2008 ANNUAL REPORT

THE AGRICULTURAL CHEMICALS AND GROUNDWATER PROTECTION ACT

Colorado Department of Agriculture
Colorado State University Extension
Colorado Department of Public Health and Environment

www.colorado.gov/ag/GW

2008 Annual Report
Colorado Department of Agriculture

Rules for Agricultural Chemical Bulk Storage Facilities and Mixing/Loading Areas

Section 25-8-205.5 (3)(b) of the Agricultural Chemicals and Groundwater Protection Act requires the Commissioner of Agriculture to develop rules where pesticides and fertilizers are stored or handled in quantities that exceed the established thresholds. These rules were adopted in July 1994 and became effective September 30, 1994.

During 2008, facilities were visited to provide information and answer specific questions regarding the rules for bulk storage and mixing/loading facilities. This educational process aids individuals in determining first, whether or not compliance with the rules is required and second, what specifically must be accomplished to meet the requirements.

Pesticide and fertilizer facility inspections continued in 2008. A total of 18 pesticide secondary containment structures and 30 pesticide mixing/loading areas were inspected. A total of 46 fertilizer secondary containment structures and 46 fertilizer mixing/loading areas were also inspected. A total of 20 follow-up inspections were also conducted to ensure that problems noted on previous facility inspections were corrected. In addition, one Violation Notice was issued during 2008. Finally, 23 follow-up inspection orders were issued for problems at facilities that were not serious enough at this time to warrant a Cease and Desist Order or Violation Notice. Inspection of pesticide and fertilizer facilities will be ongoing during 2009.

One requirement of the rules is that the facility design be signed and sealed by an engineer registered in the state of Colorado; or the design be from a source approved by the Commissioner and available for public use. The Colorado Department of Agriculture (CDA) in conjunction with Colorado State University Extension (CSUE) produced a set of plans that meet the second criteria. The document is entitled, *Plans For Small To Medium-Sized Agricultural Chemical Bulk Storage & Mix/Load Facilities*. The plans are available from CDA or CSUE free of charge. Copies of the complete rules and a summary sheet that contains a checklist to allow individuals to determine if the rules apply to their operation are also available from CDA, CSUE, or via CDA's website at *www.colorado.gov/ag.*
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Pesticide Registration and Groundwater Protection

The Program continues to review pesticide products for registration in Colorado which have groundwater label advisories, and advise CDA's Pesticide Registration Program on the merits of registering these products.

Federal Regulations for Pesticide Containment

The Environmental Protection Agency (EPA) proposed standards for pesticide containers and containment in 1994 and has taken public comment three times, in 1994, 1999, and again in 2004. The EPA's final regulations, *Standards for Pesticide Containers and Containment* (Federal Register Vol. 71, Number 158, pp. 47329 – 47437), were published on August 16, 2006. The EPA will allow states with existing pesticide containment rules to continue implementing the State's rules if EPA determines that these rules are equivalent in environmental protection to EPA's new regulations. Colorado (CDA) submitted its request to continue implementing its rules in lieu of the Federal regulations in August 2007, and is currently waiting on guidance from EPA on how to proceed with its justification for complying with the federal regulations.

Waste Pesticide Disposal

In 1995, CSUE operated a pilot waste pesticide collection program in Adams, Larimer, Boulder, and Weld counties. The purpose of this type of program is to provide pesticide users an opportunity to dispose of banned, canceled, or unwanted pesticides in an economical and environmentally sound manner. Part of the funding for the program was provided by an EPA Nonpoint Source 319 grant. Approximately 17,000 lbs. of waste pesticides from 67 participants was collected and safely disposed.

Based on the success of this pilot program, CDA was asked to continue a program that could collect and dispose of waste pesticides in other areas of the state. However, CDA had no statutory authority or funding to operate such a program. In light of this, two alternatives were discussed as a way for a waste pesticide collection program to continue. The first was for CDA to seek statutory authority and funding from the Legislature to operate a state-run program. The second was to determine if a private program, operated by a hazardous waste handling company, was possible.

The CDA spoke with hazardous waste contractors to determine if they would be interested in attempting to collect and dispose of waste pesticides as a private program. One company, MSE Environmental Inc., stated they would be interested. Discussions were initiated with the company and it appeared it would be possible for MSE to operate a private program at a reasonable cost to the participants. The collection and disposal costs for participants would be between $2.25 and $2.65 a pound.

Based on this information, it was determined that the private program option would be pursued since the possibility of getting legislation passed was slim. Furthermore, the time required for legislation to be passed would considerably delay the operation of a program. After numerous issues were addressed, MSE targeted two areas of the state to initiate the program - the San Luis Valley and six counties in northeastern Colorado. This program was very successful with over 10,500 lbs. of waste pesticides collected from 33 participants; the cost to participants was $2.65 per pound.

Based on the success of this program, MSE conducted a statewide collection program in November 1997. Over 23,000 lbs. of waste pesticides were collected from 75 participants; again the cost was $2.65 per pound. Subsequent programs are as follows:

Year	Pesticides Collected (lbs.)	Number of Participants
1998	0	0
1999	19,792	47
2000	0	0
2001	13,486	34
2002	8,762	33
2003	2,254	7
2004	8,520	10

2005	5,023	11
2006	No Report	No Report
2007	4,600	4
2008	3,109	9

In 2006, Clean Harbors, Inc. took responsibility for this program from MSE. The CDA is working with Clean Harbors to make sure this program continues in an efficient manner.

Pesticide Use Survey

The CDA and CSUE conducted an on-line pesticide use survey for Colorado in 2006 and 2007. There were over 900 licensed, commercial pesticide applicators in Colorado's 64 counties that were asked to participate in this voluntary, anonymous survey. Due to an inadequate response in 2006, the survey was conducted again in 2007. Unfortunately, the 2007 survey received only slightly better response rates but not enough to allow for any in depth data analysis. The survey process will be reevaluated before another survey is conducted.

The last pesticide use survey was conducted in 1997 and after over 10 years, updated information is needed. This information is particularly important to help the Department register pesticides for use, especially Section 18 requests, update crop profiles, and provide correct data to keep products registered under the Food Quality Protection Act (FQPA). It also helps provide unbiased, accurate information to identify and address environmental concerns and to focus CDA's water quality monitoring efforts. Updated information is also necessary to better focus the Department's resources on areas that have the greatest potential to impact public health and the environment.

Program Comprehensive Publication

In 2008, program personnel completed work on a publication that provides a history of the work and accomplishments of the Program since 1990. The publication is entitled *Agricultural Chemicals & Groundwater Protection in Colorado 1990-2006* (Colorado Water Resources Research Institute Special Report 16) and is available from CDA or CSUE.

Surface Water Sampling Project

The CDA has begun collecting surface water samples for pesticide analysis based on the recent *Pesticides of Interest* list EPA has created. The CDA is responsible for reporting on how it is managing the approximately 50 pesticides on this list that may affect ground and/or surface water. In 2008, CDA worked with CDPHE, and EPA to coordinate the collection and analysis of 20 surface water samples. After evaluating the 2008 program, the plan for 2009 is to collect and analyze about 30 samples and again evaluate the process before committing more resources to this project. From CDA's perspective, it will be interesting to see how surface water is being impacted by pesticides and how this might relate to CDA's groundwater sampling program for pesticides.

Groundwater Monitoring – Reporting Year 2008

Overview

The Groundwater Protection Program accomplished several tasks in its 18th year of monitoring responsibilities. The Weld County long-term monitoring, irrigation, and domestic well networks were all sampled and analyzed for the full suite of pesticides, nitrate- and nitrite-nitrogen. Sixteen monitoring wells were sampled as part of a sampling method study comparing the new low-flow minimum drawdown technology to the previously used conventional method of 3-5 casing volume evacuation with an electric submersible pump. Outside of comparable inorganic values for each well, very few wells had useful pesticide detections that could be statistically compared for difference between sampling methods.

