



# Groundwater Management Area (GWMA)

## **Comprehensive Nitrogen Loading Assessment for the Lower Yakima Valley Groundwater Management Area – Scope of Work and Budget**

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Version 1.2a

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# **Comprehensive Nitrogen Loading Assessment for the Lower Yakima Valley Groundwater Management Area – Scope of Work**

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## **Project Management**

### **WSDA Lead:**

**Kirk V. Cook, LG, LHG**

Mr, Cook has over 35 years of experience with the US Geological Survey, the Washington State Departments of Health and Ecology, and current oversees the Washington Department of Agriculture's Natural Resource Assessment Section comprised of 10 research staff with expertise in environmental toxicology, pesticide use, hydrogeology, water resource management, GIS application science, environmental engineering, water quality and water resource modeling, endangered species protection, and agricultural science. Combined experience and education of section staff exceeds 80 years.

## 1.0 Purpose

The goal of the Lower Yakima Groundwater Management Area is to reduce nitrate contaminations in groundwater below state drinking water standards. Within the boundaries of the Lower Yakima Groundwater Management Area exists areas where the state drinking water standard for nitrate (10mg/L) has been exceeded for years. This area has supported a variety of agricultural practices for over 100 years. Many of these practices have required the use of nitrogen fertilizers and nutrients (both organic and inorganic) or where nutrient rich effluent has been allowed to enter the soil column via permitted or otherwise sanctioned activities. These applications are suspected to have contributed to the elevated levels of nitrate in groundwater currently used as drinking water supplies. In order to determine to what extent the application of nitrogen has contributed to the elevated nitrate levels in groundwater, it is necessary to evaluate current land use management practices suspected of contributing to groundwater loading of organic and inorganic nitrogen. This is necessary to determine the activities contributing and to what degree that contribution may be impacting groundwater quality.

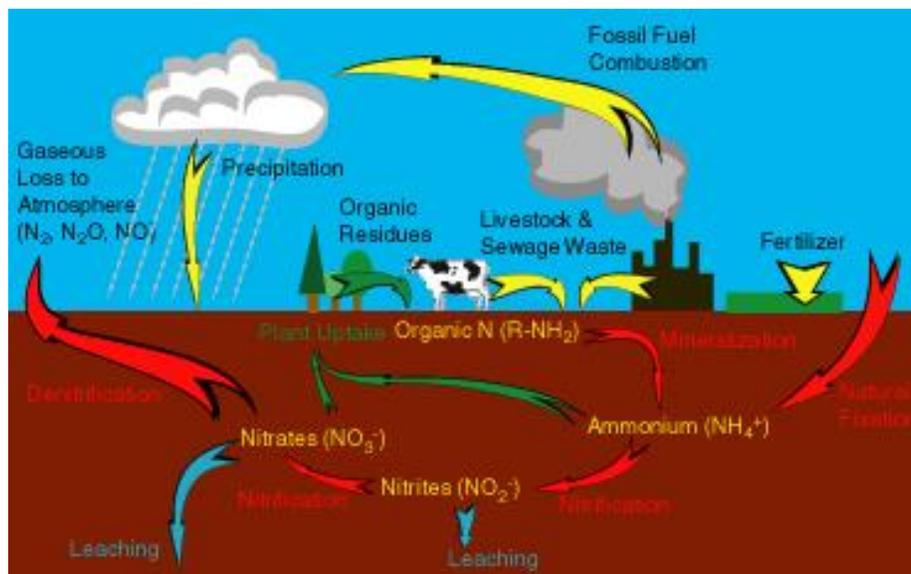


Figure One: Factors to be considered during the assessment of nitrogen loading and relationship to groundwater quality

The Nitrogen Loading Assessment is a mass-balance model. These models are the simplest models employed by researchers. These models have value in that they are able to predict mass flux in a generalized sense and do assist in estimating loading rates from various land uses and estimating input rates and concentrations for transport modeling. The limitation on these types of models is that they cannot be used to predict solute concentration at any single point in time or space. The Nitrogen Loading

Assessment will provide the information necessary to evaluate the nitrate contribution from various sectors within the boundaries of the GWMA and will provide information loading estimates to crop management / livestock management, and activities associated with residential, commercial, industrial and municipal activities. These estimates are necessary to evaluate the spatial loading of vulnerable groundwater within the Groundwater Management Area boundaries (which can result in elevated nitrate levels in drinking water), the effectiveness of current management practices in limiting that loading, and if necessary, provide a basis for implementation of new or expanded practices that may be required to achieve the goals of the GWMA.

