Lower Yakima Valley Groundwater Management Program

Volume I

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

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Thank you in particular to Vern Redifer, Lisa Freund, Chris Saunders, Phil Rosenkranz, Bobbie Brady, Patty LeBlanc, Michael Martian, and Cynthia Kozma

This program was approved by the GWAC on XXX.

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Table of Contents

Contents – Volume I

Executive Summary

The Lower Yakima Valley Groundwater Management Area (GWMA) was formed in 2012 to address the stated goal of reducing nitrate concentrations. Evaluations of historic data determined that 12% of the drinking water wells tested in the Lower Yakima Valley contained elevated nitrate concentrations exceeding the drinking water standard of 10 mg/L. (PGG 2011) A recent groundwater study in the Lower Yakima Valley, which sampled over 150 private domestic wells in 2017, found that 26 percent of the wells had at least one of its six samples exceeding the drinking water standard. Nitrate was not detected in 13 percent of the wells sampled (USGS 2017) Nitrate impacts to groundwater are common in agricultural areas (Harter 2009). While many sources contribute to nitrates in groundwater, data from these wells indicate water has been affected by activities at the land surface.

In response, Yakima County established the Lower Yakima Valley Groundwater Management Area (LYVGWMA), and formed the Groundwater Advisory Committee (GWAC) in 2012. The goal of the GWAC was to develop a Program to recommend approaches to reduce nitrate levels in groundwater and meet state drinking water standards. This document is that Program, the report of the GWAC's completed work.

The GWAC was a large and diverse committee and included representatives from all identified groups affected by the state of groundwater, including: local, state and federal government agencies, farmers, local citizens, dairy producers, agronomists, irrigation districts, conservation district, environmental groups, and other vested parties. This committee, and its workgroups met monthly over the past six years.

The diversity of the committee members' interests often made for contentious discussions, but the members were committed to resolving the issues and continued to participate, and were usually respectful. This high level of commitment is demonstrated by the tremendous amount of work that was produced and the fact that the group was able to reach consensus on many issues.

Funding

Funding to support the development and planning stage of the Lower Yakima Valley GWMA was appropriated by the Washington State Legislature primarily through the efforts of Senator James Honeyford, of Sunnyside.

Program Content

This document focuses on the following elements: 1) a description of the issue, 2) the establishment of the Lower Yakima Valley Groundwater Management Area, 3) the goals and objectives for addressing elevated nitrate in groundwater, 4) characterization of the area, 5) sources of nitrate, 6) the regulatory environment, 7) environmental and health effects of nitrate, 8) an extensive list of all the work that has been conducted by the GWMA, and 9) a list of recommendations and alternative actions to reduce nitrate concentrations in groundwater during the implementation phase.

Workgroups

Several workgroups were established to discuss and resolve specific issues. These workgroups focused on 1) Education and Outreach; 2) Residential, Commercial, Industrial, and Municipal; 3) Irrigated Agriculture; 4) Livestock and CAFO; 5) Regulatory Framework; and 6) Data Analysis workgroup. These workgroups were highly functioning, typically meeting monthly, and were responsible for reporting to the Groundwater Management Advisory Committee (GWAC) on their work.

Initiatives Completed by the GWAC

The following initiatives were completed by the GWAC:

- Free well water testing
- Point of use treatment systems for wells with elevated nitrate concentrations
- Education and outreach
- Fact sheets produced in English and Spanish
- Billboards
- Deep soil sampling
- Drinking water sampling program

- Initial locations for 30 monitoring wells for the ambient groundwater monitoring program
- Nitrogen Availability Assessment
- Documents created by PGG (listed in Appendix F)
- Best Management Practices as defined by Irrigated Agriculture and Livestock/CAFO Workgroups
- Development of a GIS (geographic information system) database where all data is consolidated.
- GIS tool that combines surface and subsurface physical conditions, nitrogen sources and land use within the LYVGWMA.

Alternative Management Strategies

Through the workgroups and other contracted work, The GWAC identified a list of over 250 potential alternative management strategies that could reduce nitrate concentrations in groundwater. The GWAC discussed each strategy and reached consensus on a set of 66 strategies, in the following categories:

- Administration
- Public Health and Safety
- Residential, Commercial, Industrial, and Municipal
- Irrigated Agriculture
- Livestock/CAFO
- Data Collection, Characterization, and Monitoring
- Regulatory Framework

Recommendations

Considering the factors listed in WAC 173-100-100 (4), the GWAC members placed weighted values on each strategy. These values were totaled to determine the total support of the GWAC for each strategy. The final recommended actions are set forth in this Program.

Implementation

The next phase of the GWMA is implementation. At one of its final meetings, the GWAC recommended, (by a vote of 14-1, 1 abstention, 1 not voting,) that Yakima County act as lead agency in future Lower Yakima Valley groundwater management programs, recognizing that the County's activity as lead agency would be subject to available funding from the State of Washington.

The body of work which the GWAC completed in the Assessment and Planning phase provides the foundation for this next phase, which is the Implementation Phase. This document, the work it represents, and its program recommendations, will facilitate implementing practices in order to meet the goal of reducing nitrate concentrations in groundwater.

Table of Figures

Table of Tables

Introduction

The Problem

Groundwater in the Lower Yakima Valley has elevated nitrate concentrations. A number of groundwater studies have documented nitrate concentrations in excess of the Safe Drinking Water Act Maximum Contaminant Level of 10 mg/L. Between 1988 and 2008, 12 percent of wells tested in the area had nitrate concentrations above that level. Another 21 percent of wells tested were below this level but higher than 5 mg/L (reported in Ecology et al., 2010).[1]

These numbers raised concerns due to the potential impact to human health (Ecology et al., 2010). Nitrate is considered an acute contaminant and may cause serious health conditions in vulnerable populations. If the condition is left untreated in newborns, death is possible. In the Lower Yakima Valley, residents may be exposed to nitrate if they obtain their drinking water through a private or shared well—the typical source of drinking water for the 6100+ rural households not served by a public water system. Assuming 12 percent of private wells exceed the Safe Drinking Water Act Maximum Contaminant Level, up to 720 of those households would be exposed to nitrate-contaminated groundwater.

The Response

Grass roots organizations such as Community Association for Restoration of the Environment (CARE) and Concerned Citizens for the Yakima Reservation (CCYR) identified the problem in 1997. Articles entitled "Hidden Wells, Dirty Water" ran in the *Yakima Herald Republic* in 2008, detailing nitrate issues affecting public and private wells. The articles suggested that a lack of coordination between local, state, and federal agencies aggravated the problem. The county permits land use, Department of Agriculture permits most dairies and agricultural activities, and under authority delegated by EPA, the

[1]Further problem definition is contained in this Program below in the sections characterizing the GWMA, describing the land uses traditionally and currently conducted within the GWMA, and the data and observations made possible by the investigation and analysis conducted by the GWAC.

Department of Ecology oversees water quality programs and the permitting of some dairies. The EPA, along with other state and local agencies, responded by facilitating public meetings in December 2008, February and October 2009, and June 2010. In November 2009, the Yakima Valley was designated as an EPA Environmental Justice Community.

In January 2010, EPA issued a finding in support of the use of SDWA Section 1431 of the Safe Drinking Water Act to address the contamination. EPA found that groundwater in the Yakima Valley is an underground source of drinking water which is contaminated, and that this contamination may present an imminent and substantial endangerment to human health. Sampling was conducted by EPA in February and April 2010, under the authority of SDWA Section 1431.

The Washington State Department of Ecology along with four other county, state, and federal agencies published a report (Ecology, February 2010) titled Lower Yakima Valley Groundwater Quality Preliminary Assessment and Recommendations Document. The report summarized the nitrate and coliform issue in the Lower Yakima Valley and was based on earlier technical reports and technical data obtained by the Washington State Departments of Ecology, Agriculture, and Health, the Yakima County Public Works Department, and the U.S. Environmental Protection Agency. The report identified a number of regulatory options for addressing the elevated nitrate concentrations including establishment of a Groundwater Management Area (GWMA), Special Protection Area, Aquifer Protection Area, Sole Source Aquifer, Watershed Management Plan, and Total Daily Maximum Load (TDML). Of these options, the Yakima County Commissioners selected to establish a GWMA and signed an interagency agreement with Ecology in September 2010.

The Lower Yakima Valley Groundwater Management Area (LYVGWMA) and Groundwater Advisory Committee (GWAC) were established in 2012. The goal of the GWAC was to develop a GWMA Program to recommend approaches to reduce nitrate levels in groundwater to below state standards. Its membership reflected the coordinative nature of the effort. Citizen and agricultural industry representatives were appointed to bring knowledge of potential sources and concern about public acceptance of the committee's work. Representatives from Ecology, Washington State Department of Agriculture (WSDA), Washington State Department of Health (DOH), the US

Environmental Protection Agency (EPA), the Yakama Nation, the Yakima Health District, and Yakima County were appointed to the GWAC so as to gather all of the relevant regulatory aspects pertinent to the problem.

The GWAC tasked itself with identifying the primary sources of nitrate contamination using scientific data, and identifying or developing practices that would minimize nitrate concentration of groundwater. To accomplish its tasks, it developed a plan that would recommend strategies for implementing improved practices and providing appropriate education and outreach on health risks and how to prevent exposure (GWAC talking points, approved February 2013).

Its objectives included problem identification, data collection, monitoring and analysis; potential measures or practices for reducing groundwater contamination, and public education and outreach (GWAC talking points, approved February 2013).

At-Risk Populations and Public Education

As the GWAC began its work, it immediately initiated an education and outreach program to reach out to at-risk populations and their families served by private or shared wells in the LYVGWMA. Infants, pregnant women, women who may become pregnant, and individuals with certain blood disorders are all considered at high risk from exposure to elevated or high levels of nitrate. Accordingly, an outreach program was implemented to inform these populations and their families of the health risks of high nitrate, how to protect themselves, and how to protect the groundwater that their drinking water wells draw from. Yakima County distributed water quality testing strips and water filtration systems, with the support of the Department of Health and Environmental Protection Agency. As Spanish is the primary language spoken in an estimated 60 percent of LYV GWMA households, a bilingual (Spanish/English) outreach program was implemented and ran concurrently with the GWMA Program development.

Meetings

The GWAC held its first meeting on June 5, 2012. Over the next six years it would meet more than 50 times to accomplish the work it identified. The GWAC initially also included representatives from Benton County. However, Benton County and the Benton County Conservation District withdrew from the LYVGWMA because they decided that it would provide their geographical area with a better approach if they took on the issue of nitrogen reduction in groundwater on their own. The makeup of the GWAC's membership adjusted over time, as people moved between professional and personal opportunities. The governmental entities and community interests represented remained the same throughout, although their personnel changed. Its subcommittees, or working groups, were tasked with the research, investigation and proposed recommendations within their area of expertise – Data Collection, Livestock/CAFO, Irrigated Agriculture, Residential, Commercial, Industrial and Municipal (RCIM), Regulatory Framework, Education and Public Outreach, and Funding. Working groups then brought their recommendations back to the GWAC for its consideration. The working groups would collectively hold over 200 meetings in the ensuing years.

Organization of the GWMA Program

The suggested content of a GWMA Program is defined by Chapter 173-100 WAC. The Program laid out in the following pages generally follows this structure. The Area Characterization describes the physical characteristics of the Lower Yakima Valley, the historic process by which it has been transformed from a semi-arid desert into an agricultural oasis, and how the land is used today. A section on demographics looks at who lives here and why. Ensuing chapters identify the GWAC's water quality goals and objectives, explore the sources of nitrogen and regulatory environment, and describe Yakima County's role in groundwater quality protection. The narrative then turns to the heart of the GWAC's work: its investigation and analysis of the sources of nitrate, the pros and cons of various recommendations, and finally, defining recommended actions at a variety of levels: legislative, state agencies, local government, and private individuals.

Boundary of the Groundwater Management Area

The Lower Yakima Valley Groundwater Management Area (LYVGWMA) is located within the Lower Yakima Valley, south of Union Gap, northeast of the Yakima River and west of the Yakima-Benton County line. Its total area is 175,161 acres. It lies in the southeastern portion of the Lower Yakima Valley north of Yakima River from Union Gap to the Benton County line, except for the southeastern end that extends south of the River onto the lower slopes of Toppenish Ridge. The Northern boundary generally lies on the southern slopes of Ahtanum Ridge several miles southwest of the Cold Creek Syncline.

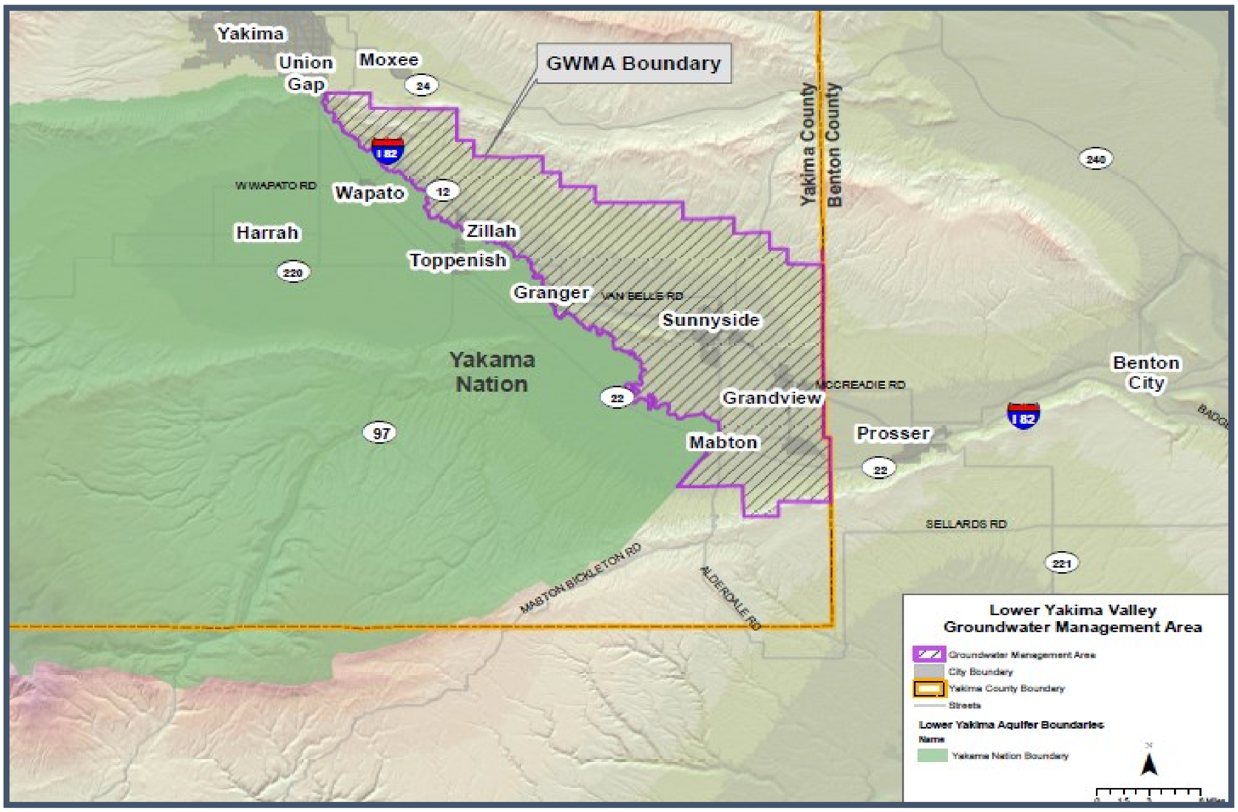


FIGURE 1 - GWMA BOUNDARY

The Groundwater Management Area addressed in this Program is essentially the same as the Western and Eastern Study Areas as identified within the 2010 *Preliminary Assessment.*[2] It includes the non-reservation lands along the northeastern side of the Yakima

[2] *Lower Yakima Valley Groundwater Quality, Preliminary Assessment and Recommendations Document*, Washington State Department of Agriculture, Washington State Department of Ecology, Washington State Department of Health, Yakima County Department of Public Works, U.S. Environmental Protection

River south of Union Gap and the southeast Yakima Valley downstream of the confluence of Satus Creek and the Yakima River. Approximately 60 percent of the valley population resides in this area. The Groundwater Management Area includes the incorporated communities of Zillah, Sunnyside, Granger, Grandview, and Mabton and the rural settlements of Buena and Outlook.

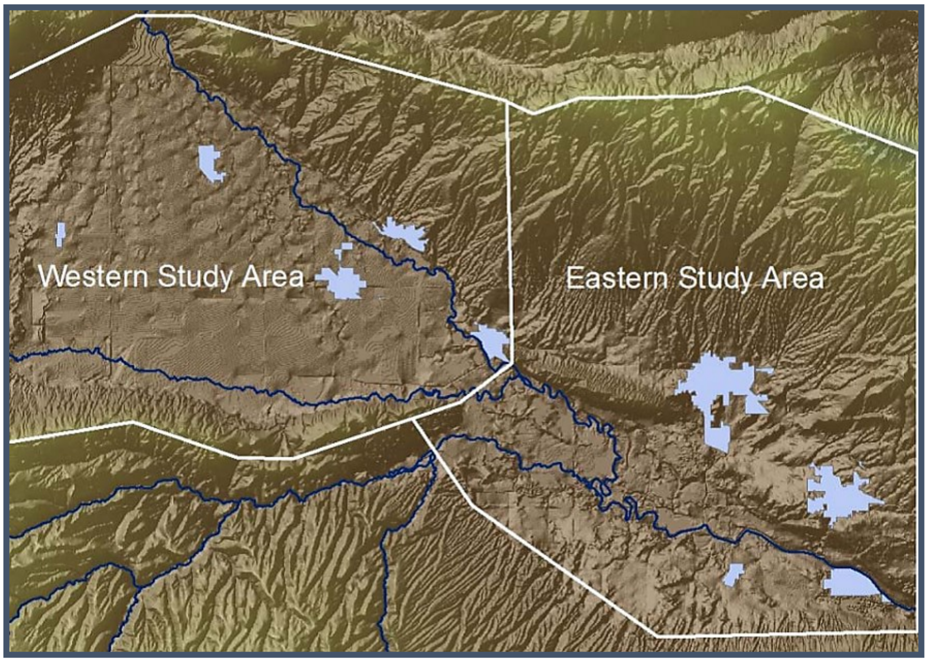


FIGURE 2 - AREAS OF PRELIMINARY ASSESSMENT

The *Preliminary Assessment* subdivided the study area in order to reflect geographic, geological, and geopolitical constraints; and corresponded to divisions reflected in the historical water quality data set.[3]

Agency, Ecology Publication No. 10-10-009, February 2010. (See Appendix A. for Administrative Background.)

[3] These two subareas roughly mirror the areas designated as upper and lower study areas in the 2002 Valley Institute for Research and Education groundwater study, and correspond to the Toppenish and Benton basins referenced in other studies. Both areas cover approximately 368,600 acres within Yakima County.

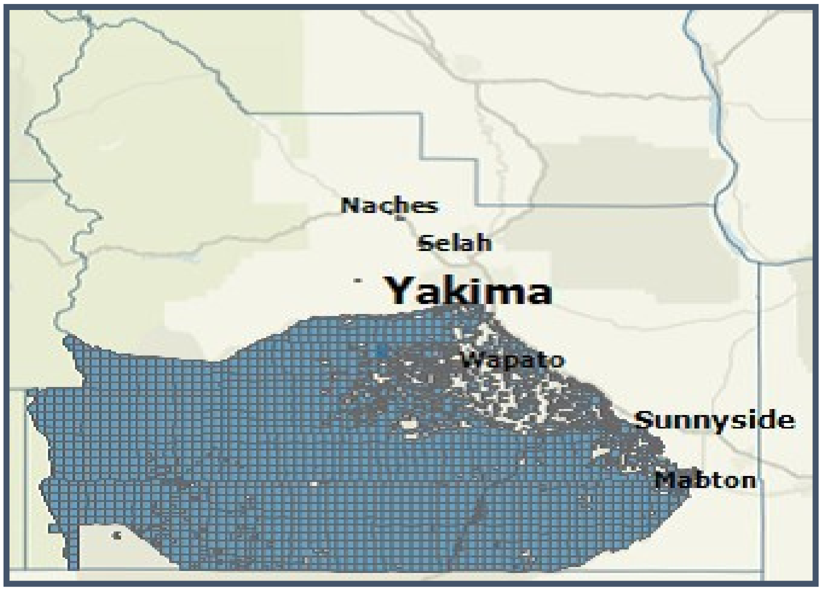


FIGURE 3 - YAKAMA INDIAN RESERVATION

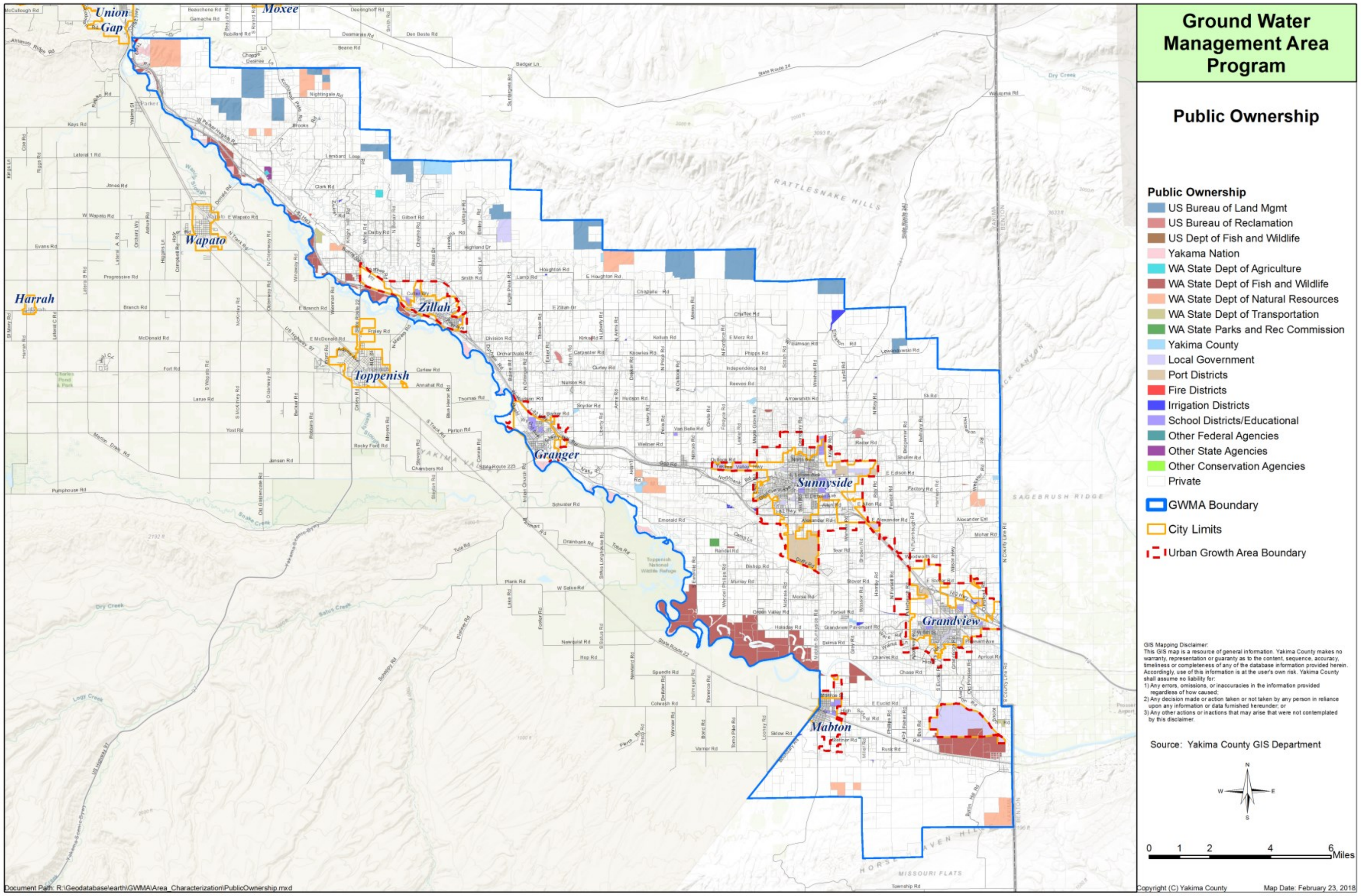
The Yakama Nation[4] elected not to participate in the deliberation of the Lower Yakima Valley Groundwater Advisory Committee, choosing to address nitrate levels independently, under the oversight of the Environmental Protection Agency.

Jurisdictional Boundaries: Federal, State, Local, Tribal

All the land within the GWMA is within the jurisdiction of Yakima County, with the exception of land within the municipalities of Zillah, Granger, Sunnyside, Grandview, and Mabton. While properties owned by the United States exist within the GWMA, they do not present relevant issue areas that relate to the nitrate problem addressed by this Program.

[4] Confederated Tribes and Bands of the Yakama Nation (Yakama Nation). The Yakama Indian Reservation lies along the southwest side of the Yakima River and extends beyond Yakima County boundaries into the northern edge of Klickitat County and Southeastern corner of Lewis County. It covers an area of approximately 1.3 million acres. The Yakama Nation has nearly 9,000 enrolled members from 14 bands and tribes.

FIGURE 4 - JURISDICTIONAL BOUNDARIES AND PUBLIC OWNERSHIP



Characterization of the Area

The following discussion describes the area as it currently exists. The information relates in some instances to Yakima County generally and in others to the LYVGWMA in particular. Caution should be exercised to notice the particular area under discussion as various information is presented. Investigations and analysis pursued during the process of the LYVGWMA are presented in a later section of this Program.

The Yakima River Basin

The Yakima River Basin is located in south-central Washington and includes three Washington State Water Resource Inventory Areas (WRIA—numbers 37, 38, and 39), part of the Yakama Nation lands, three eco-regions (Cascades, Eastern Cascades, and Columbia Basin), and touches parts of four counties: Klickitat, Kittitas, Yakima, and Benton (USGS 2006). Almost all of Yakima County and more than 80 percent of Kittitas County lie within the basin. About 50 percent of Benton County is in the basin. Less than one percent of the basin lies in Klickitat County, principally in an unpopulated upland area. Within the Yakima Basin, there are six structural sedimentary basins. The delineated sedimentary basins are from north to south, the Roslyn, Kittitas, Selah-Wenas, Yakima (Ahtanum-Moxee), Toppenish, and Benton Sedimentary Basins. All are clearly defined by the geologic structure in the Yakima River Basin. The LYVGWMA includes only parts of the Toppenish and Benton Sedimentary Basins.

The Toppenish Sedimentary Basin is fully contained within Yakima County. It is bordered on the north by the Ahtanum Ridge, on the south by the Toppenish Ridge, and bisected by the Wapato Syncline. The eastern boundary of this basin abuts the Benton Sedimentary Basin. Only the southeastern corner of the Toppenish Sedimentary Basin, northeast of the Yakima River, is included in the LYVGWMA boundaries.

The Benton Sedimentary Basin is bordered on the south by the Horse Heaven Hills structure. The northeast boundary generally follows the northern flank of the Cold Creek Syncline. The western boundary abuts the eastern boundary of the Toppenish Sedimentary

Basin and a small section of the Yakima Sedimentary Basin. Only the western portion of the Benton Sedimentary Basin, approximately a third, is in the LYVGWMA boundaries.

Geology

Stratrigraphy

<u>Basalt</u>

The Columbia River Basalt Group (CRBG) is a thick sequence of Miocene eruptive basalts, variously estimated several thousand feet thick, interbedded with a few minor sedimentary strata. It overlays the basalt rock unit, or bedrock, of the Yakima region. The total CRBG covers an area of more than 59,000 square miles (Tolan et al. 1989) and spanning parts of Washington, Oregon, and Idaho. It is subdivided into three primary units, or formations, designated the Saddle Mountains Basalt, the Wanapum Basalt, and the Grande Ronde Basalt (USGS 2009a, GSI 2009a, 2011d). The Saddle Mountains Basalt is often exposed at the surface. Its thicknesses ranges from 180 to 800 feet and averages more than 500 feet in the Yakima Basin. The Wanapum Basalt can be over 800 feet thick. The Grande Ronde Basalt underlies the Wanapum Basalt. These formations are further subdivided into several dozen members and hundreds of flows.

The uppermost basalt, the Saddle Mountains Basalt, is often visible at the bounding upland ridges of the Toppenish Basin such as the Rattlesnake Mountains, Ahtanum Ridge, Toppenish Ridge, and Horse Heaven Hills. It is made up of the Umatilla Member flows, the Wilbur Creek Member flows, the Asotin Member flows (13 million years ago), the Weissenfels Ridge Member flows, the Esquatzel Member flows, the Elephant Mountain Member flows (10.5 million years ago), the Bujford Member flows, the Ice Harbor Member flows (8.5 million years ago) and the Lower Monumental Member flows (6 million years ago). The underlying Wanapum Unit averages 600 feet thick. These units are separated by the Mabton Interbed, with an average thickness of 70 feet (EPA 2012).

Basalt is a dense rock, having a fine texture precluding identification of crystals without magnification. Basalt is resistant to erosion and weathering, and is a notable cliff-forming rock. Fresh, unweathered surfaces are black or dark gray; weathered surfaces range in color from gray to reddish brown. Basalt consists principally of small crystals of calcic labradorite, pyroxene, and olivine in a dense matrix of sodic labradorite, augite, and volcanic glass. Magnetite and apatite are common accessory minerals. Calcite, siderite, zeolites, opal, and chalcedony are common in veins and vesicles in the basalt (USGS 1962).

At the end of the Miocene Epoch, approximately 5.3 million years ago, an extended plain of basaltic lava covered most of eastern Washington (USGS 1962; USGS 2009a). The basaltic lava flows were extruded from fissures located in the eastern part of the Columbia Plateau (USGS 1962), most likely in the vicinity of Hells Canyon, Oregon. The extrusions of basaltic lava probably continued intermittently into the Pliocene Epoch (5.3-2.6 million years ago), covering sedimentary deposits, forming new basins of deposition, and changing stream courses (USGS 1962). This volcanic flow is called the Columbia Basin Basalt Group. The CRBG is that thick sequence of basaltic lava flows underlying southeastern Washington and extending into Oregon and Idaho (USGS 1962). The individual flows range in thickness from a few feet to more than 100 ft. The total basalt thickness in the central part of the plateau is estimated to be greater than 10,000 ft (USGS 1990b) and the maximum thickness in the Yakima River basin is more than 8,000 ft (USGS 1962).

Extrusions and flows of volcanic material now within the CRBG formation occurred intermittently over millions of years. Individual flow layers range from less than 20 to more than 200 feet in thickness. Individual flows may differ considerably in thickness from place to place (USGS 1962). Enough time elapsed between extrusions to allow considerable weathering of the uppermost frothy surfaces of lava flows and to allow development of thin soil zones, which were later buried by subsequent flows (USGS 1962). Bubbles of gases emitted from the solidifying molten lava created zones of abundant gas cavities (vesicles). The vesicles are sometimes filled with secondary minerals deposited by water percolating through the rocks. The vesicles are separated from each other by the encasing solid rock, except where they have been fractured or deeply weathered (USGS 1962). Natural gas was extracted from beneath the LYVGWMA between 1929 and 1941 (Alt/Hindman 2007).

The Ellensburg Formation

At the west side of the basaltic lava plain, approximately where the present Cascade Mountains now stand, there was a region of more intense volcanic activity before the period of basaltic lava extrusion ended. This volcanic activity was at an elevation somewhat higher than the lava plain but probably lower than the present Cascades. The volcanic debris created by this volcanic activity in those ancestral Cascade Mountains was the source of the sedimentary materials; which were subsequently deposited upon the lava plain, either transported by eastward flowing streams, in lakes, or aeolian processes moving ash and pumice, that together constitute the Ellensburg Formation (USGS 1962). The majority of the volcanic materials created by the volcanic activity was deposited upon the lava plain after these flows ceased and the Cascades continued to rise (USGS 1962; USGS 1999a).

The Ellensburg Formation consists of 85 to 95 percent semiconsolidated clay, silt, and sand with only 5 to 15 percent gravel and conglomerate. It often appears as sedimentary interbeds found between the various CRBG formations, members, and flow units. These interbeds vary in nature and composition, typically ranging between 1 and 100 feet thick. The color is predominantly gray, tan, and buff, although there are a few relatively thin rusty-brown sand and gravel strata. The clay and silt parts are massive at most places, but excellent bedding and shaly parting also are found. Some sand and gravel strata are crossbedded. The thickness of the individual beds ranges from a few feet to more than 100 feet; strata of clay, silt, and fine sand usually are somewhat thicker than strata of the coarser materials (USGS 1962). "More than 1,000 ft of course-grained volcanclastic sediment has accumulated over many parts of the Yakima River Basin." (USGS 1999a).

The Ellensburg formation is mostly tough and hard, although some sand and gravel strata are weakly cemented. The silt and sand are composed chiefly of pumice, volcanic ash, quartz, and scattered feldspar and hornblende particles. Clay-size particles consist mostly of finely divided pumice and ash. The gravel contains large amounts of tuff and a distinctive purple or gray tuffaceous hornblende andesite. Cementing material is mostly argillaceous (containing clay). Minor amounts of diorite, quartzite, and various granitic and metamorphic rock types also are found locally in the gravel; basaltic fragments are rare (USGS 1962).

Lower Yakima Valley Fill

A variety of fine and coarse-grained sediments, including and overlying the Ellensburg Formation and the underlying major basalt flows, also exists within the Toppenish Basin (EPA 2012). These sediments pinch out along the flanks of the ridges. They include Touchet Beds, loess, thick alluvial sands and gravels deposited by rivers and streams, including those within the Ellensburg Formation, and other unconsolidated and weakly consolidated valley-fill comprising glacial, glacio-fluvial, lacustrine, and alluvium deposits resulting from catastrophic glacial outburst floods that inundated the lower Yakima River Basin (USGS 1999a) (EPA 2012) (USGS 2009a) (USGS 1990b) (USGS 1962).

About 16,000 years ago these glacial outburst floods created "Lake Lewis" in what is today the Lower Yakima Valley and the LYVGWMA when the restricted flow of waters from periodic cataclysmic floods from Glacial Lake Missoula, pluvial Lake Bonneville, and perhaps from subglacial outbursts backed up through the constriction formed by the Wallula Gap in the Horse Heaven Hills. Water also backed up further downstream on the Columbia River between Washington and Oregon, delaying the drainage of Lake Lewis. The water remained for iterative undefined periods before the flood waters drained through Wallula Gap, permitted surfacious loess and basalt materials collected in the floods' transit southeast from the Spokane area to settle out to the lake's bottom, thus forming at least some of the fine grained gravelly and sandy materials extant today on the valley bottom of the Yakima River within the LYVGWMA. Lake Lewis intermittently reached an elevation of about 1,200 feet (370 m) above today's sea level before draining to the Columbia through Wallula Gap (Bjornstad 2006) (Alt 2001) (Carson/Pogue 1996).

Structural Geology

The Columbia Plateau has been informally divided into three physiographic subprovinces (Meyers and Price 1979; USGS 2009a). The western margin of the Columbia Plateau contains the Yakima Fold Belt subprovince.

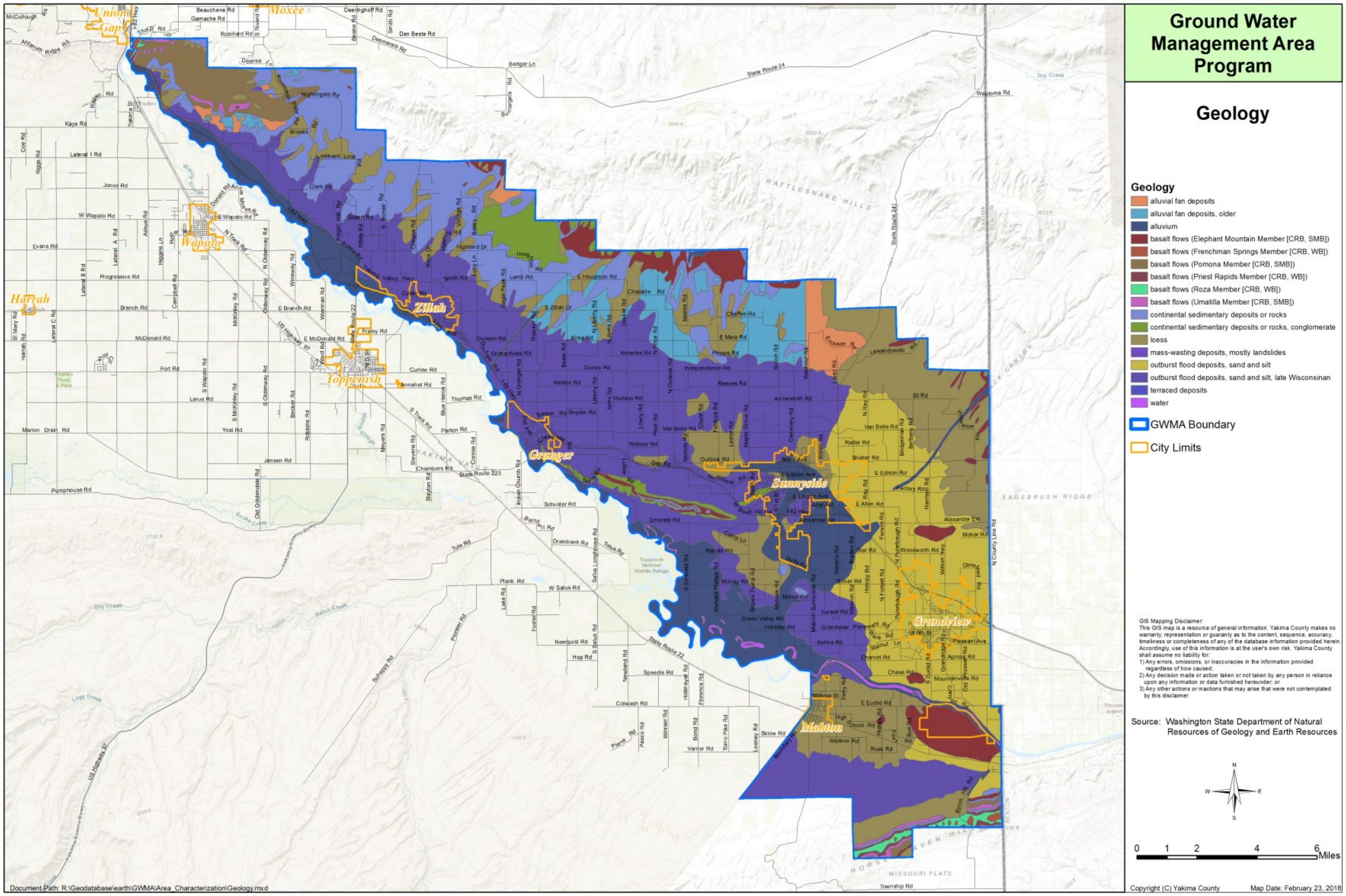
The Yakima Fold Belt

The LYVGWMA lies within the Yakima River Basin within the Yakima Fold Belt. The Fold Belt is a highly folded and faulted region underlain by various consolidated rocks ranging in age from the Precambrian Supereon to the Cenezoic Era's Miocene Epoch, and unconsolidated materials and volcanic rocks of the Quaternary Period's Pleistocene Epoch. Dominant geologic structures in the Yakima Fold Belt in the western part of the Columbia Plateau are long, narrow, east-west to east-southeasterly trending anticlinal ridges with intervening broad synclinal basins that essentially partition the groundwater flow system. "The anticlines function as groundwater flow barriers" (USGS 2009a; Vaccaro 2016).

The folding that created the anticlines and synclines within the Yakima region are the consequence of tectonic compression (McCaffrey et al., 2016), initially of the sedimentary rocks now underlying the Columbia River Basalt Group, from south of the Fold Belt region (the anticline's slopes are steeper on the north side) which probably began during the latter part of the Cenezoic Era during the Pliocene Epoch. The Ellensburg sedimentary material was still accumulating during this time. Earlier explanations suggested that the folding was likely related to the Cascade uplift and subsidence of the center of the lava body approaching from the southeast (Foxworthy 1962). The folding proceeded slowly enough so that the Yakima River could continue to erode its channel (Union Gap) as the Ahtanum Ridge anticline rose (Foxworthy 1962). The Ahtanum Ridge and the Rattlesnake Hills are the same anticline (Alt/Hyndman 2007). The Toppenish Ridge is another anticline, forming the southern boundary of the Toppenish Basin.

As the folding continued, the sedimentary material previously deposited on the parts of the plain that became the anticlinal ridges was eroded off and carried down into the centers of the synclinal basins. This process accounts in part for the great thickness of the Ellensburg formation (USGS 1962).