The Front Range Urban monitoring network, recently sampled partially in 2007, was re-sampled in its entirety in 2008 with the exception of three wells in Denver-metro, two in Pueblo, and one in Castle Rock. A total of 67 of the 73 monitoring wells in the network were sampled in 2008. Laboratory complications in 2007 prevented the samples from being analyzed for pesticides and therefore required a re-sampling in order to achieve an adequate baseline sampling for this network. Where appropriate, nitrate results for samples collected in both sampling years were compared. Results from sampling of the Front Range Urban network were presented at the 2008 South Platte Forum.

The Lower South Platte and Arkansas Valley monitoring well networks were sampled as according to the Program's long-term sampling plan initiated in 2007. Also on the schedule was the High Plains region which was last sampled in 1997-1998. The previous sampling event for this area utilized domestic and irrigation well types while this year's sampling utilized a newly installed network of 20 monitoring wells. The Program contracted the United States Geologic Survey to utilize their expertise and tools for determining appropriate locations for monitoring wells in the Ogallala formation of eastern Colorado and then contracted a drilling outfit from Fort Collins to install the well network.

Weld County Long-Term Networks

These three well networks have been sampled annually since 1995. The network of 20 monitoring wells had three problematic wells that were either consistently dry or damaged. As mentioned in the 2007 Annual Report, these three wells were re-drilled and additionally three new sites were added to the network including a site that has multi-depth wells for comparing results at different depths in the South Platte alluvial aquifer. Of the now 24 monitoring wells, at 23 sites, all were sampled with the exception of one that had too low a volume to be sampled.

As mentioned in the 2007 Annual Report, a change was made in sampling methodology from the previous conventional, electrical submersible pumping method to a new low-flow bladder pump method due to evidence that low-flow, minimal drawdown sampling of monitoring wells more accurately depicts what contaminants are actually in motion with the water in the aquifer. Furthermore, use of a bladder pump increases the likelihood that a low volume or slow yielding well can still be sampled when the conventional method is not feasible. Due to this change in methodology a sampling method comparative study was conducted on 16 of the long-standing wells in the monitoring well network to determine if any differences in analysis would result.

For the study each well was sampled first with the low-flow bladder pump method and then the conventional method promptly afterward. Each method utilized a flow-through cell and multi-parameter stabilization for determining when adequate purging had occurred which is standard protocol employed by the Program. All samples were analyzed for the full suite of pesticides, nitrate- and nitrite-nitrogen at CDA laboratory, and for basic inorganic nutrients and dissolved metals at CSU's Soil, Plant, and Water Testing Laboratory in Fort Collins, CO. In short, no statistically significant differences were observed in basic inorganic nutrients (including nitrate and nitrite) or dissolved metals when utilizing common non-parametric statistical tests.

Unfortunately, very few wells came back with quantifiable amounts of pesticide compounds so a useful comparison between wells for several pesticide compounds was not possible.

A follow-up study will be conducted in sampling year 2009 but will not be restrained to just Weld County monitoring wells. Wells from the Weld County long-term network were initially selected due to long-term history of pesticide detections and/or elevated nitrate levels. Even though these prospect wells did not turn up useful pesticide detections for the purpose of the study, several wells from various other networks contained detectable quantities of pesticide products in 2008, and from these various networks a selection of wells will be made and utilized for the follow-up study in 2009. Upon completion of the follow-up a detailed report will be completed discussing the results of the sampling method comparative study.

All of the following results are from water samples collected with the low-flow method.

Weld County Monitoring Well Network
Nitrate Concentrations 2008

Statistic	Domestic	Irrigation	Monitoring
Average	14.4	16.31	23.7
Median	8.1	14.87	21.5
Minimum	2.0	BDL	3.0
Q1	4.3	8.71	10.0
Q3	20.9	23.99	29.3
Maximum	48.0	37.04	64.6
# Samples	9	35	23
% Wells Above STD	44.4	68.6	73.9

Table 1. Nitrate-nitrogen concentrations for Weld County long-term well networks sampled in 2008. Units are in ppm or mg L^{-1}. BDL is below detectable limit.

2008 Nitrate Results

As can be seen in Table 1 all three well network types had wells with nitrate-nitrogen over the EPA drinking water standard of 10.0 ppm in 2008. The monitoring well network has the highest percent of wells over the standard as has been the case historically most likely due to the fact that these wells access the very top of the aquifer and therefore are sampling the most recently recharged water to the aquifer. The maximum nitrate concentrations in the various network types are comparable to historic values that have been reported in the past with the exception of the domestic network maximum of 48.0 ppm. The well containing this concentration of nitrate-nitrogen is a new well added to the domestic well network in 2007. The Weld County long-term study as a whole had a median nitrate-nitrogen concentration of 14.9 ppm with 67% of all wells sampled having 10.0 ppm or more.

Results in 2008 for the various Weld County long-term well networks are in line with historical data (Table 2). All long-standing monitoring well (those not recently re-installed or newly installed) results for 2008 are very comparable to their historical results as seen in Figure 1. Wells with a dotted circle around them are the recently installed wells which all have nitrate-nitrogen present at greater than 10.0 ppm. Four of the seven wells have 40.0+ ppm of nitrate-nitrogen. The sample site just north of Platteville is the location with two monitoring wells installed at different depths. The shallow well is installed so the top two feet of a 10-ft screened interval is just above the top of the water table, while the deeper well is installed so the top of its 10-ft screened interval is about 5 ft below the bottom of the screened interval of the shallow well.

Weld County Monitoring Well Network Nitrate Concentrations 1995-2007			
Statistic	**Domestic**	**Irrigation**	**Monitoring**
Average	13.45	16.9	22.8
Median	9.27	16.4	19.1
Minimum	0.25	BDL	1.7
Q1	4.37	9.5	8.21
Q3	19.75	25.4	30.4
Maximum	51.7	82	111.3
# Samples	76	554	239

Table 2. Nitrate-nitrogen concentrations for Weld County long-term well networks, sampled from 1995 to 2007. Units are in ppm or mg L^{-1}. BDL is below detectable limit.

