Public Services

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VERN M. REDIFER, P.E., Director

September 7, 2018

David Bowen
Department of Ecology, Central Region Office
1250 West Alder Street
Union Gap, WA 98903

Re: **Lower Yakima Valley GWMA - 2018 Second Quarter Report (IAA No. C 1200235)**

Dear David:

Enclosed please find one (1) copy of Yakima County's second-quarter report as required under Attachment A, Statement of Work, Agreement No. C 1200235 between the State of Washington Department of Ecology and Yakima County.

This report addresses deliverables 1.1 and 2.2 as required under the agreement.

Deliverable 2.1, invoices, was sent separately.

If you have any questions, please let me know.

Thank you.

Lisa H. Freund, Administrative Manager
Yakima County Public Services

enclosure

IAA No. C 1200235 – Second Quarter 2018 Report
Lower Yakima Valley GWMA
June 30, 2018

TASK 1 - ADMINISTRATIVE FUNCTIONS
DELIVERABLES

1.1 Meeting Records

For each meeting of the GWAC, submit a copy of the agenda, minutes, attendance and public meeting notice at the end of each quarter.

Attachment [A] includes the final GWAC meeting summaries of April 5, May 3, May 17, and June 21, 2018. No working groups met in this quarter.

TASK 2 - PROGRAM FUNCTIONS
DELIVERABLES

2.2 Status Report

Submit written quarterly status reports summarizing GWAC plans, activities and work products, and describing any interlocal agreements or other contracts by the end of each quarter.

The GWAC held four meetings in the second quarter. The April 5 meeting was held in Yakima; the remaining meetings were held in Sunnyside.

GWMA Program Development. In this quarter the GWAC completed its work on the Alternatives section of the draft GWMA program, reviewed and submitted comments to the second and third Program drafts, and received updates on the Ambient Monitoring Network. The group also discussed and made a recommendation regarding a lead agency for the implementation stage of the Program.

At the April 5 meeting, the group heard from the Data Working Group, which met in March to listen to two sets of analyses of the deep soil sampling. Ginny Stern (DOH hydrogeologist, retired) agreed to compile the most compelling information from both analyses. In the March meetings it was determined that future discussions would deal with how best to use that analyses as part of an education and outreach campaign, and to identify areas that needed future study. On April 5, the GWAC was asked whether a formal deep soil sampling study should be included on the list of GWAC strategies; however, no decision was made by the group.

USGS Update. Also on April 5, the group was presented with information USGS gathered in 2017 from its monitoring wells in the Lower Yakima Valley. USGS field crews collected 891 valid samples from 156 sites. 179 of the samples (20.1%) exceeded 10 mg/L of nitrates, and 40 of the sites (25.6%) exceeded 10 mg/L at least once. 131 of the samples were below the detection limit, 27 came up with no data, and 18 were rejected. In response to member questions, the group learned that 38 participants in the GWAC's High Risk Well Assessment surveys had volunteered for the USGS survey. It was hoped that USGS would also perform the analysis of the PGG wells.

The full report titled "Concentrations of Nitrate in Drinking Water of the Lower Yakima Basin, Yakima County Washington" by Raegan Huffman can be viewed here: **https://pubs.er.usgs.gov/publication/ds1084**.

At the May 3 meeting, the group was encouraged to continue submitting comments to the Program draft 2. The group learned that the analysis of alternatives and recommendations was continuing, with agencies tasked to gather cost estimates for each potential recommendation. Members were asked to review and rank the recommendations.

Nine maps of the GWMA were shared, with the purpose of including the maps in the final GWMA program, without drawing conclusions from them.

The GWMA Program implementation lead entity was discussed. Suggestions ranged from Department of Ecology, to the South Yakima Conservation District, WSU Extension, and Yakima County. Commissioner Elliott was asked to explore lead entity status with the County Commission. On May 17 Commissioner Elliott reported that he had had a preliminary conversation with the Commission about assuming the role of the lead entity, and discovered a willingness to do so provided they understood what those responsibilities would entail. The GWAC took a vote on the preferred lead agency and 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.

Polling Results on Draft Recommendations. The group discussed the polling recommendations and how to prioritize them. A motion was made to recommend positive-scored items, prioritized according to their scores. A vote was taken, with the majority voting 'yes' to this proposal.

At the June 21 meeting, the group discussed the status of the ambient groundwater monitoring network results. The group also discussed the remaining program budget, including the cost to fund the SEPA review and public participation related to that review. A larger concern was finding a long-term funding source for the ambient well monitoring and analysis of the results.

The "2018_0405 MASTER GWMA Strategies 1-29-18 vmr (with comments)," the May 5, 2018 Groundwater Management Area Program Maps, the "GWMA Program Vote Tally," and the "5.17.18 Voting Appendix" are included as Attachment [B].

Consideration/Approval of Program. Edits and additions to the Program (draft 2) were introduced at the June meeting. The group learned that volume 1 would need to be edited in at least two respects: the WSDA had released its final draft Nitrogen Availability Assessment (NAA) earlier that same day; and Ginny Stern offered to write a summary of the deep soil sampling results, an introduction to an appendix containing the analyses of the results, and analysis of historical data.

At the June meeting, the group discussed whether they wished to vote on accepting draft 2 of the GWMA program. The group was also asked how they wished to proceed on allowing members to submit minority reports. A couple of options were mentioned such as submitting them before SEPA review, or including them as minority reports during the SEPA process. No final decision was reached regarding the submittal of minority reports. Regarding the draft program, the committee sent it back for further edits, with a tentative plan to review and approve it in July.

Attachment [C] includes WSDA's June 2018 "Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area," the "2018_0621_Edits_Additions to Draft 2 of GWMA Program," and the Lower Yakima Valley Groundwater Management Program Volumes I and II drafts reviewed by the GWAC on June 21, 2018.

Working Group Activities

No working groups met in the second quarter.

GWMA Website

The GWMA website continued to be updated in real time.

Contracts and Interlocal Agreements

The Amendment to the Joint Funding Agreement for Water Resources Investigations between the USGS and Yakima County, extending the end date to September 30, 2018, was signed on April 10, 2018.

The amendment is included as Attachment D.

Attachment A

- Final GWAC meeting summary of April 5, 2018
- Final GWAC meeting summary of May 3, 2018
- Final GWAC meeting summary of May 17, 2018
- Final GWAC meeting summary of June 21, 2018
- GWAC agenda and public meeting notice for April 5, 2018
- GWAC agenda and public meeting notices for May 3, 2018
- GWAC agenda and public meeting notices for May 17, 2018
- GWAC agenda and public meeting notices for June 21, 2018
- GWAC attendance roster record for April 5, May 3, May 17, and June 21, 2018
- There were no Working Group meetings for the 2nd Quarter

YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA ADVISORY COMMITTEE (GWAC)

MEETING SUMMARY

Thursday, April 5, 2018 – 5:00 p.m. – 7:00 p.m.

Yakima County Roads Maintenance Conference Room
1216 South 18th Street, Yakima, WA 98901

Note: This document is only a summary of issues and actions of this meeting. It is not intended to be a transcription of the meeting, but an overview of points raised and responses from Yakima County and Groundwater Advisory Committee members. It may not fully represent the ideas discussed or opinions given. Examination of this document cannot equal or replace attendance.

I. Call to Order: This meeting was called to order at 5:01 PM by Vern Redifer, Facilitator.

Member	Seat	Present	Absent
Stuart Turner	Agronomist, Turner and Co.,	✓	
Chelsea Durfey			✓
Bud Rogers	Lower Valley Community Representative Position 1	✓	
Kathleen Rogers	Lower Valley Community Representative Position 1 (alternate)	✓	
Patricia Newhouse	Lower Valley Community Representative Position 2		✓
Sue Wedam	Lower Valley Community Representative Position 2 (alternate)		✓
Doug Simpson	Irrigated Crop Producer		✓
Jean Mendoza	Friends of Toppenish Creek	✓	
Eric Anderson	Friends of Toppenish Creek (alternate)		✓
Jan Whitefoot	Concerned Citizens of the Yakama Reservation		✓
Jim Dyjak	Concerned Citizens of the Yakama Reservation (alternate)	✓	
Steve George	Yakima County Farm Bureau	✓	
Frank Lyall	Yakima County Farm Bureau (alternate)	✓	
Jason Sheehan	Yakima Dairy Federation	✓	
Dan DeGroot	Yakima Dairy Federation (alternate)	✓	
Ron Cowin	Roza-Sunnyside Joint Board of Control	✓	
	Roza-Sunnyside Joint Board of Control (alternate)		
Laurie Crowe	South Yakima Conservation District		✓

Rodney Heit	South Yakima Conservation District (alternate)		✓
John Van Wingerden III	Port of Sunnyside	✓	
Rand Elliott	Yakima County Board of Commissioners	✓	
Vern Redifer	Yakima County Board of Commissioners (alternate)	✓	
Myers, Holly	Yakima Health District		✓
Ryan Ibach	Yakima Health District (alternate)	✓	
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center		✓
Lucy Edmondson	U.S. Environmental Protection Agency		✓
Nick Peak	U.S. Environmental Protection Agency (alternate)		✓
Elizabeth Sanchey	Yakama Nation		✓
Stuart Crane	Yakama Nation (alternate)	✓	
Gary Bahr	WA Department of Agriculture	✓	
Perry Beale	WA Department of Agriculture (alternate)		✓
Andy Cervantes	WA Department of Health	✓	
Sheryl Howe	WA Department of Health (alternate)		✓
David Bowen	WA Department of Ecology	✓	
Sage Park	WA Department of Ecology (alternate)		✓
Lino Guerra	Hispanic Community Representative	✓	
Rick Perez	Hispanic Community Representative (alternate)		✓
Jessica Black	Heritage University		✓
Alexander V. Alexiades	Heritage University (alternate)	✓	
Matt Bachmann	USGS	✓	

II. Welcome, Meeting Overview and Introductions: After the customary introductions, Vern reviewed the Agenda. There was no additional business.

III. Working Group Reports: David Bowen reported on the Data Working Group on behalf of Chair Melanie Redding. The Data group had met twice in March to listen to two sets of analyses of the deep soil sampling, one performed by Melanie Redding, the other by Jean Mendoza. Ginny Stern had agreed to compile the most compelling information from both documents. Future discussions will deal with how best to use this information as part of an education and outreach campaign, and to identify areas in need of future study.

A member referred to the line in the deep soil sampling contract that referred to a project director, and asked who that person was. Vern replied that there was nobody with the formal title of "project director", but that since he had compiled the data as it came in, it was probably him.

A member asked Vern if he wanted cost estimates on a future deep soil sampling program. Following the 3/29 Data meeting, the member had talked with people at WSU about the subject. He reported they had expressed an interest, but that further discussions would be necessary. Jim Davenport asked the group whether a formal deep soil sampling study should be included on the list of GWAC strategies. Some group members wanted more time to discuss the idea, how it might be structured, who might conduct it, whether there should be incentives for people to participate, and other questions that may come up before putting it on the list.

IV. USGS Update: Matt Bachmann presented the group with the information USGS had gathered in 2017 from its monitoring wells in the Lower Valley. The information is publicly available online at the USGS website. A report on the matter titled "Concentrations of Nitrate in Drinking Water of the Lower Yakima Basin, Yakima County Washington" by Raegan Huffman will be made public once clearance is granted from Washington, D.C.

In summary, USGS field crews collected 891 valid samples from 156 sites. 179 of the samples (20.1%) exceeded 10mg/L of nitrates, and 40 of the sites (25.6%) exceeded 10 mg/L at least once. 131 of the samples were below the detection limit, 27 came up with no data, and 18 were rejected. The crews had started gathering samples in April. Nitrate levels had gradually gotten lower over the spring and summer, and then jumped in October. Matt hypothesized this was most likely due to the start of the rainy season, although a group member suggested that plants taking up less nitrogen during the winter might be an explanation. Other group members discussed what role canal leakage might play during the irrigation season. Since the samples had been taken after the irrigation season started, there wasn't a base of information for early 2017 for comparison. A suggested area for future study may include placing wells adjacent to irrigation canals to see if nitrate levels showed significantly different variations than others over the course of the year.

A member asked whether any of the wells in the Yakima Health District's high-risk well assessment had been part of the USGS's work. Matt replied that 38 people on the YHD's list had volunteered to have their wells sampled. As for the PGG wells that have not been drilled yet, USGS will hopefully performing analysis of them. The County is currently trying to get a contract extension so this can happen.

Another member asked for more information on two outlier wells that consistently showed nitrate levels around 40 mg/L. One was 227 feet deep and was an open hole well. The other was 102 feet deep and open end. The wells were not adjacent to each other, and had a lot of low-testing wells in between them, so the anomalous results were most likely due to factors unique to the site.

V. Proposed Alternatives: Jim Davenport reminded the group that he needed agency cost estimates of the various strategies for lowering nitrate levels in order to set a priority list for the GWAC to recommend. He stated his intention to start buttonholing agency representatives in order to get their numbers. David Bowen volunteered that he had his 17 categories done, and agreed to meet in the near future.

Jim turned the floor over to Lower Valley Community Representative Kathleen Rogers, who showed the group pictures of manure that had fallen off trucks owned by a nearby dairy onto the road by her house, and spoke of her difficulties in resolving the situation with the dairy, and the Yakima County Roads Maintenance and Sheriff's Office. She expressed skepticism that any list of recommended best management practices could be translated into actions. Kathleen also asked why the GWAC had stopped meeting in the Lower Valley, since this is where most citizen representatives on the GWAC lived, and would be more convenient for members of the public to attend. Vern and Jim pledged to address the issue.

VI. GWMA Program Update/Member Comments: Jim informed the group that he had received some comments on the 2nd Draft of the GWMA program, and asked for more within the next ten days. The data section had still not been written, pending analysis of the available information.

The group discussed a member's concerns about the absence of a Problem Statement in the draft. Jim had received the member's concerns, and intended to add a brief section to the program summarizing the information already contained in the report. Discussion ensued on whether it was appropriate for the Problem Statement to include a delineation of which sectors were contributing the most towards the problem, or whether it was adequate to state that the problem was nitrate levels in excess of EPA standards. Some members felt a statement without estimated contribution levels would lead to a meaningless report. Others felt the problem was stated adequately in the reports long descriptions of the various agricultural and domestic sources of nitrates and the laws governing their disposal. Others felt that attempting to describe which groups contributed what would hinder the report's effectiveness, and the ability of a successor agency to move forward in cooperation with the Lower Valley agricultural community.

VII. **Monitoring Well Contract:** Vern stated that the PGG ambient network contract was about ready to go out to bid, pending some utility locates. He invited group members to come along to observe the drilling sites, and intended to get a map of the well drilling sites to members by the next day. Assuming there was enough money left in the GWMA's budget, he estimated they would be able to install 30 wells. Details about the timeline for installation were contingent upon when the contract went out.

VIII. **Committee Business:** Approval of the March 1 GWAC summary was tabled for the next meeting.

IX. **Public Comment:** A member requested that the next GWAC meeting be held in the Lower Valley. Vern agreed, and stated that from now on, meetings should be held in Sunnyside or Granger unless there was a good reason otherwise. Another member objected to some of the terminology used during the meeting in describing efforts to identify and quantify the sources of nitrates in the Lower Valley's groundwater, stating this information was necessary in order to reach effective solutions. Another member posited that trying to delineate which commodities contributed what amount would cause its own problems, since any data or data-source could be suspect, and if certain groups felt targeted by the GWMA, they would be unlikely to offer cooperation to the GWMA in solving the problem.

X. **Next Meeting:** May 3, 2018.

XI. **Next Steps**: 1) Members will supply Jim Davenport with comments on the 2nd Draft GWMA program within the next 10 days. 2) Vern will supply group members with maps of the PGG well drilling sites.

XII. **Meeting Summary** approved by the GWAC on May 3, 2018.

YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA ADVISORY COMMITTEE (GWAC)

MEETING SUMMARY

Thursday, May 3, 2018 – 5:00 p.m. – 7:00 p.m.

Denny Blaine Boardroom, Sunnyside School District
810 E Custer Ave, Sunnyside WA 98944

Note: This document is only a summary of issues and actions of this meeting. It is not intended to be a transcription of the meeting, but an overview of points raised and responses from Yakima County and Groundwater Advisory Committee members. It may not fully represent the ideas discussed or opinions given. Examination of this document cannot equal or replace attendance.

I. Call to Order: This meeting was called to order at 5:06 PM by Jim Davenport, facilitating in Vern's absence.

Member	Seat	Present	Absent
Stuart Turner	Agronomist, Turner and Co.,		✓
Chelsea Durfey			✓
Bud Rogers	Lower Valley Community Representative Position 1	✓	
Kathleen Rogers	Lower Valley Community Representative Position 1 (alternate)	✓	
Patricia Newhouse	Lower Valley Community Representative Position 2		✓
Sue Wedam	Lower Valley Community Representative Position 2 (alternate)		✓
Doug Simpson	Irrigated Crop Producer		✓
Jean Mendoza	Friends of Toppenish Creek	✓	
Eric Anderson	Friends of Toppenish Creek (alternate)		✓
Jan Whitefoot	Concerned Citizens of the Yakama Reservation		✓
Jim Dyjak	Concerned Citizens of the Yakama Reservation (alternate)	✓	
Steve George	Yakima County Farm Bureau	✓	
Frank Lyall	Yakima County Farm Bureau (alternate)	✓	
Jason Sheehan	Yakima Dairy Federation	✓	
Dan DeGroot	Yakima Dairy Federation (alternate)	✓	
Ron Cowin	Roza-Sunnyside Joint Board of Control	✓	
Laurie Crowe	South Yakima Conservation District	✓	

Rodney Heit	South Yakima Conservation District (alternate)		✓
John Van Wingerden III	Port of Sunnyside		✓
Rand Elliott	Yakima County Board of Commissioners	✓	
Vern Redifer	Yakima County Board of Commissioners (alternate)		✓
Holly Myers	Yakima Health District	✓	
Ryan Ibach	Yakima Health District (alternate)		✓
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center		✓
Lucy Edmondson	U.S. Environmental Protection Agency	✓	
Nick Peak	U.S. Environmental Protection Agency (alternate)		✓
Elizabeth Sanchey	Yakama Nation		✓
Stuart Crane	Yakama Nation (alternate)	✓	
Bahr, Gary	WA Department of Agriculture		✓
Beale, Perry	WA Department of Agriculture (alternate)	✓	
Andy Cervantes	WA Department of Health	✓	
Sheryl Howe	WA Department of Health (alternate)		✓
David Bowen	WA Department of Ecology	✓	
Sage Park	WA Department of Ecology (alternate)		✓
Lino Guerra	Hispanic Community Representative		✓
Rick Perez	Hispanic Community Representative (alternate)		✓
Jessica Black	Heritage University		✓
Alex Alexiades	Heritage University		✓
Matt Bachmann	USGS	✓	

Welcome, Meeting Overview and Introductions: Jim informed the group that Commissioner Elliott had been delayed by car problems. The group and members of the audience gave the customary introductions.

II. **Committee Business:** The March 1 and April 5 GWAC Meeting Summaries were approved as presented.

III. **Comments on Program Draft 2:** Jim informed the group that he had received their comments on the 2nd Draft of the GWMA Program, and had incorporated many of their suggestions into the 3rd Draft. He invited members to continue sending in comments.

IV. **Status of Well Monitoring Project:** Jim updated the group as to the status of the ambient monitoring network. The bid documents to find drillers to perform the work were almost complete, and would probably be ready in a couple more weeks. Survey crews were checking each location to make sure they really were within county right-of-way as stipulated. Of the 30 sites, 28 were in country right-of-way, one was in state, and one was in the city of Grandview. Crews were also doing utility locates to make sure the well drilling didn't accidentally damage any underground lines. They were proceeding at a pace of two sites-per-day, so it would be roughly 15 working days to complete the work.

V. **Analysis of Alternatives/Recommendations:** Jim reviewed the new list of recommended alternatives. He reminded the group that the initial list had been comprised of roughly 300 items suggested by GWAC members. Each item on the list had been discussed by the group in meetings running through the latter half of 2017, and narrowed down to those items that did not receive strong objections. Jim had consolidated the list further down to 66 items, broken up into seven broad categories: Education, Administrative, Data Collection and Monitoring, Water, Public Works, Research and Development, and Agriculture.

Jim told the group he had spent the past month meeting with GWAC members – including David Bowen, Jason Sheehan, Ryan Ibach, Ginny Stern, Laurie Crowe, Perry Beale, and Gary Bahr – gathering cost estimates for each potential recommendation. Those estimates had been included in the spreadsheet of recommendations. Jim asked the group to read the spreadsheet and send him questions. He also asked members to rank each item on the list, which would be emailed to members the next day, on a scale from 3 to minus-3, and have the results in to him in a week's time.

Some members had questions about the how these recommendations might be implemented, what funding sources might be involved, and whether there was enough information available to make informed decisions. Other GWMAs had passed on the implementation duties to a new lead entity. While some short-term funding came from federal and state sources, over the long-term, funding came from local sources. Some of the projects had long-term funding costs that were difficult to project, but Jim felt rough estimates were necessary to set priorities among the different alternatives.

VI. **Lead Entity: Whether? Who? What?:** With the GWAC's mandate nearing an end, Jim shared his thoughts on what types of qualities a successor lead entity in charge of implementing the GWMA program would need. Initial dollars would need to come through legislative appropriation or a large capital budget, then contracted to other parties. A lead entity would need to have a competent management team and credibility with the local population. In

Jim's view, there clearly needed to be a lead entity in charge of carrying out these tasks, securing and directing funding, and instilling the public and existing agencies with a sense of the importance of the issue. He asked for the group's input as to who they thought should carry those responsibilities.

A member observed that an entity trying to implement a multi-faceted program would need to have a large staff to carry out the work, and suggested the Department of Ecology. Another member observed that in other GWMAs, the lead entity had always been local in nature, oftentimes the county, or a collection of counties. The representative for Ecology stated that in a perfect world, they would prefer Yakima County to take on the role. Another member suggested that the South Yakima Conservation District or WSU Extension Service would be ideal choices, since they already have existing relationships with growers and producers, and don't spend a lot of money. Another member stated that the county already had all the GWMA information in their possession, and experience with approaching legislators for money. Jim asked Commissioner Elliott if the County Board had the authority to create a lead entity. As far as he knew, the answer was yes, although further discussions about what such a lead entity would do would need to be taken with the other commissioners first. A member asked what the appropriate WACs said about forming a lead entity, stating they hadn't found anything. Jim stated that he hadn't either, although he would look again.

Jim asked the group if there was consensus that Yakima County should be the lead entity. A member objected, citing concerns with how the County had operated the GWAC. The group discussed by what process a lead entity would be named. It was the group's goal to operate by consensus, although if necessary, actions could be approved by a vote of 75 percent or more. Since the group was one vote short of a quorum, no action was taken.

VII. Correlation of Mapped Information: Jim presented the group with nine maps of the GWMA prepared by Yakima County GIS. The first map portrayed WSDA's calculations of Total Nitrogen Availability in tons-per-year. Since not all of the nitrogen sources depicted were necessarily seeping into the groundwater, members felt this map was not useful in informing the public.

The second map contained the same nitrogen availability grid, with the 156 USGS wells from 2017 overlaid on top of them. The third map depicted the USGS wells in relation to canals and drains. A member cautioned that the orange arrows on the third map had been hand-drawn by John Vaccaro, were applicable only to the shallow water table, and didn't account for three-dimensional movement.

The fourth map depicted the WSDA's 2015 crop data with the USGS 2017 wells overlaid. A member observed that corn silage emerged as a potentially high source of nitrates, given the correlation of high-nitrate wells over that crop, although there were complicating factors like groundwater movement which made it hard to argue causation.

The next two maps depicted soil infiltration rates and soil types within the GWMA, with USGS wells overlaid. The infiltration map was essentially a simplified version of the soil type map. The source for this data came from the NRCS website.

The seventh map depicted the locations of Residential Onsite Septic Systems in relation to USGS wells, and the eighth map depicted the locations of dairies, CAFOs and settling ponds in relation to the wells. Jim stated that the purpose of bringing these maps to the group was as a starting point. There was a lot going on underground that group members didn't know, so it was important to begin with what we did. It was Jim's intention to include the maps in the final GWMA program, without drawing conclusions from them. A member cautioned that people could nonetheless use these maps to make simple causative judgments that were not warranted by the facts.

The ninth and final map was a grid depicting the mean annual recharge of water within the GWMA. The data was based on a USGS Scientific Investigations Report on irrigation methods from 1959-2001 combined with rain levels, minus crop uptake. According to the data, most of the low-elevation land was recharging two to four square feet of water.

VIII. Public Comment: There was none. The meeting adjourned at 7:01 PM.

IX. Next Meeting: May 17, 2018.

X. Next Steps: 1) Members will send in any comments on the 2nd Draft GWMA Program to Jim Davenport. 2) Members will send in their votes on recommended alternatives by the end of day Thursday, May 10.

XI. Meeting Summary approved by the GWAC on May 17, 2018.

YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA ADVISORY COMMITTEE (GWAC)

MEETING SUMMARY

Thursday, May 17, 2018 – 5:00 p.m. – 7:00 p.m.

Denny Blaine Boardroom
Sunnyside School District No. 201
810 E. Custer Ave
Sunnyside, WA 98944

Note: This document is only a summary of issues and actions of this meeting. It is not intended to be a transcription of the meeting, but an overview of points raised and responses from Yakima County and Groundwater Advisory Committee members. It may not fully represent the ideas discussed or opinions given. Examination of this document cannot equal or replace attendance.

I. Call to Order: This meeting was called to order at 5:06 PM by Jim Davenport, Facilitator.

Member	Seat	Present	Absent
Stuart Turner	Agronomist, Turner and Co.,		✓
Chelsea Durfey	Turner and Co. (alternate)		✓
Bud Rogers	Lower Valley Community Representative Position 1	✓	
Kathleen Rogers	Lower Valley Community Representative Position 1 (alternate)	✓	
Patricia Newhouse	Lower Valley Community Representative Position 2	✓	
Sue Wedam	Lower Valley Community Representative Position 2 (alternate)		✓
Doug Simpson	Irrigated Crop Producer	✓	
Jean Mendoza	Friends of Toppenish Creek	✓	
Eric Anderson	Friends of Toppenish Creek (alternate)		✓
Jan Whitefoot	Concerned Citizens of the Yakama Reservation		✓
Jim Dyjak	Concerned Citizens of the Yakama Reservation (alternate)	✓	
Steve George	Yakima County Farm Bureau		✓
Frank Lyall	Yakima County Farm Bureau (alternate)	✓	
Jason Sheehan	Yakima Dairy Federation	✓	
Dan DeGroot	Yakima Dairy Federation (alternate)	✓	
Ron Cowin	Roza-Sunnyside Joint Board of Control	✓	

	Roza-Sunnyside Joint Board of Control (alternate)		
Laurie Crowe	South Yakima Conservation District	✓	
Rodney Heit	South Yakima Conservation District (alternate)		✓
John Van Wingerden III	Port of Sunnyside	✓	
Rand Elliott	Yakima County Board of Commissioners	✓	
Vern Redifer	Yakima County Board of Commissioners (alternate)		✓
Myers, Holly	Yakima Health District		✓
Ryan Ibach	Yakima Health District (alternate)		✓
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center		✓
Lucy Edmondson	U.S. Environmental Protection Agency		✓
Nick Peak	U.S. Environmental Protection Agency (alternate)		✓
Elizabeth Sanchey	Yakama Nation		✓
Stuart Crane	Yakama Nation (alternate)		✓
Gary Bahr	WA Department of Agriculture	✓	
Perry Beale	WA Department of Agriculture (alternate)		✓
Andy Cervantes	WA Department of Health	✓	
Sheryl Howe	WA Department of Health (alternate)		✓
David Bowen	WA Department of Ecology	✓	
Sage Park	WA Department of Ecology (alternate)		✓
Lino Guerra	Hispanic Community Representative	✓	
Rick Perez	Hispanic Community Representative (alternate)		✓
Jessica Black	Heritage University	✓	
Alex Alexiades	Heritage University (alternate)		✓
Matt Bachmann	USGS		✓

II. Welcome, Meeting Overview and Introductions: Everyone introduced themselves. Jim reviewed the agenda – there were no additions. The group paused for a moment of silence.

III. Active GWAC Members: At the May 3 meeting, after coming up short of a quorum, members had desired to discuss who was still an active member of the GWAC. David Bowen had reviewed the attendance list in accordance with the GWAC's operating guidelines, which stated that if a member is not present for three consecutive meetings, the GWAC membership can ask that member to be replaced with another representative for their group, or removed from group membership altogether. As of the May 17 meeting, Dr. Troy Peters was in this position.

Jim asked the group how they wished to proceed. Group members stated that they appreciated Dr. Peters' expertise and wanted him to remain a member of the group, but expressed concern that his absence was contributing to the GWAC being unable to take action on matters before it. A member proposed that Dr. Peters be kept on as a non-voting member. There was no objection from the group.

IV. Action on Recommendations for Lead Agency: Jim reintroduced the subject of who should assume the role of lead entity once the GWMA's mandate had expired. In response to a member's question at the last meeting regarding what WAC 173-100-100 said on the matter, David Bowen replied that the WAC does not specifically mandate a lead agency, but Section 6 does contain language that the GWMA's work plan shall contain an implementation section containing a detailed work plan, a monitoring system, and a process for periodic review of the work plan, which strongly implies the presence of a lead entity in order to carry out that work.

A member asked if the new lead entity would be governed by the same rules of procedure in the WAC, or whether the group would operate according to its own rules. Jim's interpretation was the latter. There were various scenarios for how a lead entity could operate, depending on who that entity was. If it was Yakima County, rules of procedure would likely be included in the resolution setting up such an entity. If a state agency were to become the lead entity, it would operate according to that agency's guidelines. Commissioner Elliott had engaged in preliminary conversations with his fellow commissioners about taking on the role of lead entity, and discovered a willingness to do so, provided they understood what those responsibilities would entail. After some discussion, a motion was made to recommend Yakima County as the lead entity to implement the GWMA program. A vote was taken as follows:

Ayes (14)

Gary Bahr – WA Department of Agriculture
Dr. Jessica Black – Heritage University
David Bowen – WA Department of Ecology
Andy Cervantes – WA Department of Health
Ron Cowin – Roza-SVID Joint Board of Control
Laurie Crowe – South Yakima Conservation District
Jim Dyjak – Concerned Citizens of the Yakama Reservation
Rand Elliott – Yakima County Commissioners

Lino Guerra – Latino Community Rep
Patricia Newhouse – Lower Valley Community Rep
Bud Rogers – Lower Valley Community Rep
Jason Sheehan – Yakima County Dairy Federation
Doug Simpson – Irrigated Ag Producer
John Van Wingerden – Port of Sunnyside

Nays (1)
Jean Mendoza – Friends of Toppenish Creek

Present (1)
Frank Lyall – Yakima County Farm Bureau

A member asked how long it would take for the Board of County Commissioners to get an answer back to the GWAC as to whether it accepted the group's recommendation. Commissioner Elliott replied that it would take a week.

V. **Results on Polling on Draft Recommendations:** At the May 3 meeting, Jim had asked members to rank the list of recommendations. Members' votes had been tabulated into a spreadsheet, with most items scoring positive, and a few garnering negative scores. Nineteen members had responded total. In two cases, both the main representative of a group and their alternate had cast votes. Only the votes of the main representative were counted, leading to 17 votes total. The handouts provided at the meeting listed only the grand totals. Some members expressed a desire to see the individual votes, and it was eventually decided to supply the list. (See attached appendix.) The group also decided that votes cast at the meeting would be recorded in the meeting summary.

Discussion ensued as to the reasons individual members had for casting votes. In some cases, members had voted negative because they disagreed with the way the recommendation was written, or because the recommended activities were already being done. One example was the recommendation to distribute educational materials about cleaning septic systems, which are already posted online by the Yakima Health District and the Washington Department of Health. Other members believed that a more aggressive outreach campaign was in fact necessary, since many families on septic systems in rural areas don't have internet access, or the knowledge of where to look for this information.

There was further discussion on which positive-scored items the group should recommend. Some members felt that everything with a positive score should be recommended, and prioritized according to their scores. Other members felt that low-scoring positive items did not enjoy consensus, and should be dropped from the list, with only high-scoring positive items recommended. A motion was eventually made to recommend all positive-scored items, prioritized according to their scores. The vote was as follows:

Ayes (12)

Gary Bahr – WA Department of Agriculture
Dr. Jessica Black – Heritage University
Andy Cervantes – WA Department of Health
Ron Cowin – Roza-SVID Joint Board of Control
Laurie Crowe – South Yakima Conservation District
Rand Elliott – Yakima County Commissioners
Lino Guerra – Latino Community Rep
Patricia Newhouse – Lower Valley Community Rep
Bud Rogers – Lower Valley Community Rep
Jason Sheehan – Yakima County Dairy Federation
Doug Simpson – Irrigated Ag Producer
John Van Wingerden – Port of Sunnyside

Nays (3)

Jim Dyjak – Concerned Citizens of the Yakama Reservation
Frank Lyall – Yakima County Farm Bureau
Jean Mendoza – Friends of Toppenish Creek

Present (1)

David Bowen – WA Department of Ecology

VI. **Reasonable Annual Groundwater Recharge Estimates:** At the May 3 meeting, Jim had distributed a map of the GWMA showing the mean annual recharge of water based on numbers contained in a 2007 USGS report. Some members felt the map exaggerated the amount of water going into the ground. The Joint Board of Control figures showed that the average farmer was using 3.5 acre-feet of water per-year. In correspondence between Jim and Matt Bachmann, Matt had agreed that there were a number of variables that could impact the recharge numbers – for example, changing crop types, irrigation practices and climate conditions – and felt that an updated study might be a worthwhile project, assuming the GWMA was willing to spend the time or funds on it. A couple of members expressed a desire to follow up on an updated report. Other members were reluctant to make a recommendation on the spot.

Committee Business: The May 3, 2018 meeting summary was approved as presented.

VII. Public Comment: There was no public comment, although a group member distributed an analysis he had performed comparing the storage capacity of septic systems vs. lagoons and settling ponds by gallons of liquid fecal matter. He felt that the septic and point-source maps distributed at the May 3 meeting should attempt to display the difference in volume.

VIII. Next Meeting: June 21, 2018.

IX. Next Steps: 1) Rand Elliott will present his fellow commissioners with the GWAC's recommendation that Yakima County should assume the role of lead entity, with the responsibility of implementing the GWMA's work plan. 2) Jim Davenport will continue to work on the GWMA program, with discussion planned for June 21.

X. Meeting Summary approved by the GWAC on August 9, 2018.

YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA ADVISORY COMMITTEE (GWAC)

MEETING SUMMARY

Thursday, June 21, 2018 – 5:00 p.m. – 7:00 p.m.

Denny Blaine Boardroom
Sunnyside School District No. 201
810 E. Custer Ave
Sunnyside, WA 98944

Note: This document is only a summary of issues and actions of this meeting. It is not intended to be a transcription of the meeting, but an overview of points raised and responses from Yakima County and Groundwater Advisory Committee members. It may not fully represent the ideas discussed or opinions given. Examination of this document cannot equal or replace attendance.

I. Call to Order: This meeting was called to order at 5:01 PM by Vern Redifer, Facilitator.

Member	Seat	Present	Absent
Stuart Turner	Agronomist, Turner and Co.,	✓	
Chelsea Durfey			✓
Bud Rogers	Lower Valley Community Representative Position 1	✓	
Kathleen Rogers	Lower Valley Community Representative Position 1 (alternate)	✓	
Patricia Newhouse	Lower Valley Community Representative Position 2	✓	
Sue Wedam	Lower Valley Community Representative Position 2 (alternate)	✓	
Doug Simpson	Irrigated Crop Producer	✓	
Jean Mendoza	Friends of Toppenish Creek	✓	
Eric Anderson	Friends of Toppenish Creek (alternate)		✓
Jan Whitefoot	Concerned Citizens of the Yakama Reservation		✓
Jim Dyjak	Concerned Citizens of the Yakama Reservation (alternate)	✓	
Steve George	Yakima County Farm Bureau	✓	
Frank Lyall	Yakima County Farm Bureau (alternate)		✓
Jason Sheehan	Yakima Dairy Federation		✓
Dan DeGroot	Yakima Dairy Federation (alternate)	✓	
Ron Cowin	Roza-Sunnyside Joint Board of Control	✓	

	Roza-Sunnyside Joint Board of Control (alternate)		
Laurie Crowe	South Yakima Conservation District	✓	
Rodney Heit	South Yakima Conservation District (alternate)		✓
John Van Wingerden III	Port of Sunnyside		✓
Rand Elliott	Yakima County Board of Commissioners	✓	
Vern Redifer	Yakima County Board of Commissioners (alternate)	✓	
Myers, Holly	Yakima Health District	✓	
Ryan Ibach	Yakima Health District (alternate)		✓
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center		✓
Lucy Edmondson	U.S. Environmental Protection Agency	✓	
Nick Peak	U.S. Environmental Protection Agency (alternate)		✓
Elizabeth Sanchey	Yakama Nation		✓
Stuart Crane	Yakama Nation (alternate)	✓	
Gary Bahr	WA Department of Agriculture	✓	
Perry Beale	WA Department of Agriculture (alternate)		✓
Andy Cervantes	WA Department of Health	✓	
Sheryl Howe	WA Department of Health (alternate)		✓
David Bowen	WA Department of Ecology	✓	
Sage Park	WA Department of Ecology (alternate)		✓
Lino Guerra	Hispanic Community Representative		✓
Rick Perez	Hispanic Community Representative (alternate)		✓
Jessica Black	Heritage University		✓
Robert Black	USGS	✓	

II. Welcome, Meeting Overview and Introductions: After the customary introductions, Vern reviewed the agenda – there were no additions. The group paused for a moment of silence.

III. Status of Ambient Groundwater Monitoring Network Results: A member expressed concerns about the number of wells the Ambient Monitoring Network (AMN) would be installing. The text of the contract contained in the 1st Quarter GWMA Report stated that 17 wells would be drilled, and possibly more depending on how much money was left over. When the concept of an AMN had initially been presented to the group, a goal of 30-40 wells had been set. *The member was concerned that an insufficient number of wells would* end up being drilled, and that one of them was located at a high elevation in Konnowac Pass that would yield low nitrate results. Vern stated that the number of wells drilled would depend on the bids submitted by contractors in the competitive bidding process, which the

County is required by law to use. There was roughly $500,000 left in the budget, which he thought would very likely fund more than 17 wells. There were aspects of the contract, such as $9,000 set aside for analyzing the results, that were no longer necessary since Melanie Redding had agreed to take on that task, thus freeing up that money. The wells were expected to be installed by the end of the year.

The member also inquired how much it would cost to fund the SEPA review of the GWMA Program and the ensuing public participation period. Vern did not know the cost of SEPA offhand, but it was far less than $10,000. David Bowen stated that the public participation period was funded out of Ecology's budget, and would not be a large expense either. A larger concern was finding a long-term funding source for continuing the wells and analyzing their results. While Ecology had enough money in their budget to continue funding for two to three months, the County was still working on finding something more permanent.

IV. **Presentation of GWMA Program/Edits and Additions to Program Draft 2:** Jim introduced Volumes 1 and 2 of the GWMA Program and a paper indicating sections that had been added to the second draft, and figures that had been moved around. Volume 1 was the main text of the program. Volume 2 contained appendices of supporting text and information. Jim indicated that portions of Volume 1 would need to be edited in at least two respects: The WSDA had released their final draft Nitrogen Availability Assessment (NAA) earlier that same day, and the old Volume 1 still referred to the earlier NAA; and Ginny Stern had offered to write a summary of the deep soil sampling results, an introduction to an appendix containing Jean Mendoza and Melanie Redding's analyses of the results, and an analysis of historical data.

A member asked what process the group would use to manage the comments that had been submitted, and would be submitted, to Jim in writing the Program. Some members had not seen some of their comments included in the latest draft of the program. Other members felt it would be too unwieldy for the group to debate every comment.

Two members expressed concerns about the third and fourth paragraphs on page vi of the Executive Summary. The third paragraph indicated that it had been difficult for the GWAC to attain consensus due to the competing interests represented on the board, and reluctance on the part of government agencies to take bold actions. The fourth paragraph stated that a lawsuit brought against several Valley dairies in late 2012, and settled in early

2015, had hampered the ability to gather a large data set of nitrogen results from farmers. Jim defended the paragraphs as being an accurate summary of what had transpired over the six years of the GWMA's operation.

Other members expressed concern that some of the GWMA maps, particularly Figures 29, 31 and 32, depicting the location of USGS drinking water wells in relation to irrigation canals and drains, manure lagoons, and septic tanks, respectively, would lead the casual reader to assume causation of high nitrate levels in the soil due to certain factors in a way that might not be supported by scientific data. Some additional text in the Program explaining those maps raised additional concerns. Jim acknowledged the concerns, and invited feedback on how to present and explain the information given the data the group had to work with.

V. **Consideration/Approval of Program:** The group discussed whether they wished to vote at the next meeting on whether to accept the new draft of the GWMA Program. A motion was made to cast a recorded vote on whether they wished to vote, but after some discussion, no vote on the matter was held.

Jim asked the group how they wished to proceed on allowing members who held views distinct from the Program to submit minority reports. At least three members were considering the possibility of submitting minority reports. There were a couple of possibilities for how those materials might be incorporated into the public record. One would be submitting them to Jim before the document was submitted for SEPA review, and including them as separate appendices to the main document. Another approach would be to submit the minority reports during the SEPA process, and include them along with all the other public comments. No final decision was reached.

VI. **Committee Business:** The May 17, 2018 meeting summary was not approved as presented. A member withheld his support until a handout he had distributed at that meeting comparing septic and manure lagoon storage levels was included as an attachment.

VII. **Public Comment:** There were no public comments.

VIII. **Next Meeting:** July 19, 2018.

IX. **Next Steps**: Members will send Jim Davenport their comments on the latest draft of the GWMA program by July 5.

X. The meeting summary was approved by the GWAC on August 9, 2018.

LOWER YAKIMA VALLEY

GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Meeting Time and Location

Thursday, April 5, 2018 5:00 p.m. – 7:00 p.m.

Yakima County Road Maintenance Conference Room
1216 South 18th Street
Yakima, WA 98901

Agenda

Time	Topic	
5:00 – 5:10 p.m.	Welcome, Meeting Overview and Introductions: • Committee members • Others attending the meeting	Vern Redifer, Facilitator
5:10 – 5:15 p.m.	Working Group Reports • Data Collections	David Bowen
5:15 – 5:35 p.m.	USGS Update	Matt Bachmann
5:35 – 5:50 p.m.	Proposed Alternatives • Report Back on Agency Cost/Time Estimates • Best Management Practices	Jim Davenport
5:50 – 6:10 p.m.	GWMA Program Update/Member Comments	Jim Davenport
6:10 – 6:15 p.m.	Monitoring Well Contract	Vern Redifer
6:15 – 6:20 p.m.	Committee Business • Approve the March 1, 2018 GWAC Meeting Summary • Confirm Next Meeting	Vern
6:20 – 6:25 p.m.	Public Comment	

Time	Topic
6:30 p.m.	Adjourn

Committee Members

Stuart Turner, agronomist, Chelsea Durfey (alternate)	Turner and Co.
Bud Rogers, Kathleen Rogers (alternate)	Lower Valley Community Representative Position 1
Patricia Newhouse, Sue Wedam (alternate)	Lower Valley Community Representative Position 2
Doug Simpson	Irrigated Crop Producer
Dr. Jessica Black, Alexander V. Alexiades (alternate)	Heritage University
Jean Mendoza, Eric Anderson (alternate)	Friends of Toppenish Creek
Jan Whitefoot, Jim Dyjak (alternate)	Concerned Citizens of the Yakama Reservation
Steve George, Frank Lyall (alternate)	Yakima County Farm Bureau
Jason Sheehan, Dan DeGroot (alternate)	Yakima Dairy Federation
Ron Cowin	Sunnyside-Roza Joint Board of Control
Laurie Crowe, Rodney Heit (alternate)	South Yakima Conservation District
John Van Wingerden III, (alternate)	Port of Sunnyside
Rand Elliott, Vern Redifer (alternate)	Yakima County Commission
Holly Myers, Ryan Ibach (alternate)	Yakima Health District
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center
Lucy Edmondson, Nick Peak (alternate)	U.S. Environmental Protection Agency
Elizabeth Sanchey, Stuart Crane (alternate)	Yakama Nation
Gary Bahr, Perry Beale (alternate)	Washington Department of Agriculture
Andy Cervantes, Sheryl Howe (alternate)	Washington Department of Health
David Bowen, Sage Park (alternate)	Washington Department of Ecology
Lino Guerra, Rick Perez (alternate)	Hispanic Community Representative
Matt Bachmann	U.S. Geological Survey

Committee Ground Rules:

- Come to committee meetings prepared
- Treat one another with civility
- Respect each other's perspectives
- Listen actively
- Participate actively
- Honor time frames
- Silence electronic devices during meetings
- *Speak from interests, not positions.*

2018 Meeting Dates:

February 15
March 1
~~March 15~~

April 5
April 19
May 3
May 17
June 7
June 21

Meeting Materials:

Name	Date Provided	From
2018_03_01 GWAC Meeting Draft Summary_v2	3/29/2018	Lisa.freund@co.yakima.wa.us
Meeting Agenda	3/29/2018	Lisa.freund@co.yakima.wa.us

D0003

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Yakima County
Notice of Public Meeting
Lower Yakima Valley
Groundwater Advisory
Committee

NOTICE IS HEREBY GIVEN that Yakima County is holding a public meeting of the Lower Yakima Valley Groundwater Advisory Committee on **Thursday, April 5, 2018, at 5:00 PM at Yakima County Road Maintenance Conference Room, 1216 South 18th Street, Yakima, WA 98901** pursuant to Chapter 173-100-080 WAC Ground Water Management Areas and Programs.

For Additional Information
To learn more about the Lower Yakima Valley Groundwater Management Area, the Groundwater Advisory Committee, and its goals and objectives, please see the Lower Yakima Valley Groundwater Management Area on the County webpage at: http://www.yakimacounty.us/gwma/
For more information about the meeting, please contact Lisa Freund, Yakima County Public Services Administrative Manager at 574-2300.
If you are a person with a disability who needs any accommodation in order to participate in this program, you may be entitled to receive certain assistance at no cost to you. Please contact the ADA Coordinator at Yakima County no later than forty-eight (48) hours prior to the date service is needed.
Yakima County ADA Coordinator
128 N. 2nd Street, Room B27
Yakima, WA 98901
(509) 574-2210
7-1-1 or 1-800-833-6384
(Washington Relay Services for deaf and hard of hearing)
Dated this Tuesday, March 27, 2018
PUBLISH: DAILY SUN NEWS
March 28, 2018

Affidavit of Publication

STATE OF WASHINGTON
ss.
County of Yakima

Roger Harnack, being first duly sworn on oath deposes and says that he is the Publisher of the DAILY SUN NEWS, a daily newspaper.

That said newspaper is a legal newspaper and it is now and has been for more than six months prior to the date of publications hereinafter referred to, published in the English language continually as a daily newspaper in the city of Sunnyside, YAKIMA County, Washington, and it is now and during all of said time printed in an office maintained at the afforesaid place of publication of said newspaper, and that the said Daily Sun News was on the 4th Day of April, 1969 approved as a legal newspaper by the Superior Court of said Yakima County.

That the annexed is a true copy of a LEGAL PUBLICATION -
Yakima County Public Services
FC3463-100-120

published in regular issues (and not in supplemental forms) of said newspaper once each week for a period of 1 consecutive issue(s) commencing 03/28/18 and ending on 03/28/18, both dates inclusive, and that such newspaper was regularly distributed to its subscribers during all of said period. That the full amount of the fee charged for the foregoing publication is the sum of $52.50, amount has been paid in full, at the rate of $7.75 per column inch per insertion.

Subscribed and sworn to before me 03/28/18

Notary Public in and for the State of Washington

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YAKIMA HERALD-REPUBLIC

Affidavit of Publication

STATE OF WASHINGTON,)
)
COUNTY OF YAKIMA)

Danielle Rogers, being first duly sworn on oath deposes and says that she/he is the Accounting clerk of Yakima Herald-Republic, Inc., a daily newspaper. Said newspaper is a legal newspaper approved by the Superior Court of the State of Washington for Yakima County under an order made and entered on the 13th day of February, 1968, and it is now and has been for more than six months prior to the date of publication hereinafter referred to, published in the English language continually as a daily newspaper in Yakima, Yakima County, Washington. Said newspaper is now and has been during all of said time printed in an office maintained at the aforesaid place of publication of said newspaper.

That the annexed is a true copy of a:
Yakima County Notice of Public Meeti

it was published in regular issues (and not in supplement form) of said newspaper once each day and for a period of 1 times, the first insertion being on 03/28/2018 and the last insertion being on 03/28/2018

	Yakima Herald-Republic	03/28/18
YakimaHerald.com	03/28/18	

and the such newspaper was regularly distributed to its subscribers during all of the said period. That the full amount of the fee charged for the foregoing publication is the sum of $116.16

Danielle R

Accounting Clerk

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Sworn to before me this 28th day of, March 2018

Lisa M Dripps

Notary Public in and for the
State of Washington,
residing at Yakima

Yakima County

Notice of Public Meeting Lower Yakima Valley Groundwater Advisory Committee

NOTICE IS HEREBY GIVEN that Yakima County is holding a public meeting of the Lower Yakima Valley Groundwater Advisory Committee on **Thursday, April 5, 2018, at 5:00 PM at Yakima County Road Maintenance Conference Room, 1216 South 18th Street, Yakima, WA 98901** pursuant to Chapter 173-100-080 WAC Ground Water Management Areas and Programs.

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7-1-1 or 1-800-833-6384
(Washington Relay Services for deaf and hard of hearing)

Dated this **Tuesday, March 27, 2018**

(802995) March 28, 2018

Courtesy of Yakima Herald-Republic

LOWER YAKIMA VALLEY

GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Meeting Time and Location

Thursday, May 3, 2018: 5:00 p.m. – 7:00 p.m.

Denny Blaine Boardroom, Sunnyside School District No. 201
810 East Custer Ave.
Sunnyside, WA 98944

Agenda

Time	Topic	
5:00 – 5:10 p.m.	Welcome, Meeting Overview and Introductions: • Committee members • Others attending the meeting	Jim Davenport, Facilitator
5:10 – 5:20 p.m.	Comments on Program Draft 2	Jim Davenport
5:20 – 5:50 p.m.	Analysis of Alternatives/Recommendations	Jim Davenport
5:50 – 6:00 p.m.	Status of Monitoring Well Project	Jim Davenport
6:00 – 6:30 p.m.	Lead Entity: Whether? Who? What?	Jim Davenport
6:30 – 6:50 p.m.	Correlation of Mapped Information	Jim Davenport
6:50 – 6:55 p.m.	Committee Business • Approve the March 1, 2018 and April 5, 2018 GWAC Meeting Summaries • Confirm Next Meeting	Jim Davenport
6:55 – 7:00 p.m.	Public Comment	
7:00 p.m.	Adjourn	

Committee Members

Stuart Turner, agronomist, Chelsea Durfey (alternate)	*Turner and Co.*
Bud Rogers, Kathleen Rogers (alternate)	Lower Valley Community Representative Position 1
Patricia Newhouse, Sue Wedam (alternate)	Lower Valley Community Representative Position 2
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Laurie Crowe, Rodney Heit (alternate)	South Yakima Conservation District
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Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center
Lucy Edmondson, Nick Peak (alternate)	U.S. Environmental Protection Agency
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Gary Bahr, Perry Beale (alternate)	Washington Department of Agriculture
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David Bowen, Sage Park (alternate)	Washington Department of Ecology
Lino Guerra, Rick Perez (alternate)	Hispanic Community Representative
Matt Bachmann	U.S. Geological Survey

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- Participate actively
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May 17
June 7
June 21

Meeting Materials:

Name	Date Provided	From
2018_03_01 GWAC Meeting Draft Summary	4/29/2018	chriss@co.yakima.wa.us
2018_04_05 GWAC Meeting Draft Summary	4/29/2018	chriss@co.yakima.wa.us
2018_03_01 Data Collection Working Group Meting Final Summary	4/29/2018	chriss@co.yakima.wa.us
2018_03_29 Data Collection Working Group Meeting Final Summary	4/29/2018	chriss@co.yakima.wa.us
Meeting Agenda	4/29/2018	chriss@co.yakima.wa.us
GWMA Area Characterization Maps and Recommended Strategies: To Be Provided at Meeting		
GWMA Area Characterization Maps	5/3/2018	
Recommended Strategies	5/3/2018	

Yakima County
Notice of Public Meeting
Lower Yakima Valley
Groundwater Advisory
Committee

NOTICE IS HEREBY GIVEN that Yakima County is holding a public meeting of the Lower Yakima Valley Groundwater Advisory Committee on**Thursday, May 3, 2018, at 5:00 PM at Denny Blaine Boardroom, *Sunnyside School District* No. 201, 810 E. Custer, Sunnyside, WA 98944**pursuant to Chapter 173-100-080 WAC Ground Water Management Areas and Programs.

For Additional Information

To learn more about the Lower Yakima Valley Groundwater Management Area, the Groundwater Advisory Committee, and its goals and objectives, please see the Lower Yakima Valley Groundwater Management Area on the County webpage at: http://www.yakimacounty.us/gwma/

For more information about the meeting, please contact Lisa Freund, Yakima County Public Services Administrative Manager at 574-2300.

If you are a person with a disability who needs any accommodation in order to participate in this program, you may be entitled to receive certain assistance at no cost to you. Please contact the ADA Coordinator at Yakima County no later than forty-eight (48) hours prior to the date service is needed.

Yakima County ADA Coordinator
128 N. 2nd Street, Room B27
Yakima, WA 98901 (509) 574-2210
7-1-1 or 1-800-833-6384
(Washington Relay Services for deaf and hard of hearing)

Dated this Monday, April 23, 2018
Publish: Wednesday, April 25, 2018
PUBLISH: DAILY SUN NEWS
April 25, 2018

Affidavit of Publication

STATE OF WASHINGTON
ss.
County of Yakima

Roger Harnack, being first duly sworn on oath deposes and says that he is the Publisher of the DAILY SUN NEWS, *a daily newspaper.*

That said newspaper is a legal newspaper and it is now and has been for more than six months prior to the date of publications hereinafter referred to, published in the English language continually as a daily newspaper in the city of Sunnyside, YAKIMA County, Washington, and it is now and during all of said time printed in an office maintained at the afforesaid place of publication of said newspaper, and that the said Daily Sun News was on the 4th Day of April, 1969 approved as a legal newspaper by the Superior Court of said Yakima County.

That the annexed is a true copy of a LEGAL PUBLICATION -
Yakima County Public Services
FC3463–100–120

published in regular issues (and not in supplemental forms) of said newspaper once each week for a period of 1 consecutive issue(s) commencing 04/25/18 and ending on 04/25/18, both dates inclusive, and that such newspaper was regularly distributed to its subscribers during all of said period. That the full amount of the fee charged for the foregoing publication is the sum of $56.25, amount has been paid in full, at the rate of $7.75 per column inch per insertion.

Subscribed and sworn to before me 04/25/18

Notary Public in and for the State of Washington

030110–00000

DEBBIE GUERRERO
COMMISSION EXPIRES
NOTARY
PUBLIC
JUNE 17, 2020
STATE OF WASHINGTON

YAKIMA HERALD-REPUBLIC

Affidavit of Publication

STATE OF WASHINGTON,)
)
COUNTY OF YAKIMA)

Danielle Rogers, being first duly sworn on oath deposes and says that she/he is the Accounting clerk of Yakima Herald-Republic, Inc., a daily newspaper. Said newspaper is a legal newspaper approved by the Superior Court of the State of Washington for Yakima County under an order made and entered on the 13th day of February, 1968, and it is now and has been for more than six months prior to the date of publication hereinafter referred to, published in the English language continually as a daily newspaper in Yakima, Yakima County, Washington. Said newspaper is now and has been during all of said time printed in an office maintained at the aforesaid place of publication of said newspaper.

That the annexed is a true copy of a:
Yakima County Notice of Public Meeti

it was published in regular issues (and not in supplement form) of said newspaper once each day and for a period of 1 times, the first insertion being on 04/25/2018 and the last insertion being on 04/25/2018

	Yakima Herald-Republic	04/25/18
YakimaHerald.com	04/25/18	

and the such newspaper was regularly distributed to its subscribers during all of the said period. That the full amount of the fee charged for the foregoing publication is the sum of $116.16

Danielle R

Accounting Clerk

LISA M DRIPPS
NOTARY
My Comm. Expires April 05, 2021
PUBLIC
STATE OF WASHINGTON

Sworn to before me this 25th day of, April 2018

Lisa M. Dripps

Notary Public in and for the State of Washington, residing at Yakima

Yakima County

Notice of Public Meeting Lower Yakima Valley Groundwater Advisory Committee

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Yakima, WA 98901
(509) 574-2210
7-1-1 or 1-800-833-6384
(Washington Relay Services for deaf and hard of hearing)

Dated this **Monday, April 23, 2018**

(808383) April 25, 2018

Courtesy of Yakima Herald-Republic

LOWER YAKIMA VALLEY

GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Meeting Time and Location

Thursday, May 17, 2018 5:00 p.m. – 7:00 p.m.

Denny Blaine Boardroom
Sunnyside School District No. 201
810 E. Custer
Sunnyside, WA 98944

Agenda

Time	Topic	
5:00 – 5:10 p.m.	Welcome, Meeting Overview and Introductions: • Committee members • Others attending the meeting	Jim Davenport, Facilitator
5:10 – 5:20 p.m.	Current Active GWAC Members	Jim Davenport
5:20 – 5:40 p.m.	Action on Recommendations for Lead Agency	Jim Davenport
5:40 – 6:10 p.m.	Results on Polling on Draft Recommendations	Jim Davenport
6:10 – 6:40 p.m.	Reasonable Annual Groundwater Recharge Estimates	Jim Davenport
6:40 – 6:50 p.m.	Committee Business • Approve the May 3, 2018 GWAC Meeting Summary • Discuss future meeting dates	Jim Davenport
6:50 – 7:00 p.m.	Public Comment	
7:00 p.m.	Adjourn	

Committee Members

Stuart Turner, agronomist, Chelsea Durfey (alternate)	Turner and Co.
Bud Rogers, Kathleen Rogers (alternate)	Lower Valley Community Representative Position 1
Patricia Newhouse, Sue Wedam (alternate)	Lower Valley Community Representative Position 2
Doug Simpson	Irrigated Crop Producer
Dr. Jessica Black, Dr. Alex Alexiades	Heritage University
Jean Mendoza, Eric Anderson (alternate)	Friends of Toppenish Creek
Jan Whitefoot, Jim Dyjak (alternate)	Concerned Citizens of the Yakama Reservation
Steve George, Frank Lyall (alternate)	Yakima County Farm Bureau
Jason Sheehan, Dan DeGroot (alternate)	Yakima Dairy Federation
Ron Cowin	Sunnyside-Roza Joint Board of Control
Laurie Crowe, Rodney Heit (alternate)	South Yakima Conservation District
John Van Wingerden III	Port of Sunnyside
Rand Elliott, Vern Redifer (alternate)	Yakima County Commission
Holly Myers, Ryan Ibach (alternate)	Yakima Health District
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center
Lucy Edmondson, Nick Peak (alternate)	U.S. Environmental Protection Agency
Elizabeth Sanchey, Stuart Crane (alternate)	Yakama Nation
Gary Bahr, Perry Beale (alternate)	Washington Department of Agriculture
Andy Cervantes, Sheryl Howe (alternate)	Washington Department of Health
David Bowen, Sage Park (alternate)	Washington Department of Ecology
Lino Guerra, Rick Perez (alternate)	Hispanic Community Representative
Matt Bachmann	U.S. Geological Survey

Committee Ground Rules:

- Come to committee meetings prepared
- Treat one another with civility
- Respect each other's perspectives
- Listen actively
- Participate actively
- Honor time frames

- Silence electronic devices during meetings
- Speak from interests, not positions.

2018 Meeting Dates:

~~January 4~~	April 5
~~January 18~~	~~April 19~~
~~February 1~~	May 3
February 15	May 17
March 1	June 7
~~March 15~~	June 21

Meeting Materials:

Name	Date Provided	From
2018_5_3 GWAC Meeting Draft Summary	5/10/18	chriss@co.yakima.wa.us
Meeting Agenda	5/10/18	chriss@co.yakima.wa.us
Member Polling: To Be Provided at Meeting		
Member Polling on Recommendations	5/17/18	

Yakima County
Notice of Public Meeting
Lower Yakima Valley
Groundwater Advisory
Committee

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Yakima, WA 98901
(509) 574-2210
7-1-1 or *1-800-833-6384*
(Washington Relay Services for deaf and hard of hearing)

Dated this Tuesday, May 8, 2018
Publish: Wednesday, May 9, 2018
PUBLISH: DAILY SUN NEWS
May 9, 2018

Affidavit of Publication

STATE OF WASHINGTON
ss.
County of Yakima

Roger Harnack, being first duly sworn on oath deposes and says that he is the Publisher of the DAILY SUN NEWS, a daily newspaper.

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Yakima County Public Services
FC3463-100-120 5/17 Mtg.

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Subscribed and sworn to before me 05/09/18

Notary Public in and for the State of Washington

030110-00000

DEBBIE GUERRERO
COMMISSION EXPIRES
NOTARY
PUBLIC
JUNE 17, 2020
STATE OF WASHINGTON

Affidavit of Publication

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COUNTY OF YAKIMA)

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Yakima Herald-Republic 05/09/18
YakimaHerald.com 05/09/18

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Danielle R

Accounting Clerk

LISA M DRIPPS NOTARY My Comm. Expires April 05, 2021 PUBLIC STATE OF WASHINGTON

Sworn to before me this 9th day of, May 2018

Lisa M. Dripps

Notary Public in and for the
State of Washington,
residing at Yakima

Yakima County

**Notice of Public Meeting
Lower Yakima Valley
Groundwater Advisory
Committee**

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Yakima, WA 98901
(509) 574-2210
7-1-1 or 1-800-833-6384
(Washington Relay Services for deaf and hard of hearing)*

Dated this **Tuesday, May 8, 2018**

(812144) May 9, 2018

Courtesy of Yakima Herald-Republic

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Meeting Time and Location

Thursday, June 21, 2018 5:00 p.m. – 7:00 p.m.

Denny Blaine Boardroom
Sunnyside School District No. 201
810 E. Custer Ave.
Sunnyside, WA 98944

Agenda

Time	Topic	
5:00 – 5:10 p.m.	Welcome, Meeting Overview and Introductions: • Committee members • Others attending the meeting	Jim Davenport, Facilitator
5:10 – 5:20 p.m.	Status of Ambient Groundwater Monitoring Network Results	Jim Davenport
5:20 – 5:35 p.m.	Presentation of GWMA Program/Edits and Additions to Program Draft 2	Jim Davenport
5:35 – 6:05 p.m.	Comments on GWMA Program	Jim Davenport
6:05 – 6:20 p.m.	Consideration / Approval of Program	Jim Davenport
6:20 – 6:30 p.m.	Committee Business • Approve the May 17, 2018 GWAC Meeting Summary • Discuss future meeting dates	Jim Davenport
6:30 – 6:40 p.m.	Public Comments	
6:40 p.m.	Adjourn	

Committee Members

Stuart Turner, agronomist, Chelsea Durfey (alternate)	Turner and Co.
Bud Rogers, Kathleen Rogers (alternate)	Lower Valley Community Representative Position 1
Patricia Newhouse, Sue Wedam (alternate)	Lower Valley Community Representative Position 2
Doug Simpson	Irrigated Crop Producer
Dr. Jessica Black, Dr. Alex Alexiades (alternate)	Heritage University
Jean Mendoza, Eric Anderson (alternate)	Friends of Toppenish Creek
Jan Whitefoot, Jim Dyjak (alternate)	Concerned Citizens of the Yakama Reservation
Steve George, Frank Lyall (alternate)	Yakima County Farm Bureau
Jason Sheehan, Dan DeGroot (alternate)	Yakima Dairy Federation
Ron Cowin	Sunnyside-Roza Joint Board of Control
Laurie Crowe, Rodney Heit (alternate)	South Yakima Conservation District
John Van Wingerden III, (alternate)	Port of Sunnyside
Rand Elliott, Vern Redifer (alternate)	Yakima County Commission
Holly Myers, Ryan Ibach (alternate)	Yakima Health District
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center
Lucy Edmondson, Nick Peak (alternate)	U.S. Environmental Protection Agency
Elizabeth Sanchey, Stuart Crane (alternate)	Yakama Nation
Gary Bahr, Perry Beale (alternate)	Washington Department of Agriculture
Andy Cervantes, Sheryl Howe (alternate)	Washington Department of Health
David Bowen, Sage Park (alternate)	Washington Department of Ecology
Lino Guerra, Rick Perez (alternate)	Hispanic Community Representative
Matt Bachmann	U.S. Geological Survey

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~~January 18~~	~~April 19~~
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February 15	May 17
March 1	~~June 7~~
~~March 15~~	June 21

Meeting Materials:

Name	Date Provided	From
2018_05_17 GWAC Draft Meeting Summary	6/14/2018	chriss@co.yakima.wa.us
2018_06_21 GWAC Meeting Agenda	6/14/2018	chriss@co.yakima.wa.us
GWMA Final Program	6/18/2018	chriss@co.yakima.wa.us
Edits and additions to Draft 2 of the Program	6/19/2018	chriss@co.yakima.wa.us

INVOICE

Y0060

YAKIMA HERALD REPUBLIC

El Sol de Yakima

www.yakimaherald.com
P.O. Box 9668 YAKIMA, WA 98909
PHONE (509) 248-1251 FAX (509) 249-6148
FED TAX I.D. 91-1539864

BILLING DATE:	ACCOUNT NO:
06/13/2018	110536

Please Pay Upon Receipt. Thank you!

YAKIMA COUNTY SURFACE WATER
PUBLIC SERVICES
128 NORTH 2ND STREET ROOM 408
YAKIMA WA 98901

For questions or to place a classified ad call
1-800-343-2799
509-452-7355 or 509-248-1251
FAX: 509-577-7766

Office Hours:
Mon - Fri,8:00am - 5:30pm

Ad #	PO #	Description	START	STOP	Days	Amount	Prepaid	Due
819471	C3463-100-1	YAKIMA COUNTY NOTIC	06/13/18	06/13/18	2	116.16	0.00	116.16

PAYMENT IS DUE UPON RECEIPT OF THIS INVOICE

Funding Control FC3463-100-120 CS
Authorized By [signature]
Date Authorized 6/19/18

RECEIVED
JUN 15 2018
PS ACCOUNT

Total Amount Due
$116.16

Please detach and return bottom portion with your payment.

YAKIMA COUNTY SURFACE WATER
PUBLIC SERVICES
128 NORTH 2ND STREET ROOM 408
YAKIMA WA 98901

ACCOUNT NAME:	YAKIMA COUNTY SURFACE WATE
ACCOUNT NUMBER:	110536
AD NUMBER:	819471
TOTAL AMOUNT DUE:	$116.16

AMOUNT PAID
$116.16

CREDIT CARD INFORMATION

CREDIT CARD NUMBER

EXP. DATE

SECURITY CODE

CARD TYPE (Check One)

VISA MasterCard DISCOVER

SIGNATURE (Required for credit card payment)

Please make checks payable to:

YAKIMA HERALD REPUBLIC
P.O. Box 9668
YAKIMA, WA 98909

YAKIMA HERALD-REPUBLIC

Affidavit of Publication

STATE OF WASHINGTON,)
)
COUNTY OF YAKIMA)

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Yakima Herald-Republic 06/13/18
YakimaHerald.com 06/13/18

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[signature]

Accounting Clerk

Sworn to before me this 13 day of, June 2018

[signature]

Notary Public in and for the
State of Washington,
residing at Yakima

R RENE CONNATSER NOTARY PUBLIC STATE OF WASHINGTON My Comm. Expires August 15, 2019

Yakima County

Notice of Public Meeting Lower Yakima Valley Groundwater Advisory Committee

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Yakima, WA 98901
(509) 574-2210
7-1-1 or 1-800-833-6384
(Washington Relay Services for deaf and hard of hearing)

Dated this **Monday, June 11, 2018**

(819471) June 13, 2018

D0003

DAILY SUN
P.O. Box 878 • 600 S. Sixth Street
Sunnyside, WA 98944
Phone (509) 837-4500
Fax (509) 837-6397

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VISA MasterCard DISCOVER NOVUS

INVOICE

Billing Date	06/14/18
Account Number	030110-00000
Telephone	509-574-2300

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JUN 21 2018
Yakima County
PW Accounting

Yakima County Public Services
128 N. 2nd St. 4th Floor
Yakima, WA 98901

LEGAL ADVERTISING INVOICE

Item Invoiced	StartDate	EndDate	Insertions
Yakima County Notice	06/15/18	06/15/18	1
Invoice #: [illegible] 159 FC3463-100-120 6/21 Mtg.			

Total Due 56.25

↑
PLEASE INCLUDE
INVOICE NUMBER ON
ALL PAYMENTS

Legals must be paid for before
affidavits can be sent

Thank you!

Funding Control FC3463-100-120-4410 CS
Authorized By [signature]
Date Authorized 6/25/18 JB

RECEIVED
JUN 26 2018
PS ACCOUNT

Yakima County
Notice of Public Meeting
Lower Yakima Valley
Groundwater Advisory Committee

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June 15, 2018

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FC3463–100–120 6/21 Mtg.

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Subscribed and sworn to before me 06/15/18

Notary Public in and for the State of Washington

030110–00000

DEBBIE GUERRERO
COMMISSION EXPIRES
NOTARY PUBLIC
JUNE 17, 2020
STATE OF WASHINGTON

GWAC Attendance Roster

Member	5-Apr-2018	3-May-2018	17-May-2018	21-Jun-2018
Stuart Turner	Present	Absent	Absent	Present
Chelsea Durfey (alternate)	Absent	Absent	Absent	Absent
Bud Rogers	Present	Present	Present	Present
Kathleen Rogers (alternate)	Present	Present	Present	Present
Patricia Newhouse	Absent	Absent	Present	Present
Sue Wedam (alternate)	Absent	Absent	Absent	Present
Doug Simpson	Absent	Absent	Present	Present
Jean Mendoza	Present	Present	Present	Present
Eric Anderson (alternate)	Absent	Absent	Absent	Absent
Jan Whitefoot	Absent	Absent	Absent	Absent
Jim Dyjak (alternate)	Present	Present	Present	Present
Steve George	Present	Present	Absent	Present
Frank Lyall (alternate)	Present	Present	Present	Absent
Jason Sheehan	Present	Present	Present	Absent
Dan DeGroot (alternate)	Present	Present	Present	Present
Ron Cowin	Present	Present	Present	Present
Laurie Crowe	Absent	Present	Present	Present
Rodney Heit (alternate)	Absent	Absent	Absent	Absent
John Van Wingerden	Present	Absent	Present	Absent
Rand Elliott	Present	Present	Present	Present
Vern Redifer	Present	Absent	Absent	Present
Holly Myers	Absent	Present	Absent	Present
Ryan Ibach (alternate)	Present	Absent	Absent	Absent
Dr. Troy Peters	Absent	Absent	Absent	Absent
Lucy Edmondson	Absent	Present	Absent	Present
Peter Contreras/Nick Peak (alternate)	Absent	Absent	Absent	Absent
Elizabeth Sanchey	Absent	Absent	Absent	Absent
Stuart Crane (alternate)	Present	Present	Absent	Present
Gary Bahr	Present	Absent	Present	Present
Perry Beale (alternate)	Absent	Present	Absent	Absent
Andy Cervantes	Present	Present	Present	Present
Sheryl Howe (alternate)	Absent	Absent	Absent	Absent
David Bowen	Present	Present	Present	Present
Sage Park (alternate)	Absent	Absent	Absent	Absent
Lino Guerra	Present	Absent	Present	Absent
Rick Perez (alternate)	Absent	Absent	Absent	Absent
Jessica Black	Absent	Absent	Present	Absent
Alexander V. Alexiades (alternate)	Present	Absent	Absent	Absent
Matt Bachmann	Present	Present	Absent	Absent
Robert Black (alternate)	Absent	Absent	Absent	Present

Attachment B

- 2018_0405 MASTER GWMA Strategies 1-29-18 vmr (with comments)
- Ground Water Management Area Maps
- GWMA Program Vote Tally
- 5.17.18 Voting Appendix

	sort	To Whom	Strategy	Details	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs	Comments
1	**Abandoned Wells**	Legislature	*Permit the repair or decommissioning of wells by* general contractors, rather than exclusively by well-drillers, so as to diminish costs of decommissioning.		F	E	None **Rand Elliott:** DOE suggested $49,000 to decommission a well.	None	One year	Easy (Research statute and recommend language.)	Consistent with NS-8.2, 9.2, 9.8, 9.10, UT-4, 6.1, 6.5, 7.2, 8, 12.5, 13.1	**Jean Mendoza:** Do general contractors have the necessary expertise and equipment to properly decommission wells?
2	**Abandoned Wells**	DOE, Yakima Health District	Develop a plan for finding and decommissioning abandoned wells in the next 12 months, using the LYVGWMA as a pilot project.	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.	F	Unknown	Plan: Cheap Implementation: Expensive	Legislature	Any	Difficult	Consistent with NS-8.2, 9.2, 9.8, 9.10, UT-4, 6.1, 6.5, 7.2, 8, 12.5, 13.1	**DOE:** Legislative proviso through DOH or Ecology for grant funding. Need to estimate scope of problem - 100 wells vs 1000 wells - to estimate cost $4-9,000/well depending on depth **Jean Mendoza:** Ecology has been working on this difficult problem for years. They have the expertise to do this work more efficiently with adequate funding. The GWMA should allocate our limited funds to major sources of nitrate. **Rand Elliott:** Support education element for well owners. Leave bankers and realtors out of this. Google probably not a good tool for this kind of analysis. GWAC can't offer incentives or grants, don't have funds. How much is a reward or incentive?
3	**Aquifer Protection**	Yakima County	Postpone decision on creation of an aquifer protection area till a later date when more information is known.	**Chris Saunders:** The Spokane-Rathdrum Aquifer Protection Area charges households **$1.25-per-month for water and $1.25-per-month for on-site sewage disposal** for a maximum **$30-per-annum**. Non-household units are charged by meter size, ranging from *$1.25-per-month for 3/4 inch, and $80-per-month for 6 inches or larger.* Spokane County's 2018 budget lists income from those charges as $1,580,000. Spokane's APA is 321 square miles, compared to 274 square miles for the GWMA. Total number of households for the Spokane APA is unknown, although we can safely assume a minimum of 40,000, based on 2010 Census figures, compared to **16,260 households** for the GWMA. Assuming $30 paid by every household, we'd bring in **revenues of $487,800**. Non-household revenue is **unknown**. The Spokane APA is not required to spend all its revenue in one year. It has a total budget of $7,683,367 for 2018, with $5,920,367 carrying over from 2017.	Feasible **Rand Elliott:** APA requires a vote to add a new tax. It would raise money. Probably unlikely to pass.	Not Effective	No current administrative costs to postponing decision **Rand Elliott:** Election costs could be $30-50,000 depending on *what other questions* are on the ballot.	None	Any	Easy	Inconsistent with NS-8.2, 9.1, 9.2, 9.4, 9.5, 9.6, 9.8, 9.10, UT-4, 6.1, 6.5, 7.2, 8, 12.5, 13.1	**Jean Mendoza:** It would help to have an informational meeting on what an Aquifer Protection Area does and does not accomplish
4	**Aquifer Protection**	Yakima County	Amend the list of prohibited uses under the Critical Aquifer Recharge Area ordinance 16C.09.070 (6) to include activities that would add nutrients to the soil column beyond those amounts that can be taken up within a reasonable time by plant materials. Or perhaps, activities inconsistent with NCRS Code 590		Feasible	Effective **Rand Elliott:** No	Administrative costs; *Higher costs for* operations that have to comply	County General Fund	One year	Controversial	Consistent with NS-9.2, 9.3, 9.10	**Rand Elliott:** "Amend" is regulatory. Change to suggest?
5	**Aquifer Protection**	OSPI, ESD 105	Develop educational materials that could be elected by instructors at 8-12 levels about aquifer protection, groundwater and best management *practices.*	Water on Wheels costs $9,750/year for stormwater education.	Feasible	Effective depending on use	Contract with educational consultant; see what materials/models out there already	County General Fund	One year	Difficult to fit into curriculum	Consistent with NS-9.6, 9.10	**Pat Newhouse (verbal 3/1):** Teachers are already being told to incorporate lots of different goals on all sorts of subjects into their lesson plans. Please be sensitive not to overload teachers. **Rand Elliott:** *Could be a minor unit in a health curriculum but no more. Too* little time in the school day.
6	**Atmosphere**	DOE, Yakima Regional Clean Air Agency, WSDA	Estimate emissions of reactive nitrogen - gaseous *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. Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.	Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.	Ask CAA and DOE	Ask CAA and DOE	Ask CAA and DOE	Ask CAA and DOE	Ask CAA and DOE	Ask CAA and DOE	Consistent with NS-3.1, 3.2, 3.3, 8.1	**DOE:** Air Program completed 3 years ago. <1% refinement would be millions of dollars **Jean Mendoza:** There is sound data from industry that shows about half of nitrogen from animal manures is volatized. **Rand Elliott:** Need help here, don't understand the threat. Seems to me this is just moving N around, not increasing the total amount.
7	**Atmosphere**	DOE, EPA	Study the relationship between nitrogen emissions and atmospheric deposition of reactive nitrogen. Develop a model that predicts what percentage of emissions return to the GWMA area as atmospheric deposition.	**EPA:** The Community Multiscale Air Quality Modeling System (CMAQ) can be used to model nitrogen emissions and the atmospheric deposition of nitrogen in the Yakima Valley.	**EPA:** Feasible	**EPA:** Effective **Rand Elliott:** No	**EPA:** Ongoing work now, not costly	**EPA:** Agency budgets	**EPA:** 2018	**EPA:** Not difficult	Consistent with NS-3.1, 3.2, 3.3, 8.1	**DOE:** Air Program completed 3 years ago. <1% refinement would be millions of dollars **Jean Mendoza:** Reactive nitrogen is directly related to climate change. This action gives us a seat at the table during climate change discussions **Rand Elliott:** Don't trust "models". There are too many variables that can *skew the results*
8	**Atmosphere**	WSDA	Establish a monitoring system for compliance with NRCS Standard 317 on new composting facilities at Washington dairies (phased in for existing facilities).	**Ginny Stern:** 7 & 8: Would guess $250-500,000 together	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	**Rand Elliott:** is creating a monitoring system regulatory?

	sort	To Whom	Strategy	Details	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs	Comments
9	**Atmosphere**	WSDA, SYCD	Encourage prompt incorporation of manures and fertilizers after application to cropland where appropriate.		Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	
10	**Atmosphere**	WSDA, SYCD	Discourage broadcast application of manures to cropland.		Ask WSDA & SYCD	Ask WSDA & SYCD	Ask WSDA & SYCD	Ask WSDA & SYCD	Ask WSDA & SYCD	Ask WSDA & SYCD	Ask WSDA & SYCD	**Steve George**: Broadcasting manure is one of the most common practices of applying manure and has no more detrimental effect to groundwater than other types of applications. Broadcast application is a form that can be used on growing crops that would include apples, hops and other established crops. It would also include applications to open ground in preparation to grow a crop, no different than applying commercial fertilizers. It would be better to recommend "When making fertilizer applications, apply at agronomic rates." **Jean Mendoza:** Agree. Prompt incorporation of fertilizers reduces loss to the atmosphere. **Jason Sheehan:** Broadcasting manure to growing crops fits in perfectly to applying the correct amount of manure at the correct stage of growth. Alfalfa, corn, triticale, and other crops all do well with manure applications during the growing stages. The best way to apply manure to an established crop is by broadcasting the manure.
11	**Atmosphere**	WSDA, SYCD	Encourage application of manures and fertilizers by surface banding.	Banding, "dribbling," "stripping" of liquid fertilizers, https://fluidfertilizer.org/wp-content/uploads/2016/05/22P14-18.pdf	Ask WSDA, SYCD	Ask WSDA, SYCD	Ask WSDA, SYCD	Ask WSDA, SYCD	Ask WSDA, SYCD	Ask WSDA, SYCD	Ask WSDA, SYCD	**Steve George:** over all concerns about this rec. Should this be "subsurface" banding? This is going to have limited use depending on the crop. Wouldn't it be better to say "Implement application strategies that reduce N volatilization?" This could then include the use of anti volatilization products such as Agritain or the use of Super U and deal with both manure and commercial fertilizer. **Jean Mendoza:** Agree
12	**Public Health**	PEHSU, Washington State DOH, Yakima Health District, Lead Agency	Develop a health-risk education and outreach campaign	Establish a public education program regarding nitrate pollution and health risk over a 5-10 year period. Broaden the pool of people GWMA is educating or communicating with. Provide all materials distributed to the public in English and Spanish. Provide education about concepts that people can understand. Billboard campaign – urging well testing. *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) **Billboards**: Cheapest rates are $300-month for small billboards, $1,500-month for large, and $2,500 for digital. **DOH**: A similar program to address elevated lead levels in children's blood was undertaken in the state's current budget. Base budget: $516,000 for FY16-17. Lead Registry: $320,000 FY18-19. Screening & case management: $2,765,000 FY18-20. Primary Prevention: $205,000 FY18-19. **Total: $3,806,000 FY18-19.**	Feasible	Effective	Ask PEHSU, DOH, YHD **Ginny Stern:** $50,000-$150,000 over five years	Legislature	2019 Session	Not difficult	Consistent with NS-9.10	**Jean Mendoza:** I am very disappointed that we have spent so little time discussing ways to engage the people of the Lower Yakima Valley. If we seriously care about ordinary people we will invest time and effort in outreach and education and use communication methods that people accept and understand.
13	**Best Management Practices**	GWMA, WSDA, SYCD	Inform farmers of those BMPs prioritized by Livestock/CAFO and Irrigated Agriculture Work Groups to reflect greatest effectiveness in nitrate reduction.	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.	Feasible **SYCD:** Yes	Effective **SYCD:** Yes	Zero **SYCD:** funding may be needed for cost-share and technical asistance	Zero	Ask SYCD **SYCD:** Depends on what will be done and if funding is available to implement the prractice or project	Easy	Consistent with NS-9.6	**Steve George:** Concern as it promotes the adoption of BMP REGULATIONS. I do not support this as written and do not feel that it is necessary at this time. **Jean Mendoza:** The GWMA Work Plan (page 2) clearly states "Develop strategies for implementing best management practices such as technical assistance, education, ordinances and coordination with other regulatory and nonregulatory programs." We agree that agriculture is the leading contributor to nitrates in groundwater and that effective BMPs are needed to address this aspect of the problem. This says that the discussion of BMPs *must be much more comprehensive. Please review the "Vital Elements"* document from the early GWMA meetings. **SYCD:** Under details, need to add NRCS Standards and Specifications. The BMP discussion is directly with the landowner and is based on the specific resource concern that we're working on correcting. No regulations need to be adopted. **Frank Lyall:** Is the GWMA advocating or not regulations by mandatory BMPs enforced by the WSDA? That is what this Paragraph implies after a vote was taken that said no regulations were being advocated. **Rand Elliott:** Asks WSDA to adopt regulations. Regulatory.

	sort	To Whom	Strategy	Details	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs	Comments
14	**Best Management Practices**	Yakima Health District	Recommend against farming around a water well.		Feasible	Effective	Ask YHD	Ecology, Legislature	Minimal	Easy	Consistent with NS-9.6, 9.10	**Jean Mendoza:** Can we get access to the comprehensive data base that HDR created? There are many, many BMPs and we should be selective about which ones we recommend as most effective. **Frank Lyall:** This is nebulous. Depends on depth of well, soil porosityize of buffer, amount of fertilizer and water applied. Many if not most wells are located in lawns, pastures, gardens, other open areas.
15	**Composting**	Ecology, WSDA	Improve composting regulations		Ask WSDA, Ecology	Ask WSDA, Ecology	Ask WSDA, Ecology	Ask WSDA, Ecology	Ask WSDA, Ecology	Ask WSDA, Ecology	Consistent with NS-9.2 , 9.6, 9.10	**DOE:** Waste 2 Resources & WSDA, requires legislative action, Agency would need to determine priority to open any rule, all portions of a rule can potentially be changed when they are opened **Jean Mendoza:** Ag composting is a significant contributor to both leaching of nitrates to groundwater and volatization of reactive nitrogen. Such a major source must be addressed. **Rand Elliott:** Improving regulations is regulatory, should change the wording.
16	**Composting**	Yakima Health District	Issue permits for agricultural composting operations, to appropriately inspect composting operations and to enforce regulations that protect public health and the environment, as required by state rules and regs.		Ask YHD	Ask YHD	Ask YHD **Rand Elliott:** High staff costs	Ask YHD	Ask YHD	Ask YHD	Consistent with NS-9.2 & 9.6 & 9.10	**DOE:** WSDA lead in most cases in the GWMA - part of what they currently do in coordination with the CD **Rand Elliott:** "Issue permits" sounds regulatory.
17	**Composting**	DOE, Yakima Health District	Inspect, monitor and regulate stockpiled manures.		Ask DOE	Ask DOE	Ask DOE	Ask DOE	Ask DOE	Ask DOE	Consistent with NS-9.2 & 9.4 & 9.10	**Rand Elliott:** Regulatory.
18	**Composting**	Yakima Health District	Issue permits for agricultural composting operations, to appropriately inspect composting operations and to enforce regulations that protect public health and the environment, as required by state rules and regulations.		Ask YHD	Ask YHD	Ask YHD	Ask YHD	Ask YHD	Ask YHD	Consistent with NS-9.2 & 9.6 & 9.10	**Steve George:** Ag composting should be exempt, this would require legislative change. **Frank Lyall:** No mention of size of ag composting operation, garden or 10,000 CAFO and everything in between. Best left alone at county level. **Rand Elliott:** Same as 16, could they not be combined?
19	**Composting**	DOE	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 regs		Ask DOE	Ask DOE	Ask DOE	Ask DOE	Ask DOE	Ask DOE	Consistent with NS-9.2 & 9.6 & 9.10	**Steve George:** same as #18 **DOE:** WSDA and DOH rules and regulations - Ecology doesn't have dairy nutrient associated materials in their regulations - difference of opinion within the GWAC regarding if they are
20	**Composting**	DOE	Provide assistance to local departments of health regarding the regulation of agricultural composting operations		Ask DOE	Ask DOE	Ask DOE	Ask DOE	Ask DOE	Ask DOE	Consistent with NS-9.2 & 9.6 & 9.10	**DOE:** Health Ditrict would need to weigh in on costs
21	**Domestic Waste Management**	Yakima Health District, Yakima County Building Division	Limit septic system developments where soil filtration rate is high, where housing density is already big, where nitrate concentration is already great downstream of the septic plume.	Recommendations for conditions on issuance of building permits.	Ask YHD	Ask YHD	Ask YHD	Ask YHD	Ask YHD	Ask YHD	Consistent with NS-9.2 & 9.3 & 9.10	**Steve George:** Change wording from "Where housing density is already big" to "Where housing density is already at or above the EPA's definition of high density." Use of the word "big" is not descriptive enough.
22	**Domestic Waste Management**	Yakima Health District, Yakima County Building Division	Study potential nitrate contamination attributable to improperly operated septic systems.	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.	Ask YHD	Ask YHD	Costly to landowner	Ask YHD	Ask YHD	Ask YHD	Consistent with NS-9.2 & 9.3 & 9.10	**Jean Mendoza:** Concern that these actions will divert limited funds away from addressing the major sources of nitrates in the groundwater. At the beginning of the GWMA we all agreed upon the need to prioritize **Rand Elliott:** County cannot provide tax breaks. GWAC can't pay for incentives. Reword.
23	**Domestic Waste Management**	Yakima Health District	Publish and distribute homeowner guide on how to maintain septic systems		Feasible	Effective	Ask YHD	Ecology, Legislature	Ask YHD	Easy	Consistent with NS-9.6	
24	**Domestic Waste Management**	Yakima Health District, Yakima County Building Division, County Planning	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.	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.	Ask YHD, Building, Planning	Ask YHD, Building, Planning	Ask YHD, Building, Planning	Ask YHD, Building, Planning	Ask YHD, Building, Planning	Requires BOCC approval	Consistent with NS-9.2 Inconsistent with NS-9.7	**Dan DeGroot:** Recommended use of Anaerobic Digestion in Waste Storage lagoons as a BMP is not effective for Nitrogen reduction. AD removes assorted gaseous material but has no effect on Nitrogen. Effectiveness for Nitrogen to ground water in zero. Remove from list. **Rand Elliott:** Could this be combined with #21?

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25	**Domestic Waste Management**	WDOH	Determine, prior to issuing or reissuing LOSS permits, that all employee counts are regularly reported.	So that the LOSS will continue to operate as designed.	Ask DOH	Ask DOH	Ask DOH	Ask DOH	Ask DOH	Ask DOH	Consistent with NS-9.3 & 9.4	**Dan DeGroot**: Make sure that Annual Reports from LOSS operators are received in a timely manner. Business' who use LOSS should be aware that employee growth can have an effect on LOSS operation. Perhaps re-issuance of the permit should be delayed if report is not received by due date with current updated information. Cost is minimal, reporting should be occurring already.
26	**Domestic Waste Management**	Legislature	Require facility process improvements in waste treatment and food processing plants to reduce nitrogen and total discharge volume.		Difficult	Uncertain	Costly to fruit processing facilities	Private		Requires amendment to state Water Pollution Control Act (RCW 90.48)		**Rand Elliott:** "Require" would mean some kind of regulation, reword?
27	**Domestic Waste Management**	Legislature	Provide funding for municipalities to replace aging sewer system infrastructure and ensure proper system maintenance to reduce nitrate leaching.	Municipalities need to estimate costs and system integration.	Feasible	Effective	Expensive	Congressional, Legislature	Decades	Requires upgrades to meet all current standards		**Rand Elliott:** We should seek funding, not "provide" it.
28	**Domestic Waste Management**	Legislature	Make shallow (1, 2, 3 foot) soil testing reports prerequisites for funding, lending or building permits.	In the nature of Phase I Environmental Audits. Makes nitrate-related information/data available for water quality management.	Feasible	Effective **Rand Elliott:** No	Marginal	Private	Years	Amend GMA (RCW 36.70A)		**Dan DeGroot**: Soil testing as a prerequisite for funding, lending and building permits gives some information on soil nitrates but does not really address the issue of Medium and High Density OSS concentrations. Building permits and related OSS type required should be conditioned on density of conventional OSS so as to not increase the contribution of Nitrogen to ground water in an area. Skip the soil testing and look at density of conventional OSS. Doing a survey of OSS should be less cost than soil testing with much better results. Would further recommend that a phase in of properties sold to require an updated OSS (one capable of removing significant nitrogen) if density exceeds 10 per square mile. Also recommend that any OSS that has been determined to have failed or it is requested to install a new septic tank or drain field and density is over 10 per square mile then an updated OSS is required.
29	**Domestic Waste Management**	EPA, DOE	Identify and support opportunities, including educational research institutions, for private, public, and industry investment in technology specific to addressing nitrate contamination in groundwater.	EPA & DOE construct a LYVGWMA Program for coordinated implementation.	Feasible	Effective	Ask EPA & DOE	Agency budgets	2018	Easy		**DOE:** Identify is simple, support requires legislative proviso to a lead entity, industry group, higher Ed, etc...
30	**Domestic Waste Management**	WSDA	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.	WSDA construct LYVGWMA administrative program.	Feasible	Effective	Ask WSDA	Agency budget	2018	Easy		
31	**Funding**	Legislature	Fund, DOE, WSDA, and Lead Agency activities put in place pursuant to these recommendations.	Prepare fiscal request for legislature.	Feasible	Effective	Ask agencies	Operating budget	2019 Session	Difficult but essential		**Jean Mendoza:** Please remember that we agreed - we should not recommend solutions until we have accurate cost information. This means we should not accept or discard recommendations untl we know how much they will cost **Rand Elliott:** GWAC can't fund. Reword. "Support"?
32	**Funding**	Legislature, Ecology, Lead Agency, Yakima Health District, USGS	Establish or maintain ongoing, extended funding necessary for the Yakima County Department of Public Services and Yakima Health District to actively participate in water quality improvement, testing, monitoring, scientific data analysis, and infrastructure development.	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.	Feasible	Effective **Rand Elliott:** No, useful measuring tool though.	Ask WCC	State operating budget	2019 Session	Easy		**DOE:** WSDA likely lead in coordination with Ecology based on Legislative directive and MOA between agencies. Overlaps with Item 5? **Rand Elliott:** Seek funding. We can't establish funding.
33	**Funding**	Legislature, Washington Conservation Commission	Fund SYCD, through State Conservation Commission budget, for projected educational, administrative, nutrient management planning, engineering, cost share, and lending activities.		Feasible	Effective	Ask WCC	State operating budget	2019 Session	Easy		**Rand Elliott:** Seek funding.

	sort	To Whom	Strategy	Details	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs	Comments
34	**Funding**	Legislature	Require Commodity Commissions to dedicate "check off" money for research and development in water quality technology and practices.		Feasible	Effective	Estimate R&D needs	CC Members	2019	Research CC statutes		**Steve George:** Most commissions are small. They need a grant program to tap into, similar to the CDs. Commissions will not agree to be mandated on where they spend their research dollars, but they likely would agree to secure a grant to work on a specific project. There is already a template in place that many commissions tap into obtaining grant dollars from the Washington State Commission on Pesticide Registration. A slight change in the mandate of the Pesticide Commission could include allow them to distribute funds for environmental issues as well. **Frank Lyall:** Not the province of Commodity Commissions. Some can't even afford paid help. Best left to research universities. **Rand Elliott:** Can't require commissions to collect money and fund our projects.
35	**Groundwater Quality Monitoring**	Lead Agency, Yakima Health District, USGS	Implement an Ambient Groundwater Monitoring Plan	Monitoring well construction: Lead Agency; Monitoring well data collection: Yakima Health District, USGS. Study short-term seasonal variations in nitrate concentrations over next year or two--addresses how changes in nutrient application over the agricultural cycle affects things. Study long-term trends that develop over several years--to track *whether the overall picture is getting better, whether changes recommended by GWMA* are having impact.	Feasible	Effective	$700,000 in hand, balance uncertain	Legislature	2019 Session	Already designed, to be installed before 12/31/18		**Jean Mendoza:** Do we know when the purpose built wells will be drilled? Do we know how many will be drilled? **Rand Elliott:** Combine with #32.
36	**Groundwater Quality Monitoring**	Lead Agency, Yakima Health District, USGS, EPA	Implement a Drinking Water Quality Monitoring Plan	Data collection, Yakima Health District, USGS. Study short-term seasonal variations in nitrate concentrations over next year or two--addressing how changes in nutrient application over the agricultural cycle affects things. Collect more information on wells known to have high nitrate concentrations, perhaps identifying whether the concentration is self-caused. Study long-term trends that develop over several years--to track whether the overall picture is getting better, whether changes recommended by GWMA are having impact. Where drinking water wells have had a comprehensive site assessment and exceed the Maximum Contaminant Level (MCL) for nitrate, investigate the cause and consider sampling additional wells or use of groundwater monitoring wells, upgradient and downgradient, to assess the source of the nitrate.	Feasible, underway	Effective	Ask USGS	Legislature	2019 Session	Easy		**Rand Elliott:** Combine with #32.
37	**Groundwater Quality Monitoring**	USGS	Use USGS particle tracking model to indicate where groundwater moves faster (permeability).	USGS Particle Tracking Model Overview--potentially combined with MT3D MODFLOW application to the vadose Zone	Feasible, already exists	Unknown	Ask USGS	Legislature	2019 Session	Easy		**Steve George:** I'm not a fan of the USGS particle tracking modeling and do not feel that pursuing it is cost effective for the GWMA. **Jean Mendoza:** This model has already been created and is one of many useful tools for understanding our problems. Suggest also using the USGS SPARROW model that was discussed.
38	**Groundwater Quality Monitoring**	DOE	Analyze the trends of nitrate data contained within *reports required by NPDES and SWD permits.*		Ask DOE	Ask DOE	Ask DOE	Agency budget	2019	Ask DOE		**DOE:** Ecology has the data, its reviewed monthly for permit compliance, permit limits are set to protect waters of the state and be below thresholds
39	**Groundwater Quality Monitoring**	Irrigation Districts	Monitor nitrate concentrations of irrigation water at headgates.	Report nitrate concentrations annually to Department of Ecology	Feasible	Effective	Ask IDs	Ratepayers or DOE grant	2019	Ditch-rider expense		**Steve George:** Not sure why monitoring N at the irrigation headgate is cost effective. Source would need to be return flows, which Roza would not have much of. Does SVID have return flows come into the main canal from Roza water? Seems like a waste of time for irrigation dist staff as it would be a small amount, if any. I would think monitoring the drains would be a better indicator. **Jean Mendoza:** On one hand Mr. Geroge's comments make sense. Please note that BMP 1.3.14, recommended by HDR, was "Measure nitrate content of irrigation water and adjust fertilication accordingly." **Frank Lyall:** Impractical, not cost effective and provides little acual knowledge ie snapshot of weather. Difficult to trace back.
40	**Irrigated Agriculture**	WSDA, SYCD, WSU, WCC	Continue education and outreach to agriculture operators about impacts and practices related to compliance with relevant State and federal requirements for groundwater protection.	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 .*	Feasible	Effective if operators are receptive	Ask WSDA, SYCD, WSU, WCC	Legislature, operating budget	2019	Easy		**SYCD:** SYCD continues educating growers through one-on-one discussions *and workshops as much as possible.*
41	**Irrigated Agriculture**	WSU Extension Service	Update Appendices A and B of the Washington Irrigation Guide.		Feasible	Effective	Ask WSU	Legislature	2019	Already researched, not yet published		

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42	**Irrigated Agriculture**	WSU Extension Service	Continue research of water management with application of agricultural nutrients.	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.	Feasible	Effective	Ask WSU	Legislature	Five years	Continuous effort		
43	**Irrigated Agriculture**	WSU, SYCD, WSDA, WCC	Encourage advanced irrigation management.	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.	Feasible	Effective	Substantial	Identify federal, state and local incentive programs (like EQIP), such as grants, and low interest loans, financial assistance	Short & Long-Term			**Jean Mendoza:** This was a major part of our early discussions and everyone agreed on the importance of irrigation water management **SYCD:** All landowner cost-share from NRCS and SYCD is voluntary. We do not need to establish anything. The biggest problem is the funding for the landowner. Our cost-share program reimburses the landowner 50% of all eligible costs, not to exceed a specific dollar amount. Currently, SYCD can gather 1 or 2 samples with the tools we currently have. The landowner pays for the analysis, unless we included with a cost-share project. We also have a couple of soil moisture probes to lease out for an irrigation season. We would love to purchase more, but grant funding runs out at the end of June. Not sure at this point what the budget mmight be for FY19. **Frank Lyall:** May move farmers away from organic production. May or may not make sense according to crop type, soil type, other factors. **Jason Sheehan:** This should be a top priority to find cost share funding to convert all rill irrigation to more efficient irrigation types and also utilize a moisture monitoring system to help educate farmers.
44	**Irrigated Agriculture**	SYCD, WSDA, WSU	Create Irrigation Management Plans (similar to Nutrient Management Plans) for farms over a minimum size and provide financial assistance for implemented plans.	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.	Difficult		Expensive to establish, costly to producer	Legislature	2019 Session	Difficult, plans are property-specific.	Consistent with NS-9.10, 12.1, 12.2, 12.3	**SYCD:** As part of the dairy plan, irigation water management scheduling per crop and soils is provided. Other growers who receive cost-share funing will be provided with an irrigation schedule based on crops and soil types. **Frank Lyall:** Farmers already have de-facto irrigation management plans for minimizing waer and fertilizer inputs that produce optimum crop yields. **Rand Elliott:** Regulatory.
45	**Irrigated Agriculture**	NRCS, DOE	Provide financial assistance for implementation of Irrigation Management Plans.	*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.	Feasible	Effective	Expensive	Congressional, Legislature	2019 Session	Dependent on funding	Consistent with NS-9.10, 12.1, 12.2, 12.4	**DOE:** Ecology can help with this in specific locations as the Office of Columbia River implements the Yakima Basin Integrated Plan - ~$250-350,000/pivot traditionally a cost share for the landowner **Jason Sheehan:** Another priority, but it only can be accomplished if the irrigation method is updated, see #43. **Rand Elliott:** Can't provide funding. Some programs already exist, push to expand them?
46	**Irrigated Agriculture**	Producers	Develop and implement Nutrient Management Plans.	Voluntary. Farming operations currently are not required to hold permits or a DNMP.	Feasible	Effective	Unknown	Producer	Recurrent/ Annual	Not difficult	Consistent with NS-9.10	**Frank Lyall:** Again, farmers already have a de-facto NMP based on Ag Research recommendations, consultants and field men, testing and observation, economics. **Jim Dyjak (verbal 3/1):** Producing Nutrient Management Plans has not been effective for dairies, so why would it be any more effective for irrigated ag? **Rand Elliott:** Regulatory.
47	**Irrigated Agriculture**	Producers	Use effective fertilizer application procedures for specific crop requirements.	Determine schedules, placement, rate and time of application and speed of release. Where possible, apply nitrogen to plant-specific root zone, rather than broadcast application. Refrain from tilling under herbaceous remnants of prior crops, reducing plant nitrogen contributions to soil column.	Feasible	Effective	Saves Money	Producer	Recurrent/ Annual	Not difficult	Consistent with NS-9.10	**Jean Mendoza:** There are some crops such as alfalfa and hops that deliver a higher profit with heavy application of fertilizers. The profit margin makes over-application cost effective. **Frank Lyall:** Broadcasting fertilizer, may well be applying it to the root zone. Tilling may moderate the need and amount of fertilizer and/or manure. Directly contradicts #9!
48	**Irrigated Agriculture**	Western Plant Health Association	Update Western Fertilizer Handbook, Western Plant Health Association, Ninth Edition (2002)		Ask WPHA	Ask WPHA	Ask WPHA	Ask WPHA	Ask WPHA	Ask WPHA	Consistent with NS-9.10, 12.3	**Frank Lyall:** Fertilizer handbooks need to be local and region specific and even then are not gospel.
49	**Irrigated Agriculture**	Legislature	Provide funding to WSU for a mobile irrigation lab to assess the efficiency of current or advised irrigation practices, either through a singular lab or component parts.	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.	Feasible	Effective	Approx. $100,000 (IAWG)	Legislature	2019 Session	Not difficult	Consistent with NS-9.10, 12.1, 12.2, 12.4	**Rand Elliott:** Can't provide funding. Lobby for it?

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50	**Both Irrigated Agriculture and Livestock**	Ag Industry Associations, DOE, SYCD, WSDA, WSU, Yakima County	Develop a post-GWAC agricultural producer education and outreach campaign	1. 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. 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. 2. 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.	Feasible	Depends upon approach	Expensive in totality	Legislature	2019 Session	Dependent on specific approach	Consistent with NS-9.10	**DOE:** Lead Entity would take this on, 1 FTE w/ approriate equipment - $90-120,000/year **SYCD:** This is partially being done now. Workshops on various topics are always available. Most growers have consultants/field reps they rely on. Every industry has a "board", group, or association that puts on workshops on specific crops. **Frank Lyall:** The Yakima County Farm Bureau and many independent farmers would not cooperate with a regulatory approach and believe that a educational approach is the best option, that relies on the integrity of the individual and the market system which best serves the community in which they live. **Jason Sheehan:** Education is the best approach to reach the broadest group.
51	**Both Irrigated Agriculture and Livestock**	Legislature, DOE, WSDA, Washington State DOH	Make grants and allocate cost share funding or other funding assistance to people implementing environmental protection measures affecting groundwater quality.	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.	Feasible	Effective	$5 million (est)	Legislature	2019 Session	Difficult, dependent on interagency communication & relationships with producers	Consistent with NS-9.6, 9.10	**DOE:** WSDA and CD's would lead, Ecology would participate, no sense of the cost at this time **Rand Elliott:** Can't fund. Reword. Seek? Support?
52	**Both Irrigated Agriculture and Livestock**	SYCD, WSDA, WSU, Private Industry, Producers	Apply nutrients at Agronomic Rate	Develop technologies and provide information about improvements made in nutrient management and agronomic rate application of fertilizer by specific developing technologies.	Feasible	Effective	Dependent on technologies	Private, Legislature	Ongoing, 2019 Session	Dependent on technologies	Consistent with NS-9.10	**Jean Mendoza:** We need clear definitions of what constitutes agronomic rates. **SYCD:** Technologies are already in place to provide information about improvements made in nutrient management and the agronomic rate application of fertilizer. Land Grant Universities have a lot of information on new technologis for specific areas. One technology does not necessarily work in a different part of the country. **Frank Lyall:** Already addressed by #46. It is amazing to think farmers do not already apply fertilizer at an agronomic rate. **Rand Elliott:** Combine with 47, 48?
53	**Both Irrigated Agriculture and Livestock**	WSU, Producers	Integrate use of animal waste and synthetic fertilizer.	Research 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.	Feasible	Effective **Rand Elliott:** No	Potential cost-savings	Private, Legislature	Ongoing, 2019 Session	Not difficult, but requires knowledge of soil chemistry	Consistent with NS-9.10	**Frank Lyall:** Already being done where possible, often being dictated by economic and food safety implications.
54	**Both Irrigated Agriculture and Livestock**	WSDA, SYCD	Monitor changes occurring in agricultural operations. Evaluate whether those changes positively affect improvement in groundwater quality.	Prepare report to Legislature and Department of Ecology.	Feasible	Effective	Expensive	Legislature	2019 Session	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	Consistent with NS-9.10	**SYCD:** Continue to work with growers on taking soil samples (dairies are required), manure samples, and budgeting applications for each field. Tracking soil analysis is a good way to track improvements.
55	**Both Irrigated Agriculture and Livestock**	SYCD	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.	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.	Feasible	Effective	Expensive	Legislature	2019 Session	How to share data is unresolved, public distribution may limit participation by producers & landowners	Consistent with NS-9.10	**SYCD:** A 3-5 year deep soil sampling program to sample depths to 6' would cost approxmately $5,000 - $30,000 depending on equipment, amount of samples per field, and the cost for the analysis. **Jason Sheehan:** Continued deep soil sampling combined with BMP tracking will help farmers see changes in real time.
56	**Lead Agency / Administration / Adaptive Management**	Lead Agency	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.	Administration of Groundwater Quality Program. Administer funds and distribute to other entities by subcontract. Maintain Yakima County's GWMA website. Maintain a GIS data base on the GWMA.	Feasible	Effective	Ask County	Legislature	2019 Session	Not difficult	Consistent with NS-9.10	

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57	**Lead Agency / Administration / Adaptive Management**	Lead Agency, DOE, DOH, YHD	Establish time-based performance objectives against which well-monitoring data can be compared.	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.	Feasible, depends upon immediacy of expectations	Effective in measuring attainment of objectives	Ask County, DOE	Legislature	2019 Session	Difficult; need to define timeframe for water quality improvement	Consistent with NS-9.10	**DOE:** The Lead Entity would need to take this on coordinating all the stakeholder groups, agencies and organizations - needs to be done. Major source of costs, $250-500,000/year. Could be incorporated in the existing and purpose built well testing? **Jean Mendoza:** We were supposed to have done this already.
58	**Lead Agency / Administration / Adaptive Management**	Lead Agency	Assess groundwater contamination potential, and mitigation strategies in localized areas	Make use of the available information on soils, geology, and groundwater in order to identify those areas that are the most vulnerable to immediate impact of contamination *or can tolerate more nitrogen application. Overlay GIS density maps reflecting different* sources of nitrogen in order to geographically indicate the total density from all sources. Identify areas with highly permeable and susceptible soils where fertilization and pesticide application should be most carefully managed. Identify areas that are closer to surface water, areas where recharge is faster or more frequent, or areas where shallow soils overlie soluble bedrock. Identify and assess strategies near these sensitive areas to reduce contributions of nitrate sources.	Feasible	Effective in telling producers where most sensitive properties exist	Ask County	Legislature	2019 Session	Not difficult, capacity already exists	Consistent with NS-9.10	**Jean Mendoza:** We were supposed to have done this already
59	**Lead Agency / Administration / Adaptive Management**	Lead Agency	Adopt and Implement an Adaptive Management Plan	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.	Feasible	Effective	Ask County	Legislature	Continuous, 2025-2030	Not difficult, depends on funding	Consistent with NS-9.10	**Jean Mendoza:** We were supposed to have done this already
60	**Lead Agency / Administration / Adaptive Management**	Lead Agency	Perform an engineering study of water supply alternatives.	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).	Feasible	Effective	Ask County	Legislature	2019 Session	Not difficult	Consistent with NS-9.10, UT-1.1-1.7, 3.1, 3.5, 6.5	
61	**Lead Agency / Administration / Adaptive Management**	Lead Agency	Encourage municipalities within the GWMA to extend municipal sewer systems within urban growth areas and retire ROSS and LOSS.		Feasible	Effective	Ask local governments for estimates	Federal or state grant, reimbursed by water use fees	Decades	Hasn't been accomplished to date	Consistent with UT-1.3, 1.6, 11.5, 11.6, 11.7	**Steve George:** states to "Encourage extension of municipal sewer systems." *Why not promote the extension or creation of potable water systems. That* takes care of the immediate problem and has been the item of choice for many areas. Most areas work on the sewage treatment after they put in a water system. I did not see anything in these recs about promoting the water systems...
62	**Lead Agency / Administration / Adaptive Management**	Lead Agency	Encourage connection of residences within urban growth zones to sewer systems extended by municipalities.		Feasible	Effective	Ask local governments for estimates	Federal or state grant, reimbursed by water use fees	Decades	Hasn't been accomplished to date	Consistent with UT-1.3, 1.6, 11.5, 11.6, 11.7	**Steve George:** same as #61
63	**Lead Agency / Administration / Adaptive Management**	Lead Agency, Yakima Health District	*Encourage the development of group septage-*management or treatment systems in areas outside urban growth zones where the density of residential development could exacerbate the effect of multiple OSS on groundwater quality.		Only feasible alternative is connection to municipal waste treatment facility.	Not Effective	N/A	N/A	N/A	N/A	Consistent with NS-8.2. Inconsistent with UT-2.5, 12.7, 13.8	
64	**Lead Agency / Administration / Adaptive Management**	Lead Agency	Perform an engineering study of locations outside urban growth areas where there is rural residential medium to high density OSS and the nitrate concentration is greater than the state water *quality standard where community waste water* systems could feasibly be constructed in lieu of individual on-site septic systems.		Only feasible alternative is connection to *municipal waste* treatment facility.	Not Effective	N/A	N/A	N/A	N/A	Consistent with NS-8.2. Inconsistent with UT-2.5, 12.7, 13.8	
65	**Lead Agency / Administration / Adaptive Management**	Lead Agency, Municipalities, Yakima Health District	Require new developments to address potential impacts on groundwater quality	Through permitting review of site plan criteria.	Feasible	Effective	*Approx. $10-50,000;* Costly for developer & purchaser	Developer/ purchaser	Decades	Requires BOCC approval	Consistent with NS-8.2	**Rand Elliott:** "Require". Regulatory. Stormwater regs do this.
66	**Lead Agency / Administration / Adaptive Management**	Lead Agency	Develop an urban and hobby agriculturalist education and outreach campaign.	Provide information targeted to small farm/hobby farm/ranchettes about manure management. Publish public information about proper septic system construction and operation. Educate the public, particularly in towns, about lawn and garden nitrogen applications' contribution to nitrate concentrations.	Feasible	Not Effective, based on prior efforts	Ask the County	Legislature	2019 Session	Easy	Consistent with NS-8.2	

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67	**Livestock / CAFO**	Legislature	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.		Feasible	Effective	None	Legislature for implementation	2019 Session	Requires legislative approval	Consistent with NS-9.10. Inconsistent with NS-7.64. (Mutually inconsistent provisions.)	**Steve George:** This is a biased, closed-minded approach that I do not support. It would be hard to administer, fund and enforce. Better to see what voluntary approaches get done. **Jean Mendoza:** This need has been emphasized by experts throughout the GWMA discussions. **Rand Elliott:** *Amending the act is regulatory.*
68	**Livestock / CAFO**	Washington Conservation Commission, WSDA	Document and publish regulatory compliance for dairies within the GWMA that are completing and implementing Dairy Nutrient Management Plans (DNMP).	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.	Feasible	Effective	Ask WSDA	Ask WSDA	2018	Easy	Consistent with NS-9.10	
69	**Livestock / CAFO**	WSDA, WSU	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.*		Feasible	Effective	Ask WSDA/WSU	Legislature	2019 Session	Difficult without knowledge of sub-area soil chemistry and moisture information	Consistent with NS-9.10	
70	**Livestock / CAFO**	WSDA, SYCD	Continue to provide underlying soils information to individual livestock operations	So that individual property owners can evaluate contamination potential.	Feasible, info available from NRCS	Effective	Cheap **SYCD:** (Not necessarily) - Time consuming- depends amount of fields	None	N/A	Easy	Consistent with NS-9.10	**SYCD:** All DNMP's have soils information along with soils maps and soil limitations. All plans for any type of grower/producer would get the same information. Dairies are required to have it. **Rand Elliott:** "Continue"? If we are already doing this, why is it in the plan?
71	**Livestock / CAFO**	WSDA	Complete NRCS Technical Note 23 inspections on all waste storage ponds (lagoons) within the GWMA boundaries.		Feasible	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Unknown	**Jean Mendoza:** The need goes beyond inspections. Lagoon construction *standards must be followed and old lagoons must be updated*
72	**Livestock / CAFO**	WSDA	Develop strategies for marketing the economic, fertilizer value, and soil enhancing properties of appropriate application of manure and other livestock wastes.		Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Consistent with NS-9.10	**Jean Mendoza:** Not opposed. If taxpayers invest in an industry there should be a return on the investment
73	**Livestock / CAFO**	SYCD	Charge dairies for preparation of Dairy Nutrient Management Plans		Feasible	Ineffective	Ask SYCD	Producer **SYCD:** no...we do not ask for payment for our farm plans from anyone. We offer this service free of charge	2019	Dependent on producer willingness to pay the fee	Unknown	**SYCD:** Our budget currently has some funding for Dairy plans and some plans for growers. That is what we do here. This funding FY ends at the end of June. Our funding comes from the legislature thru the Conservation Commission.
74	**Livestock / CAFO**	SYCD, WCC	Establish a local forum for disseminating information and facilitating technical exchange regarding BMPs for livestock management and groundwater protection.	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.	Feasible	Effective depending on attendance	**SYCD:** Cost would be for someone to copy materials already *available and the paper* supply. May have to order additional materials, which would add to the cost. If having outreach for many growers, there would be a cost for a room and maybe speakers, along with reproducing materials.	Legislature	2019 Session	Easy	Consistent with NS-9.10	**SYCD:** There are several forums currently available for technical information that conservation district employee use. There is a plethora of information to use for grower outreach & education, and we currently use several when we visit with growers one-on-one or in specific workshops.
75	**Livestock / CAFO**	Washington Conservation Commission, WSU Extension	Provide additional funding for Yakima Valley education and outreach activities.	BMP implementation, irrigation water management, soil nutrient management and manure management and application.	Feasible	Effective	Ask WCC, WSU	Legislature	2019 Session	Ask WCC, WSU	Consistent with NS-9.10	**Rand Elliott:** Seek additional funding. This may be a duplicate.
76	**Livestock / CAFO**	WSDA	Develop a system to evaluate which farmers need *assistance in understanding appropriate farming* practices.	Clearly establish expectations, list problematic management practices, encourage *voluntary compliance, develop peer encouragement system. Provide information on* enforcement potential.	Feasible	Improbable	Ask compliant farmers	Producers	2019	Dependent on producers	Consistent with NS-9.10	**Steve George:** I don't support this strategy. Not sure how this would be carried out or by who. I think everyone needs a little assistance or expertise at times, so a good, well-funded CD would take care of this.
77	**Livestock / CAFO**	USDOE, USDOA	Explore investment in animal and agricultural waste to energy technology	Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives)	Feasible	Effective	Substantial	Congress	2020	Easy	Consistent with NS-9.10	**Jean Mendoza:** The public is already investing large amounts of tax payer monies in these programs
78	**Livestock / CAFO**	Producers	Make capital improvements	Install liners in liquid waste storage lagoons. Install impervious surfaces beneath silage storage.	Feasible	Effective	Substantial	Cost-share/ producers & WSDA (Legislature)	2019	Feasible	Consistent with NS-9.10	**Steve George:** OK, what kind of liners?? Are clay ok?? I would not support that everyone be mandated to install synthetic liners.

