Lower Yakima Valley Deep Soil Sampling Summary Analysis

By Jean Mendoza

August 2017

Between the fall of 2014 and the spring of 2016 the Lower Yakima Valley (LYV) Groundwater Management Area (GWMA) conducted four rounds of deep soil sampling (DSS) on agricultural land in the GWMA target area. All fields were voluntarily submitted and anonymously recorded. Soil sampling was done under contract by the South Yakima Conservation District and Landau Associates.

Purposes of the DSS as stated in *Deep Soil Sampling Plan Lower Yakima Valley Groundwater Management Area*, *March 2014* were:

1) Providing 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.
5) Provide information about project design, practical realities, time requirements and costs that can be used in developing subsequent project scopes.

There has been no analysis of the collected data. This summary is an attempt by one member of the GWMA advisory committee to begin that process. This summary indicates that analysis is possible for a limited number of crops – triticale, alfalfa & corn silage. These were the majority of the crops in the study – 60% of crops in fall samplings and 78% of crops in spring samplings.

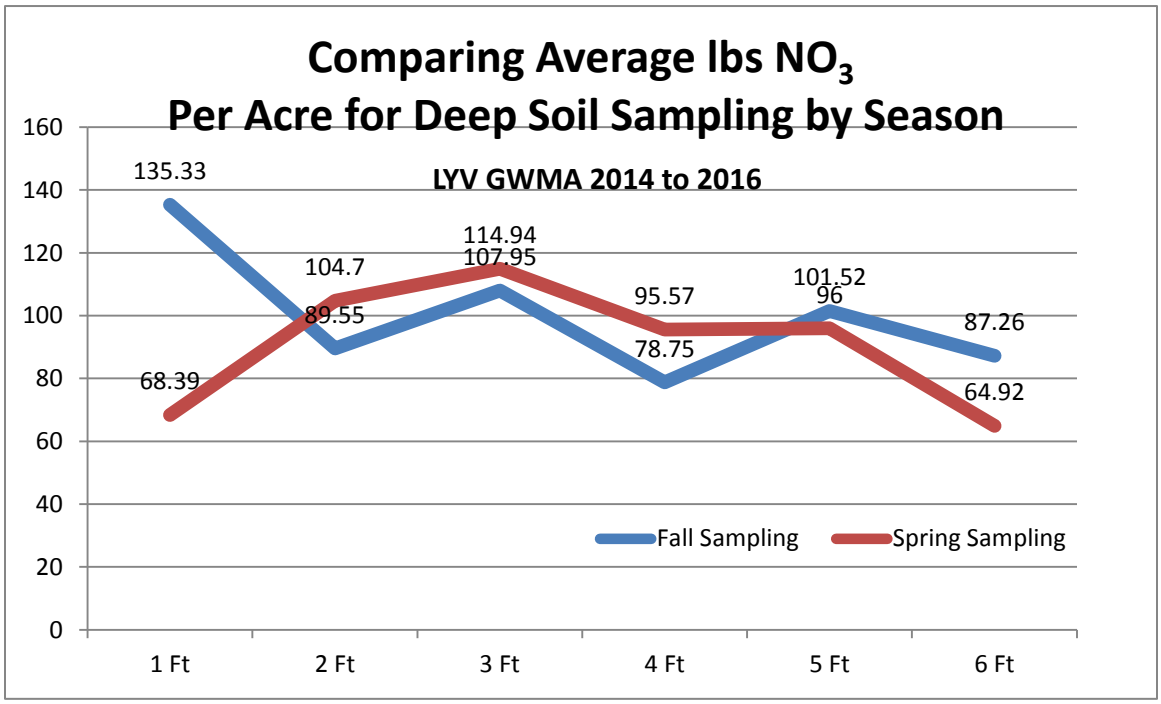
Summary of Data Parameters

There is a difference between the nitrate levels in the soil samples from the fall testing and the spring testing. This could be due to winter moisture that drives nitrates downward in the soil column. It could be due to differences in the fields and nature of the crops that were tested in each season.

Table 1. Average Nitrate Levels for Fall & Spring DSS

Seasonal Averages	1 Ft #N/Acre	2 Ft #N/Acre	3 Ft #N/Acre	4 Ft #N/Acre	5 Ft #N/Acre	6 Ft #N/Acre	Total #N/Acre	Ammonia #N/Acre	Organic Matter
Fall (N = 93)	135.33	89.55	107.95	78.75	101.52	87.26	531.78	22.7	2.01%
Spring (N = 82)	68.39	104.7	114.94	95.57	96	64.92	448.41	23.8	2.13%

Graph 1.



There are results for 93 fields in the fall sampling and 82 fields in the spring sampling for a total of 175. Part or all of the survey results are missing for 17 of the sites in the spring 2016 study. Analysis by crop, crop yield, fertilizations practices and irrigation type for the 2016 spring testing was calculated for those samples with available information. Soil information was available for all samples.

Average acreage per field was 34.23 acres for the fall testing and 45.61acres for the spring testing.

Total acreage: According to the Washington State Department of Agriculture (WSDA) there are about 96,380 acres of land in agriculture in the GWMA target area. Survey results were obtained for 6,091 acres or 6% of those fields. Acreage was missing for 3 of the fields in the fall samplings and 16 fields in the spring samplings. We do not know if any fields were tested twice and we do not know the locations of the fields.

Soil testing had been done by 74% of the growers in the fall survey and 99% of the growers in the spring survey with 3 unknown in the fall and 15 unknown in the spring. Those fields that were not routinely tested had lower nitrate levels. This indicates that many farmers know where they should be testing.

Irrigation types were:

- Rill = 21 fields or 23% for fall sampling and 7 fields or 11% for spring sampling with 17 unknown in the spring
- Sprinkler = 66 fields or 73% for fall sampling and 51fields or 78% for spring sampling with 17 unknown in the spring
- Drip = 5 fields or 3% for fall samplings and 7 fields or 11% for spring sampling with 17 unknown in the spring
- No irrigation = 1 field or 1% for the fall sampling

Crop history was provided for the past four to five years for most fields. Some fields were planted in only one crop throughout that time period while others were planted with multiple crops. This complicates the analysis. Unless otherwise stated the crop listed for each sample and analysis is the most recently harvested crop under the category *Crop #1* in the DSS spreadsheets. Remember that previous crops impact the nitrogen levels in soils.

Percentage of crops in the DSS is described below in Table 2. WSDA's percentage of crops in the GWMA target area is in parentheses. WSDA data is taken from Attachment 2, *Summary of Proposed Allocation Process.* Most DSS fields in triticale were double cropped in silage corn. Perhaps WSDA only counted triticale as a crop when it was the only crop on a field. This would account for WSDA's low estimate of land in triticale.

Table 2. Percentage of Crops in the LYV GWMA DSS

Fall	% of Crops in the Sampling	N	Spring	% of Crops in the Sampling	N
Triticale	22% (WSDA 1%)	20	Triticale	46% (WSDA 1%)	31
Alfalfa	15% (WSDA 7%)	14	Alfalfa	19% (WSDA 7%)	13
Corn Silage	14% (WSDA 19% for silage + grain)	13	Corn Silage	12% (WSDA 19% for silage + grain)	8
Corn Grain	10% (WSDA 19% for silage + grain)	9	Hops	7% (Hops 5%)	5
Grapes	6% (WSDA 11%)	6	Asparagus	3% (WSDA 1%)	2
Hops	5% (WSDA 5%)	5	Mint	3% (WSDA 1%)	2
Mint	5% (WSDA 1%)	5	Wheat	3% (WSDA 2%)	2
Pasture	5% (WSDA 6%)	5	Apples	1% (WSDA 17%)	1
Wheat	4% (WSDA 2%)	4	Cherries	1 % (WSDA 7%)	1
Apples	3% (WSDA 17%)	3	Pasture	1% (WSDA 6%)	1
Hay	3% (WSDA 1%)	3	Wine Grapes	1% (WSDA 5%)	1
Cherries	2% (WSDA 7%)	2	None	1%	1
Barley	1% (WSDA < 1%)	1			
Fallow	1%	1			
Pears	1% (WSDA 4%)	1			
Sudan Grass	1% (WSDA 1%)	1			
Wine Grapes	1% (WSDA 5%)	1			
Double Crop	24%	22	Double Crop	46%	31
Multiple Crops	30%	28	Multiple Crops	25%	17

Based on these numbers it is possible to draw limited conclusions regarding triticale, alfalfa and corn silage for the fields in this data set of voluntary samples. This descriptive analysis begins on page 8. Statistical analysis for significance begins on page 37.

Fertilization Practices were:

- Liquid Manure = 29 fields (31%) for fall sampling and 36 fields (55%) for spring
- Solid Manure = 18 fields (19%) for fall sampling and 10 fields (15%) for spring
- Commercial Fertilizer = 59 fields (63%) for fall sampling and 36 fields (55%) for spring sampling
- Biosolids = 1 field (1%) for fall sampling and 0% for spring sampling
- Compost = 2 fields (2%) for fall sampling and 0% for spring sampling
- Other = 3 fields (3%) for fall sampling and 1 field (2%) for spring sampling
- 23 fields or 25% of the fall sampling received more than one type of fertilizer
- 23 fields or 35% of the spring sampling received more than one type of fertilizer

Leaching estimates were obtained using the *Capacity of the Most Limiting Layer to Transmit Water (Ksat)* classifications found on the Natural Resource Conservation Services (NRCS) *Soils Website* at https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

Ksat soil classes for this analysis were:

- Very Low to Moderately Low =5 fields or 5% for fall, 9 fields or 11% for spring and 14 fields or 8% overall
- Moderately High to High = 78 fields or 84% for fall, 68 fields or 83% for spring and 146 fields or 83% overall.
- High to Very High = 10 fields or 11% for fall, 15 fields or 6% for spring and 25 fields or 9% overall

See Attachment 3 for a listing of the soil types and classifications in the DSS. None of the sampled fields fell into other classes.

Most frequent soil types listed in the DSS spread sheet were:

Fall –

- Warden Silt Loam 2-5% Slopes (Moderately High to High) – 24% (22)
- Quincy Loamy Fine Sand 0-10% Slopes (Moderately High to High) – 9% (8)
- Warden Silt Loam 5-8% Slopes (Moderately High to High) – 9% (8)
- Ezquatel Silt Loam 0-2% Slopes (Moderately High to High) – 8% (7)
- Warden Silt Loam 8-15% Slopes (Moderately High to High) – 6% (6)

Spring –

- Warden Silt Loam 2-5% Slopes (Moderately High to High) – 15% (12)
- Cleman Very Find Sandy Loam 0-2% Slopes (Moderately High to High) – 12%(10)
- Warden Fine Sandy Loam 0-2% Slopes (Moderately High to High) – 7%(6)
- Scoon Silt Loam 2-5% Slopes (Very Low to Moderately Low) – 6% (5)
- Sinloc Silt Loam 2-5% Slopes (Moderately High to High) – 6% (5)

Deep Soil Sampling Plan

Prior to implementation of the LYV GWMA DSS planners from the Irrigated Ag Work Group presented the advisory committee with an estimated breakdown of categories for the GWMA target area. (Attachment 2 – *Summary of Proposed Allocation Process*) These groupings were:

1. Crops by root depths:
   - More than 4 Ft – alfalfa, asparagus, tree fruits & hops ~42% of total crops
   - 2.5 Ft to 4 Ft – corn, wheat, grains/triticale, sorghum/Sudan, pasture, grapes ~54% of total crops
   - Less than 2.5 Ft – mint ~1% of total crops
   - Miscellaneous ~3% of total crops

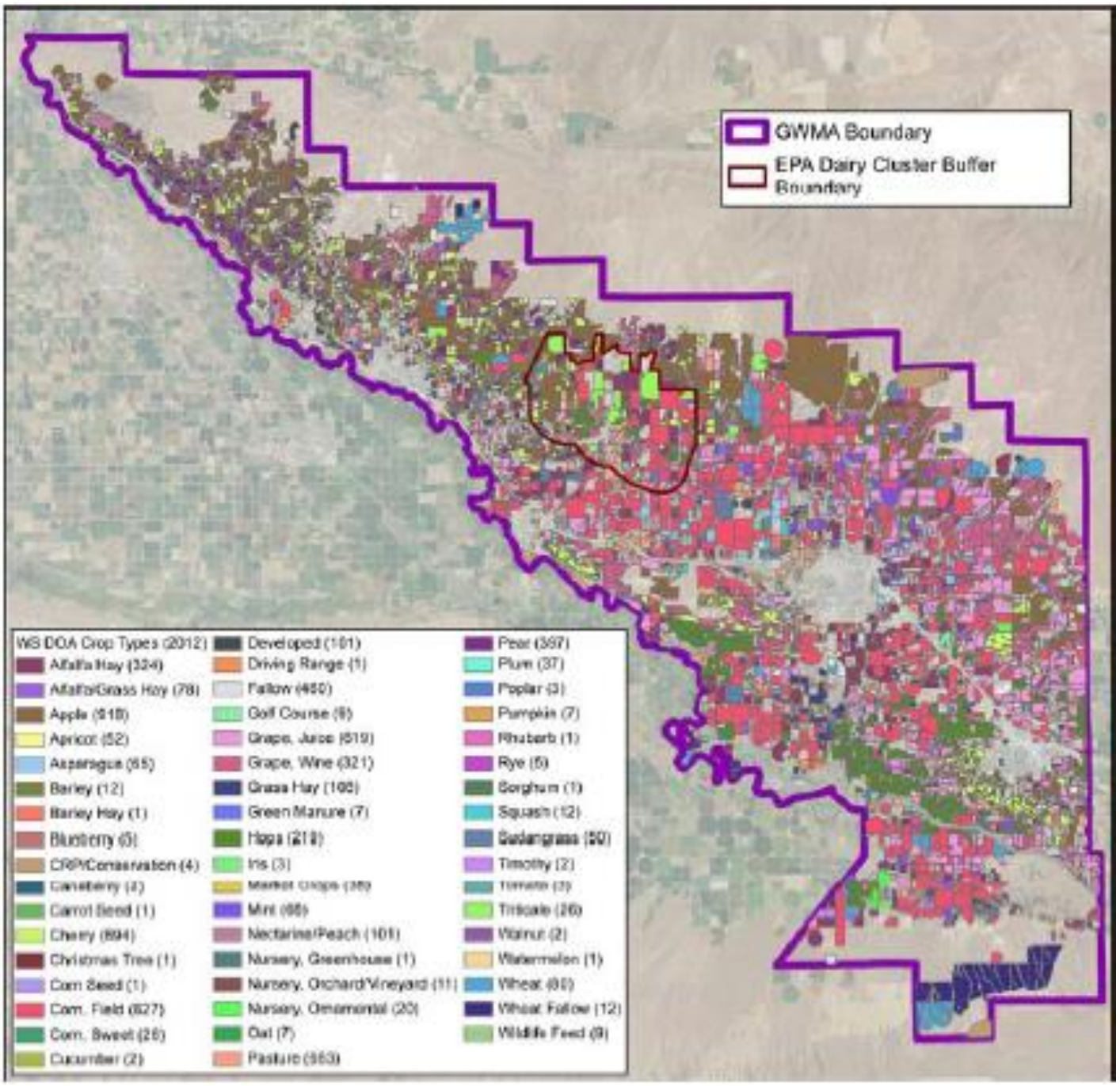
2. Irrigation Types
   - None, none + anything, unknown ~6% of area irrigation
   - Drip, micro sprinkler, drip + anything ~13% of area irrigation
   - Sprinklers, sprinklers + anything, hand ~63% of area irrigation
   - Flood, rill, rill + sprinkler ~ 16% of area irrigation

3. Leaching Potentials (percentages unknown)
   - Low
   - Medium
   - High
   - Possibly a fourth category – medium to high

The plan was to calculate total acreage for each of 36 to 96 categories and to rank categories according to acreage. Analysists would determine which categories were most prevalent in the GWMA target area. They would sample 6 fields from each of the most prevalent, 4 fields from each of the next highest grouping and 3 fields from each of the next highest grouping. There would be no sampling from approximately half of the combinations with low prevalence.

In order to determine the percentage of GWMA land in each category someone would use the WSDA map of GWMA area crops below and search the NRCS Web Soils site to determine soil type for each parcel. These calculations were apparently not done.

Map 1. WSDA Crop Map for the GWMA Target Area



Comparison of the Plan with the Collected DSS Data

For purposes of this comparison the number of categories is reduced to 27 possible combinations: (Irrigation = 3) x (Crops = 3) x (Leaching = 3).

Irrigation

The plan states there is rill irrigation on 16% of the target area. 19% of the fields in the study had rill irrigation

The plan states there is sprinkler irrigation on 63% of the fields in the target area. 74% of the fields in the study had sprinkler irrigation

The plan states there is drip irrigation on 13% of the fields in the target area. 7% of the fields in the study had drip irrigation

There is no irrigation on 6% of the fields in the target area and about 1% of the fields in the study had none. That category is omitted in this analysis of the DSS

Crops by Rooting Depth

The plan states that 1% of the crops in the target area have roots < 2.5 Ft deep. About 5% of the fields in the study had crops (mint) in this category

The plan states that 54% of the crops in the target area have roots 2.5 Ft to 4 Ft. About 66% of the fields in the study had crops in this category.

The plan states that 42% of the crops in the target area have roots > 4 Ft. About 29% of the fields in the study had crops in this category

Analysis of DSS by crops is complicated by double cropping. Most of the DSS fields planted in triticale and corn silage were double cropped. Double cropping was done on 24% of the fields in the fall soil sampling and 46% of the crops in the spring soil sampling

Crops in the DSS are not always typical of the crops grown in the area. For example 2.5% of the fields in the DSS were planted in apples but 19% of the cropland in the area is actually planted in apples according to the WSDA. For example 17% of the fields in the DSS were planted in alfalfa but 7% of the cropland in the area is actually planted in alfalfa according to the WSDA. The composition of the > 4 Ft root depth group in the DSS includes both of these crops and is especially not typical of the area.