FIGURE 5 – GEOLOGY



Hydrogeology

The geologic framework and some of its hydrogeologic units of the Columbia Plateau regional aquifer system was described by Drost and others (USGS 1990b). The aquifer system consists of a large thickness of basalt made of numerous flows with minor interbedded sediments (USGS 1990b). The principal water bearing zones in the basalt sequence are those upper parts of certain flows rendered relatively permeable by weathering, jointing, and vesicularity (USGS 1962).

The lithology, or general physical character, of the materials within the hydrogeologic units of the LYVGWMA was described by USGS in its 2009 report (USGS 2009a), see Table 1. The several units described have various consolidated or unconsolidated structure. The unconsolidated units include alluvial, alluvial fan, terrace, glacial, loess, lacustrine, and flood (Touchet Beds) deposits that range from coarse-grained gravels to fine-grained clays, with some cemented gravel (Thorp gravel and similar unnamed gravels). Most of the unconsolidated units consist of coarse-grained deposits. The consolidated units are principally deposits of the Ellensburg Formation, but also include some undifferentiated continental sedimentary deposits. These units include continental sandstone, shale, siltstone, mudstone, claystone, clay, and lenses or layers of uncemented and weakly to strongly cemented gravel and sand (conglomerate). These clastic deposits are one of the most stratigraphically complex parts of the aquifer system (USGS 2009a).

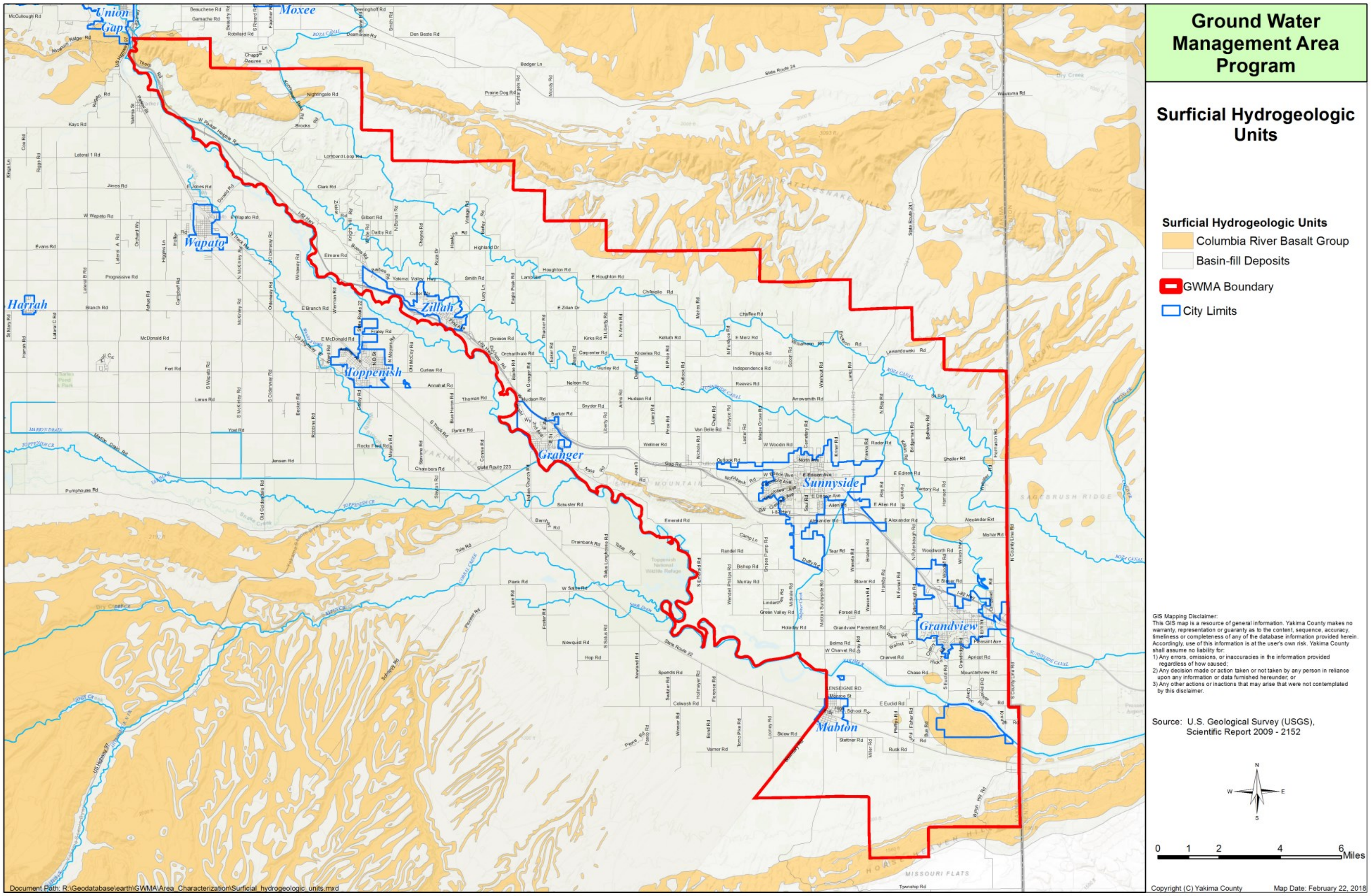
TABLE 1 – HYDROGEOLOGY WITHIN THE ELLENSBURG AND OTHER SEDIMENTARY UNITS (AFTER USGS 2009A)

Structural Basin Name	Mapped Area	Unit	Lithology	Thickness		
				Range	Average	Median
Toppenish Basin	440	1 (fine grained consolidated)	Touchet Beds, terrace, loess, and some alluvial deposits	0 to 80	10	10
		2 (coarse grained unconsolidated)	Coarse-grained sand and gravel deposits	0 to 270	90	80
		3 (consolidated)	Consolidated deposits of the upper Ellensburg Formation and undefined continental sedimentary deposits	0 to 970	350	320
		4 (fine grained deposits)	Top of Rattlesnake Ridge unit of the Ellensburg Formation or "Blue Clay unit"	0 to 520	170	140
		5 (coarse grained deposits)	Base of Rattlesnake Ridge unit of the Ellensburg Formation	0 to 140	20	20
Benton Basin	Portions of 1020	1 (unconsolidated)	Alluvial, alluvial fan, loess, terrace, dune sand, Touchet beds, Missoula flood, and Ringold Formation deposits	0 to 870	120	70
		2 (consolidated)	Ellensburg Formation and undenfined continental sedimentary deposits	0 to 680	100	60

Bedrock units underlie the hydrogeologic units (USGS 2009a). As bedrock units likely hold little or no groundwater to be taken up by wells for domestic water supply, they are not discussed here. Most domestic wells are in the sediments above basalt. There are several basalt wells providing domestic water supply along the northern fringe of the project area.

Figure 6, derived from the USGS 2009 report, shows the surficial hydrogeologic units within the LYVGWMA.

FIGURE 6 – SURFICIAL HYDROGEOLOCIC UNITS



Aquifers

In 2009, the United States Geological Survey published its study of the geology, hydrology and hydrogeology of aquifers in the Yakima River Basin. The study found that there are two main aquifer types in the LYVGWMA. The first is a surficial unconfined to semi-confined alluvial aquifer. This aquifer is composed of highly layered alluvial material with predominantly silt, sand, and cobbles with a total thickness of up to 500 feet (USGS 2009a).

The second aquifer is an extensive basalt aquifer of great thickness underlying the surficial aquifer. The basalt aquifer is believed by the USGS to be semi-isolated from the surficial aquifer and stream systems. Natural groundwater flow within the shallower, surficial aquifer generally follows topography, but may be locally influenced by irrigation practices, ponds, lagoons, drains, ditches, and canals. Groundwater in this shallower aquifer generally flows toward the Yakima River (USGS 2009a) and is used locally for irrigation and residential water supply.

An aquifer is rock material where the pore space in the material is saturated, or full of water. Ground water occurs in the interstices in the rock material, in the spaces not occupied by solid material. If there is a pressure gradient in that material and the abundance, character, and degree of interconnection of those spaces can create a pathway for water to follow, it will move or be transmitted.

Natural rock materials differ in porosity. Porosity is a measure of the ability of the rock to contain water. It is the ratio of the volume of its interstices to its total volume. The porosity of some consolidated rocks, such as tightly cemented sandstone or massive lava flows, is only a few percent or even a fraction of a percent. The porosity of some clays may exceed 50 percent. In unconsolidated rocks, the well-sorted materials, such as clay or clean even-textured sand or gravel, have very high porosity. Poorly sorted materials, in which the smaller particles fill the openings between the larger grains, have low porosity.

Both "confined" and "unconfined" aquifers are known to exist within the LYVGWMA. A "confined aquifer" is one in which water has become confined between relatively impermeable materials. Water in confined aquifers will rise higher in a well than the bottom of the overlying confining bed. Such wells are called "artesian." The level to which water will theoretically rise in an artesian well is called the potentiometric (or piezometric) surface.

An "unconfined aquifer" (or "water table aquifer") is one where the upper surface of the water in the rock mass is at atmospheric pressure due to direct contact with the atmosphere through the pore space in the overlying soil and rock, and there is not confining pressure imparted by an overlying impermeable material. This surface level is called the "water table." The water table is the upper surface of an unconfined aquifer. The level at which water stands in a well penetrating an unconfined zone of saturation represents the water table at that place.

Aquifer dynamics are generally described in terms of amounts of water entering and exiting the aquifer. "Recharge" is the natural replenishment of an aquifer's water volume by downward seepage from the surface (rainfall, snowmelt, infiltration from lakes, wetlands and streams, irrigation or waste water), or groundwater moving from other underground sources. Water exiting the aquifer (water seeping from the ground (spring), pumped from a well, or departing the aquifer into surface water (wetland, stream, lake, estuary, ocean) or the atmosphere) is "discharge". The water table fluctuates chiefly in response to variations in recharge to, and discharge from, the ground-water body. Natural recharge may occur because of precipitation. Artificial recharge may occur through irrigation. Surface water streams or irrigation canals that cross permeable zones may recharge the aquifers beneath. Surface water streams or rivers that flow at an elevation below the water table discharge water from the aquifer.

Both the potentiometric surface of a confined aquifer and the water table of an unconfined aquifer are usually sloping, irregular, fluctuating surfaces. They are higher in areas of ground-water recharge, lower in areas of discharge, and affected by differences in permeability within the aquifer. The slope of either surface is called the "hydraulic gradient."

Figure 7, derived from USGS' 2009 study (USGS 2009a), shows the location of known springs within the Toppenish Basin. Figure 8, derived from the same study, shows the mean annual recharge of the surficial aquifers within the LYVGWMA.

FIGURE 7 – SPRINGS WITHIN THE TOPPENISH BASIN

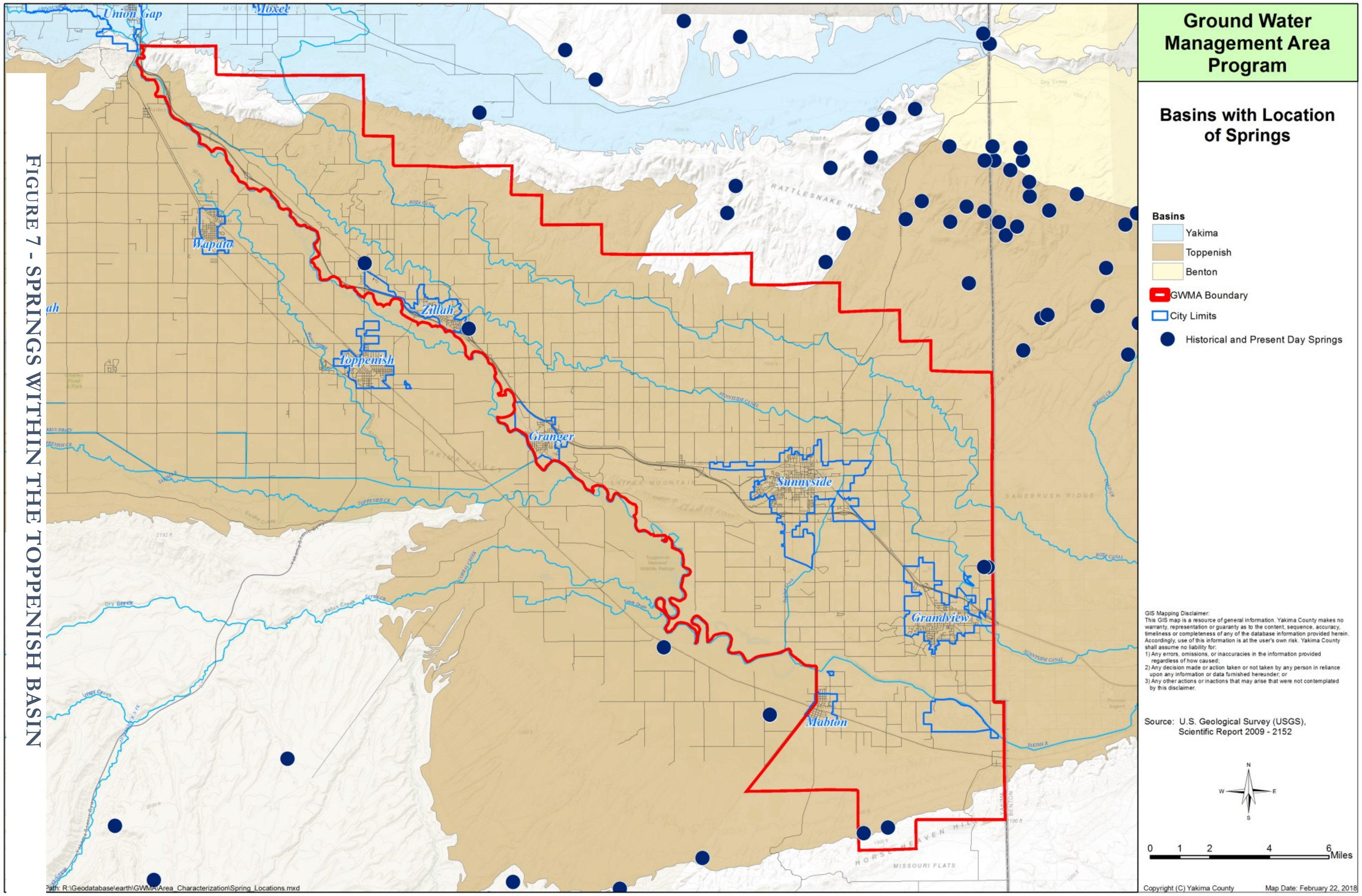
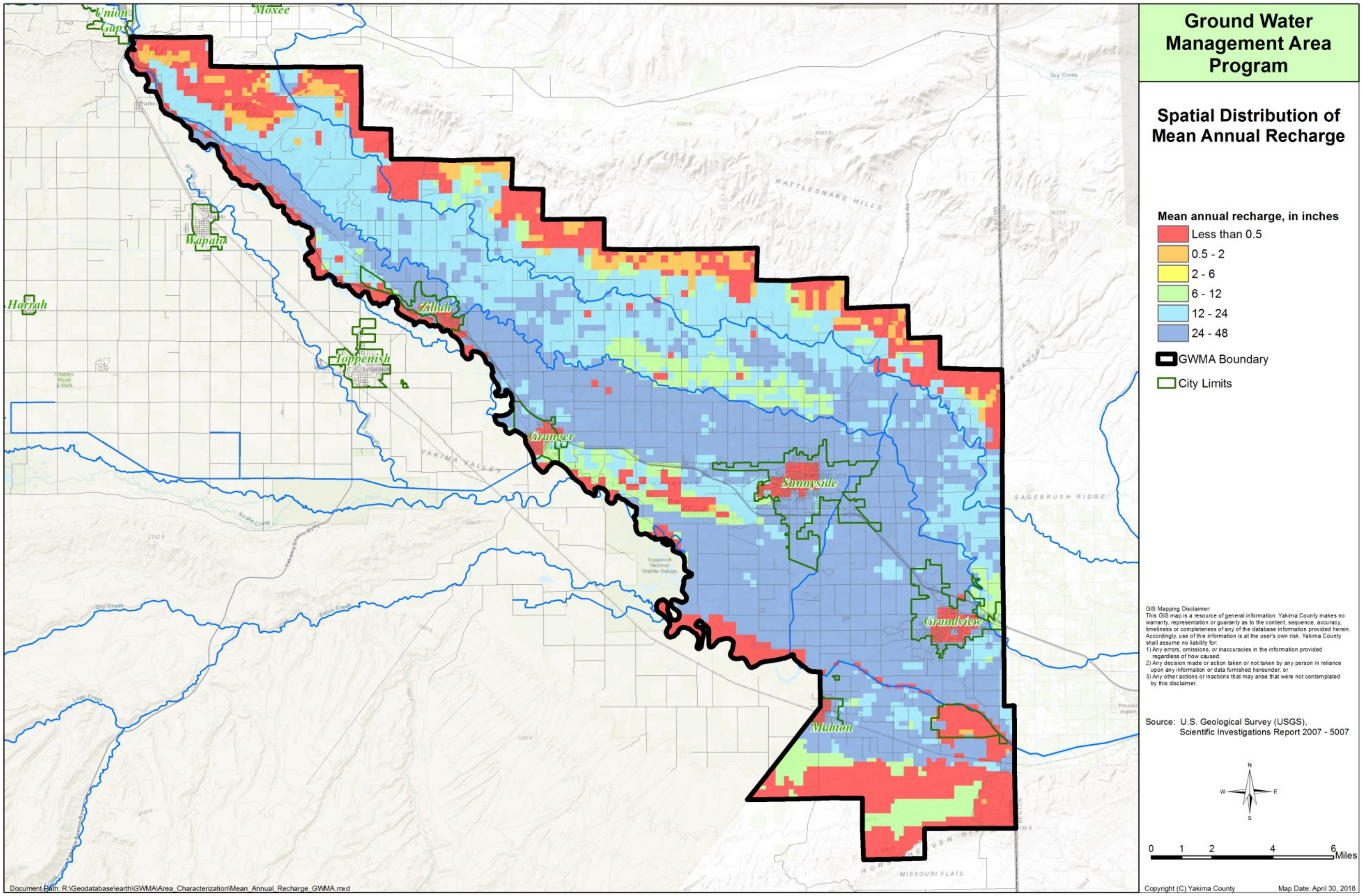


FIGURE 7 - SPRINGS WITHIN THE TOPPENISH BASIN

FIGURE 8 – MEAN ANNUAL RECHARGE WITHIN THE LYVGWMA



Mean Annual Groundwater Recharge

"Groundwater recharge" is a combination of all water (surface water, irrigation water, waste water, precipitation, etc.) that infiltrates the ground surface. "The delivery and use of surface water in the irrigation districts provide a source of recharge (more than 10 inches per year and in some areas more than 20 inches per year" (Vaccaro 2016; USGS 2007a). These are "acre-inches," a portion of the area's precipitation and around 3 acre feet of delivery by the irrigation districts. They are typically what would be called the non-consumptive portion of water use, that which actually soaks into the ground past the root zone / plant uptake. From there it goes to drains, surficial aquifers or deeper aquifers, at some eventual time either returning to the river or being pumped and returned to the surface for use. The USGS' conclusion of recharge was established by a one-day time-step model, utilizing the daily inputs from 25 years (1959-2001) of historical records, taking into account droughts, cool years, etc. It takes precipitation, temperature, humidity, evaporation and crop-specific evapotranspiration of plants into account.

Figure 8 reflects the conclusions derived from Figure 10 of the USGS' 2007 report (USGS 2007a). It is possible that the current state of mean annual groundwater recharge differs from that represented by this figure. Members of the LYVGWMA felt intuitively that the conclusions of the report were too high and failed to take into consideration changed conditions relevant to groundwater recharge. Members also believed that the increments of estimated annual recharge, i.e. 12-24 inches, 24-48 inches, were too great to be informative about any particular segment of land within the LYVGWMA. A better estimate might be derived by using a more recent period of climate condition, considering evolved irrigation methods, taking significant conversion of irrigation method into account, considering actual irrigation water application rather than estimated irrigation water application, considering irrigation canal lining, and studying the LYVGWMA more particularly rather than the basin-wide study of the USGS' 2007 report.

Vaccaro studied recharge in the context of water supply available for potential rural residential development (Vaccaro 2016). Two "domains," "Rattlesnake Hills Domain," and the "Mabton Domain," were identified within the LYVGWMA. "The Rattlesnake Hills Domain (246 square miles) includes the relevant lands south of the Moxee Drain and east and north of the Yakima River (left bank). The eastern boundary of the domain is the boundary between Yakima and Benton Counties." The "Mabton Domain" (40.9 square miles) includes the area north of Horse Heaven Hills (defined by the ridge line) east of the Yakima Nation boundary, south of the Yakima River and west of the Yakima-Benton County line. These two domains thus include the same area as that contained within the LYVGWMA. The Rattlesnake Hills Domain was divided into sectors, one below the Roza Irrigation District canal ("Sector 1"), the other above that canal ("Sector 2"), both of which are contained within the LYVGWMA boundaries. The Mabton Domain was not further divided. (Vaccaro 2016).

> "Sector 1 [of the Rattlesnake Hills Domain] (194 square miles) includes the irrigation districts present on Rattlesnake Hills such as Sunnyside Valley [SVID], Roza [RID] and Union Gap [UGID]. The delivery and use of surface water in the irrigation districts provide a source of recharge (more than 10 inches per year and in some areas more than 20 inches per year (USGS 2007a) to the system. The sector includes the cities of Zillah, Sunnyside, Granger, and Grandview. Except for the northern and eastern part of the sector, the area is typified by basin fill deposits generally over 200 feet thick. That is, basin-fill deposits over more than two-thirds of this sector are almost everywhere greater than 200 feet, and over about one-half of the sector they are greater than 400 feet. In the smaller, southeastern part of the sector, the deposits are thinner and future residential wells may need to be finished into the Saddle Mountains unit. Most of the existing wells may need to be finished in the basin-fill deposits and much of the future pumpage in this sector would occur from these deposits except along the peripheral boundary with sector 2 or where the basin-fill deposits thin toward the east. Future wells near the boundary between the two sectors likely would be needed to be drilled deeper than wells downslope. Groundwater-level hydrographs indicate stable water levels in these deposits. The groundwater levels for the units indicate that future withdrawals from the basin-fill deposits would have minimal, if any affect, on the deeper Wanapum and Grande Ronde units."
>
> "Recharge over most of th[e] area [in the Mabton Domain north of the 700 foot water level contour for the Saddle Mountains unit [described by] Vaccaro and others (USGS 2009a)] is more than 10 inches per year because of the influence of surface water irrigation [from the Roza Irrigation District]" (Vaccaro 2016).

Groundwater Levels and Flow

The two main aquifers underlying the area bordered on the north by the Ahtanum Ridge, on the south by the Toppenish Ridge, and bisected by the Wapato Syncline (USGS 2009a). These include a surficial unconfined to semi-confined alluvial aquifer and basalt aquifers underlying the sedimentary deposits (USGS 2009a). The basalt is believed to be semi-isolated from the surficial aquifer and stream systems. Groundwater flow within both aquifers generally follows topography, with natural recharge occurring within the headlands and on the sides of the valley and discharge occurring to the Yakima River. This produces a major flow direction from northwest to southeast, and a minor component flowing northeast to southwest and southwest to northeast. It is likely that the minor components of flow are enhanced by irrigation practices upland from the Yakima River (USGS 2009a; Vacarro 2016).

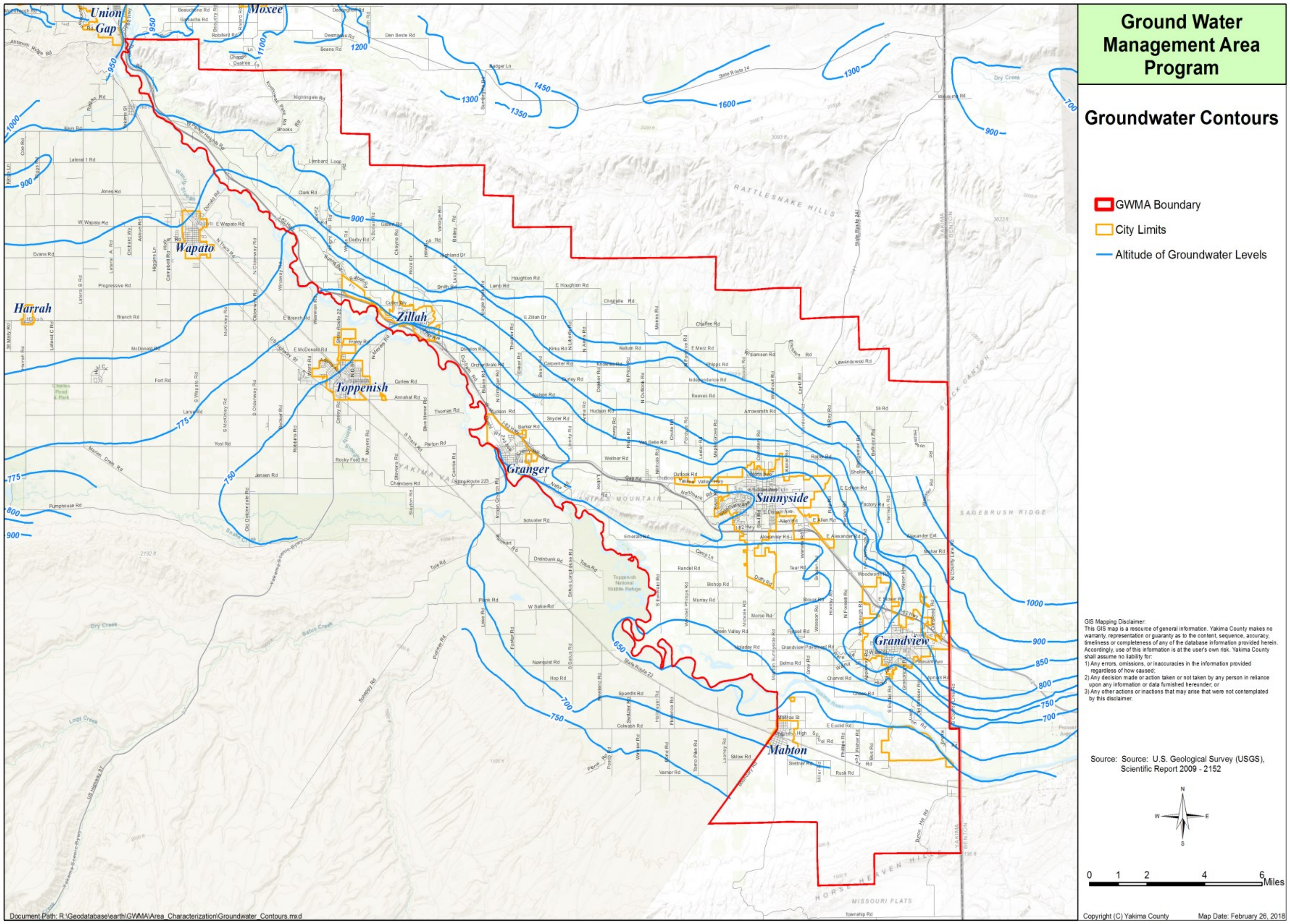
Because the potentiometric surface or water table of confined and unconfined aquifers, respectively, are variable, it is difficult to determine with certainty the depth of either from the ground surface. The USGS has, however, established groundwater level contours that can be used to compare against ground surface contours. Figure 9, derived from USGS' 2009 report (USGS 2009a), shows groundwater level contours (without distinguishing whether that level occurs within the alluvial, basalt, or both parts of the aquifer system). Figure 10 shows ground surface contours (topography) in meters. Figure 11, derived from determining the distance between the two contours, shows calculated depth to groundwater.

The vadose zone is the unsaturated zone between the land surface and the top of the water table. Depth to water is the distance between the ground surface and the water table. Time of travel through the vadose zone is dependent on depth to water, the vadose zone material, the amount of recharge, and other factors. Earthen materials within the vadose zone have different degrees of "permeability." Permeability is a measurement of the rate of infiltration. Permeability is used on both unsaturated and saturated flow. It is a measure of the intrinsic properties of a material that describes the ability of fluids to move through the material. It is independent of moisture content. It is intrinsic to the material (aquifer matrix). Moisture movement through the vadose zone is controlled by both material property and percent saturation or moisture content.

Unconfined (water-table) aquifers flow generally in accordance with the topography towards rivers, streams, lakes, and springs. The direction of groundwater flow in unconfined aquifers is normally perpendicular to groundwater contours premised upon measured or hypothetical water table levels (USGS 2009a). Groundwater flows from the direction of the highest potential energy to the lowest potential energy. The four types of potential energy that influence groundwater flow include gravitational potential, pressure potential, matric potential, and osmotic potential. The USGS has drawn its best judgment of the direction of that groundwater flow within the LYVGWMA. See Figure 16.

The hydraulic conductivity of bedrock units, CRBG basalts, and basin fill units were estimated from specific capacity data reported on drillers' logs by USGS (USGS 2009a). The median lateral K_h of bedrock, basalt, and basin fill units were 3, 3, and 6 ft/day in 9,833 and 882 wells, respectively, throughout the larger study area of the Yakima River Basin (USGS 2009a).

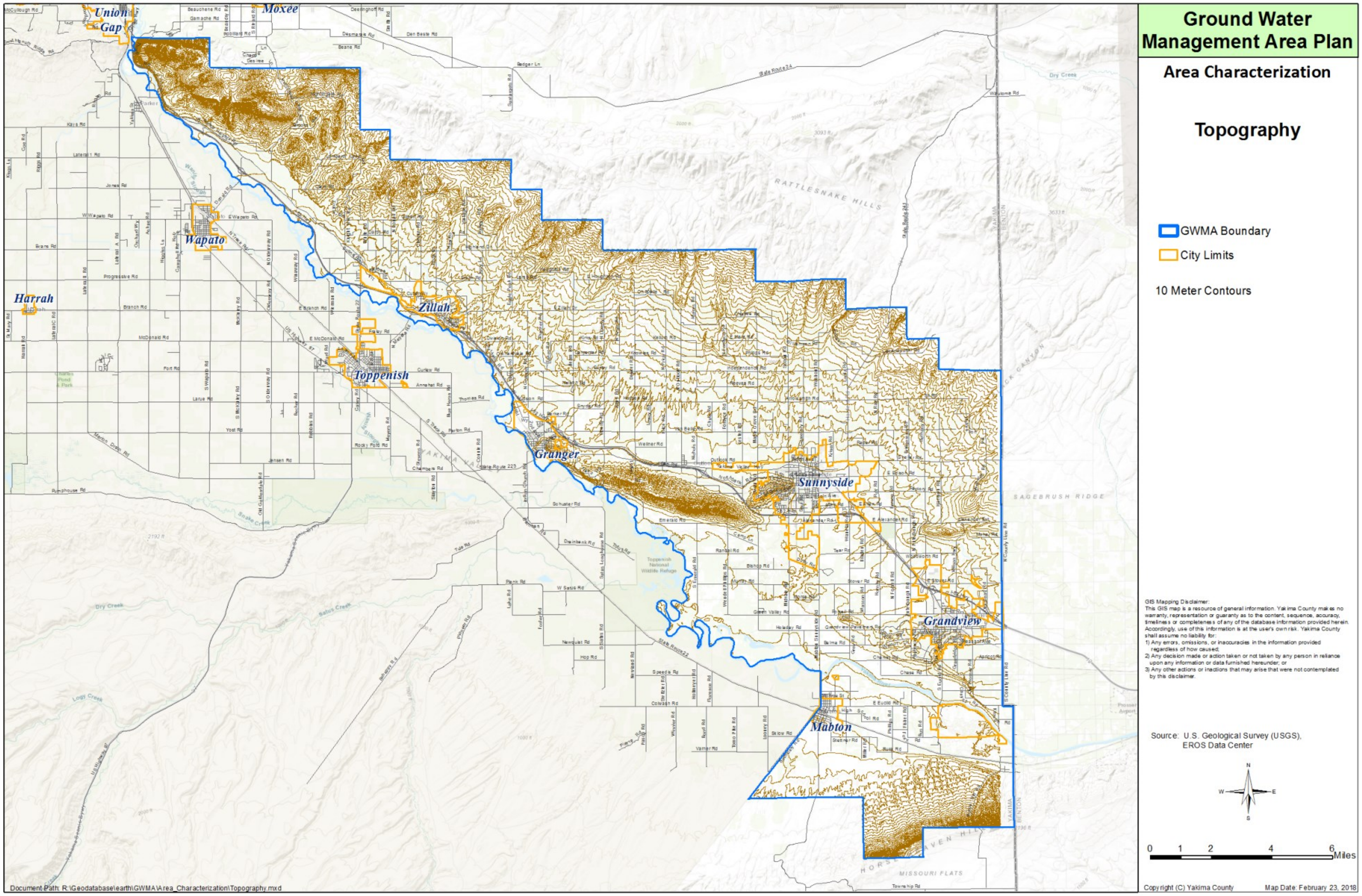
FIGURE 9 - GROUNDWATER LEVEL CONTOURS ESTABLISHED BY USGS WITHIN THE LYVGWMA



Topography

The topographical surface of the groundwater management area is undulating hillside running down (from an elevation of approximately 400 meters or 1312 feet above sea level) to the valley floor and river floodplain (at an elevation of approximately 230 meters or 755 feet above sea level). The topographical map on the next page illustrates essentially parallel elevation contours (denominated in meters)—evidence of a gradual descent from north-northeast along the Rattlesnake Ridge to south-southwest along the Yakima River.

FIGURE 10 - GROUND SURFACE CONTOURS (TOPOGRAPHY) WITHIN THE LYVGWMA



Sunnyside to Grandview and in the areas surrounding Mabton. Groundwater levels are deeper (25-100 feet) roughly in the areas between the SVID and RID irrigation canals. They become much deeper (100-1,000 feet) in areas above the RID irrigation canal.

FIGURE 11 - CALCULATED DEPTH TO GROUNDWATER WITHIN THE LYVGWMA

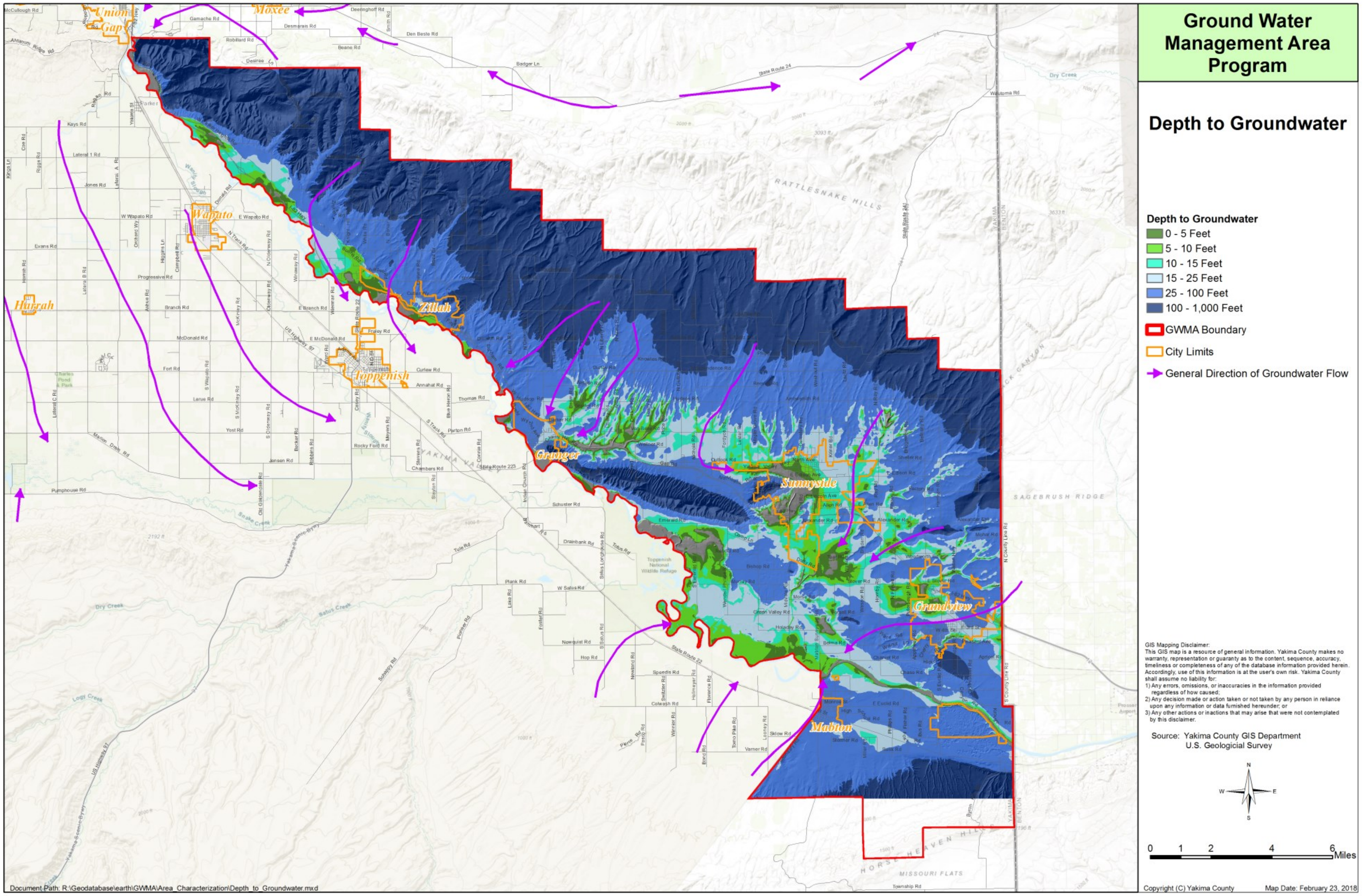
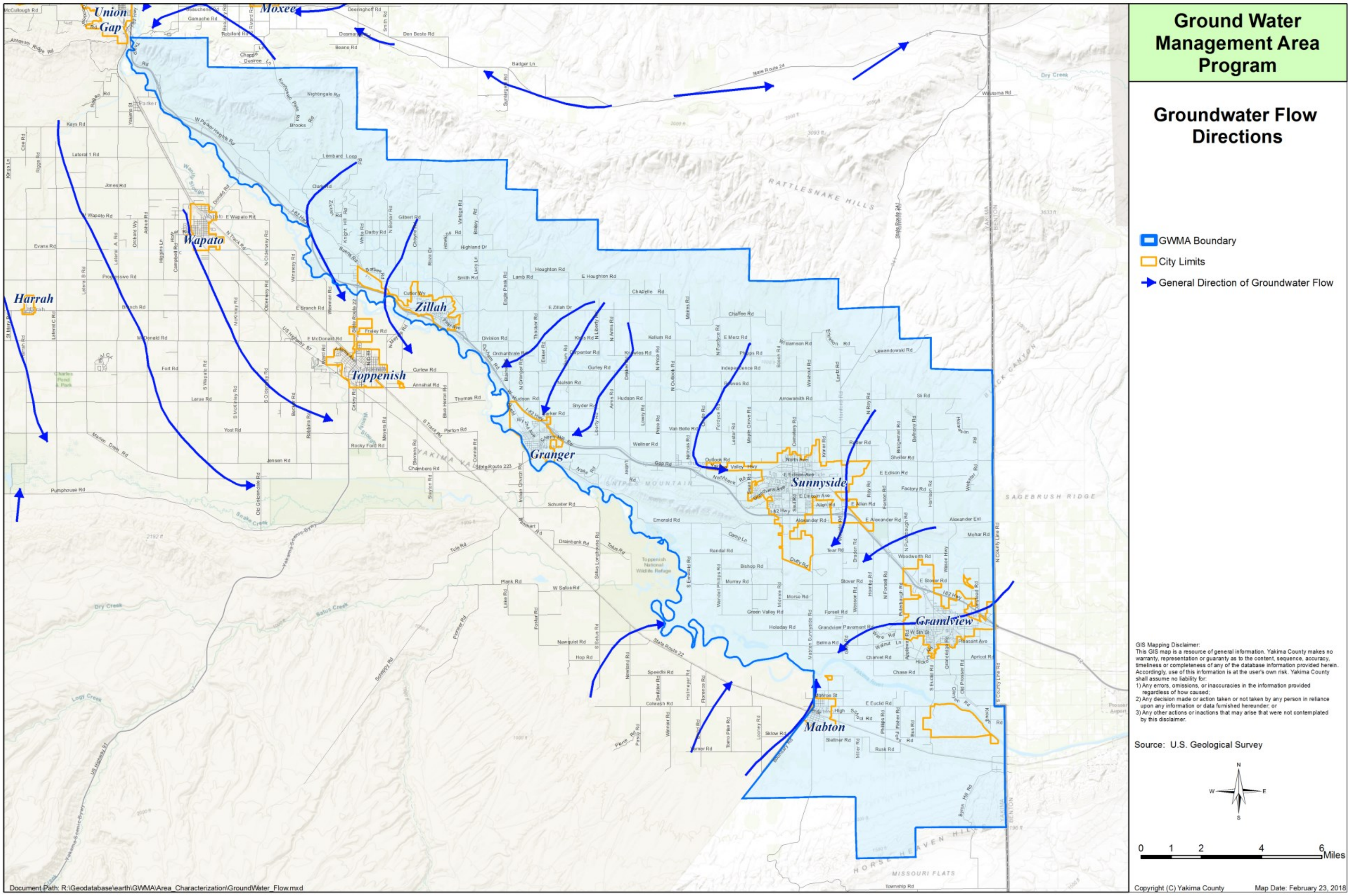


Figure 12 shows direction of groundwater flow within the LYVGWMA, as illustrated by USGS (USGS 2009a).