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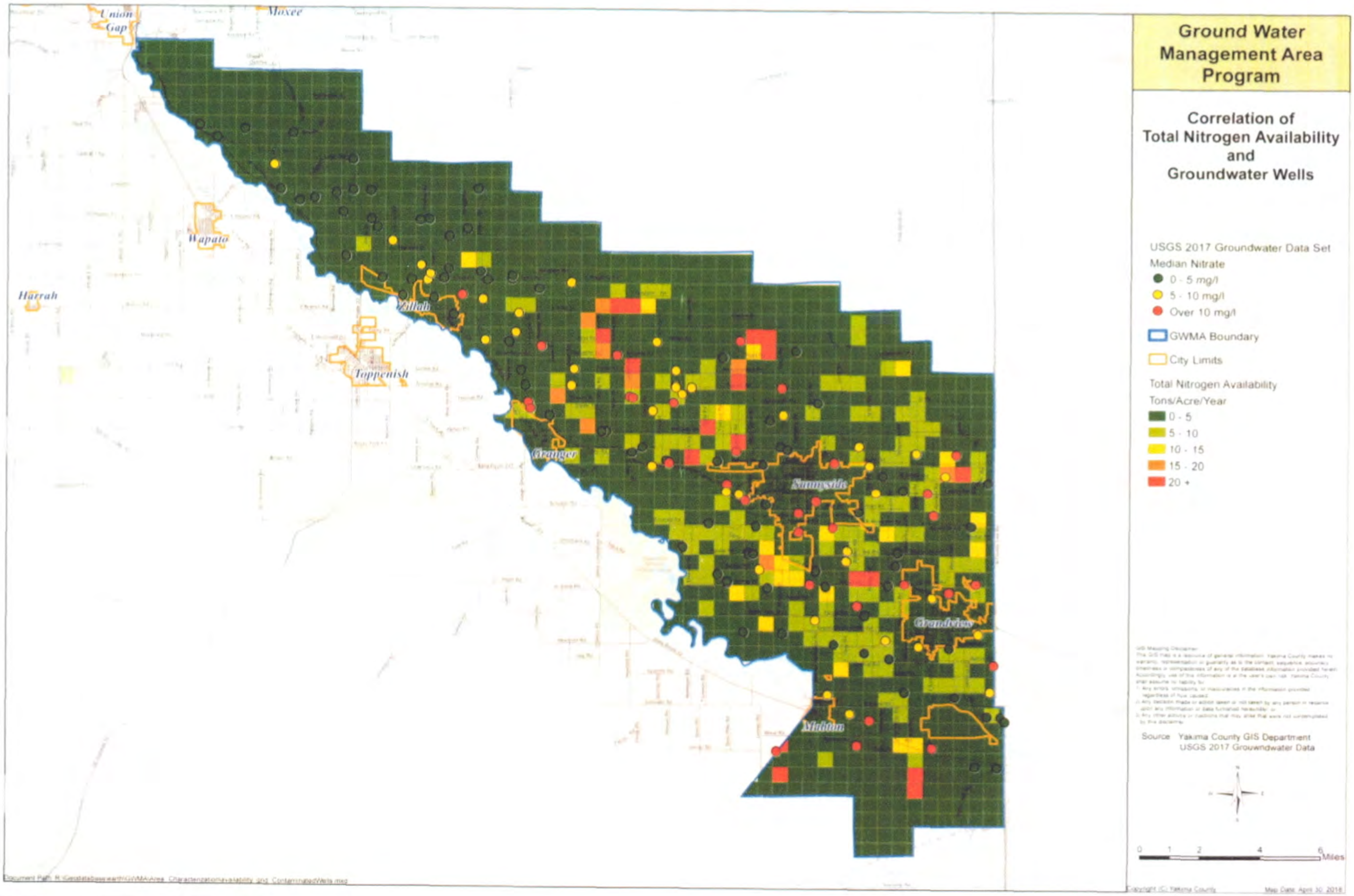
79	**Nitrogen Loading**	WSDA, DOE, Lead Agency	Assess Nitrogen Loading.	Building from the WSDA's Nitrogen Availability Assessment, develop a Nitrogen Loading Assessment for all agricultural, residential and commercial properties, using newly collected data. Hire a technical consultant to conduct a literature 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 Nitrogen Availability Assessment to compare against the currently established data. Collect data on how many acres in the GWMA are fertilized in various crops with manure and how many with commercial fertilizer. Update and monitor the percentage of acreage in various crops, particularly silage corn and field corn. Study effect of contribution of nitrogen from cover crops used to form mulch. 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 the Environmental Protection Agency to use its Community Multi-scale Air Quality Modeling System (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 in the Lower Yakima Valley. Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition. Design and implement pilot studies focusing on innovative farm techniques which reduce nitrogen loading to crops and monitor results for future expansion of findings.	Feasible	*Dependent upon completion of NAA & GWAC resolution of course of action*	Dependent upon completion of NAA & GWAC resolution of course of action	Legislature	Dependent upon completion of NAA & GWAC resolution of course of action	*Dependent upon completion of NAA & GWAC resolution of course of action*	Consistent with NS-9.10	**Steve George:** I would feel more comfortable having WSU performing these tasks rather than WSDA, DOE or EPA **DOE:** A good scope of work for the Lead Entity, TMDL information may help with drains and wasteway portion. Includes an Air Quality component. Ongoing project - staffing ~$90,000/year + project costs $200-400,000/year? USGS may be able to inform the range of project costs. **Frank Lyall:** WSU should be the lead entity.
80	**Regulations and Enforcement**	EPA, DOE, WSDA	Streamline current regulatory enforcement activities	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.	Feasible	Effective	Dependent upon personnel requirements & level of enforcement	Legislature	2019 Session	Not difficult	*Consistent with NS-9.10*	**DOE:** Upon formal request to focus on this coordination Ecology could add to *our work plan* **Rand Elliott:** Regulatory
81	**Regulations and Enforcement**	State Department of Health	Revise WAC 246-203-130 (keeping of animals)	So that it includes specific and enforceable requirements designed to protect human health.	Feasible	Effective	Minimal	Legislature	2019 Session	Not difficult	Consistent with NS-9.10	**Steve George:** WAC 246-203-130 was not intended for production ag or ag zoned areas. It was meant to control livestock issues in urban areas. It should not be expanded to include areas that are zoned for ag production. **Jean Mendoza:** Disagree. WAC 246-203-130 was designed to protect human health. **Frank Lyall:** We have a WSDA for a reason I thought. Now production Ag is to be regulated by the WSDH? **Rand Elliott:** Regulatory
82	**Regulations and Enforcement**	WSDA, Producers, Fertilizer Companies, Irrigation Districts	Integrate management of synthetic/organic fertilizers and application of water	Possible model of Nutrient Management Plans.	Needs more Definition	Needs more Definition	Worthy of study	Unknown	Five years	Unknown	Consistent with NS-9.10	
83	**Remediation**	EPA, DOE, Producers,	Pump-and-fertilize.	Use existing (or new) agricultural water wells to remove nitrate-contaminated groundwater and treat the water by using it to irrigate crops which will take up the nitrogen concentration in the irrigation water (presumes the existence of a proper nutrient management plan for the irrigated acreage).	Feasible (water rights questions)	Effective (also would supplement water supply)	Substantial	Legislature	2019 Session	Unknown	Consistent with NS-9.10	**EPA:** One important point is that, while we may suggested strategy 83, this is not a strategy that EPA would implement. Especially since the funding would come from the state legislature, we recommend this strategy move to a state or local agency -- WSDA, the county, or the Conservation District... **DOE:** Natural and financial resources not available to perform this task across GWMA area - water volume, rights, and acreage.
84	**No Action**		*Consider costs of health risks to families from* nitrate exposures, costs incurred by growers and producers of various recommendations, costs of bottled water, cost for WSDA to monitor DNMP, costs of soil sampling	Analogous to SEPA No Action alternative.								**Steve George:** This should not be a recommendation. It is not cost effective. **Jean Mendoza:** We need a plan with clear objectives and measurable outcomes. Just stating good intentions and hoping for the best is what we have done for the past 20 years. **Frank Lyall:** Do health authorities have any indication of nitrate induced health problems in the GWMA? **Rand Elliott:** Isn't this part of the "no action" section?


Ground Water Management Area Program
Correlation of Total Nitrogen Availability and Groundwater Wells
USGS 2017 Groundwater Data Set
Median Nitrate
0 - 5 mg/l
5 - 10 mg/l
Over 10 mg/l
GWMA Boundary
City Limits
Total Nitrogen Availability
Tons/Acre/Year
0 - 5
5 - 10
10 - 15
15 - 20
20 +
Source: Yakima County GIS Department
USGS 2017 Grouwndwater Data
0
1
2
4
6
Miles
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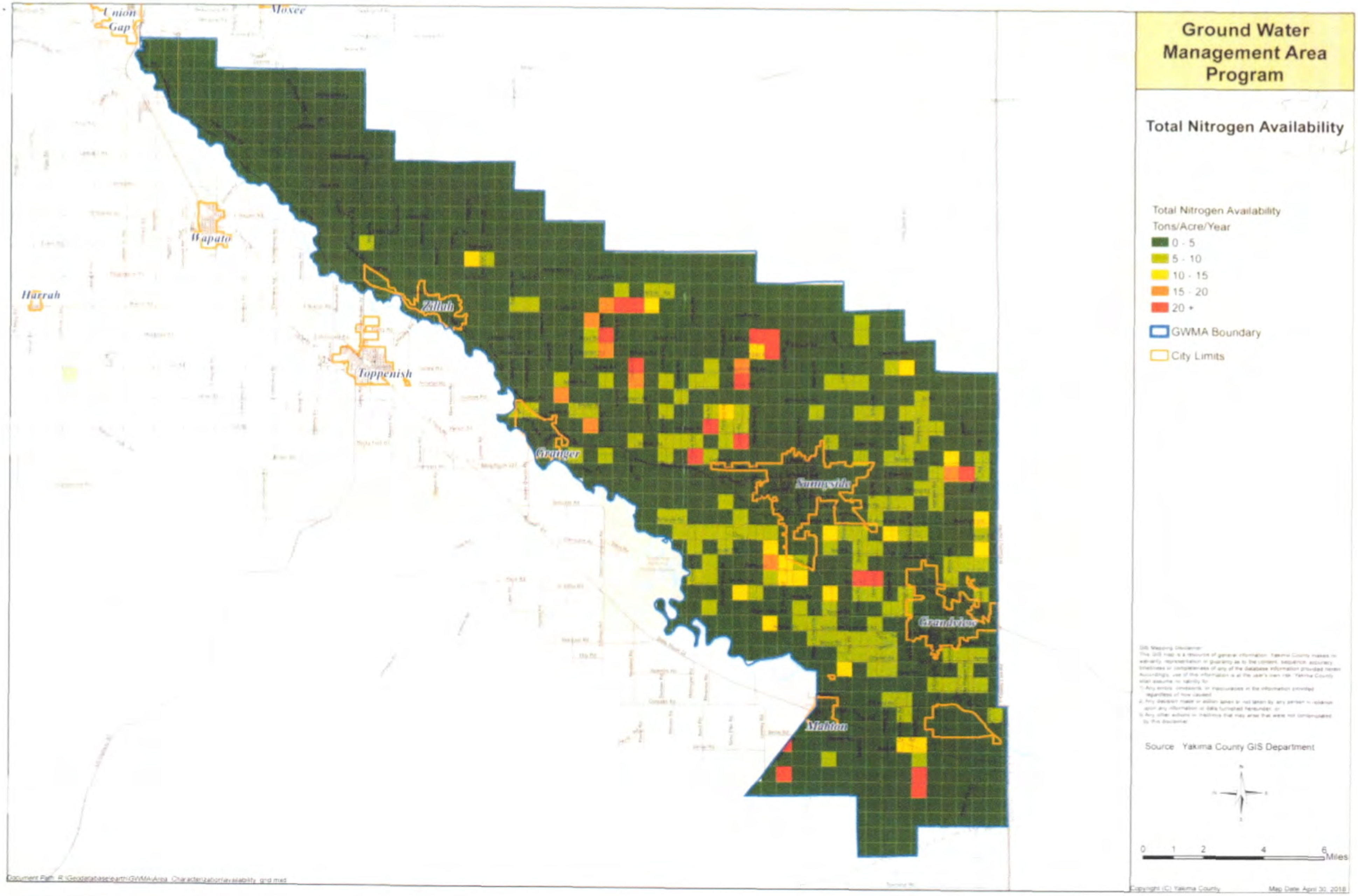
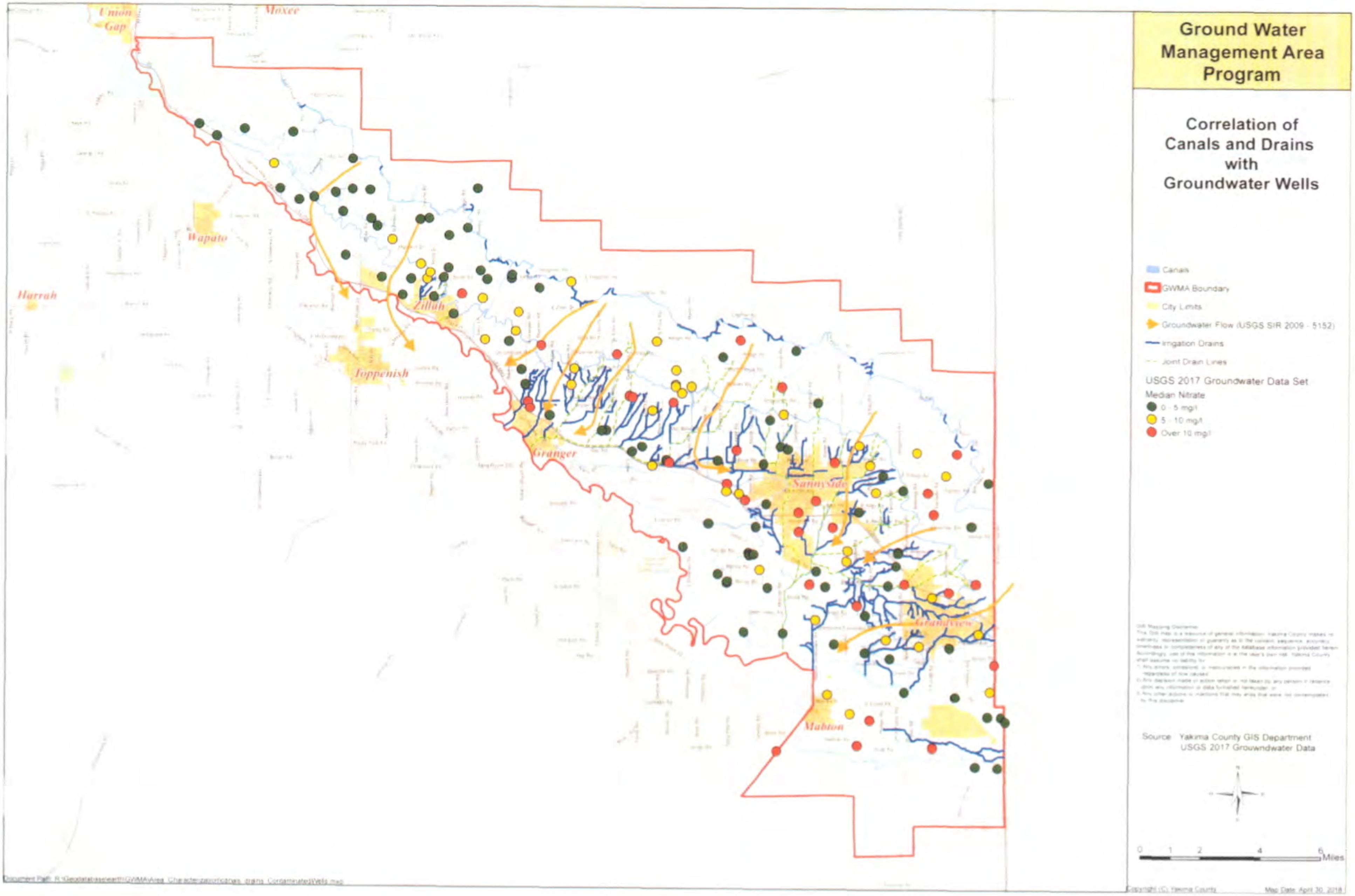
Map Date: April 30, 2018
Union Gap
Moxee
Wapato
Harrah
Zillah
Toppenish
Granger
Sunnyside
Grandview
Mabton



Ground Water Management Area Program
Total Nitrogen Availability
Total Nitrogen Availability
Tons/Acre/Year
0 - 5
5 - 10
10 - 15
15 - 20
20 +
GWMA Boundary
City Limits
Source Yakima County GIS Department
0 1 2 4 6 Miles
Copyright (C) Yakima County
Map Date April 30, 2018
Union Gap
Moxee
Wapato
Harrah
Zillah
Toppenish
Granger
Sunnyside
Grandview
Mabton



Ground Water Management Area Program
Correlation of Canals and Drains with Groundwater Wells
Canals
GWMA Boundary
City Limits
Groundwater Flow (USGS SIR 2009 - 5152)
Irrigation Drains
Joint Drain Lines
USGS 2017 Groundwater Data Set
Median Nitrate
0 - 5 mg/l
5 - 10 mg/l
Over 10 mg/l
Source Yakima County GIS Department
USGS 2017 Grouwndwater Data
0 1 2 4 6 Miles
Union Gap
Moxee
Wapato
Harrah
Zillah
Toppenish
Granger
Sunnyside
Grandview
Mabton
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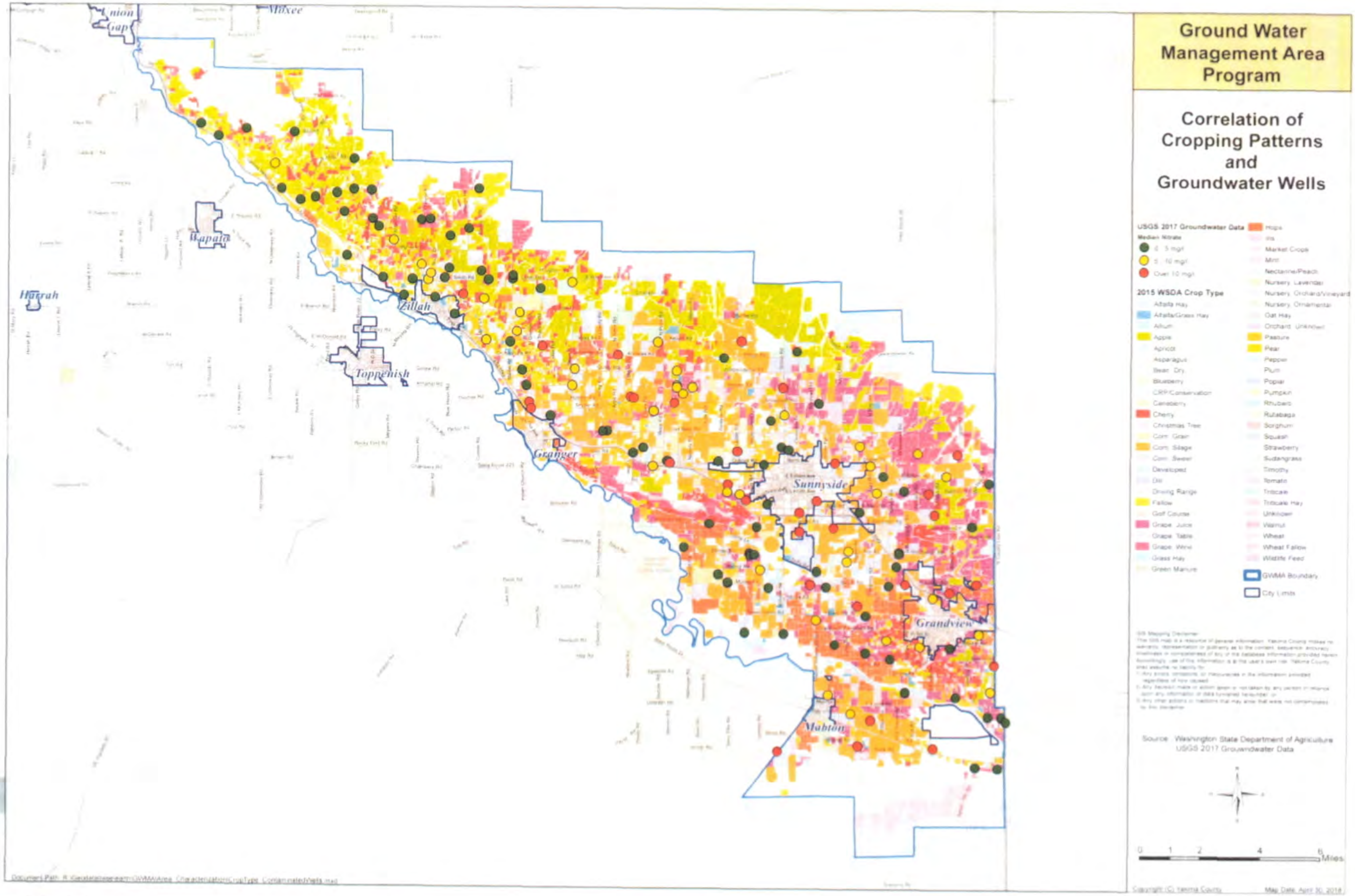
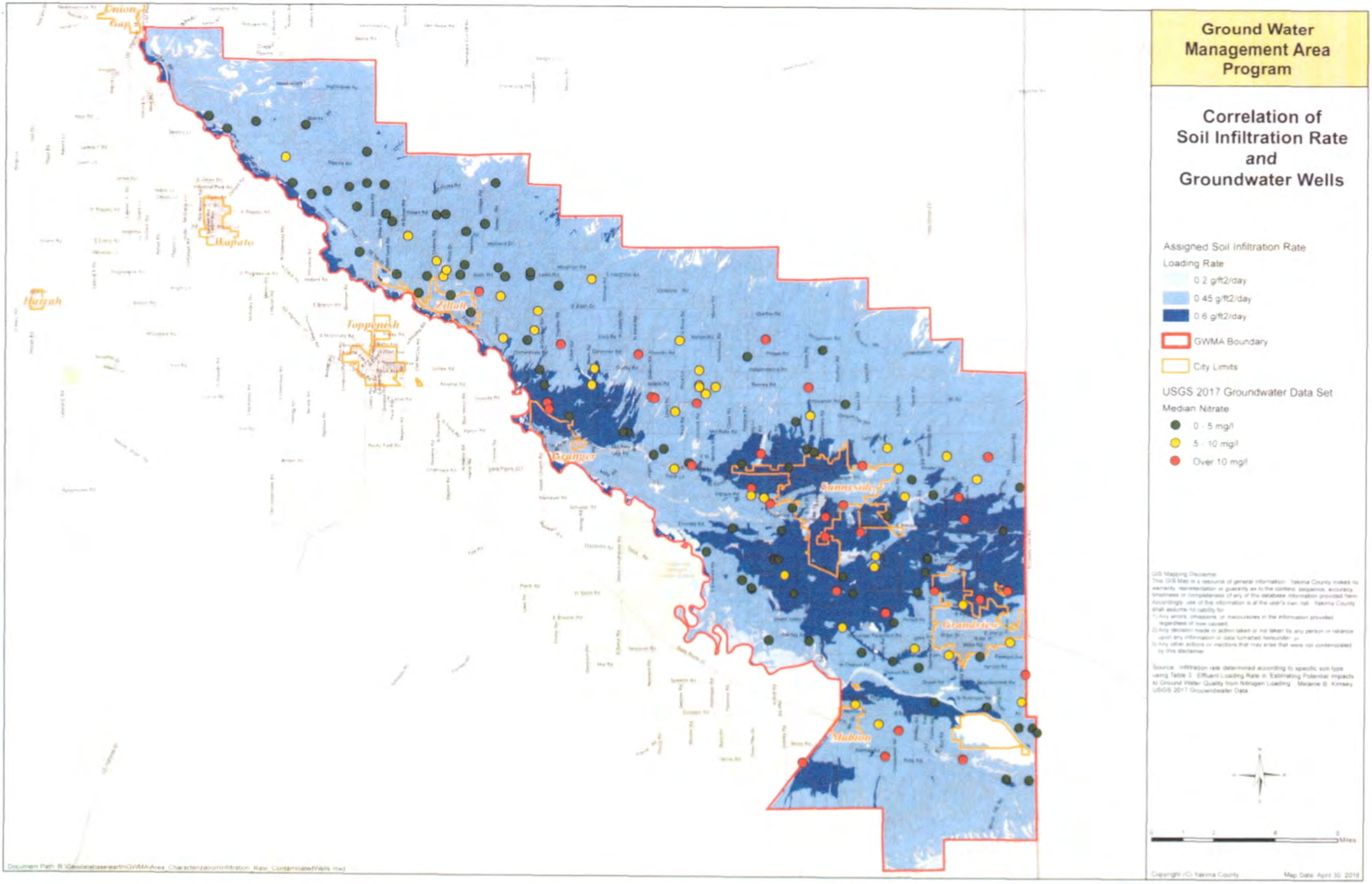

Ground Water Management Area Program
Correlation of Cropping Patterns and Groundwater Wells
USGS 2017 Groundwater Data
Median Nitrate
0 - 5 mg/l
5 - 10 mg/l
Over 10 mg/l
2015 WSDA Crop Type
Alfalfa Hay
Alfalfa/Grass Hay
Allium
Apple
Apricot
Asparagus
Bean, Dry
Blueberry
CRP/Conservation
Caneberry
Cherry
Christmas Tree
Corn, Grain
Corn, Silage
Corn, Sweet
Developed
Dill
Driving Range
Fallow
Golf Course
Grape, Juice
Grape, Table
Grape, Wine
Grass Hay
Green Manure
Hops
Iris
Market Crops
Mint
Nectarine/Peach
Nursery, Lavender
Nursery, Orchard/Vineyard
Nursery, Ornamental
Oat Hay
Orchard, Unknown
Pasture
Pear
Pepper
Plum
Poplar
Pumpkin
Rhubarb
Rutabaga
Sorghum
Squash
Strawberry
Sudangrass
Timothy
Tomato
Triticale
Triticale Hay
Unknown
Walnut
Wheat
Wheat Fallow
Wildlife Feed
GWMA Boundary
City Limits
Source: Washington State Department of Agriculture
USGS 2017 Groundwater Data
0 1 2 4 6 Miles
Union Gap
Moxee
Wapato
Harrah
Zillah
Toppenish
Granger
Sunnyside
Grandview
Mabton


Ground Water Management Area Program
Correlation of Soil Infiltration Rate and Groundwater Wells
Assigned Soil Infiltration Rate
Loading Rate
0.2 g/ft2/day
0.45 g/ft2/day
0.6 g/ft2/day
GWMA Boundary
City Limits
USGS 2017 Groundwater Data Set
Median Nitrate
0 - 5 mg/l
5 - 10 mg/l
Over 10 mg/l
Union Gap
Wapato
Harrah
Zillah
Toppenish
Granger
Sunnyside
Grandview
Mabton
Source: Infiltration rate determined according to specific soil type using Table 3: Effluent Loading Rate in 'Estimating Potential Impacts to Ground Water Quality from Nitrogen Loading' - Melanie B. Kimsey USGS 2017 Groundwater Data
Miles
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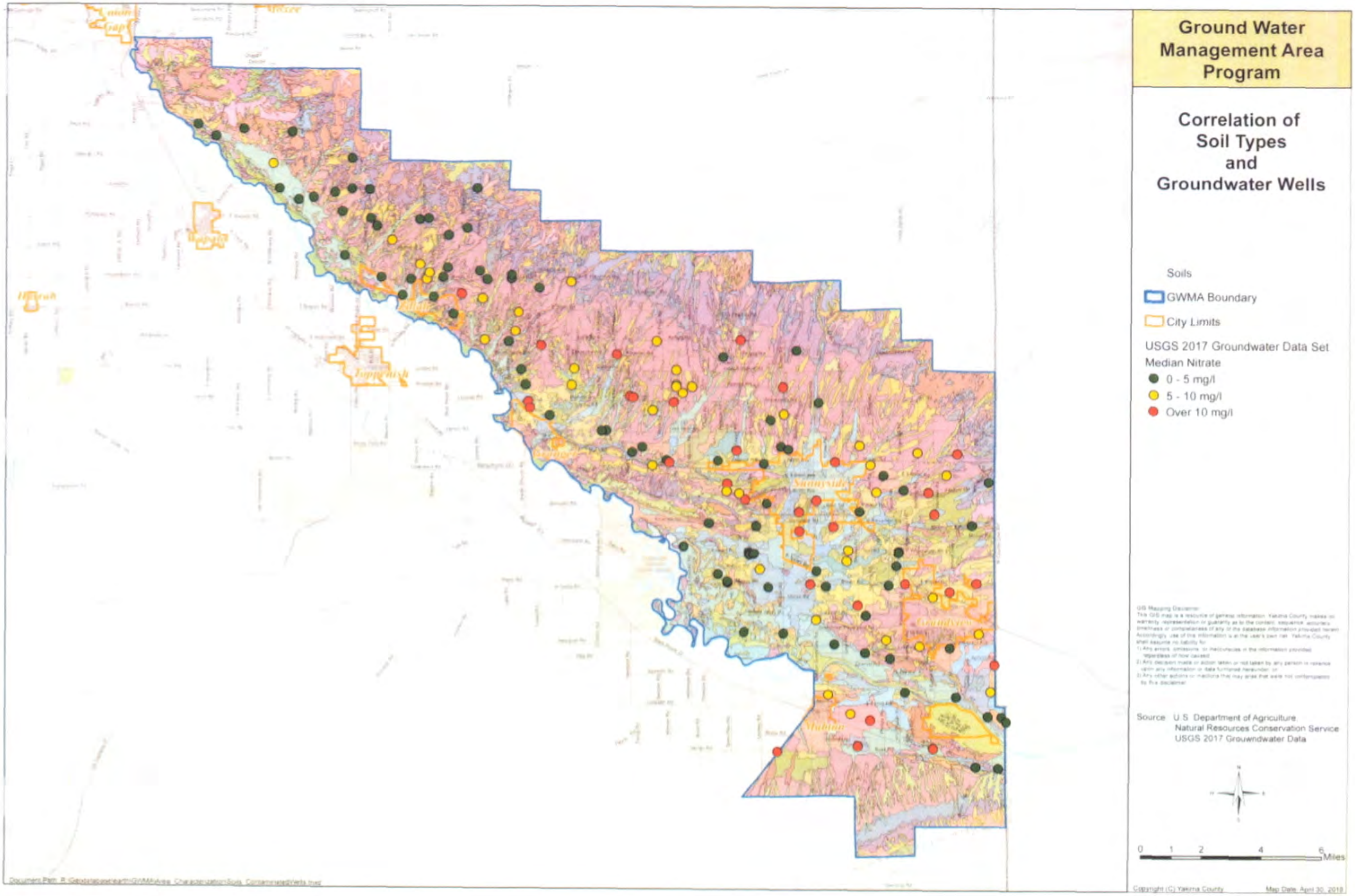
Ground Water Management Area Program
Correlation of Soil Types and Groundwater Wells
Soils
GWMA Boundary
City Limits
USGS 2017 Groundwater Data Set
Median Nitrate
0 - 5 mg/l
5 - 10 mg/l
Over 10 mg/l
Source U.S. Department of Agriculture,
Natural Resources Conservation Service
USGS 2017 Grouwndwater Data
0 1 2 4 6 Miles
Copyright (C) Yakima County
Map Date: April 30, 2018
Sunnyside
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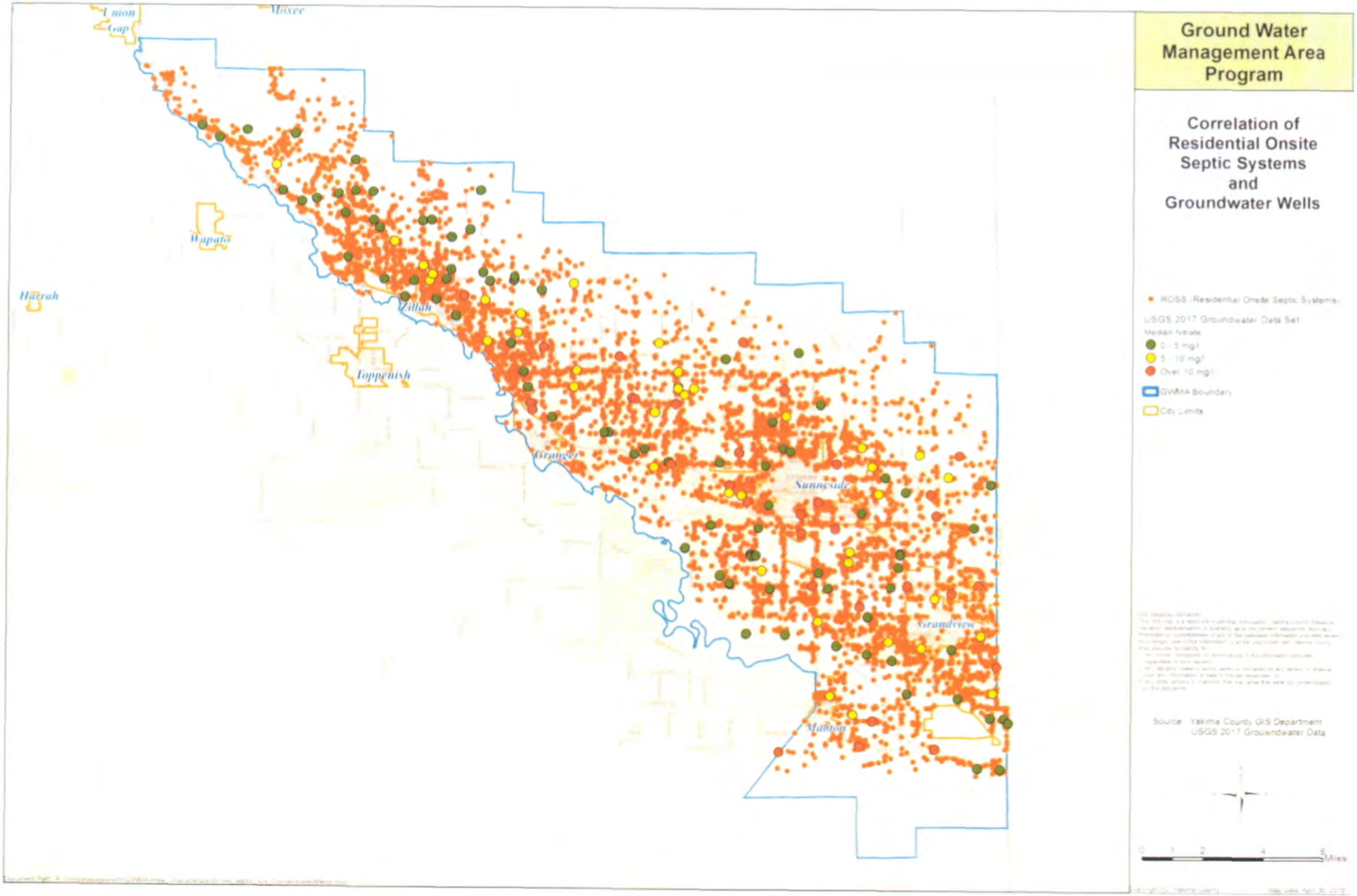
Grandview


Ground Water Management Area Program
Correlation of Residential Onsite Septic Systems and Groundwater Wells
ROSS (Residential Onsite Septic Systems)
USGS 2017 Groundwater Data Set
Median Nitrate
0 - 5 mg/l
5 - 10 mg/l
Over 10 mg/l
GWMA Boundary
City Limits
Source: Yakima County GIS Department
USGS 2017 Groundwater Data
0 1 2 4 6 Miles
Union Gap
Moxee
Wapato
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Zillah
Toppenish
Granger
Sunnyside
Grandview
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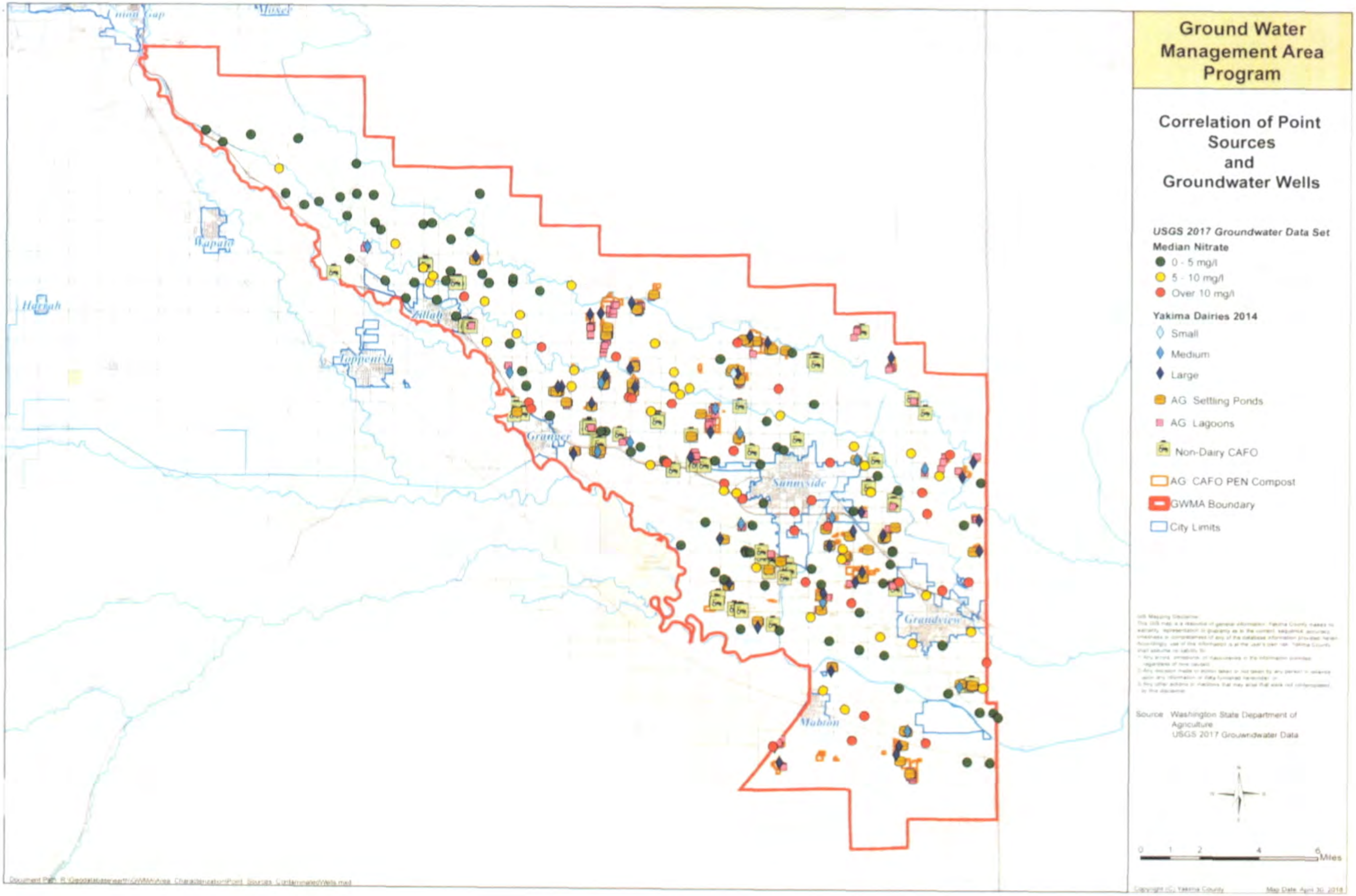
Ground Water Management Area Program
Correlation of Point Sources and Groundwater Wells
USGS 2017 Groundwater Data Set
Median Nitrate
0 - 5 mg/l
5 - 10 mg/l
Over 10 mg/l
Yakima Dairies 2014
Small
Medium
Large
AG Settling Ponds
AG Lagoons
Non-Dairy CAFO
AG CAFO PEN Compost
GWMA Boundary
City Limits
Source Washington State Department of Agriculture
USGS 2017 Grouwndwater Data
0 1 2 4 6 Miles
Union Gap
Moxee
Wapato
Harrah
Toppenish
Zillah
Granger
Sunnyside
Grandview
Mabton
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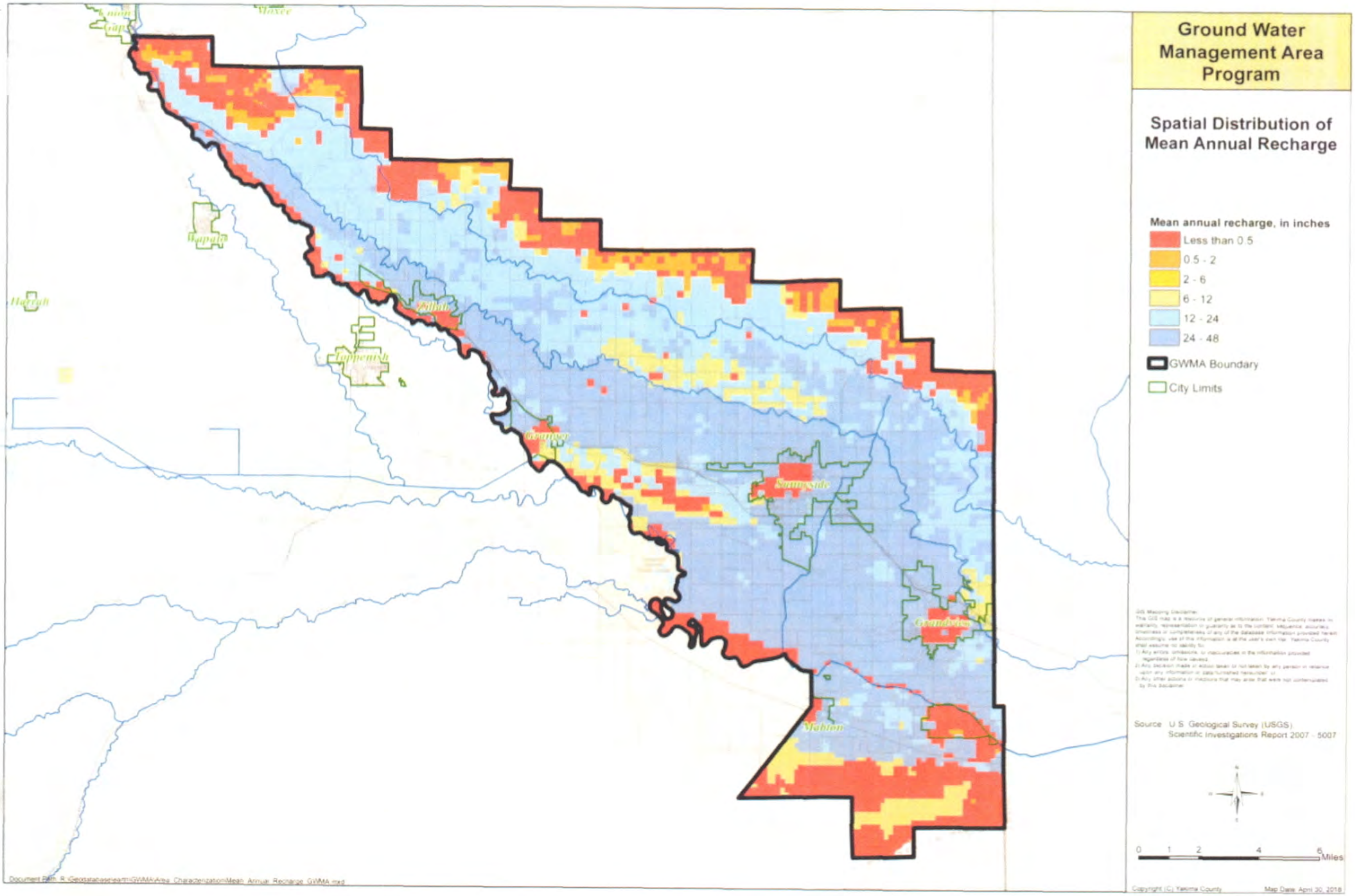
Ground Water Management Area Program
Spatial Distribution of Mean Annual Recharge
Mean annual recharge, in inches
Less than 0.5
0.5 - 2
2 - 6
6 - 12
12 - 24
24 - 48
GWMA Boundary
City Limits
Zillah
Granger
Sunnyside
Grandview
Mabton
Toppenish
Wapato
Harrah
Source U.S. Geological Survey (USGS) Scientific Investigations Report 2007 - 5007
0 1 2 4 6 Miles
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Map Date: April 30, 2018

GWMA Program Recommendations: GWAC Member Vote Tally, May 17, 2018

Education				
1	DOH, Yakima Health District, Lead Agency	Develop a health-risk education and outreach campaign	Establish a public education program regarding nitrate pollution and health risk over a 5-10 year period. Broaden the pool of people GWMA is educating or communicating with. Provide all materials distributed to the public in English and Spanish. Provide education about concepts that people can understand. Billboard campaign – urging well testing. 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)	28
2	Yakima Health District	Publish and distribute homeowner guide on how to maintain septic systems		40
3	OSPI, ESD 105	Develop educational materials that could be elected by instructors at 8-12 levels about aquifer protection, groundwater and best management practices.		-6
4	Lead Agency	Develop an urban and hobby agriculturalist education and outreach campaign.	Provide information targeted to small farm/hobby farm/ranchettes about manure management. Publish public information about proper septic system construction and operation. Educate the public, particularly in towns, about lawn and garden nitrogen applications' contribution to nitrate concentrations. Recommend against farming around a water well	10
5	WCC, WSU Extension, DOE, SYCD, WSDA, Lead Entity, Ag Industry Associations	Develop a post-GWAC agricultural producer education and outreach campaign. 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	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	36

		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.	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.	
6	SYCD, WCC	Establish a local forum for disseminating information and facilitating technical exchange regarding BMPs for irrigated agriculture and livestock management and groundwater protection.	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.	36
7	WSDA, SYCD	Inform farmers of those BMPs prioritized by Livestock/CAFO and Irrigated Agriculture Work Groups to reflect greatest effectiveness in nitrate reduction.	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.	25

8	WSDA, SYCD	Encourage appropriate use of surface banding ("dribbling," "stripping" of liquid fertilizer, "broadcasting" or prompt incorporation of manures and fertilizers after application to cropland.	broadcast is effective for corn, alfalfa, triticale. Incorporation should occur within 24 hours.	18
9	WSDA, SYCD	Continue to provide underlying soils information to individual livestock operations, provide same for all irrigated agriculture	So that individual property owners can evaluate contamination potential., already in DNMP process	25

Administrative				
1	DOE, Lead Agency, Yakima Health District	Establish or maintain ongoing, extended funding necessary for the Yakima County Department of Public Services and Yakima Health District to actively participate in water quality improvement, testing, monitoring, scientific data analysis, and infrastructure development.	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.	35
2	Washington Conservation Commission	Fund SYCD, through State Conservation Commission budget, for projected educational, administrative, nutrient management planning, engineering, cost share, and lending activities.		39
3	SYCD, WSDA	Monitor changes occurring in agricultural operations. Evaluate whether those changes positively affect improvement in groundwater quality.	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.	25
4	Lead Agency	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.	Administration of Groundwater Quality Program. Administer funds and distribute to other entities by subcontract. Maintain Yakima County's GWMA website. Maintain a GIS data base on the GWMA.	41
5	Lead Agency	Perform an engineering study of water supply alternatives.	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	14

			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).	
6	Lead Agency	Adopt and Implement an Adaptive Management Plan	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.	22
7	EPA, DOE, WSDA	Streamline current regulatory enforcement activities	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.	25
8	DOE, WSDA	Improve composting regulations (statutory)	Unclear as to particular regulations proposed	-4
9	DOE	Inspect, monitor and regulate stockpiled manures.	Coordinate with WSDA. Currently being done; currently required as part of dairy nutrient management plans	1
10	DOE	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 regs		12

11	DOE	Provide assistance to local departments of health regarding the regulation of agricultural composting operations		7
12	DOE	Analyze the trends of nitrate data contained within reports required by NPDES and SWD permits.		23
13	DOE,	Develop a plan for finding and decommissioning abandoned wells in the next 12 months, using the LYVGWMA as a pilot project.	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.	23
14	DOE	Require facility process improvements in waste treatment and food processing plants to reduce nitrogen and total discharge volume.	Addressed by Department of Ecology General Permit for Food Processing, specific problems can be addressed through "special protection areas, " WAC 173-200-090.	-3
15	DOE, EPA	Study the relationship between nitrogen emissions and atmospheric deposition of reactive nitrogen. Develop a model that predicts what percentage of emissions return to the GWMA area as atmospheric deposition.		-37

16	WDOH	Determine, prior to issuing or reissuing LOSS permits, that all employee counts are regularly reported.	So that the LOSS will continue to operate as designed.	19
17	WDOH	Revise WAC 246-203-130 (keeping of animals)	So that it includes specific and enforceable requirements designed to protect human health.	-1
18	WSDA	Design and implement pilot studies focusing on innovative farm techniques which reduce nitrogen loading to crops and monitor results.		34
19	WSDA	Document and publish regulatory compliance for dairies within the GWMA that are completing and implementing Dairy Nutrient Management Plans (DNMP).	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.	7
20	DOE, Yakima Regional Clean Air Agency, WSDA	Estimate emissions of reactive nitrogen - gaseous 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. Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.	Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.	-33
21	WSDA	Establish a monitoring system for compliance with NRCS Standard 317 on new composting facilities at Washington dairies (phased in for existing facilities).		-4
22	Yakima Health District	Issue permits for agricultural composting operations, to appropriately inspect composting operations and to enforce regulations that protect public health and the environment, as required by state rules and regs.		0

23	Yakima Health District	Require new developments outside towns to address potential impacts on groundwater quality	Through permitting review of site plan criteria.	19
24	Yakima Health District	Study potential nitrate contamination attributable to improperly operated septic systems.	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.	32
25	Yakima County Building Department	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.	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.	15

Data Collection and Monitoring				
1	DOE, DOH	Establish time-based performance objectives against which well-monitoring data can be compared.	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.	16
2	Yakima County Public Works	Install Ambient Groundwater Monitoring Wells	Monitoring well construction: Monitoring well data collection:	42
3	YHD	Collect data from Ambient Groundwater Monitoring Wells	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.	42
4	Irrigation Districts	Monitor nitrate concentrations of irrigation water at headgates.	Report nitrate concentrations annually to Department of Ecology	35
5	USGS	Contract with USGS to collect data from water well system per 2017		28
6	USGS	Contract with USGS to do particle tracking model study to indicate where groundwater moves faster (permeability).	USGS Particle Tracking Model Overview--potentially combined with MT3D MODFLOW application to the vadose Zone	9
7	WSDA, DOE, Lead Agency	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.	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	5

			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.	

Water				
1	WSU	Provide funding to WSU for a mobile irrigation lab to assess the efficiency of current or advised irrigation practices, either through a singular lab or component parts.	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.	25
2	SYCD, WSDA, WSU	Create Irrigation Management Plans (similar to Nutrient Management Plans) for farms over a minimum size and provide financial assistance for implemented plans.	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.	23
3	WSU, SYCD, WSDA, WCC	Encourage advanced irrigation management. Integrate management of synthetic/organic fertilizers and application of water	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	31

			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.	

Public Works				
1	Municipalities	Provide funding for municipalities to replace aging sewer system infrastructure and ensure proper system maintenance to reduce nitrate leaching.	Municipalities need to estimate costs and system integration.	11
2	Lead Agency	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

	Research and Development			
1	EPA, DOE	Identify and support opportunities, including educational research institutions, for private, public, and industry investment in technology specific to addressing nitrate contamination in groundwater.	EPA & DOE construct a LYVGWMA Program for coordinated implementation.	20
2	WSDA	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.	WSDA construct LYVGWMA administrative program.	26
3	USDOE, USDOA	Explore investment in animal and agricultural waste to energy technology	Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives)	22
4	WSU Extension Service	Continue research of water management with application of agricultural nutrients.	Develop water sorption graph or chart. List volumes of water applied, soil types, infiltration rates, water holding capacity, absorption/compaction rates, depths to water,	25

			pre-season and post-season appropriate moisture levels, evapotranspiration rates.	
5	WSU, Producers	Integrate use of animal waste and synthetic fertilizer.	Research 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.	23
6	WSDA, WSU	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
7	WSDA	Develop strategies for marketing the economic, fertilizer value, and soil enhancing properties of appropriate application of *manure and other livestock wastes.*		18
8	WCC	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
9	Legislature	Require Commodity Commissions to dedicate "check off" money for research and development in water quality technology and practices.	Include in funding alternatives for technology R & D	-7
10	USDOE, USDOA	Explore investment in animal and agricultural waste to energy technology	Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives)	16
11	SYCD, WSDA, WSU, Private Industry, Producers	Educate producers regarding application of nutrients at Agronomic Rate	Develop technologies and provide information about improvements made in nutrient management and agronomic rate application of fertilizer by specific developing technologies.	30

Agriculture				
1	NRCS, DOE	Provide financial assistance for implementation of Irrigation Management Plans.	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.	32
2	DOE, WSDA	Make grants and allocate cost share funding or other funding assistance to people implementing environmental protection measures affecting groundwater quality.	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	17
3	SYCD, Producers	Develop and implement Nutrient Management Plans for all farmers.	Mandatory or Voluntary. Farming operations currently are not required to hold permits or a prepare a Nutrient Management Plan.	19
4	WSDA	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
5	SYCD	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	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	25

		throughout growing year, in order to observe effects of fertilization throughout year. Share data with public.	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.	
6	WSDA	Complete NRCS Technical Note 23 inspections on all waste storage ponds (lagoons) within the GWMA boundaries.		22
7	Producers	Make capital improvements	Install liners in liquid waste storage lagoons. Install impervious surfaces beneath silage storage.	2
8	Legislature	Make shallow (1, 2, 3 foot) soil testing reports prerequisites for funding, lending or building permits.	In the nature of Phase I Environmental Audits. Makes nitrate-related information/data available for water quality management.	0

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2. Data	Yakima County Public Works	Install Ambient Groundwater Monitoring Wells	Monitoring well construction: Monitoring well data collection:	3	3	3	2	3	3	2	3	1	1	3	3	3	2	2	3	2	**42**
3. Data	YHD	Collect data from Ambient Groundwater Monitoring Wells	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.	3	3	3	3	3	3	2	3	1	1	3	3	3	2	2	3	1	**42**
4. Admin	Lead Agency	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.	Administration of Groundwater Quality Program. Administer funds and distribute to other entities by subcontract. Maintain Yakima County's GWMA website. Maintain a GIS data base on the GWMA.	3	3	3	3	2	2	3	3	3	0	3	1	3	3	2	2	2	**41**
2. Edu	Yakima Health District	Publish and distribute homeowner guide on how to maintain septic systems		2	3	3	3	3	1	3	3	1	3	3	2	1	3	1	2	3	**40**
2. Admin	Washington Conservation Commission	Fund SYCD, through State Conservation Commission budget, for projected educational, administrative, nutrient management planning, engineering, cost share, and lending activities.		0	3	0	3	3	2	3	3	0	3	3	1	3	3	3	3	3	**39**

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5. Edu	WCC, WSU Extention, DOE, SYCD, WSDA, Lead Entity, Ag Industry Associations	Develop a post-GWAC agricultural producer education and outreach campaign. 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.	1	3	1	3	3	2	3	3	2	3	2	2	3	-3	2	3	3	**36**

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6. Edu	SYCD, WCC	Establish a local forum for disseminating information and facilitating technical exchange regarding BMPs for irrigated agriculture and livestock management and groundwater protection.	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.	1	3	2	3	2	2	2	2	-1	3	3	1	2	3	2	3	3	**36**
1. Admin	DOE, Lead Agency, Yakima Health District	Establish or maintain ongoing, extended funding necessary for the Yakima County Department of Public Services and Yakima Health District to actively participate in water quality improvement, testing, monitoring, scientific data analysis, and infrastructure development.	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.	3	3	2	2	2	3	2	3	3	3	3	2	3	-3	1	2	1	**35**
4. Data	Irrigation Districts	Monitor nitrate concentrations of irrigation water at headgates.	Report nitrate concentrations annually to Department of Ecology	3	2	3	1	3	3	1	2	2	1	3	3	3	3	0	2	0	**35**
18. Admin	WSDA	Design and implement pilot studies focusing on innovative farm techniques which reduce nitrogen loading to crops and monitor results.		2	3	1	3	3	1	2	3	0	1	1	3	2	2	3	3	1	**34**

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24. Admin	Yakima Health District	Study potential nitrate contamination attributable to improperly operated septic systems.	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.	3	3	1	3	2	2	3	1	1	3	3	1	2	3	0	2	-1	**32**
1. Agriculture	NRCS, DOE	Provide financial assistance for implementation of Irrigation Management Plans.	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.	1	3	1	3	2	2	2	3	1	2	3	-3	3	3	0	3	3	**32**

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3.Water	WSU, SYCD, WSDA, WCC	Encourage advanced irrigation management. Integrate management of synthetic/organic fertilizers and application of water	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.	0	3	0	3	2	2	3	3	1	-3	3	1	2	2	3	3	3	**31**
11. R&D	SYCD, WSDA, WSU, Private Industry, Producers	Educate producers regarding application of nutrients at Agronomic Rate	Develop technologies and provide information about improvements made in nutrient management and agronomic rate application of fertilizer by specific developing technologies.	1	3	0	3	1	1	1	2	0	-1	3	3	1	3	3	3	3	**30**

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1. Education	DOH, Yakima Health District, Lead Agency	Develop a health-risk education and outreach campaign	Establish a public education program regarding nitrate pollution and health risk over a 5-10-year period. Broaden the pool of people GWMA is educating or communicating with. Provide all materials distributed to the public in English and Spanish. Provide education about concepts that people can understand. Billboard campaign – urging well testing. 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)	3	3	3	1	3	1	2	1	1	3	3	1	0	-1	1	0	3	**28**
5. Data	USGS	Contract with USGS to collect data from water well system per 2017		3	2	3	3	3	3	1	2	2	-1	3	1	2	-3	2	2	0	**28**
2. Public Works	Lead Agency	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		1	3	1	3	2	1	3	3	1	0	3	1	0	3	1	1	-1	**26**
2. R&D	WSDA	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.	WSDA construct LYVGWMA administrative program.	1	3	0	3	3	1	2	3	0	2	2	-1	1	1	2	3	0	**26**

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7. Education	WSDA, SYCD	Inform farmers of those BMPs prioritized by Livestock/CAFO and Irrigated Agriculture Work Groups to reflect greatest effectiveness in nitrate reduction.	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.*	2	3	2	3	3	2	3	2	2	-3	3	-3	3	-3	0	3	3	**25**
9. Education	WSDA, SYCD	Continue to provide underlying soils information to individual livestock operations, provide same for all irrigated agriculture	So that individual property owners can evaluate contamination potential., already in DNMP process	3	3	0	1	3	2	2	3	0	0	0	-3	3	2	2	1	3	**25**
3. Administrative	SYCD, WSDA	Monitor changes occurring in agricultural operations. Evaluate whether those changes positively affect *improvement in* groundwater quality.	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.	1	3	0	3	2	0	1	3	3	0	2	1	2	1	1	2	0	**25**
7. Administrative	EPA, DOE, WSDA	Streamline current regulatory enforcement activities	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.	2	2	0	3	1	2	2	3	1	-1	3	1	2	-1	1	3	1	**25**

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1. Water	WSU	Provide funding to WSU for a mobile irrigation lab to assess the efficiency of current or advised irrigation practices, either through a singular lab or component parts.	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.	1	2	0	3	2	1	2	3	0	1	3	2	2	-3	3	0	3	**25**
4. R&D	WSU Extension Service	Continue research of water management with application of agricultural nutrients.	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.	1	3	0	3	2	1	-3	2	1	1	3	2	2	-2	3	3	3	**25**
5. Agriculture	SYCD	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.	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.	3	3	1	3	2	2	3	2	0	-3	3	-1	3	2	1	1	0	**25**

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2. Water	SYCD, WSDA, WSU	Create Irrigation Management Plans (similar to Nutrient Management Plans) for farms over a minimum size and provide financial assistance for implemented plans.	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.	0	3	2	3	1	2	3	2	-1	-3	3	-3	1	1	3	3	3	**23**
5. R&D	WSU, Producers	Integrate use of animal waste and synthetic fertilizer.	Research 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.	1	2	0	3	1	1	1	2	1	0	3	2	2	-3	3	2	2	**23**
12. Admin	DOE	Analyze the trends of nitrate data contained within reports required by NPDES and SWD permits.		2	1	3	1	3	1	1	2	3	-3	3	-3	3	3	0	2	1	**23**

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13. Administrative	DOE	Develop a plan for finding and decommissioning abandoned wells in the next 12 months, using the LYVGWMA as a pilot project.	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.	1	2	2	3	2	2	2	2	1	-1	3	1	-3	3	1	2	0	**23**
6. Administrative	Lead Agency	Adopt and Implement an Adaptive Management Plan	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.	1	2	1	-3	3	1	3	3	3	-2	3	1	1	2	1	2	0	**22**
3. R&D	USDOE, USDOA	Explore investment in animal and agricultural waste to energy technology	Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives)	0	3	0	3	1	1	2	3	-2	2	2	3	1	1	1	1	0	**22**

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6.Agri	WSDA	Complete NRCS Technical Note 23 inspections on all waste storage ponds (lagoons) within the GWMA boundaries.		3	3	1	1	3	1	3	2	2	-3	3	-1	1	3	2	-3	1	**22**
1.Research & Dev	EPA, DOE	Identify and support opportunities, including educational research institutions, for private, public, and industry investment in technology specific to addressing nitrate contamination in groundwater.	EPA & DOE construct a LYVGWMA Program for coordinated implementation.	2	3	0	3	3	1	1	3	0	-2	3	-1	2	3	0	-3	2	**20**
16.Admin	WDOH	Determine, prior to issuing or reissuing LOSS permits, that all employee counts are regularly reported.	So that the LOSS will continue to operate as designed.	1	1	3	3	2	0	3	3	0	-3	3	-3	3	3	2	-1	-1	**19**
23.Admin	Yakima Health District	Require new developments outside towns to address potential impacts on groundwater quality	Through permitting review of site plan criteria.	2	2	1	3	3	1	2	3	2	0	3	-3	0	3	0	-3	0	**19**
6.R&D	WSDA, WSU	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.		3	3	0	3	2	2	2	1	-2	-3	3	-1	1	1	1	2	1	**19**
3.Agri	SYCD, Producers	Develop and implement Nutrient Management Plans for all farmers.	Mandatory or Voluntary. Farming operations currently are not required to hold permits or a prepare a Nutrient Management Plan.	1	2	2	3	3	1	3	2	2	2	1	-3	1	-3	3	-1	-2	**19**
8.Education	WSDA, SYCD	Encourage appropriate use of surface banding ("dribbling," "stripping" of liquid fertilizer, "broadcasting" or prompt incorporation of manures and fertilizers after application to cropland.	broadcast is effective for corn, alfalfa, triticale. Incorporation should occur within 24 hours.	1	1	0	1	3	2	1	3	0	0	2	-3	3	-3	2	3	2	**18**

	Recommend To:	Recommendation	Details	Andy Cervantes (Dept. of Health)	David Bowen (Dept. of Ecology)	Holly Myers (YHD)	Jason Sheehan (Dairy Federation)	Jessica Black (Heritage University)	John Van Wingerden (Port of Sunnyside)	Laurie Crowe (SYCD)	Lucy Edmondson (EPA)	Matt Bachmann (USGS)	Pat Newhouse (Lower Valley Rep.)	Perry Beale (WSDA)	Rand Elliott (BOCC)	Ron Cowin (SVID-Roza)	Steve George (Farm Bureau)	Stuart Crane (Yakama Nation)	Stu Turner (Agronomist)	Troy Peters (WSU Ext.)	TOTAL
7.R&D	WSDA	Develop strategies for marketing the economic, fertilizer value, and soil enhancing properties of appropriate application of manure and other livestock wastes.		0	3	0	3	1	2	1	3	-2	0	3	3	1	-3	2	1	0	**18**
8.R&D	WCC	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.		2	3	0	3	1	2	-3	2	-2	0	3	3	0	1	0	1	1	**17**
2.Agriculture	DOE, WSDA	Make grants and allocate cost share funding or other funding assistance to people implementing environmental protection measures affecting groundwater quality.	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	3	3	1	3	1	0	-3	3	3	-3	2	-1	1	1	1	3	-1	**17**
1.Data	DOE, DOH	Establish time-based performance objectives against which well-monitoring data can be compared.	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.	3	3	1	2	1	-1	2	3	1	-2	2	-3	0	1	0	2	1	**16**
10.R&D	USDOE, USDOA	Explore investment in animal and agricultural waste to energy technology	Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives)	1	2	0	3	1	1	3	2	0	-3	3	3	0	1	0	-1	0	**16**

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25.Administrative	Yakima County Building Department	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.	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.	3	1	3	3	2	0	-2	3	0	0	3	-3	1	3	1	-3	0	**15**
5. Administrative	Lead Agency	Perform an engineering study of water supply alternatives.	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).	2	1	-1	3	2	1	-3	3	1	0	2	1	0	2	3	-2	-1	**14**
10.Administrative	DOE	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 regs		1	1	1	2	3	0	3	3	-2	-3	3	-3	3	3	0	-3	0	**12**

	Recommend To:	Recommendation	Details	Andy Cervantes (Dept. of Health)	David Bowen (Dept. of Ecology)	Holly Myers (YHD)	Jason Sheehan (Dairy Federation)	Jessica Black (Heritage University)	John Van Wingerden (Port of Sunnyside)	Laurie Crowe (SYCD)	Lucy Edmondson (EPA)	Matt Bachmann (USGS)	Pat Newhouse (Lower Valley Rep.)	Perry Beale (WSDA)	Rand Elliott (BOCC)	Ron Cowin (SVID-Roza)	Steve George (Farm Bureau)	Stuart Crane (Yakama Nation)	Stu Turner (Agronomist)	Troy Peters (WSU Ext.)	TOTAL
1.Public Works	Municipalities	Provide funding for municipalities to replace aging sewer system infrastructure and ensure proper system maintenance to reduce nitrate leaching.	Municipalities need to estimate costs and system integration.	3	1	-2	3	2	1	-3	3	-1	2	2	1	0	2	1	-3	-1	**11**
4.Education	Lead Agency	Develop an urban and hobby agriculturalist education and outreach campaign.	Provide information targeted to small farm/hobby farm/ranchettes about manure management. Publish public information about proper septic system construction and operation. Educate the public, particularly in towns, about lawn and garden nitrogen applications' contribution to nitrate concentrations. Recommend against farming around a water well	1	2	0	-3	2	1	1	-1	-1	-1	3	1	-1	3	-2	2	3	**10**
6.Data	USGS	Contract with USGS to do particle tracking model study to indicate where groundwater moves faster (permeability).	USGS Particle Tracking Model Overview--potentially combined with MT3D MODFLOW application to the vadose Zone	3	2	1	-2	3	0	-3	3	3	-2	3	1	0	-3	1	-1	0	**9**
4.Agriculture	WSDA	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.		2	3	2	-3	3	2	-3	0	3	-3	2	2	1	-3	2	-2	0	**8**
11.Admin	DOE	Provide assistance to local departments of health regarding the regulation of agricultural composting operations		1	1	1	1	3	0	1	3	-2	-3	3	-3	3	1	0	-3	0	**7**

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19.Administrative	WSDA	Document and publish regulatory compliance for dairies within the GWMA that are completing and implementing Dairy Nutrient Management Plans (DNMP).	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.	2	3	2	3	2	0	-3	2	2	-3	0	1	0	-3	1	-2	0	**7**
7.Data Collection & Monitoring	WSDA, DOE, Lead Agency	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.	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 (NO_x), ammonia (NH_3), nitrous oxide (N_2O), the anion nitrate, NO_3,- from animal agriculture, manure and fertilizer applications.. Use this to inform the nitrogen balance data base and refine estimates of atmospheric deposition.	0	3	1	1	2	2	1	3	-2	-3	2	-3	0	-3	0	1	0	**5**

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22.Administrative	Yakima Health District	Issue permits for agricultural composting operations, to appropriately inspect composting operations and to enforce regulations that protect public health and the environment, as required by state rules and regs.		0	1	-1	-3	2	1	-3	2	2	-3	2	1	1	1	1	-2	2	**4**
7.Agri	Producers	Make capital improvements	Install liners in liquid waste storage lagoons. Install impervious surfaces beneath silage storage.	3	2	1	-3	3	1	-2	2	2	-3	0	-1	1	-3	2	-3	0	**2**
9.Admin	DOE	Inspect, monitor and regulate stockpiled manures.	Coordinate with WSDA. Currently being done; currently required as part of dairy nutrient management plans	2	2	0	-2	3	0	-3	2	1	-3	3	-3	3	-3	0	-2	1	**1**
8.Agri	Legislature	Make shallow (1, 2, 3 foot) soil testing reports prerequisites for funding, lending or building permits.	In the nature of Phase I Environmental Audits. Makes nitrate-related information/data available for water quality management.	3	1	-1	3	3	1	-3	1	2	-3	0	-3	1	-3	0	-3	-2	**0**
17.Admin	WDOH	Revise WAC 246-203-130 (keeping of animals)	So that it includes specific and enforceable requirements designed to protect human health.	2	1	3	-1	2	-1	-3	2	3	-3	0	-1	2	-3	0	-3	-1	**-1**
14.Admin	DOE	Require facility process improvements in waste treatment and food processing plants to reduce nitrogen and total discharge volume.	Addressed by Department of Ecology General Permit for Food Processing, specific problems can be addressed through "special protection areas," WAC 173-200-090.	2	1	0	3	1	-2	-3	2	2	-2	-1	-3	-1	1	0	-2	-1	**-3**
8.Admin	DOE, WSDA	Improve composting regulations (statutory)	Unclear as to particular regulations proposed	2	1	0	-3	1	-1	-1	2	1	-3	2	-1	0	-2	-2	-2	2	**-4**

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21.Admin	WSDA	Establish a monitoring system for compliance with NRCS Standard 317 on new composting facilities at Washington dairies (phased in for existing facilities).		0	1	0	-2	1	0	-3	3	0	-3	1	-3	1	-3	1	2	0	**-4**
3.Education	OSPI, ESD 105	Develop educational materials that could be elected by instructors at 8-12 levels about aquifer protection, groundwater and best management practices.		2	1	-3	-2	3	-3	1	-2	0	-3	3	-3	-2	1	1	-1	1	**-6**
9.R&D	Legislature	Require Commodity Commissions to dedicate "check off" money for research and development in water quality technology and practices.	include in funding alternatives for technology R & D	0	2	0	-3	1	3	-3	0	0	-3	-1	-3	0	-3	1	-1	3	**-7**
20.Admin	DOE, Yakima Regional Clean Air Agency, WSDA	Estimate emissions of reactive nitrogen - gaseous 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. Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.	Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.	1	0	-1	-3	-2	-3	-3	-3	1	-3	-3	-3	-3	-3	-2	-2	-1	**-33**
15.Admin	DOE, EPA	*Study the relationship* between nitrogen emissions and atmospheric deposition of reactive nitrogen. Develop a model that predicts what percentage of emissions return to the GWMA area as atmospheric deposition.		0	0	-3	-3	-1	-3	-3	-2	-3	-3	-1	-3	-3	-3	-1	-3	-2	**-37**

Attachment C

- WSDA's June 2018 Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area
- 2018_0621_Edits_Additions to Draft 2 of GWMA Program
- Lower Yakima Valley Groundwater Management Program Volume I
- Lower Yakima Valley Groundwater Management Program Volume II

Washington State Department of Agriculture

Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area

A Study by the Washington State Department of Agriculture and Yakima County

WSDA authors:
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June 2018

AGR PUB 103-691 (N/6/18)

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Acknowledgements

Dairy producers:
- voluntarily shared manure testing results with South Yakima Conservation District
- invited WSDA NRAS staff onto their farms to sample soil in pens and compost areas
- invited WSDA NRAS staff onto their farms to learn about operational practices

Irrigated Agriculture Working Group
- reviewed irrigated agriculture methodology and assumptions
- grower members of the IAWG supplied production information necessary for calculating triticale double-crop production acres
- Jim Trull, Scott Stephens, and SVID compiled crop nitrogen uptake data
- Jim Davenport and Stu Turner compiled water duty data for crops in this report

CAFO Working Group
- made recommendations on inputs for lagoon calculations

Peer review team:
- Melanie Redding (Department of Ecology)
- Ginny Stern (Department of Health)
- Nancy Darling (Department of Health)

WSDA Dairy Nutrient Management Program
- shared data from their lagoon assessment process
- worked closely with NRAS staff to make sure identification of facilities was as accurate as possible
- reviewed this report to make sure dairy operations were accurately described

South Yakima Conservation District
- collected and anonymized data from dairy producers
- reviewed GIS data for accuracy

Katie Hurlburt, WSDA Natural Resources Assessment Section
- conducted additional crop mapping and QA on the GIS data for this report

Joel Demory, WSDA Natural Resources Assessment Section
- conducted QA on data entry and calculations for this report

Dr. Ranil Dhammapala, Washington State Department of Ecology
- provided information on atmospheric deposition monitoring and recommendations for low, medium, and high potential rates of atmospheric deposition

Jean Mendoza, Groundwater Advisory Committee member
- provided a reference for nitrogen loss to atmosphere from irrigated agriculture

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Executive Summary

In recent years, a number of groundwater studies have pointed to concerns about nitrate levels in groundwater in the Lower Yakima Valley. Between 1988 and 2008, 12% of wells tested in the area had nitrate concentrations above the Safe Drinking Water Act Maximum Contaminant Level of 10 mg NO_3-N/L. Another 21% of wells tested were below this level but higher than 5 mg NO_3-N/L (reported in Ecology et al. 2010).

In response, the Washington State Department of Ecology (Ecology) began working with Yakima County to address the issue and provide solutions to prevent nitrate contamination of groundwater in the Lower Yakima Valley. They established the Lower Yakima Valley Groundwater Management Area (GWMA), and in 2011 the Groundwater Advisory Committee (GWAC) was formed.

- The GWMA includes the land area and groundwater located in the lower Yakima Valley from Union Gap to County Line Road in Yakima County, Washington, minus the Yakama Nation. The majority of the GWMA is used for agriculture, including nearly 99,000 acres of irrigated cropland[1] and more than 50 active dairy farms[2]. The remainder of the GWMA land area consists of towns, rural residences, roads, canals, and other nonagricultural lands.
- The GWAC has worked to assess and respond to the groundwater nitrate issues by addressing public education and health concerns, evaluating existing data on groundwater quality, designing new monitoring strategies, evaluating regulatory responsibilities, and determining potential nitrogen availability from the various potential sources.

As partners, Ecology, the U.S. Environmental Protection Agency, Yakima County, the Washington State Department of Agriculture (WSDA), and the Washington State Department of Health have been working to support the GWAC and associated workgroups with educational and scientific products that can assist in decision making to protect groundwater quality.

About the Study

In 2015, the Yakima County Public Services Department and GWAC partnered with WSDA's Natural Resources Assessment Section (NRAS) to conduct a study to provide a scientific baseline estimate of the potential amount of nitrogen available for transport from different nitrogen sources within the GWMA boundaries. Nitrogen available for transport is nitrogen that has the potential to move from the land surface or soil profile into groundwater. The study addressed how much nitrogen could be available, but did not calculate how much is actually transported to groundwater. The processes controlling nitrogen movement through the soil were not evaluated, and loading to groundwater was not estimated.

Nitrogen sources are numerous and can include agricultural, human, natural soil organic matter, and atmospheric deposition. Together, state and local partners estimated potential nitrogen availability in the landscape from 4 distinct categories:

- Concentrated animal feeding operations (CAFOs) - including both dairy and nondairy livestock pens and manure lagoons;

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[1]WSDA NRAS agricultural land use mapping program, 2015 data.
[2]WSDA Dairy Nutrient Management Program 2015 registration data.

- Irrigated agricultural activities – by estimating a nitrogen balance from the 15 types of irrigated crops that constitute 87% of the irrigated acreage in the GWMA;
- Residential, commercial, industrial, and municipal (RCIM) sources - including residential onsite septic systems (ROSS), large onsite septic systems (LOSS), commercial onsite septic systems (COSS), residential lawn fertilizers, and hobby and small-scale commercial farms;
- Atmospheric sources - including wet and dry deposition.

Depending on the source (animal agriculture, irrigated agriculture, RCIM, or atmospheric) and calculation method, the nitrogen availability was estimated at the land surface, the bottom of the root zone, or at the end of the treatment zone.

The estimates were completed using locally-derived information wherever possible, and information gaps were filled with data from scientific literature. Methodologies varied, depending on the source of nitrogen being studied. For example, some calculations used data gathered from aerial imagery. Some calculations compared inputs and outputs to determine the mass balance of nitrogen from various irrigated agriculture sources. Atmospheric calculations included adjustments to avoid double counting with other categories that already included atmospheric nitrogen. The body of the report addresses the methodologies used for each source studied.

The study was limited by a number of constraints, primarily the limited availability of local background data, the diversity of local or literature data used, and the various assumptions needed for the calculations in each section of the report. The data used as inputs and the study itself have been reviewed by experts in each field. The data inputs used in each section were reviewed by the relevant GWAC workgroups (Irrigated Agriculture, CAFO, and RCIM). The irrigated agriculture calculations were reviewed by faculty from Washington State University's Department of Crop and Soil Sciences. In addition, the report draft has been reviewed by a peer-review team composed of hydrogeologists from the Washington State Departments of Ecology and Health.

Study Results

The nitrogen available for transport was estimated under 3 scenarios for each nitrogen source category evaluated in this study. Available nitrogen was estimated both in tons and kilograms over the entire GWMA, and on a per-acre basis, providing 2 ways to evaluate nitrogen sources. WSDA and Yakima County results were summarized in associated data spreadsheets and GIS based systems, allowing them to be updated in the future as additional data becomes available.

When the 3 nitrogen availability scenarios were analyzed for all sources over the entire acreage of the GWMA (Table 1), irrigated agriculture, CAFO lagoons, and CAFO pens were the most significant contributors to potential nitrogen availability in each scenario. In scenario A (low), commercial agricultural activities constitute 80% of the estimated total nitrogen available. In the B and C scenarios (medium and high, respectively), agricultural activities constitute 95% and 96% of the estimated available nitrogen. In all 3 scenarios, the nitrogen available from irrigated agriculture is the highest of the sources evaluated. The total acreage of irrigated agriculture (with nearly 86,000 acres evaluated) is much larger than the other nitrogen sources (with the exception of atmospheric deposition).

Table 1. Estimated nitrogen available for transport from all sources in tons/year and % of total

Source		Scenario A (low)		Scenario B (medium)		Scenario C (high)	
		Tons N/year	% of total N	Tons N/year	% of total N	Tons N/year	% of total N
Irrigated agriculture		298	47	2,595	63	7,452	73
CAFO	Pens	70	11	502	12	935	9
	Lagoons	142	22	781	19	1,421	14
RCIM	All septic (ROSS, LOSS, COSS)	47	7	83	2	135	1
	Residential fertilizer	10	2	26	1	41	0
	Small scale farms	4	1	11	0	18	0
Atmospheric deposition		67	11	89	2	268	3

*All numbers in this table have been rounded to the nearest ton (for nitrogen weights), or the nearest whole number (for percentages). Some low but nonzero percentages have been rounded to zero. Percentages may not sum to 100% due to rounding.

When assessed on a per-acre basis (Table 2), the sources with the most nitrogen available differ from the top sources evaluated over the entire GWMA. Summary per-acre nitrogen available was not calculated for irrigated agriculture, instead the range of available nitrogen for all crop types evaluated is shown in Table 2. Nitrogen estimates from irrigated agriculture are the top contributor when assessed over the entire GWMA because of the large number of acres assessed, but the differences in management practices and characteristics for the 15 different crop types mean that estimated nitrogen available from irrigated agriculture varied from crop to crop. Under scenario A, the 3 land uses with the highest estimated available nitrogen per acre are CAFO lagoons, ROSS, and LOSS. Under scenarios B and C, CAFO lagoons are still estimated to make the most nitrogen available on a per-acre basis, followed by CAFO pens and ROSS.

Some land uses have relatively small acreages, but contribute large amounts of nitrogen per acre. For example, the estimated available nitrogen from LOSS for scenario A is one of the top 3 on a per-acre basis, but LOSS have an extremely small total acreage in the GWMA (3 acres), so over the entire GWMA the contribution from LOSS is small. Despite their relatively small acreage, the per-acre estimated nitrogen availability of CAFO lagoons and pens was high enough to make them the second and third highest land uses in all 3 scenarios.

Table 2. Estimated nitrogen available for transport per acre from all sources

Source		Area (acres)	Scenario A (low) (lb/acre-year)	Scenario B (medium) (lb/acre-year)	Scenario C (high) (lb/acre-year)
Irrigated agriculture		85,775	0-58	0-148	0-284
CAFO	Pens	2,096	67	480	892
	Lagoons	210	1,354	7,448	13,542
RCIM	ROSS	398	223	403	662
	LOSS	3	195	209	225
	COSS	30	163	173	183
	Residential fertilizer	4,381	4.7	11.7	18.6
	Small scale farms	2,096	4.3	10.7	17.1
Atmospheric deposition		87,082	1.53	2.05	6.15

Looking Ahead

NRAS has identified a number of next steps and additional data needed for Yakima County and the GWAC to advance these estimates. Both WSDA and Ecology are engaged in work that will aggregate information about lagoon conditions that could potentially be used to refine the lagoon estimates. Calculations could be updated as data becomes available from the WSDA Dairy Nutrient Management Program (DNMP) lagoon liner assessment ratings and Ecology CAFO permit reporting assessments and requirements. Washington State University research on lagoon seepage is beginning that may also provide relevant information. New field research on lagoon seepage could also be conducted if necessary to supply the needed data. The irrigated agriculture mass balance estimates could be compared to current and future deep soil sampling results to improve the accuracy of the analysis. An assessment of additional data for each impoundment classification (lagoon, flush/main lagoon, farm/irrigation pond, settling basin) could be used to apply seepage rates and nitrogen concentrations specific to each use. A statistically-based study of soil nitrogen concentrations beneath pens could be conducted to confirm estimates used in this study that were developed in other regions of the country. Additional areas of inquiry are discussed in each section and in the Conclusions and Recommendations section.

Even though estimates may be refined in the future, this comprehensive study was successful in making an initial estimate of potentially available nitrogen from different sources throughout the GWMA. Per-acre estimates from each source category can be reviewed spatially to identify areas where risk and vulnerability are potentially high. The use of this spatial component allows for more complex future analysis with the inclusion of other relevant data layers such as soil type, depth to groundwater, groundwater nitrate concentrations, soil sampling results, and proximity to public drinking water systems. This smaller-scale spatial analysis is intended to identify initial investigation pathways in specific areas where groundwater contamination is known to occur. It is part of a multi-faceted diagnostic approach to this issue.

Introduction and study area

Yakima County is located in central Washington State. This study focuses on the lower Yakima Valley, located in the southeastern portion of the county and bordered by the Rattlesnake Hills to the north, the Yakama Nation to the west, and Benton County to the east. The Yakima GWMA is shown in Figure 1, with major cities and roads noted. The current population of Yakima County is just over 240,000 people, and the major metropolitan area is the city of Yakima (Census 2010). The population within the GWMA itself (in 2016) was estimated at a little over 56,000 (ESRI 2016). The county's main industry is agriculture, with a 2013 farm gate value of $1.65 billion (USDA NASS 2014). The major commodities produced are apples, milk, and hay. The lower valley agricultural landscape includes more than 50 active dairy farms[3] and approximately 99,000 acres of irrigated farmland[4]. The Yakima River runs through the GWMA, and water for agriculture is collectively managed by 5 different irrigation districts: Roza, Sunnyside, Wapato, Zillah, and Grandview.

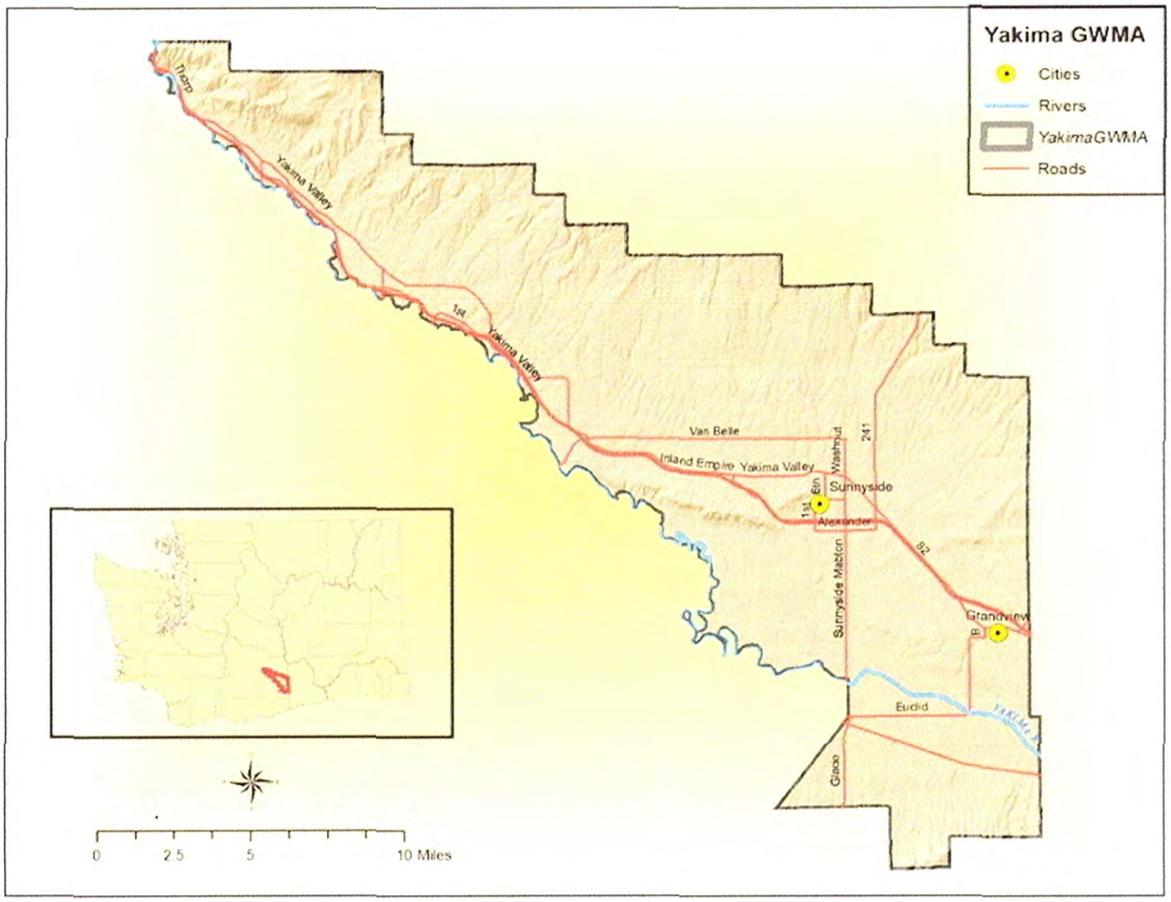

Figure 1. Map of Yakima GWMA

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[3] WSDA Dairy Nutrient Management Program 2015 registration data.
[4] WSDA NRAS agricultural land use mapping program, 2015 data.

Within some areas of the GWMA, nitrogen has negatively impacted groundwater quality. Ecology has summarized results from sampling studies conducted by state and federal agencies between the early 1990's and June 2008 (Ecology 2010). A total of 1,726 nitrate testing samples from 453 well sites were summarized. Data sources included nitrate test results from 328 domestic wells, 93 public wells, and 33 wells of other types including some used for irrigation. Of wells with nitrate detections, 67% were less than 5 mg NO_3-N/L, 21% were between 5 and 9.9 mg NO_3-N/L, and 12% were greater than 10 mg NO_3-N/L. The Maximum Contaminant Level set by the US Environmental Protection Agency (EPA) for nitrate is 10 mg NO_3-N/L; concentrations approaching and above this level are of concern due to the potential impact to human health (EPA 2013a, Ecology et al. 2010). Shallower wells (which were more likely to be domestic wells) had more nitrate detections and exceedances than deeper wells (Ecology et al. 2010). An EPA study concluded that agriculture and livestock operations within the GWMA were significant contributors to nitrogen loading to the underlying groundwater (EPA 2013a).

In 2011, Ecology authorized the formation of the lower Yakima GWMA. This group, made up of area residents, representatives from the agricultural industry, and scientists and experts from county, state, and federal government agencies, is focused on identifying potential contaminant sources and preparing a management strategy for the affected area.

EPA conducted a multi-phase study to identify potential nitrate sources and other contaminants. After source identification, EPA conducted groundwater monitoring up- and downgradient from potential sources (including several large dairies) in 2010 (EPA 2013a). As a result of this groundwater sampling, in March 2013, EPA signed an Administrative Order on Consent (Consent Order) with 5 dairies in the lower Yakima Valley (EPA 2013b). The purpose of this consent order was to address sources of nitrate contamination in groundwater downgradient of the dairies' facilities. These dairies have begun additional work to control nitrate sources, collect data, and monitor groundwater quality to assess the effectiveness of the source control actions.

This report is the result of a request in 2015 by the GWMA's Ground Water Advisory Committee for NRAS and the Yakima County Public Services Department to complete an estimate of nitrogen loading potential within different land use classes in the lower Yakima Valley. This report outlines estimated nitrogen available for transport from the following land uses: irrigated agriculture, concentrated animal feeding operations (which includes both dairies, dairy support such as heifer raising, and beef cattle feedlots), residential, commercial, industrial, and municipal sources. The land uses were divided into 3 separate sections for calculations: irrigated agriculture, CAFOs, and RCIM sources. A separate section estimates the potential contribution to groundwater nitrogen from atmospheric deposition of nitrogen. The data was collected from a variety of sources and through different methods, including phone interviews, on-farm data collection, analysis of aerial imagery, ground surveys for spatial analysis, and local zoning and land use information.

This study is the first conducted in the lower valley that uses local information to address the potential pathways for nitrogen loading. It is also the first project completed for the GWMA that pairs estimated nitrogen surpluses with GIS-based land use information. The purpose of this report is to understand available nitrogen from nitrogen sources and enable the GWMA advisory committee to better direct remediation strategies throughout the region.

Methodology and Limitations

The objective of this report was to provide information to the GWAC that could be used to make decisions about the prioritization of limited resources to meet the long-term goals of reducing nitrogen concentrations in groundwater. This report is not intended as a final statement on potential nitrogen contributions from different sources, instead it represents a first step. Recommendations are made for future experimental research to improve estimates, and additional data sets have been identified for future inclusion that are currently available or will become available in the future. These calculations can and should be updated as new information becomes available.

Nitrogen availability was calculated differently in each section (irrigated agriculture, CAFO, and RCIM). Fate and transport of nitrogen through the soil profile to groundwater was not assessed in this document. For each potential source the objective was to determine the total nitrogen available for transport at the end of the 'treatment zone'. This evaluation location was different for different sources,

- for irrigated agriculture available nitrogen was evaluated at the bottom of the root zone, when it can no longer be taken up by plants,
- for lagoons the location was the bottom of the lagoon liner, where nitrogen can enter the soil and move through it under some conditions,
- for pens the location was the bottom of the manure-soil interface layer, where nitrogen can move through the soil profile under some conditions,
- for septic systems the location was the end of the drainfield,
- for residential fertilizer the evaluation location was the land surface, and
- for small scale commercial and hobby farms the evaluation location was also the land surface.

These different nitrogen sources often have areas of overlap. For example, when CAFO lagoons and pens are cleaned, manure (and nitrogen) is removed. This material is often used for crop production (both of dairy support crops like corn and for other crops). Manure is counted as an explicit input in the mass balance that was used to estimate available nitrogen from irrigated agriculture. Atmospheric deposition is included as an input in the irrigated agriculture mass balance, included in the CAFO pen and lagoon estimates because those estimates rely on experimentally-estimated nitrogen concentrations, and also calculated separately in the atmospheric deposition. In area of potential overlap like this, double counting contributions from the same nitrogen sources has been avoided, and potential double counting has been discussed in more detail in each section.

Another challenge for both conducting this study and interpreting and comparing the results in the different sections is the diversity of data sources used for calculations. Data sources included self-reported data from producers, data from peer-reviewed literature, data from state and federal government studies, averaged data, specific local data, general national data, and estimates based on best professional judgment. Examples of just a few of the many data sources used for calculations in this study are:

- fertilizer use practices (local and crop-specific data, self-reported survey of practices of growers and crop consultants),
- analytical results from testing of lagoon nitrogen concentrations (local data, analysis by certified labs, data self-reported by dairy producers, samples not statistically selected),
- analytical results from testing of lagoon nitrogen concentrations (local data, EPA sampling and analysis procedures, sample not statistically selected),
- GIS data derived from ground-based mapping, human analysis of aerial imagery, and automated analysis of aerial imagery with ArcMap tools (local data, accuracy may vary depending on analysis method),
- estimates by experts in different specialties (local data, estimates may vary depending on expert judgment), and
- national- and state- level data and estimates for performance of septic systems (larger-scale data may not be accurate for local conditions).

In addition, in the many data sources used (both peer-reviewed literature and experimental results) many different units of measure and species of nitrogen were reported. Nitrogen can be reported as nitrate, nitrate-N, organic nitrogen-N, total Kjeldahl nitrogen (TKN), ammonia/ammonium, ammonia/ammonium-N, combinations of these, or as total nitrogen, which makes comparison of literature results difficult and sometimes impossible.

This study relies on a wide variety of data sources, which has to be considered when interpreting and using the results. Not all sources will be considered equally credible according to the Water Quality Data Act (RCW 90.48.570-90.48.590, Water...2004). This can make it difficult to compare data sources and calculation results. In order to allow readers to evaluate data sources on a case-by-case basis each data source used, the calculation it was used for, the source, and potential concerns with the data source have been collected in a table (Appendix A: Data sources, uses, and potential concerns). Wherever possible, summary statistics have been presented and a careful choice has been made for what value (mean, median, or an alternative) to use in calculations.

The conclusions section of this report makes suggestions to Yakima County and the GWAC for critical additional research to refine these estimates through additional data collection. The spatial component of this data is extremely important. Wherever possible, nitrogen availability has been presented both as an aggregate over the entire GWMA and on a per-acre basis. This per-acre nitrogen availability can be spatially associated with sources to examine nitrogen availability at different scales and in different regions.

1. CONCENTRATED ANIMAL FEEDING OPERATIONS

WSDA authors: Margaret Drennan, Jaclyn Hancock, Gary Bahr

Background and literature review

Over the past 90 years, the number of cattle and dairy farms in Yakima County has been decreasing, according to United State Department of Agriculture (USDA) Census of Agriculture data (Figure 2). During that time, number of cattle and calves (including dairy animals) has increased relatively steadily. The number of dairy cows was relatively stable between 1925 and 1969, but after 1969 the number of dairy cows also began to increase steadily, a trend that has continued through 2012. Between 1969 and 2012 USDA's estimate of dairy operations went from 7,868 cows on 301 farms to 99,532 cows on 97 farms (Commerce 1972, USDA NASS 2014). As the number of dairy farms is decreasing, individual farms are increasing in size. As of 2012, USDA also notes the presence of relatively low numbers of other livestock: hogs and pigs, sheep, goats, horses, and poultry (USDA NASS 2014). This USDA statistical data is available only at the county level.

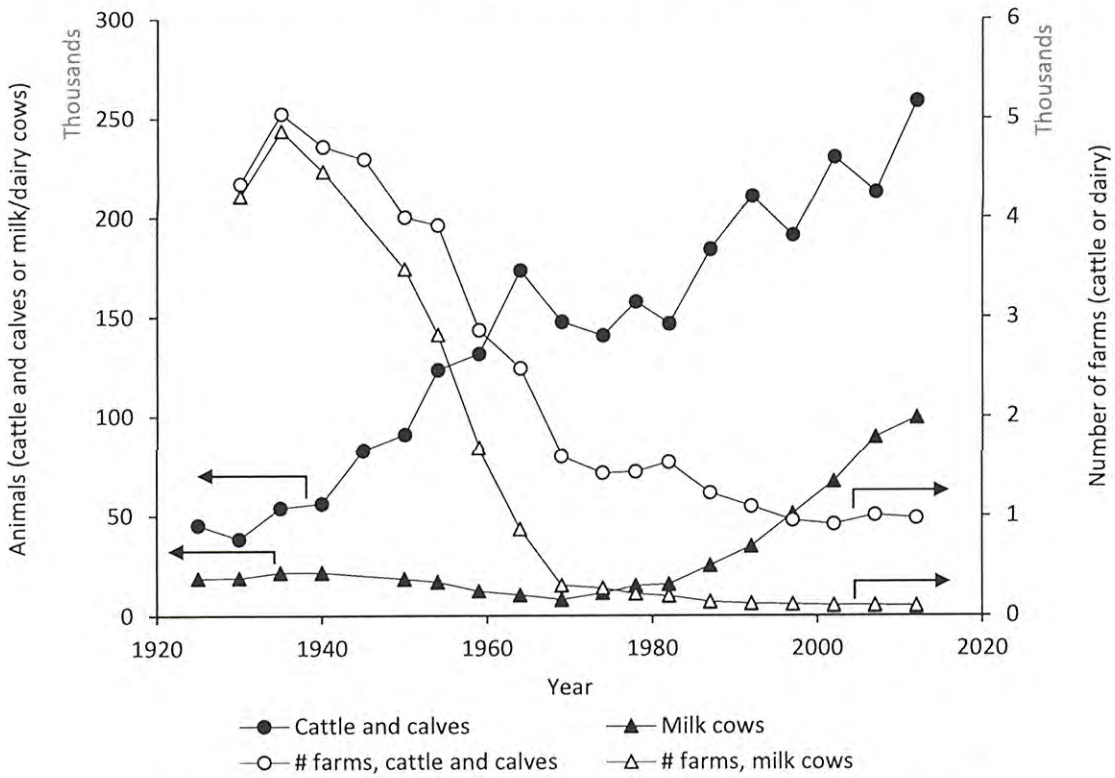

Figure 2. Livestock (cattle and dairy cows) in Yakima County since 1925[5]

[5] (Commerce 1927, Commerce 1932, Commerce 1936, Commerce 1942, Commerce 1946, Commerce 1952, Commerce 1956, Commerce 1961, Commerce 1967, Commerce 1972, Commerce 1977, Commerce 1981, Commerce 1984, Commerce 1989, Commerce 1994, USDA NASS 1999, USDA NASS 2004, USDA NASS 2009, USDA NASS 2014)

Commercial dairies are the only Washington State livestock operation whose manure management is inspected and regulated by WSDA, in accordance with Washington's Dairy Nutrient Management Act (Dairy, 1998). Dairies are required to register with WSDA's Dairy Nutrient Management Program, develop nutrient management plans, maintain records of manure applications, conduct soil tests, and each dairy's manure management systems are inspected regularly. As a result, dairies are the facilities with the most information available regarding management practices, animal numbers, and structures onsite. Dairy support animals (dry cows, calves, and heifers) are sometimes onsite or in adjacent facilities and sometimes (in the case of calf and heifer raising operations) moved offsite until maturity.

Whether nitrogen or other contaminants move from dairy facilities to surface or groundwater depends on dairy age, management practices, meteorological conditions, soil types, geological conditions, unsaturated zone thickness, and groundwater characteristics. Several studies have attempted to quantify nitrogen loading from entire farms and identify which source (pens, lagoons, or irrigated fields) makes the largest contribution. Two studies in California used monitoring wells up- and downgradient from different potential sources in an attempt to measure nitrogen additions to groundwater from each management unit (Harter et al. 2002, van der Schans et al. 2009). Harter monitored groundwater at 5 dairies for 4 years and found that although it was very difficult to distinguish effects from neighboring sources, the largest nitrogen contributor on dairies was manure-treated cropland. Total contributions from cropland were much larger than pens or lagoons largely because the acreage of cropland was much larger and made it difficult to identify contributions from individual pens and lagoons (Harter et al. 2002). Another study in California used monitoring wells to calibrate groundwater models specific to 2 dairy farms in California. The study identified nitrate-N losses of 486 kg/ha-yr from manure-treated fields, 872 kg/ha-yr from pens, and 807 kg/ha-yr from lagoons (van der Schans et al. 2009). Another study conducted by a University of California at Davis (UC Davis) team assessed nitrate loading to groundwater in prominent agricultural and dairy production areas within the Tulare Lake Basin and Salinas Valley of California. The UC Davis study estimated loading from pens at 75-1,000 kg N/ha-yr. Based on a variety of estimates of seepage rates from manure lagoons and lagoon nitrogen concentrations the UC Davis study estimated nitrogen loading from lagoons at 200-2,000 Mg/year for the entire study area. With a total lagoon area of 1,265 ha this results in a loading rate of 158-1581 kg N/ha-yr (Viers et al. 2012).

Pens

Dairies contain a variety of different structures and facilities dedicated to animal housing, manure management and storage. Some dairies also include irrigated agricultural land used for feed production. Animal holding areas can include concrete-surfaced freestall barns or outside holding areas which are generally constructed with compacted earth surfaces. These are referred to by a variety of names in different studies but will be referred to in this report as pens. Pens at facilities housing dairy support animals have been classified as "nondairy CAFO" pens while pens at facilities housing milking cows have been classified as "dairy CAFO" pens. In addition, pens at 2 facilities identified as cattle feedlots have been classified as "nondairy CAFO" pens.

The combination of weight and compaction due to the presence of cattle with the physical and chemical changes to underlying soil due to the mixing of soil and manure have been observed to form an interface layer under the deposited manure that allows very little infiltration of liquid to the underlying soil (Mielke et al. 1974). At one feedlot site, researchers were not able to record any infiltration during a 20-day period (Mielke et al. 1974). A study of 3 feedlots in Alberta, Canada confirmed that this interface layer formed within 2 months of cattle stocking. In addition, experimentally-determined permeabilities were similar for coarse- and fine-textured soils. However, despite this interface layer and resultant expected low leaching potential, chloride leaching was detected at all 3 feedlots (Miller et al. 2008). Similarly, at feedlots in Kansas, despite apparently limited infiltration, soil testing beneath pens found elevated concentrations of ammonium, organic nitrogen, nitrate, chloride, and phosphorus. This study compared a mass balance approach for estimating nitrogen leaching to subsurface soil testing results. Although elevated concentrations of contaminants were detected, movement of contaminants through the feedlot surface was much lower than what was expected from the mass balance calculation and concentrations were consistent with contaminants moving through the interface layer by diffusion (Vaillant et al. 2009). Seepage rates through feedlot surfaces documented in other studies ranged from 0.005 to 2.4 mm/day (reported in Vaillant et al. 2009). The effectiveness of this manure-soil interface layer is dependent on maintenance and surface conditions. Dry conditions combined with animal hoof action or on-farm practices such as pen scraping can damage the aggregated structures, compromising the interface layer and allowing infiltration or altering subsurface conditions to favor nitrogen transformations and subsequent leaching (Mielke et al. 1974, Vaillant et al. 2009).

The UC Davis report identified 2 large beef cattle feedlots in the study area, with stocking rates of 125 and 300 animals/acre. The dairies in the region had stocking rates of 50 animals/acre, which did not include heifers and calves (Viers et al. 2012). As of the 2014 DNMP dairy registration, dairies in Yakima County had just over 100,000 milking and dry cows (the vast majority of which were located within the GWMA boundary), making for a stocking rate of around 50 cattle/acre, based on the NRAS estimate of pen acreage, similar to that of dairies in the UC Davis study.

The UC Davis study assessed these studies and local soil testing data (unpublished) to choose low and high nitrogen loading rates for pens. The authors chose 75 kg N/ha-yr as the low loading rate, based on a locally-observed recharge rate below corrals of 50 mm/year and soil moisture nitrate concentrations of 675 mg/L (unpublished data referenced in Viers et al. 2012). Citing recharge rates as high as 300 mm/year reported in other studies the UC Davis study used 1,000 kg N/ha-yr as an upper limit for nitrogen loading from pens. However, the authors of that study suggest that the upper bound is an overestimate, potentially as much as an entire order of magnitude too high (Viers et al. 2012).

Lagoons

Depending on the dairy's management practices, manure and urine deposited in freestall barns and pens is transported to storage areas which may be liquid storage impoundments (generally through underground piping and pumping systems) or solids storage and composting areas where solids are dried, stacked, and sometimes composted for further use.

Liquid storage impoundments themselves serve a variety of on-farm uses. Lagoons can provide storage for manure and urine cleaned from barns, but may also capture runoff from roofs and other surfaces and process water from the milking parlor. In addition, lagoon liquid may be recirculated to clean barns with flush systems. Distinguishing between an impoundment primarily used for manure storage and one primarily used for irrigation water storage can be difficult. Contents are transferred between impoundments as needed to meet cleaning, storage capacity, and maintenance needs. The term lagoons is used here to refer to impoundments whose primary purpose is manure storage. In addition to lagoons, some dairies also have dedicated impoundments used for separating solids and liquids. The technical sophistication of these impoundments could range from a pond with a weeping wall to an engineered concrete basin with baffles directing and slowing flow to promote settling.

There is substantial variation both in the composition of solids, liquids, and dissolved constituents, and in seepage rates from lagoons (Ham 2002; Harter et al. 2014). A study of 20 lagoons (14 swine, 5 feedlot, and 1 dairy) found seepage rates between 0.2 and 2.4 mm/day, with an average of 1.1 mm/day (Ham 2002). Groundwater monitoring up- and downgradient from lagoons confirms that contaminants leaching from lagoons contribute to shallow groundwater contamination (Harter et al. 2002, van der Schans et al. 2009, Viers et al. 2012). In one study, testing detected elevated concentrations of TKN (total Kjeldahl nitrogen, a measure of organic N and ammonium/ammonia N combined) outside the edges of 3 dairy lagoons, and the authors estimated a leaching rate of approximately 1 m/year (Harter et al. 2002).

Nitrogen concentrations within lagoons have been tested in a number of studies, and are extremely variable. The UC Davis study conducted extensive literature review as well as modeling of lagoons and the authors used nitrogen concentrations of 500 and 1,000 mg N/L in their estimates (Viers et al. 2012). A survey of lagoon contents in California sampled more than 60 dairies in California's San Joaquin Valley in 1999 and 2000 and found lagoon TKN concentrations of 47-2,420 mg N/L, with an average of 560 mg N/L (Campbell Mathews et al. 2001). A University of California Cooperative Extension publication reported master's thesis research at UC Davis, where 7 California dairy lagoons had a TKN range of 320-1,010 mg TKN/L with a mean of 670 mg TKN/L (Pettygrove et al. 2010). Sampling at 5 Yakima Valley dairies by EPA found total nitrogen concentrations ranging from 290 to 1,800 mg N/L with an average of 1,212 mg N/L (EPA 2013a). These results are summarized in Table 3.

Table 3. Dairy lagoon sampling results derived from or used by studies in California and the Yakima Valley

Citation	Project Location	Actual or estimated nitrogen concentration
EPA 2013a	Yakima Valley, 5 dairies	range 290-1,800 mg N/L average 1,212 mg N/L
Viers et al. 2012	Tulare Lake Basin and Salinas Valley, California	500 mg N/L 1,000 mg N/L
Campbell Mathews et al. 2011	San Joaquin Valley, California	range 47-2,420 mg TKN/L average 560 mg TKN/L
Pettygrove et al. 2010 (reporting UC Davis research)	California	range 320-1,010 mg TKN/L average 670 mg TKN/L

PENS AND COMPOST AREAS

Methods, limitations, and assumptions

Limitations

Every effort has been made in this report to identify facilities and facility uses that are current as of 2015. WSDA's DNMP worked closely with NRAS to correctly identify facilities and onsite structures. However, facilities close and open, and the use of individual pens and impoundments changes. As a result some dairies are included in this analysis that have since closed. Individual pens have been associated with either dairy or nondairy CAFOs, based on DNMP information about most common use at the time this study was conducted. The majority of pens that have been identified as nondairy CAFOs are 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 or adult cows may be moved into that same pen. NRAS has attempted to capture primary uses of different pens but use practices are subject to variation. A small number of the pens identified as nondairy CAFOs are associated with 2 beef cattle feedlots. The calculation used for pens identified as either dairy or nondairy CAFOs is the same, both are based on the methods used by the UC Davis study team (Viers et al. 2012). The same rate was used for both dairy and nondairy CAFOs despite the fact that beef cattle feedlots, dairies, and heifer raising facilities have different characteristics and management practices that would be likely to affect nitrogen loss. Stocking rates, manure volume, manure nitrogen content, animal size, and feed choices would be likely to differ between dairy and nondairy CAFOs, all of which would affect the nitrogen loss at these facilities. NRAS did not have the amount of facility-specific on-site information that would be needed to generate different rates for dairy and nondairy CAFOs. Dividing pens into dairy and nondairy CAFOs would allow these calculations to be updated in the future if more facility-specific information becomes available. This analysis also does not account for any contribution from cattle kept anywhere other than CAFO pens, such as rangeland or pasture. An estimate of nitrogen available for transport from pasture land is included in Section **2.** IRRIGATED AGRICULTURE.

Manure composting areas were identified and the acreage was calculated as part of this analysis. Differences between composting areas and pens include surface construction, the lack of animal movement compacting surfaces, and the difference in moisture inputs between composting areas and pens. Due to these differences, as well as the diversity of potential compost management practices, NRAS did not feel use of the dairy/nondairy CAFO pen rate was appropriate for compost areas. The diversity of composting practices could include composting in windrows, composting in bags, spreading material out over a large surface to dry, turning frequency, moisture additions to maintain optimal composting conditions, or the use of a concrete pad for composting. With no information available in scientific literature about potential loading from compost areas, NRAS did not attempt a calculation for these areas. With the locations and dimensions of composting areas already identified, nitrogen loss from compost areas could easily be calculated in the future if new information becomes available.

Potential nitrogen loss from buildings housing animals was not assessed. Animals may spend time in freestall barns and milking parlors. These facilities are built with concrete floors and cleaned multiple times a day. Although poorly maintained or old concrete may develop cracks that could provide a pathway for contaminants to reach the soil profile, any potential losses from these types of buildings would be orders of magnitude smaller than potential losses from pens and lagoons. Additionally, material removed from these facilities is often transported to lagoons onsite, making an analysis without risk of counting the same material twice challenging.

Calculating storage in corral subsurface soil was beyond the scope of this report. An accurate calculation would require historic information about dairy and beef cattle numbers and management practices. However, other research demonstrates that soil beneath corrals may hold large amounts of nitrogen that could be released when these facilities are turned to other uses and demonstrates the importance of appropriate decommissioning procedures (Vaillant et al. 2009, Viers et al. 2012).

Potential emissions of nitrogen compounds to the atmosphere from pens and corrals have not been estimated in this report. It is unknown what proportion of emissions from GWMA CAFOs may redeposit within the GWMA, as emissions may travel large distances before eventual deposition (Viers et al. 2012). The rates used for the pen calculations are based on leaching rates and soil and groundwater testing results from other studies. The influence of atmospheric nitrogen deposition would be accounted for in those testing results already; any atmospheric nitrogen deposited on pen surfaces and lost to soil or groundwater would contribute to nitrogen detected when soil and groundwater are tested. As a result, the pen acreage was removed from the atmospheric deposition summary calculation conducted in the atmospheric deposition section (4. ATMOSPHERIC DEPOSITION).

