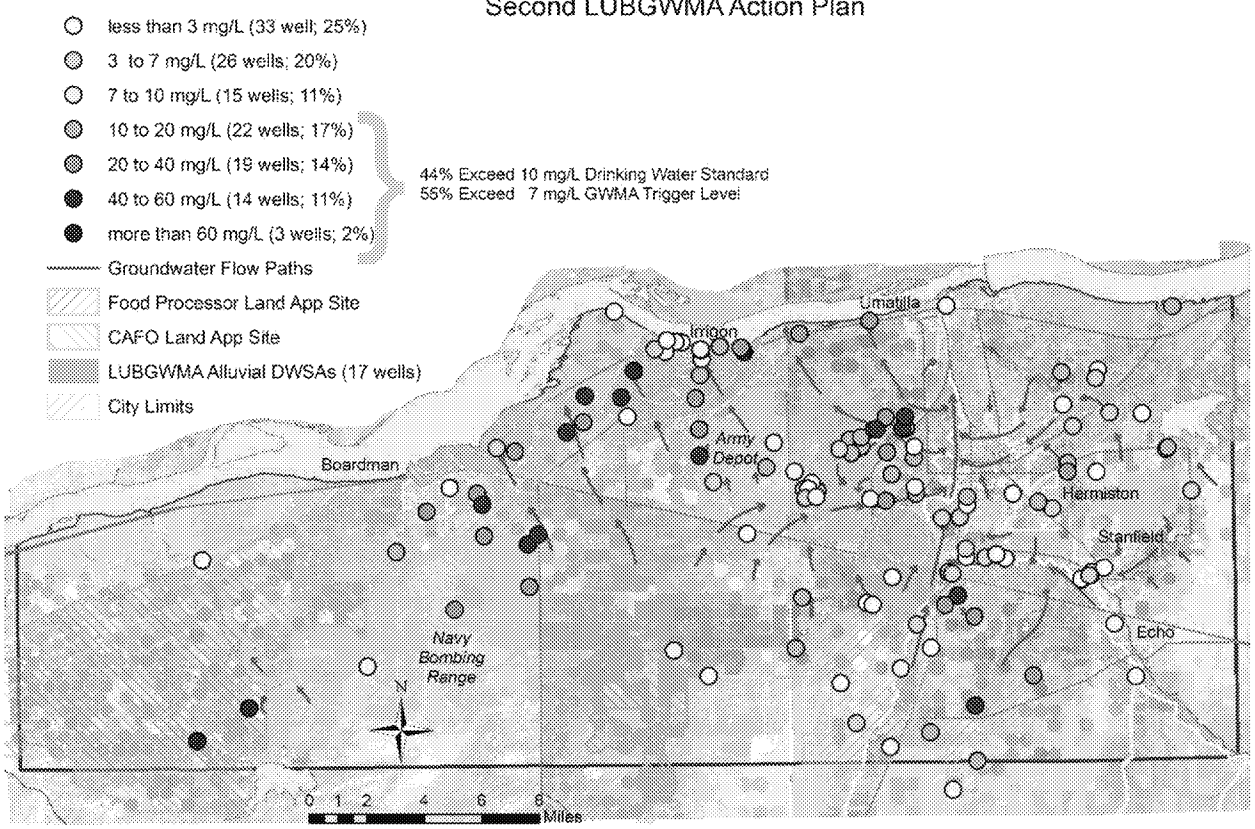
2.4.5 Synoptic Sampling Event Results

As described in Section 2.4.1.3, the first synoptic sampling event was conducted in 1992, and involved approximately 250 samples including 205 wells. Subsequent synoptic sampling events have been conducted in 2003, 2009, and 2015 and involved 107 to 132 wells. These snapshots of groundwater quality allow both a comparison of snapshots over time, as well as a comparison of sampling events that contained a large amount of wells sampled infrequently to events that contained a small amount of wells sampled frequently.

Figure 2-9 illustrates the nitrate results from the fourth synoptic sampling event. The figure shows nitrate results from 132 wells sampled between November 2015 and April 2016, including the LUBGWMA network wells. Most wells were sampled in November and December 2015. Most irrigation wells were not available for sampling until spring of 2016. In addition to the nitrate results, Figure 2-9 also shows the locations of the sites that land apply food processing wastewater, sites that land apply CAFO waste, the locations of the Drinking Water Source Areas for the 17 alluvial aquifer public supply wells, and general groundwater flow paths.

Figure 2-9
Fourth Synoptic Sampling Event Nitrate Results
Second LUBGWMA Action Plan



132 wells sampled between November 2015 and April 2016.

Nitrate results ranged from non-detectable (i.e., < 0.005 mg/L) to 72.6 mg/L with a median of 8.06 mg/L and an average of 15.3 mg/L. The nitrate concentration exceeded the 7 mg/L GWMA trigger level in 55% of the samples. The nitrate concentration exceeded the 10 mg/L drinking water standard in 44% of the wells. These percentages are higher than those of just the LUBGWMA well network sampled at the time (i.e., 42% > 7 mg/L; 32% > 10 mg/L). As discussed in Section 2.4.1.2, the LUBGWMA well network is predominantly private domestic wells. This synoptic sampling event added both monitoring wells and domestic wells, but more monitoring wells than domestic wells.

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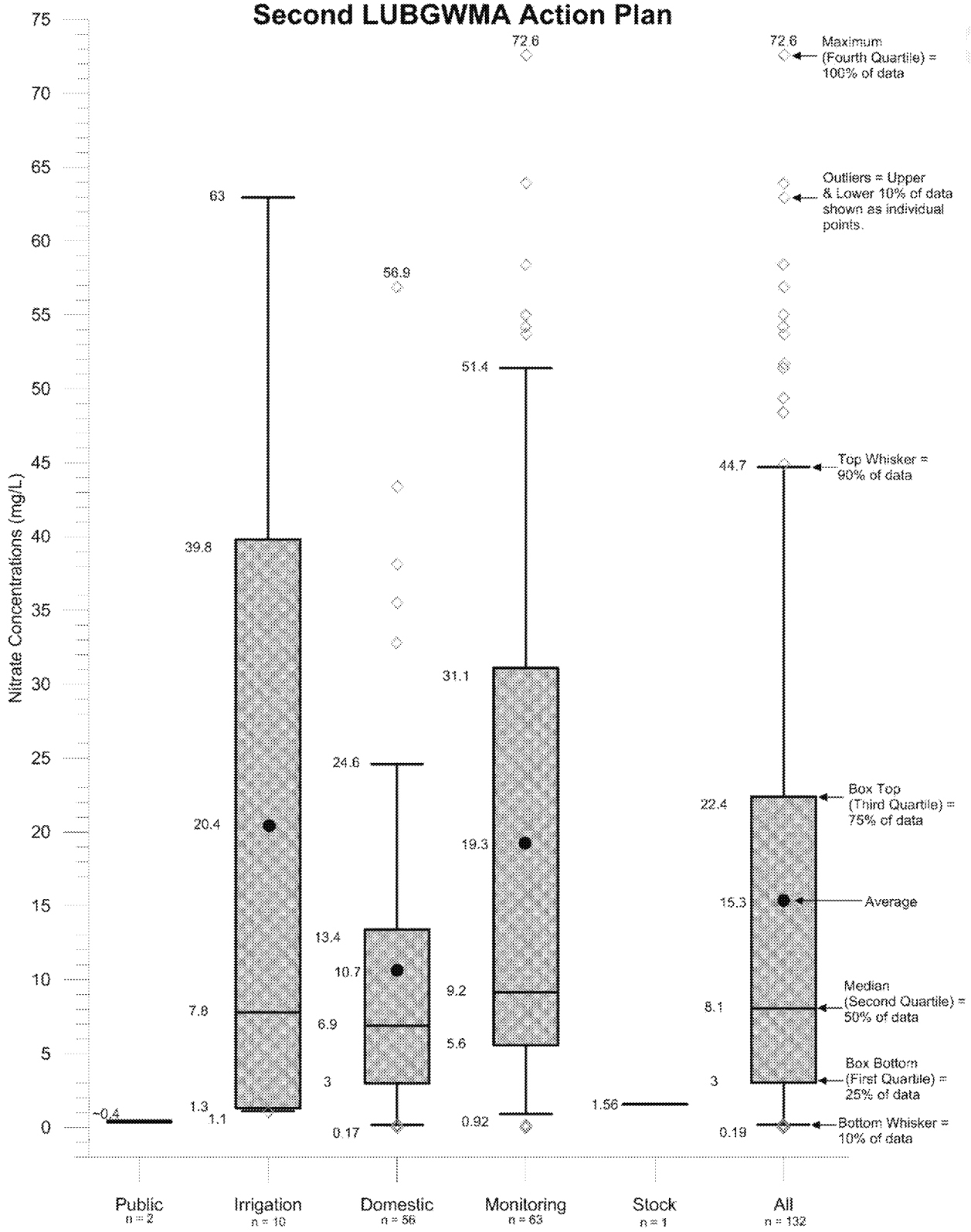
Figure 2-10 uses box plots to illustrate the fourth synoptic event nitrate concentrations by well type.

Figure 2-10
Box Plots of Fourth LUBGWMA Synoptic Event Nitrate Data by Well Type
Second LUBGWMA Action Plan



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The figure shows a box plot for all 132 wells in addition to a box plot for each of the five well types (i.e., public supply, irrigation, domestic, monitoring, and stock watering). Ninety percent of the wells tested were either domestic (56 wells) or monitoring (63 wells). The category of monitoring wells include 33 wells at food processing wastewater land application sites, 18 wells at the Umatilla Army Chemical Depot (UMCD), five wells at the Boardman Bombing Range, four wells at CAFO waste land application sites, and three wells near an old sewage lagoon. Other types of wells sampled include two public supply wells, ten irrigation wells, and one stock watering well. Figure 2-10 visually illustrates the lower nitrate concentrations observed in domestic wells compared to monitoring wells. The small number of other types of wells sampled (e.g., public, irrigation, and stock) limits the usefulness of comparing results by those well types.

While Figure 2-10 visually illustrates the lower nitrate concentrations at domestic wells compared to monitoring wells, both the Mann-Whitney Test and the Wilcoxon Signed Rank Test indicates there is a statistically significant difference between nitrate concentrations at the monitoring wells and at the domestic wells. The higher nitrate concentrations at monitoring wells compared to domestic wells is likely because monitoring wells are generally installed at locations where groundwater contamination is known, suspected, or believed to be a significant potential. Another factor is that monitoring well screens are generally installed at the water table while domestic well screens are generally installed tens of feet below the water table. Wells screened at or near the water table are more likely to show contamination from nearby land surface activities than deeper wells.

For a variety of reasons, not all wells were sampled during all four synoptic sampling events. However, 85 wells have been sampled in all four events. Table 2-4 summarizes the changes in some summary statistics of the four events. Section A of the table shows the minimum, median, average, and maximum nitrate concentration for the four complete events. Section B of the table shows the same summary statistics for just the 85 wells sampled all four events.

Table 2-4 shows the minimum concentration during each event was at non-detectable levels (e.g., <0.02 mg/L in 1992 and 2003 but <0.005 mg/L in 2009 and 2015). These "non-detects" show that unaffected areas are being sampled and the detection limit has been lowered over time. The table also shows the median nitrate concentration increased twice then decreased, suggesting that some wells are recently decreasing. However, average nitrate concentrations consistently increased, suggesting that increases are greater than decreases. The table also shows that the well exhibiting the highest nitrate concentration was the same well in the first three events.

In summary, regardless of whether the entire data sets are compared or just the 85 wells sampled in all events, nitrate concentrations are increasing more than they are decreasing.

Final Draft For Public Comment

ED_005296_00000290-00039

Table 2-4
Summary of Changes Between LUBGWMA Synoptic Sampling Events
Second LUBGWMA Action Plan

A. Comparison of All Results From All Four Events

	1992 Event	2003 Event	2009 Event	2015 Event	Comment
number of samples	205	135	107	132	
minimum	<0.02	<0.02	<0.005	<0.005	Unaffected areas are being sampled
median	6.1	7.8	8.7	8.1	Median increased twice then decreased, showing some wells are decreasing.
average	9.2	13.0	14.7	15.3	Average consistently increased, showing increases are greater than decreases.
maximum	67.0	51.1	103.4	72.6	Same well was max in 1992, 2003, & 2009

B. Comparison of Results from 85 Wells Sampled All Four Events

85 wells sampled in all 4 events					Comment
minimum =	<0.02	<0.005	<0.005	<0.005	Unaffected areas are being sampled
median =	5.5	8.0	8.3	7.7	Median increased twice then decreased, showing some wells are decreasing.
average =	9.9	12.8	14.9	15.4	Average consistently increased, showing increases are greater than decreases.
maximum =	67	51.1	103.4	72.6	Same well was max in 1992, 2003, & 2009

The # and % of wells showing increases or decreases are not mirror images because some wells had the same concentration two events in a row.

E:\LUB\Fourth Synoptic Sampling Event\[Comparison of SYnoptic Events.xlsx]Summary of Changes - All 4

Figure 2-11 is a box plot of the nitrate data from the 85 wells sampled during each of the four synoptic sampling events. When visually comparing the 1992 results to the 2015 results, it is clear that nitrate increased at these wells. Every aspect of the box plot (with one exception) shows an increase in nitrate concentration (i.e., increases in the first, second, third, and fourth quartiles as well as the top whisker and average). The exception is the bottom whisker, which is slightly lower in 2015 because detection limits are now lower. Both the Mann-Whitney Test and the Wilcoxon Signed Rank Test indicates there is a statistically significant difference between the medians of the 1992 and 2015 data sets.

When comparing 2009 to 2015 results, there are some indications of decreasing nitrate (i.e., the bottom whisker, first quartile, and second quartile are lower), but the magnitude of increases is greater than the magnitude of decreases. This is illustrated by the slight decrease in size of the bottom half of the box and the larger increase in size of the top half of the box. Neither the Mann-Whitney Test nor the Wilcoxon Signed Rank Test identified a statistically significant difference between the 2003, 2009, and 2015 medians.

These observations are consistent with the LUBGWMA well network area-wide trend, which has been increasing since 1997 but at slower rates since about 2004.

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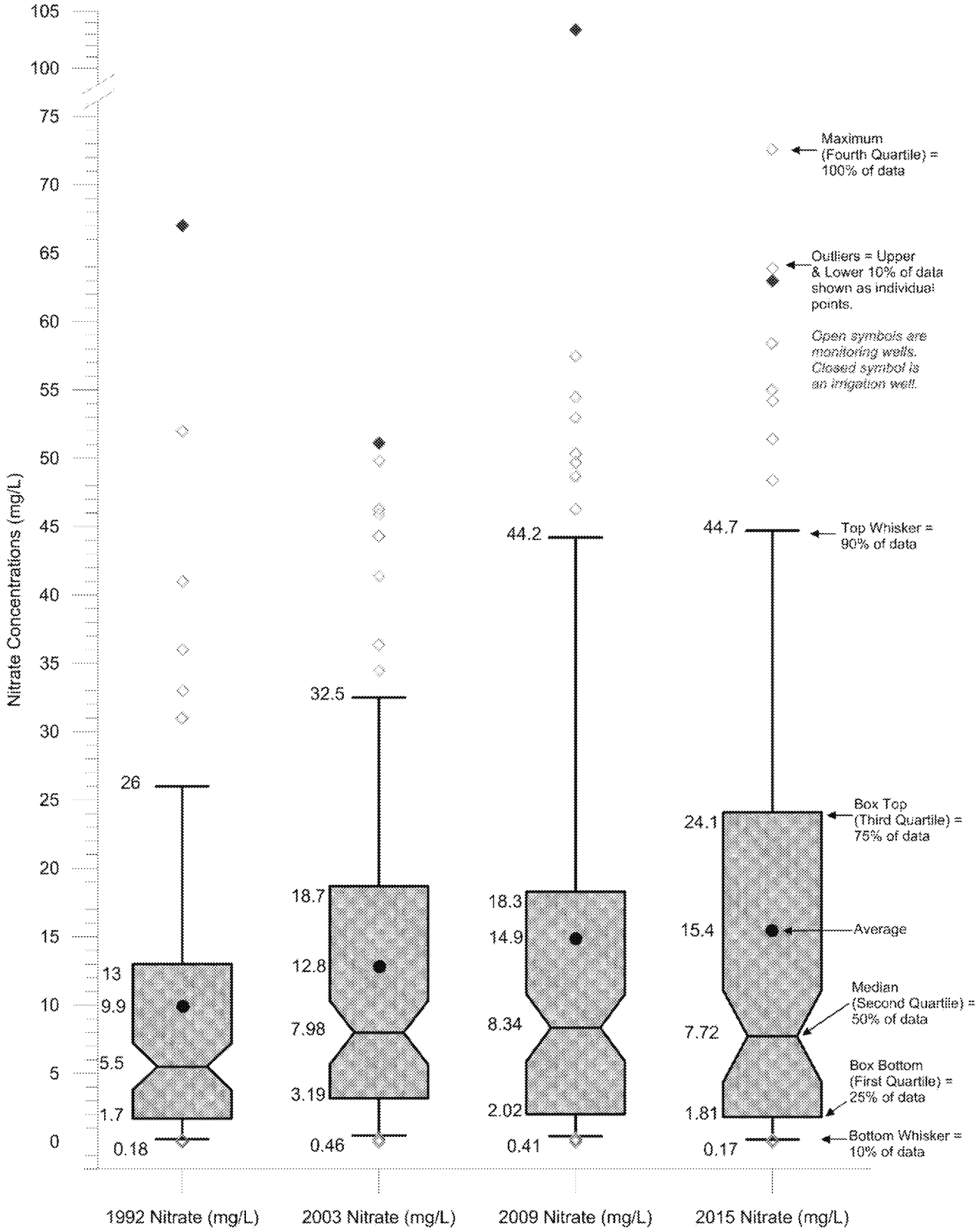
Figure 2-11
Box Plots of Data from 85 Wells Sampled in Four LUBGWMA Synoptic Events
Second LUBGWMA Area Action Plan



Synoptic Events "Implied Trends"

In an effort to relate the trends observed at the LUBGWMA well network to the wider GWMA, nitrate results from 114 wells sampled during both the first (1992) and fourth (2015) synoptic sampling events were used to calculate an "implied trend" between the two events. If the 2015 value was larger than the 1992 value then the implied trend was increasing. If the 2015 value was smaller than the 1992 value then the implied trend was decreasing. Table 2-5 shows the results of this comparison. Part A of the table quantifies the number of implied trends while Part B of the table quantifies the implied increasing and decreasing trends by magnitude.

Table 2-5 Part A shows there are more than twice as many implied increasing trends (76) as implied decreasing trends (35). There are also three implied flat trends where nitrate was not detected in either event at three wells.

Table 2-5 Part B indicates there are more implied increasing trends than implied decreasing trends, particularly among wells showing big changes. For example, when the change was less than one mg/L, the number of implied increasing trends was only slightly larger (12) than the number of implied decreasing trends (11). The ratio between 12 implied increasing trends and 11 implied decreasing trends is 1.1 (i.e., 12÷11 = 1.1). This ratio increases as the absolute value of the change increases from 1.1 for changes of less than 1 mg/L up to 13 for changes of more than 20 mg/L. The single largest increase was at a CAFO monitoring well[5]. The single largest decrease was at a UMCD monitoring well close to the bomb washout lagoon pump & treat system.

Table 2-5
Implied Trends at Wells Sampled in First and Fourth Synoptic Events
Second LUBGWMA Action Plan

A. By Direction

# Implied Increasing Trends =	76	67%
# Implied Decreasing Trends =	35	31%
# Implied Flat Trends =	3	3%
TOTAL	114	100%

B. By Magnitude	**<1 mg/L**	**1-5 mg/L**	**5-10 mg/L**	**10-20 mg/L**	**>20 mg/L**	**TOTAL**
# Implied Increasing Trends =	12	28	11	12	13	76
# Implied Decreasing Trends =	11	14	5	4	1	35
Ratio	*1.1*	*2.0*	*2.2*	*3.0*	*13*	*2.2*

The implied trends (using 2 data points between 1992 and 2015) match the Seasonal Kendall trends (using ~100 data points between September 1991 and May 2016) at 25 of the 31 LUBGWMA network wells (80%). This suggests the implied trends are a good, but not perfect, predictor of the actual trend. The implied trends at these 114 wells suggest nitrate is increasing at more wells than it is decreasing, which is consistent with observations made at the LUBGWMA well network and the food processor well networks.