Figure 12 - Direction Of Groundwater Flow Within The LYVGWMA



Soil Types

There are 89 soil types within the GWMA (NRCS Soil Survey). They differ based on constituency of materials (coarse to very fine sands, loams, clay), values of porosity, specific yield, hydraulic conductivity and infiltration rate. "Hydraulic conductivity" and "infiltration rate" are calculated presuming complete saturation of the soil material. Both quantify the three-dimensional volume of a liquid through a two-dimensional plane of a matrix.

Predominant soil types within the GWMA are Scoon silt loam and Burke silt loam (ground surface roughly above 300 meters or 1000 feet above sea level), Warden fine sandy loam interlineated generally northeast to southwest with Harwood-Burke-Wiehl very stony silt loams and Esquatzel silt loam (ground surface roughly between 300 meters or 1000 feet and 250 meters or 800 feet above sea level), and Esquatzel silt loam, Quincy loamy fine sand, Wanser loamy find sand, Warden fine sandy loam and Warden silt loam (roughly within the valley bottom between 250 meters or 800 feet and 200 meters or 650 feet above sea level). The hydraulic conductivity of each of these primary soil types is available from NRCS' *Web Soil Survey* at https://websoilsurvey.nrcs.usda.gov/app/ and is presented in Table 2 below. The rates set forth in the table presume full soil saturation. Because soils in the vadose (unsaturated) zone within the LYVGWMA are only intermittently wetted, by irrigation or precipitation, the rates set forth must be variously reduced for those soils.

TABLE 2 - PRIMARY SOIL TYPES HYDRAULIC CONDUCTIVITY (K) (NRCS SOIL SURVEY)

Primary Soil Types Within LYVGWMA		
Soil Type	cu. In / hr	NRCS rate
Warden silt loam	0.57-1.98	Moderate
Warden fine sandy loam	0.57-1.98	Moderate
Esquatzel silt loam	0.57-1.98	Moderate
Shano silt loam	0.57-1.98	Moderate
Quincy loamy fine sand	5.95-19.98	Rapid
Wanser loamy fine sand	5.95-19.98	Rapid
Harwood Burke-Wiehl silt loam	0.00-0.06	Very slow, impermeable
Burke silt loam	0.00-0.06	Very slow, impermeable
Scoon silt loam	0.00-0.06	Very slow, impermeable

Figure 13 - Soil Types

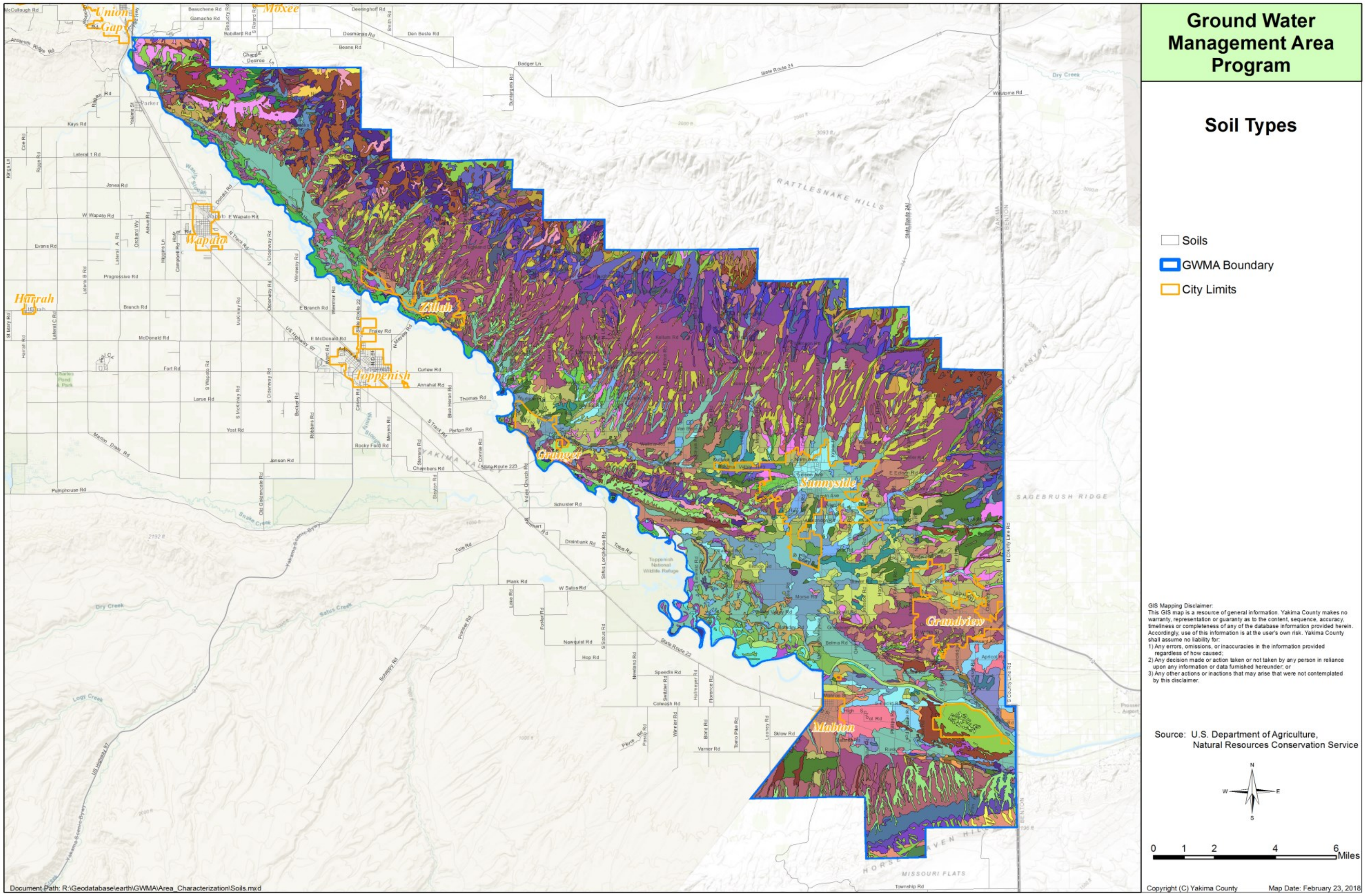


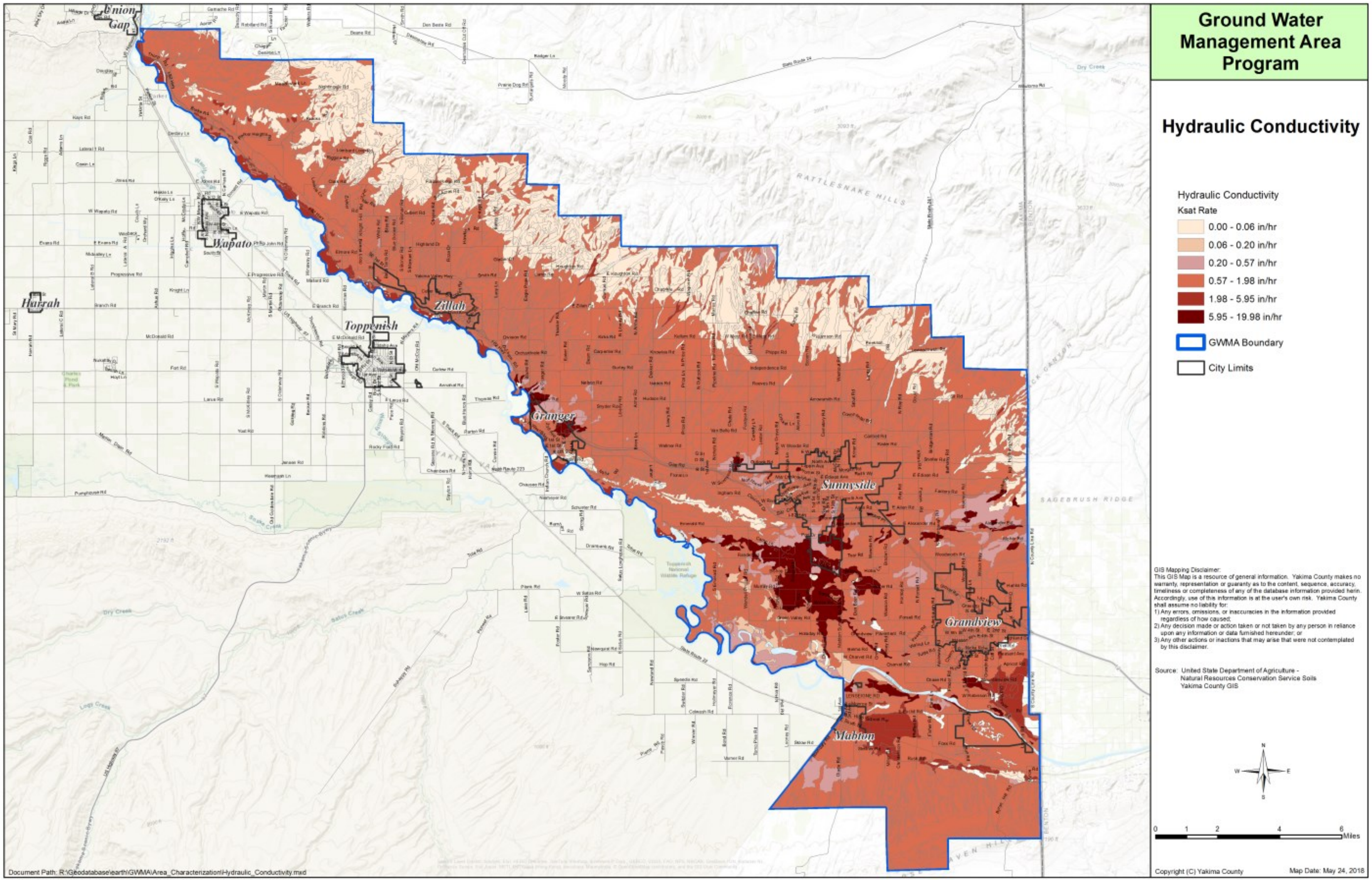
Table 3 - List Of All Soil Types Within The LYVGWMA

Soils

- Bakeoven very cobbly silt loam, 0 to 30 percent slopes
- Burke silt loam, 2 to 5 percent slopes
- Burke silt loam, 5 to 8 percent slopes
- Burke silt loam, 8 to 15 percent slopes
- Cleman very fine sandy loam, 0 to 2 percent slopes
- Cleman very fine sandy loam, 2 to 5 percent slopes
- Dam
- Esquatzel silt loam, 0 to 2 percent slopes
- Esquatzel silt loam, 2 to 5 percent slopes
- Fiander silt loam
- Finley cobbly fine sandy loam, 0 to 5 percent slopes
- Finley silt loam, 0 to 2 percent slopes
- Finley silt loam, 2 to 5 percent slopes
- Finley silt loam, 5 to 8 percent slopes
- Finley silt loam, 8 to 15 percent slopes
- Gorst loam, 2 to 15 percent slopes
- Harwood-Burke-Wiehl silt loams, 15 to 30 percent slopes
- Harwood-Burke-Wiehl silt loams, 2 to 5 percent slopes
- Harwood-Burke-Wiehl silt loams, 30 to 60 percent slopes
- Harwood-Burke-Wiehl silt loams, 5 to 8 percent slopes
- Harwood-Burke-Wiehl silt loams, 8 to 15 percent slopes
- Harwood-Burke-Wiehl very stony silt loams, 15 to 30 percent slopes
- Hezel loamy fine sand, 0 to 2 percent slopes
- Hezel loamy fine sand, 2 to 15 percent slopes
- Kiona stony silt loam, 15 to 45 percent slopes
- Kittitas silt loam
- Lickskillet very stony silt loam, 5 to 45 percent slopes
- Logy silt loam, 0 to 2 percent slopes
- McDaniel-Rock Creek complex, 5 to 30 percent slopes
- Mikkalo silt loam, 0 to 5 percent slopes
- Mikkalo silt loam, 15 to 30 percent slopes
- Mikkalo silt loam, 5 to 15 percent slopes
- Moxee cobbly silt loam, 0 to 30 percent slopes
- Moxee silt loam, 15 to 30 percent slopes
- Moxee silt loam, 2 to 15 percent slopes
- Outlook fine sandy loam
- Outlook silt loam
- Pits
- Prosser silt loam, 0 to 15 percent slopes
- Quincy loamy fine sand, 0 to 10 percent slopes
- Ritzville silt loam, 15 to 30 percent slopes
- Ritzville silt loam, 2 to 5 percent slopes
- Ritzville silt loam, 30 to 60 percent slopes
- Ritzville silt loam, 5 to 8 percent slopes
- Ritzville silt loam, 8 to 15 percent slopes
- Ritzville silt loam, basalt substratum, 15 to 30 percent slopes
- Ritzville silt loam, basalt substratum, 5 to 15 percent slopes
- Scoon silt loam, 15 to 30 percent slopes
- Scoon silt loam, 2 to 5 percent slopes
- Scoon silt loam, 5 to 8 percent slopes
- Scoon silt loam, 8 to 15 percent slopes
- Scooteney cobbly silt loam, 0 to 5 percent slopes
- Scooteney silt loam, 0 to 2 percent slopes
- Scooteney silt loam, 2 to 5 percent slopes
- Scooteney silt loam, 5 to 15 percent slopes
- Shano silt loam, 15 to 30 percent slopes
- Shano silt loam, 2 to 5 percent slopes
- Shano silt loam, 5 to 8 percent slopes
- Shano silt loam, 8 to 15 percent slopes
- Sinloc fine sandy loam, 0 to 2 percent slopes
- Sinloc silt loam, 0 to 2 percent slopes
- Sinloc silt loam, 2 to 5 percent slopes
- Sinloc silt loam, 5 to 8 percent slopes
- Starbuck silt loam, 2 to 15 percent slopes
- Starbuck-Rock outcrop complex, 0 to 45 percent slopes
- Starbuck-Rock outcrop complex, 45 to 60 percent slopes
- Umapine silt loam, drained, 0 to 2 percent slopes
- Umapine silt loam, drained, 2 to 5 percent slopes
- Wanser loamy fine sand
- Warden fine sandy loam, 0 to 2 percent slopes
- Warden fine sandy loam, 2 to 5 percent slopes
- Warden fine sandy loam, 5 to 8 percent slopes
- Warden fine sandy loam, 8 to 15 percent slopes
- Warden silt loam, 0 to 2 percent slopes
- Warden silt loam, 15 to 30 percent slopes
- Warden silt loam, 2 to 5 percent slopes
- Warden silt loam, 5 to 8 percent slopes
- Warden silt loam, 8 to 15 percent slopes
- Water
- Weirman fine sandy loam
- Weirman gravelly fine sandy loam
- Weirman sandy loam, channeled
- Willis fine sandy loam, 2 to 5 percent slopes
- Willis silt loam, 2 to 5 percent slopes
- Willis silt loam, 8 to 15 percent slopes
- Yakima silt loam
- Zillah sandy loam
- Zillah silt loam
- Zillah silt loam, channeled

All of the 89 soil types within the LYVGWMA illustrated in Figure 13 were sorted by Yakima County GIS into the hydraulic conductivity rate categories utilized by the U.S. Department of Agriculture, Natural Resources Conservation Service. These are illustrated in Figure 14.

Figure 14 - Soil Types In LYVGWMA Simplified In Hydraulic Conductivity Groups



Climate

The Western Regional Climate Center (WRCC) maintains climate data at three stations within the Lower Yakima Valley at Wapato, Sunnyside, and Prosser. Temperatures have historically ranged from 90 to 24 degrees Fahrenheit over the course of a year (WRCC). The data does not anticipate or address climate change.

TABLE 4 – CLIMATE (WRCC)

WAPATO, WASHINGTON (458959)													
Period of Record Monthly Climate Summary, Western Regional Climate Center, wrcc@dri.edu													
Period of Record : 10/01/1915 to 09/05/2013													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	39	47	58	66	75	81	89	88	80	67	50	40	64.8
Average Min. Temperature (F)	23	27	33	39	47	54	59	57	49	38	30	25	40.1
Average Total Precipitation (in.)	1	0.7	0.6	0.5	0.5	0.6	0.2	0.3	0.3	0.5	1	1.2	7.35
Average Total SnowFall (in.)	5.8	2.2	0.7	0	0	0	0	0	0	0	1.9	5.4	15.9
Average Snow Depth (in.)	2	1	0	0	0	0	0	0	0	0	0	1	0

SUNNYSIDE, WASHINGTON (458207)													
Period of Record Monthly Climate Summary, Western Regional Climate Center, wrcc@dri.edu													
Period of Record : 09/14/1894 to 01/05/2014													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	39	47	58	67	75	82	90	89	80	67	51	40	65.3
Average Min. Temperature (F)	23	27	32	38	45	51	54.7	53	46	37	30	25	38.4
Average Total Precipitation (in.)	0.9	0.6	0.5	0.5	0.5	0.5	0.18	0.3	0.4	0.6	0.9	0.9	6.8
Average Total SnowFall (in.)	4.5	1.8	0.2	0	0	0	0	0	0	0	1.8	4	12.4
Average Snow Depth (in.)						No	Data						

PROSSER, WASHINGTON (456768)													
Period of Record Monthly Climate Summary, Western Regional Climate Center, wrcc@dri.edu													
Period of Record : 07/01/1925 to 01/04/2015													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	38	46	56	65	73	80	89	87	78	65	49	40	63.9
Average Min. Temperature (F)	24	28	33	38	45	50	55	53	47	39	31	26	38.9
Average Total Precipitation (in.)	1.1	0.7	0.6	0.6	0.6	0.7	0.2	0.3	0.4	0.7	1	1.2	7.95
Average Total SnowFall (in.)	2.6	1.2	0.1	0	0	0	0	0	0	0	0.9	2.3	7.2
Average Snow Depth (in.)	1	0	0	0	0	0	0	0	0	0	0	0	0

Land Use

Agriculture is the primary economic and land use activity in the area. Approximately 70-80 percent of the area is used for agriculture. Agricultural production on the 464,000 irrigated acres within the Yakima River Basin is estimated to be worth over $2 billion (apples: $1 billion, dairy: $900 million, hops: $500 million) annually.

In 2007, the total market value of Yakima County crops sold was $1,203,806,000, and the average market value per farm was $340,058. In 2012, the total market value of Yakima County crops sold was $1,645,510,000 and the average market value per farm was $523,548 (YCDAa).

In 2007, the value of Yakima County milk production was $325,000,000. In 2012, the value of Yakima County milk production was $439,000,000 (YCDAb).

In 2007, Yakima County's Net Cash Farm Income was $372,055,000 and its Net Cash Farm Income per farm was $105,100. In 2012, its Net Cash Farm Income was $321,705,000 and its Net Cash Farm Income per farm was $102,356 (YCDAc).

In 2007, the 68,087 acres of fruit trees in Yakima County were valued at $749,883,000. In 2012, the 62,415 acres of fruit trees in the County were valued at $935,452,000 (YCDAd).

Most cropland in the area is irrigated. Major commodities grown in the valley include apples, pears, cherries, peaches, vegetables, hay, mint, and hops. In 2002, Yakima County ranked first statewide for apple, milk, hop, and grape production and first nationally for apple and hop production. Dairy operations were greatly expanded starting in the late 1980's, (WSDA 2013) and Yakima County cattle reached nearly 40 percent of Washington State's cattle population by 2018 (YCDAe). Also, animal feeding operations operate at various sizes from very small home lots to large commercial feedlots. The dairies and animal feeding operations are concentrated in the lower parts of the valley in and around the cities of Sunnyside, Grandview, Mabton and Granger; although some occur in more disperse parts of the valley on the Yakama Indian Reservation.

Viewed from the perspective of American history, problems of nitrate contamination have been identified in locations throughout the United States where community and rural population growth and more intensive agricultural practices have been practiced for extended periods. (USGS 2003c) (Roman et al.) (USGS 1990a) (Foster) (Vermont) (USGS 1993a) (Anderson) (USGS1985) (Beck) (Royte) (USGS 1984) (Lilbra et al.) (Kross et al.). Nitrate contamination has been identified as a public concern in New England, the Ohio Valley, southwest Georgia, the Middle West, and ultimately in the American West; particularly in Montana, Idaho, California, and now Eastern Washington.

Catholic Missionaries arrived in the Yakima River Basin in 1848. They established a mission in 1852 on Atanum (now Ahtanum) Creek, using irrigation on a small scale. Miners and cattlemen immigrated to the basin in the 1850s and 1860s. In 1859, Ben Snipes first drove cattle through the Yakima Valley. Five years later, he returned and established the Snipes and Allen Company; grazing 40,000-50,000 head of cattle in the Lower Yakima Valley. By the 1880s, it is estimated that there were 200,000 cattle; 350,000 sheep; and 125,000 horses grazing in the Yakima Valley. With increasing settlement in the mid-1860s, irrigation of the valley bottoms began. Outlying areas were used extensively for raising stock. Private companies began to deliver water through canal systems built between 1880 and 1904 for the irrigation of large areas. Irrigated agriculture began to be practiced more widely at this time. The Northern Pacific Railway was constructed through the Yakima Valley, reaching Yakima in December 1884 and Seattle in 1896, facilitating the development of irrigated agriculture through transport of agricultural goods to markets. Statehood in 1889 assisted Lower Yakima Valley agricultural growth, Yakima contending for state capital. When the National Reclamation Act was passed in 1902; about 85,000 acres were under irrigation in the Yakima Valley, mostly by surface water (Boening).

By 1901, farming had largely replaced livestock ranching in the easily irrigated acres of the valley. A state survey of that year reported the following crops grown in the Yakima Valley: apples, pears, prunes, plums, cherries, apricots, peaches, and grapes; alfalfa, corn, wheat, barley, oats, rye, flax, broom corn, other grasses including brome, orchard, tall meadow fescue, timothy, red top, and clover; melons, potatoes, garden vegetables, hops and sugar beets (Jensen).

Crops

The Yakima Valley Museum maintains a collection of photographs that indicate significant production of hops in the early period, primarily in the Moxee and North Yakima area.[5]

Above Union Gap, early crops included hops. In the Lower Valley, early agriculture primarily involved the production of hay (Jensen).

[5] Historical photographs courtesy of the Yakima Valley Museum. For further study, see http://www.yakimamemory.org/

Newly planted orchards were planted in the Sunnyside area by 1908:

Between 1905 and 1912 the lower Yakima Valley towns of Sunnyside, Mabton, Toppenish, Wapato, Grandview, Granger, and Zillah were all incorporated.

Another survey assembled in 1917 showed the following crops and agricultural products produced in the Yakima Valley: strawberries, cherries, prunes, apples, peaches, pears, apricots, grapes, cantaloupes, and watermelons; onions, turnips, green corn, carrots, rutabagas, cabbage, asparagus, tomatoes, green peppers, squash, pumpkins, beans, potatoes, hops, and sugar beets; alfalfa hay, wheat, oats and barley (WSDA 2013).

Field crops such as potatoes, onions, and corn; primarily watered by flood irrigation, either through total inundation or rill irrigation, were successful crops by the early 1920s:

.

Tree fruits had become successful export products by the 1930s.

The Federal Reclamation Act of 1902 and Washington State's Yakima Federal Reclamation Act of 1905 authorized construction of water delivery facilities to irrigate about 500,000 acres of land within the Yakima River Basin, including those within the Lower Yakima Valley. Six dams and five reservoirs were constructed as part of the Yakima Project.

These Federal reservoirs provide storage to meet water requirements of the major irrigation districts during the period of the year, called "storage control," when the natural streamflow from unregulated streams can no longer meet demands.

Farm sizes were relatively small during the first half of the twentieth century. There were 6,351 farms in Yakima County, making up 600,106 acres of farmland, in 1925 (WSDA 2013).

> "Farmers often produced their own livestock feed on farm, and maintained soil fertility through crop rotations and the retention of manure and crop residues on-farm. Weeds, insects, and plant diseases were controlled largely through mechanical practices, crop rotation, and the use of natural predators. During this time the conversion from horse-powered farming to the widespread use of tractors was taking place. . . . This spread of mechanization made it possible for farmers to use agricultural practices like intensive inversion-based tillage that remove all cover from the soil and use large amounts of fuel" (WSDA 2013).

The National Map Company's 1930 map entitled *Latest Official Survey of Washington* shows the route of two railroads then running through the GWMA area, with which to ship agricultural goods to market (Presby Museum; Goldendale, Washington). The density of the railroad's depots indicates the abundance of agricultural commodity available to be sent to market. The Union Pacific route stopped in Grandview, Forsell, Waneta, Midvale, Morris, Emerald, Bain, Noride, Granger, Blaine Acres, Dalton, Boone, Pam, Zillah, Buena, Flint, Sawyer, Dunbro and Parker en route to Union Gap and Yakima. The Northern Pacific route stopped at Grandview, Lichty, Sunnyside, Outlook Nass, Sinto, Granger, Boone, Gilliland, Cenauer, Zillah, Keck, Cutler, Buena, Sawyer, Donald, Mellis, and Parker en route to Union Gap and Yakima.

The number of farms and the area being farmed throughout Yakima County both stabilized during the 1940s. In the 1950s, the total number of farms began to decrease while the total amount of land being farmed increased, due primarily to the growth of land used as pasture. Between the 1960s and early 2000s, the total amount of land being farmed in Yakima County remained relatively static. It is reasonable to presume that the same trends occurred more specifically within the Lower Yakima Valley area.

Information regarding the total number of acres farmed in each crop category throughout Yakima County was collected by the U.S. Department of Commerce (USDOC), Bureau of the Census and published in the United States Census of Agriculture (USDOC Agriculture). The census information does not segregate data into geographic subdivisions of Yakima County. Nevertheless, the information does reflect trends in agricultural practices within the LYVGWMA, as this area constitutes a major portion of the County's agricultural economy.

TABLE 5 - AGRICULTURAL CENSUS DATA - GENERAL CROP TYPES

Summary of Yakima County Acres Farmed--- As Reported in USDOC Agricultural Censuses (numbers rounded) (WSDA 2013)				
	Number of acres farmed (x1000)			
	1935	1959	1982	2007
Apples, cherries, peaches, pears, plums, prunes and grapes	52.0	83.0	89.0	95.0
Corn, wheat, oats, barley, rye and triticale	55.0	94.0	101.0	83.0
Hay, forage, haylage and silage (including small grains cut for hay, wild hay, sorghum cut for silage or greenchop)	71.0	49.0	32.0	52.0
Potatoes, sugar beets, mint, hops, dill and dried herbs	18.0	48.0	36.0	44.0
Vegetables (including snap and string beans, cabbages, sweet corn, tomatoes and watermelons)	6.0	23.0	20.0	10.0
Field seeds and grass seeds	0.0	10.0	0.5	1.0
Legumes (excluding cover crops)	0.1	0.3	3.3	0.5
Berries	0.0	0.1	0.0	0.1

Some County-wide information on specific field crops is also available from the USDOC Agricultural Censuses.

TABLE 6 - AGRICULTURAL CENSUS DATA - FIELD CROPS

USDOC Agricultural Censuses (numbers rounded) (WSDA 2013)				
	Number of acres farmed (x1000)			
	1935	1959	1982	2007
Sweet Corn	1.00	9.00	5.00	2.00
Asparagus	2.00	10.00	10.00	2.50
Hops	4.00	19.00	19.00	19.00
Mint	0.00	10.00	25.00	10.00
Sugar Beets	1.00	19.00	8.00	2.00
Alfalfa	65.00	40.00	30.00	41.00
Alfalfa seed	0.30	10.00	3.00	1.00
Wheat	20.00	31.00	60.00	21.00
Corn for grain and silage	8.00	43.00	21.00	42.00
Barley	7.00	17.00	17.00	0.50

According to the information contained in several years' Agricultural Census, the number of cattle raised in Yakima County (excluding dairy cows) increased from 45,403 animals in 1925 to 212,762 animals in 2007. The number of dairy cows in Yakima County was stable at about 20,000 animals between 1925 and 1950. The number decreased during the 1950s and 1960s, reaching a low of 7,868 animals in 1969. The total number of dairy cows (excluding calves) reached 89,575 by 2007 (WSDA 2013).

TABLE 7 - AGRICULTURAL CENSUS - LIVESTOCK

Yakima County Livestock--As Reported by USDA Census (numbers rounded) (WSDA 2013)				
	Number of Livestock (x1000)			
	1935	1959	1982	2007
Cattle and calves	51	135	152	213
Dairy Cows	20	18	19	90
Chickens	220	240	520	300
Sheep	100	75	25	10

Trends in U.S. farming began shifting after World War II from mixed crop and livestock operations to specialized monocultures. Livestock became commonly raised separately on feedlots. Crop rotation decreased. Livestock manure, commercial fertilizer, and pesticides became more greatly available. Yields of corn, wheat, and rice increased during the latter half of the Twentieth Century due to large-scale mechanization of tilling, planting and harvesting, improved plant varieties, development of irrigation infrastructure, availability of low cost fertilizers and pesticides, and favorable commodity prices. Economies of scale led farm sizes to increase. By 2007, there were 3,540 farms, making up 1,649,281 acres, in Yakima County (WSDA 2013).

The Washington State Department of Agriculture maintains an annual inventory of crops grown on particular properties. The inventory is maintained in a Geographic Information System (GIS) format. Figure 15 illustrates the variety and location of crops grown within the LYVGWMA in 2015.

A more defined inventory, within the LYVGWMA was conducted by the Washington State Department of Agriculture (Figure 15). In 2015, the crops constituting one percent or more of the acreage within the GWMA are shown on Figure 15.

Figure 15 - Locations Of Crops Grown Within The LYVGWMA (2015)

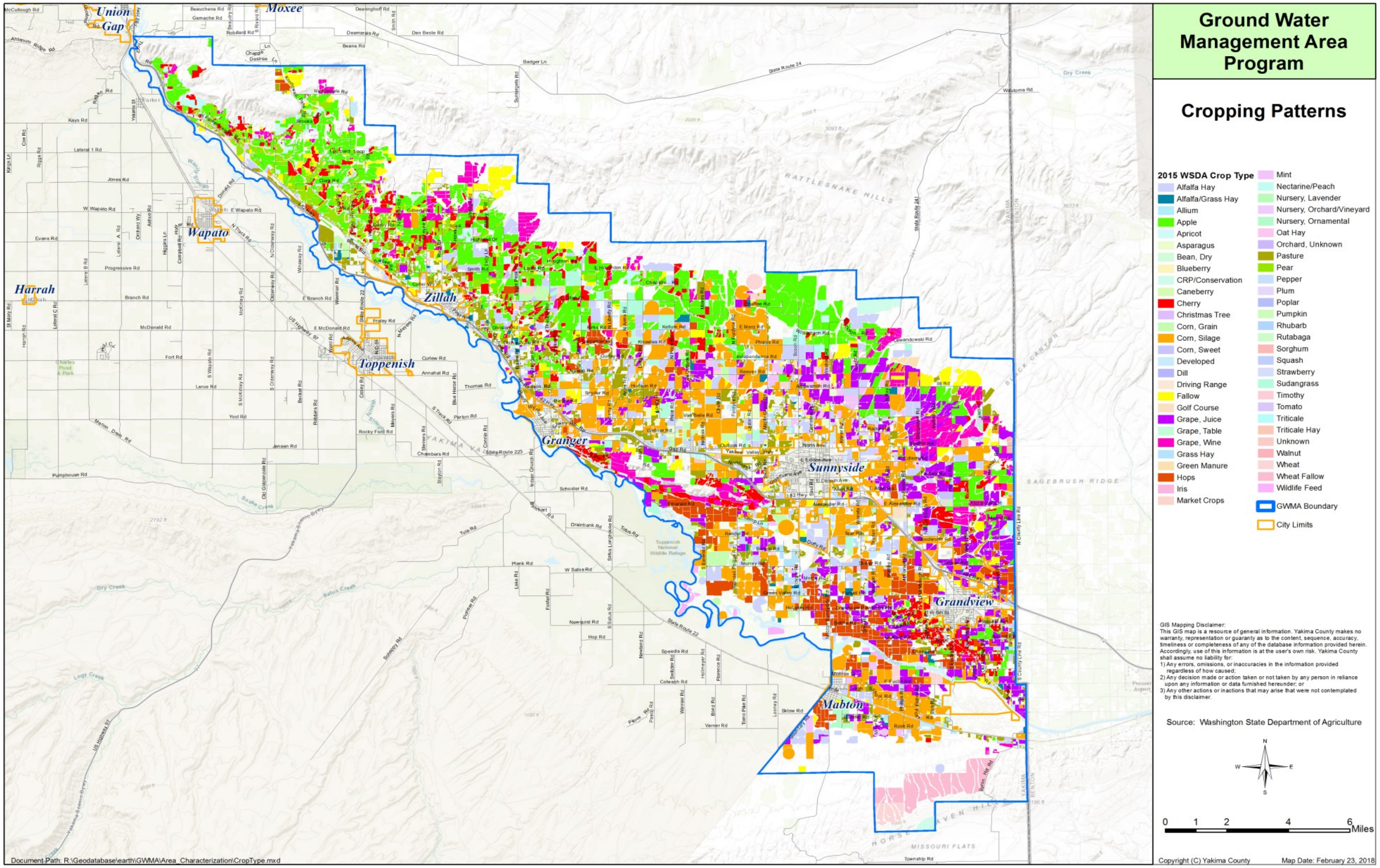


TABLE 8 - WSDA 2015 CROP INVENTORY WITHIN LYVGWMA

Top 20 Crop Types	Acres	% of Total Acres
Apple	17,351	18%
Corn Silage	16,826	17%
Grape, Juice	10,269	11%
Alfalfa Hay	7,977	8%
Pasture	6,702	7%
Cherry	6,361	7%
Hops	5,922	6%
Grape, Wine	5,129	5%
Fallow	4,791	5%
Pear	3,335	3%
Wheat Fallow	1,761	2%
Sudangrass	1,623	2%
Mint	1,414	1%
Wheat	1,283	1%
Corn, Grain	1,148	1%
Grass Hay	1,133	1%
Developed	1,019	1%
Asparagus	853	1%
Nectarine/Peach	843	1%
Alfalfa/Grass Hay	648	1%
Total Acreage	96,459	

The acreage totals in Table 8 do not account for multiple cropping of any particular acreage in a single year. According to WSDA, 10,780 acres of triticale were farmed ("double-cropped"), primarily on the same ground as corn silage, after the corn silage had been harvested. Double cropping was taken into account however in the WSDA's Nitrogen availability assessment (WSDA 2018).

Fertilizers

According to the USDOC Agricultural Census, as reported in the Agricultural History of Yakima County (WSDA 2013); 136,553 farmed acres were fertilized in Yakima County in 1954. In 1964; 203,062 farmed acres were fertilized. The number of fertilized acres remained at about that rate through 2007. In 2002, 28,152 acres were fertilized by manure. In 2007; 27,742 acres were fertilized by manure, or approximately 14 percent of total fertilized acres within the county.

The USDOC Agricultural Census also collected information, between 1954 and 1974, about the number of acres within Yakima County that were fertilized with chemical fertilizer. The maximum number of acres fertilized with chemical fertilizer occurred in 1970, when approximately 110,000 acres received chemical fertilizer (WSDA 2013).

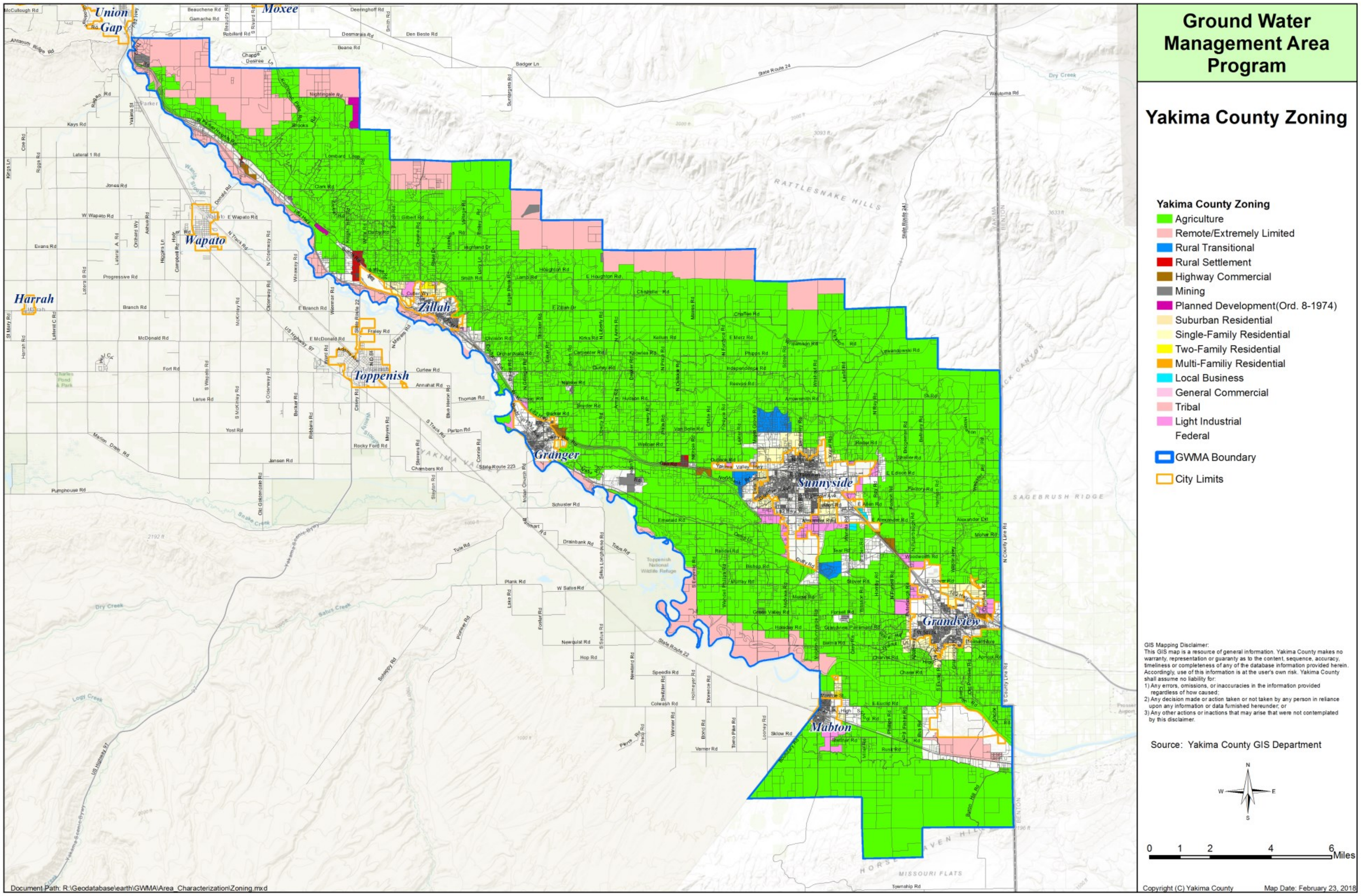
The use of synthetic (commercial) fertilizers began to increase between 1900 and 1944. After WWI, the use of chemical pesticides increased as well. WSDA's 2018 interview of commodity-specific experts to obtain a typical range of use rates for manure, compost, and commercial fertilizer for each of the GWMA's 15 top commodities (WSDA 2018) indicated that 19 percent of total GWMA irrigated acreage was fertilized by manure, 74 percent by commercial fertilizer, and 8 percent by compost.