Leaching Potential

In the collected data the DSS leaching potential categories were:

- Very low to moderately low – 6% of fields
- Moderately high to high – 84% of fields
- High to very high – 10% of fields

We do not know the actual percentages of leaching categories in the GWMA target area.

Results for Most Prevalent Categories in the DSS

The DSS gathered data for 15 out of the 27 categories.

Table 3. LYV GWMA DSS Categories with Soil Testing Results

Irrigation	Root Depth	Leaching Potential	Number of fields in the DSS	% of DSS Fields
Rill	< 2.5 Ft	Moderately High, Moderately High to High	6	4%
Rill	2.5 Ft to 4 Ft	Moderately High, Moderately High to High	19	12%
Rill	2.5 Ft to 4 Ft	High to Very High	1	1%
Rill	> 4 Ft	Moderately High, Moderately High to High	3	2%
Rill	> 4 Ft	High to Very High	1	1%
Sprinkler	< 2.5 Ft	Moderately High, Moderately High to High	2	1%
Sprinkler	2.5 Ft to 4 Ft	Very Low to Moderately Low	8	5%
Sprinkler	2.5 Ft to 4 Ft	Moderately High, Moderately High to High	65	40%
Sprinkler	2.5 Ft to 4 Ft	High to Very High	12	7%
Sprinkler	> 4 Ft	Moderately High, Moderately High to High	31	19%
Sprinkler	> 4 Ft	High to Very High	2	1%
Drip	2.5 Ft to 4 Ft	Very Low to Moderately Low	1	1%
Drip	2.5 Ft to 4 Ft	Moderately High, Moderately High to High	1	1%
Drip	> 4 Ft	Very Low to Moderately Low	1	1%
Drip	> 4 Ft	Moderately High, Moderately High to High	9	6%

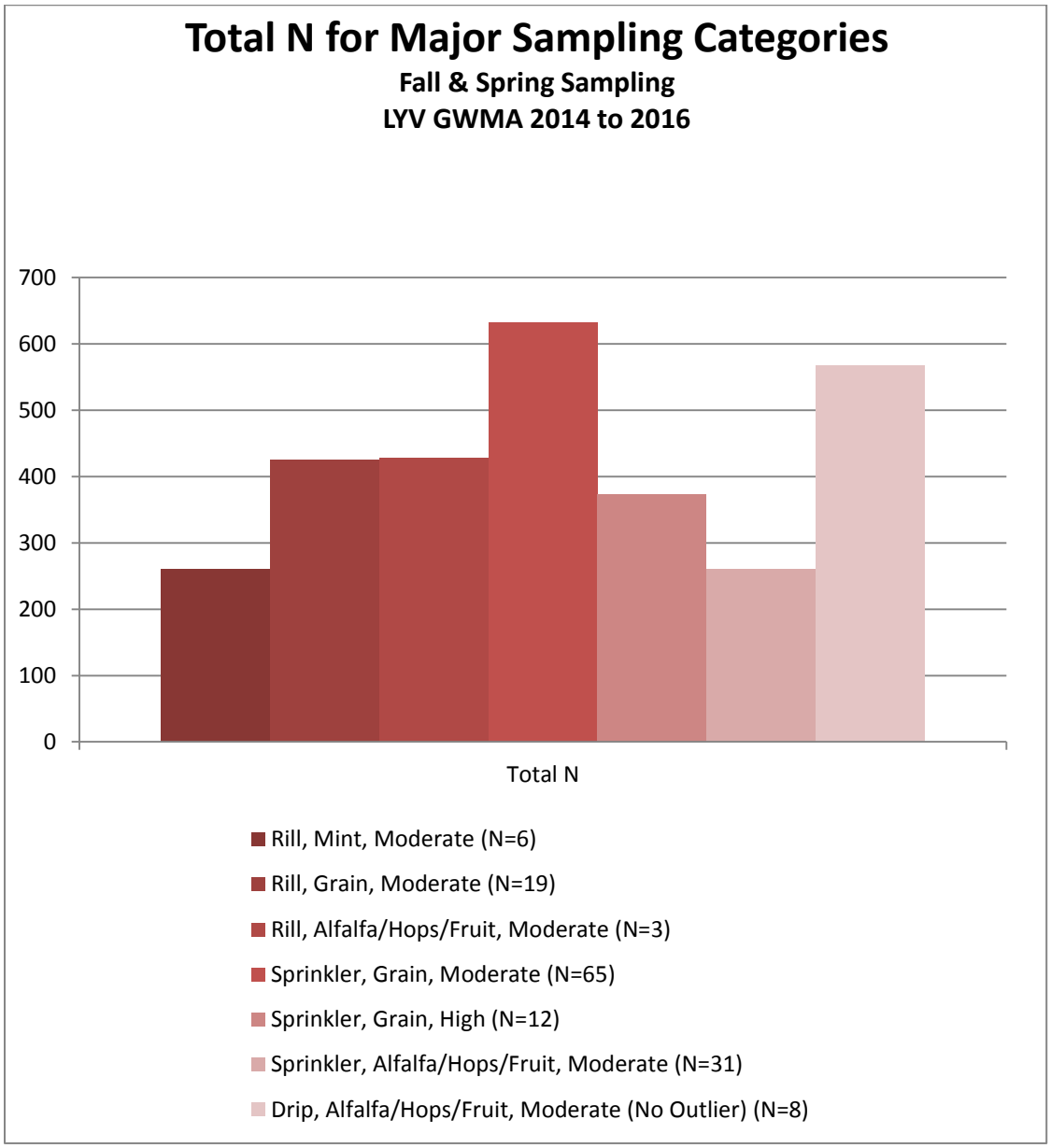
Here are the average readings for nitrates in the soil for the categories with more than three samples. The bar graph that follows shows the calculated total nitrogen for these major groups. Note that early refusal of the auger results in fewer samples and a lower total N. For this reason the category "Sprinkler, Grain, Low" was omitted from the bar graph since that grouping had no measurements below 3 ft.

Table 4. Average NO_3 Levels by Sampling Category for LYV GWMA DSS

Category	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total N
Rill, Mint, Moderate (N=6)	85.33	26.17	63.67	18.67	57.17	9.17	260.17
Rill, Grain, Moderate (N=19)	157.95	74.42	69.74	47.37	52.88	33.69	425.16
Rill, Alfalfa/Hops/Fruit, Moderate (N = 3)	138.33	84.67	63	62.67	58	21	427.67
Sprinkler, Grain, Low (N=8)	92.88	80.83	103.67		Early Refusal		
Sprinkler, Grain, Moderate (N=65)	101.09	130.69	145.08	124.88	111.7	102.77	631.43
Sprinkler, Grain, High (N=12)	102.5	61.5	89.1	60	62.67	50.44	373.08
Sprinkler, Alfalfa/Hops/Fruit, Moderate (N = 31)	60.83	35.72	53.56	53.67	65.67	37.75	260.72
Drip, Alfalfa/Hops/Fruit, Moderate with Outlier (N = 9) *	287.44	168.56	164.67	36.56	217.86	187.57	972.44
Drip, Alfalfa/Hops/Fruit, Moderate without Outlier (N = 8)	204.63	182.25	110.75	34	30.17	18.17	567.75

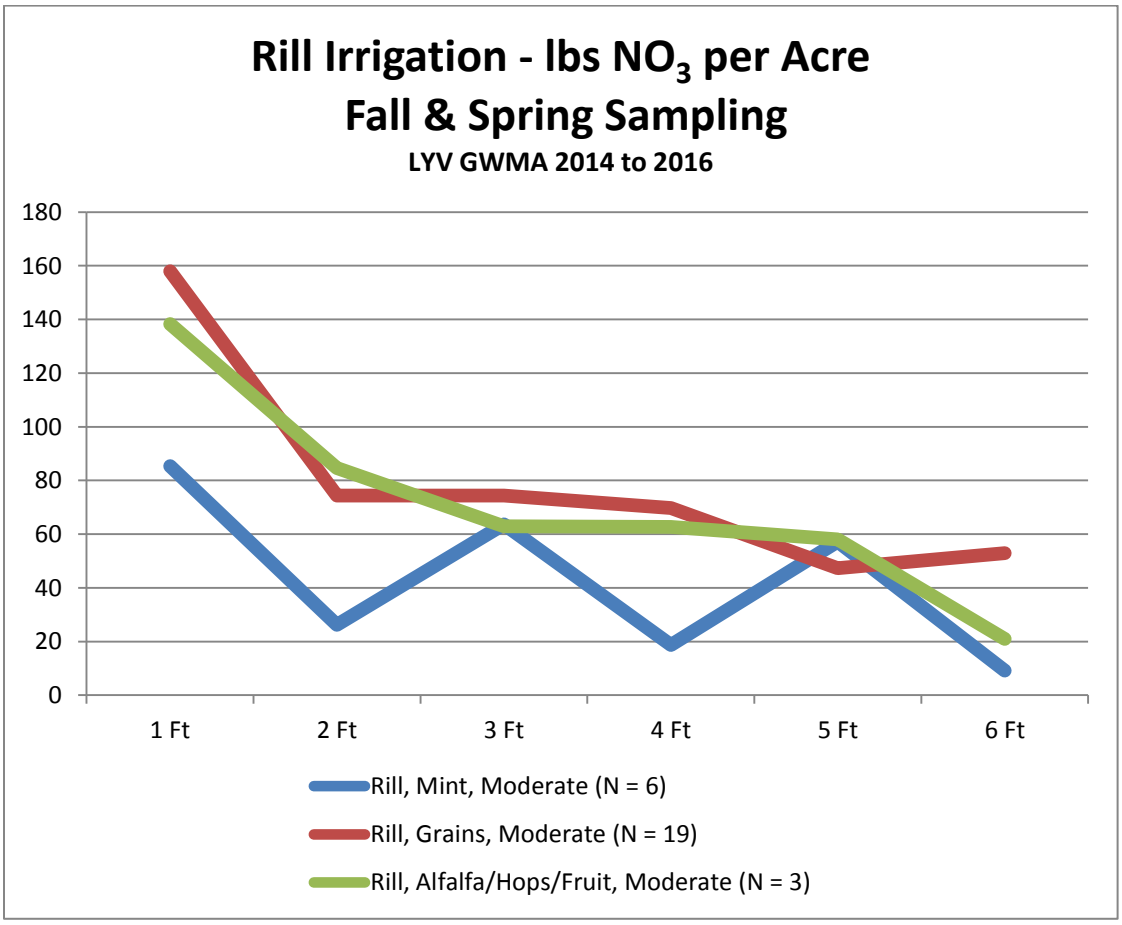
* Field #3141 had extremely high nitrate levels at the 5 ft and 6 ft levels. At this depth the readings cannot be explained by the parameters in the study. This field was excluded from the analysis on this page, but not from later analyses.

Graph 2. Total Nitrogen for Major Sampling Categories LYV GWMA DSS

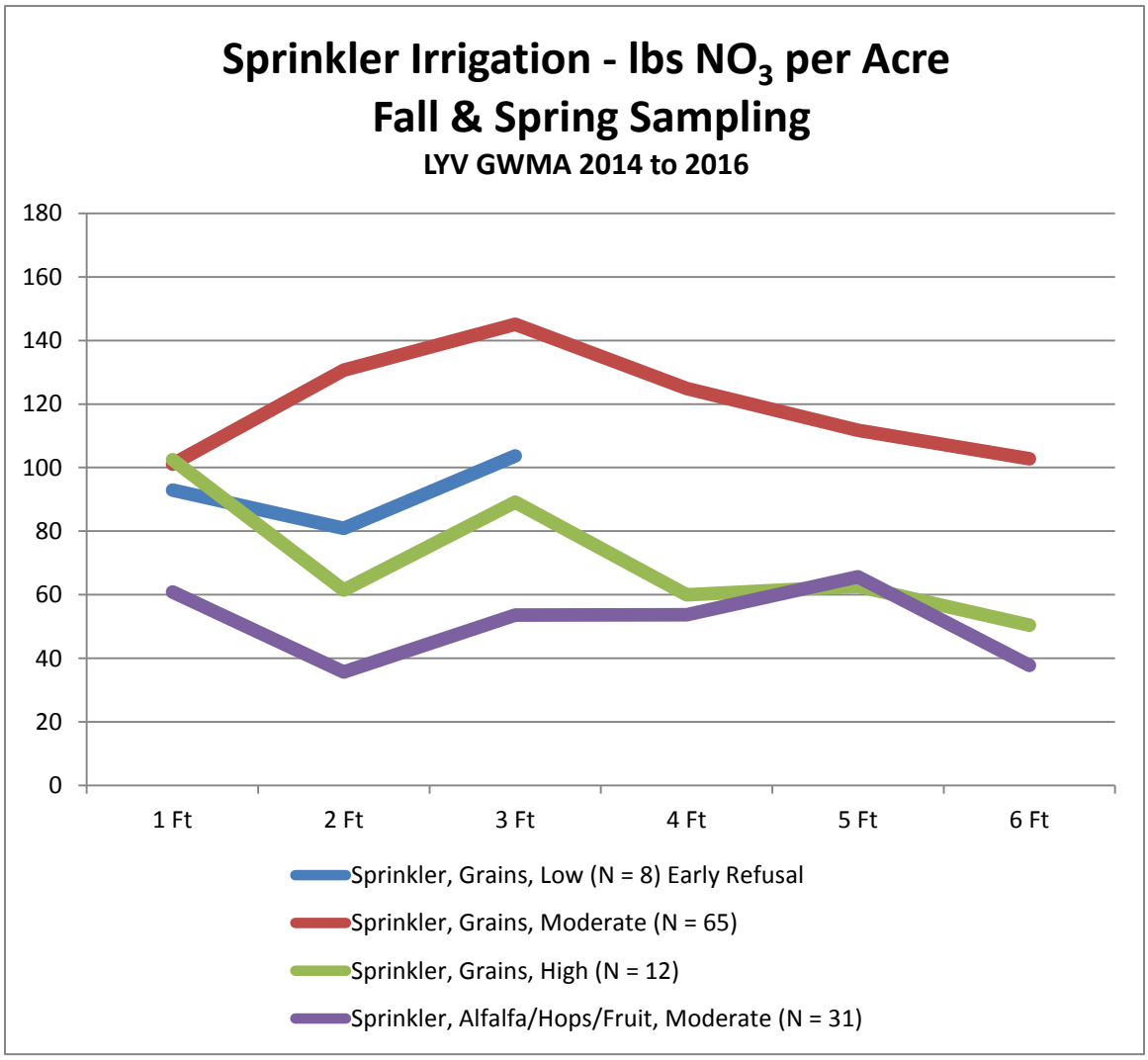


Following are graphs that provide easy viewing of common factors in the 15 groupings.

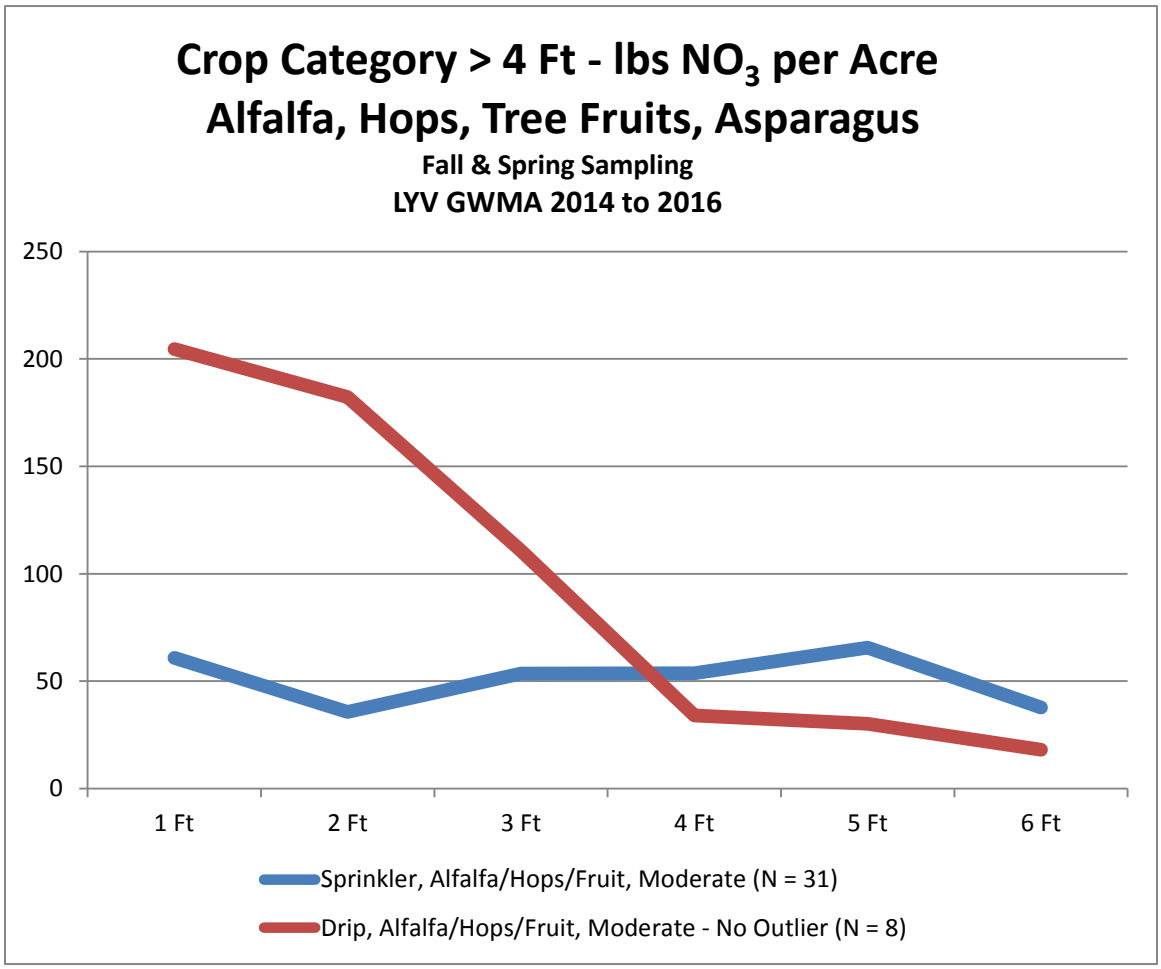
Graph 3.