Composite of Available Data

Figure 2-12 shows the nitrate concentrations at 255 wells. The figure includes the 132 wells sampled as part of the fourth synoptic sampling event plus results from 123 other wells not sampled by DEQ during the same timeframe (i.e., between November 2015 and April 2016). Most of the wells were sampled in November or December 2015.

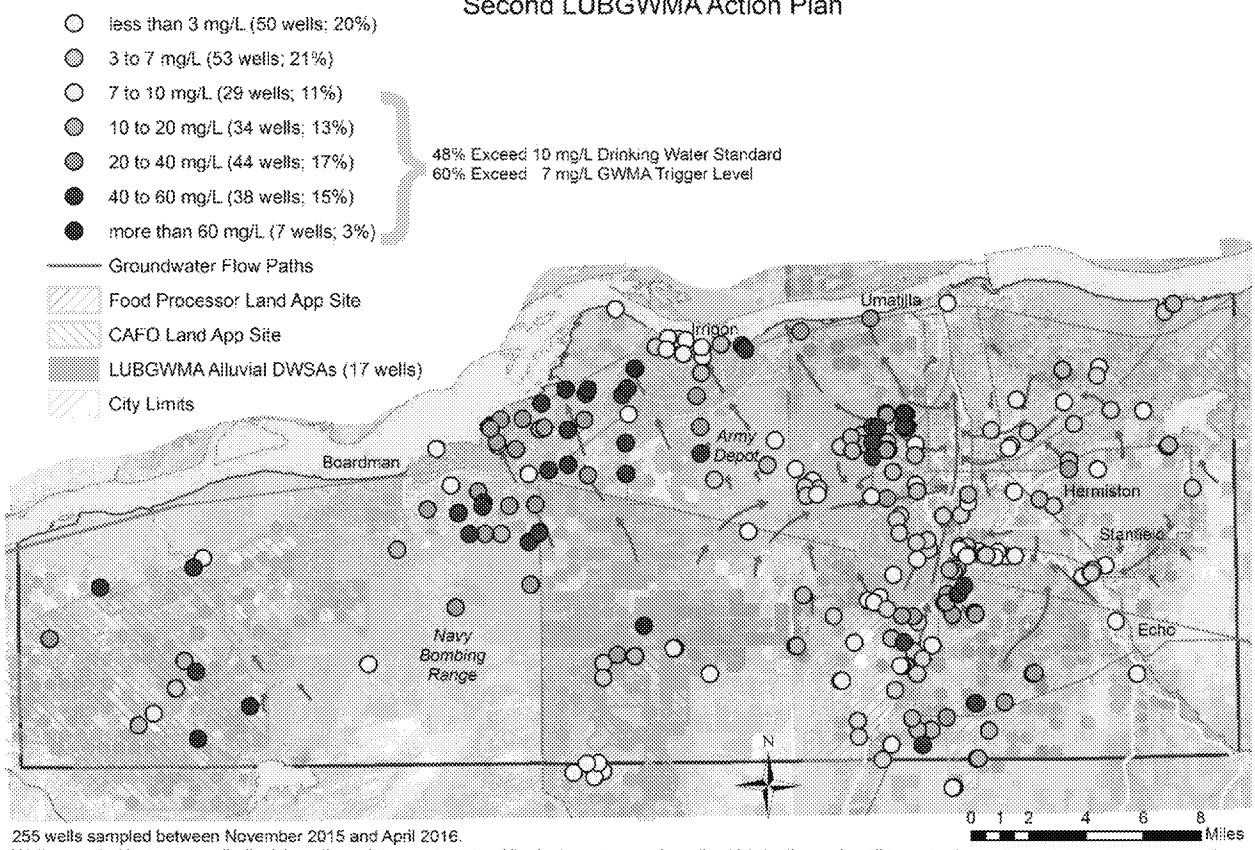
The wells added include the remaining 15 alluvial aquifer public supply wells in the GWMA not sampled during the synoptic sampling event and 108 monitoring wells. In total, the 255 well data set includes the 17 alluvial

[5] The land surrounding the monitoring well was traditional irrigated farm ground in 1992. By 2015, the land surrounding the monitoring well was being used as part of a CAFO waste land application system.

ED_005296_00000290-00042

aquifer public supply wells, 56 private domestic water supply wells, 10 irrigation wells, 171 monitoring wells, and one stock watering well. The monitoring wells include 18 wells at CAFO waste land application sites, 18 wells at the UMCD, 122 wells at food processing wastewater land application sites, 5 wells at the Finley Buttes landfill, five wells at the Boardman Bombing Range, and three wells around an old sewage lagoon near Irrigon. The data from these 255 wells were generated by DEQ, public water systems, and permitted entities.

Figure 2-12
Composite of Available Nitrate Data in the LUBGWMA
Second LUBGWMA Action Plan



255 wells sampled between November 2015 and April 2016.
Wells sampled include the 17 alluvial aquifer public supply wells, 56 private water supply wells, 10 irrigation wells, 171 monitoring wells, and 1 stock watering well.

Figure 2-12 shows 48% of the 255 wells exceeded the 10 mg/L nitrate drinking water standard and 60% exceeded the 7 mg/L GWMA trigger level. The higher nitrate concentrations at monitoring wells than domestic wells observed in the Fourth Synoptic Sampling Event data described above is also evident in this composite data set.

It is noteworthy that 17 wells supply water to 12 alluvial aquifer Public Water Systems in the LUBGWMA. During the timeframe of the fourth LUBGWMA Synoptic Sampling Event, four wells (24%) exceed the GWMA Trigger Level. Four of the 12 Public Water Systems (33%) have exceeded the 10 mg/L drinking water standard at least once since 2011.

ED_005296_00000290-00043

2.4.6 Summary and Conclusions of Previous Sampling Events

An evaluation of the groundwater nitrate sampling conducted in the LUBGWMA by public entities and permitted facilities discussed above indicate:

- Nitrate concentrations exceed the 7 mg/L GWMA trigger level, as well as the 10 mg/L federal drinking water standard in many area wells,
- Nitrate concentrations are higher in monitoring wells located where nitrogen-rich waste is land applied than at private domestic drinking water wells,
- Nitrate trends are increasing at more wells than they are decreasing,
- Increasing trends are generally steeper than decreasing trends,
- The first LUBGWMA Action Plan's goal of a decreasing nitrate trend throughout the GWMA by 2009 was not met.

These conclusions are summarized again below for the respective sampling events.

Reconnaissance Sampling

The Reconnaissance Sampling conducted from July 1990 through September 1991 documented the area-wide nitrate contamination, elevated levels of total dissolved solids, and scattered pesticide/industrial chemical detections. The highest nitrate concentration detected was 76 mg/L from an irrigation well located within a center pivot field. Approximately 24% of the 205 wells sampled contained more than 10 mg/L nitrate. The median nitrate concentration was 4.25 mg/L.

LUBGWMA Well Network (aka Bi-Monthly Well Network)

With some modifications to the frequency of sample collection and wells to be sampled, the LUBGWMA well network has been sampled continuously since September 1991. Most of the wells in the network are private domestic wells with some irrigation wells also included.

The first LUBGWMA Action Plan called for this well network to be the source of information to be used to gauge GWMA nitrate trends through 2009. By the end of 2009, seven of the 38 wells were no longer being sampled leaving 31 wells still being sampled. The trend analysis of nitrate data from this network indicated over twice as many wells showed increasing trends (15 of 31 wells) than decreasing trends (7 of 31 wells). When viewed by magnitude, there were more small, medium, and large increasing trends than small, medium, and large decreasing trends. The average slope of the small *decreasing* trends was steeper than the average slope of the small *increasing* trends (suggesting improving water quality at wells showing small changes). However, the average slope of the medium and large *increasing* trends was steeper than the average slope of the medium and large *decreasing* trends (suggesting worsening water quality at wells showing medium and large changes). The average nitrate concentration exceeded the 10 mg/L nitrate drinking water standard at 10 of the 31 wells (32%). The average nitrate concentration exceeded the 7 mg/L GWMA trigger level in 12 of the 31 wells (39%). The area-wide trend calculated with this data set was increasing at 0.018 ppm/year.

A second trend analysis was conducted in late 2016 using data through May 2016. The trend analysis indicated fewer statistically insignificant trends and more statistically significant trends. The analysis also showed there were still more increasing trends than decreasing trends but the spread was less than before (increasing trends went from 15 to 16; decreasing trends went from 7 to 10). As was the case with the first analysis, when viewed by magnitude, there were more small, medium, and large increasing trends than small, medium, and large decreasing trends. Again, as was the case with the first analysis, the average slope of the small *decreasing* trends was steeper than the average slope of the small *increasing* trends (suggesting improving water quality at wells showing small changes). Again, as was the case with the first analysis, the average slope of the medium and large *increasing* trends was steeper than the average slope of the medium and large *decreasing* trends (suggesting worsening water quality at wells showing medium and large changes).

The area-wide trend calculated with this data set was 0.0024 ppm/yr. Eliminating the most recent year of data and re-running the analysis multiple times shows the area-wide trend has been consistently increasing since enough data has been collected to calculate a trend (i.e., 1998). The slope of the trend line consistently decreased in

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magnitude (but remained increasing) until about 2004. Since 2004, the trend line continues some reduction in slope while also fluctuating, but remains slightly increasing.

The average nitrate concentration at the 31 long-term wells exceeded the 10 mg/L nitrate drinking water standard at 32% of these wells. The average nitrate concentration exceeded the 7 mg/L GWMA trigger level in 45% of these wells. In other words, the percentage of wells exceeding the drinking water standard did not change but the percentage of wells exceeding the GWMA trigger level increased. It is noteworthy that the average nitrate concentration increased at 17 wells, decreased at nine wells, and did not change at five wells.

Based on data collected from the LUBGWMA well network, it is concluded that nitrate concentrations are increasing more than they are decreasing, and that the overarching goal of reducing nitrate concentrations below 7 mg/L has not been met.

Food Processor Permitted Facility Well Networks

At the time of the first LUBGWMA Action Plan, the only permitted facilities with groundwater monitoring well networks were three landfills, the UMCD's bomb washout lagoon, and several food processor waste land application sites. None of the four CAFOs identified in the first Action Plan had comprehensive groundwater monitoring programs.

One of the first LUBGWMA Action Plan goals was "improving groundwater quality trends for nitrate" at the food processor land application sites by the end of 2001, the end of 2005, and the end of 2009. A trend analysis was done at food processor land application sites during each of these timeframes to evaluate that specific Action Plan goal.

Results of the first trend analysis indicate 64% (i.e., 72 of the 113 wells) analyzed from the 10 sites were increasing, 7% were decreasing, 3% were flat, and 27% were statistically insignificant.

Results of the second trend analysis indicate 58% (i.e., 74 of the 127) analyzed from the 12 sites were increasing, 20% decreasing, 0% flat, and 22% statistically insignificant.

Results of the third trend analysis indicate 54% (i.e., 61 of the 113 wells) from the 12 sites were increasing, 20% decreasing, 1% flat, and 25% statistically insignificant.

Conclusions from all three trend analyses included that nitrate was increasing at most wells, and at most sites. Therefore, the measure of Action Plan success calling for decreasing trends at these sites was not met.

Synoptic Sampling Events

LUBGWMA synoptic sampling events were conducted in 1992, 2003, 2009, and 2015. The most recent synoptic sampling event included 132 wells, mostly domestic drinking water wells and monitoring wells at permitted facilities that land apply nitrogen-rich waste. Nitrate results ranged from non-detectable (i.e., < 0.005 mg/L) to 72.6 mg/L with a median of 8.06 mg/L and an average of 15.3 mg/L. The nitrate concentration exceeded the 10 mg/L drinking water standard in 44% of the wells. As a whole, monitoring wells exhibited higher nitrate concentrations (19.3 mg/L average) than domestic wells (10.7 mg/L average).

Eighty-five wells have been sampled in all four events. Some wells show non-detectable amounts of nitrate in each event, indicating that some unaffected areas are being sampled. The median concentration increased twice then decreased, suggesting some wells are recently decreasing in nitrate concentration. However, the average concentration of these 85 wells consistently increased over time, suggesting more wells are consistently increasing in nitrate concentration. The median of nitrate concentrations from these wells in 1992 is statistically lower than during 2003, 2009, or 2015. These observations are consistent with the LUBGWMA well network area-wide trend, which has been increasing since 1997 but at slower rates since about 2004.

The trend "implied" by comparing two data points between 1992 and 2015 appears to be a good, but not perfect, predictor of the actual trend. The implied trends at 114 wells sampled in 1992 and 2015 suggest nitrate is

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increasing more than it is decreasing, particularly among wells showing big changes. These observations are consistent with the more statistically robust conclusions made from the LUBGWMA well network and the food processor well networks.

Results from the synoptic sampling events indicate nitrate concentrations remain above the GWMA Trigger Level in many wells, and that nitrate concentrations are increasing more than they are decreasing.

Composite of Available Data

Nitrate concentrations (from late 2015 through early 2016) available from all known data sources were compiled into one map. The wells include the 132 wells sampled during the Fourth Synoptic Sampling Event plus 108 monitoring wells and the remaining 15 alluvial aquifer public supply wells in the GWMA not already sampled. These results show that 48% of the 255 wells exceeded the 10 mg/L nitrate drinking water standard and 60% exceeded the 7 mg/L GWMA trigger level. The higher nitrate concentrations at monitoring wells than domestic wells observed in the Synoptic Sampling Event data is also evident in this composite data set.

Final Draft For Public Comment

ED_005296_00000290-00046

2.5 Statistical Approach

As part of an ODA Fertilizer Research Grant awarded to the LUBGWMA Irrigated Agriculture Sub-Committee in 2012, an OSU statistician conducted a review of the statistical methods used to evaluate nitrate trends in the LUBGWMA and the conclusions drawn from those analyses. The appendix of this document includes a summary of the statistician's recommendations along with DEQ's response, a discussion of some complexities that can affect how groundwater nitrate data are interpreted, and a discussion of the revised statistical approach to be used to evaluate groundwater nitrate trends in the future. Readers interested in the full discussion are encouraged to read the report and response, which are available upon request.

2.5.1 Complexities Affecting Interpretation of Groundwater Nitrate Data

Beyond imperfections in the statistical foundation of groundwater monitoring networks, groundwater nitrate data can be difficult to interpret due to natural spatial and temporal variability in nitrate concentrations. Some of this difficulty is because nitrogen is continually cycled in the environment, and the heterogeneous nature of contaminant transport in soil and rock materials. For example, nitrification and denitrification processes may alternate in time and space based on changing soil moisture conditions and the amount of organic matter present in soils. Similarly, the porosity of soil and rock materials is complex and affects the movement of contaminants through soil; with relatively slow movement through small pores in the lower conductivity materials and more rapid, preferential flow through larger pores, macropores, and along structural planes.

Spatial variability of nitrate concentrations and trends has been attributed by Alley (1993) to several factors including the nitrogen cycle and biogeochemical processing, variable sources of nitrogen in the environment, and temporal changes in source and delivery. The nitrate concentration observed at any well will reflect a complex interaction of the land uses and nitrogen sources in areas of differing recharge characteristics, the nature and thickness of material over the aquifer, the hydraulic properties of the surface materials and aquifer, the three-dimensional groundwater flow system, and possible related stratification of solutes (either because of chemical properties, flow system effects, denitrification, or temporal changes in loading). With stratification of solutes and/or the non-uniform, preferential flow of water and contaminants, even subtle differences in the depth of the open portion of a well can make a major difference in nitrate concentrations. In fact, large variability in nitrate concentrations in groundwater is the rule, not the exception, particularly in areas where variable thickness of an aquitard overlies an aquifer (Alley, 1993). Even nearby wells may show seasonal variations that are out of phase, because of differences in the time of arrival of the "seasonal changes" to a well. Given these effects, the time frame over which sampling is carried out, or repeated, in a given area can also affect the apparent nature of these variations (Alley, 1993).

2.5.2 Summary of Revised Statistical Approach

Given the limitations of the available well networks, and general complexities in interpreting groundwater nitrate data from a regional groundwater monitoring network, this second LUBGWMA Local Action Plan calls for conclusions regarding regional groundwater nitrate concentrations and trends to rely on multiple lines of evidence from multiple sources of information including, but not limited to the LUBGWMA well network, synoptic sampling events, wells at permitted facilities, public supply wells, and other publicly available data. It is recognized that the statistical robustness will likely vary between data sources and between the methods of data analysis. More weight will be given to data sources and methods of data analysis that are more robust (e.g., groundwater quality data collected and analyzed following industry-recognized quality assurance / quality control procedures, and industry-recognized statistical techniques).

ED_005296_00000290-00047

3.0 Sources and Solutions

This chapter provides a summary of the factors that are potentially impacting groundwater quality in the Lower Umatilla Basin and the methods that can be used to protect groundwater quality for the benefit of the entire region. It is organized into sub-sections according to the six major focus areas addressed by the LUBGWMA Committee and Sub-Committees. These six focus areas include:

- Irrigated Agriculture
- Land Application of Food Processing Industrial Process Wastewater
- Rural, Open, and Green Spaces
- Confined Animal Feeding Operations
- Livestock Operations
- Public Water Systems

Each sub-section consists of an overview, inventory of potential contaminant sources, and goals, objectives, strategies, and actions. The overview describes how a particular land use or activity is potentially impacting and/or is impacted by nitrate. In the case of public water supplies, other potential contaminants identified in the Source Water Assessments completed by DEQ and DHS are also considered. The inventory of potential sources catalogs the activities associated with each focus area that may be impacting groundwater quality. The Public Water Supply section identifies all the potential sources of groundwater contamination within a portion of the Drinking Water Supply Areas for those systems.

The core elements of each sub-section are the goals, objectives, strategies, and actions that the GWMA Committee recommends as the optimal ways to address the problem of nitrate groundwater contamination in the region. Most of the recommendations are specific to a particular interest and source category. Other recommendations suggest actions that cut across all land uses and interest groups, such as erecting signs along major roadways to inform people that they are entering a drinking water supply area.

Each interest category has goals with specific strategies under each goal. Each strategy then contains detailed actions on how to implement the strategy. Each goal has one or more objectives. The following definitions provide a guide to understanding the differences between these four components:

Goal: An ultimate aim or aspiration

Strategy: Conceptual means to achieve a goal

Action: Specific procedures, processes, and activities to accomplish strategies, and ultimately, the goal

Objective: Measurable, longer-term ways to determine if the goals are being achieved.

Responsible Entity: Local, State or Private Sector entity with primary responsibility for implementing an action

Schedule: Timeline for completion of Action

Final Draft For Public Comment

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3.1 Irrigated Agriculture

3.1.1 Overview

Irrigated agriculture is the largest user of fertilizer nitrogen in the Lower Umatilla Basin and, at approximately 180,000 acres, is the single largest land-use by type within the LUBGWMA. Nitrogen used in irrigated agriculture has been a contributing source of nitrate input into the region's groundwater. Widespread irrigation water management and use of nutrient management guidelines in fertilizer use and application on agricultural lands is the most effective method of groundwater protection. This Local Action Plan recognizes that coupling groundwater protection objectives with irrigation water and fertilizer input efficiencies will achieve mutually inclusive beneficial goals. This in turn will enhance agronomic competitiveness and groundwater protection will decrease externalized costs of nitrate treatment for drinking water in the LUBGWMA.

In this arid climate with sandy soils of low organic matter, it is essential to supply crops with nutrients and water for maximum agronomic yield. The technology used to deliver water to crops in the Basin has advanced from gravity-fed flood irrigation to computer-controlled pressurized systems designed to maximize energy and water application efficiency. Similarly, nutrient management practices have advanced over the past few decades and many growers use precision techniques to maximize nutrient use efficiency and apply nutrients and irrigation water at the right time, location, type and rates.