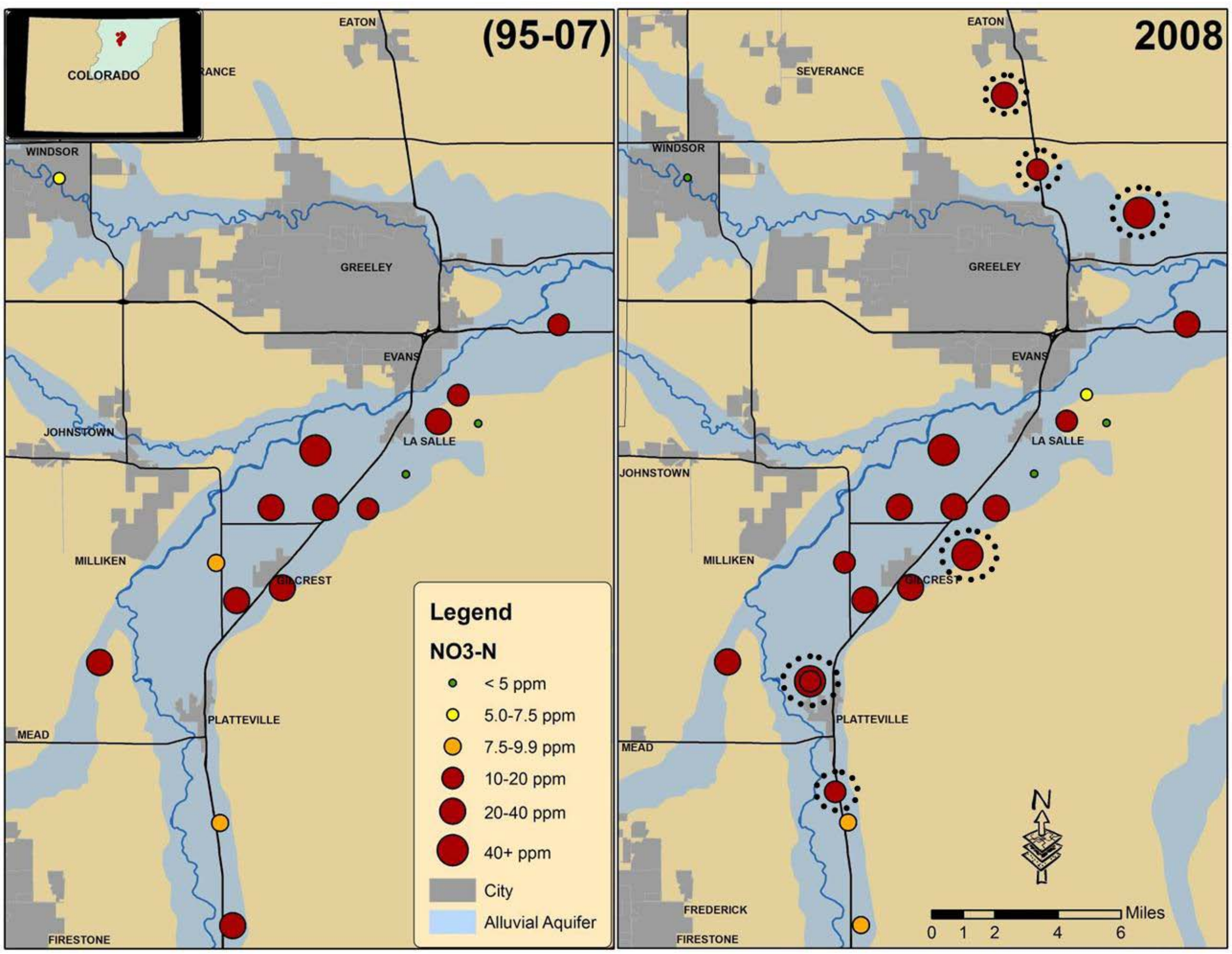

Figure 1. Historical and 2008 median nitrate results for Weld County monitoring wells. Graduated symbols represent relative amounts of nitrate. Red symbols signify locations with nitrate above EPA Drinking Water Standard. Wells with dotted spheres signify a newly installed or repaired well.

The reason for installing two wells in this fashion was to learn of any variation in nitrate concentration in the South Platte alluvial aquifer. It is known that in most cases nitrate concentrations will be higher in the shallower sections of the aquifer for multiple reasons including the lack of a dilution affect encountered deeper in the aquifer and the higher dissolved oxygen levels which do not facilitate the facultative anaerobic bacteria responsible for denitrification which tends to lower nitrate concentration through degradation to nitrogen gas. Other factors may affect nitrate concentrations with depth in an alluvial aquifer but the above mentioned factors are some of the main factors.

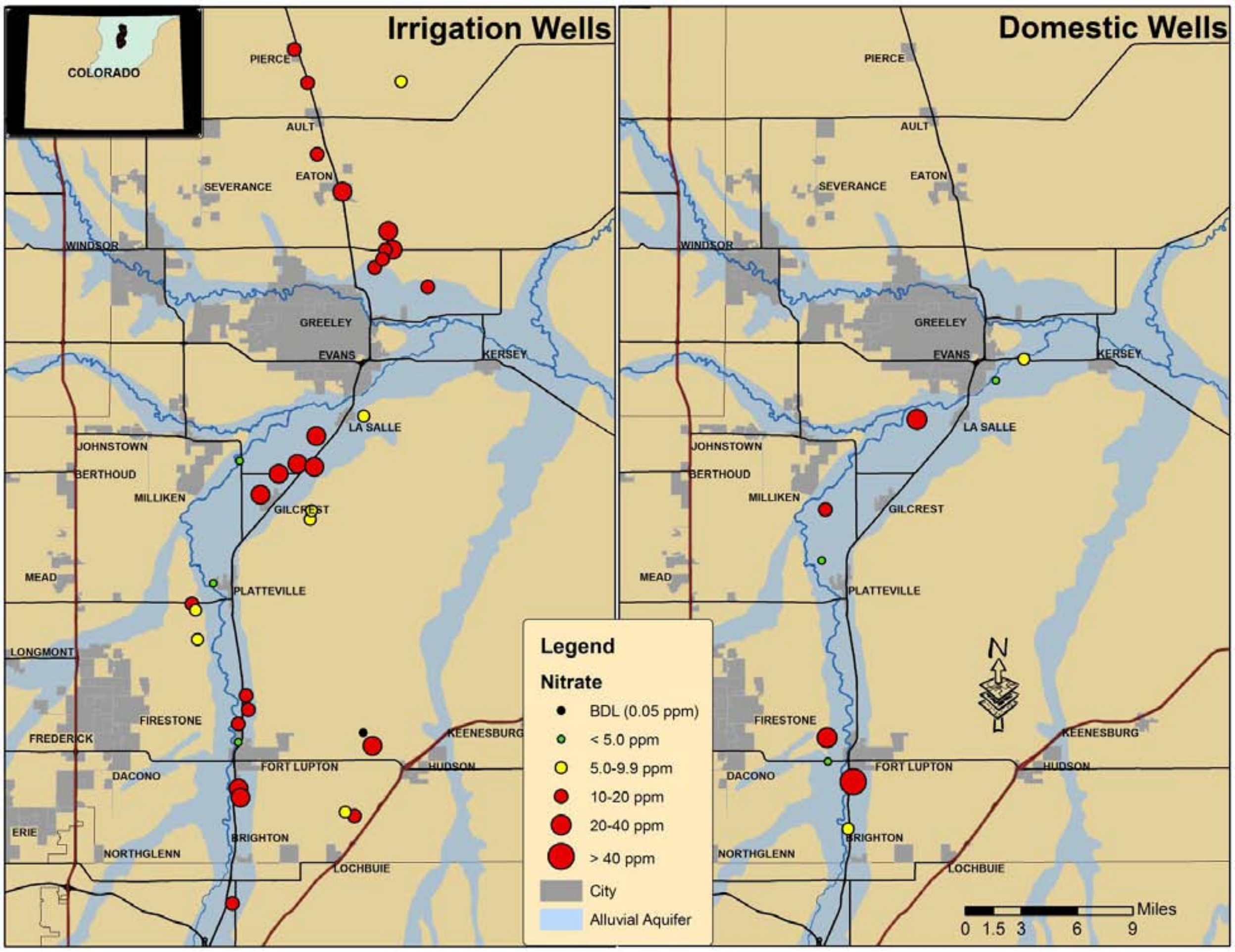

Figure 2. Nitrate-nitrogen results for Weld County long-term irrigation and domestic wells sampled in 2008. Relative concentrations are shown with graduated symbols where red symbols signify nitrate concentrations at or above the EPA Drinking Water Standard. BDL is below detection limit.

In 2008, the shallow well contained 44.25 ppm of nitrate-nitrogen while the deeper well contained only 10.96 ppm. That constitutes a 75% difference in nitrate-nitrogen at this location with a difference in depth of 14 ft between the center point of each 10-ft screened interval. Static water levels were nearly identical at 4818 ft above mean sea level with the shallower well being 0.2 ft higher. Two other multi-depth well sites were installed in similar fashion as part of the Front Range Urban monitoring network in Colorado Springs. Both locations showed a similar response with a significant reduction in nitrate-nitrogen concentration in the deeper well.