GIS methodology

The results of this study were summarized using geographic information systems (GIS). A spatial database called a file geodatabase contains all the GIS data for the livestock section of this study. This database contains both attributes and spatial locations of this data. It contains five feature classes and one table: YakimaGWMA (polygon, GWMA boundary), WSDACrop_2015 (polygons, crop identification), Lagoons (points), Ponds (points), and CAFO_Pen_Compost (polygons, boundaries of pens and compost areas). This database also contains a table, IrrigatedMassBalance, which contained the mass balance calculations and results.

Pen and compost area boundaries represent the locations of dairy and nondairy CAFO facilities including dairy and feedlot pens and manure composting areas. These are displayed as polygons in the geodatabase and attributes include the category (dairy CAFO, nondairy CAFO, or compost), area in acres, and low, medium, and high potential nitrogen loss (if calculated). Polygons were drawn by WSDA staff using published 2014 dairy registration locations as a reference along with 2013 National Agricultural Imagery Program (NAIP) imagery from USDA. Dairy and nondairy CAFO pens were distinguished based on information from WSDA's Animal Services Division (feedlot locations), facility size, and proximity to a known dairy location, which was based on records from WSDA's DNMP. DNMP staff were consulted to assure accuracy of both location and type of operation. Any roofed area likely to be a freestall barn or milking parlor was excluded.

Quality assurance was performed from November 2015 through February 2016 on all components of the geodatabase. This was a 3-step process. First, a random sampling of each dataset was performed using Excel's random number function and a field survey was conducted of the selected polygons and points in conjunction with USDA NAIP 2013 imagery to ensure the accuracy and location of the data. For the pen and compost boundaries, it was to ensure the operation was a CAFO or compost facility. The last step was to double-check all polygons and points with USDA NAIP 2015 imagery that became available in early 2016, which resulted in several updates due to changes in facility status. All geospatial data used in this study met WSDA data quality error rate of less than 10% (Beale and Baker 2009).

Metadata is included with the GIS database to further describe the additional aspects of the GIS data. This includes information such as the extent, credits, use limitations, scale, processing environment, author, and spatial reference.

Calculation methodology

The pen nitrogen calculation (for both dairy and nondairy CAFO pens) was based on the low and high loading range used in the UC Davis nitrogen loading study (Viers et al. 2012). The loading rates used in the UC Davis study were chosen based on several other research studies. The low range (75 kg N/ha-yr, or 67 lb N/ac-yr) was chosen based on unpublished research conducted by UC Davis study authors in the Tulare Lake Basin that was reported in the UC Davis study (Viers et al. 2012). Meteorological conditions in the GWMA are similar to the Tulare Lake Basin, with 7.55 inches or rain each year, on average, in Tulare, CA, and 6.8 in Sunnyside, WA (mean 1894-2012, WRCC 2012, Viers et al. 2012). The high range used in the UC Davis study (1,000 kg N/ha-yr, or 892 lb N/ac-yr) was based on research conducted in the Tulare Lake Basin and Salinas Valley by the study authors, as well as research in California's San Joaquin Valley (van der Schans et al. 2009) and in Kansas (Vaillant et al. 2009). Meteorological conditions in Kansas are significantly different from conditions in either the Tulare Lake Basin or the Yakima Valley (annual rainfall ranged from 24 to 36 inches at the study sites) (Vaillant et al. 2009). The high rate is likely a significant overestimation of the available nitrogen, due to factors that include lower precipitation and higher evapotranspiration in the Yakima Valley than in the regions where the research this nitrogen loading rate was based on was conducted. The lower precipitation and higher evapotranspiration would result in both lower groundwater recharge and higher losses of nitrogen to the atmosphere, reducing the nitrogen available to move through the pen surface. While this study has attempted to calculate nitrogen available to move through the soil profile, the authors of the UC Davis study were estimating actual nitrogen loading to groundwater. Only a proportion of the nitrogen available to move through the soil to groundwater will actually do so. Additional work that could be conducted to improve these estimates is discussed in the conclusions of the CAFO section.

The calculation itself consisted of multiplying either the low or the high rate by the acreage of each pen. The medium rate for pens was determined by averaging the results of the low and high rates for each individual pen; it has no physical significance. Individual pen results were added to determine estimated losses for all pens in the region. For the following calculation, all significant digits were kept until the final estimate was determined. At that point, calculations were rounded to the nearest lb/ac, kg/ha, ton/year, or 1,000 kg/year.

$$N\ loading\ rate\ \left(\frac{lb\ N}{acre \cdot year}\right) \times Pen\ acreage\ (acre) = Potential\ N\ available\ \left(\frac{lb\ N}{year}\right)$$

Results and discussion

The total area of pens and compost areas is summarized in Table 4. Areas were categorized as either dairy CAFO (pens associated with a dairy operation), nondairy CAFO (pens believed to be associated with a beef cattle feedlot or used for dairy support animals, housing calves or heifers), or compost (areas at either dairy or nondairy facilities where composting is taking place). Dairy CAFO pens made up 60.7% of the total 2,632 acres identified as pens or composting areas. Nondairy CAFO pens and compost areas made up 18.9 and 20.4% of the total, respectively.

Table 4. Total area of dairy CAFO pens, nondairy CAFO pens, and compost areas in the GWMA, with percent of total

	Acres	%
Dairy CAFO pens	1,597	60.7
Nondairy CAFO pens	499	18.9
Compost	536	20.4
Total (pens and compost)	2,632	100

Based on the low and high rates discussed in the calculation methodology and the acreage of different facilities in Table 4, the following potential nitrogen losses were determined (Table 5). Results were rounded to the nearest lb/ac, kg/ha, ton/yr, or 1,000 kg/yr, to be consistent with the estimated accuracy of these calculations. Available nitrogen was calculated for the 2,096 acres of dairy CAFO and nondairy CAFO pens only, as discussed in the Limitations section above. No calculation was conducted for compost areas. The rates used for this calculation were the low and high rates identified by the UC Davis study, which were based on research conducted in California's Tulare Lake Basin and Salinas Valley (Viers et al. 2012). This study only identified a low and a high rate. In order to generate a medium value for comparison to other potential nitrogen sources, the low and the high were averaged. The medium value in this calculation is for comparison purposes only. This calculation was not based on mass loading, so manure removal during pen cleaning does not appear as a term in the calculation. However, the rates used for the calculation were experimentally derived from subsurface nitrogen concentrations at working livestock pens in California and other regions. Regular cleaning as a management practice influences the experimentally-derived rates that were used.

Table 5. Potential nitrogen available for transport from dairy and nondairy CAFOs

	lb N/ac-yr	kg N/ha-yr	Ton N/yr	kg N/yr
Low rate (Viers et al. 2012)	67	75	70	64,000
Medium rate (average)	480	538	502	456,000
High rate (Viers et al. 2012)	892	1000	935	848,000

The high rate is an entire order of magnitude above the low rate. With the information currently available, WSDA is not able to narrow this range.

Management practices onsite such as maintaining an intact interface layer to inhibit liquid movement through the pen surface, changes in precipitation and evapotranspiration from season to season, and animal stocking rates will all affect potential loading.

The 2 large feedlots in the Yakima Valley have a combined acreage of 291 acres. Because only dairies are required to share animal numbers with WSDA, the numbers of animals on these feedlots is unknown. The total number of cattle and calves in Yakima County is 258,663 as of the 2012 Census of Agriculture by USDA NASS. Also from the 2012 Census of Agriculture, the total number of dairy cows in Yakima County is 99,532, which would include only milking and dry cows, not other dairy support animals (calves and heifers) (USDA NASS 2012). The difference (159,131 animals) would include beef cattle on feedlots, cattle and calves on range, and dairy support animals (for example, calves and heifers at dedicated facilities). Of these animals, cattle on feedlots and dairy support animals are accounted for in the calculations, while cattle on rangeland or pasture are not. The census information is for the entire county rather than specific to the GWMA region, and it is unknown which animals are within the GWMA.

In July 2015, NRAS conducted a soil sampling survey in pens and compost areas at 5 dairies within the GWMA. This data is used here to compare conditions observed beneath pens in the GWMA to conditions observed beneath pens in the Tulare Lake Basin and Salinas Valley, where the loading rates used in the UC Davis study were derived. Similar soil testing results would suggest that the loading rates used in the UC Davis study are appropriate for the GWMA.

Producers who participated in this study allowed NRAS staff to come onto their property, dig large pits to sample at depths up to 6 feet, and sample multiple locations on the property. Project quality assurance documentation (such as standard operating procedures or a quality assurance project plan) was not developed before sampling, and as a result this data is not considered credible under the requirements of Washington's Water Quality Data Act (RCW 90.48.570-90.48.590, Water...2004). This data should not be used for decision making and it was not used to develop the nitrogen loss rates used in this report. *NRAS believes that there are 2 main potential sources of bias* or error in this data set. The first is the lack of a statistically-based sampling procedure, meaning that the results may not be useful for assessing the subsurface nutrient concentrations at all the dairies in the GWMA, just at the dairies that were sampled. The second is the potential for sample cross-contamination due to sample transfer on equipment, meaning that making conclusions based on individual sample results is not recommended. Samples were analyzed at an accredited lab (Northwest Agricultural Consultants, Kennewick, WA). NRAS has used these results (in the aggregate) to gain a better understanding of nitrogen movement and retention in the soil underlying dairy pens and composting areas in the region. These data were compared to subsurface conditions reported in the literature that potential nitrogen loading rates were drawn from. The soil testing results were not used to identify specific rates to use, however, similarities between soil testing results from GWMA dairies and literature results give more confidence that these rates are appropriate for this study.

Pen samples were collected from 12 locations at depths of 0 (surface) to 6 feet in 1-foot intervals. The table below displays the range in nitrate concentrations found in pens at each 1-foot depth interval (Table 6). Nitrate concentrations from different samples at the same depth were extremely variable. The average concentration decreased throughout the soil profile from 273.3 mg NO_3-N/kg at the surface to 30.4 mg NO_3-N/kg at a depth of 6 feet. The average nitrate concentrations by depth were also plotted in a nitrate profile in Figure 3.

Table 6. Soil sampling results beneath 12 pens in the Yakima Valley

Depth in pen (ft)	0	1	2	3	4	5	6
Minimum (mg/kg NO_3-N)	22.6	21.8	10.6	8.3	6.1	6.5	3.8
Maximum (mg/kg NO_3-N)	962.6	409.7	199.2	186.5	109.6	93.4	124.7
Average (mg/kg NO_3-N)	273.3	165.9	98.5	71.2	45.7	36.7	30.4
Median (mg/kg NO_3-N)	118.6	153.8	89.9	63.6	38	29.6	17.1
Standard dev. (mg/kg NO_3-N)	308.6	115.3	54.5	45.9	31.1	26.4	36.8

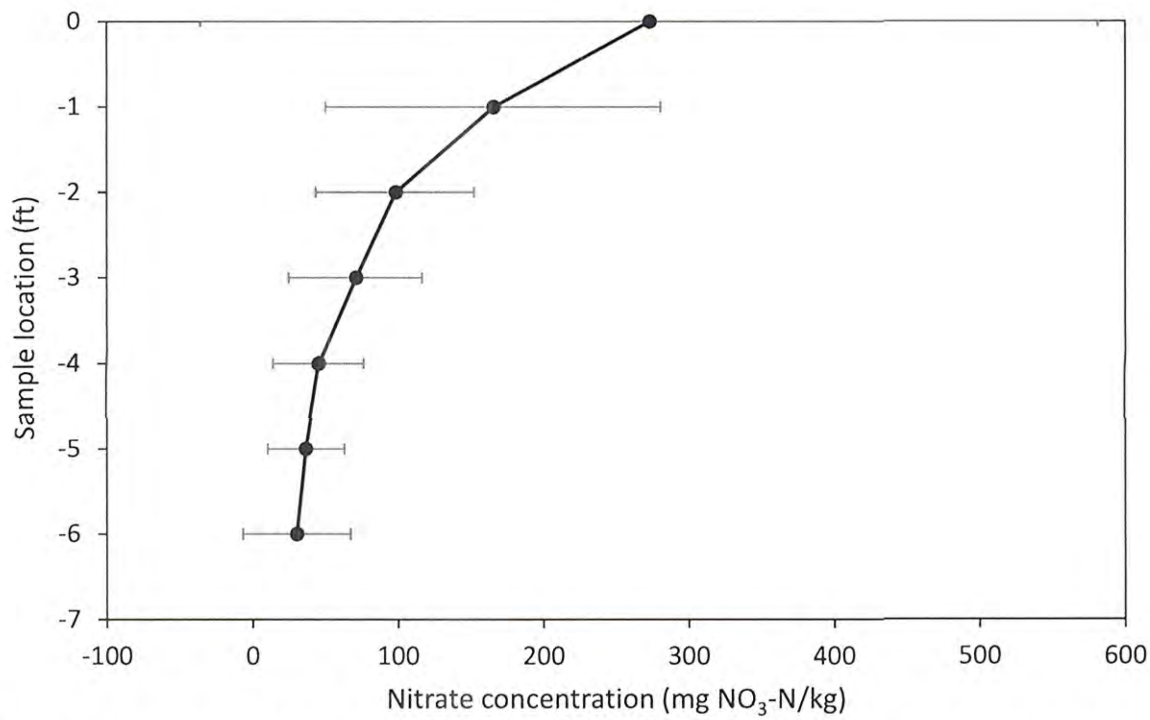

Figure 3. Average nitrate profile beneath 12 pens in the Yakima Valley. Error bars represent one standard deviation from the mean.

Pen soil samples were elevated at the surface and decreased with increasing depth. Soil sampling results are generally compared to a reference number to identify the depth at which numbers return to background levels; no such reference is available in this case. The trends in these results are consistent with those found by Viers et al. (2012) where soil nitrate concentrations were around 200 mg NO_3-N/kg near the surface with a slow decrease to 20-50 mg NO_3-N/kg at depths of 10-15 m. A more detailed comparison is impossible because individual core results, aggregated data, and intermediate depths were not reported in that study. Another study that published soil testing results sampled soil to depths ranging from 1.8 to 4.7 m at 4 beef cattle feedlots in Kansas (Vaillant et al. 2009). A total of 18 soil cores were taken, of which 12 were below their chosen background level (4.1 mg NO_3-N/kg) for the entire core. The remaining 6 cores had elevated nitrate in the top meter of the core ranging from 10.7 mg NO_3-N/kg to 510 mg NO_3-N/kg and a return below the background concentration with increasing depth. Again, the soil testing results from GWMA dairies are similar to these results in magnitude of nitrate concentration, although the nitrate levels at depths greater than 1 m (3.28 feet) were higher in the GWMA soil sampling results than the Kansas feedlot results. Since this study (Vaillant et al. 2009) was the source that the UC Davis researchers (Viers et al. 2012) relied on to identify their high range loading rate of 1,000 kg N/ha-yr, similarity with these results gives us another indicator that this rate is appropriate for use in the GWMA. One large challenge in reviewing literature and comparing results in this field is the diversity of units and species of nitrogen reported in papers. Reporting of nitrogen as nitrate, nitrate-N, organic nitrogen-N, TKN, ammonia/ammonium, ammonia/ammonium-N, combinations of these, or as total nitrogen is common and makes comparison of literature results difficult and sometimes impossible. Next steps for field research in the GWMA to improve estimates of loading rates from pens should include development and execution of a credible statistical sampling program whose results could be used to develop a GWMA-specific rate with a narrower range.

LAGOONS

Methods, limitations, and assumptions

Limitations

As with the pen identification, every effort has been made in this section to identify facilities and facility uses that are current as of 2015. It can be difficult to distinguish between a lagoon, a settling basin, a settling pond, or an irrigation pond. Different professionals in this industry use different terms for different manure storage impoundments, and different impoundments may be used for different purposes at different times of year. In addition, producers may mix manure and water in impoundments before land application. NRAS has identified impoundments which are primarily used for storage of manure, as opposed to impoundments which are primarily used for storing irrigation water or which are used for mixing manure and water for land application. These impoundments (primarily used for storing manure) will be referred to as lagoons in this report. This difficulty in classification may result in impoundments being placed in the wrong category, despite NRAS's efforts at accuracy.

Lagoon nitrogen concentrations depend on animal housing and facility cleaning practices as well as local environmental conditions. Variations can include the use of flush versus scrape systems to clean barns, the type and efficiency of solids separation systems used, whether and where irrigation water is mixed with manure for land application, and seasonal effects such as precipitation and evaporation rates. Lagoon nitrogen concentrations used in this report are based on 2 data sources. The first is a relatively large subset of farms in the GWMA (approximately 20) whose operators voluntarily shared lagoon nitrogen testing results with NRAS for this study. The second was EPA's lagoon testing results from 5 dairies sampled in 2010 (EPA 2013a). All testing results from these 2 sources were combined and averaged. The resulting nitrogen concentration is higher than lagoon nitrogen concentrations reported in other studies.

Calculating storage in lagoon subsurface soil was beyond the scope of this report. An accurate calculation would require historic information about dairy and beef cattle numbers, management practices, and lagoon construction practices. However, other research indicates that soil beneath lagoons holds large amounts of nitrogen that could be released and emphasizes the importance of appropriate decommissioning at the end of use (Viers et al. 2012).

GIS methodology and lagoon identification

Lagoon points included in the geodatabase represent locations for both dairy and non-dairy lagoons. Point locations were derived using latitude and longitude locations from the DNMP database in conjunction with aerial imagery from Google Maps and USDA NAIP 2013 imagery. Identified lagoon points were compared with DNMP lagoon assessment data followed by direct consultation with DNMP staff to ensure accuracy. Lagoon area is an attribute and was determined using aerial imagery technology (area = length X width), known dimensions from DNMP (length, width), or using the polygon area (calculated area using GIS) from the DNMP assessment. Depth is also an attribute; depth used was the design depth of the impoundment. Lagoons where the design depth was unknown were assigned an estimated depth, which was the average of all depth measurements for lagoons with known depths. Whether depth was the actual design depth or an estimate was documented in an additional Depth Method attribute with values of Actual or Estimate.

The quality assurance procedure conducted for the lagoon points was the same as that for pens and compost areas. Randomly selected points were field surveyed to confirm the identification and accuracy of the lagoon location. Any errors were corrected, and all points were checked against USDA NAIP 2015 imagery.

Lagoon dimensions

WSDA's DNMP conducted a lagoon assessment project in 2015 according to the methods in Natural Resource Conservation Service (NRCS) Technical Note 23 (USDA NRCS 2013). DNMP staff visited every lagoon on a licensed dairy, with the exception of the Consent Order dairies, either 2 or 3 times in 2015 in order to assess each lagoon both when it was near full and near empty. During these assessments staff recorded design length, width, storage capacity, and depth. Length, width, and depth of lagoons were determined from existing nutrient management plans and were likely measured at the time of lagoon construction. If DNMP did not have access to the design dimensions, staff used ArcGIS Collector to delineate the lagoon perimeter. These measurements (both design length and width and polygons) were taken along the lagoon embankment and are the dimensions at maximum capacity. Surface area was calculated from the polygon or the length and width measurements.

NAIP imagery was utilized to identify additional lagoons that were not included in this assessment process. This included the Consent Order dairies. DNMP staff were consulted to determine if the impoundments identified in the aerial imagery were lagoons, ponds, or neither. Only polygons identified as lagoons were included in this analysis. NRAS staff used NAIP 2015 imagery to measure the length and width of these lagoons. NRAS staff then randomly selected a population of these lagoons for quality assurance checks. Staff visited each of these randomly selected lagoons to confirm identification and location.

Individual lagoon design depths were used when this data was available. The average design depth of the 105 lagoons with known depths was 11.3 ft. This average design depth was used as the depth for lagoons that did not have a measured design depth.

In addition, for the lagoons that were part of the NRCS assessment, at each visit DNMP staff estimated the percentage of the lagoon's total capacity in use, and categorized each lagoon as either empty or full. The percentage of lagoon capacity utilized (and as a result, the liquid depth and surface area) varies depending on both season and on-farm management practices. The same farm may have several lagoons that transition from full to empty and back again throughout the year, while another is consistently full; farms may also use lagoons to store irrigation water in addition to manure or use lagoon contents to operate flush systems. During the lagoon assessment process, DNMP staff visited each lagoon either 2 or 3 times in an attempt to view each lagoon both while it was full and while it was empty.

In an attempt to capture a reasonable average yearly liquid depth and surface area to use, NRAS staff used the information recorded by DNMP staff on repeated lagoon visits during the lagoon assessment process. The total number of lagoons visited in 2015 was 115, of which 102 were visited twice and 13 were visited 3 times. Lagoon utilization (% full) varies dramatically depending on the season, so DNMP generally visited each lagoon during both the summer and the winter to account for seasonal variability. The percentage of total capacity utilized at successive visits to the same lagoon was averaged for each of the 115 unique lagoons visited to generate an average capacity used for each lagoon. This average utilization for each lagoon was then averaged across all lagoons, resulting in an average percent capacity used for 2015 visits of 43%. The depth used in the Darcy's law calculations is 43% of the actual or estimated design depth.

This percentage depth reduction was also used to adjust the surface area of the lagoons. Surface area of the lagoons was determined based on one of the methodologies discussed above (lagoon assessment or aerial imagery). Because of the side slope of lagoons, a reduction in depth results in a corresponding reduction in surface area. The surface areas used for calculations were adjusted based on NRAS's estimation that a lagoon with a working depth of 43% of its design depth would have a corresponding surface area reduction to 73% of the design surface area. The basis for this estimate is described in Appendix C: Lagoon surface area reduction methodology.

Lagoon nitrogen concentration

WSDA relied on pre-existing sources of information on lagoon nitrogen concentration for this study. One source of lagoon total nitrogen concentrations was the EPA's sampling in 2010, which was published in their 2013 report (EPA 2013a). This data set consists of 15 lagoon samples from 5 dairy farms (at each farm, 1 sample was taken at the inflow to the farm's lagoon system, and 2 samples were taken at the outflow of the farm's lagoon system). Influent concentrations were slightly higher than outflow concentrations, but a statistical comparison was not conducted (EPA 2013a). The average of the 5 influent concentrations was 1,317 mg N/L and the average of the 10 *outflow concentrations was* 1,159 mg N/L. *The range of sample concentrations was* 290- 1,800 mg N/L with a mean of 1,212 mg N/L (EPA 2013a).

Another source of lagoon nitrogen concentration data was lagoon testing conducted by the dairy producers themselves. Dairy producers are required to take yearly samples of lagoon content and have them analyzed by an accredited laboratory. This is regulatory data used by WSDA's DNMP to assess whether or not producers are making nutrient applications at agronomic rates. The South Yakima Conservation District (SYCD) asked dairy producers to voluntarily share lagoon testing results with NRAS for use in this assessment; SYCD collected testing results from producers, anonymized them, and forwarded the information to NRAS. A total of 23 lagoon total nitrogen testing results were provided. The exact number of dairy farms that shared data is not known; SYCD staff estimated the number at 20 farms. The sample concentrations ranged from 180 – 3,624 mg N/L with a mean of 949 mg N/L. More detailed analysis of these data sources is presented in Appendix B: Lagoon nitrogen concentration statistical analysis.

The mean of the SYCD data set is lower than the mean of the EPA data set. There are many potential reasons for this difference. Neither data set was collected using a statistically-based sampling procedure. The SYCD data was voluntarily shared with WSDA; producers with high lagoon nitrogen concentrations may not have been comfortable sharing their testing results. The EPA study was an effort to identify potential contributors to groundwater contamination; dairies identified for sampling were large, far from other potential nitrate sources, in areas with consistent groundwater flow, and close to drinking water wells with known high nitrate levels. Details of on-farm practices at the dairies in both data sets are unknown. Flush or scrape cleaning systems and the presence and scale of solids separation may affect in-lagoon nitrogen concentrations. At a flush dairy, separated lagoon water is often recirculated to clean barns, while at a scrape dairy, lagoon contents are not generally recirculated. The degree of solids separation depends on the system (and corresponding removal of nitrogen contained in or bound to solids) and also affects lagoon nitrogen concentration.

NRAS consulted supplemental data provided by DNMP to gain additional information about the types of dairy operations within the GWMA boundary. Of the 52 dairies in the data set, 12 were flush dairies, 39 were not flush dairies, and 1 was out of business. Most (83%) of the dairies had some type of solids separator system on site. A minority of the dairies (25%) relied solely on settling basins for solids separation, while 58% of the dairies had secondary processes including slope screen separators, centrifuges, barrel screen roller presses, screw presses, and gravity flow separation. A small number (15%) of dairies had no solids separation systems.

Total nitrogen concentration data used in other studies varies greatly. The UC Davis report used concentrations of 500 and 1,000 mg N/L for different calculations and estimates (Viers et al. 2012). Dairies in California's San Joaquin Valley have lagoon TKN concentrations between 47 and 2,420 mg N/L (Campbell Mathews et al. 2001). Lagoon TKN concentrations from another study in California were reported in a University of California Cooperative Extension publication; of the 7 lagoon results published the range was 320-1,010 mg N/L with an average TKN of 670 mg N/L (reported in Pettygrove et al. 2010). Local data was chosen over non-local literature data in an attempt to use the most accurate values. In addition, this provides a more protective estimate since local values were higher than those utilized in the literature. The SYCD voluntarily shared testing results were combined with the EPA results from testing of the Consent Order dairy lagoons, resulting in an average total nitrogen concentration of 1,053 mg N/L (n = 38); this is the value that will be used in the calculations in this section. Calculations in this section can be updated if additional data is made available.

Atmospheric deposition and volatilization in lagoons

The lagoon nitrogen concentration used for calculations in this report was derived from analysis of lagoon samples. Any nitrogen present in the lagoons due to atmospheric deposition onto the lagoon surface affect the testing results. As a result, these testing results already include the effects of atmospheric deposition. No information was available about the age of the material being tested (for example, how many days before testing the lagoon was most recently filled, emptied, or cleaned). During storage, nitrogen concentration in lagoons typically drops due to volatilization to the atmosphere. Without information about when the material was added to the lagoon and how long it was retained, it would be impossible to determine whether the tested nitrogen concentration represented material that had not yet experienced storage losses or had already experienced storage losses. It was assumed that the nitrogen testing results included a range of fresh and aged manure and that the sample would provide enough variety to be representative.

Since this data already accounts for atmospheric deposition to lagoons, the total area of all lagoons was removed from the atmospheric deposition analysis in section 4. ATMOSPHERIC DEPOSITION. The area that was deducted from the total acreage of the GWMA was the lagoon design surface area.

Lagoon liner permeability and thickness

Current NRCS standards for lagoon liners depend on site characteristics, proximity to wells, depth to groundwater, and soil and aquifer characteristics. Depending on conditions, a site may be considered too vulnerable for lagoon construction or may require the use of a synthetic, compacted clay, or potentially no liner. Rather than specifying hydraulic conductivity or permeability required of liners or underlying soils, current guidelines require that lagoon construction meet required specific discharge rates. These specific discharge rates have been based on historically used permeability of 1×10^{-7} cm/s, with an assumed order of magnitude reduction in permeability due to manure sealing, allowing liner permeability to be 1×10^{-6} cm/s (USDA NRCS 2009). Lagoon liner permeability options were also discussed with some GWMA workgroups in 2015. The groups agreed that 2 liner permeability scenarios should be considered in lagoon seepage calculations. Based on these discussions and limitations in the data available, liner permeabilities of 1×10^{-7} and 1×10^{-6} cm/s were used to determine a low and high rate seepage estimate, respectively.

Construction dates for lagoons in the GWMA are unknown. Without information on how many lagoons were constructed before the 2004 standard, it is impossible to say how many lagoons may have permeabilities higher than 1×10^{-6}. The current NRCS Engineering Handbook and other documentation outlines historic practices and guidance published by NRCS (USDA NRCS 2009, USDA NRCS 2016a, USDA NRCS 2016b).

- Prior to 1990: manure sealing was assumed to significantly reduce seepage from lagoons.
- Late 1980s: A guidance document (South National Technical Center (SNTC) Technical Guide 716) was released specifying that relying on manure sealing to reduce seepage in a finished lagoon was insufficient and specified some site conditions when clay liners should be used.
- 1993: SNTC Technical Guide 716 was updated and reissued. All waste storage ponds are required to have a 1-foot liner and soil must meet certain characteristics (percent fines).

- 1998: Agricultural Waste Field Management Handbook is issued containing material from SNTC Technical Guide 716.
- December 2004, Practice Standard 313 is updated, still requiring a minimum 1-foot liner thickness and adding a required permeability less than $1x10^{-6}$ cm/s.

Clearly lagoons constructed prior to the current guidance documents are unlikely to meet current NRCS standards. However, no information is available about what seepage might be for lagoons constructed before 1990, or between the 1993 guidance and the 2004 guidance. As a result, it is impossible to estimate what the permeability endpoint would be to estimate a high seepage rate. In addition, lagoon liners can be damaged through inappropriate operation and maintenance activities, which would result in increased leakage rates. The only experimental data on lagoon water loss found was Ham's study of Kansas feedlot and swine lagoons, which identified a seepage rate of 1.1 mm/day. The authors used this rate and experimentally determined depths and liner characteristics of lagoons to calculate a liner permeability of $1.8x10^{-7}$ cm/s (Ham 2002). A top priority for additional research on potential nitrogen loss from lagoons would be to conduct similar water balance lagoon seepage measurements to determine typical rates for GWMA lagoons. This information could be used to narrow the large range of these estimates.

Although the date of construction is not known, the type of liner was known for most of the lagoons that were part of the DNMP lagoon assessment process. Liner types of the lagoons assessed (n=115) were bentonite amendment (45, or 39%), compacted clay (58, or 50%), flexible membrane (10, or 9%), and unknown (2 or 2%). Current NRCS standards for minimum liner thickness are based on the normal full pool storage depth. The average design depth of lagoons visited by DNMP was calculated to be 11.3 feet. For lagoons with depths of 16 feet or less, the minimum liner thickness required is 1 foot (USDA NRCS 2016a). The average liner thickness of several lagoons studied in Kansas was approximately 1 foot (Ham, 2002). No local data was used to support the 1 foot liner thickness used in the seepage calculations. Based on the current NRCS standard, WSDA has chosen to use the minimum liner thickness required for lagoon seepage calculations.

The DNMP lagoon assessment process identified 10 lagoons with flexible membrane liners, of which 8 were positively identified in the geodatabase. This information was added to the geodatabase with a new attribute (Liner) noting the lagoons with flexible membrane liners. Lagoons with flexible membrane liners will have much lower permeabilities (potentially even permeabilities of 0 cm/s) than lagoons with compacted clay or bentonite liners. However, performance even for flexible membrane liners relies on condition and maintenance. Without information about current condition and maintenance history, NRAS did not change the permeability for these lagoons. This attribute does not reflect the current status of Consent Order dairy lagoons with flexible membrane liners installed since 2015, but the 2015 status. This attribute can be updated in the future to reflect information about more recent flexible membrane liner installations.

Calculation methodology

Potential seepage from dairy lagoons was calculated using Darcy's law. Darcy's law is the method described by NRCS in the Agricultural Waste Management Field Handbook to calculate needed liner composition, permeability, and thickness for lagoons of different depths (USDA NRCS 2009). This approach relied both on assumptions derived from the literature (liner permeability and thickness) as well as local information (GWMA lagoon surface areas, depths, and nitrogen concentrations). The result of these calculations is the amount of nitrogen expected to pass through the liner, which is then available to move through the soil profile under some conditions. Transport and fate of nitrogen through the soil profile after exiting the lagoon liner was not within the scope of this study.

For the following calculations, all significant figures were kept until the final nitrogen loss estimate was determined. At this point, calculations were rounded to the nearest lb/ac, kg/ha, ton/year, or 1,000 kg/year. The medium rate for lagoons was determined by averaging the results of the low and high rates for each individual lagoon (the low and high permeabilties used in Darcy's Law); it has no physical significance.

First, the volume of fluid leaving the lagoon was estimated using Darcy's law, then multiplied by the total N concentration to determine the nitrogen loss from lagoons within the GWMA.

$$Q = k * \frac{(H + d)}{d} * A$$

Where

Q = the calculated volumetric flow rate (L^3/T)

k = coefficient of permeability (hydraulic conductivity, $1x10^{-7}$ or $1x10^{-6}$ cm/s) ($L^3/L^2/T$)

d = thickness of soil liner (estimated at 1 foot) (L)

H = vertical distance between top of liner and top of liquid storage (L)

A = lagoon area (L^2)

L = length

T = time

$$N\ Loading = Q * C$$

C = Total N concentration, 1053 mg N/L

Results and discussion

Potential loading was calculated for each individual lagoon within the GWMA boundary. Actual measurements for lagoon depth and surface area were used when available. Estimates for these parameters were used when actual measurements did not exist as discussed above. An example calculation can be found in Appendix D: Darcy's law example calculation.

This calculation was not based on mass loading, so manure removal from lagoons during regular operations (for use in crop growth or during cleaning) does not appear as a term in the calculation. However, the inputs to the calculation include typical lagoon utilization identified during the DNMP lagoon assessment process. This typical utilization, or percentage of capacity in use, was determined from repeated visits by DNMP staff to operating lagoons. At each visit, the percentage of capacity in use was recorded. Lagoons may have been full on one visit and empty on a subsequent visit. Some lagoons were full or empty on every visit. This observation of capacity in use was used to develop a typical utilization, which was used to reduce the design depth and surface area of each lagoon to a working depth and surface area that were used in the Darcy's law calculation. While not appearing as an explicit term in the calculation, manure removed from lagoons for crop production would show up (as lagoons with a low utilization when visited by DNMP staff) and be accounted for in the final estimate.

Darcy's law calculations were run using the 2 different permeabilities discussed above (1×10^{-7} and 1×10^{-6} cm/s) to determine a low and high range estimate. Since this is the only parameter that differed between the calculation scenarios, the estimated loss for high and low differs by a factor of 10. The medium rate was calculated by averaging the low and high rates. Table 7 displays the results from these calculations. The rate per area was determined by dividing the total loss by the total design surface area of lagoons in the GWMA.

Table 7. Estimated high and low loss rates based on Darcy's law

	Low	Medium	High
N Loss (lb N/ac-year)	1,354	7,448	13,542
N Loss (kg N/ha-year)	1,518	8,348	15,178
N Loss (ton N/year)	142	781	1,421
N Loss (kg N/year)	129,000	709,000	1,289,000

These estimates are much higher than those calculated in the UC Davis study (Viers et al. 2012). The totals are not comparable because of the much larger geographic area studied by the UC Davis authors, but the results can be compared on a per-acre basis. In the UC Davis study, the authors identified several different potential loading rates, including several upper limits via different methods and an expected range for loading under typical circumstances. The UC Davis report determined an upper and an alternative upper value for nitrogen loading of 5,100 tons N/year and 1,100 tons N/year, respectively. Using the total area of lagoons identified in the UC Davis study (3,126 acres) to calculate the loading rates on a per-acre basis give upper limits of 0.35 – 1.63 tons N/ac-yr, or 700 – 3,260 lb N/ac-yr. These upper limits were chosen based on liquid loss rates and lagoon nitrogen concentrations from research reviewed here: Ham 2002, van der Schans et al. 2009, Campbell Mathews et al. 2001, and Pettygrove et al. 2010. This research was conducted in Kansas and California. In addition to these upper limits, the authors of the UC Davis study also chose an estimated loading range based on unpublished data from the Tulare Lake Basin and Salinas Valley of 220 – 2,200 tons N/year. Making the same adjustment for lagoon area of 3,126 acres in the UC Davis study, this results in a loading rate range of 0.07 – 0.70 tons N/ac-yr, or 141 – 1,407 lb N/ac-yr (Viers et al. 2012).

The expected loading range for the UC Davis study is much lower than the range expected in GWMA lagoons from the Darcy's law calculation. The high end of the UC Davis expected loading range is similar to the low end of the GWMA expected range. Even the upper limits of the UC Davis expected loading are extremely low compared to the range identified for GWMA lagoons. One contributing factor is the difference in lagoon nitrogen concentrations between the UC Davis study and this calculation. The UC Davis study estimates were largely based on lagoon nitrogen concentrations of 500 mg N/L, although a lagoon nitrogen concentration of 1,000 mg N/L was discussed in that study also. In contrast, the Darcy's law calculations use a much higher lagoon nitrogen concentration of 1,053 mg N/L, which results in a large increase in estimated losses. In addition, the UC Davis estimates are based on experimentally determined rates, while the Darcy's law calculations are based on a theoretical model that, while it includes real world data on lagoon characteristics, is not calibrated with experimental data on lagoon seepage.

SETTLING PONDS

Some challenges of identifying settling ponds have been discussed above, in the lagoon limitations. Distinctions between impoundment functions may be difficult to identify and impoundment functions themselves can fluctuate. Different industry experts classify impoundments based on different 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 ponds that are drained and cleaned as needed. Some are concrete lined, engineered basins, which would make using permeabilities for a clay lined impoundment inappropriate. The lack of information about the diversity of settling basins and their construction techniques makes it impossible to make reasonable assumptions for calculation. The work involved in correctly identifying and characterizing settling ponds or basins well enough for an accurate calculation makes addressing settling ponds beyond the scope of this report.

Conclusions and recommendations

This work is intended to be used as a planning and management tool for the GWMA when determining where to use limited resources. Although the best available information has been used to assess nitrogen available for transport, many of these calculations are partially based on literature values and assumptions due to a lack of local data. Current and new work by state agencies may provide additional information about lagoon conditions that could be used to adjust the permeabilities chosen for the Darcy's law calculation: WSDA's DNMP assessment of Yakima County lagoons through the Natural Resources Conservation Service's Technical Note 23 (USDA NRCS 2013) and the CAFO permit recently issued by the Washington State Department of Ecology, which requires producers to assess lagoons by the process in Technical Note 23. However, translating these condition ratings into a functional permeability that could be used in Darcy's law may be challenging.

WSDA has identified several next steps to refine these estimates:

- measuring lagoon seepage rates in the GWMA would contribute the most useful information to improve this estimate and refine the range of permeabilities used for the lagoon calculation,
- both lagoon and corral estimates could be improved through additional statistical sampling of total nitrogen concentrations in lagoons and statistical sampling of soil nitrogen concentrations below pens,
- and any lagoon condition ratings should be incorporated when they become available.

2. IRRIGATED AGRICULTURE

WSDA authors: Kelly McLain, Perry Beale, Margaret Drennan, Jaclyn Hancock

Background

This section covers irrigated agricultural production, including estimates of nitrogen inputs from commercial fertilizer, manure, and compost. Cropland associated with dairies is discussed here instead of the CAFO section of the report. Nitrogen available for transport from irrigated agriculture in the GWMA was estimated using a mass balance technique, in which all inputs and outputs of nitrogen were accounted for. The largest and most complicated inputs in this mass balance are crop fertilizer applications. Fertilizer applications are influenced by crop type, crop nitrogen needs, application recommendations, and expected yields. Other inputs and outputs (potential nitrogen fixing, nitrogen removal through crop harvest, irrigation water use, and plant residual removal or incorporation) are also crop dependent. Because of the large number of different crops grown in the GWMA (50 different crop types), WSDA NRAS staff identified the top 15 crops by acreage (based on 2014 WSDA crop data) within the GWMA boundary[6]. NRAS staff then interviewed commodity-specific experts to obtain a typical range of use rates for commercial fertilizer, manure, and compost for each of these top 15 commodities. These top 15 commodities represent 87% of the irrigated agricultural land within the GWMA, and irrigated agriculture makes up 56% (approximately 99,000 acres) of the total land area within the GWMA boundary[7]. A significant proportion of the acreage of these top 15 commodities (33,033 acres or 38%) is dedicated to crops and land uses (corn, triticale, pasture, and alfalfa) that support livestock operations. The other main crops in the region are tree fruit, grapes (both juice and wine), hops, wheat, mint, and asparagus. These top 15 commodities and their acreage are listed in Table 8.

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[6] WSDA NRAS agricultural land use mapping program, 2014 data.
[7] WSDA NRAS agricultural land use mapping program, 2015 data.

Table 8. Top 15 crops and their acreage in the GWMA

Crop	Acreage
Apple	17,333
Corn (silage)	16,778
Triticale	10,780
Grape (juice)	10,257
Alfalfa	7,989
Pasture	6,731
Cherry	6,336
Hops	5,961
Grape (wine)	5,126
Pear	3,331
Mint	1,418
Wheat	1,283
Corn (grain)	1,166
Asparagus	854
Peach/Nectarine	843

Methods, limitations, and assumptions

Limitations

This assessment is not intended to evaluate the practices of individual farming operations within the GWMA. Information about commercial fertilizer, manure, and compost was collected voluntarily from crop consultants and growers. Growers are not obligated to share fertilizer or soil amendment application information with outside entities (like WSDA) unless required by statute or legal discovery. The objective was to identify the range of commonly used nitrogen application rates for the top 15 crops by acreage grown within the GWMA boundary. The data is grouped by commodity; this allows as much anonymity as possible to agronomists and growers who provided nutrient application information. Information was gathered from crop consultants and growers with the goal of targeting experts who could provide information about a large percentage of the acreage for each crop. As a result, for each crop the number of experts consulted may be relatively small. Although for most crops a large proportion of the acreage was covered, in some cases only one consultant was responsible for most of the acres of a commodity, meaning if that consultant's recommendations or practices were atypical, that may have a large influence on the accuracy of the results.

Data was summarized here for the top 15 crops within the GWMA by acreage, which were identified from 2014 agricultural land use mapping. The top 15 crops will change from year to year, based on weather, economic pressures, and other factors.

This report does not explicitly associate information on irrigation methods with the crop types and mass balance. Irrigation practices can affect the likelihood of nitrogen leaching through the soil profile. In addition, nitrogen removed from the field by irrigation water and traveling with irrigation return flows is a potential output that was not included in this mass balance. In managed irrigation systems, water can be used as many as 4 or 5 times before being discharged from the system. Nitrogen concentration of this water will be increased by repeated use; accurately estimating this was beyond the scope of this study. In addition, it is possible for nitrogen-containing water to leak from unlined irrigation canals; an assessment of this potential was also beyond the scope of this study.

Results from this study were not compared to the Yakima county deep soil sampling results: that was beyond the scope of this study. Grower responses about application practices and soil organic matter content were the only deep soil sampling results used in this study. An analysis of the deep soil sampling results for comparison to the mass balance would provide a valuable opportunity to calibrate and adjust the mass balance results.

Timing of fertilizer applications, plant uptake, irrigation applications, and crop residue incorporation was not part of this study. Timing of these events as well as timing of weather events such as rainfall, snowfall, and freezing temperatures can all affect whether or not nitrogen in the soil will be taken up by plants, be likely to move with runoff, or be available to leach through the soil profile. In addition, this study does not account for the timing of nitrogen availability from the different nitrogen sources. Commercial fertilizers are formulated to release a specific amount of nutrients at a specific rate over a certain period of time. In contrast, a large amount of the nitrogen present in an application of manure or compost fertilizers is organic nitrogen, which is not immediately available for plant growth. This organic nitrogen will mineralize over time, making more nitrogen available for plant growth for several years after the initial application. The actual nitrogen available in the first and subsequent years depends on the nitrogen source, weather and temperature conditions, and the breakdown rate of the organic matter containing the nitrogen. NRAS did not attempt to account for these nuances of nitrogen availability from different sources; all nitrogen contained in any fertilizer application is assumed to be immediately available in the first year after application, regardless of source.

Pasture was included as a crop in this assessment, and grower applications of commercial fertilizer, manure, and compost were part of that assessment. However, manure and urine deposition by livestock in pastures was not assessed. Adding this information would improve the estimate of available nitrogen from irrigated agriculture.

No estimate of nitrogen fixing by alfalfa was calculated because of the variability in crop behavior due to differences in management practices, pH, nutrient availability, and the presence of rhizobia bacteria throughout the GWMA. Also, the majority of survey respondents indicated that fertilizer was applied to alfalfa which would limit nitrogen fixing.

This assessment is based on 2015 agricultural land use data. Crops may go through rapid expansion or decline of acreage due to economic pressure, changes in weather patterns, or other factors. Similarly, technological innovations and changes in cropping systems or irrigation systems may result in rapid change in crop management characteristics such as planting density (with resultant changes in yield per acre) or the volume of water needed for irrigation. In order to maintain consistency and comparability across the 4 sections of this report, 2015 data was used throughout. Information can be updated uniformly when new information becomes available.

Data collection

WSDA's NRAS maps irrigated agriculture statewide, including the area within the Yakima GWMA boundary. This statewide data was clipped to the Yakima GWMA boundary to limit the dataset to only those crops grown within the GWMA. It was also updated with the 2015 crop mapping data. NRAS did additional mapping work for field corn to distinguish between grain and silage corn acreage for this project. The crop data is captured in the GIS database as polygons with attributes that include locations, crop type, irrigation method, acres, date surveyed, and if it was documented as organic according to WSDA organic program GIS data. In addition, acreage double cropped with field corn and triticale was identified.

Fertilizer application data was collected via telephone survey. In order to increase participation, respondent's identities were not recorded; the goal was to gather enough data to develop a typical use range, not connect application rates to specific farming operations. Data was collected for the top 15 crops (representing 87% of the total irrigated acreage in the GWMA) for applications of commercial fertilizer, manure, and compost.

In order to develop an estimate for each crop, WSDA's goal was to survey enough producers and crop consultants to get nutrient application data covering a minimum of 30% of the acreage for each target commodity. Because there are thousands of individual farms operating within the GWMA, collecting information from individual farmers would be extremely time consuming. Crop consultants or agronomists are used by the majority of commercial farms operating in the valley. There are only a few companies that do this type of work, limiting the number of interviews required to access information. While these consultants are not usually farmers, they create prescriptions for fertilizer applications across multiple crops on many different farms. All respondents were asked to provide both typical use rates and a range of use rates, if applicable, for commercial fertilizer, manure, and compost. In addition, respondents were asked how many acres of each crop they work with or represent.

Data about fertilizer use practices was also drawn from the surveys conducted through the deep *soil sampling process.* These responses cover much smaller acreages than the information from crop consultants, but provide useful additional information. These two sources of survey information could be compared to identify discrepancies or potential inaccuracies. Unfortunately for most of the commodities surveyed, the majority of the responses are from either professional crop consultants or the deep soil sampling surveys, making a statistical comparison between the two sources impossible.

The data collection goal of 30% of acreage was met for all commodities, with the exception of pasture, for which information on only 11% of the GWMA acreage could be collected. In total, NRAS gathered information about more than 58,000 acres of the 15 targeted commodities, or 68% of the acreage dedicated to those commodities in the GWMA (Table 9).

Table 9. Acreage in each commodity, with data collection targets and collection results

Commodity	Total acreage of commodity in GWMA	30% goal (acres to collect)	Acreage collected	Percent of total acreage collected
Apple	17,333	5,200	14,165	82%
Corn (silage)	16,778	5,033	11,480	68%
Triticale	10,780	3,234	7,696	71%
Grape (juice)	10,257	3,077	3,849	38%
Alfalfa	7,989	2,397	6,194	78%
Pasture	6,731	2,019	725	11%
Cherry	6,336	1,901	3,826	60%
Hops	5,961	1,788	3,760	63%
Grape (wine)	5,126	1,538	2,500	49%
Pear	3,331	999	1,741	52%
Mint	1,418	425	780	55%
Wheat	1,283	385	490	38%
Corn (grain)	1,166	350	348	30%
Asparagus	854	256	506	59%
Peach/Nectarine	843	253	630	75%

Mass balance

In a mass balance (in this case, focused on nitrogen) all material moving into or out of a system is accounted for. In this case, the system was defined as a 1-acre crop field. Inputs, or additions of nitrogen to the field, were categorized as positive (+). Outputs, or removals of nitrogen from the field, were categorized as negative (-). In addition, processes that transform nitrogen may be significant, resulting in either an increase (+) or decrease (-) of available nitrogen in the field. All known inputs, outputs, and transformations are summed, and the sign and magnitude of the resulting sum can be used to determine whether there is a net accumulation or a net loss of material in the field, or whether there are unknown material flows or transformations.

$$N\ accumulation\ or\ loss\ = Inputs \pm Transformations - Outputs$$

In this case, the list of inputs and transformations includes:

- commercial nitrogen applications (lb N/ac-yr) (evaluated at low, weighted average, and high values);
- manure nitrogen applications (lb N/ac-yr) (evaluated at low, weighted average, and high values);
- compost nitrogen applications (lb N/ac-yr) (evaluated at low, weighted average, and high values);
- atmospheric nitrogen deposition (lb N/ac-yr) (evaluated at low, medium, and high values);
- irrigation water nitrogen (lb N/ac-yr);
- calculated residual nitrogen incorporated (lb N/ac-yr) (evaluated at low, average, and high for some crops and one value for others);

- soil organic matter conversion (lb N/ac-yr) (evaluated at low, average, and high values).

The outputs (or nitrogen losses) are:

- crop nitrogen uptake, removed through harvest (lb N/ac-yr) (evaluated at low, average, and high for some crops and one value for others); and
- nitrogen loss to atmosphere (lb N/ac-yr).

Determination of inputs, outputs, and transformations

Commercial, manure, and compost nitrogen applications: Growers and agronomists reported use of commercial fertilizer, manure, or compost, as well as application rates and acreages. In order to account for the use of multiple nitrogen sources, within each commodity the proportion of acres each source was used on was a weighting factor in the final calculation. This weighting factor appears as a multiplier for each nitrogen source and was calculated separately for each commodity and nitrogen source. It was generated by calculating what proportion of acres that nitrogen source was used on out of the total acres of that commodity surveyed. For example, in apple production commercial nitrogen application was reported on 86.3% of the total surveyed acres, so 0.863 is used as a multiplier whenever inputs to apple production from commercial nitrogen applications are calculated. This weighting allows the survey data to be scaled from the hundreds of acres for which applications were reported to the theoretical 1-acre field the mass balance is calculated for and make standardized comparisons between crops and other nitrogen sources.

The low, medium, and high application rates were drawn directly from the survey results. The low and high rates used were the lowest and highest reported application rates for each nutrient source and commodity. The medium application rate was a weighted average of all single application rates reported where each reported rate was weighted by the acreage that survey respondent controlled before averaging.

Commercial fertilizers are formulated to release nutrients at a specific rate over a certain period of time. The nitrogen in compost or manure is released over a longer period of time at a lower rate, and these products are often applied to improve soil health in addition to providing fertilization. In soils with a history of regular manure applications, the breakdown of organic matter from applications in previous years combines with the available nitrogen from the current year's application to make the full applied amount of nitrogen available during that growing season. For this calculation, NRAS has assumed that growers using manure or compost have been applying manure or compost regularly and the nitrogen content from those materials is considered to be immediately available because of the nitrogen contributions from previous applications.

Atmospheric nitrogen deposition: This input is the same for every crop assessed. The low rate for atmospheric deposition for the lower Yakima Valley was taken from the most recently reported (2012) wet and dry atmospheric deposition at the Mt. Rainier National Atmospheric Deposition Program (NADP) station; 1.53 lb N/ac (EPA 2016). The medium deposition rate is the result of a 5-day modeled average from December 2015; 2.05 lb N/ac. To estimate a high rate, the medium atmospheric deposition was multiplied by a safety factor of 3 to account for potential higher deposition during weather conditions resulting in decreased circulation and poor air quality[8]. More details on the methodology and assumptions for atmospheric deposition can be found in Section 4. ATMOSPHERIC DEPOSITION.

Irrigation water nitrogen: The nitrogen input from irrigation water is also unique to each commodity. It is based on the nitrogen content of the lower Yakima River and the irrigation water duty for each commodity. Yakima River nitrogen concentration was taken at the U.S. Geological Survey station on the Yakima River at Kiona during the 2012 irrigation season (April through September) (USGS 2012). This time period was chosen to represent the typical time frame during which irrigation water would be withdrawn for use, including both high flow conditions during the late spring (when nitrogen concentration would be low) and low flow conditions during the late summer (when nitrogen concentration would be high). Summary information about this data set was calculated, and the mean (0.809 mg N/L) of the 10 samples was used in the mass balance (Table 10).

Table 10. Summary statistics for Yakima River nitrogen concentrations (n=10) (USGS 2012)

Minimum (mg N/L)	0.42
Maximum (mg N/L)	1.26
Mean (mg N/L)	0.809
Standard deviation (mg N/L)	0.366
Median (mg N/L)	0.675

Although the sampling location is located in the mainstem of the Yakima River and downstream of the irrigation districts serving the GWMA agricultural lands, NRAS believes that it serves as a good surrogate for potential irrigation water nitrogen levels in the area. The majority of the irrigation water in the lower Yakima Valley is surface water. Very little groundwater is used for irrigation with the exception of drought years when use of emergency drought wells is permitted. However, variation in nitrogen between different irrigation water sources, and in the same irrigation water source from year to year is expected. A detailed analysis of sources of irrigation water was not within the scope of this project.

The second part of this input includes commodity specific irrigation water duty for the 15 commodities included in the mass balance. It also takes into account total precipitation and effective precipitation. The data was drawn from the Washington Irrigation Guide and reviewed by the Irrigated Agriculture Working Group (IAWG) of the GWMA. The water duty (in inches) values for apples and cherries were reflective of current use patterns, and were edited by Stu Turner, agronomist and member of the IAWG (Appendix F: Irrigation water use).

Calculated residual nitrogen: Calculated residual nitrogen is the nitrogen taken up during the growing season that is left in the plant after harvest. This term is based on plant nitrogen uptake during the growing season (which appears in the mass balance as an output) and the amount of nitrogen removed when the crop is harvested. As a result, it is different for each commodity. The

[8] Medium and high deposition values were recommended by Dr. Ranil Dhammapala, an atmospheric scientist with Washington State Department of Ecology's Air Quality Program, during a meeting on November 3, 2016.

components of the residual nitrogen calculation were estimated by the Jim Trull and Scott Stevens, as well as the IAWG and Sunnyside Valley Irrigation District and were based on regularly used resources. Depending on the crop type, the residual nitrogen taken up during the growing season but remaining after harvest may be left in the field and incorporated (as in the case of annual crops) or that residual nitrogen may be retained in the plant, in the new growth of vegetation during the season (as in the case of perennial crops). For perennial crops, some of this new growth will be removed during pruning and through seasonal leaf loss and will eventually still return to the soil, and some may be retained on the plant and not return to the soil. For this analysis, it was assumed that calculated residual nitrogen should be wholly counted as an input to the system for all crop types, despite the fact that some crops may differ in that regard; this is an input that can be varied as more information becomes available. Estimates of nitrogen removed during harvest and the inputs used are presented in Appendix G: Nitrogen uptake estimates. This appendix includes data on typical crop yields, nitrogen removed through harvest, nitrogen uptake by the plant during its growing cycle, and estimates of nitrogen applied.

Soil organic matter conversion to nitrate: This term represents the breakdown of organic matter (containing nitrogen) to nitrate-nitrogen available for both crop uptake and leaching below the crop root zone. This input was the same for every commodity analyzed. The native organic matter content of most lower Yakima Valley soils is around 1% but when these soils have a history of organic inputs such as manure, it can increase by 2 to 3 times[9]. This was confirmed by a review of the deep soil sampling results. WSDA reviewed results from the fall and spring sampling of 2015 (Table 11) and decided to use the average organic matter content of 2.17% from this set of sampling results to represent these soils.

Table 11. Summary statistics of organic matter percentage of sampling in the 2015 Yakima Valley deep soil sampling study (n = 108)

Minimum (%)	0.84
Maximum (%)	4.24
Mean (%)	2.17
Standard deviation	0.69
Median (%)	2.15

In general, organic matter in soils can mineralize to provide between 20 and 65 lb N/ac per 1% organic matter. In soils with no history of manure applications the mineralization is expected to be 20-40 lb N/ac per 1% organic matter. In soils with a history of manure applications the mineralization is expected to be 40-65 lb N/ac per 1% organic matter[10]. In this mass balance, WSDA used 2.17% organic matter (based on the deep soil sampling results) and soil mineralization rates that varied for different crops based on the expected history of manure applications (Table 12).

[9] Personal communication, based on experience and best professional judgment of Virginia 7Prest, WSDA Dairy Nutrient Management Program manager and agronomist

[10] Based on the recommendation of Dr Haiying Tao, Department of Crop & Soil Sciences, Washington State University

Table 12. Range of soil organic matter mineralization used for different crops

Organic matter mineralization range (lb N/ac per 1% organic matter)	Crops
20 (L), 30 (M), 40 (H)	Apple, juice grape, cherry, wine grape, pear, mint, asparagus, peach/nectarine
40 (L), 52.5 (M), 65 (H)	Silage corn, triticale, alfalfa, pasture, hops, wheat, grain corn

Manure represents only one potential source for this soil organic matter content, and the average 2.17% organic matter content of the soil tested during the deep soil sampling may be due to a history of manure applications on those fields. However, there are a number of agricultural practices that producers use to increase the organic matter content of their soil. Direct seed and no-till practices both leave the soil undisturbed, preventing the rapid decomposition of organic matter that takes place when the upper layers of the soil profile are exposed to the atmosphere. Cover cropping can also be used to increase soil organic matter content.

Crop nitrogen uptake: This is the amount of nitrogen taken up by the plant from the soil during the growing season. The crop nitrogen uptake is also part of the calculation for residual nitrogen above. This output is unique for each commodity, and was estimated by the IAWG. This output represents the amount of nitrogen taken up by the crop during the growing season; the estimates, ranges, and sources are detailed in Appendix G: Nitrogen uptake estimates.

Loss to atmosphere: The numbers used in this output of the mass balance equation were taken directly from Table 36, pages 117-118 of the 2006 NRCS publication "Model Simulation of Soil Loss, Nutrient Loss, and Change in Organic Carbon Associated with Crop Production" (Potter et al. 2006).

The full equation, with all inputs and outputs, is:

$$\begin{aligned} Est.\,N\ Loading\ per\ year \\ &= \Big(\big((Comm\ N \times proportion) + (Compost\ N \times proportion) \\ &+ (Manure\ N \times proportion) \\ &+ (Atmos\ N\ Dep + Irrigation\ Water\ N + Calculated\ Residual\ N \\ &+ N\ Soil\ Conversion)\big) - \big((Crop\ Uptake\ N + N\ Loss\ to\ Atmosphere)\big)\Big) \\ &\times (Total\ Commodity\ Acres) \end{aligned}$$

This calculation was used for each individual commodity of the top 15 identified.

GIS compilation

The GIS data for the irrigated agriculture section of this study is stored in a file geodatabase that contains both attributes and spatial locations of this data. It contains 6 feature classes and one table: YakimaGWMA (polygon, GWMA boundary), WSDACrop2015 (polygons, crop identification), TriticaleDoubleCrop2015 (polygons, crop identification), Lagoons (points), Ponds (points), and CAFO_Pen_Compost (polygons, boundaries of pens and compost areas). This database also contains a table, IrrigatedMassBalance, which contained the mass balance calculations and results.

Metadata is included with the GIS database to further describe the additional aspects of the GIS data. This includes information such as the extent, credits, use limitations, scale, processing environment, author, and spatial reference.

Cover crops

Cover crops are plants grown to manage weeds, reduce erosion, improve soil quality, retain water, and prevent pests and diseases; they may help prevent nutrient leaching[11]. Although cover crops benefit soil health and can provide nutrients for future crops, an in-depth analysis of behavior, cultivation, and nitrogen influence of different cover crops used in cropping systems was beyond the scope of this study due to their highly variable use and the limited research available.

The most common area where cover crops are grown in the Yakima GWMA is in alleys between rows used for cultivation of tree fruit, grapes, and hops. Depending on the cropping system and management practices, these cover crops may or may not be fertilized. Cover crops are typically mowed (with the residue left onsite) or reincorporated, so the nitrogen is recycled rather than removed through harvest. This practice increases the organic matter content of soils in the alley over time.

In orchards, the tree row is approximately 30% of the area while the alley is 70%. With dwarfing trees, approximately 80% of the roots are in the rows with 20% in alleys. In older orchards, tree roots extend into the alley. In one orchard study (in Quincy, Washington), with grass used as an alley cover crop, there were 4 cuttings each year, with the nitrogen recycled each time into regrowth. With 8-foot wide alleys in the orchard, the cover crop provided 30-60 lb N/ac-yr[12]. Of the orchard cover crops in the valley, 95% are grasses, with some volunteer clover. Straight legume cover crops are not used in the Yakima area.

The historic orchard fertilization practice was to broadcast over the entire tree row and alley cover crop, but practices have generally changed in recent years and now typically the tree row receives a banded fertilizer application. This leaves the alley cover crop nitrogen starved which results in a scenario with minimal nitrogen available for leaching (Granatstein et al. 2017). In older orchards, tree roots extend into the alley with grass cover crops and broadcast fertilization may be practiced. Tree roots will utilize some of the N in the alleys but the cover crop is often shaded and not very productive, and thus less effective at N scavenging to prevent leaching.

In juice (Concord) grape vineyards, fertilizer is applied only on the vineyard row (through drip or banded) and not in the alley[13]. Juice grapes may or may not have cover crops as bare dirt alleys are common. The historically used cover crop was cereal rye, but due to costs this is no longer common. The primary cover crop currently used is resident vegetation (native grasses, forbs and weeds). Cover crops can vary depending on whether or not the operation is organic. Common cover crops in organic juice grape systems are vetch and Austrian pea (about 5-6% of the juice grape acreage in

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[11] Personal communication 5/4/2017, Harold Crose, cover crop and soil health specialist, USDA Natural Resource Conservation Service, retired.

[12] Personal communication 5/4/2017, 8/14/17 David Granatstein, Sustainable Agriculture Specialist, Washington State University Center for Sustaining Agriculture and Natural Resources, Wenatchee Washington

[13] Personal communication 5/8/2017, Dr. Joan Davenport, Washington State University Irrigated Agriculture Research & Extension Center, Prosser, Washington

the Yakima Valley is organic [14]) which can produce 118-130 lb N/ac-yr, but contribute very little excess nitrogen[12,13] (Bair et al. 2008).

In wine grapes and hops cereal grains may be used as cover crops, but they are not typically fertilized and are primarily drip irrigated so are unlikely to elevate the risk of nitrogen loss[13].

Because of the variability in which orchards and vineyards have cover crops, which cover crops are used, the age of the planting, the management practices used, and the low risk of nitrogen loss in cover crop cultivation, the influence of cover crops was not included in this estimate.

Results and discussion

During the data collection phase of the irrigated agriculture component of this report, interviewees were asked what percentage of their acreage were fertilized with commercial fertilizer, manure, or compost. Table 13 shows the results from this survey; the most commonly used product is commercial fertilizer. The only exceptions are silage corn and triticale where more acres are fertilized with manure than with commercial fertilizer. In this table, crop acres fertilized with multiple products appear more than once. As a result, for some crops the percentages sum to more than 100%. For example, all acres grown (100%) of wine grapes were fertilized with commercial fertilizer. In addition, 20% of the acres of wine grapes were fertilized with compost. As a result the total acres fertilized for wine grapes adds up to 120%: 20% of the acres were fertilized with 2 different products. The only crops where growers or crop consultants reported use of all 3 fertilizer products were hops and triticale. The percentage of acres on which multiple sources were used is calculated in the last column.

[14] Personal Communication 5/8/2017 Mike Concienne, Manager, National Grape Cooperative Association, Grandview Washington

Table 13. Summary of fertilizer types used for the top 15 crops by acreage in the GWMA

Crop	Commercial fertilizer (% of acres)	Manure (% of acres)	Compost (% of acres)	Acres using multiple sources (%)
Apple	86.3	0	13.7	0
Corn (silage)	49.6	53.9	0	3.5
Triticale	27.2	74.8	0.8	2.8
Grapes (juice)	91.0	0	11.6	2.6
Alfalfa	91.8	8.2	0	0
Pasture	97.2	2.8	0	0
Cherry	80.5	0	19.5	0
Hops	97.3	2.7	16.0	16
Grapes (wine)	100.0	0	20.0	20
Pear	76.6	0	23.4	0
Mint	100.0	0	0	0
Wheat	93.9	22.4	0	16.3
Corn (grain)	71.3	62.6	0	33.9
Asparagus	100.0	0	0	0
Peach/Nectarine	81.0	0	19.0	0

Application rates reported by growers are presented in Table 14. The range of application rates is first, followed by the weighted average (used for the medium rate calculations) in parentheses. For several crops (apples, alfalfa, and pears), some growers reported using no commercial fertilizer during some years. For almost all crops, the range spans an order of magnitude between low and high. This indicates the diversity of practices used by different growers. It also suggests that some growers are customizing application rates to crop needs each year, based on soil testing results.

Table 14. Ranges of application rates (with weighted average in parentheses) reported for commercial fertilizer, manure, and compost

Crop	Commercial fertilizer (lb N/ac)		Manure (lb N/ac)		Compost (lb N/ac)	
Apple	0-150	(60)	0	(0)	15-100 (47)	(47)
Corn (silage)	40-434	(214)	20-324	(203)	0	(0)
Triticale	60-225	(107)	20-350	(104)	170	(170)*
Grapes (juice)	0-100	(80)	0	(0)	21.5-90	(64)
Alfalfa	0-210	(74)	10-300	(161)	0	(0)
Pasture	50-200	(120)	17	(17)*	0	(0)
Cherry	20-125	(56)	0	(0)	15-72	(52)
Hops	25-225	(192)	132	(132)*	30	(30)*
Grapes (wine)	15-40	(25)	0	(0)	36.6-54.9	(46)
Pear	0-100	(57)	0	(0)	15-80	(58)
Mint	80-300	(269)	0	(0)	0	(0)
Wheat	60-120	(106)	90-240	(131)	0	(0)
Corn (grain)	100-300	(214)	50-220	(135)	0	(0)
Asparagus	40-100	(99)	0	(0)	0	(0)
Peach/Nectarine	30-80	(51)	0	(0)	15-30	(28)

*When no range was reported only a single value is presented in this table.

To better understand the role different nutrient sources play in the amount of nitrogen available for transport, the mass balance inputs were examined (Figure 4). All inputs other than nutrient applications were categorized together ("Other"). The "other" category includes atmospheric deposition, irrigation water concentration, calculated residual nitrogen, and soil organic matter conversion; these inputs are not directly influenced by fertilizer applications. The magnitude of this category is largely determined by calculated residual nitrogen and soil organic matter conversion. Calculated residual nitrogen is unique to the individual crop type, while soil organic matter conversion is related to soil properties and the same calculation was used for all crops. For most crops, fertilizer applications consist mostly of commercial fertilizer. Some exceptions are corn (silage and grain) and triticale, some of which consistently receive manure applications and are often grown to support dairy operations.

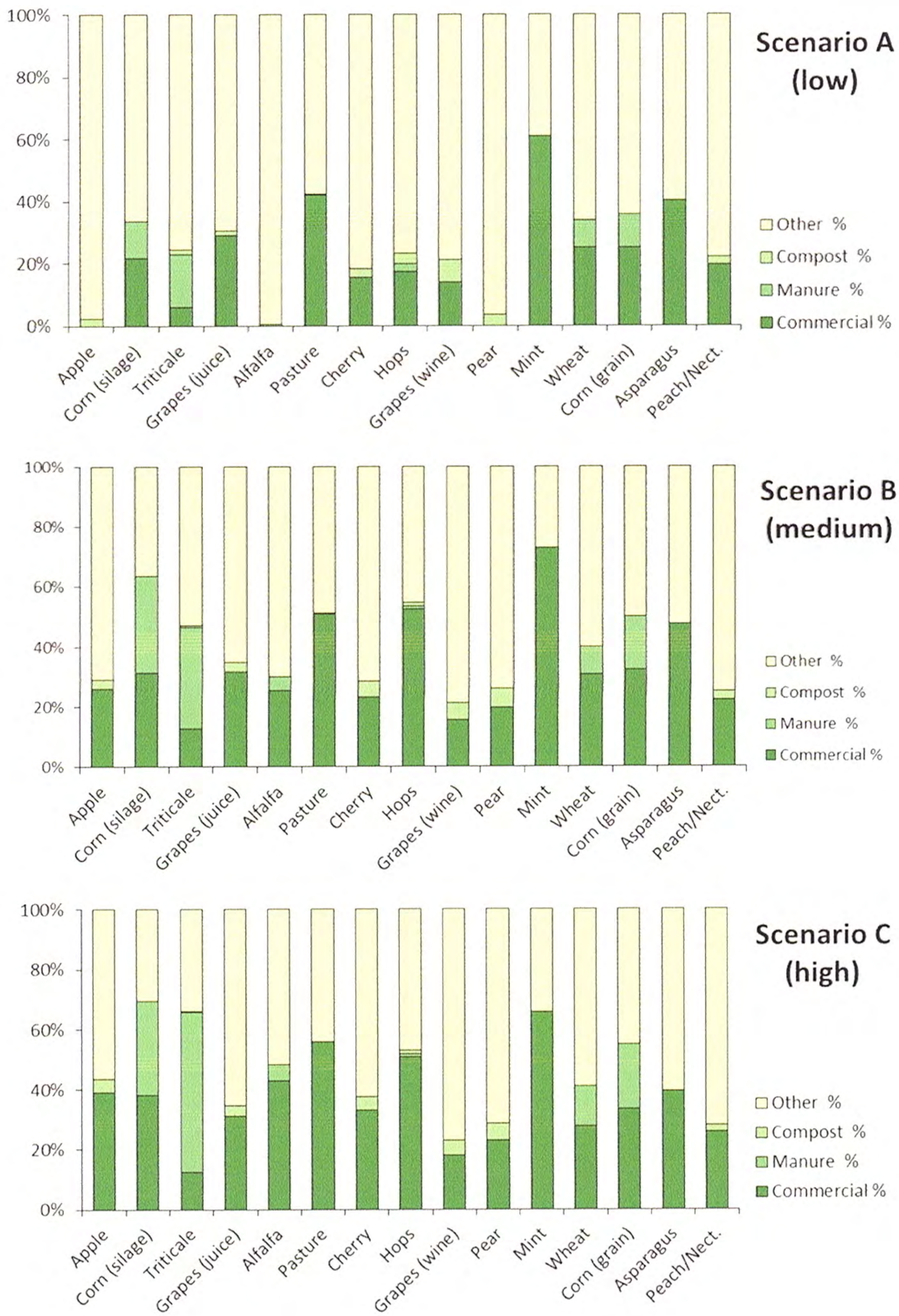

Figure 4. Inputs in the irrigated agriculture mass balance

Data on irrigation practices was collected through WSDA's agricultural land use mapping (Figure 5). For this report irrigation types were divided into 4 main categories based on whether the irrigation type is likely to result in water loss through the soil and contribute to available nitrogen: sprinkler, micro, macro, and miscellaneous. This information is summarized for both all the irrigated acreage in the GWMA and for the top 3 crops in terms of nitrogen surplus per acre (identified in Table 15).

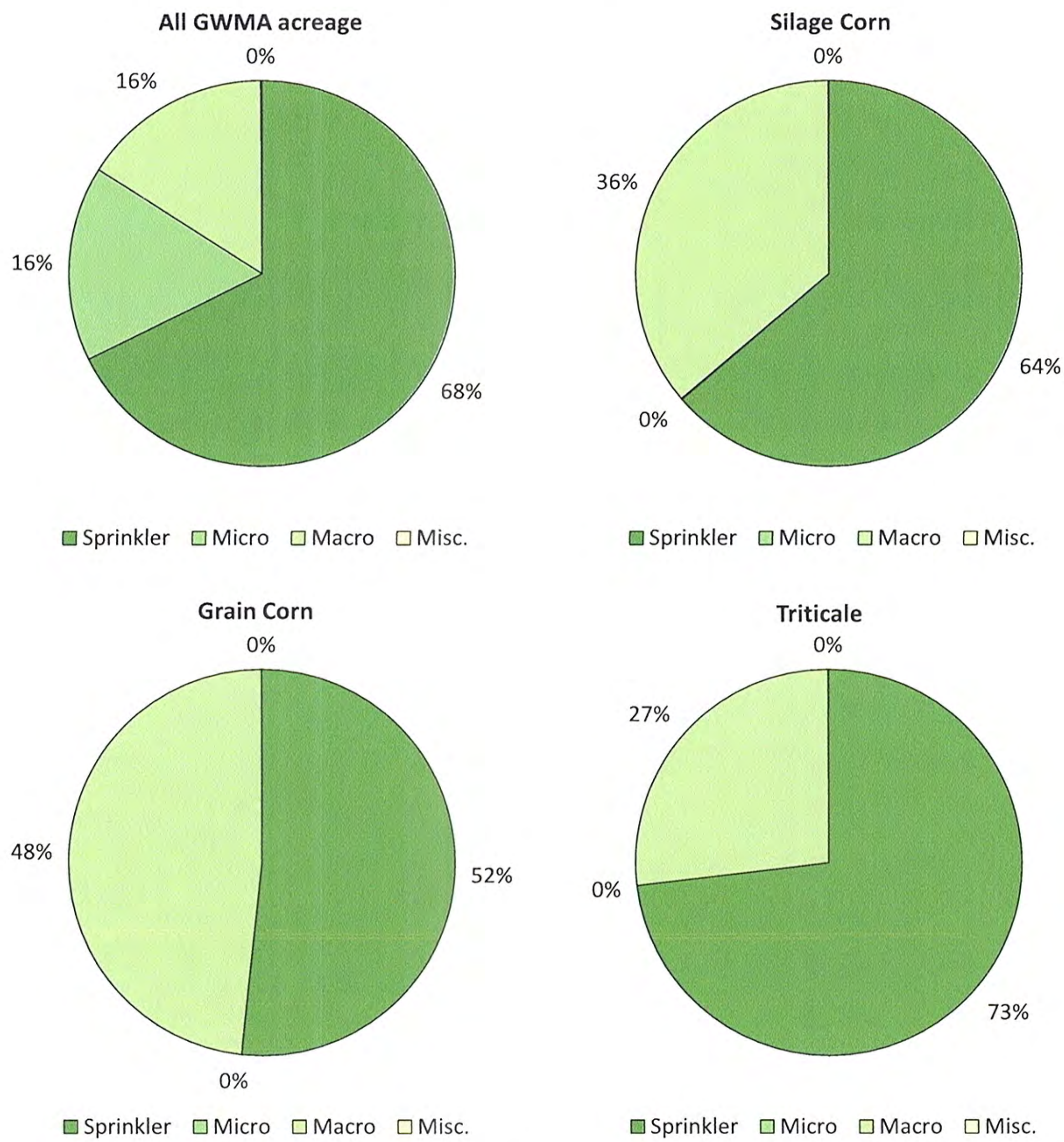

Figure 5. Irrigation types for all GWMA acreage and top 3 commodities with surplus nitrogen inputs (per acre). Due to rounding, categories with 0% are either 0 or values less than 1 that rounded to 0.

The most used irrigation type in the GWMA's irrigated acreage was sprinkler irrigation, which includes center pivot, big gun, sprinkler, wheel line, and combinations of these. Of the total irrigated acreage in the GWMA, sprinkler irrigation was used on 68%. Micro irrigation was the second most common and accounts for about 16% of the irrigation. Micro irrigation includes drip, micro sprinkler, drip/sprinkler, and combinations. The third most common was macro irrigation which includes flood, rill, and combinations with the sprinkler group; macro irrigation accounted for almost as much acreage as micro irrigation, accounting for over 15% of the GWMA acreage (these values have been rounded in Figure 5). The miscellaneous group included irrigation by hand or acreage for which the irrigation type is unknown; this group made up less than 1% of the irrigated acreage in the GWMA.

Because of the potential for irrigation type to affect nitrogen leaching, the irrigation types for the top 3 crops with nitrogen surpluses on a per acre basis (silage corn, grain corn, and triticale) were also analyzed individually. For each of these crops, over 50% of the acreage was irrigated with sprinklers. For silage corn, the second most common technique is macro irrigation (the most likely to result in excess water application and leaching), which accounts for approximately 36% of the acreage. Macro irrigation is also the second most commonly used irrigation type for both grain corn and triticale, used on 48% and 27% of the acreage, respectively. Micro irrigation and miscellaneous irrigation types were used on less than 1% of the acreages of silage corn, grain corn, and triticale. Without detailed information about water loss through excess application, nitrogen content of lost water, and soil testing results, WSDA was unable to specifically relate the individual irrigation practices to any potential nitrogen surpluses.

The results of the mass balance equation are shown below for the 15 commodities evaluated (comprising 87% of the total irrigated agricultural acreage in the GWMA). These values represent the estimated nitrogen surplus resulting from one year of inputs and outputs. These estimates do not account for nitrogen already present in the soil before fertilization. Values shown in Table 15 include low, average, and high potential nitrogen surplus in lb/ac-yr for each commodity resulting from one year's worth of applications and removals. Negative values represent a localized removal of nitrogen and do not offset excess nitrogen from other crops or areas within the GWMA. An example mass balance calculation for scenario B (medium) for the estimate of potential nitrogen surplus for apples is presented in Appendix H: Mass balance example calculation, apples.

Table 15. One year's worth of inputs and outputs for the top 15 crops in the GWMA

Commodity	Acreage	Sum of inputs and outputs for one year (lb N/ac-yr)		
		Low	Medium	High
Apple	17,333	-5	64	165
Corn (silage)	16,778	-156	47	242
Triticale	10,780	-92	13	250
Grapes (juice)	10,257	15	105	142
Alfalfa	7,989	-322	-214	-46
Pasture	6,731	-143	-47	62
Cherry	6,336	27	78	156
Hops	5,961	-41	99	113
Grapes (wine)	5,126	40	67	102
Pear	3,331	-1	65	119
Mint	1,418	-166	46	102
Wheat	1,283	-36	44	113
Corn (grain)	1,166	-4	148	284
Asparagus	854	58	130	156
Peach/Nectarine	843	12	54	104

At the low end of the range, the sum of one year's worth of inputs and outputs for many crops is less than zero. The survey results these calculations are based on include both typical year-after-year application practices and a range of practices which should encompass both a producers best possible year (where high nitrogen in a pre-plant soil test allowed a producer to make very low or even no nitrogen applications) and worst possible year (where a producer needed to make high nitrogen applications to meet crop growth needs). In addition, a net negative sum from a year's worth of inputs and outputs doesn't mean that there is no nitrogen loss during the year – losses may still take place after fertilizer applications if heavy rainfall or irrigation applications take place before plant growth uses the applied nutrients. However, the presence of these low values in the range of practices suggests that producers are responsive to the information in pre-plant soil tests and work to tailor nutrient applications to crop growth needs as possible. Successive years with a net nutrient deficit are likely to be followed by higher nitrogen applications to maintain yields.

Table 16 has been shaded to illustrate which commodities, based on the mass balance, have agricultural practices that may remove nitrogen (green) or add excess nitrogen (yellow) to the system. Commodities that have a negative value for the sum of the inputs and outputs are displayed with a dashed line to reduce confusion. Practices used on these crops are not making nitrogen available for transport (considered over the course of a year) nor are they removing excess nitrogen available from fertilization practices of another commodity. Only positive values are summed for the totals estimated in the low, medium, and high scenarios.

Table 16: Sum of inputs and outputs for the top 15 crops in the GWMA

	Estimated total N surplus in GWMA (ton N/yr)		
Commodity	Low	Medium	High
Apple	-	551	1427
Corn (silage)	-	390	2029
Triticale	-	69	1346
Grapes (juice)	78	538	730
Alfalfa	-	-	-
Pasture	-	-	209
Cherry	87	248	495
Hops	-	296	337
Grapes (wine)	103	171	261
Pear	-	108	197
Mint	-	32	73
Wheat	-	28	72
Corn (grain)	-	86	165
Asparagus	25	55	67
Peach/Nectarine	5	23	44
Total	298	2,595	7,452

A nonzero result in a mass balance (Table 16) can indicate either unknown inputs, outputs, or transformations, or net accumulation or loss. Of the 15 crops assessed, 10 did not have a yearly nitrogen surplus when evaluated at the low range estimates. Only juice grapes, cherries, wine grapes, peaches/nectarines, and asparagus had calculated nitrogen surpluses at the low range. At the high level, the majority of crops had calculated excess nitrogen. The only crop that did not was alfalfa.

Alfalfa was not estimated to have a nitrogen surplus at any evaluation level (low, medium, or high). Alfalfa is a complex perennial crop. It removes large quantities of nutrients from the soil (Koenig et al. 2009). 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 and will use 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, which may contribute to the fact that these crops largely did not have calculated nitrogen surpluses. Due to the variability in the crop behavior depending on the presence of rhizobia bacteria, pH, and nutrient availability, and the variability in management practices in the GWMA, no estimate of nitrogen fixing of alfalfa was calculated.

One of the reasons for differences in the excess nitrogen for different commodities lies in the unique cultivation practices for each crop. The orchard and vineyard crops listed above (apples, grapes, cherries, pears, and peaches/nectarines) are permanent crops. Producers of these crops do not have access to options like crop rotations or fumigation to deal with disease and pest pressure and as a result may rely on tools like high nutrient applications or applications of multiple nutrient sources in order to improve soil health and maximize fruit production. In addition, producers of crops intended for human consumption may be reluctant to make manure and compost applications because of concerns about pathogen transfer, reducing their fertilization options further. The majority of manure and compost applications observed were taking place on crops intended for animal feed or prior to planting permanent crops.

Annual crops such as silage corn, grain corn, triticale, and wheat use both commercial nitrogen and manure throughout the GWMA. Triticale is double-cropped (2 crops in one growing year) with silage corn, and triticale cultivation occurs on almost all sprinkler or center pivot irrigated fields in the GWMA. Triticale cultivation rarely occurs on rill irrigated fields. In this case, triticale is planted in the fall, harvested in the spring (April-May) with silage corn, wheat, or oats seeded immediately afterward and harvested late summer or fall (August-September). Generally, the nitrogen application for this corn/triticale cropping system is split – 1 application in the fall and 1 in the spring. Corn (silage and grain) use fairly even amounts of commercial nitrogen and manure on most of the acreage.

The crops with the highest estimated total nitrogen surplus (over the entire GWMA) are not necessarily the crops with the highest surpluses per acre. The top 4 crops in terms of nitrogen surplus are also the 4 crops with the highest cultivated acreage. There are crops with comparable or higher nitrogen surpluses per acre (cherries, grain corn, and asparagus) but these crops are cultivated on far fewer acres. They may still represent localized risk to groundwater.

The mass balance sums at low, medium, and high range were combined with WSDA's cropland data layer to generate maps showing which areas of the GWMA have nitrogen surpluses under low, medium, and high range scenarios (Figure 6, Figure 7, and Figure 8). In these maps, commodities have been shaded according to the estimated nitrogen surplus in lb N/ac-yr; commodities where the estimate was less than zero have been grouped and represented as 0 lb N/ac-yr).

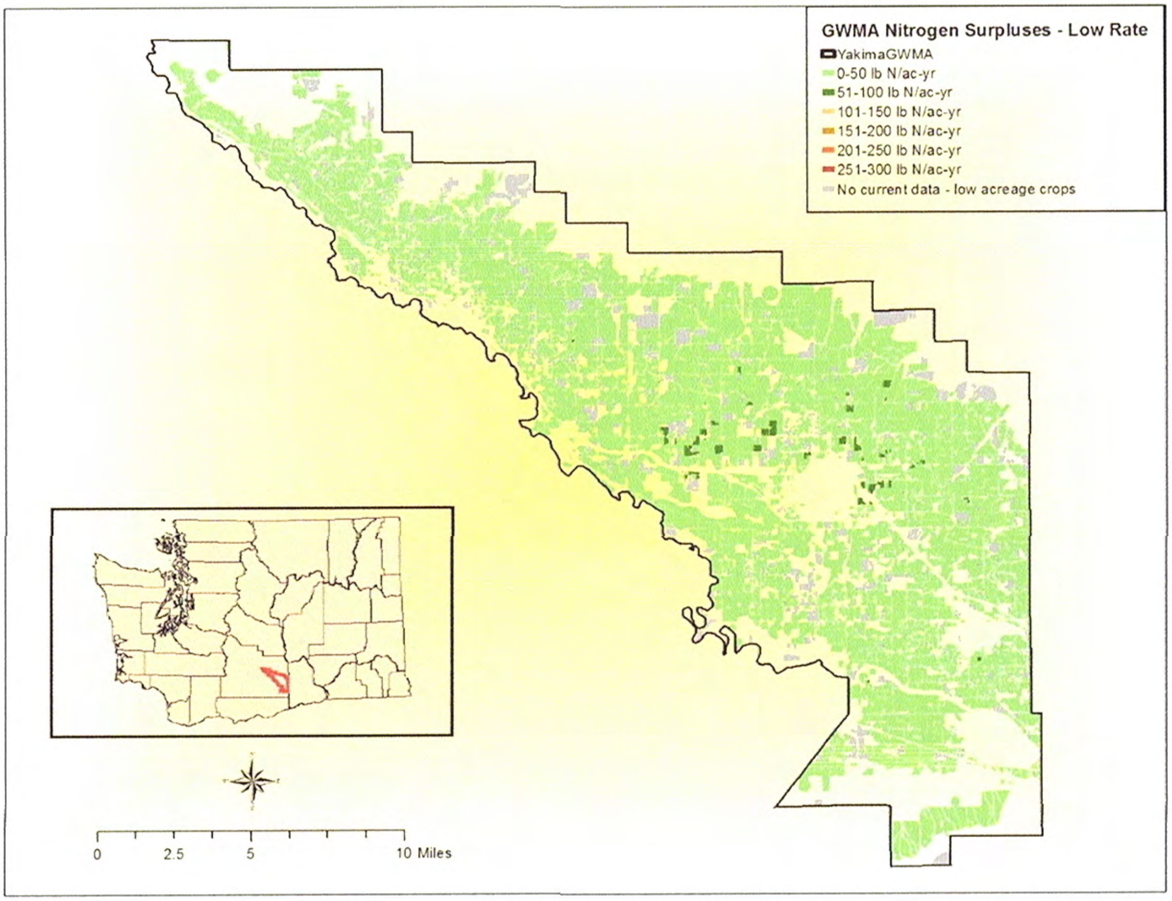

Figure 6. Map of Yakima GWMA with low range nitrogen availability estimates

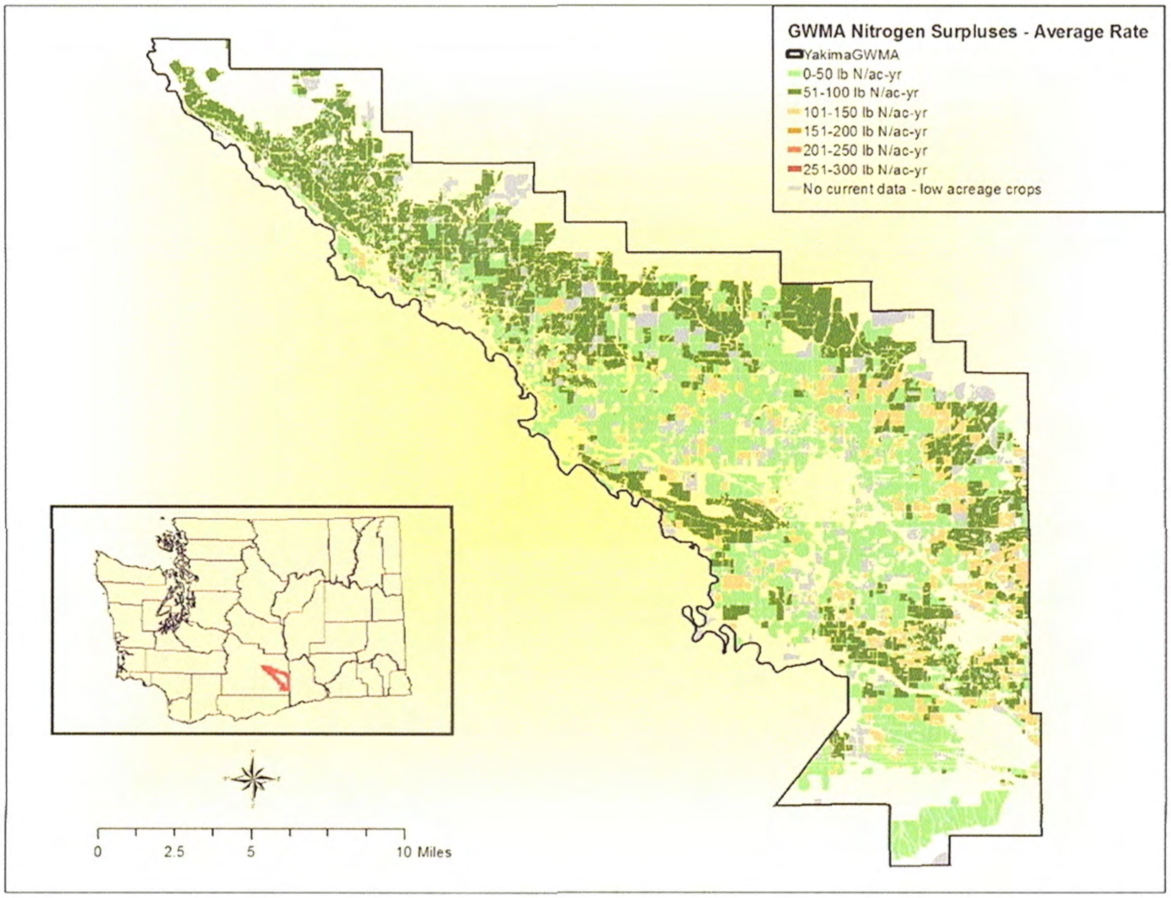

Figure 7. Map of Yakima GWMA with medium range nitrogen availability estimates

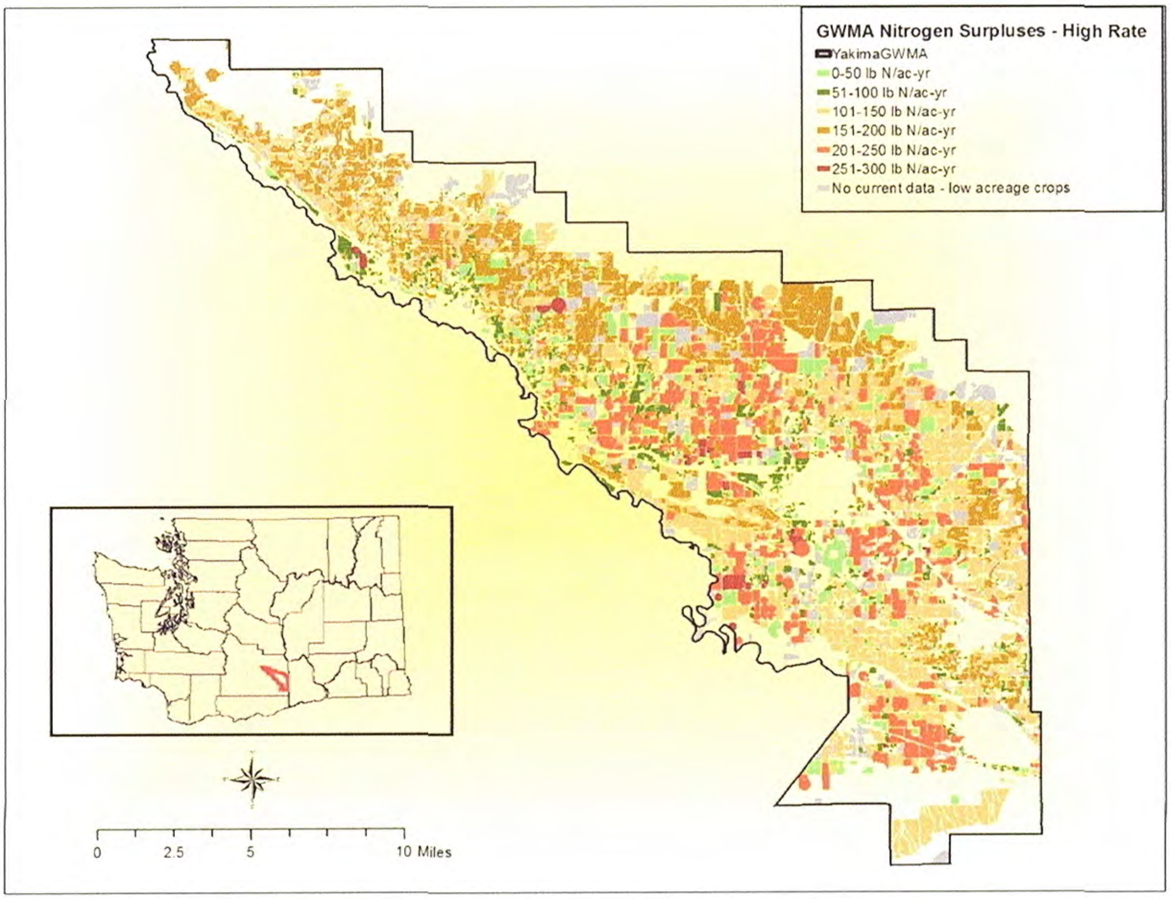

Figure 8. Map of Yakima GWMA with high range nitrogen availability estimates

Based on the information gathered through the survey and crop mapping, it is impossible to identify which part of the range (low, medium, or high) is the most likely scenario. It is likely that there are producers and crop types whose application practices occupy all parts of the range (some making low range applications, some making high range applications). Nutrient application decisions are complicated and depend on expected crop pricing, anticipated yields, 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, will all affect whether or not any fertilizer application will result in a nitrogen surplus. Additional variation comes from soil type and organic matter content, soil nutrient content, manure nutrient content, handling, and storage before application, organic carbon cycling and mineralization, and fertilization and nitrogen fixing in alfalfa.

Conclusions and recommendations

Based on this initial survey data, NRAS has identified specific commodities where nitrogen surpluses could results in available nitrogen that could move from the soil profile into groundwater in the lower Yakima Valley. This information can be used to identify crops and practices where excess nitrogen is high. In addition, NRAS has identified both next steps to improve this study and recommendations for research that would supply useful information to growers making nutrient management decisions.

- It will be easier and more accurate to account for double-cropped acreage if an extra record is created in the mass balance for field corn/triticale double-cropped acres so that inputs and outputs can be customized for that specific land use.
- The estimated nitrogen surpluses from different commodities from the mass balance should be compared to the deep soil sampling results for validation and improvement of the nitrogen mass balance.
- If information becomes available about animal stocking numbers on pasture, input estimates for pasture should be adjusted to account for manure and urine deposition by pastured livestock.
- With new permit requirements, information may be available about soil nitrogen content in some crops that could be used to calibrate the mass balance calculations.
- Most Washington State University Extension fertilizer guidance dates to the 1970's; updating and expanding this guidance would make a valuable information source available to growers. Information on considerations when combining nutrient applications from commercial sources with manure and compost applications should be included.
- Field research on the following topics would provide growers with information about the fate of fertilizer applications, plant uptake, and nitrogen availability from different fertilizer sources:
    - in-depth evaluation of potential nitrogen surpluses on higher risk and larger acreage crops and crops that receive applications of commercial fertilizer, manure, and compost combined;
    - research on manure nutrient content, manure application strategies, and the subsequent fate of nitrogen, other nutrients, and salts;
    - research to better understand organic matter in soils including plant nitrogen availability;
    - the long-term agronomic, environmental, and economic feasibility of available sustainable management practices.

3. RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL SOURCES

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Background

Yakima County GIS Department was tasked with evaluating the nitrogen loading potential from non-agricultural sources within the GWMA boundaries. For this this assessment, the analysis was divided into five distinct categories:

1. Residential Onsite Sewage Systems (ROSS)
2. Large Onsite Septic Systems (LOSS)
3. Commercial Onsite Septic Systems (COSS)
4. Residential Lawn Fertilizers
5. Hobby Farms

This also includes a separate analysis for migrant worker impacts within the ROSS category.

Residential on-site sewage systems

The Yakima County GIS Department developed a model to determine the nitrogen loading from individual residential on-site sewage systems located within the GWMA.

Methods

The Yakima County GIS Department incorporated all data sources having a geographical or spatial aspect into the county's GIS. The following was determined using geospatial analysis:

- There are 6,044 households within the GWMA that discharge wastewater to a ROSS.
- Figure 9 shows the location of each ROSS. The relative density of ROSS within the GWMA is shown in
- Figure 10.
- The average number of persons per household for each household discharging to a ROSS was obtained from census tract data provided by (OFM 2010). The household size used in the loading calculations for each ROSS is equal to the average household size for the census tract containing the household. The average household size for households discharging wastewater to a ROSS is 3.5 persons per household. The average household size ranges from 2.72 persons per household to 4.16 persons per household.
- The approximate location of each ROSS was determined. A ten foot buffer was graphically drawn around the building footprint to provide the best estimation of where a ROSS for each building would be located. If a parcel did not have a building footprint available, then a point was generated in the center of the parcel.
- The soil type underlying the approximate location of each ROSS was determined using (USDA NRCS 2014). Using GIS, the specific soil type was determined at each residential property within the GWMA and then each soil type was classified according to description to determine its corresponding maximum hydraulic loading rate based on Table VIII of

WAC 246-272A-0234. Table 17 shows the soil classifications, infiltration rate for each soil classification, and the number of ROSS within each soil classification (On-Site...2005)

Table 17. Maximum hydraulic loading rate

Soil type	Soil textural classification description	Loading rate for residential effluent (gal/sq. ft-day)	Number of ROSS
1	Gravelly and very gravelly coarse sands, all extremely gravelly soils excluding soil types 5 & 6, all soil types with greater than or equal to 90% rock fragments.	1.0	
2	Coarse sands.	1.0	
3	Medium sands, loamy coarse sands, loamy medium sands.	0.8	
4	Fine sands, loamy fine sands, sandy loams, loams.	0.6	
5	Very fine sands, loamy very fine sands; or silt loams, sandy clay loams, clay loams and silty clay loams with a moderate structure or strong structure (excluding a platy structure).	0.4	5,961
6	Other silt loams, sandy clay loams, clay loams, silty clay loams.	0.2	69
7	Sandy clay, clay, silty clay and strongly cemented firm soils, soil with a moderate or strong platy structure, any soil with a massive structure, any soil with appreciable amounts of expanding clays1	Not suitable	14

- Using the approximate location of each ROSS, a land elevation was determined at each site using the GIS land elevation contours. It is important to note that the GIS land elevation model was derived by interpolating between 10 foot contours developed by aerial photogrammetry.
- The estimated depth to groundwater measured from the land surface at the approximate location of each ROSS. It is important to note that GIS groundwater elevation model was derived by interpolating between 25 foot contours developed by (Vaccaro et al. 2009).

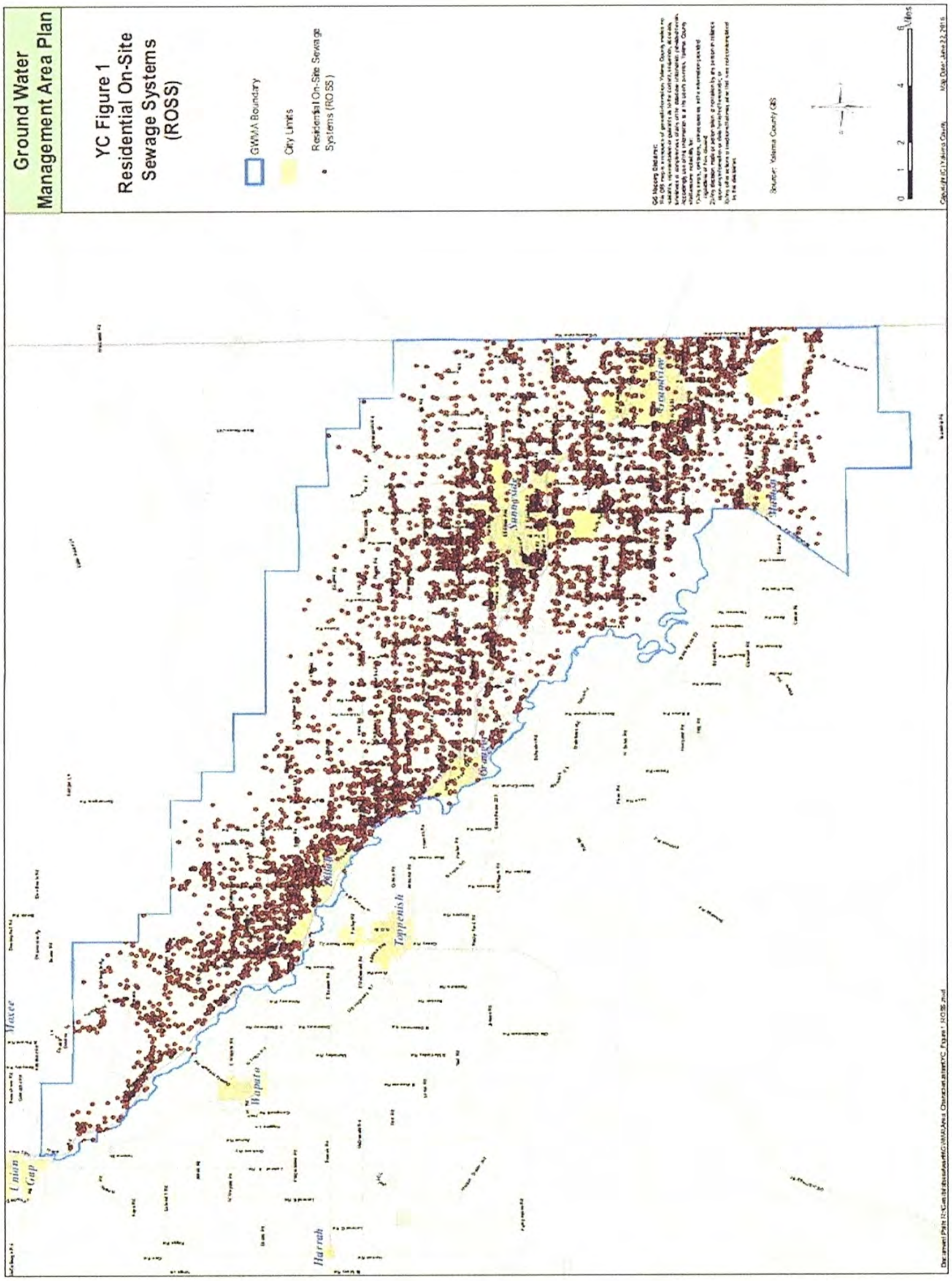

Figure 9: Residential on-site sewage systems

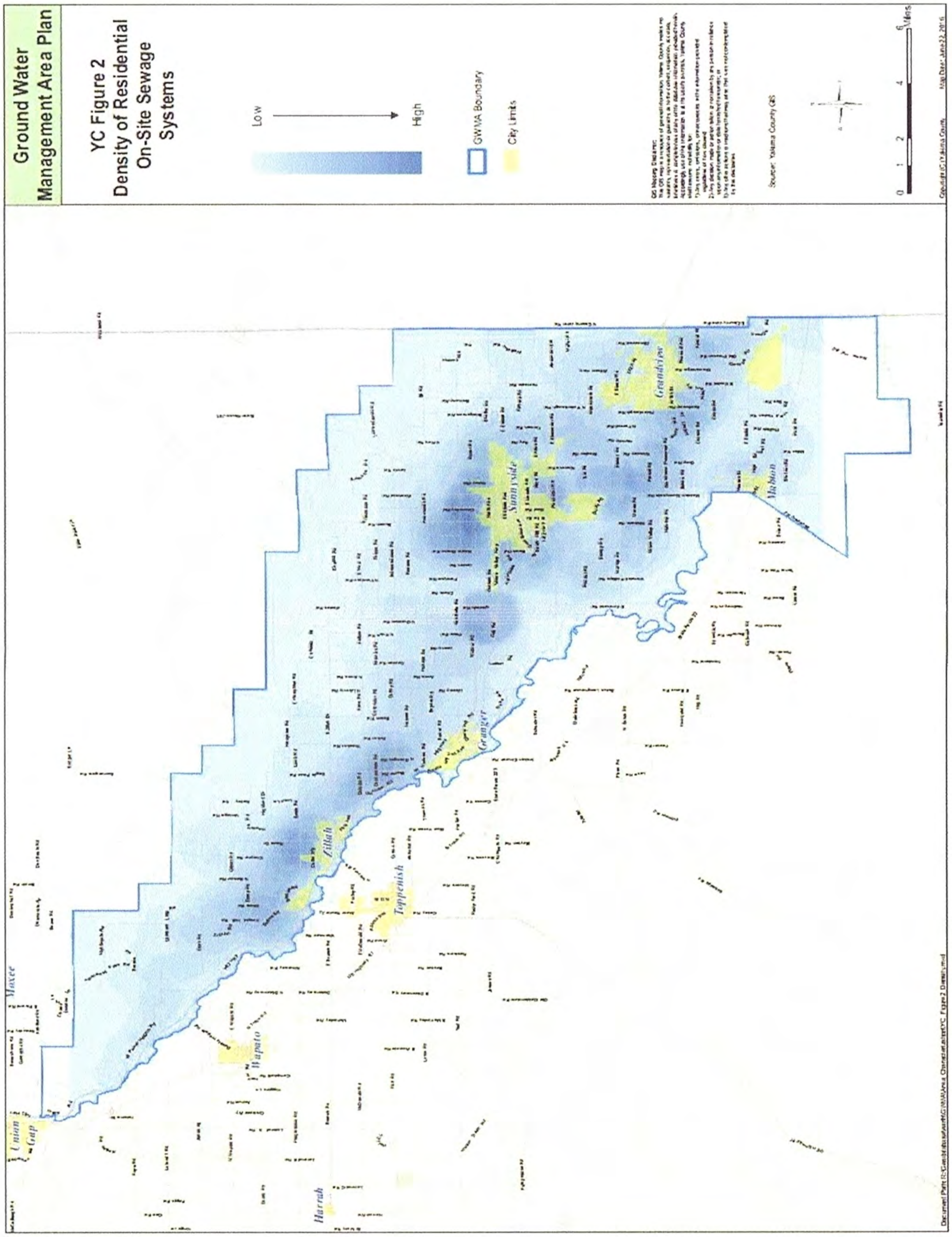

Figure 10. Density of residential on-site sewage systems*Nitrogen loading to a ROSS*

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. This assessment of nitrogen loading from on-site sewage systems utilizes the mass loading approach.

Table 3-7 of (EPA 2002a) reports that the total nitrogen (TN) loading to a ROSS ranges from six to seventeen grams per person per day and assumes a water use of 60 gallons/person/day (227 liters per person per day). Table 4.4 of (EPA 1992) reports the total nitrogen loading to a ROSS is approximately 11.2 grams per person per day. The nitrogen mass loading assessment for the residential on-site sewage systems within the GWMA utilizes a high, medium, and low approach. Accordingly, this ROSS assessment assumes a nitrogen loading of 17, 11.2, and 7 grams TN per person per day. These mass loading rates equate to TN concentrations of 26.4, 49.3, and 74.8 mg/L respectively assuming a water use of 227 liters/person/day Note: WAC 246-272A-0230 *Design Requirements-General* under section (2) (E) (ii) requires that designs for on-site systems, other than systems for single-family residences, be designed in accordance with (EPA 2002a) (On-Site...2005).

Nitrogen removal by denitrification

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 soils and the environmental conditions of the soil through which the wastewater percolates. Wastewater parameters, such as levels of nitrogen are removed to varying degrees. 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 ground water. Under anaerobic soil conditions, nitrification will not occur, but the positively charged ammonium ion is retained in the soil by adsorption onto the soil particles. The ammonium may be held until aerobic soil conditions return allowing nitrification to occur (EPA 1992).

Factors found to favor denitrification are fine-grained soils (silts and clays) and layered soils (alternating fine-grained and coarser-grained soils with distinct boundaries between the texturally different layers), particularly if the fine-grained soil layers contain organic material. However, it is difficult to predict removal rates for wastewater-borne nitrate or other nitrogen compounds in the soil matrix (EPA 2002a). Table 3-17 (EPA 2002a) provides examples from studies conducted in 1976 and 1977 that showed that 10 to 40 percent of the total nitrogen can be removed by denitrification by soil infiltration in a conventional drainfield. In 1990, Jenssen and Siegrist found in their review of several laboratory and field studies that approximately 20 percent of nitrogen is lost from wastewater percolating through soil (EPA 2002a).

The predominant soil type underlying the ROSS drainfields located within the GWMA are characterized as very fine sands, loamy very fine sands; or silt loams, sandy clay loams, clay loams and silty clay loams with a moderate structure or strong structure (Table 17). The estimated depth to groundwater is equal to or greater than 10 feet at approximately 90% of the ROSS locations. When considered together, this information is useful to the extent that it is reasonable to assume that the environmental conditions underlying the drainfields are conducive to some level of denitrification. Accordingly, taking a conservative approach and relying on (EPA 2002a), this nitrogen mass loading assessment, in keeping with a high, medium, and low approach, uses denitrification percentages of 10, 15, and percent respectively. Plant uptake for this assessment is assumed to be zero.

Nitrogen removal by septage pumping

WAC 246-272A-0010 defines a septic tank as "a watertight treatment receptacle receiving the discharge of sewage from a building sewer or sewers, designed and constructed to permit separation of settleable and floating solids from the liquid, detention and anaerobic digestion of the organic matter, prior to discharge of the liquid." "The mixture of solid wastes, scum, sludge, and liquids pumped from within septic tanks, pump chambers, holding tanks, and other OSS components." is defined as septage (On-Site...2005).

The total nitrogen content of septage generated in the GWMA is not available. However, Table 2-2 *Characteristics of Septage Conventional Parameters (1)* contained in (EPA 1994) reports that the average Kjeldahl nitrogen in septage is 588 mg/L with a range from 66 mg/L to 1060 mg/L. Accordingly, this assessment uses an average concentration in septage of 588 mg/L total nitrogen.

WAC 246-272A-0232 establishes the minimum liquid volume for a septic tank serving a single family residence as 900 gallons for a residence containing 3 or fewer bedrooms, 1,000 gallons for a four bedroom residence, and an additional 250 gallons per bedroom for each bedroom over four. The actual septic tank size at each OSS within the GWMA is unknown. For analysis purposes, this assessment assumes that the tank size at each ROSS meets, and is equal to, the minimum WAC requirements of 900 gallons (3,407 liters) (On-Site...2005).

The amount of nitrogen removed by pumping a 900 gallon tank when it is full using TN = 588 mg/L and a 900 gallon (3,407 liters) septic tank is 2.0 Kg (4.417 pounds). The effective annual rate of TN removal by septic tank pumping can be estimated by taking the TN removed by pumping and dividing by the length of time in years between pumping events. Similarly, the reduction in TN concentration in wastewater entering the septic tank compared to the wastewater leaving the septic tank can be estimated by taking the TN removed by pumping and dividing by the total water entering the septic tank during the time between pumping events. Doing so, using an average household size of 3.5 persons and a per capita water use of 60 gallons per day, results in TN concentration reductions of 2.3 mg/L, 1.4 mg/L, and 0.7 mg/L for 3,5, and 10 year pumping events respectively.

WAC 246-272A-0270 makes the owner of a ROSS responsible for operating, monitoring, and maintaining their ROSS including the requirement to employ an approved pumper to remove the septage from the tank when the level of solids and scum indicates that removal is necessary (On-Site...2005). The frequency of septic tank pumping at each ROSS in the GWMA is unknown. However, the Groundwater Advisory Committee for the GWMA initiated a "*Well Assessment Survey*" that was conducted by the Yakima Health District for 458 households within the GWMA. That survey included the question "Have you had your septic tank pumped recently?" Of the 458 surveys completed, 82% of the respondents answered "yes" and 18% of the respondents answered "no" or "I don't know." This survey, though not a valid statistical sampling (survey respondents volunteered and were not necessarily geographically dispersed), does provide information that indicates that the majority of households within the GWMA are more than likely having their septic tanks pumped periodically. Typical maintenance guidelines recommend that a septic tank be pumped every 3 to 5 years (EPA 2002b). Accordingly, this nitrogen mass loading assessment, in keeping with a high, medium, and low approach, assumes septic tank pumping occurs every 10, 5, and 3 years respectively.

Model input summary

Table 18 summarizes the inputs used for estimating the nitrogen loading from residential septic tanks:

Table 18. Input parameters for estimating total nitrogen from ROSS

Parameter	**Units**	**Low**	**Medium**	**High**
Household Size	Persons / Household	Census Tract Average	Census Tract Average	Census Tract Average
TN Loading to ROSS	gm/person/day	7	11.2	17
Denitrification	Percent	20	15	10
Septic Tank Size	Liters	3,407	3,407	3,407
TN in Septage	gm/L	0.588	0.588	0.588
TN in Septic Tank When Pumped	gm	2,003	2,003	2,003
Septic Tank Pumping Frequency	Years	3	5	10

ROSS results

Model output summary

The low, medium, and high estimated net nitrogen loads from all of the ROSS within the GWMA using the input factors contained in Table 18 are 43.7 tons, 79.2 tons, and 130.3 tons respectively. The estimated nitrogen loads are summarized in Table 19.

Table 19. ROSS nitrogen loading estimate

	Units	TN Generated by 6,044 Households	Denitrification	Average Annual TN Removed by Pumping	Total N
LOW	Grams/Year	54,636,835	(10,927,367)	(4,035,377)	39,674,091
	Lbs/Year	120,454	(24,091)	(8,896)	87,466
	Tons/Year	60.23	(12.05)	(4.45)	43.73
MEDIUM	Grams/Year	87,418,937	(13,112,840)	(2,421,226)	71,884,870
	Lbs/Year	192,726	(28,909)	(5,338)	158,479
	Tons/Year	96.36	(14.45)	(2.67)	79.24
HIGH	Grams/Year	132,689,457	(13,268,946)	(1,210,613)	118,209,898
	Lbs/Year	292,530	(29,253)	(2,669)	260,608
	Tons/Year	146.27	(14.63)	(1.33)	130.30

About the model

The model created for this assessment is maintained by the Yakima County Public Services Department. It has been designed such that it provides the ability to estimate the nitrogen loading from ROSS within the GWMA by changing any or all of the input parameters. As an example, using a denitrification rate of 15%, a TN Loading to a ROSS of 11.2 gm/person/day, and a septic tank pumping frequency of 4 years results in a TN of 78.3 tons.