Establishing a relationship between nitrogen loading to land surface and underlying water quality requires an understanding of, the factors influencing the degree to which that nitrogen is used by crops, lost to the atmosphere, or modified as it passes through the soil column. This assessment will utilize a combination of peer reviewed scientifically derived estimates applicable to the Yakima Valley in combination with specific land use management data collected through the Deep Soil Sampling project and supplemented by targeted data collection activities conducted by WSDA, Yakima County, the Washington Departments of Ecology and Health.

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## 2.0 Overall Concept

The Nitrogen Loading Assessment is a cooperative project between Yakima County and The WA Department of Agriculture. The goal of the Assessment will be to develop a mass balance for nitrogen usage within the GWMA. In achieving this goal, assessments of specific activities conducting both permitted and non-permitted nitrogen application will be developed and will provide data on which to base both land use recommendations within the Groundwater Management Area Plan and educational materials for use by residents within the GWMA. The results will provide focus on those modifications in land management or facility operations that have the greatest potential to reduce or eliminate excess nitrogen loading to the land surface which ultimately result in excessive nitrate leaching to underground sources of drinking water.

The assessment, in addition to accessing the degree to which current land management activities may be impacting groundwater quality, will provide data (in conjunction with the Deep Soil Sampling Project) regarding the extent to which current groundwater quality is being impacted by historic nitrogen management techniques.

The assessment of nitrogen loading and loss will be divided into two sub-activities. One for irrigated and livestock agriculture, the other for residential, commercial, industrial municipal activities. WSDA will have primary responsibility for the assessment of irrigated and livestock activities, Yakima County will focus on assessment of residential, commercial, industrial, and municipal activities. These two areas of interest will be addressed in the application of the following overriding equation:

$$NLGW = RL + BL + IACF + IAOF + CAFOPP + AL$$

Where

- NLGW = nitrogen load to groundwater, which assumes that all nitrogen present below the root zone will become nitrate and either be denitrified or leach to groundwater.
- RL = nitrogen loading to groundwater from residential sources including septic tanks, lawn fertilization, and onsite septic systems
- BL = nitrogen loading to groundwater from sites with municipal biosolids, and municipal and industrial wastewater (under State Waste Discharge Permits, or NPDES permits)
- IACF = nitrogen loading to groundwater from irrigated agriculture land use where chemical fertilizers are applied and further discussed below

- IAOF = nitrogen loading to groundwater from irrigated agriculture land use where organic fertilizers (e.g., manure) are applied
- CAFOPP = nitrogen loading to groundwater from livestock pond and pen sources this will include such activities as lagoon operations, composting activities, feeding and milking areas
- AL = nitrogen loading to groundwater from atmospheric deposition. Local values from national atmospheric monitoring data sets will be used and applied evenly across the GWMA.

*Note: Where appropriate denitrification will be factored into the overall sector contribution for the equation above. As specified in Sections 4 thru 6 below, denitrification will (when appropriate) will be applied to the original nitrate load as calculated or estimated in the respective source category.*

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### 3.0 Development of Comprehensive Nitrogen Source Database

In order to adequately evaluate the effects of nitrogen application for the majority of land uses within the GWMA boundaries, it will be necessary to develop a database or GIS linkage capable of housing application and management data from a wide variety of source specific information collected using differing methodologies. Some database fields will be similar for all sources, whereas other data fields will be source-specific, and it will be designed so that it will be expandable and able to include additional fields. Data collected for the major sectors identified by the GWAC will be clearly identifiable within the data so that analysis can be conducted on a sector by sector basis if desired. Most data fields will be identified during the initial creation of the database or GIS linkage, though some will likely be added as management practices change or updated information becomes available. WSDA and Yakima County have taken steps toward the development of a GIS linkage structure. This structure will be submitted for review to the County, and the Data, RCIM, IA, and Livestock/CAFO working groups prior to entering source data into it. This review will apply to the final draft report and will exclude any trial or developmental runs of the database). The database will include numeric fields to support calculations, as well as fields necessary for display within the GIS environment. Three main tasks are associated with this activity; data evaluation prior to database development in order to develop necessary fields and evaluate the utility of a single database or two separate databases linked to operate as one, development of database structure, and database population.

Task 3.1 Evaluate current and planned data sources to determine necessary database fields<sup>1</sup>

*Estimated Budget* 100 hours @ 26.00/hr \$ 2600.00

Task 3.2 Develop comprehensive database for all nitrogen sources covered by RCIM, Irrigated Agriculture, and Livestock Agriculture. Database will be developed using Access from which a geodatabase will be created for use within the ESRI environment.