TABLE 9 - PERCENTAGE DISTRIBUTION OF COMMERCIAL, MANURE, AND COMPOST FERTILIZER (WSDA 2018)

Crop	Area (acres)	Commer-cial N % of load	Acres of Commercial N	Manure N % of load	Acres of Manure N	Compost N % of load	Acres of Compost N
Apple	17333	86.3%	14958	0.0%	0	13.7%	2375
Corn (silage)	16778	49.6%	8322	53.9%	9043	0.0%	0
Triticale	10780	27.2%	2932	74.8%	8063	0.8%	86
Grape (juice)	10257	91.0%	9334	0.0%	0	11.6%	1190
Alfalfa	7989	91.8%	7334	8.2%	655	0.0%	0
Pasture	6731	97.2%	6543	2.8%	188	0.0%	0
Cherry	6336	80.5%	5100	0.0%	0	19.5%	1236
Hops	5961	97.3%	5800	2.7%	161	16.0%	954
Grape (wine)	5126	100.0%	5126	0.0%	0	20.0%	1025
Pear	3331	76.6%	2552	0.0%	0	23.4%	779
Mint	1418	100.0%	1418	0.0%	0	0.0%	0
Wheat	1283	93.9%	1205	22.4%	287	0.0%	0
Corn (grain)	1166	71.3%	831	62.6%	730	0.0%	0
Asparagus	854	100.0%	854	0.0%	0	0.0%	0
Peach/Nectarine	843	81.0%	683	0.0%	0	19.0%	160
Total			72992		19129		7805
Per cent of total			0.73		0.19		0.08

Land use within the LYVGWMA is subject to the Yakima County Code. Most of the land within the GWMA is within the Agricultural Zone. Figure 16 illustrates Yakima County zoning districts within the LYVGWMA.

FIGURE 16 - YAKIMA COUNTY ZONING WITHIN LYVGWMA



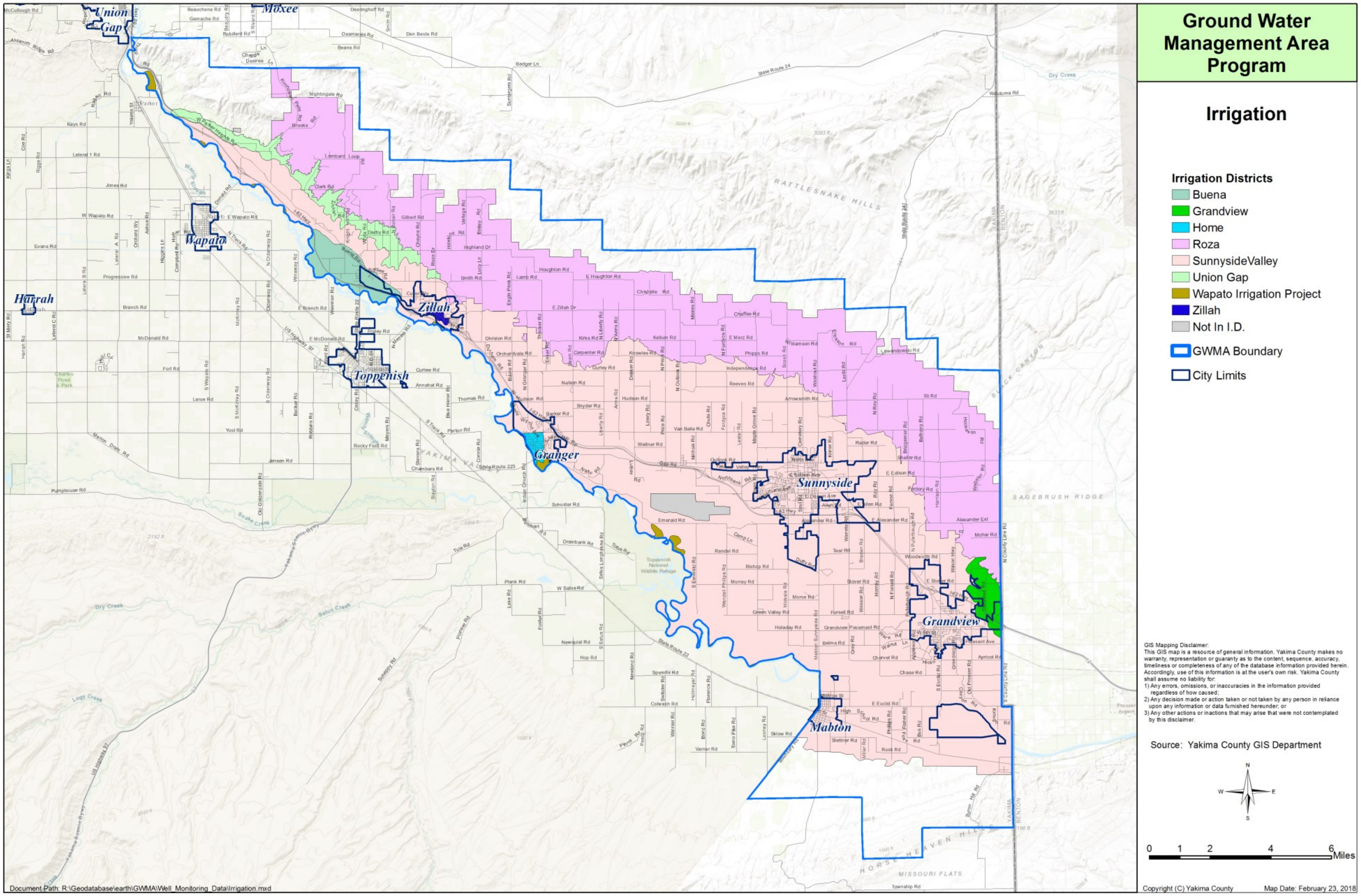
Water Use

The Lower Yakima Valley, south of Union Gap, is semi-arid with a mean annual precipitation of 6.8 inches. Precipitation and snowpack in the Cascade Mountains provide the source water and natural storage capacity for the Yakima River and the primary irrigation supply. Diversions from the river are managed by the U.S. Bureau of Reclamation (USBR). Irrigation water can also be drawn from wells pursuant to individual water rights recognized by the Washington State Department of Ecology. Under the Washington State Groundwater code (RCW 90.44.050), prospective groundwater users must obtain authorization of a water right for irrigation (other than that exempted by the statute). Post-1945 well-drilling technologies, legal rulings, and the onset of a multi-year dry period in 1977 stimulated the drilling of numerous irrigation wells. Population growth in the basin has also resulted in increased drilling of shallow domestic wells in addition to deeper public-supply wells. There are now more than 20,000 wells in the basin, more than 70 percent of which are shallow, 10–250 ft deep, domestic wells. The Department of Ecology's online water-rights database indicates that there are 2,874 active groundwater rights associated with wells in the Yakima basin. They collectively withdraw about 529,231 acre-ft during dry years. The irrigation rights are for the irrigation of about 129,570 acres. There are about 16,600 groundwater claims in the basin, for some 270,000 acre-ft of groundwater (USGS 2011). The more limited numbers of groundwater irrigation rights and acreage watered by groundwater specifically within the LYVGWMA has not been determined.

The three largest irrigation providers in the lower valley are the Wapato Irrigation Project, Sunnyside Valley Irrigation District, and the Roza Irrigation District. Wapato Irrigation Project serves irrigators within the Yakama Indian Reservation and is managed by the U.S. Bureau of Indian Affairs on behalf of the U.S. Bureau of Reclamation. In 2012, the Sunnyside Valley Irrigation District (SVID) served 94,614 acres on the valley floor and lower slopes. SVID diverts its water near Parker into a 60-mile canal running generally northwest to southeast through the GWMA, in essentially the same direction of groundwater flow. The SVID's primary canal and delivery laterals are unlined. The Roza Irrigation District (RID) serves 72,491 acres, some of which are not within the LYVGWMA, at higher elevations. Those within the LYVGWMA are on the north slopes of the valley (WSDA 2013). The RID diverts its water from the Yakima River upstream of the City of Selah into a

94.8-mile canal. Its primary canal is lined and its delivery laterals are for the most part contained. The waste ways in both the SVID's and RID's irrigation systems are unlined. Diverse crops are grown in both the SVID and RID service areas. Generally, forage crops dominate the SVID and tree fruits dominate the RID. Both canals end, returning tail water to the Yakima River, near Benton City. From the canals, water is delivered through 709 miles of laterals to over 5,300 individual deliveries. Diversions usually begin in March to prime the canal system and cease in mid-October. On-farm deliveries typically begin in early April. Figure 17 shows the service areas of the SVID and RID within the LYVGWMA.

FIGURE 17 - SUNNYSIDE VALLEY AND ROZA IRRIGATION DISTRICTS WITHIN THE LYVGWMA



Irrigation Methods

Irrigation in the Yakima River Basin is accomplished using one of three methods: rill, sprinkler, or drip. Rill (or gravity) irrigation is the oldest and simplest form in use. In its simplest form, an open channel (head ditch) delivers water to the high point of a field. Water is siphoned out of the head ditch and into small furrows cut into the field between each crop row. Water exits the furrows at the low point of the field, and is collected in a second open channel (tail ditch). This water may be reused by pumping back to the head ditch, sometimes repeatedly. The tailwater in the tail ditch may then be routed to a drain that feeds into the regional drainage network. On many rill-irrigated fields, the open head ditch has been replaced with PVC pipe. Instead of siphon tubes, manually operated spigots or sliding gates direct irrigation water into the furrows.

A variety of sprinkler systems are used throughout the Yakima River Basin, and each system varies in its efficiency of delivering water. Portable solid set, wheel lines, and big guns are examples of simple systems to operate, but typically do not provide a uniform coverage of water to a field. They also require manual labor to move from place to place in a field. Fixed solid set, center pivots, and liners are more expensive to install and more complex to operate, but they provide a more even coverage and give the farmer greater control over the irrigation process. These systems can be fully automated, enabling the farmer to irrigate a large area with less labor. The most sophisticated systems use feedback from soil-moisture probes to cycle the irrigation system off and on (USGS 2004).

Drip irrigation employs plastic lines with small openings to deliver water directly to the base of the plant. The drip lines may be installed above or below the soil. A properly operating drip-irrigation system enables a farmer to make maximum use of his allotment of water—very little water is lost to evaporation, no tailwater is generated, and virtually no water is lost to the groundwater system. Drip systems also enable the farmer to deliver nutrients and some pesticides through the lines, significantly reducing the amount of chemicals used on the field and reducing the potential for the chemical to leave the field (USGS 2004).

Sprinkler irrigation systems increased in the Roza and Sunnyside Irrigation Districts between 2005 and 2012, the years in which records are available. Rill (gravity) irrigation systems have decreased. Sprinkler irrigation in those districts is somewhat lower than it is statewide. Low-flow drip irrigation had increased to 26.16 percent of the acreage in the Roza District by 2010 (WSDA 2013).

Demographics

Population

Yakima County is the eighth largest county in state by population, with 244,654 people (USDOC 2010). It is the second largest county in State by land mass: 4,311 square miles. The population within the LYVGWMA was: 56,210, with 19,952 living in a rural area (USDOC 2010).

There are five of cities in the LYVGWMA —Sunnyside, Grandview, Granger, Zillah, and Mabton. Over half of the GWMA's residents live in those cities (USDOC 2010):

- City of Sunnyside-15,858
- City of Grandview-10,862
- City of Granger-3,246
- City of Zillah-2,964
- City of Mabton-2,286

The remaining population resides in an unincorporated area. Most of that remaining population– approximately 19,952 individuals – reside in a rural area not served by public water or sewer. These residents typically rely on a private or shared well for their drinking water. A nearly equal number rely on an on-site sewage system (OSS, or septic system) to dispose of their waste (derived using ARCGIS, a geographic information system, in combination with the 2010 Decennial Census).

In the GWMA, economics and livelihood play a critical role in the decision to live in a rural area instead of an urban one. Affordable housing is a draw to rural areas, and so is the proximity to agricultural-related employment. Farmers, for example, usually live on or near the acreage they farm.

However, other factors are at play in addition to affordable housing and agriculture. In recent decades in Yakima County, large-tract farmsteads have been parceled off and sold in smaller pieces over time. The smaller parcels were not large enough to make a living at farming, but they did offer part-time farming opportunities for people already employed in seeking a country lifestyle. This is perhaps the chief characteristic of "rural" living in Yakima County and the GWMA (Horizon 2040 5.9.4 Rural Lands-Existing Conditions). The desire for a "country" environment in part accounts for the growing number of rural GWMA households— ranging in property size from .5 to 10 acres— whose distance from urban areas preclude them from receiving municipal water or sewer services.

Income and Poverty

Yakima County's median household income of $43,506 is below Washington State's median income of $59,478. The County's per capita income of $19,433 is also below Washington State's per capita income of $30,742 (USDOC 2013).

22.6 percent of Yakima County's population was living below the poverty level, an increase of 2.4 percent since 1990. In comparison, only 13.4 percent of all persons in Washington State live below the poverty level (USDOC 2013) (Horizon 2040).

The population of the GWMA is generally poorer than the rest of Yakima County, with over a quarter of the GWMA's population living in poverty. There is also a higher percentage of children in the GWMA living in poverty, which is in line with the larger percentages of children living there.

Education

The educational disparity between the State, Yakima County, and the GWMA is even greater than the income disparity. In Washington State, for example, 10 percent of the population did not graduate from high school or receive a high school diploma. In Yakima County that rate is almost 3 times higher at 29 percent. Yet in the GWMA it is almost 4 times higher than the state at 39.6 percent. In some GWMA pockets the span is even greater: in the city of Mabton, which lies in the southeast section of the GWMA, 28.1 percent of the population over the age of 25 has less than a ninth-grade education.

Households and Families

The average household size in the GWMA ranges from 3.36 to 3.98 people per household, larger than the County (3.02 people) and State (2.54 people). Average family size in the GWMA ranges from 3.72 to 4.38 people—again, larger than the average County family size (3.53) or the State (3.11). In the GWMA, 80.2 percent of all households are comprised of families compared to 73.0 percent for the County and 64.5 percent for the State (USDOC 2013).

Race and Ethnicity

The GWMA has a higher concentration of individuals whose ethnicity is Hispanic/Latino compared to Yakima County, Washington State, or the Nation, and a lower concentration of American Indian/Alaska natives and Blacks/African-Americans (USDOC 2013).

Within Yakima County there is a wide gap between communities for both race and ethnicity. For example, the range for individuals who are Hispanic/Latino ranges from 0.4 percent in the City of Naches to 96.1 percent in the City of Mabton. Additionally, the range of individuals who are American Indian/Alaskan Native ranges from 0.0 percent in the city of Selah to 21.7 percent in the town of Harrah, which is located outside of the GWMA on the Yakama Indian Reservation (USDOC 2013).

The racial groups of Asian, Black or African-American, and native Hawaiian or other Pacific Islander represent a very small part of the population in the GWMA as well as Yakima County when compared to the State and the Nation.

Language

In Yakima County, 39.6 percent of the population over age 5 speaks a language other than English at home (predominantly Spanish). Additionally, 18.6 percent speak English less than "very well," indicating that the other 21.0 percent are bilingual. In the GWMA, 60.6 percent of the population over age 5 speaks a language other than English at home – 24 percent speak English less than "very well" indicating that the other 36.4 percent are bilingual (USDOC 2013).

Sources of Nitrate

Irrigated Agriculture

There are 360,906 acres of crops in Yakima County. Of those acres; 96,459 (27 percent) are located within the GWMA (WSDA 2018). In 2015, irrigated agriculture within the GWMA occupied 55 percent of the total land area within the GWMA boundaries (175,161 acres) (WSDA 2018).

Most crops grown in the GWMA have the potential for positive nitrogen loading under some management practices. WSDA 2015 crop data shows that there is a large and diverse number of crops grown in the GWMA. The top 15 crops by acreage represent 96 percent of the irrigated agricultural land within the GWMA. Each crop has a unique cultivation practice.

Nitrogen from organic matter becomes available for crop uptake as well as losses including leaching below the crop root zone with water.

Crops Supporting Livestock Operations

A significant portion of irrigated agricultural acreage within the GWMA (31,790 acres or 32 percent) is dedicated to crops and land uses (corn, triticale, pasture, and alfalfa) that support dairy or other livestock operations. The majority of manure and compost applications observed by representatives of the WSDA during interviews with farmers and crop consultants were taking place on crops intended for animal feed.

Triticale is normally "double-cropped" (two crops in one growing year (WSDA 2018). Triticale is planted in the fall (September-October) and harvested in the spring (April-May). Silage corn is seeded immediately afterward and harvested in late summer or fall (August-October).

Alfalfa is also planted. Alfalfa is a complex perennial crop. It removes large quantities of nutrients from the soil (PNW). It can meet most of its nitrogen needs from the atmosphere through nitrogen fixation, but is dependent both on the presence of rhizobia bacteria in the soil and on whether or not supplemental nitrogen is added. Alfalfa is considered a "lazy" plant, using nitrogen from other sources such as manure or commercial fertilizer if given the chance. The practice of nitrogen supplementation on alfalfa does occur within the GWMA. However, agricultural practices used for perennial crops like alfalfa and pasture remove the majority of the plant residue from the field during harvest (hay/silage) or through grazing.

During 1998-2003, 29 percent of the irrigated acres in the Granger drainage and 12 percent in the Sulphur drainage were owned by dairies (Crowe) and there were 20, 24, 2, and 0 dairies in Granger, Sulphur, Spring and Snipes drainages, respectively (RSJB 2009).

Tree Fruit and Vegetable Crops

The primary crops grown in the region are tree fruit, grapes (both juice and wine), hops, wheat, mint, and asparagus. The orchard and vineyard crops, e.g., apples, grapes, cherries, pears, peaches/nectarines are not replanted annually. Rather, they are replanted as appropriate to enhance farming efficiency and anticipate market preference and demand.

Fertilizers

Fertilizers available within the GWMA include commercial fertilizer, green manure (growing plants that are plowed back into the soil) or compost (made from manure). There is no current measured data regarding the distribution of the amounts of these three nitrogen sources within the GWMA. WSDA interviews with farmers and crop consultants indicate that the most commonly used product is commercial fertilizer. The only exceptions were silage corn and triticale, where more acres were fertilized with manure than with commercial fertilizer. The only crops where growers or crop consultants reported use of all three fertilizer products were hops and triticale.

Fertilizer application timing can affect nitrogen availability for plant uptake and resultant leaching of excess nitrogen. For instance, synthetic fertilizers are formulated to release a specific amount of nutrients at a specific rate over a select period of time. Nitrogen from compost or manure would be released over a much longer period of time at a much lower rate. Crop fertilizers (manure, compost, and synthetic fertilizer) also react differently at the point of application. Compost or manure also contain components with soil health improvement properties.

Generally, crop fertilizer application choices are affected by several parameters including fertilizer type, crop nitrogen needs, application recommendations, expected crop pricing, and anticipated yields. They also may be influenced by recommendations from crop consultants and fertilizer guides, historical practices, and practices of other growers in the community. This variability, in combination with effects of fertilizer types used, irrigation type and practices, and nutrient application timing, soil type and organic matter content, soil nutrient content, manure nutrient content, handling, and storage before application, organic carbon cycling and mineralization, and fertilizer fixing in alfalfa will all affect whether or not any fertilizer application represents a nitrogen loading risk. Alfalfa will resort to fixing nitrogen (i.e., create its own nitrogen by pulling it out of the air) only if there is insufficient nitrogen already in the soil. If there is sufficient nitrogen in the soil, it will utilize the soil nitrogen first.

High nutrient applications or application of multiple nutrient sources may be used on permanent tree fruit and vegetable crops to improve soil health and maximize fruit production. Producers of crops intended for human consumption may be reluctant to make manure and compost application because of concerns about pathogen transfer, reducing fertilization options (WSDA 2018).

Annual crops such as silage corn, triticale (for silage), and wheat use both commercial nitrogen and manure throughout the GWMA (WSDA 2018). Generally, the nitrogen application for this corn/triticale cropping system is split - one in the fall and one in the spring. Corn (silage and grain) use fairly even amounts of commercial nitrogen and manure on most of the acreage (WSDA 2018).

Fertilizers of any type should be applied only at an "agronomic rate" that is, the rate of application of nutrients to supply crop or plant nutrient needs to achieve realistic yields, while at the same time minimizing the movements of nutrients to surface and groundwaters. Cf. WAC 16-611-010. **"** '**Agronomic rates' means the application rate (dry weight basis) that will provide the amount of nitrogen or other critical nutrient required for optimum growth of vegetation, and that will not result in the violation of applicable standards or requirements for the protection of ground or surface water as established under chapter 90.48 RCW, Water pollution control and related rules including chapter 173-200 WAC, Water quality standards for groundwaters of the state of Washington, and chapter 173-201A WAC, Water quality standards for surface waters of the state of Washington." WAC .173-350-100. Where the root zone of agricultural crops are within saturated ground, the "agronomic rate" is limited by the groundwater standard.

Organic Fertilizers: Cover Crops, Manure and Compost

Cover crops can fix nitrogen within the soil, if plowed into the soil onsite. The variety of cover crop and number of years of integration of cover crops into the soil can affect overall nitrogen concentrations in the soil.

Manure from dairy and livestock operations within the GWMA is a widely-used source of organic fertilizer for irrigated crops within the GWMA. While total volume of manure production can be calculated, as a function of total animals, no public records are currently maintained from which to analyze whether, in gross (minus exportation of such materials), the application of such volume on available irrigated acreage within the GWMA equates to an agronomic rate in gross. Some pre-application site-specific soil characterization is practiced, so as to accomplish specific site application at an agronomic rate.

Manure contains two primary forms of nitrogen: ammonium and organic nitrogen. Organic nitrogen is nearly immobile. It becomes mobile, and available to crops as fertilizer, through mineralization, the process by which soil microbes decompose organic nitrogen into ammonium. The rate of mineralization varies with soil temperature, soil moisture, and the amount of oxygen in the soil. After mineralization, microorganisms within the soil convert ammonium into nitrate. This process, called nitrification, occurs most rapidly when the soil is warm, moist, and well-aerated.

Livestock wastes contain high concentrations of nitrogen and ammonium, and low concentrations of nitrate relative to inorganic fertilizer. It is difficult to estimate nitrogen loading to soil, air, and water from manure application without sufficient analysis of nitrogen content in these waste streams. These are subject to some nitrogen loss to air and soil under natural conditions.

Synthetic Fertilizers

There is no public record of the total amount of synthetic fertilizers sold or used within the LYVGWMA. Crop consultants or agronomists, either academic or mercantile (G.S. Long, Co., D & M Chemical, Bleyhl's, Wilbur-Ellis, Simplot, Crop Production Services, Husch and Husch), are used by the majority of commercial farms operating within the GWMA. There are only a few companies that do this type of work. These consultants are not usually farmers. They create prescriptions for pesticide and fertilizer applications across multiple crops on many different farms. Mercantile crop consultants have economic incentives to recommend larger applications of fertilizers. Agronomists without such incentives could review and evaluate such recommendations for farmers.

Water Applications

Irrigation practices can affect both amounts and rates of nitrogen leaching and the potential for increased nitrogen concentrations in irrigation return flows (which relocate nitrogen applied through fertilizer).

Irrigation water requirements vary based on crop type. The nitrogen concentration of irrigation water likely resembles that of the Yakima River. The average N concentration of high flow (late spring) and low flow (late summer) conditions of the Yakima River at Kiona during the 2012 irrigation season was 0.809 mg N/L (USGS 2013).

Irrigated agriculture is mapped statewide by WSDA, including the area within the GWMA. There is no current measured data regarding the distribution of the three general irrigation methods (sprinkler, drip, macro/rill) within the GWMA. Interviews with farmers and crop consultants indicate that sprinkler irrigation was used on 61 percent of the total irrigated acreage in the GWMA, drip irrigation (including drip, micro sprinkler, drip/sprinkler, and combinations) was used on 23 percent of the acreage. Macro, or rill, irrigation was used on 15 percent of the acreage (total does not equal 100 percent due to rounding) (WSDA 2018).

Silage corn and triticale cultivation is almost all irrigated with sprinkler or center pivot irrigation systems. Triticale cultivation rarely occurs on rill irrigated fields (Sheehan).

Any improperly decommissioned wells beneath livestock operations, including crop fields onto which waste is applied, could provide a direct conduit for contaminants to reach the groundwater.

Livestock Operations/CAFOs

Dairy Operations

USDA's 2012 estimate of dairy operations was 99,532 milk cows on 97 farms (USDA NASS 2014) in Yakima County (WSDA 2018). The majority, or near total of these, are thought to be located within the GWMA. Dairy farms are increasing in size, while the number of farms is decreasing (WSDA 2018).

Manure and other animal wastes supply nutrients to crops because they contain nitrogen and other elements essential to plant growth, and the recycling of animal nutrients to increase soil fertility and crop yield is a historic practice. Manures are recommended over commercial fertilizers where there is a desire to build the soil profile by increasing and diversifying soil organisms, increasing moisture holding capacity, and reducing the need for inputs.

Livestock operations have the potential to release nitrate, chloride, sulfate, and bacteria to surface or groundwater (Harter et al., 2002; Harter et al., 2012). Whether groundwater contamination occurs depends on contaminant characteristics, management practices, meteorological conditions, soil types, geological conditions, and groundwater characteristics (Viers et al., 2012). Contaminant sources can be animal holding areas, manure storage impoundments (either lagoons or settling ponds/basins), and manure applications to cropland (Harter et al., 2002).

The national statistical average of manure production of milk cows (in 2000) was 15.24 tons per animal unit of manure excreted per year. The national statistical average of nitrogen per ton of manure excreted is 10.69 pounds of nitrogen per ton (Kellog et al., 2000). The formulas used by the EPA to calculate animal manure production, nitrogen production, and losses due to volatilization or denitrification for Holstein cows (EPA 2012, attributable to WSDA) in the Yakima Valley are as follows:

> Annual manure production is calculated using the following formula: [((# of milking cows)*1.4 108) + ((# of dry cows)*1.4*51) + 99# of heifers)*0.97*56) = ((# of calves)I0.33*83)] *365/2000 (WSDA 2010)
>
> Nitrogen production is calculated using the following formula: [((# of milking cows)*1.4*.710 = ((# of dry cows)*1.4*.3) + ((# of heifers)* 0.97*.27)+((# of calves)*0.33*.42)]*365/2000 (WSDA 2010)
>
> Losses due to volatilization or denitrification during storage are estimated at 35 percent. This does not include application losses (WSDA 2010; EPA 2012).

Waste Storage Facilities (Lagoons)

Liquid manure stored in lagoons can be a source of nitrate and other contaminants. Contents of lagoons often consist of liquid manure (including urine), rainfall and snowmelt, any other liquid corral runoff, and process water from feeding pens and milking areas. Design, construction and management of lagoons are all very important for the protection of groundwater. In studying dairy, beef, and swine lagoons, researchers found substantial variation in the composition of solids, liquids, and dissolved constituents and leakage rates causing a wide variation in the potential to impact groundwater quality (Ham 2002; Harter et al., 2012a).

The distinction between a lagoon, a settling basin, a settling pond, or a pond is uncertain. Different professionals use different terms for different manure storage impoundments, and different impoundments may be used for different purposes at different times of year. Producers may mix manure and water in additional ponds before land application.

Not all industry experts classify impoundments based on the same criteria and experience. In addition, there are a wide variety of different construction techniques and operational techniques for settling ponds and basins. Some are earthen impoundments that are drained and cleaned as needed. Some ponds are concrete lined, engineered basins.

Lagoon nitrogen concentration depends on farm practices and unit operations on site. Operational differences are often related to whether a dairy uses a flush or scrape system to clean barns, the type of solids separation systems utilized and whether irrigation water is mixed with liquid manure for land application, and potential seasonal effects.

Animal Holding Areas or Corrals

Animal holding areas or corrals at animal feeding operations are typically unvegetated areas that include pens, freestalls, corrals, and resting and feeding areas. Some areas have extensive concrete and other areas are dominated primarily with a flooring or surface of unlined and compacted soil that can be susceptible to leaching or runoff to contaminant areas. If properly constructed and maintained, concrete floor surfaces can contain wastes and minimize leaching. Corral surfaces become compacted with use and become dense enough to slow down the downward movement of water and pollutants. Manure accumulating on the surface mixes with the soil layer and forms a low-permeability interface layer that further reduces the permeability of corral and pen surfaces (Harter et al., 2012a). Nitrogen loading from corrals and pens at dairy and feedlot facilities is governed by engineered sloping, soil type, dairy or feedlot age, unsaturated zone thickness, stocking rate, rainfall, and evapotranspiration rates. In some situations, increased short-term leaching in corrals may occur due to cracking during seasonal weather events.

Pens and Composting Areas

There are 2,632 acres within the GWMA identified by WSDA as pens or composting areas (1,597 acres Dairy CAFO, 499 acres Nondairy CAFO, 536 acres compost) (WSDA 2018). The nitrogen loading rates of pens vary depending upon number and size of stock contained within them and the management of those pens. Nitrogen leaching potential in pens and compost areas is mitigated by low annual precipitation, management of the amount of manures in those pens and compaction of those areas by livestock or equipment. Beef cattle feedlots and dairies have different number of animals per lot. The majority of pens that have been identified as non-dairy CAFOs are most likely dedicated to raising or housing dairy support animals (calves and heifers). However, individual pens may hold calves during one time period and after those animals are moved out, heifers and adult cows may be moved into that same corral or pen.

" 'Composting' means the biological degradation and transformation of organic solid waste under controlled conditions designed to promote aerobic decomposition. Natural decay of organic solid waste under uncontrolled conditions is not composting" WAC 173-350-100. "Composting" may refer to a category of activities rather than a specific practice or technology, may occur in windrows, composting in bags, spreading material out over a concrete pad or large surface area to dry, turning frequency, potential moisture additions to material that has dried out. Composting reduces the weight of the basic material. Composted waste can be desired by organic growers as a source of additive to soil structure, soil density, nutrient and weed defoliant.

Buildings Housing Animals

Animals may spend time in freestall barns, milking parlors, or loafing sheds. These facilities are built with concrete floors and are cleaned multiple times a day. Potential leaching from these types of buildings, even anticipating cracks in concrete floors that could provide a pathway to leaching, is much smaller than potential from pens and lagoons.

Residential, Commercial, Industrial and Municipal Groundwater

Non-agricultural sources of potential contamination of groundwater within the LYVGWMA boundaries include the following:

Residential Onsite Sewage Systems (ROSS)

Residential Onsite Sewage Systems (OSS) are present throughout the LYVGWMA outside of those areas served by municipal sewage collection and treatment systems. Residential OSS are especially common in and near the urban growth boundaries of many of the valley's municipalities. Non-residential OSS are also scattered throughout the project area serving a variety of public and private entities. The OSS comprise one of the several potential sources contributing nitrate-N to the underlying shallow alluvial groundwater system.

There are 6,044 residential households within the GWMA that discharge wastewater to an onsite sewage system (WSDA 2018). Nitrogen in residential wastewater is mainly generated from human body wastes and food materials from kitchen sinks and dishwashers. The amount of nitrogen present in the wastewater is typically expressed as a concentration in milligrams per liter (mg/L) and/or as a mass loading in grams/person/day.

The highest density of OSS is within and near urban growth areas associated with municipalities. Specifically:

- The highest density of OSS are found on the east and north side of Sunnyside where OSS density ranges from 80 to 100 OSS per section.
- West of Sunnyside near Outlook where OSS density approaches 80 OSS per section.
- In the Zillah to Buena area where density approaches 80 OSS per section.

- Slightly lower OSS density is found south of Grandview, Sunnyside, and Mabton where the OSS range from 50 to 70 per section.

The absence of public water systems in some rural areas where OSS are densely sited, due in part to the date of development of these areas, may cause too-close proximity of septic systems and drinking water wells. Nearby municipalities are constrained in providing new public water service to these denser rural populations by cost and growth limitations imposed by growth management areas established pursuant to the Growth Management Act. Too great a density of ROSS can be a cause of groundwater pollution (EPA 1977) (Swann). In the case of the Buena community within the LYVGWMA, failing septic systems and related contaminated wells caused Yakima County to respond with grant-funded installation of a public water system and a wastewater treatment system utilizing a combined septic/sewer system (Redifer).

The frequency of septic tank pumping in each ROSS in the GWMA is unknown. In a survey conducted by Yakima County, without statistical sampling methodology, 82 percent of 458 surveys collected indicated that they had had their "septic tank pumped recently."

Wastewater discharged to a ROSS is subject to several biological processes including nitrification and denitrification. These processes can take place depending on the environmental conditions and occur most effectively when the soil is unsaturated because the wastewater is forced to percolate over the soil particle surfaces where treatment can take place and air is able to diffuse through the soil. Whether these processes occur and their effectiveness in treatment depends on the physical characteristics of the soil and the environmental conditions of the soil through which the wastewater percolates. Wastewater parameters, such as levels of nitrogen, are removed to varying degrees. Under good conditions (and proper operation and management), organic or ammonia nitrogen is readily and rapidly nitrified biochemically in aerobic soil and some biochemical denitrification can occur in the soil, but without plant uptake, 60 to 90 percent of the nitrate enters the groundwater. Under anaerobic soil conditions, nitrification will not occur, but the positively charged ammonium ion is retained in the soil by absorption onto the soil particles. The ammonium may be held until aerobic soil conditions return allowing nitrification to occur (EPA 2002). Within the GWMA, moderate denitrification occurs about three months a year and poor denitrification occurs about three months (soil saturated and no warmth). These factors determine that the total denitrification average in the GWMA is in the range of 10 to 13 percent.

Conventional ROSS technology relies on primary treatment (settling) for solids and organic reduction prior to dispersion to the ground. Innovative ROSS technologies combine the primary treatment with biological treatment to achieve a higher level of treatment. The biological processes promote the removal of nitrogen from wastewater through the multi-step bacterial conversion of ammonia and organic nitrogen to nitrates (nitrification) and the reduction of nitrates to gaseous nitrogen (denitrification). The optimum nitrogen removal of properly operating conventional ROSS technology is up to 10 to 30 percent (WDOH 2005). Innovative ROSS technology utilizing biological nitrogen removal or introduction of carbon source can increase nitrogen removal (WDOH 2005).

The predominant soil types underlying the ROSS drain fields located within the GWMA are characterized as silt loams that are porous and have a well-developed structure. The estimated depth to groundwater is equal to or greater than 10 feet at approximately 90 percent of the ROSS locations. See Figure 11, Depth to Groundwater. It is reasonable to assume that the environmental conditions underlying the drain fields are conducive to some level of denitrification.

Large Onsite Sewer Systems (LOSS)

A LOSS is a septic system serving multiple residences or nonresidential establishments serving twenty or more people per day or having a design volume over 3,500 gallons. Washington State Department of Health records show that there are two LOSS located within the GWMA. One is located outside of Zillah with a design capacity of 5,000 gallons. The second LOSS site is located outside of Granger with a design capacity of 4,850 gallons. Annual reports for LOSS are submitted to the DOH.

Commercial Onsite Sewer Systems (COSS)

A COSS is a septic system used for employees working at agricultural or other businesses that operate year-round and are not classified as a LOSS by the DOH. The most likely locations of these facilities within the GWMA are wineries, schools, agriculture packing lines, small businesses (stores, fire stations), agricultural business offices and maintenance buildings, churches, and confined animal feeding operations (CAFOs).

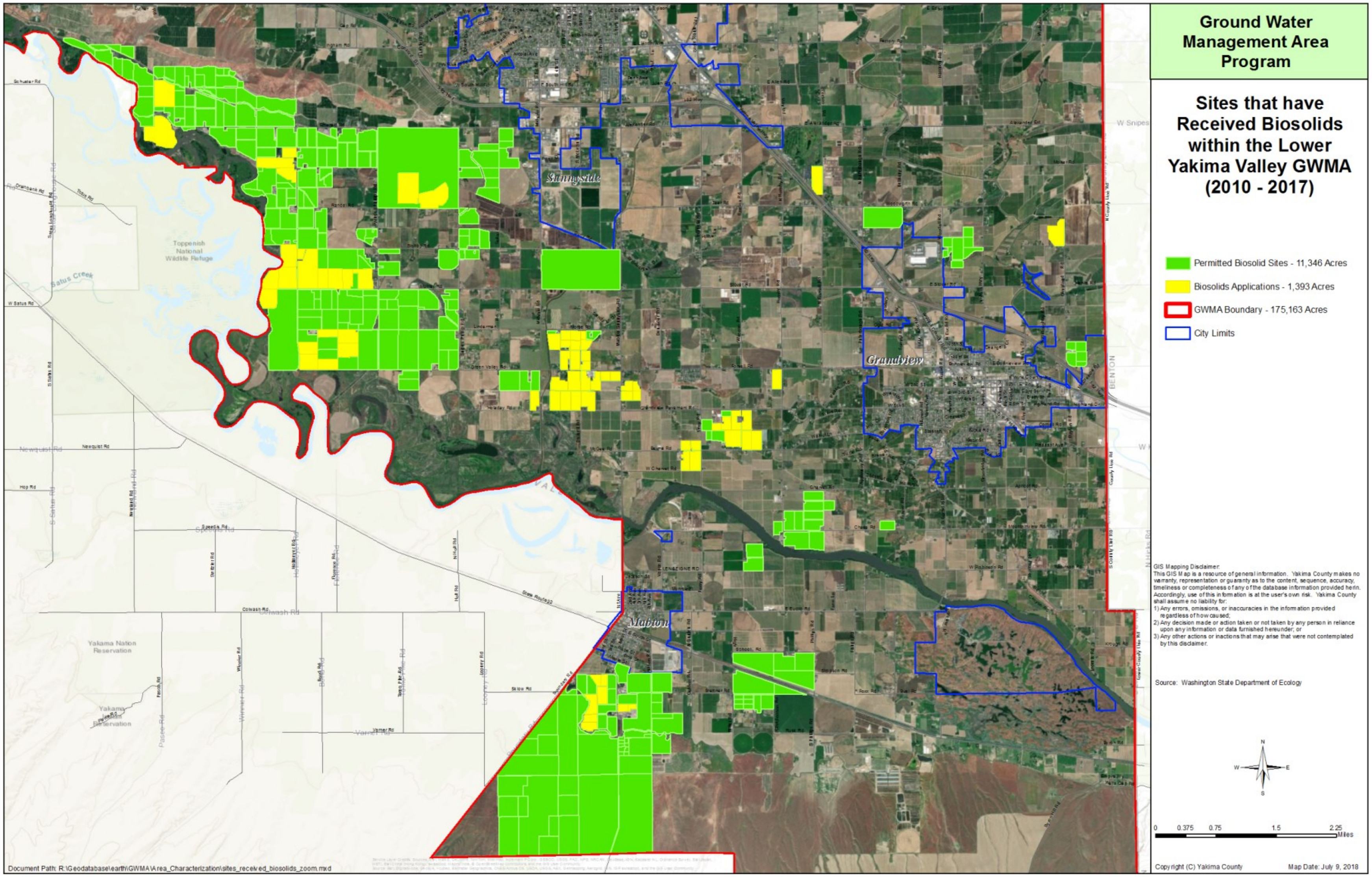
Biosolids

Biosolids are a nutrient rich soil amendment derived from public waste treatment plant septage. Septage is a class of biosolids that comes from septic tanks, treatment works, and similar systems receiving domestic wastes (WAC 173-308-050). Biosolids are produced by treating sewage sludge to meet certain quality standards that allow it to be applied to the land for beneficial use.

Biosolid application rates require advanced approval based on pre-plant soil tests, evaluation of crop type and yield estimates, soil types, and use of irrigation. Intermittent post-harvest tests are also conducted. The single site approved for land application of biosolids within the GWMA is Natural Selection

Farms located at 6800 Emerald Road in Sunnyside. Yakima County also receives some biosolids and County landfills.

FIGURE 18 - BIOSOLIDS APPLICATION SITES



Residential Lawn Fertilizers

Residential lawns exist primarily within towns or urban growth areas within the GWMA. All residents do not fertilize their lawn regularly. Some do not fertilize their lawns at all. Rough estimates are necessary to evaluate how much nitrogen is applied within the GWMA to residential lawns. Nitrate accumulation in the groundwater is not just a matter of nitrogen application rates but also water application rates and removal of "thatch" (grass clippings generated through mowing). While not everyone fertilizes regularly, overwatering and improper thatch management may occur at municipal properties, including residences, schools and businesses, particularly if mowing or watering is frequent. Both can have an effect on the loading of even a small amount of nitrogen. Higher population density areas can have a higher percentage of lawn area and the associated potential for more fertilization and overwatering that could be a factor in N loading.

"Hobby Farms"

The term "hobby farm" is intended to mean a land, which may or may not contain a residence, other than lawns, upon which minimalist agriculture is maintained without the intention of profit. It may contribute nitrogen within the GWMA area. These land uses are on parcels of land less than 10 acres that are not included in the WSDA's crop inventory. Nitrogen contributions on these parcels may come from individual gardens, pastures, pets, and other animals. Co-location of septic drain fields and hobby farming operations, particularly animal farming operations, may cause drain field failure and reduction of denitrification potential.