Migrant worker effect on ROSS nitrogen loading

The number of persons living within the GWMA has a direct effect on the nitrogen loading from septic tanks and the above ROSS assessment only accounts for those persons living within the GWMA boundary on a permanent basis. Yakima County agricultural producers supplement their work force during peak periods by hiring migrant workers. A migrant worker is defined as a farm worker whose employment requires travel that prevented the worker from returning to his/her permanent place of residence the same day (USDA NASS 2014). In 2012 there were 9,598 migrant workers employed by agriculture throughout all of Yakima County (USDA NASS 2014). It is not known precisely where these migrant workers were employed or where they lived. However, it is possible to estimate the number of migrant workers working in the GWMA boundary by prorating the total number of migrant workers for the county by acres of crop land in Yakima County. This approach assumes that the estimated amount of migrant workers working within the GWMA also resided within the GWMA.

There are 360,906 acres of crops in Yakima County with 99,976 (28%) of those acres located within the GWMA (WSDA 2016). Prorating the number of migrant workers by crop acres results in a GWMA migrant worker population of 2,687 migrant workers (28% of 9,598). (USDA NASS 2014) does not provide information relative to the amount of time each migrant worker worked - a worker working just one day is recorded as one migrant worker and a worker working 30 days is also reported as one migrant worker. On the other hand, (ESD 2015), reports the total number of agricultural workers by month employed, but does not report the number of migrant workers. Nonetheless, by assuming that the monthly migrant workforce reported by (USDA NASS 2014) follows the same trending pattern as the total monthly agricultural workforce reported by (ESD 2015), an estimate of an annualized migrant population can be derived. Doing so results in an average annual migrant population within the GWMA of 224 persons (2,687 person months ÷12 months = 224 persons). Table 20 shows the calculations for the estimated migrant worker population. Consequently, employing the same methodology used for residential ROSS, the estimated additional TN loadings per year from migrant workers using the low, medium, and high format are 0.50 tons, 0.90 tons, and 1.40 tons respectively.

Table 20. Migrant workforce estimate

Month (A)	Total County Ag Workers / Month (B)	Monthly Distribution of Total County Ag Workers / month by % of Total ('C)	Prorated Migrant County Ag Workers / month = (B) X ('C) (D)	Prorated GWMA Migrant Ag Workers / yr = ('C) X 28% ÷ 12 (E)
Jan	20,120	0.058	555	13
Feb	22,540	0.065	622	15
Mar	23,220	0.067	640	15
Apr	25,540	0.073	704	16
May	26,410	0.076	728	17
Jun	38,550	0.111	1,063	25
Jul	39,920	0.115	1,101	26
Aug	33,080	0.095	912	21
Sep	38,440	0.110	1,060	25
Oct	35,720	0.103	985	23
Nov	24,320	0.070	671	16
Dec	20,130	0.058	555	13
Totals:	347,990	1	9,598	224

Nitrogen Loading from ROSS per Land Area

Nitrogen loading estimates per land area were determined using the OSS design requirements contained in WAC 246-272A-0230 as a means of comparing the nitrogen loading from ROSS with other potential nitrogen sources that are typically land area based. According to the WAC, the design flow for an OSS is determined by multiplying the number of bedrooms by 120 gpd based on an occupancy of 2 persons per bedroom. This results in a design load of 60 gpd per person per day. The design flow for each ROSS is estimated by multiplying the household size by 60 gpd (a household size of 4.16 persons would have a design flow of 250 gallons per day). It is important to note that the minimum design flow established by the WAC is 240 gallons per day0 (On-Site...2005).

The area of the drainfield for a ROSS is used to estimate the land area where nitrogen discharged from a septic tank is applied. The size of this area for each ROSS is estimated by first dividing the design flow for the ROSS by the infiltration rate for the soils underlying the drainfield. A household with a design flow of 250 gpd in a soil having an infiltration rate of 0.45 gallons/ft^2/day would have an estimated infiltrative surface of 556 ft^2. Second, taking a simple approach, the size of the drainfield can be approximated by assuming that infiltration trenches are one foot wide and 60 feet long (60ft^2/ trench) and that the lateral separation between trenches is five feet resulting in the need for 10 trenches and a drainfield size of 60 feet by 45 feet or 2,700 ft^2 . Finally, the nitrogen loading per land area can then be estimated by dividing the annual nitrogen load for the ROSS by the area of the drainfield. If the above household has a TN discharge of 28 lbs/yr, then the annual nitrogen loading per land area is 0.01 lbs/ft^2 (436 lbs/acre).

The size of each ROSS drainfield was estimated using the above methodology resulting in a total drainfield area for all of the ROSS in the GWMA of 398 acres. Consequently, the TN loadings summarized in Table 21 result in low, medium, and high land application rates of 223 lbs/acre, 403 lbs/acre, and 662 lbs/acre respectively. Total loadings from ROSS drainfields are summarized in Table 21.

Table 21: Estimated total nitrogen loadings from ROSS drainfields

	Low	Medium	High
Loading (lb N/acre)	223	403	662
Loading (kg N/hectare)	249	452	743
Loading (ton N/year)	44.2	80.1	131.7
Loading (kg N/year)	40,131	72,663	119,461

Large on-site septic systems

Background

A Large Onsite Septic System is a septic system having a design volume over 3,500 gallons. The design and operation of LOSS are overseen by the Washington State Department of Health (WDOH). WDOH records show that there are 2 LOSS located within the GWMA. The design capacity, location, and times of use of both of the LOSS were provided to the GIS Department by WDOH.

LOSS results

One LOSS site is located outside of Zillah (Zillah LOSS) with a design capacity of 5,000 gallons. This LOSS serves the employees of a large fruit packing operation and warehouse. The LOSS is used by employees throughout the year with peak use during the fruit packing season. It is presumed that the loading to the LOSS is predominantly human waste from toilet flushing. The average loading generated by toilet flushing is 16.2 gallons/capita/day with a nitrogen loading of 8.7 grams/capita/day (EPA 1992) at Tables 4-2 and 4-4. WAC 246-272 B 06450(4) (b) requires that the size of a LOSS septic tank be equal to 3 times the daily design flow (Large...2011). As such, the design flow for the 5,000 gallon tank is 1,667 gpd. Dividing the design flow by 16.2 g/cap/day equates to 103 persons per day. The annual nitrogen loading from 103 persons, using the ROSS methodology and substituting a TN loading of 8.7 grams/capita/day, is a low of 575 lbs/year, a medium of 612 lbs/year, and a high of 649 lbs/year or 0.29 tons/year, 0.31 tons/year, and 0.32 tons/year from the Zillah LOSS. Of note is that this estimate is based on the peak loading during the packing season and does not reflect a smaller work force during the remainder of the year.

The second LOSS site is located outside of Granger (Granger LOSS) with a design capacity of 4,850 gallons. The design flow is 1,620 gpd (one third of the size of the tank). This LOSS serves migrant workers for approximately 30 days each year during the cherry harvest season. It is presumed that the migrant workers reside at this site and that the loading to the LOSS is typical of the loading to ROSS. Accordingly, the number of persons this LOSS was designed to serve is 27 persons. Using the same methodology used to calculate the total nitrogen load for ROSS, a nitrogen load for the LOSS was determined. This results in a low of 9 lbs/year, a medium of 16.0 lbs/yr and a high 27 lbs/year of total nitrogen from the Granger LOSS. Results from LOSS systems are summarized in Table 22.

Table 22: Estimated loading from LOSS systems

	Low	Medium	High
Loading (lb N/acre)	195	209	225
Loading (kg N/hectare)	218	235	252
Total loading (ton N/year)	0.29	0.31	0.34
Total loading (kg N/year)	265	285	307

Commercial on-site septic systems

Background

The term "Commercial" Onsite Septic Systems, as used in this report, refers to septic systems that are used for employees working at agricultural businesses that operate year-round and are not classified as a LOSS by WDOH. The most likely location for these facilities within the GWMA are at confined animal feeding operations (CAFOs).

COSS results

The Washington State Department of Agriculture reported that there were 52 operating CAFOs located within the GWMA in 2014. Each CAFO was classified by WSDA by herd size ranges as shown in Table 23. Presumably, each CAFO provides a restroom facility for its employees. It is not known if the facilities are a COSS or some type of portable facility. This nitrogen loading assessment for COSS assumes that there is a COSS at each CAFO location.

It is assumed that the loading to the COSS is predominantly human waste from toilet flushing. The number of employees at each CAFO is unknown but can be estimated using a paper published by the University of California in 2004 titled "*For Wages and Benefits, Bigger Dairies May be Better*" written by Barbara Reed (Reed 1994). The following is extracted from that paper:

Number of employees: Larger dairies had a higher cow-to-employee ratio than smaller dairies. Dairies of more than 700 cows averaged 151 cows per employee; dairies with fewer than 250 cows averaged 82 cows per employee. Dairies with fewer than 250 cows employed 3.5 workers on average; dairies with more than 700 cows employed 12 workers. The largest number of employees reported for any dairy was 31 (1,900 cows).

This assessment uses a cow to employee ratio of 82 for CAFOs smaller than 700 cows and a cow to employee ratio of 151 for CAFOs larger than 700 cows. The number of cows is assumed to be the highest number in the range, with 8,000 cows used for the largest CAFOs. This methodology is represented in Table 23.

Table 23. GWMA CAFO herd size and employee estimate

Mature Herd Range (cows)	Number of CAFOS	Employees/ CAFO	Total Employees
200 to 699	14	9	126
700 to 1699	18	11	198
1700 to 2699	10	18	180
2700 to 3699	4	25	100
3700 to 4699	1	31	31
4700 to 5699	1	38	38
5700 to 6839	2	45	90
6840 and above	2	53	106
Total	52		869

The average loading generated by toilet flushing is 16.2 gallons/capita/day with a nitrogen loading of 8.7 grams/capita/day (EPA 1992) at Tables 4-2 and 4-4. The annual nitrogen loading from 869 persons, using the ROSS methodology and substituting a TN loading of 8.7 grams/capita/day, is a low of 4,865 lbs/year, a medium of 5,170 lbs/year, and a high of 5,475 lbs/year. Results from COSS are summarized in Table 24.

Table 24: Estimated loading from COSS

	Low	Medium	High
Loading (lb N/acre)	163	173	183
Loading (kg N/hectare)	182	194	205
Total loading (ton N/year)	2.43	2.59	2.74
Total loading (kg N/year)	2207	2345	2483

Residential lawn fertilizer

Methods

The overall nitrogen loading assessment includes an estimate of nitrogen from fertilizers applied to residential lawns located within the GWMA. The GIS Department developed a method for approximating the area of maintained lawn areas. This method involved the use of ArcMap Spatial Analysis and color infrared orthophotography to determine "green" spaces within the residential areas of the GWMA. The infrared photography shows actively growing vegetation as variations of red on the orthophotography.

A classification tool in ArcGIS was "trained" to search for these red spots and identify them as grass, trees, or shrubs. These areas represent a "green" layer within the GIS and are considered areas where fertilizer may be applied. Using the green layer, four representative areas within the GWMA were examined to determine the percentages of land area that were green. Each of the areas were one square mile in size and the buildings and crop lands were subtracted from the green areas. The four areas examined were:

- An urban area located within the City of Sunnyside city limits (Urban) representing urban density properties. The average parcel size for this urban area is 0.28 acres and the amount of green area is 33.4% of the total acreage resulting in an average green area per parcel of 0.09 acres.
- A suburban area located outside the City of Sunnyside, but within the Sunnyside Urban Growth Boundary (Suburban), representing suburban density properties. The average parcel size for this suburban area is 4.95 acres and the amount of green area is 25.2% of the total acreage resulting in an average green area per parcel of 1.25 acres.
- A rural area that encompasses the unincorporated community of Outlook (Rural High) representing rural properties within the GWMA that are relatively small in size. The average parcel size for this suburban area is 4.90 acres and the amount of green area is 13.0% of the total acreage resulting in an average green area per parcel of 0.64 acres.
- A rural area within the County (Rural Low) representing rural properties within the GWMA that are relatively large in size. The average parcel size for this rural area is 23.7 acres and the amount of green area is 3.1% of the total acreage resulting in an average green area per parcel of 0.73 acres.

Table 25 summarizes the representative areas.

Table 25. Representative lawn areas in the GWMA

Representative Area	Average Parcel Size (acres)	Green Area (acres)	Percent Green	Green Area per parcel (acres)	Green Area per parcel (sf)
Urban	0.28	20.04	33.4%	0.09	4,074
Suburban	4.95	161.28	25.2%	1.25	54,337
Rural High Density	4.9	83.2	13.0%	0.64	27,748
Rural Low Density	23.7	19.84	3.1%	0.73	32,004

Residential lawn areas for the entire GWMA were approximated using Table 25 values and the following criteria:

- Each residential parcel located within an incorporated City was given a lawn area of 0.09 acres.
- Each residential parcel located within an urban growth boundary and outside of an incorporated city was given a lawn area of 1.25 acres.
- Each residential rural parcel (outside of an urban growth boundary) that had a total parcel area equal to or less than 5.0 acres was given a lawn area of 0.64 acres.
- Each residential rural parcel (outside of an urban growth boundary) that had a total parcel area greater than 5.0 acres was given a lawn area of 0.73 acres.

Table 26 summarizes the approximated total lawn area within the GWMA using the above criteria:

Table 26. Residential lawn areas

Representative Area	Application	Green Area per Parcel (acres)	Number of Parcels	Green Area in GWMA (acres)
Urban	All parcels located in incorporated cities	0.09	7,180	646
Suburban	All parcels located in UGA outside of cities	1.25	892	1115
Rural high density	All rural parcels <= 5 acres	0.64	3,285	2102
Rural low density	All rural parcels > 5 acres	0.73	709	518
Totals			12,066	4,381

The lawn care practices used by residents within the GWMA are unknown relative to the amount of nitrogen applied to their lawns each year. Anecdotal evidence indicates that some residents fertilize their lawns regularly and some do not fertilize their lawns at all. Consequently, this estimate for the amount of nitrogen used on lawns within the GWMA is entirely based upon the assumption that residents that do fertilize their lawns do so once each year using a typical commercial lawn fertilizer such as Scotts® Turf Builder. This product's application guidelines equate to the application of 23.3 pounds of nitrogen per acre for each application. (13.35 lb. bag, 20-0-8 analysis, covers 5,000 sf).

Residential fertilizer use results

In keeping with the high, medium, and low approach, it is assumed that the percent of residents who fertilize are 80, 50, and 20 percent respectively. Accordingly, the high nitrogen loading estimate is 40.8 tons, the medium estimate is 25.5 tons, and the low estimate is 10.2 tons. It is important to note that this lawn loading assessment does not take into consideration any nitrogen lost to plant uptake, denitrification, and volatilization as is normal practice. Given the coarseness of the assumptions contained in the assessment already, it is believed that any further refinement is unjustified. Table 27 shows the low, medium, and high estimated loading from residential fertilizer use.

Table 27: Estimated N loading from residential fertilizer

	Low	Medium	High
Loading (lb N/acre)	4.7	11.7	18.6
Loading (kg N/hectare)	5.2	13	20.9
Total loading (ton N/year)	10.2	25.5	40.8
Total loading (kg N/year)	9,260	23,152	37,043

Small-scale commercial and hobby farms

Background

"Small-scale commercial and hobby farms" is a term used in this report to represent residential land uses other than lawns that may contribute nitrogen to the GWMA area. These land uses are attributable to relatively small parcels that that are not included in the Washington State Department of Agriculture's Crop inventory. Nitrogen contributions on these parcels may come from individual gardens, pastures, pets, and other animals.

Methods

The GIS Department developed an ArcGIS model to determine the potential number of hobby farms in the GWMA. To do so, using the GWMA parcel information, all parcels located within the city limits were removed, all parcels greater than 10 acres were removed, non-residential properties were removed, and parcels that overlapped with the WSDA's Cropland Data Layer were removed. The remaining parcels were then categorized into 3 size categories - (1) Acres 0 ≤ 2.5, (2) Acres ≥ 2.51 and Acres ≤ 5.00, and (3) Acres ≥ 5.01 and Acres ≤ 10.0. Once the parcels were categorized, the parcels were matched to the residential lawn data in order to remove the lawn area from the parcel area and to eliminate double counting of nitrogen loading. In addition, a building allowance of 2,000 ft^2 for each parcel was also deducted from the parcel area to arrive at an effective area for hobby farms.

Small-scale commercial and hobby farms results

The analysis yielded the results shown in Table 28.

Table 28. Parcel size and total acres

Parcel Size Range of Small-Scale Farm (acres)	Number of Parcels	Total Parcel Area (acres)	Lawn Area (acres)	Building Allowance @ 2,000 sf/parcel (acres)	Effective Area (acres)
0 to 2.5	2335	2,481.5	1,804.1	107.2	570.2
2.51 to 5.0	311	1,075.6	223.0	14.3	838.4
5.1 to 10.0	110	776.1	83.3	5.1	687.7
Totals	2756	4,333.2	2,110.4	126.5	2,096.3

The recommended amount of fertilizer applied to each of these groups as proposed by the GWMA's RCIM Work Group is shown in Table 29. In keeping with the high, medium, and low approach, it is assumed that the percent of residents who fertilize are 80, 50, and 20 percent respectively similar to the assumption for residential lawn fertilizer.

Table 29. Percent of fertilizer application by hobby farm size

Parcel Size of Small-Scale Farm (acres)	Nitrogen Fertilizer Application (lb/acre/yr)	Nitrogen Fertilizer Application (kg/hectare/year)
0 ≤ 2.5	14	15.7
2.51 ≤ 5.0	21	23.5
5.01 < 10.0	28	31.4

The loading rate was then applied to the corresponding Small-Scale Farm size using the effective area. The results are shown in Table 30.

Table 30. Total nitrogen loading for hobby farms

Parcel Size of Small-Scale Farm	Small-Scale Farm Effective Area (acres)	Application (lbs)	TN Low at 20% (tons)	TN Medium at 50% (tons)	High at 80% (tons)
0 ≤ 2.5 Acres	570.2	14	0.80	2.00	3.19
2.51 Acres ≤ 5.0 Acres	838.4	21	1.76	4.40	7.04
5.01 Acres ≤ 10.0 Acres	687.7	28	1.93	4.81	7.70
Total (ton N/year)			**4.48**	**11.21**	**17.94**
Total (kg N/year)			**4,068**	**10,171**	**16,273**

4. ATMOSPHERIC DEPOSITION

WSDA author: Kelly McLain

Background

Atmospheric deposition is the process by which aerosol particles collect or deposit themselves on the earth's surfaces. It can be divided into two general sub-processes: dry and wet deposition. Nitrogen emissions in the Pacific Northwest may come from transportation, agriculture, power plants, industrial, and natural sources. In coastal areas, transport of nitrogen due to emissions in Southeast Asia may also be a source. In urban areas, emissions will mainly be in the form of oxidized sulfur compounds (NO_x) while in agricultural areas emissions from fertilized cropland and CAFOs will be largely in reduced forms (ammonia and ammonium). In general, emissions of both oxidized and reduced nitrogen have been increasing in recent decades (Fenn 2003). Emissions may travel distances ranging from meters to thousands of kilometers before subsequent wet (through precipitation) or dry redeposition takes place (Viers et al. 2012). Monitoring of deposition is conducted by the National Atmospheric Deposition Program, which conducts both monitoring of and modeling of N species emissions concentrations and deposition throughout the United States. Monitoring is conducted mainly at fairly remote sites; there are 5 wet deposition monitoring stations in Western Washington and 1 in Eastern Washington (in Whitman County) (NADP 2017). In conjunction with this wet deposition modeling, EPA uses emissions and ambient concentration data to model dry deposition based on emissions and one dry deposition station in Mt. Rainier National Park (now discontinued) (EPA 2015, EPA 2016).

NRAS reviewed similar studies to assess what, if any, atmospheric deposition information was available from other agricultural areas on the west coast. A significant nitrogen loading study by the University of California at Davis (Viers et al. 2012) includes atmospheric deposition data for California's Central Valley. EPA modeling in the Tulare Lake Basin and Salinas Valley was reviewed for that study to identify atmospheric deposition levels of 9 and 5 lb N/ac-yr, respectively. These numbers greatly exceed atmospheric deposition estimates for this study area. There are a few reasons why the levels seen in the Tulare Lake Basin and the Salinas Valley are not comparable to those estimated in Yakima. The first major difference between the regions is proximity to major urban areas; a significant source of deposition in California's Central Valley is the San Francisco Bay area transportation corridor. The Yakima Valley does not have a transportation or population hub of similar magnitude and proximity. In addition, the scale of animal agriculture in the Central Valley is an order of magnitude greater than that found in Yakima County (approximately 640 dairies compared to about 50 in the GWMA). Finally, the numbers in the Tulare Lake Basin and Salinas Valley are likely higher due to the effect of the Sierra Nevada – winds travelling from heavily populated areas meet the Sierra Nevada and deposit atmospheric pollutants in the adjacent valleys (Viers et al. 2012). Again, this is not a scenario seen in the Yakima Valley where winds travel mostly away from the mountains towards the Columbia River Basin. It is not surprising that the atmospheric nitrogen deposition estimates would be much higher in the UC Davis study than in the Lower Yakima Valley GWMA.

Methods, limitations, and assumptions

Limitations

The lower Yakima Valley has low annual rainfall (6.8 inches) and moderate winter snowfall (12.4 inches per year), from mean yearly records kept from 1894 – 2012 at Sunnyside, WA (Western Regional Climate Center 2017). As mentioned above, Washington State has 5 wet deposition monitoring stations in the National Atmospheric Deposition Program but only 1 located on the eastern side of the Cascade Mountains (NADP 2017). One limitation of this study is the very small amount of deposition data collected in the study area. The location of the eastern Washington NADP station (in Whitman County, NADP 2017) is similar in precipitation but not in geography or land use practice (Whitman County produces dryland crops such as wheat, barley, and dry peas) (WSDA 2016). There is also a limited amount of development and only small transportation corridors located in Whitman County, as compared to our study area in the lower Yakima Valley, surrounded by mountains, reasonably sized cities and towns, and bisected by a major interstate. In addition, the Yakima Valley is largely planted in irrigated cropland and a large number of concentrated animal feeding operations (none of which are found in Whitman County)[15]. Use of the wet deposition data from the Whitman County station would likely underestimate the influence of atmospheric deposition on the geographic footprint of the lower Yakima Groundwater Management Area. This limitation makes it more difficult to use Washington measurements in the analysis.

Another limitation of this estimate is categorization of ecosystems and development types that may result in deposited atmospheric nitrogen available for transport to groundwater. It is expected that in most urban areas (with a high percentage of impervious surface), any atmospheric deposition would likely be retained in the natural ecosystem through turfgrass sequestration or make its way to surface water via stormwater runoff. Natural areas are often nitrogen limited and atmospheric deposition in those regions may be used in the production of increased biomass and not available for leaching (Viers et al. 2012). It is assumed that atmospheric deposition does not contribute significantly to groundwater loading in these systems. However, this study does not include a refined analysis to exclude these areas.

Methods

The mechanism for nitrogen loading through atmospheric deposition to cropland is mobilization to groundwater through irrigation; atmospheric deposition to cropland is included as an input in the mass balance conducted in Section **2.** IRRIGATED AGRICULTURE. As a result, this section of the report excludes the acreage from the irrigated agriculture section. In addition, the known areas of pens and lagoons are excluded (both of these estimates already account for atmospheric nitrogen deposition).

In order to establish low, medium, and high estimated available nitrogen due to atmospheric deposition, WSDA relied on 2 main sources; a state atmospheric scientist with the Washington State

[15] WSDA NRAS agricultural land use mapping program, 2015 data.

Department of Ecology (Dr. Ranil Dhammapala[16]) and the data available for wet and dry deposition from the NADP-managed Mt. Rainier station.

The lowest number used is the combination of the most recently available annual wet and dry deposition data from the NADP Mt. Rainier station. Deposition reported includes dry nitric acid, dry ammonium, dry nitrate, wet ammonium, and wet nitrate (EPA 2016). This is believed to be a good surrogate for low deposition due to the considerable transportation corridor along I-5 in western Washington mimicking farm-related emissions and deposition seen in eastern Washington.

The average estimate provided by Dr. Dhammapala takes into account modeled deposition in the lower Yakima Valley over a 5-day period during December, when stagnant air and regular inversions result in poor regional air quality. For the highest rate estimate, WSDA again relied on feedback from Dr. Dhammapala to include a multiplier of 3 times the average rate to generate an expected upper limit for atmospheric deposition.

An underlying assumption included in this analysis is that deposition within the design surface area of each lagoon is conveyed to the lagoon liquid and accounted for as lagoon nitrogen concentration in the lagoon seepage calculation.

The total area used in the final annual calculations excludes 210 acres of lagoons, 2,096 acres of dairy and non-dairy livestock pens, and 85,775 acres of irrigated agricultural land. Atmospheric deposition on these areas was incorporated into calculations elsewhere in this report. The total remaining acreage used in the calculation below is 87,082 acres (ton N/yr calculation) or 35,241 hectares (kg N/yr calculation).

Results

The low, medium, and high atmospheric deposition rates are listed in the table below (Table 31).

Table 31. Low, medium, and high atmospheric deposition rates

	Deposition rate (kg N/ha)	Deposition rate (lb N/ac)
Low	1.69	1.53
Medium	2.30	2.05
High	6.89	6.15

The low rate of 1.53 lb/acre is the result of the most recently reported year (2012) of wet and dry atmospheric nitrogen deposition at the Mt. Rainier station (EPA 2016).

The medium rate, as mentioned above, is the result of a 5-day modeled average from December 2015. The final estimate of 2.05 lb/acre was provided by state atmospheric scientist Dr. Ranil Dhammapala.

The high rate multiplies the medium rate by a safety factor of 3, accounting for transient atmospheric conditions retaining local emissions in the valley when air quality is already poor. This

[16] Medium and high deposition values were recommended by Dr. Dhammapala during a meeting on November 3, 2016.

high rate of 6.15 lb/acre is also in the range of values used in the UC Davis study of the Salinas Valley and Tulare Lake Basin (Viers et al. 2012).

Conclusions and recommendations

The total estimated deposition across the entire GWMA (excluding irrigated agricultural lands, animal pens and manure lagoons) is shown in Table 32.

Table 32. Estimated atmospheric nitrogen deposition in the GWMA

	Total Deposition (kg N/yr)	Total Deposition (tons N/yr)
Low	60,000	57
Medium	81,000	76
High	243,000	227

These estimates likely represent a significant overestimate of loading potential from atmospheric deposition. The number used as the rate is the amount of nitrogen deposited on the landscape, but the amount of nitrogen that subsequently is available for transport to groundwater is very different. Deposited nitrogen may be used by the ecosystem or be transported with precipitation to surface water before it leaches to groundwater. There are likely environments in the GWMA where very little or none of the deposited nitrogen reaches groundwater. A more detailed literature review and GIS analysis of regions likely and unlikely to result in leaching of deposited nitrogen to groundwater would result in a large improvement of the accuracy of this estimate. This would not have to involve additional modeling or monitoring work. However, the deposition numbers used are also estimates based on best professional judgment and evaluation of limited data. In the future, the GWAC may benefit from additional model runs and collection of local wet and dry deposition information to refine this estimate of the potential impacts of atmospheric deposition on the system.

Conclusions and recommendations

Conclusions

These estimates of nitrogen available for transport can be used at different scales to evaluate which sources play a role in different regions of the GWMA and how the contribution from different sources changes with scale and the area examined. For example, examining a smaller urban area will give a very different result than a large area dominated by irrigated agriculture. Management practices needed to reduce available nitrogen in a region where dairies are the dominant source will be different from management practices needed in a region where other sources dominate.

The ranges calculated (between low and high evaluation points) were very large for irrigated agriculture, lagoons, and pens (an entire order of magnitude). For RCIM sources, the ranges were much smaller. For this reason, agricultural activities (both irrigated agriculture and activities at CAFOs) should be the first candidate for additional research to narrow the range of estimated available nitrogen.

In all scenarios (low, medium, and high), evaluated over the entire GWMA acreage, the largest nitrogen contributors are irrigated agriculture, CAFO lagoons, and then CAFO pens. These activities account for 80, 94, and 96% of the available nitrogen in low, medium, and high scenarios, respectively (Figure 11). However, the large contribution to available nitrogen from irrigated agriculture is largely due to the high acreage of irrigated agriculture, with about 99,000 acres of irrigated land in the GWMA (of which more than 85,000 acres was part of the mass balance). The nitrogen from different land uses was also evaluated on a per-acre basis (Table 33). In this analysis, *the top contributor to estimated available nitrogen at all evaluation levels was CAFO lagoons*. With per-acre nitrogen losses 1-2 orders of magnitude above any other contributor, in an area with large numbers of lagoons, based on these calculations, the lagoons will supply the most nitrogen. Additional top contributors on a per-acre basis varied in the low, medium, and high scenarios. In the low rate scenario, the top 3 were CAFO lagoons, ROSS, and LOSS. In the medium and high rate scenarios, the top 3 were CAFO lagoons, CAFO pens, and ROSS. This variability in per-acre available nitrogen estimates suggests that evaluating small geographic areas individually based on the activities present will be very important to identify management needs in different regions.

Table 33. Estimated nitrogen available per acre from all sources at low, medium, and high range

Source		Area (acres)	Scenario A (low) (lb/acre-year)	Scenario B (medium) (lb/acre-year)	Scenario C (high) (lb/acre-year)
Irrigated Agriculture		85,775	0-58	0-148	0-284
CAFO	Pens	2,096	67	480	892
	Lagoons	210	1,354	7,448	13,542
RCIM	ROSS	398	223	403	662
	LOSS	3	195	209	225
	COSS	30	163	173	183
	Residential fertilizer	4,381	4.7	11.7	18.6
	Small scale farms	2,096	4.3	10.7	17.1
Atmospheric deposition		87,082	1.53	2.05	6.15

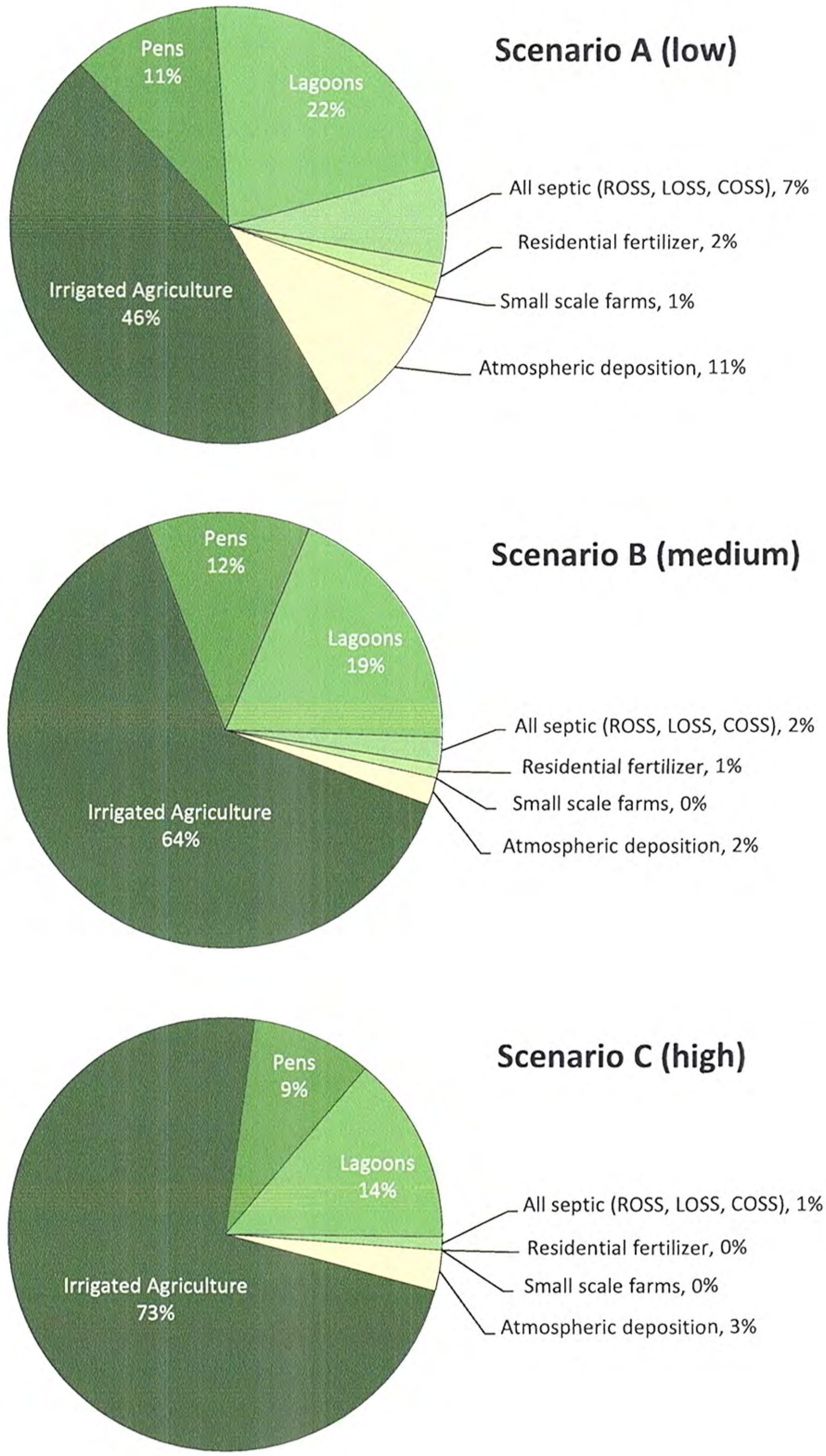

Figure 11. Low, medium, and high estimates from all sources, over the entire GWMA, with percentage of total for each category

Recommendations

WSDA has identified top priorities for researchers to improve the estimates made in this study. These items were chosen because they relate to land uses with large acreages, large estimates of available nitrogen, or they would provide calibration for modeled estimates.

- Update all calculations as and when new information becomes available (for example, if information on lagoon liner condition ratings or seepage rates becomes available, that information should be incorporated into these estimates).
- Compare irrigated agriculture mass balance predictions to the deep soil sampling results to calibrate the model.
- Conduct a statistically-based study of lagoon seepage rates in the GWMA to improve seepage estimates.
- Conduct a statistically-based study of soil nitrogen concentrations beneath pens to provide local data for pen nitrogen loss estimates.
- Conduct a statistically-based study of lagoon nitrogen concentrations to confirm lagoon nitrogen concentrations used in this study.

In addition to these recommendations, there are other steps that Yakima County or the GWAC could take to improve these estimates. These additional options are lower priority because WSDA believes they are less likely to result in changes to the estimates.

- A sensitivity analysis over all inputs to identify which inputs have the largest effect on the estimates; those inputs should be the top priority for additional study.
- Categorize impoundments by primary use, and use-specific parameters could be included in the estimate (for example, main or flush lagoons vs secondary lagoons).
- Research construction dates of existing lagoons, pair with liner condition ratings and historic NRCS recommendations, and generate effective permeabilities for each lagoon.
- Conduct a statistically-based study of soil nitrogen concentrations beneath lagoons to estimate nitrogen loss rates and storage in the soil.
- Identify impoundments are used as settling basins or ponds and review construction techniques to determine whether additional analysis for settling basins is needed.
- Conduct a statistically-based study of soil beneath composting areas to provide data for compost area nitrogen loss estimates.
- Review literature on the fate of deposited nitrogen for different ecosystems and land uses; pair with GIS analysis to determine the fate of deposited nitrogen for different land uses.

During this project WSDA has also identified some critical information gaps affecting growers.

- Most Washington State University Extension fertilizer guides currently available date to the 1970's. Updating these would provide crop growers with valuable information to use in decision making.
- Synthesis of existing data and new research on several topics would also help: soil organic matter mineralization, organic fertilizer composition and breakdown rates, and the interactions and effects when fertilizers of different types (for example, manure and commercial fertilizer) are applied during the same growing season.

These study results can be used in several different ways to aid the GWAC as they choose how to allocate limited resources.

- Review contributions from all sources simultaneously, spatially throughout the GWMA, to identify areas where available nitrogen is high or where contributions from several sources overlap.
- Review nitrogen availability data in conjunction with other data layers (depth to groundwater, soil type, documented groundwater nitrogen concentrations, deep soil sampling results, proximity to drinking water supply wells, or proximity to vulnerable or susceptible aquifer areas) to identify locations where elevated risk of potential nitrogen loading and resultant impacts to groundwater can be prevented.

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Appendix A: Data sources, uses, and potential concerns

Section	Data	Source	Use	Concerns
CAFO: Pens and compost areas	Pen locations and dimensions	2014 dairy registration locations USDA National Agricultural Imagery Program 2013, 2015 imagery	Pen calculation	Potential for human error. Changes in operation since data collection.
CAFO: Pens and compost areas	Pen location QA	WSDA NRAS QA procedure (Beale and Baker 2009)	Pen calculation	Entire data set not ground truthed.
CAFO: Pens and compost areas	Dairy CAFO pens	NAIP 2013, 2015 imagery WSDA DNMP WSDA Animal Services	Pen calculation	Potential for human error. Changes in operation since data collection.
CAFO: Pens and compost areas	Non-Dairy CAFO pens	NAIP 2013, 2015 imagery WSDA DNMP WSDA Animal Services	Pen calculation	Potential for human error. Changes in operation since data collection.
CAFO: Pens and compost areas	Compost locations	NAIP 2013, 2015 imagery 2014 dairy registration locations	Pen calculation	Potential for human error. Changes in operation since data collection. Potential misidentification of silage storage as compost area.
CAFO: Pens and compost areas	High rate for pens	Viers et al. 2012	Pen calculation	Data is not specific to Yakima Valley. Research conducted in California's San Joaquin Valley and in Kansas where meteorological conditions are very different from Yakima.
CAFO: Pens and compost areas	Low rate for pens	Viers et al. 2012	Pen calculation	Data is not specific to Yakima Valley. Research conducted in California's Tulare Lake Basin where meteorological conditions are similar to Yakima.

Section	Data	Source	Use	Concerns
CAFO: Lagoons	All lagoon locations	WSDA DNMP staff NAIP 2013, 2015 Google Earth	Lagoon calculation	Potential for human error. Potential misidentification of irrigation pond or settling pond as lagoon and vice versa.
CAFO: Lagoons	Lagoon location QA	WSDA NRAS QA procedure (Beale and Baker 2009)	Lagoon calculation	Entire data set not ground truthed.
CAFO: Lagoons	Lagoon capacity	DNMP lagoon assessment project	Lagoon calculation	Provides an average snapshot in time. Lagoon capacity varies throughout year.
CAFO: Lagoons	Length and width of lagoons	Nutrient management plans DNMP staff onsite data collection using ArcGIS Collector	Lagoon calculation	Potential for human error.
CAFO: Lagoons	Individual lagoon design depth	DNMP lagoon assessment Average from DNMP lagoon assessment	Lagoon calculation	All lagoons do not have recorded design depth.
CAFO: Lagoons	Lagoon total nitrogen concentration	EPA 2013a Self-reported data to SYCD	Lagoon calculation	Potential bias in both sources. EPA data set: small sample size, not statistically selected. SYCD data set: voluntarily self-reported, not statistically selected.
CAFO: Lagoons	Lagoon liner permeability and thickness	USDA NRCS 2009, USDA NRCS 2016a, USDA NRCS 2016b	Lagoon calculation	Unknown what percentage of lagoons were constructed to NRCS standards. Permeability and liner thickness chosen may not accurately represent range of lagoon construction.
Irrigated Agriculture	Acreage of crops in GWMA	WSDA crop mapping	Irrigated agriculture mass balance	Potential for human error.
Irrigated Agriculture	Fertilizer application data	Telephone survey	Irrigated agriculture mass balance	Potential bias from self-reported data, only a subset of each commodity represented in data.
Irrigated Agriculture	Atmospheric Deposition	Dr Ranil Dhammapala EPA 2016	Irrigated agriculture mass balance	Few deposition monitoring stations: may not accurately reflect deposition in GWMA

Section	Data	Source	Use	Concerns
Irrigated Agriculture	Irrigation water nitrogen concentration	Lower Yakima River nitrogen levels at USGS Yakima River station at Kiona (USGS 2012) Washington State Irrigation Guide precipitation data	Irrigated agriculture mass balance	Located downstream of irrigation districts serving the GWMA. Does not account for potential increase in nitrogen concentration if water is used by successive growers.
Irrigated Agriculture	Crop residue left in fields and incorporated	Irrigated Agriculture Work Group "Estimated Nitrogen Usage for Agricultural Production in the GWMA"	Irrigated agriculture mass balance	Potential bias from IAWG.
Irrigated Agriculture	Crop uptake	Irrigated Agriculture Work Group "Estimated Nitrogen Usage for Agricultural Production in the GWMA"	Irrigated agriculture mass balance	Potential bias from IAWG.
Irrigated Agriculture	Nitrogen loss to atmosphere	Potter et al. 2009	Irrigated agriculture mass balance	
Irrigated Agriculture	Soil organic matter conversion to nitrate-nitrogen	Dr Haiying Tao, Department of Crop & Soil Sciences, Washington State University SYCS deep soil sampling 2015 results	Irrigated agriculture mass balance	Changing assumptions based on new information; not yet established science.
RCIM	Number of households and number of people per household	Census 2010	Residential on-site sewage system calculation	Information is outdated.
RCIM	Soil type, soil classification, infiltration rate	USDA NRCS 2014	Residential on-site sewage system calculation	
RCIM	Total nitrogen per person per day	EPA 2002a	Residential on-site sewage system calculation	

Section	Data	Source	Use	Concerns
RCIM	Denitrification in septic	EPA 2002a	Residential on-site sewage system calculation	
RCIM	Total nitrogen content of septage	EPA 1994	Residential on-site sewage system calculation	
RCIM	Average size of septic tank	WAC 246-272A-0232 (On-site...2005)	Residential on-site sewage system calculation	Actual sizes of septic tanks are unknown, the assumption that each tank meets or is equal to the minimum requirement may not be valid.
RCIM	Septic tank pumping frequency	GWMA Survey "Well Assessment Survey" EPA 2002b	Residential on-site sewage system calculation	Survey of GWMA residents is voluntary and not necessarily geographically dispersed.
RCIM	Number of migrant workers	USDA NASS 2014 Prorated total Yakima County number by crop acres within GWMA ESD 2015	Residential on-site sewage system calculation	Proration of migrant workers by crop acres may not be valid, some crops require migrant workers and others do not.
RCIM	Design capacity, location, and times of use for LOSS	Washington Department of Health GIS Department	Large on-site septic system calculation	
RCIM	Average loading generated by toilet flushing	EPA 1992	Large on-site septic system calculation	Value may be outdated considering new technology.
RCIM	Design flow for LOSS	WAC 246-272B 06450(4) (b) (Large...2011)	Large on-site septic system calculation	No actual measurements of flow from LOSS system.
RCIM	Locations of COSS	WSDA DNMP number of CAFOs in GWMA	Commercial on-site septic systems calculation	Assumes all COSS are on CAFOs and that every CAFO has a COSS.

Section	Data	Source	Use	Concerns
RCIM	Number of employees using COSS	Reed 2004	Commercial on-site septic systems calculation	Assumes COSS at CAFOs in Yakima Valley will be the same as those in California.
RCIM	Area of maintained lawn areas	ArcMap Spatial Analysis by Yakima County	Residential lawn fertilizer calculation	Tool may misidentify some areas as lawn and miss other areas.
RCIM	Lawn fertilization frequency and rate	Scott's Turf Builder	Residential lawn fertilizer calculation	Assumes proportion of residents who fertilize Assumes that residents who fertilize follow fertilizer guidelines.
RCIM	Number of hobby farms	ArcGIS model developed by Yakima County	Small-scale commercial and hobby farms calculation	Potential for model error.
RCIM	Fertilizer application for hobby farms	RCIM Work Group	Small-scale commercial and hobby farms calculation	Potential bias in data from RCIM workgroup.
Atmospheric Deposition	Atmospheric Deposition	Dr Ranil Dhammapala EPA 2016	Atmospheric deposition estimates over GWMA	Few deposition monitoring stations: may not accurately reflect deposition in GWMA

Appendix B: Lagoon nitrogen concentration statistical analysis

Descriptive statistics were calculated for the two datasets for comparison purposes; a summary of these statistics is displayed in Table 34. With the exception of the maximum, standard deviation, and sample size all values in the EPA data set were higher than those in the SYCD data.

Table 34. Comparison of EPA and SYCD lagoon nitrogen concentration (mg N/L)

	EPA	SYCD	Combined
Sample Size	15	23	38
Minimum	290	180	180
Q1	1000	355	455
Median	1400	768	1028
Mean	1212	949	1054
Mode	1200	336	1200
Q3	1600	1092	1401
Maximum	1800	3633	3632
Standard Deviation	492	802	702

Figure 12 displays the data from both sources on one boxplot. Two measurements in the SYCD data set are classified as outliers because they exceed 1.5 times the interquartile range (the difference between the 1st and 3rd quartile). These measurements are displayed as small circles in the figure.

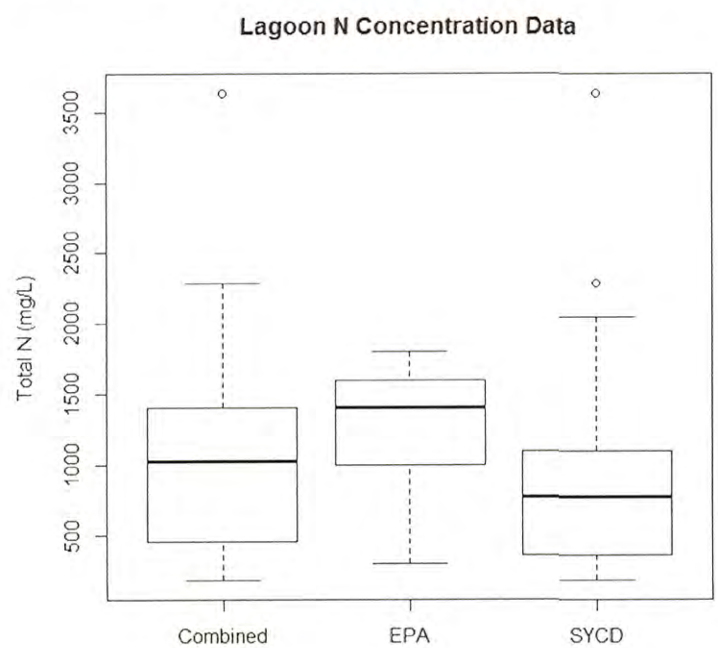

Figure 12. Boxplots of EPA and SYCD lagoon nitrogen concentration data

Appendix C: Lagoon surface area reduction methodology

Manure storage lagoons are constructed with sloping interior and exterior sides. As a result, a change in the liquid level within the lagoon changes the liquid surface area. Since liquid surface area was used as an input in the Darcy's law calculations in the CAFO section, it was necessary to calculate the needed adjustment to surface area based on the average lagoon capacity that was used to adjust the lagoon design depths. When DNMP conducted the lagoon assessment, the site information recorded was surface area, based on delineation of the lagoon perimeter, and side slope for lagoons where the liquid level was low enough to allow determination of side slope. The following diagram (Figure 13) shows a profile (side) view of a typical manure storage lagoon. In this diagram (which is not drawn to scale) the vertical dimension has been increased to show the liquid level and side slopes, which were used to adjust the surface area. The excavation depth H is used with the liquid depth D to determine what reduction in surface dimensions (length, width, and surface area) is necessary based on the side slope X. The interior side slope (often written as a proportion, X:1) determines the amount of lateral shift (X) for every 1-unit change in height. This determines the total reduction in a horizontal dimension; the difference between the excavation depth H and the liquid level D (H-D) is multiplied by the horizontal translation in side slope for every 1-unit reduction in height, which would be multiplied by two to find the total reduction in one horizontal dimension (length or width):

$$(H - D)X$$

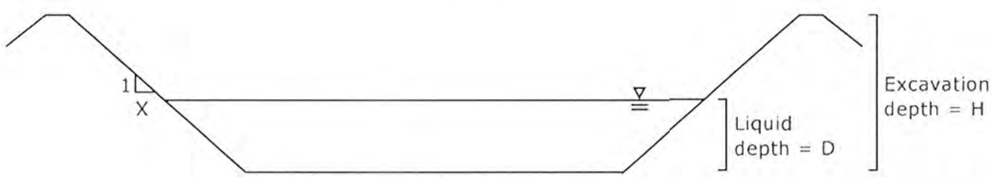

Figure 13. Profile view of typical manure storage lagoon construction. Not drawn to scale; the vertical scale on this diagram is exaggerated to show the side slopes and liquid level clearly.

This surface area adjustment depends on the typical liquid depth, the interior side slope, and also on the lagoon shape in plan view (from the top). Reducing the depth of a round lagoon from the full design depth to 43% of the full design depth would reduce the full surface area by a different proportion than the same reduction for a rectangular lagoon, for example. In order to estimate this surface area reduction it was necessary to generally characterize the range of lagoon shapes represented. The GIS data was informally reviewed; the vast majority of dairy lagoons had plan outlines ranging from a square to a rectangle with length equal to twice the width (L = 2W). Other shapes represented were largely regular rectangles with proportions of length greater than twice the width (from L = 3W to L = 5W). Less than 5 lagoons were triangular; these other shapes (long rectangles and triangles) were an estimated less than 10% of the lagoons in the study. Because of this relative uniformity in shape, surface area reductions were calculated for only two shapes: square and L = 2W rectangle. These calculations provided enough information about the trend that the surface area reduction would follow to make a conservative estimate. In order to do these sample calculations it was necessary to determine an example depth, surface area, and side slope to work with. The values used were derived from the field measurements taken during the DNMP's lagoon assessment process. Note that numbers are reported in these examples to 4 decimal places and rounded at the end, corresponding to the method used for the actual calculations in which all digits were retained during the calculation.

Average surface area at full capacity: 70659.7289 ft^2 (n = 90)

Average depth at full capacity: 11.3029 ft (n = 105)

Average side slope: 3:1 (n = 99)

Average depth at reduced capacity:

$$0.4326 \times 11.3029\, ft = 4.8896\, ft$$

A typical square lagoon with these average values is used for a sample calculation. The following diagram (Figure 14) shows the parameters needed for the calculation: surface area at full capacity is used to calculate side length. Side length at full capacity is then used to calculate side length at reduced capacity, which is used to calculate surface area at reduced capacity. The percent reduction is based on the surface area at full capacity and the surface area at reduced capacity.

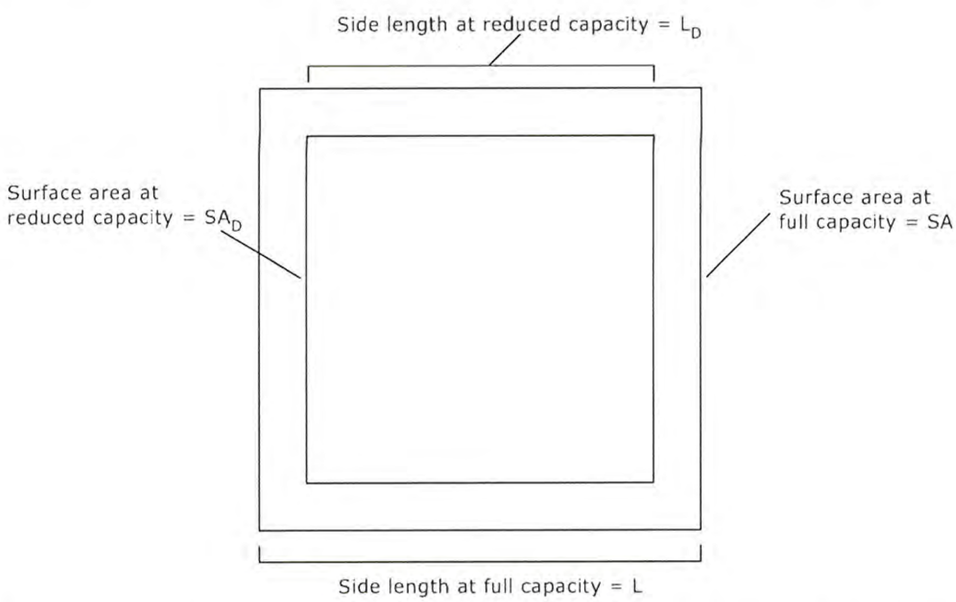

Figure 14. A typical square manure storage lagoon, with side length and surface area shown at both full and reduced capacities

$$SA = 70{,}659.7289\, ft^2, surface\ area\ at\ full\ capacity$$

$$SA_D = Surface\ area\ at\ reduced\ capacity, unknown$$

$$L = \sqrt{SA} = 265.8190\, ft$$

$$L_D = L - 2(H - D) = 265.8190\, ft - 2((11.3029\, ft - 4.8896\, ft)3) = 227.3395\, ft$$

$$SA_D = L_D^2 = 51{,}683.2623\, ft^2$$

$$\frac{SA_D}{SA} = 0.7314; 73\%\ reduction$$

A typical rectangular lagoon (L = 2W) with the same average values for surface area at full capacity, depth at full capacity, reduced depth, and side slope was used for the same calculation (Figure 15).

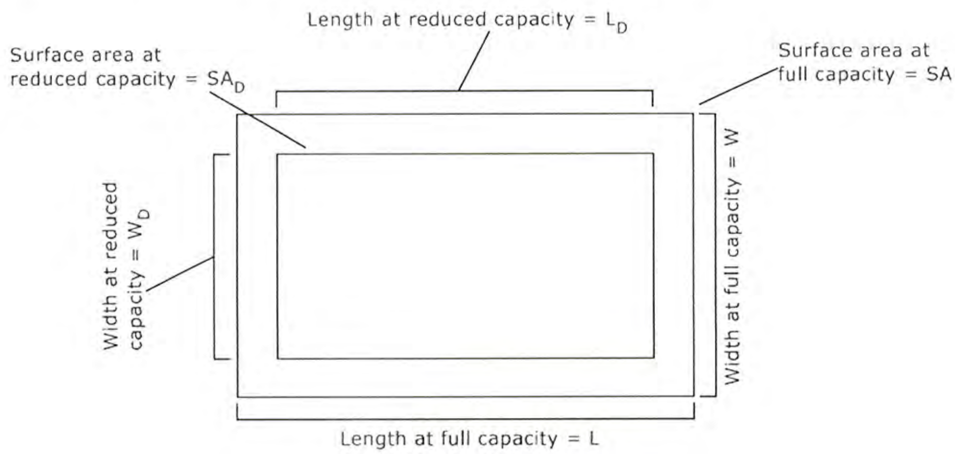

Figure 15. A typical rectangular manure storage lagoon, showing length, width, and surface area at full and reduced capacities

$$SA = 70{,}660\ ft^2, surface\ area\ at\ full\ capacity$$

$$SA_D = Surface\ area\ at\ reduced\ capacity, unknown$$

$$W = \sqrt{\frac{SA}{2}} = 187.9624\ ft$$

$$L = 2 \times W = 375.9248\ ft$$

$$W_D = W - 2(H - D)X = 187.9624\ ft - 2((11.3028\ ft - 4.8896\ ft)3) = 149.4830\ ft$$

$$L_D = L - 2(H - D)X = 375.9248\ ft - 2((11.3028\ ft - 4.8896\ ft)3) = 337.4453\ ft$$

$$SA_D = W_D \times L_D = 50{,}442.3290\ ft^2$$

$$\frac{SA_D}{SA} = 0.7139; 71\%\ reduction$$

Based on the preceding calculations, the surface area reduction due to the depth reduction used to adjust the depths for the Darcy's law calculation is 73% for a square lagoon and 71% for a rectangular lagoon. Additional longer, thinner rectangular lagoons would continue the same trend, with a larger surface area reduction due to the depth reduction. As a result, the 73% reduction was chosen to adjust the surface areas for Darcy's law in order to use the most conservative value available.

Appendix D: Darcy's law example calculation

Darcy's law

$$Q = k * \frac{(H + d)}{d} * A$$

Where:

Q = the calculated volumetric flow rate (L^3/T)

k = coefficient of permeability (hydraulic conductivity, either $1x10^{-7}$ or $1x10^{-6}$ cm/s) ($L^3/L^2/T$)

d = thickness of soil liner (estimated at 1 foot) (L)

H = vertical distance between top of liner and top of liquid storage (L)

A = lagoon area (L^2)

L = length

T = time

$$N\ Loading = Q * C$$

Q = volumetric flow rate calculated using Darcy's law (L^3/T)

C = Total N concentration, 1053 mg N/L

<u>Example Calculation</u>

Inputs:

K = $1x10^{-7}$ cm/s= $1x10^{-9}$ m/s (low range hydraulic conductivity)

D = 1 ft = 0.3048 m

H = 11.3028 ft = 3.4451 m * 0.4326 = 1.4903 m

A = 70659.7289 ft^2 = 6467.5036* 0.7314 = 4801.5322 m^2

C = 1052.6965 mg N/L = $10.526965x10^{-4}$ kg N/L

Darcy's law:

$$Q = 1x\,10^{-9}\text{m/s} * \frac{(1.4903\text{ m} + .3048\text{ m})}{.3048\text{ m}} * 4801.5322\text{ m}^2$$

$$Q = 2.8279 \times 10^{-5}\ m^3/s$$

$$Q = 2.8279 \times 10^{-5}\ m^3/s * \frac{86400\ s}{day} * \frac{365\ day}{year} = \mathbf{891.8085\ m^3/year}$$

Potential N Loss:

$$N\ Loss = 891.8085\ m^3/year * 10.526965x10^{-4}\ kg\ N/L * \frac{1000\ L}{m^3}$$

N Loss = 938.8037 kg N/year **= 939 kg N/year**

N Loss = 938.8037 kg N/year * 1 ton/907.1848 kg =1.0348 tons N.year = **1 ton N/year**

Appendix E: Sensitivity analysis on Darcy's law

In order to identify which inputs to the Darcy's law calculation would have the greatest influence on the calculation's result, WSDA conducted a sensitivity analysis. Each input parameters was evaluated (keeping all other parameters constant) at a range of values Figure 16). Average parameters were used for this analysis, and then the outcome flow was evaluated for variation in each parameter individually (while the other parameters were held constant). Each parameter was evaluated for a range from 75% of the average to 125% of the average, with step sizes of 5%.

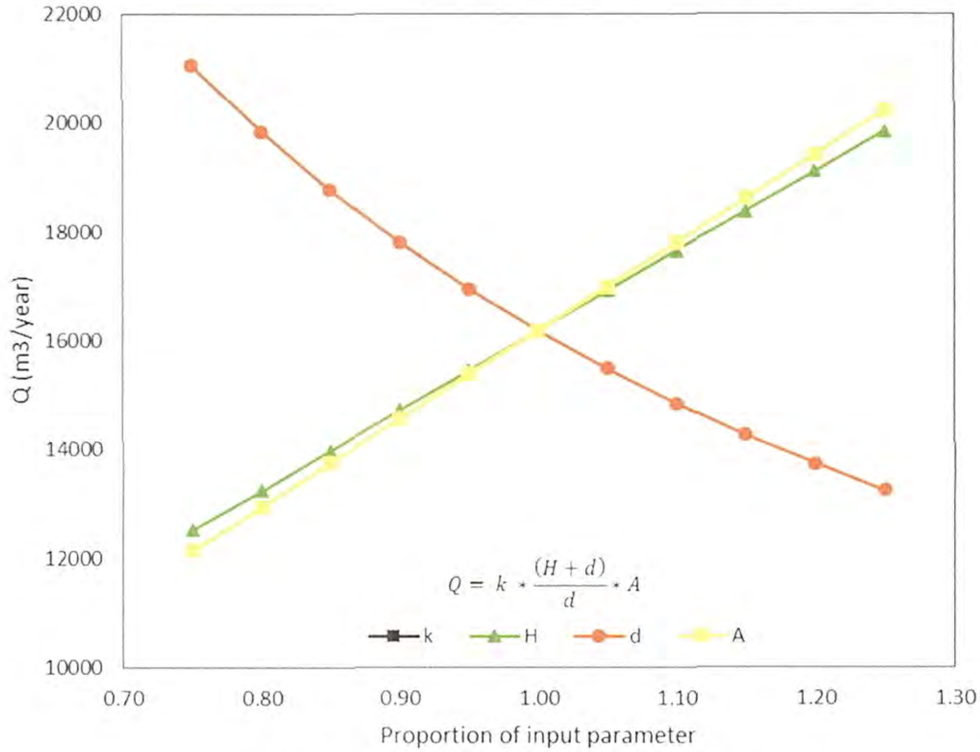

Figure 16. Results of sensitivity analysis on Darcy's law

As a result, NRAS concluded that the flow resulting from Darcy's law, calculated for an individual lagoon, is equally sensitive to all inputs. Permeability (k), surface area (A), and depth (H) are directly proportional to flow. K is invisible because it is hidden by one of the other parameters. Liner thickness (d) is inversely proportional to flow.

Appendix F: Irrigation water use

Source: Jim Davenport, Stuart Turner								
	Water Duty (in/acre)	Water Duty (in/acre)	Water Duty (in/acre)	**Water Duty (in/acre)**	**Water Duty (in/acre)**	**Water Duty (ac-ft/ac)**	**Water use (liters/ac)**	**Irrig water lb N/ac (based on 0.809 mg N/L, USGS 2012)**
Location	Yakima	Sunnyside	Prosser	**Average**	**Stu's #'s***	**Average**		
Total Precip (in)	7.98	6.70	7.74	7.47				
Effective Precip (in)	3.04	3.00	3.40	3.15				
Crop Type								
Silage Corn	28.20	29.31	28.13	28.55		2.38	2934316.238	5.23
Field Corn (Grain)	28.20	29.31	28.13	28.55		2.38	2934316.238	5.23
Triticale				28.55		2.38	2934658.872	5.23
Apple	42.42	44.37	42.42	43.07	30.00	2.50	3083704.594	5.50
Grape, Juice	26.14	27.35	26.04	26.51		2.21	2724966.959	4.86
Alfalfa Hay	35.31	37.01	35.30	35.87		2.99	3687425.426	6.58
Pasture	37.29	39.07	37.30	37.89		3.16	3894376.268	6.95
Cherry	42.94	44.94	42.92	43.60	30.00	2.50	3083704.594	5.50
Grape, Wine	26.14	27.35	26.04	26.51		2.21	2724966.959	4.86
Hops	29.52	30.76	29.39	29.89		2.49	3072397.677	5.48
Pear	39.25	41.09	39.21	39.85		3.32	4096187.602	7.31
Wheat	22.67	24.35	22.85	23.29		1.94	2393982.666	4.27
Mint	34.35	35.93	34.32	34.87		2.91	3583950.006	6.39
Asparagus**				0.00		0.00	0	0.00
Nectarine/Peach***	39.81	41.70	39.76	40.42		3.37	4155120.623	7.41

Washington State Irrigation Guide, Appendix A, Climatic Stations for Consumptive Use, WA210-VI-October 1985

*Stu Turner best professional judgement numbers are used for water duty for apples and cherries.

**No data

***Washington State Irrigation Guide, Appendix A, Climatic Stations for Consumptive Use, WA210-VI-October 1985 (added by WSDA)

Appendix G: Nitrogen uptake estimates

Source: Jim Trull, SVID, Scott Stephens

ESTIMATE OF NITROGEN USAGE FOR AGRICULTURAL PRODUCTION IN THE GWMA

Crop	Typical Yield[1]/Acre	Yield (Scott)[4]	Nitrogen Removed in Harvested Portion of the Crop - (lbs/acre)	Removal (Scott)[4]	Reference[3]	Nitrogen Uptake in Plant in Growing Cycle (lb./acre)	Uptake (Scott)[4]	Estimate of Nitrogen Applied[2] (lbs/acre)	Range		Scott's opinion[4]	Yield parameters[4]
									Production	Application		
Silage Corn	30 tons	30	250	270	A		250-290	250	25-40	12-592	22-40	Tons at 68% moisture
Grain Corn	4-8 tons	6-6.5	186	170-190	A	214	290-325	250	2.5-8.0	90-375	5.5-8	Tons Grain weight
Triticale	8 tons	7.5-8	455	190-210	B		200-225	0-100	5.0-15	0-575	6-10	Tons at 50% moisture
Apples	20 tons	20	120	40-60	A		80-120	50-100			15-40	
Grapes, Juice	10 tons	10	125	20-40	A		80-100	80			8-16	
Alfalfa Hay	8 tons	8	448	400	A	449	480				7-11	Tons at 15% moisture
Pasture	6 tons	6	300	270	A		270+				5-7	Tons at 15% moisture
Cherries	5 tons	5-6	95	25-40	A		60-100		4-8	30-50	4-8	
Grapes, Wine	6 tons	6	100	15-30	A		50-65	83	2.5-5.0	0	4-8	
Hops	1 ton	1.25	180	150-250	A		200-300		0.3-1.5	150-175	1-1.8	
Pears	20 tons	25	85	40-60	A		80-160		20-27.5	150	18-35	
Wheat	120 bu	125	175	187	A	226	275		65-120	90-213	115-140	

Crop	Typical Yield[1]/Acre	Scott's opinion	Nitrogen Removed in Harvested Portion of the Crop - (lbs/acre)	Removal (Scott) See References below	Reference[3]	Nitrogen Uptake in Plant in Growing Cycle (lb./acre)	Uptake (Scott) See references below	Estimate of Nitrogen Applied[2] (lbs/acre)	Range		Scott's opinion	Yield parameters
									Production	Application		
Mint	160 lb	160	160	280	D		280-320		68-70	0-275	140-180	
Asparagus	3000 lb	3500	95	20	A		50				?	
Nectarine/Peach	15 tons	15	95	50	A		95				?	

[1]. SYCD and IAWG

[2]. *Various sources*

[3]. References: A-Western Fertilizer Handbook; B - NRCS Crop Nutrient Tool; C-SYCD; D- WSU Fertilizer Guides

[4]. Reference from the following resources:

International Plant Nutrition Institute (ipni.net)

USDA Crop Nutrient Tool

Potash Corp (http://potashcorp-ekonomics.com/)

(wfsag.com) Potash and Phosphate Institute-Agriliance

Appendix H: Mass balance example calculation, apples

$$N\ accumulation\ or\ loss\ = Inputs \pm Transformations - Outputs$$

Inputs:

Commercial, manure, and compost nitrogen applications

Commercial nitrogen	Medium application rate: 59.78 lb N/acre % using: 86.3%
Manure nitrogen	Medium application rate: 0 lb N/acre % using: 0%
Compost nitrogen	Medium application rate: 46.6 lb N/acre % using: 13.7%

$$Commercial\ N * \%\ using + Manure\ N * \%\ using + Compost\ N * \%\ using =$$

$$59.78\ \frac{lb\ N}{acre} * 86.3\% + 0\ \frac{lb\ N}{acre} * 0\% + 46.6\ \frac{lb\ N}{acre} * 13.7\% = 57.974340 \frac{lb\ N}{acre}$$

Atmospheric nitrogen deposition

Atmospheric nitrogen deposition, medium rate:

$$2.05 \frac{lb\ N}{acre}$$

Irrigation water nitrogen

Water duty for apples: 30 ac-in/acre
Water nitrogen concentration: 0.809 mg N/L

$$30\ \frac{ac \cdot in}{acre} * \frac{1\ ac \cdot foot}{12\ ac \cdot in} * \frac{1233.481838\ m^3}{1\ ac \cdot foot} = \frac{3083.704595\ m^3}{acre}$$

$$\frac{0.809\ mg\ N}{L} * \frac{3083.704595\ m^3}{acre} * \frac{1000\ L}{m^3} * \frac{1\ g}{1000\ mg} * \frac{1\ kg}{1000\ g} * \frac{1\ lb}{0.453592\ kg} = \frac{5.499914\ lb\ N}{acre}$$

Calculated residual nitrogen

Estimated nitrogen uptake by crop, medium rate: 100 lb N/acre
Estimated nitrogen removed through harvest, medium rate: 50 lb N/acre

$$Residual\ nitrogen = N\ uptake\ by\ crop - N\ removal\ by\ harvest$$

$$100 \frac{lb\ N}{acre} - 50 \frac{lb\ N}{acre} = 50 \frac{lb\ N}{acre}$$

Transformation:

Soil organic matter conversion to nitrate

Soil organic matter content: 2.17%
Soil organic matter conversion rate to nitrate, medium rate: 30 lb N/% organic matter

$$2.17\%\ organic\ matter * 30 \frac{lb\ N}{\%\ organic\ matter} = 65.1 \frac{lb\ N}{acre}$$

Outputs:

Crop nitrogen uptake

Estimated crop nitrogen uptake, medium rate:

$$100 \frac{lb\ N}{acre}$$

Loss to atmosphere

Estimated nitrogen lost to atmosphere:

$$17 \frac{lb\ N}{acre}$$

Complete calculation:

$$N\ applications + atmospheric\ N\ deposition + irrigation\ water\ N + calculated\ residual\ N + soil\ organic\ matter\ conversion - crop\ N\ uptake - N\ loss\ to\ atmosphere =$$

$$57.974340 \frac{lb\ N}{acre} + 2.05 \frac{lb\ N}{acre} + 5.499914 \frac{lb\ N}{acre} + 50 \frac{lb\ N}{acre} + 65.1 \frac{lb\ N}{acre} - 100 \frac{lb\ N}{acre} - 17 \frac{lb\ N}{acre} = 63.6 \frac{lb\ N}{acre}$$

YAKIMA COUNTY

GEOGRAPHIC INFORMATION SERVICES

201008-13402

Owner Name: ARTHUR & CHARLOTTE BATIN JR
Organization:
Tax Lot Number: 20100813402
Situs Address: 251 ROBBINS RD

Mailing Address: 271 ROBBINS RD
TOPPENISH, WA 98948
Parcel Size: 3.15 Acre(s)
Use Code: 11 Single Unit
Yakima County Zoning: R-1
Comp Plan: Information Not Available
UGA: Toppenish
Soil Type: N/A, N/A
Soil Names: N/A
N/A
Mineral Resource: Outside
ESLU Location: Parcel WITHIN 1/2 Mile from an ESLU
National Forest: Outside National Forest Area
Natural Resource: N/A
FEMA Designation: Outside,,
Firm Panel #: 53077C1850D,,
Greenway Overlay: Outside
Airport Overlay: Outside
Irrigation District: Yakima-Wapato
Sewer District: N/A
Well Heads: N/A Well: N/A
Well Head Protection Area: N/A
School District: Toppenish
Fire District: Fire District #5
Urban Wildlands Risk: Medium,
Stock Restricted Area: Within
Critical Areas:
Local Wetland Inventory: N/A
National Wetland Inventory: N/A
Stream Type Present: N/A
SMP Lakes Environments: N/A
SMP Streams Environments: N/A
Floodway/CMZ: N/A
WDFW Wildlife Heritage: N/A
Contours:
Minimum: 760
Maximum:
SEAW Ground Snow Load ISO Lines:
Lowest: 0.0185
Highest: 0.0186
IRC Seismic Design Cat: C
Functional Class: Urban Access,Urban Access
Narrative Description:
SP 89-100: LOT 2

0 100 200 Feet

1"= 200 Feet

Parcel lot lines are for visual display only.

Plot Date: Sep 7, 2018

```
****             OVERLAY INFORMATION            ****
========================================================

Owner Name :                  ARTHUR & CHARLOTTE  BATIN JR
Organization:
Tax Lot Number:               20100813402
Situs Address:                251 ROBBINS RD

Mailing Address:              271 ROBBINS RD
                              TOPPENISH WA 98948
Parcel Size:                  3.15 Acre(s)
Use Code:                     11 Single Unit
Zoning:                       R-1 - Yakima County Zoning
Comp Plan:                    Information Not Available
UGA:                          Toppenish
Soil Type:                    N/A
                              N/A
Soil Names:                   N/A
                              N/A
Mineral Resource:             Outside
ESLU Location:                Parcel WITHIN 1/2 Mile from an ESLU
National Forest:              Outside National Forest Area
Natural Resource:             N/A
Urban Wildlands Risk:         Medium,
Fire District:                Fire District #5
Local Wetland Inventory:      N/A
National Wetland Inventory:   N/A
Lakes or Ponds:               No Lakes or Ponds
Stream Type Present:          N/A
Shoreline Designations:
  SMP Lakes Environments:     N/A
  SMP Streams Environments:   N/A
  Floodway/CMZ:               N/A
WDFW Wildlife Heritage:       N/A
Geologic-Hazards:             N/A
CARA:                         High , High
Fema Designation:             Outside,,
Firm Panel Number:            53077C1850D,,
Greenway Overlay:             Outside
Airport Overlay:              Outside
Commissioner District:        Ron Anderson
Irrigation District:          Yakima-Wapato
Sewer District:               N/A
Well Heads:                   N/A    Well: N/A
Well Head Protection Area:    N/A
School District:              Toppenish
Stock Restricted Area:        Within
Contours:
    Minimum:                  760
    Maximum:
SEAW Ground Snow Load
            ISO Lines:
    Lowest:                   0.0185
    Highest:                  0.0186
IRC Seismic Design Cat:       C
Functional Class:             Urban Access,Urban Access
Narrative Description:        SP 89-100: LOT 2
```

YAKIMA COUNTY

GEOGRAPHIC INFORMATION SERVICES

201008-13401

Owner Name: MARK BATIN
Organization:
Tax Lot Number: 20100813401
Situs Address: 271 ROBBINS RD

Mailing Address: 1460 W 5830 NORTH
ST GEORGE, UT 84770
Parcel Size: 0.50 Acre(s)
Use Code: 11 Single Unit
Yakima County Zoning: R-1
Comp Plan: Information Not Available
UGA: Toppenish
Soil Type: N/A, N/A
Soil Names: N/A
N/A
Mineral Resource: Outside
ESLU Location: Parcel WITHIN 1/2 Mile from an ESLU
National Forest: Outside National Forest Area
Natural Resource: N/A
FEMA Designation: Outside,,
Firm Panel #: 53077C1850D,,
Greenway Overlay: Outside
Airport Overlay: Outside
Irrigation District: Yakima-Wapato
Sewer District: N/A
Well Heads: N/A Well: N/A
Well Head Protection Area: N/A
School District: Toppenish
Fire District: Fire District #5
Urban Wildlands Risk: Medium,
Stock Restricted Area: Within
Critical Areas:
Local Wetland Inventory: N/A
National Wetland Inventory: N/A
Stream Type Present: N/A
SMP Lakes Environments: N/A
SMP Streams Environments: N/A
Floodway/CMZ: N/A
WDFW Wildlife Heritage: N/A
Contours:
Minimum: 760
Maximum:
SEAW Ground Snow Load ISO Lines:
Lowest: 0.0185
Highest: 0.0186
IRC Seismic Design Cat: C
Functional Class: Urban Access
Narrative Description:
SP 89-100: LOT 1

0 100 200 Feet
1"= 200 Feet

Parcel lot lines are for visual display only.

Plot Date: Sep 7, 2018

**** OVERLAY INFORMATION ****

==

Owner Name :	MARK BATIN
Organization:	
Tax Lot Number:	20100813401
Situs Address:	271 ROBBINS RD
Mailing Address:	1460 W 5830 NORTH ST GEORGE UT 84770
Parcel Size:	0.50 Acre(s)
Use Code:	11 Single Unit
Zoning:	R-1 - Yakima County Zoning
Comp Plan:	Information Not Available
UGA:	Toppenish
Soil Type:	N/A N/A
Soil Names:	N/A N/A
Mineral Resource:	Outside
ESLU Location:	Parcel WITHIN 1/2 Mile from an ESLU
National Forest:	Outside National Forest Area
Natural Resource:	N/A
Urban Wildlands Risk:	Medium,
Fire District:	Fire District #5
Local Wetland Inventory:	N/A
National Wetland Inventory:	N/A
Lakes or Ponds:	No Lakes or Ponds
Stream Type Present:	N/A
Shoreline Designations:	
SMP Lakes Environments:	N/A
SMP Streams Environments:	N/A
Floodway/CMZ:	N/A
WDFW Wildlife Heritage:	N/A
Geologic-Hazards:	N/A
CARA:	High , High
Fema Designation:	Outside,,
Firm Panel Number:	53077C1850D,,
Greenway Overlay:	Outside
Airport Overlay:	Outside
Commissioner District:	Ron Anderson
Irrigation District:	Yakima-Wapato
Sewer District:	N/A
Well Heads:	N/A Well: N/A
Well Head Protection Area:	N/A
School District:	Toppenish
Stock Restricted Area:	Within
Contours:	
Minimum:	760
Maximum:	
SEAW Ground Snow Load ISO Lines:	
Lowest:	0.0185
Highest:	0.0186
IRC Seismic Design Cat:	C
Functional Class:	Urban Access
Narrative Description:	SP 89-100: LOT 1

Edits / additions to Draft 2 of GWMA Program

Executive Summary

Table of Figures, Table of Tables

p. 32/168, Figure 8, Mean Annual Groundwater Recharge

p. 34/168, Table 2, Amount and Direction of Groundwater Flow

p. 45/168, Table 3

p. 49/168, Figure 14

p. 63/168, Table 10

p. 111/168, Transport (Abandoned Wells)

pp. 115/168 – 168/168 (end of document)

Lower Yakima Valley Groundwater Management Program

Volume I

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Advisory Committee

Name	**Affiliation**
Rand Elliott	Yakima County Board of Commissioners
Vern Redifer	Yakima County Public Services
Elizabeth Sanchey	Yakama Nation
Stuart Crane	Yakama Nation
Steve George	Yakima County Farm Bureau
Frank Lyall	*Yakima County Farm Bureau*
Jason Sheehan	Yakima Dairy Federation
Dan DeGroot	Yakima Dairy Federation
Stuart Turner	Agronomist, Turner and Co.
Chelsea Durfey	Agronomist, Turner and Co.
Jean Mendoza	Friends of Toppenish Creek
Eric Anderson	Friends of Toppenish Creek
Jan Whitefoot	Concerned Citizens of the Yakama Reservation
Jim Dyjak	Concerned Citizens of the Yakama Reservation
Laurie Crowe	South Yakima Conservation District
Rodney Heit	South Yakima Conservation District
John Van Wingerden	Port of Sunnyside
Gary Bahr	WA Department of Agriculture
Perry Beale	WA Department of Agriculture
Andy Cervantes	WA Department of *Health*
Sheryl Howe	WA Department of Health
David Bowen	WA Department of Ecology
Sage Park	WA Department of Ecology
Lucy Edmondson	U.S. EPA
Nick Peak	U.S. EPA
Holly Myers	Yakima Health District
Ryan Ibach	Yakima Health District
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center
Ron Cowin	*Roza-Sunnyside Joint Board of Control*
Lino Guerra	Hispanic Community Representative
Rick Perez	Hispanic Community Representative
Doug Simpson	Irrigated Crop Producer
Bud Rogers	Lower Valley Representative Pos. 1
Kathleen Rogers	Lower Valley Representative Pos. 1
Patricia Newhouse	Lower Valley Representative Pos. 2
Sue Wedam	Lower Valley Representative Pos. 2
Dr. Jessica Black	Heritage University
Dr. Alex Alexiades	Heritage University
Matt Bachmann	USGS Washington Water Science Center

No Longer Participating:

Name	Affiliation
Helen Reddout	Community Association for Restoration of the Environment
Wendell Hannigan	Community Association for Restoration of the Environment
Bruce Perkins	Benton-Franklin Health District
Mark Nielson	Benton Conservation District
Heather Wendt	Benton Conservation District
Jaclyn Ford	WA Department of Agriculture
Tom Ring	Yakama Nation
Ginny Prest	WA Department of Agriculture
Charlie McKinney	Department of Ecology
Tom Tebb	Department of Ecology
Robert Farrell	Port of Sunnyside
Lonna Frans	USGS Washington Water Science Center
Robert Morales	Lower Valley Community Representative
Ramon Tobias	Hispanic Community Representative
Margarita Tobias	Hispanic Community Representative
Don Young	Yakima County Farm Bureau
Justin Waddington	Yakima County Farm Bureau
Dr. Kefy Desta	WSU Irrigated Agriculture Research and Extension Center
Ginny Stern	WA Department of Health
Gordon Kelly	Yakima Health District
David Cole	Yakima Health District
Tom Eaton	U.S. EPA
Marie Jennings	U.S. EPA
Bill Dunbar	U.S. EPA
Jim Newhouse	South Yakima Conservation District
Jim Trull	Sunnyside Valley Irrigation District

Executive Summary

Between 1988 and 2008, 12 percent of drinking water wells tested in the Lower Yakima Valley of Washington State had nitrate concentrations above the Safe Drinking Water Act Maximum Contaminant Level of 10 milligrams per liter (mg/L). Another 21 percent of wells tested were below this level but higher than 5 mg/L. These numbers raised concern due to the potential impact to human health. Nitrate is considered an acute contaminant and may cause serious health conditions in vulnerable populations. In response, the Washington State Department of Ecology (Ecology) and 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 to be within state drinking water standards. This document is that Program, the report of the GWAC's completed work.

The GWAC's intended objectives included data collection, monitoring and analysis; public education and outreach; problem identification; and potential measures or practices for reducing groundwater contamination. This Program collects information describing, or "characterizing," the area as it currently exists, including area boundary, relevant jurisdiction, the Yakima River Basin, geology, hydrology, mean annual groundwater recharge, depth to groundwater, topography, soil types, climate, land use, crops, fertilizers, water use, irrigation methods and demographics. It discusses nitrate, the nitrogen cycle and nitrate leaching.

This Program discusses the sources of available nitrogen including general legacy agricultural activity, current irrigated agriculture, including crops supporting livestock operations and tree fruit and vegetable crops, current organic and chemical fertilizers supporting livestock operations and tree fruit and vegetable crops, current livestock/CAFO operations utilizing dairy, feeding, waste facility, animal holding in corals or pens, composting areas, or buildings housing animals.

It examines current residential, commercial, industrial and municipal sources including residential on-site sewage (i.e., septic) systems, large on-site sewage systems, commercial onsite sewage systems, biosolids, residential lawn fertilizers, and "hobby farms," underground injection wells, and air deposition. The Program also discusses the current regulatory framework with respect to each of these sources.

The Program also identifies possible transporters of nitrogen including shallow, improperly constructed private drinking water wells, abandoned or decommissioned water supply wells, irrigation supply canals, irrigation water applications, irrigation waste water drains, and groundwater flow.

The Program then reports the investigation that was pursued during the period of the GWAC's tenure. That investigation included identification of "best management practices" particularly applicable to nitrogen sources within the LYVGWMA (accomplished by GWAC working groups), development of a groundwater monitoring plan, development of a public education and outreach program, a drinking water testing program, a deep soil sampling program, a nitrogen availability assessment, a geographic information system study, and suggested a future mean annual groundwater recharge study.

The GWAC originally intended that all its decisions would be made by consensus. The makeup of the group, however, made consensus, at best, challenging. WAC 173-100-090 requires that GWAC membership include "a broad spectrum of the public" and further requires representation from "public and special interest groups such as agriculture, well drilling… environmental, business and/or industrial groups." These diverse and sometimes competing interests made it difficult to establish the trust that the Program's investigative process required. Most governmental representatives, including those representing the lead agency, were apprehensive of specific source/contamination event analysis due to possible suggestions of liability, mandate of remediation, or disparagement of agricultural industry groups important to the community's economic well-being.

A lawsuit brought against the dairy industry by one of the interest groups early in the process challenged good faith participation. Mutual trust – the cornerstone of consultative process – and vital for participation in investigations such as deep soil sampling – was absent. In this environment it was unlikely that consensus could be reached regarding any correlation between specific sources and specific high nitrate findings.

Despite these challenges, the agencies, interest groups and private individuals comprising the GWAC persevered. No one questioned the importance of developing a program. The majority regularly attended both the GWAC meetings and working group meetings. Very few dropped out of the six-year process. The results of their work, while not as comprehensive as originally envisioned, do provide the cornerstone for the next phase of a complex, and lengthy process to reduce nitrates in groundwater.

GWAC findings: The greatest correlation between source and effect appears to be that between total nitrogen availability and USGS' 2017 well data, particularly when the large amount of irrigation water applied is taken into account. Most all the non-compliant wells are down-gradient of the SVID irrigation canal (See Figure 29) and within the area where more than half the irrigation water delivered makes it past the plants' root zone to become "recharge" (See Figure 8) and located where soil infiltration rates are relatively fast (See Figure 28). Even if all the N applied in the agricultural process were applied at an "agronomic rate," the plant community may not take it up sufficiently if twice the necessary water supply washes it past the root zone. The obvious general conclusion is that the LYVGWMA's groundwater contamination problem is the result of lengthy and continuous aggressive agricultural practices and that proactive measures should be taken with any and all potential nitrogen sources in order to address the general groundwater contamination problem. More precise irrigation management may be the most consequential proactive measure.

Table of Contents

Contents – Vol I

Table of Figures

Table of Tables

Introduction

The Problem:

In recent years, a number of groundwater studies have pointed to concerns about nitrate levels in groundwater in the Lower Yakima Valley. Between 1988 and 2008, 12 percent of wells tested in the area had nitrate concentrations above the Safe Drinking Water Act Maximum Contaminant Level of 10 mg/L. 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:

In response, the Washington State Department of Ecology (Ecology) began working with Yakima County to address the issue and provide solutions to prevent nitrate contamination of groundwater in the Lower Yakima Valley. They established the Lower Yakima Valley Groundwater Management Area (LYV GWMA), and formed the Groundwater Advisory Committee (GWAC) 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

[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 GWMA.

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

To accomplish its work, the GWAC tasked itself with identifying the primary sources of nitrate contamination using scientific data, identifying or developing practices that would minimize nitrate concentration of groundwater; developing 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 data collection, monitoring and analysis; public education and outreach; problem identification; potential measures or practices for reducing groundwater contamination (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 LYV GWMA. 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. 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 had tasked itself. The makeup of its membership adjusted over time, as individuals 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 WAC 100-100. 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.

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.

Boundary of the Groundwater Management Area

The Lower Yakima Valley Groundwater Management Area (or LYV GWMA) is located within the Lower Yakima Valley, south of Union Gap, northeast of the Yakima River and west of the Yakima-Benton County line. It lies in the southeastern portion of the Lower Yakima Valley. Its total area is 175,161 acres. The western boundary abuts the Toppenish Basin. The southern boundary is bordered by the Horse Heaven Hills. The northeastern boundary generally follows the northern flank of the Cold Creek Syncline, as the project area lies generally south of that Syncline.

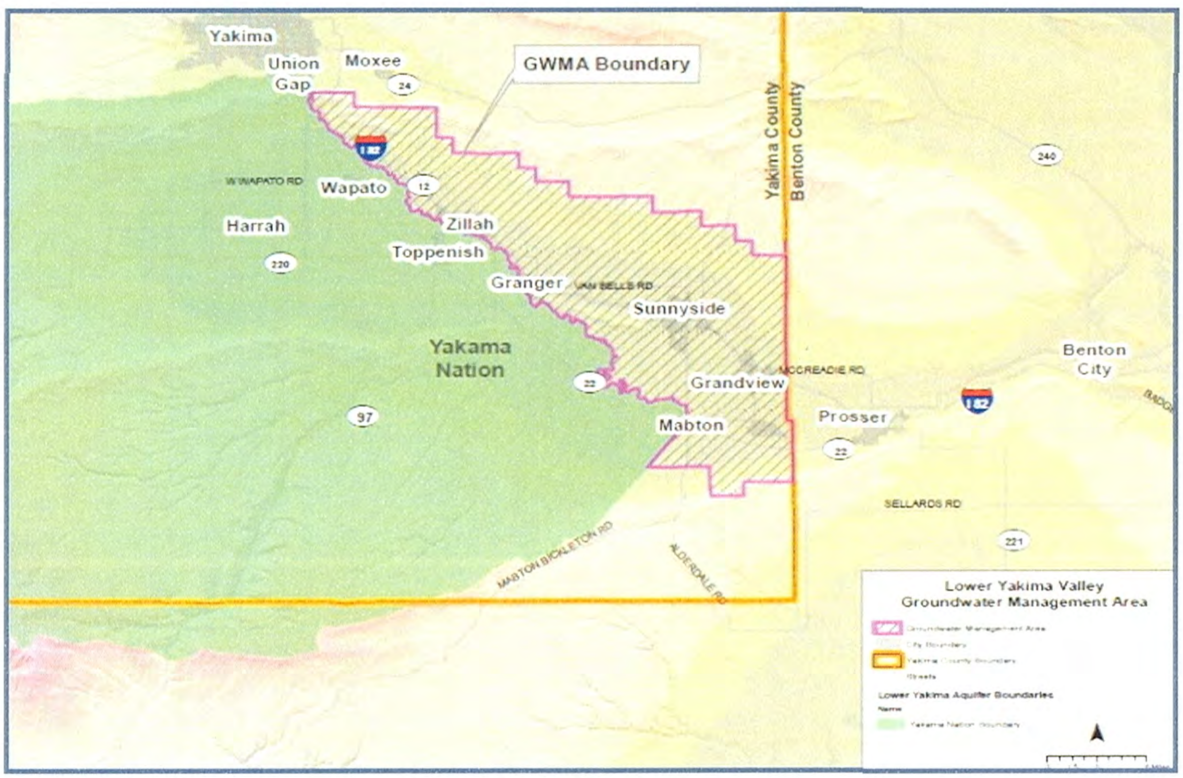

FIGURE 1 - GWMA BOUNDARY

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 River south of Union Gap and the southeast Yakima Valley downstream of the confluence of the Satus and Yakima Rivers. 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.

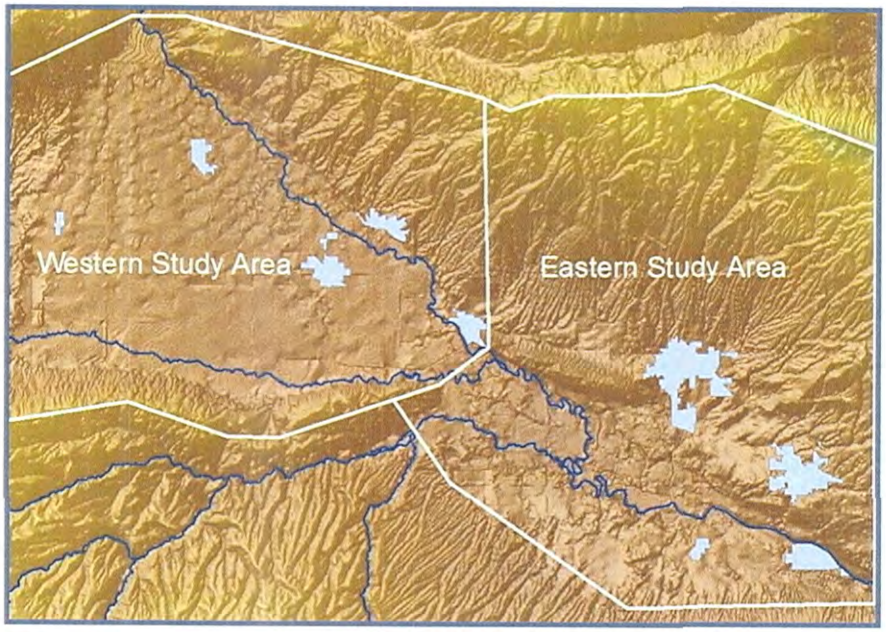

FIGURE 2 - AREAS OF PRELIMINARY ASSESSMENT

The *Preliminary Assessment* had 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]

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[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 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.

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.

FIGURE 3 - YAKAMA INDIAN RESERVATION

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.

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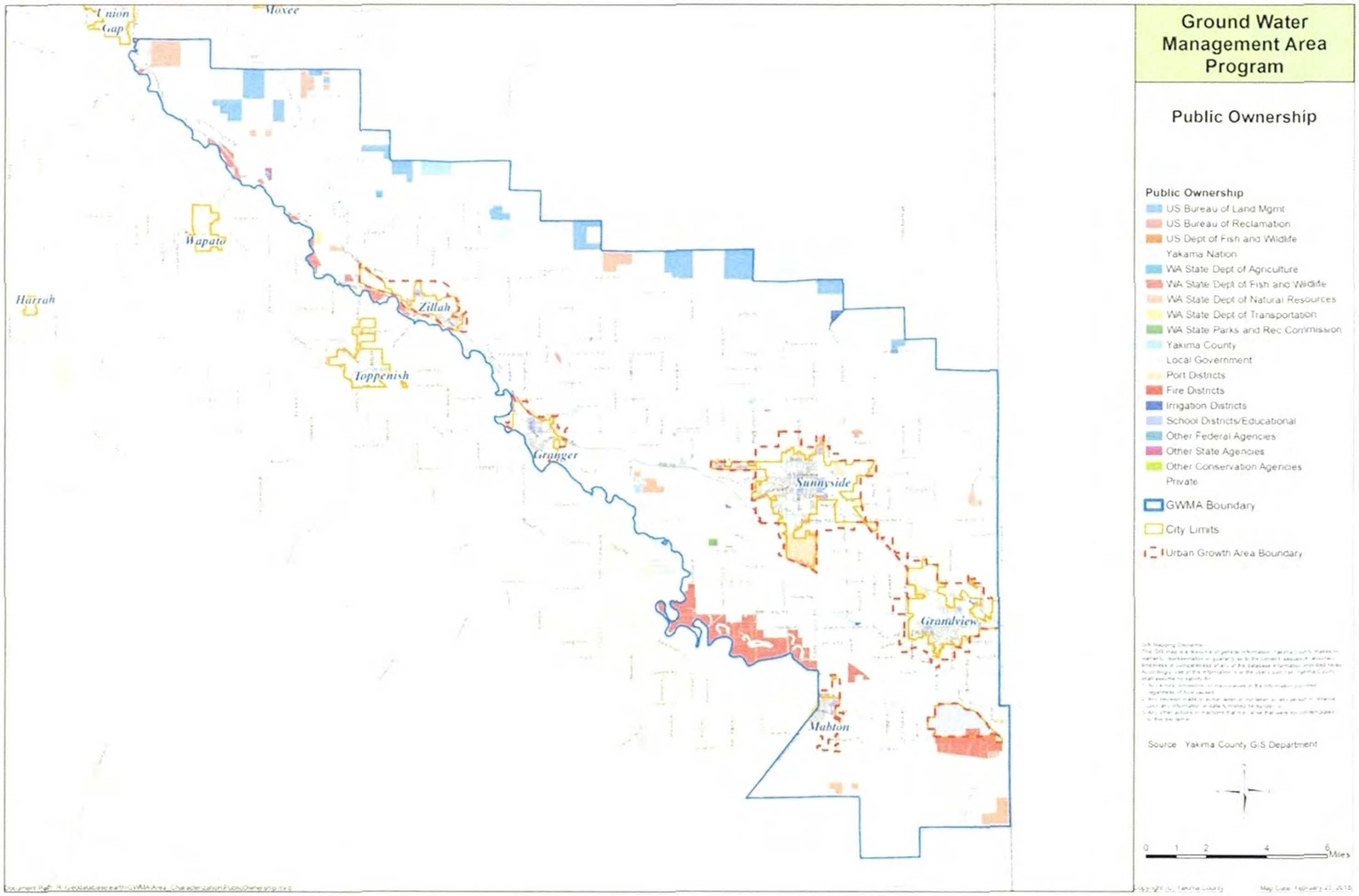
[4] Confederated Tribes and Bands of the Yakama Nation (Yakama Nation). The Yakama Indian Reservation, lies along the southwest side of the Yakima River and extends beyond Yakima County boundaries into the northern edge of Klickitat County and Southeastern corner of Lewis County. It covers an area of 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



General Land Description

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, and 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. The basin is dissected with numerous faults and folds surrounding the Rattlesnake Hills structure in its eastern part. The western part is dissected by the Wapato Syncline and several unnamed folds that lie within the broad flat plain that encompasses the Yakima River floodplain. Only the western portion of the Benton Sedimentary Basin, approximately a third, is in the LYVGWMA boundaries.

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.

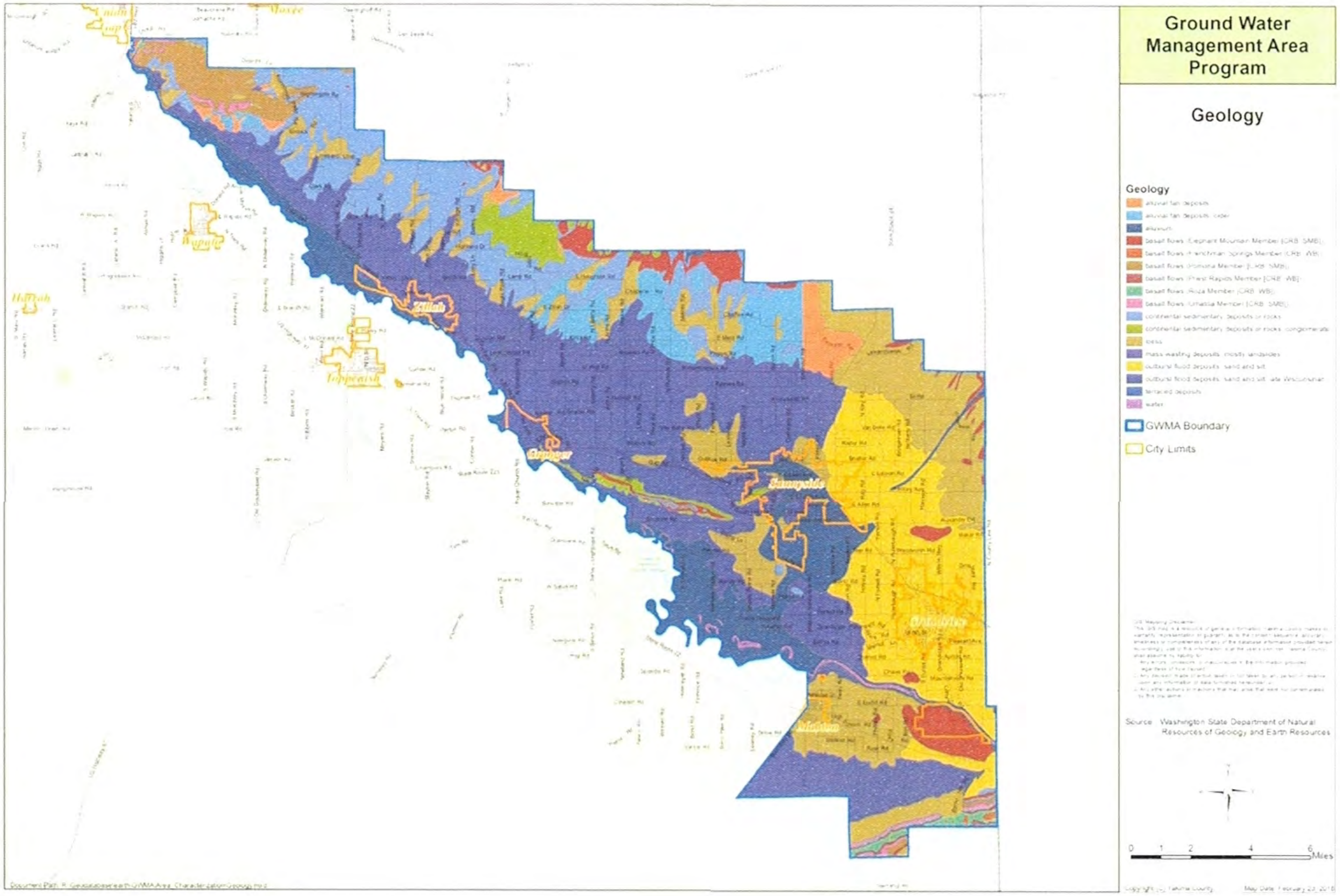
The Yakima Fold Belt

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



Basalt

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 basal 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 range 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 1990) 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

The basalts of the CRBG is overlain in many places by 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 creates 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 and only 5 to 15 percent gravel and conglomerate. It often appears as sedimentary interbeds found between the various Yakima Basalt 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 1000 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 1990) (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).

Hydrogeology

The geologic framework and some of its hydrogeologic units of the Columbia Plateau regional aquifer system was described by Drost and others. (USGS 1990) The aquifer system consists of a large thickness of basalt made of numerous flows with minor interbedded sediments. (USGS 1990) 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). The five 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).

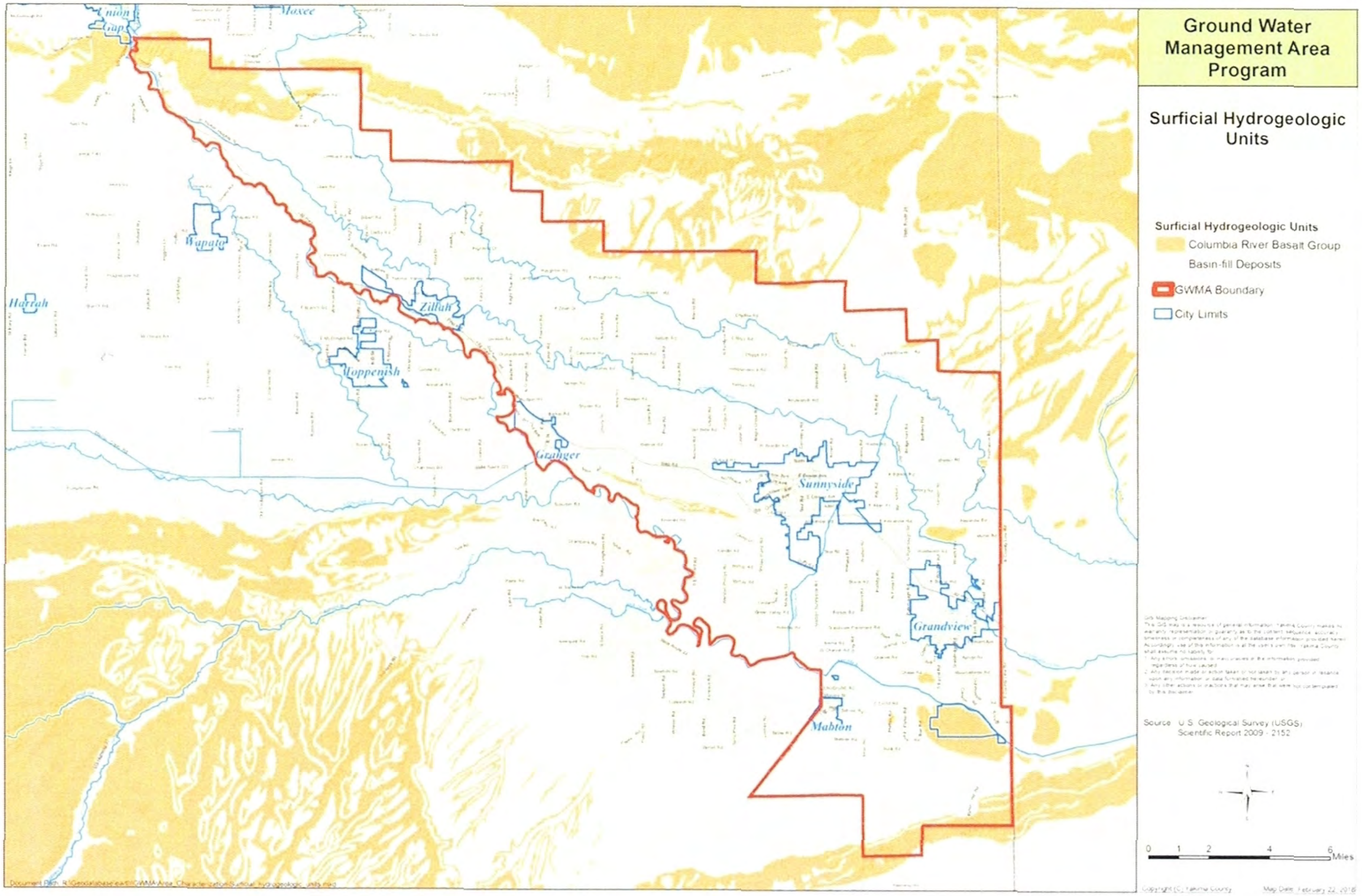
TABLE 1 - HYDROGEOLOGIC UNITS (AFTER USGS 2009A)

LYVGWMA Hydrogeologic Units						
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

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.

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

FIGURE 6 – SURFICIAL HYDROGEOLOGIC 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 and, according to USGS, has a total thickness of up to 500 feet.

The second aquifer is an extensive basalt aquifer of great thickness underlying the surficial aquifer described above. 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 to the south, down the valley, and is used locally for residential water supply and eventually feeds the Yakima River.

An aquifer is rock material that is sufficiently saturated to be capable of transmitting and yielding appreciable amounts of water. Ground water occurs in the interstices in rock materials, in the spaces not occupied by solid material. The ability of soil or rock to transmit water is determined by the abundance, character, and degree of interconnection of those spaces.

Natural rock materials differ greatly 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 due to the weight of the water in an unconfined part of the aquifer. 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 piezometric surface.

An "unconfined aquifer" (or "water table aquifer") is one where the upper surface of the water in the rock mass is free to find a relatively even level. This 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, or irrigation), or groundwater moving from other underground sources. Water exiting the aquifer (water seeping from the ground (spring) 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 piezometric 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 and lower in areas of discharge and affected by differences in permeability within the aquifer. The slope of either surface is called the "hydraulic gradient." The slope adjusts automatically to the velocity of the moving water and the permeability of the rock. It is highest in areas of recharge, where water is added to the aquifer, and slopes downward to areas of discharge, where water leaves, or is removed from, the aquifer.

The water table has irregularities that are generally comparable with the configuration of the land surface, although more subdued. Additional irregularities are caused by local differences in the permeability of the rock materials and by local differences in ground-water discharge and recharge. Rocks of low permeability require a steeper gradient than more permeable rocks to transmit water at a given rate.

An aquifer is "perched" if it is held above an unsaturated zone by a relatively impermeable rock stratum.

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.

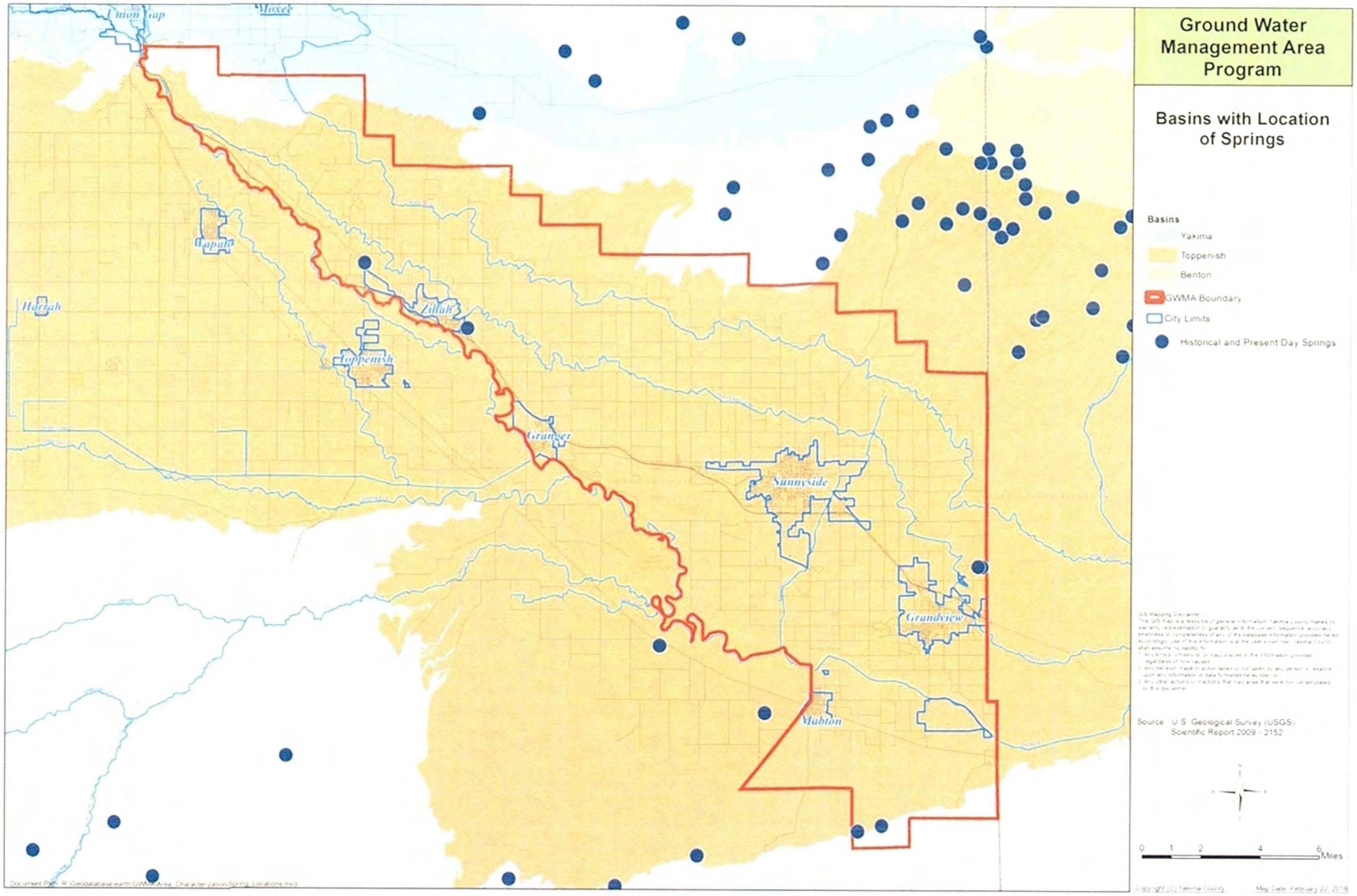
Vaccaro's Assessment of the Availability of Groundwater for Residential Development in the Rural Parts of Yakima County, Washington (Vaccaro 2016) identified the "Rattlesnake Hills Domain," and the "Mabton Domain," "particularly described geographic" areas where water consumption "strategies would take into account specific measures that could be taken . . . that would mitigate the effect of water use on the aquifer system, senior ground and surface water rights, flow-related habitat conditions and habitat use." "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 LTVGWMA boundaries. The Mabton Domain was not further divided.

> "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 than10 inches per year because of the influence of surface water irrigation [from the Roza Irrigation District]." (Vaccaro 2016)

Figure 7 – Springs within the Toppenish Basin

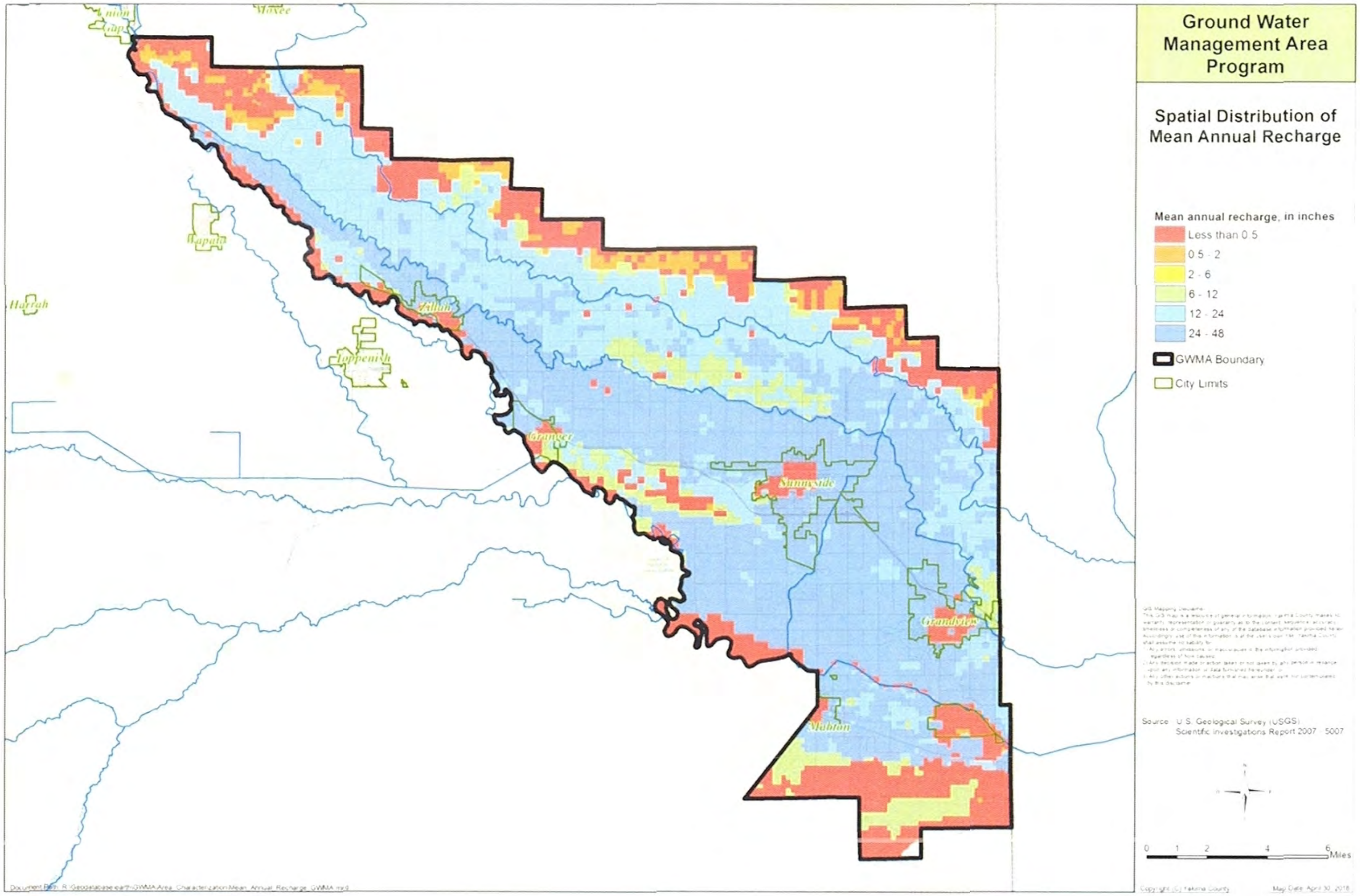


Mean Annual Groundwater Recharge

"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 20inches per year." (Vaccaro 2016, USGS 2007a). These are "acre-inches," a portion of the areas 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, below, 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 may differ 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. These might include using 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. 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

FIGURE 8 – MEAN ANNUAL RECHARGE WITHIN THE LVYGWMA



Amount and Direction of Groundwater Flow

The volume and velocity of groundwater flow is measured in hydraulic conductivity (K_h), the measure of a medium's maximum ability to transmit water laterally. It is expressed in units of cubic feet (or meters) per square feet per day ($m^3/ft^2/day$)—simplified to (ft/d), or per second (m^3/sec). Values of hydraulic conductivity can be estimated from specific-capacity data reported on drillers' logs, or determined from aquifer tests or groundwater flow modeling.