Best Management Practices (BMPs) for nutrient management focus on implementing the 4Rs of agronomic practice (right rate, timing, placement & source or type) to minimize irrigation water and fertilizer movement of nitrogen below the root zone during the growing and winter seasons. Agronomic rates of nitrogen applied in accordance with the timing, amount, and placement of crop nitrogen demand will minimize the build-up of inorganic nitrogen that contributes to winter leaching events. The use of winter cover crops can also minimize movement of nitrogen deeper into the soil profile.

Due to the unique soils and growing environment in the region, practices developed in other regions may need to be modified before adoption in the Basin. Area specific procedures should be continually evaluated and improved to account for not only the climate and soils present in the LUBGWMA, but common crops and rotational systems as well. A failure to appropriately manage the application of agricultural resources through ongoing research and technical assistance increases the likelihood of negative environmental impacts. In the case of nitrogen fertilization, mismanagement can result in nitrate contamination of groundwater.

To minimize the leaching of nitrogen from irrigated agriculture, *both* irrigation and nutrient management must be considered and managed. Components of the soil-water balance that can be controlled should be managed to minimize winter leaching and runoff (e.g. managing field capacity through deficit irrigation, frequent light irrigation, etc.).

All nitrogen applied to the soil (including ammonium and organic forms) will eventually be subject to transformation to nitrate (except for volatilization losses). The total transformation of organic to inorganic nitrogen may take a few weeks to a few years, depending on the nature of the organic waste. Nitrate moves readily with water in the soil profile and can reach groundwater if not taken up by crops or denitrified/volatilized. Other forms of nitrogen are less mobile. Organic or inorganic nitrogen applications that (on average) exceed crop nitrogen uptake (plus loss to gaseous emissions of denitrification and volatilization) will accumulate inorganic nitrogen in the soil, which will be susceptible to leaching in nitrate form. Additionally, root systems are not spatially uniform and cannot perform with perfect uptake efficiency. Soil nitrogen that moves below the root zone cannot be taken up by crops and will eventually leach to groundwater as nitrate. Denitrification may help to reduce nitrate loading to groundwater under some conditions. (Hermason, et.al.)

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3.1.2 Potential Sources of Nitrate from Irrigated Agriculture

Potential sources of nitrate in irrigated agriculture include:

- Inorganic commercially manufactured fertilizer products
- Organic residues such as soil organic matter, previous crop residues and manures/compost
- Atmospheric nitrogen fixed by soil microbiology
- Irrigation source water

Each of these potential sources is discussed below.

3.1.2.1 Inorganic Commercially Manufactured Fertilizer

The three common forms of nitrogen in commercial fertilizer are Urea-N, Ammoniacal-N (Ammonia/Ammonium), and Nitrate-N. Many fertilizer products contain a blend of two or all three of the different forms of nitrogen. Urea is the most chemically complex of the three forms and it has very limited availability to plants. When in contact with moist soil, it is hydrolyzed to ammonium (NH_4^+). Ammonium is then either taken up by plant roots or soil microorganisms, attached to negatively charged soil colloids or converted to ammonia gas (NH_3) in which state it is vulnerable to loss to the atmosphere. Ammonium can also be oxidized by soil biology during nitrification to form nitrate (NO_3^-), a compound that is also readily utilized by plants but is much more susceptible to leaching deeper into the soil with irrigation or precipitation. Each of these forms of nitrogen have distinct chemical characteristics that affect their potential loss to the environment, whether it's through volatilization to the atmosphere from the soil surface or being carried out of the root zone with water.

Many commercial forms of nitrogen are now available with treatments that reduce the rate of conversion from one form of nitrogen to another. This may dramatically reduce the amount of nitrogen available for leaching or volatility at any given time. Knowing which form(s) of nitrogen a fertilizer contains is the first step in determining how and when it should be applied to insure that it is available to the growing crop and less available for loss to the environment.

3.1.2.2 Organic Residues

Residue from the previous crop, soil organic matter and manures, or composts applied to the soil are all sources of nitrogen that can potentially be converted to nitrate by soil biological processes.

Much of the nitrogen present in animal manures and composts is tied up in organic compounds and as such, is not immediately available for either utilization by plants or loss to the environment. The second most abundant form of nitrogen in manure is ammonium, which, like ammonium in inorganic commercial fertilizers, is susceptible to high volatile loss as ammonia gas if mismanaged during application. Very little of the nitrogen in manures and composts is in the nitrate form. The fraction of total nitrogen in these products that mineralizes and becomes available is typically highest during the first growing season after application and the rate of additional mineralization rapidly diminishes during subsequent years.

The amount and type of plant residue remaining after the harvest of the previous crop is an important consideration in nitrogen management. Residues high in carbon and low in total nitrogen, such as the chaff and straw of small grain crops, contribute relatively little nitrogen to the next crop. They can utilize a significant portion of the available soil nitrogen in the process of decomposition resulting in a seasonal "tie-up" of soil nitrogen. Conversely, green crop residues such as those from potatoes, peas, or other fresh vegetables where the majority of the plant's lush vegetative material remains in the field, can contain higher levels of total nitrogen and typically decompose faster than high carbon residues. Therefore, they potentially contribute substantial levels of crop available nitrogen to the soil.

In addition to residue contributions from the previous crop and any manures or composts that may be added as fertilizer, nitrogen can also come from soil organic matter. This organic nitrogen pool within the soil is complex and heavily influenced by soil texture, environmental conditions, and agronomic practices. As a result, organic matter levels can vary significantly from region to region and from farm to farm within an area. Soils with higher organic matter levels will release more mineralized nitrogen each cropping season than low organic matter soils.

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3.1.2.3 Atmospheric Nitrogen

Another way that nitrogen can be introduced to a cropping system is through the incorporation of leguminous crops into the crop rotation. Legumes are a family of plants that bear root nodules containing nitrogen fixing bacteria and include such crops as peas, beans, alfalfa, and clover. When these plants die, their root nodules break down, releasing the nitrogen they contained back into the soil for potential use by the following crop. In addition to the bacteria living symbiotically with legumes, there are other free-living soil bacteria that can also fix atmospheric nitrogen. However, their abundance in a field is greatly influenced by the management practices that are used by the farmer. As a result, their presence may be highly variable.

3.1.2.4 Irrigation Water

Depending upon the source, irrigation water can contain high amounts of nitrogen. Unlike most of the other sources of nitrogen discussed, fresh irrigation water contains mainly nitrate. Irrigation water can easily move through the soil profile with the water it arrives with and is readily taken up by plants as soon as it reaches the root zone. Water with a nitrate concentration of 10 milligrams per liter (mg/L) supplies ~2.26 pounds of nitrogen per acre for every inch of water applied, which is enough to supply 60-70 lbs/acre nitrogen during the typical potato growing season. Sampling irrigation water for nitrate at the beginning of the season and crediting the amount against fertilizer application is required to avoid over applying nitrogen fertilizer.

Precipitation and irrigation water that does not transpire or evaporate becomes either runoff or infiltrates into the ground or both. From the water that infiltrates, a part is used to replenish the soil moisture and any excess is lost as drainage water or deep percolation at the bottom of the soil. This is called field capacity of the soil. When field capacity of the soil is exceeded, water passes through the soil becoming drainage water or deep percolation to groundwater (Hermanson, et.al.).

The Lower Umatilla Basin (LUB) region has sandy soils, which have a relatively low field capacity. The difference in volumetric water content between field capacity and wilting point is less in sandy soils (as compared to a silty loam). The optimal range for balancing irrigation and groundwater protection is smaller and requires robust data capture and decision-making. Crop water use early in the spring is less because of lower evapotranspiration (ET) demand during cooler temperatures and early crop growth stages. The management of irrigation water as a solute transport mechanism is a key component of the agronomic practice that will achieve groundwater protection in the LUB. For a brief introduction to soil water best management principles and practices in Nebraska, please see: https://youtu.be/YULwrICaB1Y

3.1.3 Irrigated Agriculture's Goals, Objectives, Strategies and Actions

Oregon's 1989 Groundwater Quality Protection Act (Act) [ORS 468B.160] requires programs to be established to prevent groundwater quality degradation through the use of best management practices (BMPs).

The goals for irrigated agriculture within the LUBGWMA are focused on continuing to reduce nitrate contributions to groundwater from agricultural systems, while maintaining the economic viability of those systems in the Basin. In addition to implementing BMPs, growers and the agencies responsible to address groundwater issues need strategies to evaluate and continuously improve BMPs, as well as a way to track the extent of BMP implementation. This includes ongoing research evaluating BMP effectiveness, a voluntary BMP documentation and certification program that recognizes growers' existing BMP practices, and improves upon BMP practices throughout the Basin.

Oregon State University (OSU) Hermiston Agricultural Research & Extension Center (HAREC) and Oregon ODA will support limiting nitrogen loss to groundwater during agronomic practice by:
1.) Evaluating and documenting current BMPs,
2.) Identifying possibilities for improvement in current BMP systems through research in the effectiveness of practices that prevent root zone winter leaching events,

ED_005296_00000290-00051

3.) Providing updated technical and educational outreach to growers on effective nitrogen and irrigation management strategies, while continuing to fund research into new methodologies and requirements for crop irrigation and fertilization that prevent leaching below the root zone.
4.) Updating and implementing Willow Creek and Umatilla Agricultural Water Quality Management Area Plans

The goals of the Irrigated Agricultural Sub Committee of the LUBGWMA are:

Goal 1: Procure funding for a United States Geological Survey (USGS) to study, characterize, and develop a comprehensive groundwater and hydrology transport model for the Lower Umatilla Basin.

Goal 2: Procure funding to develop and market a voluntary BMP certification program to inventory and document the extent of BMP implementation in the basin.

Goal 3: Research, catalog, and publish on the effectiveness of current agronomic best management practices (BMPs) in reducing nitrate contamination of groundwater.

Goal 4: Create and maintain an online list of reference materials which recommend best management practices and strategies to reduce nitrate loading for targeted crops and conditions in the Lower Umatilla Basin, as well as materials associated with soil health, conservation, and sustainable farming practices.

Goal 5: Determine what monitoring methods and frequencies are most efficient and effective at helping growers manage in-season water and fertility resources for crops commonly grown in the Basin. Continue to fund research, education, and outreach to improve and encourage the adoption of agronomic BMPs by growers within the Basin

Goal 6: Develop criteria for achieving GWMA repeal in ORS 468B.188 "*Repeal of declaration of groundwater management area*".

Goal 7: Create an Interagency Task Force to achieve groundwater management goals of the irrigated agricultural community.

Goal 8: Evaluate the feasibility of a nitrogen mass-balance model and biogeochemical research projects that would spatially identify nitrogen loading in support of Goal 9.

Goal 9: Evaluate the feasibility of re-defining the LUBGWMA into smaller sections based upon land use, a USGS hydrogeology transport, model and possibly a nitrogen mass-balance model.

Goal Strategies and Actions

Goal 1: Procure funding for a United States Geological Survey (USGS) to study, characterize, and develop a comprehensive groundwater & hydrology transport model for the Lower Umatilla Basin.

Strategy 1.1
Develop the data, information, and understanding necessary to make informed management decisions regarding groundwater in the Umatilla Basin.

Final Draft for Public Comment

ED_005296_00000290-00052

Actions

- Develop, test, and refine a conceptual transport model of the hydrologic system of the Umatilla Basin.
- Describe the hydrologic system through reports and presentations that promote a common understanding of the groundwater resource within the Umatilla Basin.
- Construct numerical models that accurately represent the hydrologic system and can be used as tools to evaluate the effects of proposed management alternatives (for example, future droughts or floods due to changing rainfall patterns).
- Use the hydrologic models to identify optimal management alternatives based on specific quantity and quality management objectives of water resources.

Responsible Entity: DEQ, GWMA Committee stakeholders, USGS
Schedule: 2025

Goal 2: Procure funding to develop and market a voluntary BMP certification program and/or other comprehensive strategies that would inventory, document, and market the extent of BMP implementation in the basin and identify and address opportunities for improvement.

Strategy 2.1
Develop nutrient best management practice & guidelines and irrigation water best management practice and guidelines. Facilitate farm-scale implementation of the nutrient and irrigation water best management practices guidelines. Support activities and share resources to achieve goals and objectives of reducing and eliminating in-season and winter leaching of nitrate to groundwater.

Actions
State, local, and non-profit cooperators such as Salmon Safe, Oregon State University, Umatilla County and Morrow SWCDs, Oregon Department of Agriculture, and others to conduct research, develop recommendations, and incorporate research results into the design and implementation of a voluntary BMP certification program that promotes:

- Increased market visibility and access through development of a BMP groundwater protection standard within existing Salmon Safe (or other) certification and labeling.
- Develop recommended nutrient and irrigation water management guidelines for crops.
- Develop crop specific recommendations for fertilizer rates, types, placement and timing for achieving maximum economic yields for the top five irrigated crops (by acreage) grown in the LUB based on standard cropping practices.
- Develop soil-water field capacity model for the predominantly occurring soils in the LUB. Based upon maximum economic yields and LUB soils, develop crop specific recommendations for irrigation rates, type, timing, and placement.
- Develop and implement data capture and decision making at the field scale based on right rate, type, timing, and placement of fertilizer and irrigation water.
- Deep soil testing for tracking effectiveness of fertilizer and irrigation water management techniques.
- Recommendations for requisite field scale instrumentation, analytical data collection, monitoring methods, and default values (N source/losses, water meters, soil moisture, ET, etc.) that support active management of nitrogen and water inputs to LUB soils.
- Develop pre-season nutrient & water management plans coupled with post-season (winter) evaluation.
- Crediting the different sources of nitrogen that crops may use beneficially.
- Update & develop tools and services to provide recommendations and data for irrigation water and fertilizer management, including weather and soil moisture data collection and distribution.
- Conversion to more efficient irrigation systems.
- Recommend fertilizer source, rate, placement, timing of application, and economically realistic crop yield goals.

Final Draft For Public Comment

ED_005296_00000290-00053

- Procedures for crediting the various sources of nitrate including inorganic fertilizers, organic sources, residual soil nitrogen, and irrigation water.
- Recommendations on soil and tissue sampling to reduce uncertainty about crop nutrient needs.
- Recommendations regarding the efficient use of irrigation systems and uniform application of irrigation water for all crops.
- Recommendations to manage for all crops in the rotation and not focus on one crop.
- Schedule maintenance leaching to minimize groundwater impact.
- Promote cropping systems to manage nitrate movement. These systems may include the use of second crops, cover crops, and deep-rooted crops to recover and/or store nitrogen that would otherwise pass the crop root zone.
- Recommend methods, approaches, and reporting that supports data interpretation of actively managed nitrogen and water inputs into the vadose zone of LUB soils that achieve maximum economic yield while decreasing groundwater impacts.

Responsible Entity: Salmon Safe, Oregon State University, Oregon Department of Agriculture, Umatilla County and Morrow SWCDs, DEQ.
Schedule: 2020

Strategy 2.2
Apply for available Western SARE grants to fund a voluntary BMP certification program and BMP research. Continue to apply for DEQ 319 funding when it is available.

Actions
- Communicate with Oregon DEQ about the availability of 319 funding opportunities.
- Work with State and local cooperators such as Oregon Department of Agriculture, Umatilla County and Morrow SWCDs, Oregon State University, and others to help design and implement a voluntary BMP certification program and BMP research grant proposals.

Responsible Entity: DEQ, Oregon State University, Oregon Department of Agriculture, Umatilla County and Morrow SWCDs.
Schedule: 2020

Strategy 2.3
Seek out and apply for new and upcoming sources of funding for a voluntary BMP certification program and BMP research grant proposals.

Actions
- Perform periodic searches for new funding opportunities.
- Work with State and local cooperators such as Oregon Department of Agriculture, Umatilla County and Morrow SWCDs, Oregon State Universit,y and others to help design and implement a voluntary BMP certification program.

Responsible Entity: Oregon State University, Oregon Department of Agriculture, Umatilla County and Morrow SWCDs.
Schedule: 2020

Strategy 2.4
Distribution of new educational and promotional materials on Basin BMPs to grower groups within the Basin during the roll-out of a voluntary BMP certification program.

Final Draft For Public Comment

ED_005296_00000290-00054

Actions

- Evaluate materials currently disseminated at public forums for growers. Work with professional service providers, local conservation districts, and OSU to develop new materials to present new technologies and information.

Responsible Entity: Oregon State University, Oregon Department of Agriculture, Umatilla County and Morrow SWCDs.
Schedule: 2020

Goal 3: Oregon State University researches, catalogs and publishes an evaluation of the effectiveness of current agronomic best management practices (BMPs) in reducing nitrate contamination of groundwater. Research, catalog and evaluate current BMPs that reduce nitrate loss to groundwater. Identify and develop a comprehensive system of irrigation and fertilization practices based on the agronomic practice of the 4Rs (right source, right amount, right timing, right placement) that will improve upon the current level of BMP effectiveness to prevent winter and in-season leaching events.

Strategy 3.1
Monitor in-season and winter soil moisture and soil-test nitrogen across time on a center-pivot irrigated field within the Basin that is being managed with typical BMPs for the crops grown.

Actions

- Monitor crop nitrogen removal, soil nitrate accumulation, and nitrate leaching for several years.
- Implement a lysimeter study project measuring nitrate losses from fields in areas with improved fertilizer management. Soil water samples from existing and newly placed lysimeters are collected once a month for two years, and analyzed by a laboratory to determine levels of nitrate and phosphorus leaching below the crop rooting zones in fields using precision agriculture and other innovative fertilizer management practices.
- Monitor soil moisture and soil nitrogen content pre-plant, during the cropping season and post-harvest (winter) to assess the potential for having pushed nitrate below the root zone.
- Document pre-plant soil test nitrogen, in season nitrogen fertilization, and remaining post-harvest soil test nitrogen.
- Compare common methods of soil moisture monitoring to evaluate whether irrigation management effectiveness is influenced by the type and/or frequency of generated data.
- Update and unify all fertilizer rate application tables for the recommended agronomic rate of nitrogen addition to the soil that is needed to produce maximum economic yield, while minimizing adverse environmental effects. The recommended agronomic rate must account for nitrogen available to the crop throughout the growing season from all sources such as mineralization of organic residues and soil organic matter, residual inorganic nitrogen in the rooting zone, and nitrogen from irrigation water or other sources.

Responsible Entity: Oregon State University
Schedule: 2020

Strategy 3.2
Characterize physical variability across the same field and assess the effects of that variability on water and nitrate movement given a uniform application of both resources across the field.

Actions

- Grid sample the field for soil textural analysis to determine areas where deeper percolation is likely to occur.

Final Draft For Public Comment

ED_005296_00000290-00055

- Analyze elevation and slope data for the field looking for areas where run-off and/or ponding are likely to occur.
- Make visual observations of the field during irrigation looking for wet and dry areas as the soil surface dries out.
- Monitor subsurface moisture movement in areas identified as having abnormal wetting and drying patterns compared to the average of the field.

Responsible Entity: Oregon State University
Schedule: 2020

Goal 4: Oregon State University evaluates existing nutrient management publications and as necessary, adds to its publication catalog of agronomic best management practices to reduce nitrate loading to groundwater. Create and maintain an online list of reference materials that recommend management practices and strategies to reduce nitrate loading for targeted crops and conditions in the Lower Umatilla Basin as well as materials associated with soil health, conservation, and sustainable farming practices.

Objectives: Maintain a high level of BMP understanding, adoption, and voluntary certification among growers within the Basin.

Strategy 4.1
Utilize a cooperative agency such as Umatilla County, Morrow SWCDs, or OSU Extension to host a webpage for growers to access that would be able to link them to resources on crop specific fertility information, soil and water conservation practices, irrigation management technology and strategies, crop water use curves, etc.