Irrigation and domestic well nitrate-nitrogen results for 2008 are shown relatively with graduated symbols in Figure 2. Nearly 70% of sampled irrigation wells contained nitrate-nitrogen at or greater than 10.0 ppm. The area between Gilcrest and La Salle continues to show elevated nitrate levels in the groundwater in results from all three well networks, but where the monitoring well network is weak around Fort Lupton, the domestic and irrigation well networks show several locations with elevated nitrate levels in the groundwater. The domestic well just south of Fort Lupton – containing the maximum nitrate value of 48.0 ppm – is an old domestic well down-gradient of several irrigated agricultural fields to the south.

All monitoring and domestic wells will continue to be sampled annually; however, the Program needs to review the irrigation well network's status due to the declining number of available wells from year to year because of drought conditions and Colorado water law mandates. Many wells have been lost permanently from this network and every year more wells seem to be on the way out. The Program will answer the following questions for the irrigation well network by the 2009 field season:

- Should the irrigation well network continued to be sampled, as is, with the remaining available wells that have been sampled consistently since 1995 in order to maintain a running history for trend analysis?
- Should analysis of irrigation well samples be limited to just nitrate/nitrite analysis, or should we re-implement the triazine immuno-assay screen that was ceased after 2005?
- Should we attempt to fill in gaps in the irrigation well network to ensure a more thorough representation of the alluvial aquifers in Weld County for the purpose of increased accuracy in data interpretation at the county level?

Ultimately, there are two strong reasons for continuing to sample the irrigation well network with one being the long-term trend analysis work the program has been working on since 1995, and the other being the usefulness of the water quality data to farmers using the wells for irrigation. It will need to be decided how important information on detected pesticides is to our various cooperators in the irrigation well network in order to determine the feasibility of re-implementing the triazine screen. It is very likely that analysis of irrigation samples for the entire suite of 100+ pesticides will not be conducted from now on.

2008 Pesticide Results

Sample results for the Weld County monitoring wells turned up several detections of tebuthiuron (Trade names Spike or Graslan). Concentrations ranged from 0.039 to 0.768 ppb with a 0.073 ppb from 9 wells with detections. The multi-depth site north of Platteville detected tebuthiuron in both wells. The deeper well had about 74% more tebuthiuron than did the shallow well which is an opposite response from the nitrate-nitrogen results for these wells. These are the first detections of tebuthiuron in the history of the Program; however, the Program only began monitoring for this active ingredient in 2007. Tebuthiuron is a systemic, lowly selective herbicide that inhibits photosynthesis. Products containing it as an active ingredient do have a groundwater advisory label which advises users of the dangers associated with using this product in areas of shallow groundwater and soils with high leaching potential.

Recent age-dating of groundwater in a portion of the South Platte alluvial aquifer by the USGS has unveiled the likelihood that water at or near the top of the water table could range from less than five years to thirty years in age with the older ages occurring closer to the river. Paschke et al. (2008) used Chlorofluorocarbon analysis and Tritium and Helium analysis to determine the approximate recharge date of groundwater at five locations in the South Platte alluvial aquifer. The locations of the flow-path wells used in their study are located between Gilcrest and La Salle and they state that water samples from these wells last came in contact with the atmosphere from

4 to 30 years ago. If these results can validly be extenuated to our wells in the South Platte alluvial aquifer then it is possible that tebuthiuron applications made upwards of 30 years earlier, with methods that could impact groundwater quality, are just now being detected. With the first registration of tebuthiuron occurring back in 1974 by Elanco Products Company, this scenario is plausible. However, without any use history for this product within the South Platte Basin it is not known when exactly tebuthiuron might have been applied. It will be interesting to see results from future monitoring of these wells.

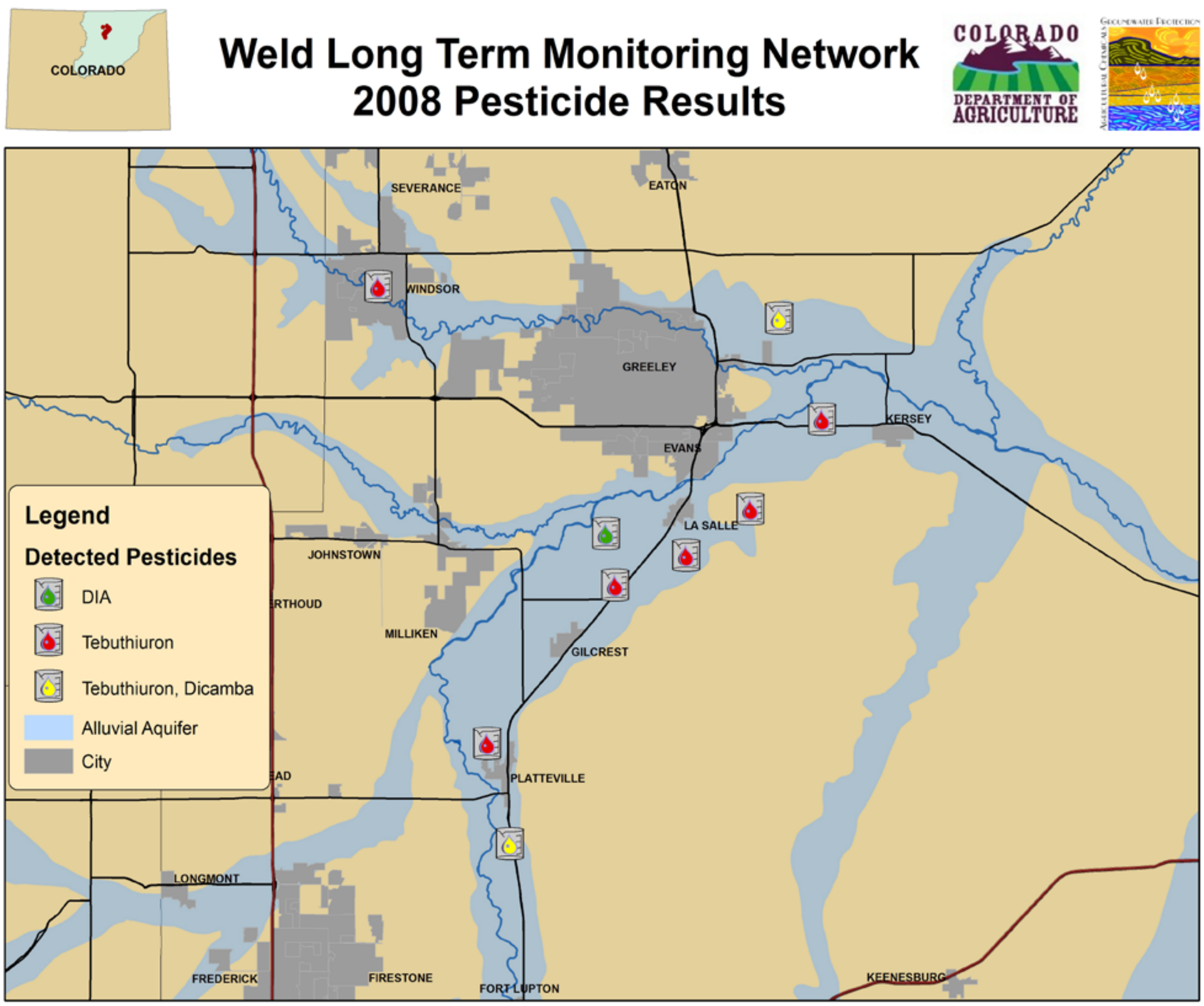

Figure 3. Map showing locations of wells with pesticide detections in 2008

Two other pesticides were detected in the monitoring well network – one detection of desisopropyl atrazine (an atrazine breakdown product) at 0.0966 ppb and two detections of dicamba at concentrations of 2.878 and 3.541 ppb. Quantities of all pesticides detected in 2008 are either below any established drinking water standard or no standards have been established.