The movement of water into, within, or out of an aquifer is typically called "groundwater flow." Within the aquifer ground water flows through the ground from where it is recharged to where it is discharged. Groundwater flow is generally measured in "groundwater travel time." Groundwater travel time is usually measured in feet per day. The pace of flow is influenced by the "hydraulic conductivity" of the geologic matrix that composes the aquifer. The higher the hydraulic conductivity, the faster the flow. The direction of groundwater flow is determined by "gradients." The "gradient" is the difference in elevation between two locations of the water table or the differences in pressure between locations in a confined aquifer. The direction of groundwater flow is from the higher elevation or pressure to the lower elevation or pressure. The higher the gradient, the variance between the two, the faster the flow.

TABLE 2 - POROSITY, SPECIFIC YIELD, HYDRAULIC CONDUCTIVITY

Representative values of porosity, specific yield and hydraulic conductivity for selected geologic materials			
Material	Porosity % by volume	Specific Yield	Hydraulic Conductivity m^3/sec
Clay	40-70	1-10	0-0.00094
Sand	25-50	10-30	0.005-0.14
Gravel	25-40	15-30	0.05-0.71
Sand and Gravel	20-35	15-25	0.009-0.24
Sandstone	5-30	5-15	0.000005-0.002
Shale	1-30	.5-5	0-0.000005

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. The direction of hyporheic flow, that flow of the mixture of surface and groundwater in the saturated area beneath and alongside the bed of a river or stream is generally in the direction of the surface water, but is also influenced by the hydraulic conductivity of the medium through which it passes and the general direction of groundwater flow. Groundwater in confined aquifers flows from the direction of the highest pressure to the lowest pressure. Ground water moves primarily in response to gravity, taking into account the resistance imposed by physical obstruction or pressure gradient. The USGS uses the normal approach with respect to surficial groundwater flow and 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). No statistics have yet been developed for that portion of the data base consisting of those wells exclusively within the LYVGWMA.

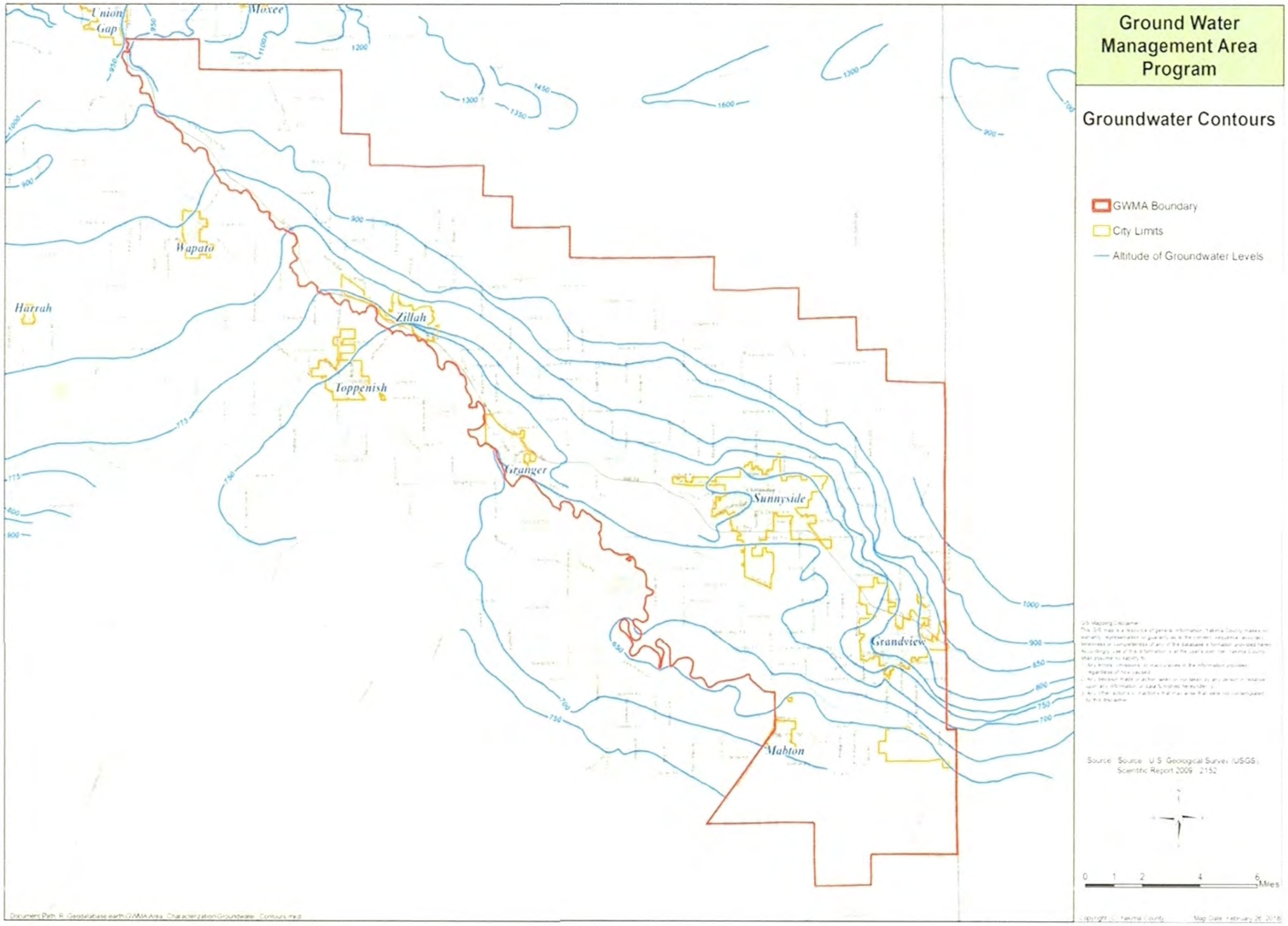
The two main aquifers underlying the area include a surficial unconfined to semi-confined alluvial aquiver and basalt aquifers underlying the sedimentary deposits. The basalt is believed to be semi-isolated from the surficial aquifer and stream systems. Groundwater flow within both aquifers generally 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 significantly enhanced by irrigation practices upland from the Yakima River.

Other factors may be relevant in determining groundwater flow direction within the area. The EPA, for example, suggests a "pattern" involving deeper basaltic layers that may convey waters across local flow divides to more regionally significant discharge locations such as the Columbia River. "This pattern produces a major flow direction from northwest to southeast as water moves down the valley parallel to the course of the Yakima River." (EPA 2012) The EPA acknowledges that flow at shallower depth in the uppermost sediments tends to be "toward the Yakima River" and that direction may be modified by geologic structures and irrigation practices, drains, ditches, canals and other hydrologic features. (EPA 2012).

Because the piezimetric 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. Figure 10 shows ground surface contours (topography) (in meters). Figure 11, derived from determining the distance between the two contours, shows depth to groundwater.

The ground surface material above the aquifer is called the "vadose zone." The vadose zone is the vertical depth between ground surface and an aquifer. It consists of unsaturated earthen materials. Depth to water is the distance between the ground surface and the water table or piezometric surface through the vadose zone. The deeper the water table and less permeable the vadose zone, the longer the travel time from the surface to the aquifer. Earthen materials within the vadose zone have different degrees of "permeability." Permeability is a measurement of the rate of infiltration in inches of water per hour. Infiltration rate is a measure of how fast water and pollutants can move downwards through the earthen materials of the vadose zone. The more permeable ground is, the faster water moves down through it. Coarse sands and gravels are more permeable and allow water to pass through much more quickly than fine silts, clays or glacial till which are less permeable.

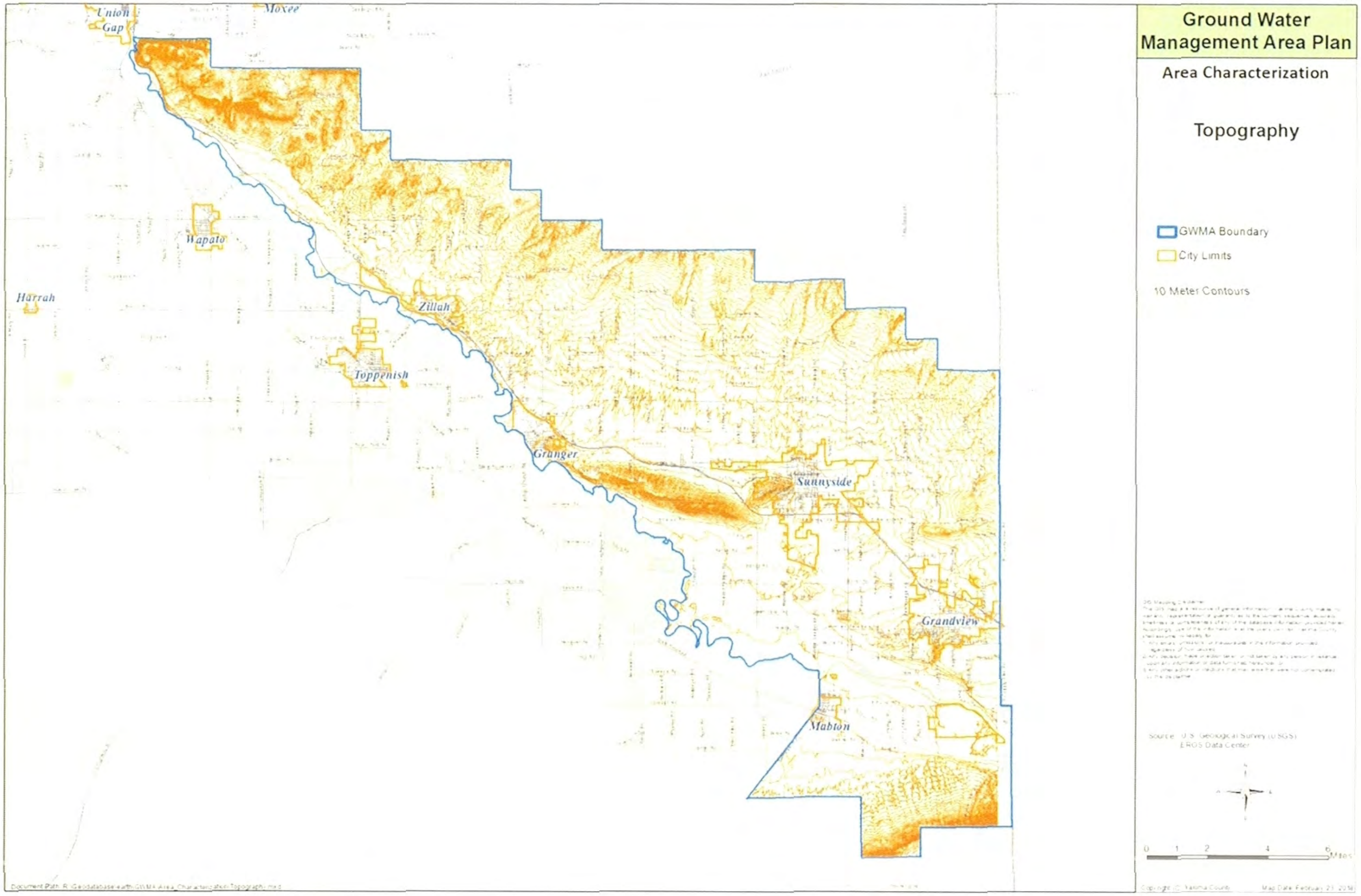
FIGURE 9 - GROUNDWATER LEVEL CONTOURS ESTABLISHED BY USGS WITHIN THE LYVGWMA



Topography

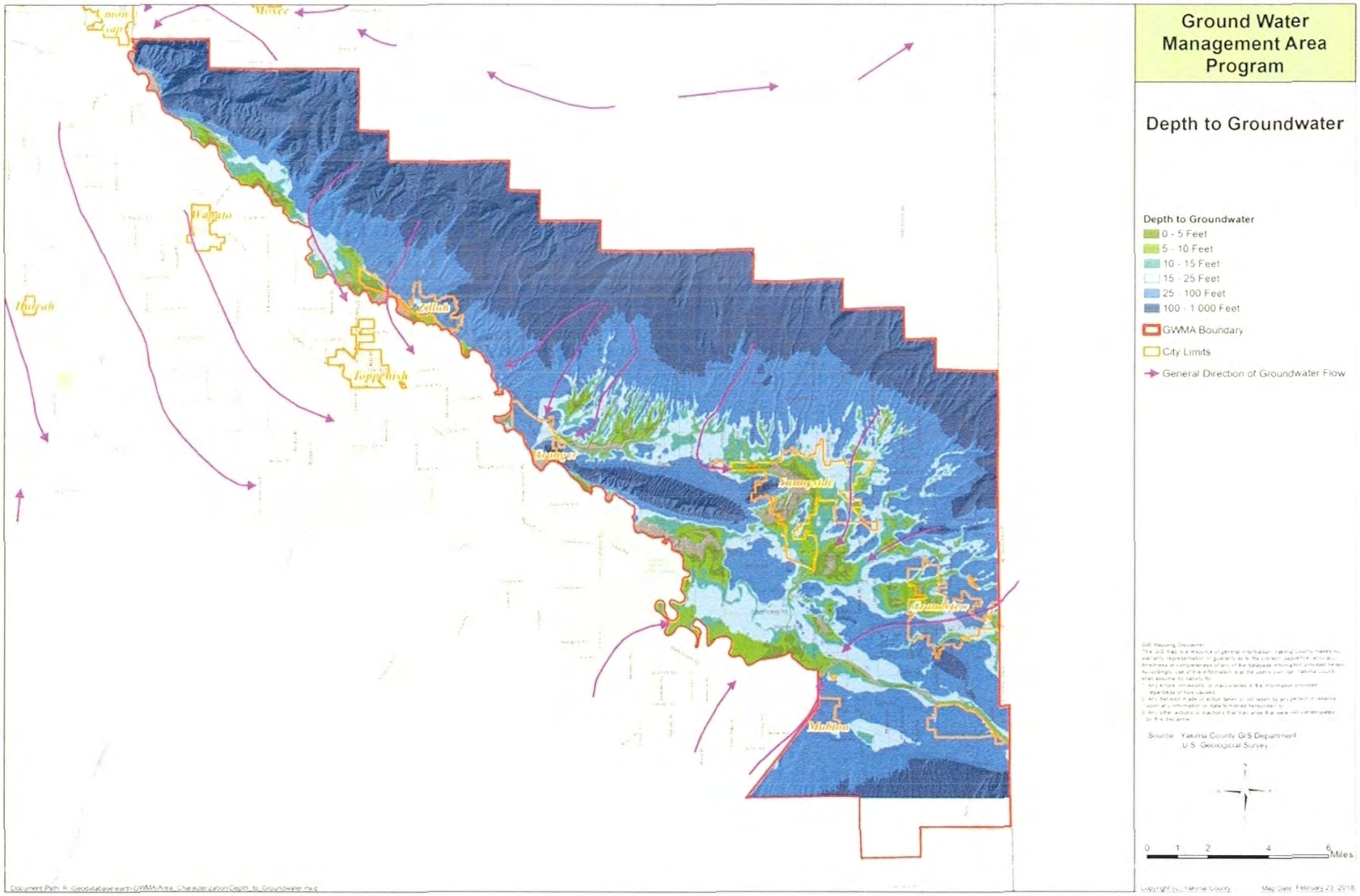
The topographical surface of the groundwater management area is undulating hillside running down (from an elevation of approximately 400 meters (1312 feet) above sea level) to the valley floor and river floodplain (at an elevation of approximately 230 meters (755 feet) above sea level). The topographical 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 LYVGMA



Groundwater levels are very shallow (0-15 feet) in the valley bottom and in several areas northeast of Granger, north and southeast of Sunnyside, surrounding Grandview and southeast of Mabton. They are marginally deeper (15-25 feet) in adjacent lands running east-southeastward from north of Granger past areas north of 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- 1000 feet) in areas above the RID irrigation canal.

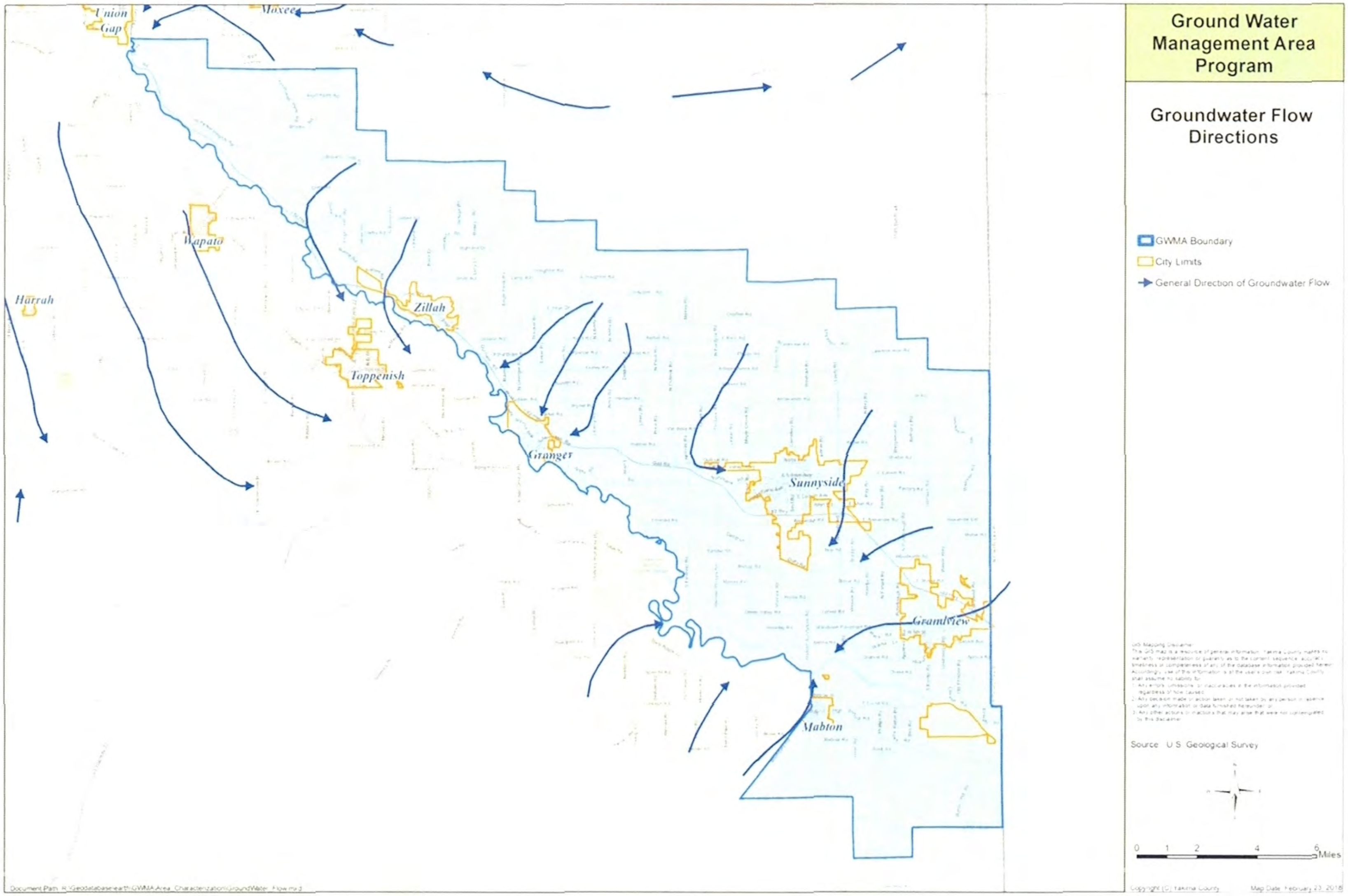
Figure 11 - Calculated Depth To Groundwater Within The LYVGMA



Water movement can also be influenced by "chemical retardation" or "adsorption." Chemical retardation is a measurement of how clays and organic matter react with some chemicals to slow their passage or change them chemically. "Adsorption" is a measurement of the tendency of ions dissolved in water to stick to particles of silt or clay. Particle size and the amount of organic matter affect adsorption. A sand with no organic matter may not adsorb at all, while an organic silt or clay may adsorb well.

Based on the configuration of groundwater surface contours (see Figure 9), USGS determined the direction of groundwater flow. Figure 12, derived from USGS 2009 report (USGS 2009a) shows direction of groundwater flow within the LYVGWMA.

FIGURE 12 - DIRECTION OF GROUNDWATER FLOW WITHIN THE LYVGWMA



Soil Types

There are 89 soil types within the GWMA. 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 (1000 ft.) 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 (1000 ft) and 250 meters (800 ft) 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 (800 ft.) and 200 meters (650 ft.) 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 3 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 3 - PRIMARY SOIL TYPES HYDRAULIC CONDUCTIVITY (K)

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
Quncy loamy find sand	5.95-19.98	Rapid
Wasnser loamy find 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

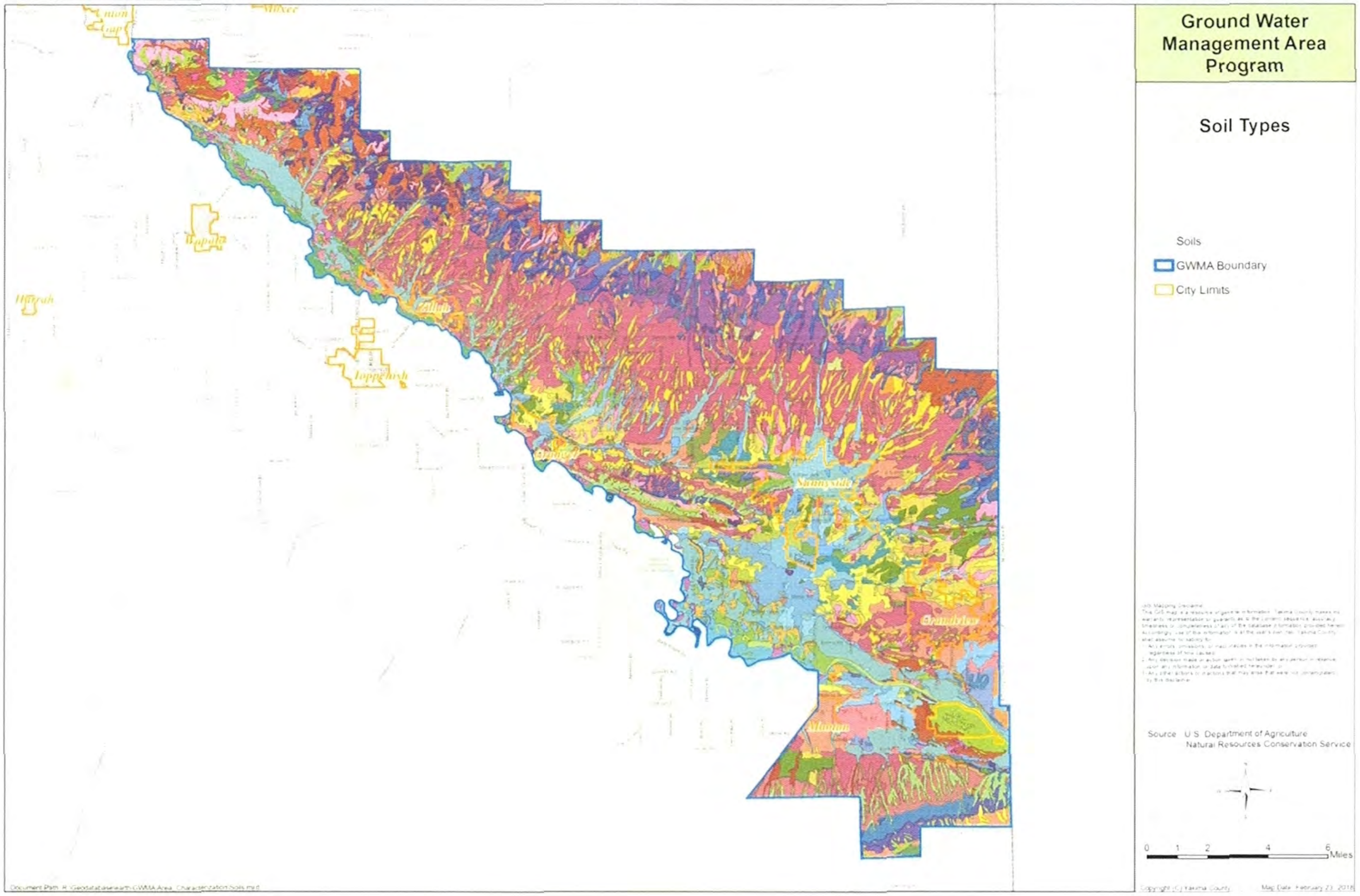


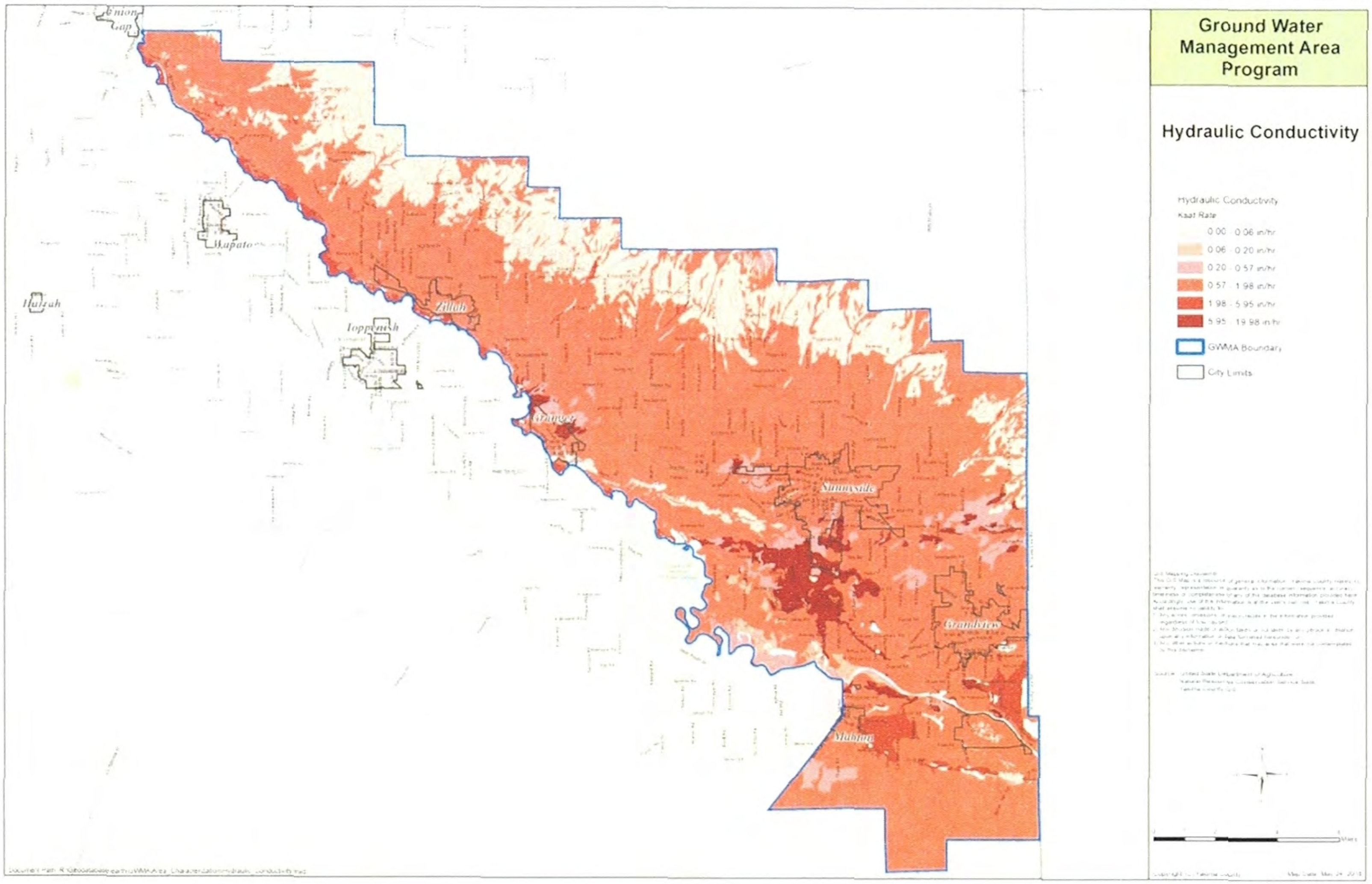
Table 4 - List Of All Soil Types Withing The LYVGWMA

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 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 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.

TABLE 5 - CLIMATE

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 annually worth over $2 billion (apples: $1 billion, dairy: $900 million, hops: $500 million). 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. 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 progressively from eastern to western regions of the United States, corresponding with community and rural population growth and more intensive agricultural practices in those regions. Nitrate contamination was identified as a public concern first in New England, then in the Ohio Valley, progressing to the Middle West and ultimately in the American West, particularly in Montana, Idaho, California, and now Eastern Washington. In each case, the length of more intensive agricultural practice history has reached about 100 years before the degree of contamination has become sufficiently great to cause public or governmental response.

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, 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. By 1902, about 120,000 acres were under irrigation, mostly by surface-water.

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.

Crops

The Yakima Valley Museum maintains a collection of photographs which 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.

[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, appled, 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.

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. According to the Agricultural History of Yakima County, a report prepared by Margaret Drenna, there were 6,351 farms in Yakima County, making up 600,106 acres of farmland, in 1925.

> "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* now located within the Presby Museum in Goldendale Washington, shows the route of two railroads then running through the GWMA area, with which to ship agricultural goods to market. 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, Bureau of the Census and published in the *United States Census of Agriculture:* It was assembled by Margaret Drennan in a report entitled "Agricultural History of Yakima County." (WSDA 2013) The census information does not segregate data into geographic subdivisions of Yakima County. Nevertheless, the information does reflect trends in agricultural practices within the LVTGWMA, as this area constitutes a major portion of the County's agricultural economy.

TABLE 6 - AGRICULTURAL CENSUS DATA - GENERAL CROP TYPES

Summary of Yakima County Acres Farmed--- As Reported in USDOC Agricultural Censuses (numbers rounded)				
	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 agrains 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 7 - AGRICULTURAL CENSUS DATA - FIELD CROPS

Yakima County Acres Farmed--Several Specific Crops (numbers rounded)				
	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.

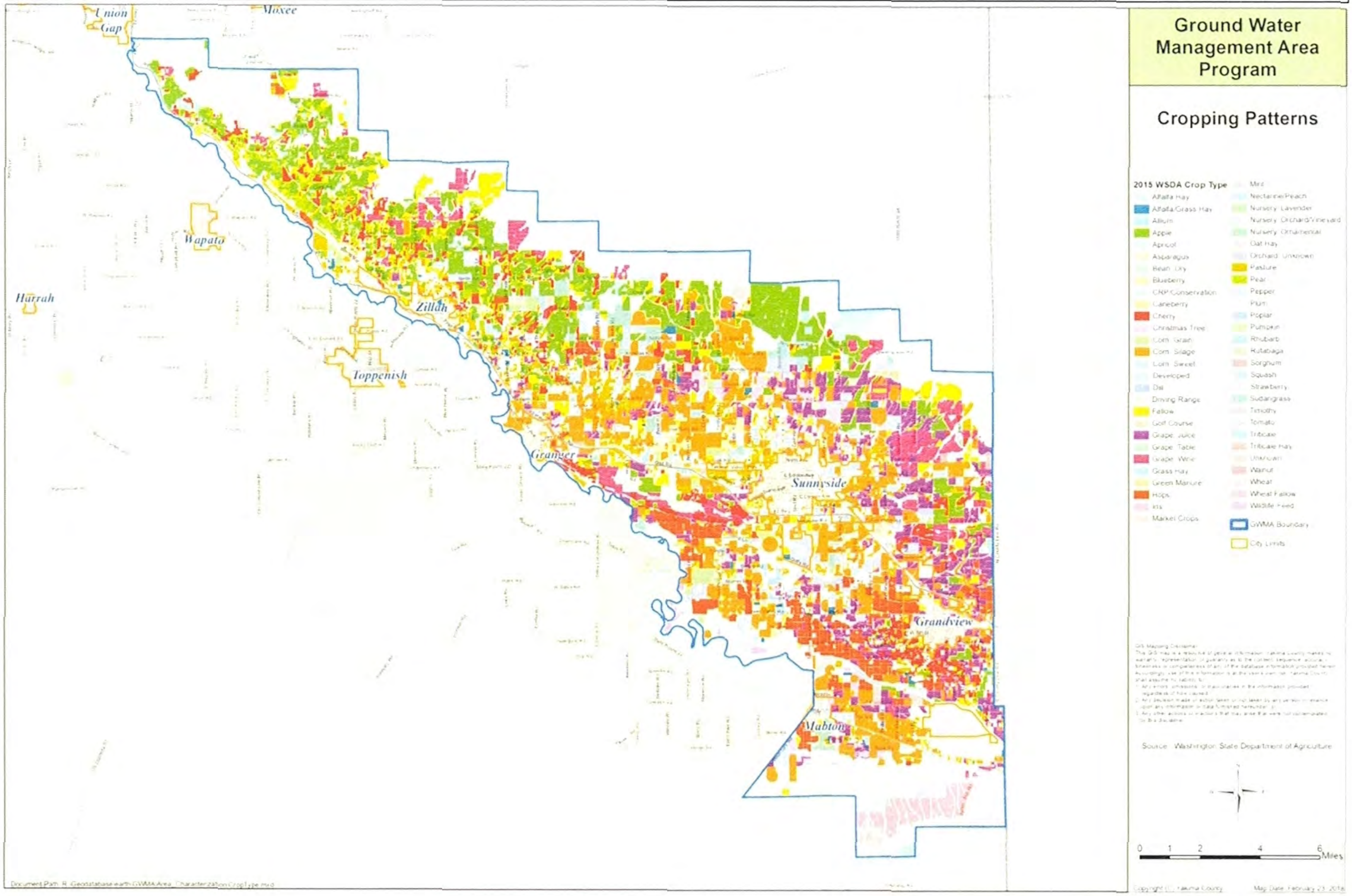
TABLE 8 - AGRICULTURAL CENSUS - LIVESTOCK

Yakima County Livestock--As Reported by USDA Census				
	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.

FIGURE 15 - LOCATIONS OF CROPS GROWN WITHIN THE LVYGWMA (2015)



A more narrow inventory, limited only to the acreage within the LYVGWMA was conducted by the Washington State Department of Agriculture. See figure 15. In 2015, the crops constituting 1 percent or more of the acreage within the GWMA were:

TABLE 9 - WSDA 2015 CROP INVENTORY WITHIN LVYGWMA

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 10 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.

203,062 farmed acres were fertilized in 1964. 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).

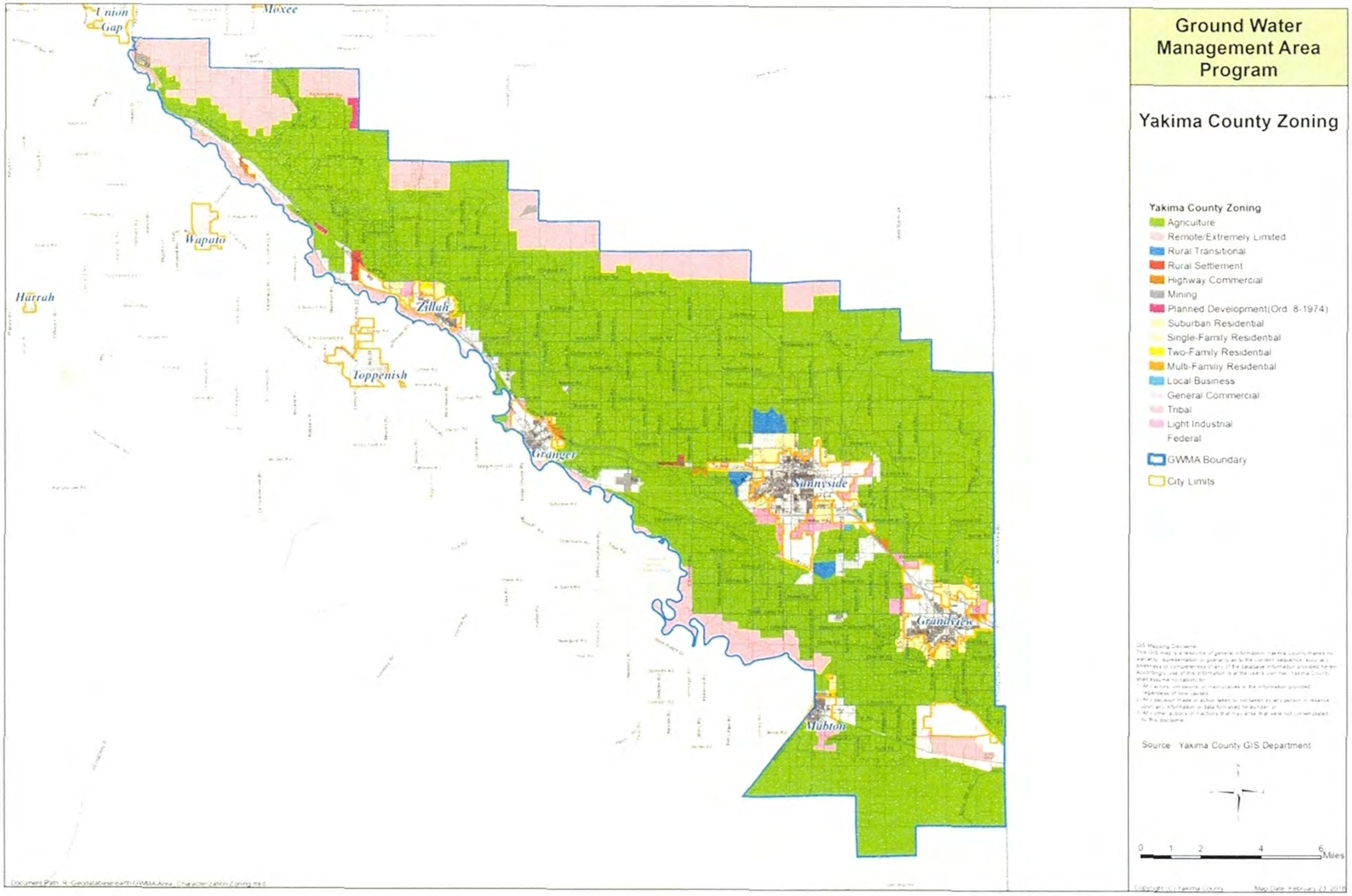
The use of synthetic (commercial) fertilizers began to increase between 1900 and 1944. After WWI, the use of chemical pesticides increased as well. WSDA's 2018 interview of commodity-specific experts to obtain a typical range of use rates for manure, compost and commercial fertilizer for each of the 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 10 - PERCENTAGE DISTRIBUTION OF COMMERCIAL, MANURE AND COMPOST FERTILIZER

Crop	Area (acres)	Commercial 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 equivalent to about 60 percent of its mean annual flow.[6] Five major reservoirs in the Cascade Mountains, with the total capacity of 1,065,400 acre-feet (ac-ft), provide 40 percent of the April to October water users' entitlements (2,490,755 ac-ft).[7]

Surface and groundwater use within the GWMA is conducted pursuant to individual water rights recognized by the Washington State Department of Ecology.

Irrigation water can also be drawn from wells. 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 as also resulted in an increase drilling of shallow domestic wells as well as 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

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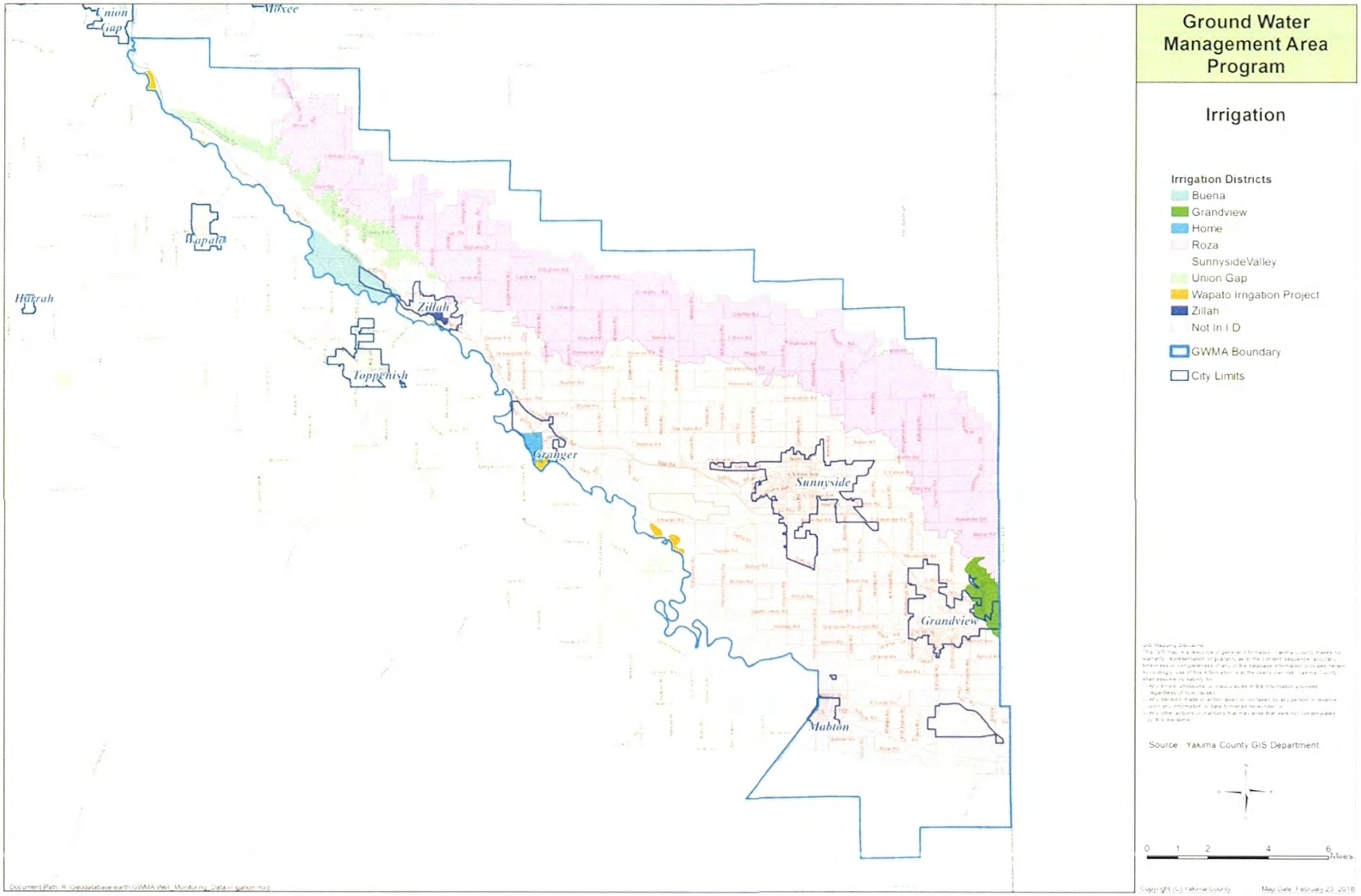
[6] The mean annual run-off of the Yakima River varies greatly; for example, 1.3 million ac-ft in 1977, the lowest water-year on record, and 4.4 million ac-ft in the abundant water year of 1999. The mean annual irrigation diversion from 1961 to 1990 was 2.2 million ac-ft. Mean annual streamflow from 1961 to 1985 was 2.6 million ac-ft at Kiona.

[7] Bumping Dam (1910, Kachess Dam (1912), Clear Creek Dam (1914), Keechelus Dam (1917), Tieton Dam (Rimrock Lake) (1925), Cle Elum Dam (1933). About 78 percent of storage capacity is in the upper arm of the Yakima River and 22 percent is in the Naches River arm.

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) serves 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) 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 of 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. (Joint Board 2009) Figure 17 shows the service areas of the SVID and RID within the LVYGWMA.

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



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 ground-water 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

Where People Live

> **Yakima County Quick Facts**
>
> - Eighth largest county in state by population: 244,654
> - 2nd largest county in State by land mass: 4,311 square miles
> - 14 Cities and Towns
> - GWMA population: 56,210
> - GWMA population living in a rural area: 19,952
>
> Source: figure derived using ARCGIS, a geographic information system, in combination with the 2010 Decennial Census. (See original text)

There are 14 cities in Yakima County. Five of those cities are in the LYV GWMA —Sunnyside, Grandview, Granger, Zillah and Mabton. Over half of the GWMA's residents live in those cities—10,158 of its 16,260 households:

- City of Sunnyside-4,556 households
- City of Grandview-3,136 Households
- City of Granger-813 Households
- City of Zillah-1,105 Households
- City of Mabton-2,548 Households

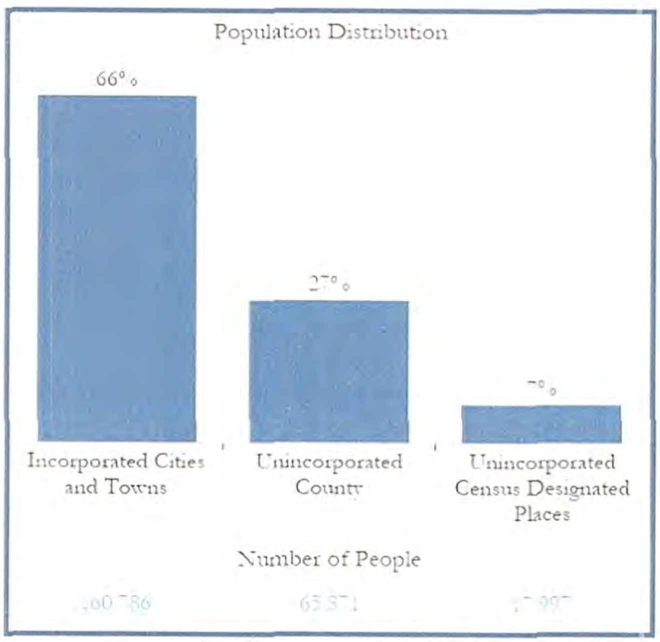


FIGURE 18 - POPULATION DISTRIBUTION

The remaining 6,511 households reside in an unincorporated area. Most of those remaining households– approximately 6,185 (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.

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.

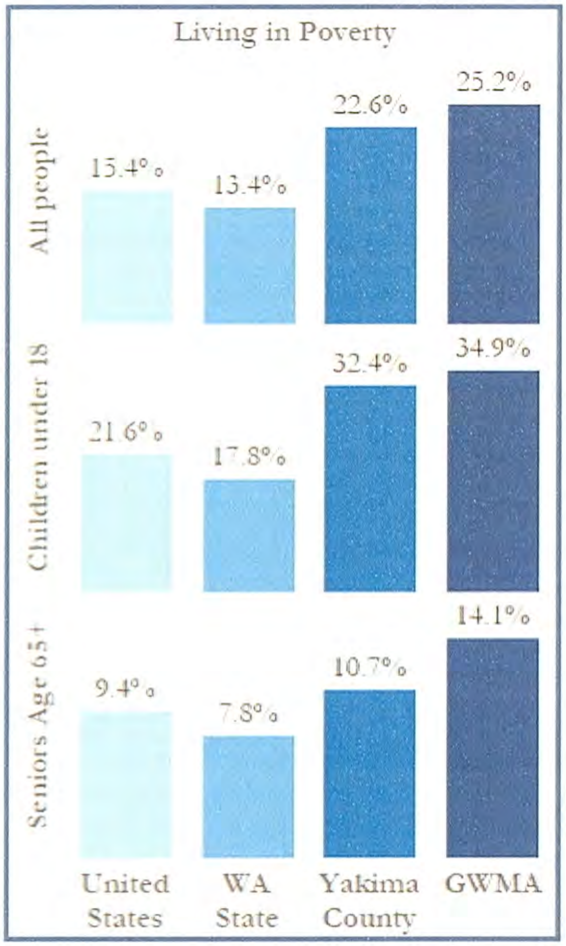


FIGURE 19 - POVERTY

However, other factors are at play in addition to affordable housing and agricultural. 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

The U.S. Census (5-Year American Community Survey for the years 2009-2013), has Yakima County's median household income at $43,506, well below the $59,478 median for Washington State. The County's per capita income was $19,433, compared to $30,742 for the State.

According to the U.S. Census (5-Year American Community Survey for the years 2009-2013), 22.6 percent of the population of Yakima County 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 [Yakima County's Comprehensive Plan, Horizon 2040-GMA Update June 2017]

FIGURE 20 - EDUCATIONAL ATTAINMENT

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.

Caution should be exercised in comparing Yakima County income to the .incomes in other parts of Washington State. Many members of the Yakima County agricultural labor pool come to the County because labor and educational opportunities and income potential are better here than their previous place of residence. Both new and permanent residents often favor rural and agricultural life style over income maximization.

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

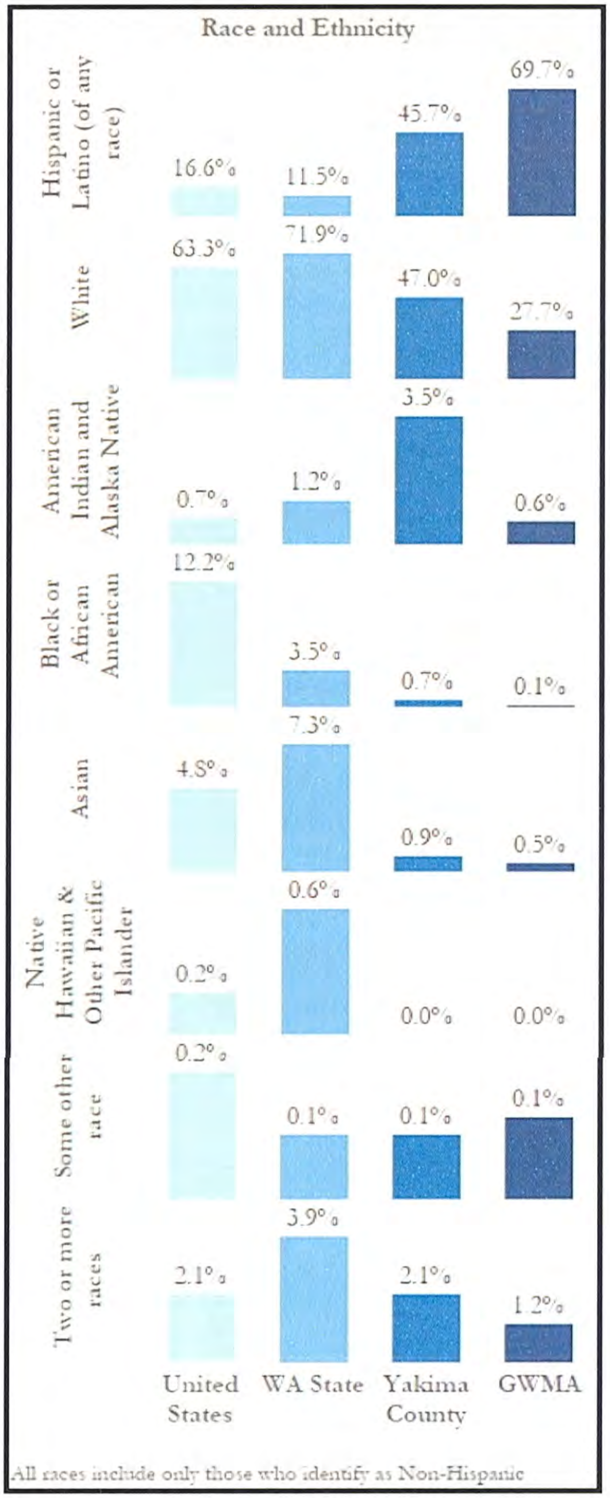


FIGURE 21 - RACE AND ETHNICITY

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.

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.

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 of the town of Harrah, which is located outside of the GWMA on the Yakama Indian Reservation.

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

> 60 percent of people in the GWMA do not speak English at home.

In Yakima County, 39.6 percent of the population over age 5 speaks a language other than English at home (predominantly Spanish). 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 five 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.

Sources of Nitrate and the Regulatory Environment

Groundwater quality in Washington is regulated by the federal Safe Drinking Water Act and Clean Water Act, the state Water Pollution Control Act and Water Resources Act and the State Department of Health's authorizing statute.

While we have attempted to make this document as readable as possible, this section contains in-depth discussion of scientific and regulatory topics. As a result, clarity of language may suffer.

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. "States are responsible for reviewing, establishing, and revising water quality standards." "States may develop water quality standards more stringent than required" by federal regulations 40 CFR § 131.4 (a). DOE has adopted Chapter 173-200 WAC, Water quality standards for groundwaters of the State of Washington. Washington's drinking water quality standard for nitrate is 10 milligrams per liter (mg/L), or 10 parts per million (ppm). State law 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.

DOE's groundwater regulations, WAC 173-200, implement Washington's Water Pollution Control Act, Ch. 90.48 RCW, and Water Resources Act of 1971, Ch. 90.54 RCW. The goal of the regulations is to maintain the highest quality of the state's groundwaters and protect existing and future beneficial uses of the groundwater through the reduction or elimination of the discharge of contaminants to the state's groundwaters. The regulations set groundwater quality standards that, together with the state's technology-based treatment requirements, seek to protect the environment, human health and existing and future beneficial uses of groundwaters. The regulations apply to all groundwaters of the state that occur in a saturated zone or stratum beneath the surface of land or below a surface water body. They do not apply to:

> (a) contaminant concentrations found in saturated soils where those contaminants are chemicals or nutrients that have been applied at agronomic rates for agricultural purposes if those contaminants will not cause pollution of any groundwaters below the root zone;
>
> (b) contaminant concentrations found in saturated soils where those contaminants are constituents that have been applied at approved rates and under approved methods of land treatment if those contaminants will not cause pollution of any groundwaters below the root zone; or
>
> (c) clean up actions approved by the Department under the Model Toxics Control Act, ch. 70.105D RCW, or approved by the United States Environmental Protection Agency under the Comprehensive Environmental Response Compensation and Liability Act, 42 U.S.C. 9601 et seq., WAC 173-200-010.

WAC 173-200-040 (2) establishes "groundwater concentrations" that groundwaters of the state may not exceed. Nitrate concentrations in groundwater may not exceed 10 mg/L. WAC 173-200-040 (2) (Table 1).

> No person shall engage in any activity that violates or causes the violation of [ch. 173-200 WAC]." WAC 173-200-100 (2).

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.

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 "wilfull," 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.

Clean Water Act

The Clean Water Act, 33 U.S.C. §1251 et seq., establishes the basic structure for regulating discharges of pollutants into the waters of the United States. Under the Clean Water Act, states develop water quality standards to protect waters of the U.S. and EPA approves those standards. The standards are comprised of: criteria, designated uses and antidegredation. Those standards are used to establish effluent limits in NPDES permits. If standards are not being attained in a water body, then the states must add the water body to their §303(d) impaired water body list and develop total maximum daily loads, "TMDLs," for the water body. These TMDL's should set forth an implementation plan for ultimately achieving water quality standards in the impaired water body. 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) NPDES permitting authority has been delegated to the DOE. (33 U.S.C. 1342 (b)).

The DOE is the primary agency in Washington State responsible for the protection of both ground and surface water quality. DOE's Water Quality Program operates primarily pursuant to the Water Pollution Control Act, Chapter 90.48 RCW. The Act 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)

DOE may implement measures to protect both ground and surface waters from pollutants, and has established regulations for the protection of ground and surface water quality, permitting of discharging activities, and financing of water quality protection activities. This regulation lists numerical limits for specific contaminants ("water quality criteria") that apply to all groundwaters in the state. These criteria are used when evaluating the performance of permitted discharge activities (such as sprayfields and holding ponds), implemented best management practices, or when conducting clean-up activities at historical or current waste sites.

DOE's water quality standards incorporate an "antidegradation policy," an otherwise existing part of state water quality law (WAC 173-200-030). This policy forbids 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. Washington's water quality standards are enforceable through DOE's actions. 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).

DOE's water quality standards 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.

DOE's permits describe penalty provisions which may be put into effect if discharge limitations (or other conditions specified in the permit) are not met. DOE has the enforcement discretion to impose those penalties.

"General permits" 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 have been issued to industries and municipalities for treated discharges into surface waters such as Sulphur Creek Wasteway or the Yakima River.

General permits establish standards for management. The standards apply to all underground waters in the saturated zone (generally at or below the water table), but do not apply in the root zone of saturated soils where agricultural pesticides and nutrients have been applied at agronomic rates for agricultural purposes and pollution does not occur below the root zone. (WAC 173.200.010(3)(a)).

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))

Currently, the permit framework is reactive, a permit is not required unless there is or was a documented discharge to surface waters. The permitting process now requires a facility to submit a complete Nutrient Management Plan with the permit application. The Nutrient Management Plan is approved by DOE and becomes the facility's effluent limitation. After a facility is permitted, it must submit an updated Nutrient Management Plan if it wants to make changes to its operation.

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 program—a program that relates to discharges to surface water only.

State Department of Health

DOH 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.

DOH 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).

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)

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 that can be used as fertilizers or soil conditioners may be the disposal of solid waste.

Irrigated Agriculture

There are 360,906 acres of crops in Yakima County. 96,459 (27 percent) of those acres 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.

Anecdotal information provided by members of the GWMA's Irrigated Agriculture Working Group indicates that growers do not want to over-irrigate and have disincentives to over-applying commercial fertilizers.

The native organic matter content of lower Yakima soils is around one percent but when these soils have a history of organic inputs such as manure, there can be an increase in organic matter levels of two to three percent. In general, organic matter in soils can mineralize to provide between 20 and 65 lbs N per one percent organic matter for crop utilization.

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 "double-cropped" (two crops in one growing year). 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-September).

Alfalfa is also planted. Alfalfa is a complex perennial crop. It removes large quantities of nutrients from the soil (Pacific Northwest Extension Publication PNW0611). 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 and will use 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.

Based on a DOE survey during 1998-2003, 29 percent of the irrigated acres in the Granger drainage and 12 percent in the Sulphur drainage were owned by dairies (Laurie Crowe, South Yakima Conservation District, personal communication, February 2004) and there were 20, 24, 2, and 0 dairies in Granger, Sulphur, Spring and Snipes drainages, respectively. (RSJB 2009).

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. 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.

Tree Fruit and Vegetable Crops

The other main crops 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 permanent crops.

Fertilizers

Fertilizers available within the GWMA include commercial fertilizer, manure, or compost. 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.

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.

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.)

Generally speaking, 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 ground waters. Cf. WAC 16-611-010.

Further information should be developed about the use of each of the three fertilization materials, as well as information about application timing and specific application site characterization prior to application.

Crops Supporting Livestock Operations

Annual crops such as silage corn, triticale (for silage) and wheat use both commercial nitrogen and manure throughout the GWMA. 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.

Tree Fruit and Vegetable Crops

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.

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.

Although livestock wastes contain low concentrations of nitrogen 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 GWMA. Anecdotal evidence suggests that the form of synthetic fertilizers has shifted, generally, from dry, granulated fertilizers to liquid fertilizers capable of simultaneous application with irrigation water ("fertigation").

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.

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.

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).

The irrigation water nitrogen input is unique to each commodity. 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.)

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

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.

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.

Livestock Operations/CAFOs and Groundwater Quality Regulation

Dairy Operations

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

Manure and other animal wastes supply nutrients to crops because they contain nitrogen and other elements essential to plant growth, and that 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. Manure 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)

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 (EPA, 2012c, 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) + ((# of heifers)*0.97*56) + ((# of calves *0.33*83)]*365/2000 (WSDA 2010)
>
> Nitrogen production is calculated using the following formula: [((# of milking cows)*1.4*.71) + ((# 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.

The effects of livestock operations on groundwater quality are addressed through the Clean Water Act's regulations and Washington's Dairy Nutrient Management Act. DOE has authority under Washington's Water Pollution Control Act to enforce the Clean Water Act. Voluntary financial and technical assistance programs are available from the National Resource Conservation Service to eligible landowners and agricultural producers to help them manage natural resources in a sustainable manner.

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 GWMA's Livestock/CAFO Working Group found consensus that DNMPs are important tools for managing nitrate concentrations in groundwater within the GWMA but was unable to reach consensus whether alternative or additional regulatory approaches should be implemented.

Concentrated Animal Feeding Operations

The Clean Water Act's regulations (40 CFR, Part 122) define dairies with 750 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, approves the nutrient management plan that is required under the permit and is responsible for enforcing the permit.

In Washington, the NPDES permit program, including the CAFO permit, is the responsibility of the DOE. On February 3, 2017, the DOE announced its reissuance of a new CAFO NPDES and a new State Waste Discharge (SWD) General Permit. These permits became effective on March 3, 2017, and expire March 2, 2022. They were reissued as two separate permits, the CAFO SWD General Permit (state permit) and the CAFO NPDES and SWD General Permit (combined permit). 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 state permit conditionally authorizes discharges to groundwater only. The combined permit conditionally authorizes discharges to surface and groundwater, including agricultural stormwater. Coverage under a general permit will be available to facilities that meet the definition of a CAFO and that have a discharge or that voluntarily apply for permit coverage.

The CAFO permit requires large-scale livestock operations in Washington to implement specific practices to better protect groundwater, rivers, lakes and marine waters from manure pollution. Discharges conditionally authorized by the CAFO permit must not cause or contribute to a violation of water quality standards.

The DOE has the authority to decide when a facility is required to apply for a permit, approves the nutrient management plan that is required under the permit and is responsible for enforcing the permit. DOE issued a CAFO General permit in 2006 that covered five of the 69 dairies in Yakima

County. None of the 11 small or medium sized dairies in the county were considered CAFOs and were not covered by the prior CAFO permit.

The permittee is 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 except when:

> 1. Precipitation events cause an overflow of manure, litter, feed, process wastewater, or other organic by-product management and storage facilities which are designed, constructed, operated, and maintained to contain all manure, litter, feed, process wastewater, and other organic by-products including the contaminated runoff and direct precipitation from a 25-year, 24-hour rainfall event for the location of the facility and still have lagoon design freeboard;
>
> And,
>
> 2. The production area is operated in accordance with the applicable inspection, maintenance, recordkeeping, and reporting requirements of this permit.

Also, a permittee is prohibited by the permit from discharging manure, litter, feed, process wastewater, or other organic by-products from their land application fields, unless the discharge is generated only by precipitation, not caused by human activities during the precipitation, and the permittee is otherwise in compliance with the permit. The permit establishes production area runoff controls, including the requirement that the permittee must keep manure, litter, and process wastewater from being tracked out onto public roadways. If manure, litter, process wastewater, or other sources of pollutants are tracked out onto public roadways, the permittee must clean-up the material tracked onto the roadway.

The permit establishes conditions related to solid manure, litter, and feed storage, composting facilities, above and below-ground infrastructure, diversion of clean water, prevention of direct contact between animals and water, handling of chemicals, management of dead animals, sampling and analysis of manure, litter, process wastewater, and other organic by-products, and soil sampling.

The permittee must land-apply manure, litter, process wastewater, or other organic by-products in accordance with their yearly field nutrient budgets and at the appropriate rates and times. If the permittee generates more manure, litter, process wastewater, or other organic by-products than the land application fields available to the permittee can appropriately utilize according to their yearly field nutrient budgets, the permittee must find other avenues of appropriately utilizing the excess manure, litter, process wastewater, or other organic by-products e.g., export, composting. The permittee's staff must have sufficient training to be able to land apply in accordance with the yearly field nutrient budgets and at appropriate rates and times to comply with permit conditions.

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

The GWMA's Livestock/CAFO Working Group found consensus that the DOE's reissued CAFO permits are an affirmative action in addressing groundwater nitrate concentrations within the GWMA, but did not find consensus whether the conditions contained in the reissued CAFO permits are overly, satisfactorily, or insufficiently restrictive.

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. 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" efforts that the Department accomplishes through its administrative activities under its Dairy Nutrient Management Program.

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).

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 can be hard to clarify. 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.

Different industry experts classify impoundments based on different 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, which would make using permeabilities for a clay lined impoundment inappropriate.

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.

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.

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). 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 and management of the amount of manures in those pens. 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.

Management practices are required 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

"Composting," which as a term 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.

WSDA, although it does not regulate dairy waste composting, reports that a number of dairies compost their manure on site. 30 percent to 40 percent of that composted material is exported out of Yakima Valley. Limiting factors are the costs of processing and loading. Generally, liquids are applied close to dairies, solids can be transported mid-range and compost may be moved further, due to weight reduction.

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.

Administration and Enforcement

The 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 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 DNMA does not authorize the WSDA to compel nutrient management consistent with dairy nutrient management plans, Washington's Water Pollution Control Act authorizes the 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)

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. 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.

Washington's Water Pollution Control Act authorizes the 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)

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 2009. 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.

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.

Residential, Commercial, Industrial and Municipal Groundwater Quality Regulation

Residential and non-residential Onsite Sewage Systems (OSS) are present throughout the Lower Yakima Valley Ground Water Management Area (LYV GWMA) outside of those areas served by municipal sewage collection and treatment systems. Outside of the municipal sewage systems, OSS provide some level of sewage treatment and disposal for both residential and non-residential activities. Residential OSS are especially common in and near the urban growth boundaries of many of the valley's municipalities. Non-residential OSS are scattered throughout the project area serving a variety of public and private entities. OSS comprise one of the several potential sources contributing nitrate-N to the underlying shallow alluvial groundwater system.

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

Residential Onsite Sewage Systems (ROSS)

Residential Onsite Sewage Systems (OSS) are present throughout the Lower Yakima Valley Ground Water Management Area (LYV GWMA) 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 and public and private entities. OSS comprise one of the several potential sources contributing nitrate-N to the underlying shallow alluvial groundwater system.

"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. Information about the septic system should be disclosed to any future buyer of the property.

There are 6,044 residential households within the GWMA that discharge wastewater to an onsite sewage system. 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.

Density of 1-10 ROSS per section are considered to be low density, 11-40 ROSS per section is considered medium density, and over 40 ROSS per section are considered to be high density by the EPA.

The absence of public water systems in some rural areas where OSS density exists, due in part to the date of development of these areas, cause there to be problems of septic system-drinking water well proximity. 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. In a comparative case, that of the Buena community, 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.

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 adsorption 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 20 percent. The projected nitrogen removal of properly operating innovative ROSS technology could be up to 50 percent.

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. It is reasonable to assume that the environmental conditions underlying the drain fields are conducive to some level of denitrification.

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).

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. 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 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.

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.

TABLE 11 - (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 acre	12,500 sq. ft.	15,000 sq. ft.	18,000 sq. ft.	20,000 sq. ft.	22,000 sq. ft.
	2.5 acres					
Individual, on each lot	1.0 acre	1 acre	1 acre	1 acre	2 acres	2 acres
	2.5 acres					

TABLE 12 -(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.

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.

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.

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.

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. Application rates require advance approval based on pre-plant soil tests, evaluation of crop type and yield estimates, soil types, use of irrigation. Intermittent post-harvest tests are also conducted. 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. Application rates require advance approval. Intermittent post-harvest tests are also conducted. The single site approved for land application of biosolids within the GWMA is Natural Selection Farms, 6800 Emerald Road, Sunnyside. Yakima County also receives some biosolids and County landfills.

Residential Lawn Fertilizers

Residential lawns exist primarily within towns or urban growth areas within the GWMA. Anecdotal evidence indicates that not all residents fertilize their lawn regularly, and 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.

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"

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.

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

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.

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).

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 data base 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 data base 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.

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).

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.

"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) 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.

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.

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).

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

Environmental Effects

Nitrate

Nitrate is an acute contaminant. It is colorless and odorless. It is found in most fertilizers, manure, liquid waste from septic tanks, and food processing waste. Rain 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)

Attenuation, Soils and Climate

Attenuation of nitrogen in Lower Yakima Valley soils, or the gradual loss in intensity of the amount of nitrates in flux through the soil profile, depends upon the specific type and condition of the local soils, micro-environment and, where the overlying property is farmed, the particular horticultural variety being farmed. Attenuation is more likely in the near-surface root zone of agricultural activities than in the deeper soils or deeper geologic strata.

Health Effects to People and Animals

Exposure to excessive nitrate concentrations can reduce the ability of red blood cells to carry oxygen. (Harter 2012) 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, but there have been no deaths reported by medical professionals within the GWMA since it was established.

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 "Investigation and Analysis"

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 (10 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. However, no direct correlation has been established between nitrogen in groundwater and nitrogen in the Yakima River.

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.

Ecology has proposed three TMDL projects within the Lower Yakima River area. Two have been approved by the EPA. The third is in development. 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 are:

- Establishment of a reliable, safe drinking water source for residents within the LYVGWMA.
- Improvement of the general condition of nitrate contamination of groundwater to a condition compliant with Washington State water quality standards.
- Reduction of the number of incidents of measured exceedance of Washington State water quality standards.

Investigation and Analysis

Investigation

The GWMA project is a multi-agency, citizen-based, coordinated effort to reduce groundwater nitrate concentrations in the Lower Yakima Valley to below Washington State drinking water standards. To achieve this goal, activities contributing to elevated groundwater nitrate concentrations must be identified. The GWAC Work Plan identified the following tasks to be undertaken:

- Characterize the nature and extent of nitrate concentrations in Lower Yakima Valley groundwater.
- 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.
- 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.
- Establish a monitoring program to identify sources of nitrate contamination and their relative importance.
- Establish and conduct a long-term groundwater quality monitoring program and evaluate progress.

Regulatory Framework

The GWAC first identified applicable local, state, and federal regulatory requirements that control and manage nitrates in groundwater. These were integrated into the discussion of Sources of Nitrate in this document.

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.

In other words, a successful GWMA Program would require an informed and field-tested educational strategy, but a successful strategy could not be defined without the groundwork laid during Program development. It would be the success (or failures) of educational efforts during Program development that would ultimately determine how to engage the public in the GWMA Program, how to implement proposed educational alternatives, and how to measure the success of multiple milestones across 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 LYV GWMA 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 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.

While the Nitrate Treatment Program illustrated the challenge of communicating complex messages to a discrete, hard-to-reach audience, 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.

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 map 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.

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. 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 were 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 would 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 includes wells that already have pumps (private, public, and irrigation supply wells) and monitoring wells that require use of sampling pumps. Groundwater samples were 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.

Drinking Water Quality Testing Program

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. 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).

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. Data collected from the project is essentially anecdotal. However, 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. [Amend after receiving analysis from Ginni Stern.]

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 draft report in 2017, 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.

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. The penultimate draft of the report (4/26/18) listed the low, medium and high estimates for irrigated agriculture with specific numeric values.

TABLE 13 - 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

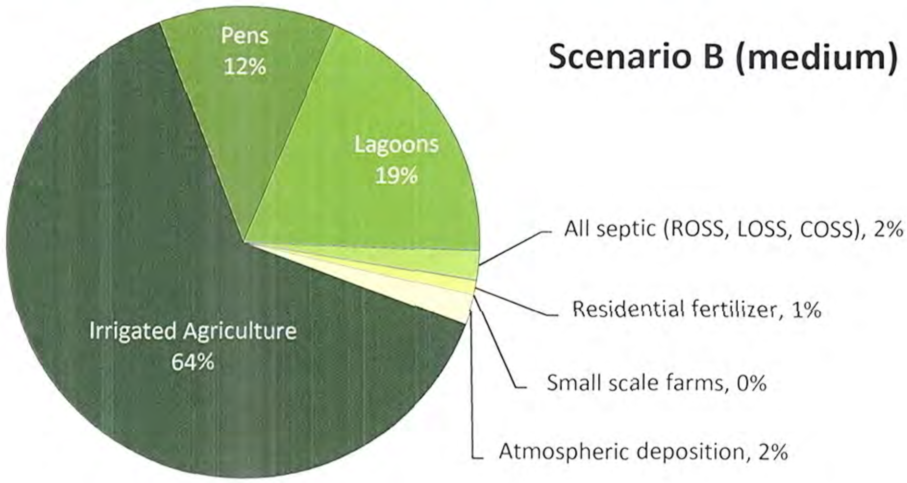
WSDA's 4/26/2018 draft of the report also listed the low, medium and high estimates for the other nitrogen use categories:

TABLE 14 – 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, one percent to residential fertilizers and less than one percent to small scale farms.

FIGURE 22 - PERCENT OF TOTAL N AVAILABLE BY SOURCE (WSDA)



Selecting the WSDA's "medium"[8] 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.

[8] The "medium" nitrogen availability is 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 15 - 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.

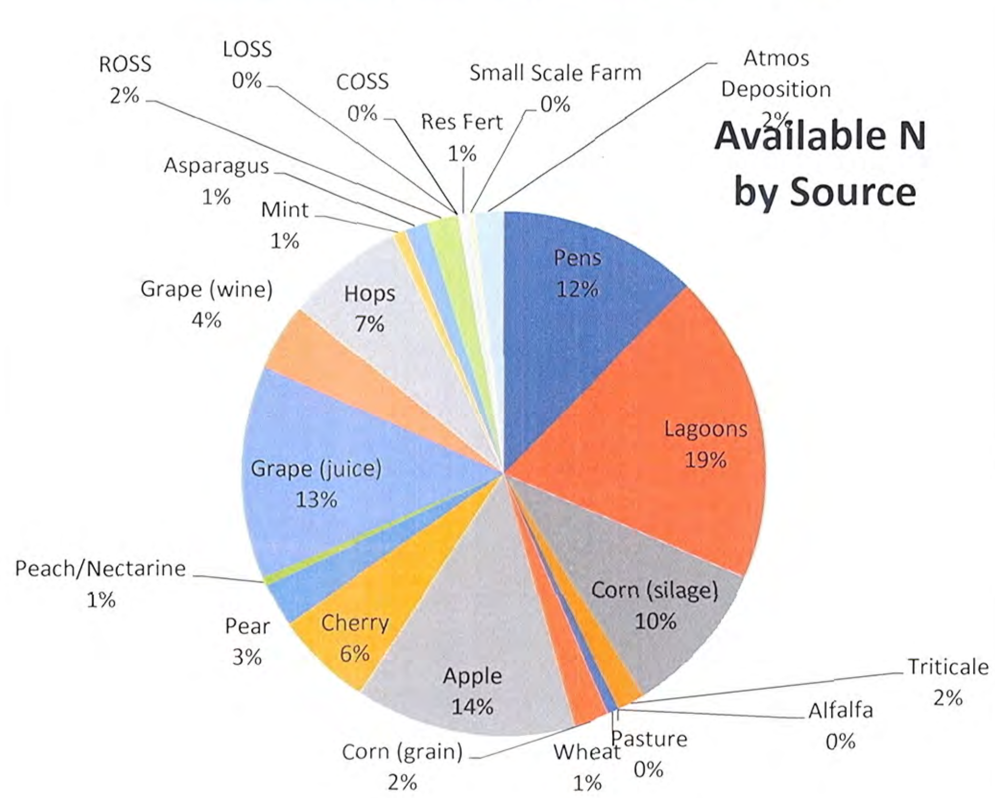
TABLE 16 - TOTAL ACREAGE FOR N AVAILABILITY COMPUTATIONS

	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 23 - NITROGEN AVAILABLE BY SPECIFIC SOURCE



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

TABLE 17 - NITROGEN AVAILABILITY ASSEMBLED BY INDUSTRY GROUP

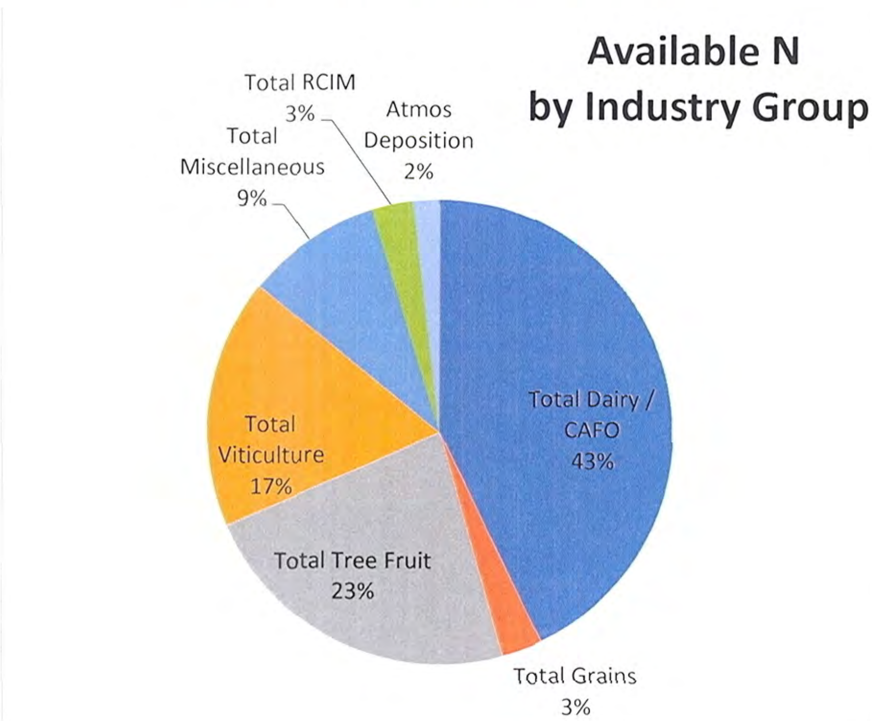
Nitrogen Availability by Industry Group				
	Acres	Medium N (lbs/ac/yr)	Total N Medium (lbs/yr)	Total N Medium (tons/yr)
Pens	2,096.0	480.0	1,006,080.0	503.04
Lagoons	*210.0*	*7,448.0*	*1,564,080.0*	*782.04*
Corn (silage)	16,778.0	47.0	788,566.0	394.28
Triticale	10,780.0	13.0	140,140.0	70.07
Alfalfa	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 Depositior	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 18 - 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 24 - NITROGEN AVAILABLE BY INDUSTRY



Mean Annual Groundwater Recharge Study

Understanding mean annual groundwater recharge is an important component of understanding potential causes of nitrate concentrations within the GWMA. The modeled estimates of mean annual groundwater recharge should be determined utilizing the approach taken by USGS 2007(a) with 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 should also be refined to as 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 that could be "overlaid" to evaluate structural or causal relationship between various data, events or outcomes.

Correlation of Source and Measured Well Contamination

Above, we have identified the possible sources of nitrate contamination including:

- General legacy agricultural activity
- Current irrigated agriculture, including crops supporting livestock operations and tree fruit and vegetable crops
- Current organic and chemical fertilizers supporting livestock operations and tree fruit and vegetable crops
- Current livestock/CAFO operations utilizing dairy, feeding, waste facility, animal holding in corrals or pens, composting areas, or buildings housing animals

- Current residential, commercial, industrial and municipal sources including residential on-site sewage systems, large on-site sewage systems, commercial onsite sewage systems, biosolids, residential lawn fertilizers, and "hobby farms"
- Underground injection wells
- Air deposition

We have also identified possible transporters of nitrogen including:

- Abandoned or improperly constructed or decommissioned water supply wells
- Irrigation supply canals
- Irrigation water applications
- Irrigation waste water drains
- Groundwater flow

And we have noted the uncertainties important to clear understanding of groundwater movement: gravity, porosity of soils, hydraulic conductivity, intervening matrix variation, seasonal influence of irrigation supply-induced groundwater pressures, seasonal influence of groundwater flushing or dilution.

The beauty (and difficulty) of what we know about the underground environment is that we do not know what we do not know. And yet we know a lot. The GWAC transpired during a phase of litigation in which particular liability for particular groundwater contamination was explored. The effect of that litigation, however, was to stifle the willingness of agriculturalists to contribute information to source identification. GWAC was thus presented with the question: "If you don't know what it is that you don't know, how can you possibly find it?"

It seems logical that correlation between source and well contamination depends upon volume (concentration) of source material, moving agent, proximity/distance, together with the characteristics of the intervening matrix. However, as with John Godfrey Saxe's elephant-seeking, blind theologians, six independent theses of explanation of the elephant will not suffice alone to describe the beast. The LYVGWMA's water contamination problem appears to have a consortium of plausible and interactive causes, no one being the single trunk, ear or leg of the elephant.

> It was six men of Indostan
> To learning much inclined,
> Who went to see the Elephant
> (Though all of them were blind),

However, lest we "Rail on in utter ignorance," it is better to understand the trunk, ear or leg, even though the elephant may not be known.

It is not possible to correlate general legacy agricultural activity with specific site groundwater contamination due to the change over time in crop type, irrigation, fertilization, tillage or other agricultural practices, density of use, climate or other factors. Only in one respect is the legacy factor consistent, that being the application of irrigation water in significant volume since approximately 1920.

The easiest example of correlation is that between density of septic tanks and groundwater contamination. Septic tanks are the easy case because of the short underground distance between cause and effect. In many of its case studies, EPA found that as onsite septic (sewer) system (OSS) density increased, so did groundwater contamination, particularly after reaching 40 OSS per section. Yakima County's GIS maps do seem to suggest some correlation between source (septic tanks) and effect (water wells testing high in nitrates), particularly where a high density of OSS can be located, such as *urban growth areas and rural roads leading into population centers.* Drain fields are directed to be located in soils that have good drainage. Soil must "percolate" as a requirement of septic system siting. Systems must be designed to release waste water below the root zone, so little nitrogen is taken up by surface plantings. About 65 percent of the waste water nitrogen remains untreated by septic systems and arrives at below the root zone together with the drain field water.

Where the distance and the volume of moving agent (water) are greater, there are more unknowns in the hydrogeology between the putative cause and known effect. So, correlations are more conjectural. Nevertheless, they can be hypothesized and accepted/rejected based on what else is known or unknown.

The GIS maps presented below suggest some correlation between some areas of a given source, e.g., densely-farmed (double-cropped), heavily-fertilized dairy or irrigated agriculture, or densely-sited septic systems, and the effect (water wells testing high in nitrates). But direct correlation depends upon certain awareness of intervening hydrogeologic condition. It does appear that high nitrogen availability and down-gradient well contamination do correlate.

Different questions arise, however, when making a correlation between surface application of nitrogen at the time of planting with a controlled water application, if in fact irrigated agriculturalists are utilizing agronomic rates. In the perfect case, there would be no extra nitrogen available for leaching, as the botanical needs of the crop will have fully consumed the added supply of nitrogen. It is not known whether nitrogen becomes bound up with organic matter, in which case it may not move much.

The WSDA's Nitrogen Availability Assessment (WSDA 2018) contained information about a number of sources of nitrogen that may be available to descend 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 25.) The USGS 2017 well test data was then mapped and laid atop the map of total nitrogen availability. (Figure 26.) 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. (Figure 27.)

FIGURE 25 - TOTAL NITROGEN AVAILABLE

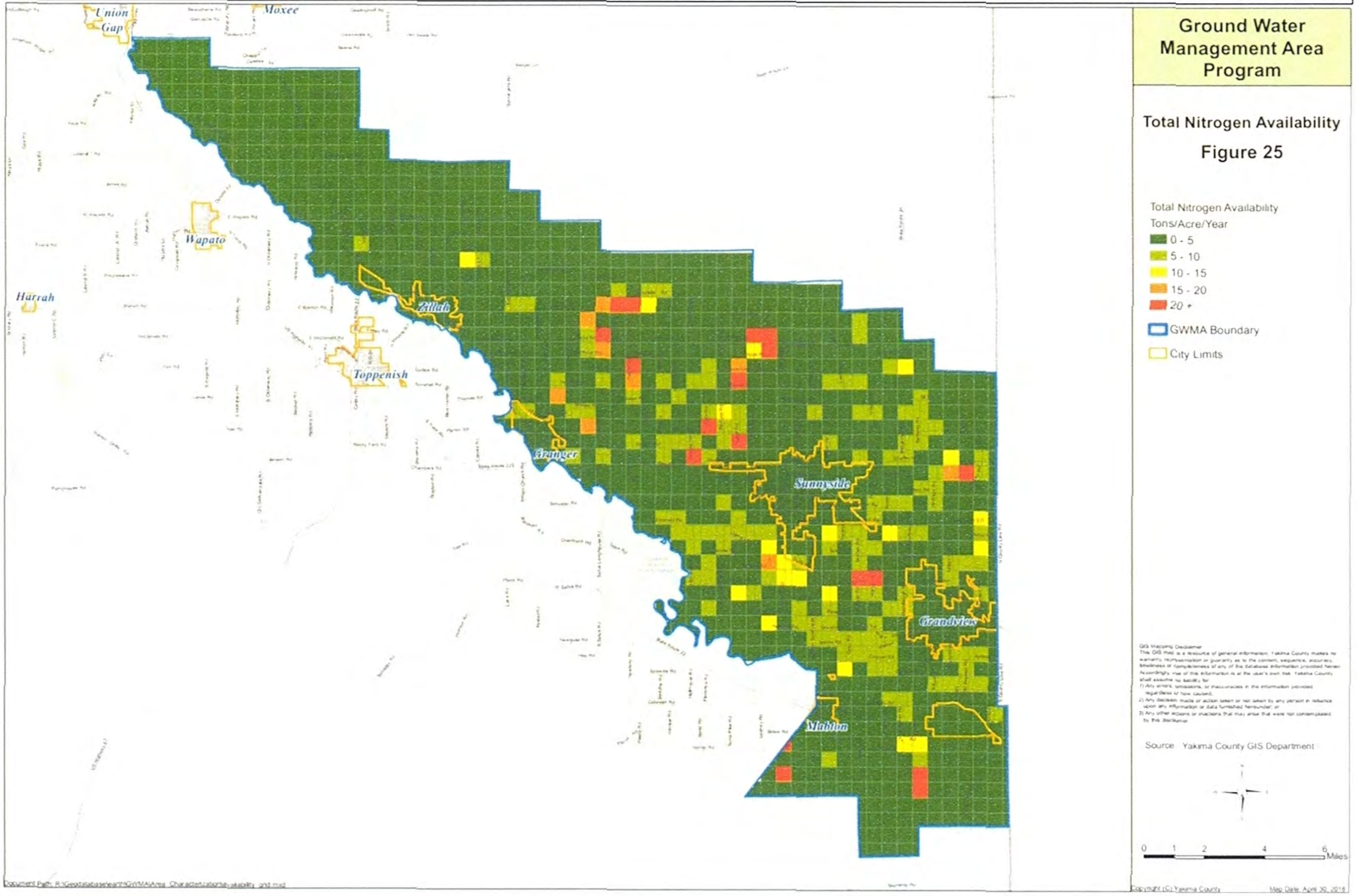


FIGURE 26 - OVERLAY OF TOTAL NITROGEN AVAILABILITY AND GROUNDWATER WELLS

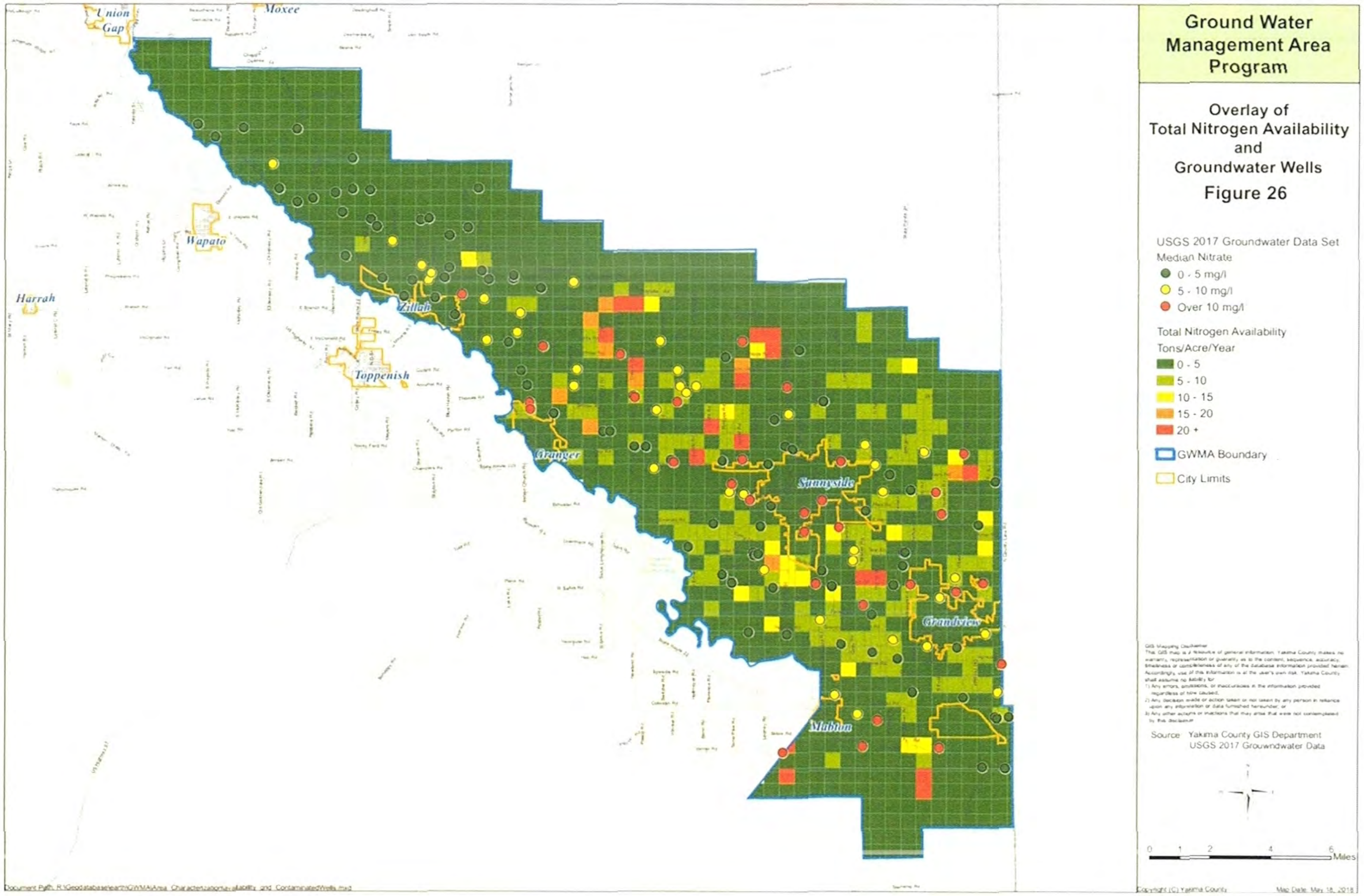


FIGURE 27 - USGS WELL DATA OVERLAID ON SOIL TYPES

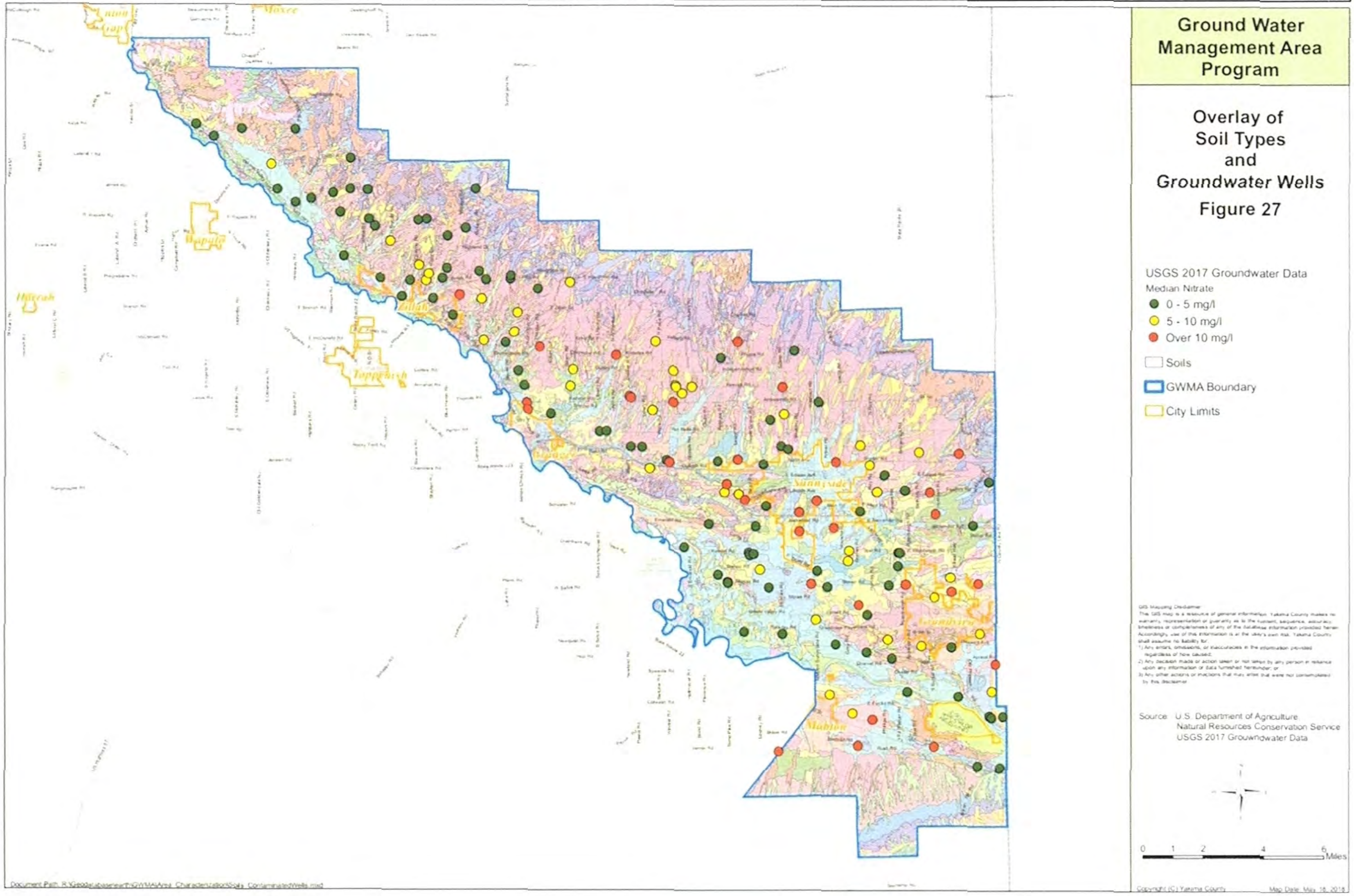


FIGURE 28 - USGS WELL DATA OVERLAID ON SOIL TYPES SIMPLIFIED BY HYDRAULIC CONDUCTIVITY GROUPS

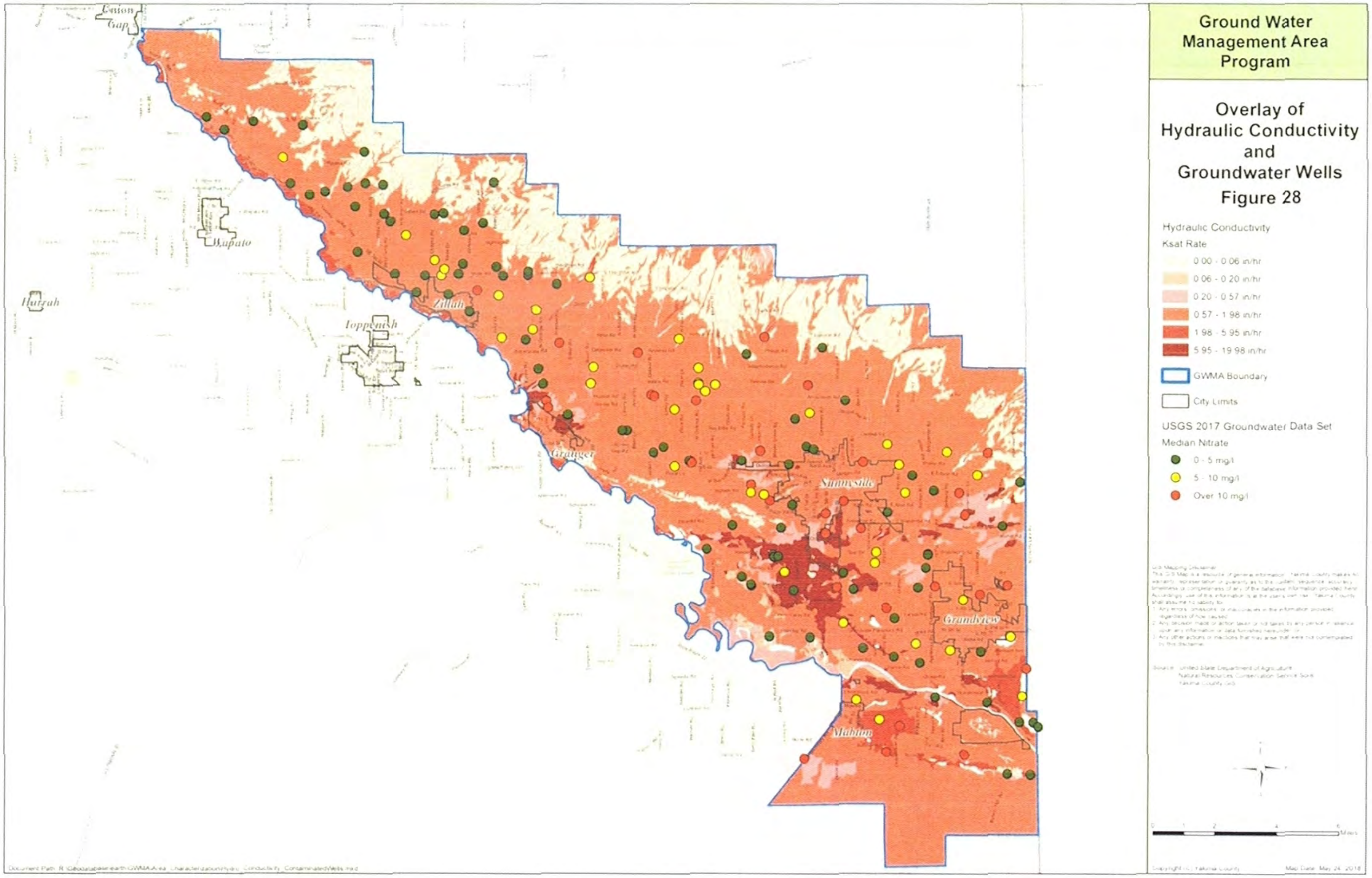


FIGURE 29 - USGS WELL DATA OVERLAID ON IRRIGATION CANAL AND DRAIN INFORMATION

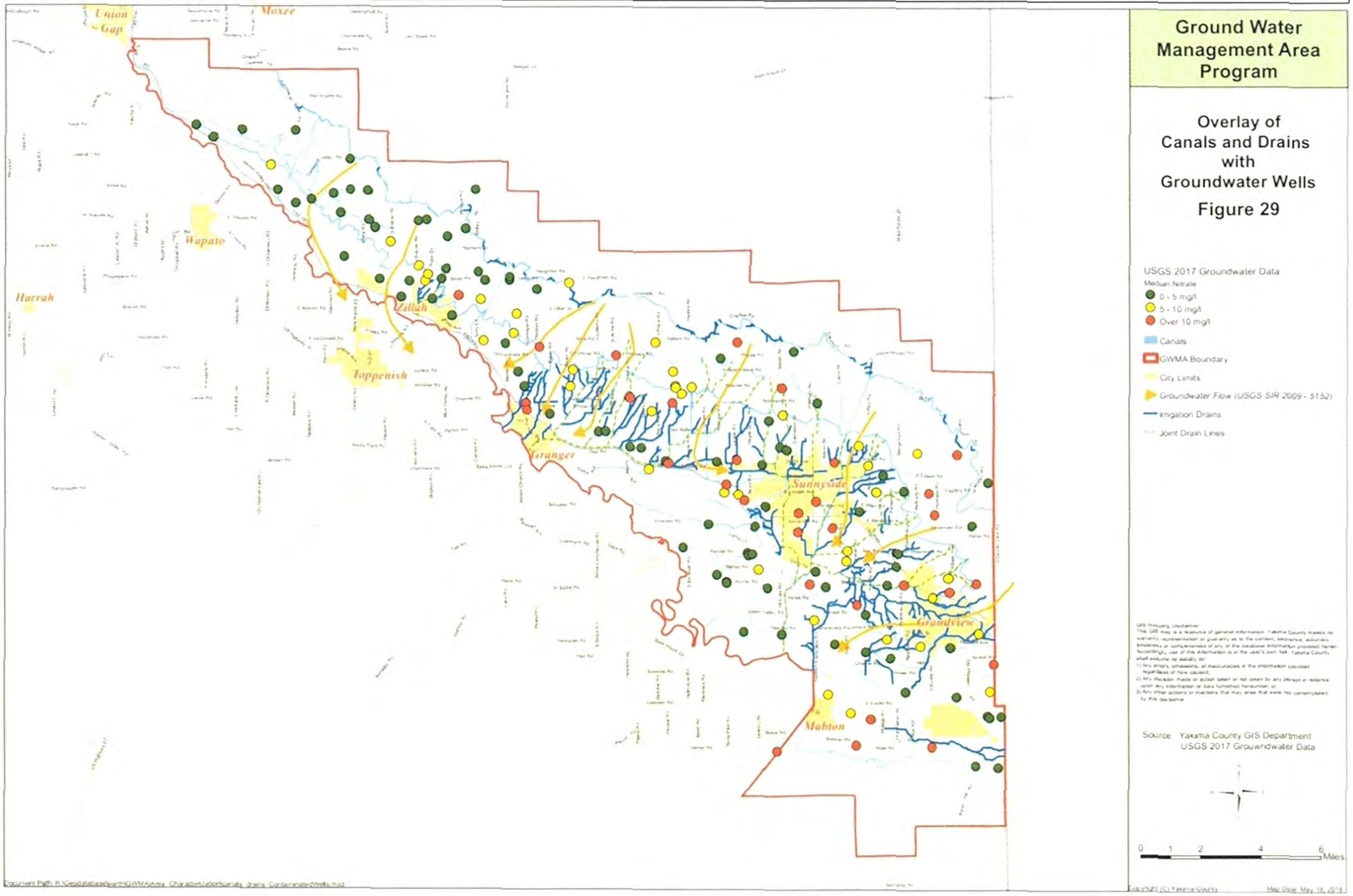


FIGURE 30 - USGS WELL DATA OVERLAID ON CROPPING PATTERNS

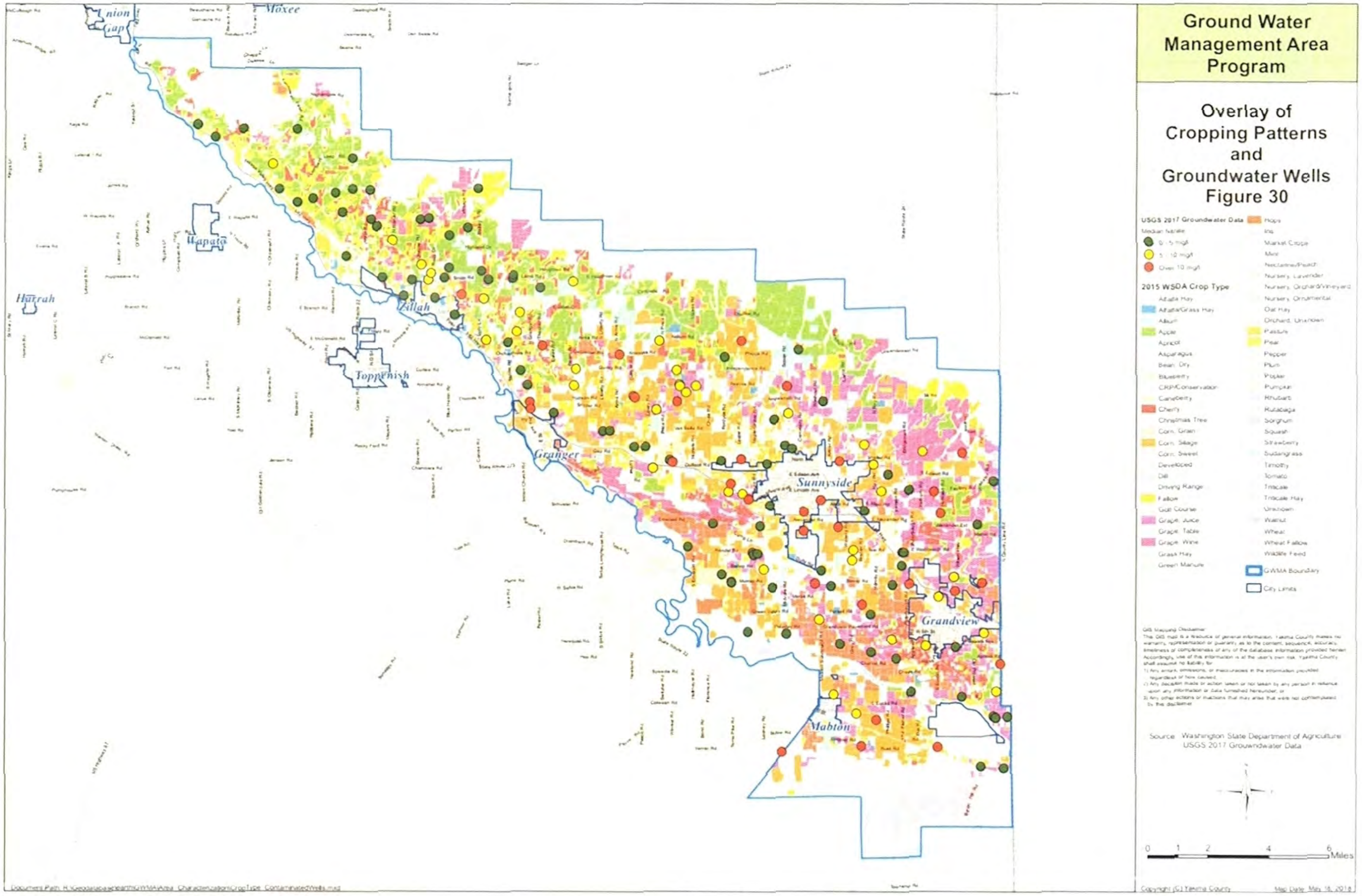


FIGURE 31 - USGS WELL DATA OVERLAID ON MAP OF POINT SOURCES

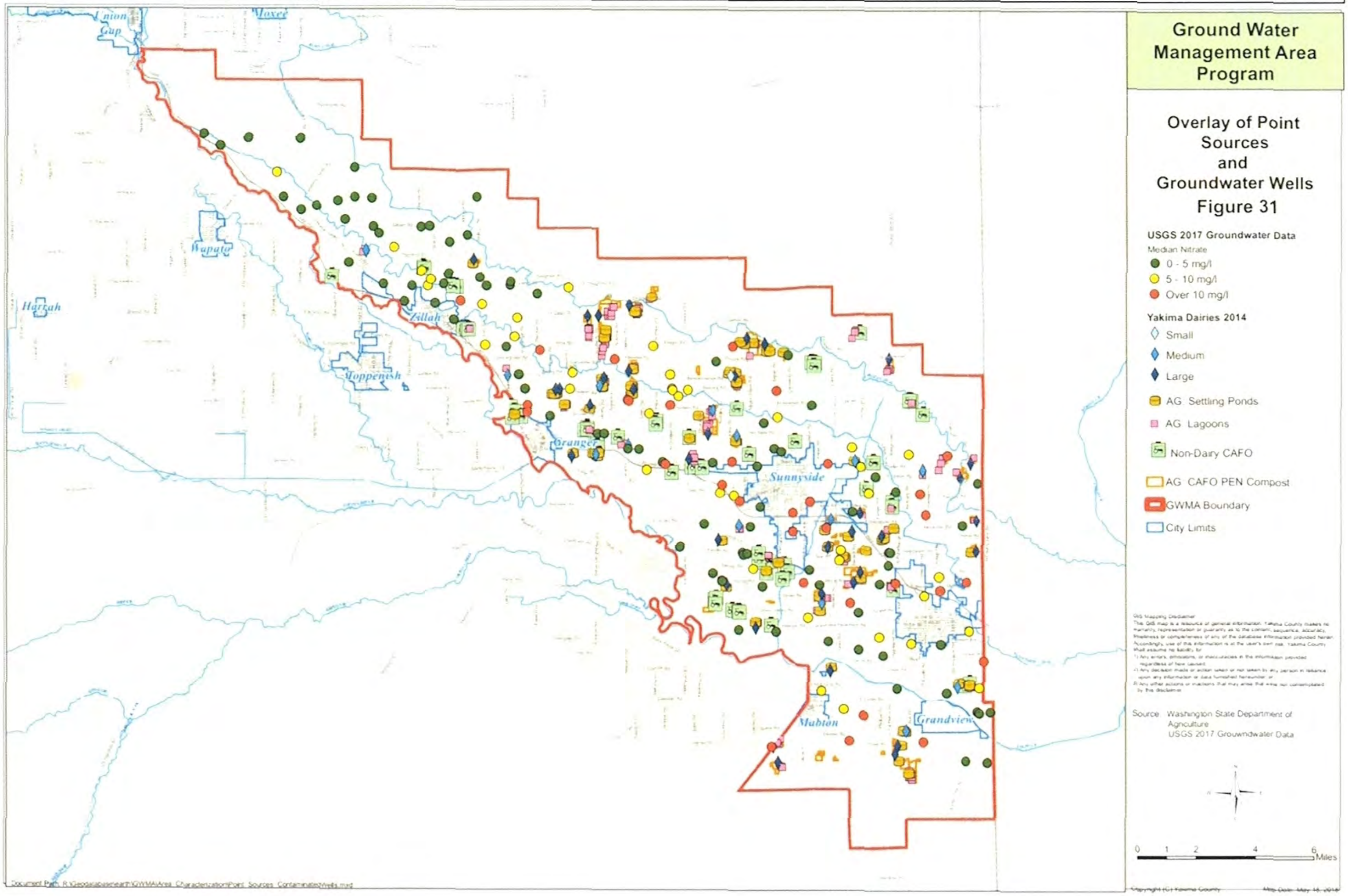
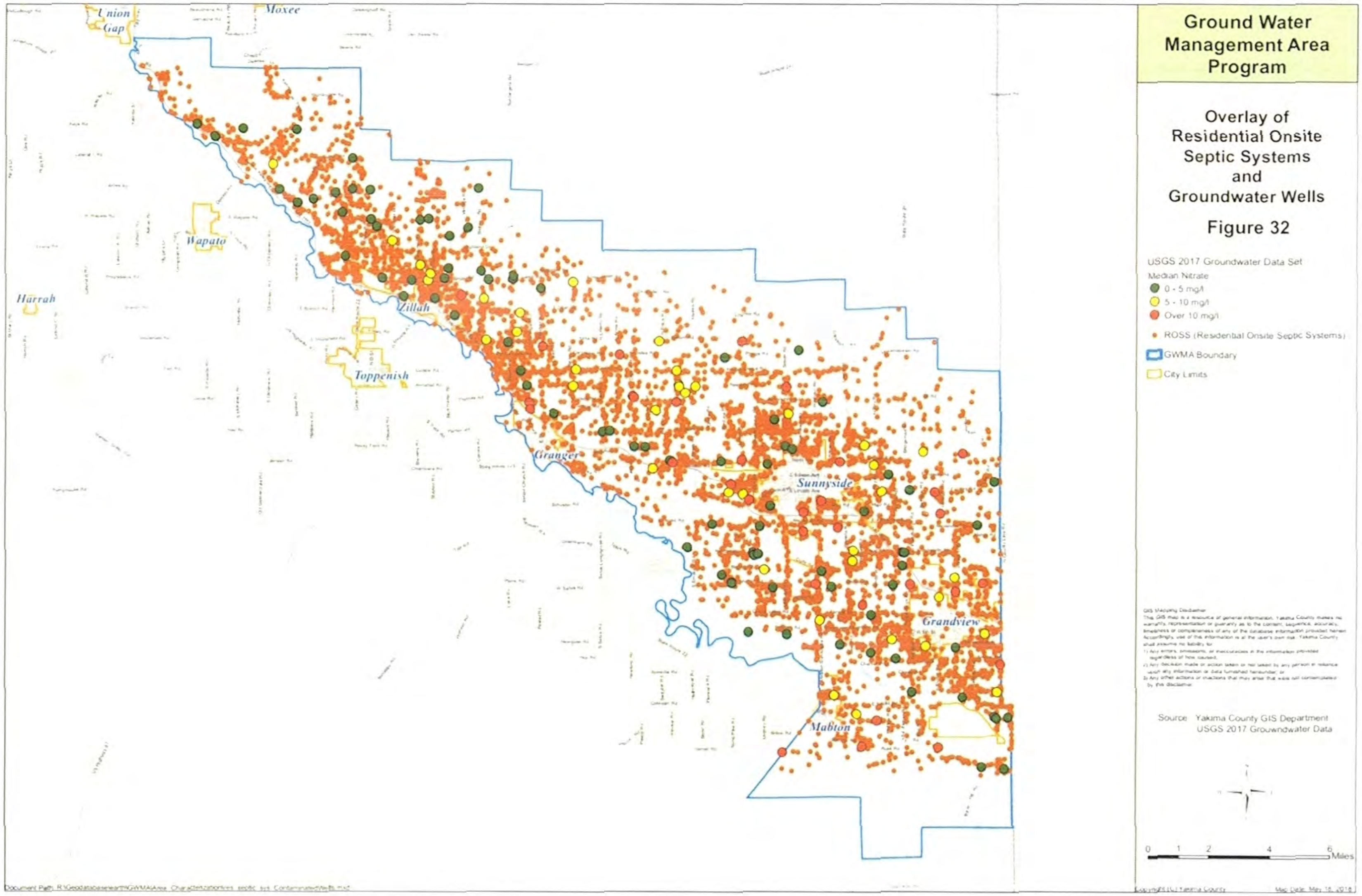


FIGURE 32 - USGS WELL DATA OVERLAID ON MAP OF SEPTIC SYSTEMS



Consensus is difficult in any group, and so has it been with finding consensus within the GWAC. It was unlikely that consensus could be reached on the correlation between specific sources and specific contaminated water well. Some members desired investigation of specific source/contamination cases. Other members desired no investigation. Most governmental representatives, including those representing the lead agency, were apprehensive of specific source/contamination event analysis due to possible suggestions of liability, mandate of remediation, or disparagement of agricultural industry groups important to the community's economic well-being.