Actions

- Catalog and publish all agronomic BMPs that ensure groundwater protection.
- Create a "Groundwater Protection & Agronomic Factor" (GPAF) scoring system, that incorporates groundwater protection and agronomic viability, and apply a GPAF score to each cataloged BMP published by OSU.
- Update the BMP catalog and GPAF scoring on an annual basis.
- Utilizing the GPAF scores, create a standardized suite of BMPs that represent an economically achievable baseline of BMP implementation for growers across the Basin. Provide this standard suite of BMPs to a voluntary BMP certification program that involves active outreach to growers. Active outreach includes recognizing existing BMP performance and improving upon BMP performance.
- Contact potential project partners about the project and determine their willingness and ability to help.
- Compile a list of reference material that can be organized and posted to the webpage.
- Periodically update webpage content.
- Provide a means for growers or industry professionals to suggest additional materials.
- Perform outreach to inform local growers that this source of information exists and is easily accessed.

Responsible Entity: Oregon State University
Schedule: 2020

Goal 5: Oregon State University Agricultural Extension Office in partnership with Oregon Department of Agriculture determines what monitoring methods and frequencies that are most efficient and effective at helping growers manage in season water and fertility resources for crops commonly grown in the Basin. Continue to support research, education, and outreach to improve upon and encourage the adoption of agronomic BMPs by growers within the Basin.

Final Draft for Public Comment

ED_005296_00000290-00056

Objectives: Help growers obtain the most cost effective BMPs that can be used to make in season irrigation and fertilization management decisions and determine if different methods of monitoring may be appropriate for different crops. Keep BMP information up to date through research and adaptive management. Answer any questions concerning new crops and technologies.

Strategy 5.1
Instrument a field with multiple styles of soil moisture monitoring devices that provide for variable sampling frequencies and cost.

Actions

- Contract with local service professionals to install, maintain, and read moisture monitoring devices.
- Collect and compare data sets.
- Assess grower confidence in the data and their ability to make management decisions from it.
- Evaluate total costs of data generation for each style of device.

Responsible Entity: Oregon State University
Schedule: 2020

Strategy 5.2
Compare irrigation practices across common Basin crops and evaluate whether certain types of moisture monitoring devices may be more appropriate than others for certain types of crops.

Actions

- Work with local professional service providers to determine common irrigation practices and quantify the variability of those practices across crop types.
- Conclude whether there is a strong correlation between crop type and irrigation management.
- Assess variables such as irrigation frequency, root zone depth, and seasonal water and fertilizer requirements for different Basin crops. Determine if specific soil moisture monitoring devices are more appropriate than others for specific crops.
- Promote and certify the use of the most appropriate BMP technology for each crop.

Responsible Entity: Oregon State University
Schedule: 2020

Goal 6: Develop criteria for achieving GWMA repeal in ORS 468B.188 "*Repeal of declaration of groundwater management area*".

Objectives: Objectives include development of criteria for achieving ORS 468B.188. The objectives outlined in ORS 468B.188 are partially achieved through the existence of this revised local action plan.

Responsible Entity: GWMA Committee
Schedule: 2020

Goal 7: Interagency Task Force to achieve groundwater management goals of the irrigated agricultural community.

Objectives: The objective of the structured Interagency Task Force is to coordinate between ODA, ODEQ, OWRD, OSU, and OHA to achieve groundwater management goals of the irrigated agricultural community and basin stakeholders. Success will include interagency consensus, direct liaison authority, coordinating authorities, channels, terms of commitment, and MOAs or MOUs that support policy, legitimacy, defined purpose,

Final Draft For Public Comment

ED_005296_00000290-00057

authorities, leadership parameters, functional protocols, unified effort, centralized planning and direction, decentralized execution, and management of resources.

Responsible Entity: GWMA Committee
Schedule: 2020

Goal 8: Evaluate the feasibility of a nitrogen mass-balance model and biogeochemical research projects that would spatially identify nitrogen loading in support of Goal 9.

Objectives: Conduct a nitrogen mass-balance model and biogeochemical research projects that would spatially identify nitrogen loading.

Responsible Entity: GWMA Committee, OSU, EPA
Schedule: 2020

Goal 9: Evaluate the feasibility of re-defining the LUBGWMA into smaller sections based upon land use, a USGS hydrogeology transport model, and possibly a nitrogen mass-balance model that incorporates source loading isotopic signatures.

Objectives: Re-define the LUBGWMA into smaller sections based upon land use, a USGS hydrogeology transport model and possibly a nitrogen mass-balance model.

Responsible Entity: GWMA Committee
Schedule: 2020

Final Draft For Public Comment

ED_005296_00000290-00058

3.2 Land Application of Food Processing Industrial Process Wastewater

3.2.1 Overview

Food processing facilities generate large volumes of nutrient rich process water as part of their daily operations. These facilities are one of the few sources of nitrate to groundwater that are already under direct regulatory requirements. These facilities are required to obtain National Pollution Discharge Elimination System (NPDES) or Water Pollution Control Facilities (WPCF) permits from the state to discharge waste water to waters of the state or land apply waste water. Originally, food processors land applied their waste water to limited areas, during all seasons, and at amounts exceeding crop needs. These activities contributed to local nitrate-nitrogen groundwater contamination. Today, DEQ's regulatory waste discharge permit system are designed to reduce nitrate loading to the groundwater and will continue to do so.

3.2.2 Inventory of Sources

Historically, the food processing industry did not apply process water at agronomic rates. Their main emphasis was process water disposal in order to avoid nuisance conditions such as, odor, flies, and truck traffic problems. Neither the industry nor DEQ considered the impact of process water application on groundwater quality. The focus was preventing run off from the application fields. Once the impact of the process water disposal practices were realized, modification to the process water disposal practices began. DEQ worked with the facilities to modify the industry's facility process water discharge permits to protect groundwater quality.

3.2.3 Food Processing Wastewater Goals, Objectives, Strategies, and Actions

Implementation of this plan will rely on current permitting practices of DEQ with input from the food processing industry. The industry will address the intent of the laws and regulations established for groundwater protection. The industry will continue to follow their permit conditions and requirements and meet or exceed all requirements. Additionally, the industry is committed to continued use of the Operation, Monitoring, and Management (OMM) strategy developed through the permitting process. DEQ and food processors will jointly be responsible for implementation of this component.

Goal 1: Assess and adopt best management practices for land application.

Goal 2: Minimize site conditions and land application practices that increase the chance of leaching nitrate to groundwater.

Goal Strategies and Actions

Goal 1: Assess and adopt best management practices for land application.

Objective: Assess current OMM and land application practices and compare them to current BMPs of other land application sites in the area.

Strategy: Review current practices and collaborate with other applicants and DEQ to develop a standardized way of applying food processor waste.

Actions: Review and adopt Irrigated Agriculture's action plan items, including participation in a voluntary BMP certification program.

Responsible Entity: DEQ and WPCF permit holders who land apply food processing wastewater.

Final Draft - Public Comment

ED_005296_00000290-00059

Schedule: As Irrigated Ag evaluates and adopts practices lined out in its section of the Action Plan.

Actions: Review OMM and current practices and compare to other food processors/WPCF permit holders to create a more standard application process with DEQ and permit holders.

Responsible Entity: DEQ and WPCF permit holders who land apply food processing wastewater.

Schedule: Within one year of Action Plan adoption for existing fields and prior to land application at new sites.

Goal 2: Minimize site conditions and land application practices that increase the chance of leaching nitrate to groundwater.

Objective: Identify and minimize site conditions and land application practices that increase the chance of leaching nitrate to groundwater.

Strategy: Evaluate site conditions and land application practices to identify conditions or practices that increase the chance of leaching nitrate to groundwater.

Actions: Evaluate site conditions (e.g., soil type, soil moisture variability, NRCS's Nitrate Leaching Potential http://websoilsurvey.nrcs.usda.gov/app/) and identify fields or portions of fields with high nitrate leaching potential. Evaluate land application practices (e.g., crop selection, crop rotation, fertilization practices (including form, placement, and timing), and irrigation practices (including method, timing, and soil moisture movement beneath the root zone).

Responsible Entity: DEQ and WPCF permit holders who land apply food processing wastewater

Schedule: Within one year of Action Plan adoption for existing fields, and prior to land application at new sites.

Goal 3: Develop nitrogen mass balance model for the LUBGWMA.

Objective: Model nitrogen budget and transport

Strategy: Model nitrogen budget and transport

Actions: Evaluate site conditions (e.g., soil type, soil moisture variability, NRCS's Nitrate Leaching Potential http://websoilsurvey.nrcs.usda.gov/app/) and identify fields or portions of fields with high nitrate leaching potential. Evaluate land application practices (e.g., crop selection, crop rotation, fertilization practices (including form, placement, and timing), and irrigation practices (including method, timing, and soil moisture movement beneath the root zone).

Responsible Entity: DEQ and WPCF permit holders who land apply food processing wastewater

Schedule: Within one year of Action Plan adoption for existing fields, and prior to land application at new sites.

Final Draft For Public Comment

ED_005296_00000290-00060

3.3 Rural, Open, and Green Spaces (ROGs)

3.3.1 Overview

Oregon's 1989 Groundwater Quality Protection Act (Act) [ORS 468B. 184 (1) (f)] requires amendments to affected city or county comprehensive plans and land use regulations (in accordance with the schedule and requirements of periodic review set forth in ORS chapter 197) to address identified groundwater protection and management concerns.

Additionally, Oregon's 1989 Groundwater Quality Protection Act [ORS 468B.187] requires, *within 120 days after the department accepts the final action plan*, each agency of the group that is responsible for implementing all or part of the plan *shall adopt rules* necessary to carry out the agency's duties under the action plan.

This portion of the Local Action Plan is focused on activities that take place in residential areas (lawns, gardens, pastures, domestic wells and septic systems), parks and other open space (city parks, walking paths, and golf courses), and agricultural areas smaller than 40 acres (row crops, hobby farms, livestock and pastures). These sub areas will outline the Goals, Objectives, Strategies, and Actions that will achieve success. A new category has been added to address agricultural practices that happen on small acreages of less than 40 acres on land not zoned for Exclusive Farm Use (EFU).

For this Second Local Action Plan the Residential, Open, and Green Spaces (ROGs) Subcommittee, formally the Rural Residential Subcommittee, have updated the list of contributing sources to reflect what has been learned and to have a broader application beyond residential, to include open and green spaces as well.

To assist readers of this Second Local Action Plan the following definitions, specific to this Action Plan Section, are included:

Rural: lands zoned for rural residential use, including rural residential, farm residential, rural service center, or other pertinent use zones, in north Morrow County and west Umatilla County; lands within the urban growth boundary of Boardman, Irrigon, Umatilla, Hermiston, Echo, and Stanfield, particularly those lands that have ongoing agricultural uses; lands within those same cities for the purposes of land application of chemicals to public lands that are considered open or green space; and any residential use that includes yards and gardens.

Open Space: lands that are generally owned by a public entity that may have public access, but are not maintained with a lawn or other plantings that would require watering and maintenance. Examples might be land owned by the Army Corps of Engineers along the Columbia River in either Umatilla or Morrow County, or land owned by the Bureau of Reclamation that has portions of the Hermiston walking path installed on it.

Green Space: lands that are generally owned by a public entity that may have public access, and that are maintained with a lawn and other plantings that would require watering and maintenance. Examples might include school or city sports complexes, golf courses, cemeteries, or city parks.

It should be noted that this Local Action Plan does not address the impacts to groundwater quality that events such as flooding may have. Other community plans would address these events and may include information about how to manage environmental impacts. Both Umatilla and Morrow Counties have adopted Natural Hazard Mitigation Plans that address flooding and other natural hazards.

ED_005296_00000290-00061

3.3.2 Sources of Nitrates from Residential, Open and Green Space

The principle activities that may contribute nitrate to groundwater include septic systems, lawn and garden practices, conditions of wells, small irrigated operations, and pasture management. The following continuing sources of nitrites and nitrates are addressed within this Local Action Plan:

- Improperly sited, installed or maintained septic systems;
- Density of installed septic systems;
- Wells and their construction, location and leakage;
- Over fertilization of landscaped areas including yards, gardens, and open spaces including parks, play and school grounds;
- Small (less than 40 acres) irrigated operations that are not located on lands zoned for Exclusive Farm Use; and
- Pasture management as an alternative to animal density.

3.3.2.1 Septic System Installation and Maintenance

The standard household septic system is not designed to effectively treat waste water for nitrates. Properly operating systems deliver amounts of nitrate in the range of 50 to 60 mg/L to the soil profile above the groundwater table. Under certain soils, denitrification takes place, however, treatment in the basin's soils are limited because of its sandy, porous nature. Septic systems that have been improperly installed or are not maintained contribute to the movement of nitrite and nitrate to groundwater.

Septic Systems are found throughout the Lower Umatilla Basin Groundwater Management Area (LUB GWMA) outside of the Urban Growth Boundary of city limits. Significant concentrations of septic systems can be found alongside and within urban growth boundaries and in areas where exception lands, otherwise known as lands zoned for rural residential, commercial or industrial uses, have seen significant development. A growing trend is the requirement for the installation of septic systems using Advanced Treatment Technology, often referred to as ATTs. A variety of factors can trigger this requirement, including shallow water tables, limited treatment area based on soil types, and other locational factors.

3.3.2.2 Septic System Density

Generally, this source of nitrate is not a concern from a regional perspective when the volume of wastewater is relatively small compared to the volume of groundwater. However, there is a regional concern when the density or clustering of septic systems exceeds the dilution capabilities of the groundwater system or a local concern when a drinking water well is located too close to a septic system drain field. In some areas of the LUB GWMA, septic system density or clustering affects groundwater quality.

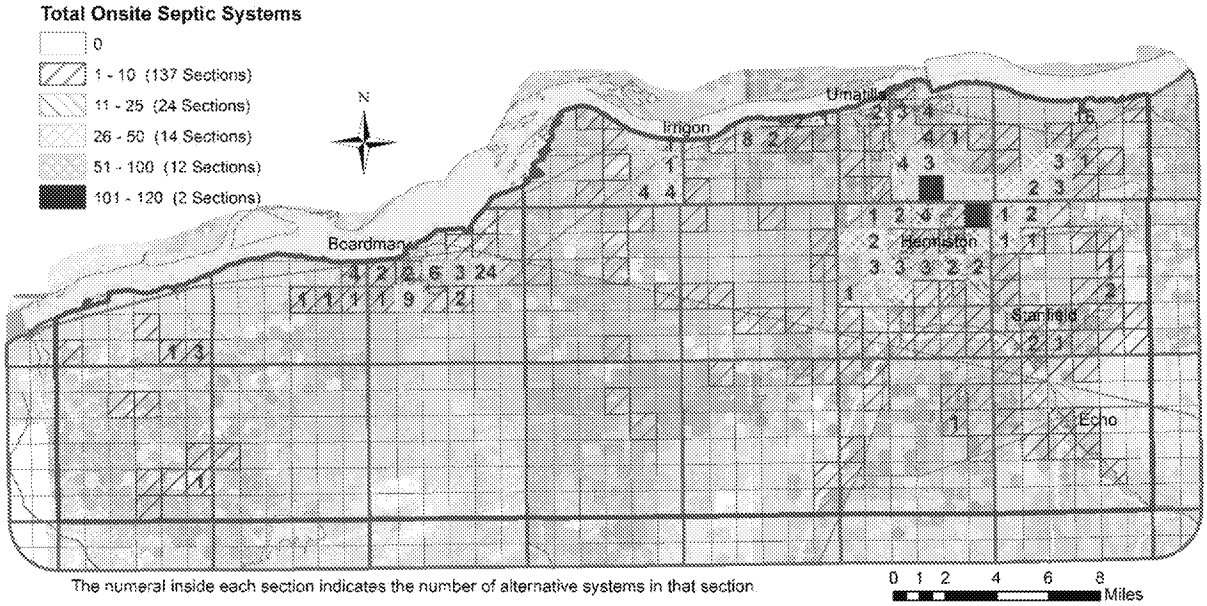
Figure X shows the density of onsite septic systems in the LUBGWMA. The numerals indicate how many alternative systems have been installed within that square mile. The conditions that required the installation of alternative systems are summarized as follows:

- Boardman area: where the permanent water table is shallow and/or where the effective soil depth is shallow. Some denials occur west of Boardman due to a shallow water table.
- Irrigon area: in pockets where the permanent water table is shallow, and where lots are small.
- Irrigon to Umatilla: where the permanent water table is shallow. There have been some denials due to a shallow water table.
- Hat Rock area: where the effective soil depth is shallow (i.e., where bedrock is shallow), and where lots are small.
- Hermiston area: where lots are small. Historically there have been some areas of high water table but this condition is seen less often since flood irrigation has decreased.

Final Draft for Public Comment

ED_005296_00000290-00062

Figure X
Onsite Septic System Density
Lower Umatilla Basin Groundwater Management Area



This map was created using information from the DEQ Eastern Region Onsite Application Database. Information entered into the database starting in 1990 includes such things as owner, location, system type, inspection dates, installer, and fees.

This map contains information from January 1990 through December 2015.
A total of 2,367 onsite systems (including 182 alternative systems) were installed during these 26 years.

Alternative systems are required at locations when a high water table, minimal soil depth, poor soil type, and/or small lot size prevent a standard system. Alternative systems include capping fill systems, pressure distribution systems, and sand filters. Most areas requiring alternative systems could be more vulnerable to groundwater contamination.

Since the first Action Plan was adopted, the Oregon Department of Environmental Quality (DEQ) initiated changes within the Oregon Statewide Planning Program to assure that rural residential lot sizes are 10 acres in size with significantly higher standards to acquire development at lot sizes of two acres.

3.3.2.3 Wells and their Construction, Location and Leakage

Contaminated water moving down a well casing from land surface to groundwater or moving between aquifer units via well bores could contribute to or exacerbate the nitrate contamination problem. Many basin wells were constructed before strict seal requirements came into effect. Improperly sealed wells can facilitate water movement, possibly carrying contaminants from land surface to the groundwater or between aquifer units. The following link is to applicable Oregon Administrative Rules for well construction: http://arcweb.sos.state.or.us/pages/rules/oars_600/oar_690/690_210.html. This link is to the Oregon Water Resources Department and Oregon Health Authority's "Water Well Owner's Handbook": http://www.oregon.gov/owrd/pubs/docs/Well_Water_Handbook.pdf

Locating a septic system or other contamination source too close or up gradient from a poorly sealed well may cause the well to capture contaminated water and allow contaminated water to move further into the aquifer or between aquifers. Well construction and protection of the wellhead is essential to preserving the integrity of the well and the well water.

3.3.2.4 Landscaped Areas: Lawns, Gardens, Open Spaces, Parks, Play and School Grounds

Landscaping, lawn, and garden activities on the basin's sandy soils can deliver nitrate to the groundwater through over-fertilizing and watering; by poor timing of fertilizing and watering; and by not understanding the causes of

ED_005296_00000290-00063

landscape, lawn and garden problems. Golf courses, large school grounds or parks, and residential management of lawns and gardens can all become sources of increased nitrate in groundwater by many activities. Watering too much or too long after fertilization can simply wash the applied fertilizer past the root systems of the plants and into the groundwater.

3.3.2.5 Small Irrigated Operations

Small irrigated agricultural or hobby farm operations on the basin's sandy soils can deliver nitrate to the groundwater much in the same way as what happens with landscaped areas described above. For the purposes of this Second Local Action Plan, this section focuses on areas where agriculture or hobby farm operations may be happening, but the land is not zoned for Exclusive Farm Use. This may be within city limits, an urban growth boundary or other areas zoned for residential development.

3.3.2.6 Pasture Management

Pasturing animals on small acreages can degrade groundwater if not managed properly. Allowing excess manure to build up in a pasture will allow nutrients to accumulate in the soil making them available to leach when irrigation or precipitation occurs. Exceeding the carrying capacity of a pasture can enable animals to over-graze grasses reducing their ability to utilize manure for plant growth. This leads to an accumulation of nitrates and other chemicals, which is then available for leaching to groundwater. Improperly storing manure where precipitation or irrigation water is allowed to percolate through the manure will leach nutrients into the groundwater.