Front Range Urban Network

As mentioned in the 2007 Annual Report, installation of monitoring wells in Fort Collins and Colorado Springs was completed to add to the coverage of the Front Range Urban well network. The sampling in 2008 included these two new areas in addition to a re-sampling of wells in the Denver-metro and Greeley areas. A total of 67 monitoring wells were sampled between Fort Collins, Greeley, Denver-metro, and Colorado Springs in 2008. Three wells in SE Denver-metro and one well in Castle Rock were sampled in 2007 by USGS personnel but a re-sampling for 2008 was not possible. Two wells in Pueblo that were sampled in 2007 were not sampled in 2008. In all 39 wells in Denver-metro and Greeley were sampled in both 2007 and 2008. All samples collected in 2007 were analyzed for nitrate- and nitrite-nitrogen concentration only due to laboratory complications that prevented pesticide analysis. Samples collected in 2008 were analyzed again for nitrate- and nitrite-nitrogen concentration, in addition to 100+ pesticide compounds and basic inorganic nutrients.

Nitrate-nitrogen results for samples collected in 2007 and 2008 are presented in Table 3. Even though there were 27 new wells sampled in Fort Collins, Denver-metro, and Colorado Springs, the statistics between 2007 and 2008 are similar for nitrate-nitrogen concentrations. The maximum nitrate-nitrogen concentration of 31.6 ppm for 2007 was in Denver-metro and actually

Figure 4. Map show distribution of Front Range Urban monitoring wells sampled in 2007 and 2008.

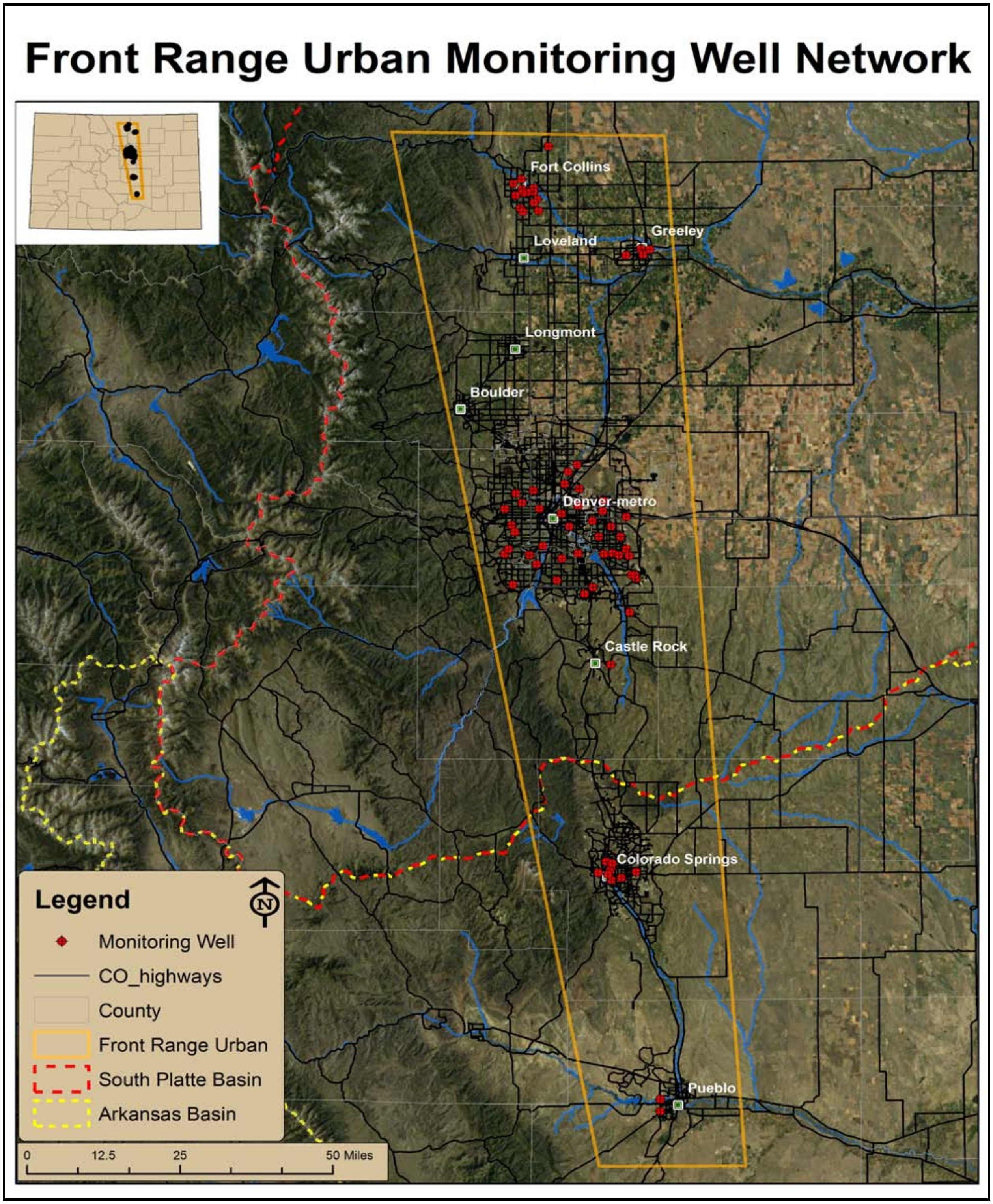

Figure 4. Map showing distribution of monitoring wells in the Front Range Urban Network. Sampling events in 2007 and 2008 resulted in the sampling of all 73 wells at least once.

decreased nearly 10.0 ppm by the spring sampling event. The maximum concentration for 2008 was from the shallow well of a multi-depth site in Colorado Springs. Five wells sampled in 2007 had nitrate-nitrogen concentrations above the EPA Drinking Water Standard, while this number increased to 13 in 2008. Of these 13 wells seven of them were in either Fort Collins or Colorado Springs which points to the fact that the baseline statistics for the Front Range Urban network should definitely be based on the 2008 sampling event. However, 39 wells were sampled in both 2007 and 2008 so the different sampling events can be compared.

Front Range Urban Monitoring Well Results

	Nitrate-nitrogen		Dissolved Oxygen		Static Water Level	
Statistic	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**
	ppm or mg L-1				ft	
Mean	4.7	5.7	2.01	2.83	16.1	16.5
Median	3.2	3.7	0.98	2.08	12.7	12.9
STD	5.5	6.2	1.98	2.01	10.6	11.3
Minimum	BDL	BDL	0.26	0.51	2.4	3.2
Q 25%	1.0	1.0	0.62	0.98	1.0	9.6
Q 75%	6.3	8.4	3.05	4.46	6.3	19.7
Maximum	31.6	30.8	6.51	7.16	56.6	57.7

Table 3. Nitrate-nitrogen, dissolved oxygen, and static water level data for Front Range Urban monitoring wells sampled in 2007 and 2008.