All of the maps overlaid with USGS well data 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 the suggested correlations proves any causative relationship. In some cases, however, the correlation may appear obvious. But the greatest correlation appears to be that between total nitrogen availability and USGS well data, particularly when the large amount of irrigation water applied is taken into account. Most all the non-compliant wells are down-gradient of the SVID irrigation canal (See Figure 29) within the area where more than half the irrigation water delivered makes it past the plants' root zone to become "recharge" (See Figure 8) and located where they hydraulic conductivity of soils are relatively fast (See Figure 28). Even if all the nitrogen applied in the agricultural process were applied at an "agronomic rate," the plant community may not take it up sufficiently if greater than necessary water supply washes it past the root zone. The obvious general conclusion is that the LYVGWMA's groundwater contamination problem is the result of lengthy and continuous aggressive agricultural practices and that proactive measures should be taken with any and all potential nitrogen sources in order to address the general groundwater contamination problem. Greater understanding of particular "agronomic rate" and more precise irrigation management may be the most consequential proactive measures.

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).

Addressing groundwater nitrate contamination requires addressing both the symptoms and the cause of the problem. Monitoring and assessment of the ongoing condition of the contaminated groundwater is also required, as is establishment of financial resources adequate to support these three prior elements. One study has characterized this as addressing: "(a) safe drinking water actions for affected areas, (b) reducing sources of nitrate contamination for groundwater, (c) monitoring and assessment of groundwater and drinking water, and (d) revenues to help fund solutions." (Harter et al. 2002)

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).

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. Breaking with prior practice, the GWAC membership took a recorded vote at its May 17, 2018 meeting whether to recommend all alternatives which had received a positive score. The GWAC voted 17 - 1, 1 not voting to recommend those alternatives obtaining a value greater than zero. They appear below as "Recommended Actions."

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.

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). New materials should be developed under any of the recommendations made below to address the specific needs of the Lower Valley residents and should be written and delivered in means which are most likely to reach all components of the residents of the LYVGWMA (see Interim Education and Outreach)

Recommended Actions

The GWAC refined that list of alternatives (Appendix H) to the following recommended actions:

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.

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.

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.

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.

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

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.

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: Study potential nitrate contamination attributable to improperly operated septic systems.

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 5: Provide funding for municipalities to replace aging sewer system infrastructure and ensure proper system maintenance to reduce nitrate leaching.

Municipalities need to estimate costs and system integration.

WA Department of Ecology should:

RCIM 6: Develop a plan for finding and decommissioning abandoned wells in the next 12 months, using the LYVGWMA as a pilot project.

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 7: Determine, prior to issuing or reissuing LOSS permits, that all employee counts are regularly reported.

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.

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.

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.

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.

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.

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.

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.

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.

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.

Producers should:

LC 4: Make capital improvements.

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

Washington State University should:

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

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.

Washington State University and Producers should collaboratively:

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

Research 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.

US Department of Energy and US Department of Agriculture should collaboratively:

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

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.

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.

US Department of Energy and **US Department of Agriculture** should collaboratively:

LC 10: Explore investment in animal and agricultural waste to energy technology.

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

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

LC 11: Educate producers regarding application of nutrients at Agronomic Rate.

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.

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.

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.

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.

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.

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.

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

Data Collections, Characterization, Monitoring

<u>Department of Ecology</u>, <u>Yakima County</u> and <u>Yakima Health District</u> 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.

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.

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.

Yakima County should:

DATA 3: Adopt and Implement an Adaptive Management Plan.

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.

South Yakima Conservation District 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.

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.

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.

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.

Monitoring well construction: Monitoring well data collection:

Yakima Health District should:

DATA 8: Collect data from Ambient Groundwater Monitoring Wells.

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.

Report nitrate concentrations annually to Department of Ecology.

United States Geological Survey should:

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

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

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.

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.

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.

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.

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

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).

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, as required by state rules and regulations.

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

Through permitting review of site plan criteria.

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.

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.

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.

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

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 not inconsistent 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.

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Appendices

Appendix A—Administrative Background

In May 1985, the Washington Legislature adopted a law authorizing the identification of ground water management areas and the identification of groundwater management procedures.1 Shortly thereafter, the Department of Ecology adopted "guidelines, criteria, and procedures for the designation of groundwater management areas, subareas or zones."2 They set forth "a process for the development of groundwater management programs for such areas, subareas, or zones, in order to protect groundwater quality, to assure groundwater quantity, and to provide for efficient management of water resources for meeting future needs while recognizing existing water rights." The regulations adopted an approach intended to "forge a partnership between a diversity of local, state, tribal and federal interests in cooperatively protecting the state's groundwater resources."

In February 2010, the Department of Agriculture, Department of Ecology, Department of Health, Yakima County Department of Public Works and U.S. Environmental Protection Agency published a report entitled *Lower Yakima Valley Groundwater Quality, Preliminary Assessment and Recommendations Document.*3 That Preliminary Assessment found that:

> "The existing studies and related water quality data indicate that nitrate and bacterial contamination of groundwater exist in the Lower Yakima Valley."4

and that:

> "Over 2,000 people in the area are exposed to nitrate over the maximum contaminant level (MCL) through their drinking water. While not all groundwater supplies have been impacted, many residents rely on private wells

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1 Ch. 453, Laws of 1985 (RCW 90.44.400-.440.)

2 December 1985, pursuant to RCW 90.44.430.

3 *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 Agency, Ecology Publication No. 10-10-009, February 2010. (Hereafter, "*Preliminary Assessment*.")

4 *Preliminary Assessment* p. ES 2.

that are in the most vulnerable portions of the aquifer. Approximately 12% of domestic well users are exposed to nitrate levels in their drinking water that exceed the health-based standard of 10 mg/L."5

The *Preliminary Assessment* made recommendations for subsequent action, including:

- Development of a conceptual site model for the Lower Valley
- Development of a nitrogen loading model for the Yakima basin
- Acknowledgement of the connection between groundwater and surface water
- Determination of the sources of contamination
- Identification of agricultural operations that use flood irrigation
- Assessment of agricultural applications of nitrogen fertilizers and Best Management Practices
- Education and outreach regarding nitrates and bacteria
- Assessment of cumulative risk factoring in synergistic health effects
- Exploration of shifting residents to public water systems where feasible
- Involvement of the Yakima Health District
- Exploration of the concept of developing a groundwater management area as one potential funding option
- Development of measures of success
- Identification and implementation of appropriate enforcement actions

The *Preliminary Assessment* also identified four "needs":

1. Better characterization of vulnerable groundwater supplies.
2. Improve water quality monitoring and coordination of data that can identify trends in water quality.
3. Funding options to support lower valley initiatives to better manage potential contaminant sources and improve groundwater quality.

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5 *Preliminary Assessment*, p. ES 2.

4. A mechanism to coordinate future efforts and implement actions that result in improved water quality.

On April 17, 2012, the Department of Ecology and Yakima County executed an Interagency Agreement. The Agreement provided funds from Ecology to the County for the formation of a Groundwater Management Area for the lower Yakima Valley as set forth in WAC 173-100. The Agreement stated that "The purpose of the GWMA is to reduce nitrate contamination in groundwater to below state drinking water standards."

Yakima County was charged by the Agreement with performing the actions of Lead Agency[6] for the development of a Groundwater Management Program, prepare a work plan, budget for development of a GWMA Program. The contents of a GWMA Program are identified in RCW 90.44.410.[7] Yakima County has therefore conducted studies, collected and analyzed data, drawn conclusions, and drafted reports related to hydrogeology, water quality, water use, land use, and population projections for GWAC review.

The GWMA Program, adopted by the Groundwater Management Committee, is implemented by the Department of Ecology.[8]

Appendix B—RCW 90.44.410

Requirements for groundwater management programs—Review of programs.

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6 The role of lead agency is described in WAC 173-100-080.

> The lead agency shall be responsible for coordinating and undertaking the activities necessary for development of the groundwater management program. These activities shall include collecting data and conducting studies related to hydrogeology, water quality, water use, land use, and population projections; scheduling and coordinating advisory committee meetings; presenting draft materials to the committee for review; responding to comments from the committee; coordinating SEPA review; executing interlocal agreements or other contracts; and other duties as may be necessary. The lead agency shall also prepare a work plan, schedule, and budget for the development of the program that shows the responsibilities and roles of each of the advisory committee members as agreed upon by the committee. Data collection, data analysis and other elements of the program development may be delegated by the lead agency to other advisory committee members.

7 See Appendix A.

8 Pursuant to RCW 90.44.420, See Appendix A.

(1) The groundwater area or sub-area management programs shall include:

(a) A description of the specific groundwater area or sub-areas, or separate depth zones within any such area or sub-area, and the relationship of this zone or area to the land use management responsibilities of county government;

(b) A management program based on long-term monitoring and resource management objectives for the area or sub-area;

(c) Identification of water resources and the allocation of the resources to meet state and local needs;

(d) Projection of water supply needs for existing and future identified user groups and beneficial uses;

(e) Identification of water resource management policies and/or practices that may impact the recharge of the designated area or policies that may affect the safe yield and quantity of water available for future appropriation;

(f) Identification of land use and other activities that may impact the quality and efficient use of the groundwater, including domestic, industrial, solid, and other waste disposal, underground storage facilities, or storm water management practices;

(g) The design of the program necessary to manage the resource to assure long-term benefits to the citizens of the state;

(h) Identification of water quality objectives for the aquifer system which recognize existing and future uses of the aquifer and that are in accordance with department of ecology and department of social and health services drinking and surface water quality standards;

(i) Long-term policies and construction practices necessary to protect existing water rights and subsequent facilities installed in accordance with the groundwater area or sub-area management programs and/or other water right procedures;

(j) Annual withdrawal rates and safe yield guidelines which are directed by the long-term management programs that recognize annual variations in aquifer recharge;

(k) A description of conditions and potential conflicts and identification of a program to resolve conflicts with existing water rights;

(l) Alternative management programs to meet future needs and existing conditions, including water conservation plans; and

(m) A process for the periodic review of the groundwater management program and monitoring of the implementation of the program.

(2) The groundwater area or sub-area management programs shall be submitted for review in accordance with the state environmental policy act.

Appendix C—WAC 173-100-100

Groundwater management program content.

The program for each groundwater management area will be tailored to the specific conditions of the area. The following guidelines on program content are intended to serve as a general framework for the program, to be adapted to the particular needs of each area. Each program shall include, as appropriate, the following:

(1) An area characterization section comprised of:

(a) A delineation of the groundwater area, subarea or depth zone boundaries and the rationale for those boundaries;

(b) A map showing the jurisdictional boundaries of all state, local, tribal, and federal governments within the groundwater management area;

(c) Land and water use management authorities, policies, goals and responsibilities of state, local, tribal, and federal governments that may affect the area's groundwater quality and quantity;

(d) A general description of the locale, including a brief description of the topography, geology, climate, population, land use, water use and water resources;

(e) A description of the area's hydrogeology, including the delineation of aquifers, aquitards, hydrogeologic cross-sections, porosity and horizontal and vertical permeability estimates, direction and quantity of groundwater flow, water-table contour and potentiometric maps by aquifer, locations of wells, perennial streams and springs, the locations of aquifer recharge and discharge areas, and the distribution and quantity of natural and man-induced aquifer recharge and discharge;

(f) Characterization of the historical and existing groundwater quality;

(g) Estimates of the historical and current rates of groundwater use and purposes of such use within the area;

(h) Projections of groundwater supply needs and rates of withdrawal based upon alternative population and land use projections;

(i) References including sources of data, methods and accuracy of measurements, quality control used in data collection and measurement programs, and documentation for and construction details of any computer models used.

(2) A problem definition section that discusses land and water use activities potentially affecting the groundwater quality or quantity of the area. These activities may include but are not limited to:

- Commercial, municipal, and industrial discharges
- Underground or surface storage of harmful materials in containers susceptible to leakage
- Accidental spills
- Waste disposal, including liquid, solid, and hazardous waste
- Storm water disposal
- Mining activities
- Application and storage of roadway deicing chemicals
- Agricultural activities
- Artificial recharge of the aquifer by injection wells, seepage ponds,

land spreading, or irrigation

- Aquifer over-utilization causing seawater intrusion, other contamination, water table declines or depletion of surface waters
- Improperly constructed or abandoned wells
- Confined animal feeding activities

The discussion should define the extent of the groundwater problems caused or potentially caused by each activity, including effects which may extend across groundwater management area boundaries, supported by as much documentation as possible. The section should analyze historical trends in water quality in terms of their likely causes, document declining water table levels and other water use conflicts, establish the relationship between water withdrawal distribution and rates and water level changes within each aquifer or zone, and predict the likelihood of future problems and conflicts if no action is taken. The discussion should also identify land and water use management policies that affect groundwater quality and quantity in the area. Areas where insufficient data exists to define the nature and extent of existing or potential groundwater problems shall be documented.

(3) A section identifying water quantity and quality goals and objectives for the area which (a) recognize existing and future uses of the aquifer, (b) are in accordance with water quality standards of the department, the department of social and health services, and the federal environmental protection agency, and (c) recognize annual variations in aquifer recharge and other significant hydrogeologic factors;

(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. If necessary, alternative data collection and analysis programs shall be defined to enable better characterization of the groundwater and potential quality and quantity problems. 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. 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.

(5) A recommendations section containing those management strategies chosen from the alternatives section that are recommended for implementation. The rationale for choosing these strategies as opposed to the other alternatives identified shall be given;

(6) An implementation section comprised of:

(a) A detailed work plan for implementing each aspect of the groundwater management strategies as presented in the recommendations section. For each recommended management action, the parties responsible for initiating the action and a schedule for implementation shall be identified. Where possible, the implementation plan should include specifically worded statements such as model ordinances, recommended governmental policy statements, interagency agreements, proposed legislative changes, and proposed amendments to local comprehensive plans, coordinated water system plans, basin management programs, and others as appropriate;

(b) A monitoring system for evaluating the effectiveness of the program;

(c) A process for the periodic review and revision of the groundwater management program.

Appendix D—BMPs Recommended by Irrigated Agriculture Work Group

Best Management Practices for Irrigated Cropland

OB = objective; MT = management target; BMP = best management practice

The IAWG has reviewed the list of BMPs compiled by HDR that could be implemented on irrigated cropland activities which may provide protections to nitrate (N) leaching to groundwater. These include irrigation practices, cropping practices, and N source management (type, quantity, and timing).

The IAWG believes that the core BMPs to reduce negative impacts to ground water are
1) managing nutrient inputs to ensure that the 4R's are utilized (right amount, the right source, the right timing, and the right location) (accounting for all sources including soil amendments, compost, biosolids, manure and commercial fertilizer) and
2) irrigation water management.
The IAWG felt that these two BMPs had the greatest potential to reduce the problem. They are also beneficial to all parties.
The IAWG believes the BMPs included in the table below will not replace the core BMPs above but may provide additional proctections to ground water. The BMPs listed in the table below have a range of applicability in the Lower Yakima Valley GWMA. Some are potentially very effective, some moderately effective, and some that have no applicability in this GWMA. The comments in the right hand column are a compilation of input from the IAWG and are intended to provide the GWAC with some sense of the effectiveness of the BMPs as they would apply to this specific GWMA. The IAWG emphasized that the BMPs are voluntary, not always suited to a particular farm, and still require the judgment of the farm operator to achieve the desired results.

Management Target	Best Management Practices	References	Work Group Comments
MT 1.1.1 Perform irrigation system evaluation and monitoring	BMP 1.1.1.1 Conduct irrigation system performance evaluation	EM 4885 – IP 2.01.03; PNW 293; EM4828	More practical to preform routine maintenance and observe uniformity of coverage.
	BMP 1.1.1.2 Install and use flow meters or other measuring devices to track water volume applied to each field at each irrigation	EM 4885 – IP 2.01.01	Meters not practical; soil moisture sensing devices are used effecively - even required in some cases, to monitor and schedule irrigation.
	BMP 1.1.1.3 Conduct pump performance tests	EM 4885 – IP 2.01.02	Relatively simple and easy to do. Requires an ultrasonic flow meter and pressure gage.
MT 1.1.2 Improve irrigation scheduling	BMP 1.1.2.1 Use weather based irrigation scheduling	EM 4885 – IP 2.01.05, 2.01.06	This is one of the most practical way to help solve the issues. It is now free and easy to do. (http://weather.wsu.edu/is)
	BMP 1.1.2.2 Use plant-based irrigation scheduling	EM 4885 – IP 2.01.05, 2.01.06; EM4821; EB1513	Time consuming to do, unless there are automated sensors. Research is still being done in this area. It is not easy or very accurate.
	BMP 1.1.2.3 Measure soil moisture content to guide irrigation timing and amount	EM 4885 – IP 2.01.05, 2.01.06; PNW0475	Soil moistures sensors are expensive and data-interpretation requires assistance.
	BMP 1.1.2.4 Avoid heavy pre-plant or fallow irrigations		Depends on definition of "heavy"

MT 1.1.3 Improve surface gravity system design and operation	BMP 1.1.3.1 Convert to surge irrigation	EM 4885 – IP 2.02.03; EM4826	A good idea, but requires a certain field setup. Most people who have tried surge, migrate back to conventional rill irrigation. Better to encourage to conversion to sprinkler or drip.
	BMP 1.1.3.2 Use high flow rates initially, then cut back to finish off the irrigation	EM 4885 – IP 2.02.10; EM4828	Good idea, but difficult to implement unless irrigation delivery can be variable.
	BMP 1.1.3.3 Reduce irrigation run distances and decrease set times	EM 4885 – IP 2.02.04; EM4828	Good, but increases labor and equipment costs
	BMP 1.1.3.4 Increase flow uniformity among furrows (e.g., compaction furrows)	EM 4885 – IP 2.02.02	Encourange use of PAM
	BMP 1.1.3.5 Grade fields as uniformly as possible	EM 4885 – IP 2.02.05, 2.02.05	Good but within constraints of topography.
	BMP 1.1.3.6 Where high uniformity and efficiency are not possible, convert to drip, center pivot, or linear move systems	EM 4885 – IP 2.01.08	Good

MT 1.1.4 Improve sprinkler system design and operation	BMP 1.1.4.1 Monitor flow and pressure variations throughout system	EM 4885 – IP 2.03.02	Good idea on district scale (they already do much of this), but logging pressure and flow variation is not cost-effective for individual growers.
	BMP 1.1.4.2 Repair leaks and malfunctioning sprinklers, follow manufacturer recommended replacement intervals	EM 4885 – IP 1.00.05, 2.03.03	Power companies often have monitary energy savings incentives for repair of irrigation systems.
	BMP 1.1.4.3 Operate sprinklers during the least windy periods	EM 4885 – IP 2.03.05	For the most part not possible when water delivered by a major irrigation entitiy.
	BMP 1.1.4.4 Reduce distance between lateral lines or alternate lateral line location over successive irrigations	EM 4885 – IP 2.03.04, 2.03.06	Requires additional moves (labor $) and sometimes additional hardware (e.g. an additional wheel line). Get a good design!
	BMP 1.1.4.5 When pressure variation is excessive, use flow control or pressure regulating nozzles	EM 4885 – IP 2.03.02	Good.
MT 1.1.5 Improve micro-irrigation system design and operation	BMP 1.1.5.1 Use appropriate lateral hose length to improve uniformity	EM 4885 – IP 2.04.02	Good. i.e. get a good and appropriate irrigation system design.
	BMP 1.1.5.2 Check for clogging potential and prevent or correct clogging	EM 4885 – IP 2.04.03	Good and necessary for good crop yields and uniformity.
MT 1.1.6 Make other irrigation infrastructure improvements	BMP 1.1.6.1 Installation of subsurface drains	EM 4885 – IP 5.01.01	Good. When necessary.
	BMP 1.1.6.2 Backflow prevention	EM 4885 – IP 6.00.03, EB1722	Required by law if chemigating.

MT 1.2.1 Modify crop rotation	BMP 1.2.1.1 Grow cover crops	EM 4885 – IP 5.01.01	Good in areas where they are not water limited. Probably not cost effective.
	BMP 1.2.1.2 Include deep-rooted or "nitrogen scavenger" crop species in annual crop rotations	PNW513	Good.
	BMP 1.2.1.3 Grow more crops per year (double cropping)	Bul 869	Utilize extra cropping to utilize excess nutrients on soil
	BMP 1.2.1.4 Include perennial crop rotation	PNW513	Encourage crop rotation
MT 1.2.2 Monitor crops	BMP 1.2.2.1 Monitor crop performance for each field including yield, nitrogen content, estimate of nitrogen removed from field versus remaining in field	NRCS Part 651. Ch. 13, Appendix 13B	Great
MT 1.3.1. Improve rate, timing, and placement of N fertilizers	BMP 1.3.1.1 Adjust nitrogen fertilization rates based on soil nitrate testing	EM 4885 – IP 3.02.01	Great
	BMP 1.3.1.2 Adjust timing of nitrogen fertilization based on plant tissue analysis	EM 4885 – IP 3.02.03	Good.
	BMP 1.3.1.3 Apply nitrogen fertilizer in small multiple doses rather than single large dose	EM 4885 – IP 3.02.05	Great - use fertigation
	BMP 1.3.1.4 Measure nitrate content of irrigation water and adjust fertilizer accordingly	EM 4885 – IP 3.02.02	Very little N in irrigation water. More in rainfall, but that is negligible in the Yakima River Basin.
	BMP 1.3.1.5 Use low rates of foliar nitrogen instead of higher rates applied		This is an OK method for micro-nutrients, but not for macro-nutrients.

MT 1.3.1. Improve rate, timing, and placement of N fertilizers	BMP 1.3.1.6 Vary nitrogen application rates within large fields according to expected needs (precision agriculture)	Peters and Davenport	Good.
	BMP 1.3.1.7 When fertilizing in surface gravity systems, use delayed injection procedures		Chemigating with surface gravity systems is not recommended
	BMP 1.3.1.8 Develop a nitrogen budget that includes crop nitrogen harvest removal, supply of nitrogen from soil, and other inputs	CSU-XCM-173	Good.
	BMP 1.3.1.9 Use controlled release fertilizers, nitrification inhibitors, and urease inhibitors	EM 4885 – IP 3.02.06	Good.
	BMP 1.3.1.10 Assess the risk of contamination of ground and surface water due to fertilizer leaching or runoff	EM 4885 – IP 3.01.01	Good.
	BMP 1.3.1.11 Maintain records of all soil, tissue, and water tests, cropping rotations, yields, and applications (dates, material, method, results)	CSU-XCM-173	Good.
	BMP 1.3.1.12 Develop realistic yield goals	EM 4885 – IP 3.02.07	Good.

MT 1.3.2. Improve rate, timing, and placement of animal manure applications	BMP 1.3.2.1 Apply moderate rates of manure and compost, and use materials with high nitrogen content (inorganic fertilizer) to meet the peak nitrogen demand		Good.
	BMP 1.3.2.2 Incorporate solid manure immediately to decrease ammonia volatilization loss	EM 4885 – IP 3.03.05	Good.
	BMP 1.3.2.3 When applying liquid manure in surface gravity irrigation systems, use the delayed injection procedure to improve application uniformity		Not recommended
	BMP 1.3.2.4 Use quick test methods to monitor dairy lagoon water nitrogen content immediately before and during application, and adjust application rate accordingly		By law, dairies are required to test waste water once in the spring prior to the first application.
	BMP 1.3.2.5 Develop a nitrogen budget that includes crop nitrogen harvest removal, supply of nitrogen from manure, and other inputs	CSU-XCM-173; USU 2010	Good.
	BMP 1.3.2.6 Calibrate solid manure and compost spreaders	EM 4885 – IP 3.03.01; NRCS Part 651. Ch. 13, Appendix 13A	Good.
	BMP 1.3.2.7 Ensure uniformity of application with manure	EM 4885 – IP 3.03.07	Good.
	BMP 1.3.2.8 Do not apply manure to frozen ground, especially sloping fields	EM 4885 – IP 3.03.08	Good. Although this is a surface runoff issue, not a groundwater issue.
	BMP 1.3.2.9 Test manure or other waste materials for nutrient content	EM 4885 – IP 3.02.04; NRCS Part 651. Ch. 13, Appendix 13B	Great
	BMP 1.3.2.10 Use synchronized rate nutrient application of lagoon water to reduce or eliminate the need for fertilizer	NDESC 2005 (II)	

MT 1.3.3. Use fertilizer guides to determine and apply appropriate fertilizer amounted.	BMP 1.3.3.1 Follow recommendations of Fertilizer Guide: Home Vegetable Gardens, Irrigated Central Washington	FG0052	Good.
	BMP 1.3.3.2 Follow recommendations of Fertilizer Guide: Irrigated Alfalfa Central Washington	FG0003	All FG need to be looked at to make sure they are not outdated.
	BMP 1.3.3.3 Follow recommendations of Fertilizer Guide: Irrigated Asparagus	FG0012	Good.
	BMP 1.3.3.4 Follow recommendations of Fertilizer Guide: Irrigated Field Beans for Central Washington	FG0005	Good.
	BMP 1.3.3.5 Follow recommendations of Fertilizer Guide: Irrigated Field Corn for Grain or Silage	FG0006	Good.
	BMP 1.3.3.6 Follow recommendations of Fertilizer Guide: Irrigated Hops for Central Washington	FG0011	Good.
	BMP 1.3.3.7 Follow recommendations of Fertilizer Guide: Irrigated Mint Central Washington	FG0008	Good.
	BMP 1.3.3.8 Follow recommendations of Fertilizer Guide: Irrigated Peas for Central Washington	FG0033	Good.

MT 1.3.3. Use fertilizer guides to determine and apply appropriate fertilizer amounted.	BMP 1.3.3.9 Follow recommendations of Fertilizer Guide: Irrigated Small Grains, Central Washington	FG0009	Good.
	BMP 1.3.3.10 Follow recommendations of Fertilizer Guide: Irrigated Sudangrass Pasture or Silage	FG0036	Good.
	BMP 1.3.3.11 Follow recommendations of Fertilizer Guide: Irrigated Vineyards for Entire State	FG0013	Good.
	BMP 1.3.3.12 Follow recommendations of Fertilizer Guide: Ornamentals, Entire State Except Central Irrigated Washington	FG0049	Does not pertain to Irrigated AG
	BMP 1.3.3.13 Follow recommendations of Fertilizer Guide: Vegetable and Flower Gardens, Except Irrigated Central Washington	FG0050	Does not pertain to Irrigated AG
	BMP 1.3.3.14 Follow recommendations of Fertilizer Guide: Improved Pasture, Hay, Eastern Washington	FG0037	Good.
	BMP 1.3.3.15 Follow recommendations of Fertilizer Guide: Grass Seed for Eastern Washington	FG0038	Good.

MT 1.3.3. Use fertilizer guides to determine and apply appropriate fertilizer amounted.	BMP 1.3.3.16 Follow recommendations of Fertilizer Guide: Barley for Eastern Washington	FG0029	Good.
	BMP 1.3.3.17 Follow recommendations of Fertilizer Guide: Soil Samples/Orchards	FG0028C	Good.
	BMP 1.3.3.18 Follow recommendations of Fertilizer Guide: Instructions for Tree Fruit Leaf Nutrient Analysis	FG0028E	Good.
	BMP 1.3.3.19 Follow recommendations of Fertilizer Guide: Peas and Lentils for Eastern Washington	FG0025	Good.
	BMP 1.3.3.20 Follow recommendations of Fertilizer Guide: Lawns, Playfields and Other Turf, East and Central Washington	FG0024	Good.

MT 1.4.1 Avoid fertilizer material and manure spills during transport, storage, and application	BMP 1.3.4.1 Do not overfill trailers or tanks. Cap or cover loads.	EM 4885 – IP 4.01.06	Good
	BMP 1.3.4.2 When transferring fertilizer, take care not to allow materials to accumulate on the soil		Good.
	BMP 1.3.4.3 Maintain all fertilizer storage facilities and protect them from the weather		Good.

MT 1.4.1 Avoid fertilizer material and manure spills during transport, storage, and application	BMP 1.3.4.4 Clean up fertilizer spills promptly		Good.
	BMP 1.3.4.5 Shut off fertilizer applicators during turns and use check valves		Good.
	BMP 1.3.4.6 Maintain proper calibration of fertilizer application equipment	EM 4885 – IP 3.03.01	Good.
	BMP 1.3.4.7 Create a buffer around wellheads from fertilizer and manure storage, handling, and application	EM 4885 – IP 6.00.02	Good.
	BMP 1.3.4.8 Distribute rinse water from fertilizer application equipment throughout field		Good.
	BMP 1.3.4.9 Avoid manure spills/discharges during transport, storage, and application		Good.
	BMP 1.3.4.10 Prevent back siphonage/flow of chemicals or nutrients down a well after injection	EM 4885 – IP 6.00.03, EB1722	Required by law.
	BMP 1.3.4.11 Identify and properly seal all abandoned and improperly constructed wells	EM 4885 – IP 6.00.04	Good.

Appendix E—BMPs Recommended by Livestock/CAFO Work Group

NRCS Standards Recommended by Livestock/CAFO Work Group

Title	Revision Date
Amendments for Treatment of Agricultural Wastes (591) Standard	1/27/2014
Anaerobic Digester (366) Standard	1/11/2011
Animal Mortality Facility (316) Standard	1/11/2011
Composting Facility (317) Standard	1/11/2011
Dam (402) STANDARD	2/25/2013
Diversion (362) STANDARD	2/25/2013
Feed Management (592) Standard	1/15/2013
Filter Strip (393) Standard	2/11/2015
Heavy Use Area Protection (561) Standard	2/12/2015
Monitoring Well (353) Standard	2/11/2015
Nutrient Management (590) Standard	2/18/2014
Pond Sealing or Lining, Bentonite Sealant (521C) Standard	11/4/2015
Pond Sealing or Lining, Compacted Clay Treatment (521D) Standard	11/4/2015
Pond Sealing or Lining, Flexible Membrane (521A) STANDARD	2/25/2013
Pond Sealing or Lining, Soil Dispersant (521B) Standard	11/4/2015
Pumping Plant (533) Standard	2/12/2015
Roof Runoff Structure (558) STANDARD	2/12/2015
Short Term Storage of Animal Waste and By Products (318) – National NRCS Standard http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1263507.pdf	
Solid/Liquid Waste Separation Facility (632) Statement of Work	1/11/2008
Sprinkler System (442) Standard	11/4/2015
Stream Crossing (578) Standard	2/12/2015
VegetativeTreatment Area (635) Standard	1/29/2016
Waste Facility Closure (360) STANDARD	2/25/2013
Waste Recycling (633) STANDARD	2/25/2013
Waste Separation Facility (632) STANDARD	1/27/2014
Waste Storage Facility (313) Standard	2/11/2015
Waste Transfer (634) Standard	2/12/2015
Waste Treatment (629) Standard	2/12/2015
Waste Treatment Lagoon (359) STANDARD	2/25/2013
Water Well (642) Standard	2/12/2015
Well Decommissioning (351) Standard	2/11/2015
Groundwater Testing (355) Standard	2/11/2015

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Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs
Remediation								
Pump, treat and reinject groundwater	WGD	not feasible, treatment area too large	not effective because of 3-dimensional size of treatment area	excessive				
Pump-and-fertilize. Use existing (or new) agricultural water wells to remove nitrate-contaminated groundwater and "treat" the water by using it to irrigate crops which will take up the nitrogen concentration in the irrigation water (presumes the existence of a proper nutrient management plan for the irrigated acreage).	JD							
Fill irrigation ditches with water and let it sit there to leak into groundwater. Use groundwater recharge as a means to dilute nitrate concentrations in the groundwater.	WGD						irrigation district canal maintenance in winter, increased personnel?, irrigation district compensation, relation to water rights? problem of freezing of flow meters in laterals, interaction with Bureau of Reclamation	
Drill new 1,500 foot wells to replace contaminated wells .	WGD			$12 million				
Regionalize and connect users to a larger system with reliable quality water.—pipe connection to an existing system	WGD							
Blend better quality water with contaminated water to reduce nitrate concentrations	JD	works for larger community systems with more than one water source.						
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).	JD							
Discontinue use of shallow wells. Rebuild, repair or replace poorly constructed wells.	WGD							
Remediate local nitrate contamination hotspots only .	JD							

Alternative land and water use management strategies for reaching *program goals and objectives per WAC 172-100-100(4)*		*Evaluation Criteria per WAC 173-100-100 (4)*							
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs	
Administration/Lead Agency--Yakima County?									
Identify or create of an organization (Lead Entity) responsible for implementation and oversight of the LYV GWMA Groundwater Management Plan and acquisition of stable funding to support their activities. Potential entities include, Yakima County, South Yakima Conservation District (SYCD), Yakima County Health District, Washington State Department of Agriculture (WSDA), Ecology, and/or a yet to be formed entity.	L/C WG								
Implement an Adaptive Management Plan utilizing data collected, progress made, or lack of progress to inform the community on adjustments that need to be implemented. Plan could incorporate 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.	L/C WG								
Let the lead agency determine who will do monitoring. Possible assignment of long-term monitoring after 2017 to Yakima Health District.	WGD								
Inform livestock operators and facilitate a dialogue with representatives of the regulatory agencies, other agricultural producers, and the general public through a public information/education program to protect the quality of the area groundwater resource. Information and incentives provided to Lower Yakima Valley agricultural operators will expedite implementation of BMPs.	L/C WG								
Collect, analyze, and interpret data to track water quality improvement progress, nutrients generated, applied, or exported, which will inform the implementation of an Adaptive Management Plan within the LYV GWMA.	L/C WG								
Focus implementation of analyzed data based on information and data included in the Nitrogen Loading Assessment, Soil Sampling Program, Ambient Groundwater Monitoring Plan, USGS Reports, and other similar scientifically based publications.	L/C WG								
Increase education and outreach efforts by improving the availability of technical assistance to develop nutrient management plans for all livestock industries. Assist industry trade organizations to enhance their local efforts to bring information to their members. Help increase livestock operator awareness of the need for procedures for proper management of animal wastes and wastewater. Potential funding sources include industry, government, educational institutions, grants, industry associations, etc...	L/C WG								
Cooperate with the WCC and WSDA in their efforts to document regulatory compliance for dairies within the GWMA that are completing and implementing Dairy Nutrient Management Plans (DNMP). Explore the possibility of disclosing non-proprietary data produced through the DNMP process.	L/C WG								
Further develop a local forum for disseminating information and facilitating technical exchange regarding BMPs for livestock management and groundwater protection. Endorse and distribute materials by all effective means that will educate the public about the facts of livestock waste management and the science of groundwater protection.	L/C WG								

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs
Quantify the nutrient value and rate of release of nitrate from livestock waste under various Lower Yakima Valley conditions to become part of the nutrient management guidelines.	L/C WG							
Voluntary development and implementation of NMPs by operations not already required to hold permits or a DNMP as an effective means of environmental protection.	L/C WG							
Allocate cost share funding or other funding assistance to operators implementing environmental protection measures.	L/C WG							
Develop strategies for marketing the economic, fertilizer value, and soil enhancing properties of appropriate application of manure and other livestock wastes.	L/C WG							
Provide Yakima County fiscal support to maintain its GIS data base on the GWMA over time.	JD							
Overlay GIS density maps reflecting different sources of nitrogen in order to geographically indicate the total density from all sources.	JD							
Map those areas that can tolerate more nitrogen application and areas that are more vulnerable to its application.	JD							
Use USGS particle tracking model to indicate where groundwater moves faster (permeability).	WGD							
Assess groundwater contamination potential, making use of the available information on soils, geology, and groundwater in order to identify those areas that are the most vulnerable to contamination. These areas may be closer to surface water, areas where recharge is faster or more frequent, or areas where shallow soils overlie soluble bedrock. Identify strategies "upstream" of sensitive areas to reduce contributions of nitrate sources.	WGD							
Enact County ordinances that would affect the problem grower.	WGD						Difficult to enforce.	
Maintain the County's GWMA website.	WGD							
Create an aquifer protection area.	WGD	Requires vote of people within protection area		Generates tax revenue				
Consider the enactment of a county ordinance addressing the density of segments of nitrate producing agricultural activity within the areas currently zoned as agricultural within the GWMA.	WGD		Prospective application					
Consider creation of subcategories of agricultural zoning, limiting density in those areas where soils are more permeable or groundwater moves faster.	WGD		Prospective application					
Consider "overlay" zoning ordinance adding special groundwater conservancy restrictions to otherwise conventionally zoned properties. Uses consumptive of groundwater quality resources are precluded or more generally regulated. Uses that are not consumptive of groundwater quality resource are permitted. Specific limitations might include limitations of water use, drainage, development density, septic use.	JD		Prospective application					

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs
Define "conditional uses" that can be allowed after assurance that groundwater resources would not be damaged.	JD		Prospective application					
Consider a county ordinance concerning overapplication of manure.	WGD		Prospective application				Difficult to enforce	
Create county ordinance limiting total number or density of cows or dairies (lid).	WGD		Prospective application				Difficult to enforce	
Adopt a LYC GWMA or county-wide CAFO ordinance	L/C WG (no consensus in WG)	Lengthy public process to create a CAFO Ordinance. Uncertain outcomes and timing. Too much uncertainty to rely on this option for the plan at this time. The county might consider legislative action as an alternative if public outreach, voluntary compliance, implementation of identified BMP's, and other efforts are not						
Establish a quota system through zoning regulations establishing how much nitrogen could be applied (based on agronomic rates for individual crop types) within fixed zones.	WGD		Prospective application				Difficult to enforce	
Consider density limitations, building codes for farm structures, development standards for farm activities.	WGD		Prospective application					
Regulate crop mix to weight more toward nitrogen-light crops--	JD						Difficult to enforce	

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs
Consider limitation of septic systems (therefore building permit) where soil filtration rate is high, where housing density is already big, where nitrate concentration is already great downstream of the septic plume	JD	Applied admnistratively, requires GIS mapping of soil zones					Growers view as governmental interference with economic choice if nitrogen-heavy crops generate better returns	
Property tax for properties with onsite septic systems, waived in the case of proper inspection and pumping	JD							
Protect Critical Aquifer Recharge Areas	WGD							
Require bonding as prerequisite to permitting of livestock operations so as to assure financial capability for clean up in the instance of bankruptcy or other economic failure.	GWACD							
Measure the effects of GWAC program on Yakima County economics.	WGD							
Establish a more interactive and frequent relationship between Yakima County and NRCS.	WGD							
Education								
Develop post GWAC education and outreach campaign	EPO							
Broaden the pool of people GWMA is educating or communicating with.	EPO							
Maintain a public education program regarding nitrate pollution and health risk over a 5-10 year period. Provide all materials distributed to the public in English and Spanish.	EPO							
Billboard campaign – urging well testing	EPO							
Create 1 FTE Bilingual Outreach Coordinator Position to implement a post-adoption outreach campaign (EPO meeting summary 8/1/2014 & proposed to GWAC 8/21/14 - voted low priority)	EPO	Low	Unknown	$83,000 annually		1 FTE	Requires clear, measurable outcomes[1], a "home" agency to house, provide oversight, and to measure effectiveness; and ongoing funding.	
Develop a K-12 education program about groundwater and best management practices-- mobile program visiting schools.	EPO							
Employ/enlist college students to conduct surveys, consider outreach methodologies as part of classwork to assist with GWMA education	EPO							
Educate the public, particularly in towns, about lawn and garden nitrogen applications' contribution to nitrate concentrations	EPO							
Educate private well owners: Re: protect your family; know who's at risk; test your well regularly.	EPO							
Private well owners' responsibility to protect WQ	EPO							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs
Publish public information about proper septic system construction and operation	EPO							
Advise the public that GWMA is looking for abandoned wells. Wellhead protection education	EPO							
Offer incentives for property owners to identify and properly abandon wells.	EPO							
Offer incentives to drill deeper wells for homeowners served by shallow, poorly constructed, poorly located wells.	EPO							
Offer incentives to connect households on private wells near community water systems to connect to a community water system. (Nitrate Treatment Pilot Program-June 2011)	EPO							
Provide a resource hotline (as proposed by RCIM on 8/2014)	EPO							
Prepare a fact sheet/develop outreach campaign to growers that explains agronomic rates – applying nutrients at the right time/right place/right amount	EPO							
Study report outreach: Show/Identify how much nitrogen is left after nutrient uptake in crops.	EPO							
Encourage commodity groups to provide education on water management and fertilizer use through regular meetings.	EPO							
Outreach targeted to small farm/hobby farm/rachettes manure management	EPO							
Educate irrigation users on the consequences of too much irrigation.	EPO							
Inform farmers about technological improvements in irrigation that permit easier management of water, descriptions of specific improved technology, and economic viability of technological advancements .	EPO							
Enlist advocacy groups/Farm Bureau/federations/associations to host workshops/informational meetings regarding GWMA education goals and partnerships in success	EPO							
Make presentations at trade shows, communicate with agricultural consultants who have positive relationships with farmers suggesting that they change practices	EPO							
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)	EPO	Feasible	Effective	Up to $30,000 annually (.25 FTE; + translation, printing, coordination)	Unknown	.25 FTE	Coordinate partnership through either DOH or YHD	
Advise the public that GWMA is looking for abandoned wells	WGD							
Encourage commodity groups to provide education on water management and fertilizer use through regular meetings	WGD							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
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Research and Data Collection								
Use both method-based measurement and performance-based measurement.	WGD							
Establish performance objectives against which monitoring data can be compared--number of at risk wells, BMP implementation, funding success, reduction in number of underperforming farming practices	JD							
Implement Ambient Groundwater Monitoring Plan	GWAC	Feasable						
Implement Drinking Water Quality Monitoring Plan	GWAC	Feasable						
Establish a fund and plan to analyze data collected in ambient water quality monitoring and drinking water well monitoring programs. Study short-term seasonal variations in nitrate concentrations over next year or two--addresses how changes in nutrient application over the agricultural cycle affects things. Study long-term trends that develop over several years--to track whether the overall picture is getting better, whether changes recommended by GWMA are having impact.	WGD							
Use hydro-geologically directed monitoring well placement to detect cause/effect remediation opportunities.	JD							

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Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs	
Building from the WSDA's Nitrogen Availability Assessment, develop a Nitrogen Loading Assessment for all agricultural, residential and commercial properties, using newly collected data. 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 Nitrogen Availability Assessment to compare against the currently established data. Collect data on how many acres in the GWMA are fertilized in various crops with manure and how many with commercial fertilizer. Update and monitor the percentage of acreage in various crops, particularly silage corn and field corn. Study effect of contribution of nitrogen from cover crops used to form mulch. 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.	WGD, JD								
Get fertilizer loading numbers per crop type. Get economic engine factors per crop type. Determine crop/fertilizer utility ratios. Consider economic benefit of various crop type categories. Consider agricultural usage categories (e.g., field crop, row crop, vineyard, orchard, dairy. Determine amount of land appropriate for each, and location best for each given soil, climate, effect upon groundwater, etc. Ensure adequate supply of each in order to permit opportunity of market choice.	JD								
Recommend that the Yakima Health District or Yakima County continue the High Risk Well Assessment (survey to identify outreach messaging related to health risks and well sampling) periodically over a 5-10 year period. Collect more information on wells known to have high nitrate concentrations, perhaps identifying whether the concentration is self-caused	WGD								
Conduct recurrent drinking water testing where drinking water standards have previously been exceeded.	JD								
Design and implement pilot studies focusing on innovative farm techniques which reduce nitrogen loading to crops and monitor results for future expansion of findings.	JD								
Explore whether nitrate leaching is greater with vetch amended soil or commercial fertilizer amended soil. The results of one study indicate that vetch nitrogen, in comparison to fertilizer nitrogen, leads to lower concentrations of soil inorganic nitrogen and greater immobilization of added nitrogen in soil organic matter. This would reduce the potential for nitrate leaching.	JD								
Recommend that WSU Extension Service update Appendices A and B of the Washington Irrigation Guide.	WGD								
Recommend that Western Fertilizer Handbook, Western Plant Health Association, Ninth Edition (2002) be updated.	WGD								
Fund professional adaptation of Utah Fertilizer Guide for Washington State http://extension.usu.edu/files/publications/publication/AG_431.pdf	JD								

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Washington State Department of Agriculture								
Develop Nitrogen Loading Assessment as provided in Research and Data Collection above.	WGD							
Summarize the DNMP reporting and provide information that would disclose the amount of manure the CAFO's in the GWMA created and where it was distributed.	WGD							
Review and evaluate the WSDA Dairy Nutrient Management Program inspection protocols to assist in determining if additional resources should be allocated and identify any areas for improvement of the inspections themselves.	L/C WG							
Add staff to WSDA to oversee Dairy Nutrient Management Plans and complaints regarding manure spills.	WGD							
Promote on-going research for managing animal nutrients.	WGD							
Southern Yakima Conservation District								
Ask SYCD for projected plan to expand fiscal and administrative capacity	JD							
Fund post GWMA education and outreach through Conservation District	WGD							
Put request for $$$ for SYCD in State Conservation Commission budget	WGD							
Enhance engineering expertise (personnel) within Conservation District--none there or at NRCS	WGD							
Charge dairies for Conservation District preparation of Dairy Nutrient Management Plans	WGD							
Recommend funding for Southern Yakima Conservation District review of Dairy Nutrient Management Plans	WGD							
Provide better funding and more staffing for Conservation District: hard money funding, increase property tax assessment, create exceptions to taxation for demonstrated testing and monitoring.	WGD							
Develop water sorption graph or chart. List volumes of water applied, soil types, absorption/compaction rates, depths to water, pre-season and post-season appropriate moisture levels.	JD							
US Geological Survey								
Use USGS Particle Tracking Model	WGD							
Use USGS particulate tracking model to identify targets of education	WGD							
USGS Particle Tracking Model Overview--potentially combined with MT3D MODFLOW application to the vadose Zone	WGD							
Yakima Health District								
Study potential nitrate contamination attributable to improperly operated septic systems. Consider restoration/retrofit of older septic systems through incentives or county property tax breaks.	WGD							
Drill deeper water wells further from septic drain systems	WGD							
Require builders to demonstrate that septic system design will not add to nitrogen loading problem as condition of construction	WGD							
Publish and distribute homeowner guide on how to use septic systems	WGD							
Department of Ecology								

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Publish the Department of Ecology's lists of certified laboratories that can test private wells for nitrates and pathogens and Ecology's providing funding to low income, private well users, in order to conduct this testing.	WGD							
Encourage an increase in the number and availability of soil testing laboratories.	JD							
Make grants that complement projects related to non-point source pollution.	WGD							
Provide grant funding for well decommissioning.	WGD							
Search for abandoned wells.	WGD							
Send a postcard to 10 % of known property owners on record having a well asking about knowledge of older wells.	WGD							
Compare Google Earth to Yakima County GIS images to determine building changes and thus possible well usage changes. Focus first on hotspot high density areas in GWMA. Ground truth suspected problem wells.	WGD							
Educate realtors and banking industry about disclosure of abandoned wells in property transfers.	WGD							
Educate public regarding liability of an ill-secured well.	WGD							
Provide some form of protection for self-reporting of abandoned or improperly decommissioned wells.	WGD							
Seek legislative change on requirements for well decommissioning, making them cheaper.	WGD							
Amend RCW 18.104.055 to dedicate a portion of "notice of intent" fees to a fund to be used by Ecology (or Health) for the proper decommissioning of wells in those cases where DOE (or Health) determines that such publicly-funded action is necessary in the public interest to protect or enhance the quality of public health ("infirmity" of the public health).	JD							
Amend authority of Department of Ecology to gain access to properties where manure is spread outside land subject to nutrient management plans	WGD							
Residential, Commercial, Industrial, Municipal								
Encourage municipalities within the GWMA to extend municipal sewer systems within urban growth areas and retire ROSS and LOSS.	RCIM WG							
Encourage connection of residences within urban growth zones to sewer systems extended by municipalities.	RCIM WG							
Encourage the development of group septage-management or treatment systems in areas outside urban growth zones where the density of residential development could exacerbate the effect of multiple OSS on groundwater quality.	RCIM WG							
Establish or maintain ongoing, extended funding necessary for the Yakima County Department of Public Services and Yakima Health District to actively participate in water quality improvement, testing, monitoring, scientific data analysis, and infrastructure development.	RCIM WG							

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Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs
Request Yakima County Public Services to perform an engineering study of locations outside urban growth areas where there is rural residential medium to high density OSS and the nitrate concentration is greater than the state water quality standard where community water systems could feasibly be constructed in lieu of individual water wells.	RCIM WG							
Request Yakima County Public Services to perform an engineering study of locations outside urban growth areas where there is rural residential medium to high density OSS and the nitrate concentration is greater than the state water quality standard where community waste water systems could feasibly be constructed in lieu of individual on-site septic systems.	RCIM WG							
Request that the Yakima Health District prepare a plan, as required and described by WAC 246-272A-0015, giving primary emphasis on educational programs for operation and maintenance of existing on-site septic systems (OSS), reserving a determination regarding the advisability of the establishment of regulatory or enforcement programs until data is available from the GWMA's monitoring well system.	RCIM WG							
Request the Yakima Health District to consider the nitrate density element when approving proposed septic systems, including those technologies verified by the U.S. EPA's Environmental Technology Verification Program, for reducing the nutrient nitrogen in domestic wastewater discharged from OSS, including fixed film trickling filter biological treatment, media filter biological treatment, and submerged attached-growth biological treatment.	RCIM WG							
Recommend that soil testing be performed below at least two ROSS drain fields (one with a shallow water table, one with a deeper water table) in high density areas to analyze nitrogen loads as the septage approaches the water table.	RCIM WG							
Request that the State Department of Health determine, prior to issuing or reissuing LOSS permits, that all employee counts are regularly reported, so that the LOSS will continue to operate as designed.	RCIM WG							
Recommend that the State Department of Health consider not approving additional LOSS or otherwise require an effective nitrate removal system.	RCIM WG							
Request that the Department of Ecology analyze the trends of nitrate data contained within reports required by NPDES and SDWA permits.	RCIM WG							
Educate the public regarding the importance of the integrity of wells, particularly those without a well log, and fund and encourage periodic well inspection by the Yakima Health District or professional well engineers.	RCIM WG							
Require that site inspections for possible abandoned wells be performed before building permits are issued for properties that are proposed to be redeveloped after prior development of domestic, agricultural or industrial uses.	RCIM WG							

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Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs	
Request that the Department of Ecology develop a plan for finding and decommissioning abandoned wells in the next 12 months, using the LYVGWMA as a pilot project.	RCIM WG								
Permit the repair or decommissioning of wells by general contractors, rather than exclusively by well-drillers, so as to diminish costs of decommissioning.	RCIM WG								
Assist hobby farmers to locate ROSS drain fields on their property so as to avoid animal farming over the drain field.	RCIM WG								
Request the county include the EPO flyer on OSS maintenance in correspondence with GWMA home owners for 5 years. i.e. tax bills, property transfers.	RCIM WG								
Make facility process improvements in waste treatment and food processing plants to reduce nitrogen and total discharge volume.	JD								
Replace aging sewer system infrastructure and ensure proper system maintenance to reduce nitrate leaching.	JD								
Require new developments to address impacts on groundwater quality through permitting review of "site plan review criteria."	JD								
Technology									
Identify and support opportunities, including educational research institutions, for private, public, and industry investment in technology specific to addressing nitrate contamination in groundwater.	L/C WG								
AKART--industry can't keep up with technology, required if performance already meets performance standards?	WGD								
AKART problems--does standard mandate installation of new technologies even when existing ones accomplish the measured objective	WGD								

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Require nitrogen reducing technologies for onsite septic systems:	WGD			estimated installation costs $20,000, yearly operational costs about $1,500, recirculating sand filters, carbon systems, old system retrofits cost $5,000-7,000 per system					
Explore public investment in waste to energy technology	WGD								
Promote new products that are found through research	WGD								
Promote markets for those products	WGD								
Use commodity group "check off" money for research and development	WGD								
BMPs									
Inform farmers of those BMPs prioritized by Livestock/CAFO and Irrigated Agriculture Work Groups from HDR list to reflect greatest effectiveness in nitrate reduction	WGD								
Determine who implements the BMP and who monitors it and the time frame in which to measure/monitor it--problem with available expertise, timing, installation cost	WGD								
Identify and publish a list of poor management practices. Recommend that they be terminated or avoided.	JD								
Establish a BMP monitoring well network. Monitor BMP performance and effectiveness with the monitoring well network first, then monitor water quality.	Bowen: *Having a monitoring plan for the BMP's in place is part of the work the GWAC is required to do.*								

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Livestock								
Recommend that dairies and CAFOs use those Best Management Practices contained within Attachment B to the Livestock/CAFO Work Group's Report to GWAC	L/C WG	Feasable	GWAC has not reached consensus that pursuing this recommendation alone would accomplish Goals # 1, 2.					
Encourage the WSDA and Conservation Districts to continue education and outreach to livestock operators about impacts and practices related to compliance with relevant State and federal requirements for groundwater protection, particularly addressing those not currently acting in good faith toward that objective.	L/C WG	Feasability depends upon available resources		2 additional FTE's cost ?	Industry, government, private or public research and development, foundations, and industry associations.			
Implement an Education and Outreach Program (EOP) informing producers of Best Management Practices (BMP's) including increased funding for the DNMP assistance program.	L/C WG							
Create and maintain a central depository of public information online, as part of an Education and Outreach Program (EOP) informing producers of the nitrate issue, community impacts, and Best Management Practices (BMP's).	L/C WG				Industry, government, private or public research and development, foundations, and industry associations.			
Increase funding for the local Conservation District and Natural Resources Conservation Service (NRCS) so that assistance programs for nutrient management planning, engineering, cost share, and loan funds are more available.	L/C WG				Industry, government, private or public research and development, foundations, and industry associations.			
Streamline current enforcement activities so as to 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.	L/C WG							

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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.	L/C WG								
Support and advocate private, public, and industry investment in technology, including at research institutions, specific to addressing nitrate contamination in groundwater, especially where it creates improvements for the public good.	L/C WG								
Require more complete disclosure of Dairy Nutrient Management Plans.	WGD								
Incentivize technology and management of fertilizers and manures.	WGD								
Install separation systems--separate liquids from solids.	WGD								
Use anaerobic digestion in waste storage lagoons	WGD			Very expensive					
Install liners in liquid waste storage lagoons.	WGD								
Install impervious surfaces beneath silage/feed storage.	WGD								
Revise WAC 246-203-130 so that it defines "health hazard" and "nuisance" and includes specific and enforceable requirements designed to protect human health.	WGD, JD								
Compost more manure	WGD								
Improve composting regulations	WGD								
Provide underlying soils information to each livestock opeeration so that individual evaluations can be made.	JD								
Remove wastes from barnyards and other areas of animal concentrations and frequently convey them to waste storage or treatment facilities.	JD								
Prevent contaminants from flowing into wells by ensuring that the external areas around well casings are properly sealed and that wastes are kept the recommended distance from wells.	JD								
Entrain water (as rain or snow-melt) collected from roofs away from animal pen or manure collection facilities.	JD								
Drain low areas where ponds accumulate to collect and manage waste waters.	JD								
Treat manure supply in excess of that which can reasonably be applied as nutrient to agricultural lands as a "waste" product. Apply waste management strategies including land disposal at designated site, incineration, centralized waste-to-energy facility.	JD								
Create a state CAFO Siting Team, composed of representatives of relevant state agencies with support from USGS, to which the county commission could refer proposed CAFO sitings or expansions. The CAFO Siting Team would provide a recommended site suitability determination, based upon a predetermined scoring system, including description of environmental risk factors and mitigation strategies.	WSDA, Gary Bahr								
Amend Dairy Nutrient Management Act to extend WSDA's authority t land application acreage with which dairy facilities contract pursuant to nutrient management plans.	JD								

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Irrigated Agriculture								
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. 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.	WGD			Expensive	Federal or State			
Do deep soil sampling on fields within GWMA that apply biosolids.	WGD							
Make shallow (1, 2, 3 foot) soil testing reports prerequisites for funding, lending or building permits.	WGD							
Hire soil scientists to do publicly funded "spot auditing" soil checks for feedback to farmers and fertilizer sellers.	JD							
Incentivize development and provide information about improvements made in nutrient management and agronomic rate application of fertilizer by specific developing technologies	JD							
Commission the creation of a data assembly software that could receive, translate, assemble and analyze the data produced by agricultural equipment technology manufactured by different agricultural equipment manufacturers, so as to permit integration of data per field, crop or enterprise.	WGD, Doug Simpson							
Monitor nitrate concentrations of irrigation water at headgates.	JD							
Stimulate news coverage of progress in irrigation technology.	WGD							
Land acquisition—purchase properties with greatest nitrate contribution and retire uses that generate nitrate.	JD							
Incentives—provide credit against county real property tax for investment in source abatement.	WGD							
Develop farmer-specific irrigation water use programs including collection of data, records of irrigation management, education of farmer regarding new processes and technology.	WGD							
Create irrigation management plans (similar to nutrient management plans) for farms over a minum size and provide financial assistance for implemented plans.	WGD							
Encourage advanced irrigation management. Recognizing that there is significant cost involved in changing an irrigation system, look for strategic opportunities in the area 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, such as grants, and low interest loans, to facilitate a transition to more advanced irrigation management in those areas	EPA Region 10							
Provide funding for a mobile irrigation lab to assess the efficiency of current or advised irrigation practices, either through a singular lab or component parts.	WGD							

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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.	WGD								
Establish a voluntary irrigation management cost-share program with SYCD. Data shared with public.	WGD								
Manage sprinkler systems so they do not drive nutrients past the root system.	WGD								
Advise farmers of the relative propensity of wheel lines, center pivots, and drip lines to cause leaching.	JD								
Use available techniques to determine how much and when irrigation is needed instead of irrigating according to a prearranged schedule.	JD								
Schedule water and nitrogen application according to the need for optimal crop yields.	JD								
Analyze irrigation practices to discover whether frequency or volume creates greater propensity for leaching.	JD								
Identify and decommission abandoned agricultural irrigation wells.	JD								
Upgrade irrigation districts' open, earthen or concrete delivery laterals and head ditches to PVC pipe.	JD								
Route irrigation-return flow through a constructed managed wetland to reduce concentrations of nutrients and suspended sediment.	JD								
Add polyacrylamide (PAM) to irrigation water.	JD								
Install effective backflow prevention devices on supply lines of water supplied from groundwater wells to avoid backflow from chemigation.	JD								
Structure irrigation water pricing by volume per acre used with preference for lower volume use.	JD								
Improve micro-irrigation system design and operation.	JD								
Recommend that irrigation districts be authorized to condition delivery of irrigation water on irrigation practices consistent with agronomic rate of application of water.	WGD								
Require irrigated agriculture nutrient management plans. Record the source and type of fertilizer and number of acres fertilized with each.	WGD								
Establish water use "domains" (zones) to apply water use constraints, or well construction design constraints, for agricultural uses.	JD								
Develop and implement Nutrient Management Plans (NMPs) for all producers (those that apply manure and those that apply synthetic fertilizer that include annual soil testing for phosphorus and nitrogen and which follow available guidance (i.e. Land Grant University) for developing appropriate land application rates for phosphorus and nitrogen. These NMPs can identify site specific conservation practices that are, or will be, implemented to minimize the transport of phosphorus or nitrogen to surface and ground waters. NMPs that are "adaptive" -- adjusted based on annual soil tests, the types of crops grown, and other site or field specific factors – allow producers to adjust their plans and practices as new information becomes available.	EPA Region 10								

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Provide funding for nutrient management education or information distribution.	WGD							
Make Nutrient Management Plan records available upon Department of Agriculture determination of potential excessive application of nutrients.	JD							
Incentivize investment in crops that require less fertilization, or which take up greater amounts of nitrogen.	JD							
Distribute information to farmers on what can happen with applied manure, what should be applied and reasonable, agronomic rates of application.	WGD							
Integrate use of animal waste and synthetic fertilizer, balancing nutrient application amounts so as to maximize crop production and full nitrogen uptake.	JD							
Track nutrients and their application regardless of the end user, including commercial fertilizer.	L/C WG		Nutrients from animal waste are tracked now while in the control of dairy operations. Once those nutrients are transferred to a third party no further regulation exists.					
Keep track of synthetic fertilizer sales.	WGD							
Avoid fertilizer material and manure spills during transport, storage, and application.	WGD							
Use effective application schedules, placement, rate and time of application and speed of release for specific crop requirements.	JD							
Where possible, apply nitrogen through to plant-specific root zone means, rather than broadcast application.	JD							
Identify areas with highly permeable and susceptible soils where fertilization and pesticide application should be most carefully managed.	JD							
Amend Yakima County Code 16C.09.070 to include excess fertilizer application to list of prohibited uses within critical aquifer recharge areas.	WGD							
Amend the list of prohibited uses under the Critical Aquifer Recharge Area ordinance 16C.09.070 (6) to include "activities that would add nutrients to the soil column beyond those amounts that can be taken up within a reasonable time by plant materials." Or perhaps, activities inconsistent with NCRS Code 590	JD							
Inform farmers that fertilization and supplemental irrigation beyond the optimum rate will not necessarily produce better yields or higher profits without serious side effects.	WGD							
Develop an approach for data collection of volume and location of manure application off dairy sites.	WGD							
Place areawide limitation on number of acres where manure can be spread as fertilizer. Require permit to spread manure as fertilizer. Allow market in permits. Allow dairies to own permits which could be leased to other agricultural properties.	JD							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Degree of consistency with local comprehensive plans and water management programs
Intermittent fallowing (leaving lands dormant) to reduce both natural plant nitrogen and fertilizer nitrogen additions to the soil.	JD							
Refrain from tilling under herbaceous remnants of prior crops, reducing plant nitrogen contributions to soil column.	JD							
No Action								
Consider costs of health risks to families from nitrate exposures, costs incurred by growers and producers of various recommendations, costs of bottled water, costs to connect to public sewage systems, cost for WSDA to monitor DNMP, costs of soil sampling	WGD							

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Difficult to implement?	Consistent with local comprehensive plans and water management programs?
	Education									
1	DOH, Yakima Health District, Lead Agency	Develop a health-risk education and outreach campaign	Establish a public education program regarding nitrate pollution and health risk over a 5-10 year period. Broaden the pool of people GWMA is educating or communicating with. Provide all materials distributed to the public in English and Spanish. Provide education about concepts that people can understand.Billboard campaign – urging well testing. 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)	Feasible	Effective	$50K; $100K (5 Year plan)	Ecology, Legislature	2019 Session	Not difficult	Consistent with NS-9.10
2	Yakima Health District	Publish and distribute homeowner guide on how to maintain septic systems		Feasible	Effective	Part of previous item cost.	Ecology, Legislature	2019 Session	Easy	Consistent with NS-9.6
3	OSPI, ESD 105	Develop educational materials that could be elected by instructors at 8-12 levels about aquifer protection, groundwater and best management practices.		Feasible	Effective depending on use	$10K. Contract with educational consultant; see what materials/models out there already	County General Fund	One year	Difficult to fit into curriculum	Consistent with NS-9.6, 9.10
4	Lead Agency	Develop an urban and hobby agriculturalist education and outreach campaign.	Provide information targeted to small farm/hobby farm/ranchettes about manure management. Publish public information about proper septic system construction and operation. Educate the public, particularly in towns, about lawn and garden nitrogen applications' contribution to nitrate concentrations. Recommend against farming around a water well	Feasible	Not Effective, based on prior efforts	$30 K	Legislature	2019 Session	Easy	Consistent with NS-8.2
5	WCC, WSU Extention, DOE, SYCD, WSDA, Lead Entity, Ag Industry Associations	Develop a post-GWAC agricultural producer education and outreach campaign. 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.	Feasible	Effective	DOE: $100 K /yr; SYCD: $100 K / yr, WSDA $50-100 K / yr	Operating budgets	2019 Session	Ask WCC, WSU	Consistent with NS-9.10
6	SYCD, WCC	Establish a local forum for disseminating information and facilitating technical exchange regarding BMPs for irrigated agriculture and livestock management and groundwater protection.	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.	Feasible	Effective depending on attendance	Included in above item	Operating budgets	2019 Session	Easy	Consistent with NS-9.10
7	WSDA, SYCD	Inform farmers of those BMPs prioritized by Livestock/CAFO and Irrigated Agriculture Work Groups to reflect greatest effectiveness in nitrate reduction.	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 a llist 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.	Feasible	Effective	Included in above item	Operating budgets	2019 Session	Easy	Consistent with NS-9.6
8	WSDA, SYCD	Encourage appropriate use of surface banding ("dribbling," "stripping" of liquid fertilizer, "broadcasting" or prompt incorporation of manures and fertilizers after application to cropland..	broadcast is effective for corn, alfalfa, triticale. Incorporation should occur within 24 hours.	Ask WSDA	Effective	Included in above item	Operating budgets	2019 Session	Ask WSDA	Ask WSDA
9	WSDA, SYCD	Continue to provide underlying soils information to individual livestock operations, provide same for all irrigated agriculture	So that individual property owners can evaluate contamination potential., already in DNMP process	Feasible, info available from NRCS	Effective	Current service of NRCS, SYCD	None	N/A	Easy	Consistent with NS-9.10

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Difficult to implement?	Consistent with local comprehensive plans and water management programs?
		Administrative								
1	DOE, Lead Agency, Yakima Health District	Establish or maintain ongoing, extended funding necessary for the Yakima County Department of Public Services and Yakima Health District to actively participate in water quality improvement, testing, monitoring, scientific data analysis, and infrastructure development.	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.	Feasible	Effective	DOE $250 K yr. Other cost included in other itemized recommendations	DOE: State operating budget; YHD paid by applicant	2019 Session	Easy	
2	Washington Conservation Commission	Fund SYCD, through State Conservation Commission budget, for projected educational, administrative, nutrient management planning, engineering, cost share, and lending activities.		Feasible,	Effective	Cost included in other itemized recommendations	State operating budget	2019 Session	Easy	
3	SYCD, WSDA	Monitor changes occurring in agricultural operations. Evaluate whether those changes positively affect improvement in groundwater quality.	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.	Feasible	Effective	$100 K at SYCD; $50 K at WSDA	WCC Operating Budget; WSDA Operating Budget	2019 Session	Requires cooperation of producers	Consistent with NS-9.10
4	Lead Agency	Establish a Lead Agency reponsible for implementation and oversight of the LYV GWMA Groundwater Management Plan and acquisition of stable funding to support their activities.	Administration of Groundwater Quality Program. Administer funds and distribute to other entities by subcontract. Maintain Yakima County's GWMA website. Maintain a GIS data base on the GWMA.	Feasible	Effective	$100 K / yr	Legislature	2019 Session	Not difficult	Consistent with NS-9.10
5	Lead Agency	Perform an engineering study of water supply alternatives.	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).	Feasible	Effective	$100 K	Legislature	2019 Session	Not difficult	Consistent with NS-9.10, UT-1.1-1.7, 3.1, 3.5, 6.5
6	Lead Agency	Adopt and Implement an Adaptive Management Plan	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 availabley 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.	Feasible	Effective	$100 K / yr	Legislature	Continuous, 2018-2030	Not difficult, depends on funding	Consistent with NS-9.10
7	EPA, DOE, WSDA	Streamline current regulatory enforcement activities	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.	Feasible	Effective	$ 0 - $ 300 K / yr, WSDA $100 K	Legislature	2019 Session	Not difficult	Consistent with NS-9.10
8	DOE, WSDA	Improve composting regulations (statutory)	Unclear as to particular reguations proposed	Yes	Potentially effective..	$50 K	Legislature	2019	Unceertain	Consistent with NS-9.2 , 9.6, 9.10
9	DOE	Inspect, monitor and regulate stockpiled manures.	Coordinate with WSDA. Currently being done; currently required as part of dairy nutrient management plans	Feasible	DOE:	$0 (part of current work)	NA	2018	Not difficult	Consistent with NS-9.2 & 9.4 & 9.10
10	DOE	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 regs		Feasible	Currently being done	$0 (part of current work)	NA	2018	Not difficult	Consistent with NS-9.2 & 9.6 & 9.10
11	DOE	Provide assistance to local departments of health regarding the regulation of agricultural composting operations		Feasible	Currently being done	$0 (part of current work), 1/4 FTE/yr	NA	2018	Not difficult	Consistent with NS-9.2 & 9.6 & 9.10
12	DOE	Analyze the trends of nitrate data contained within reports required by NPDES and SWD permits.		Feasible	Currently being done	$0 (part of current work), 1/4 FTE/yr	NA	2018	Not difficult	

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Difficult to implement?	Consistent with local comprehensive plans and water management programs?
13	DOE.	Develop a plan for finding and decommissioning abandoned wells in the next 12 months, using the LYVGWMA as a pilot project.	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 decomissioning. Provide some form of protection for self-reporting of abandoned or improperly decommissioned wells.	Feasible	Unknown	$30-50 K / yr	Legislature	Two years	Difficult	Consistent with NS-8.2, 9.2, 9.8, 9.10, UT-4, 6.1, 6.5, 7.2, 8, 12.5, 13.1
14	DOE	Require facility process improvements in waste treatment and food processing plants to reduce nitrogen and total discharge volume.	Addressed by Department of Ecology General Permit for Food Processing, specific problems can be addressed through "special protection areas." WAC 173-200-090.	Difficult, in general, feasible in specific	Uncertain	$20 K administrative cost. Costly to fruit processing facilities	DOEOperating Budget, Private	2019	Requires amendment to state Water Pollution Control Act (RCW 90.48)?	
15	DOE, EPA	Study the relationship between nitrogen emissions and atmospheric deposition of reactive nitrogen. Develop a model that predicts what percentage of emissions return to the GWMA area as atmospheric deposition.		Feasible, but inconsequential	Not effective, has deminimus impact on problem	Cost disproprotionate to benefit		2019-2122	Possible	Consistent with NS-3.1, 3.2, 3.3, 8.1
16	WDOH	Determine, prior to issuing or reissuing LOSS permits, that all employee counts are regularly reported.	So that the LOSS will continue to operate as designed.	Feasible, already being done	Effective	$0 part of current work	DOH operating budget	2018	Easy	Consistent with NS-9.3 & 9.4
17	WDOH	Revise WAC 246-203-130 (keeping of animals)	So that it includes specific and enforceable requirements designed to protect human health.	Feasible	Effective	$200K	Legislature	2019 Session	Not difficult	Consistent with NS-9.10
18	WSDA	Design and implement pilot studies focusing on innovative farm techniques which reduce nitrogen loading to crops and monitor results..		Feasible	Effective	$ 25 K	WSDA operating budget			
19	WSDA	Document and publish regulatory compliance for dairies within the GWMA that are completing and implementing Dairy Nutrient Management Plans (DNMP).	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 tha GWMA create and where it is distributed.	Feasible	Effective	$ 50 K	WSDA / DNMP operating budget	2018	Easy	Consistent with NS-9.10
20	DOE, Yakima Regional Clean Air Agency, WSDA	Estimate emissions of reactive nitrogen - gaseous 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. Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.	Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.	Not Feasible CAA Not Willing		"big and expensive"				Consistent with NS-3.1, 3.2, 3.3, 8.1
21	WSDA	Establish a monitoring system for compliance with NRCS Standard 317 on new composting facilities at Washington dairies (phased in for existing facilities).		Feasible but inconsequential	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA
22	Yakima Health District	Issue permits for agricultural composting operations, to appropriately inspect composting operations and to enforce regulations that protect public health and the environment, as required by state rules and regs.		Feasible, requires authorization from County Board of Health	Effective	$10K, depends upon number of composting facilities	Legislature, balance funded by permit applicant.	2019	Not difficult	Consistent with NS-9.2 & 9.6 & 9.10
23	Yakima Health District	Require new developments outside towns to address potential impacts on groundwater quality	Through permitting review of site plan criteria.	Feasible	Effective	Approx. $25-50 K Costly for developer & purchaser	Developer/ purchaser	Decades	Requires BOCC approval	Consistent with NS-8.2
24	Yakima Health District	Study potential nitrate contamination attributable to improperly operated septic systems.	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.	Feasible	Effective	$700 per applicant for system repair permit application fee. 100 applicants subsidezed = $70K; subsidize cost of reconstruction = $500K	permit applicant	2020	Not difficult	Consistent with NS-9.2 & 9.3 & 9.10
25	Yakima Health District	Issue permits for agricultural composting operations, to appropriately inspect composting operations and to enforce regulations that protect public health and the environment, as required by state rules and regulations.		Uncertain	Uncertain	Cost would be charged to permittee	Permit applicant	?	?	Consistent with NS-9.2 & 9.6 & 9.10
26	Yakima County Building Department	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.	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.	Feasible; Not Feasible for YHD, Would need authorization from County Board of Health. Feasible for YC Planning	Effective	Approx. $10-50 K; Costly for developer & purchaser. $410 per applicant for septic permit from YHD; Building permit application fee	Developer / purchaser / permit applicant	Decades	Requires BOCC approval. Requires knowledge of specific area soils and current septic densities.	Consistent with NS 8.2; NS-9.2 & 9.3 & 9.10; Inconsistent with NS-9.7

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Difficult to implement?	Consistent with local comprehensive plans and water management programs?
		Data Collection and Monitoring								
1	DOE, DOH	Establish time-based performance objectives against which well-monitoring data can be compared. Establish criteria by which to measure whether performance of nitrate reduction strategies is successful.	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.	Feasible, depends upon immediacy of expectations	Effective in measuring attainment of objectives	DB: $200-250K / Yr; GS 25 K, 1/4 FTE	DOE, DOH Operating Budget	2019 Session	Difficult; need to define timeframe for water quality improvement	Consistent with NS-9.10
2	Yakima County Public Works	Install Ambient Groundwater Monitoring Wells	Monitoring well construction: Monitoring well data collection:	Feasible	Effective	$700,000 in hand, balance uncertain;	Balance from DOE Capital Budget	2019 Session	Already designed, to be installed before 12/31/18	
3	YHD	Collect data from Ambient Groundwater Monitoring Wells	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.	Feasible	Effective	$20K / year	DOE Operating Budget			
4	Irrigation Districts	Monitor nitrate concentrations of irrigation water at headgates.	Report nitrate concentrations annually to Department of Ecology	Feasible	Effective	$30 K	Ratepayers or DOE grant	2019	Ditch-rider expense	
5	USGS	Contract with USGS to collect data from water well system per 2017		Feasible	Effective	$300K				
6	USGS	Contract with USGS to do particle tracking model study to indicate where groundwater moves faster (permeability).	USGS Particle Tracking Model Overview--potentially combined with MT3D MODFLOW application to the vadose Zone	Feasible, already exists	Unknown	$50K Agency Memo only, $500 + K for 5-year study	Legislature	2019 Session	Easy	
7	WSDA, DOE, Lead Agency	Assess Nitogen 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.	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.	Feasible	Dependent upon completion of NAA & GWAC resolution of course of action	WSDA $1 million DOE $250 K	WSDA, DOE Operating Budget	Dependent upon completion of NAA & GWAC resolution of course of action	Dependent upon completion of NAA & GWAC resolution of course of action	Consistent with NS-9.10
		Water								
1	WSU	Provide funding to WSU for a mobile irrigation lab to assess the efficiency of current or advised irrigation practices, either through a singular lab or component parts.	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.	Feasible	Effective	Approx. $100 K / yr (IAWG)	WSU Operating Budget	2019 Session	Not difficult	Consistent with NS-9.10, 12.1, 12.2, 12.4
2	SYCD, WSDA, WSU	Create Irrigation Management Plans (similar to Nutrient Management Plans) for farms over a minimum size and provide financial assistance for implemented plans.	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.	Difficult	Effective	WCC $200 K / yr; SYCD $200 K / yr	WCC , WSU Operating Budgets	2019 Session	Difficult, plans are property-specific,	Consistent with NS-9.10, 12.1, 12.2, 12.3
3	WSU, SYCD, WSDA, WCC	Encourage advanced irrigation management. Integrate management of synthetic/organic fertilizers and application of water	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.	Feasible	Effective	$25 million (18 K acres of rill irrigation in GWMA @ $3 K / acre, split 50/50 with landowner) $36 million @ $4 K / acre.	Identify federal, state and local incentive programs (like EQIP), such as grants, and low interest loans, financial assistance	Short & Long-Term		Consistent with NS-9.10

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Difficult to implement?	Consistent with local comprehensive plans and water management programs?
		Public Works								
1	Municipalities	Provide funding for municipalities to replace aging sewer system infrastructure and ensure proper system maintenance to reduce nitrate leaching.	Municipalities need to estimate costs and system integration.	Feasible	Effective	$10 million	Congress, Infrastructure Bill	Decades	Requires upgrades to meet all current standards	Consistent with UT-1.3, 1.6, 11.5, 11.6, 11.7
2	Lead Agency	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		Feasible	Effective	$5 million	Congress, Infrastructure Bill	Decades	Hasn't been accomplished to date	Consistent with UT-1.3, 1.6, 11.5, 11.6, 11.7
		Research and Development								
1	EPA, DOE	Identify and support opportunities, including educational research institutions, for private, public, and industry investment in technology specific to addressing nitrate contamination in groundwater.	EPA & DOE construct a LYVGWMA Program for coordinated implementation.	Feasible	Effective	$100-250 K / yr	Agency budgets	2018	Easy	
2	WSDA	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.	WSDA construct LYVGWMA administrative program.	Feasible	Effective	$1.75-$4 million, WSDA $10 million	WSDA Capital Budget	2018	Easy	
3	USDOE, USDOA	Explore investment in animal and agricultural waste to energy technology	Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives)	Feasible	Effective	Included in item above	Congress, Energy Bill	2020	Easy	Consistent with NS-9.10
4	WSU Extension Service	Continue research of water management with application of agricultural nutrients.	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.	Feasible	Effective	$250 K	WSU Operating Budget	Five years	Continuous effort	
5	WSU, Producers	Integrate use of animal waste and synthetic fertilizer.	Research chemical integration of animal waste and synthetic ferlizers with objective of balancing nutrient application amounts in order to maximize crop production and full nitrogen uptake.	Feasible	Effective	$250 K	Private, WSU Operating Budget	Ongoing, 2019 Session	Not difficult, but requires knowledge of soil chemistry	Consistent with NS-9.10
6	WSDA, WSU	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.		Feasible	Effective	$500 K. $100 K	WSDA, WSU Operating Budgets	2019 Session	Difficult without knowledge of sub-area soil chemistry and moisture information	Consistent with NS-9.10
7	WSDA	Develop strategies for marketing the economic, fertilizer value, and soil enhancing properties of appropriate application of manure and other livestock wastes.		Feasible	Effective	$25 K	WSDA Operating Budghet	2019 Session	Ask WSDA	Consistent with NS-9.10
8	WCC	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.		Feasible	Effective	$1 million	WCC Capital Budget	2019 Session	Not difficult	
9	Legislature	Require Commodity Commissions to dedicate "check off" money for research and development in water quality technology and practices.	include in funding alternatives for technology R & D	Feasible	Effective	Portion of other estimates above.	CC Members	2019	Research CC statutes	
10	USDOE, USDOA	Explore investment in animal and agricultural waste to energy technology	Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives)	Feasible	Effective	$1 million	Congress	2020	Easy	Consistent with NS-9.10
11	SYCD, WSDA, WSU, Private Industry, Producers	Educate producers regarding aplication of nutrients at Agronomic Rate	Develop technologies and provide information about improvements made in nutrient management and agronomic rate application of fertilizer by specific developing technologies.	Feasible	Effective	Dependent on technologies included in combined education recommendation GB $500,000	Private, Legislature	Ongoing, 2019 Session	Dependent on technologies	Consistent with NS-9.10

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Difficult to implement?	Consistent with local comprehensive plans and water management programs?
		Agriculture								
1	NRCS, DOE	Provide financial assistance for implementation of Irrigation Management Plans.	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.	Feasible	Effective	$ 1 million one time ($250 K x 4; NRCS EQIP program limited to $450 K per farmer unless new Farm Bill authorization)	Congress (Farm Bill), DOE Capital Budget	2019 Session	Doable	Consistent with NS-9.10, 12.1, 12.2, 12.4
2	DOE, WSDA	Make grants and allocate cost share funding or other funding assistance to people implementing environmental protection measures affecting groundwater quality.	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	Feasible	Effective, depending upon definition of "environmental measures"	DOE: $1 million, WSDA: $500 K	DOE, WSDA Capital Budget	2019 Session	Difficult, dependent on interagency communication & relationships with producers	Consistent with NS-9.6, 9.10
3	SYCD, Producers	Develop and implement Nutrient Management Plans for all farmers.	Mandatory or Voluntary. Farming operations currently are not required to hold permits or a prepare a Nutrient Management Plan.	Feasible	Effective	SYCD $200 K, on farm costs born by producer	WCC Operating Budget	Recurrent/ Annual	Not difficult	Consistent with NS-9.10
4	WSDA	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.		Feasible	Effective	$200 K / yr	WSDA Operating Budget	2019 Session	Requires legislative approval	Consistent with NS-9.10. Inconsistent with NS-7.64. (Mutually inconsistent provisions.)
5	SYCD	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.	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.	Feasible	Effective	$250 K / year for 5 years to finance extensive deep soil sampling program;	WCC Operating Budget	2019 Session	How to share data is unresolved, public distribution may limit participation by producers & landowners	Consistent with NS-9.10
6	WSDA	Complete NRCS Technical Note 23 inspections on all waste storage ponds (lagoons) within the GWMA boundaries.		Feasible	Ask WSDA	WSDA $20 K	WSDA Operating Budget	2019 Session	Ask WSDA	Unknown
7	Producers	Make capital improvements	Install liners in liquid waste storage lagoons. Install impervious surfaces beneath silage storage.	Feasible	Effective	$10 million	Cost-share/ producers & WSDA (Legislature)	2019	Feasible	Consistent with NS-9.10
8	Legislature	Make shallow (1, 2, 3 foot) soil testing reports prerequisites for funding, lending or building permits.	In the nature of Phase I Environmental Audits. Makes nitrate-related information/data available for water quality management.	Feasible	Effective	$2 k / per mit application	Private	2019	Amend GMA (RCW 36.70A)	

Appendix I

What You Can Do_7 things Well Water Health Finalpng_Page1.docx

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

What you can do to protect well water

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Steps to assure you have safe drinking water

Things to consider if you are a private household well owner:

Have your water tested – at least once a year for nitrates and coliform bacteria. High nitrates can harm pregnant women, new-born babies and the elderly, and high bacteria counts can cause illnesses. More information on Lower Yakima Valley Groundwater Management Area at http://www.yakimacounty.us/1617/Ground-Water-Management-Area. A list of certified labs and information on water testing are available online at http://www.yakimacounty.us/344/Drinking-Water-Testing.

Locate all wells on your property, both active and inactive. Make sure to cap your wells securely with manufactured or welded caps to prevent pollution and objects from entering your well.

Have your septic pumped - Neglecting septic system maintenance can result in backed-up sewage, expensive repairs and surface seepage that can pollute your well. A system for a four-person household should be pumped every three years.

Use less water – Not only does your septic system function better with less water, pumping more water from your well can pull nearby pollution toward your home.

Manage fertilizers and chemicals – Excess fertilizer moves easily through the soil and contributes to high nitrate levels. Spilled chemicals can reach your well water. Recycle household and hazardous wastes at the County collection facility. Never dump these items on your property or pour them down the drain.

Shield animal waste – Animal yards and piles of composting manure are sources for nitrates and bacteria. Take steps to prevent runoff and soil seepage.

Install backflow preventers – on all your outdoor faucets. Sometimes water can siphon backwards through a hose and down your well. Be very careful when you attach a chemical sprayer to your hose.

Do your part to keep groundwater safe and clean.

GROUNDWATER MANAGEMENT AREA

The purpose of the Lower Yakima Valley Groundwater Management Area is to reduce nitrate *contamination where concentrations do not meet drinking water standards.*

GWAC
Working Groups

- Data Collection, Characterization, Monitoring
- Education and Public Outreach
- Funding
- Irrigated Agriculture
- Livestock/CAFO
- Regulatory Framework
- Residential, Commercial, Industrial and Municipal

To get involved, call (509) 574-2300

More information at: www.yakimacounty.us

What You Can Do_Septic Systems Finalpng_Page1.docx

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Septic Safety: What you can do

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Failing septic systems can pollute drinking water wells

Check it, fix it, maintain it:

Bacteria, viruses and other pollutants from the sewage of a failing septic system, may contaminate drinking water wells, groundwater aquifers, lakes, rivers and streams.

A septic system doesn't have to be a problem.

- Get regular inspections and maintenance. Choose a date or time of the year that's easy to remember for the inspection. Mark it on the calendar.
- Regularly pump your system. Typically, once every three years for a four-person household.
- Learn how to keep your system working properly. Be careful what you flush or pour down the drain. No pet waste, medications, grease, or toxic chemicals.
- Watch for clues that your tank is nearing capacity or your system is failing. Got odors? Get someone to check it out right away. Then fix it, if needed.
- Keep trees at least 30 feet from edge of drain field to keep their roots from invading. Never drive over the system.
- Conserve water. Too much can cause solids to escape your tank and plug your drain field.
- Repair or replace your system when it fails or is otherwise inadequate.

Locate your septic tank and drain field:

- Use your property map or follow discharge pipe from your house. Probe the ground with a rod to determine the location of your septic tank.
- Underground pipes distribute wastewater in a drain field. Wet spots can indicate a failing drain field that needs professional attention.

Do your part to keep groundwater safe and clean.

For more information:
http://www.ecy.wa.gov/programs/wq/wqguide/septic.html
http://www.yakimacounty.us/335/Septic-Systems

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LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Small Farms: What you can do

Groundwater Management Area (GWMA):
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Poor manure management can threaten drinking water wells

Collect, cover and compost:

Livestock manure can be great fertilizer. It may also be a source of water pollution when exposed to the weather. If you keep livestock, even just one or two, you have a special role to play in protecting drinking water, groundwater aquifers, rivers and streams.

What can you do to help?

- Use downspouts to direct runoff away from manure.
- Pick up manure from farm yards and paddocks at least every three days.
- Store manure under cover in a convenient site that's sheltered from heavy winds.
- When you use a tarp for a cover, secure it well. The tarp should be durable, heavy-weight and large enough to fully cover the pile.
- Work with the local conservation district office to make a plan and learn how to best handle your manure.
- Build a compost system or have an off-site compost facility collect the manure.

Washington's Dairy Nutrient Management Act requires all licensed dairies to develop and implement nutrient management plans. Large livestock operations must follow confined animal feeding operation (CAFO) regulations to protect water quality.

Good manure management also helps you:

- Prevent parasite re-infestation.
- Keep groundwater clean.
- *Build goodwill with your neighbors.*
- Support a healthy watershed.

Do your part to keep groundwater safe and clean.

For more information:
http://www.ecy.wa.gov/washington_waters/farms.html

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LOWER YAKIMA VALLEY
GROUNDWATER
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Well Safety: What you can do

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

The dangers of uncapped, abandoned or hand dug wells

Capping prevents pollution, serious injuries:

All wells must be securely capped, including those that are not in use, temporarily out of service, or not yet decommissioned, to protect the drinking water and the aquifer from contamination. Proper capping also prevents objects, animals and people from falling into the well.

Common methods of capping wells, include using:

- Manufactured well caps.
- Metal plates welded to the top of the well casing.
- A well-seal/artesian style cap for wells in vaults or located in areas where surface water ponds.

These can be found at pump and water supply stores. Securely attach the cap so that it prevents contamination and unpermitted access to the wells. *Don't use an overturned bucket or loose plate to cover the well casing.*

What to look for when searching for an abandoned well:

Landowners who don't know the history of wells on their property should look for the following when searching for abandoned wells:

- Pipes sticking out of the ground.
- Old well houses.
- Depressions.
- Concrete vaults, pits or tile.
- Metal plates, or old plywood lying on the ground or over concrete tile or vaults.

Do your part to keep groundwater safe and clean.

For more information:
http://www.ecy.wa.gov/programs/wr/wells/abandon-wells.html
https://fortress.wa.gov/ecy/publications/publications/96br097.pdf

GROUNDWATER MANAGEMENT AREA

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LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Granjas pequeñas: Lo que usted puede hacer

Área de Manejo de Aguas Subterráneas (GWMA):
El propósito de GWMA es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado.

Un mal manejo del estiércol puede amenazar los pozos de agua potable

Recoja, cubra y haga composta:

El estiércol de ganado puede ser un gran fertilizante. También puede *ser una fuente de contaminación del agua cuando se expone al clima.* Si tiene ganado, incluso solo uno o dos, usted tiene un papel especial que desempeñar en la protección del agua potable, los acuíferos subterráneos, los ríos y arroyos.

Qué puede hacer para ayudar?

- Use canalones para dirigir el escurrimiento de agua lejos del estiércol.
- Recoja el estiércol de los corrales y potreros por lo menos cada tres días.
- Almacene el estiércol bajo cubierta en un sitio conveniente que esté al abrigo de vientos fuertes.
- Cuando utilice una lona como cubierta, asegúrela bien. La lona debe ser durable, pesada y lo suficientemente grande para cubrir totalmente el montón.
- Trabaje con la oficina local de conservación del distrito para hacer un plan y aprender a manejar mejor su estiércol.
- Construya un sistema de composta o busque una planta de compostaje para que recoja su estiércol.

La Ley de Manejo de Nutrientes de Leche de Washington Dairy Nutrient Management Act requiere que todas las lecherías con licencia desarrollen e implementen planes de manejo de nutrientes nutrient management plans. Las operaciones mayores de ganado deben seguir las regulaciones de operación de animales confinados (CAFO) para proteger la calidad del agua.

El buen manejo del estiércol también lo ayuda a:

- La prevención de reinfestación de parásitos.
- Mantener el agua subterránea limpia.
- Desarrollar buena voluntad con sus vecinos.
- Apoyar una cuenca acuífera saludable.

Haga su parte para mantener las aguas subterráneas limpias y seguras.

Para más información viste:
http://www.ecy.wa.gov/washington_waters/farms.html

ÁREA DE MANEJO DE AGUAS SUBTERRÁNEAS

El propósito del Área de Manejo de Aguas Subterráneas del Valle Bajo de Yakima es reducir la contaminación de nitratos donde la concentración no cumplen con standares de Agua potable.

Grupos de trabajo GWAC

- Recolección de datos, caracterización, monitoreo
- Educación y divulgacion al publico
- Financiacion
- Agricultura de riego
- Ganado/CAFO
- Marco Regulatorio
- Residencial, comercial, industrial y municipal

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LOWER YAKIMA VALLEY
GROUNDWATER
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Qué puede hacer para proteger el agua de pozo

Área de Manejo de Aguas Subterráneas (GWMA):

El propósito de GWMA es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado.

Pasos para asegurar que tenga agua potable

Cosas a considerar si tiene una vivienda con pozo privado:

Haga pruebas a su agua – Al menos una vez al año para nitratos y bacterias coliformes. Los altos niveles de nitratos pueden afectar a mujeres embarazadas, a los recién nacidos y a los ancianos, y las altas concentraciones de bacterias pueden causar enfermedades. Más información sobre el Área de Manejo de Aguas Subterráneas del Valle Bajo de Yakima en: http://www.yakimacounty.us/1617/Ground-Water-Management-Area. Una lista de laboratorios certificados e información sobre pruebas de agua está disponible en línea en: http://www.yakimacounty.us/344/Drinking-Water-Testing.

Localice todos los pozos en su propiedad, activos e inactivos. Asegúrese de tapar sus pozos de forma segura con tapas prefabricadas o soldadas para evitar que contaminación y objetos caigan a su pozo.

Haga un bombeo a su fosa séptica – Descuidar el mantenimiento de su sistema séptico puede resultar en que se regresen las aguas residuales, reparaciones costosas y filtración superficial que puede contaminar su pozo. Un sistema para un hogar de cuatro personas debe bombearse cada tres años.

Utilice menos agua – No solo su sistema séptico funciona mejor con menos agua, sino también el bombear más agua de su pozo puede atraer contaminación cercana hacia su hogar.

Maneje los fertilizantes y productos químicos – El exceso de fertilizante se mueve fácilmente a través del suelo y contribuye a altos niveles de nitrato. Productos químicos derramados pueden alcanzar el agua de su pozo. Recicle los residuos domésticos y peligrosos en los centros de recolección del Condado. Nunca tire estos productos en su propiedad ni los vierta en el drenaje.

Aísle los residuos animales– Los corrales de animales y los montones de estiércol son fuentes de nitratos y bacterias. Tome medidas para evitar el escurrimiento y la filtración del suelo.

Instale válvulas preventivas de reflujo – en todas sus llaves de agua fuera de la casa. A veces, el agua puede sifonar de regreso a través de una manguera y hacia su pozo. Tenga cuidado cuando conecte rociadores de químicos a su manguera.

ÁREA DE MANEJO DE AGUAS SUBTERRÁNEAS

El propósito del Área de Manejo de Aguas Subterráneas del Valle Bajo de Yakima es reducir la contaminación de nitratos donde la concentración no cumplen con standares de Agua potable.

Grupos de trabajo GWAC

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Haga su parte para mantener las aguas subterráneas limpias y seguras.

LOWER YAKIMA VALLEY
GROUNDWATER
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COMMITTEE

Seguridad de sistemas sépticos: Lo que usted puede hacer

Área de Manejo de Aguas Subterráneas (GWMA):
es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado

Los sistemas sépticos que fallan pueden contaminar los pozos de agua potable

Revíselo, arréglelo y dele mantenimiento:

La bacteria, los virus y otros contaminantes de las aguas residuales de un sistema séptico que falla pueden contaminar pozos de agua potable, acuíferos subterráneos, lagos, ríos y arroyos.

Un sistema séptico no tiene que ser un problema.

- Obtenga inspección y mantenimiento regular. Elija una fecha o una época del año que sea fácil de recordar para tener la inspección. Anótelo en su calendario.
- Bombee regularmente su sistema. Normalmente, una vez cada tres años para un hogar de cuatro personas.
- Aprenda a mantener su sistema funcionando correctamente. Tenga cuidado con lo que vierte por el desagüe. No desechos de mascotas, medicamentos, grasas ni químicos tóxicos.
- Esté atento a las señales de que su tanque está cerca de la capacidad o de que su sistema está fallando. ¿Tiene olores? Pídale a alguien que lo revise inmediatamente. Luego, arréglelo si es necesario.
- Mantenga los árboles por lo menos a 30 pies del borde del campo de drenaje para evitar que las raíces lo invadan. Nunca conduzca sobre el sistema.
- Conserve agua. Demasiada agua puede causar que los sólidos escapen del tanque y que tapen las líneas del campo de drenaje.
- Repare o reemplace el sistema cuando falle o cuando sea inadecuado.

Localice el tanque séptico y el campo de drenaje:

- Utilice el plano de su propiedad o siga la línea de descarga de su casa. Pruebe el suelo con una barra para determinar la ubicación del su tanque séptico.
- Las tuberías subterráneas distribuyen las aguas residuales en el campo de drenaje. Las áreas húmedas pueden indicar un campo de drenaje defectuoso que necesita atención profesional.

Haga su parte para mantener las aguas subterráneas limpias y seguras.
Para más información visite:
http://www.ecy.wa.gov/programs/wq/wqguide/septic.html
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ÁREA DE MANEJO DE AGUAS SUBTERRÁNEAS

El propósito del Área de Manejo de Aguas Subterráneas del Valle Bajo de Yakima es reducir la *contaminación de nitratos* donde la concentración no cumplen con standares de Agua potable.

Grupos de trabajo GWAC

- Recolección de datos, caracterización, monitoreo
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Seguridad en pozos: Lo que usted puede hacer

Área de Manejo de Aguas Subterráneas (GWMA):
El propósito de GWMA es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado.

Los peligros de pozos destapados, abandonados o excavados a mano.

Las tapas evitan la contaminación y lesiones graves:

Todos los pozos deben estar tapados, incluyendo los que no están en uso, temporalmente fuera de servicio o que todavía no están retirados de servicio para proteger el agua potable y el acuífero de la contaminación. Una cubierta adecuada también impide que objetos, animales y personas caigan en el pozo.

Los métodos comunes de tapado de pozos, incluyen el uso de:

- Tapas para pozo prefabricadas.
- Placa de metal soldada a la parte superior del revestimiento del pozo.
- Una tapa de sello para pozo estilo artesiano en bóvedas o localizados en áreas donde el agua superficial se acumula.

Estos pueden encontrarse en tiendas de materiales para irrigación y bombas de agua. Fije la tapa para evitar la contaminación y el acceso no permitido al pozo. *No utilice solo un balde volteado o una placa suelta para cubrir el pozo.*

En qué debe fijarse durante la búsqueda de un pozo abandonado:

Los propietarios que no saben la historia de los pozos en su propiedad deben fijarse en lo siguiente durante la búsqueda de pozos abandonados:

- Tuberías que salen de la tierra.
- Estructuras y cobertizos para pozos.
- Depresiones en el suelo.
- Bóvedas de hormigor, hoyos, o Azulejo.
- Placas de metal o madera en el suelo o sobre revestimientos o bóvedas de concreto.

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COMMITTEE

Seguridad de sistemas sépticos: Lo que usted puede hacer

Área de Manejo de Aguas Subterráneas (GWMA):

El propósito de GWMA es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado

Los sistemas sépticos que fallan pueden contaminar los pozos de agua potable

Revíselo, arréglelo y dele mantenimiento:

La bacteria, los virus y otros contaminantes de las aguas residuales de un sistema séptico que falla pueden contaminar pozos de agua potable, acuíferos subterráneos, lagos, ríos y arroyos.

Un sistema séptico no tiene que ser un problema.

- Obtenga inspección y mantenimiento regular. Elija una fecha o una época del año que sea fácil de recordar para tener la inspección. Anótelo en su calendario.
- Bombee regularmente su sistema. Normalmente, una vez cada tres años para un hogar de cuatro personas.
- Aprenda a mantener su sistema funcionando correctamente. Tenga cuidado con lo que vierte por el desagüe. No desechos de mascotas, medicamentos, grasas ni químicos tóxicos.
- Esté atento a las señales de que su tanque está cerca de la capacidad o de que su sistema está fallando. ¿Tiene olores? Pídale a alguien que lo revise inmediatamente. Luego, arréglelo si es necesario.
- Mantenga los árboles por lo menos a 30 pies del borde del campo de drenaje para evitar que las raíces lo invadan. Nunca conduzca *sobre el sistema.*
- Conserve agua. Demasiada agua puede causar que los sólidos escapen del tanque y que tapen las líneas del campo de drenaje.
- Repare o reemplace el sistema cuando falle o cuando sea inadecuado.

Localice el tanque séptico y el campo de drenaje:

- Utilice el plano de su propiedad o siga la línea de descarga de su casa. Pruebe el suelo con una barra para determinar la ubicación del su tanque séptico.
- Las tuberías subterráneas distribuyen las aguas residuales en el campo de drenaje. Las áreas húmedas pueden indicar un campo de drenaje defectuoso que necesita atención profesional.

Haga su parte para mantener las aguas subterráneas limpias y seguras.
Para más información visite:
http://www.ecy.wa.gov/programs/wq/wqguide/septic.html
http://www.yakimacounty.us/335/Septic-Systems

ÁREA DE MANEJO DE AGUAS SUBTERRÁNEAS

El propósito del Área de Manejo de Aguas Subterráneas del Valle Bajo de Yakima es reducir la contaminación de nitratos donde la concentración no cumplen con standares de Agua potable.

Grupos de trabajo GWAC

- Recolección de datos, caracterización, monitoreo
- Educación y divulgacion al publico
- Financiacion
- Agricultura de riego
- Ganado/CAFO
- Marco Regulatorio
- Residencial, comercial, industrial y municipal

Para participar, llame al: (509) 574-2300

Para más información visite: www.yakimacounty.us

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Granjas pequeñas: Lo que usted puede hacer

Área de Manejo de Aguas Subterráneas (GWMA):

El propósito de GWMA es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado.

Un mal manejo del estiércol puede amenazar los pozos de agua potable

Recoja, cubra y haga composta:

El estiércol de ganado puede ser un gran fertilizante. También puede ser una fuente de contaminación del agua cuando se expone al clima. Si tiene ganado, incluso solo uno o dos, usted tiene un papel especial que desempeñar en la protección del agua potable, los acuíferos subterráneos, los ríos y arroyos.

Qué puede hacer para ayudar?

- Use canalones para dirigir el escurrimiento de agua lejos del estiércol.
- Recoja el estiércol de los corrales y potreros por lo menos cada tres días.
- Almacene el estiércol bajo cubierta en un sitio conveniente que esté al abrigo de vientos fuertes.
- Cuando utilice una lona como cubierta, asegúrela bien. La lona debe ser durable, pesada y lo suficientemente grande para cubrir totalmente el montón.
- Trabaje con la oficina local de conservación del distrito para hacer un plan y aprender a manejar mejor su estiércol.
- Construya un sistema de composta o busque una planta de compostaje para que recoja su estiércol.

La Ley de Manejo de Nutrientes de Leche de Washington Dairy Nutrient Management Act requiere que todas las lecherías con licencia desarrollen e implementen planes de manejo de nutrientes nutrient management plans. Las operaciones mayores de ganado deben seguir las regulaciones de operación de animales confinados (CAFO) para proteger la calidad del agua.

El buen manejo del estiércol también lo ayuda a:

- La prevención de reinfestación de parásitos.
- Mantener el agua subterránea limpia.
- Desarrollar buena voluntad con sus vecinos.
- Apoyar una cuenca acuífera saludable.

Haga su parte para mantener las aguas subterráneas limpias y seguras.

Para más información viste:
http://www.ecy.wa.gov/washington_waters/farms.html

ÁREA DE MANEJO DE AGUAS SUBTERRÁNEAS

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LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Seguridad en pozos: Lo que usted puede hacer

Área de Manejo de Aguas Subterráneas (GWMA):

El propósito de GWMA es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado.

Los peligros de pozos destapados, abandonados o excavados a mano.

Las tapas evitan la contaminación y lesiones graves:

Todos los pozos deben estar tapados, incluyendo los que no están en uso, temporalmente fuera de servicio o que todavía no están retirados de servicio para proteger el agua potable y el acuífero de la contaminación. Una cubierta adecuada también impide que objetos, animales y personas caigan en el pozo.

Los métodos comunes de tapado de pozos, incluyen el uso de:

- Tapas para pozo prefabricadas.
- Placa de metal soldada a la parte superior del revestimiento del pozo.
- Una tapa de sello para pozo estilo artesiano en bóvedas o localizados en áreas donde el agua superficial se acumula.

Estos pueden encontrarse en tiendas de materiales para irrigación y bombas de agua. Fije la tapa para evitar la contaminación y el acceso no permitido al pozo. *No utilice solo un balde volteado o una placa suelta para cubrir el pozo.*

En qué debe fijarse durante la búsqueda de un pozo abandonado:

Los propietarios que no saben la historia de los pozos en su propiedad deben fijarse en lo siguiente durante la búsqueda de pozos abandonados:

- Tuberías que salen de la tierra.
- Estructuras y cobertizos para pozos.
- Depresiones en el suelo.
- Bóvedas de hormigor, hoyos, o Azulejo.
- Placas de metal o madera en el suelo o sobre revestimientos o bóvedas de concreto.

Haga su parte para mantener las aguas subterráneas limpias y seguras.

Para más información viste:
http://www.ecy.wa.gov/programs/wr/wells/abandon-wells.html
https://fortress.wa.gov/ecy/publications/publications/96br097.pdf

ÁREA DE MANEJO DE AGUAS SUBTERRÁNEAS

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Para más información visite: www.yakimacounty.us

Lower Yakima Valley Groundwater Management Area

Education & Public Outreach (EPO's) Accomplishments Timeline

2012-2017

2012

1. EPO develops the Education and Public Outreach (EPO) Plan as required under WAC 173-100-090 (1) Groundwater advisory committee.
2. December 12, 2012 - GWAC approves the outreach plan; Yakima County submits it to the Department of Ecology.

***2013 - EPO Implements Education and Outreach Plan**

3. EPO creates GWAC logo options for GWAC consideration.
4. March 13, 2013 - GWAC approves a GWMA logo, which is used for all subsequent outreach materials, including but not limited to the website, letterhead, news releases, outreach flyers, program banner, and billboards.
5. **Public Awareness Survey (English & Spanish).** GWAC contracts with Heritage University to conduct **bilingual** door-to-door surveys in the GWMA. EPO designs survey to gauge the public's awareness of the nitrate issue and its potential health impacts. (Work included but was not limited to creating the survey content (**English & Spanish)** and packets, mapping the areas to be surveyed, training 16 Heritage University **bilingual** students to conduct the survey, troubleshooting issues, conducting quality control of the survey methods, and entering data into a spreadsheet.)

a. **Outreach results:** 300 Direct **Bilingual** Contacts (direct mail, in person, flyers) to households in the GWMA.

b. 136 surveys completed

c. **Spanish/English** news releases issued to media (pre-and post-survey).

d. EPO issues survey results in English/**Spanish** and posts to the website.

6. **Health provider outreach.** Over 200 healthcare providers receive nitrate-related health information and a survey asking them if they have observed symptoms of methemoglobinemia in their maternal or infant patients (English).

7. July 18- Commissioner Rand Elliott and Andy Cervantes make a presentation to the Central Family Medicine Residency Program on the GWMA and nitrates.

8. September - EPO creates script for—and GWAC/EPO member Andy Cervantes participates in—an **Hispanic Affairs Commission "Connect with Your Government" Spanish-language** statewide radio talk show to increase awareness about the GWMA

9. **December -** Commissioner Elliott gives a presentation on the GWMA, and seeks support of the upcoming well assessment survey, to the Community Advisory Board for **El Proyeto Bienestar**

10. **December-High Risk Well Assessment Survey Phase I (English/Spanish)** EPO Creates a survey instrument and develops an outreach campaign for a well assessment survey in the target area. (Wrote and released **bilingual** materials including PSA's, a direct mail piece, GWAC Chair letter to area newspapers; explored ministerial outreach to churches)

11. **GWMA website.** EPO develops and launches a community website that offers information about the committee, its meetings and information on nitrate-related topics.

***2014-**

12. January-EPO issues a news release announcing the GWAC's accomplishments

13. EPO updates the website and maintains it in "real time" from its inception to the present (English)

14. EPO continues **(English/Spanish)** outreach for High Risk Well Assessment Survey Phase I

    April 7 - issues an **(English/Spanish)** news release announcing that the survey deadline has been extended

15. **New Mom Campaign (English/Spanish)**

    a. EPO develops and obtains GWAC approval for new mom messages to be distributed in hospitals and clinics.

    b. EPO prints and distributes over 2000 English/**Spanish** new mom flyers to hospitals, clinicians and at health fairs and community events (including but not limited to Zillah Days and Granger Agricultural bilingual event)

    c. **EPO seeks and obtains partnership with the University of Washington's** Pediatric Environmental Health Specialty Unit (PEHSU) to collaborate on the New Mom campaign

        i. PEHSU conducts clinician trainings in Yakima and Lower Valley to raise clinician awareness of nitrate issue, resources and treatment

        ii. PEHSU obtains authorization to offer Continuing Education Units (CEU) to participating healthcare providers.

        iii. PEHSU creates and distributes Clinician Training video

iv. Nitrate/new mom materials posted to PEHSU's national website

16. **GWAC educational materials**: EPO creates and obtains GWAC approval of GWAC slide deck (GWAC background information and nitrate education series); posted to website

17. **May - Deep Soil Sampling Launched.** EPO partners with Irrigated Ag working group to promote program.

18. May 2 - EPO issues a **bilingual** news release reminding households of the May 31 deadline to participate in Phase I Free Well Testing.

19. **Phase I of the (English/Spanish) High Risk Well Assessment Sampling Surveys is completed** (172 Total)

    a. **Outreach: Bilingual** outreach included multiple presentations to Sunnyside Workforce clients, talk show **participation** on **Spanish** (KDNA) and English radio stations, paid advertisement on **Spanish** and English-language radio, 600 **Spanish**-English direct mail pieces, and GWAC Chair editorial outreach published in area English and **Spanish** papers.

20. GWAC approves a two-year outreach budget developed by the EPO

TOTAL <u>$267,000:</u>

- Abandoned Wells and Septic System Maintenance $76,000
- Educational Outreach Campaigns $54,000
- Wellhead Risk Assessment Surveys-Phase 2 $100,000
- Redesign and Maintain GWMA Website $12,000
- Community Outreach Surveys $25,000

21. EPO releases the High Risk Well Assessment results.

22. EPO prints and distributes 2000 double-sided English/**Spanish** New Mom Flyers at health fairs in Prosser, Yakima and other outlets.

***2015 –**

23. EPO rebuilds and launches the new GWMA website

24. High Risk Well Assessment Follow-up (English/Spanish)

EPO communicates test results, prevention messages and GWAC information to high risk well assessment participants (171 unique mail pieces in English and **Spanish**)

25. EPO evaluates and reports back to the GWAC regarding the Phase I High Risk Well Assessment results. They agree that the data show a great need for well owners to be familiar with their wells, and to test their wells more frequently.

26. EPO announces Phase II Well Assessment survey. EPO's goal is to complete 200 sampling surveys.

EPO agrees to use Phase I methodology for messaging in Phase II. Targets: areas of known high nitrate, areas where little nitrate data exists. Direct mail list is increased from 600 (Phase I) to 1000 in Phase II.

27. Phase II **(English/Spanish)** outreach continues. December-EPO evaluates its outreach methods (direct mail, radio advertising, flyers and newspaper coverage.) Response from survey participants indicates that direct mail is the most cost-effective method of eliciting participation. Accordingly, EPO plans a second direct-mail release in January 2016.

***2016**

28. County sends 115 **(English/Spanish)** results letters to recent well assessment participants with their certified lab results and educational materials. January- 350 additional household invitation letters are sent.

29. January and March-**(English/Spanish)** news releases inviting well assessment participation are released.

30. March 31-Phase II high risk well assessment survey closes.

31. April-the County mails the last round of **(English/Spanish)** results letters to the Phase II well assessment participants with their certified lab results and educational materials. The letters included **(English/Spanish)** handouts on nitrate, coliform, and private well and septic system maintenance.

32. EPO Completes Phase II of the High Risk Well Assessment Sampling Surveys (289) for a total of 466 completed surveys (Phase I-177 + Phase II-289).

   a. **Outreach: Bilingual** outreach included multiple presentations to Sunnyside Workforce clients, talk show participation on **Spanish** and English radio stations, paid advertisement on **Spanish** and English-language radio, 600 Spanish-English direct mail pieces, and GWAC Chair editorial outreach published in area English and **Spanish** papers.

   b. **Follow-up (English/Spanish)** County communicates test results, prevention messages, septic system maintenance and GWAC information to high risk well assessment participants (289 unique mail pieces in English and **Spanish**)

33. *GWAC/EPO participate in five Spanish-language Fred Hutch-sponsored health fairs (Sunnyside, Mabton, Zillah, Granger and Toppenish) between May and August 2016.

Volunteers make **bilingual**, one-on-one contact with approximately 250 lower Valley residents.

(English/Spanish) Information on private wells, nitrate in groundwater, new mom flyers is distributed to visitors.

Visitors are also asked to complete the GWAC's **(English/Spanish)** public survey.

Residents on private wells are offered **(English/Spanish)** nitrate test step strips for a "do-it-yourself" drinking water test. Self-addressed stamped envelopes are included with the test strips so people can return their test results directly to Yakima County.

34. EPO develops, presents and receives GWAC approval to launch a "Test Your Well" English/**Spanish billboard** campaign in the Lower Yakima Valley.

35. December - first (English/Spanish) billboard goes live in the LYV GWMA.

***2017**

36. January - Second of two (English/Spanish) "Test Your Well" Billboards Goes Live

37. EPO creates, translates and posts five **(English/Spanish)** "**What You Can Do**" flyers to the GWMA website.

38. EPO Launches a (English/Spanish) "What You Can Do to Protect Well Water Campaign

(in response to wide-spread local flooding, especially in the unincorporated community of Outlook) March & April 2017

- **(English/Spanish)** "What You Can Do to Protect Well Water" flyers "(English/Spanish) and test trips distributed door-To-door in Outlook (Yakima Health District).

- **(English/Spanish)** 12,000 What You Can Do to Protect Well Water flyers inserted in the Sunnyside Daily Sun News on March 29, 2017
- **(English/Spanish)** 10,700 flyers inserted in the Spanish-language *El Sol* weekly publication on March 30, 2017
- **Spanish-language** KDNA news show participation – April 4, 2017 (Andy Cervantes and Ignacio Marquez)
- KIT interview-March 30, 2017 (Commissioner Rand Elliott)
- April 29- **(English/Spanish)** flyers (using a **Spanish-speaking EPO member)** distributed at the Sunnyside Walmart store

39. PEHSU (English/Spanish) New Mom Flyers

200 **(English/Spanish)** flyers are distributed to the Toppenish Community Hospital (restock order)

40. EPO Requests Working Groups to Complete an EPO Questionnaire

EPO asks all working groups to answer EPO's questions related to their mission, accomplishments, discoveries, target audiences and messages.

The purpose of this exercise is to help the EPO develop a short-and long-term (post adoption) Communications and Outreach Plan for the GWAC's consideration.

This information is compiled in a summary distributed to the GWAC.

41. June - EPO begins to develop its alternatives recommendations for the GWMA program.

- EPO requests GWAC assistance to identify specific messages and outreach it would like conducted.

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

YAKIMA HEALTH DISTRICT 1911 PREVENTION IS OUR BUSINESS

PUBLIC HEALTH Prevent • Promote • Protect BENTON-FRANKLIN HEALTH DISTRICT

Dear Medical Provider:

The Lower Yakima Valley Ground Water Management Area Advisory Committee (GWAC) is working to address nitrate contamination and its sources in a wide area where elevated levels of nitrate have been identified in private drinking water wells (see attached map).