3.3.3 Goals, Objectives, Strategies, and Actions

The primary goal is to reduce nitrate in groundwater throughout the LUBGWMA. The objectives, strategies, and actions are mechanisms to achieve the goal. Success is measured by the actions of achieving the goal. The following ROGS goals are used to attain the primary goal:

Goal 1: Achieve an increased level of knowledge and cooperation around groundwater quality resulting in reduction of nitrate levels.

Goal 2: Reduce nitrate concentrations by implementing best practices in residential, open and green space areas.

Goal 3: Reduce the nitrate concentration from septic systems.

Goal 4: Reduce the potential for contamination of wells; conduct analytical testing for nitrates in domestic wells and educational outreach to domestic well owners on point-of-use treatment options.

Goal 5: Provide technical support for local governing bodies to adopt rules in accordance with Oregon statute.

Goal Strategies and Actions

Goal 1: Achieve an increased level of knowledge and cooperation around groundwater quality resulting in reduction of nitrate levels.

Objectives:

- Increased knowledge with owners and renters of homes, developers, businesses and other facilities within the LUBGWMA
- Increased knowledge of land use planning agencies and state agencies concerning the impacts to the LUBGWMA
- Provide technical support for local governing bodies

Strategy 1.1 Compile information from the industry or regulatory agencies and provide education.

Final Draft For Public Comment

ED_005296_00000290-00064

Actions

- Information gathered can be compiled into a single brochure or broader information packet that can be used by the Oregon DEQ, county planning departments and appropriate city planning staffs to better inform citizens or potential citizens about groundwater quality.
- Offer workshops for realtors on groundwater quality concerns and provide continuing education credits.
- Identify funding and offer a free drinking water well nitrate testing program.
- Implement a project that looks at what types of messages resonate with rural residents to get their drinking water wells tested or treated. The project will gather baseline data on community awareness of local groundwater contamination in specific geographic areas in the GWMA. The results from this study will help the GWMA Committee, DEQ staff, and others better understand constituents' needs, create the appropriate communication tools, and encourage beneficial practices.
- Create and implement a school age program for delivery within the LUBGWMA. Topics should include, but not be limited to, the following: what not to put down your drain, how to have your drinking water tested, and how to maintain a healthy lawn.
- Integrate a groundwater quality component into the local area watershed curriculum initiative and other educational forums (such as: 4H, FAA and Scouts).

Responsible Entity: Morrow County and Umatilla County
Schedule: 2020

Strategy 1.2 Provide information to the public about groundwater quality.

Actions

- Develop appropriate articles and newsletters for local publication and media outlets. Emphasize and encourage the adoption of recommended practices to reduce nitrogen loading to the groundwater.
- Submit a monthly press release to local newspapers, publish a biannual newsletter and submit articles to the Ruralite magazine (written by various agency personnel and active citizens).

Responsible Entity: Morrow County and Umatilla County
Schedule: 2020

Strategy 1.3 Provide the rural residential community with information and alternatives on how to develop property while protecting groundwater quality.

Actions

- Establish an educational/outreach program and material for the region.
- Encourage local area libraries to house information.
- Develop bilingual outreach material for the Hispanic community.

Responsible Entity: Morrow County and Umatilla County
Schedule: 2020

Strategy 1.4 Offer technical support to elected officials, city and county staff, and citizens' advisory groups about the GWMA and associated issues.

Actions

- Provide workshops, briefing sheets, meeting speakers, and other educational tools for local policy-makers and those implementing the policies.
- Coordinate with local partners to include relevant GWMA-related information on their websites.

Responsible Entity: Morrow County and Umatilla County

Final Draft for Public Comment

ED_005296_00000290-00065

Schedule: 2020

Strategy 1.5 Identify organizations, both locally, across the region and state, and nationally that have expertise in this or related areas and utilize their knowledge and materials to benefit the LUBGWMA and assist with implementing this and other portions of the Local Action Plan.

Actions

- Oregon DEQ, County Planning Departments and Commissions, and affected cities lead identification of amendments to city or county comprehensive plans and land use regulations to assist county planning commissions, departments and the development community in addressing the groundwater quality impacts of future development.

Responsible Entity: Oregon DEQ, Morrow County and Umatilla County
Schedule: 2020

Goal 2: Reduce nitrate concentrations by implementing best practices in residential, open and green space areas

Objectives:

- Increase knowledge by providing education about elevated nitrates and the causes
- Implementation of best management practices

Strategy 2.1 Perform outreach and education about best practices to reduce nitrate leaching from residential, open and green space activities

Actions

- Educate and inform landscapers and yard maintenance companies, owners and operators of large public open and green space, and residents generally about best management practices concerning watering, fertilizing and general management of these areas.
- Measure via a survey or other instrument the knowledge of residents about the application of fertilizers at the correct agronomic rate for the plants being fertilized as well as the amount and times of water needed to maintain a healthy landscape, lawn or garden.
- Assist landowners to know about and encourage pasture nutrient, and irrigation management practices for long term viability and to prevent possible groundwater contamination.

Responsible Entity: Morrow County SWCD and Umatilla County SWCD
Schedule: 2020

Strategy 2.2 Assist owners of medium and large animals to better understand the impacts of animals on groundwater and how proper nutrient, manure and irrigation water management can be beneficial to clean drinking water and their environment.

Actions

- Assist landowners to follow general grazing accepted pasture management practices to avoid over grazing of pastures. Include pasture maintenance and renovation, pasture rotation and winter grazing management.
- Assist landowners to practice proper manure management techniques which include the proper collection, storage of manure, waste water control and application techniques.
- Assist landowners to know about and implement measures to minimize wastewater by providing dry manure storage facilities and diverting surface runoff.
- Outreach through animal feed suppliers and veterinarians.
- Morrow and Umatilla County Planning Departments and affected cities amend their animal density

Final Draft for Public Comment

ED_005296_00000290-00066

requirements toward a pasture management system that could allow for more animals if certain conditions are met. Document and map if possible.

Responsible Entity: Morrow County SWCD and Umatilla County SWCD
Schedule: 2020

Strategy 2.3 Umatilla County and Morrow Soil and Water Conservation Districts, the OSU Master Gardener Program, County Planning Departments, County weed managers or supervisors, and the Cities within the LUBGWMA work cooperatively to educate and inform.

Actions

- Provide homeowners and others managing open or green space information about causes of different plant problems, including watering and fertilizing, available to them that is regionally specific with references to available assistance.
- Organize information and develop an educational outreach program on methods and alternatives to properly maintain landscaping, lawns and gardens to prevent leaching nutrients to the groundwater.
- Identify programs currently offered by and through the Umatilla County or Morrow SWCD that could be expanded into the LUBGWMA and determine if there are incentives involved.
- Reengage the cities within the LUBGWMA relative to both residential impacts and the impacts from public lands.
- Engage the OSU Master Gardener Program utilizing their organization, meetings and outreach efforts to the benefit of the residents within the LUBGWMA.

Responsible Entity: Umatilla County and Morrow Soil and Water Conservation Districts, the OSU Master Gardener Program, County Planning Departments, County weed managers or supervisors, and the Cities within the LUBGWMA
Schedule: 2020

Goal 3: Reduce the nitrate concentration from septic systems

Objectives:

- Proper installation and continued maintenance of septic systems to reduce the movement of nitrite and nitrate to groundwater.
- Through amendments to city or county comprehensive plans and land use regulations, address developments proposals with high densities or clusters of installed septic systems and the negative impacts of allowing new areas with increased septic density.
- All low or moderate income residents within high risk areas of the GWMA have access to financial assistance for analytical testing and treatment technologies that reduce nitrate exposure in drinking water.
- Identify impacts to septic systems from various sources, including but not limited to, cancer treatment and other drugs, and misinformed use of septic treatment products. Introducing these other components or compounds into the septic system impacts the proper operation of the system.

Strategy 3.1 Provide ongoing education and information to address groundwater quality and other effects of improperly installed or maintained systems.

Actions

- Take into consideration the location of existing wells, septic systems, and other possible contamination sources before siting a septic system.
- Encourage periodic inspections and replacement or upgrading of septic systems to meet current standards.
- Encourage routine maintenance of septic systems to extend the useful life of the system and minimize groundwater impacts.

Final Draft for Public Comment

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- Use information obtained by surveying septic system pumpers to determine what type of information septic system owners need to improve maintenance of their systems.
- Use information from complaints or through other developed mechanisms to determine failing or impaired septic systems.
- Through amendments to city or county comprehensive plans and land use regulations, consideration should be given to the use of Alternative Treatment Technologies
- Provide information to drug stores and pharmacies about impacts of drugs on septic systems and wastewater treatment facilities. Develop and implement prescription drug take back programs

Responsible Entity: Morrow County and Umatilla County
Schedule: 2020

Strategy 3.2 Morrow and Umatilla County Planning Departments adopt and implement Comprehensive Plan policy statements or other land use measures and rules that implement and maintain a seven to ten acre rural residential parcel size when new lands are converted from resource to non-resource, particularly residential, use.

Actions

- Amend Land Use Plans and Codes to incorporate groundwater concerns and incorporate groundwater quality as criteria in land use review of development proposals.
- Through amendments to city or county comprehensive plans and land use regulations, develop solutions for county and city governments to use to address the cumulative impacts of clustered and high-density septic systems when planning for and reviewing developments.

Responsible Entity: Morrow County and Umatilla County
Schedule: 2020

Strategy 3.3 Facilitate the use of financial incentives to encourage the use of technologies that reduce nitrate contributions from septic systems to groundwater.

Actions

- Promote utilization of Clean Water Loans offered through DEQ to make repairs more affordable.
- Explore options to make use of the State Revolving Loan Fund to finance grants and loans to low- and moderate-income residents for installations or upgrades to meet an approved nitrate reduction standard.
- Investigate the possibilities of using current or new state income tax or county property tax credits or deductions for individuals who install onsite wastewater systems that meet an approved nitrate reduction standard, similar to the idea of a tax credit for water conserving appliances.
- Network with local, state, and federal agencies that provide financial assistance for home rehabilitation and water-quality-protection to ensure that septic system enhancement is an allowable use of those funds.

Responsible Entity: Oregon DEQ, Morrow County and Umatilla County
Schedule: 2020

Strategy 3.4 Minimize septic system wastewater loadings that could create a groundwater quality problem.

Actions

- Utilize septic system density map, hydrogeology, the current built environment overlaid with current zoning.
- Investigate possible methods for determining where in the LUBGWMA high densities of septic systems, in conjunction with soil types and other limiting factors, are likely to have an adverse impact on groundwater quality.

Final Draft for Public Comment

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- Complete amendments to city or county comprehensive plans and land use regulations to guide future land use decisions for zone changes, subdivisions or other land use actions that would decrease wastewater loading.

Responsible Entity: Morrow County and Umatilla County
Schedule: 2020

Goal 4: Reduce the potential for contamination of wells and conduct analytical testing for nitrates in domestic wells and educational outreach to domestic well owners on point-of-use treatment options.

Strategy 4.1 Provide nitrate analytical testing and point-of-use treatment options information to owners and users of wells. Provide information to well drillers, realtors, landscapers and yard maintenance companies concerning various aspects of well construction and maintenance

Actions

- Implement nitrate analytical testing for domestic wells in Morrow and Umatilla County.
- Provide educational outreach to domestic well users regarding point-of-use nitrate treatment options.
- Assure that older wells with poor construction or known leakage are repaired.
- Assure that new wells are installed in such a way as to avoid creating new problems relative to a wells construction, location, or leakage.
- Work with the Oregon Water Resources Department (OWRD), the Oregon Drinking Water Program, and city and county planning departments to provide information
- Construct and repair wells to prevent possible contamination from the surface and the concern about the use of sand points.
- Encourage owners of older wells to get their well casings and seals inspected to ensure that no leakage is occurring.
- Take into consideration the location of existing wells, septic systems, and other possible contamination sources before siting a well
- Locate potential liquid or solid contaminates away from well heads or provide barriers to prevent well contamination.
- When using chemigation provide anti back siphoning devices to prevent contamination of the well and groundwater through back siphoning of chemigation tanks.
- Repair wells that are commingling alluvial and basalt aquifers so contamination in one aquifer does not contaminate another.

Responsible Entity: Morrow County and Umatilla County, OHA, OWRD,
Schedule: 2020

Strategy 4.2 Facilitate the use of financial incentives to encourage proper abandonment or repair of wells

Actions

- Work with Oregon Water Resources Department and Oregon's Drinking Water Program to identify grants and make available loans to improve well construction and repair problem wells.
- Create an incentives program that would encourage owners of problem wells to address the situation.
- Request increased inspection of wells by OWRD and take necessary steps to support the agency in doing this.
- Agency cooperation to identify needs and risks of the LUBGWMA.

Responsible Entity: Oregon (OWRD), Morrow County and Umatilla County
Schedule: 2020

Final Draft For Public Comment

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Goal 5: Provide technical support for local governing bodies to adopt rules in accordance with Oregon statute.

Provide technical support for rule making by city or county comprehensive plans and land use regulations that incorporate groundwater concerns and incorporate groundwater quality as criteria in land use review of development proposals.

Responsible Entity: Oregon DEQ, Morrow County and Umatilla County
Schedule: 2020

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3.4 Confined Animal Feeding Operations (CAFOs)

3.4.1 Overview

An animal feeding operation (AFO) is the holding of animals; including, cattle, sheep, or other animals; in buildings, pens, or lots where the surface has been treated to support animals in wet weather. A confined animal feeding operation (CAFO) that confines animals for more than four months in a year and has a disposal system for liquid waste or a wastewater control facility is required to obtain a permit from ODA (see Table 1 in either the Oregon CAFO National Pollutant Discharge Elimination System General Permit or the Oregon CAFO Water Pollution Control Facilities General Permit). Any reference to "CAFO" in this Local Action Plan refers to an AFO that is required to obtain a permit in the state of Oregon.

Currently there are ten operating CAFO facilities in the LUBGWMA. Each facility operates under a water quality permit jointly issued by DEQ and ODA and each facility is inspected at minimum of once per year to ensure compliance. Of these ten facilities, four are cow dairies and six are cattle feedlots. Cumulatively these CAFOs also manage approximately 42,000 acres of crop and pasture land in the LUBGWMA.

3.4.2 Potential Sources of Nitrate from CAFOs

Primary source are nitrogen from animal manure and process wastewater. Secondary sources are synthetic fertilizer and irrigation water.

CAFOs in the Basin are a source of nitrogen from the animal manure and process wastewater generated at the feeding operation. If these sources are not properly managed, excess nitrate from the manure and process wastewater may leach into groundwater. The CAFO permit requires that an ODA-approved Animal Waste Management Plan (AWMP) be developed and implemented, which must describe the facility's best management practices (BMPs) to store, handle, and utilize manure. CAFOs are required to meet state design standards for impoundments and surfaces where manure liquids and solids will be stored to prevent discharge or leaching of nutrients. The land application of manure and nutrients at CAFOs is regulated and must be applied at or below agronomic rates; and they are required to manage irrigation (manure liquids and fresh water) to prevent runoff and leaching of soluble nutrients (NO^{3-} and NO^{2-}). Also, CAFOs in the basin are required to make records of crops planted, total manure nutrients applied to each field and total additional synthetic fertilizers applied.

Goal 1: Collect, contain, treat and/or store manure and process wastewater at CAFOs in a manner that is protective of groundwater.

Goal 2: Beneficially utilize nutrients at CAFOs and prevent leaching of nutrients to groundwater.

Goal 3: Keep current with CAFO BMPs and provide CAFO education outreach.

Goal Strategies and Actions

3.4.3 Goals, Objectives, Strategies and Actions:

Goal 1: Collect, contain, treat and/or store manure and process wastewater at CAFOs in a manner that is protective of groundwater.

Objective 1: In each 4-year period, CAFOs in the LUB GWMA will have an average annual routine inspection compliance rating of at least 90%.

Strategy 1.1: Surface Water Management. Precipitation, or water, that comes in contact with potential pollutant sources at CAFOs continues to be collected, contained and/or treated. Additionally, CAFOs may incorporate

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facility management techniques that will divert clean surface water and stormwater runoff away from the production area facilities where they can come in contact with manure and stored feed products.

Actions:

- CAFO operators inspect and maintain their systems that collect, contain and/or treat surface and stormwaters that have come into contact with potential pollutants sources at their facility (CAFO permit requires this).
- CAFO operators with fresh water diversion systems inspect and maintain the diversion structures (CAFO permit requires this).

Responsible Entity: CAFO Operators
Schedule: Ongoing; these actions are already required and being implemented

Strategy 1.2. Wastewater Conveyance and Storage Management. Surface and groundwater protection measures for wastewater management include lagoons, evaporative ponds, and conveyance facilities that direct, catch and hold manure, process wastewater and runoff waters that come in contact with manure or feed stores. These facilities allow the capture, management, and storage of manure, process wastewater, and runoff water.

Actions:

- ODA and the CAFO permit will continue to require CAFOs to operate with an approved AWMP that includes a list of planned structural improvements. Newly proposed manure handling structures requires ODA approval prior to constructing.
- CAFOs planning to construct new lagoons, solid storage, and wastewater conveyance facilities submit design plans to ODA for review and receive ODA approval prior to construction.
- ODA reviews design plans for new lagoons, solid storage and wastewater conveyance facilities to ensure that they are designed and constructed in accordance with current state standards to minimize leakage of stored wastewater. ODA may request that DEQ assist in these reviews.
- Existing lagoons and wastewater conveyance facilities meet state design standards for storing wastes, leachates and effluent. All manure and process wastewater structures must be operated and maintained to deliver the designed water quality protections.
- CAFOs follow their operation and maintenance plan in their ODA-approved AWMP when cleaning out sediments from lagoons and holding ponds to prevent damage to the seals or structures, which could result in leakage.

Responsible Entity: CAFO Operators
Schedule: Ongoing; these actions are already required and being implemented

Strategy 1.3. Management of Solid Storage Areas and Feed yard Surfaces. Studies have shown that concentrating animals in a small area produces a surface seal of compacted organic matter and soil that inhibits movement and leaching of effluent through the seal of feed yard surfaces. Anaerobic conditions can also be created in the seal, which will assist in the denitrification process. New pens, manure storage, and feed storage areas are designed and constructed according to state design standards to minimize groundwater issues.

Actions:

- CAFOs store manure in designated locations identified in the ODA-approved AWMP and in a manner that minimizes impact to surface and groundwater.
- CAFOs maintain the surface seal while removing manure and shaping the feedlot pens.
- CAFOs direct runoff to adequately constructed effluent storage or treatment facilities.

Responsible Entity: CAFO Operators
Schedule: Ongoing; these actions are already required and being implemented

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Goal 2: Beneficially utilize nutrients at CAFOs and prevent leaching of nutrients to groundwater.

Objectives: In each 4-year period: 100% of all nutrient applications at CAFOs are done at or below the agronomic rates approved in the respective CAFOs AWMP or other ODA-approved rate plan. ODA will survey CAFOs for their current irrigation management practices to track changes and improvements in CAFO irrigation management systems.

Strategy 2.1. Manure and Process Wastewater Utilization. Manure liquids and solids are beneficially utilized as a nutrient source for growing crops. Combinations of the BMPs are implemented to prevent leaching of nitrates to the groundwater. Additional CAFO-specific nutrient management requirements are contained in the facility's approved Animal Waste Management Plan and Oregon CAFO permit. CAFOs apply nutrients at or below the agronomic rates in their ODA approved AWMP. CAFOs utilize a suite of BMPs that are outlined in their ODA-approved AWMP.

Actions:

- Analyze manure and process wastewater for its nutrient value for use when applying to crops.
- Time nutrient applications to coincide with crop uptake requirements.
- Account for any additional nutrients in irrigation water when determining amount of manure and process wastewater to apply to crop systems.
- Account for the nutrient value of all manure and process wastewater or other nutrient source spread on a field. CAFOs cannot exceed the agronomic application rates listed in the ODA-approved AWMP.
- Irrigation water management practices to prevent transport of soluble nutrients as contained in their ODA approved AWMP
- Implement a rotational crop cycle with deep-rooted crops (>3ft rooting depth) to manage nitrates that may have moved past the root zones of shallower rooted crops. Utilizing this deeper nitrate makes it unavailable for leaching to groundwater.
- Employ real-time monitoring and precision agriculture techniques.
- Conduct frequent soil sampling including pre-side dress soil nitrate test (for corn) and end of growing season post-harvest soil tests to evaluate nitrate levels remaining in soil and plan strategies for the next crop cycle.