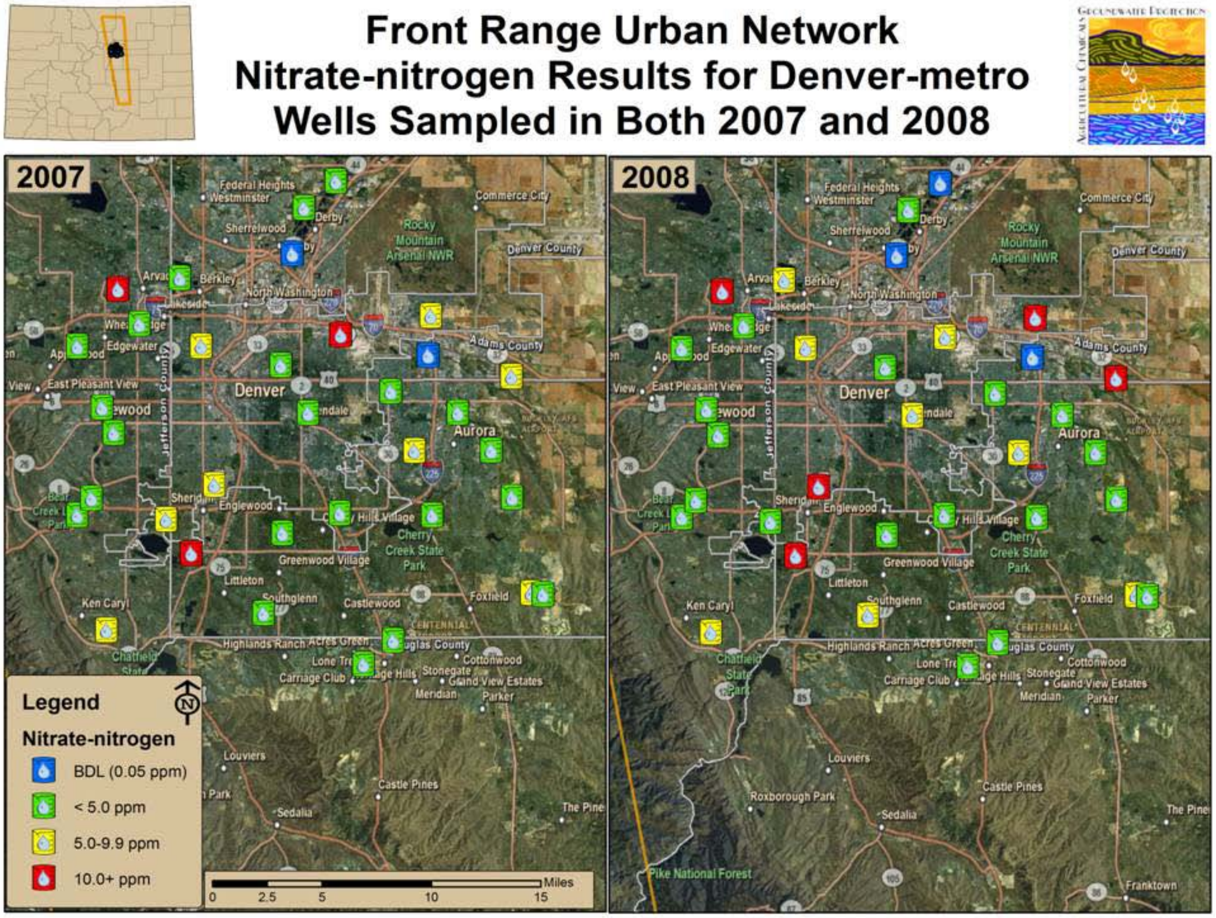

Figure 5. Map showing spatial variability of nitrate-nitrogen concentrations in samples collected from 35 Denver-metropolitan monitoring wells as part of the Front Range Urban Network. These wells were sampled twice within a 5-month period.

In viewing statistics for these wells there is even less of a difference between sampling events in nitrate-nitrogen concentration, dissolved oxygen, and static water levels. Figure 5 shows the differences in nitrate-nitrogen concentrations between 2007 and 2008 for the wells sampled in both years. The key difference was a monitoring well in Denver-metro that decreased in nitrate-nitrogen concentration from 31.6 to 21.8 ppm from October 3, 2007 to May 14, 2008. This large drop in concentration shows the potential variation that can occur between seasons even in urban environments. This monitoring well in NW Denver-metro is actually down-gradient from a community garden that was created in an old settling pond from the water treatment plant that used to occupy the space. It is possible that nitrate from fertilizer applied to

Front Range Urban 2008 Nitrate			
Statistic	**Fort Collins**	**Greeley**	**Colo. Springs**
Mean	4.33	5.64	9.78
Median	2.55	6.48	8.24
STD	5.94	3.77	10.04
Minimum	0.07	0.87	BDL
Q 25%	0.61	3.49	2.39
Q 75%	3.89	8.63	12.2
Maximum	19.48	8.73	30.76
Count	13	4	11

Table 4. Nitrate results for samples collected in three individual areas of the Front Range Urban network: Fort Collins, Greeley, and Colorado Springs. BDL is below detection limit. Units are in ppm or mg L-1.

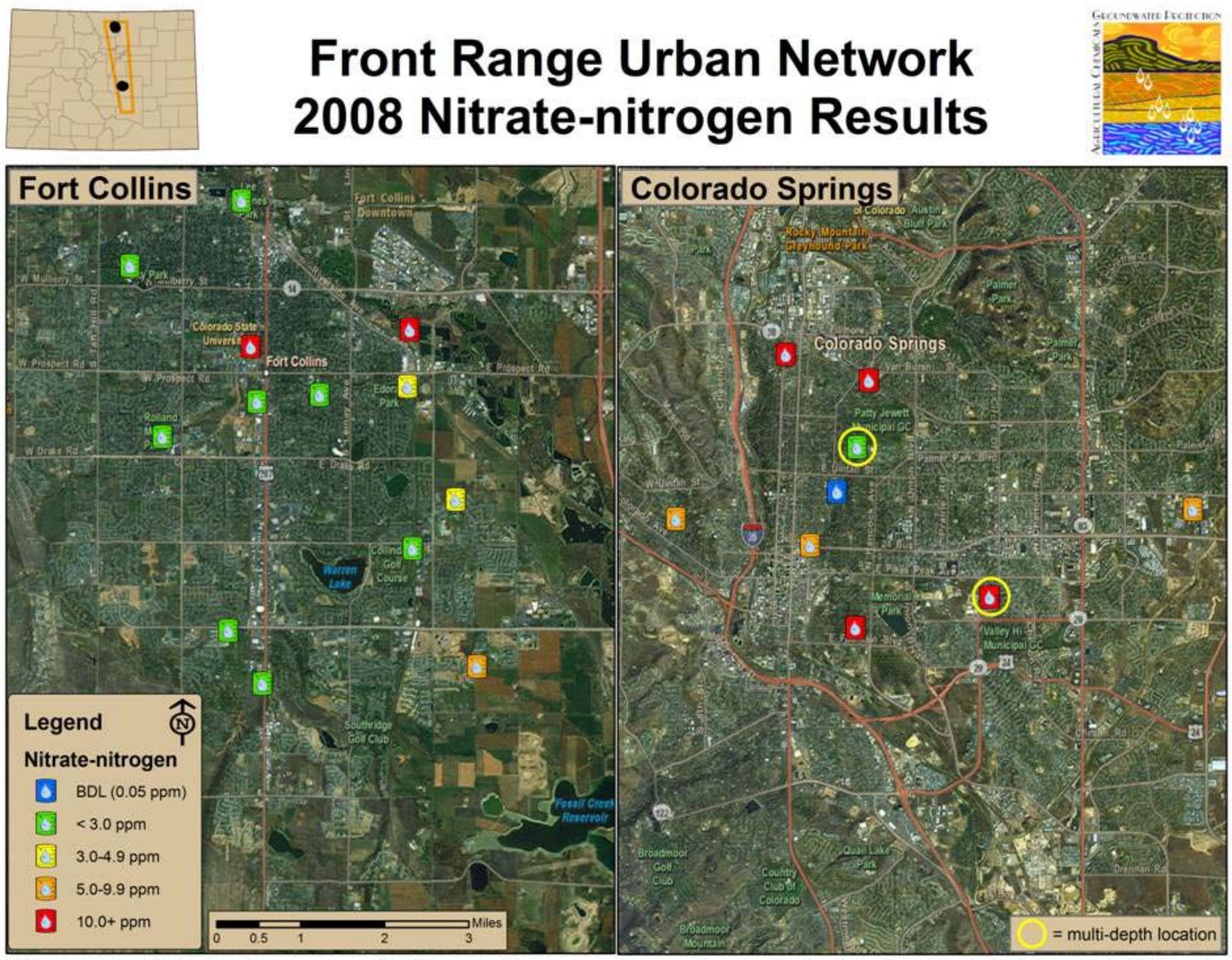

Figure 6. Nitrate-nitrogen results for monitoring well samples collected in the Fort Collins and Colorado Springs areas of the Front Range Urban Network. BDL is below detection limit in parentheses.