This letter is being written in cooperation with the Benton-Franklin and Yakima County Health Districts, which are active members of the advisory committee, and is designed to alert you to the health risks associated with nitrate contamination.

Attached is a handout to provide you with a brief refresher about methemoglobinemia in infants. Symptoms are common and have the potential of being under diagnosed.

At greatest risk are infants younger than six months of age because of the immaturity of their enzyme systems which convert methemoglobin back to hemoglobin.

Maternal exposure to environmental nitrates and nitrites may increase the risk of pregnancy complications such as anemia, abortion, premature labor, or preeclampsia. Study of other potential reproductive, developmental, or carcinogenic effects has not produced conclusive results.

If you are concerned about a patient the appropriate testing should be done to verify your diagnosis. Upon confirmation you should report the condition to the communicable disease section at the Yakima or Benton-Franklin Health Districts depending on your patient's county of residence. Environmental Health personnel at each district should be able to assist you with water quality information, if available, as well as assist the family with sampling of their water as needed.

Yakima County Health District Communicable Disease Report Line: 509-249-6521; for information about water quality, treatment, options, call be Environmental Health help desk at 509-249-6508. Benton-Franklin Health District: 509-460-4200.

We hope you will consider discussing the drinking-water conditions of your patients as you treat them, especially if they reside in the Lower Yakima Valley and exhibit symptoms of methemoglobinemia.

Suspected sources of nitrate contamination are from a variety of land uses, including commercial fertilizers for crop production, animal manures, septic systems and land application of waste water.

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

YAKIMA HEALTH DISTRICT 1911 PREVENTION IS OUR BUSINESS

PUBLIC HEALTH Prevent • Promote • Protect BENTON-FRANKLIN HEALTH DISTRICT

More information about the Lower Yakima Valley Ground Water Management Area is available online at: http://www.yakimacounty.us/gwma/

Sincerely,

Andre Fresco, Administrator

Yakima County Health District

Amy D. Person, M.D., District Officer

Benton-Franklin Health District

attachments: Methemoglobinemia in infants

LYVGWMA Vicinity Map

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):

The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Questionnaire for Health Care Providers

Nitrate contamination of drinking water is a growing concern in the United States and around the world. The Lower Yakima Valley has a history of elevated nitrates in groundwater wells that sometimes exceed drinking water standards. In 2011, the Lower Yakima Valley Groundwater Management Area (GWMA) was formed to address nitrate contamination.. The most pressing health issue related to elevated nitrate levels in drinking water is methemoglobinemia in very young children. You can help us gather critical information by completing and returning this questionnaire. We understand that confidentiality prevents sharing of patient information and ask that you provide general information only. Thank you very much for sharing your time and expertise.

1. During the past five years have you cared for infants with signs and symptoms of methemoglobinemia, such as cyanosis in the absence of heart and lung pathology? YES NO

Comments:

____

____

2. Are you aware of the relationships between methemoglobinemia and

   a. infants (<6 mo.) and well water contaminated with nitrates? YES NO

   b. diarrhea in infants? YES NO

   c. sepsis in infants? YES NO

3. Do you question about the use of well water when dealing with infants <6 mo. YES NO

4. Do you question about the use of well water when dealing with pregnant women? YES NO

5. Do you encourage families with a newborn to have their well tested for bacteria and nitrates to find out if it's safe before using it to mix formula for their new infant? YES NO

6. How would you like to learn more about nitrate related problems?

ON-LINE _____ WORKSHOPS _____ WRITTEN SELF STUDY _____HEALTH DEPARTMENT

MAILING _____ OTHER (Please describe) ____________________

Questionnaire for Health Care Providers

7. Please share your thoughts on this subject

____

____

(END OF SURVEY)

If you wish to receive additional information on the Lower Yakima Valley Groundwater Management Area, you may either visit www.yakimacounty.us/GWMA/ or provide the following:

Name: ____

Mailing Address: _____________________________________

Phone: ____

E-mail: ____

Thank you for participating in this survey.

Please return this survey to: Lower Yakima Valley Groundwater Management Area, c/o Yakima County Public Services, 128 N 2nd St, Fourth Floor, Yakima WA 98901.

METHEMOGLOBINEMIA

IN INFANTS < 6 MONTHS OF AGE

SYMPTOMS/SIGNS:

Bluish discoloration of skin (cyanosis): fails to respond to inhaled O2

Fatigue/lethargy

Shortness of breath/tachypnea

Nausea

Diaphoresis

Mental status changes

In severe intoxication (50-70% methemoglobin): shock, seizures, acidosis, death

DIAGNOSIS:

Methemoglobin level: normal <1%

bluish/chocolate brown blood

Arterial blood gas: usually normal PO2 in the face of cyanosis

Pulse oximetry: usually inaccurate in the face of methemoglobinemia

O2 saturation: usually low but inaccurate in the face of methemoglobinemia

ETIOLOGY:

Nitrates/nitrites in water supply (Sources: fertilizer, manure, damaged well heads, leaking septic systems): EPA recommends <10 ppm

Infants who have diarrhea, sepsis, or other infections may have increased endogenous production of nitrites. Infants already exposed to nitrates in their water source would be at greater risk for methemoglobinemia with these infections.

TREATMENT:

1% Methylene blue: 1-2mg/kg IV (beware of risks with G6PD deficiency)

ascorbic acid

oxygen

exchange transfusion

WEBSITES:

http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001588/

http://www.nap.edu/catalog.php?record_id=4795

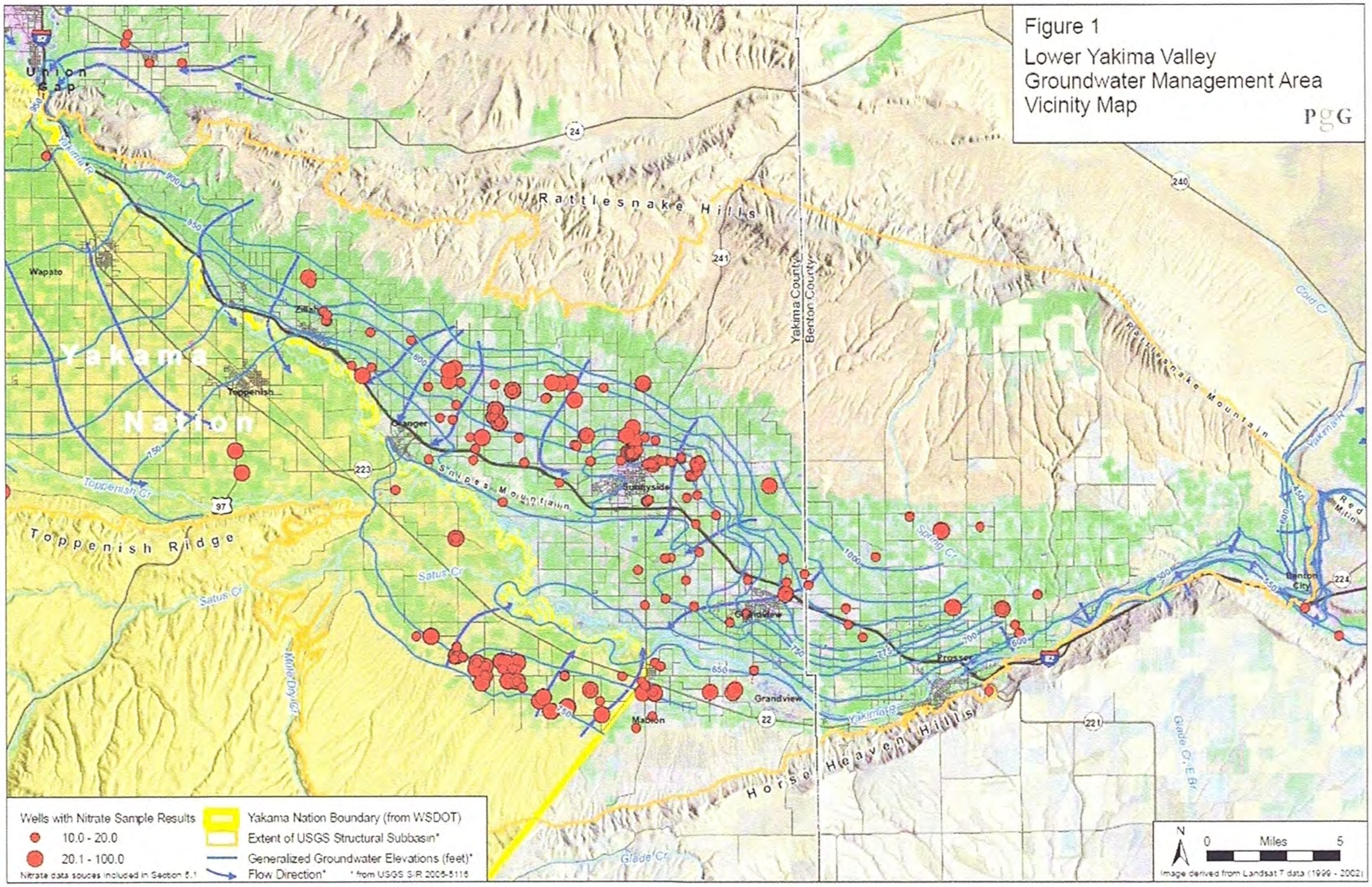


Figure 1
Lower Yakima Valley
Groundwater Management Area
Vicinity Map
PgG
Union Gap
Rattlesnake Hills
Wapato
Zillah
Yakama Nation
Toppenish
Granger
Sunnyside
Snipes Mountain
Toppenish Cr
Toppenish Ridge
Satus Cr
Yakima County
Benton County
Rattlesnake Mountain
Cold Cr
Spring Cr
Grandview
Mabton
Prosser
Benton City
Red Mtn
Horse Heaven Hills
Yakima R
Glade Cr
Wells with Nitrate Sample Results
10.0 - 20.0
20.1 - 100.0
Nitrate data souces included in Section 5.1
Yakama Nation Boundary (from WSDOT)
Extent of USGS Structural Subbasin*
Generalized Groundwater Elevations (feet)*
Flow Direction*
* from USGS SIR 2006-5116
Miles
0
5
Image derived from Landsat 7 data (1999 - 2002)

5 GWAC Public Opinion Survey Summary Report_2013_0927_ke v5.xls - Survey Question Answers.docx

#9	#11
Who would you trust to give you reliable information about nitrates in drinking water?	Are there things that you do to make sure your drinking water is safe?
18 Responses: County	42 Responses: Filter
14 Responses: Health Department	6 Responses: Test
10: Doctor	4: Purchase drinking water
9: Don't know	4-Reverse Osmosis
6: Government Agency	Have it checked
6: Independent Company	Inspection
3: Department of Health	Lab
2: Lab	A person was coming in that specializes in water treatment.
2: Testing Service	Refrigerator treats water
2: himself	Soft water tester
City	Buy Culligan
Culligan	Water Softener
Cascade Testing/Independent	Water system
Ask Owner	Whole house filter, considering upgrading (well drilled in 2009)
Down town	Zero test often number low
Drinking water Kinetico Personnel	
EPA	
Fed water	
Central Washington University	
Heritage University Students	
Local School	
Clean water in Tri Cities, from the fair	
4 years tested	
Labon Yakima	
My own research (not counting on 2nd hand info.)	
myself	
Nobody	
Anyone knows	
People who know about it	
Professionals who test the water	
Rain Water in Sunnyside	
Reputable servicer	
Service who tests water	
Somebody who test for nitrates	
Son	
Water officials @ clinic	
Water system facility	
Whoever his landlord tells him	
Yes but she/he lives in Texas	
Don't care	

	LOWER YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA INFORMATIONAL PUBLIC QUESTIONNAIRE							
		Number	Percentage	TOTAL				
	Number of Households in Survey			300				
	Number of Surveys Completed	136	45%					
	Number of households Not Possible (dogs, gates, etc)	88	29%					
	Number of Households Declining	60	20%					
	Number of Households Not Attempted	16	5%					
	TOTAL	**300**	**100%**					
	QUESTION	**YES**	**DON'T KNOW**	**NO**	**NOT ANSWERED**	**TOTAL**		
#1	Where does the water in your home come from?	**PRIVATE WELL**	**SHARED WELL**	**COMM. WELL**	**DON'T KNOW**			
		122	5	2	7	136		
		90%	4%	1%	5%			
#2	If you have a private or shared well, where do you get your drinking water?	**TAP WATER**	**BOTTLED WATER**	**TREATED WATER**	**NOT ANSWERED**			
		69	24	41	2	136		
		51%	18%	30%	1%			
#3	If you are on a community water system, where do you get your drinking water	**TAP WATER**	**BOTTLED WATER**	**TREATED WATER**	**NOT ANSWERED**			
		1	0	0	1	2		
		50%		50%				
		YES	**DON'T KNOW**	**NO**	**NOT ANSWERED**	**TOTAL**		
#4	Are you aware of the potential health hazards in drinking water with high levels of nitrates?	94	35		7	136		
		69%	26%		5%			
#5	Has your well water been tested for nitrates?	73	23	40		136		
		54%	17%	29%				
#6	Has your well water been tested for bacteria?	45	28	63		136		
		33%	21%	46%				
		OWN	**RENT**					
#7	Do you own your home or rent?	115	17					
		85%	12%					
#8	If you rent, do you feel comfortable asking your landlord to have the water tested.	12		5		17		
		71%		29%				
#9	Who would you trust to give you reliable information about nitrates in drinking water? (answers on p.2)							

#10	Are you aware of anyone in your homes that has become ill from drinking your water?	6		125	5	136		
		4%		92%				
#11	Are there things you do to make sure your drinking water is safe? (answers on p. 2)	81	39	16	0	136		
		59%	29%	12%	0%			
#12	How long have you lived in your home							
	Less than a year	8						
	1-10years	50						
	10-15years	24						
	15-20year	13						
	20-43years	21						
	Not Answered	20						
#13	Is there a child under the age of six months in your household?	1		134	1	136		
		<1.0%		99.0%	<1.0%			
#14	Are there pregnant women in your household?	1		134	1	136		
		<1.0%		99%	<1.0%			
#15	Are there chronically ill people in your household?	7		128	1	136		
		5%		94%	<1.0%			
#16	Have you heard of the Lower Valley GWMA?	57		73	6	136		
		42%		54%	4%			
					Percentages rounded to the nearest			
#17	Where have you heard of the Lower Yakima Valley Ground Water Management Area (GWMA)	**RADIO**	**TV**	**NEWSPAPER**	**AT WORK**	**HEALTH CARE**	**OTHER**	**NOT ANSWERED**
		8	4	24	1	2	18	79
		5%	2%	17%	0%	0%	13.0%	58.0%
#18	Are you interested in being contacted for a survey of your well at a later date?	45		76	15	136		
		33%		56%	11%			
#19	Do you have any information about your well or your well log?	17	24	81	14	136		
		13%	18%	59%	10%			

5a_GWAC Public Opinion survey_(Eng) public questionnaire-FINALpng_Page1

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Form # GWMA0001 A
Revised 7/25/13

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Lower Yakima Valley Groundwater Management Area
Informational Public Questionnaire

☐ Survey Completed ☐ Survey Attempted/Not Completed:
No One Home____ Declined____ Other____
Number of Attempts____

***Address:**________________________

***Parcel Number**______________ ***Survey Date**________ ***Surveyor**____________

***Mandatory Information**

The purpose of this questionnaire is to learn more about water quality and nitrates in drinking water from people who live here. Thank you for sharing your ideas.

1. Where does the water in your home come from?
   PRIVATE WELL SHARED WELL COMMUNITY WATER DON'T KNOW
2. If you have a private or shared well, where do you get your drinking water?
   TAP WATER BOTTLED TREATED WATER
3. If you are on a community water system, where do you get your drinking water?
   TAP WATER BOTTLED
4. Are you aware of the potential health hazards in drinking water with high levels of nitrates? YES NO
5. Has your well water been tested for nitrates? YES NO DON'T KNOW
6. Has your well water been tested for bacteria? YES NO DON'T KNOW
7. Do you own your home or rent? OWN RENT
8. If you rent, do you feel comfortable asking your landlord to have the water tested? YES NO
9. Who would you trust to give you reliable information about nitrates in drinking water?
   ____
10. Are you aware of anyone in your home that has become ill from drinking your water? YES NO
    Please describe: ________________________

Has this been confirmed by a physician? YES NO DON'T KNOW

11. Are there things that you do to make sure your drinking water is safe? YES NO
    Please describe ________________________
12. How long have you lived in your home? Years_____ Months _____
13. Is there a child under the age of six months in your household? YES NO
14. Are there pregnant women in your household? YES NO
15. Are there chronically ill people in your household? YES NO
16. Have you heard of the Lower Yakima Valley Ground Water Management Area (GWMA)? YES NO
17. Where have you heard of the GWMA? Please circle all that apply:
    RADIO TELEVISION NEWSPAPER NEIGHBORS AT WORK HEALTH CARE OTHER
18. Are you interested in being contacted for a survey of your well at a later date? YES NO
    If yes, please provide the following:
    Name:____________________
    Mailing Address (Street or P.O. Box, City, State, Zip)______________
    Phone: ______________E-mail: ______________
19. Do you have any information about your well or your well log? YES NO DON'T KNOW

Thank you for participating in this survey. We will use the information to increase our understanding of what people know about groundwater contamination and to improve our efforts to educate people on how to identify and prevent nitrate contamination of the groundwater.

Please return this survey to: Lower Yakima Valley Groundwater Management Area, c/o Yakima County Public Services, 128 N 2nd St, Fourth Floor, Yakima WA 98901.

5b GWAC Public Opinion SURVEY- (Sp) GWMA Public_Heritage Door-To-Door _FINAL.doc

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Forma # GWMA0001 A
Refrito 7/25/13

Groundwater Management Area (GWMA): The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Lower Yakima Valley Groundwater Management Area
Informational Public Questionnaire

☐ Encuesta terminada ☐ Se intentó hacer la encuesta/No se hizo:
No habia nadie en casa_____ No se quiso hacer_____
Otra razón_____ Número de intentos_____

***Domicilio:**___________________________

Número de parcela**_______________Fecha de la encuesta**________***Encuestador**____________

***Información requerida**
El propósito de este cuestionario es saber más de los nitritos y la calidad del agua potable según las personas que viven en esta propiedad. Gracias por atendernos y compartir sus comentarios.

1. ¿De donde viene el agua de su casa?
POZO PRIVADO POZO COMPARTIDO AGUA DE LA COMUNIDAD NO SÉ
2. Si usted tiene un pozo privado o compartido ¿de donde toma el agua para beber?
DE LA LLAVE EMBOTELLADA AGUA TRATADA
3. Si usted recibe su agua de un sistema comunitario ¿de donde toma el agua para beber?
DE LA LLAVE EMBOTELLADA
4. ¿Sabe usted los riesgos potenciales de tomar agua que contenga altos niveles de nitritos? SI NO
5. ¿Se le ha hecho prueba de nitritos a su agua? SI NO NO SÉ
6. ¿Se le ha hecho prueba de bacteria a su agua? SI NO NO SÉ
7. ¿Vive en casa propia o de renta? PROPIA DE RENTA
8. Si usted renta ¿podría usted pedirle al dueño de la propiedad que le haga pruebas al agua? SI NO
9. ¿A quién le confiaría usted que le dé información confiable acerca de nitritos en el agua?
____
10. ¿Sabe usted si alguien se ha enfermado por tomar el agua potable de su casa? SI NO
Por favor describa: ____
¿Se ha confirmado esto con un médico? SI NO NO SÉ
11. ¿Hace usted algo para asegurarse de que su agua sea segura para tomarse? SI NO
Por favor describa: ____
12. ¿Por cuánto tiempo ha vivido en su casa? Años _______ Meses ________
13. ¿Vive en su casa algún niño menor de seis meses? SI NO
14. ¿Vive alguna mujer embarazada en su casa? SI NO
15. ¿Hay alguna persona en su casa con alguna enfermedad crónica? SI NO
16. ¿Había escuchado usted del área de manejo de agua subterránea del valle bajo de Yakima o Lower Yakima Valley Ground Water Management Area (GWMA)? SI NO
17. ¿Dónde había escuchado de GWMA? Por favor circule todos los que corresponden:
RADIO TELEVISIÓN PERIÓDICO VECINOS EN EL TRABAJO EN LA CLÍNICA OTROS
18. ¿Está usted interesado de que le visitemos en una fecha futura para evaluar su pozo? SI NO
Si así es, por favor indique lo siguiente:
Nombre:_____________________________
Domicilio de correo (calle o P.O. Box, Ciudad, Estado, Código postal)_____________________
Teléfono: ___________________________Correo electrónico:____________________
19. ¿Usted tiene otra información de su pozo o archivos de lecturas de su pozo? SI NO NO SÉ

Gracias por participar en esta encuesta. Utilizaremos esta información para poder entender mejor lo que la gente sabe acerca de la contaminación del agua subterránea y para mejorar nuestros esfuerzos para informar a la gente a identificar y prevenir la contaminación de nitritos en el agua subterránea.

Lower Yakima Valley Groundwater Management Area

Informational Public Questionnaire

Por favor devuelva esta encuesta a: Lower Yakima Valley Groundwater Management Area, c/o Yakima County Public Services, 128 N 2nd St, Fourth Floor, Yakima WA 98901.

5c_Handout Updated Certified Laboratories 7-23-13_v1.xls

Lower Yakima Valley GWMA Program
Certified Testing Laboratories
(Updated July 23, 2013)

Laboratory Name	Address	Phone	Web Site	Approximate Cost
Ag Health Laboratories, Inc.	445 Barnard Boulevard Sunnyside, WA	(509) 836-2020	www.aghealthlabs.com	Nitrate - $30 Coliform - $21
Benton-Franklin Health District Lab	7102 West Okanogan Place Kennewick, WA	(509) 460-4206	www.bfhd.wa.gov	Nitrate - $24 Coliform - $24
Cascade Analytical Inc. - Yakima	1008 West Ahtanum Road, #2 Yakima, WA	(509) 452-7707	www.cascadeanalytical.com	Nitrate - $27.50 Coliform - $25
Mukang Labs, Inc.	2526 E. Saint Helens Street Pasco, WA	(509) 544-2159	www.mukanglabs.com	Nitrate - $18.50 Coliform - $20
Northwest Agricultural Consultants, Inc.	2545 West Falls Ave. Kennewick, WA	(509) 783-7450	www.nwag.com	Nitrate - $17.50 Coliform - NA
Valley Environmental Laboratory	201 East D Street Yakima, WA	(509) 575-3999	http://www.valleylab.net/	Nitrate - $35 Coliform - $25

All of the above laboratories are certified by the Washington State Department of Ecology to test for nitrate in drinking water. Ag Health Laboratories, Benton-Franklin Health District, Cascade Analytical, Mukang Labs and Valley Environmental Laboratory are also certified to test for coliform in drinking water.

Costs shown for nitrate and coliform tests are approximate and subject to change.

Lower Yakima Valley GWMA Program
Laboratorios Certificados

Nombre del laboratorio	Dirección	Teléfono	Web Site	Costo aprox.
Ag Health Laboratories, Inc.	445 Barnard Boulevard Sunnyside, WA	(509) 836-2020	www.aghealthlabs.com	Nitratos - $30 Coliforme - $21
Benton-Franklin Health District Lab	7102 West Okanogan Place Kennewick, WA	(509) 460-4206	www.bfhd.wa.gov	Nitratos - $24 Coliforme - $24
Cascade Analytical Inc. - Yakima	1008 West Ahtanum Road, #2 Yakima, WA	(509) 452-7707	www.cascadeanalytical.com	Nitratos - $27.50 Coliforme - $25
Mukang Labs, Inc.	2526 E. Saint Helens Street Pasco, WA	(509) 544-2159	www.mukanglabs.com	Nitratos - $18.50 Coliforme - $20
Northwest Agricultural Consultants, Inc.	2545 West Falls Ave. Kennewick, WA	(509) 783-7450	www.nwag.com	Nitratos - $17.50 Coliforme - NA
Valley Environmental Laboratory	201 East D Street Yakima, WA	(509) 575-3999	http://www.valleylab.net/	Nitratos - $35 Coliforme - $25

Todos los laboratorios en éste documento están certificados por el Departamento de Ecología del Estado de Washington para probar nitratos en el agua potable Los laboratorios Ag Health Laboratories, Benton-Franklin Health District, Cascade Analytical, Mukang Labs, y Valley Environmental Laboratory también están certificados para probar la presencia de coliformes en el agua potable.

El costo por la prueba de nitratos y coliforme es aproximado y sujeto a cambio.

Agua de Pozos Privados

Información sobre las bacterias coliformes y el nitrato para usuarios de pozos privados

¿Por qué debería hacer un análisis del agua de mi pozo?

Beber agua contaminada es un riesgo para la salud. Algunos contaminantes no se pueden ver, oler ni notar por el sabor. Dos de los contaminantes más comunes del agua potable son las bacterias coliformes y el nitrato, los cuales pueden ser nocivos.

¿Quién debería analizar el agua de mi pozo?

Usted o su arrendador. Los usuarios de pozos privados son responsables de analizar su propia agua. Si usted no es propietario de su vivienda pero utiliza un pozo privado, hable con su arrendador para analizar el agua o ver los resultados más recientes. Siempre podrá tomar una muestra de agua usted mismo y hacerla analizar.

¿Qué debería buscar en el análisis y con qué frecuencia?

El Departamento de Salud recomienda que analice el agua de pozo privado todos los años para verificar que no existan bacterias coliformes y nitrato.

También deberá analizar el agua cuando:

- Note un cambio en el agua, tal como el sabor, color y olor.*
- El pozo se haya inundado.
- Reemplace cualquier parte de su sistema de pozo.
- Alguna mujer de su hogar esté embarazada, amamantando o tenga una enfermedad inexplicable y usted sospeche de que el agua puede estar en riesgo.
- Escuche que el agua de su vecino está contaminada.
- Viva cerca de zonas industriales o agrícolas.*

*Estos casos pueden requerir un análisis para evitar la existencia de otros elementos distintos de las coliformes o el nitrato.

Si ha tenido problemas de contaminación previos o está preocupado por contaminantes específicos, usted debería analizar el agua del pozo con mayor frecuencia.

¿Dónde me dirijo para analizar el agua?

Los laboratorios de análisis de agua potable certificados se encuentran en todo el estado. El laboratorio que seleccione o el departamento de salud local podrán ayudarlo a decidir qué buscar en el análisis, cómo tomar las muestras y cómo interpretar los resultados. Estos análisis tienen un costo. Los costos de este año (2010) van desde los $20 a los $25 por análisis de bacterias coliformes, y desde los $30 a los $42 para el análisis de nitrato. La mayoría de los laboratorios prefieren proporcionar sus propios recipientes para muestra.

El nivel del nitrato es *menor de* 10 ppm, ¿qué debo hacer?

Los niveles de nitrato pueden variar a lo largo del año, por lo tanto si el nivel es de 5 ppm o mayor, deberá volver a tomar una prueba dentro de seis meses.

El nivel de nitrato es *mayor de* 10 ppm, ¿qué debo hacer?

Si su análisis de nitrato muestra niveles mayores a 10 partes por millón, busque un suministro de agua potable diferente y más seguro. Lo primero que debe hacer es comenzar a utilizar agua embotellada para beber y cocinar. No hierva agua con altos niveles de nitrato. Hervir el agua puede incrementar el nivel de nitrato, ¡empeorando el problema!

Otra opción es instalar un dispositivo o filtro diseñado para eliminar el nitrato del agua. Estos dispositivos se instalan con frecuencia en los grifos de la cocina, donde las personas toman agua para beber y cocinar. El nitrato no se absorbe a través de la piel, por lo tanto es seguro utilizar esta agua para limpiar y bañarse.

Otras soluciones a largo plazo incluyen:

- Cavar un pozo más profundo en una fuente diferente de aguas subterráneas;
- Conectarse a un sistema de agua público; o
- Trabajar con otras personas de su comunidad para desarrollar un nuevo sistema público de agua para su hogar y los vecinos de la zona.

Los resultados de mi análisis indican coliformes en el agua, ¿qué debo hacer?

Los análisis de coliformes por lo general indican SATISFACTORIO o NO SATISFACTORIO. Si recibe un informe SATISFACTORIO, significa que su agua no contiene estas bacterias al momento de tomar la muestra. Asegúrese de realizar este análisis de coliformes todos los años.

Si recibe un informe NO SATISFACTORIO, el agua podría estar contaminada. No beba el agua hasta que el análisis sea SATISFACTORIO. Busque un suministro de agua potable distinto y seguro. Lo primero que debe hacer es comenzar a utilizar agua embotellada o hervida para beber y cocinar. Además, debe utilizarla para preparar hielo o café, lavarse los dientes y lavar frutas y verduras que come crudas. Hervir el agua durante un minuto por lo general mata las bacterias.

El laboratorio y el departamento de salud local pueden ayudarlo a determinar si debe volver a tomar una muestra, desinfectar el pozo o tomar otras medidas basadas en el resultado.

¿Qué son las bacterias coliformes y por qué debería tener cuidado?

Las bacterias coliformes son organismos que están en el medio ambiente y en las heces de humanos y animales. Las bacterias coliformes probablemente no causan enfermedades, pero su presencia en el agua potable indica que también puede haber organismos causantes de enfermedades.

¿Qué es el nitrato?

El Nitrógeno es un químico que se encuentra en la mayoría de los fertilizantes, en estiércol de animales y en los tanques sépticos. Las bacterias naturales de la tierra pueden cambiar el nitrógeno a nitrato. El agua de lluvia y el agua de riego pueden arrastrar el nitrato por debajo de la tierra hacia las aguas subterráneas.

¿Qué me puede hacer el nitrato?

El exceso de nitrato en el cuerpo dificulta el transporte de oxígeno que deben realizar los glóbulos rojos. Aunque muchas personas no noten la diferencia, esto puede ser muy peligroso para los bebés y las mujeres embarazadas. Los bebés expuestos a grandes cantidades de nitrato pueden desarrollar el "síndrome del bebé azul," una enfermedad extraña pero que puede ser fatal.

¿Cuáles son los síntomas del síndrome del bebé azul?

Los síntomas se pueden confundir con los de otras enfermedades. Un bebé con el síndrome del bebé azul leve a moderado puede tener diarrea, vómitos y estar apático.

En casos más graves el bebé puede tener:

- piel que cambia a color gris, café oscura o azul, o
- labios, dedos o las uñas de los pies de color azulado; o
- problemas para respirar.

Los resultados de mi análisis indican *tanto* coliformes *como* nitrato, ¿qué debo hacer?

Busque un suministro de agua potable distinto y seguro. Lo primero que debe hacer es comenzar a utilizar agua embotellada para beber y cocinar. Hervir el agua mata las bacterias coliformes, pero no elimina el nitrato. NO hierva agua con coliformes y nitrato. Puede incrementar el nivel de nitrato, ¡empeorando el problema! Consulte otras opciones bajo nitrato y coliformes más arriba.

Los resultados del análisis indican que está bien, pero no me gusta el sabor/olor/la apariencia del agua. ¿Qué está pasando?

Algunos contaminantes hacen que el agua no tenga buen olor, sabor o apariencia pero no son nocivos para su salud. Su laboratorio y el departamento de salud local pueden ayudarlo a determinar si necesita analizar o tratar su agua.

¿Qué son las unidades domésticas de tratamiento de agua? He escuchado que son útiles.

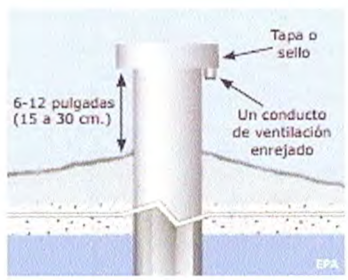
Los sistemas de filtro en el punto de uso (POU) tratan el agua en un sólo grifo. Los sistemas de filtro en el punto de entrada (POE) tratan el agua utilizada por toda la vivienda.

Los tres tipos de sistemas que peuden eliminar el nitrato del agua son:

- Unidad de ósmosis inversa
- Unidad de destilación
- Unidad de intercambio iónico

Importante: Todos los sistemas de filtro POU y POE o las unidades de tratamiento requieren mantenimiento para funcionar bien. Si no reciben el mantenimiento adecuado, los contaminantes se podrían acumular en las unidades y empeorar el agua. Además, algunos vendedores podrían declarar su efectividad aunque no esté basado en la ciencia. EPA no analiza ni certifica las unidades de tratamiento, pero si lo hacen dos organizaciones: la NSF International y el Underwriters Laboratory.

¿Cómo puedo proteger el agua de mi pozo de la contaminación?



Asegúrese que la boca del pozo se extienda entre 6 a 12 pulgadas (15 a 30 cm.) por encima de la superficie del suelo y que esté tapado para que no entren los contaminantes. Selle el suelo alrededor de la boca del pozo y hágalo en declive para que el agua no se acumule y filtre dentro del pozo.

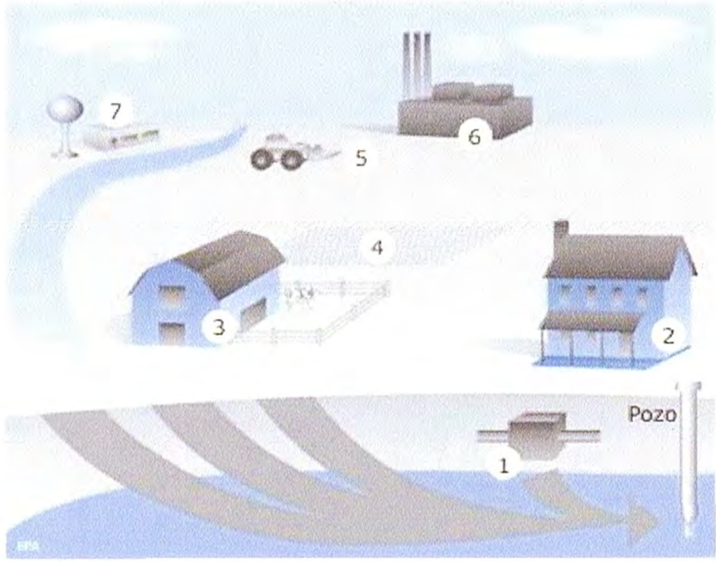
Es importante mantener el pozo protegido de contaminantes potenciales que pueden estar alrededor de su vivienda. Cuánto más lejos de las fuentes de contaminación, mucho mejor.

Los expertos sugieren que el pozo debe estar al menos:

- a 50 pies (15 metros) del tanque séptico,
- a 100 pies (30 metros) del borde de un campo de drenaje, tanque de combustible, graneros y cualquier depósito de fertilizantes y pesticidas, y
- a 250 pies (75 metros) de un montículo de estiércol.

Fuentes potenciales de contaminación del agua de pozos

1. Tanque séptico
2. Residuos domésticos
3. Residuos de animales
4. Pesticidas y fertilizantes
5. Vertedero
6. Industria local
7. Tanques de almacenamiento subterráneo



Recursos adicionales (información en inglés)

Departamentos de salud locales
www.doh.wa.gov/LHJMap/LHJMap.htm

Laboratorios certificados en su zona
www.ecy.wa.gov/apps/eap/acclabs/labquery.asp

Organizaciones certificadoras de unidades domésticas de tratamiento de agua
NSF International (Anteriormente, Fundación de Sanidad Nacional), www.nsf.org
Underwriters Laboratory, www.ul.com

Publicaciones del Centro para el Control y la Prevención de Enfermedades
Pozos privados, www.cdc.gov/healthywater/drinking/private/wells/location.html
Desinfección de emergencia de pozos, http://emergency.cdc.gov/disasters/wellsdisinfect.asp

Publicaciones de la Agencia de Protección Ambiental
Pozos domésticos, www.epa.gov/safewater/privatewells/pdfs/household_wells.pdf
Estándares secundarios, www.epa.gov/safewater/consumer/2ndstandards.html
Folleto sobre datos de filtración, www.epa.gov/safewater/faq/pdfs/fs_healthseries_filtration.pdf
Protección de fuente de agua, http://cfpub.epa.gov/safewater/sourcewater

Washington State Department of Health
DOH 333-171 mayo 2010

Para personas con discapacidades, este documento está disponible en otros formatos. Por favor llame al 1-800-525-0127 (TTY/TDD 1-800-833-6388).

Private Well Water

Coliform Bacteria and Nitrate Information for Private Well Users

Why should my well water be tested?

Drinking contaminated water is a health risk. Some contaminants cannot be seen, smelled, or tasted. Two of the most common contaminants in drinking water are coliform bacteria and nitrate and they can be harmful.

Who should be testing my well water?

You or your landlord. Private well users are responsible for testing their own water. If you don't own your home but you use a private well, talk with your landlord about getting your water tested or seeing the most recent results. You can always take a water sample yourself and have it tested.

What should I test for and how often?

The Department of Health recommends that you test your private well water every year for coliform bacteria and nitrate.

You should also test your water when:

- You notice a change in your water, such as taste, color, or smell.*
- Your well has been flooded.
- You replace any part of your well system.
- Someone in your household is pregnant, nursing, or has an unexplained illness and you suspect your water may be at risk.
- You hear that a neighbor's water is contaminated.
- You live near industrial or agricultural activities.*

*These may require testing for something other than coliform or nitrate.

If you have had previous contamination problems or are concerned about specific contaminants, you may want to test your well water more often.

Where do I go to get my water tested?

Certified drinking water labs are located across the state. The lab you select or your local health department can help you decide what to test for, how to collect samples, and how to understand results. There is a cost for these tests. Costs this year (2010) range from $20 to $25 per test for coliform bacteria, and $30 to $42 per test for nitrate. Most labs like to provide their own sample bottles.

My nitrate level is *less than* 10 ppm, what should I do?

Nitrate levels can vary throughout the year, so if your level is 5 ppm or higher, you may want to re-sample in six months.

My nitrate level is *more than* 10 ppm, what should I do?

If your nitrate test shows levels higher than 10 parts per million, find a different and safe drinking water supply. The quickest thing to do is to begin using bottled water for drinking and food preparation. Do NOT boil water with high nitrate. Boiling water may actually increase the nitrate level, making the problem worse!

Another option is to install a device or filter designed to remove nitrate from your water. These devices are often installed on kitchen faucets, where people get their water for drinking and cooking. Nitrate is not absorbed through the skin, so it is safe to clean and bathe with it.

Other, longer term solutions include:

- Drilling a deeper well into a different groundwater source;
- Connecting to a public water system; or
- Working with others in your community to develop a new public water system to serve your home and nearby neighbors.

My test results came back with coliform in the water, what should I do?

Coliform tests usually come back as SATISFACTORY or UNSATISFACTORY. If you receive a SATISFACTORY report, it means your water was free of these bacteria at the time of the sample. Be sure to test every year for coliform bacteria.

If you receive an UNSATISFACTORY report, it may be contaminated. Do not drink the water until it tests SATISFACTORY. Find a different and safe drinking water supply. The quickest thing to do is either begin using bottled water or boil all water for drinking and food preparation. This also includes water used for making ice or coffee, brushing teeth, and washing fruits and vegetables you eat raw. Boiling water rapidly for one minute usually kills bacteria.

Your lab and local health department can help you determine if you should resample, disinfect your well, or take other action based on your results.

What are coliform bacteria and why should I care?

Coliform bacteria are organisms that are present in the environment and in the feces of humans and animals. Coliform bacteria will not likely cause illness, but their presence in drinking water indicates disease-causing organisms may also be present.

What is nitrate?

Nitrogen is a chemical found in most fertilizers, animal manure, and in septic tanks. Natural bacteria in the soil can change nitrogen into nitrate. Rain water and irrigation water can carry nitrate down through the soil into the groundwater.

What can nitrate do to me?

Too much nitrate in your body makes it harder for red blood cells to carry oxygen. While many people do not notice a difference, this can be very dangerous for infants and pregnant women. Infants exposed to high amounts of nitrate may develop "blue -baby syndrome," a condition that is rare but can be fatal.

What are the symptoms of blue-baby syndrome?

Symptoms can be confused with other illnesses. An infant with mild to moderate blue-baby syndrome may have diarrhea, vomiting, and be lethargic.

In more serious cases, the infant may have:

- skin that becomes gray, darker brown, or blue, or
- lips, finger or toe nails with a blue-like color, or
- trouble breathing.

My test results came back with *both* coliform and nitrate, what should I do?

Find a different and safe drinking water supply. The quickest thing to do is to begin using bottled water for drinking and food preparation. Boiling water kills coliform bacteria, but does not remove nitrate. Do NOT boil water with both coliform and nitrate. It may increase the nitrate level, making the problem worse! See other options under nitrate and coliform above.

My test results came back OK, but I don't like the taste/smell/ appearance of my water. What is wrong with it?

Some contaminants make water smell, taste, or look bad but are not harmful to your health. Your lab and local health department can help you determine if you need to test or treat your water.

What about Home Water Treatment Units? I've heard that these can help.

Point of use (POU) filter systems treat water at a single tap. Point of entry (POE) filter systems treat water used throughout the house.

Three types of systems that can remove nitrate from your water are:

- Reverse Osmosis Unit
- Distillation Unit
- Anion Exchange Unit

Important: All POU and POE filter systems or treatment units need maintenance to operate effectively. If they are not maintained properly, contaminants may accumulate in the units and make your water worse. In addition, some vendors may make claims about their effectiveness that are not based on science. The EPA does not test or certify treatment units, but two organizations that do are NSF International and Underwriters Laboratory.

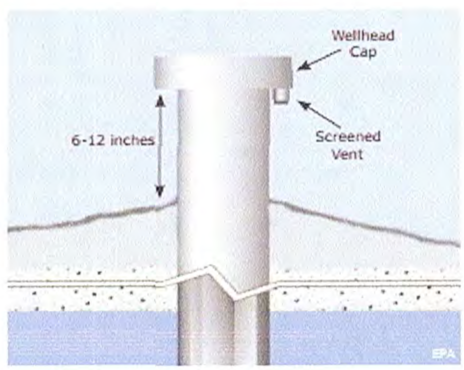
How can I protect my well water from contamination?

Make sure your wellhead extends 6 to 12 inches above the surface of the ground and is capped to keep contaminants out. Seal the ground around the wellhead and slope it away so water does not collect and seep into the well.

It is important to keep your well safe from potential contaminants that may be around your home. The further away from contamination sources, the better.

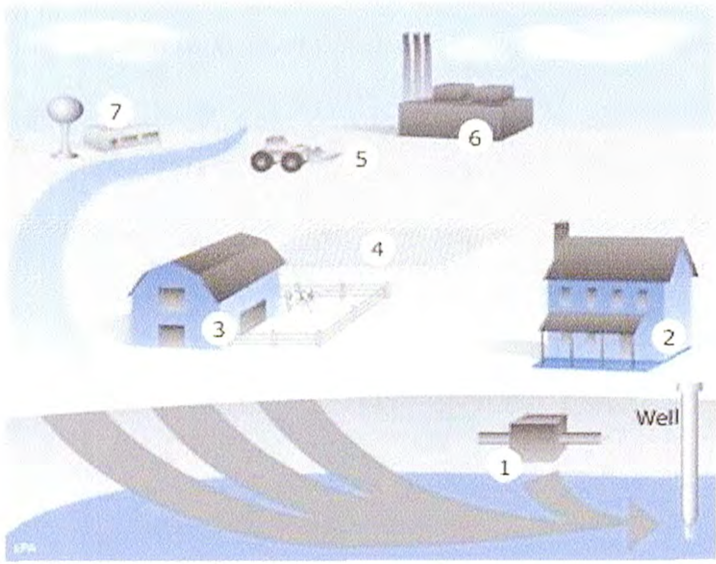
Experts suggest your well should be at least:

- 50 feet from a septic tank,
- 100 feet from the edge of a drainfield, fuel tank, barn, and any storage shed for fertilizers and pesticides, and
- 250 feet from a manure stack.



Potential Well Contaminants

1. Septic Tank
2. Household Wastes
3. Livestock Wastes
4. Pesticides and Fertilizers
5. Landfills
6. Local Industries
7. Underground Storage Tanks



Additional Resources

Local Health Departments
www.doh.wa.gov/LHJMap/LHJMap.htm

Certified Labs in Your Area
www.ecy.wa.gov/apps/eap/acclabs/labquery.asp

Certifying Organizations for Home Water Treatment Units
NSF International (Formerly National Sanitation Foundation), www.nsf.org
Underwriters Laboratory, www.ul.com

Center for Disease Control and Prevention Publications
Private Wells, www.cdc.gov/healthywater/drinking/private/wells/location.html
Emergency disinfection of wells, http://emergency.cdc.gov/disasters/wellsdisinfect.asp

Environmental Protection Agency Publications
Household wells, www.epa.gov/safewater/privatewells/pdfs/household_wells.pdf
Secondary Standards, www.epa.gov/safewater/consumer/2ndstandards.html
Filtration Facts booklet, www.epa.gov/safewater/faq/pdfs/fs_healthseries_filtration.pdf
Source Water Protection, http://cfpub.epa.gov/safewater/sourcewater

Washington State Department of Health
DOH 333-171 May 2010

For persons with disabilities, this document is available in other formats. To make a request, call 1-800-525-0127 or 1-800-833-6388 (TTY/TDD).

Preguntas y Respuestas

Nitratos en el agua potable

Julio 2013
DOH 331-214s
Revisado

El nitrato es un químico que se encuentra en la mayoría de los fertilizantes, estiércol, y residuos líquidos que se liberan de los tanques sépticos. Las bacterias naturales del suelo pueden convertir nitrógeno al nitrato. La lluvia o agua de irrigación puede llevar el nitrato a través del suelo hasta las aguas subterráneas. Su agua potable puede contener nitrato si su pozo saca agua de tales aguas subterráneas.

El nitrato es un contaminante que puede ocasionar enfermedades agudas, lo que significa que una sola exposición puede afectar a la salud de alguien.

¿Cómo afecta a la salud el nitrato?

El nitrato reduce la capacidad de los glóbulos rojos para llevar oxígeno. En la mayoría de los adultos y niños, estos glóbulos rojos se normalizan rápidamente. Sin embargo, en los lactantes, los glóbulos rojos pueden demorar más tiempo para normalizarse. Los lactantes que beben agua con altos niveles de nitrato (o comen alimentos hechos con agua contaminada con nitrato) pueden desarrollar una enfermedad seria debido a la falta de oxígeno. Esta enfermedad se llama metahemoglobinemia o "síndrome del bebé azul." Algunos científicos piensan que la diarrea puede empeorar este problema.

¿Está regulado por el estado el nitrato en el agua?

Sí. La ley estatal requiere que los sistemas de agua pública hagan pruebas para muchas contaminantes incluyendo el nitrato con regularidad. Nuestra norma para calidad del agua es 10 miligramos por litro (mg/L). Los sistemas de agua pública que contienen niveles de nitrato por encima de 10 mg/L deben notificar a las personas quien recibe agua de ellos.

Los niveles bajos de nitrato en el agua no tendrán un efecto de largo plazo en su bebé. Si su bebé no tiene ningunos de los signos del síndrome del bebé azul, no es necesario que su doctor le examine por la enfermedad de metahemoglobinemia.

¿Cuáles son los signos del síndrome del bebé azul?

El síndrome del bebé azul **moderado a serio** puede causar un tono de piel café-azulado dado la falta de oxígeno. Esta condición puede ser difícil de detectar en lactantes con piel oscura. Para bebés con piel oscura, busca un color azulado dentro de la nariz y la boca, en los labios, o la piel debajo de las uñas de las manos o los pies.

El síndrome del bebé azul **suave a moderado** puede causar signos parecidos a un resfriado u otra infección (irritado, cansado, con diarrea o vómitos). Aunque existe una prueba de sangre para ver si un lactante tiene el síndrome del bebé azul, es posible que los médicos no hagan esta prueba para los bebés con síntomas suaves a moderados.

¿Qué debo hacer si mi bebé tiene el síndrome del bebé azul?

Lleve el bebé al hospital de inmediato si el tono de la piel tiene un color café-azulado o tiene un color azulado en los labios, la lengua, las encías, la piel debajo de las uñas y la nariz. Un medicamento llamado "azul de metileno" normalizará rápidamente la sangre del bebé.

Washington State Department of Health
Environmental Public Health
Office of Drinking Water

HELPING TO ENSURE SAFE AND RELIABLE DRINKING WATER

¿Puedo prevenir el síndrome del bebé azul?

Si. No dé a los bebés menores de 12 meses de edad agua potable con niveles de nitrato más alto de 10 mg/L. No les dé verduras con alto contenido en nitrato como la remolacha, brócoli, zanahorias, coliflor, ejotes o judías, espinaca, y nabos hasta que el bebé tenga más de siete meses de edad.

Los niveles de nitrato en el agua de pozo pueden variar a través del año. Si usted tiene un pozo privado y no está seguro de la calidad del agua, es posible que desee usar agua en botella para preparar la comida y bebidas de su bebé. Aunque hervir el agua elimina las bacterias, no remueve químicos como el nitrato. De hecho, hirviendo causa la evaporación del agua que puede resultar en el incremento del nivel de nitrato.

¿Puede la lactancia materna ocasionar el síndrome del bebé azul?

Se ha encontrado bajos niveles de nitrato en la leche materna, pero los niveles no son bastantes altos para causar el "síndrome del bebé azul."

¿Puede el nitrato afectar a los adultos?

Aunque las células rojas vuelven rápidamente a la normalidad, las condiciones de salud de algunas personas las hacen más susceptible a los problemas de salud por nitrato. Las personas con las siguientes condiciones de salud no deberían beber agua con más de 10 mg/L de nitrato:

- Las personas que no tienen suficientes ácidos estomacales.
- Las personas con pérdida hereditaria de la enzima que convierte los glóbulos rojos afectados en células normales (metahemoglobina reductasa).
- Las mujeres embarazadas o que están tratando de quedar embarazadas. Alto contenido de nitratos puede incrementar el riesgo de aborto espontáneo o ciertos defectos de nacimiento.

¿Cómo puedo saber si mi agua de pozo tiene nitrato?

Los pozos poco profundos, mal sellados o construidos o los pozos que extraen agua de acuíferos poco profundos tienen riesgo más alto de tener agua contaminada con nitrato. El abono (estiércol) y los desechos de un tanque séptico pueden también contener bacterias y virus que causan enfermedades.

Si usted es el dueño de un pozo privado nosotros recomendamos que analice el agua por bacterias y nitrato cada año. El departamento de salud de su condado puede decirle donde puede obtener el análisis de su agua y pudiera tener recomendaciones específicas para el análisis. Muchos laboratorios certificados cobran entre $20 a $40 por análisis. Si el resultado del análisis de nitrato es de 5 mg/L o más alto, recomendamos que vuelva a hacer otro análisis en 6 meses.

¿Dónde puedo obtener más información?

Si usted obtiene agua de un sistema público, llame a su servicio de agua o al Departamento de Salud del Estado de Washington, Oficina de Agua Potable, al número de teléfono (800) 521-0323 o visítenos en línea en: http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater.aspx

Si tiene un pozo privado, llame al departamento de salud local. También puede encontrar información en **Pozos Privados: Información para los propietarios (331-349s)** una publicación disponible en Inglés y Español https://fortress.wa.gov/doh/eh/dw/publications/publications.cfm

Para una lista de laboratorios certificados, visite en línea al Departamento de Ecología de Washington en: http://www.ecy.wa.gov/apps/eap/acclabs/labquery.asp. Bajo "Location" seleccione su estado, ciudad y condado. En la parte baja de la página haga click en "Show results." Haga click en el nombre de un laboratorio para ver qué tipo de análisis hace. Llame al laboratorio para asegurarse que esté acreditado para hacer análisis de nitrato.

Si usted necesita esta publicación en un formato diferente, llame al 800-525-0127. Para TTY/TDD, llame al 800-833-6388.

5g_Handout DOH Nitrate In Drinking Water Pub 331-214

Questions & Answers

Nitrate in Drinking Water

May 2012
DOH 331-214
Revised

Nitrate is a chemical found in most fertilizers, manure, and liquid waste discharged from septic tanks. Natural bacteria in soil can convert nitrogen into nitrate. Rain or irrigation water can carry nitrate down through the soil into groundwater. Your drinking water may contain nitrate if your well draws from this groundwater.

Nitrate is an acute contaminant. That means one exposure can affect a person's health.

Does the state regulate nitrate in drinking water?

Yes. State law requires public water systems to sample for many contaminants, including nitrate, on a regular basis. Our drinking water quality standard for nitrate is 10 milligrams per liter (mg/L). Public water systems with nitrate levels over 10 mg/L must notify people who receive water from them.

How does nitrate affect health?

It reduces the ability of red blood cells to carry oxygen. In most adults and children, these red blood cells rapidly return to normal. However, in infants it can take much longer for the blood cells to return to normal. 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." Some scientists think diarrhea makes this problem worse.

Low levels of nitrate in water will not have a long-lasting effect on your baby. If your baby doesn't have any of signs of blue baby syndrome, you do not need to have a doctor test for methemoglobinemia.

What are the signs of blue baby syndrome?

Moderate to serious blue baby syndrome may cause brownish-blue skin tone due to lack of oxygen. This condition may be hard to detect in infants with dark skin. For infants with dark skin, look for a bluish color inside the nose and mouth, on the lips, or fingernail and toenail beds.

Mild to moderate blue baby syndrome may cause signs similar to a cold or other infection (fussy, tired, diarrhea or vomiting). While there is a 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.

What should I do if my infant has blue baby syndrome?

Take a baby who has brownish-blue skin tone or a bluish color to the lips, tongue, gums, nail beds, or nose to a hospital immediately. A medication called "methylene blue" will quickly return the baby's blood to normal.

Health

HELPING TO ENSURE SAFE AND RELIABLE DRINKING WATER

Can I prevent blue baby syndrome?

Yes. Do not give infants younger than 12 months drinking water with nitrate levels above 10 mg/L. Do not offer high-nitrate vegetables such as beets, broccoli, carrots, cauliflower, green beans, spinach, and turnips until the baby is at least seven months old.

Nitrate levels in well water can vary throughout the year. If you have a private well and you're not sure about your water quality, you may want to use bottled water to prepare your baby's food and drinks. Although boiling water kills bacteria, it will not remove chemicals such as nitrate. In fact, boiling may actually increase the nitrate level.

Will breast-feeding give my infant blue baby syndrome?

Low levels of nitrate have been found in breast milk, but the levels are not high enough to cause blue baby syndrome.

Can nitrate affect adults?

Although red blood cells quickly return to normal, some health conditions can make people more susceptible to health problems from nitrate. Individuals with the following health conditions should not drink water with more than 10 mg/L of nitrate:

- Individuals who don't have enough stomach acids.
- Individuals with an inherited lack of the enzyme that converts affected red blood cells back to normal (methemoglobin reductase).
- Women who are pregnant or trying to become pregnant. Some studies have found an increased risk of spontaneous abortion or certain birth defects.

How can I tell if my well water has nitrate?

Shallow wells, poorly sealed or poorly 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.

If you own a private well, we recommend that you test for coliform bacteria and nitrate every year. Your county health department can tell you where you can get your water tested and may have specific recommendations for testing. Many certified labs in Washington charge $20 to $40 per test. If your nitrate test results are 5 mg/L or higher, you may want to re-sample in six months.

Where can I get more information?

If you get your water from a public water system, call your water utility or the state Department of Health at 800-521-0323. You can also visit online at http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater.aspx

If you have a private well, call your local health department. You can also find information in *Private Wells: Information for owners* (331-349) a publication available in English and Spanish at https://fortress.wa.gov/doh/eh/dw/publications/publications.cfm

For a list of certified labs, visit the state Department of Ecology online at http://www.ecy.wa.gov/apps/eap/acclabs/labquery.aspUnder "Location," select your state, city, and county. Scroll down and click on "Show results." Click on the name of a lab to see the tests it performs. Call the lab to make sure it's accredited to analyze for nitrate in drinking water.

PUBLIC HEALTH
ALWAYS WORKING FOR A SAFER AND HEALTHIER WASHINGTON

If you need this publication in an alternate format, call 800-525-0127. For TTY/TDD, call 800-833-6388.

NITRATES, METHEMOGLOBINEMIA, AND DRINKING WATER: A Factsheet for Clinicians

PEHSU Pediatric Environmental Health Specialty Units

Nitrates are chemicals that occur naturally in drinking water and also result from human activities. In some areas private wells are contaminated with nitrates. Excessive nitrates can cause acquired methemoglobinemia in young infants. This severe syndrome of inadequate tissue oxygenation is potentially fatal; prompt clinical recognition and treatment is vital. Families should be counseled on nitrate safety.

Nitrate Background

- Nitrates and nitrites are naturally occurring inorganic nitrogen ions found in soil, water, and some foods. They are a natural part of the human diet. However, excessive consumption (e.g. drinking water or eating food from areas where ground water has become contaminated by excessive nitrate from fertilizers or improper manure management) can cause serious adverse health effects.

Nitrate Sources

- Drinking water
  - Nitrates occur naturally in water at low concentrations. Nitrates are also present as a result of human activities, such as the use of fertilizers and manure on irrigated farm fields that can run off and seep into wells. Nitrate-contaminated water can also be due to improper management of farm animal (i.e. cow) waste, leaky sewage pipes, and septic system failures.
  - Large suppliers of public water sources are required to monitor nitrate concentrations regularly, but *private wells are not. In some areas private wells are contaminated with nitrates.*
  - The American Academy of Pediatrics (AAP) consensus panel recommends that all prenatal and well-infant visits need to include questions about the home water supply.
  - The only way to know if the nitrate level in well water is at a safe level is to have the well water tested by a certified laboratory. <u>All private wells should be tested before use and once per year for nitrates.</u> Families should contact their state health department for assistance with selecting a certified laboratory.
  - Regulations and water testing frequency:
    - The United States Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) for nitrates is 10 mg/L (or 10 parts per million, 10 ppm). The 10 mg/L standard was set to protect infants from nitrates. When a nitrate water test result is 10 mg/L or less, the water is considered safe for infant use.
    - Nitrates may change seasonally or randomly throughout the year. If the nitrate concentration is between 5 – 10 mg/L, monitor more closely and test the well drinking water every 3 months to confirm the water is still safe. When nitrates are present, pesticides or bacteria may also be present and additional water tests may be needed. Families should contact their local health department for guidance.
- Food
  - Nitrates can also be a problem in some vegetables, including spinach, beets, lettuce, cabbage, green beans, squash, carrots, and turnips. Because these vegetables may contain higher amounts of nitrates, recommend other foods until infants are over 6 months old.

Infant Nitrate Exposure

- Infants are exposed to nitrates when they drink contaminated well water or when contaminated well water is used to make infant formula or baby food.
- Nitrates in water are not significantly absorbed through the skin.
- Breastfeeding is safe even if a mother drinks water polluted with nitrates.

Methemoglobinemia and Other Health Effects

- Hemoglobin in blood contains iron normally found in the Fe^{2+} (ferrous) state. Excessive nitrates or nitrites can alter the iron in hemoglobin to the Fe^{3+} (ferric) state, forming methemoglobin (an abnormal form of hemoglobin which cannot bind oxygen). Methemoglobinemia (an excess of methemoglobin) results in poor tissue oxygenation and anoxia.

- Methemoglobinemia, also known as "blue baby syndrome", can be inherited or acquired. The acquired form, such as from excessive nitrate exposure, is a serious medical emergency. Among the reported cases of acquired methemoglobinemia in US infants, most have been attributed to the use of nitrate contaminated well water for preparation of infant formula.
- Infants less than 1 year old are physiologically vulnerable to the development of methemoglobinemia due to several factors:
    - Their higher gastric pH favors nitrate-reducing bacteria that convert ingested nitrate into methemoglobin-producing nitrite.
    - Fetal hemoglobin, the predominant form in infants up to 3 months of age, is oxidized more readily to methemoglobin by nitrite than is adult hemoglobin.
    - The activity of the red blood cell enzyme systems that reduce methemoglobin back to normal hemoglobin is reduced by about half in infants compared with adults.
    - Gastroenteritis can increase the risk of developing methemoglobinemia.
- **Women who are thinking about pregnancy or who are pregnant should avoid water contaminated with nitrates. Women considering pregnancy or who are pregnant should drink water from public water supplies, water that has been tested and has safe nitrate levels, or bottled water.** While not conclusive due to study limitations, epidemiological data suggest an association between maternal ingestion of nitrate from drinking water and preeclampsia, spontaneous abortion, intrauterine growth restriction, and various birth defects. A few studies have hinted at a role for childhood nitrate intake in the risk for later developing diabetes mellitus.

METHEMOGLOBINEMIA CLINICAL MANAGEMENT

Clinical presentation

- In children and adults with acute acquired methemoglobinemia, methemoglobin levels >20% are associated with clinical symptoms.
- Early methemoglobinemia symptoms include nonspecific headache, fatigue, dyspnea, and lethargy. In infants, this may present as unusual fussiness, decreased alertness, diarrhea, vomiting, shortness of breath, and increased work of breathing.
- At higher methemoglobin levels, cyanosis becomes visible. A brownish-blue skin tone may be present due to anoxia. This condition may be harder to detect in infants with dark skin- look for a bluish color of the nasal or oral mucosa, lips, or nail beds.
- Respiratory depression, altered consciousness, shock, seizures, and death may occur. Acquired methemoglobinemia is life threatening when methemoglobin comprises more than 30% of total hemoglobin and mortality rates are high when methemoglobin levels exceed 40%.

Diagnosis

- Initial diagnosis is based on history and exam findings. In addition, the presence of methemoglobin should be suspected with 1) clinical cyanosis despite normal arterial pO2, or 2) a significant difference between the oxygen saturations measured by pulse oximetry and by arterial blood gas analysis ("saturation gap").
- A diagnosis of methemoglobinemia should be confirmed by laboratory analysis, to be done in the emergency setting (i.e. not in primary care). Hemoximetry, also called co-oximetry, is recommended way for measuring methemoglobin. Most current blood gas analyzers have incorporated the ability to do hemoximetry
- A fresh blood specimen (venous is fine) should always be obtained as methemoglobin levels tend to increase with storage.
- Note that routine pulse oximetry is inaccurate for monitoring oxygen saturation when methemoglobin is present, and should not be used for diagnosis.

Treatment

- Acute onset of acquired methemoglobinemia should be considered a medical emergency and requires immediate treatment in the ER setting.
- When the patient is symptomatic or the methemoglobin level is >20%, intravenous methylene blue (MB, dosed at 1 to 2 mg/kg over five minutes) can be life-saving and is considered the treatment of choice. Blood transfusion or

exchange transfusion may be helpful in patients who are in shock. See appropriate clinical guidelines for more detailed treatment and monitoring guidance.

Prevention and Advice for Families

- **Only use water from public water supplies, water that has been tested and confirmed as safe, or bottled water.**
- **Test well water for nitrates to ensure it is safe to drink. A nitrate test is around $50.**
- **Don't use nitrate-contaminated well water to make baby formula or to make baby food.**
- **Don't let infants drink nitrate-contaminated water.**
- **Women who are pregnant or trying to get pregnant should not drink nitrate-contaminated well water.**
- **Breastfeeding is safe even if the mother drinks water contaminated with nitrates.**
- **Because some vegetables may contain higher amounts of nitrates, choose other solid foods until infants are over 6 months old.**

Reporting

- Methemoglobinemia is not currently a mandatory notifiable condition in Washington State. However new passive surveillance has been initiated by the Yakima Health District under the supervision of Health Officer Dr. Chris Spitters. Yakima Health District requests notification of laboratory-confirmed methemoglobinemia by calling (509) 249-6541 within three days of diagnosis. Please include an exposure history and your clinical impression regarding etiology, if known.

Resources and References

For acute poisoning assistance contact your state poison center at 1-800-222-1222.
For additional non-urgent clinical and public health assistance, contact the NW PEHSU. The University of Washington based Pediatric Environmental Health Specialty Unit (PEHSU) serves medical and public health professionals in Alaska, Washington, Idaho, and Oregon. For more information contact us at 1–877–543-2436 (1-877-KID-CHEM) or pehsu@uw.edu. Visit our website http://www.depts.washington.edu/pehsu.

- ATSDR ToxFAQsTM for Nitrates and Nitrites: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=1186&tid=258
- ATSDR Case Studies in Environmental Medicine (CSEM): Nitrate/Nitrite Toxicity (course: WB2342): http://www.atsdr.cdc.gov/csem/csem.asp?csem=28&po=0
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Disclaimer: PEHSU funding was made possible (in part) by the cooperative agreement award number UTI Grant Number U61 TS000118 from the Agency for Toxic Substances and Disease Registry (ATSDR). The views in this guidance do not necessarily reflect the official policies of the Department of Health and Human Services; nor does mention of trade names, commercial practices, or organizations imply endorsement by the U.S. Government.
Acknowledgement: The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing funds to ATSDR under Inter-Agency Agreement number DW-75-92301301-0. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.

GWMA Mission

Groundwater Management Area (GWMA):

The goal of the Lower Yakima Valley GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards.

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater
Management Area
(GWMA)

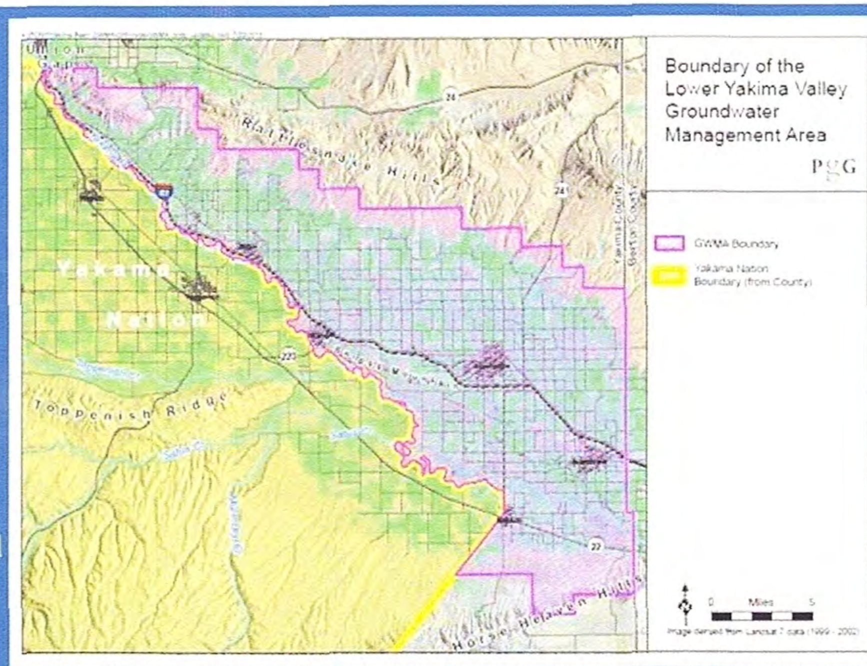
Background

- In 2011, the Lower Yakima Valley Groundwater Management Area (GWMA) was formed to address nitrate contamination in groundwater.
- The GWMA is a response to the elevated nitrate levels found in the Lower Yakima Valley which exceed the state standard of 10.0 mg/L.
- Private drinking water wells with nitrate levels higher than the state standard, pose a greater health risk to those individuals susceptible to elevated nitrate in their drinking water.

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA)

GWMA Boundaries



The GWMA boundaries extend west from Union Gap east to County Line Road, minus the Yakama Nation.

The GWMA encompasses 175172.66 acres or 273.7 square miles.

http://www.yakimacounty.us/1617/Ground-Water-Management-Area

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Groundwater
Management Area
(GWMA)

What the GWMA Intends to Do:

Yakima County requested Dept of Ecology to recognize the GWMA and provide assistance for helping reduce the nitrate level in the groundwater. *Objectives include:*

- Data Collection, Monitoring and Analysis.
- Public Education and Outreach.
- Problem Identification.
- Potential Measures or Practices for Reducing Groundwater Contamination.

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA)

GWMA GroundWater Advisory Committee

- The Lower Yakima Valley Groundwater Management Area Committee (GWAC) is responsible for developing the (GWMA) plan.

- The GWAC is a multi-agency and citizen-based group with 22 primary members and alternates.

  - To learn about their progress or to attend a meeting, please visit: http://www.yakimacounty.us/agendacenter

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Groundwater
Management Area
(GWMA)

GWMA GroundWater Advisory Committee Membership

Commissioner Rand Elliott,

Yakima County Board of Commissioners

Vern Redifer, P.E. (alternate),

Yakima County Public Services

Lower Yakima Valley GWAC Members and Alternates

http://www.yakimacounty.us/541/Ground-Water-Management-Area

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA)

GWMA Working Groups:

http://yakimacounty.us/583/Working-Groups

Livestock / CAFO
Chair: David Bowen

Irrigated Agriculture
Chair: Dr. Troy Peters

Residential, Commercial, Industrial, Municipal
Chair: Dan DeGroot

Data Collection, Characterization, Monitoring
Chair: Melanie Redding

Regulatory Framework
Chair: Jean Mendoza

Education & Public Outreach
Chair: Lisa Freund

Funding
Chair: Pending

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA)

GWAC Working Groups

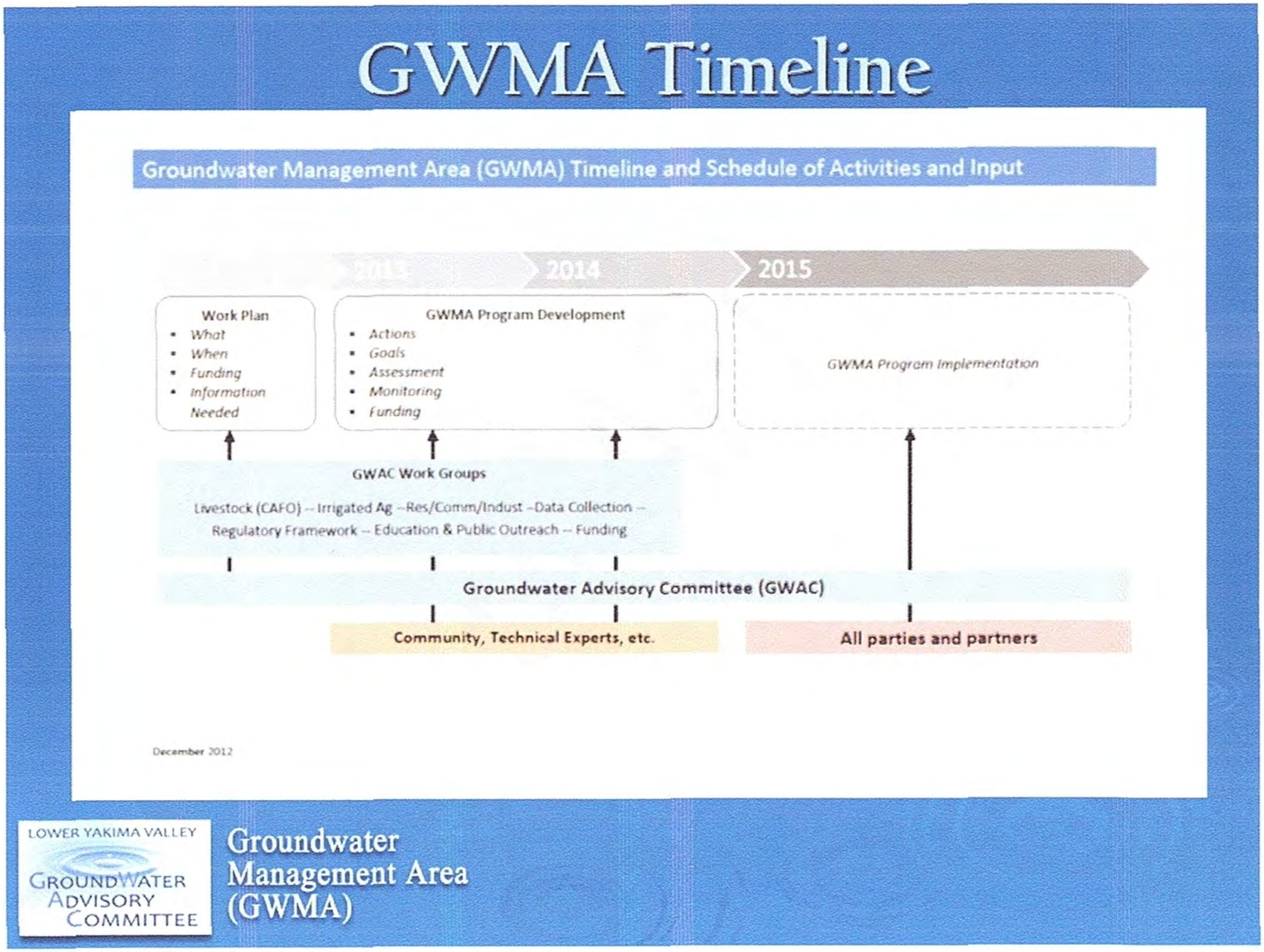
Working groups were convened to provide focused information and plans for the objectives identified in the request.

The GWMA website offers reference material and guides users to agency partners who have additional information.

The working group meetings are posted on the website and are open to the public just like the committee meetings.

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater
Management Area
(GWMA)


GWMA Timeline
Groundwater Management Area (GWMA) Timeline and Schedule of Activities and Input
2013
2014
2015
Work Plan
What
When
Funding
Information Needed
GWMA Program Development
Actions
Goals
Assessment
Monitoring
Funding
GWMA Program Implementation
GWAC Work Groups
Livestock (CAFO) -- Irrigated Ag --Res/Comm/Indust --Data Collection --
Regulatory Framework -- Education & Public Outreach -- Funding
Groundwater Advisory Committee (GWAC)
Community, Technical Experts, etc.
All parties and partners
December 2012
LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE
Groundwater Management Area (GWMA)

Citizen-Based Pollution Prevention

Pollution prevention will be a guiding principle for all work.

A coordinated effort to address groundwater contamination in the Yakima Basin.

Seeks credibility with the general public, the farming community, stakeholders, and special interest groups.

Multiple approaches including education, technical assistance and accountability strategies.

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA)

How To Get It Done?

Identify the primary sources of nitrate contamination using scientific data.

Identify or develop practices that will minimize nitrate contamination of groundwater

Develop a plan that recommends strategies for implementing improved practices

Provide appropriate education and outreach on health risks and how to prevent exposure.

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA)

How To Get It Done?

Citizen surveys.

Multi-language media outreach.

Health community education, awareness and participation.

Partnerships with Agricultural businesses and employers, farming community, special interest groups, medical organizations, and other interested stakeholders.

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA)

Summary

The goal of the LYV GWMA is the reduction of nitrate levels in the groundwater to below state standards.

Previous studies conducted by EPA and others, have shown a significant problem with elevated nitrate in the shallow aquifer.

Nitrate is an Acute contaminant which can affect those residents at higher risk from nitrate rather quickly, and from a single exposure.

The biggest threat is to the private wells, that are shallow, poorly constructed, poorly located, and rarely tested.

Surveys within the LYV with residents may continue as a tool for providing outreach to residents.

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Groundwater
Management Area
(GWMA)

Contact

Who do I report suspected nitrate contamination to?

Yakima County Health District Communicable Disease Report Line: 509-249-6521

For information about water quality, treatment, options, call the Environmental Health help desk at 509-249-6508

On the Yakama Nation

Indian Health Services -Environmental Health

Shawn Blackshear 509-865-1776

Shawn.blackshear@ihs.gov

For more information on the Lower Yakima Valley Groundwater Management Area or the Groundwater Advisory Committee, please visit: http://www.yakimacounty.us/541/Ground-Water-Management-Area

Thank you for your interest.

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA)

Results of the 2014 Free Well Testing
Offered by the Lower Yakima Valley Groundwater Advisory Committee (GWAC)
Lower Yakima Valley Groundwater Management Area (GWMA)

Background

- The Lower Yakima Valley Groundwater Management Area (GWMA) was formed in 2011 to address nitrate contamination in groundwater.
- The GWMA is a response to elevated nitrate levels found in the lower Yakima Valley.
- The GWMA boundaries extend west from Union Gap east to County Line Road, minus the Yakama Nation. (273.7 $mi.^2$)
- Its goal is to reduce nitrate in groundwater to below state drinking water standards (below 10 mg/L).
- The GWAC is a multi-agency and citizen-based group with 21 primary members and alternates. It is responsible for developing the GWMA Program.
- The GWMA Program will be a comprehensive program designed to protect groundwater quality in the Lower Yakima Valley.

Why was the well testing conducted?

- To help private well owners learn about the health of their drinking water and how to protect themselves against possible contamination.
- To remind well owners to test their well at least once a year.
- To spread the word about the GWAC's work and the LYV Groundwater Management Area.

What did you test for?

Nitrate and coliform.

Who participated?

- Households on private or shared wells in the Lower Yakima Valley GWMA were invited to participate.

How many wells were tested?
172 private and shared wells

What did you learn?

Of the 172 wells tested:

- *59% (101) had little or no nitrates (0-4.99 mg/L)*
- 25% (43) had moderate (still acceptable) amounts of nitrate (5.0-9.99 mg/L)
- 16% (28) had nitrates at or above 10 mg/L

What will you do with this information?
While the sample size is too small to draw meaningful conclusions, we did learn we have a lot of work ahead of us:

- Many people don't know that they should test their wells regularly.
- They don't know who is at risk from elevated nitrates for how to protect themselves.

We will use these results to help educate well owners and to prepare for the next round of the free well testing, which we expect to conduct later this year.

Is there anything else you'd like to add?
Yes. If you missed out on our free well testing, we will be offering it again soon. Please call 509-574-2300 to sign up for this year's free testing.

6a Phase I High Risk Survey Instrument

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

☐ Survey Completed ☐ Survey Attempted/Not Completed:

☐ No One Home ☐ Declined ☐ Other ______Number of Attempts

Date Survey Completed____________________________

Parcel #________________________________Surveyor____

Name Of Person Surveyed____

Address______________________________________City_________________State______ Zip_____________

Email____

Home Phone_______________________________________Cell Phone_____________________________________

Answers to the following questions will help assess the potential health risk for private well owners. Specifically, those risks associated with high levels of nitrate in their well. A potential High Public Health Risk (HPHR) is identified with a yellow highlight and a heavy border around the checkbox. A potential Public Health Risk (PHR) is only identified with a yellow highlight in the checkbox. . Water supply wells found with a potential HPHR will be given recommendations for testing, repairs, or maintenance of their well.

As a general rule the Washington Departments of Health and Ecology recommend private groundwater wells be tested for nitrate every three years and bacteria every year.

Classify the surrounding area as	☐ **Farm**	☐ **Rural**	☐ **Rural Community Sub-Division**	☐ **Suburb**
Does the home have a treatment system installed?			☐ **Yes**	☐ **No**
If yes what kind?	☐ **POU**	☐ **POE**	☐ **Ion Exchange (Water Softener)**	☐ **Other**
Does the home have bottled water?			☐ **Yes**	☐ **No**
Sample Scheduled or Taken?	☐ **Nitrate**	☐ **Nitrate Test Strip**	☐ **Coliform**	☐ **Other**
GPS Coordinates	X:		Y:	

High Risk: (80% of PHR and HPHR boxes checked) Possible contamination of the water supply and for the long term may need testing, improvements, repairs, or replacement. You should test your water immediately. If tests are positive for Fecal or E.Coli bacteria or have a nitrate level higher than 10 mg/L, you should consider using an alternative source of drinking water for daily uses, until the observed risk(s) can be corrected. If you believe you or your family is experiencing health effects associated with your drinking water, you should discuss the test results with your health care provider.

Moderate Risk: (60% of PHR and HPHR boxes checked) Your well may be a potential health threat to anyone consuming the water and may be susceptible to contamination. Recommend regular maintenance of the well and frequent water tests for nitrate and coliform bacteria.

Low Risk: Recommend regular maintenance of the well and water tests for nitrate and coliform bacteria.

Section Summary		Boxes Checked HPHR	PHR
1	☐ Yes ☐ No		
2	☐ Yes ☐ No		
3	☐ Yes ☐ No		
4	☐ Yes ☐ No		
Total	Yes:________ No:________		

☐ **High** ☐ **Moderate** ☐ **Low**

Section 1: General Population Questions	Yes	No	Unk	Comments
1. How many residents live in your household?				

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

2. Are there very young children less than 1-yr old in your household?	☐	☐	☐	
3. Are there pregnant women in your household?	☐	☐	☐	
4. Women who can possibly become pregnant in your household?	☐	☐	☐	
5. Are there chronically ill people in your household?	☐	☐	☐	
6. Would you be willing to provide your household income?				
7. What is the primary language spoken in your home?				
Total High Risk Boxes Checked: At Risk Population:	Yes: ☐		No: ☐	

Section 2: General Water Quality Questions	Yes	No	Unk	Comments
8. *Has the well been tested for Total Coliform (Bacteria)?*	☐	☐	☐	
a. Answered yes to previous question, was the sample positive for Total Coliform?	☐	☐	☐	
b. Answered yes to previous question, was the sample positive for Fecal or E. Coli?	☐	☐	☐	
9. Has the well been tested for nitrate?	☐	☐	☐	
a. Answered yes to previous question (9), was the sample lower than 5.0 mg/L?	☐	☐	☐	
b. Answered no to previous question (9a), was the sample higher than 10.0 mg/L?	☐	☐	☐	
10. Does the well water have an unusual taste, odor, or color?	☐	☐	☐	
Total High Risk Boxes Checked: Potential Public Health Risk(s):	Yes: ☐		No: ☐	

Section 3: Sanitary Control Area Risk Factors	Yes	No	Unk	Comments
11. Does the owner live on a small lot with an onsite septic system (less than 1-acre)?	☐	☐	☐	
a. Is the well within 50 ft of a septic tank or 100 ft of a drainfield?	☐	☐	☐	
b. Have you had your septic tank pumped recently?	☐	☐	☐	
c. Do neighbors live on small lots with onsite septic systems?	☐	☐	☐	
12. Is there surface water within 100 feet of the well? (like ponds, lagoons, rivers, unlined irrigation ditches)	☐	☐	Surface Water Type	
a. Is there surface water within 200 feet of the well?	☐	☐	Surface Water Type	
13. Do you use the area surrounding the well as a pasture or have structures to house personal animals?	☐	☐	Type:___ How Many:___	
a. Does your neighbor use the area surrounding the well as a pasture or have structures for housing personal animals?	☐	☐	Type:___ How Many:___	
14. Do you see large mounds of manure near your well, within 100-ft?	☐	☐	Owner:___ Neighbors:___	
a. Do you see large mounds of manure near your well, within 200-ft?	☐	☐	Owner:___ Neighbors:___	
15. Have you seen manure spreading near your well, within 100-ft?	☐	☐	How Often:	
a. Have you seen manure spreading near your well, within 200-ft?	☐	☐	How Often:	
16. Is your well located within 100-ft of any type of agricultural field or orchard?	☐	☐	Crop:___ Distance:___	
a. Is your well located within 200-ft of any type of agricultural field or orchard?	☐	☐	Crop:___ Distance:___	

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

17. Have you sprayed or seen sprayed any chemicals within 100-ft of your well?	☐	☐	How Often:______ How Close:______
a. Have you sprayed or seen sprayed any chemicals within 200-ft of your well?	☐	☐	How Often:______ How Close:______
Total High Risk Boxes Checked:	**Well Susceptible to Surface Contamination:**	**Yes:** ☐	**No:** ☐

Section 4: Well Construction	**Yes**	**No**	**Unk**	**Comments**
18. Do you have a copy of the well log?	☐	☐	☐	______-yr
19. Do you know how old your well is?	☐	☐	☐	
20. Do you know the depth of your well?	☐	☐	☐	______-ft
21. Is it a hand dug well?	☐	☐	☐	
22. Is it a driven well (sand point)?	☐	☐	☐	
23. Does the well appear poorly maintained (condition of wellhead or pump house)?	☐	☐	☐	
24. Does the well appear to have a broken wellhead seal or holes in the casing?	☐	☐	☐	
25. Is the wellhead subject to flooding?	☐	☐	☐	
Total High Risk Boxes Checked:	**Well Vulnerable to Surface Contamination:**	**Yes:** ☐		**No:** ☐

Section 5: Long Term Monitoring Consideration

26. Type of Well:	☐ Domestic	☐ Public Supply	☐ Industrial	☐ Irrigation
27. Describe Wellhead Completion (pitless adapter, wellhouse, etc.): ____________				
28. Record the Ecology UWID if tagged on the wellhead or noted on the well log:	_ _ _-_ _ _			
29. GPS Latitude of the Wellhead (valid coordinates must be positive and from 45-47, must be a minimum of 4 decimal places):				
30. GPS Longitude of the Wellhead (valid coordinates must be negative and from -119 to -121, must be a minimum of 4 decimal places):				
31. Depth to Water (ft below Measuring Point, MP):				
a. MP Description:				
b. DTW Method Description (e.g. well log, measured, etc.):				
32. Is Type of Pump Known?	☐ Yes	☐ No	☐ Unknown	
a. Pump Is (e.g. Submersible, Suction-lift, Jet pump, Line Shaft Turbine):				
33. Is Sampling Port available downstream (before water enters) treatment system, holding tanks, or pressure tanks?	☐ Yes	☐ No	☐ Unknown	
a. Description of sampling port (location, type):				

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Form #GWMA0002 A Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

34. Is Participant interested in having their well considered for Long-Term Monitoring?	☐ Yes	☐ No	☐ Unknown
a. Directions for gaining access to the site (notification request, allowed if owner/resident not present, etc.):			
b. Special tools or materials to access/open sampling port or to manage purge water:			
c. Safety considerations for samplers (e.g. domestic animals, rodents):			

Section 5: Graphics (Required)

Site Sketches and Photos: Must include sufficient detail and scale to enable field personnel unfamiliar with the site to readily locate the well from the driveway or street. Include land cover/use features from Section 3 (septic, agriculture, etc.). Compass directions and horizontal scale required.		
a. Site Sketch is on additional page(s) attached to this Survey form:	☐ Yes	☐ No
b. Digital Photos of the site taken (if camera does not have GPS capabilities, first photo in series at individual site must clearly document Site ID):	☐ Yes	☐ No

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

Wellhead Sketches and Photos: Must include sufficient detail and scale to enable field personnel unfamiliar with the well to readily locate the sampling port and water level measuring point if applicable.		
a. Wellhead Sketch is on additional page(s) attached to this Survey form:	☐ Yes	☐ No
b. Digital Photos of the wellhead taken (if camera does not have GPS capabilities, first photo in series at individual site must clearly document Site ID):	☐ Yes	☐ No

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

6 Well Assessment Survey Test Results thru 2_15-16.pdf

Well Assessment Survey Test Results

Through February 15, 2016

Nitrate Test Results

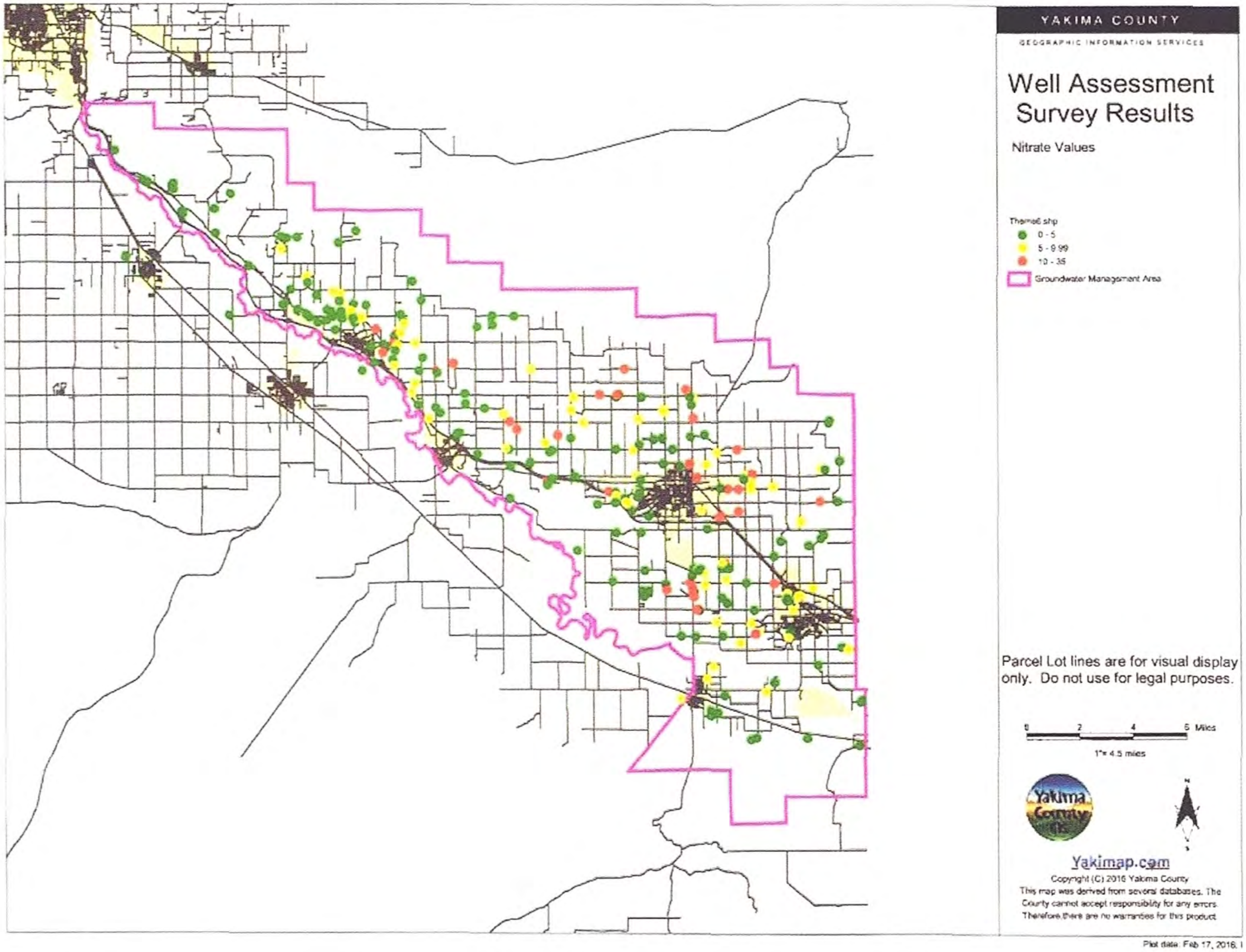
Nitrate Range	Number of Wells	Percent
0 to 5.0	172	60%
5.01 to 9.99	76	26%
10.0 to 35	40	14%
Grand Total	288	100%

Bacteria Test Results

Result	Number of Wells		
	Bacteria Present	Ecoli Present	Fecal Present
Satisfactory	228	286	288
Unsatisfactory	60	2	0
Grand Total	**288**	**288**	**288**

Nitrate and Bacteria Test Results

Nitrate Range	Number of Wells	Bacteria Present	Ecoli Present	Fecal Present
0 to 5.0	172	40	2	0
5.01 to 9.99	76	14	0	0
10.0 to 35	40	6	0	0
Grand Total	**288**	**60**	**2**	**0**


YAKIMA COUNTY
GEOGRAPHIC INFORMATION SERVICES
Well Assessment Survey Results
Nitrate Values
Theme6.shp
0 - 5
5 - 9.99
10 - 35
Groundwater Management Area
Parcel Lot lines are for visual display only. Do not use for legal purposes.
0 2 4 6 Miles
1" = 4.5 miles
Yakimap.com
Copyright (C) 2016 Yakima County
This map was derived from several databases. The County cannot accept responsibility for any errors. Therefore there are no warranties for this product.
Plot date: Feb 17, 2016

6b All results letters-variables & enclosures list.docx

High Risk Well Assessment Letters-Variables

Where:

Nitrate Results Are	**And Coliform Results Are**	**And**	**Letter is**
N is 0-4.9 mg/L	Satisfactory	N/A	Letter #1
N is 0-4.9 mg/L	Unsatisfactory	N/A	Letter #1 with coliform variation
N is 5-9.9 mg/L	Satisfactory	N/A	Letter #2
N is 5-9.9 mg/L	Unsatisfactory	N/A	Letter #2 with coliform variation
N is 10 mg/L or greater	Satisfactory	N/A	Letter #3
N is 10 mg/L or greater	Unsatisfactory	E-Coli Not present	Letter #3 with coliform variation
N is ???	Unsatisfactory	E-Coli Present	Letter #?? With disinfect message

# of pages	**Letter #1 Enclosures**	**Letter #2 enclosures**	**Letter #3 enclosures**
1 (single)	Lab results	Lab results	Lab results
1 (single)	2A_Certified Lab List (English/Spanish)	2A_Certified Lab List (English/Spanish)	2A_Certified Lab List (English/Spanish)
1 (double)	2B_DOH Coliform 331-79 Q&A	2B_DOH Coliform 331-79 Q&A	2B_DOH Coliform 331-79 Q&A
1 (double)	2B_(Sp) DOH Coliform 331-79 Q&A	2B_(Sp) DOH Coliform 331-79 Q&A	2B_(Sp) DOH Coliform 331-79 Q&A
1 (double)	2C_DOH Nitrate in Drinking Water 331-214	2C_DOH Nitrate in Drinking Water 331-214	2C_DOH Nitrate in Drinking Water 331-214
1 (double)	2C_(Sp) DOH Nitrate in Drinking Water 331-214	2C_(Sp) DOH Nitrate in Drinking Water 331-214	2C_(Sp) DOH Nitrate in Drinking Water 331-214
			Emergency disinfect

6bi ltr 1 (Eng) well survey _satisfactor N results and what they mean.docx

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

May 2015

Parcel number
Name
Address
City State Zip

Dear Resident:

Thank you for participating in the 2014 Lower Yakima Valley Groundwater Management Area (LYV GWMA) High Risk Well Assessment Survey. A certified lab analyzed the water quality samples taken from your home or well during the survey. These samples included an inorganic sample for Nitrate and a bacteriological sample for Coliform.

We enclosed a copy of the lab results for your drinking water.

* The Nitrate level detected was fill in here mg/L. These results are normal and well within the acceptable range for nitrate.

* The coliform results were satisfactory.

We recommend you continue sampling for nitrate each year, even though your nitrate levels are within an acceptable range (less than 10 mg/L).

We also enclosed fact sheets on Nitrate, Coliform, and websites (links) that you may find helpful. These websites have more information about many drinking water contaminants, Maximum Contaminant Levels, treatment options, as well as proper maintenance for your well. For example:

* You may enter your results into the Ohio Watershed Interpretation Tool at (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool) for a detailed explanation of your results for any drinking water contaminant sampled and possible treatment recommendations, or

* Go to Well Owner.org http://www.wellowner.org/water-quality/water-testing/, for information on private wells, recommended testing, treatment, maintenance, and so on.

Why was my well water tested for Nitrate and Coliform?
The Lower Yakima Valley Groundwater Advisory Committee (GWAC) is a multi-agency and citizen-based group coordinating efforts to reduce nitrate contamination in drinking water in the Lower Yakima Valley. To learn more about the GWAC, please visit: http://www.yakimacounty.us/gwma/. Our interest in the study was to inform residents and homeowners served by private or shared wells in the Lower Yakima Valley of the potential health risks associated with their drinking water. We were also interested in gathering more information about the Nitrate level in your drinking water.

Can I be of more help?
Yes, and again we are very grateful for the assistance you have already given us. There is more funding available for doing more tests and surveys on homes served by private wells. Our interest is to get the word out to more residents of the Lower Yakima Valley. Please give us a call at (509) 574-2300 or email us at PSWebContacts@co.yakima.wa.us if you know a neighbor or friend in the area who is interested in having their well tested and the survey completed. As part of our effort to evaluate the levels of nitrate in the LYV, we may be looking for permanent ongoing monitoring sites. Please call
(509) 574-2300 if you want us to consider your well for part of this effort.

Sincerely,

J. Rand Elliott, Chairman
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

Enclosures

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

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Lower Yakima Valley Groundwater Advisory Committee (GWAC)

Enclosures

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Groundwater Management Area (GWMA):
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May 2015

parcel #
name
address
city state zip

Dear Resident:

Thank you for participating in the 2014 Lower Yakima Valley Groundwater Management Area (LYV GWMA) High Risk Well Assessment Survey. A certified lab analyzed the water quality samples taken from your home or well during the survey. These samples included an inorganic sample for Nitrate and a bacteriological sample for Coliform.

We enclosed a copy of the lab results for your drinking water.

* The Nitrate level detected was fill in here mg/L. A score between 5 - 9 mg/L shows the nitrate levels are high but still acceptable. However, they may be rising to an unacceptable range.
* The bacteria (Total Coliform) results were satisfactory.

Because your Nitrate level is approaching the State Standard of 10.0 mg/L, we recommend you consider sampling your well for Nitrate once every 3 to 6 months.

We also enclosed fact sheets on Nitrate, Coliform, and websites (links) that you may find helpful. These websites have more information about many drinking water contaminants, Maximum Contaminant Levels, treatment options, as well as proper maintenance for your well. For example:

* You may enter your results into the Ohio Watershed Interpretation Tool at (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool) for a detailed explanation of your results for any drinking water contaminant sampled and possible treatment recommendations, or

* Go to Well Owner.org http://www.wellowner.org/water-quality/water-testing/, for information on private wells, recommended testing, treatment, and maintenance.

Why was my well water tested for Nitrate and Coliform?
The Lower Yakima Valley Groundwater Advisory Committee (GWAC) is a multi agency and citizen-based group coordinating efforts to reduce nitrate contamination in drinking water in the Lower Yakima Valley. To learn more about the GWAC, please visit: http://www.yakimacounty.us/gwma/. Our interest in the study was to inform residents and homeowners served by private or shared wells in the Lower Yakima Valley of the potential health risks associated with their drinking water. We were also interested in gathering more information about the Nitrate level in your drinking water.

Can I be of more help?
Yes, and again we are very grateful for the assistance you have already given us. There is more funding available for doing more tests and surveys on homes served by private wells. Our interest is to get the word out to more residents of the Lower Yakima Valley. Please give us a call at (509) 574-2300 or email us at PSWebContacts@co.yakima.wa.us if you know a neighbor or friend in the area who is interested in having their well tested and the survey completed. As part of our effort to evaluate the levels of nitrate in the LYV, we may be looking for permanent ongoing monitoring sites. Please call (509) 574-2300 if you want us to consider your well for part of this effort.

Sincerely,

J. Rand Elliott, Chairman
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

Enclosures

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Mayo, 2015

parcel #
name
address
city state zip

Estimado residente:

Gracias por su participación en la Encuesta de Evaluación de Pozos de Alto Riesgo del Área de Manejo de Agua Subterránea del Valle Bajo de Yakima (LYV GWMA), 2014. Un laboratorio certificado analizó la calidad de las muestras de agua que se tomaron de su casa o pozo durante la encuesta. Las muestras se sometieron a una muestra inorgánica para Nitrato y una muestra bacteriológica para Coliforme.

Adjuntamos en esta carta una copia de los resultados de laboratorio de su agua para beber.

* El nivel de Nitrato detectado fue de fill in here mg/L. Un resultado entre 5 y 9 mg/L indica que los niveles de nitrato son altos, pero continúan siendo aceptables. Sin embargo, pudiera ser que los niveles estén en aumento y pudieran llegar a un rango inaceptable.
* Los resultados para bacteria (Coliforme Total) fueron Satisfactorios.

Debido a que su nivel de Nitrato se está acercando al Estándar Estatal de 10.0 mg/L, le recomendamos que considere hacer pruebas por Nitrato a su pozo de cada 3 a 6 meses.

También adjuntamos hojas con factores acerca del Nitrato, Coliforme y sitios en el internet (enlaces) que pudieran ser útiles. Estos sitos en el internet tienen más información acerca de muchos contaminantes en el agua para beber, Niveles Máximos de Contaminación, opciones de tratamiento y también del mantenimiento apropiado de su pozo. Por ejemplo:

* Para obtener una explicación detallada de sus resultados para cualquier contaminante al que se le haya echo la prueba a su agua para beber y recomendaciones para un tratamiento posible, usted puede ingresar sus resultados en la Ohio Watershed Interpretation Tool en: (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool), o
* Para información sobre pozos privados, pruebas que se recomiendan, tratamientos y mantenimiento vaya a Well Owner.org http://www.wellowner.org/water-quality/water-testing/.

¿Por qué se hicieron pruebas por Nitrato y Coliforme al agua de mi pozo?
El grupo GWAC del Valle Bajo de Yakima es un grupo formado de varias agencias y ciudadanos que está coordinando esfuerzos para reducir la contaminación por nitrato en el agua para beber en el Valle Bajo de Yakima. Para más información acerca de GWAC, por favor visite: http://www.yakimacounty.us/gwma/. Nuestro interés en el estudio fue informar a los residentes y propietarios de casas que usan el agua de pozos privados o compartidos en el Valle Bajo de Yakima de los riesgos potenciales de salud asociados con su agua para beber. También estamos interesados en reunir más información sobre el nivel de Nitrato en su agua para beber.

¿Puedo ayudar en algo?
Si, y una vez más, estamos muy agradecidos por la asistencia que ya nos ha brindado. Existen más fondos disponibles para hacer más pruebas y encuestas en casas que usan pozos privados. Nuestro interés es pasar la palabra a más residentes del Valle Bajo de Yakima. Por favor, si conoce a un vecino o amigo en el área que esté interesado en que se le hagan pruebas a su pozo y en hacer la encuesta, llámenos al (509) 574-2300 ó envíe un email a: PSWebContacts@co.yakima.wa.us. Como parte de nuestro esfuerzo para evaluar los niveles de nitrato en el Valle Bajo de Yakima, quizás busquemos lugares permanentes para monitoreo continuo. Por favor, si desea que consideremos su pozo para parte de este esfuerzo llámenos al (509) 574-2300.

Atentamente,

J. Rand Elliott, Presidente
Comité Asesor de Aguas Subterráneas del Valle Bajo de Yakima (GWAC)

Adjuntos

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

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May 2015

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We enclosed a copy of the lab results for your drinking water.

* The Nitrate level detected was fill in here mg/L. A score of 10 mg/L or greater indicates a high unacceptable nitrate level that exceeds the State Standard of 10.0 mg/L.
* The bacteria (Total Coliform) results were fill in here [satisfactory or unsatisfactory].

Because your Nitrate level is at 10.0 mg/L or above, we recommend you have your well tested every three months for nitrate. You should also consider installing a treatment system to remove excess nitrate or use bottled water for drinking and cooking if a member of your household is:

* An infant less than one year of age
* Pregnant
* May become pregnant or
* Has certain blood disorders

We also enclosed fact sheets on Nitrate, Coliform, and websites (links) that you may find helpful. These websites have more information about many drinking water contaminants, Maximum Contaminant Levels, treatment options, as well as proper maintenance for your well. For example:

* You may enter your results into the Ohio Watershed Interpretation Tool at (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool) for a detailed explanation of your results for any drinking water contaminant sampled and possible treatment recommendations, or
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Can I be of more help?
Yes, and again we are very grateful for the assistance you have already given us. There is more funding available for doing more tests and surveys on homes served by private wells. Our interest is to get the word out to more residents of the Lower Yakima Valley. Please give us a call at (509) 574-2300 or email us at PSWebContacts@co.yakima.wa.us if you know a neighbor or friend in the area who is interested in having their well tested and the survey completed. As part of our effort to evaluate the levels of nitrate in the LYV, we may be looking for permanent ongoing monitoring sites. Please call at (509) 574-2300 if you want us to consider your well for part of this effort.

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Enclosures

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LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

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Mayo, 2015

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Adjuntamos en esta carta una copia de los resultados de laboratorio de su agua para beber.

* El nivel de Nitrato detectado fue de fill in here mg/L. Un resultado mayor de 10 mg/L indica niveles altos no aceptables de nitrato que exceden el estándar Estatal de 10.0 mg/L.

* Los resultados para bacteria (Coliforme Total) fueron Satisfactorios.

Debido a que su nivel de Nitrato se encuentra en los 10.0 mg/L o lo excede, le recomendamos que hagan pruebas a su pozo por Nitrato cada 3 meses. También, debería considerar la instalación de un sistema especial para retirar el exceso nitrato o el uso de agua embotellada para tomar y cocinar si en su hogar vive alguien con las siguientes condiciones:

* Infante menor a un año de edad
* Embarazo
* Pudiera embarazarse
* Algún trastorno sanguíneo

También adjuntamos hojas con factores acerca del Nitrato, Coliforme y sitios en el internet (enlaces) que pudieran ser útiles. Estos sitos en el internet tienen más información acerca de muchos contaminantes en el agua para beber, Niveles Máximos de Contaminación, opciones de tratamiento y también del mantenimiento apropiado de su pozo. Por ejemplo:

* Para obtener una explicación detallada de sus resultados para cualquier contaminante al que se le haya echo la prueba a su agua para beber y recomendaciones para un tratamiento posible, usted puede ingresar sus resultados en la Ohio Watershed Interpretation Tool en: (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool), o

* Para información sobre pozos privados, pruebas que se recomiendan, tratamientos y mantenimiento vaya a Well Owner.org http://www.wellowner.org/water-quality/water-testing/.

¿Por qué se hicieron pruebas por Nitrato y Coliforme al agua de mi pozo?
El grupo GWAC del Valle Bajo de Yakima es un grupo formado de varias agencias y ciudadanos que está coordinando esfuerzos para reducir la contaminación por nitrato en el agua para beber en el Valle Bajo de Yakima. Para más información acerca de GWAC, por favor visite: http://www.yakimacounty.us/gwma/. Nuestro interés en el estudio fue informar a los residentes y propietarios de casas que usan el agua de pozos privados o compartidos en el Valle Bajo de Yakima de los riesgos potenciales de salud asociados con su agua para beber. También estamos interesados en reunir más información sobre el nivel de Nitrato en su agua para beber.

¿Puedo ayudar en algo?
Si, y una vez más, estamos muy agradecidos por la asistencia que ya nos ha brindado. Existen más fondos disponibles para hacer más pruebas y encuestas en casas que usan pozos privados. Nuestro interés es pasar la palabra a más residentes del Valle Bajo de Yakima. Por favor, si conoce a un vecino o amigo en el área que esté interesado en que se le hagan pruebas a su pozo y en hacer la encuesta, llámenos al (509) 574-2300 ó envíe un email a: PSWebContacts@co.yakima.wa.us. Como parte de nuestro esfuerzo para evaluar los niveles de nitrato en el Valle Bajo de Yakima, quizás busquemos lugares permanentes para monitoreo continuo. Por favor, si desea que consideremos su pozo para parte de este esfuerzo llámenos al (509) 574-2300.

Atentamente,

J. Rand Elliott, Presidente
Comité Asesor de Aguas Subterráneas del Valle Bajo de Yakima (GWAC)

Adjuntos

LOWER YAKIMA VALLEY

GROUNDWATER
ADVISORY
COMMITTEE

Groundwater Management Area (GWMA):
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May 2015

Parcel #
Name
Address
City, State Zip

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We enclosed a copy of the lab results for your drinking water.

* The Nitrate level detected was fill in here mg/L. These results are normal and well within the acceptable range for nitrate.

  We recommend you continue sampling for nitrate each year, even though your nitrate levels are within an acceptable range (less than 10 mg/L).

* The coliform results were UNSATISFACTORY.

Your coliform sample was Unsatisfactory. An Unsatisfactory result means Total Coliform was found in your sample. The presence of this bacteria indicate there is a breach in your well or pipes where dirt is getting into your pipes. We recommend having another coliform sample taken to the lab for analysis.

We also enclosed fact sheets on Nitrate, Coliform, and websites (links) that you may find helpful. These websites have more information about many drinking water contaminants, Maximum Contaminant Levels, treatment options, as well as proper maintenance for your well. For example:

* You may enter your results into the Ohio Watershed Interpretation Tool at (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool) for a detailed explanation of your results for any drinking water contaminant sampled and possible treatment recommendations, or

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(509) 574-2300 if you want us to consider your well for part of this effort.

Sincerely,

J. Rand Elliott, Chairman
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

enclosure: copy of lab results
Fact Sheets

LOWER YAKIMA VALLEY

GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
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Mayo, 2015

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Adjuntamos en esta carta una copia de los resultados de laboratorio de su agua para beber.

- El nivel de Nitrato detectado fue de fill in here mg/L. Este resultado es normal y el pozo está dentro de los niveles aceptables por nitrato.

  Aunque los niveles de Nitrato estén dentro de un rango aceptable (menos de 10.0 mg/L), le recomendamos que continúe haciendo pruebas por Nitrato a su pozo cada año.

- Los resultados para bacteria Coliforme fueron INSATISFACTORIOS.

Los resultados para la bacteria coliforme fueron INSATISFACTORIOS. Un resultado Insatisfactorio significa que en su muestra se encontró bacteria Coliforme Total. La presencia de esta bacteria indica que en su pozo o tuberías existe alguna ruptura que permite que entre tierra al sistema. Le recomendamos tome otra muestra para que la analicen en el laboratorio.

También adjuntamos hojas con factores acerca del Nitrato, Coliforme y sitios en el internet (enlaces) que pudieran ser útiles. Estos sitos en el internet tienen más información acerca de muchos contaminantes en el agua para beber, Niveles máximos de Contaminación, opciones de tratamiento y también del mantenimiento apropiado de su pozo. Por ejemplo:

- Para obtener una explicación detallada de sus resultados para cualquier contaminante al que se le haya echo la prueba a su agua para beber y recomendaciones para un tratamiento posible, usted puede ingresar sus resultados en la Ohio Watershed Interpretation Tool en: (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool), o
- Para información sobre pozos privados, pruebas que se recomiendan, tratamientos y mantenimiento vaya a Well Owner.org http://www.wellowner.org/water-quality/water-testing/.

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El grupo GWAC del Valle Bajo de Yakima es un grupo formado de varias agencias y ciudadanos que está coordinando esfuerzos para reducir la contaminación por nitrato en el agua para beber en el Valle Bajo de Yakima. Para más información acerca de GWAC, por favor visite: http://www.yakimacounty.us/gwma/. Nuestro interés en el estudio fue informar a los residentes y propietarios de casas que usan el agua de pozos privados o compartidos en el Valle Bajo de Yakima de los riesgos potenciales de salud asociados con su agua para beber. También estamos interesados en reunir más información sobre el nivel de Nitrato en su agua para beber.

¿Puedo ayudar en algo?
Si, y una vez más, estamos muy agradecidos por la asistencia que ya nos ha brindado. Existen más fondos disponibles para hacer más pruebas y encuestas en casas que usan pozos privados. Nuestro interés es pasar la palabra a más residentes del Valle Bajo de Yakima. Por favor, si conoce a un vecino o amigo en el área que esté interesado en que se le hagan pruebas a su pozo y en hacer la encuesta, llámenos al (509) 574-2300 ó envíe un email a: PSWebContacts@co.yakima.wa.us. Como parte de nuestro esfuerzo para evaluar los niveles de nitrato en el Valle Bajo de Yakima, quizás busquemos lugares permanentes para monitoreo continuo. Por favor, si desea que consideremos su pozo para parte de este esfuerzo llámenos al (509) 574-2300.

Atentamente,

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Adjuntos

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LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

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The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Mayo, 2015

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Los resultados para bacteria coliforme fueron INSATISFACTORIOS. Un resultado Insatisfactorio significa que en su muestra se encontró bacteria Coliforme Total. Además al evaluarse la muestra más a fondo se encontró E. Coli (Fecal) (Presente / No Presente). La presencia de esta bacteria indica que en su pozo o tuberías existe alguna ruptura que permite que entre tierra al sistema. Le recomendamos que revise la hoja de factores adjunta para que realice los procedimientos de desinfección de emergencia y que tome otra muestra para que la analicen en el laboratorio.

También adjuntamos hojas con factores acerca del Nitrato, Coliforme y sitios en el internet (enlaces) que pudieran ser útiles. Estos sitos en el internet tienen más información acerca de muchos contaminantes en el agua para beber, Niveles máximos de Contaminación, opciones de tratamiento y también del mantenimiento apropiado de su pozo. Por ejemplo:

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Adjuntos

6bv ltr 5 well survey _unsatisfactor coliform_E-Coli and what they mean1a.docx

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Your coliform sample was Unsatisfactory. An Unsatisfactory result means Total Coliform was found in your sample. In addition, further testing found E. coli (Fecal) present. The presence of this bacteria indicate there is a breach in your well or pipes where dirt is getting into your pipes. We recommend reviewing the enclosed fact sheet for emergency disinfection procedures and having another coliform sample taken to the lab for analysis.

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Why was my well water tested for Nitrate and Coliform?
The Lower Valley Groundwater Advisory Committee (GWAC) is a multi agency and citizen-based group coordinating efforts to reduce nitrate contamination in drinking water in the Lower Yakima Valley. To learn more about the GWAC, please visit: http://www.yakimacounty.us/gwma/. Our interest in the study was to inform residents and homeowners served by private or shared wells in the Lower Yakima Valley of the potential health risks associated with their drinking water. We were also interested in gathering more information about the Nitrate level in your drinking water.

Can I be of more help?
Yes, and again we are very grateful for the assistance you have already given us. There is more funding available for doing more tests and surveys on homes served by private wells. Our interest is to get the word out to more residents of the Lower Yakima Valley. Please give us a call at (509) 574-2300 or email us at PSWebContacts@co.yakima.wa.us if you know a neighbor or friend in the area who is interested in having their well tested and the survey completed. As part of our effort to evaluate the levels of nitrate in the LYV, we may be looking for permanent ongoing monitoring sites. Please call
(509) 574-2300 if you want us to consider your well for part of this effort.

Sincerely,

J. Rand Elliott, Chairman
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

enclosure: copy of lab results
Fact Sheets

7 NewMomNitratesFactSheet__EnglishSpanish_FINAL_2014_0715.pdf

LOWER YAKIMA VALLEY

GROUNDWATER ADVISORY COMMITTEE

How to Keep Your Baby Safe from Nitrates in Drinking Water

Groundwater Management Area (GWMA):

The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Nitrates are chemicals that occur naturally in drinking water and also result from human activities. Some private wells in the Yakima Valley are contaminated with nitrates. Nitrates can cause babies less than one year old to become sick. A symptom of nitrate exposure is your baby's skin turning brown or blue. You might see this inside the nose or mouth, the lips, or the fingernail and toenail beds. Contact a doctor immediately if you see these changes in a baby.