Underground Injection Wells

Most UIC's in Yakima County are road based and county-owned, put in place to receive surface water runoff from county roads.

Transport (Abandoned Wells)

Abandoned or improperly-constructed wells can be a conduit for nitrogen entering the ground. In Washington State, the construction of groundwater wells was first required to be reported in 1972. Consequently, the Department of Ecology well database includes only those wells constructed after 1972, and those wells identified in information supporting water right claims, permits or certifications predating 1972. A reasonable estimate of wells within Yakima County that are identified in DOE's well database is 45,000. Some portion of that is located within the Groundwater Management Area.

Groundwater wells typically have a life of about 40 years. This is due to: mechanical failure, deterioration of material (primarily steel well casings), settling of casings within ground materials, change in aquifer conditions (mineralization, scale deposits within casing). In most instances, it is cheaper to drill a new well than to repair an old one (Richardson).

Not all wells have the same risk of failure, or if abandoned the same risk to the public health and welfare. Wells differ in design, construction, diameter of casing, depth of casing, depth to water, water chemistry, etc. Wells constructed pursuant to regulatory standards have less risk of failure, even if "abandoned." "Dug wells," those wells constructed by digging a pit in the ground in order to collect water near ground surface, either with or without a small-diameter casing hammered into the ground from the bottom of the pit have the greatest risk of failure and risk to the public health and welfare. In addition to potential groundwater contamination from dug wells, people and animals can fall into these wells (Richardson).

"Vaulted" wells also present a significant risk of groundwater contamination, whether in use or abandoned. A "vaulted" well is essentially a dug well with a concrete reinforcement of the sides, or bottom, of the pit, creating a "vault". Water can collect in vaults which may migrate down the well casement, or along the annulus (the circular void between the well casing and the ground material through which the well was drilled) of the well casing. Wells with casing top elevations at or near ground level (as opposed to raised above ground level), or cut off below ground level, also present risk of groundwater contamination, due to possible "overtopping" of surface contamination into the well casing. Similar risk occurs where the well casing has no cap. Otherwise properly constructed wells may present risk of groundwater contamination if they have not been "sealed." Sealing is accomplished through the infusion of bentonite clay or cement into the casing annulus for a distance sufficient to prevent surface water intrusion into the subsurface (Richardson).

Deeper wells generally have larger diameters than shallower wells. Industrial, public water system, or irrigation wells are more likely to have larger diameter wells than single-user domestic wells. Unused irrigation wells may be less likely to be discovered because of change of land use or crop choice (Richardson).

Abandoned wells or wells that have not been decommissioned are often located by purchasers of property, parties who may become liable upon foreclosure of real estate financing instruments (banks), and reviewing entities (e.g., county planning officials) when reviewing proposals for change of parcel definitions (short plats, site plans for building permits) (Richardson).

Surface water, streams, and wasteways may also be a means of transportation of nitrogen to the ground.

Atmospheric Deposition

Atmospheric deposition of nitrogen is the process by which aerosol particles collect or deposit themselves on the earth's surfaces. It may be either wet or dry deposition. Nitrogen emissions may come from transportation agriculture, power plants, industrial and natural sources. In agricultural areas emissions from operations involving animals or fertilized cropland. Emissions may travel from very long or very short distances (Viers et al., 2012). Deposition monitoring is conducted by the National Atmospheric Deposition Program. There is one monitoring station in Eastern Washington, in Whitman County (WSDA 2018).

The Regulatory Environment

The water molecules in the ground beneath the LYVGWMA fall within the regulatory structure of the federal Safe Drinking Water Act and Washington Department of Health regulations (as "drinking water") and Washington's Water Pollution Control Act and Water Resources Act (as "groundwater"). Those molecules' potential contribution to surface water quality makes the federal Clean Water Act and surface-water authorities assigned to the Washington State Department of Ecology by the Water Pollution Control Act also apply.

Safe Drinking Water Act

The EPA has broad authority, under Section 1421 of the Safe Drinking Water Act, 42 U.S.C. 300g-1(b)(1)(A), (B), to establish national primary drinking water standards, "if the Administrator determines that . . . the contaminant may have an adverse effect on the health of persons;" "is known to occur . . . in public water systems with a frequency and at levels of public health concern;" or there is "a meaningful opportunity for health risk reduction for persons served by public water systems."

> For each contaminant that the Administrator determines to regulate under subparagraph (B), the Administrator shall publish maximum contaminant level goals and promulgate, by rule, national primary drinking water regulations under this subsection (42 U.S.C. 300g-1(b)(1)(E)).

EPA sets legal limits on over 90 contaminants in drinking water. The legal limit for a contaminant reflects the level that protects human health and that water systems can achieve using the best available technology. EPA rules also set water testing schedules and methods that water systems must follow. The EPA set the maximum contaminant level for nitrate, nitrite and total nitrate, and nitrite in 40 CFR § 141.62:

Contaminant	MCL (mg/l)
(7) Nitrate	10 (as Nitrogen)
(8) Nitrite	1 (as Nitrogen)
(9) Total Nitrate and Nitrite	10 (as Nitrogen)

EPA may approve states to assume primary enforcement authority under the Safe Drinking Water Act. Washington's drinking water quality standard for nitrate is 10 milligrams per liter (mg/L), or 10 parts per million.

When drinking water in private wells contains or is likely to contain a contaminant that may present an imminent and substantial endangerment, such as nitrate, EPA may take an emergency action under the SDWA, Section 1431. EPA must first determine that the state and local authorities have not taken action to protect the health of such persons. An emergency action pursuant to SDWA Section 1431 may include any order that may be necessary to protect the health of persons, including ordering the collection of samples to investigate the sources of the contamination. In addition, where appropriate, EPA may issue orders to require the provision of alternative water supplies. EPA may also judicially enforce its orders, through action seeking civil penalties for each day of such violation. If violation of EPA's orders is "willful," EPA may seek criminal penalties of fines or imprisonment for not more than three years (42 U.S.C. § 300g-2(b)). Citizens may also seek protection of underground sources of drinking water, under 42 USC 300j-8, so as to mandate EPA regulatory or litigative action.

The EPA may also designate sole source drinking water aquifers under Section 1427 of the Safe Drinking Water Act, 42 U.S.C. 300h.

State Department of Health

The Washington State Department of Health is authorized to adopt regulations "to protect public health" (RCW 43.20.050(2)). These may include rules for Group A public water systems, as necessary, to assure safe and reliable public drinking water and to protect the public health. Those rules set requirements regarding: (i) The design and construction of public water system facilities, including proper sizing of pipes and storage for the number and type of customers; (ii) Drinking water quality standards, monitoring requirements, and laboratory certification requirements; (iii) Public water system management and reporting requirements; (iv) Public water system planning and emergency response requirements; (v) Public water system operation and maintenance requirements; (vi) Water quality, reliability, and management of existing but inadequate public water systems; and (vii) Quality standards for the source or supply, or both source and supply, of water for bottled water plants.

The DOH also sets rules for Group B public water systems, as defined in RCW 70.119A.020. These rules establish minimum requirements for the initial design and construction of a public water system and "rules and standards for prevention, control, and abatement of health hazards and nuisances related to the disposal of human and animal excreta and animal remains" (RCW 42.30.050 (2) (b), (c)).

The Department of Health requires that nitrate levels (concentrations) (as N) in Group A public water systems not exceed the maximum contaminant level ("MCL") of 10 mg/L, and that nitrite levels (concentrations) not exceed the MCL of 1 mg/L (WAC 246-290-310(3) (Table 4)). The requirements for Group B public water systems are the same (WAC 246-291-170 (2)(b)). Nitrate and nitrite are "primary inorganic contaminants" and the MCL for nitrate and nitrite are "primary MCLs." When primary MCLs are exceeded by a public water system the water purveyor must "determine the cause of the contamination" and "take action as directed by the Department of Health" (WAC 246-290-320(1)(b)(iii)).

WAC 246-290-300 requires public water systems to sample for many contaminants, including nitrate, on a regular basis. Public water systems with nitrate levels over 10 ppm must notify the people who receive water from them (WAC 246-290-320).

Clean Water Act

Surface water quality in Washington is regulated by the federal Clean Water Act (33 U.S.C. 1342, et seq.) and Washington's Water Quality Standards for Surface Waters (Chapter 173-201A), which are authorized by the State Water Pollution Control Act (Chapter 90.48).

The Clean Water Act makes it unlawful to discharge any pollutant from a point source into waters of the U.S. unless a National Pollutant Discharge Elimination System (NPDES) permit is obtained (33 U.S.C. 1342). The NPDES permitting authority has been delegated to the Department of Ecology (See 33 U.S.C. 1342 (b);

RCW 90.48.260). The Department exercises this delegated authority, together with its authority under the Water Pollution Control Act, in issuing NPDES permits and State Waste Discharge Permits (SWDPs) (pursuant to WAC 273-226-030). DOE's water quality standards are used to establish effluent limits in NPDES permits and SWDPs.

DOE's water quality standards and SWDPs apply to both point source activities and nonpoint source activities. Point source activities are activities where a source of pollution can be readily distinguished, such as the industrial discharge of waste onto or into the ground. State law requires point sources to operate under permits that set conditions for discharges. These permits may be issued to a specific entity with conditions designed to protect water quality.

A "point source" is "any discernible, confined, and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture." (WAC 273-226-030 (21))

"Nonpoint sources" are more diffuse in nature. They often consist of many small pollutant sources that have a cumulative effect, like highway runoff, on-site septic systems in developed areas, and application of pesticides or nutrients in both agricultural and urban areas. Some nonpoint sources are managed through the development of siting and design standards.

Groundwater contamination may affect surface water quality. Under §303(d) of the Clean Water Act, states are required to develop lists of impaired waters. These are waters for which technology-based regulations and other required controls are not stringent enough to meet the water quality standards set by the state. The law requires that states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDL) for these waters. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards. A TMDL is generally administered by establishing limits on the discharge of pollutant materials otherwise permitted under the NPDES or state regulatory programs.

Washington's Water Pollution Control Act and Water Resources Act

Groundwater quality in Washington is regulated by the Groundwater Quality Standards (Chapter 173-200 WAC) which are authorized by the state Water Pollution Control Act (Chapter 90.48 RCW) and Water Resources Act (Chapter 90.54 RCW). Discharges to groundwater are regulated through a variety of permitting mechanisms which are authorized by the Water Pollution Control Act (Chapter 90.48. RCW). These permitting regulations include State Waste Discharge Permits, which may be issued as General Permits.

The Water Pollution Control Act, Chapter 90.48 RCW makes it "unlawful for any person to throw, drain, run, or otherwise discharge into any of the waters of this state, or to cause, permit or suffer to be thrown, run, drained, allowed to seep or otherwise discharged into such waters any organic or inorganic matter that shall cause or tend to cause pollution of such waters." (RCW 90.48.080)

The Department of Ecology is the primary agency in Washington State responsible for implementation of this mandate. DOE has adopted Chapter 173-200 WAC, Water Quality Standards for Groundwaters. The standards include "water quality criteria" (numerical limits for specific contaminants that apply to all groundwaters in the state). WAC 173-200-040 (2) (Table 1) establishes that Nitrate concentrations in groundwater may not exceed 10 mg/L.

The standards apply to all groundwaters of the state that occur in a saturated zone (generally at or below the water table) or stratum beneath the surface of land or below a surface water body. The groundwater standards do not apply in the root zone of saturated soils where agricultural pesticides and nutrients have been applied at agronomic rates for agricultural purposes, but only if those contaminants will not cause pollution of groundwaters below the root zone. (WAC 173-200-010(3)(a)) In other words (removing the double negative), the standards do apply in saturated root zones if pollution is caused in groundwaters below.

DOE's water quality standards incorporate an "antidegradation policy," an otherwise existing part of state water quality law (WAC 173-200-030). This policy precludes degradation which would harm existing or future beneficial uses of groundwater (drinking water, irrigation and support of wildlife habitat). DOE has antidegradation implementation procedures that explain what needs to be done for an antidegredation analysis. The standards provide numeric values which must not be exceeded to protect the beneficial use of drinking water.

"General permits" issued by the Department of Ecology (either as a "combined" NPDES and SWDP or as a "state-only" SWDP) may be issued to a group of entities with common discharge characteristics and conditions. (WAC 273-226-020) Permits issued under Chapter 273-226 WAC are designed to satisfy the requirements for discharge permits under Sections 307 and 402(b) of the federal Water Pollution Control Act (33 U.S.C. §1251) and the state law governing water pollution control (Ch.

90.48 RCW). (WAC 273-226-020). If eligible, a point source must obtain general permit coverage before discharging to surface or ground waters or the point source may be found to be in violation of state or federal law for discharging without a permit.

General permits establish standards for management. General permits are issued for fixed terms not exceeding five years from the effective date. Point source facility operators must apply to the DOE for coverage under a general permit. (WAC 227-226) All permittees covered under a general permit must submit a new application for coverage under a general permit or an application for an individual permit at least 90 days prior to the expiration date of the general permit under which the permittee is covered. When a permittee has made timely and sufficient application for the renewal of coverage under a general permit, an expiring general permit remains in effect and enforceable until the application has been denied, a replacement permit has been issued by the DOE, or the expired general permit has been terminated by the DOE. Coverage under an expired general permit for permittees who fail to submit a timely and sufficient application shall expire on the expiration date of the general permit. (WAC 173-226-200)

A general permit may be modified, revoked and reissued, or terminated, during its term if information is obtained by DOE which indicates that cumulative effects on the environment from dischargers covered under the general permit are unacceptable. (WAC 173-226-230 (1)(d)) DOE may require any discharger to apply for and obtain an individual permit, or to apply for and obtain coverage under another more specific general permit. Also, any interested person may petition the DOE to require a discharger authorized by a general permit to apply for and obtain an individual permit. (WAC 173-226-240 (2), (3))

DOE may revoke, or "terminate coverage under" a general permit where terms or conditions of the general permit are violated, conditions change such that either temporary or permanent reduction or elimination of permitted discharges is required, or DOE determines that the permitted activity endangers human health, safety, or the environment, or contributes to water or sediment quality standards violations. (WAC 173-226-240 (1) (a), (c), and (d))

Washington's Water Pollution Control Act authorizes DOE to "bring any appropriate action, in law or equity, including action for injunctive relief . . . as may be necessary to carry out the provisions" of that Act (RCW 90.48.037), including its prohibition of the discharge of organic or inorganic matter that may cause pollution of ground or surface water. (RCW 90.48.080).

Violations of maximum concentrations may be addressed by enforcement "through all legal, equitable, and other methods available to the department including, but not limited to: issuance of state waste discharge permits, other departmental permits, regulatory orders, court actions, review and approval of plans and specifications, evaluation of compliance with all known, available, and reasonable methods of prevention, control, and treatment of a waste prior to discharge, and pursuit of memoranda of understanding between the department and other regulatory agencies." WAC 173-200-100 (3).

If DOE determines that a potential to pollute the groundwater exists, it may request a permit holder or responsible person to prepare and submit a groundwater quality evaluation program for its approval. Each evaluation program must be based on soil and hydrogeologic characteristics and be capable of assessing impacts on groundwater at the "point of compliance." The evaluation program approved by DOE may include (a) groundwater monitoring for a specific activity; (b) groundwater monitoring at selected sites for a group of activities; (c) monitoring of the vadose zone; (d) evaluation and monitoring of effluent quality; (e) evaluation within a treatment process; or (f) evaluation of management practices. WAC 173-200-080 (2). The "point of compliance" is the location where the "enforcement limit," is "measured and shall not be exceeded." WAC 173-200- 060 (1). The "enforcement limit" is established in accordance with WAC 173-200-050.

The DOE may also designate a groundwater "special protection areas" if it determines that the groundwater in an area requires "special consideration or increased protection because of one or more unique characteristics." WAC 173-200-090 (1). These unique characteristics are then to be taken into consideration by DOE when regulating activities, developing regulations, guidelines and policies and when prioritizing department resources for groundwater quality protection programs. WAC 173-200-090 (2). Characteristics to guide designation of a special protection area are set forth in the rule. WAC 173-200-090 (2). Designation of special protection areas must be in the public interest. WAC 173-200-090 (5)(b).

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) (Pub. L. No. 94-590, 90 Stat 2795, 42 U.S.C. §§6901-6987, 9001-9010) contains both regulatory standards and remedial provisions to achieve goals of conservation, reducing waste disposal, and minimizing the present and future threat to human health and the environment. RCRA provides a comprehensive national regulatory structure for the management of nonhazardous solid wastes (subtitle D, 42 U.S.C. §§ 6941/y-6949a) and hazardous solid wastes (subtitle C, 42 U.S.C. §§ 6921/y-6939b). "Solid waste" is defined as "any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities . . . .” 42 U.S.C. §6903(27)

Materials are discarded if they are either abandoned or recycled or are inherently waste-like. 40 C.F.R. § 261.2. Materials are “disposed” if they are discharged, deposited, injected, dumped, spilled, leaked or otherwise placed into or on land or water such that it may enter into the environment or be emitted into the air or discharged into any waters, including groundwaters 42 U.S.C. §6903(3). Agricultural wastes, including manures, crop residues, or commercial chemical fertilizers applied to the soil in amounts greater than can be used as fertilizers or soil conditioners may be the disposal of solid waste.

Washington’s Right to Farm Law

Washington State’s right to farm law, RCW 7.48.300-320, was first enacted in 1979, with the purpose of protecting agricultural activities conducted on farm and forest lands from lawsuits sounding in nuisance. As a consequence, “agricultural activities conducted on farmland and forest practices, if consistent with good agricultural and forest practices and established prior to surrounding nonagricultural and nonforestry activities, are presumed to be reasonable and shall not be found to constitute a nuisance.” RCW 7.48.305 (1. The defense does not apply however if “the activity or practice has a substantial adverse effect on public health and safety.” “Agricultural activities and forest practices undertaken in conformity with all applicable laws and rules are presumed to be good agricultural and forest practices not adversely affecting the public health and safety.” RCW 7.48.305 (2). The Yakima County Code protects the right to farm in similar terms to the state statute. Ch. 6.22, YCC .

In 2005, Washington’s right to farm law was amended to provide for full recovery of costs of litigation in the defense of nuisance suits where the right to farm law was a successful defense. RCW 7.48.315.

Interagency Cooperation

DOE and WSDA signed a Memorandum of Understanding (MOU) in 2003 to guide coordination and cooperation between the two agencies for dairies, CAFOs and other animal feeding operations. A key element of the MOU is that WSDA inspectors must provide field inspections and technical assistance to DOE for CAFO and other AFO related water quality activities. The two agencies continue to coordinate on livestock and manure related complaints and in implementing the CAFO permit. An updated MOU was signed in 2011. The MOU can be found at http://agr.wa.gov/FP/Pubs/docs/MOUAgricultureEcology2011Final.pdf

Under the MOU, DOE is responsible to EPA for Clean Water Act compliance for AFOs and CAFOs. DOE maintains authority under Ch. 90.48 RCW to take compliance actions on any livestock operations where human health or environmental damage has or may occur due to potential or actual discharges, for pasture or rangeland based operations, for manure spreading operations when it is determined the manure was not applied by a dairy, for non-dairy AFOs, CAFOs and permitted CAFOs, and ultimately for permitted dairies. Where compliance actions are against non-permitted dairies, DOE recognizes WSDA as lead. Where DOE is involved in investigations and compliance actions against non-permitted dairies, DOE will discuss the compliance actions with WSDA to ensure that timely compliance actions are sufficient to protect human health and the environment. DOE is responsible for the approval of best management practices used to show compliance with water quality standards. DOE must provide available monitoring data and trend analysis for livestock related pollutants to WSDA upon request. DOE's TMDL process must involve WSDA as a stakeholder if livestock issues are anticipated.

The DOE/WSDA MOU requires that both agencies provide the other all livestock related records that either may possess as necessary to fulfill state and federal requirements for livestock under the Clean Water Act (MOU ¶ C.2), and that the two agencies will coordinate in response to public disclosure requests for AFOs, CAFOs and dairies. (MOU ¶ C.4)

WSDA is responsible for implementing Ch. 90.64 RCW and is required to follow Ch. 43.05 RCW. WSDA is responsible for inspections and may initiate compliance actions on permitted dairies, but must notify DOE if there is a discharge to waters of the state and provide a Recommendation for Enforcement. WSDA is responsible for inspections, complaint response and warning letters for all non-dairy permitted CAFOs. DOE is responsible for complaint response for non-dairy AFOs and CAFOs but WSDA may respond for initial complaint response if resources are available and may write warning letters. WSDA must coordinate, but seldom becomes involved with DOE when compliance actions beyond warning letters are necessary for non-dairy AFOs and CAFOs or permitted CAFOs. WSDA must enter complaint inspections and warning letters on non-permitted AFOs and CAFOs into DOE's PARIS database.

NRCS offers voluntary financial and technical assistance programs to eligible landowners and agricultural producers to help them manage natural resources in a sustainable manner. Those under contract with NRCS to participate in voluntary programs must adhere to relevant standards for funded projects. Current financial assistance programs in Washington State include:

- Agricultural Management Assistance (AMA): helps agricultural producers use conservation to manage risk and solve natural resource issues through natural resources conservation.

- Conservation Stewardship Program (CSP): helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns.

- Environmental Quality Incentives Program (EQIP): provides financial and technical assistance to agricultural producers in order to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, reduced soil erosion and sedimentation or improved or created wildlife habitat.

Regulations Pertaining to Particular Sources

Crops Supporting Livestock Operations

WSDA's regulations implementing the Dairy Nutrient Management Act, Ch. 16-611 WAC, require dairy producers to maintain records to demonstrate that applications of nutrients to crop land are within acceptable agronomic rates. Soil analysis should include annual postharvest soil nitrate nitrogen analysis; triennial soil analysis that includes organic matter; pH, ammonium nitrogen; phosphorus, potassium; and electrical conductivity. Nutrient analysis is required for all sources of organic and inorganic nutrients including, but not limited to, manure and commercial fertilizer supplied for crop uptake. Manure and other organic sources of nutrients must be analyzed annually for organic nitrogen, ammonia nitrogen, and phosphorus. WSDA conducts on-site inspections of dairies and reviews their records a minimum of every 18 months. Any significant operational change requires an updated dairy nutrient management plan. Dairies are subject to complaint inspections by WSDA, DOE and EPA at all times." There is no equivalent requirement for non-dairy agricultural producers.

Nutrient application records should include field identification and year of application, crop grown in each field where the application occurred, crop nutrient needs based on expected crop yield, nutrient sources available from residual soil nitrogen including contributions from soil organic matter, previous legume crop, and previous organic nutrients applied, date of applications, method of application, nutrient sources, nutrient analysis, amount of nitrogen and phosphorus applied and available for each source, total amount of nitrogen and phosphorus applied to each field each year; and the weather conditions twenty-four hours prior to and at time of application. (WAC 16-611-020 (2))

Tree Fruit and Vegetable Crops

There are no groundwater-specific regulations specifically addressing production of tree fruit and vegetable crops

Fertilizers

Bulk commercial fertilizer distributors are required by RCW 15.54.275 to be licensed. They are also required by RCW 15.54.362 to report the number of net tons of fertilizer distributed within the state during six-month periods (January to June, July to December) (annual report permitted if less than 100 tons). 220,909 tons (200,406,000 kg) of commercial fertilizer was purchased in Washington State in 2011. As the statute does not require that the report be subdivided by county, region or groundwater management area, there is no specific information with which to evaluate the amount of commercial fertilizer sold within the GWMA. "Bulk fertilizer" is commercial fertilizer distributed in a nonpackage form such as tote bags, tanks, trailers, spreader trucks, and railcars. Fertilizers are required to meet the nutrient value guaranteed by the fertilizer manufacturer. There is no requirement that agricultural producers be licensed to apply commercial or any other fertilizer. Unmanipulated animal and vegetable manures, organic waste-derived materials and biosolids are not commercial fertilizer. WAC 16-200-701.

Regulations pertaining to "chemigation" (Ch. 16-202 WAC) do not pertain to "fertigation," the application of chemical fertilizer through irrigation water delivery systems. "Chemigation" is the application of any substance a pesticide, plant or crop protectant, or system maintenance compound applied with irrigation water. WAC 16-202-1002 (17). All pesticide laws apply to chemigation. Pesticides cannot be applied with an open surface, gravity irrigation system unless allowed by the product label.

The Director of the Department of Agriculture may adopt regulations for the appropriate use and disposal of commercial fertilizers for the protection of groundwater. RCW 15.54.800. Although "deep percolation" ("the movement of water downward through the soil profile below a plant's effective rooting zone") is defined by WSDA regulations, WAC 16-202-1002 (23), the regulations do not specifically prohibit deep percolation.

There are no federal, state or local regulations specifically pertaining to the application of nitrogen-based fertilizer to agricultural crops, so long as they are applied at an agronomic rate so long as it does not pollute groundwaters below the root zone. WAC 173-200 100-(3) Manure applied as fertilizer is a "dairy nutrient" under Washington State's Dairy Nutrient Management Act. Ch. 90.64 RCW "'Dairy nutrient' means any organic waste produced by dairy cows or a dairy farm operation." RCW 90.64.010 (11). The 2017

CAFO general permit specifically requires that application of nitrogen-based fertilizers not pollute the groundwater.

Livestock Operations

Washington's Dairy Nutrient Management Act (DNMA) (Ch. 90.64 RCW) authorizes WSDA to "determine if a dairy-related water quality problem requires immediate corrective action under the Washington state water pollution control laws, chapter 90.48 RCW, or the Washington state water quality standards adopted under chapter 90.48 RCW." (RCW 90.64.050 (1)(d)). and to "help maintain a healthy agricultural business climate." Dairies that are licensed to sell Grade A milk and who generate large quantities of animal waste that can pollute surface water and ground water must have an "approved" Nutrient Management Plan (DNMP) on site within six months after licensing. DNMP's must be implemented within two years after licensing. (RCW 90.64.026 (7)) The purpose of such plan is to prevent the discharge of livestock nutrients to surface and ground waters of the state.

The DNMA authorizes local conservation districts to "provide technical assistance to dairy producers in developing and implementing a dairy nutrient management plan;" and to "review, approve, and certify dairy nutrient management plans that meet the minimum standards." (RCW 90.64.070 (1)(d),(e)) An employee of the South Yakima Conservation District often writes the DNMP. "Approved" means the local conservation district has determined that the facility's plan to manage nutrients meets all the elements identified on a checklist established by the Washington Conservation Commission. Certified means the local conservation district has determined all plan elements are in place and implemented as described in the plan. To be certified, both the dairy operator and an authorized representative of the local conservation district must sign the plan. Dairies whose NPDES permits require dairy nutrient management plans need not be otherwise "certified." "Farm Plans," developed and approved by local conservation districts for farmers, must include "livestock nutrient management measures." RCW 89.08.560. Local conservation districts also provide dairies with technical assistance and planning services with which to implement nutrient management plans.

Local Conservation Districts are authorized to provide dairies and other farms with technical assistance and planning services (RCW 89.08.560) and are required to approve and certify all NMPs. "Farm Plans" developed by conservation districts for farmers must include "livestock nutrient management measures." RCW 89.08.560 The South Yakima Conservation District (SYCD) often writes the NMPs for dairy farms and later certifies them.

The primary goal of an NMP is to protect water quality from dairy nutrient discharges. The required elements of an NMP specified by the State Conservation Commission include the collection, storage, transfer and application of manure, waste feed and litter, and any potentially contaminated runoff at the site. Plans should focus on management of nitrogen, and phosphorus as well as preventing bacteria and other pollutants, such as sediment, from reaching surface or ground water. Excess nutrients must be exported off site.

The elements of a dairy nutrient management plan may include methods and technologies of the nature prescribed by the Natural Resources Conservation Service, a department of the U.S. Department of Agriculture RCW 90.64.026(3).

Nutrient management plans are required to be maintained on the farm for review by WSDA inspectors. The DNMA requires that all dairies be inspected for implementation of their nutrient management plans and to ensure protection of waters of the state. Most dairies keep their NMP and associated sampling data on location.

WSDA's regulations implementing the DNMA are published at chapter 16-611 WAC. WAC 16-611-010 defines "agronomic rate" as "the application of nutrients to supply crop or plant nutrient needs to achieve realistic yields and minimize the movements of nutrients to surface and ground waters." The same section defines "Nutrient" as "any product or combination of products used to supply crops with plant nutrients including, but not limited to, manure or commercial fertilizer." The phrase "transfer of manure" is defined as "the transfer of manure, litter or process waste water to other persons when the receiving facility is in direct control of application acreage, rate or time, and transfer rate and time.

Dairy producers must maintain records to demonstrate that applications of nutrients to crop land are within acceptable agronomic rates. Those records should demonstrate that applications of nutrients to the land were within acceptable agronomic rates. Soil analysis should include annual postharvest soil nitrate nitrogen analysis; triennial soil analysis that includes organic matter; pH, ammonium nitrogen; phosphorus, potassium; and electrical conductivity. Nutrient analysis is required for all sources of organic and inorganic nutrients including, but not limited to, manure and commercial fertilizer supplied for crop uptake. Manure and other organic sources of nutrients must be analyzed annually for organic nitrogen, ammonia nitrogen, and phosphorus.

The Dairy Nutrient Management Act requires that manure application and transfer records, including imports or exports, be maintained by dairies that transfer ownership of manure to others. Nutrient application records should include field identification and year of application, crop grown in each field where the application occurred, crop nutrient needs based on expected crop yield, nutrient sources available from residual soil nitrogen including contributions from soil organic matter, previous legume crop, and previous organic nutrients applied, date of applications, method of application, nutrient sources, nutrient analysis, amount of nitrogen and phosphorus applied and available for each source, total amount of nitrogen and phosphorus applied to each field each year; and the weather conditions twenty-four hours prior to and at time of application. Manure transfer records, including imports or exports should include date of manure transfer, amount of nutrients transferred, the name of the person supplying and receiving the nutrients, and a nutrient analysis of manure transferred. Irrigation water management records should include field identification and the total amount of irrigation water applied to each field each year.

The elements of a NMP must include methods and technologies of the nature prescribed by the Natural Resources Conservation Service (NRCS), a department of the U.S. Department of Agriculture. RCW 90.64.026(3). NRCS provides technical assistance to farmers and other private landowners and managers. NRCS has six mission goals: high quality, productive soils, clean and abundant water, healthy plant and animal communities, clean air, an adequate energy supply, and working farms and ranchlands.

NRCS helps landowners develop conservation plans and provides advice on the design, layout, construction, management, operation, maintenance, and evaluation of recommended, voluntary conservation practices. NRCS activities include farmland protection, upstream flood prevention, emergency watershed protection, urban conservation, and local community projects designed to improve social, economic, and environmental conditions. NRCS conducts soil surveys, conservation needs assessments, and the National Resources Inventory to provide a basis for resource conservation planning activities.

NRCS conservation practice standards contain information on why and where the practice is applied, and sets forth the minimum quality criteria that must be met during the use of that practice. State conservation practice standards are available through the Field Office Technical Guide (FOTG). NRCS believes that nutrient management for the protection of groundwater, although different on each farm, is best accomplished through best management practices beginning with those stated in Standards 590, 449 and 313.

Ch. 90.64 RCW does not require that the best management practices recommended by the NRCS be followed, but allows the use of "alternative methods and standards and specifications" of the NRCS. RCW 90.64.016 (3). Nutrient Management Plans are required to be maintained on the farm for review by inspectors. The DNMA requires that all dairies be inspected for implementation of their Nutrient

Management Plans and to ensure protection of waters of the state. Most dairies keep their NMP and associated sampling data on location.

The DNMA does not authorize the WSDA to compel nutrient management consistent with NMPs. Representatives of the WSDA state that most "enforcement" is accomplished through the "soft enforcement" effo4ts that the Department accomplishes through its administrative activities (visitation and advice) under its Dairy Nutrient Management Program. (Prest)

Although "farm plans" are not subject to disclosure under Washington's public records law, (RCW 42.56.270 (17)), plans, records, and reports obtained by state and local agencies from dairies, animal feeding operations, and concentrated animal feeding operations not required to apply for a NPDES permit are disclosable under Washington's public records law (Ch. 42.56 RCW), but only in ranges that provide meaningful information to the public while ensuring confidentiality of business information regarding: (1) number of animals; (2) volume of livestock nutrients generated; (3) number of acres covered by the plan or used for land application of livestock nutrients; (4) livestock nutrients transferred to other persons; and (5) crop yields. The ranges of the information required to be disclosed by the public disclosure law (Ch. 42.56 RCW) are set forth in the WSDA's rules implementing that law and Ch. 90.64 RCW, WAC 16-06-210 (29).

The WSDA's mission under the DNMA is to "protect water quality from livestock nutrient discharges" and to "help maintain a healthy agricultural business climate." The WSDA encourages compliance by providing technical assistance as a first step as required by RCW 43.05, but when that is not successful the WSDA has authority under both RCW 90.64 and RCW 90.48 and has informal (warning letters and notices of correction) and formal (civil penalties and orders) enforcement tools available.

In 2013-2014, WSDA issued 17 notices of correction, one order, and 11 notices of penalty for discharges of pollutants to surface waters, statewide, as well as 122 warning letters and 27 notices of correction for potential to pollute (including failures in record-keeping). WSDA usually begins with informal enforcement, using warning letters and notices of correction, then proceeding to formal enforcement through civil penalty or administrative order. Most penalties include a settlement process including reduction in penalty, requirements to adopt specific management practices, to abstain from discharge and collection of entire penalty in the event of non-performance.

Concentrated Animal Feeding Operations

The Clean Water Act's regulations (40 CFR, Part 122) define dairies with 700 or more animals and feedlots with 1,000 or more animals as Large Concentrated Animal Feeding Operations (CAFO). Large CAFOs are defined as point sources of water pollution if they can or do discharge to surface waters, becoming subject to the National Pollutant Discharge Elimination System (NPDES) requirement for permit. However, unlike other point sources that have continuous or regular discharges to surface waters, CAFOs are not considered to automatically have a surface water discharge. Consequently, they may be required to obtain an NPDES CAFO permit only if they have a discharge or potential to discharge. The DOE administers the CAFO permit, decides when a facility is required to apply for a permit and is responsible for enforcing the permit.

The Washington Department of Ecology issued two CAFO permits under its general permitting authority (Chapter 173-226 WAC) in January 2017 (effective March 3 2017). (Ecology 2017). (A National Pollutant Discharge Elimination System and State Waste Discharge General Permit for Concentrated Animal Feeding Operations (combined permit) and a State Waste Discharge General Permit (state only). The state and combined permits regulate the discharge of pollutants such as manure, litter, or process wastewater from CAFOs into waters of the state.

The permits conditionally authorizes the permittees to discharge, but only in a manner that does not o cause or contribute to a violation of water quality standards. The permittees are prohibited from discharging manure, litter, feed, process wastewater, other organic by-products, or water that has come into contact with manure, litter, feed process wastewater, or other organic by-products, to surface waters of the state from the production area with a few exceptions.

The permittees must implement measures to address the pollution prevention performance objectives listed in special conditions of the permit. Livestock may not be allowed to come into contact with surface waters or conduits to surface waters. Each calendar year, the permittees must develop a field-specific nutrient budget for each land application field they will control at to which they plan to apply manure, litter, process wastewater, or other organic by-products. (Ecology 2017)

The permittees must have all sources of manure, litter, process wastewater, and other organic by-products sampled and analyzed prior to land application and at least twice more, spaced evenly throughout the land application season, to account for seasonal variation in nutrient concentration (e.g. dilution due to rainfall or concentration from evaporation). (Ecology 2017)

The permittees must land-apply manure, litter, process wastewater, or other organic byproducts in accordance with their yearly field nutrient budgets and at the appropriate rates and times to comply with permit conditions. If the permittees generate more manure, litter, process wastewater, or other organic by-products than the land application fields available to the permittees can appropriately utilize according to their yearly field nutrient budgets, the permittees must find other avenues of appropriately utilizing the excess manure, litter, process wastewater, or other organic by-products (e.g. export, composting). (Ecology 2017)

Lands to which manure, litter, process wastewater, and other organic byproducts have been applied must be sampled in spring and fall. The permittees must manage the application irrigation water so that the amount of water applied from precipitation and irrigation does not exceed the water holding capacity in the top two feet of soil, thereby preventing the downward movement of nitrate.

The permittees must use field discharge management practices on their land-application fields to limit discharge of manure, litter, process wastewater, and other organic by-products to down-gradient surface waters or to conduits to surface or ground water.

The permittees are permitted to "export" manure, i.e., to relinquish control of how the manure is used. When exporting manure, the permittees must provide the most recent manure, litter, process wastewater, or other organic by-product nutrient analysis to the recipient as part of export. The permittees must keep records of its manure exports.

Waste Storage Facilities (Lagoons)

Under the 2017 CAFO permit, the permittee must have adequate storage space for the manure, litter, process wastewater, feed, and any other sources of pollutants on-site during the storage period for the area where the CAFO is located. Lagoons and other liquid storage structures built, expanded, or having major refurbishment e.g., complete emptying and re-compaction to restore the earthen liner done after the issuance of this permit must achieve a permeability of $1x10^{-6}$ cm/s without consideration for manure sealing and there must be a minimum of two feet of vertical separation between the bottom of the lagoon (measured from the outside of the earthen liner) and the water table, including seasonal high water table. Lagoons must be inspected, maintained as to structure and volume, and permanently decommissioned when closed. Existing lagoons are required to be assessed.

Pens and Composting Areas

Management practices are advisable on the site of dairy CAFO pens, such as maintaining an intact layer between the cattle and the underlying ground to inhibit leaching through the surface of the pen, changes in precipitation and evapotranspiration from season to season, and animal density rates. Particulate matter practices require that the pens maintain a certain percentage of moisture to reduce dust emissions."

Water Applications

There are no federal, state or local regulations specifically pertaining to the application of irrigation water to agricultural crops. State water law generally precludes wasting water. RCW 90.03.005. Water may only be used for "beneficial use," the opposite of which is "waste."

Residential Onsite Sewage Systems (ROSS)

"Septage" is "the mixture of solid wastes, scum, sludge and liquids pumped from within septic tanks, pump chambers, holding tanks and other OSS components." WAC 246-271A-0010 The total nitrogen content of septage generated in the GWMA varies under individual circumstances. An area-wide average is not available.

WAC 246-272A-0270 provides that the owner of an OSS is responsible for its operation, monitoring, maintaining, repairing, altering or expanding an OSS. The owner must also assure that an evaluation of a simple gravity septic system's components happens at least once every three years and that an evaluation of all other systems occurs every year. The solids and scum must be pumped from the septic system by an approved pumper generally every three to five years or whenever necessary (EPA 2002) The septic system must not be covered by structures or impervious material. Surface drainage must be trained away from the septic system. The soil above the drain field should not be compacted by vehicles or livestock. It is advisable to inform prospective buyers about the septic system. Most septic systems are now pumped prior to transfer of title to the property.

The location, design, installation, operation, maintenance, and monitoring of OSS is regulated by Chapter 246-272A WAC. The chapter is intended to coordinate with other statutes and rules for the design of OSS under Chapter 18.210 RCW and Chapter 196-33 WAC.

A local board of health must apply to the state DOH to approve local regulations. They must be at least as stringent as the regulations of the state department WAC 246-272A-0015 (9), (10). Yakima County does not have additional regulations.

Permitting for septic systems is done by the Yakima Health District. That agency is also authorized by WAC 246-272A-0015 (5) to "develop a written plan that will provide guidance to the local jurisdiction regarding development and management activities for all OSS within the jurisdiction." The elements of the plan are listed in the WAC.

The amount of land necessary for the installation of an onsite sewage (septic) tank varies depending upon soil type. Table X in WAC 246-272A-0320 establishes the minimums. Table V in WAC 246- 272A-0220 describes the soil types. A site is required to meet certain ground absorption parameters, pass a percolation test, in order to qualify for a permit to install a septic system. If the ground does not have a certain absorption rate, it does not qualify for a septic system.