Graph 4.

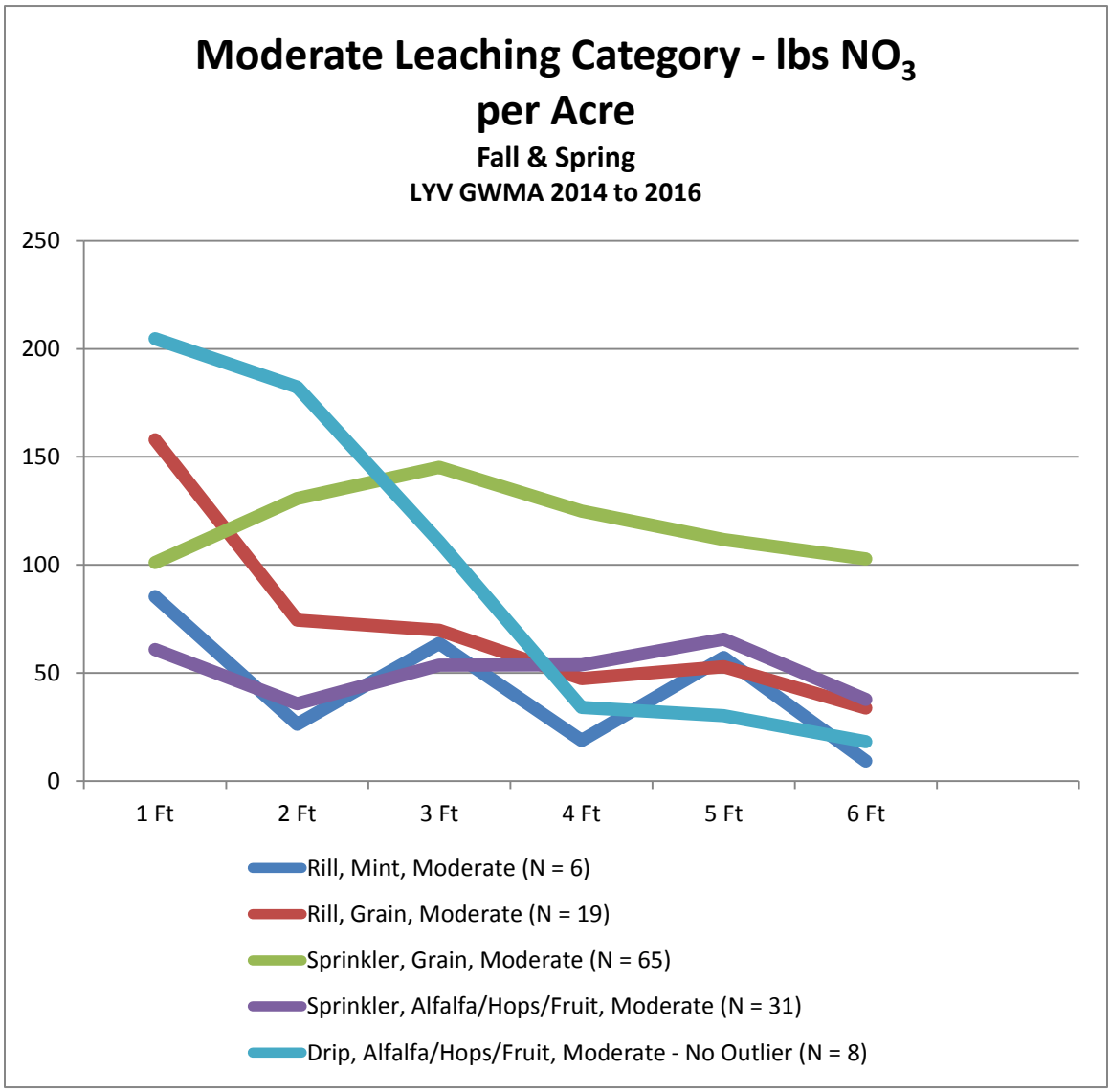

Sprinkler Irrigation - lbs NO_3 per Acre
Fall & Spring Sampling
LYV GWMA 2014 to 2016
180
160
140
120
100
80
60
40
20
0
1 Ft
2 Ft
3 Ft
4 Ft
5 Ft
6 Ft
Sprinkler, Grains, Low (N = 8) Early Refusal
Sprinkler, Grains, Moderate (N = 65)
Sprinkler, Grains, High (N = 12)
Sprinkler, Alfalfa/Hops/Fruit, Moderate (N = 31)

Graph 5.



Note change in scale

Graph 6.



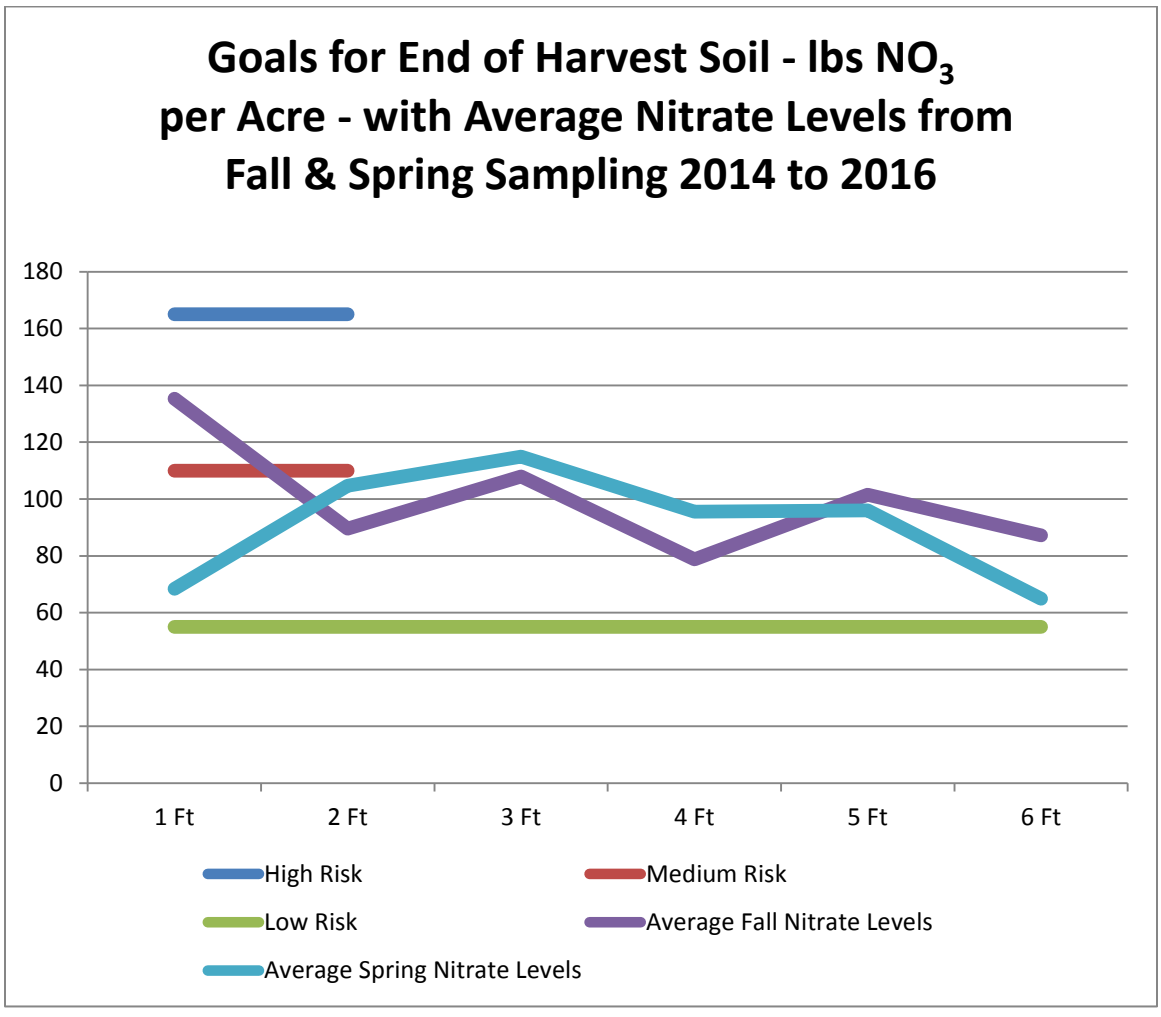
Descriptive Analysis of the DSS Data

Based on the number of samples available certain groupings of data in the DSS lend themselves to limited analysis. In the pages that follow there is discussion of data for the crops: alfalfa, alfalfa + other, triticale & corn silage. There is limited discussion of other crops: grapes, hops, mint, grain corn, & wheat. There is analysis of the impact of double cropping, fertilizer practices and root depth. This study is not sufficiently sophisticated to analyze combinations of factors. The results apply only to the data in the DSS and should only be applied to the entire GWMA target area with caution. Spring and fall data collections are analyzed separately in most of the analyses that follow.

DSS Goals: Suggested goals for end of harvest soil testing at the two foot level in Eastern Washington can be adapted from the WA State General NPDES permit for Concentrated Animal Feeding Operations. (Ecology, 2017). According to this document there is low risk when end of harvest nitrate levels at two feet are < 55 # per acre, medium risk when levels are 55# per acre to 110 # per acre, high risk when levels are 110 # per acre to 165 # per acre and very high risk when levels are > 165 # per acre.

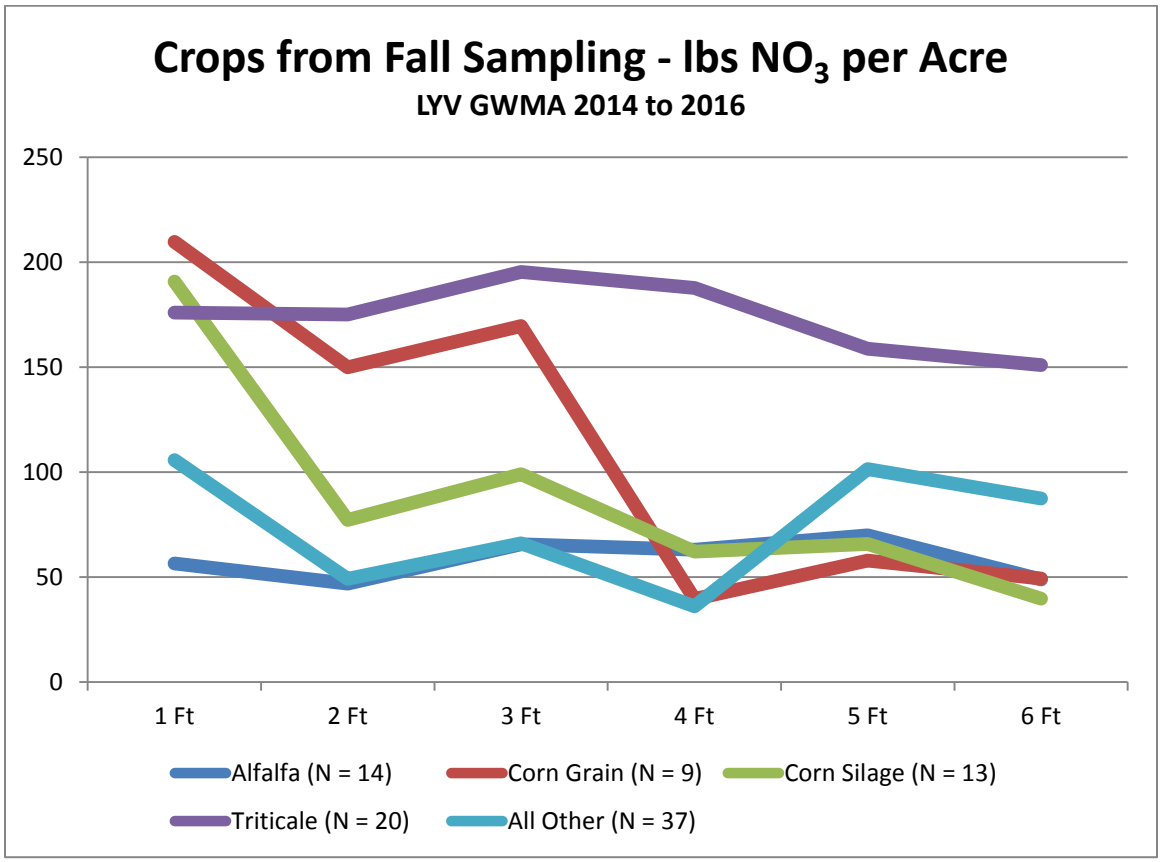
Here is a graphic representation with the average nitrate levels from fall and spring DSS testing in the LYV GWMA target area:

Graph 7.

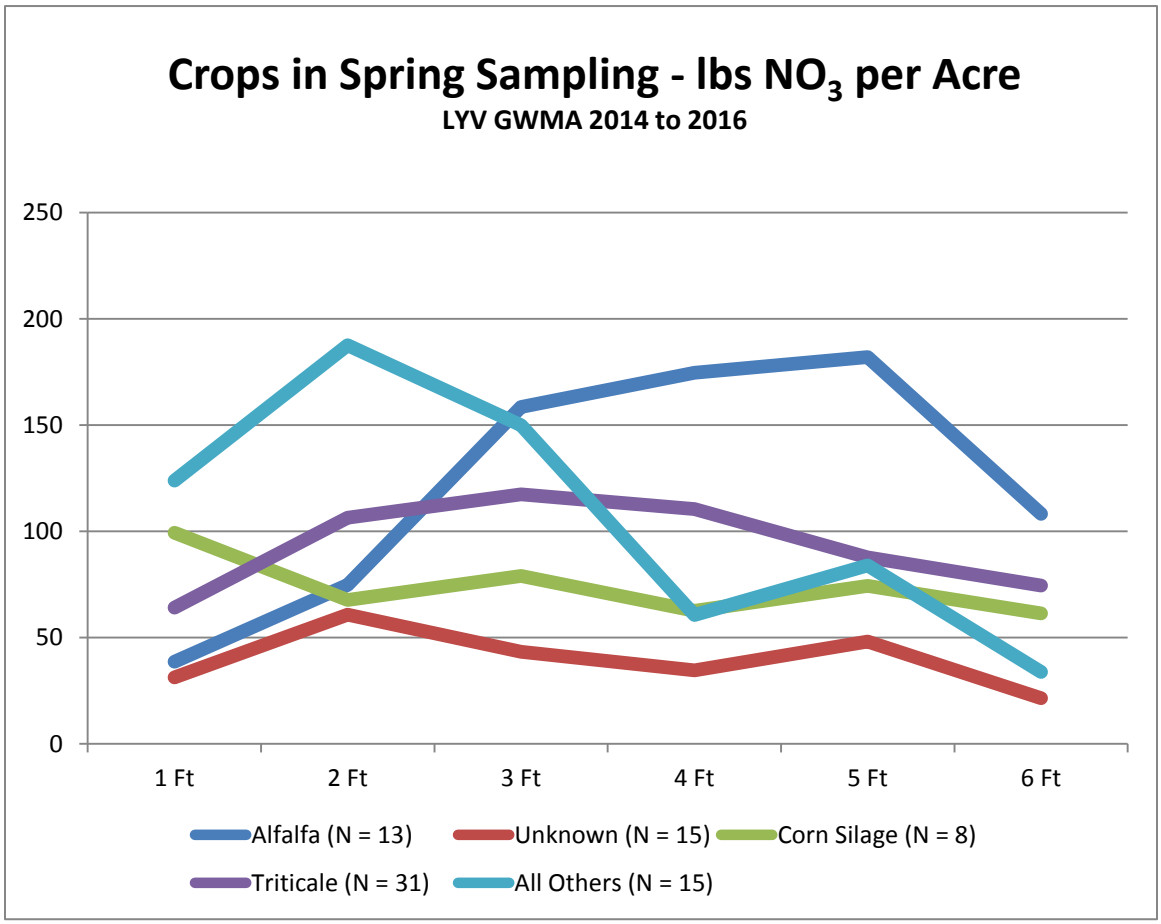


Major Categories: The majority crops in the fall sampling were triticale (n=20), alfalfa (n = 14), corn silage (n=13), corn grain (n=9) and all others (n=37). The majority crops in the spring sampling were triticale (n=31), unknown (n=15), alfalfa (n=13), corn silage (n=8) and all others (n=15).

Graph 8.

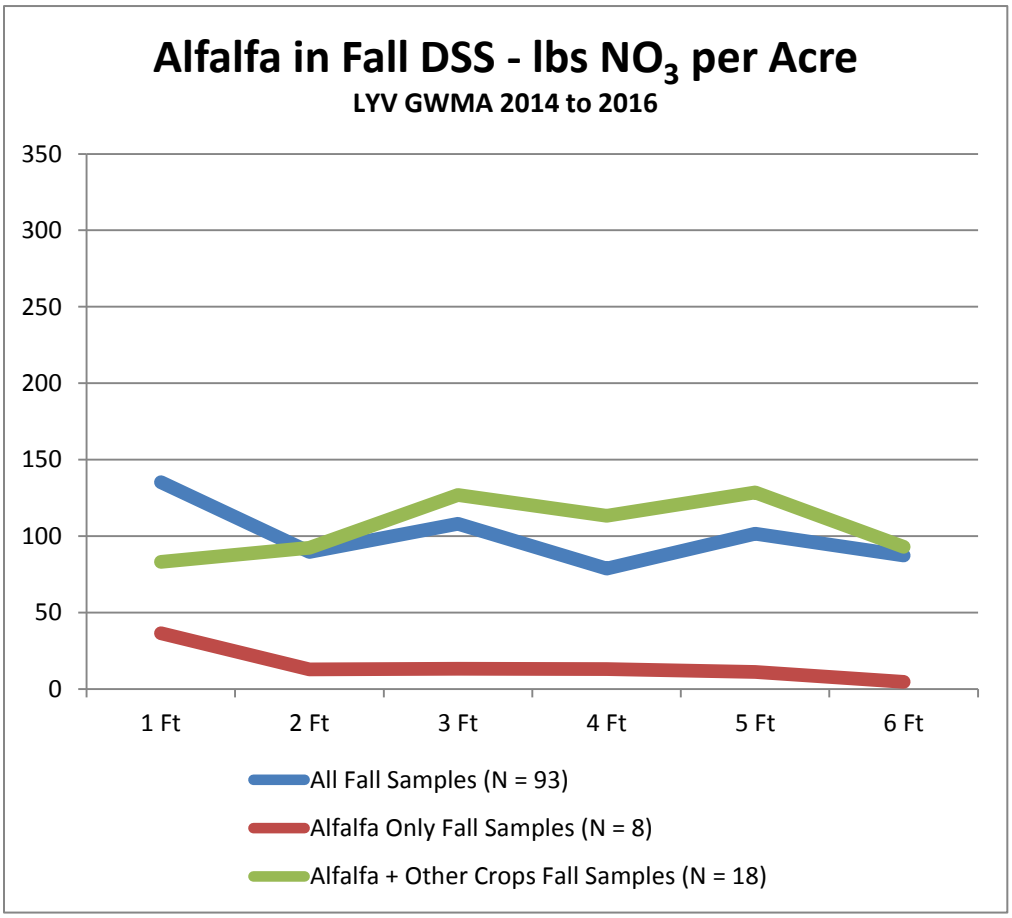


Graph 9.