Responsible Entity: CAFO Operators
Schedule: Ongoing; these actions are already required and being implemented

Strategy 2.2: Irrigation Management. Irrigation applications of water and process wastewater are managed to prevent leaching of nitrates to the groundwater utilizing crop sensors that provide real-time moisture information to maximize irrigation use and efficiency as well as nutrient management. Knowing the soil moisture assists in preventing leaching of nitrates.

Actions:

- At least annually, and prior to the start of irrigation season, CAFOs review the irrigation water management section of their ODA-approved AWMP so that subsequent irrigation operations do not exceed the soil intake rate or provide more water than the rooting depth profile can store.
- CAFOs implement combinations of BMPs, or strategies, when irrigating such as:
  1. Develop operation and maintenance schedules for irrigation equipment to ensure water is applied at correct rates.
  2. Maintain irrigation equipment.
  3. Use soil moisture monitoring systems, real-time monitoring, precision agriculture techniques, and/or other technologies.

Final Draft for Public Comment

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4. Balance irrigation applications with crop needs and soil characteristics throughout the irrigation season.
5. Use dammer-diker, or similar type of implement where possible with row crops on sloped fields to help control irrigation run-off and prevent ponding at low spots, thus subsequently help prevent leaching of nutrients from those areas.
6. Convert to more efficient irrigation systems and practices with a lower potential to leach excess water to the groundwater.

Responsible Entity: CAFO Operators
Schedule: 2020

Goal 3: Keep current with CAFO BMPs and provide CAFO education outreach.

Objective: In each 4-year period provide a written summary of any updated CAFO BMPs information and of activities accomplished to develop and/or deliver CAFO education outreach.

Strategy 3.1: Keep current with CAFO BMPs, emerging technologies and monitoring advances.

Actions:

- Periodically review, research, and identify emerging BMPs and technologies that will improve waste management practices within CAFOs.
- CAFOs annually review their ODA-approved AWMP to make sure that is reflective of the actual operations at the CAFO. AWMP amendments are necessary to include any new BMPs or changes to existing BMPs.
- Attend CAFO manure management conferences.
- Review scientific literature and studies relating to CAFO operations such as groundwater quality management, cropping system nutrient utilization, irrigation water management system, and advances in soil and crop systems monitoring techniques.

Responsible Entity: CAFO Operators and technical service providers
Schedule: 2020

Strategy 3.2: Develop and implement ongoing CAFO education outreach.

Actions:

- ODA provides upon request on site planning assistance and educational reviews to AFOs and CAFOs. This provides an operation the opportunity to assess current or proposed BMPs effectiveness in groundwater protection. SWCD and NRCS are also available to provide individual farm evaluations of CAFOs to assess the adequacy of groundwater protection measures.
- Develop a brochure that explains when a CAFO permit is required, and also maintain this information on a web site.
- ODA will develop and maintain a web page with a contact list of individuals and agencies with technical expertise in design, construction, and operation of CAFOs.
- SWCD, NRCS, and ODA will develop and maintain a list of web links that directs CAFOs to BMP information.
- Develop a public outreach plan to educate the public about the BMPs that CAFOs implement to protect surface and groundwaters.

Responsible Entity: ODA and CAFO Operators
Schedule: 2020

Final Draft for Public Comment

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Final Draft For Public Comment

ED_005296_00000290-00075

3.5 Livestock Operations

3.5.1 Overview:

Livestock operations constitute an important agricultural activity in the GWMA that support local markets and the economy. Livestock operations range from large irrigated pastures grazed year round or in rotation with other pastures to small rural properties that may have a few animals year around. It would also include seasonal grazing of crop aftermath.

For this action plan, livestock will be defined as domesticated animals being raised or fed within the LUBGWMA in pastures, rangeland, or confinement areas except for animals in permitted CAFOs. For more information about CAFOs see the CAFO section of this action plan and the ODA CAFO Program web site at: http://www.oregon.gov/oda/programs/NaturalResources/Pages/CAFO.aspx.

Livestock operations include, but are not limited to: cattle and calves, horses, ponies, donkeys and mules, sheep, goats, llamas, swine, chickens, and fowl. All livestock operations are regulated by local Agriculture Water Quality Management Area Rules, and are prohibited from discharging pollution to surface or groundwater.

There is an estimated 16,000 acres of irrigated pasture in the GWMA. Using an animal density of 0.5 animals per acre* there is an estimated 8000 cattle and horses in the GWMA. There is no way, at this time, to estimate the number of smaller animals - goats, sheep, pigs, etc.

The waste (manure) from livestock operations is a potential source of nitrate available for leaching into groundwater. Generally, on a well-managed irrigated pasture, the nutrients in manure are utilized to sustain the growing vegetation, with little available to be leached to groundwater. Areas where animals are concentrated on bare or sparsely vegetated ground, especially if irrigated or where water is ponded, pose the greatest threat for excess nutrients to leach to shallow groundwater.

* *Estimation of Nitrogen Sources, Nitrogen Applied, and Nitrogen Leached to Groundwater in the Lower Umatilla Basin Groundwater Management Area,* June 13, 2011

3.5.2 Inventory of Livestock Operation Sources:

Potential livestock sources of nitrate in the groundwater include:

- Pasture Management
- Solid Manure Management
- Confinement Area Management
- Irrigation Management
- Wastewater Runoff
- Stormwater Runoff

Pasture Management

A grazing management system should promote and maintain adequate vegetative cover, for protection of water quality, by consideration of intensity, frequency, duration, and season of grazing. Allowing excess manure to build up in a pasture will allow nutrients to accumulate in the soil making them available to leach or run off to surface water when irrigation or precipitation occurs. Exceeding the carrying capacity of a pasture can enable animals to over-graze grasses reducing their ability to utilize manure for plant growth. This leads to an accumulation of nitrates that is then available for leaching to groundwater.

Final Draft for Public Comment

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Recommended Management Practices

- Follow generally accepted pasture management practices to avoid over-grazing of pastures. Include pasture maintenance and renovation, pasture rotation, and winter grazing management.
- Encourage pasture, nutrient, and irrigation management practices for long-term viability and to prevent possible groundwater contamination.

Solid Manure Management

Allowing manure to accumulate or storing manure where precipitation or irrigation water is allowed to percolate through the manure will leach nutrients into the groundwater. Solid manure exported or properly stored and applied at agronomic rates. Proper storage includes covering manure piles in months when precipitation could transport nutrients, organic material and bacteria in the manure to surface or groundwater.

Recommended Management Practices

- Practice proper manure management techniques that include the proper collection, storage of manure, waste water control and application techniques.
- Follow the recommendations on fertilizing and irrigation practices outlined in the irrigated agriculture portion of the action plan.
- Divert clean surface water and stormwater runoff away from confinement areas where they can come in contact with manure and stored feed products.

Confinement Area Management

Concentrating animals in small areas can lead to bare ground, manure accumulation, and wet areas that will make nutrients available for leaching in to groundwater. Recommended management practices include the following:

- The surface of the confinement area (corral, feedlot, loafing area) should be prepared by compaction, shaping, sloping, or adding impervious material that allows water and nutrients to drain to a safe area. A surface seal of compacted organic matter and soil can inhibit movement and leaching of effluent through the seal.
- Minimize wastewater by providing dry manure storage facilities and diverting surface runoff.
- Care should be taken to avoid locating confinement areas near wellheads.

Irrigation Management

Application of irrigation water to pastures, like any other agricultural operation, can lead to over-application or uneven application that could make nutrients available for leaching into groundwater. Small acreages are often flood irrigated on a fixed schedule. Pastures often lack irrigation systems that allow for precision application of water. Recommended management practices include the following:

- On occupied pastures, practice irrigation scheduling, including amount and timing, and equipment maintenance, to apply the proper amount of water to pastures for optimum forage production without runoff or ponding.
- Convert flood irrigation systems to precision irrigation systems to improve irrigation efficiency and reduce runoff or ponding.

3.5.3 Livestock Goals, Objectives, Strategies, and Actions

These goals and the associated strategies focus on addressing the potential of nitrate contamination of groundwater caused by livestock in the GWMA. Education and outreach is the primary mode for helping producers understand the best and most economical means for making any necessary changes to reduce nitrate loading to groundwater.

Final Draft for Public Comment

ED_005296_00000290-00077

Goal 1: Reduce groundwater nitrate concentrations caused by livestock.

Goal 2: Organize outreach and education efforts to increase community awareness of groundwater vulnerability and best management practices for livestock operations.

Goal 3: Identify best management practices (BMP) effectiveness and best management practice adoption of updated BMP's

Goal Strategies and Actions

Goal 1: Reduce groundwater nitrate concentrations caused by livestock.

Objectives:

- By 2020, determine sub-regions of the GWMA with high risk of groundwater contamination from livestock operations.

Strategy 1.1 ODA and the SWCDs will complete a comprehensive inventory of large and small livestock operations including acreage, irrigation methods and drainage paths.

Actions:

- Inventory large and small livestock operations.
- Inventory livestock operations manure and irrigation management
- Assess information to determine sub-regions of the GWMA with highest risk of groundwater contamination from livestock operations.

Responsible Entity: ODA, Morrow and Umatilla SWCDs
Schedule: 2020

Strategy 1.2 Select and implement a Focus Area (FA) in the GWMA.

Actions:

- Based on initial inventory, the SWCDs will select a sub-region determined to be a high risk of groundwater pollution
- The intent in selecting Focus Areas is to deliver systematic, concentrated outreach and technical assistance in small geographic areas through the SWCDs and other partners.
- Working within a Focus Area is not intended to prevent implementation within the remainder of the GWMA. The remainder of the GWMA will continue to be addressed through general outreach and technical assistance.

Responsible Entity: ODA, Morrow and Umatilla SWCDs
Schedule: 2020

Goal 2: Organize outreach and education efforts to increase community awareness of groundwater vulnerability and best management practices for livestock operations.

Objectives:

- In three years, a survey of livestock producers and field representatives in the GWMA shows that 90% are aware of the GWMA and 25% are taking steps to protect groundwater.
- By 2020, the number of livestock operations converting from flood irrigation to sprinklers have increased by 20%.

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ED_005296_00000290-00078

Strategy 2.1 Write and publish articles to promote and improve the livestock producer's awareness of water quality issues in the GWMA.

Actions:

- Implement LUBGWMA Outreach Plan.
- Organize and deliver workshops and demonstration projects aimed at livestock producers to show BMP implementation and foster improved BMP use.
- Work with the Umatilla and Morrow County Land Use Departments to review and update county livestock ordinances for compatibility with GWMA goals.
- Once a year, provide an update on the status of the Lower Umatilla Basin GWMA and associated water quality data in each of the Umatilla & Morrow County SWCD newsletters. This should begin in the first state fiscal year after DEQ approves and implements the Local Action Plan.
- Publish two media articles or public service announcements per year in the LUBGWMA about FA activities and successful agricultural resource management practices.
- Work with Irrigation Districts to continue upgrading delivery systems and conversion of flood irrigation to sprinkler and drip systems.
- Work with ROGS committee to address livestock operations in small acreage rural residential settings.

Responsible Entity: Morrow and Umatilla SWCDs
Schedule: 2020

Strategy 2.2 Share information and coordinate with agribusiness, producers, and producer groups to promote groundwater quality.

Actions

- Meet with agribusiness field representatives active in the LUBGWMA to review the groundwater nitrate issue and share appropriate outreach materials from ODA, DEQ, SWCDs, OSU Extension Service, and other appropriate sources. This should occur once every two years. Some possible ways to meet with field representatives include:
  - Grower meetings, Hermiston Farm Fair.
  - Individual company meetings.
  - Oregon Agriculture Chemical and Fertilizer safety training workshops.
  - Breakfast or lunch for local field representatives sponsored by local SWCDs and partners such as ODA, OSU Extension Service, and Natural Resource Conservation Service.
- Each SWCD will deliver one groundwater quality presentation (either as a stand-alone presentation or part of a broader presentation) at one Ag-related or producer group meeting per year.
- Target one producer group per year and distribute OSU Extension Service best management practice (BMP) descriptions to producers and field representatives.
- Make at least 20 groundwater quality contacts per year within the areas served by the Umatilla and Morrow SWCDs.
- Deliver compliance and BMP implementation % and success rates discovered in initial FA implementation. Have operators located in FA describe process from their perspective.

Responsible Entity: Morrow and Umatilla SWCDs
Schedule: 2020

Strategy 2.3 Encourage conversion of flood irrigation systems to more efficient systems.

Actions:

- Work with Irrigation Districts and irrigators to continue upgrading delivery systems and conversion of flood irrigation to more efficient systems. Assist landowners in obtaining financial support for conversion of flood irrigation to more efficient systems.

Final Draft For Public Comment

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Responsible Entity: Morrow and Umatilla SWCDs
Schedule: 2020

Goal 3: Identify best management practices (BMP) effectiveness and best management practice adoption of updated BMP's

Objectives:

- ODA and SWCDs will survey local livestock owners for currently used BMPS, evaluate and publish results to the livestock community.

Responsible Entity: ODA, Morrow and Umatilla SWCDs
Schedule: 2020

Strategy 3.1 Write and publish articles to promote and improve the livestock producer's awareness of current BMPs in the GWMA.

Actions:

- Organize and deliver workshops and demonstration projects aimed at livestock producers to show BMP implementation and foster improved BMP use.
- Review county livestock ordinances for compatibility with GWMA goals.
- Collaborate with OSU, SWCDs on the updated list of BMPS that should be utilized more frequently to protect groundwater quality.
- Survey (2nd time) local livestock owners of updated BMPS, evaluate and publish results to the livestock community and document changes.

Responsible Entity: Morrow and Umatilla SWCDs
Schedule: 2020

Strategy 3.2 Develop methodology to assist landowners to evaluate the proper carrying capacity of pastures.

Actions:

- Assist landowners determine carrying capacity of pasture by evaluating soil and pasture health.
- Use soil sampling and tissue sampling techniques to determine individual pasture health based on soil fertility and plant health (organic matter, protein and carbohydrate content).

Responsible Entity: Morrow and Umatilla SWCDs
Schedule: 2020

3.6 Public Water Systems

3.6.1 Overview

There are 81water systems (both active an inactive) that historically and/or currently provide drinking water to the people living in the GWMA. Public water systems are defined as having either more than three connections or serving greater than 10 people. Most of the public systems in the region depend on the shallow aquifer to provide a clean, steady supply of water.

There is a blend of both large and small public water systems in the region. There are 19 larger public water systems (systems serving at least 25 people or having 15 connections) such as the City of Hermiston, serving over 15,000 people, and Westland Estates Water System, serving about 60 people. The remainder of public water

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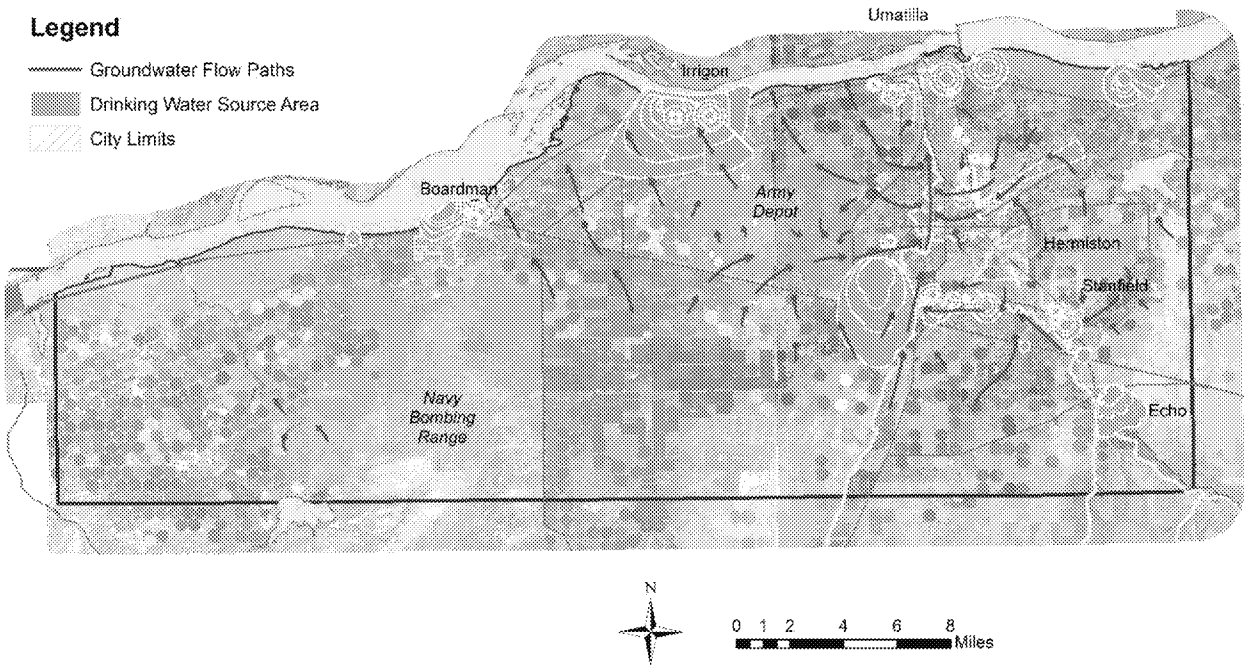
ED_005296_00000290-00080

systems consists of 15 smaller state regulated systems, such as trailer parks or small businesses, which serve fewer than 25 people or have less than 15 connections. The majority of water systems are located in or near municipalities located in the northeastern portion of the GWMA.



Public water supply systems are concerned about nitrate because they are required to provide safe water that meets federal drinking water standards. Public water systems in the GWMA have tested positive for nitrate levels greater than 7 mg/L in the past five years (Oregon Health Authority, 2011 through 2016). The location of public and private drinking water wells that have exceeded the nitrate drinking water standard at least once are shown in the next figure.

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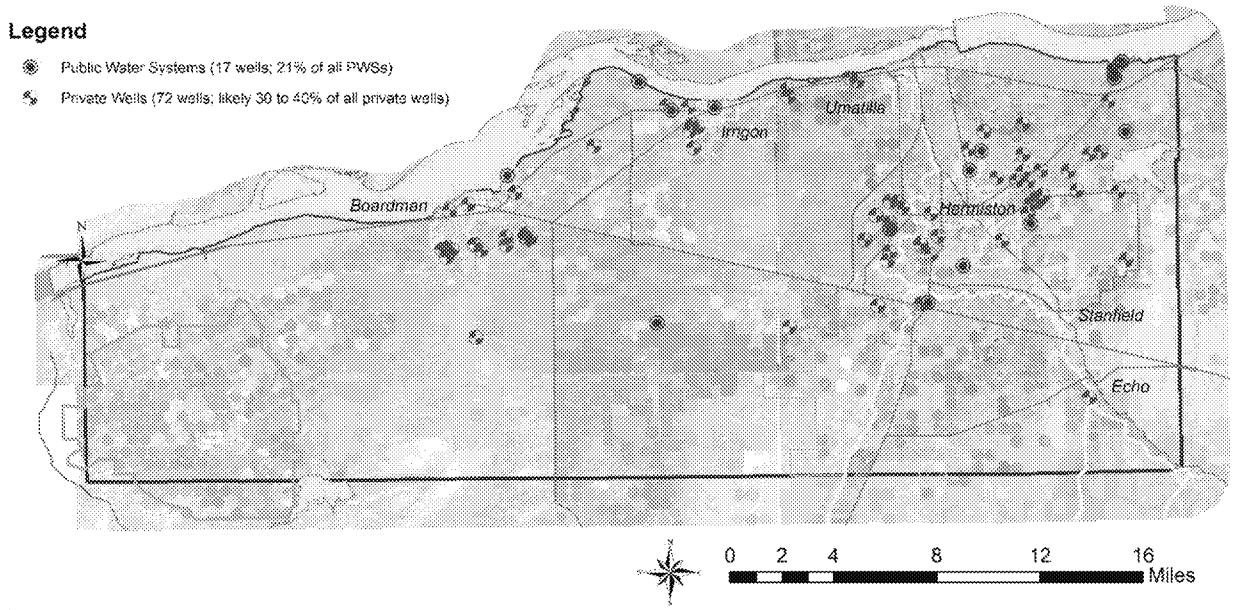
Public and Private Drinking Water Wells that Have Exceeded the Nitrate Drinking Water Standard
Lower Umatilla Basin Groundwater Management Area



Notes:
Public wells include both active and inactive Public Water Systems monitored by Oregon Health Authority. Of the 181 PWSs in Umatilla and Morrow County, 18 (10%) have exceeded the nitrate drinking water standard at least once. 17 of these wells (94%) are within the LUBGWMA. Of the 81 PWSs in the LUBGWMA, 17 (21%) have exceeded the standard at least once. These percentages do not take into account which aquifer these wells tap. Because some PWS wells are likely completed in the basalt aquifer, the percentage of PWS wells with high nitrate that utilize only the alluvial aquifer is likely higher than 21%.