*Estimated Budget* 100 hours @ 35.00/hr \$ 3500.00

Task 3.3 Population of database with data collected as a result of grower surveys, estimates for various land uses associated with residential, commercial, industrial, and municipal sources, and data collected from on-site livestock operations.

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<sup>1</sup> Data quality will be guided by a developed QA/QC plan, some of which currently exists within documents produced by PGG for environmental data collection.

*Estimated Budget 80 hours @ 26.00/hr* \$ 2080.00

***Total Budget for Task 3.0*** **\$ 8180.00**

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## **4.0 Residential, Commercial, Industrial, and Municipal Assessment**

Yakima County will be the lead for assessing the overall nitrogen loading that occurs as a result of activities associated with RCIM activities. This will include assessment of septic systems, state waste discharge permits (Ecology), underground injection well contribution, and hobby farm activities. WSDA will provide technical assistance to Yakima County regarding application of various methodologies applied to the parcels to estimate N loading. WSDA will also assist the County by facilitating the involvement of technical experts currently working for cooperating state and federal agencies, or consultants.

### *Residential and Municipal Septic Systems and other Residential Sources*

Parcel data from Yakima County will be used by the County to identify parcels where residential septic systems are present. Septic loads from each parcel will be calculated assuming an average sized household in Yakima County (based on census data), consultation with Yakima County, WA Department of Ecology and the Washington State Department of Health. In estimating daily septage volumes and nitrogen loads per person, WSDA will utilize a septic system leaching model developed by the Environmental Assessment Program at the Department of Ecology. Model developers will assist WSDA in its application. These data sources and assessment methodology will be referenced in the final report. Prior to employing these sources/references, project leader(s) will consult the Monitoring and Data Work Group for review and comment.

If a large on-site septic system (LOSS) is designed to enhance denitrification and that design is identifiable in WDOH or Ecology records, the enhanced denitrification rate will be considered.

In addition to septic loads, other residential nitrogen sources such as fertilization of lawns and gardens will be examined. Information on fertilization practices and the percent of homeowners who actively fertilize will be pursued and the data most representative of LYV (given geography, environment, and socio-economic factors) will be used for this project. If local data are unavailable, regionally recommended fertilization practices and data will be reviewed to estimate nitrogen loading due to lawn fertilization. These data currently exist in peer reviewed documents published by the University of California-Davis, and other research institutions. Existing data sources (GIS coverage's, aerial photographs, and previous reports) will be reviewed to assess the most feasible way to quantify local lawn areas. City parks and golf courses with their associated fertilization rates will be included in this analysis.



nor will there be an attempt to identify UIC not currently noted in Ecology's UIC database.

*Estimated Budget 60 hours @ 30.00/hr \$ 1800.00*

Task 4.4 Develop N loading estimates from hobby farm operations. This task will require coordination with WSDA and CD's within the GWMA. Typical N loading for pasture parcels will be developed by WSDA and CD's and applied to existing parcel database. Loading estimates due to application for lawn and garden uses will be captured in this Task.

*Estimated Budget 60 hours @ 30.00/hr \$ 1800.00*

Task 4.5 Assemble data analysis for RCIM elements and produce estimated N loading in both database and GIS formats.

*Estimated Budget 60 hours @ 30.00/hr \$ 1800.00*

***Total Budget for Task 4.0 \$ 9000.00***

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## 5.0 Irrigated Agriculture Source Quantification

Data for the irrigated agriculture nitrogen loading assessment will be collected using three different methods:

- 1) County specific crop use, irrigation method, and fertilizer databases
- 2) Information gathered from a voluntary grower questionnaire that will report site-specific information regarding nitrogen application and removal over several growing cycles and
- 3) Information collected through a series of group interviews/surveys with local crop consultants and agronomists.

Because collection of the deep soil survey data set may take up to two years as part of the GWMA's Deep Soil Sampling program, WSDA has developed a GIS layer based on recommended fertilizer application from published crop-specific growing manuals. This will be used as an initial baseline and modified as additional information collected from grower surveys (from DSS project) and group interviews becomes available<sup>2</sup>. As the representative set of grower surveys increase in numbers they will be compiled and calculations will be updated using that additional site specific data.