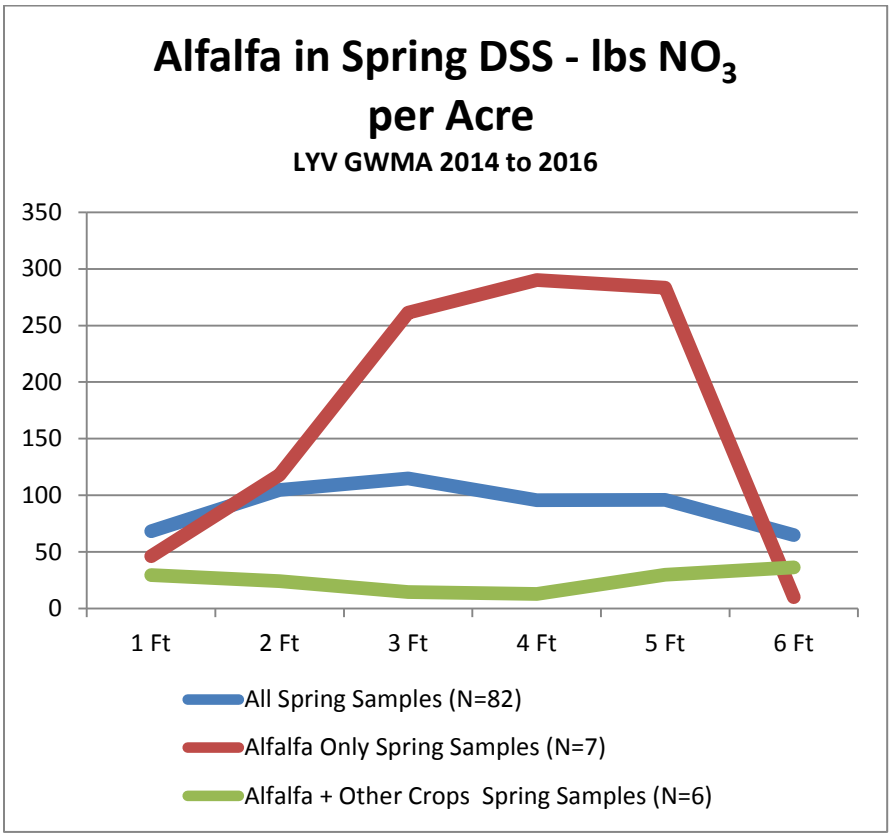
Alfalfa: Analysis of the data for alfalfa from the fall samplings strongly suggests that when alfalfa is the only crop planted on a field for several years, then nitrate levels tend to be low. When other crops are rotated onto the field then nitrate levels tend to be higher. Fertilization practices naturally have a strong influence.

Graph 10.



But when the alfalfa data from spring sampling is analyzed there are surprises. The spring alfalfa fields have much higher nitrate levels than the combined fields for all spring sampling. Alfalfa only fields have higher nitrates than the fields with alfalfa plus multiple other crops in the spring sampling.

Graph 11.



A closer look at the spring "alfalfa only" data provides a clue. There are some extreme values in fields #2044, #2047 and #4152. The range of values for these fields is huge.

Table 5. Spring Sampling: Alfalfa = Only Crop

Field ID	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total	Ammonia	Organic
2045	29	4	20	22	13	31	119	25	2.37
2047	113	466	913	951	626	242	3321	21	3.11
2073	36	35	31	38			140	27	2.42
2074	75	55	68	97	94	26	415	26	2.51
4152	25	106	319	279	256	219	1204	26	2.63
2044	29	152	457	623	706	409	2376	31	3.4
4153	17	9	21	21	5	10	83	17	2.62
Averages	46.29	118.14	261.29	290.14	283.33	10	1094	24.7	2.72

According to the DSS spreadsheets for the fields with high nitrate levels:

- No irrigation type is listed for #2044 but it is likely sprinkler. Soil testing is done annually. “No nutrients have been applied during last four years.” Crop yield is slightly less than average at 7.5 tons per acre. Soil type is Outlook Silt Loam with a moderately high to high Ksat. Rooting depth averages 3.7 ft with a range of 1.5 ft to 5.4 ft
- Irrigation is pivot sprinkler for #2047. Soil testing is done annually. This field received 300#/acre of N from liquid manure in 2012, 2013, & 2014 and 150#/acre of N from liquid manure in 2015. Average crop yield was 8.75 tons per acre. Soil type is Warden Silt Loam 5-8% slopes with moderately high to high Ksat. Average rooting depth is 3.8 ft with a range of 2ft to 5.9 ft.
- Irrigation is pivot sprinkler for #4152 and moisture sensors had been in place for a year. Soil testing is done annually. “No nutrients applied from 2013 thru 2016”. Average crop yield was 8 tons per acre. Soil type is Sinloc Silt Loam 2-5% slopes with a moderately high to high Ksat. Rooting depth averaged 4 ft with a range of 1.5 ft to 6 ft.

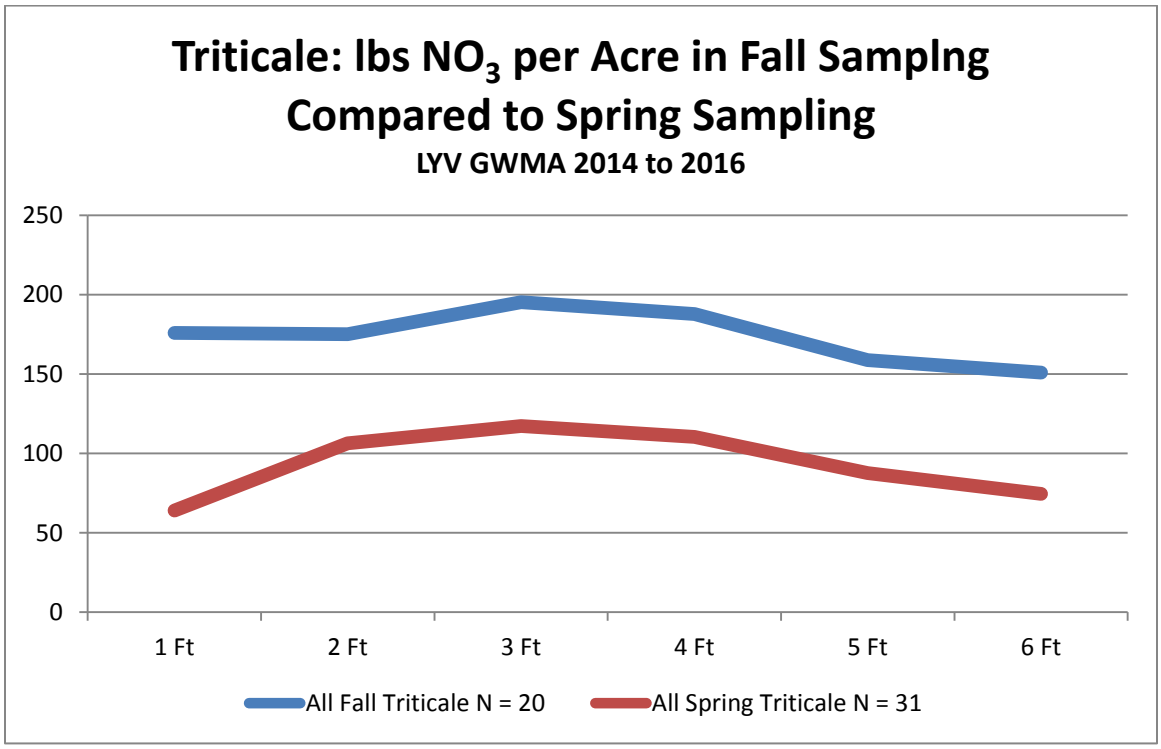
For the fields with low nitrate levels:

- Irrigation is by wheel lines on field #2045. Soil testing is done annually. “No nutrients applied since fall of 2011.” Crop yield is slightly less than average at 7.5 tons per acre. Soil type is Sinloc Fine Sandy Loam 0-2% slopes with moderately high to high Ksat. Rooting depth averaged 3.55 ft with a range of 3 ft to 4.7 ft.
- Irrigation is by pivot sprinkler on field #2073. Soil testing is done twice a year. The field received 150# of N per acre from liquid manure in 2012, 2013, 2014 & 2015. Crop yield was 9.75 tons per acre. Soil type is Warden Silt Loam 8-15% slopes with moderately high to high Ksat. Rooting depth averaged 3 ft with a range of 2.4 ft to 3.3 ft. There was refusal of the auger at < 4 ft at all four bore holes.
- Irrigation is by wheel lines on field #2074. Soil testing is done annually and soil moisture sensors are used. The field received 106 #N per acre in 2012 and 177 #N per acre in 2013 & 2014 from liquid manure. Crop yield averages 8 tons per acre. Soil type is Finley Silt Loam 0-2% slopes with high Ksat. Rooting depth averages 3.9 ft with a range of 2.6 ft to 6 ft.
- Irrigation is by wheel lines on field #4153. Soil testing is done annually. “No nutrients applied 2013 thru 2016.” Crop yield averages 16.7 tons of green chop per year. Soil type is Warden Silt Loam 5-8% slopes with moderately high to high Ksat. Rooting depths average 3.9 ft with a range of 3 ft to 4.8 ft.

This information is insufficient to explain the great differences in nitrate levels.

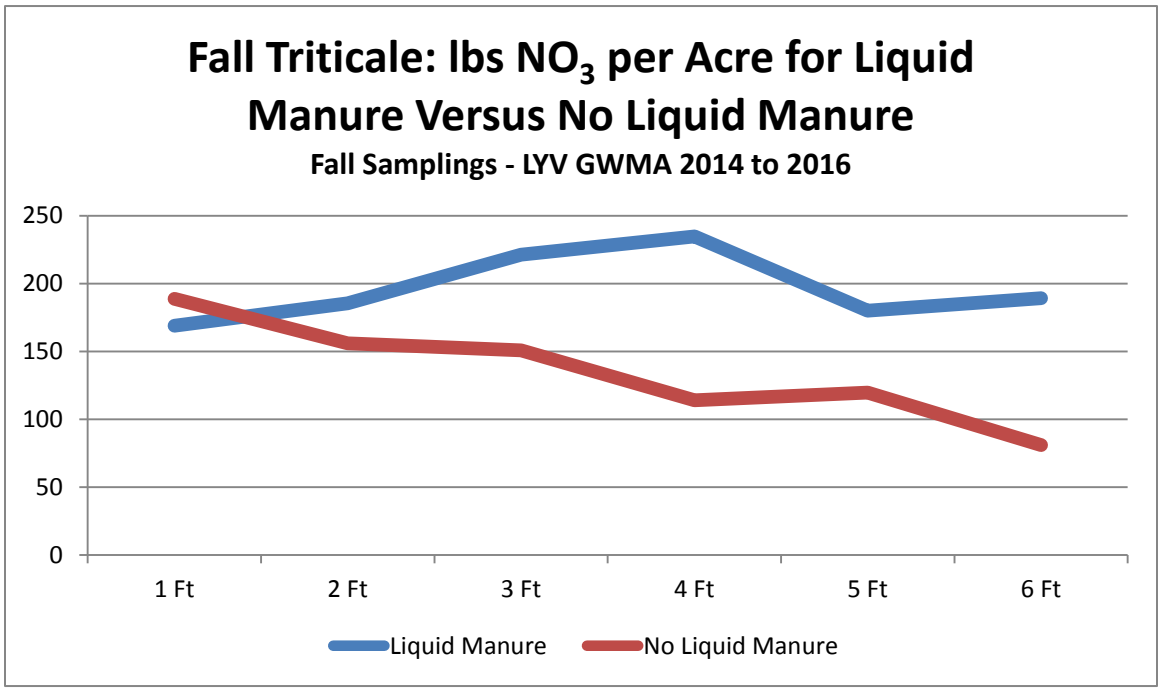
Triticale: Most of the fields planted in triticale are double cropped with corn silage. For purposes of analysis the fields in which triticale is listed as the most recently harvested crop in the *Crop #1* category are considered. Nitrate levels from triticale fields were higher during the fall sampling than during the spring sampling. Overall nitrate levels tended to peak at a depth of 3 ft.

Graph 10.

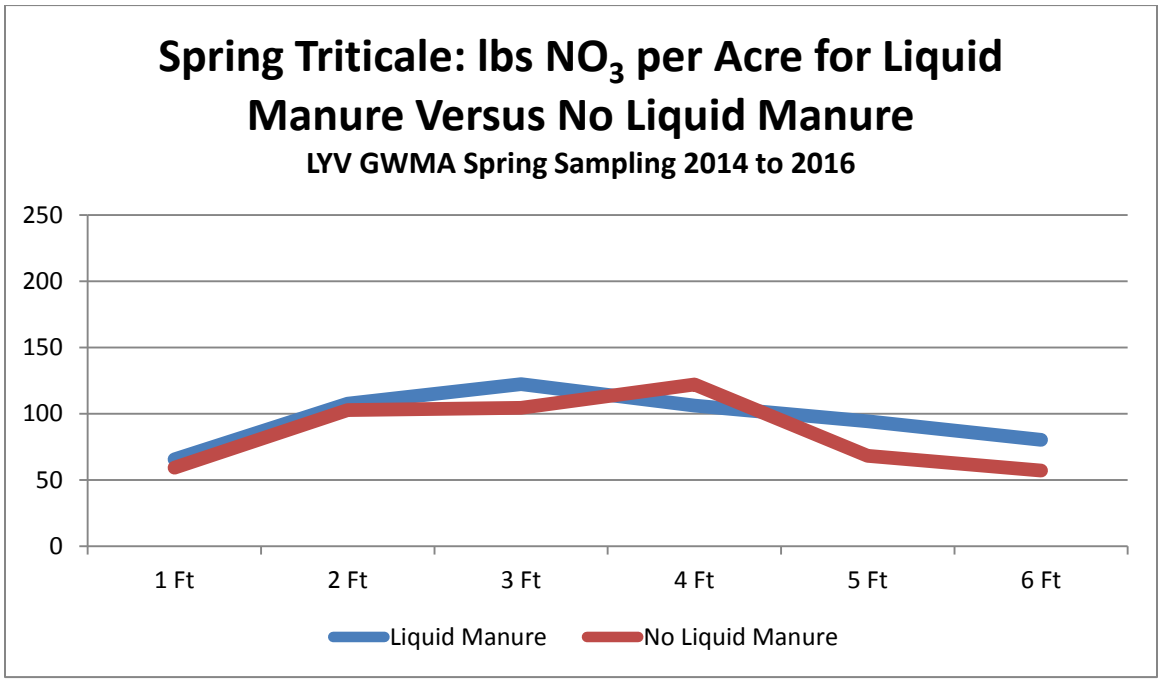


In the fall sampling triticale fields that received liquid manure tended to have higher nitrate levels than those that did not.

Graph 11.

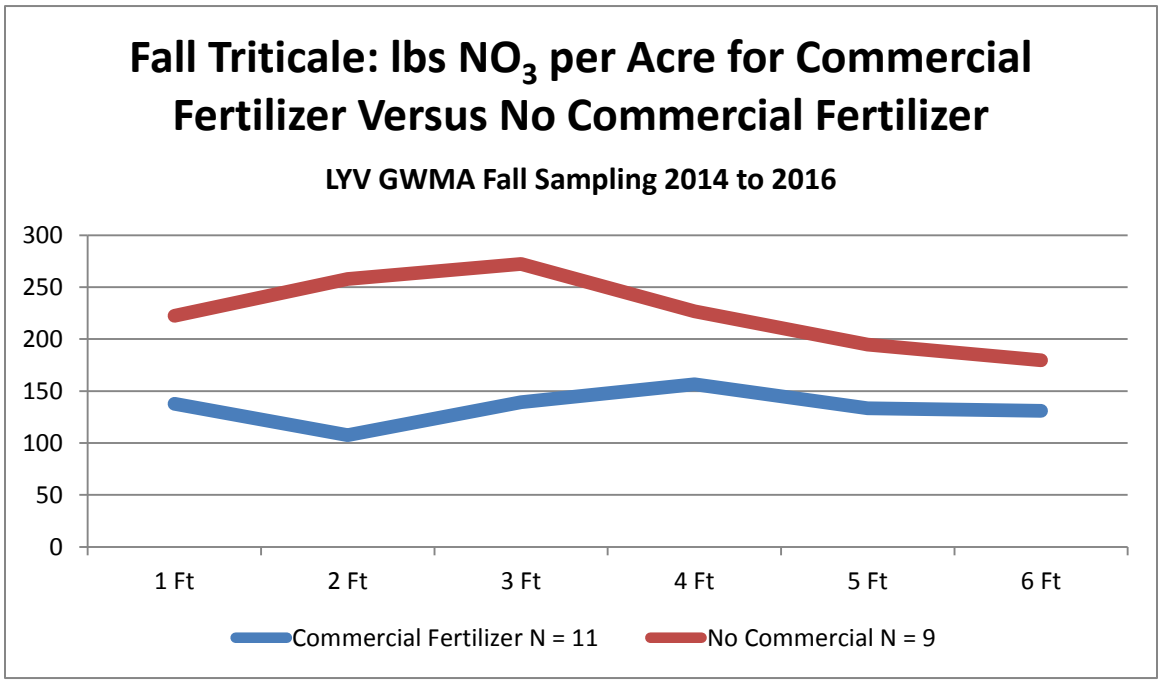


Graph 12.