TABLE 10 - (WAC 246-272A-0320)
MINIMUM LAND AREA REQUIREMENT
SINGLE FAMILY RESIDENCE OR UNIT VOLUME OF SEWAGE

Type of Water Supply	**Soil Type (defined by WAC 246-272A-0220)**					
	1	**2**	**3**	**4**	**5**	**6**
Public	0.5 2.5	12,500 sq. ft.	15,000 sq. ft.	18,000 sq. ft.	20,000 sq. ft.	22,000 sq. ft.
Individual, on each lot	1.0 2.5	1 acre	1 acre	1 acre	2 acres	2 acres

TABLE 11 -(WAC 246-272A-220)

Soil Type	Soil Textural Classifications
1	Gravelly and very gravelly coarse sands, all extremely gravelly soils excluding soil types 5 and 6, all soil types with greater than or equal to 90 percent rock fragments.
2	Coarse sands.
3	Medium sands, loamy coarse sands, loamy medium sands.
4	Fine sands, loamy fine sands, sandy loams, loams.
5	Very fine sands, loamy very fine sands; or silt loams, sandy clay loams, clay loams and silty clay loams with a moderate or strong structure (excluding platy structure).
6	Other silt loams, sandy clay loams, clay loams, silty clay loams.
7 **Unsuitable for treatment or dispersal**	Sandy clay, clay, silty clay, strongly cemented or firm soils, soil with a moderate or strong platy structure, any soil with a massive structure, any soil with appreciable amounts of expanding clays.

The minimum liquid volume for a septic tank serving a single-family residence containing three or fewer bedrooms is 900 gallons. A septic tank serving a single-family residence containing four bedrooms may be 1,000 gallons. Each bedroom after that requires an additional 250 gallons of septic capacity. The actual size of each ROSS within the GWMA is unknown.

The local health officer may require the owner of a failing OSS located within 200 feet of a public sewer service to hook up to that system WAC 246-272A-0025. Design specifications for OSS tanks are located at WAC 246-272C.

Large Onsite Sewer Systems (LOSS)

Regulations for large on-site sewage (septic) systems (LOSS) are found at WAC 264-272B. LOSS are inventoried with the Department of Ecology as UIC wells (WAC 173-218-040) under a memorandum agreement between DOE and DOH.

Biosolids

The DOE's biosolid program is administered independently of other agencies, but coordinated with health districts. Land application of biosolids requires pre-approval of application rates that are based upon agronomic crop requirements. Permittees receive coverage under a statewide general permit. Permit coverage is mandated for those who produce and/or land apply biosolids. The DOE's regulatory program incorporates site specific approvals with specific testing and analysis procedures, development of land application plans that prescribe specific practices and prohibitions, and a review and approval process for land application of the wastewater solids. Land application may only occur on permitted sites with pre-established buffers and setbacks.

"Regarding the statistics, the fields in the GWMA are almost all irrigated, high value crops: corn, hops, & alfalfa. As an example, the appropriate yield table for silage corn (attached) shows a requirement of 270 lbs/acre for a 30 ton yield—the median yield value. I make the pre-plant calculation so you look on the top line and ignore the soil-test-value column. So my average approval rate of 248 lbs/acre of plant available N (pre-plant soil N + biosolids N) is a very defensible value." (Sievertson).

Residential Lawn Fertilizers

There are no known laws or regulations regarding homeowner maintenance of residential lawns. There are also no known laws or regulations regarding municipal maintenance of parks or grounds

"Hobby Farms"

There are no known laws or regulations regarding maintenance of animals or herbaceous material on "hobby farms."

Underground Injection Wells

Part C of the Federal Safe Drinking Water Act (SDWA), 42 U.S.C. §300h-3, regulates underground injection wells (UIC). Washington's UIC program is administered by the Department of Ecology. Its UIC regulations are found at WAC 173-218. The program is approved by the EPA pursuant to SDWA §1422, 40 CFR 147.2400. The program regulates the injection of fluids underground for storage, enhanced recovery, in the context of Class II, and disposal to prevent the contamination of underground sources of drinking water. Injection activities may be authorized by rule or permit. The regulations establish a non-endangerment standard designed to ensure that injected fluids do not cause or contribute to the movement of a contaminant into an underground source of drinking water if the presence of that contaminant may cause or contribute to the exceedance of a drinking water standard ("MCL") or otherwise adversely affect the health of persons. (40 CFR 144.12, WAC 173-18-080).

Abandoned Wells

Wells no longer in use are required by law to be "decommissioned." RCW 18.104.020 (3). WAC 173-160-381 describes the processes that must be used to decommission wells. A permit must be obtained before decommissioning may occur. RCW 18.104.030.

An "abandoned well" is one "that is unmaintained or is in such disrepair that it is unusable or is a risk to public health and welfare." RCW 18.104.020 (1).

Environmental Effects

Nitrate

Nitrate is an acute contaminant. It is colorless and odorless. It is found in many fertilizers, manure, liquid waste from septic tanks, and food processing waste. Prexcipitation or irrigation water can carry nitrate down through the soil into groundwater. Drinking water wells may contain nitrate if they draw from this groundwater (Ecology 2010).

The Nitrogen Cycle

The Nitrogen Cycle was adequately described in the EPA's 2012 Report, "Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley":

Nitrogen is present in many chemical forms in the environment. Nitrogen gas (N2) composes about 78 percent of the atmosphere. Nitrite (NO2-), nitrate (NO3-) and organic nitrogen, ammonium (NH4) are also present.

Nitrogen is critical to plant growth. It aids in the formation and function of cellular tissue, proteins, and reproductive structures. Nitrogen can be supplied to plants through the application of synthetic fertilizers or animal waste products or by the organic decomposition of other plants. Atmospheric nitrogen must be processed, or fixed, to be used by plants. The majority of fixation occurs by bacteria. Small quantities of nitrate may wash out of the atmosphere from aerosol salt particles from the ocean or dusts from arid regions, or from fossil fuel combustion. (EPA 2012)

Important processes in the nitrogen cycle include nitrogen fixation, mineralization, nitrification, and denitrification. The mobility of nitrogen is highly dependent on its form and the matrix through which it moves. Organic nitrogen is nearly immobile. Mineralization occurs when organic nitrogen in the soil is converted by bacteria into ammonium (NH4). Nitrification occurs as ammonium is biologically oxidized to become nitrite. Nitrite is then biologically oxidized to become nitrate as it moves through the vadose zone.

Nitrate is the most mobile form of nitrogen in both the vadose and saturated zones. Nitrate moves quickly in the saturated zone, together with migrating groundwater. Its mobility is enhanced by the action of negatively charged soil particles, which repel the negatively charged nitrate ion. (USGS 2000b). In the absence of denitrification, nitrate moves with the groundwater until the groundwater is discharged to surface water, or extracted from a well. Denitrification is the conversion of nitrate back into nitrogen gas (N2) by bacteria. It can occur in anoxic conditions (where oxygen is depleted in the root zone). (EPA 2012).

Nitrate Leaching

"Leaching" is the process of the removal of soluble material from a substance through the percolation of water. Nitrate can "leach" from the agricultural soils to the elevation of the groundwater aquifer. "The increase in groundwater nitrate concentration measured in domestic wells, irrigation wells, and public supply wells lags significantly behind the actual time of nitrate discharge from the land surface. The lag is due, first, to travel time between the land surface, which ranges from less than one year in areas with shallow water table to several years or even decades where the water table is deep. High water recharge rates shorten travel time to a deep water table, but in irrigated areas with high irrigation efficiency and low recharge rates, the transfer to a deep water table may take many decades." (Harter 2012)

Health Effects to People

Exposure to excessive nitrate concentrations can reduce the ability of red blood cells to carry oxygen. (WDOH 2007c, WDOH 2016, Harter 2012, Appendix J) In most adults and children these red blood cells rapidly return to normal. However, in infants it can take much longer. Infants who drink water with high levels of nitrate (or eat foods made with nitrate contaminated water) may develop a serious health condition due to the lack of oxygen. This condition is called methemoglobinemia or "blue baby syndrome."

> "Infants younger than 6 months may develop acquired methemoglobinemia from contaminated well water that has excess nitrates. Bacteria in a baby's digestive system mixes with the nitrates and leads to methemoglobinemia. Fully developed digestive systems keep children older than 6 months and adults from developing this nitrate poisoning." (McDowell/Biggers 2017)

While the problem is relatively well understood, there are no accurate statistics on the causal relationship between high nitrate concentrations in drinking water and the occurrence of methemoglobinemia. Acute cases do occur. There have been no deaths reported by medical professionals within the GWMA.

Bottled water is recommended for use in babies' foods and drinks. Although boiling water kills bacteria, it will not remove chemicals such as nitrate. In fact, boiling may actually increase the nitrate level. "Some studies have shown a positive association between long term exposure to nitrate in drinking water and risk of cancer and certain reproductive outcomes." (EPA 2012, Ward 2005) Other studies have shown no association. (Ward 2005, Avery 1999). As nitrates rise in water supplies, the potential for increasing the health risk rises.

An infant with moderate to serious "blue baby syndrome" may have a brownish-blue skin tone due to lack of oxygen. This condition may be hard to detect in infants with dark skin. Infant decolorization is not required to be reported by physicians as health effects data. An infant with mild to moderate "blue baby syndrome" may have symptoms similar to a cold or other infection (fussy, tired, diarrhea or vomiting). While there is a simple blood test to see if an infant has "blue baby syndrome," doctors may not think to do this test for babies with mild to moderate symptoms.

The best way to prevent "blue baby syndrome," is to avoid giving babies water that may be contaminated with nitrate or foods that are high in nitrate. Infants less than one-year-old should not be given drinking water with nitrate levels more than 10 ppm. High-nitrate vegetables such as beets, broccoli, carrots, cauliflower, green beans, spinach, and turnips should not be offered until after six months of age. If a baby has a brownish-blue skin tone, he or she should be taken to a hospital immediately. A medication called "methylene blue" will quickly return the baby's blood to normal.

Red blood cells in older children and adults quickly return to normal. However, some health conditions make people susceptible to health problems from nitrate. They include individuals who don't have enough stomach acids and individuals with an inherited lack of the enzyme that converts affected red blood cells back to normal (methemoglobin reductase).

The *Preliminary Assessment* concluded that over 2,000 people in the area are exposed to nitrate over the maximum contaminant level (MCL) through their drinking water. (EPA 2010) But it also found that not all water supplies in the area have been affected, particularly including public water system supply. Public water systems are regularly monitored for suspected contaminants. They must meet national and state drinking water standards, and public systems that use contaminated water are required by law to treat the water, thus maintaining a safe supply of drinking water to their customers. Until treatment has been installed, or if the treatment isn't working, public water systems must notify their users if nitrate levels exceed the standard.

The *Preliminary Assessment* found that many families of the Lower Yakima Valley are served by private wells and do not have access to public water systems. Regular testing of drinking water is not required for private water wells. The *Preliminary Assessment* concluded that "There is sufficient data to suggest that many of these well water supplies are at risk, even if they do not currently exceed a drinking water standard." (EPA 2012). The Valley Institute for Research and Education collected data from the wells of low income households in 2001 and 2002. In some areas, up to 40 percent of the wells sampled were above 5 mg/L nitrate, a level below the 10 mg/L Drinking Water Standard., but nevertheless recognized in the *Preliminary Assessment* as a concern. The LYVGWMA has caused testing of private groundwater wells to occur since it was organized. The data collected from that testing is set forth below under the section entitled "Initiatives Completed by the GWAC."

Owners of private wells who are unsure about their water quality may have their water tested for coliform bacteria and nitrate. The Yakima Health District (YHD) can advise where to get water tested and has specific recommendations for testing. Many certified labs in Washington charge $20 to $40 per test. If nitrate test results are over 8 mg/L, annual testing is recommended. If results are less than 8 mg/L, testing every three years is recommended.

The *Preliminary Assessment* expressed the concern that those who rely on private well water may not know the quality of the drinking water within their homes. They may not use tested wells, and if so, they may not know how to interpret the test results. Many residents are renters and are not the property or well owners. The well owner of record may not be the current property owner. Current property owners may not live on the property. Property owners may fear or question the implications of owning a contaminated well (in terms of liability, responsibility, property values, and access to safe and affordable housing) (EPA 2012).

Nitrates in groundwater may impact both domestic animals and wildlife. This can be either directly by ingestion, or indirectly through impacts to habitats, where groundwater discharging to surface water contributes to nutrient loading of streams, lakes, and wetlands.

The *Preliminary Assessment* found that nitrate-nitrogen concentrations are greatest in shallow groundwater. Shallow wells, poorly sealed or constructed wells, and wells that draw from shallow aquifers are at greatest risk of nitrate contamination. Manure and septic-tank waste may also contain disease-causing bacteria and viruses. Nitrate levels in well water can vary throughout the year. A significant decrease in nitrate-nitrogen concentrations was found in groundwater samples collected from depths below 300 feet. The highest percentage of samples exceeding State Drinking Water Standards (l0 mg/l nitrate-nitrogen) was obtained from shallow wells (less than 300 feet deep), a well depth typical of most private domestic drinking water wells. (EPA 2012)

Yakima River Surface Water Quality

The USGS' Hydrogeologic Framework the Yakima River Basin Aquifer System (USGS 2009a) posited a hydrologic connection between the surface water within the Yakima River and the groundwater beneath lands adjacent to the river. The USGS report did not establish any direct correlation between nitrogen in groundwater and nitrogen in the Yakima River. Water quality testing of agricultural surface-drains (which deliver water directly to the River) in 2017 found that 12.8 percent of drain samples had nitrate concentrations that exceeded the maximum contaminant level (MCL) of 10 milligrams per liter.

Section 303(d) of the CWA, 33 U.S.C., § 1313(d), requires states to identify waters where current pollution control technologies alone cannot meet the water quality standards set for that waterbody. Every two years, states are required to submit a list of impaired waters plus any that may soon become impaired to EPA for approval. The impaired waters are prioritized based on the severity of the pollution and the designated use of the waterbody (e.g., fish propagation or human recreation). States must establish the "total maximum daily load(s)" of the pollutant(s) in the waterbody for impaired waters on their list.

A "total maximum daily load" or "TMDL" is the amount of a specific pollutant that a waterbody can receive and still meet water quality standards. A TMDL is made up of the sum of all the point source loads ("wasteload allocation") and load associated with nonpoint sources and background sources ("load allocation"). TMDLs must include a margin of safety (explicit or implicit) and consider seasonal variations. Potential wasteload allocations include background, groundwater inflow, diffuse runoff, irrigated agriculture return flow, agricultural stormwater, atmospheric deposition, nonpoint sources, stormwater point sources, and non-stormwater point sources.

Numerous water quality assessments of the Yakima River are contained within Washington State's 303(d) list. Primary Yakima River surface water quality problems of concern are temperature, dissolved oxygen (DO) and acidity (pH). Nitrogen is an aquatic nutrient in surface water, which contributes to algae growth, but not included in the Yakima River's surface water quality problems.

EPA has approved two Ecology-proposed TMDL projects within the Lower Yakima River area. They are: Lower Yakima River Suspended Sediment and DDT TMDL—project approved for DDT and TSS parameters. See: http://www.ecy.wa.gov/programs/wq/tmdl/yakima_wq/LowerYakTMDL.html; https://fortress.wa.gov/ecy/publications/documents/97321.pdf; Granger Drain Bacteria TMDL—project approved for fecal coliform bacteria parameter. See: http://www.ecy.wa.gov/programs/wq/tmdl/GrangerTMDL.html.

Water Quantity and Quality Goals and Objectives

The LYVGMA goals and objectives for water quantity are set forth in the Yakima River Basin Integrated Water Management Plan (WBIWRP 2012).

The LYVGWMA goals for water quality published in the LYVGWAC Work Plan (9/30/2013) were as follows. Some, but not all, of the Goals and Objectives have been realized.

LOWER YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA

GOALS AND OBJECTIVES

The GWMA will be a multi-agency, citizen-based, coordinated effort to reduce groundwater nitrate contamination in the lower Yakima Valley. It will receive input from people affected or interested in the problems and solutions and will coordinate their energies toward action. It will work to achieve credibility with the general public and the farming community.

GWMA GOAL

The primary long-term goal of the GWMA is to reduce concentrations of nitrate in groundwater to below Washington State drinking water standards.

PROPOSED OBJECTIVES

Objectives have been divided into six categories: Data and Monitoring. Problem Identification, Measures to Reduce Groundwater Contamination, Education, Drinking Water Systems, and General objectives.

Input from the GWAC and citizen input will be used to refine and prioritize objectives. In general, refinement of objectives in each category will begin with an updated assessment of the current status of work.

DATA AND MONITORING

- Collect and incorporate existing nitrate and nitrogen data into a shared data management system or data sharing site to improve understanding of the sources and extent of contamination.
- Establish a monitoring program to identify sources of nitrate contamination and their relative importance.

- Establish and conduct long-term groundwater quality monitoring program and evaluate progress.

PROBLEM IDENTIFICATION

- Characterize the nature and extent of nitrate concentrations in Lower Yakima Valley groundwater.
- Identify and rank the sources of elevated nitrate in groundwater, with site-specific characteristics developed for 'hot spots" as appropriate.
- Identify and describe activities contributing to groundwater contamination based on scientific data and evaluation. Scientific and other data will be shared among the partners to facilitate development of effective programs and strategies.

MEASURES TO REDUCE GROUNDWATER CONTAMINATION

- Develop effective and coordinated best management practices (BMP5) to address specific nitrate sources.
- Develop strategies for implementing best management practices such as technical assistance, education, ordinances and coordination with other regulatory and nonregulatory programs.
- Support enforcement of new and existing laws and ordinances.

EDUCATION

- Establish educational programs to promote the protection of groundwater quality and provide a forum for stakeholders to discuss nitrate reduction methods and improvement of groundwater quality. This will include culturally-appropriate education and outreach.
- Establish a clearinghouse for pertinent public health, environmental, and business information.
- Educate private well owners on water quality testing methods, frequencies, interpretation of results, and funding sources.

DRINKING WATER SYSTEMS

- Provide water quality and hydrogeologic data to assess needs and methods of expanding public water supplies, and provide a forum for initiation of these plans.
- Consider options to encourage appropriate expansion of public water supplies to areas that are currently dealing with contaminated private supplies.

- Assist residents whose supplies have been contaminated to access safe and reliable water supplies, using culturally-appropriate communications.

GENERAL

- Pollution prevention will be a guiding principle for all work done by the GWMA.
- Participation by the Yakama Nation will be requested and encouraged in a way that is consistent with their sovereignty.
- Participating agencies will maintain their regulatory authority using their own discretion as appropriate. They will also seek opportunities to coordinate actions and address regulatory gaps.
- The GWMA will seek sustainable funding sources to carry out its mission.

GWAC Initiatives

Interim Education and Outreach

The education and public outreach (EPO) objectives identified in the GWMA Work Plan recognized the role that public health, time, evolving investigations, and the final GWMA Program would play in an outreach strategy. Accordingly, multiple objectives were identified for the Education Program component, from early Program development, to post-GWMA Program implementation and future Program reviews.

The first objective: to develop a strategy to guide the GWAC's education and public outreach during Program development. The plan identified four central components for the GWAC to follow. The first three were:

> *"… establish educational programs to promote the protection of groundwater quality and provide a forum for stakeholders to discuss nitrate reduction methods and improvement of groundwater quality. This will include culturally-appropriate education and outreach. Establish a clearinghouse for pertinent public health, environmental, and business information." (GWAC Work Plan, Adopted February 6, 2013)*

A fourth component—to educate private well owners on water quality testing methods, frequencies, interpretation of results, and funding sources—completed the educational expectations set forth in the GWAC Work Plan.

The role of education, however, did not stop at the GWMA Program adoption. The work plan suggested that the outreach conducted during Program development would inform—and be an integral part of—the final GWMA Program's sections on water quality goals and objectives, the regulatory environment, and investigation and analysis of Program alternatives.

A successful GWMA Program would require an informed and field-tested educational strategy, which could not be defined without the groundwork laid during Program development. Success of educational efforts made during Program development was would define how to better to engage the public in the GWMA Program, to implement proposed educational alternatives, and to measure the success of multiple milestones over time within the GWMA Program.

2011 Nitrate Treatment Pilot Program

In 2010-11, Yakima County partnered with the Departments of Health, Ecology, EPA, the Yakima Health District, the Yakama Nation and others to provide free water treatment systems, public education, and technical assistance to households with individuals at high public health risk from nitrate contaminated wells in the lower Yakima basin. (Lower Yakima Basin Nitrate Treatment Pilot Program Final Report June 2011). The Program boundaries followed what would become the LYVGWMA as well as encompassing the Yakama Nation.

An intensive bilingual outreach effort was implemented (7641 English/Spanish packets either mailed or hand-delivered to every household on a private well in the target area; bilingual public meetings were held; bilingual radio and TV spots aired; door-to-door intensive Spanish-language outreach conducted, a toll-free bilingual hot line established) to provide education, technical assistance and free water treatment systems to households that exceeded the 10 mg/L standard.

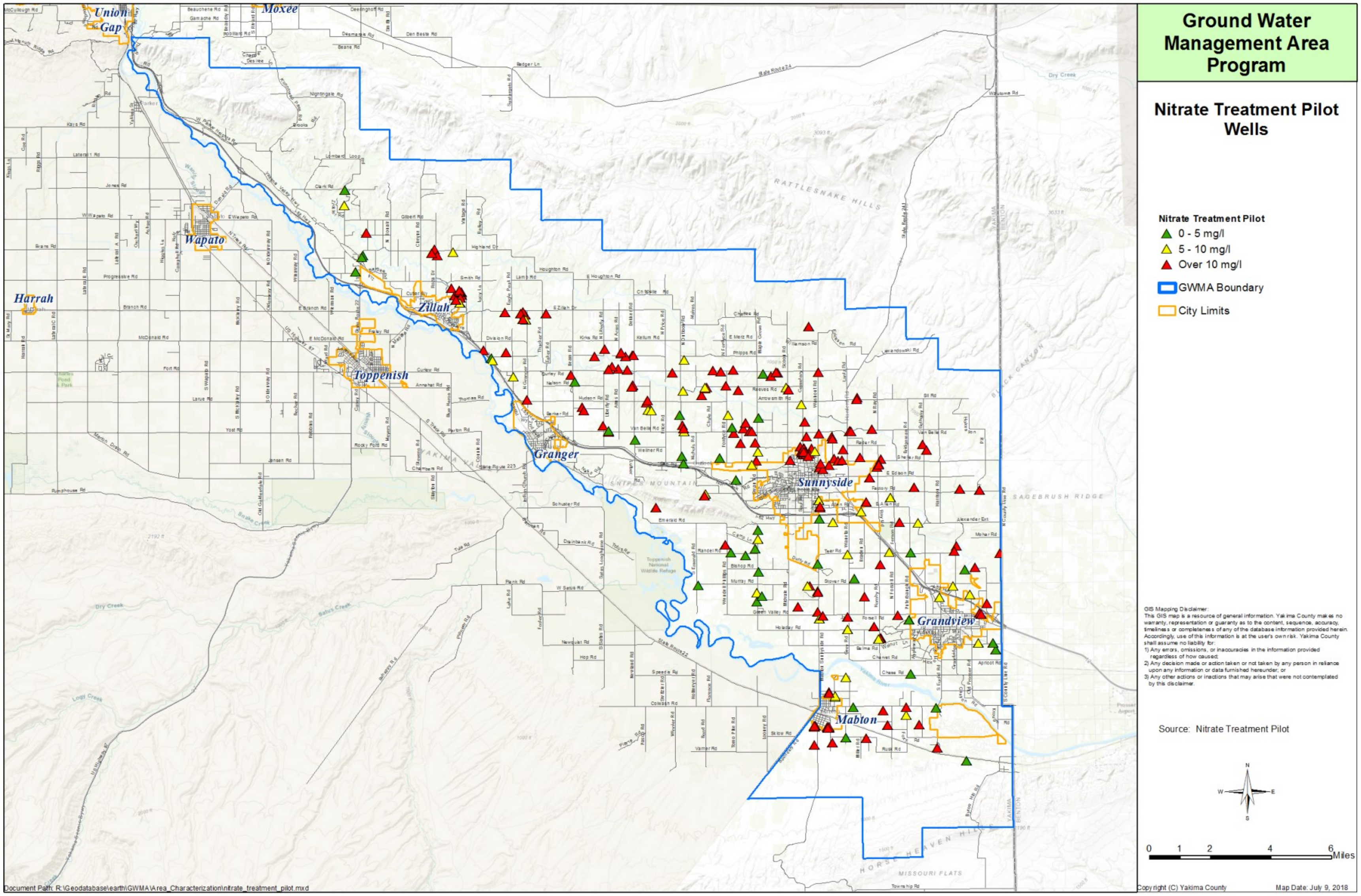
While it was estimated that between 700 and 1,000 homes in the Program area were supplied by water wells with nitrates in excess of the drinking water standard, only 177 households requested (and qualified for, based on certified lab results) the water treatment system. The lessons learned that would inform future outreach included:

- Health effects of nitrate are difficult to convey, not visible, not easily understood related to contamination threshold and risk factors.
- A lack of interest from the public. With no local reports of nitrate-related health problems, the public's concern was not high.
- Due to the large size of the project area and its rural character, there is little "community" presence and community leadership to draw upon for outreach.
- Illiteracy and low reading comprehension skills in some households required one-on-one site assistance to verify Program eligibility and to complete applications.

The Nitrate Treatment Program illustrated the challenge of communicating complex messages to a discrete, hard-to-reach audience. But it did introduce the nitrate issue to residents within the target area. Therefore, residents who participated in the Treatment Program were familiar with the nitrate issue when the GWMA Outreach Program was launched.

Water quality samples were also taken. See Appendix K for data collected.

FIGURE 19 - NITRATE PILOT PROJECT WATER TEST LOCATIONS



GWMA Program Development, Early Products

With immediate contractual obligations to create both an outreach program and a web-based information application (IAA No. C1200235, the Department of Ecology and Yakima County), the Education and Public Outreach (EPO) working group was organized and began regular meetings in the fall of 2012.

The outcome of those early meetings was the *Public Education and Outreach Plan* (adopted December 12, 2012), and the creation of the first GWMA website. The website would be redesigned twice and undergo numerous revisions as GWAC activities, outreach, and the evolving GWMA Program took shape.

The outreach work of the next four years – 2013-2017 – was guided by the *Public Education and Outreach Plan* objectives: 1) educating at-risk audiences about the risks of elevated nitrate to human health and how to protect themselves from that risk; 2) informing audiences about the GWAC planning process, and 3) inviting participation in the development of the GWMA Program.

The work: message development, audience targeting, evaluating and responding to outreach requests from the GWAC and working groups. The products: "boots on the ground" bilingual campaigns that included door-to-door surveys, "New Mom" hospital brochures, presentations to Sunnyside WorkSource clients, free private well testing, direct mail, billboards, participation at health fairs, and radio and TV outreach. Partnership: A new partnership was developed with the University of Washington's Pediatric Health Specialty Unit (PEHSU) to train healthcare providers to be aware of the nitrate issue and address it with their at-risk patients. These campaigns would be the field tests for the final GWMA Program outreach strategy. [Full list – Appendix I]

Three outreach campaigns that would help inform the Program are highlighted below.

2013 Door-To-Door Public Opinion Survey

A 2013 bilingual door-to-door survey was developed to measure what residents in the GWMA served by private wells knew – or didn't know –about their private wells, about nitrates in drinking water, and about the formation of the GWMA. The eight targeted areas encompassed 300 households in the LYVGWMA ranging from Konnowac Pass in the northeast to County Line Road to the southeast. The areas chosen were known to either have high nitrate in groundwater or were in areas where little data on nitrate levels existed.

136 households responded to the survey, administered by Heritage University students. The results indicated that 69 percent (94 households) surveyed were aware of the potential health risks associated with drinking water with high levels of nitrate. Over half of those surveys had had their private well tested for nitrate. Four percent (six households) believed someone in their home had become ill from drinking their well water. None, however, indicated that high levels of nitrate were the source of the illness.

Out of the 136 households, only one reported having an infant. Only one household had a pregnant woman. Seven households reported having a chronically ill individual; however, the survey did not ask for the specific illness.

Less than half (42 percent) had heard of the lower Yakima Valley Groundwater Management Area (see Appendix I for survey results). Participants were also asked if they were interested in participating in a more in-depth private well testing. The participants responding "yes" would be invited to a second, more in-depth study of private wells in the Lower Yakima Valley.

High Risk Well Assessment Surveys Phases I & II (2014 and 2016, respectively). This campaign took a closer look at the water quality of private wells in the GWMA, and measured households' understanding of their well maintenance responsibilities, how their own actions might influence groundwater quality, and also measured households' awareness of how to protect the quality of their drinking water. 466 sampling surveys were conducted. See survey instrument in Appendix I.

Although the sample size was too small to assess data patterns, the lessons learned included:

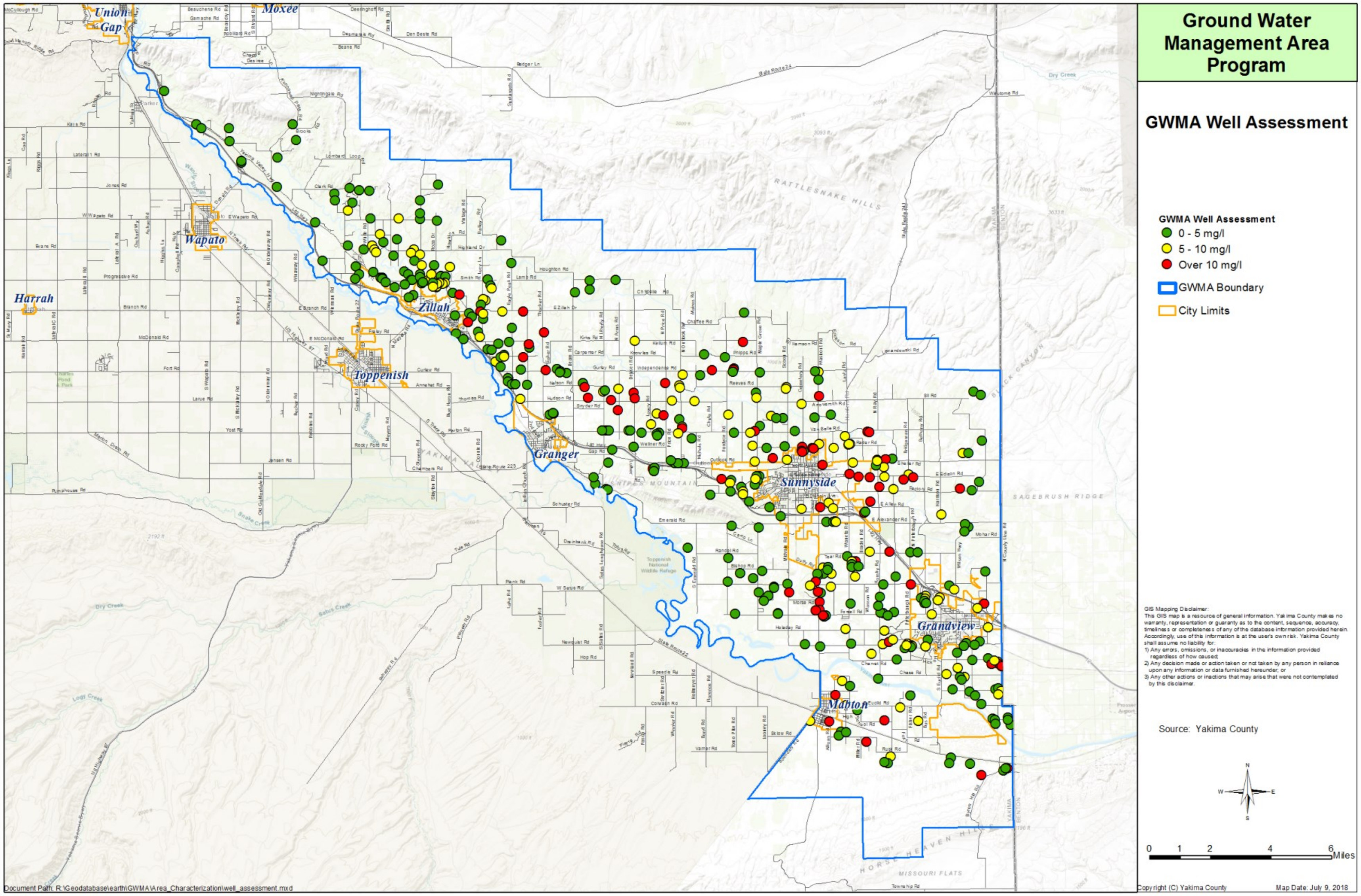
1) Residents on private wells need to test their wells;

2) Well owners should become more familiar with their wells (e.g., location of their well log, depth of well, condition of well);

3) The need to explore the possible connection between not testing a well and its likelihood of testing high for nitrate.

Water quality samples were also taken. See Appendix L for collected data.

FIGURE 20 - HIGH RISK WELL ASSESSMENT TEST LOCATIONS



GWMA Website

The GWMA Website (http://www.yakimacounty.us/541/Groundwater-Management-Area) served as the information clearinghouse required under the Work Plan. It provided a central source of information about the GWAC, the working groups and their products, and links to technical assistance. It was also intended to inform the public about the GWMA Program development.

Although the website link was advertised on nearly every English/Spanish document, presentation and billboard the EPO produced, the hits the website received and the specific pages that were viewed (resource materials) suggested that the primary users were GWAC members and researchers from outside the Program area (some access to Spanish language pages requires navigation first .through English language pages).The EPO working group speculated that the web's most practical use was for agencies and individuals seeking academic information about the GWMA. While efforts were made to make it more inviting to the public (bilingual content, graphics, surveys), there was no evidence (e.g., increased page hits) that the effort was successful.

The results of the EPO's outreach campaigns and the products it produced are set forth in Appendix I of this Program.

Best Management Practices

The LYVGWMA initially contracted with HDR to produce a complete list of all the potential best management practices that may be applicable to agricultural, industrial, urban and domestic activity within the LYVGWMA. The Irrigated Agriculture Work Group of the Groundwater Advisory Committee reviewed the HDR produced list and selected those best management practices they felt particularly relevant to their respective operations. Those best management practices are set forth in Appendix D of this Program. The Livestock/CAFO Work Group of the Committee elected to review the best management practices listed by the Natural Resource Conservation Service (NRCS) to determine those particularly relevant to livestock/CAFO operations. Those best management practices are set forth in Appendix E of this Program.

Groundwater Monitoring Plan

The GWAC developed an Interim Final Groundwater Monitoring Plan (PGG 2014) in order to establish a network of wells and field procedures with which to evaluate current and future nitrate concentrations in the Area's groundwater. The objectives of this Plan were to establish procedures for the collection and analysis of representative groundwater samples for nitrate and nitrate-related analyses. Data collected pursuant to the Plan is intended to be used to: evaluate BMP effectiveness, evaluate groundwater trends, identify nitrate hotspots, and calculate basin-wide average nitrate concentrations. Analytic results from the same data was intended to be used by the GWAC to make administrative decisions and policy recommendations. The Plan, prepared in accordance with hydrogeologic practices generally accepted at this time in the relevant area, addressed sampling procedures, sampling schedule (developed following identification of the sampling network), establishment of a sampling network, quality assurance/quality control, reporting frequency and schedule.

The sampling program described in the Plan involved collecting groundwater samples from a network of wells for analyses of nitrate, nitrite, ammonia, and the sum of organic nitrogen + ammonia + ammonium (Total Kjeldahl Nitrogen). The network could include wells that already have pumps (private, public, and irrigation supply wells) and monitoring wells that require use of sampling pumps. Groundwater samples would be analyzed by labs accredited by the Washington State Department of Ecology (Ecology). A Groundwater Monitoring Quality Assurance/Quality Control Plan (PGG 2013) was prepared in anticipation of the Groundwater Monitoring Plan.

Yakima County has begun to contract for the installation of monitoring wells. The network is formative but not complete at this time. No private, public or irrigation supply wells are included in the anticipated monitoring well network. No plan for data gathering or analysis has yet been established to determine whether there is a reduction of the number of incidents of measured exceedance of water quality standards.

USGS Drinking Water Quality Testing

Yakima County contracted with the USGS to test and evaluate the quality of drinking water supplies within the LYVGWMA. USGS identified 160 water wells common to USGS' water testing data base and Yakima County's water testing data base all of which had existing drilling records from which to determine water levels, well construction details and some prior testing history. USGS then tested these wells six times each during calendar year 2017, with the objective of determining whether measurements vary based on the seasons of the year or agricultural cropping schedules.

USGS, in cooperation with the LYVGWMA group, conducted an intensive groundwater sampling collection effort of collecting nitrate concentration data in drinking water to provide a baseline for future nitrate assessments within the LYVGWMA. About every 6 weeks from April through December 2017, a total of 1,059 samples were collected from 156 wells and 24 surface-water drains. See Appendix M for collected data. The domestic wells were selected based on known location, completion depth, ability to collect a sample prior to treatment or filtration, and distribution across the LYVGWMA. The drains were pre-selected by the GWAC, and further assessed based on ability to access sites and obtain a representative sample. More than 20 percent of samples from the domestic wells and 12.8 percent of drain samples had nitrate concentrations that exceeded the maximum contaminant level (MCL) of 10 milligrams per liter established by the U.S. Environmental Protection Agency. At least one nitrate concentration above the MCL was detected in 26 percent of wells and 33 percent of drains sampled. Nitrate was not detected in 13 percent of all samples collected. (USGS 2018).