Nitrogen application and removal rates will be evaluated to estimate nitrogen excess or deficiency for groups of crop, soil, fertilization, irrigation, and removal combinations. This evaluation will be conducted by a group of qualified agronomists selected by WSDA for their expertise in nitrogen behavior and local expertise. Fields contained within the operational boundaries of livestock operations and upon which manure is applied will be evaluated using the same process as outlined below for irrigated agriculture fields using manure, chemical fertilizer, or combination of chemical fertilizer and manure. Excess nitrogen determined through the evaluation will be assumed to be available for leaching to groundwater. The 2013 WSDA field-specific crop distribution map will then be used as a platform to allocate nitrogen loading across the GWMA based on crop acreage and growing areas. This process will identify a long-term nitrogen balance consistent with current (and recent historical) practices which is not dependent on irrigation or weather (these factors mostly affect timing of nitrate percolation which is not addressed in this analysis).

### *Use of Grower Survey Data*

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<sup>2</sup> WSDA has developed a contingency explained in Section 9 that can be used to supplement data collection in the event that the number of grower surveys completed are insufficient to provide a statically valid population on which to conduct the analysis.

WSDA will use data collected from voluntary grower surveys that will provide detailed information regarding nitrogen application and loss over several growing cycles. WSDA will conduct an assessment as to the statistical validity of the surveys as compared to the total number of crop specific parcels. Coordination with the National Agricultural Statistics Service (NASS) will be sought to determine at which level statistical validity will occur, This will be completed prior to assessment of the N loading for irrigated crop lands.

Survey data from a representative sample of the major crops grown in the GWMA boundaries will be analyzed and a typical application/loss determination made for each major crop or livestock activity. Using the 2013 WSDA crop distribution map those typical results would be allocated across the GWMA based on acreage for each crop and/or activity and determination made as to excess or deficient of nitrogen available for leaching to groundwater across the GWMA or in smaller sub-areas as deemed necessary. Based on these results targeted Best Management Practices and educational products can be selected or developed to address those areas, crops, or activities that are determined to contribute to nitrate loading to shallow groundwater.

WSDA, is aware that a sufficient number of surveys may not be received to allow for extrapolation of typical use of nitrogen for each major crop within the boundaries of the GWMA. To address this potential “issue”, WSDA will conduct a series of group interviews for growers, consultants, and agronomists to collect data regarding nitrogen timing, application amount, irrigation, etc. This process will mimic that used in the collection of pesticide use data that WSDA has implemented since 2002 with good results. This data combined with that received from grower surveys should provide for an adequate population to conduct the necessary analysis. Depending upon the number of these “meetings” that are considered necessary; the budget estimate may vary by \$1000.00 to \$2,000.00 this activity.

#### *General*

The following equation will be used to estimate nitrate loading to groundwater from irrigated agricultural fields:

***Nitrogen load to ground water = (Nitrogen input - Nitrogen removed by cropping)\*(1- denitrification fraction)***

For crops that fix nitrogen (legumes such as alfalfa and peas), either a fixation term will be included in the nitrogen input term or a calculation using a leached concentration and recharge volume will be used to calculate loading (as performed in other studies), depending on data availability.

Use of the above equation requires the following assumptions and limitations:



## 6.0 Livestock Sources Quantification

Evaluation of N loading from livestock sources will be confined to those areas under the jurisdiction of WSDA (Dairy) or under permit by Ecology as a Confined Animal Feeding Operation<sup>3</sup>. Movement of manure off these designated facilities on to cropland will be captured under the assessment for irrigated agriculture. Nitrogen sources from livestock are divided into two categories, and will focus on dairy and CAFO operational lands:

- Lagoons, feeding and milking pens on unpaved surfaces, composting facilities, manure storage areas, liquid (stormwater) storage areas
- Other possible sources (ditches and pipelines between lagoons and solids separators, and silage leachate)

*Agricultural areas where manure is spread to grow a crop will be covered under the irrigated agriculture chapter*

Existing data from WSDA and Ecology will be evaluated and may include number of animals per facility, lagoon size, manure storage system, and animal yard size. Required data for this analysis is the current number of head per facility.

Additional data that will be obtained through a literature review or data collection include:

- Manure produced per dairy cow and per beef cow and manure nitrogen content
- A range of lagoon seepage and nitrogen leaching rates
- Ammonia volatilization rates from stored and applied manure
- Typical nitrogen loads generated in unpaved animal yards
- Typical manure management practices for animal yards
- Amount of solids/compost or other nitrogen-containing material that is exported from the GWMA

One meeting is planned with the Livestock/CAFO working group to review and receive feedback regarding “typical” management practices and implemented BMPs within the LYV. Potential nitrogen sources and sinks on local CAFOs will also be discussed as an exercise to identify potentially overlooked nitrogen sources or sinks.