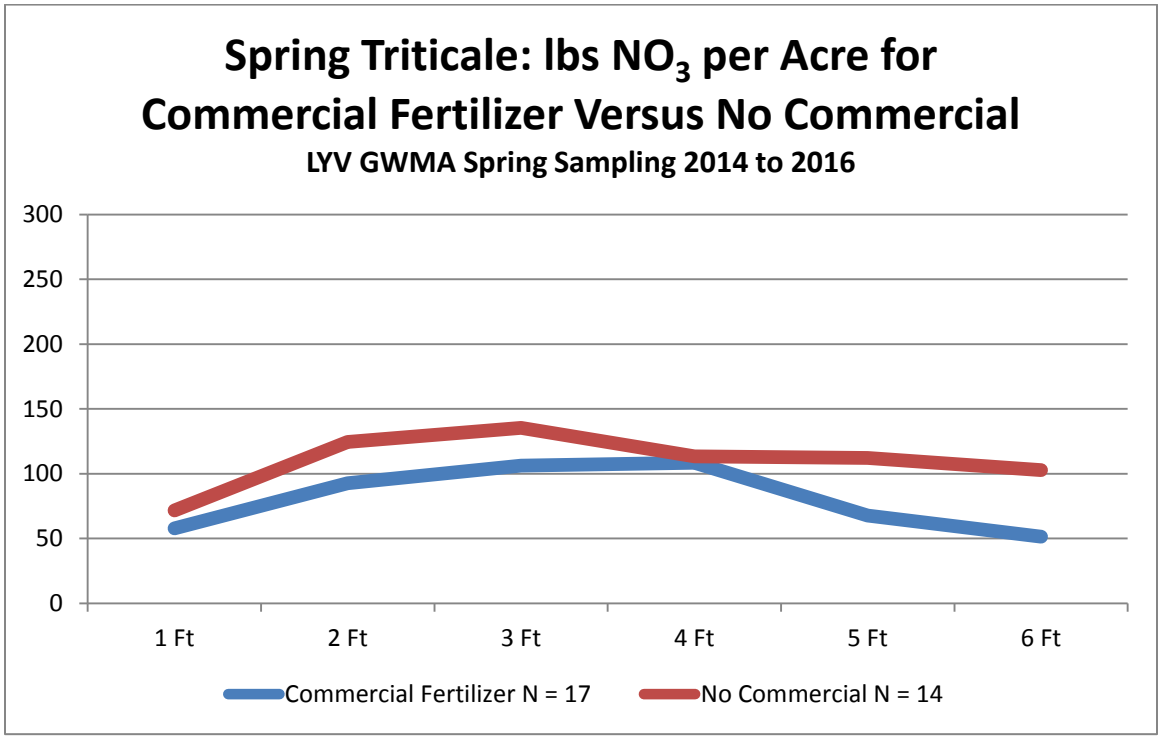


Triticale fields that received commercial fertilizer tended to have lower nitrate levels than those that did not.

Graph 13.

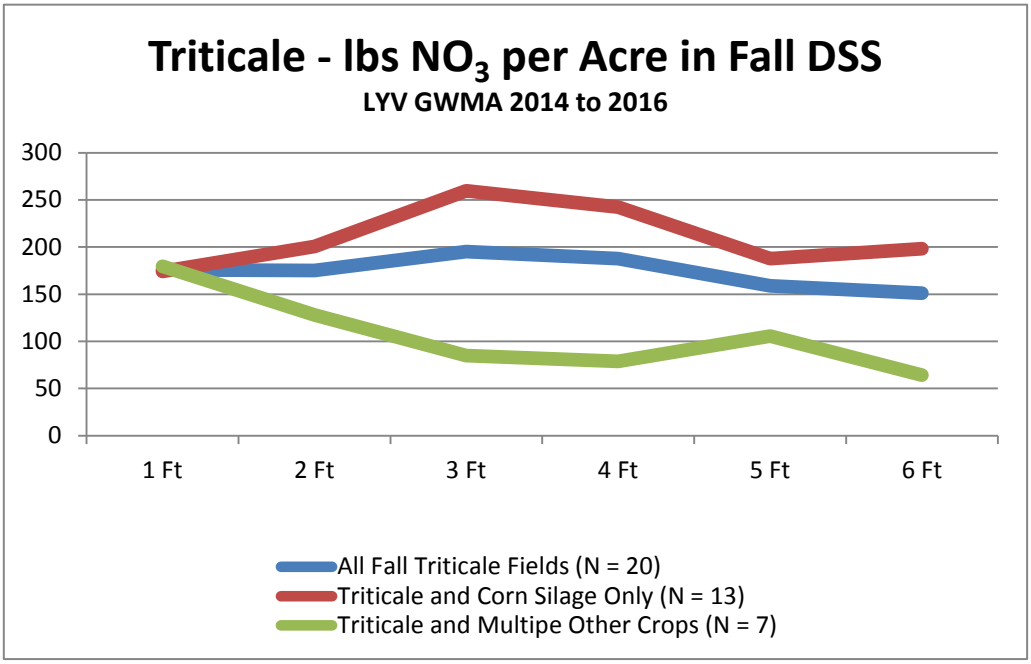


Graph 14.

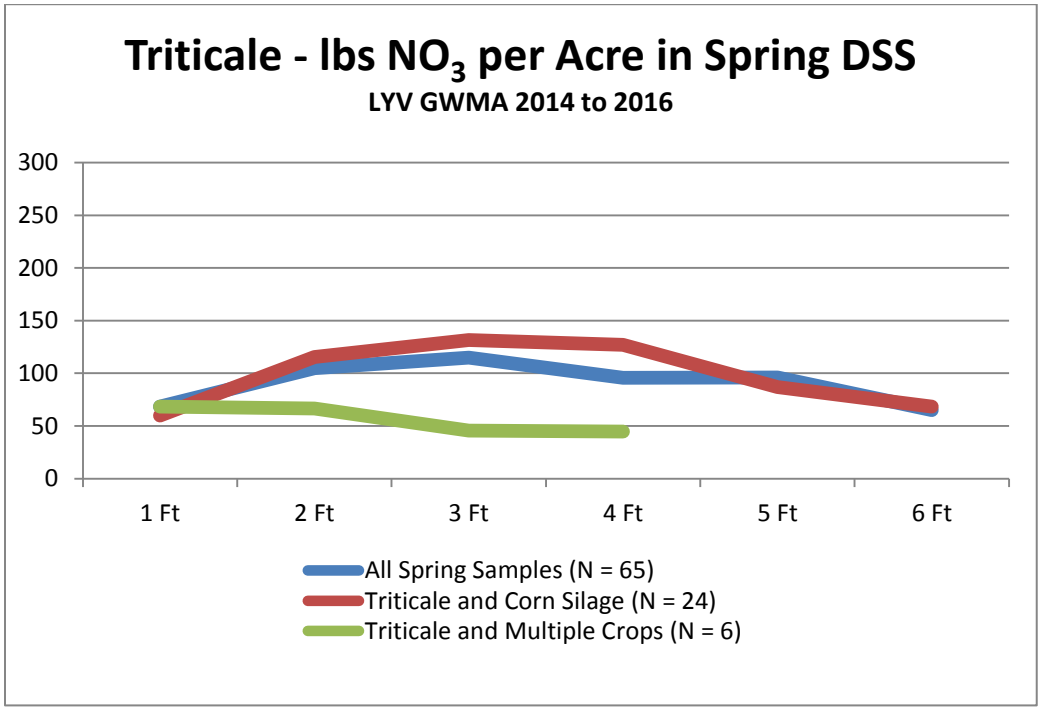


Fields planted only in triticale and corn silage tended to have higher nitrate levels than fields planted in triticale plus multiple other crops.

Graph 15.

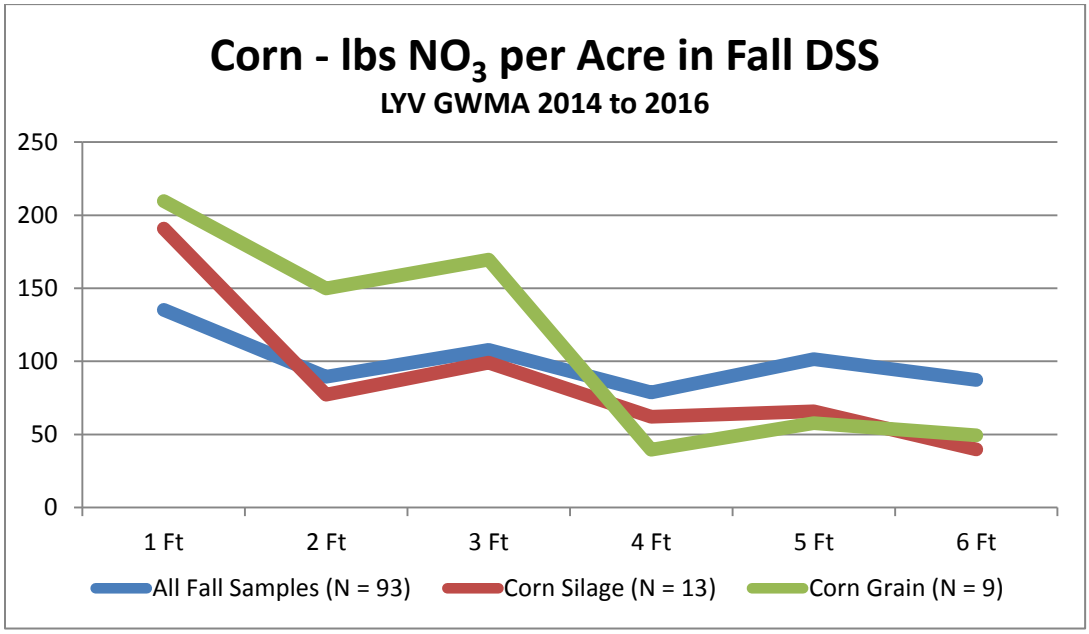


Graph 16.

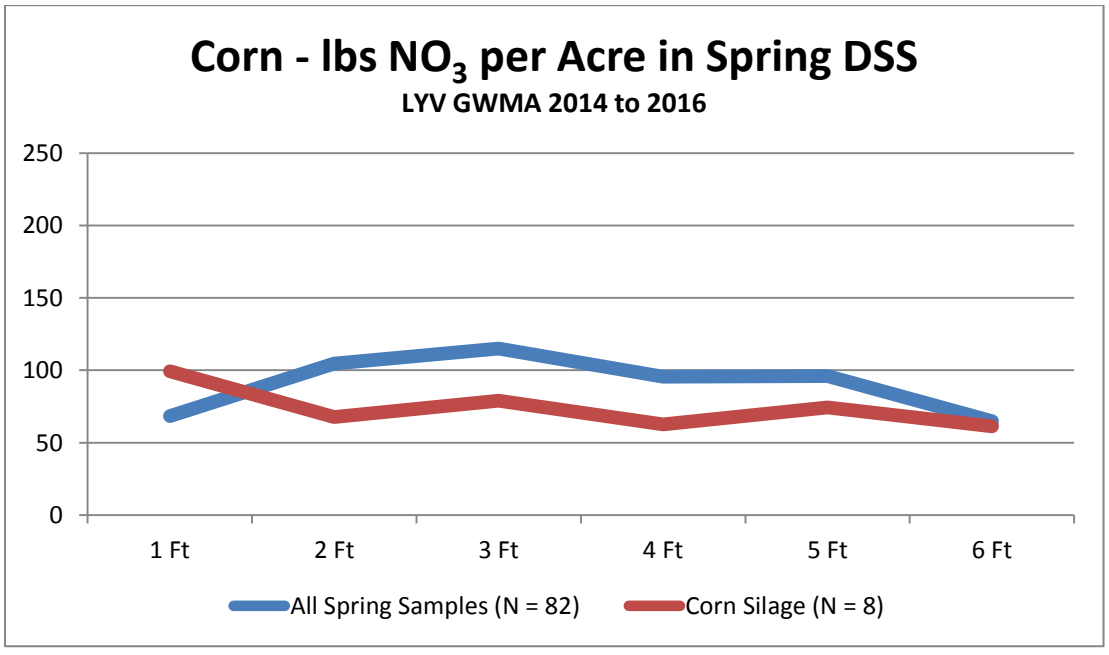


Corn: Both grain corn and silage corn fields were sampled in the fall. Only silage corn was sampled in the spring. Except for the first foot silage corn had lower nitrate levels than the average of all crops in both fall and spring. The fields described below had corn as the most recently harvested crop in the *Crop #1* category of the spreadsheets.

Graph 17.



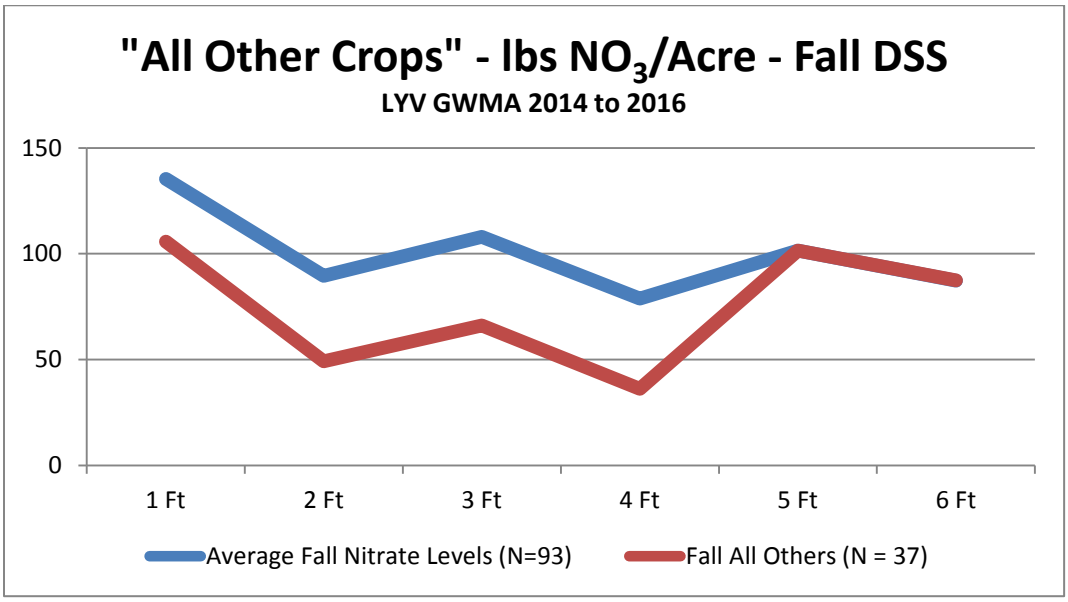
Graph 18.



"All Other Crops": This includes first listed crops other than alfalfa, corn and triticale.

Fall Sampling: There were 37 fields out of 93 for this category in the fall samplings. Crops were: apples (3), barley (1), cherries (2), fallow (1), grapes (6), hay (3), hops (5), mint (5), pasture (5), pears (1), Sudan grass (1), wheat (3), and wine grapes (1)

Graph 19.



Here are the nitrate levels at depths for those fall DSS crops with more than 2 samples. There was refusal before six feet for 17 out of 37 fields so total nitrogen is not included. There were potential outliers.

Table 6. NO_3 Levels for "All Other" Crops for LYV GWMA Fall Sampling

	N	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Ammonia	Organic
"All Other"	37	105.68	49.11	66.03	36.13	101.43	87.43	21.76	1.86
Apples	3	35.33	19	7	3.5	3	3	13.33	1.87
Cherries	2	34	4.5	3	3			6.5	1.26
Grapes *	6	19.33	111.5	182	146	301	292	10.67	1.35
Hay	3	15	5.67	9	7.67	14	18	19.33	1.89
Hops *	5	519.8	27	161	28.2	377.5	304	17.2	1.64
Mint	5	33.8	6.8	21.4	17.8	14.6	13.2	28.8	1.944
Pasture	5	27.8	27	4	4.25	9.25	8	40.4	2.28
Wheat	3	59.33	185	112	45	31	19	27.33	2.02

Possible Outliers are included in the table. These extreme values strongly influence the averages:

The potential outliers are

Grapes:

- Field #3117 is a 37 acre grape field with solid set irrigation. Soil testing is done annually. “This is an organic grape vineyard. No fertilizer is applied. We use vetch legume with triticale as a cover crop and the vetch does nitrogen fixing.” Crop yield averages 6.75 tons per year. Soil type is Warden Silt Loam 2-5% slopes with moderately high to high Ksat.
- Field #3119 is a 15 acre grape field with solid set irrigation. Soil testing is done every two years. No fertilizer is applied. “Previous farmer 40 years ago had a history of excessive nitrogen application according to current farmer.” Crop yield averages 7.5 tons per acre. Soil type is Warden Silt Loam 8-5% slopes with moderately high to high Ksat.