FIGURE 21 - USGS 2017 GROUNDWATER WELL TEST LOCATIONS

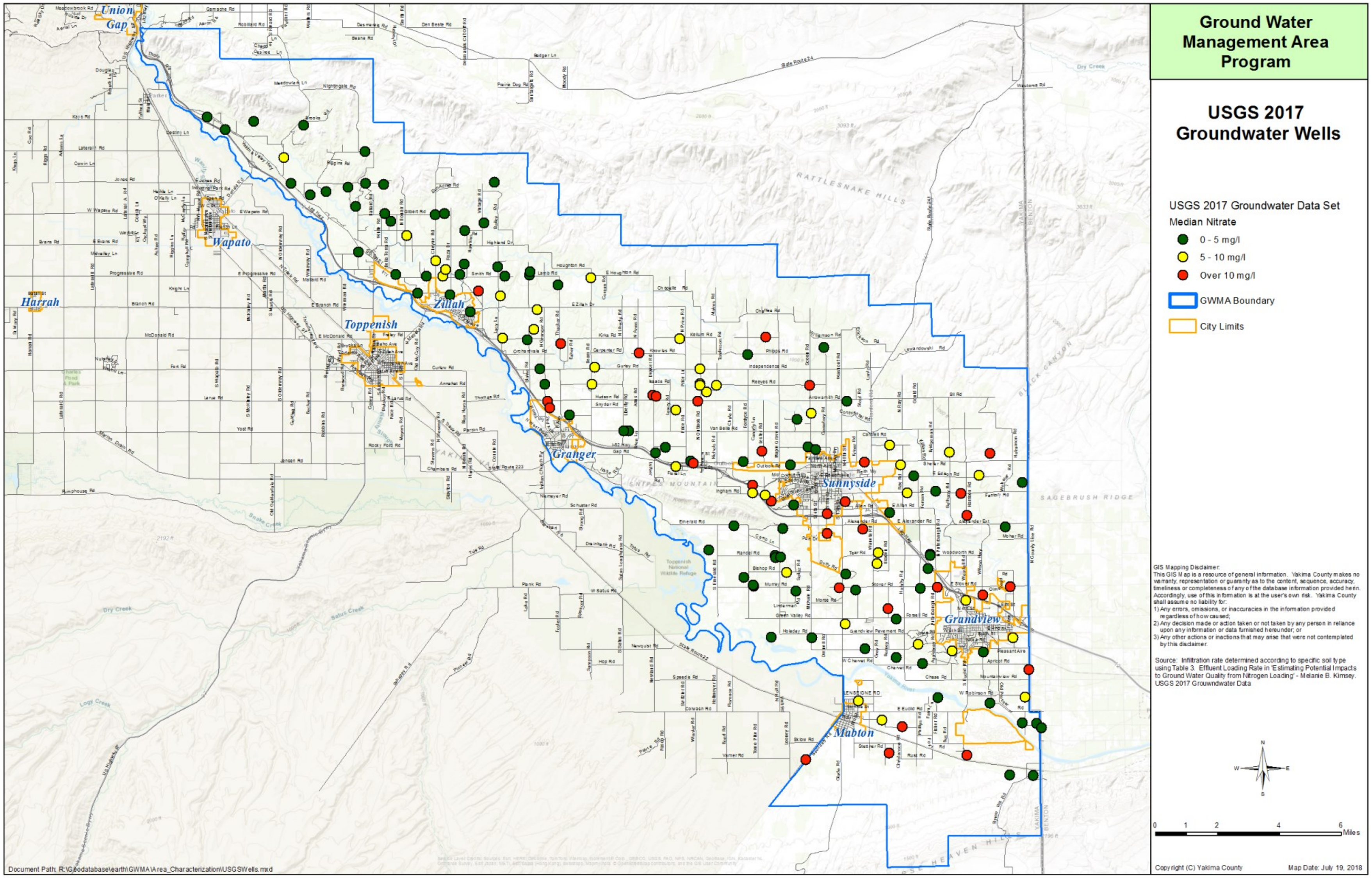
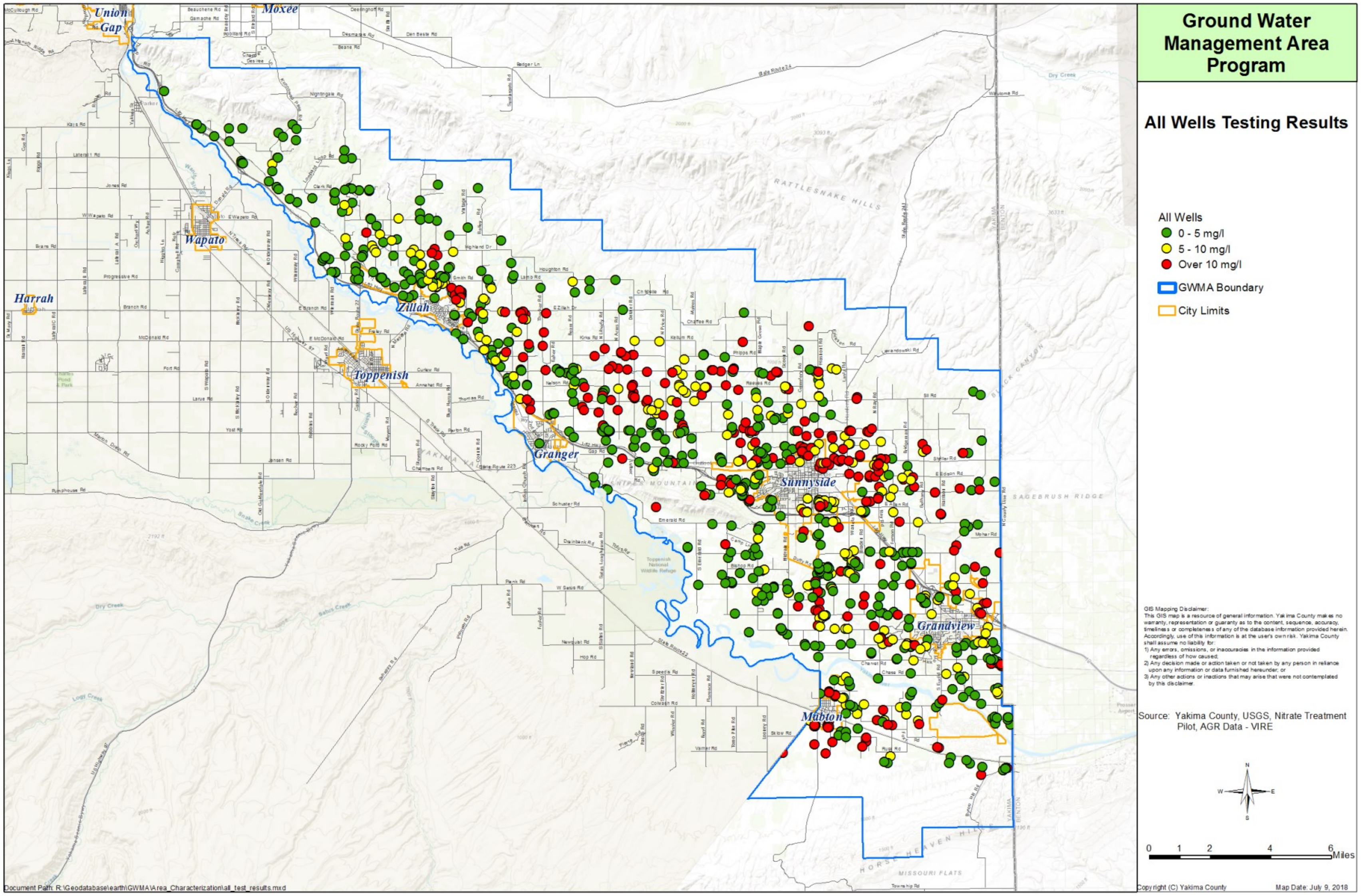


FIGURE 22 - ALL WATER QUALITY SAMPLING LOCATIONS (3 TESTING PROGRAMS)



Deep Soil Sampling Program

Between the fall of 2014 and the spring of 2016, Yakima County contracted with the South Yakima Conservation District and Landau Associates to perform four rounds of deep soil sampling (DSS) on agricultural land in the GWMA target area. All participants volunteered to participate in the Program, subject to the condition that the physical location of sampling was anonymous and undisclosed.

The purposes of the DSS as stated in the Sampling Plan were to 1) provide baseline data regarding the nitrogen content (nitrate, ammonium, and organic matter) of soils underlying a variety of soil, crop, and irrigation systems that represent a cross-section of agricultural activities; 2) provide an initial assessment of current nitrogen and water management practices in place today and in the past; 3) provide information regarding availability of soil nitrogen to crops; 4) provide the foundation for a technically based education program; and 5) provide information about project design, practical realities, time requirements and costs that can be used in developing subsequent project scopes.

Due to the fact that the physical location of sampling was not disclosed, all of the project's purposes were not realized. Nitrate concentration were measured at 6 ft below ground surface at 175 sites. Members of the GWAC who are actively farming stated that they believe that property owners who volunteered to participate in the project gathered helpful information that would improve their management practices related to nitrogen application and movement of nitrates within the soil of their agricultural property. Analysis of the practical realities, time requirements and costs of the project indicate that, without possible identification of particular locations tested, the project would be too expensive to continue or repeat.

Identification and Ranking of Sources of Elevated Nitrate in Groundwater

The LYVGWAC identified sources of elevated nitrate generically (presented above). No ranking was made of these sources.

Development of Specific Characteristics of "Hot Spots"

The LYVGWAC did not develop specific characteristics of hot spots nor locate them. The Groundwater Monitoring Program does not include an approach for identifying hot spots.

Nitrogen Loading Assessment

Yakima County contracted with the Washington State Department of Agriculture to study the amount of nitrogen "loaded" to groundwater within the LYVGWMA. WSDA produced a final report in June 2018 incorporating analysis provided by Yakima County regarding nitrogen contributions from residential, commercial, industrial and municipal sources. (WSDA 2018) That report estimated and analyzed the amount of nitrogen "available" for potential loading, but did not take into account soil processes between the point of availability and the groundwater surface.

The report estimated potential nitrogen availability in the landscape in four categories: Concentrated Animal Feeding Operations (CAFOs and dairies), including livestock pens and manure lagoons, irrigated agriculture activities including 15 types of irrigated crops that constitute 96 percent of irrigated acreage within the LYVGWMA, residential, commercial and municipal sources and atmospheric deposition. Both locally-derived information (particularly from mass-balance calculations of irrigated agriculture within the area) and data from scientific literature (particularly related to CAFOs and dairies) was used. The report based its conclusions on low, medium and high estimates of nitrogen available within the four categories. No measurement or analysis was done regarding biosolids. Atmospheric deposition of nitrogen was assumed within the calculations performed with respect to irrigated crops, animal pens and lagoons, and otherwise estimated for other acreage. (WSDA 2018)

The report estimated the nitrogen available within the GWMA from irrigated agriculture, CAFO/dairies, on-site septic/sewer systems, residential lawn fertilizers and small scale (hobby) farms, and atmospheric deposition. The final report listed the low, medium and high estimate for irrigated agriculture in ranges, each beginning with zero.

TABLE 12 - AVAILABLE N OF IRRIGATED AGRICULTURE

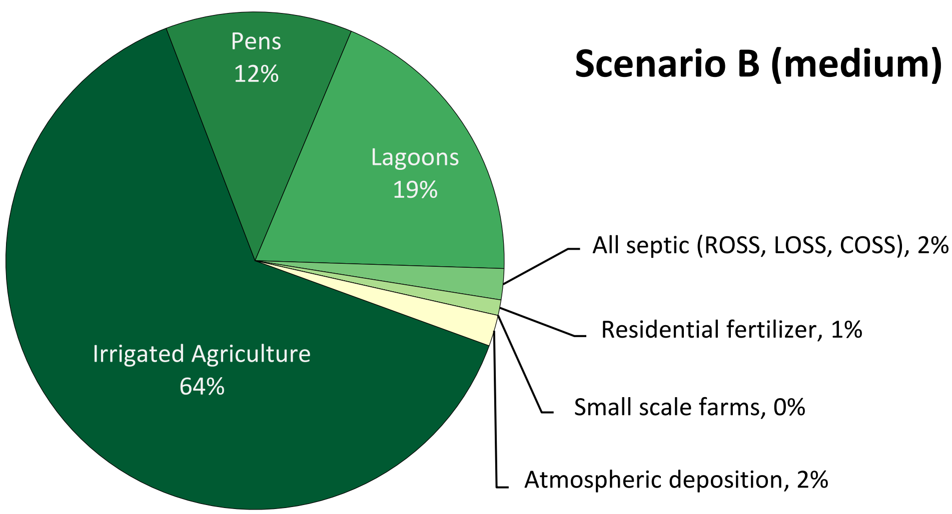
Commodity	Acreage	Sum of inputs and outputs for one year (lb N/ac-yr)		
		Low	Medium	High
Apple	17,333.0	-	64.0	165.0
Corn (silage)	16,778.0	-	47.0	242.0
Triticale	10,780.0	-	13.0	250.0
Grape (juice)	10,257.0	15.0	105.0	142.0
Alfalfa	7,989.0	-	-	-
Pasture	6,731.0	-	-	62.0
Cherry	6,336.0	27.0	78.0	156.0
Hops	5,961.0	-	99.0	113.0
Grape (wine)	5,126.0	40.0	67.0	102.0
Pear	3,331.0	-	65.0	119.0
Mint	1,418.0	-	46.0	102.0
Wheat	1,283.0	-	44.0	113.0
Corn (grain)	1,166.0	-	148.0	284.0
Asparagus	854.0	58.0	130.0	156.0
Peach/Nectarine	843.0	12.0	54.0	104.0
Total	96,186.0	152.0	960.0	2,110.0

TABLE 13 – AVAILABLE N OF CAFO / DAIRY, ON-SITE SEPTIC/SEWAGE, RCIM WASTE AND ATMOSPHERIC DEPOSITION

	Acres	Low (lbs/ac/yr)	Medium (lbs/ac/yr)	High (lbs/ac/yr)
Pens	2,096.0	67.0	480.0	892.0
Lagoons	210.0	1,354.0	7,448.0	13,542.0
ROSS	398.0	223.0	403.0	662.0
LOSS	3.0	195.0	209.0	225.0
COSS	30.0	163.0	173.0	183.0
Res Fert	4,381.0	4.7	11.7	18.6
Small Scale Farm	2,096.0	4.3	10.7	17.1
Atmospheric Deposition	73,976.0	1.5	2.1	6.2

WSDA's final study concluded that approximately 64 percent of the available N was attributable to irrigated agriculture, 12 percent to dairy and cattle pens, 19 percent to liquid manure lagoons, two percent to all septic systems, two percent to atmospheric deposition (that portion attributable to irrigated agricultural acreage) one percent to residential fertilizers and less than one percent to small scale farms.

FIGURE 23 - PERCENT OF TOTAL N AVAILABLE BY SOURCE (WSDA)



Selecting the WSDA's "medium" estimate of the "sum of inputs and outputs" (otherwise the "available" nitrogen) of the 15 crops with the greatest acreage within the GWMA, and the medium estimate of the of pens, lagoons, on-site septic/sewage, RCIM waste and atmospheric deposition, then multiplying the acreage of each times the amount of N available, the total contribution of all sources can be estimated.

The "medium" nitrogen availability has been chosen as the preferred analytic measure because of the numerous assumptions and subjective estimates contained in the mass balance analysis done for irrigated agriculture and the potential variance of location, climate, latitude, soils or other conditions in the cases cited in the scientific literature relied upon for CAFO/dairy facilities.

TABLE 14 - TOTAL AVAILABLE N FROM ALL SOURCES STUDIED IN WSDA 2018

Source of Available N	Acres	Medium (lbs N/ac-yr)	Total (lbs N/yr)	Total (Tons N/yr)	% of Total N Available
Apple	17,333.0	64.0	1,109,312.0	554.66	13.83%
Corn (silage)	16,778.0	47.0	788,566.0	394.28	9.83%
Triticale	10,780.0	13.0	140,140.0	70.07	1.75%
Grape (juice)	10,257.0	105.0	1,076,985.0	538.49	13.43%
Alfalfa	7,989.0	-	-	-	0.00%
Pasture	6,731.0	-	-	-	0.00%
Cherry	6,336.0	78.0	494,208.0	247.10	6.16%
Hops	5,961.0	99.0	590,139.0	295.07	7.36%
Grape (wine)	5,126.0	67.0	343,442.0	171.72	4.28%
Pear	3,331.0	65.0	216,515.0	108.26	2.70%
Mint	1,418.0	46.0	65,228.0	32.61	0.81%
Wheat	1,283.0	44.0	56,452.0	28.23	0.70%
Corn (grain)	1,166.0	148.0	172,568.0	86.28	2.15%
Asparagus	854.0	130.0	111,020.0	55.51	1.38%
Peach/Nectarine	843.0	54.0	45,522.0	22.76	0.57%
Pens	2,096.0	480.0	1,006,080.0	503.0	12.54%
Lagoons	210.0	7,448.0	1,564,080.0	782.0	19.50%
ROSS	398.0	403.0	160,394.0	80.2	2.00%
LOSS	3.0	209.0	627.0	0.3	0.01%
COSS	30.0	173.0	5,190.0	2.6	0.06%
Res Fert	4,381.0	11.7	51,257.7	25.6	0.64%
Small Scale Farm	2,096.0	10.7	22,427.2	11.2	0.28%
Total	105,400.0	9,695.4	8,020,152.9	4,010.1	100.00%

When the acreages utilized by WSDA are summed, the total is greater than the acreage within the GWMA.

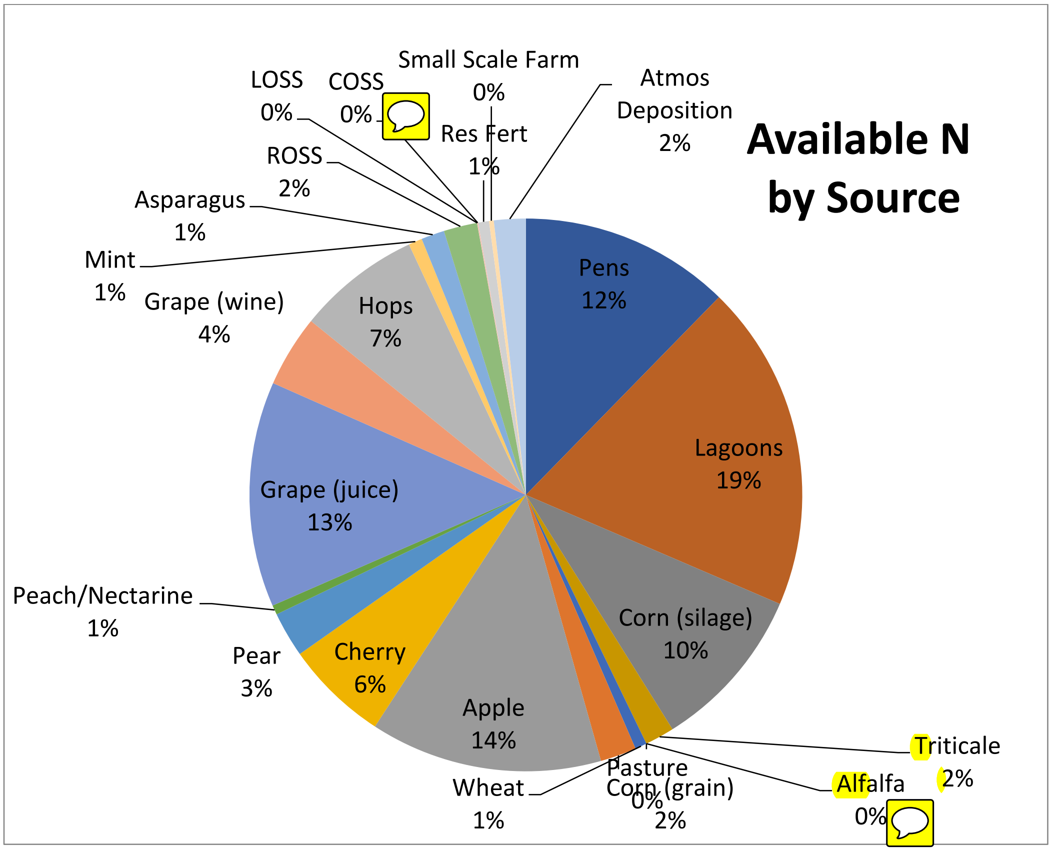
TABLE 15 - TOTAL ACREAGE FOR N AVAILABILITY COMPUTATIONS

	Acres
Total Irrigated Agriculture	96,186.0
Total Other	9,214.0
Total Acreage	105,400.0

This is a result of double-counting of acreage which is "double cropped" (corn (silage), triticale, alfalfa), or "double used" (farming, septic). The double counting of acreage is necessary to obtain total nitrogen availability.

It is thus possible to see the contribution of total nitrogen available from all studied sources.

Figure 24 - Nitrogen Available By Specific Source



The information provided by WSDA (WSDA 2018) can also be assembled by more general industry groups:

TABLE 16 - NITROGEN AVAILABILITY ASSEMBLED BY INDUSTRY GROUP

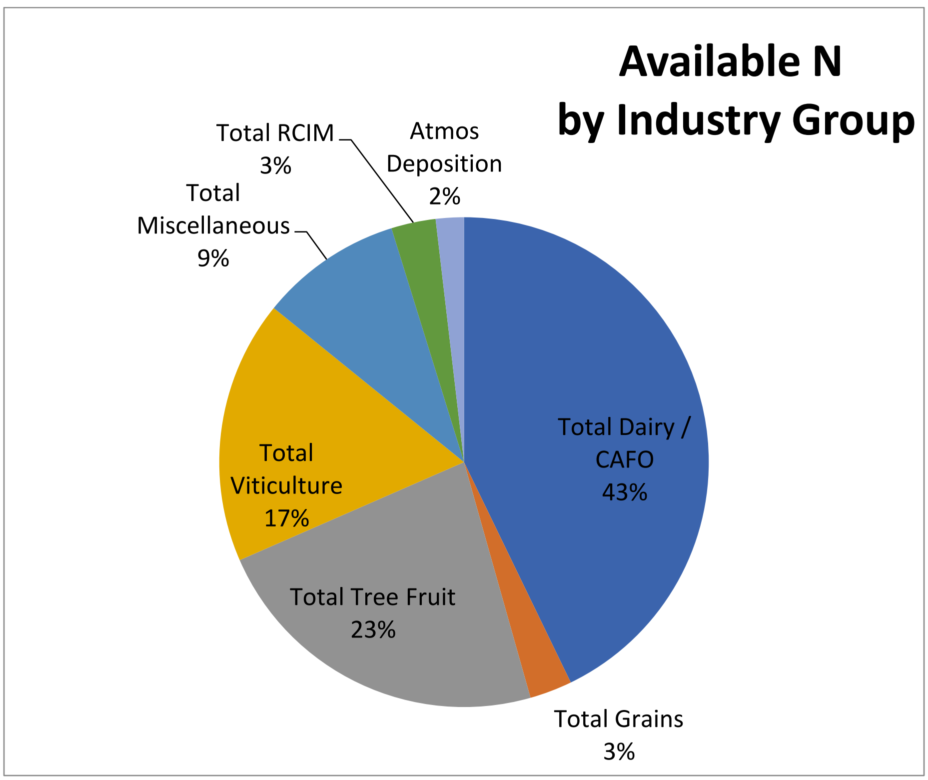
Nitrogen Availability by Industry Group				
	Acres	Medium N (lbs/ac/yr)	Total N Medium (lbs/yr)	Total N Medium (tons/yr)
Pens	2,096.0	480.0	1,006,080.0	503.04
Lagoons	210.0	7,448.0	1,564,080.0	782.04
Corn (silage)	16,778.0	47.0	788,566.0	394.28
Triticale	10,780.0	13.0	140,140.0	70.07
Alfalfa	7,989.0	-	-	-
Pasture	6,731.0	-	-	-
Wheat	1,283.0	44.0	56,452.0	28.23
Corn (grain)	1,166.0	148.0	172,568.0	86.28
Apple	17,333.0	64.0	1,109,312.0	554.66
Cherry	6,336.0	78.0	494,208.0	247.10
Pear	3,331.0	65.0	216,515.0	108.26
Peach/Nectarine	843.0	54.0	45,522.0	22.76
Grape (juice)	10,257.0	105.0	1,076,985.0	538.49
Grape (wine)	5,126.0	67.0	343,442.0	171.72
Hops	5,961.0	99.0	590,139.0	295.07
Mint	1,418.0	46.0	65,228.0	32.61
Asparagus	854.0	130.0	111,020.0	55.51
ROSS	398.0	403.0	160,394.0	80.20
LOSS	3.0	209.0	627.0	0.31
COSS	30.0	173.0	5,190.0	2.60
Res Fert	4,381.0	11.7	51,257.7	25.63
Small Scale Farm	2,096.0	10.7	22,427.2	11.21
Atmos Deposition	73,976.0	2.1	151,650.8	75.83

When the components of industry groups are totaled, a somewhat different view of nitrogen availability is possible:

TABLE 17 - INDUSTRY GROUP TOTAL N AVAILABILITY

Industry Group	Total N Medium (tons/yr)
Total Dairy / CAFO	1,749.43
Total Grains	114.51
Total Tree Fruit	932.78
Total Viticulture	710.21
Total Miscellaneous	383.19
Total RCIM	119.95
Atmos Deposition	75.83

FIGURE 25 - NITROGEN AVAILABLE BY INDUSTRY



Mean Annual Groundwater Recharge Model

The LYVGWMA did not remodel estimates of mean annual groundwater recharge as modeled by USGS (USGS 2007a). Remodeliing could consider more recent data inputs including a more recent period of climate condition, evolved irrigation methods, actual irrigation water application rather than estimated irrigation water application, and more particularized study of the LYVGGWMA, rather than the basin-wide study of the USGS' 2007 report. The increments of estimated annual recharge could also be refined to be more informative about any particular segment of land within the LYVGWMA

Geographic Information System Study

Yakima County maintains a geographic information system (GIS) data bank of numerous categories of information delivered to or through the county's various governmental processes. Data requests were made to the Washington State Departments of Agriculture, Ecology, Health, and Natural Resources, U.S. Departments of Agriculture (NRCS), Geological Survey (USGS), Census Bureau, Environmental Protection Agency and National Atmospheric Deposition Program for additional relevant information maintained or organized by geographic coordinates capable of inclusion in Yakima County's GIS system. Information from WSDA's nitrogen availability study (WSDA 2018) was fully integrated into the GIS system, as was the data from several water well testing programs administered by Yakima County and the Department of Health. All that information relevant to the LYVGWMA was structured into layers of GIS-mapped information.

The WSDA's Nitrogen Availability Assessment (WSDA 2018) contained information about a number of sources of nitrogen that may be available to the groundwater in such a way as to contribute to a contaminated well. The nitrogen available from all those sources within gridded section were totaled and mapped. (Figure 26.) The USGS 2017 well test data was then mapped and laid atop the map of total nitrogen availability. (Figure 27.) Similar overlaid maps created include USGS well data over soil types, soil infiltration rates, irrigation canals and drains, cropping patterns, point sources, and septic system locations. (Figures 27-32.)