various crops being grown in this garden could be contributing to the elevated nitrate concentrations. Quarterly monitoring of this site which coincides with the dormant *vs.* in-use status of the community gardens might help clarify whether this is likely or not.

Nitrate results from various individual areas in the Front Range Urban network our shown in Table 4. The highest median nitrate concentration for all individual areas, including Denver-metro, was 8.24 ppm in Colorado Springs. This was a little more than 1.5 ppm higher than the median for the Greeley and over three times the median for Fort Collins. The maximum concentration for 2008 was also found in Colorado Springs; however, with two wells below the detection limit of 0.05 ppm, compared to no wells below detection in Fort Collins or Greeley, not all wells in the Colorado Springs area had elevated nitrate concentrations. Figure 6 shows the spatial variability of nitrate concentrations in Fort Collins and Colorado Springs. There are 8 of 13 locations in Fort Collins (61.5%) that have nitrate-nitrogen below 3.0 ppm which is believed to be the approximate upper level of the nitrate concentration that occurs naturally. While Colorado Springs may have two locations with wells testing below detection limit (one is the deeper well of a multi-depth location south of Patty Jewett Municipal Golf Course) more than 50% of the other wells had nitrate concentrations greater than 5.0 ppm, with four wells being greater than 10.0 ppm.

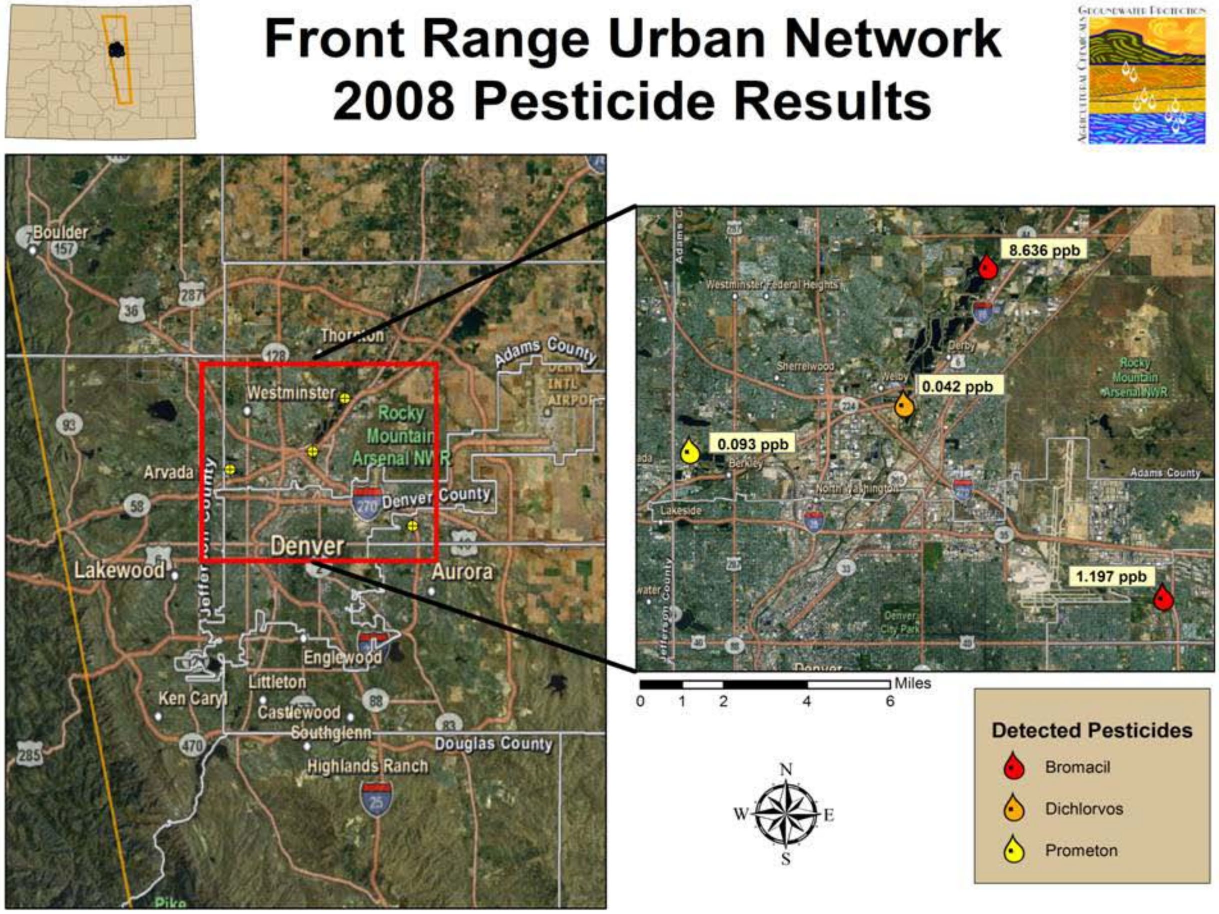

Figure 7. Pesticide detections in Denver-metropolitan monitoring wells sampled in 2008 as part of the Front Range Urban Network.

It is not entirely clear what might be causing the elevated nitrate levels in multiple locations of Colorado Springs. A variety of urban land use types are located up-gradient of wells with nitrate concentrations above the EPA Drinking Water Standard. These include commercial-residential areas, golf course-residential areas, residential areas, and open space-residential areas. In briefly looking at general land-use types around wells throughout the Front Range Urban network it is seen that those surrounded by residential or a mix of residential-commercial development had the highest median nitrate concentrations at 5.9 ppm. Areas of commercial-industrial development have a median of 4.9 ppm. Median concentrations for golf course-residential, open space-parkland and golf course are less than 2.0 ppm and third quartile (75% of sampled locations) concentrations for these areas are less than 5.0 ppm.

Bromacil, dichlorvos, and prometon were detected in the 2008 baseline sampling of the Front Range Urban network, and all four wells detecting one of these three pesticide active ingredients are located in the Denver-metropolitan area. As can be seen in Figure 7, all four wells with pesticide detection are in or near the more commercial-industrial areas of Denver-metropolitan. The rather high detection of bromacil at 8.636 ppb is still well below the health advisory level of 30 ppb.

The detection of dichlorvos is rather peculiar given that its chemical-physical properties do not lend it to be a typical groundwater contaminant concern. Dichlorvos is a degradate product of trichlorfon (Trade name Dipterex or Dylex) which **is** a groundwater contaminant concern due to its high leaching potential, high solubility, and low affinity for adsorption to organic material in the soil. Products containing trichlorfon as the active ingredient are registered for use in Colorado but do not have a groundwater advisory label on them. Another active ingredient that dichlorvos is a degradate of is naled (Trade name Trumpet or DiBrom) which is a restricted use product (RUP). Colorado has several products currently registered for use. These product labels do not have a groundwater advisory on them as their characteristics do not suggest that naled is a leacher. It is highly toxic to bees and has a significant toxicity to humans as a known cholinesterase inhibitor and developmental or reproductive toxin.