Tips to Reduce Exposure

- Test your well water for nitrates and bacteria to ensure it is safe to drink for your baby. Information on testing well water is offered below.
- Do not use nitrate-contaminated well water to make baby formula.
- Do not let baby drink nitrate-contaminated water.
- If you have city water it should be safe to use for baby, or use well water that has been tested and is safe, or bottled water for baby.
- Nitrates can be a problem in some vegetables. Try to choose commercially prepared vegetable baby foods until the baby is 7 months old. Doctors recommend no solid foods before 4-6 months old.
- If you are pregnant, or plan to get pregnant, do not drink nitrate-contaminated well water
- Breast milk is safe for baby even if the mother drinks water contaminated with nitrates.

Children over one year old have the ability to break down nitrates so they're not at risk. To keep babies safe, women who are pregnant or thinking of getting pregnant should not drink water with elevated nitrates.

Test your drinking water. All private wells should be tested before use and once per year for nitrates and bacteria. Nitrate concentrations change randomly throughout the year in the Yakima Valley. If nitrates are present in well water, other contaminants may also be present such as pesticides or bacteria.

Certified laboratories in the Yakima area that will test well drinking water for nitrates and bacteria:

- Cascade Analytical, Inc., 1008 W. Ahtanum, Yakima, WA 98903, (509) 452-7707
- Valley Environmental Laboratory, 201 E. "D" St., Yakima, WA 98901, (509) 575-3999
- Ag Health Laboratories, 445 Barnard Blvd, Sunnyside, WA 98944, (509) 836-2020

The total cost for nitrates and bacteria tests is between $52 and $70. Follow the directions provided by the laboratory – this is important to get good test results.

If a nitrate water test result is 10 mg/L or less the drinking water is safe. This means the water is safe for infants to drink and the water can be used to make formula for infants. The water is also safe for women who are pregnant or thinking about getting pregnant.

For more information about nitrates contact: Yakima Health District Help Line at (509)249-6508.

For clinician diagnosis and treatment guidance or other health effects: University of Washington (UW) PEHSU (Pediatric Environmental Health Specialty Unit) at 1-800-543-2436.

For more children's health information: www.epa.gov/children and

ATSDR at http://www.atsdr.cdc.gov/csem/csem.asp?csem=28&po=0

Benton County: Benton Franklin Health District (509) 460-4200

Yakama Nation: Indian Health Services - Environmental Health (509) 865-1776

Map: http://www.yakimacounty.us/gwma/documents/GWMA_Boundary.pdf

LOWER YAKIMA VALLEY

GROUNDWATER
ADVISORY
COMMITTEE

Cómo Mantener Seguro a su Bebé de los Nitratos en el Agua Potable

Área de Manejo de Agua Subterránea (GWMA):

El propósito de GWMA es reducir la concentración de contaminación por nitrato en el agua subterránea a niveles por debajo de los estándares del estada para el agua potable.

Los nitratos son químicos que se dan de manera natural en el agua potable pero también pueden ser el resultado de las actividades humanas. Algunos pozos privados en el Valle de Yakima están contaminados con nitratos. Los nitratos pueden causar que se enfermen los bebés menores de un año de edad. Un síntoma de exposición a nitrato es la piel de su bebé cambia de color café o azul. Es posible que vea esto dentro de la boca y la nariz, los labios o en las uñas de las manos y de los pies. Si ve estos cambios de coloración en su bebé, comuníquese inmediatamente con su doctor.

Recomendaciones para reducir la exposición

- Haga la prueba por nitratos y bacteria al agua de su pozo para asegurar que es segura que su bebé la beba. En este folleto encontrará información para la prueba al agua de su pozo.
- No utilice agua de pozo contaminada con nitratos para preparar la fórmula del bebé.
- No permita que su bebé beba agua contaminada con nitratos.
- Si Ud. recibe agua de la ciudad debe ser seguro de usar para el bebé. Para el bebé sólo use agua de pozo que ha sido probado y es segura o use agua embotellada.
- Los nitratos pueden ser un problema para algunas verduras. Escoja alimentos para bebés con verduras preparadas comercialmente hasta que su bebé tenga 7 meses de edad. Los doctores no recomiendan que los bebés coman alimentos sólidos antes de tener de 4 a 6 meses de edad.
- Si usted está embarazada o planea quedarse embarazada, no beba agua de pozo contaminada con nitratos.
- La leche materna es segura para el bebé aun cuando la madre beba agua contaminada con nitratos.

Los niños mayores de un año de edad tienen la capacidad de descomponer los nitratos y por lo tanto no están en riesgo. Para mantener seguros a los bebés, las mujeres embarazadas o las que planean quedarse embarazadas no deben beber agua con niveles altos de nitratos.

Haga la prueba a su agua para beber. A todos los pozos privados se les debería hacer la prueba por nitratos y bacteria antes de usarslos y una vez al año después. En el Valle de Yakima, la concentración de nitrato varía durante el año. Si en el agua de su pozo hay nitratos presentes, también pudiera haber presentes otros contaminantes como pesticidas o bacteria.

Los laboratorios certificados en el área de Yakima que realizan la prueba para nitratos y bacteria al agua de pozo son:

- Cascade Analytical, Inc., 1008 W. Ahtanum, Yakima, WA 98903, (509) 452-7707
- Valley Environmental Laboratory, 201 E. "D" St., Yakima, WA 98901, (509) 575-3999
- Ag Health Laboratories, 445 Barnard Blvd, Sunnyside, WA 98944, (509) 836-2020

El costo total de las pruebas por nitrato y bacteria es entre $52 a $70 dólares. Siga las instrucciones proveídas por el laboratorio seleccionado. Esto es especialmente importante para obtener buenos resultados en la prueba.

Si el resultado de la prueba por nitrato es de 10 mg/L o menos, el agua es segura para beber. Esto significa que el agua es segura para que la beban los bebés y para utilizar en preparar la fórmula del bebé. Este nivel también indica que el agua es segura para mujeres embarazadas o aquellas que piensan quedarse embarazadas.

Para más información acerca de los nitratos comuníquese a: línea de asistencia de Yakima Health District (509)249-6508.

Para diagnosis clínico y guía de tratamiento u otro efecto en la salud: University of Washington (UW) PEHSU (Pediatric Environmental Health Specialty Unit) al 1-800-543-2436.

Más información sobre la salud de los bebés: www.epa.gov/children y ATSDR http://www.atsdr.cdc.gov/csem/csem.asp?csem=28&po=0

Benton County: Benton Franklin Health District (509) 460-4200

Yakama Nation: Indian Health Services - Environmental Health (509) 865-1776

Mapa: http://www.yakimacounty.us/gwma/documents/GWMA_Boundary.pdf

7 PEHSU nitrates_Clinician Fact Sheet New Mom Companion_2014_1013.pdf

NITRATES, METHEMOGLOBINEMIA, AND DRINKING WATER: A Factsheet for Clinicians

PEHSU Pediatric Environmental Health Specialty Units

Nitrates are chemicals that occur naturally in drinking water and also result from human activities. In some areas private wells are contaminated with nitrates. Excessive nitrates can cause acquired methemoglobinemia in young infants. This severe syndrome of inadequate tissue oxygenation is potentially fatal; prompt clinical recognition and treatment is vital. Families should be counseled on nitrate safety.

Nitrate Background

- Nitrates and nitrites are naturally occurring inorganic nitrogen ions found in soil, water, and some foods. They are a natural part of the human diet. However, excessive consumption (e.g. drinking water or eating food from areas where ground water has become contaminated by excessive nitrate from fertilizers or improper manure management) can cause serious adverse health effects.

Nitrate Sources

- Drinking water
    - Nitrates occur naturally in water at low concentrations. Nitrates are also present as a result of human activities, such as the use of fertilizers and manure on irrigated farm fields that can run off and seep into wells. Nitrate-contaminated water can also be due to improper management of farm animal (i.e. cow) waste, leaky sewage pipes, and septic system failures.
    - Large suppliers of public water sources are required to monitor nitrate concentrations regularly, but private wells are not. In some areas private wells are contaminated with nitrates.
    - The American Academy of Pediatrics (AAP) consensus panel recommends that all prenatal and well-infant visits need to include questions about the home water supply.
    - The only way to know if the nitrate level in well water is at a safe level is to have the well water tested by a certified laboratory. <u>All private wells should be tested before use and once per year for nitrates</u>. *Families should contact their state health department for assistance with selecting a certified laboratory.*
    - Regulations and water testing frequency:
        - The United States Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) for nitrates is 10 mg/L (or 10 parts per million, 10 ppm). The 10 mg/L standard was set to protect infants from nitrates. When a nitrate water test result is 10 mg/L or less, the water is considered safe for infant use.
        - Nitrates may change seasonally or randomly throughout the year. If the nitrate concentration is between 5 – 10 mg/L, monitor more closely and test the well drinking water every 3 months to confirm the water is still safe. When nitrates are present, pesticides or bacteria may also be present and additional water tests may be needed. Families should contact their local health department for guidance.
- Food
    - Nitrates can also be a problem in some vegetables, including spinach, beets, lettuce, cabbage, green beans, squash, carrots, and turnips. Because these vegetables may contain higher amounts of nitrates, recommend other foods until infants are over 6 months old.

Infant Nitrate Exposure

- Infants are exposed to nitrates when they drink contaminated well water or when contaminated well water is used to make infant formula or baby food.
- Nitrates in water are not significantly absorbed through the skin.
- Breastfeeding is safe even if a mother drinks water polluted with nitrates.

Methemoglobinemia and Other Health Effects

- Hemoglobin in blood contains iron normally found in the Fe^{2+} (ferrous) state. Excessive nitrates or nitrites can alter the iron in hemoglobin to the Fe^{3+} (ferric) state, forming methemoglobin (an abnormal form of hemoglobin which cannot bind oxygen). Methemoglobinemia (an excess of methemoglobin) results in poor tissue oxygenation and anoxia.

- Methemoglobinemia, also known as "blue baby syndrome", can be inherited or acquired. The acquired form, such as from excessive nitrate exposure, is a serious medical emergency. Among the reported cases of acquired methemoglobinemia in US infants, most have been attributed to the use of nitrate contaminated well water for preparation of infant formula.
- Infants less than 1 year old are physiologically vulnerable to the development of methemoglobinemia due to several factors:
    - Their higher gastric pH favors nitrate-reducing bacteria that convert ingested nitrate into methemoglobin-producing nitrite.
    - Fetal hemoglobin, the predominant form in infants up to 3 months of age, is oxidized more readily to methemoglobin by nitrite than is adult hemoglobin.
    - The activity of the red blood cell enzyme systems that reduce methemoglobin back to normal hemoglobin is reduced by about half in infants compared with adults.
    - Gastroenteritis can increase the risk of developing methemoglobinemia.
- **Women who are thinking about pregnancy or who are pregnant should avoid water contaminated with nitrates. Women considering pregnancy or who are pregnant should drink water from public water supplies, water that has been tested and has safe nitrate levels, or bottled water.** While not conclusive due to study limitations, epidemiological data suggest an association between maternal ingestion of nitrate from drinking water and preeclampsia, spontaneous abortion, intrauterine growth restriction, and various birth defects. A few studies have hinted at a role for childhood nitrate intake in the risk for later developing diabetes mellitus.

METHEMOGLOBINEMIA CLINICAL MANAGEMENT

Clinical presentation

- In children and adults with acute acquired methemoglobinemia, methemoglobin levels >20% are associated with clinical symptoms.
- Early methemoglobinemia symptoms include nonspecific headache, fatigue, dyspnea, and lethargy. In infants, this may present as unusual fussiness, decreased alertness, diarrhea, vomiting, shortness of breath, and increased work of breathing.
- At higher methemoglobin levels, cyanosis becomes visible. A brownish-blue skin tone may be present due to anoxia. This condition may be harder to detect in infants with dark skin- look for a bluish color of the nasal or oral mucosa, lips, or nail beds.
- Respiratory depression, altered consciousness, shock, seizures, and death may occur. Acquired methemoglobinemia is life threatening when methemoglobin comprises more than 30% of total hemoglobin and mortality rates are high when methemoglobin levels exceed 40%.

Diagnosis

- Initial diagnosis is based on history and exam findings. In addition, the presence of methemoglobin should be suspected with 1) clinical cyanosis despite normal arterial pO2, or 2) a significant difference between the oxygen saturations measured by pulse oximetry and by arterial blood gas analysis ("saturation gap").
- A diagnosis of methemoglobinemia should be confirmed by laboratory analysis, to be done in the emergency setting (i.e. not in primary care). Hemoximetry, also called co-oximetry, is recommended way for measuring methemoglobin. Most current blood gas analyzers have incorporated the ability to do hemoximetry
- A fresh blood specimen (venous is fine) should always be obtained as methemoglobin levels tend to increase with storage.
- Note that routine pulse oximetry is inaccurate for monitoring oxygen saturation when methemoglobin is present, and should not be used for diagnosis.

Treatment

- Acute onset of acquired methemoglobinemia should be considered a medical emergency and requires immediate treatment in the ER setting.
- When the patient is symptomatic or the methemoglobin level is >20%, intravenous methylene blue (MB, dosed at 1 to 2 mg/kg over five minutes) can be life-saving and is considered the treatment of choice. Blood transfusion or

exchange transfusion may be helpful in patients who are in shock. See appropriate clinical guidelines for more detailed treatment and monitoring guidance.

Prevention and Advice for Families

- **Only use water from public water supplies, water that has been tested and confirmed as safe, or bottled water.**
- **Test well water for nitrates to ensure it is safe to drink. A nitrate test is around $50.**
- **Don't use nitrate-contaminated well water to make baby formula or to make baby food.**
- **Don't let infants drink nitrate-contaminated water.**
- **Women who are pregnant or trying to get pregnant should not drink nitrate-contaminated well water.**
- **Breastfeeding is safe even if the mother drinks water contaminated with nitrates.**
- **Because some vegetables may contain higher amounts of nitrates, choose other solid foods until infants are over 6 months old.**

Reporting

- Methemoglobinemia is not currently a mandatory notifiable condition in Washington State. However new passive surveillance has been initiated by the Yakima Health District under the supervision of Health Officer Dr. Chris Spitters. Yakima Health District requests notification of laboratory-confirmed methemoglobinemia by calling (509) 249-6541 within three days of diagnosis. Please include an exposure history and your clinical impression regarding etiology, if known.

Resources and References

For acute poisoning assistance contact your state poison center at 1-800-222-1222.
For additional non-urgent clinical and public health assistance, contact the NW PEHSU. The University of Washington based Pediatric Environmental Health Specialty Unit (PEHSU) serves medical and public health professionals in Alaska, Washington, Idaho, and Oregon. For more information contact us at 1–877–543-2436 (1-877-KID-CHEM) or pehsu@uw.edu. Visit our website http://www.depts.washington.edu/pehsu.

- ATSDR ToxFAQsTM for Nitrates and Nitrites: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=1186&tid=258
- ATSDR Case Studies in Environmental Medicine (CSEM): Nitrate/Nitrite Toxicity (course: WB2342): http://www.atsdr.cdc.gov/csem/csem.asp?csem=28&po=0
- Brender JD, et al. Prenatal nitrate intake from drinking water and selected birth defects in offspring of participants in the National Birth Defects Prevention Study. Environ Health Perspect. 2013 121:1083 – 1089.
- Karr C. Children's Environmental Health in Agricultural Settings. Journal of Agromedicine. 2012 April; 17(2), 127-139.
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- Washington State Department of Health: Nitrate in Drinking Water WEB site. Last accessed March 31, 2014. http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/Contaminants/Nitrate.aspx
- Yakima Health District Drinking Water WEB site last accessed March 31, 2014. http://yakimacounty.us/yakimahealthdistrict/drinking_water.php

Authors: N. Beaudet, MS, CIH; A. Otter, DNP, ARNP; C. Karr, MD, PhD; S. Sathyanarayana, MD, MPH, A. Perkins, BA. Last updated July 2014.

Disclaimer: PEHSU funding was made possible (in part) by the cooperative agreement award number UTI Grant Number U61 TS000118 from the *Agency for Toxic Substances and Disease Registry (ATSDR). The views in this guidance do not necessarily reflect the official policies of the* Department of Health and Human Services; nor does mention of trade names, commercial practices, or organizations imply endorsement by the U.S. Government.
Acknowledgement: The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing funds to ATSDR under Inter-Agency Agreement number DW-75-92301301-0. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.

High Risk Well Assessment

Section 3 - Survey Questions

6. Do you drink your tap water — ☐ No ☐ Yes

7. What is the main source of your drinking water? — ☐ Specify Below

☐ Tap water ☐ Bottled Water ☐ Other ______

8. Do you have a system to remove nitrates from your water? — ☐ No ☐ Yes - Specify below

Where is it located? ☐ Before the house ☐ At the sink

What type is it? ☐ R/O ☐ Ion

☐ Ultra-filtration ☐ Other ______

9. Just a few questions about your household:

☐ # of people ☐ Children < Year ☐ Vulnerable Health Condition *[Script]*

☐ W Child bearing age ☐ Pregnant ☐ Household Income < $48,000

10. Has your well been tested within the past 3 years? — ☐ No ☐ Yes - Specify below

☐ Coliform ☐ Fecal/E. coli ☐ Nitrate ______ mg/L

11. Are you familiar with your well? — ☐ No ☐ Yes - Specify below

☐ Well log ______ Age of well ______ Depth of well

12. Is your well subject to flooding? — ☐ No ☐ Yes

13. Has your on-site septic system been pumped in the last 5 years? — ☐ No ☐ Yes ☐ N/A

14. Has there been manure or any chemicals applied within 50 ft. of the well? — ☐ No ☐ Yes - Specify below

☐ Manure ______ Frequency ______ By who

☐ Chemicals ______ Frequency ______ Type

15. Have you ever participated in a Yakima County well survey? — ☐ No ☐ Yes ☐ Return

High Risk Well Assessment

Section 1 - General Information

Parcel #: ☐ **Date:** ☐

Address: ☐
Street *Apt. #*
☐
City *State* *Zip*

GPS: ☐ N ☐ W
___ ° ___ ' ___ " ___ ° ___ ' ___ "

Surveyor Name: ☐

Resident Name: ☐

Resident Type: ☐ Resident ☐ Owner ☐ Both

Primary Phone: ☐ ☐ Home ☐ Work

Section 2 - Site Information

1. Is there an onsite septic system? ☐ **No** ☐ **Yes - Specify Below**

☐ Septic tank within 50 ft. of well ☐ Drain field within 100 ft. of well

2. Is there surface water within 100 ft. of the well? ☐ **No** ☐ **Yes - Specify Below**

☐ Ponds ☐ Lagoons ☐ Lined irrigation canal
☐ Unlined irrigation canal ☐ River ☐ Other

3. Are there animals/agriculture within 100 ft. of the well? ☐ **No** ☐ **Yes - Specify Below**

☐ Orchard/Field ☐ Structure/Animals Type/# ☐

4. Are there large mounds of manure within 100 ft of the well? ☐ **No** ☐ **Yes - Specify Below**

☐ Owner ☐ Neighbor

5. Can you see the condition of the well and wellhead? ☐ **No** ☐ **Yes - Specify Below**

☐ Driven Well (sand point) ☐ Hand Dug ☐ Poorly Maintained
☐ Broken wellhead seal ☐ Holes in casing ☐ Other ☐

Materials Requested ☐

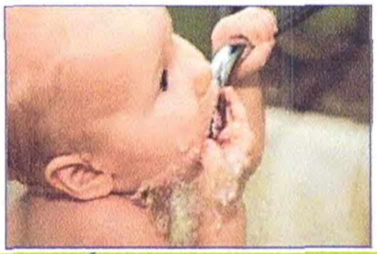
12 Well Assessment Survey July13_2015.pdf

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Yakima Health District
Prevention is our Business

Comité Asesor del Área de Manejo de Agua Subterránea (GWMA):
El propósito de GWMA es reducir la concentración de contaminación por nitrato en el agua subterránea por debajo del estándar estatal para el agua potable.

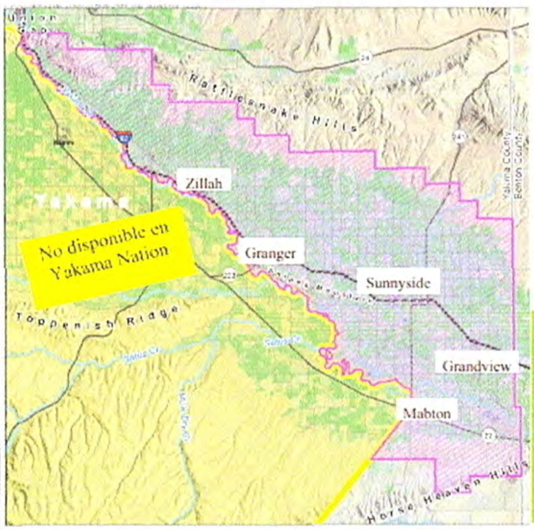
¡Atención Residentes del VALLE BAJO!



¿El agua que usted bebe viene de un pozo privado?

SÓLO POR TIEMPO LIMITADO usted puede ser elegible para una
PRUEBA GRATIS DEL AGUA DE SU POZO
a través del
Comité Asesor de Agua Subterránea del Valle Bajo de Yakima (GWAC)

¿De qué se trata? **Se evaluará por nitrato y bacteria a pozos de agua potable. Un empleado del Departamento de Salud de Yakima tomará la muestra de su pozo y se le invitará a participar en una encuesta corta. Usted puede consultar sobre cualquier preocupación que tenga del agua de su pozo y los resultados de las prueba estarán disponibles.**



¿Qué puedo hacer para ser considerado para la prueba gratis?

Para ser considerado, usted debe vivir en el Valle Bajo de Yakima y obtener el agua que bebe de un pozo privado o de un pozo compartido.

Para más información o para participar, llame a la Línea de información del Departamento de Salud de Yakima

509.249.6508

Estas pruebas son posibles gracias a GWAC. Su participación ayudará al comité a entender mejor y a ayudar a encontrar soluciones a la posible contaminación en los pozos de agua potable. Para más información, visite: http://www.yakimacounty.us/gwma/

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Yakima Health District

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

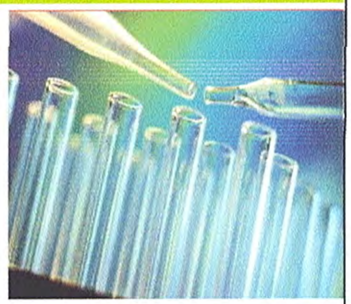
Attention LOWER VALLEY Residents!

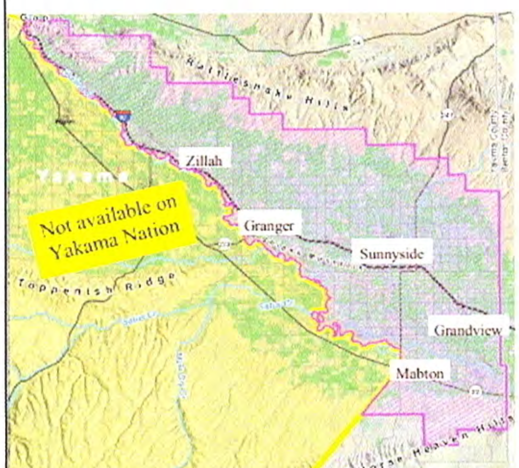
Does your drinking water come from a private well?

For a LIMITED TIME ONLY you may be eligible for
FREE WELL WATER TESTING
through the
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

What's involved?

- Your drinking water well sampled for nitrates and bacteria for free
- A short survey by a Yakima Health District employee where you can share your concerns and learn about nitrates
- You receive sampling results to help you protect your drinking water and family





How can I be considered for free testing?

- You must live in the Lower Yakima Valley *and*
- Obtain your drinking water from a private or shared well

For more information or to participate, please call
The Yakima Health District Help Desk

509.249.6508

This sampling is made possible by the GWAC. Your participation will help the committee to better understand and help find some solutions to possible contamination in drinking water wells.
For more information, please visit: **http://www.yakimacounty.us/gwma/**

12_Free Well Water Testing _Phase II_English_v2015.pdf

Public Service Announcement
GWAC Lower Yakima Valley Well Sampling

The Lower Yakima Valley Groundwater Advisory Committee (GWAC) is offering free well water sampling to Lower Yakima valley residents beginning in September.

Drinking water wells will be sampled for nitrate and bacteria. A Yakima Health District employee will be available to discuss any concerns or questions with the survey or sample results with survey participants or the general public. This sampling will help the Committee to better understand and help find solutions to possible contamination in drinking water wells.

For more information and to participate, contact the Yakima Health District Help Desk at:
509-249-6508

12_Letter_invite to participate in well testing_Engl_2015_09_with signature.pdf

LOWER YAKIMA VALLEY

GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA): The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

September 2015

Dear Resident:

The Lower Yakima Valley Groundwater Advisory Committee (GWAC) in partnership with the Yakima Health District is offering *free* nitrate and coliform samples for private and shared wells. This is part of an ongoing effort to help residents in the Lower Yakima Valley learn more about the water quality and impact to public health of the area's drinking water.

We are writing to encourage you to participate in our sampling program that should take about 30 minutes. This will be a quick look at conditions surrounding your well that may impact water quality and the health of your family. The samples will show if the water quality may also be a concern to your family's health. The short survey and samples will be completed by an environmental health specialist from the Yakima Health District.

The sampling will be paid for by state funds made available to Yakima County to address areas where there may be high levels of nitrate in drinking water. The survey will help us understand the conditions that exist around the wells and how to best help the residents. It is not our intention to collect personal data for any other use or purpose.

All information collected will be made available to you and will help you make informed decisions about your drinking water and your family's health.

To set up an appointment to participate, please call the Yakima Health District Help Desk at 509-249-6508.The sampling program will begin in September.

The Lower Yakima Valley GWAC is a multiagency and citizen-based group coordinating efforts to reduce nitrate contamination in drinking water in the Lower Yakima Valley. To learn more about the GWAC and this program, please visit: http://www.yakimacounty.us/gwma/.

We look forward to working with you.

Sincerely,

J. Rand Elliott, Yakima County Commissioner
Chairman
The Lower Yakima Valley Groundwater Management Area Advisory Committee

12_Letter_invite to participate in well testing_Spanish_2015 with signature.pdf.docx

LOWER YAKIMA VALLEY

GROUNDWATER
ADVISORY
COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Septiembre 2015

Estimado residente:

El Comité Asesor del Área de Manejo de Agua Subterránea del Valle Bajo de Yakima (GWAC) en asociación con el Distrito de Salud de Yakima está ofreciendo muestras *gratis* de nitrato y bacterias coliformes para los pozos privados y compartidos. Como parte de un esfuerzo continuo para ayudar a los residentes en el Valle Bajo de Yakima a informarse más sobre la calidad y el impacto que tiene el agua para beber del área en la salud pública.

Le escribimos para animarle a que participe en nuestro programa de muestreo que sólo debe durar aproximadamente 30 minutos. La encuesta es un vistazo rápido a las condiciones que rodean su pozo y que pueden afectar la calidad del agua y la salud de su familia. Las muestras mostrarán si la calidad del agua pudiera ser también una preocupación para la salud de su familia. La encuesta corta y las muestras serán tomadas por un especialista en salud ambiental del Distrito de Salud de Yakima.

Las muestras serán pagadas con fondos estatales disponibles para atender áreas del Condado de Yakima donde pudiera haber niveles altos de nitratos en agua para beber. La encuesta nos ayudará a entender las condiciones que existen alrededor de los pozos y la manera de apoyar mejor a los residentes. No es nuestra intención recolectar datos personales para ningún otro uso o propósito.

Toda la información recolectada estará disponible para usted y le ayudará a tomar decisiones informadas acerca de su agua para beber y la salud de su familia.

Para hacer una cita para participar, por favor llame a la línea de ayuda del Distrito de Salud de Yakima al 509-249-6508. El programa de muestreo iniciará este mes. El comité GWAC del Valle Bajo de Yakima es un grupo formado por varias agencias y ciudadanos que coordinan los esfuerzos para reducir la contaminación por nitrato en el agua para beber en el Valle bajo de Yakima. Para más información acerca de GWAC y de este programa, visite: http://www.yakimacounty.us/gwma/.

Esperamos poder trabajar con usted.

Atentamente,

J. Rand Elliott, Presidente de Comisionados del Condado de Yakima
Comité Asesor del Área de Manejo de Agua Subterránea del Valle Bajo de Yakima

Figure 4 - Public Ownership

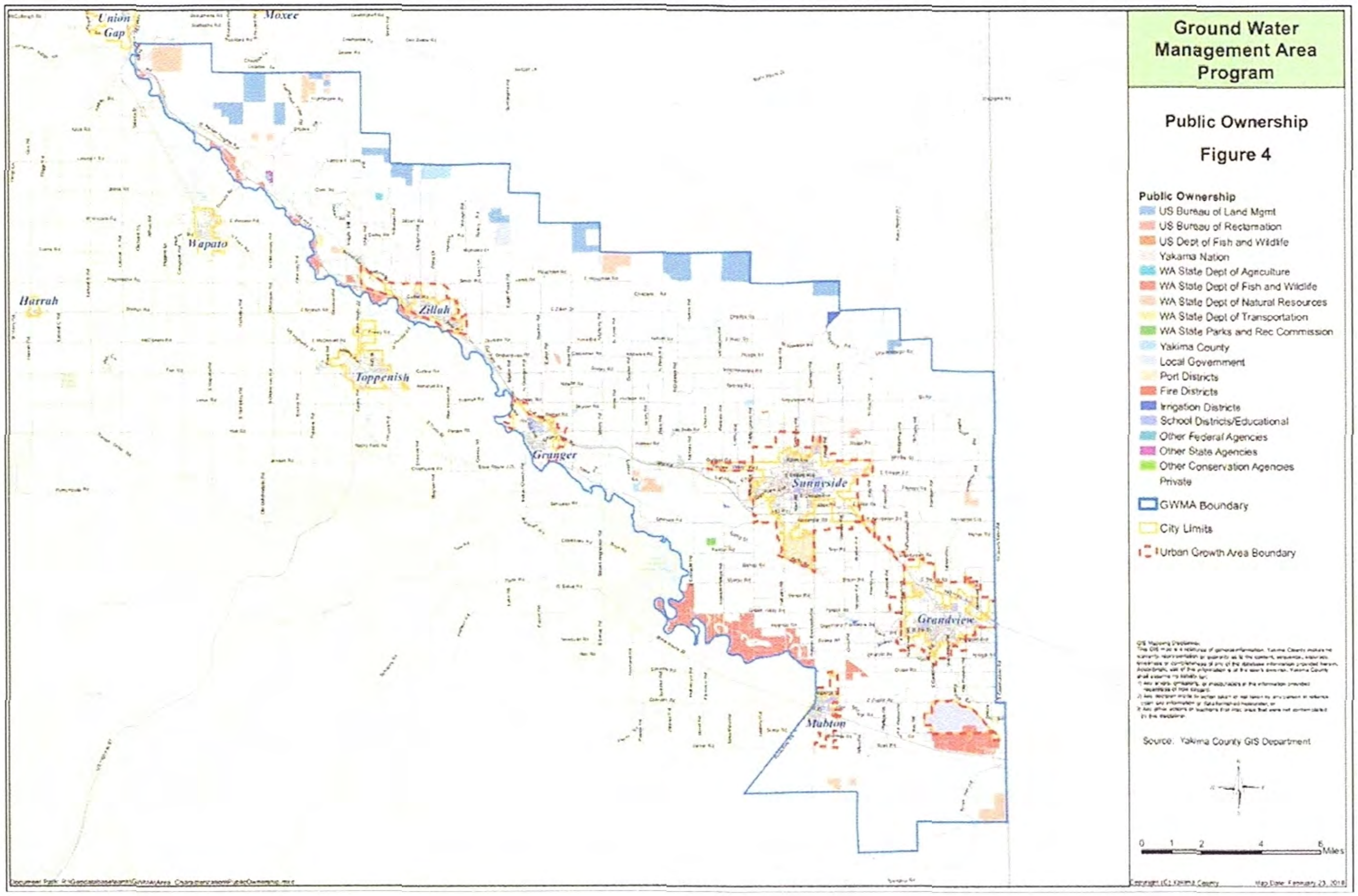


Figure 5 - Geology

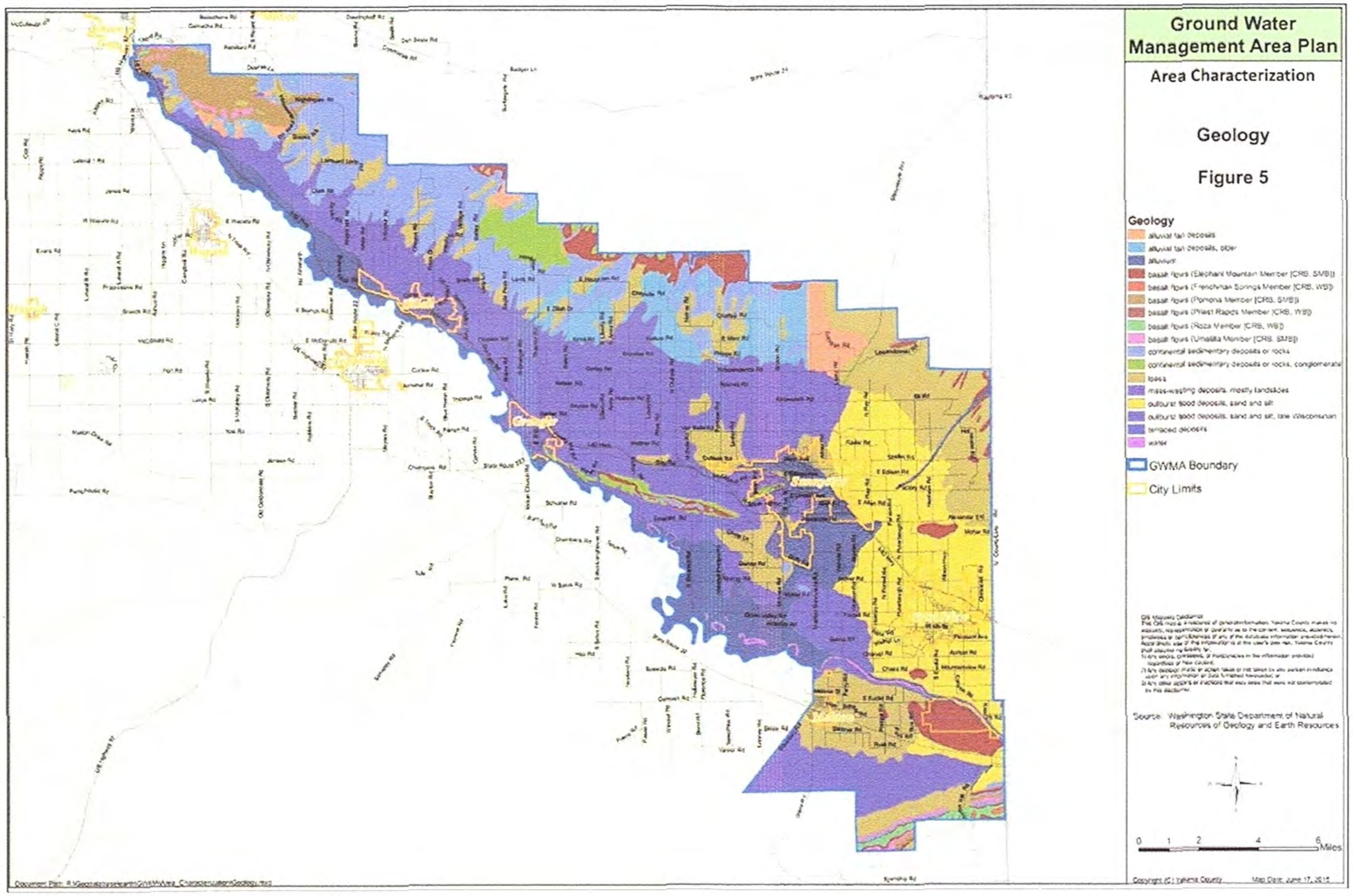


Figure 6 – Suficial Hydrogeolgic Units

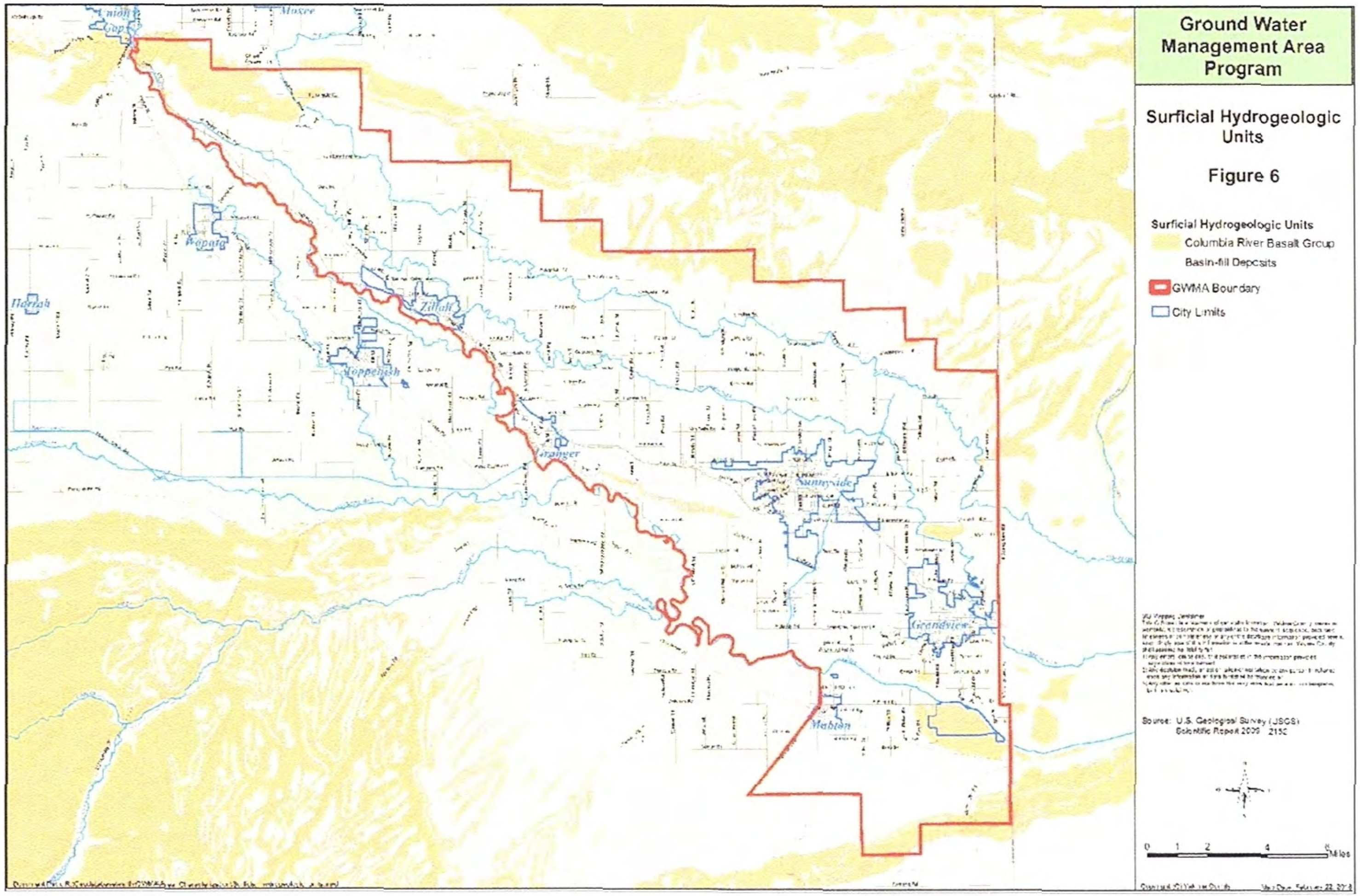


Figure 7 – Basins with Location of Springs

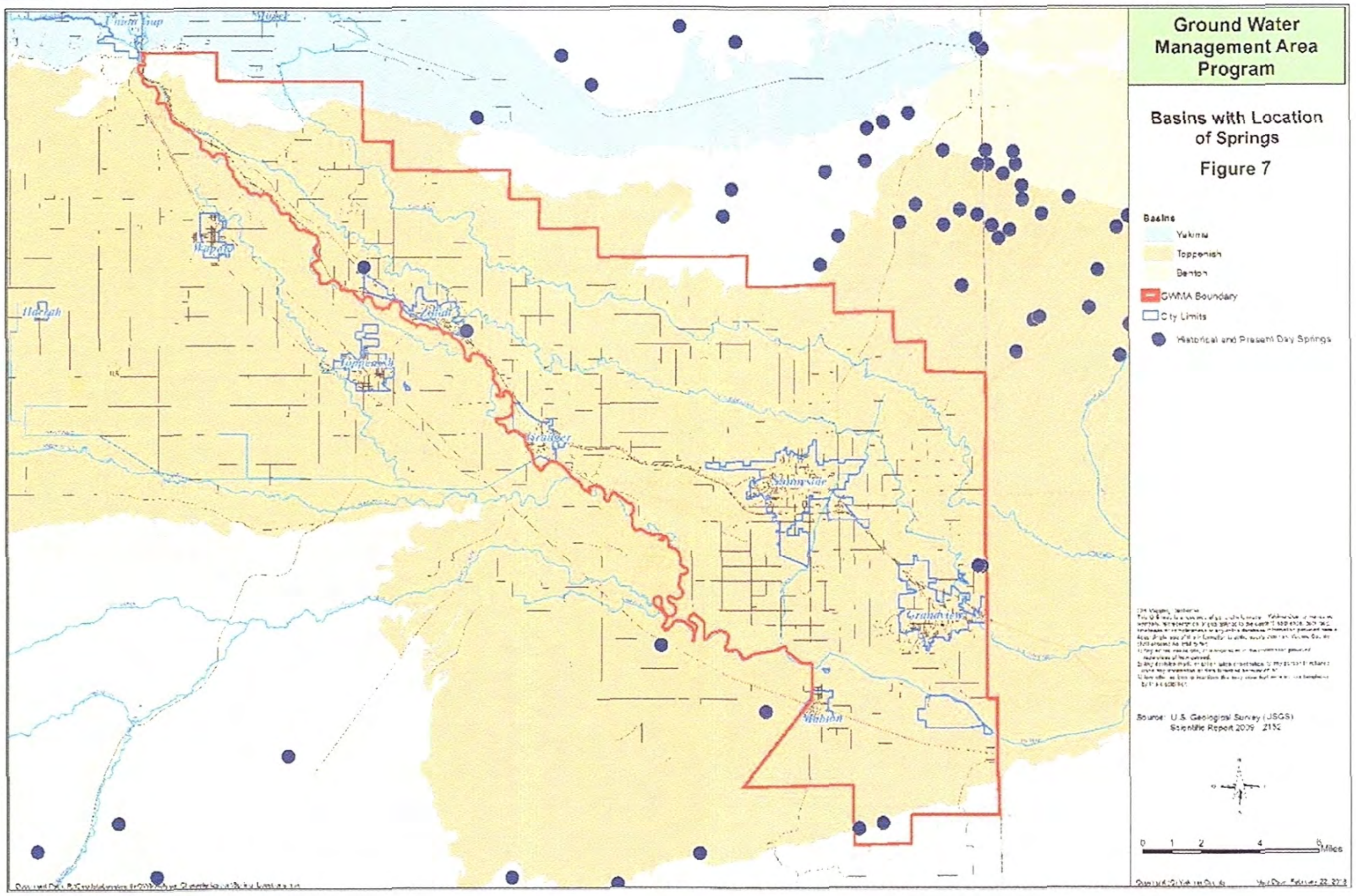


Figure 8 – Spatial Distribution of Mean Annual Recharge

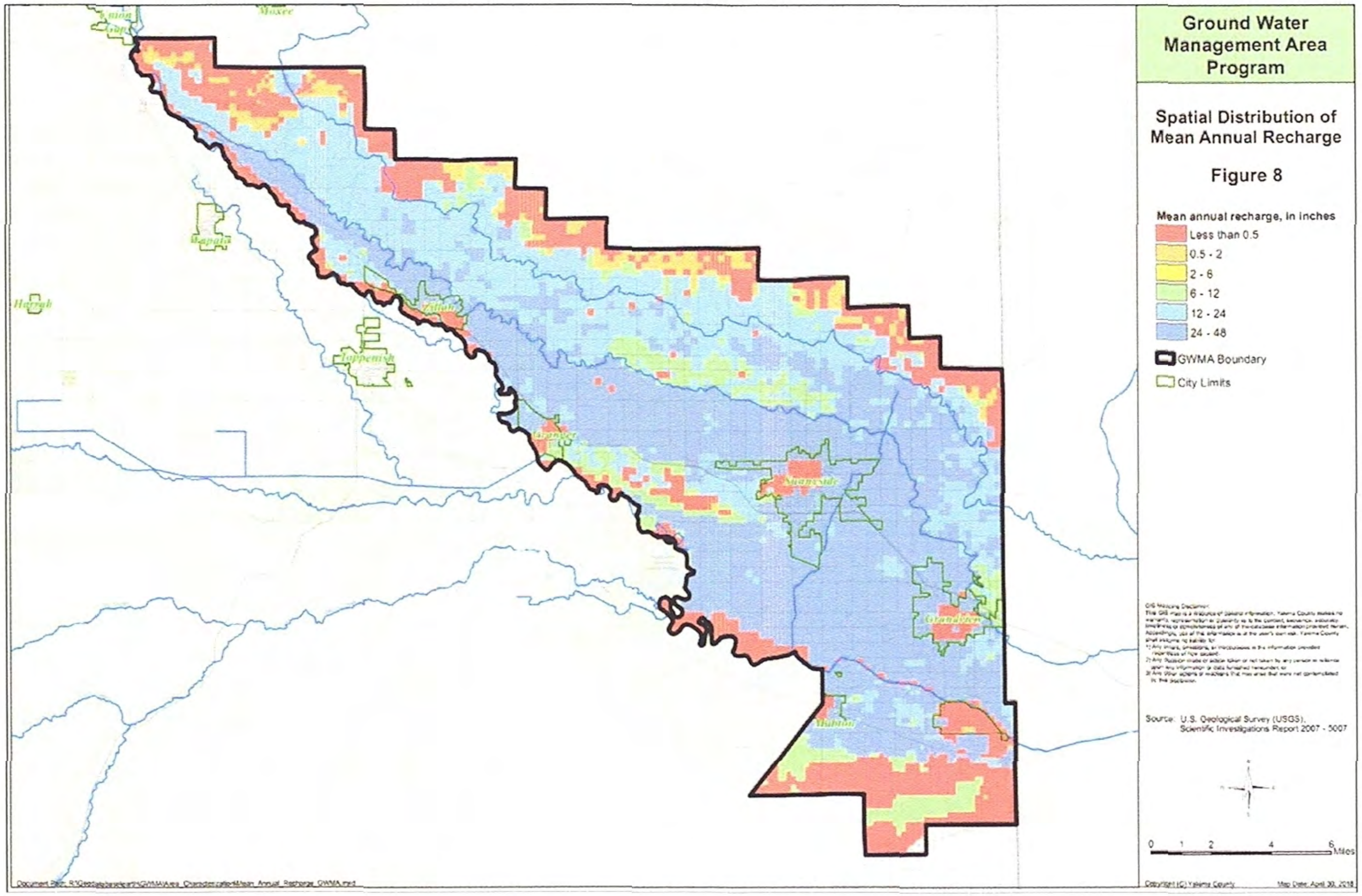


Figure 9 – Groundwater Contours

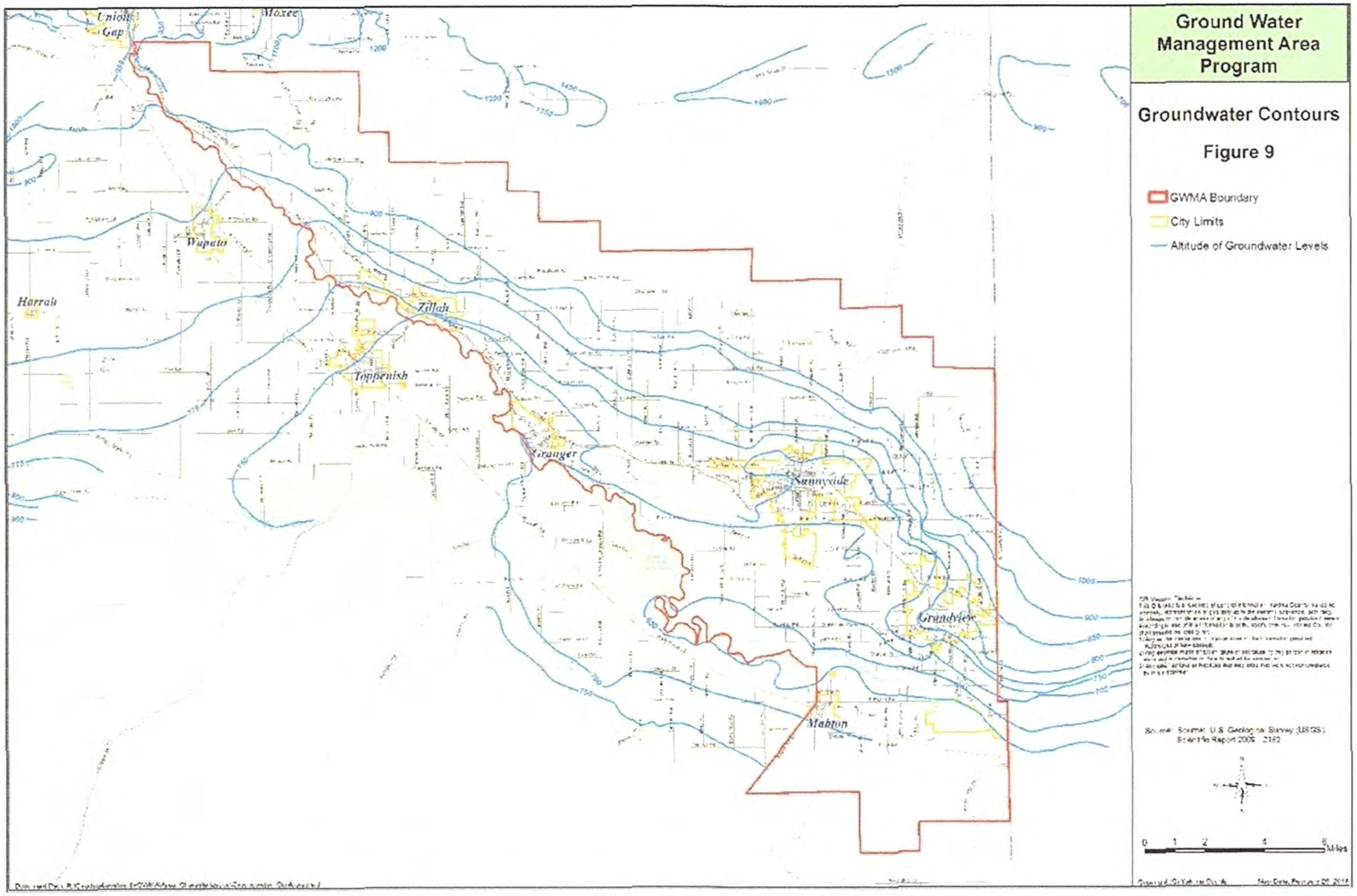


Figure 10 - Topography

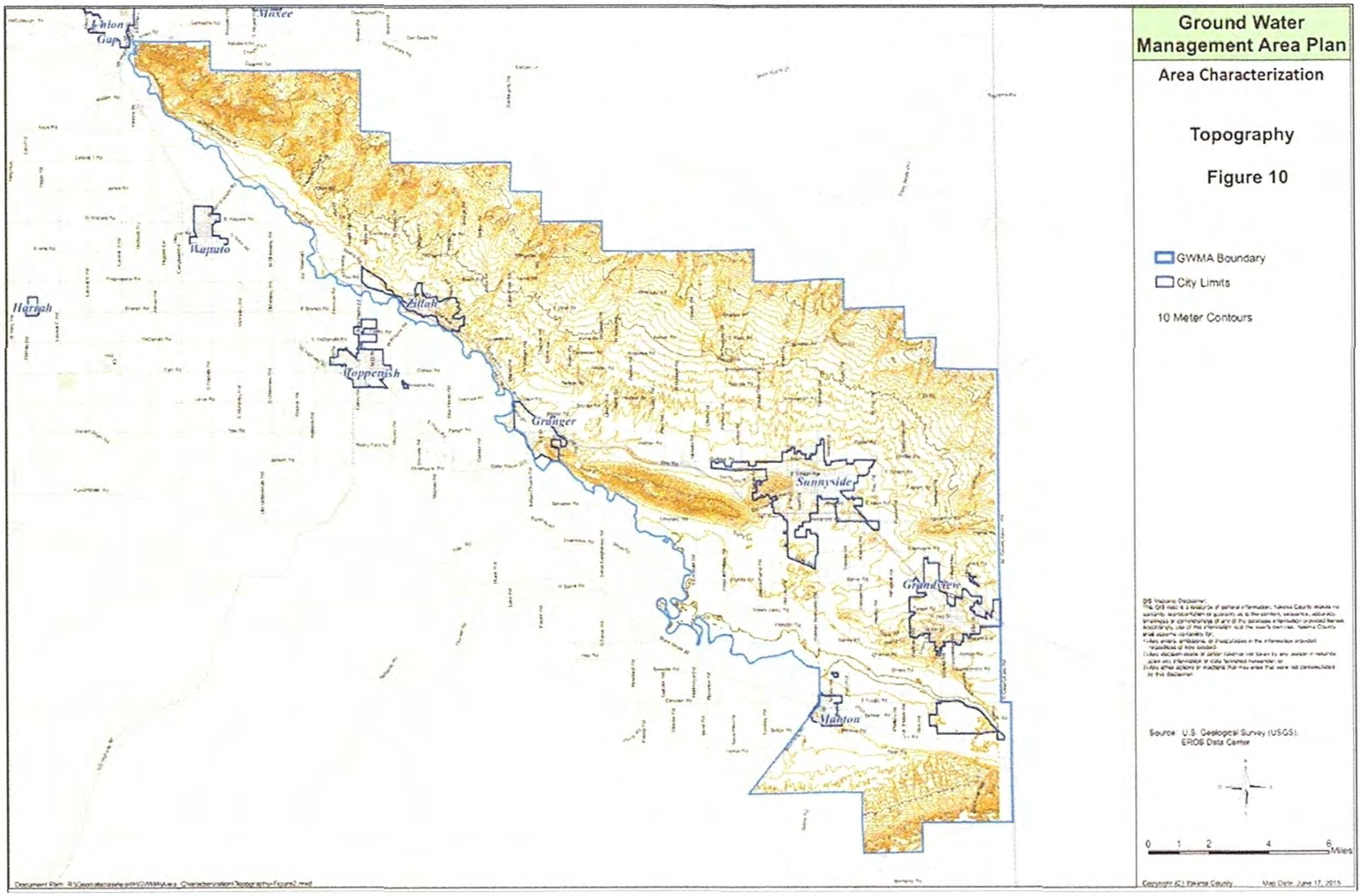


Figure 11 – Depth to Groundwater

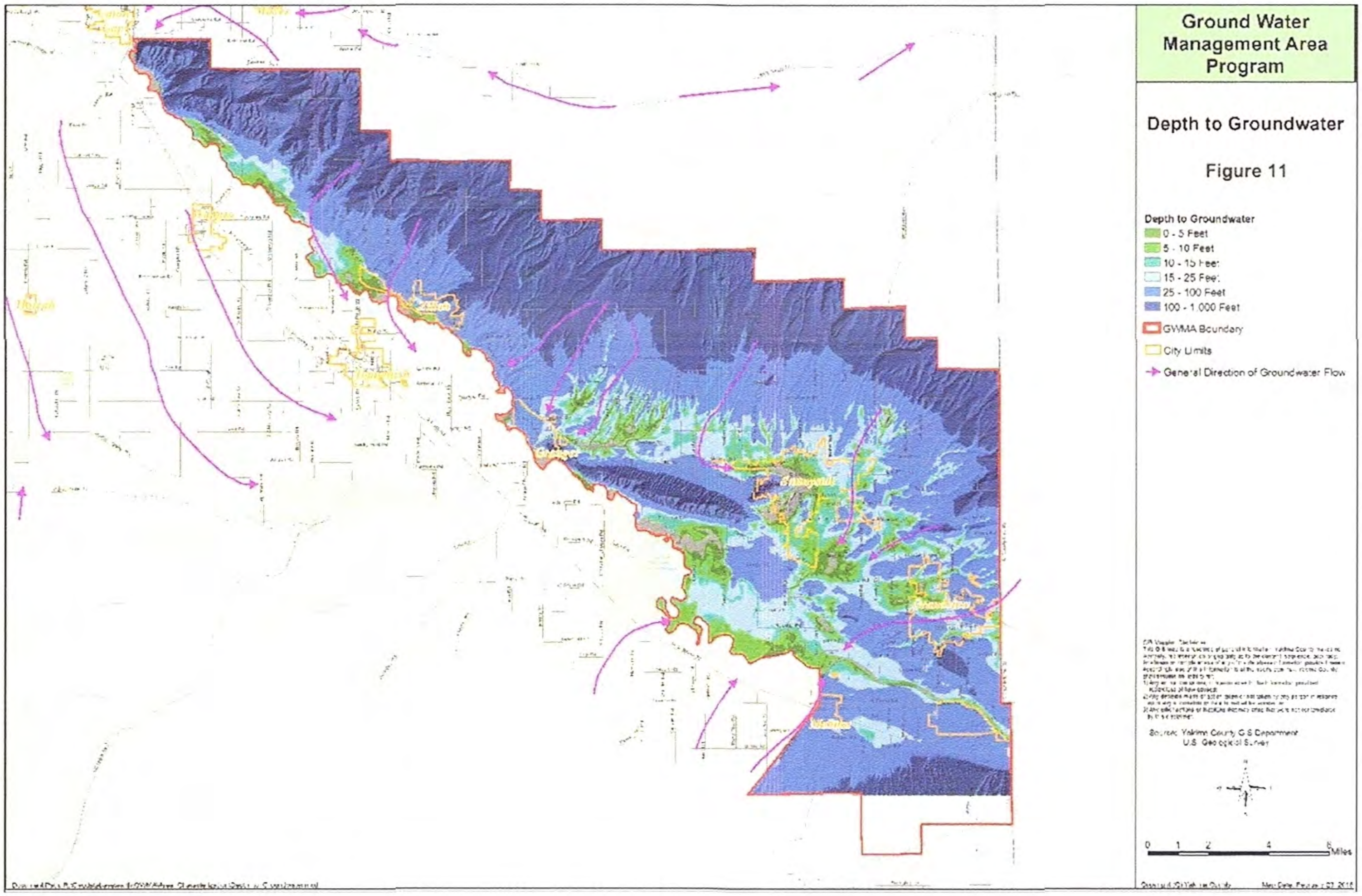


Figure 12 – Groundwater Flow Directions

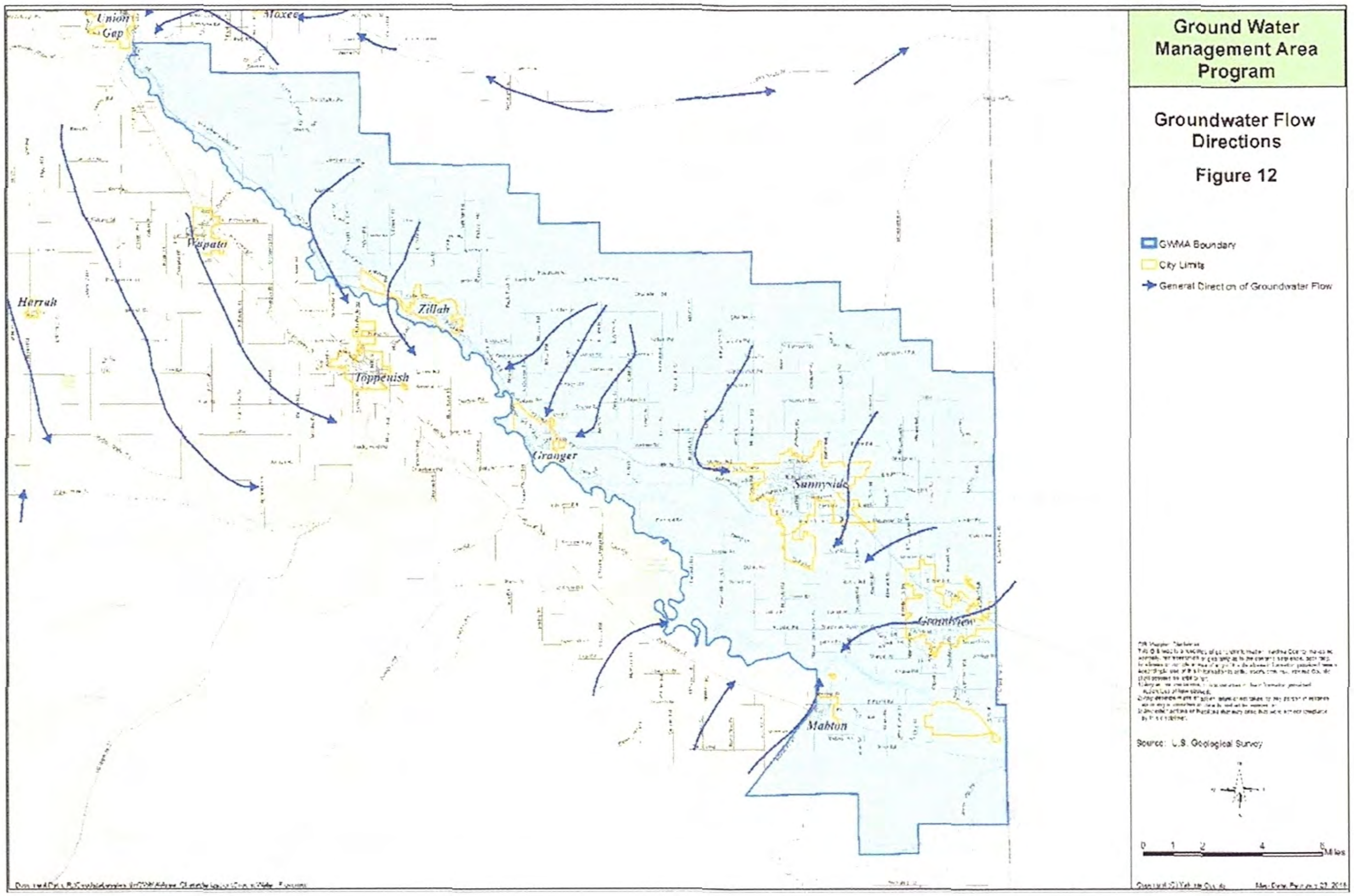


Figure 13 Soils Key

Figure 13 – Soil Types

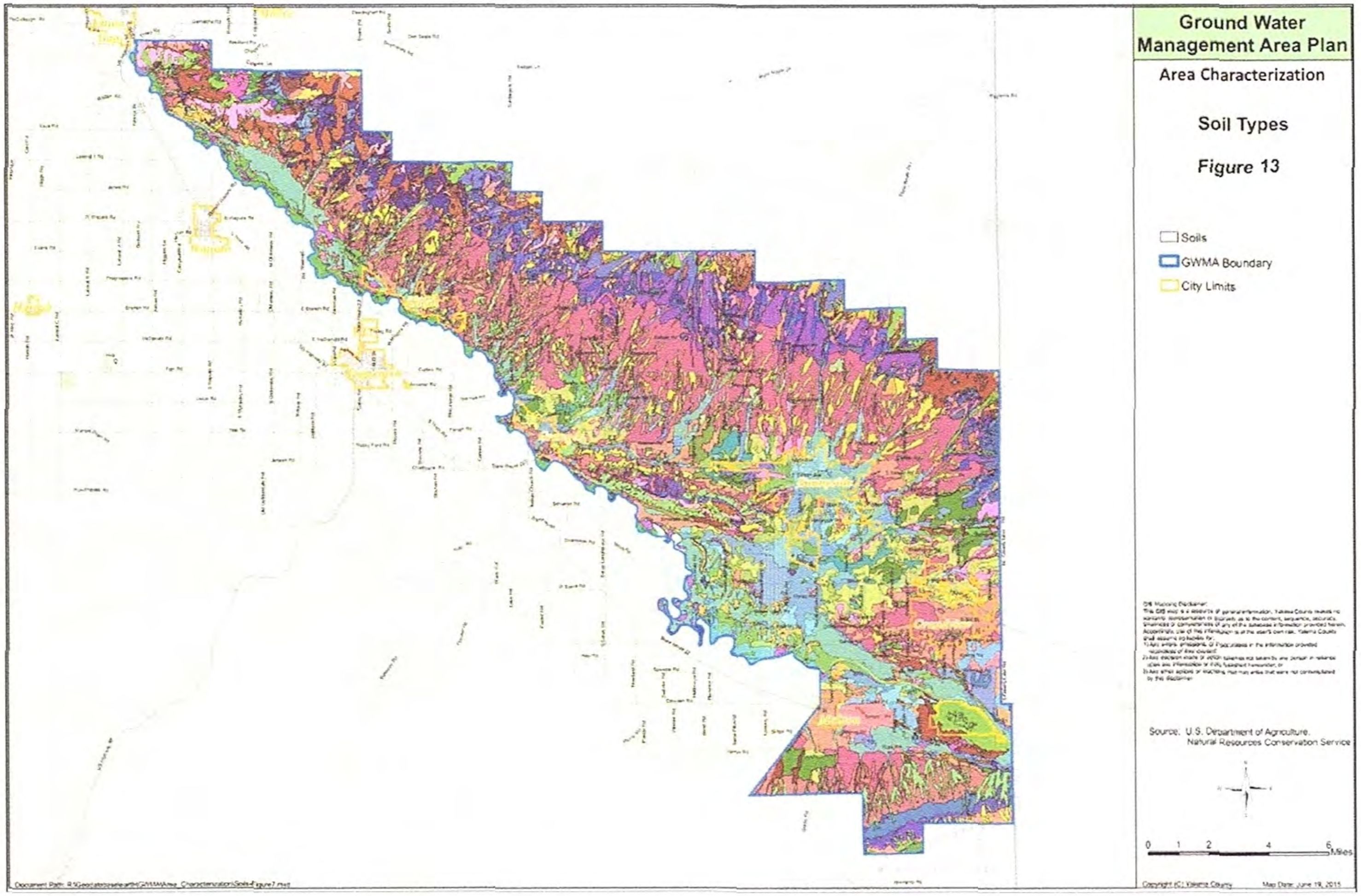


Figure 14 – Hydraulic Conductivity

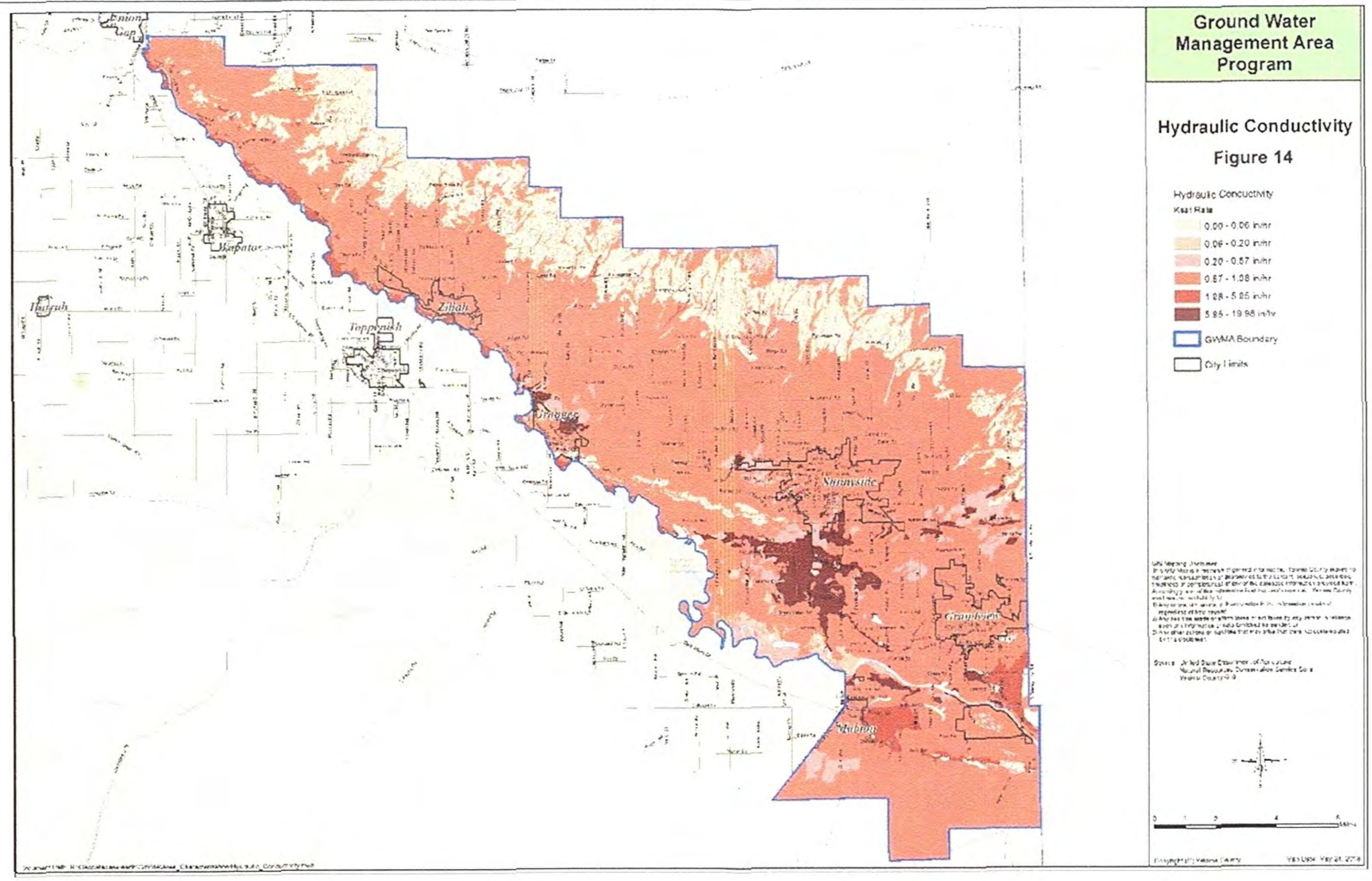


Figure 15 – Cropping Patterns

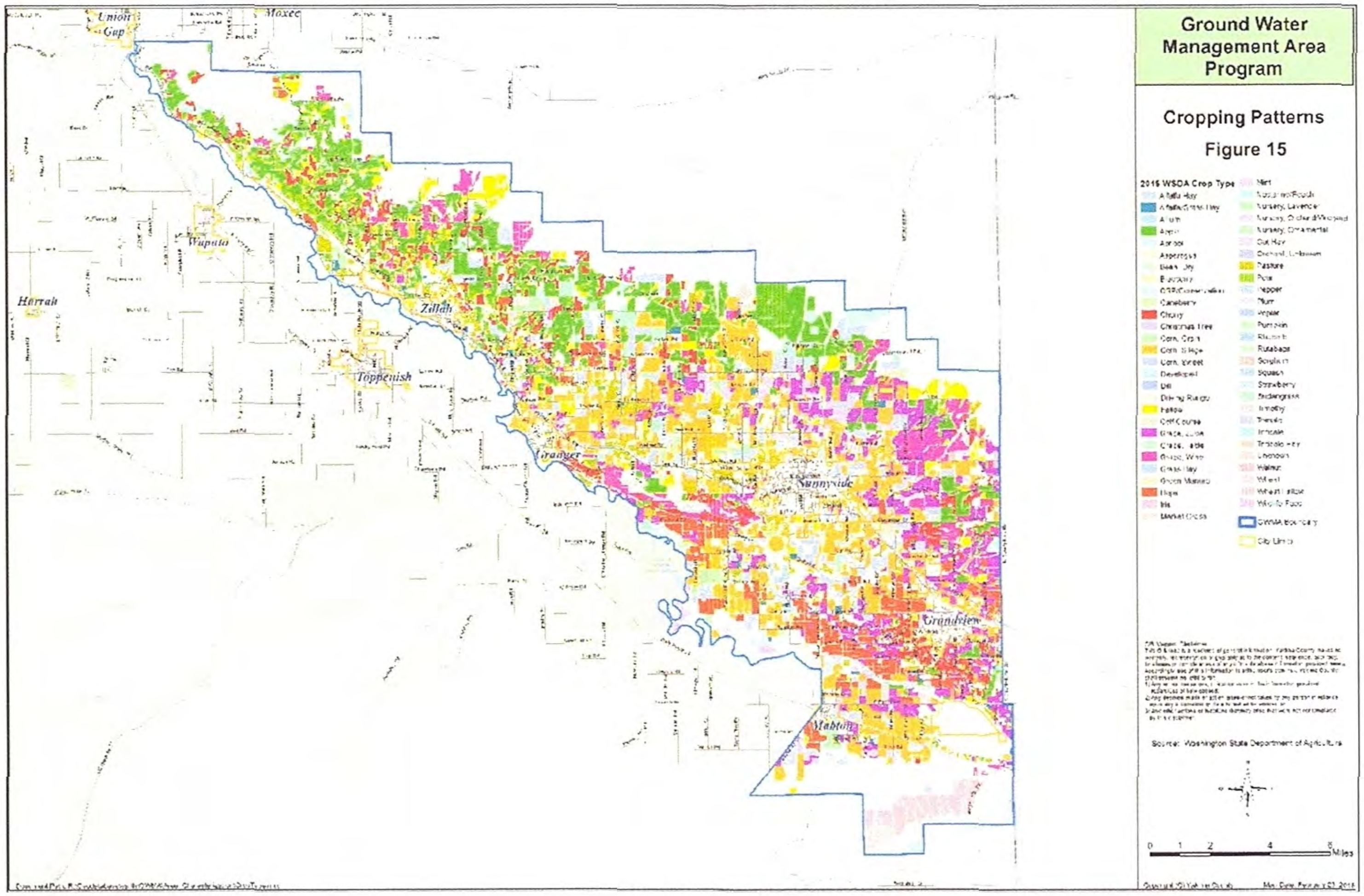


Figure 16 – Yakima County Zoning

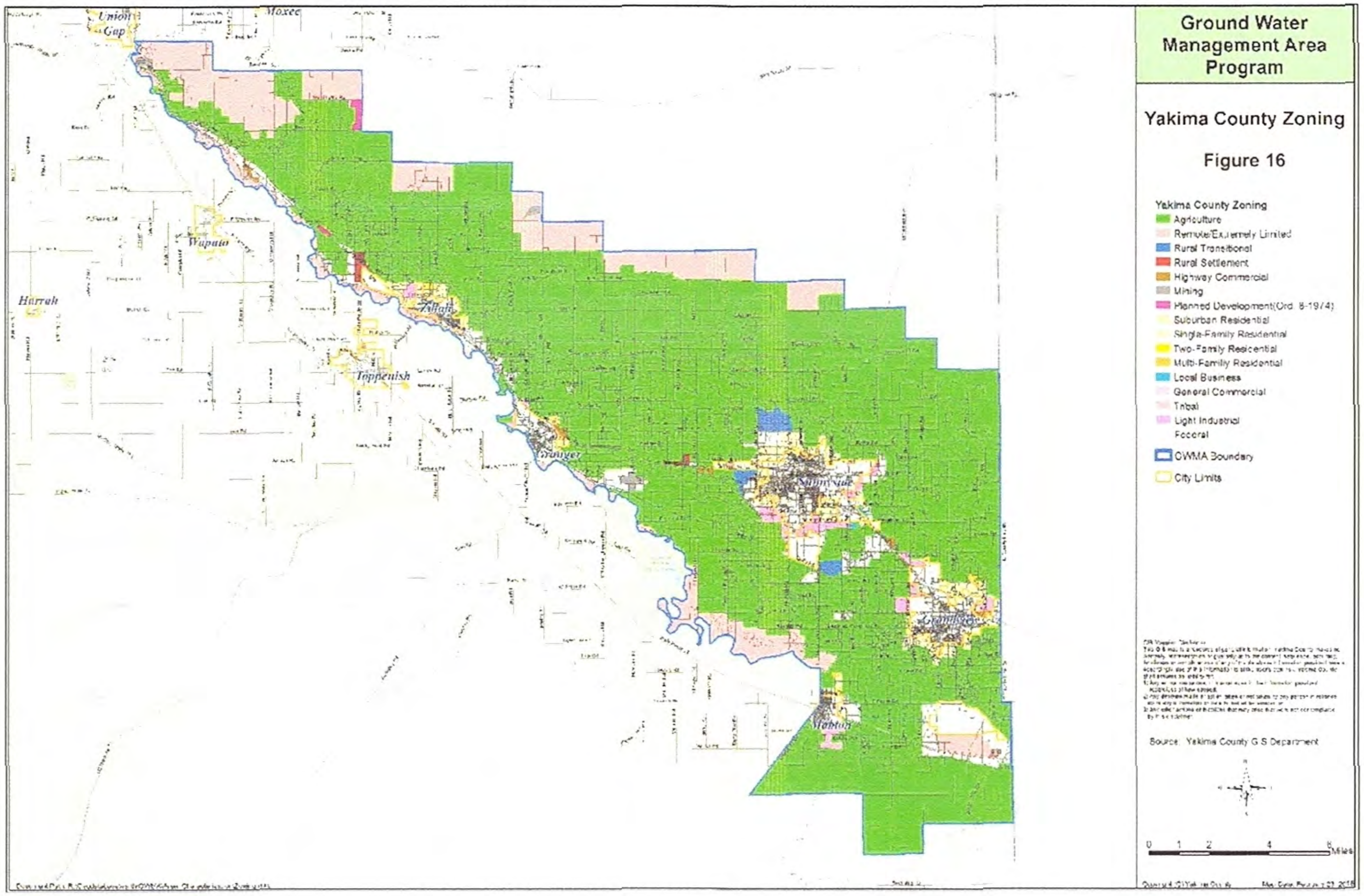


Figure 17 - Irrigation

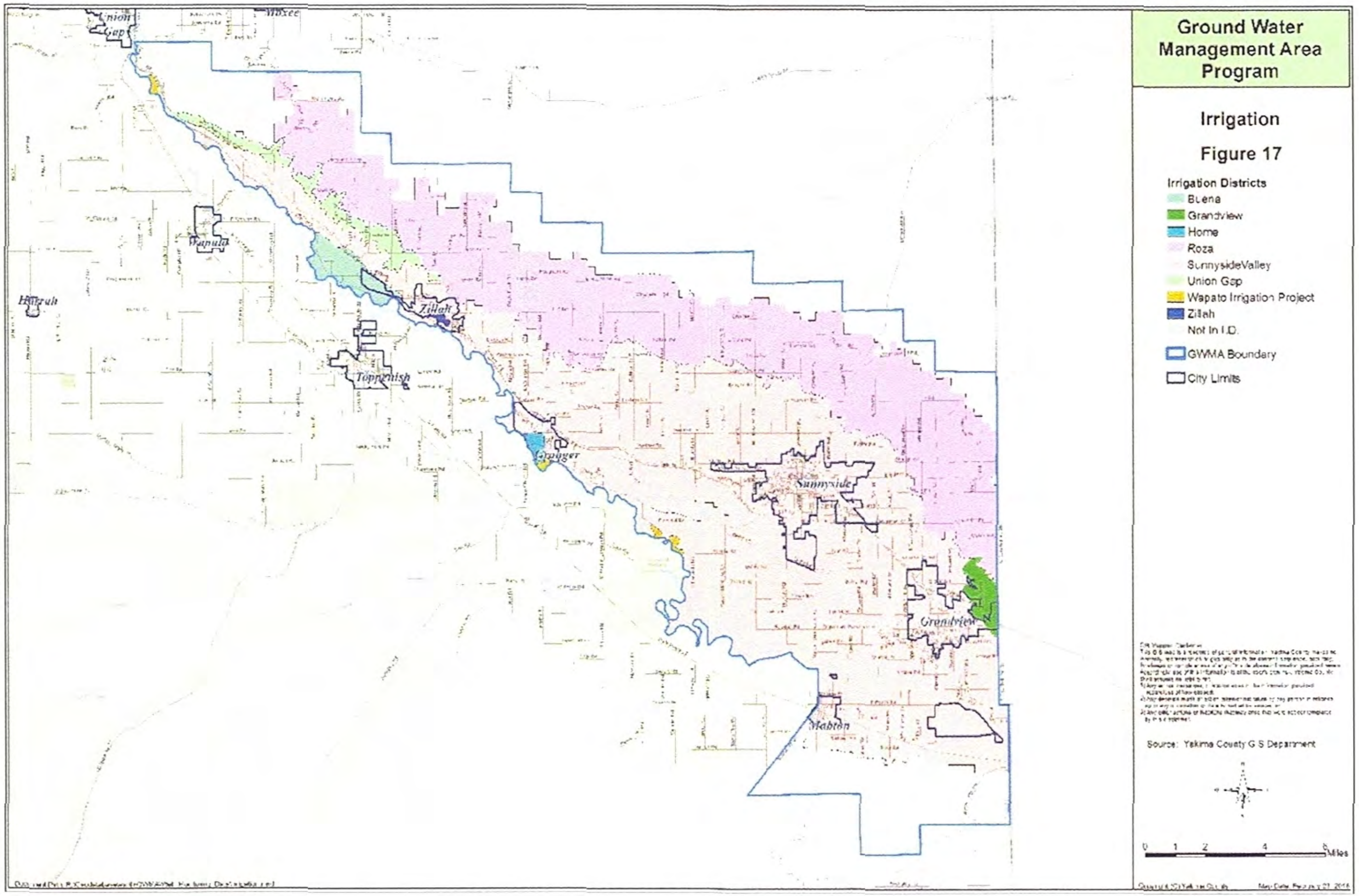


Figure 25 – Total Nitrogen Availability

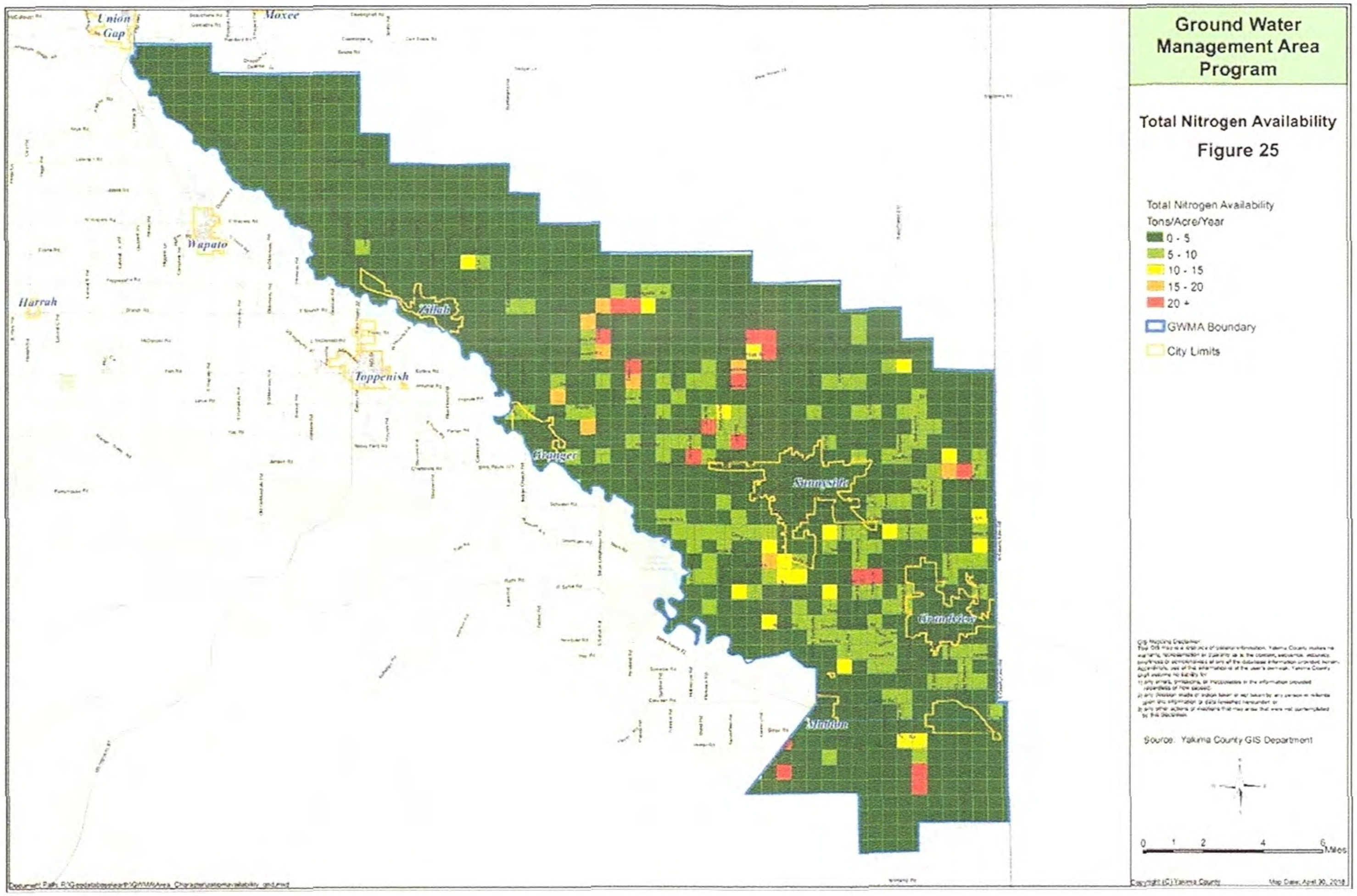


Figure 26 – Overlay of Total Nitrogen Availability and Groundwater Wells

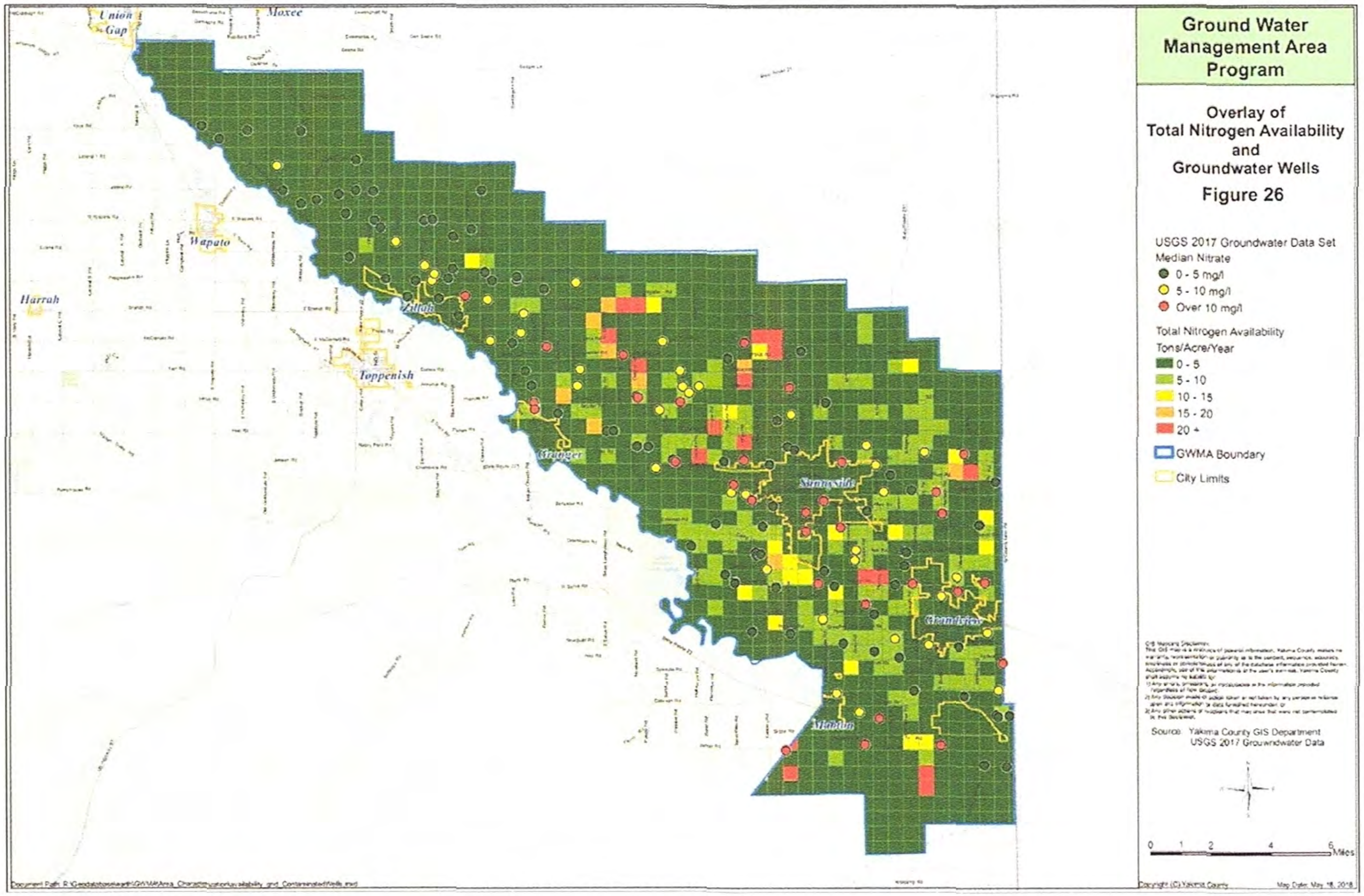


Figure 27 – Overlay of Soil Types and Groundwater Wells

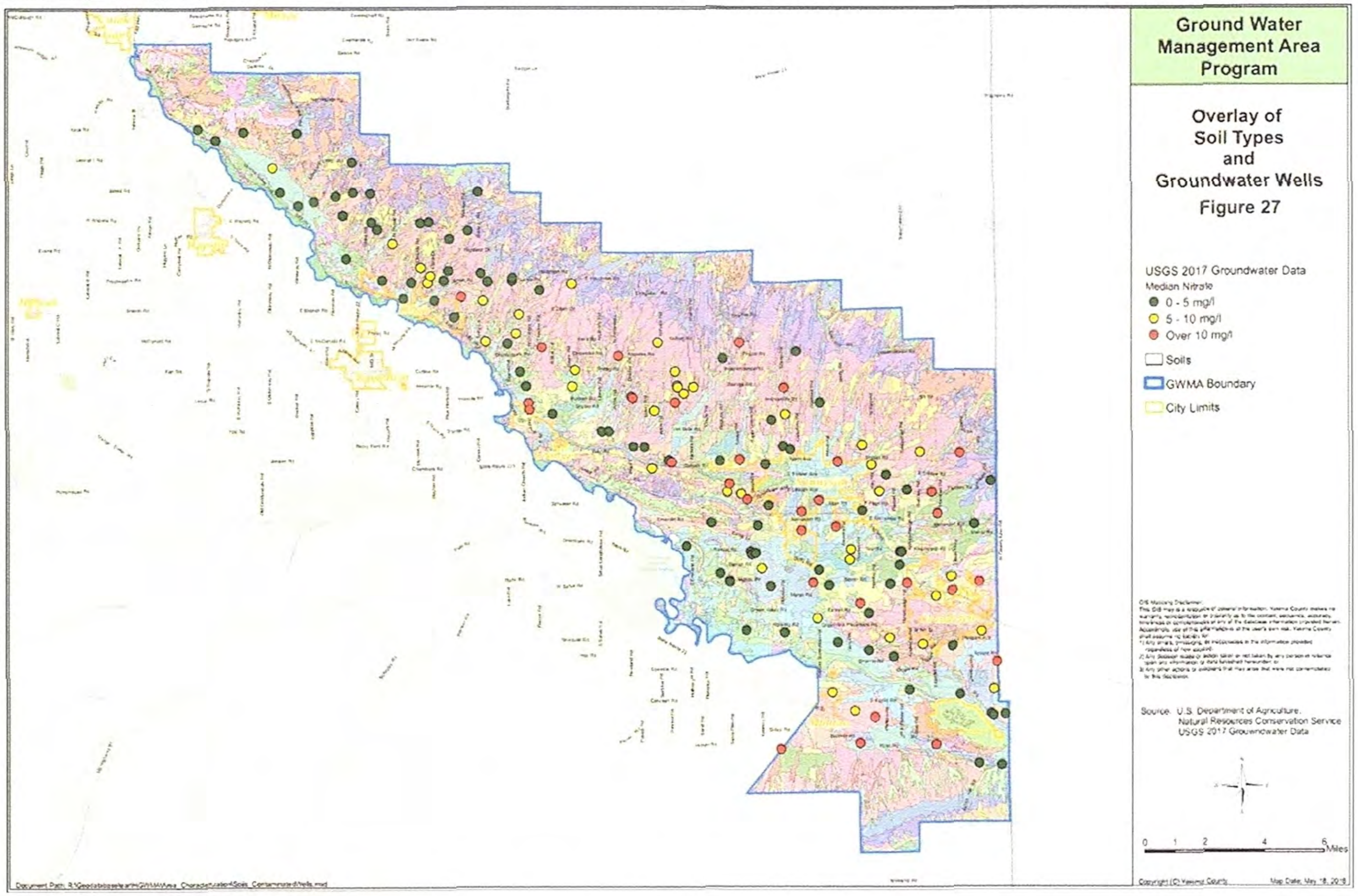


Figure 28 – Overlay of Hydraulic Conductivity and Groundwater Wells

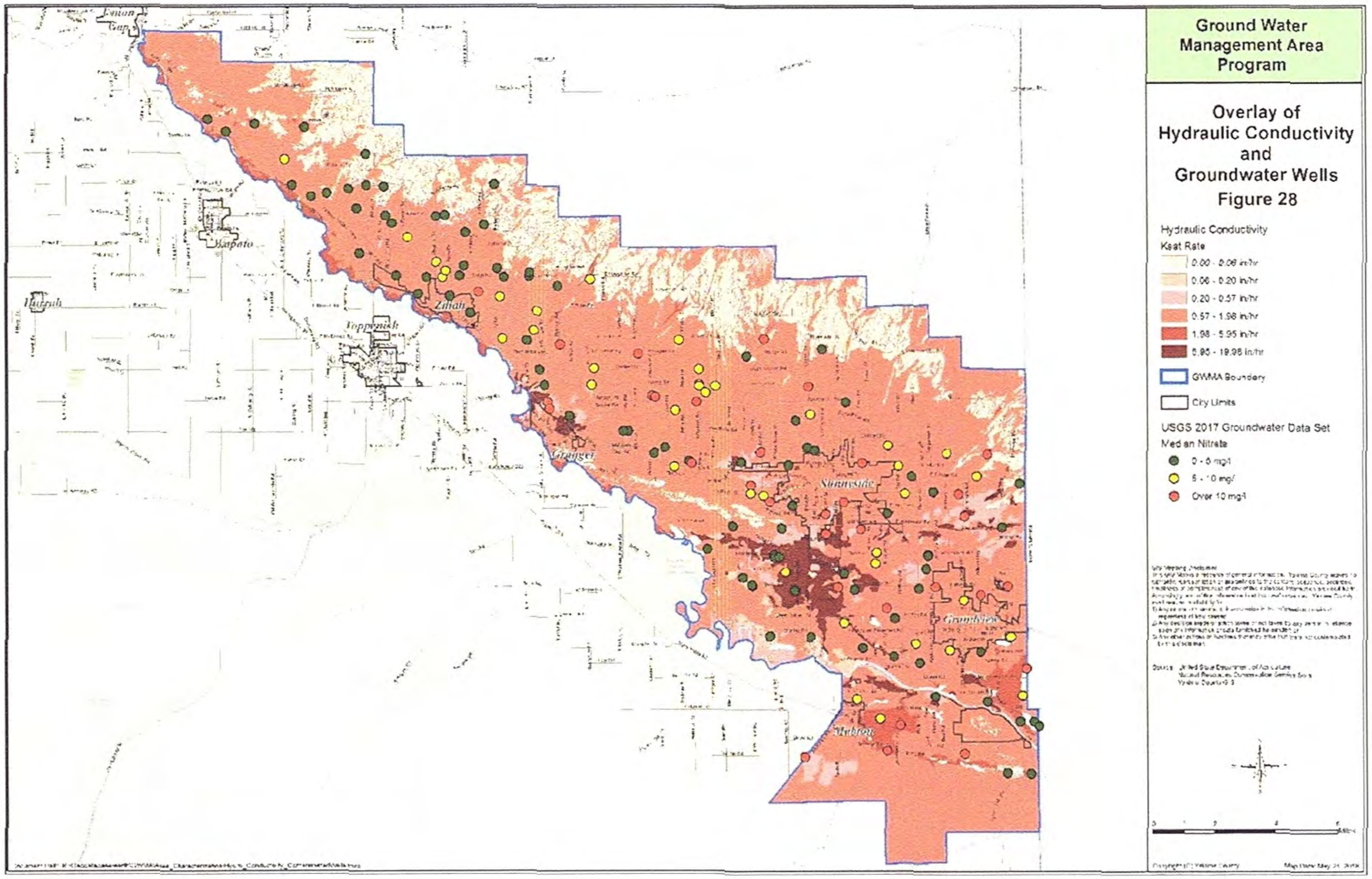


Figure 29 – Overlay of Canals and Drains with Groundwater Wells

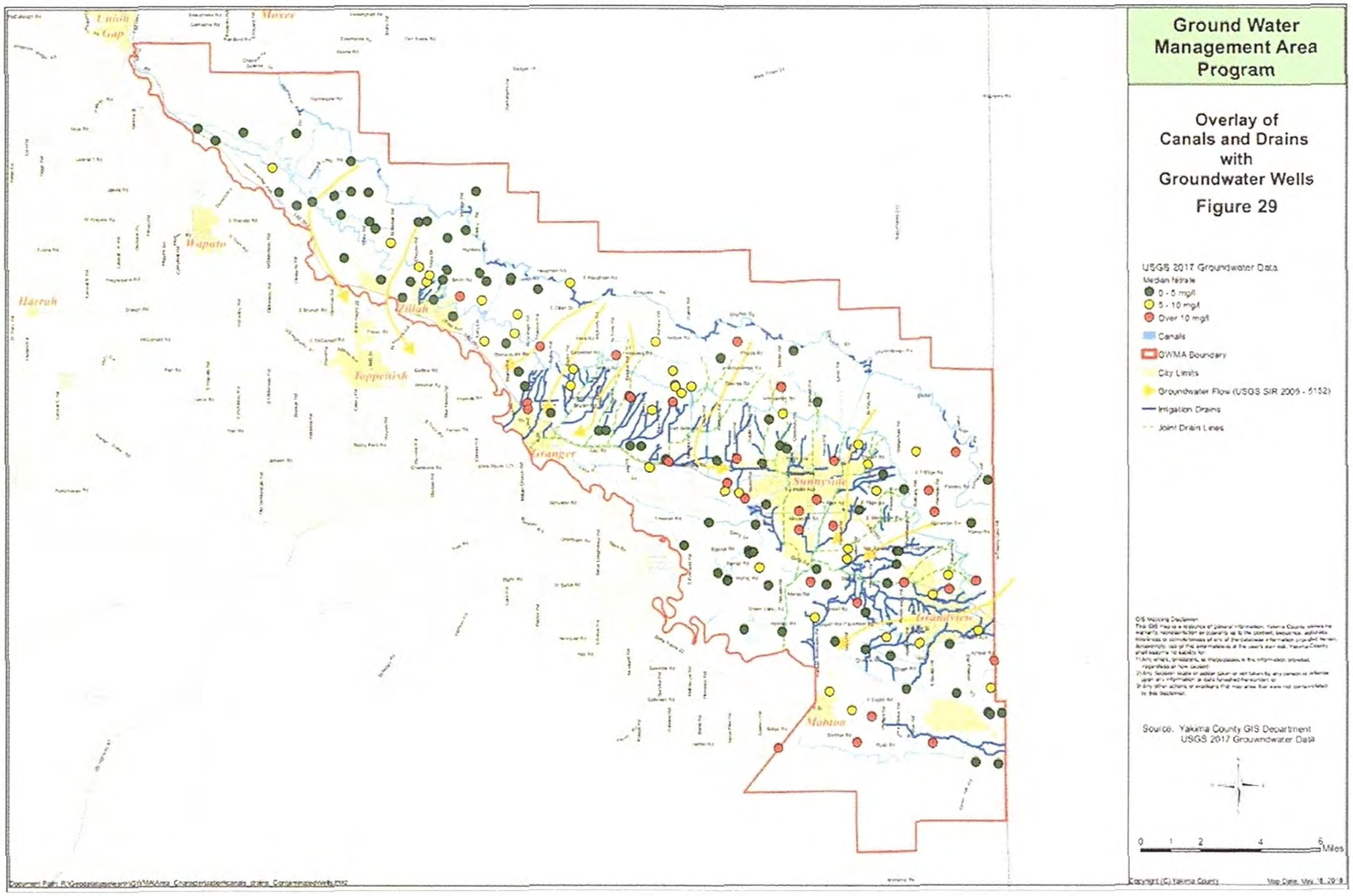


Figure 30 – Overlay of Cropping Patterns and Groundwater Wells

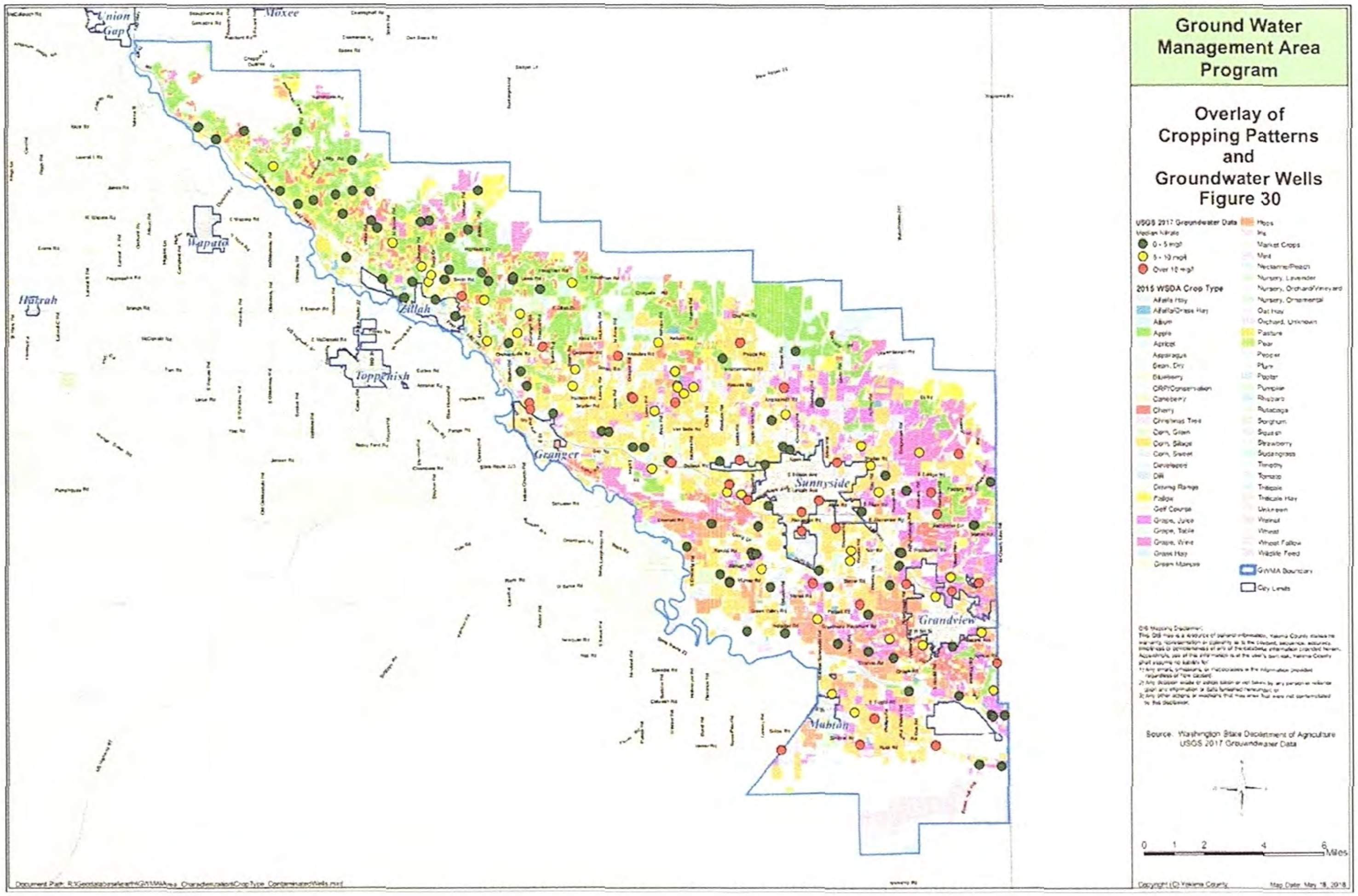


Figure 31 – Overlay of Point Sources and Groundwater Wells

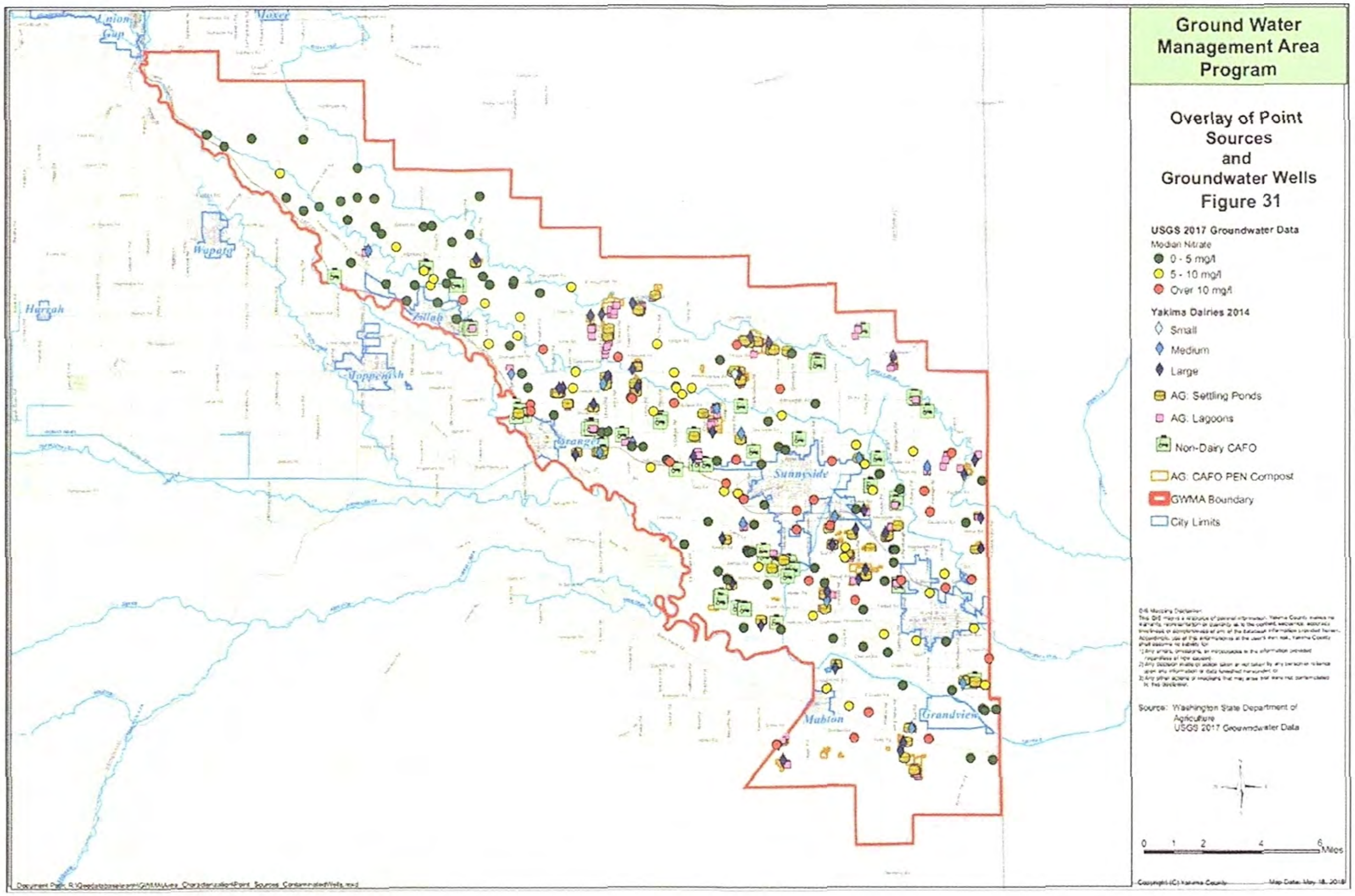
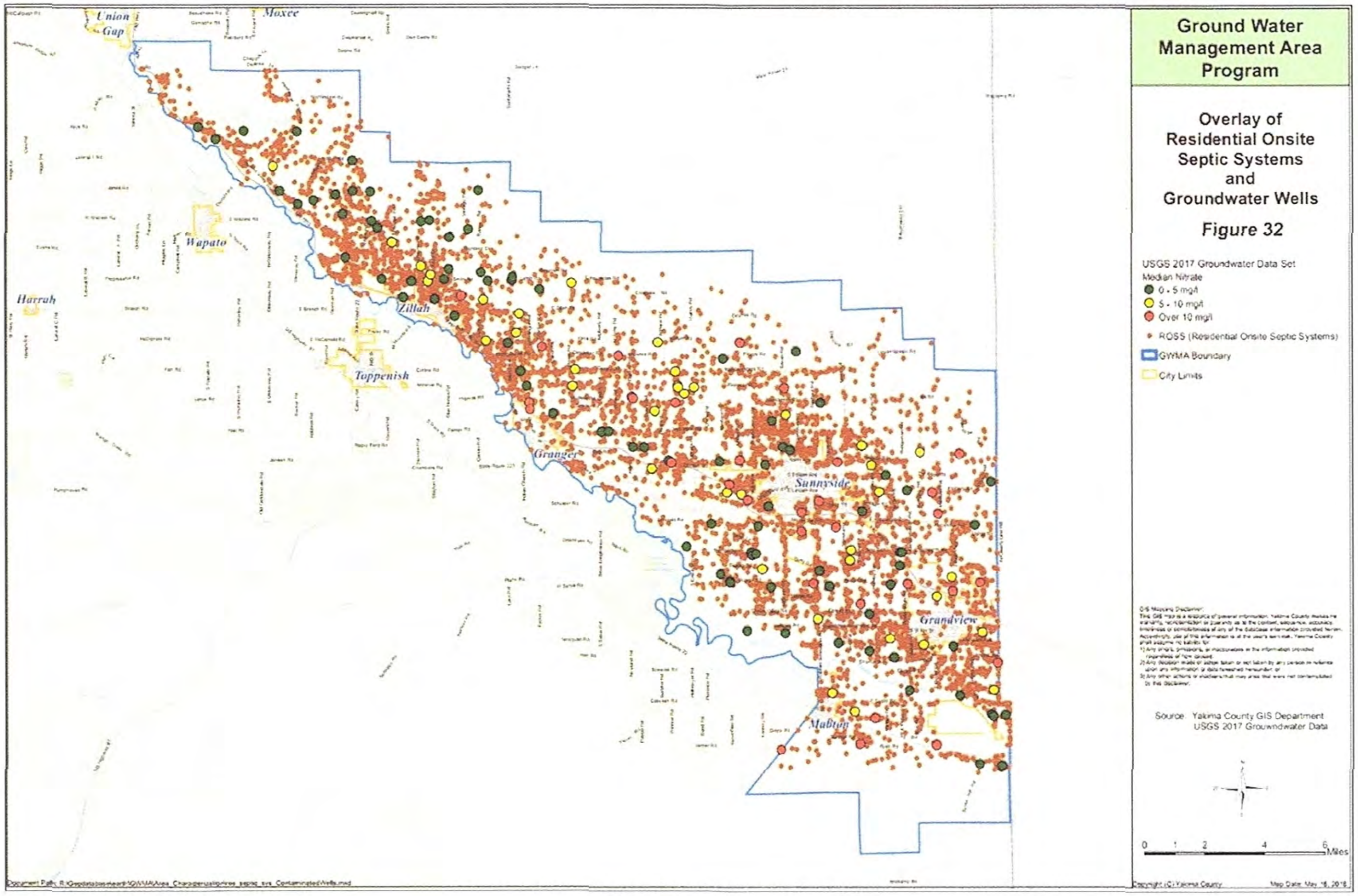


Figure 32 – Overlay of Residential Onsite Septic Systems and Groundwater Wells



Attachment D

- USGS Amendment 2018

RECEIVED

APR 19 2018

Yakima County
PW Accounting

60000005745/17WNWA30054/FY18Amend.1

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
AMENDMENT OF JOINT FUNDING AGREEMENT
FOR
WATER RESOURCES INVESTIGATIONS

This amendment is for the agreement dated February 16, 2017

Paragraphs 2a and 2b of the agreement are hereby modified to read as follows:

(a) $0 by the party of the first part during the period February 16, 2017 to September 30, 2018.

(b) $491,320 by the party of the second part during the period February 16, 2017 to September 30, 2018.

The Joint Funding Agreement (JFA) between the USGS and the County of Yakima to collect suffcient nitrate concentration data from the Lower Yakima Valley Groundwater Management area is hereby amended to extend the end date to September 30, 2018.

Total funding for this work is unchanged and remains $491,320

All remaining terms and conditions as reflected in the original JFA are unchanged.

UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY	County of Yakima 128 N. 2nd St, 4th floor Yakima, WA 98901
Acting (Signature)	(Signature)
Cynthia Barton, Ph.D., L.G., LHG (Name)	Vern Redifer (Name)
Center Director (Title)	Manager (Title)
Date 4/3/2018	Date 4/10/2018