Private wells on this map include 50 wells from the Real Estate Transaction database, 14 wells from the regular LUBGWMA Network wells, 7 domestic wells that were included in the 2009 Synoptic Sampling Event, and the Navy Bombing Range well. Approximately 10% of the RET results show nitrate values over the standard. Because the RET database is known to contain results from treated samples and basalt wells, it is likely not a good indicator of the magnitude or extent of nitrate contamination. Approximately 42% of the domestic wells in the LUBGWMA network show nitrate values over the standard. Approximately 30% of the domestic wells sampled during the 2009 Synoptic Sampling Event showed nitrate values over the standard.

Nitrate is difficult and expensive to remove from public drinking water systems. Therefore, measures to prevent nitrate contamination can help meet health standards while reducing the need for expensive treatment. The presence of nitrate in drinking water indicates higher vulnerability to other contaminants such as herbicides, insecticides, and bacteria. DEQ and Oregon Health Authority Drinking Water Services have completed Source Water Assessments for the public water systems in the GWMA. These assessments clearly identify the area from which public systems get their water and include an inventory of potential risks and risk ratings within that area.

The established methodology of the Source Water Assessments provides a tool to examine all potential risks to groundwater for a limited area within the GWMA. Although not confirmed, some of the same risks may exist for people who rely on household wells. The Source Water Assessment work provides valuable information that, although specific to a defined portion of the GWMA, can be a useful tool for overall evaluation of groundwater risk in the area.

3.6.2 Inventory of Potential Risks to Public Water Supplies

The Source Water Assessment delineation identifies the area from which a well draws its water. Time of travel zones were developed to give a tangible indication of how quickly contamination could reach the water distribution network. There are two-, five-, 10-, and 15-year time of travel zones. According to the models used, a drop of water that enters the aquifer within the two-year time of travel zone could potentially reach the drinking water supply within two years, in the five-year zone it will take five years, and so on.

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The Source Water Assessment inventory of potential contaminant sources is designed to identify and locate significant potential sources of contamination within the drinking water protection area. The sites and areas identified are only potential sources of contamination to the drinking water, and water quality is not likely to be impacted if contaminants are managed properly. Potential contaminant sources are assigned a risk rating of high, medium, or low to indicate the level of potential risk to the water supply. The risk ratings were developed by the EPA. These ratings are not site specific, but are based on the general nature of the land use activity

Within the area that is relatively close to the wells, where it is estimated that a contaminant could reach the water supply within a five-year time frame. There are different types of potential contaminant sources in the GWMA that are considered a high or medium risk (Oregon Health Authority and Oregon Department of Environmental Quality, 1999-2005).

The most common potential contaminant sources identified in the assessments of the public water systems include agriculture (irrigated and non-irrigated), heavily used transportation corridors, large onsite septic systems, wells/abandoned wells, and high-density housing with septic systems. With the exception of transportation corridors, all of these are potential sources of nitrate. Potential sources of nitrate are the same for public water supplies as in other areas of the GWMA and have been discussed in previous sections. There are many additional potential risks to drinking water safety including hazardous waste or fuel spills on heavily used highways or railroads, releases from vehicle and equipment repair facilities, leaks from current and past fuel or chemical storage tanks, and contaminants released from a variety of commercial enterprises.

The source water assessment evaluates the soil sensitivity of the soils present in the delineated drinking water source area (DWSA). Soil sensitivities are determined based on time of travel rates in terms of hours. Groundwater under soils with higher sensitivities are more likely to become contaminated than groundwater under soils with lower sensitivities. Water soluble chemicals, such as nitrate, are more prone to moving through the soil. A Public Water System may have few sources inside its 10-year time-of-travel zone, but still be affected by long-term regional problems. Previous studies have shown that agriculture is typically a larger nitrate source than urban development and onsite septic systems (Ceplecha et al 2004, McMahon et al 2008), but both are important contributors of nitrate (Mueller et al 1995). Even relatively low densities of septic systems (0.2 systems per acre) can cause violations of the nitrate drinking water criterion when there is little recharge from other sources (Bauman and Schafer 1985). Nitrate impacts of septic system could be exacerbated by the presence of antibiotics in the effluent if denitrifying bacteria are damaged, inhibiting the potential for nitrate to be reduced into a less harmful form of nitrogen (Underwood et al 2011).

3.6.3 Public Water Supply Goals, Objectives, Strategies, and Actions

The Source Water Assessment information provided a thorough evaluation of the potential contamination sources in the region and ensured that the strategies are targeted to the most pressing risks. The goals' strategies and actions of potential risks to public water supplies focus on pollution prevention to: protect the drinking water source, meet water quality standards, avoid costly remediation, prevent the burden of finding a new source, and uphold the community's reputation for having a clean drinking water supply.

Goal 1: Develop nitrogen mass balance model for the LUBGWMA.

Goal 2: Increase public awareness of groundwater vulnerability, what can be done to protect drinking water, and resources available to aid protection efforts.

Goal 3: Recognize and promote actions that are being taken to protect drinking water.

ED_005296_00000290-00083

Goal 4: **Supplement existing employee training programs, provide GWMA-specific information to trainers, and seek out technical assistance opportunities related to drinking water protection.**

Goal 5: **Encourage land use planning and public health procedures that prevent or minimize groundwater contamination.**

Goal 6: **Work with regulatory authorities to provide prioritized, focused, and customized efforts for regulated and permitted activities within the five year time of travel drinking water protection areas.**

Goal 7: **Evaluate remediation feasibility to dilute nitrogen hotspots in groundwater and source water protection.**

Goal Strategies and Actions

Goal 1: Develop nitrogen mass balance model for the LUBGWMA.

Objectives:
- Model nitrogen budget and transport in the LUBGWMA through sample data and proxy data.

Strategy 1.1
Work with EPA researchers to identify data and complete a nitrogen mass balance model for the LUBGWMA.

Actions:
- Evaluate land-use, CAFOs, N deposition, stream chemistry, and crop-level and county-level fertilizer use to assess the N inputs, exports and retention in the LUBGWMA.

Responsible Entity: EPA, DEQ, OHA, ODA
Schedule: 2020

Goal 2: Increase public awareness of groundwater vulnerability, what can be done to protect drinking water, and what resources are available to aid protection efforts.

Objectives:
- Increase GWMA population awareness of groundwater vulnerability and groundwater protection activities.
- Increase the number of residents and targeted businesses that have changed at least one practice to improve groundwater protection and/or water conservation.

Strategy 2.1
Public Water Systems notify state and local emergency response planners of the locations of their Drinking Water Source Areas and ensure that water system operators are notified in case of a spill or other emergency that may impact the water supply.

Actions:
- OHA and DEQ prepare and distribute a "tipsheet" including a list with contact information for all agencies involved with spill response, links to GIS-based maps of the Drinking Water Source Areas in the region, and triggers for reporting spills to first responders.
- Public Water Systems coordinate with state, regional, and local emergency responders to identify and address gaps in communication related to spill response.

Final Draft For Public Comment

ED_005296_00000290-00084

- Public Water Systems keep information current and make contacts every 2-3 years.
- Public Water Systems request spill response maps from OHA as needed.

Responsible Entity: OHA and DEQ
Schedule: 2020

Strategy 2.2
Municipal Public Water Systems distribute GWMA-specific educational materials and drinking water protection materials focused on new development through local planning departments, with permit applications, and at public works offices.

Actions:
- Every two years, review available information and develop new GWMA-specific materials as necessary.
- Identify distribution methods and locations, get approval, and continue distribution through OSU Extension, planning department counters, public water suppliers and other appropriate mechanisms.

Responsible Entity: Municipal Public Water Systems
Schedule: 2020

Strategy 2.3
Public Water Systems erect signs along major roadways to inform people that they are entering a drinking water supply area and provide a contact number for more information.

Actions:
- Public Water Systems work with stakeholders to determine what information to include and design signs.
- Establish informational phone number to include on the sign.
- Contact public works departments, determine locations for signs, contact appropriate jurisdictions for approval, and erect signs.
- Explore OHA grant funding to implement strategy.
- OHA/DEQ provide assistance as needed.

Responsible Entity: Municipal Public Water Systems
Schedule: 2020

Strategy 2.4
Develop a social marketing template based on focus group outcomes and distribute information to residents, commercial and industrial businesses, and farmers informing them of their location within the GWMA and the Drinking Water Source Area of a public water system and identify things they can do to help protect the resource.

Actions:
- Review results from the residential and agricultural focus groups.
- Divide target markets into categories and tailor messages and mechanisms for distribution based on group characteristics.
- Obtain information specific to different land uses that could contribute to groundwater contamination.
- Identify appropriate distribution channels (mailings, workshops, planning counters, etc.).
- Public Water Systems work with County to develop address list of residents with on-site systems in high risk areas (such as 5-year time of travel zones, older systems, etc.) and obtain booklet
- Public Water Systems coordinate with DEQ to distribute a booklet on proper septic system care, maintenance, and inspection to rural residents within the five-year time of travel zones of drinking water protection areas. Ensure that each household in the defined high risk areas receives this booklet

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ED_005296_00000290-00085

Responsible Entity: Municipal Public Water Systems
Schedule: 2020

Strategy 2.5
OHA and DEQ document all available funding sources to address drinking water protection issues and share this information with water system operators, public officials, and interested residents (This strategy is a precursor to many other strategies).

Actions:
- Identify all sources and prepare matrix of funding sources.
- Make information available to water system operators via website or mailing.
- Update previously developed funding matrix.
- Public Water Systems consult with OHA and DEQ as needed to secure groundwater protection grant funding.
- OHA and DEQ provide individualized technical assistance to Public Water Systems (prioritizing with Community and Non-transient Non-Community systems) to promote specific best management practices and adequate funding.
- Inform GWMA coordinator of OHA Drinking Water Protection Grant LOI application period dates.

Responsible Entity: OHA and Municipal Public Water Systems
Schedule: 2020

Goal 3: Recognize and promote actions that are being taken to protect drinking water.

Objectives: OHA and DEQ establish and/or maintain programs to actively engage Public Water Systems and stakeholders in drinking water protection actions.

Strategy 3.1
DEQ oversees the Tim Bunnell Community Hero Awards Program for public water system operators that are leaders in protecting drinking water.

Actions:
- Identify partners and collaborate with them to advertise award and request nominations.
- Present award and advertise results.

Responsible Entity: DEQ and Municipal Public Water Systems
Schedule: 2020

Goal 4: Supplement existing employee training programs and provide GWMA-specific information to trainers, and seek out technical assistance opportunities related to drinking water protection.

Objectives:
- Contact the high and medium risk businesses within the 5-year time of travel zones about the GWMA. Encourage those businesses to change at least one practice that will better protect groundwater.
- Increase the number of high and medium risk businesses in the five-year time-of-travel that have drinking water protection information included in training.

Strategy 4.1

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DEQ works with existing land management, watershed management, and pollution prevention groups to increase awareness about groundwater contamination in the GWMA and promote practices to reduce risk.

Actions:

- Identify or establish Pollution Prevention groups in/for Umatilla and Morrow counties.
- Brainstorm project ideas with partners to increase residents' adoption of best practices
- Gain support and research funding for development of regional pollution prevention team to address issues in GWMA; prepare supporting documents.
- Obtain support from jurisdictions for expanded pollution prevention efforts in the region through presentations and staff contacts, secure funding and in-kind support.
- Invite staff and professionals to be involved in pollution prevention the actions.

Responsible Entity: Oregon DEQ
Schedule: 2020

Strategy 4.2
Provide forums designed to make technical assistance and training opportunities available to water systems, local government officials, and planning staff to reduce contamination risks within established drinking water source areas.

Actions:

- OHA and DEQ Drinking Water staff continue to work with public water systems to deliver training sessions for area planners and community leaders (sponsored by water system).
- OHA and DEQ organize an annual meeting of public water systems within the GWMA to update them on Local Action Plan accomplishments and engage them in next steps.
- OHA and DEQ Drinking Water staff will partner with public water systems to provide drinking water protection materials for local businesses to use in employee training programs.

Responsible Entity: OHA and DEQ
Schedule: 2020

Strategy 4.3
Continue to partner with agricultural organizations to promote on-farm technical assistance to landowners regarding risks to public water supplies within the GWMA's Drinking Water Source Areas.

Actions:

- Drinking Water staff meet with County SWCDs, ODA, NRCS staff, and OSU Extension staff working within GWMA to develop project proposal, including scope of work and funding source(s).
- Partners with agriculture interests (such as ODA, NRCS, etc.), with support from Drinking Water staff, advertise opportunity for farmers to participate in on-farm assistance.
- Partners provide assistance and maintain relationship with participating farmers to monitor results.

Responsible Entity: OHA, County SWCDs, ODA, NRCS staff, and OSU Extension
Schedule: 2020

Strategy 4.4
Establish a mentoring program with large businesses helping smaller, less regulated businesses in drinking water source areas within the GWMA.

Actions:

- Research successful mentoring programs and develop appropriate materials.

Final Draft For Public Comment

ED_005296_00000290-00087

- Deliver presentation on mentoring program to business coalitions/Chamber of Commerce to gain support.
- Develop plan for conducting outreach to businesses to encourage participation in mentoring effort.

- Share spill response resources with businesses and sponsor joint employee training workshops.

Responsible Entity: DEQ
Schedule: 2020

Goal 5: Encourage land use planning and public health procedures that prevent or minimize groundwater contamination

Upon request, OHA can provide water systems with drinking water source area maps/and/or provide a location for statewide drinking water source area layer download location.

Zoning/Health Ordinance Objective

- DEQ and OHA will partner with local staff to inform all local jurisdictions in the GWMA about possible zoning/health ordinance changes and provide examples.

Strategy 5.1
Where applicable, work with local jurisdiction(s) to establish drinking water protection overlays in the 5-year time of travel zones of the Community and Non-Transient, Non-Community water systems in the GWMA.

Actions:

- Establish a contact list of planning staff and elected officials in the GWMA.
- Meet with city and county planners to present examples of drinking water protection overlays. Upon request provide public water systems guidance with example overlay zones.
- Upon request, assist local and county government staff in proposing overlay zone to planning commissions and elected officials.

Responsible Entity: DEQ and OHA
Schedule: 2020

Strategy 5.2
Provide information to staff and local officials about model ordinances available to governing bodies to implement drinking water protection measures.

Actions:

- Compile information about the costs of drinking water contamination, examples of ordinances other than overlay zones, and information detailing examples of communities that had to address contaminated drinking water.
- Contact public officials and staff and arrange a time to discuss potential drinking water protection measures.
- Meet with cities and counties to identify barriers to implementation and propose solutions to address these issues.

Responsible Entity: DEQ and OHA
Schedule: 2020

First Draft for Public Comment

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Strategy 5.3
PWS(s) request that all county and city planning departments in the GWMA notify water systems of proposed development actions in the five-year time-of-travel zones or provide operators with web-site information where they can access development information.

Actions:
- PWS(s) compile contact information of all county and city planning staff and create detailed maps of the five-year time-of-travel zones within each jurisdiction.
- Obtain support from water system operators and public works directors and provide information to planning staff.
- Monitor development actions within the five-year time-of-travel zones.

Responsible Entity: Municipal Water Systems
Schedule: 2020

Goal 6: Work with state agencies to provide prioritized, focused, and customized pollution reduction efforts for regulated and permitted activities within the five year time of travel zone in drinking water source areas in the GWMA.

- State agencies such as the Water Resources Department (OWRD), DEQ, OHA, ODA, and the Department of Geology and Mining Industries (DOGAMI) have initiated steps to focus efforts in the GWMA.

Strategy 6.1
Partner with the OWRD to better understand the location and concentration of temporarily and permanently abandoned wells in the five-year time of travel drinking water source areas. Help the OWRD to prioritize efforts to address temporary and permanent well decommissioning.

Actions:
- Contact the OWRD to discuss ways to collaborate on identifying wells that should be permanently and properly decommissioned.
- Establish a method to prioritize 'higher risk' wells.
- Identify funding sources for the permanent abandonment/decommissioning of 'higher risk' wells.

Responsible Entity: OWRD
Schedule: 2020

Strategy 6.2
Public water systems and agency partners will alert DEQ to the presence of confirmed leaking underground storage tanks and underground storage tanks of unknown status within public water system five-year time-of-travel zones in drinking water source areas.

Actions:
- Contact responsible entity at regional DEQ office about the known leaking underground storage tanks.
- Bring DEQ personnel to working group and GWMA Committee meetings to talk about the Underground Storage Tank program.
- DEQ enforces clean-up of leaking underground storage tanks.

Responsible Entity: DEQ
Schedule: 2020

Final Draft For Public Comment

ED_005296_00000290-00089

Strategy 6.3
OHA and DEQ continue to notify DOGAMI of all sand and gravel mining operations within Drinking Water Source Areas in the GWMA and work with DOGAMI to provide operators information on best management practices to reduce risks to groundwater contamination.

Actions:
- Compile up-to-date groundwater protection mining BMP information, contact DOGAMI and provide them with maps and information about high priority operations.
- Partner with DOGAMI to focus efforts on operations within drinking water source areas.
- Ensure OHA drinking water staff continue to be formal reviewers on mining permit applications.

Responsible Entity: DEQ and OHA
Schedule: 2020

Strategy 6.4
DEQ will continue to: 1) provide ODA updated maps and GIS layers of the drinking water source areas and the CAFO sites within the 5-year time of travel zones in the GWMA to help ensure compliance with permits; 2) provide updated information to ODA about the GWMA that can be shared with CAFO operators during site visits.

Actions:
- Update CAFO BMP information, contact ODA, and give them an updated map of PWS and 5-year time-of-travel and information about high priority operations and recent water quality concerns.
- Work with ODA to encourage regular, routine site visits to these CAFOs and inform operators of their location within drinking water source areas in the GWMA.

Responsible Entity: DEQ
Schedule: 2020

Strategy 6.5
DEQ in collaboration with OHA drinking water staff evaluates the factors influencing nitrate risks in the GWMA for the public water supply wells not already examined and included in the 2011 report, "Factors Influencing Nitrate Risks at Oregon Public Water Systems" Actions:
- Using the methodology in the DEQ, 2011 report, evaluate the soil sensitivity (a combination of the soil's leaching potential and sorption potential) and produce soil sensitivity maps for each public water system in the GWMA.
- Determine the percent of the total area in each soil sensitivity category.
- Analyze the nitrate-N data to determine the influence of aquifer vulnerability (a combined rating of aquifer confinement and well construction), aquifer confinement, well construction in confined aquifers, and soil sensitivity on the median and 90th percentile nitrate-N values for each well.
- Analyze the Nitrate-N values (median and 90th percentile for each public supply well) in unconfined and semi-confined aquifers against the percentage of the Time-of-Travel (TOT) zones' total area that has soil sensitivity greater than Low (i.e. % area in Moderate, High, and Very High categories.)
- Using soil sensitivity maps, aquifer and hydrogeology characteristics, or models such as NLEAP, prioritize the most vulnerable locations for management changes.