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<sup>3</sup> Data collected as a result of US EPA’s consent order with four dairies will be considered as appropriate and where QA/QC requirements meet federal data collection protocols



*Estimated Budget* 35 hours @ 45.00/hr \$ 1575.00

***Total Estimated Budget Task 6.0*** **\$ 6405.00**

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## **7.0 Comparison of Nitrogen Loading Assessment to Other Related Estimates**

Quality Assurance/Quality Control evaluations are proposed to check assumptions and parameters used in the Nitrogen Loading Assessment. These activities include:

- Compare livestock mass balance results with grower survey results to verify assumptions used related to manure application. If the total nitrogen applied across the GWMA as organic fertilizer based on grower survey data differs significantly from the mass expected based on the number of livestock in the GWMA and other identified organic nitrogen sinks, input parameters for the nitrogen loading assessment will be reevaluated. This activity will be addressed through periodic revisions to the document as is warranted as new information become available.
- Conduct an assessment on synthetic fertilizer use using the mass applied to fields (based on grower surveys and WSU rates) compared to nitrogen fertilizer mass sold by fertilizer distributors (assuming data are available). This will provide a check on amounts claimed on grower surveys.
  - Use of current and historical groundwater quality data may be used to assist in defining areas where the results of the mass balance appear to be at odds with groundwater data. Care will be exercised not to confuse water quality that may be the result of historic application from land management activities currently being conducted.
- Upon completion of the Deep Soil Sampling analysis, compare and contrast Nitrogen Loading Assessment with DSS findings. Existing shallow groundwater nitrate data may also be used for this purpose. *The installation of shallow groundwater wells for N loading verification is not considered part of this project. If deemed necessary, this activity should be included in any future groundwater monitoring projects.*

Task 7.1 Conduct evaluation of synthetic fertilizer use (grower survey vs. synthetic fertilizer sold). This task is dependent upon willingness of fertilizer outlets and crop consultants to supply WSDA with data.

*Estimated Budget* 40 hours @ 45.00/hr \$ 1800.00

Task 7.2 Evaluate DSS results with N Assessment results and determine relative gaps in assessment.

*Estimated Budget 80 hours @ 55.00/hr \$ 4400.00*

***Total Estimated Budget Task 7.0 \$ 6200.00***

## **8.0 Communication and Reporting**

A GWMA-wide nitrogen balance will be calculated using the database(s) at the parcel/field scale. The total load from a parcel/field will be the sum of loads from all sources considered. The data will then be mapped at a scale necessary for the GWAC to base GWMA plan recommendations.. A draft report will then be submitted to the Data, IA, RCIM, and Livesock/CAFO work groups for review. It is assumed that up to four conference calls will occur for comments, feedback, and clarification for working group members. The chairs of the working groups will compile, summarize, and resolve conflicting written comments and generate a set of comments for Yakima County/WSDA to complete a GWAC-review draft. Yakima County/WSDA will address working group comments, then produce a GWAC-draft report. A final report will be generated after addressing GWAC comments.

Task 8.1 Develop draft report on nitrogen loading and loss for the Lower Yakima Valley Groundwater Management Area. This will include sub-assessments of the three major areas of concern: RCIM, Irrigated Agriculture, and Livestock/CAFO operations. This report will be submitted to the GWAC for comment. This will be a cooperative effort between WSDA and Yakima County

*Estimated Budget 120 hours @ 45.00/hr \$ 5400.00*

Task 8.2 Review comments from GWAC, and workgroups. This item includes up to four single or joint meetings with workgroups to consider comments, and will conclude with the presentation of a final report on N loading in the Lower Yakima Valley. This will be a cooperative effort between WSDA and Yakima County

*Estimated Budget 50 hours @ 45.00/hr \$ 2250.00*

***Total Estimated Budget Task 8.0 \$ 7650.00***

**Total Project Budget Estimate**

**\$ 56660.00 - \$58660.00**

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This budget is for the combined work from Yakima County and WSDA and represents and estimated split of \$ 13,000.00 for Yakima County specific activities and \$ 45,000.00 due WSDA.

It should be noted that the budget submitted does not reflect the true cost of the project but rather approximately 70% of the cost. Because of the critical nature of the project and the need to establish a N loading baseline, WSDA and Yakima County will contribute significant staff resources not funded by GWMA monies to ensure the timely completion of the project.

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# Nitrogen Loading Assessment – Yakima Groundwater Management Area

## Project Timeline – Major Milestones