Hops:

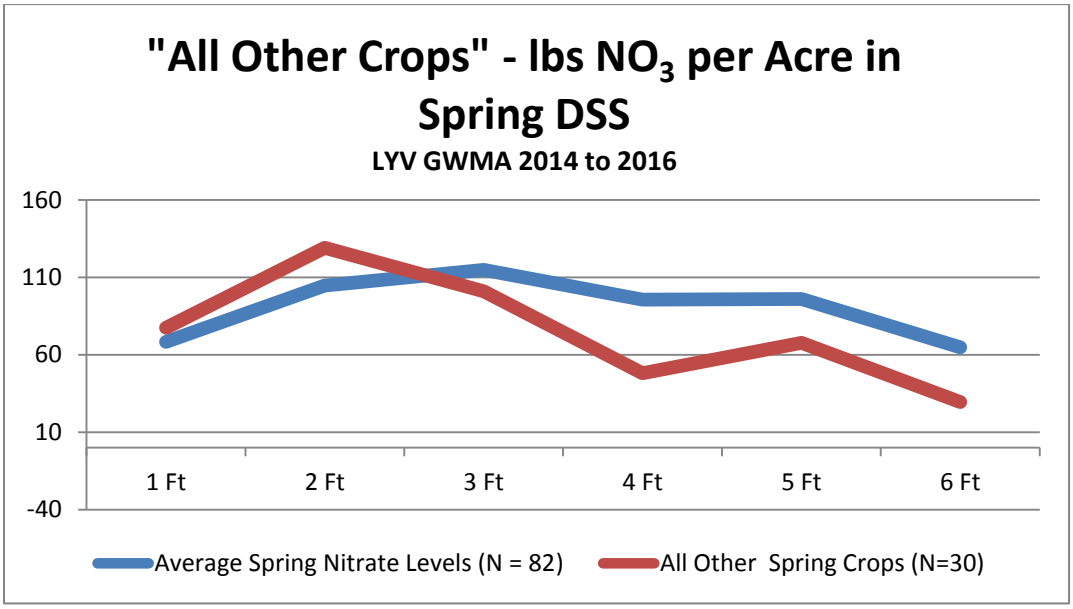
- Field #3141 is a 20 acre hop field with drip irrigation. Soil testing is done annually. 200# N per acre of commercial fertilizer was applied in 2013, 2014 & 2015. Crop yield averages 1.25 tons per acre. Soil type is Esquatzel Silt Loam 0-2% slopes with moderately high to high Ksat.

Table 7. NO_3 Levels: Potential Outliers for “All Other” Crops in LYV GWMA Fall Sampling

Field #	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total	Ammonia	Organic
3117	51	301	573	400			1325	9	1.67
3119	20	213	260	213	559	580	1845	11	1.49
3141	950	59	596	57	1344	1204	4210	22	2.25

Spring Sampling: There were 30 out of 82 fields in this category for the spring samplings. Crops were: apples (1), asparagus (2), cherries (1), hops (5), mint (2), pasture (1), wheat (2), wine grapes (1) and unknown (15)

Graph 20.



Here are the nitrate levels at depths for those spring DSS crops with more than 2 samples. There was refusal before six feet for 14 out of 30 fields so total nitrogen is not included. There were potential outliers.

Table 8. NO_3 Levels for "All Other" Crops for LYV GWMA Spring Sampling

	N	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Ammonia	Organic
All Other Crops	30	77.5	129.04	101.04	48.17	67.85	29.47	16.87	1.75
Asparagus *	2	231.5	499.5	412	207	212	111.5	14	0.91
Hops	5	124	223	111.8	28.8	30.2	20	11.4	1.43
Mint	2	176.5	68.5	175.5	48.5	158	18.5	10	162.63
Wheat	2	104	40					42	3.38
Unknown	15	31.2	60.83	43.27	34.64	48.11	21.5	16.87	1.79

Potential outliers were Fields # 4175 & 4176. These are the only asparagus fields in the DSS and should not be considered typical of asparagus in the area.

- Field # 4175 is a 10 acre asparagus field. The irrigation type is not identified and soil testing is done annually. "No nutrients applied for at least the last three years. No manure applied for over 10 years. Field gets subby when SVID canal fills up in spring and dries out when canal shuts off." No crop yield is recorded. Soil type is Cleman Very Fine Sandy Loam 0-2% slopes with moderately high to high Ksat.
- Field #4176 is a 20 acre asparagus field with rill irrigation. Soil testing is done annually. "No nutrients applied for at least the last three years. No manure applied for over 10 years. Field gets subby when SVID canal fills up in spring and dries out when canal shuts off." No crop yield is recorded. Soil type is Cleman Very Fine Sandy Loam 0-2% slopes with moderately high to high Ksat.

Here are the nitrate levels for the asparagus fields:

Table 9. Asparagus fields in the LYV GWMA Spring DSS

Field #	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total	Ammonia	Organic
4175	427	766	664	242	281	169	2549	12	0.69
4176	36	233	160	172	143	54	798	16	1.12
Average	231.5	499.5	412	207	212	111.5	1673.5	14	0.91

Here are the nitrate levels for the fields in which crops were unknown for the Spring DSS. There was early refusal on 9 out of 15 fields in this group.

Table 10. Fields with Unknown Crop in Spring DSS

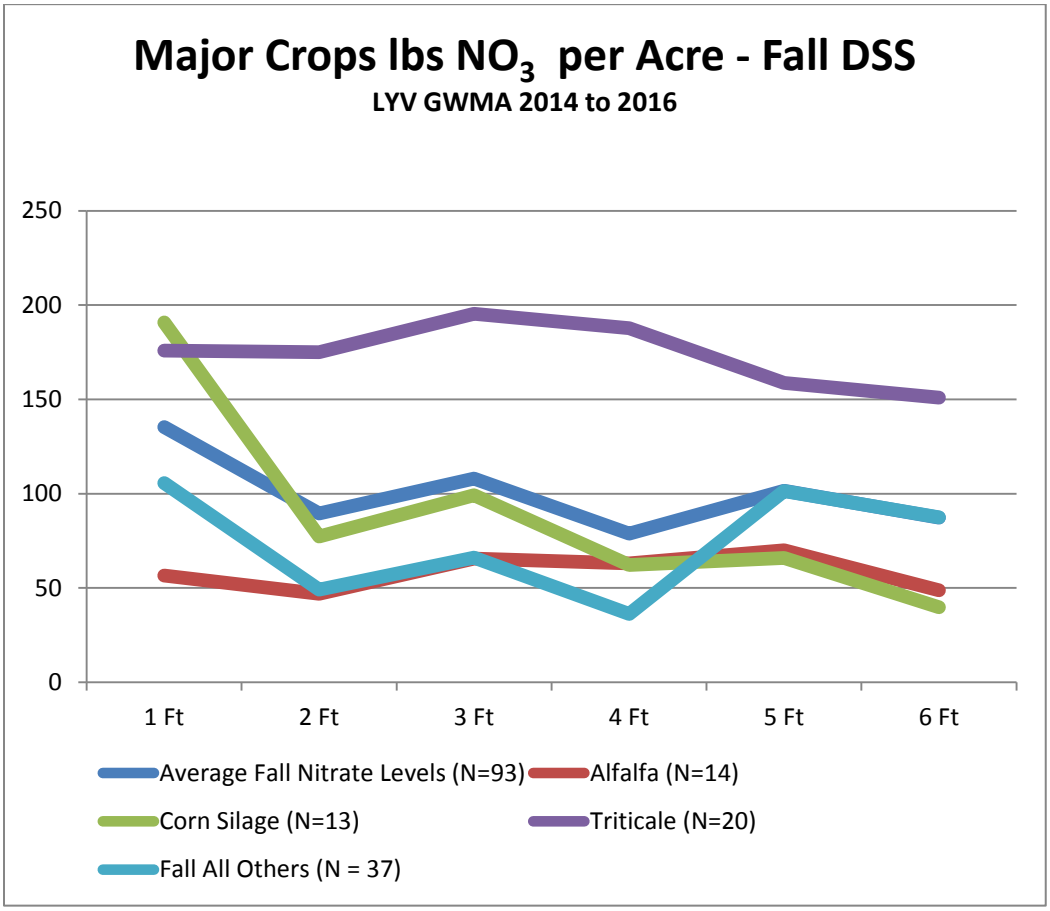
Field #	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total	Ammonia	Organic
2061	5	3	10	4			22	9	1.78
2062	5	6	11	14	10		46	7	0.84
4146	35						35	9	1.64
4147	54	51	96	197	323		721	13	1.82
4148	41	39					80	36	2.95
4151	37	10	6	4	5	3	65	16	1.19
4160	9						9	19	1.79
4162	14	4	3	3	3	63	30	30	1.66
4163	11	5	13	4	38	3	74	19	1
4164	6	3	3	5	16	14	47	12	1.54
4165	4	51	4	4	6		69	10	1.47
4168	52						52	21	3.2

4171	29	6	16	22	29	27	129	13	1.3
4172	25	11	3	3	3	19	64	15	2.02
4173	141	541	311	121			1114	24	2.64
Average	31.2	60.83	43.27	34.64	48.11	21.5	170.47	16.87	1.79

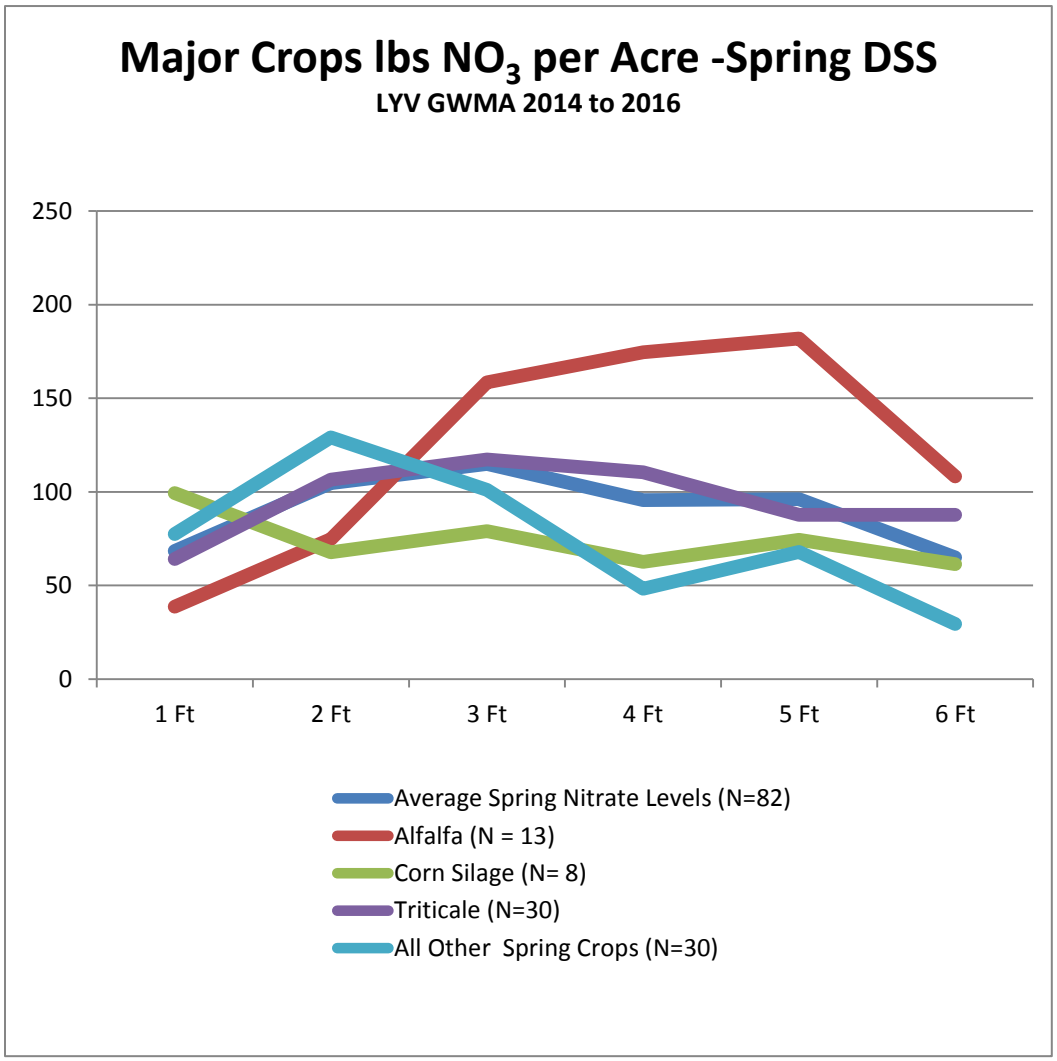
Comparison of Major Crops for Fall & Spring DSS:

Below are graphs that compare average nitrate levels for all crops to nitrate levels for: alfalfa, corn silage, triticale, and all other crops for the fall and spring DSS.

Graph 21.

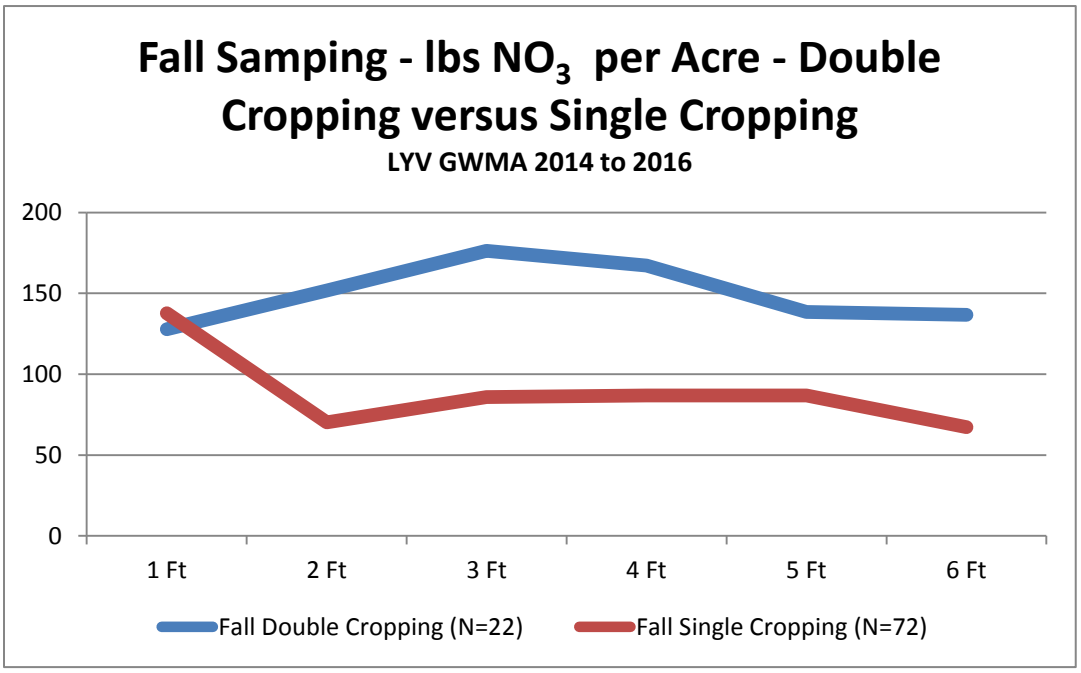


Graph 22.

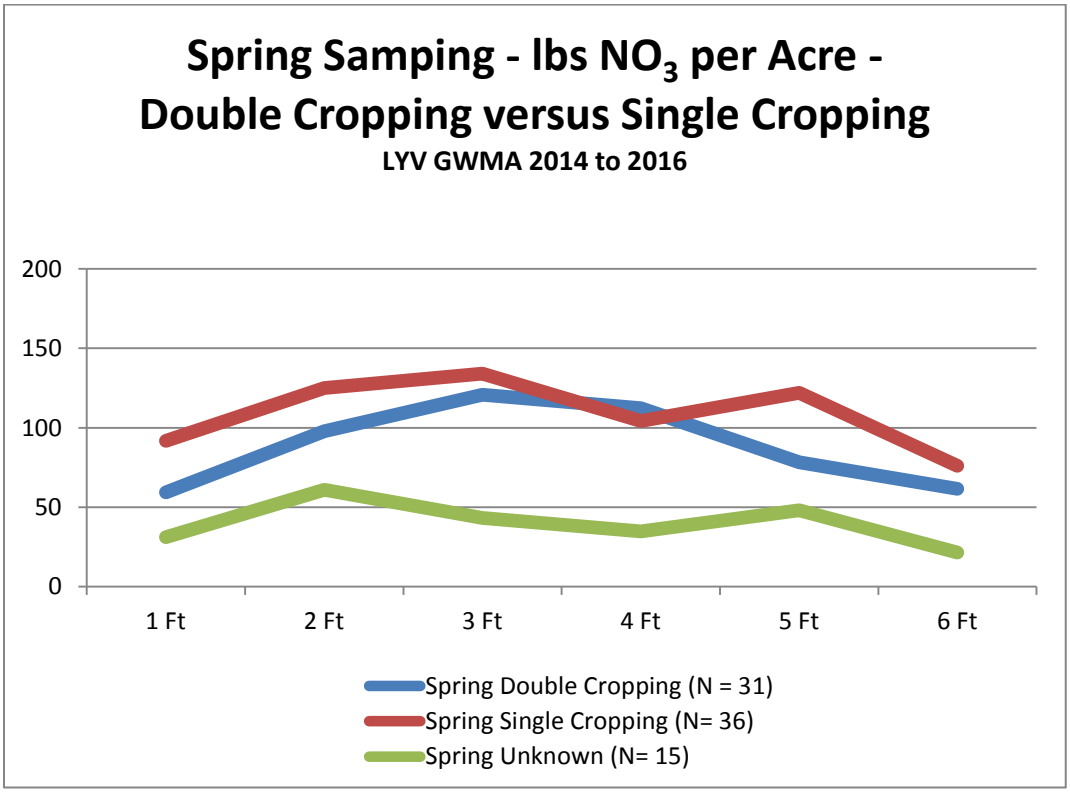


Double Cropping: This practice shows higher nitrate levels than single cropping in the fall sampling and general lower levels in the spring sampling. The 15 samples without cropping information for spring sampling complicate the analysis.

Graph 23.