Responsible Entity: DEQ and OHA
Schedule: 2020

Final Draft For Public Comment

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Goal 7: Evaluate remediation feasibility to dilute nitrogen hotspots in groundwater and source water protection.

Objectives:

- Evaluate feasibility of remediation of nitrates in groundwater to address hotspots and/or source water protection.

Strategy 1.1
Work with hydrogeologists to study and evaluate remediation feasibility.

Actions:

- Study and evaluate groundwater remediation feasibility to address nitrates in the LUBGWMA.

Responsible Entity: DEQ, OHA
Schedule: 2020

4.0 Implementation: Measuring Success through Plan Implementation Performance (PIP) Indicators and Groundwater Monitoring

The ultimate goal of the Local Action Plan is to improve the overall groundwater quality by obtaining declining nitrate concentrations of less than 7 mg/L throughout the region. The achievement of this goal necessitates active involvement from many difference entities, assessment of progress in implementing strategies, and finally, measuring groundwater quality.

4.1 Implementation Participants

Implementation of the strategies identified in Section 3 is critical to the overall success of the Local Action Plan and the eventual decline of nitrate levels in the GWMA. Implementation relies on voluntary actions among the agencies and land use groups in the region. This voluntary approach is built on the belief that local jurisdictions in the area are best suited to develop and implement actions to reduce risks to groundwater quality.

Forward movement will require coordinating oversight from the Lead Agency and other entities willing and able to coordinate specific portions of the Local Action Plan. Implementation of the strategies is highly dependent on allocation of staff resources and funding. Using a voluntary approach has benefits and challenges. There has been considerable support from many local governments and individuals to restore groundwater quality to a safer level. However, because of time and resource constraints, these same entities are often under great pressure to complete many mandatory activities prior to implementing voluntary and non-regulatory tasks. An active Lead Agency should offer support and guidance to those entities and individuals who are the best fit for implementing various sections of the Local Action Plan.

At a time when federal, state, and local budgets are already stretched, many of the strategies will rely on a potential implementing entity or partnering entities either adding the task to their existing workloads, pooling funds from several jurisdictions/agencies to accomplish a set of tasks, and/or finding grant funding to accomplish one or more tasks. Potential grant funding can come from a variety of different resources.

It is recommended that the DEQ and ODA continue to allocate staffing for the long-term assessment of the GWMA and prioritize staff resources, grant funding, and legislative funding that will assist in the effort to lower drinking water risks to the residents in the Basin.

Draft for Public Comment

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ODA's willingness to work with the local SWCDs and DEQ to identify priority actions and develop funding requests and allocations will assist with the progress in implementing the Local Action Plan. It is recommended that ODA continue with efforts to implement the Willow Creek and Umatilla Agricultural Water Quality Management Area Plan through achievement of the Plan Implementation Performance (PIP) goals of this Local Action Plan.

OSU and OSU Extension Service in Hermiston bring important research to the region and direct contact with Operators in the GWMA through outreach and education efforts. These agencies should seek and procure funding for continued success in Plan Implementation Performance. OHA is encourage to work with local drinking water utilities in long-term planning to decrease risk to public and private water supplies. OWRD is encourage to engage in groundwater quality through regulation of groundwater quantity.

Project work plans will be developed for activities that describe specific objectives, tasks, and methodologies to obtain and interpret data, deliverables, schedules, and the agencies to implement the strategy. Results of the analysis will be presented in progress reports that document the successful implementation of these projects by local citizen participation with support from cooperating state and local agencies

4.2 Plan Implementation Performance (PIP) Indicators

The GWMA Committee also plays a key role in the implementation process, evaluating the Local Action Plan success, and recommending adjustments to the Plan on an annual basis. The GWMA Committee will continue to meet regularly. DEQ will provide the Committee with updates on monitoring results and trends. DEQ, ODA, Morrow SWCD (the lead agency), and the GWMA sub-committees will provide updates to the full Committee on progress made towards implementation of the strategies and actions in the Local Action Plan.

Each strategy identified in Section are to be matched with Measures of Implementation and Potential (or recommended) Implementing Entities. Measures of Implementation are outcome indicators or the methods used to track the actual implementation of the strategies and an indication of when the activity should be completed. Potential Implementing Entities are the recommended organizations, agencies, jurisdictions, or groups that have the authority and/or capacity, could develop the ability, or could form partnerships to implement actions.

4.2.1 PIP Timeline and Benchmarks

The measures of plan implementation performance (PIP) and implementing entities for each strategy provide an evaluative mechanism to determine progress and set benchmarks for tracking the plan implementation performance (PIP) of the GWMA Local Action Plan. These measures of implementation will provide a tool for future tracking and reporting on plan implementation and for identifying ways to adapt the plan if necessary. For more detailed explanations of the strategies and related information, see Section 3.

4.2.2 Groundwater Monitoring

Even though the area-wide trend continues to increase at a small rate, it is expected that through continued refinement and implementation of BMPs as well as through mitigation efforts, groundwater nitrate concentrations will eventually begin to decrease. There is no decision matrix in rule or statute for a method to determine when the "less than 7 mg/L" threshold has been accomplished, thus each GWMA Committee can select the tool that makes sense for their situation. There will be several types of groundwater monitoring occurring to evaluate the changes of nitrate as a whole in the Lower Umatilla Basin GWMA. Some sources are viewed as primary sources of information while others are viewed as supplemental sources of information. These data sources are discussed below.

4.2.2.1 Primary Monitoring Data

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LUBGWMA Well Network
DEQ conducted a large reconnaissance sampling event (involving 198 wells) as part of the initial hydrogeologic characterization of the region in 1990 and 1991. DEQ selected 40 of these wells and established the "bi-monthly" network to determine seasonal variability and trends over time. The first bi-monthly sampling event was conducted in September 1991. Samples were collected from this well network every other month (i.e., January, March, May, July, September, and November) through 2010, when budget shortfalls caused DEQ to scale back the network. An evaluation of existing data was conducted to determine which months could be dropped from the sampling schedule with the least effect on the data set as a whole, and the ability to detect trends. It was determined that the best months to drop from the sampling schedule were January and July. Groundwater samples continue to be collected every March, May, September, and November from the well network.

Over time, nine wells have been dropped from the network for a variety of reasons beyond DEQ's control. There are currently 31 of the original 40 wells still being sampled. Two additional wells in the Irrigon area were added to the network in March 2013. Most of the wells in the LUBGWMA well network are private domestic wells, but there are two irrigation wells in the network. This network's dataset is a primary source of information to be used to evaluate regional trends, particularly in and around rural residential development.

Food Processing Wastewater Land Application Sites
DEQ requires the installation and quarterly sampling of groundwater monitoring wells in and around 11 sites operated by five facilities in the LUB GWMA where food processing wastewater is stored and treated through land application. Some of these wells have been sampled since 1987. Most wells have been installed and sampled since the mid-1990s. A comparison of upgradient to downgradient wells at a site allows an assessment of nitrate contribution from the site.

Because many of these land application sites are located in agricultural areas, the upgradient wells at these facilities are some of the best sources of information currently available to evaluate potential contributions from adjacent traditional irrigated agricultural fields. These networks are a primary source of information to be used to evaluate groundwater quality trends in and around food processing wastewater land application sites.

CAFO Waste Storage and Land Application Sites
ODA requires the installation and periodic sampling of groundwater monitoring wells in and around three facilities in the LUB GWMA where animal waste is stored and treated through land application.
These wells are a primary source of information to be used to evaluate groundwater quality trends in and around CAFO waste storage and land application sites.

4.2.2.2 Supplemental Monitoring Data

Synoptic Sampling Events
Since declaration of the LUBGWMA, DEQ has conducted four synoptic sampling events: in 1992, 2003, 2009, and in late 2015 / early 2016. Each of these events involved the sampling of about 100 to 200 wells in as short a time as possible (typically a few months) to give a "snapshot" of regional nitrate concentrations. A comparison of concentrations between synoptic sampling events allows an evaluation of nitrate changes over a larger area than the primary data sources discussed above, but is less statistically robust.

Public Water Systems
As discussed in previous sections, 17 Public Water System wells (21% of all PWSs in the LUBGWMA) have had nitrate concentrations at or above the 10 mg/L drinking water standard at least once. PWSs are not legally allowed to deliver water that exceeds the standard. When nitrate concentrations exceed the standard, PWSs are required to increase the frequency of sampling and, if nitrate exceedances persist, mitigate the problem. Mitigation is accomplished by blending with a low-nitrate source water, drilling new or deeper wells to find low-nitrate groundwater, or installing a nitrate treatment system.

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PWSs regularly test the quality of the water they deliver to customers, but test the untreated source water less often. Because PWSs are not legally allowed to deliver water with more than 10 mg/L nitrate (and therefore do some type of mitigation relatively soon after an exceedance occurs), it is unusual to have large data sets of detectable nitrate concentrations from PWSs. Therefore, nitrate data from PWSs can be used to supplement other sources of information that identify locations where nitrate concentrations are elevated, but are not likely to be useful for the calculation of trends.

Real Estate Transaction Data

Every time a property with a private domestic well is transferred, the owners are required to test the well for nitrate, arsenic, and total coliform bacteria, then send the results to the Oregon Health Authority. Because of limitations of the data (e.g., there is little Quality Assurance /Quality Control on the collection and reporting of these samples, the aquifer tapped by these wells is unknown, and some treated samples are included in the database) these results should be treated as qualitative information. Therefore, nitrate data from private domestic wells can be used to supplement other sources of information that identify locations where nitrate concentrations are elevated, but are not likely to be useful for the calculation of trends.

Final Draft For Public Comment

ED_005296_00000290-00094

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Registered Professional Geologist Seal

In accordance with Oregon Revised Statutes Chapter 672.505 to 672.705, specifically ORS 672.605 that states:

"All drawings, reports, or other geologic papers or documents, involving geologic work as defined in ORS 672.505 to 672.705 which shall have been prepared or approved by a registered geologist or a subordinate employee under the direction of a registered geologist for the use of or for delivery to any person or for public record within this state shall be signed by the registered geologist and impressed with the seal or the seal of a nonresident practicing under the provisions of ORS 672.505 to 672.705, either of which shall indicate responsibility for them.",

I hereby acknowledge that the document cited below was prepared by me.

Document Title:	Chapter 2 of the Lower Umatilla Basin Groundwater Management Area Local Action Plan
Document Author(s):	Phil M. Richerson
Document Date:	Date: _____
Name of Oregon RPG:	Phil M. Richerson (G1906)
Signature of Oregon RPG:	_____
Date of Seal:	_____

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Statistician's Comments and DEQ's Response

The OSU statistician reviewed four specific reports and provided multiple comments and recommendations. Each comment and recommendation is fully addressed in DEQ's response to the report. Section 6 (the "Discussions and Recommendations" section) of the statistician's report is reiterated below. A discussion of how DEQ is addressing these comments then follows.

Discussion and Recommendations

There are three main statistical issues that I see as having the biggest impact on the overall message conveyed by these documents: (1) the lack of probability sampling (or in its place substantive arguments about the representativeness of the sampled wells); (2) the oversimplification of results by tabulations of increasing/decreasing trends without accounting for their magnitude and/or practical significance and (3) a lack of focus on the 2000 to 2009 time period for critical evaluation of the efficacy of the Action Plan. Unaddressed, these three issues combine to provide an overall negative view of the LUBGWMA in terms of nitrate concentrations. It remains unclear what the true picture of nitrate concentrations in the GWMA is today, but I believe that much of what the DEQ has reported over the last ten years should be tempered and qualified by language that reflects some of the issues I have described in this report. I provide recommendations corresponding to each of these main issues below. More than a re-analysis of the statistics, the DEQ reports could benefit from clear enumeration of all the assumptions that go into drawing inferences from sampled wells to the entire GWMA, that are involved with tabulating results and that justify the appropriate time frame for analysis.

0.1 The lack of probability sampling to select wells into the bi-monthly well network, the synoptic sampling event network or any of the remaining sub-area networks.

> *The lack of probability sampling is difficult to overcome from a statistical perspective. Nevertheless, some work could be done to evaluate and compare characteristics (i.e., not just nitrate concentrations) of the wells in the bi-monthly network with those included in the synoptic sampling events and even those not included in either sample. This could provide a least a little assurance that the bi-monthly network wells are representative of the GWMA as a whole. Or, it could provide some insight into the ways in which those wells* are not *representative of the GWMA so that adjustments could be considered to account for those differences. In either case, all generalizations from a sample of wells to the GWMA as a whole must be tempered by the fact that no probability sampling was used and that it can therefore not be assumed that the sampled represents the unobserved wells in the entire management area. All of the DEQ reports would benefit from a clear discussion of the extent to which sampled wells adequately represent the entire GWMA, and this must involve a reconsideration/evaluation of the original selection of the wells into the different sampling networks.*

0.2 The over-simplification inherent in tabulations of increasing/decreasing (linear) trends and the minimal accounting for alternative sources of variation in making those increasing/decreasing determinations.

> *Evaluation of change at a particular well should involve an accounting of sources of variation (e.g., seasonality at the well), the magnitude of the change and the practical significance of the change. There should be some discussion about defining what is meant by a meaningful, scientific change in nitrate concentration, recognizing that such a definition might be different at different wells. For example, at a well with historically low values (i.e., below the 7 mg/L trigger), a practical change may be different than it would be for a well with historically high values (i.e., above the trigger). Clear details about, and agreement upon what constitutes a "substantial" change in nitrate concentration would be useful for future reports, and justification for the appropriate cut-off for declaring "statistical significance" should be provided. Qualitative evaluation of the lowess lines is quite informative, though hard to generalize beyond the sampled wells. If we are willing to assume that observations from different wells within the bi-monthly*

ED_005296_00000290-00097

well network (or within the synoptic sampling event network) are statistically independent, we could use a statistical test for paired comparisons, such as the Wilcoxon Signed Rank test, to compare nitrate concentrations in 2009 with those in 2000. Alternatively, Mixed effects regression models could be fit to account for covariate information (e.g., land-use, geology and the like), other sources of variation and/or spatial/serial autocorrelation while providing an overall estimate of change in nitrate concentrations over an appropriate time window. Most importantly, by simply making a tabulation of increases/decreases DEQ puts a well that had an increase in nitrate concentration of 5 ppm over a 10 year period (say from a level of 10 ppm to one of 15 ppm) on the same footing as a well that had an increase in nitrate concentration of 0.6 ppm over the same period (say from 2.1 ppm to 2.7 ppm), and this tends to misrepresent the situation.

0.3 A lack of focus on the 2000 to 2009 time-frame for evaluating the efficacy of the Action Plan.

For evaluating the efficacy of the Action Plan, the focus should be on the period of time since 2000. Using data between 1997 and 2000 to establish a "baseline" for nitrate concentrations may be useful, but I don't see the benefit of going all the way back to 1991. I suggest using lowess to model behavior at wells starting in 2000, and then taking a closer examination of those wells that do show high and/or increasing nitrate concentrations as compared to those that do not. This can provide some insight into the types of wells in the broader GWMA that might also be problematic, so that future components of the Action Plan could target those problematic wells.

DEQs Response to Recommendation 0.1

DEQ does not have the resources to redesign the well networks using a probabilistic approach. However, we can use the data we already have to give us as much insight as possible, and also improve on what we have going forward. DEQ's view is that while the well networks are not perfect, they do provide a good representation of the land uses that contribute to the groundwater nitrate contamination in the LUBGWMA. We acknowledge that probabilistic sampling is an assumption of many statistical analyses. We acknowledge that the well networks used by DEQ and their permittees utilize other criteria for well selection/location, and that we should acknowledge the differences in rationale used in developing the well networks. We also acknowledge that the well networks we use change over time with wells being dropped and added for various reasons throughout the years. This variability in the networks can complicate and limit the analyses that can be done.

DEQ acknowledges that the synoptic well network, the bi-monthly well network, and the well networks of permitted facilities were not set up using probabilistic sampling. Instead, wells for both DEQ networks were selected based on their hydrogeological placement, geographic location, groundwater chemistry characteristics, and sampling logistics. These well networks rely heavily on domestic water supply wells, in part because DEQ did not have the resources to install a monitoring well network, and in part because these wells represent the water that people are drinking. The bi-monthly well network is comprised mostly of domestic drinking water wells but also contains five irrigation wells. The synoptic well network is also comprised predominantly of domestic wells. Because domestic wells with moderate to high nitrate concentrations (or other anthropogenic contamination) were preferentially selected to be a part of the bi-monthly network, the network is likely biased towards rural residential areas that already had significant groundwater contamination. The long-term effect of this focus is expected to be a downward trend that is easier to detect, because starting concentrations were already high. Monitoring well networks associated with the land application of food processing wastewater were designed to quantify the quality of water upgradient and downgradient of the land application sites. These networks are located predominantly in agricultural areas, so those networks are likely biased towards monitoring the effects of land application of wastewater and, particularly at the upgradient wells, traditional agricultural practices.

The fact that sources of nitrate contamination are not static over time also complicates the issue of well network representativeness. For example, the largest CAFO in the area at the time of Action Plan adoption (C&B Livestock) no longer exists, while a much larger CAFO (Three Mile Canyon Farms) now exists west of the bi-monthly well network. Three Mile Canyon Farms has its own network of wells.

ED_005296_00000290-00098

DEQ's view is that the LUBGWMA well network is skewed towards rural residential land uses, but does monitor a mix of land uses that contribute to the groundwater nitrate contamination, and is adequate to answer the question posed in the first Action Plan (i.e., are area-wide nitrate concentrations decreasing?). However, adding additional wells to the network and/or including data from other regularly sampled wells would allow a more thorough evaluation of area-wide nitrate concentrations and trends. It is worth noting that the first LUBGWMA Action Plan identifies the bi-monthly well network as the source of the data to be used in the area-wide trend analysis. The first Action Plan also identifies the food processor well networks as the source of data to be used to evaluate trends at those sites. This (the second) Local Action Plan expands the sources of data to be used in the overall analysis of regional trends to include monitoring wells at food processing sites, permitted CAFO land application sites, permitted landfills, and at all of the public water supply wells that pull water from the alluvial aquifer.

DEQs Response to Recommendation 0.2

As recommended, the Wilcoxon Signed Rank test was used to compare the medians of the four synoptic sampling events. In addition, the Mann-Whitney test was also used to compare the medians of the four events. Results from both tests indicate the 1992 event is statistically different (i.e., lower) than the 2003, 2009, and 2015 events at a 95% confidence level. The tests also indicated there is no statistically significant difference between the 2003, 2009, and 2015 events. Discussion of additional statistical evaluations are provided in Section 2.4.4.

Readers interested in the full discussion of the "magnitude/practical significance" issue are encouraged to read the report and response. However, the summary of DEQ's response to the "magnitude" issue is that the point is well taken, but it does not change the overall conclusion of generally increasing nitrate trends because there are more increasing trends than decreasing trends when viewed as a whole or when compared to trends of similar magnitude. The summary of DEQ's response to the "practical significance" issue is that as a regulatory agency, we are often required to determine compliance. In this case, DEQ uses statistical significance as a "bright line" for evaluating compliance. This could mean something can have statistical significance and regulatory significance but be practically insignificant. This is a double-edged sword: a statistically significant trend that is slightly increasing does not meet the compliance goal but a slightly decreasing trend does. Either trend might arguably be called practically insignificant.

DEQs Response to Recommendation 0.3

Readers interested in the full discussion of the "time frame" issue are encouraged to read the report and response. However, the summary of DEQ's response to the "time frame" issue is that DEQ's view is the goal's intent is to evaluate changes in groundwater quality resulting from changes in land use practices. Since changes in land use began years prior to signing the plan, the entire data set should be used to evaluate water quality trends. However, it does not change the overall conclusion of generally increasing nitrate trends because trends calculated using the entire data set or just the data collected since 2000 both show the regional trend is slightly increasing through May 2016.

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