FIGURE 26 - TOTAL NITROGEN AVAILABILITY

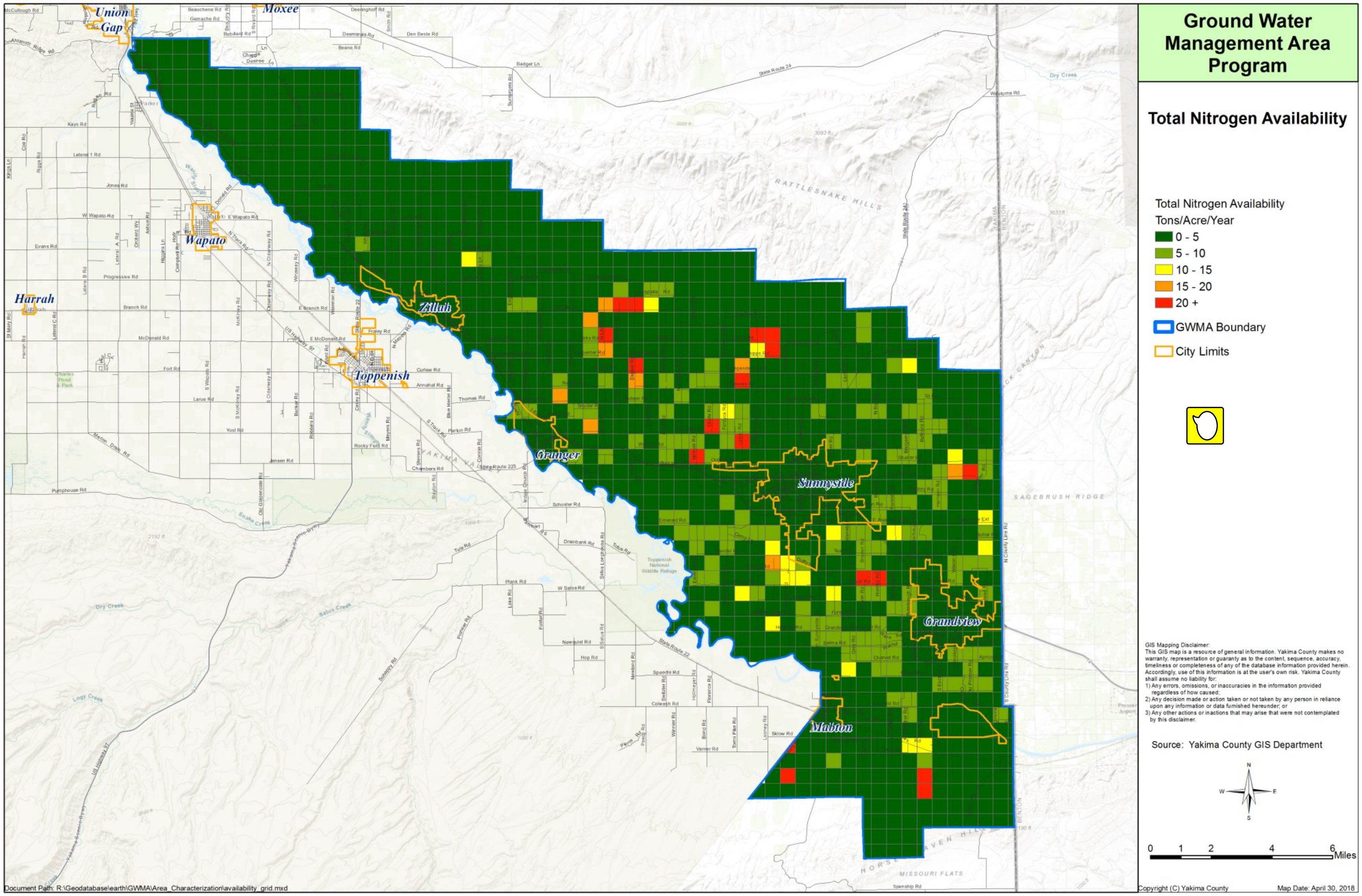


FIGURE 27 - NITROGEN AVAILABILITY AND USGS WELLS

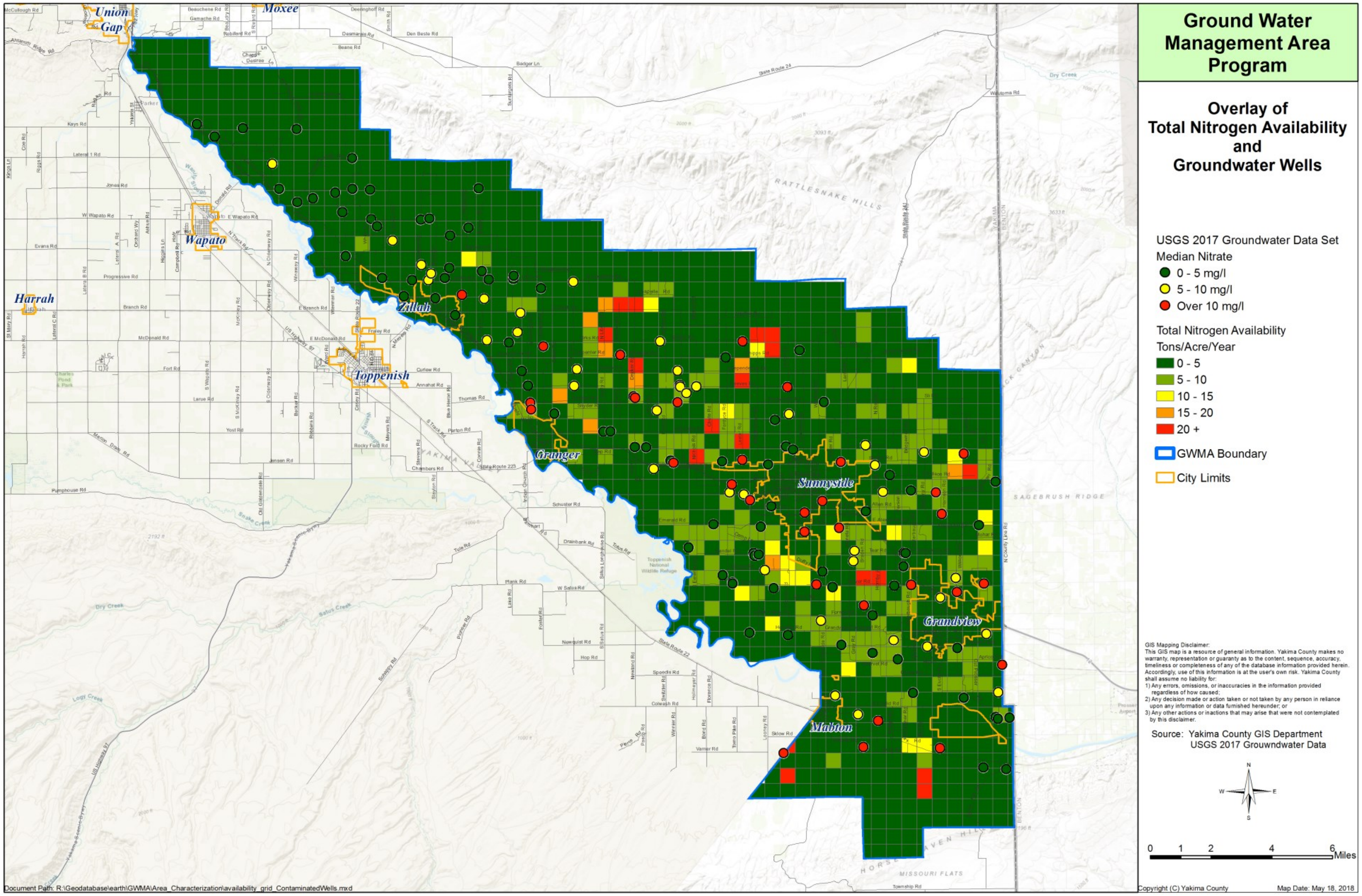


FIGURE 28 - USGS WELL DATA OVERLAID ON SOIL TYPES SIMPLIFIED BY HYDRAULIC CONDUCTIVITY GROUPS

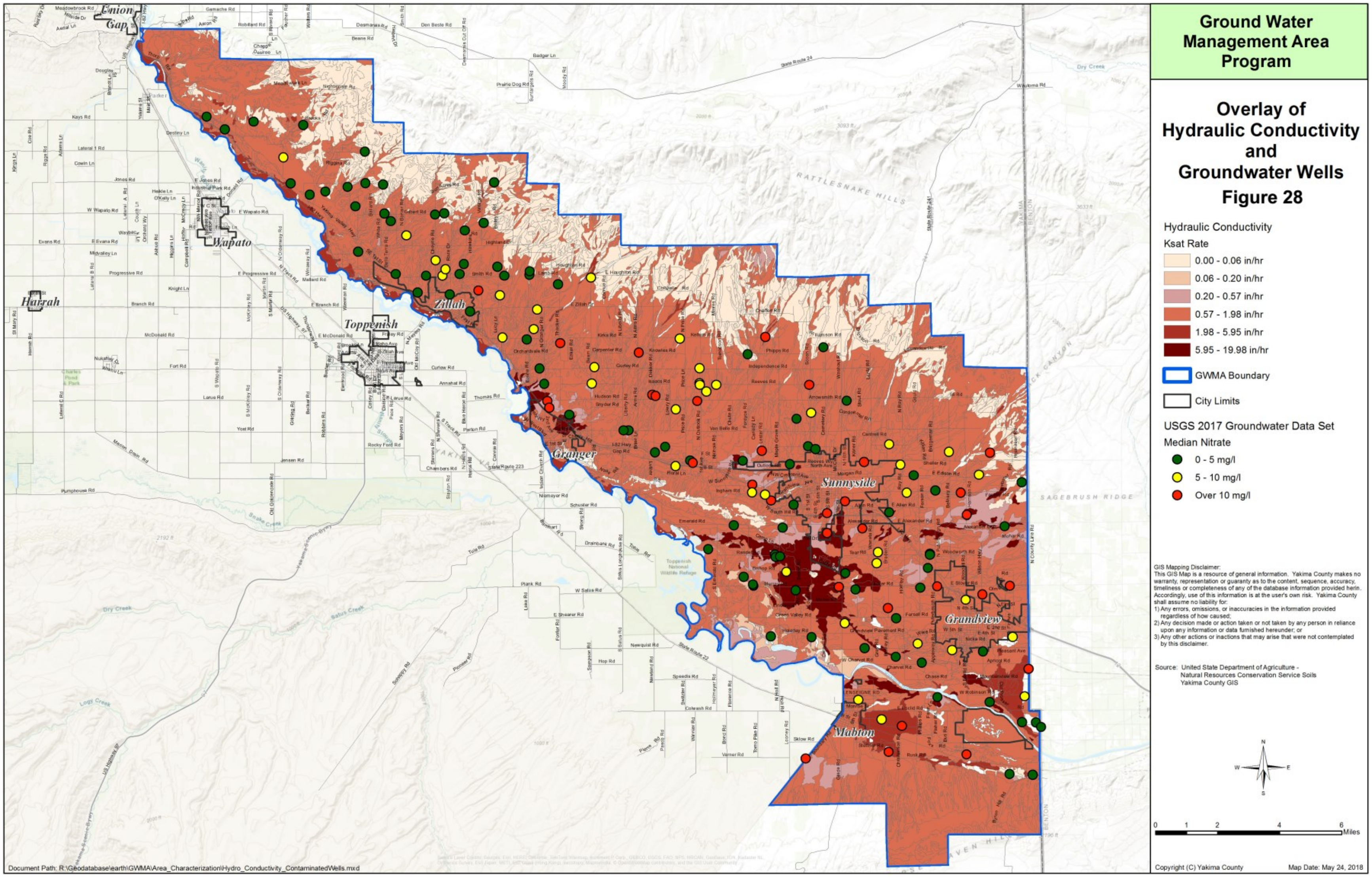


Figure 29 - USGS Well Data Overlaid on Irrigation Canal and Drain Information

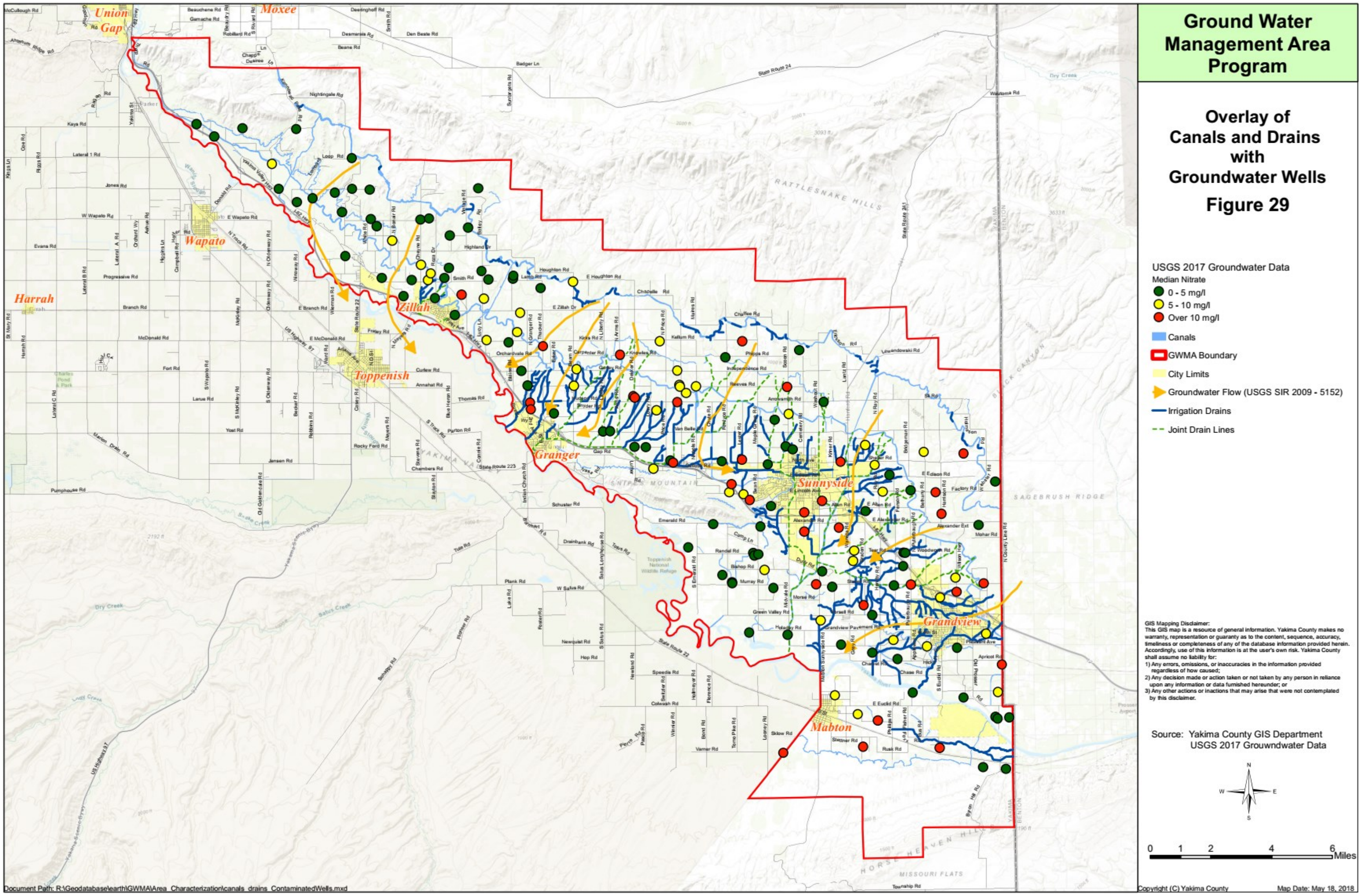


FIGURE 30 - USGS WELL DATA OVERLAID ON CROPPING PATTERNS

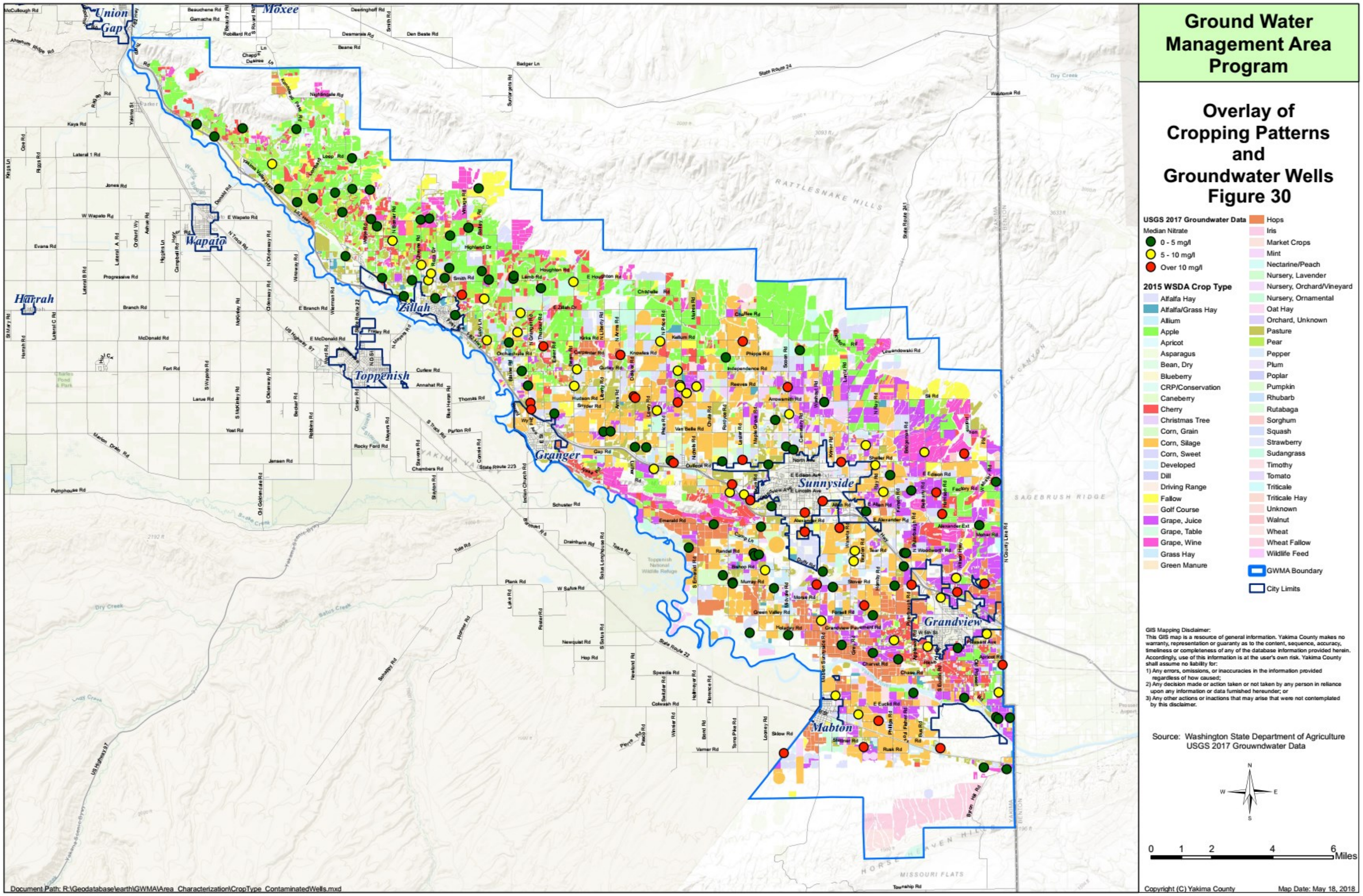


FIGURE 31 - USGS WELL DATA OVERLAID ON MAP OF POINT SOURCES

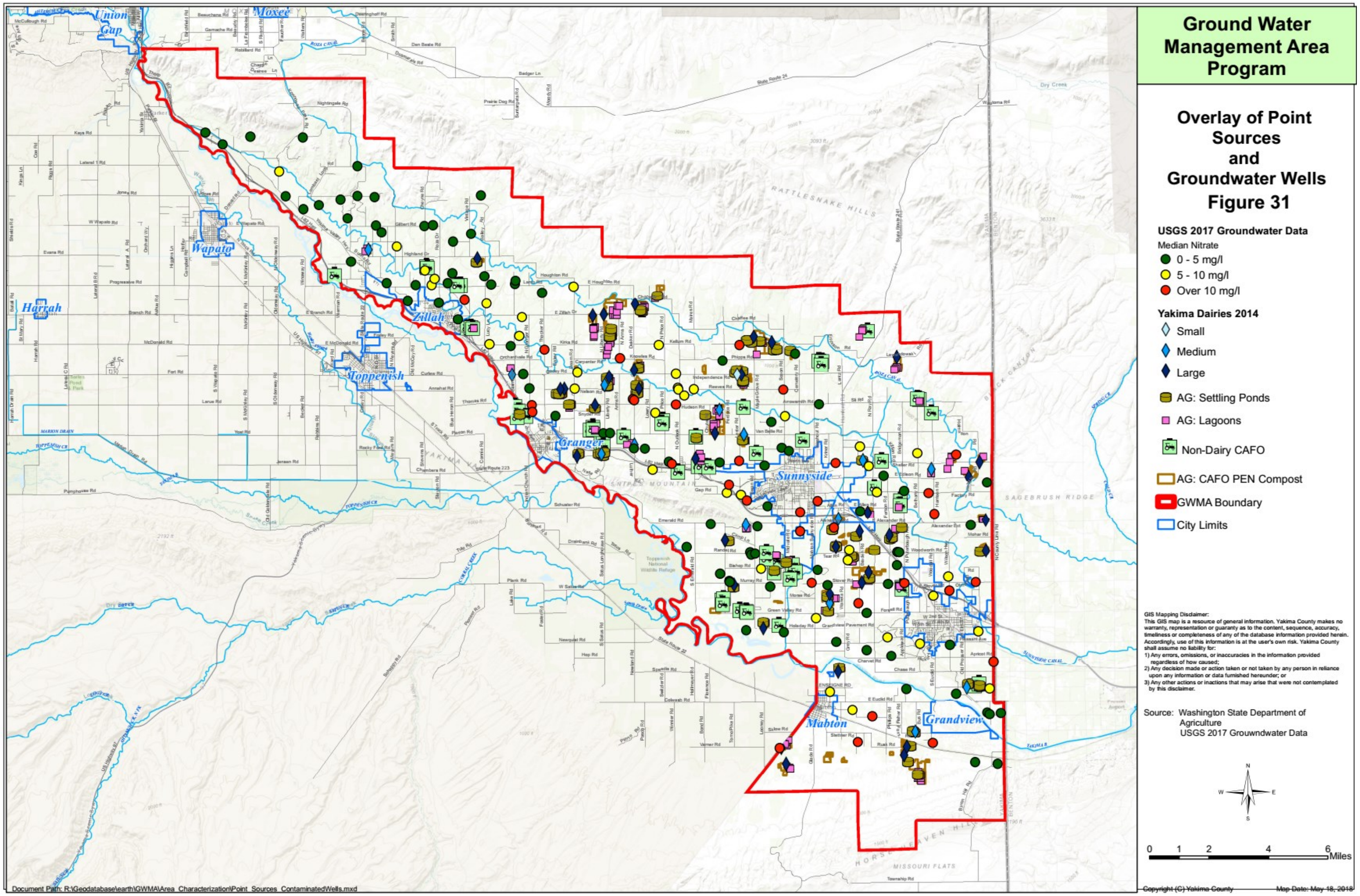
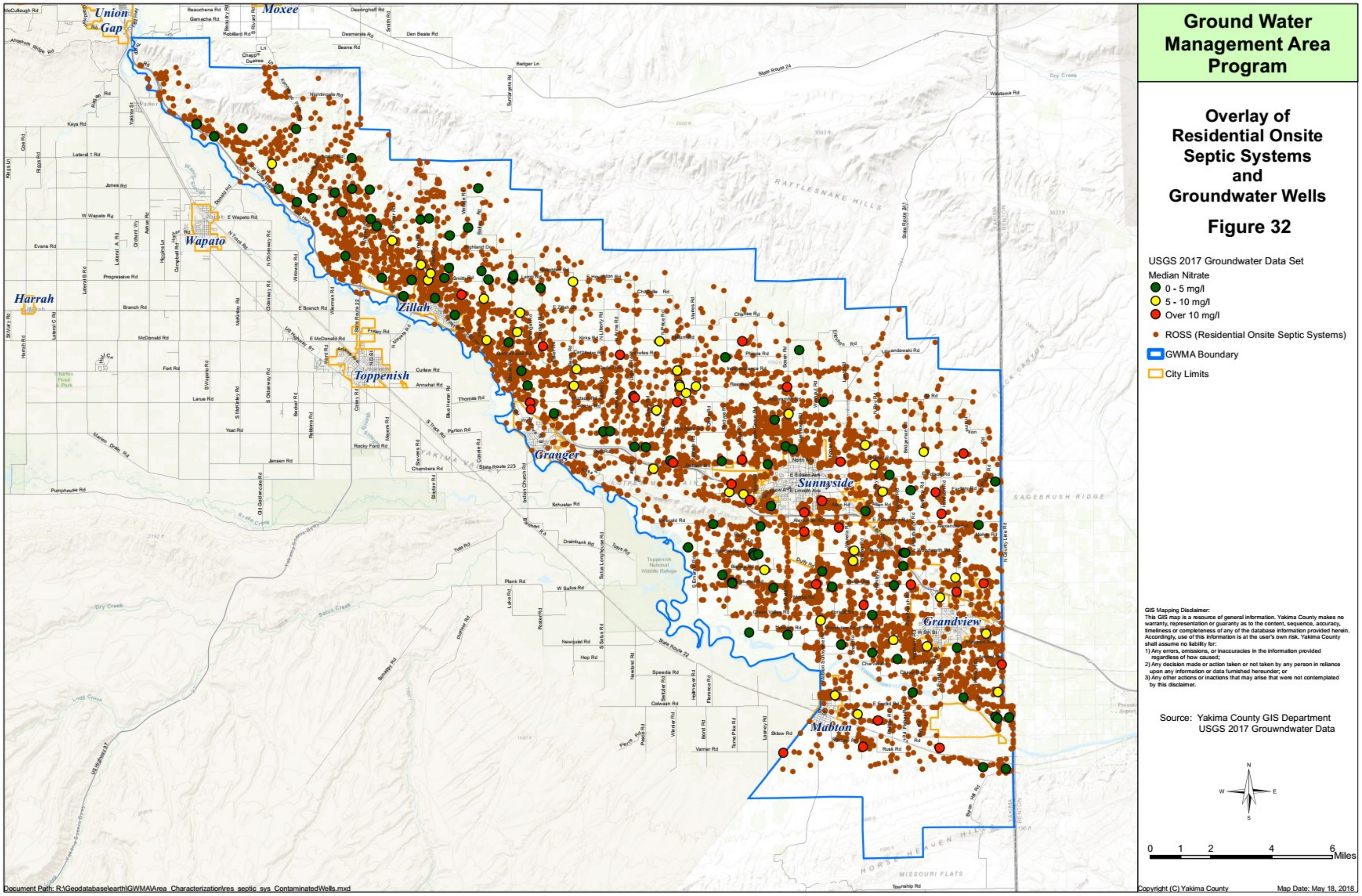


Figure 32 - USGS Well Data Overlaid on Map of Septic Systems



Caution should be taken to distinguish between few source locations (as with other point sources, Figure 31) and many source locations (as with septic systems, Figure 32). The ratio of actual combined gross settling pond and lagoon capacity to actual gross septic system capacity, for example, is 132/1. There are 6022 septic tanks, 105 settling ponds, and 172 lagoons, respectively, within the GWMA. The gross settling pond capacity (8,596,140 gallons) is equivalent to the capacity of 8,596 individual septic tanks. The gross lagoon capacity (784,650,928 gallons) is equivalent to the capacity of 784,651 individual septic tanks.

The average capacity of a septic tank when full is 133 cu. ft. (1,000 gallons); the average capacity of a settling pond when full is 81,868 cu. ft. (612,418 gallons); the average capacity of a lagoon when full is 609,840 cu. ft. (4,561,924 gallons). Not all of the relevant capacity is in use at any given time. These comparisons do not lead to reliable conclusions of relative contribution to ambient groundwater conditions.

While the broad distribution of septic systems throughout the GWMA suggest that they are a factor contributing to the ambient condition, and that some specific well contamination events may occur because of proximity to a specific septic system, caution should be taken when considering their relative total contribution of nitrogen available to the ambient groundwater system. See, Figure 22, Percentage of Total N Available by Source (WSDA) and Figure 23, Nitrogen Available by Specific Source.

It is difficult to compare particular sources directly, as they have different design and performance objectives. For example, septic systems are best sited in soils with high porosity (perc test required), settling ponds and lagoon systems are best sited in soils with low porosity (clays as impediment to flow).

All of the maps overlaid with USGS well data may suggest some correlation between source and effect. It is not suggested, however, that any is the sole cause of a given effect, nor that a particular combination of mapped data suggests any causative relationship. The distance between all potential sources inside a given radius of each of the USGS wells with greater than 10 mg/L nitrate has not been measured, nor has the geology, hydrogeology or water quality condition between them been analyzed.

Description of Alternative Actions to Address the Problem

WAC 173-100-100 (4) requires that this Program include:

> (4) An alternatives section outlining various land and water use management strategies for reaching the program's goals and objectives that address each of the groundwater problems discussed in the problem definition section. . . . . Each of the alternative strategies shall be evaluated in terms of feasibility, effectiveness, cost, time and difficulty to implement, and degree of consistency with local comprehensive plans and water management programs such as the coordinated water system plan, the water supply reservation program, and others. . . .

WAC 173-100-100 (4) suggests that the Program may include, "if necessary, alternative data collection and analysis programs" with which to "enable better characterization of the groundwater and potential quality and quantity problems."

> "the alternative management strategies shall address water conservation, conflicts with existing water rights and minimum instream flow requirements, programs to resolve such conflicts, and long-term policies and construction practices necessary to protect existing water rights and subsequent facilities installed in accordance with the groundwater management area program and/or other water right procedures."

In Yakima County, including the area within the LYVGMA, these subjects are being addressed through the Yakima River Basin Integrated Water Resource Plan (WBIWRP 2012).

The Groundwater Management Committee first made a list of some 300 potential alternatives, incorporating working group recommendations, ideas raised in working group conversations and reviews of scientific and environmental literature. [See Appendix G.] The GWAC first applied a "consensus" screen in order to reduce the large list of alternatives to those potential recommendations with which no one would disagree. This produced a shorter list of 83 potential recommendations to be evaluated by the criteria established by WAC 173-100-100 (4). [See Appendix H.]

Discussion of Pros and Cons of Alternative Actions

The GWAC first considered a lengthy list of ideas and thoughts that had surfaced throughout the several years of work group and GWAC meetings, particular recommendations made by working groups, or ideas derived from technical literature reviewed in preparation of this Program. The GWAC first removed from this list all those ideas where it was clear, through open meeting discussion, that consensus could not be reached. A spreadsheet was prepared listing all the remaining ideas. With respect to each, the feasibility, effectiveness, cost, proposed funding, timing, difficulty of implementation and consistency with Yakima County's Comprehensive Plan was estimated and set forth. (See Appendix H) This information was made available to all GWAC members prior to their final evaluation of the then-draft recommendations. Seventeen of the twenty-two primary GWAC members responded to a request to evaluate the draft recommendations, placing a value of -3 to +3 on each draft recommendation. The results were totaled. A unanimous consensus could not be obtained that the outcome of this method represented the consensus of the GWAC regarding its recommendations. The GWAC membership took a recorded vote at its May 17, 2018 meeting whether to recommend all draft recommendations which had received a total score greater than zero. The GWAC voted 17 - 1, 1 not voting, to recommend those draft recommendations. They appear below as "Recommended Actions." Those draft recommendations obtaining a total value of zero or less appear further below

Environmental Justice

An additional criterion with which to evaluate alternatives, other than those suggested by WAC 173-100-100, is "environmental justice." Environmental justice is the "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations and policies." (Ex. Ord. 1994) Federal and state agencies seek to implement this policy. Because abatement of nitrogen contamination in drinking water should have a positive effect for poorer, minority communities without alternative drinking water supply, alternatives that abate contamination should be considered favorably.

Discussion of environmental justice in LYVGWAC work group meetings led to argument about the applicability of the concept of environmental justice to the LYVGWMA groundwater problem.

The *Preliminary Assessment* (EPA 2010) found that the demographics of the Lower Yakima Valley require that final implementation of any or all the recommendations "takes into account, cultural, economic, and geographic factors." English is not the primary language (written or spoken) in many households in the Lower Yakima Valley. Prior outreach materials in Spanish and other languages were limited and focused for specific audiences and purposes (coliform boil water notices, nitrate advisories for high risk populations). When new materials are developed under any of the recommendations to address the specific needs of the Lower Valley residents, they should be written and delivered in a manner that is most likely to reach all residents of the LYVGWMA (see Interim Education and Outreach)

Recommended Actions

The GWAC refined that list of alternatives (Appendix H) to the recommended actions set forth below. The parenthesized number following the recommendation represents the total of all values provided by GWAC members.

Administration

Yakima County should:

ADM 1: Establish a Lead Agency responsible for implementation and oversight of the LYV GWMA Groundwater Management Plan and acquisition of stable funding to support their activities. (41)

Subject to state funding: Administer the Groundwater Quality Program. Administer funds and distribute to other entities by subcontract. Host the LYV GWMA website. Maintain a GIS data base on the GWMA.

Environmental Protection Agency and WA Department of Ecology should collaboratively:

ADM 2: Identify and support opportunities, including educational research institutions, for private, public, and industry investment in technology specific to addressing nitrate contamination in groundwater. (20)

Public Health and Safety

WA Department of Health, Yakima Health District, Yakima County should collaboratively:

PHS 1: Develop a bilingual, health-risk education and outreach campaign. (28)

Establish a public education program regarding nitrate pollution and health risk over a 5-10-year period. Partner with UW Pediatric Environmental Health Specialty Unit (PEHSU) to continue training local healthcare providers to recognize and address Nitrate risk in their patients (pregnant women and infants up to six months).

Residential, Commercial, Industrial, and Municipal

Yakima County should:

RCIM 1: Encourage municipalities within the GWMA to extend municipal sewer systems within urban growth areas and retire ROSS and LOSS., alternatively extend public water systems. Encourage connection of residences within urban growth zones to sewer systems extended by municipalities. (26)

RCIM 2: Perform an engineering study of water supply alternatives. (14)

Possible alternatives: 1) Discontinue use of contaminated shallow wells. Build new 1,500-foot community wells. 2) Rebuild, repair or replace poorly constructed wells. 3) Construct a potable water line from nearby developed area into deadhead water stations at central rural location (permit potable water collection at deadhead water stations). 4) Offer incentives to drill deeper wells or connect households on private wells near community water systems to connect to a community water system. (Nitrate Treatment Pilot Program-June 2011).

RCIM 3: Develop an urban and hobby agriculturalist education and outreach campaign. (10)

Provide information targeted to small farm/hobby farm/ranchettes about manure management. Publish and distribute homeowner guides on proper septic system construction, operation, and maintenance. Educate the public, particularly in towns, about lawn and garden nitrogen applications' contribution to nitrate concentrations. Recommend against farming around a water well.

Yakima Health District should:

RCIM 4: Publish and distribute homeowner guide on how to maintain septic systems. (40)

RCIM 5: Study potential nitrate contamination attributable to improperly operated septic systems. (32)

Consider restoration/retrofit of older septic systems through incentives or county property tax breaks. Require nitrogen reducing technologies for onsite septic systems where appropriate. Assist hobby farmers to locate ROSS drain fields on their property so as to avoid animal farming over the drain field.

Municipalities should:

RCIM 6: Provide funding for municipalities to replace aging sewer system infrastructure and ensure proper system maintenance to reduce nitrate leaching. (11)

Municipalities need to estimate costs and system integration.

WA Department of Ecology should:

RCIM 7: Develop a plan for finding and decommissioning abandoned wells in the next 12 months, using the LYVGWMA as a pilot project. (23)

Educate the public regarding liability of an ill-secured well, and the importance of the integrity of wells, particularly those without a well log. Educate realtors and banking industry officials about disclosure of abandoned wells in property transfers. Compare Google Earth to GIS images to determine where building or usage changes indicate possible well usage changes. Focus first on hotspot high density areas in GWMA. Ground truth suspected problem wells. Offer incentives, for property owners to identify and properly abandon wells. Offer grant funding to Yakima Health District or professional engineers for well inspections and to assist in abandoned well decommissioning. Provide some form of protection for self-reporting of abandoned or improperly decommissioned wells.

WA Department of Health should:

RCIM 8: Determine, prior to issuing or reissuing LOSS permits, that all employee counts are regularly reported. (19)

So that the LOSS will continue to operate as designed.

Irrigated Agriculture

Washington State University should:

IA 1: Operate a mobile irrigation lab to assess the efficiency of current or advised irrigation practices, either through a singular lab or component parts. (25)

Inform farmers of the relative propensity of wheel lines, center pivots, and drip lines to cause leaching and that fertilization and supplemental irrigation beyond the optimum rate will not necessarily produce better yields or higher profits without serious side effects. Advise re corn and triticale water practices.

WA Department of Agriculture should:

IA 2: Design and implement pilot studies focusing on innovative farm techniques which reduce nitrogen loading to crops and monitor results. (34)

South Yakima Conservation District, WA Department of Agriculture, and WSU Extension Service should collaboratively:

IA 3: Create Irrigation Management Plans (similar to Nutrient Management Plans) for farms over a minimum size and provide financial assistance for implemented plans. (23)

Use available techniques to determine how much and when irrigation is needed instead of irrigating according to a prearranged schedule. Analyze irrigation practices to discover whether frequency or volume creates greater propensity for leaching. Manage sprinkler systems so they do not drive nutrients past the root system. Improve micro-irrigation system design and operation. Schedule water and nitrogen application according to the need for optimal crop yields. Monitor the timing of application of fertilizers to fields and how much water was then applied.

IA 4: Encourage advanced irrigation management. Integrate management of synthetic /organic fertilizers and application of water. (31)

Recognizing that there is significant cost involved in changing an irrigation system, look for strategic opportunities where the use of more advanced irrigation management systems could have the greatest benefit for reducing nitrogen impacts to groundwater. One example of advanced irrigation management is electronic sensor irrigation water management (IWM). Identify federal, state and local incentive programs (like EQIP), such as grants, and low interest loans, to facilitate a transition to more advanced irrigation management in those areas. Provide financial assistance for 1) conversions from rill irrigation to sprinkler or drip irrigation, 2) installation of flow meters and moisture meters to reflect over-irrigation, high water table, drought conditions, 3) the cost of hiring third party sampling, measuring equipment, personnel or self-test kits, 4) management of sprinkler systems so they do not drive nutrients past the root system. Establish a voluntary irrigation management cost-share program from which data may be shared with the public.

Natural Resources Conservation Service and Department of Ecology should collaboratively:

IA 5: Provide financial assistance for implementation of Irrigation Management Plans. (32)

Details include: 1) conversions from rill irrigation to sprinkler or drip irrigation, 2) installation of flow meters and moisture meters to reflect over-irrigation, high water table, drought conditions, 3) the cost of hiring third party sampling, measuring equipment, personnel or self-test kits, 4) management of sprinkler systems so they do not drive nutrients past the root system.

Department of Ecology and WA Department of Agriculture should collaboratively:

IA 6: Make grants and allocate cost share funding or other funding assistance to people implementing environmental protection measures affecting groundwater quality. (17)

Assign personnel to investigate which environmental protection measures utilized by irrigated agriculturalists and livestock/dairy producers have positive influence on groundwater quality and explore means to share costs of implementing such measures. (Coordinated DOE, WSDA, Conservation District program). See NRCS Environmental Stewardship Program (2012). Also WCC, Voluntary Stewardship Program (Bill Isler), USDA Rural Community Assistance Group environmental program.

Livestock/CAFO

WA Department of Agriculture should:

LC 1: Complete NRCS Technical Note 23 inspections on all waste storage ponds (lagoons) within the GWMA boundaries. (23)

LC 2: Identify and support opportunities, including education research institutions for private, public and industry investment in technology and management of fertilizers and manures, including separation of solid and liquid wastes. (17)

WSDA construct LYVGWMA administrative program.

LC 3: Develop strategies for marketing the economic, fertilizer value, and soil enhancing properties of appropriate application of manure and other livestock wastes. (18)

<u>Producers</u> should:

LC 4: Make capital improvements. (2)

Install liners in liquid waste storage lagoons. Install impervious surfaces beneath silage storage.

<u>Washington State University</u> should:

LC 5: Continue research of water management with application of agricultural nutrients. (25)

Develop water sorption graph or chart. List volumes of water applied, soil types, infiltration rates, water holding capacity, absorption/compaction rates, depths to water, pre-season and post-season appropriate moisture levels, evapotranspiration rates.

<u>Washington State University</u> and <u>Producers</u> should collaboratively:

LC 6: Integrate use of animal waste and synthetic fertilizer. (23)

<u>Research</u> chemical integration of animal waste and synthetic fertilizers with objective of balancing nutrient application amounts in order to maximize crop production and full nitrogen uptake.

<u>US Department of Energy</u> and <u>US Department of Agriculture</u> should collaboratively:

LC 7: Explore investment in animal and agricultural waste to energy technology. (22)

Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives).

WA Department of Agriculture and Washington State University should collaboratively:

LC 8: Quantify the nutrient value and rate of release of nitrate from livestock waste under various Lower Yakima Valley conditions to become part of nutrient management guidelines. (19)

Washington Conservation Commission should:

LC 9: Identify and support opportunities, including education research institutions for private, public and industry investment in technology and management of fertilizers and manures, including separation of solid and liquid wastes. (26)

South Yakima Conservation District, WA Department of Agriculture, Washington State University, Private Industry and Producers should collaboratively:

LC 10: Educate producers regarding application of nutrients at Agronomic Rate. (30)

Develop technologies and provide information about improvements made in nutrient management and agronomic rate application of fertilizer by specific developing technologies.

Recommendations for Irrigated Agriculture and Livestock CAFO Together

Washington Conservation Commission, WSU Extension Service, WA Department of Agriculture, Department of Ecology, Yakima County, South Yakima Conservation District and Ag Industry Associations should collaboratively:

IALC 1: Develop a post-GWAC agricultural producer education and outreach campaign. (36)

Create a broad-based advocacy group (e.g., regulatory agencies, AG industry associations such as the Farm Bureau, Dairy Federation, hop growers, wine grape growers and producers) to carry out the educational components. Create a central repository (e.g., website) of agricultural information that provides technical assistance to growers and producers, provides education on nitrate, and identifies BMPs specific to each local agricultural industry. Address consequences of too much irrigation. Technological improvements in irrigation that permit easier management of water. Descriptions of specific improved technology. Economic viability of technological advancements BMP implementation, irrigation water management, soil nutrient management and manure management and application.

Elements could include: encourage commodity groups to provide education on water management and fertilizer use through regular meetings; distribute information to producers on what can happen with applied nitrogen, what should be applied and reasonable, agronomic rates of application; encourage agencies and subject matter experts to make presentations at trade shows; ask agricultural consultants to share the latest BMP developments with their clients; increase livestock operators' awareness of the need for procedures for proper management of animal wastes and wastewater; provide producers with information on funding sources (e.g., industry, government, educational institutions, industry associations etc.) that will improve their ability to apply BMPs; enlist partners (Farm Bureau/federations/ associations) to host workshops/ informational meetings regarding GWMA goals and recommendations.

Washington Conservation Commission should:

IALC 2: Fund SYCD, through State Conservation Commission budget, for projected educational, administrative, nutrient management planning, engineering, cost share, and lending activities. (39)

South Yakima Conservation District and Washington Conservation Commission should collaboratively:

IALC 3: Establish a local forum for disseminating information and facilitating technical exchange regarding best management practices (BMPs) for irrigated agriculture and livestock management and groundwater protection. (36)

Prepare a fact sheet/develop outreach campaign to growers that explains agronomic rates, applying nutrients at the right time/right place/right amount. Endorse and distribute materials that will educate producers about the facts related to all fertilizer types, including livestock waste and the science of groundwater protection.

WA Department of Agriculture and South Yakima Conservation District should collaboratively:

IALC 4: Inform farmers of those BMPs prioritized by Livestock/CAFO and Irrigated Agriculture Work Groups to reflect greatest effectiveness in nitrate reduction. (25)

Focus implementation of BMPs based on information and data included in the Nitrogen Availability Assessment, Soil Sampling Program, Ambient Groundwater Monitoring Plan, USGS Reports, and other similar scientifically based publications. GWMA: Publish lists as appendices to GWMA Program. WSDA: Adopt regulations listing Lower Yakima Valley GWMA-specific BMPs; Determine who implements each BMP and who monitors it. Determine the time frame in which to measure/monitor each BMP. SYCD: provide farmer-specific consultation.

IALC 5: Encourage appropriate use of surface banding ("dribbling," "stripping" of liquid fertilizer, "broadcasting" or prompt incorporation of manures and fertilizers after application to cropland. (18)

Broadcast is effective for corn, alfalfa, triticale. Incorporation should occur within 24 hours.

IALC 6: Continue to provide underlying soils information to individual livestock operations, provide same for all irrigated agriculture. (25)

So that individual property owners can evaluate contamination potential, already in DNMP process.

Data Collections, Characterization, Monitoring

Department of Ecology, Yakima County and Yakima Health District should collaboratively:

DATA 1: Establish or maintain ongoing, extended funding necessary for the Yakima County Department of Public Services and the Yakima Health District to actively participate in water quality improvement, testing, monitoring, scientific data analysis, and infrastructure development. (35)

Collect data to track water quality improvement progress and nutrients generated, applied, or exported within the LYV GWMA. Generate data through soil testing, Ambient Groundwater Monitoring Plan implementation - including purpose built and existing wells, sampling of liquid and solid waste to be field applied, composted, or exported, the CAFO General Permit, and tracking nutrients applied by non-dairy operations. Collect, analyze, and interpret data to track water quality improvement progress, nutrients imported, generated, applied, or exported, which will inform the implementation of an Adaptive Management Plan within the LYV GWMA.

<u>South Yakima Conservation District</u> and <u>WA Department of Agriculture</u> should collaboratively:

DATA 2: Monitor changes occurring in agricultural operations. Evaluate whether those changes positively affect improvement in groundwater quality. (25)

Requires cooperation of producers & landowners, multi-year effort to account for crop rotation, dry vs. wet years, changing technology, decades to monitor groundwater quality change. WSDA: prepare report to Legislature and Department of Ecology.

<u>Yakima County</u> should:

DATA 3: Adopt and Implement an Adaptive Management Plan. (22)

Utilizing data collected, progress made, or lack of progress, to inform the community on adjustments that need to be implemented. Plan would incorporate necessary adjustments to availability of technology, education and outreach, tracking exports, land use regulations, treatment systems, and other changes to inform decision makers regarding management changes necessary for a successful Program.

<u>South Yakima Conservation District</u> should:

DATA 4: Establish a multi-year Deep Soil Sampling Program where farmers subscribe for a duration with pre-determined fiscal remuneration for completed sampling. Cost share with farmer. Farmer to provide checklist indicating performance with BMPs. Test throughout growing year, in order to observe effects of fertilization throughout year. Share data with public. (25)

Farmers would subscribe for a duration with pre-determined fiscal remuneration for completed sampling. Cost share with farmer. Farmer would provide checklist indicating performance with BMPs. Testing would occur throughout growing year, in order to observe effects of fertilization throughout year. Data grossly accumulated would be shared with public without attribution to individual farmers. Anecdotal results of deep soil sampling carried out by SYCD with farmers with pre-existing relationship with SYCD were informative. Word-of-mouth reporting within farmer community greatly increased acres sampled.

Department of Ecology should:

DATA 5: Analyze the trends of nitrate data contained within reports required by NPDES and SWD permits. (23)

Department of Ecology and WA Department of Health should collaboratively:

DATA 6: Establish time-based performance objectives against which well-monitoring data can be compared. (16)

E.g., number of at risk wells, BMP implementation, funding success, reduction in number of underperforming farming practices. Use both method-based measurement and performance-based measurement.

Yakima County should:

DATA 7: Install Ambient Groundwater Monitoring Wells. (42)

Monitoring well construction: Monitoring well data collection:

Yakima Health District should:

DATA 8: Collect data from Ambient Groundwater Monitoring Wells. (42)

Study short-term seasonal variations in nitrate concentrations over next year or two--addresses effects of changes in nutrient application over the agricultural cycle. Study long-term trends that develop over several years--to track whether time-based performance objectives are being met.

Roza-SVID Joint Board of Control should:

DATA 9: Monitor nitrate concentrations of irrigation water at headgates. (35)

Report nitrate concentrations annually to Department of Ecology.

Yakima County should:

DATA 10: Contract with USGS to collect data from water well system per 2017. (28)

DATA 11: Contract with USGS to do particle tracking model study to indicate where groundwater moves faster (permeability). (9)

USGS Particle Tracking Model Overview--potentially combined with MT3D MODFLOW application to the vadose Zone.

WA Department of Agriculture, Department of Ecology and Yakima County should collaboratively:

DATA 12: Assess Nitrogen Loading. Building from the WSDA's Nitrogen Availability Assessment, develop a Nitrogen Loading Assessment for all agricultural, residential and commercial properties, using newly collected data. (5)

Hire a technical consultant to conduct a literature review to determine the most relevant information and accurate factors for use in the Nitrogen Loading Assessment. Periodically repeat the grower survey used in the NAA to compare against currently established data. Collect data on how many acres in the GWMA are fertilized in various crops with manure and/or commercial fertilizer. Update and monitor the percentage of acreage in various crops, particularly silage corn and field corn. Study effect nitrogen contribution from cover crops. Determine acreage for triticale. Discover commercial fertilizer tonnage for Yakima County and/or for GWMA. Explore how much nitrogen leaches into groundwater from drains and wasteways. Study atmospheric deposition more comprehensively. Understand the difference between plant uptake and plant removal of nitrogen. Ask EPA to use its CMAQ model, or other tools, to estimate emissions of reactive nitrogen - gaseous nitrogen oxides (NOx), ammonia (NH3), nitrous oxide (N2O), the anion nitrate, NO3,- from animal agriculture, manure and fertilizer applications.. Use this to inform the nitrogen balance data base and refine estimates of atmospheric deposition.

Regulatory Framework

Environmental Protection Agency, WA Department of Agriculture and Department of Ecology should collaboratively:

REG 1: Streamline current regulatory enforcement activities. (25)

Improve customer service and protocols, increase clarity of process, escalate enforcement for facilities not following management practices, identify methods to discourage repeatedly unfounded complaints, and improve overall transparency.

Department of Ecology should:

REG 2: Inspect, monitor and regulate stockpiled manures. (1)

Coordinate with WSDA. Currently being done; currently required as part of dairy nutrient management plans.

REG 3: Review applications for and issue exemptions for agricultural composting operations in a manner that protects public health and the environment, as required by state rules and regulations. (12)

REG 4: Provide assistance to local departments of health regarding the regulation of agricultural composting operations. (7)

WA Department of Agriculture should:

REG 5: Document and publish regulatory compliance for dairies within the GWMA that are completing and implementing Dairy Nutrient Management Plans (DNMP). (7)

Explore the possibility of disclosing non-proprietary data produced through the DNMP process. Summarize the DNMP reporting and provide information that would disclose the amount of manure the CAFO's in the GWMA create and where it is distributed.

Yakima Health District should:

REG 6: Issue permits for agricultural composting operations, to appropriately inspect composting operations and to enforce regulations that protect public health and the environment, per WAC 173.350.040. (4)

REG 7: Require new developments outside towns to address potential impacts on groundwater quality. (19)

Work with Yakima County Planning and Building Divisions' permit program to identify methods of permitting while reducing impacts to groundwater.

Yakima County should:

REG 8: Require new developments to address potential impacts on groundwater quality. Limit new development utilizing septic system where soil filtration rate is high, where housing density is already big, where nitrate concentration is already great downstream of the septic plume. Consider the nitrate density element (# of systems per-area) when approving proposed septic systems in order to reduce the nutrient nitrogen in domestic wastewater discharged from OSS. (15)

Recommendations for conditions on issuance of building permits. Determine "density" evaluation criteria. Including those technologies verified by the U.S. EPA's Environmental Technology Verification Program: fixed film trickling filter biological treatment, media filter biological treatment, and submerged attached-growth biological treatment. Recommend use of anaerobic digestion in waste storage lagoons as a best management practice.

South Yakima Conservation District and Ag Producers should collaboratively:

REG 9: Develop and implement Nutrient Management Plans for all farmers. (19)

Mandatory or Voluntary. Farming operations currently are not required to hold permits or a prepare a Nutrient Management Plan.

WA Department of Agriculture should:

REG 10: Amend the Dairy Nutrient Management Act to extend WSDA's authority to manure application on properties other than those owned by dairies, provide more complete disclosure of Nutrient Management Plans. (8)

Draft Recommendations Obtaining a Total Value of Zero or Less

The Washington Legislature should.

Make shallow (1, 2, 3 foot) soil testing reports prerequisites for funding, lending or building permits. (0)

In the nature of Phase I Environmental Audits. Makes nitrate-related information / data available for water quality management.

WA Department of Health should.

Revise WAC 246-203-130 (keeping of animals) (-1)

So that it includes specific and enforceable requirements designed to protect health.

WA Department of Ecology should.

Require facility process improvements in waste treatment and food processing plants to reduce nitrogen and total discharge volume. (-3)

Addressed by Department of Ecology General Permit for Food Processing, specific problems can be addressed through "special protection areas," WAC 173-200-090.

WA Department of Ecology and WA Department of Agriculture should.

Improve composting regulations (statutory) (-4)

Unclear as to particular regulations proposed.

WA Department of Agriculture should.

Establish a monitoring system for compliance with NRCS Standard 317 on new composting facilities at Washington dairies (phased in for existing facilities). (-4)

WA Superintendant of Public Instruction and Educational Service District 105 should.

Develop educational materials that could be elected by instructors at 8-12 levels about aquifer protection, groundwater and best management practices. (-6)

The Washington Legislature should.

Require commodity commissions to dedicate "check off" money for research and development in water quality technology and practices. (-7)

WA Department of Ecology, Yakima Regional Clean Air Agency and WA Department of Agriculture should.

Estimate emissions of reactive nitrogen—gaseoous nitrogen oxides (NO_x), ammonia (NH_3), nitrous oxide (N_2O), the anion nitrate (NO_3)—from animal agriculture, manure and fertilizer applications in the Lower Yakima Valley. (-33)

Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.

WA Department of Ecology and U.S. Environmental Protection Agency should.

Study the relationship between nitrogen emissions and atmospheric deposition of reactive nitrogen. (-37)

Develop a model that predicts what percentage of emissions return to the GWMA area as atmospheric deposition.

Implementation Work Plans

Parties Responsible for Implementation of the Recommended Actions

The parties responsible for implementation of the recommended actions include:

- Yakima County
- Washington State Department of Ecology
- Washington State Department of Agriculture
- Washington State Department of Health
- Washington State Conservation Commission
- South Yakima Conservation District
- Washington State University Extension Service
- Agricultural Producers

The LYVGWMA did not develop a ”detailed work plan for implementing each aspect of the groundwater management strategies as presented in the recommendations section” as recommended by the general framework guidelines listed in WAC 173-100-100

Yakima County as “Lead Agency”

The LYVGWAC recommended by a vote of 14-1, 1 abstention, 1 not voting, at the May 17, 2018 meeting that Yakima County act as “lead agency” in future Lower Yakima Valley groundwater management programs. The County’s activity as lead agency would be subject to available funding from the State of Washington.

As the Lower Yakima Groundwater Management Area’s Lead Agency, Yakima County may perform any of the following functions, subject to available funding:

- Seek and administer funding for the accomplishment of recommendations made by the final GWMA Program.
- Encourage the Washington State Departments of Ecology, Agriculture and Health, the Yakima Health District, the South Yakima Conservation District, and Washington State University to perform those activities recommended by the final GWMA Program.
- Host the GWMA website. Maintain a GIS data base on the GWMA.

- Participate in educational activities in partnership with the South Yakima Conservation District, Departments of Ecology, Agriculture or Health in a manner consistent with GWMA recommendations.
- Install ambient groundwater monitoring wells and arrange for data collection from those wells.
- Collect data to track water quality improvement progress and nutrients generated, applied, or exported within the GWMA.
- Describe the characteristics or volume of groundwater.
- Analyze nitrogen availability periodically, at least equivalent to WSDA 2018, in order to compare and contrast changes over time.
- When appropriate, call upon citizen involvement in decision making.
- Report at least triennially on the status of groundwater quality within the LYGWMA.
- Recommend strategies to the Yakima County Commission, Ecology, Agriculture consistent with the GWMA Program, by which to mitigate adverse effects to groundwater quality within the GWMA.
- Develop and implement an Adaptive Management Plan within the GWMA.

Schedule For Implementation Of The Recommended Actions

Those recommendations based upon the implementation of best management practices by agricultural producers should begin immediately.

Those recommended actions that depend upon the availability of public funding will likely require one-two years' lead time to secure that funding prior to their implementation.

Those recommended actions that collect data over time, including the proposed Ambient Water Quality Monitoring Well Program, or voluntary Deep Soil Sampling Program, will be implemented over a multi-decade time span.

Monitoring System For Evaluation Of Effectiveness Of Recommended Action

The Ambient Water Quality Monitoring System is intended to be comprised of at least 30 randomly placed, water-table elevation groundwater quality monitoring wells. Data from these wells will be collected sufficiently often to track seasonal variation and general water quality over time.