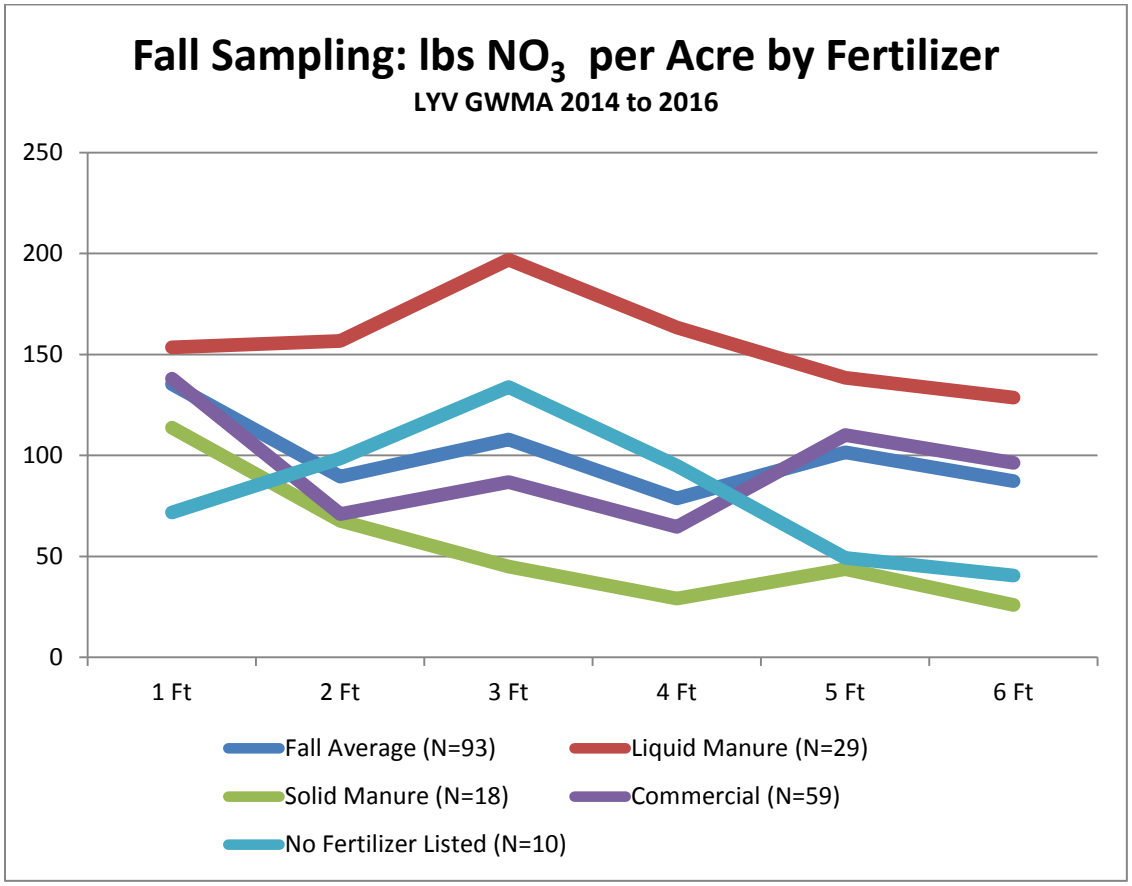


Graph 24.



Type of Fertilizer: For the fall sampling (N=93) there were fairly clear differences in nitrate levels for the various fertilizer types.

Graph 25. Fall Sampling by Fertilizer Type



There were 29 fields (31%) that received liquid manure. These fields had the highest percentage of organic matter. They were most likely to be double cropped and most likely to use sprinkler irrigation. Soil testing was highest for this group.

There were 18 fields (19%) that received solid manure. These fields had the highest ammonia levels and second highest levels of organic matter. They had the most rill irrigation and were least likely to receive sprinkler irrigation.

There were 59 fields (63%) that received commercial fertilizer. These fields had the lowest percentage of organic matter and were least likely to receive more than one type of fertilizer.

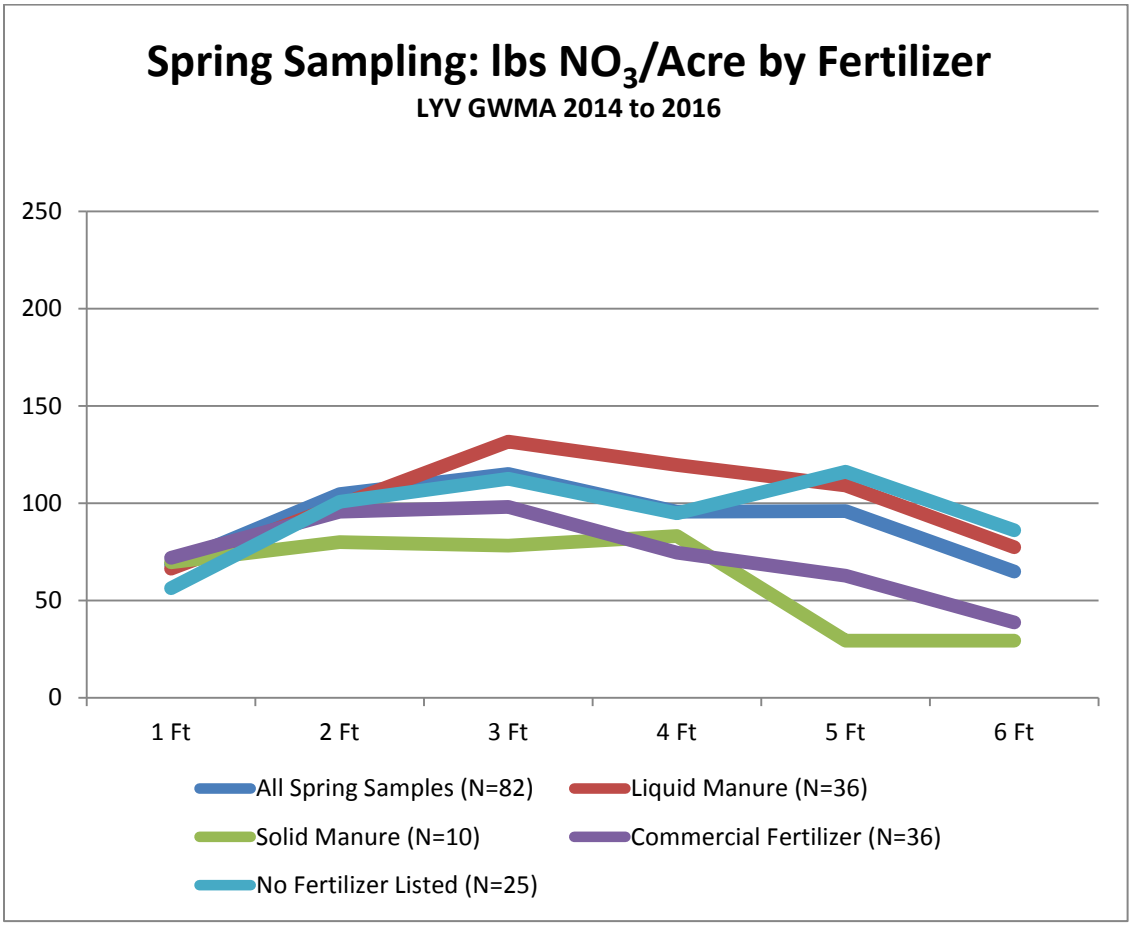
There were 10 fields (11%) with no fertilizer listed. These fields had the lowest ammonia levels and second lowest levels of organic matter. Soil testing was only done on half of these fields, the lowest percentage of all.

Table 11. Analysis of Fertilizer Types for Fall Sampling – LYV GWMA DSS

	NH_3 #/ac Average	Organic Matter	Double Cropped	Rill Irrigation	Sprinkler Irrigation	Soil Testing	> 1 Type Fertilizer
Fall Total N = 93	22.7	2.01%	24%	23%	71%	75%	
Liquid = 29	24.62	2.28%	38%	12%	88%	90%	55%
Solid N = 18	32.33	2.15%	28%	39%	61%	78%	50%
Commercial N = 59	20.27	1.9%	20%	26%	67%	80%	37%
None listed N = 10	15.5	1.94%	20%	10%	80%	50%	

For the spring sampling (N=82) nitrate levels were close together at shallow levels and spread out at deeper levels.

Graph 26. Spring Sampling by Fertilizer Type



There were 36 fields (44%) that received liquid manure. 18 of these fields also received commercial fertilizer. All had soil testing. These fields had the highest ammonia levels and the highest percentage of organic matter. They were most likely to be double cropped and had the highest percentage of sprinkler irrigation.

There were 10 fields (12%) that received solid manure. In contrast to the fall soil sampling these fields with solid manure had the lowest ammonia levels and the lowest levels of organic matter. They were least likely to be double cropped, least likely to receive sprinkler irrigation and most likely to receive drip irrigation. 60% received other additional fertilizers.

There were 36 fields (44%) that received commercial fertilizer. 18 of these fields also received liquid manure. These fields had the second highest ammonia levels and the second highest levels of organic matter.

There were 25 fields with no documented fertilizers. This includes fifteen fields with no survey data returned. These fields had the lowest levels of ammonia and organic matter.

Table 12. Analysis of Fertilizer Types for Spring Sampling – LYV GWMA DSS

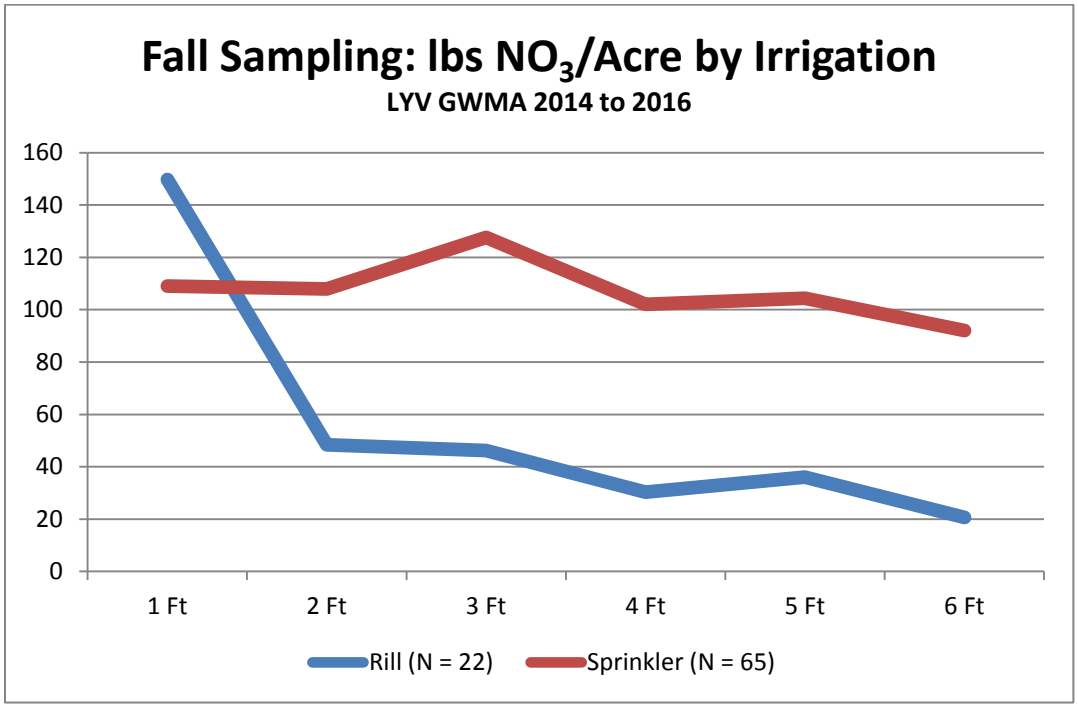
	NH_3 lbs/ac	Organic Matter	Double Cropped	Rill Irrigation	Sprinkler Irrigation	Drip Irrigation	Soil Testing	> 1 Type Fertilizer
Spring Total N = 82	23.8	2.13%	46%	10%	76%	10%	99%	35%
Liquid N = 36	30.86	2.36%	69%	8%	92%	0%	100%	56%
Solid N = 10	20.8	2.07%	50%	10%	70%	20%	100%	60%
Commercial N = 36	26.28	2.21%	56%	8%	78%	14%	97%	58%
None Listed N = 25	18.44	1.85%	4%					

Type of Irrigation: One field in the 93 fall samples received no irrigation. Five fields received drip irrigation and that analysis was complicated by early refusals and the fact that two fields had extremely high and unusual nitrate readings. For this reason drip irrigation is not included in the fall analysis.

Nitrate levels for the 65 fields that received sprinkler irrigation remained around 100 lbs per acre at all levels while the readings for the 22 fields that received rill irrigation rapidly declined after 1 foot.

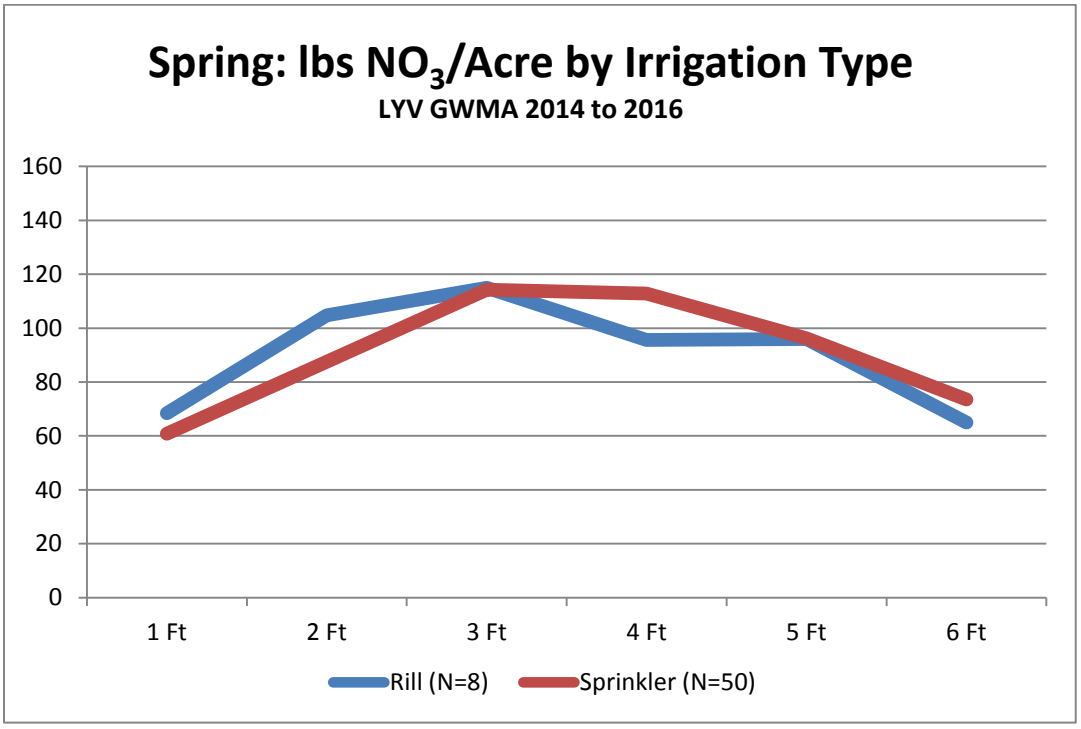
There were 2 fields that had both rill and sprinkler irrigation. They were placed in the rill category according to the DSS plan.

Graph 27.



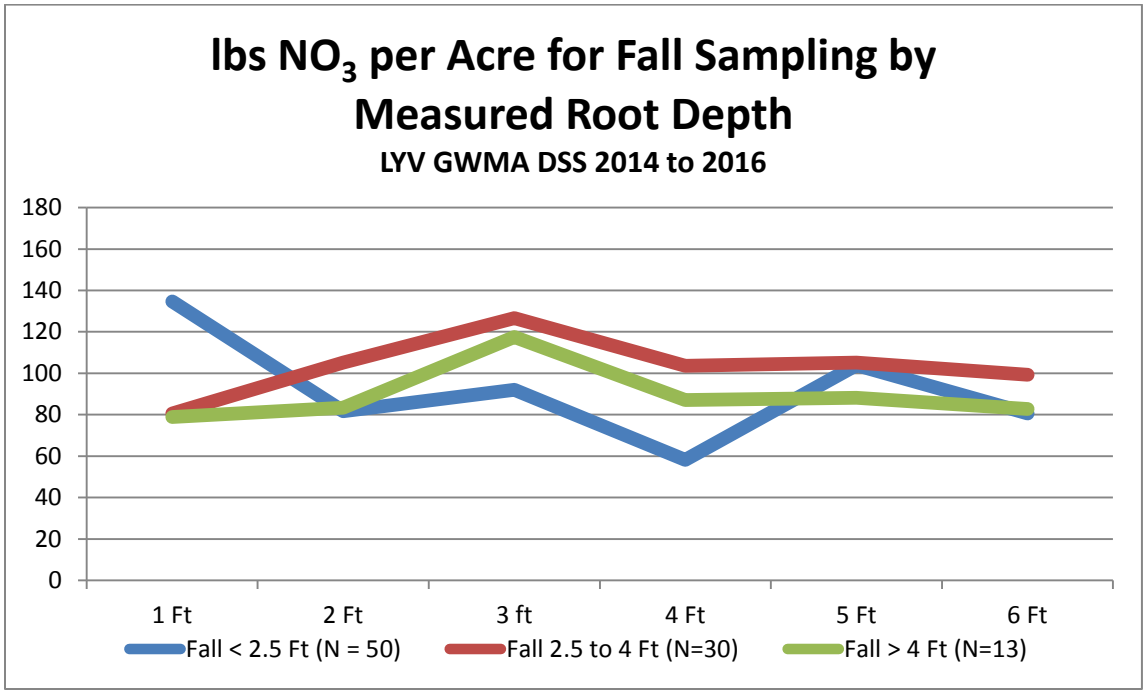
For clarity only rill and sprinkler irrigation for spring sampling are presented here.

Graph 28.



Measured Root Depth: The teams that gathered the soil samples measured root depths on each sampled field. This makes possible a comparison of nitrate levels based on how deep the root of crops penetrated the soil. This is not the same as grouping root depth by crops.

Graph 29.



Graph 30.

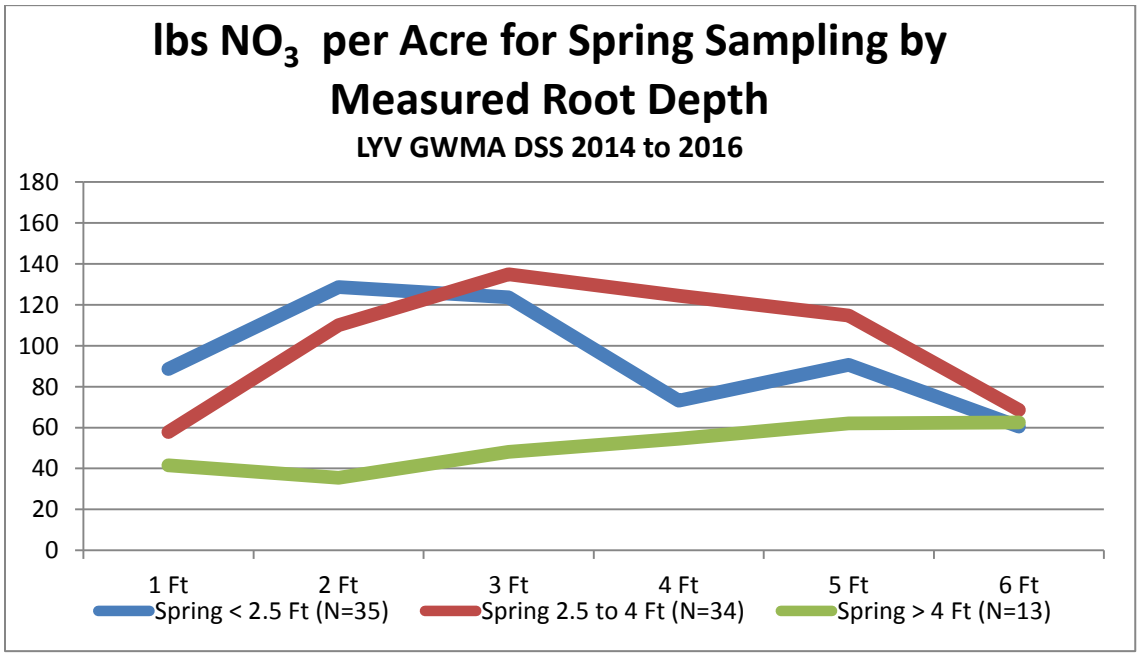


Table 13. NO_3 Levels by Measured Root Depths for Fall & Spring DSS

	Fall 2014 & 2015		Average N by Measured Root Depths						
Group	N	1 FT	2 Ft	3 Ft	4 Ft	5 Ft	6 Ft	Ammonia	Organic
< 2.5 Ft	50	134.72	81.76	92.02	58.15	103.91	80.63	35.46	2.06%
2.5 to 4 Ft	30	160.8	105.2	126.63	103.57	105.23	99.32	17.67	1.87%
> 4 Ft	13	78.92	83.38	117.54	87.08	88.17	82.83	23.69	2.12%
	Spring 2015 & 2016		Average N by Measured Root Depths						
Group	N	1 FT	2 Ft	3 Ft	4 Ft	5 Ft	6 Ft	Ammonia	Organic
< 2.5 Ft	35	88.6	128.63	123.64	73.1	90.6	60.5	23.23	2.21%
2.5 to 4 Ft	34	57.85	110.06	134.88	124.47	114.68	68.54	21.79	2.1%
> 4 Ft	13	41.54	35.46	48.08	54.54	62	62.46	30.62	2.03%

The measured root depths are different from the classification of root depths according to crop type. There is a full range of crops in each category of measured root depths. For example the category < 2.5 feet in the fall sampling included fields planted in triticale, corn, pasture, alfalfa, grapes, barley, mint, apples, grass hay, hops, and pears.

Note the lower nitrate levels for samples where the roots extend to deeper levels.

Statistical Analysis

Another way to look at the data is to describe the sampling at different soil depths. For the sake of brevity this paper only looks at the 2 Ft and 4 Ft depths. Two feet is the approved level for deep soil testing in Ecology's newly released CAFO General Permit. Four feet is below the root depth for most crops in the DSS and consequently estimates nitrate available for leaching.

The analyses that follow look at the results of soil testing at these levels from a statistical perspective. Previous graphing shows apparent differences in nitrate levels with respect to crops, irrigation, fertilizers and leaching factors. The Student T-test is used here to determine whether those differences have statistical significance. The calculations are

based on whether a factor is present or not present. There is no attempt to measure complex associations.

Two Foot Analysis

Table14. Characteristics of Risk Levels at Two Foot Sampling Depths (Low Risk is < 55 lbs NO_3/Acre, Medium Risk/High Risk is 55 lbs NO_3/Acre to 165 lbs NO_3/Acre, Very High Risk is > 165 lbs NO_3/Acre)

		Low Risk	Medium/High Risk	Very High Risk
N		96	47	27
Irrigation				
	Rill	19 (20%)	6 (13%)	3 (11%)
	Sprinkler	62 (65%)	35 (74%)	18 (67%)
	Drip	4 (4%)	4 (9%)	4 (15%)
	Unknown/None	12 (12%)	2 (4%)	2 (7%)
Crops				
	Alfalfa	19 (20%)	6 (13%)	2 (7%)
	Apples	3 (3%)		1 (4%)
	Asparagus			2 (7%)
	Barley	1 (1%)		
	Cherries	3 (3%)		
	Corn Grain		2 (4%)	2 (7%)
	Fallow		1 (2%)	
	Corn Silage		9 (19%)	2 (7%)
	Grapes	3 (3%)	1 (2%)	2 (7%)
	Hay	3 (3%)		
	Hops	4 (4%)	3 (6%)	3 (11%)
	Mint	6 (6%)	1 (2%)	
	Pasture	5 (5%)	1 (2%)	
	Pears	1 (1%)		
	Sudan Grass		1 (2%)	
	Triticale	19 (20%)	21 (45%)	10 (37%)
	Wheat	2 (2%)		2 (7%)
	Wine Grapes	1 (1%)	1 (2%)	
	Unknown	11 (11%)		1 (4%)
	Double Crop	26 (27%)	15 (32%)	10 (37%)

Fertilizer							
	Liquid Manure		29 (30%)		22 (47%)		12 (44%)
	Solid Manure		17 (18%)		8 (17%)		3 (11%)
	Commercial		54 (56%)		26 (55%)		13 (52%)
	Biosolids						1 (4%)
	Compost		2 (2%)				
	Unknown/None				7 (15%)		5 (19%)
Leaching							
	Low		5 (5%)		4 (9%)		1 (4%)
	Moderate		78 (81%)		39 (83%)		25 (93%)
	High		13 (14%)		4 (9%)		1 (4%)

A. Irrigation Types: Analysis using the Student T-test at the 2 foot soil testing depth finds no statistically significant difference in nitrate levels for different types of irrigation except that rill irrigation is associated with lower nitrate levels at the $p < .10$ level of significance.

Rill Irrigation: The average nitrate level at two feet for fields that received rill irrigation is 61.67 lbs per acre. The average nitrate level at two feet for fields with documented irrigation type that did not receive rill irrigation is 102.66 lbs per acre. *The t-value is -1.41917. The p-value is .078941. The result is not significant at p < .05 but it is significant at p < .10.*

B. Crops by Category from DSS Plan: Analysis using the Student T-test was performed for crops at the < 2.5 ft root depth, 2.5 to 4 ft root depth, > 4 ft root depth, > 4 ft root depth minus alfalfa, for alfalfa, corn silage and triticale. Soil tests for fields with no documented crops were omitted from the calculations. Most results were not statistically significant. Here are the noteworthy results.

< 2.5 Ft Root Depth: The average nitrate level at two feet for this category was 24.43 lbs per acre (N=7). The average nitrate level for all other categories was 102.58 lbs per acre. *The t-value is -1.34184. The p-value is .090799. The result is not significant at p < .05 but it is significant at p < .10.*

Alfalfa: The average nitrate level at two feet for alfalfa was 60.30 lbs per acre. The average nitrate level for all other crops was 107.11 lbs per acre. *The t-value is -1.47226. The p-value is .071482. The result is not significant at p < .05 but it is significant at p < .10.*

Triticale: The average nitrate level at two feet for triticale was 133.90 lbs per acre. The average nitrate level for all other crops was 83.01 lbs per acre. *The t-value is 1.98851. The p-value is .024252. The result is significant at p < .05.*

C. Fertilizer: It appears that the type of fertilizer impacts nitrate levels at two feet.

a. Looking at all 170 samples with results at two feet the Student T-test tells us that the higher levels of nitrates seen with application of liquid manure are significant.

Liquid M: The average nitrate level at two feet for fields that received liquid manure is 125.57 lbs per acre. The average level for fields that did not receive liquid manure is 79.24 lbs per acre. *The t-value is 1.94819. The p-value is .026529. The result is significant at p < .05.*

Commercial: The average nitrate level for fields that received commercial fertilizer is 80.18 lbs per acre. The average nitrate level for fields that did not receive commercial fertilizer is 116.49 lbs per acre. *The t-value is -1.56554. The p-value is .059669. The result is not significant at p < .05 but it is significant at p < 0.10.*

Differences in nitrate levels for other fertilizer types are not significant for this data set.

b. If we leave out the fields with no documented fertilizer applications and look only at the 135 samples known to receive fertilizer the Student T-test tells us that, at two feet, the higher levels of nitrates seen with application of liquid manures and the lower levels seen with application of commercial fertilizer are significant.

Liquid M: The average nitrate level at two feet for fields that received liquid manure is 125.57 lbs per acre. The average nitrate level for fertilized fields that did not receive liquid manure is 67 lbs per acre. *The t-value is 2.39048. The p-value is .009114. The result is significant at p < .05.*

Commercial: The average nitrate level at two feet for fields that received commercial fertilizer is 80.18 lbs per acre. The average nitrate level for fertilized fields that did not receive commercial fertilizer is 126.78 lbs per acre. *The t-value is -1.73592. The p-value is .042447. The result is significant at p < .05.*

D. Leaching Categories: 142 out of the 170 fields (84%) with data at two feet had soils in the moderate to moderately high Ksat category. This makes analysis of leaching less certain. This data showed no significant differences in nitrate levels for the three leaching categories except for a possible mild effect at the p < .10 level of significance.

Moderate: The average nitrate value at the two foot level for fields with moderately high to high Ksat soils was 103.93 lbs per acre. The average nitrate level for fields not in that category was 58.29 lbs per acre. *The t-value is 1.46704. The p-value is .072118. The result is not significant at p < .05 but it is significant at p < .10.* Note that both low to moderately low and high to very high fields had lower nitrate levels than moderately high to high. The graph is dome shaped and not a straight line.

Four Foot Analysis

Table15. Characteristics of Risk Levels at Four Foot Sampling Depths (Low Risk is < 55 lbs NO_3/Acre, Medium Risk/High Risk is 55 lbs NO_3/Acre to 165 lbs NO_3/Acre, Very High Risk is > 165 lbs NO_3/Acre)

		Low Risk	Medium/High Risk	Very High Risk
N		89	34	24
Irrigation				
	Rill	21 (23%)	6 (18%)	2 (8%)
	Sprinkler	52 (59%)	23 (68%)	19 (79%)
	Drip	7 (8%)	4 (12%)	
	Unknown/None			3 (13%)
Crops				
	Alfalfa	16 (18%)	3 (9%)	4 (21%)
	Apples	2 (2%)	1 (3%)	
	Asparagus			2 (8%)
	Barley	1 (1%)		
	Cherries	1 (1%)		
	Corn Grain	4 (4%)	2 (6%)	
	Corn Silage	13 (15%)	5 (15%)	2 (8%)
	Grapes	2 (2%)	1 (3%)	2 (8%)
	Hay	3 (3%)		
	Hops	7 (8%)	3 (9%)	
	Mint	5 (6%)	2 (6%)	
	Pasture	5 (6%)		
	Pears	1 (1%)		
	Sudan Grass	1 (1%)		
	Triticale	16 (18%)	15 (44%)	12 (50%)

	Wheat		1 (1%)		1 (3%)		
	Wine Grapes		2 (2%)				
	Unknown		9 (10%)		1 (3%)		1 (4%)
	Double Crop		19 (21%)		13 (38%)		12 (50%)
Fertilizer							
	Liquid Manure		20 (23%)		17 (50%)		11 (46%)
	Solid Manure		20 (23%)		5 (15%)		1 (4%)
	Commercial		47 (53%)		16 (47%)		8 (33%)
	Biosolids		2 (2%)				1 (4%)
	Compost						
	Unknown/None		10 (11%)		1 (3%)		9 (38%)
Leaching							
	Low		2 (2%)				1 (4%)
	Moderate		76 (85%)		30 (88%)		22 (92%)
	High		11 (12%)		4 (12%)		1 (4%)

A. Irrigation Type: Analysis using the Student T-test at the 4 foot level finds a statistically significant association between sprinkler irrigation and higher nitrate levels and a statistically significant association between rill irrigation and lower nitrate levels.

Rill Irrigation: The average nitrate reading at 4 feet for fields that receive rill irrigation was 40.3 lbs per acre. The average reading for fields that did not receive rill irrigation was 98.54 lbs per acre. *The t-value is -1.92605. The p-value is .028124. The result is significant at p < .05.*

Sprinkler Irrigation: The average nitrate reading at 4 feet for fields that receive sprinkler irrigation was 106.59 lbs per acre. The average reading for fields that did not receive sprinkler irrigation was 37.66 lbs per acre. *The t-value is 2.54584. The p-value is .006025. The result is significant at p < .05.*

Drip Irrigation: The average nitrate reading at 4 feet for fields that receive drip irrigation was 30.45 lbs per acre. The average reading for fields that did not receive drip irrigation was 90.42 lbs per acre. *The t-value is -1.29622. The p-value is .098581. The result is not significant at p < .05 but it is significant at p < .10.*

B. Crops: Analysis using the Student T-test was performed for crops at the < 2.5 ft root depth, 2.5 to 4 ft root depth, > 4 ft root depth, > 4 ft root depth minus alfalfa, for alfalfa, corn

silage and triticale. Soil tests for fields with no documented crops were omitted from the calculations. The only statistically significant results were for triticale.

Triticale: The average nitrate level at four feet for triticale was 142.81 lbs per acre. The average nitrate level at four feet for all other crops was 66.46 lbs per acre. The *t*-value is 2.75448. The *p*-value is .003348. The result is significant at $p < .05$.

Unusually high nitrate levels at four feet for a few alfalfa fields complicate the analysis.

C. Fertilizer: The data suggests that the type of fertilizer impacts nitrate levels at four feet.

a. Looking at all 147 samples that had data at 4 feet the Student T-test tells us that the higher levels of nitrates seen with application of liquid manure are significant. There may be a more modest reduction of nitrate levels with solid manure and commercial fertilizer.

Liquid M: The average nitrate level at four feet for fields that received liquid manure is 139.65 lbs per acre. The average for fields that did not receive liquid manure is 60.61 lbs per acre. *The t-value is 3.08855. The p-value is .001206. The result is significant at p < .05.*

Solid M: The average nitrate level at four feet for fields that received solid manure is 47.85 lbs per acre. The average for fields that did not receive solid manure is 94.7 lbs per acre. *The t-value is -1.45353. The p-value is .074119. The result is not significant at p < .05 but it is significant at p < .10.*

Commercial: The average nitrate level at four feet for fields that received commercial fertilizer is 68.19 lbs per acre. The average for fields that did not receive commercial fertilizer is 108.79 lbs per acre. *The t-value is -1.64521. The p-value is .051047. The result is not significant at p < .05 but it is significant at p < .10.*

b. Looking only at the 117 samples that had data at 4 feet and received fertilizer, the Student T-test tells us that the increased nitrate levels associated with liquid manure and the decreased nitrate levels associated with commercial fertilizer are significant.

Liquid M: The average nitrate level at four feet for fields that received liquid manure is 139.65 lbs per acre. The average for fertilized fields that did not receive liquid manure is 45.71 lbs per acre. *The t-value is 3.4706. The p-value is .000366. The result is significant at p < .05.*

Solid M: The average nitrate level at four feet for fields that received solid manure is 47.85 lbs per acre. The average for fertilized fields that did not receive solid manure is 94.65 lbs per acre. *The t-value is -1.40234. The p-value is .081753. The result is not significant at p < .05 but it is significant at p < .10.*

Commercial: The average nitrate level at four feet for fields that received commercial fertilizer is 68.19 lbs per acre. The average for fertilized fields that did not receive commercial fertilizer is 120.39 lbs per acre. *The t-value is -1.74448; p-value is .041874. The result is significant at p < .05.*

D. Leaching: There were no statistically significant differences in the nitrate levels at four feet for the three leaching categories in this study.

Conclusion

This summary of the LYV GWMA DSS concludes that:

- There are differences between spring and fall deep soil testing results
- There was unequal coverage of the various combinations of irrigation practices, crop types and leaching factors.
    - Data was gathered for 15 out of 27 categories.
    - Only 7 categories had six or more samples
    - One category had 3 samples
    - Two categories had 2 samples
    - Five categories had only one sample.
- Sixty five of 175 samples or 37% fell into the category of sprinkler irrigation, 2.5 ft to 4 ft crops and moderately high to high Ksat
- There were fields with extreme values that would ideally be re-tested. Those fields are #'s 3141, 2044, 2047, 4152, 3117, and 3119.
- The two asparagus samples, #'s 4175 and 4176 may not be representative of that crop
- The range of values for alfalfa is huge and suggests a need for further study
- The range of values for hops is large and suggests a need for further study
- Over half of the fields planted in triticale are at medium to high risk for leaching nitrate to the groundwater
- Double cropping is associated with higher nitrate levels
- In this data set rill irrigation is more protective of the groundwater than sprinkler irrigation
- Application of liquid manure is significantly more likely to result in high nitrate levels
- There is more soil testing on fields with higher nitrate levels.
- There are wide ranges in values for many of the crops in this data set.
- Some of the project purposes were not achieved in this round of DSS. Baseline data for many of the crops and conditions is still lacking. However there is adequate information to proceed with recommendations regarding triticale and application of liquid manure.

References

Lower Yakima Valley Groundwater Management Area (2014) *Deep Soil Sampling Plan Lower Yakima Valley Groundwater Management Area.* (Attachment 1)

Lower Yakima Valley Groundwater Management Area (2013) *PP Summary of Proposed Allocation Processes.* (Attachment 2)

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