The Program does not currently analyze for either naled or trichlorfon but recent creation of a pesticide properties database to assist with discerning which active ingredients should be monitored for, included trichlorfon in a list of 100 priority pesticides. Future analysis for trichlorfon at the CDA laboratory is desired but is dependant mostly on laboratory capabilities for analyzing for trichlorfon.

Lower South Platte Network

The Lower South Platte network is composed of 20 monitoring wells: 16 wells to which the Program has been granted access by the Lower South Platte Water Conservancy District, and four other wells owned permitted by CDPHE. The previous sampling effort for this network was in 2001. In 2008, 17 of the 20 wells were sampled. Of those wells not sampled, one CDPHE well was not sampled due to the land owner not allowing access, one LSPWCD was in the middle of a corn field and was not accessible with the low-flow bladder pump, and another LSPWCD well has been dry since 2001. Sampling was completed between 16 July 2008 and 23 July 2008. Samples were analyzed for 100+ pesticides, nitrate- and nitrite-nitrogen at CDA's laboratory.

In 2001 the mean nitrate-nitrogen was 12.3 ppm with a maximum of 73.98 ppm. The maximum concentration came from a well in Brush, CO. When this well's data is excluded from the statistics the mean drops to 8.9 ppm; however, the median concentration only goes from 9.6 to 9.3 ppm when the Brush well is excluded. Instances such as this are why median values are more commonly preferred when comparing environmental data, especially for non-point source data analysis. In 2008, this same well measured at 260.2 ppm for nitrate-nitrogen and nearly tripled the mean concentration for the network when included in the statistics. As can be seen in Table 5 the median nitrate-nitrogen concentration, as well as many of the other statistics for the Lower South Platte network, 2008 values compare favorably to 2001 values when the Brush well is omitted.

Lower South Platte Network Nitrate Results		
Statistic	**2001**	**2008**
Mean	8.9	8.9
Median	9.3	5
STD	4.5	7.9
Minimum	2.2	1.2
Q 25%	5.7	3.3
Q 75%	10.3	18.2
Maximum	17.7	22.5
Count	18	16

Table 5. Nitrate-nitrogen results for Lower South Platte monitoring wells sampled in 2001 and 2008. Units are ppm or mg L^{-1}.

While the median nitrate increased to 9.3 ppm in 2008, up from 5.0 ppm in 2001, the concentration for 75% of all samples was less than 10.3 ppm in 2008. In 2001, the 3rd Quartile was 18.2 ppm. The standard deviation also dropped from 7.9 ppm in 2001 to 4.5 ppm in 2008. Besides the Brush well, five other wells contained nitrate-nitrogen at levels above the EPA Drinking Water Standard of 10.0 ppm. Four of these wells also had greater than 10.0 ppm in 2001 while one well increased 10 ppm from the 2001 sampling. All nitrate results for the sampled wells are shown in Figure 8. An area within the network that had the highest nitrate-nitrogen concentrations was that north of Wiggins, CO. The three wells with red symbols in Figure 8, north of Wiggins, had a median nitrate concentration of 20.4 ppm.

When the laboratory confirmed a rather high nitrate concentration in the sample collected from the well in Brush, CO, and Program personnel visited the site to try and determine what might be visibly contributing to the contamination. Upon visiting the location the Program decided to inform the Colorado Department of Public Health and Environment so they could follow up on investigating whether any point sources in the area could be contributing to the contamination of the shallow groundwater.

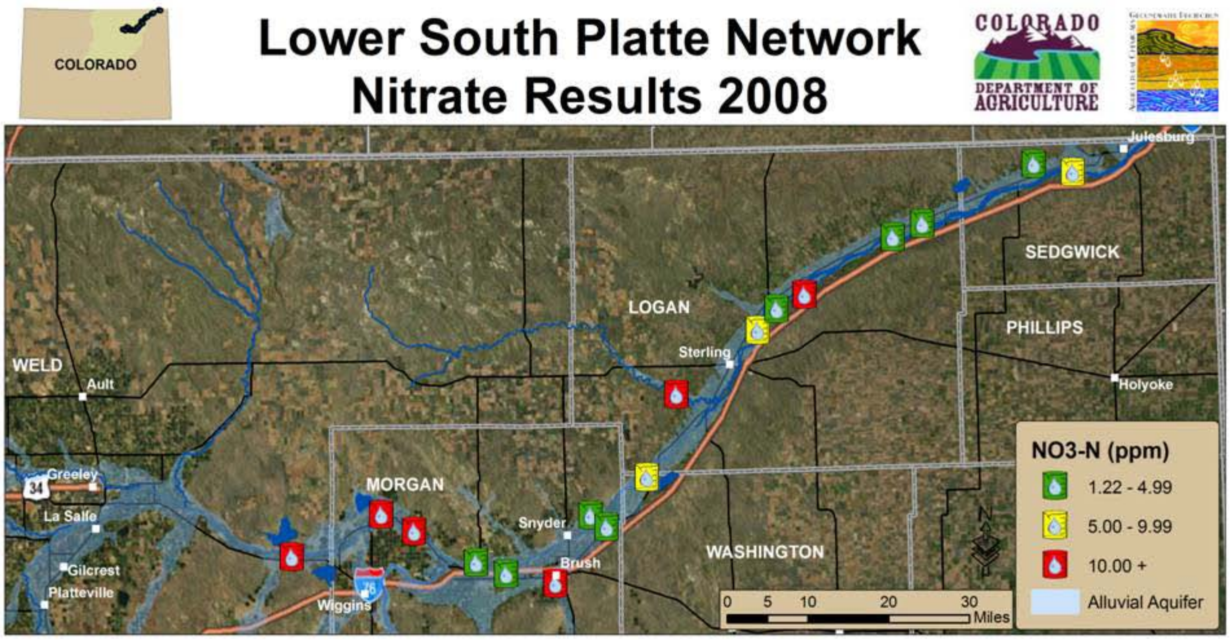

Figure 8. Map showing distribution of nitrate-nitrogen results for samples collected from monitoring wells in the Lower South Platte Network in 2008.

Only two samples from monitoring wells in the Lower South Platte network had detectable quantities of pesticide compounds in them. The well northeast of Sterling, with the red symbol in Figure 8, had a detection of desethyl atrazine at 0.8253 ppb. Desethyl atrazine is a commonly detected breakdown product of atrazine which has a EPA Drinking Water Standard of 3.0 ppb. The well in Brush was the other well detecting pesticide product and the following active ingredients were found: atrazine (1.641 ppb), clopyralid (3.865 ppb), metalaxyl (2.2712 ppb), and MCPA (0.055 ppb). Atrazine and metalaxyl were both found in the sample collected back in 2001 for this well. This was the first detection of clopyralid in the Lower South Platte network but it has been detected as recently as 2006 in the Weld County monitoring well network. MCPA had never been detected in Colorado prior to this detection. There is a 10.0 ppb Health Advisory Level in place for MCPA.

All four of the pesticides detected in the Brush monitoring well have groundwater advisories on their product labels and all have moderate to very high leaching potential. While it is surprising that all four of these active ingredients showed up in one well, their characteristics warrant the likelihood of their contamination. Without sufficient pesticide use information for the area it is not possible to know which entity's use may be contributing the pesticide product to the aquifer. It is known that the likely contributors of the nitrate contamination are not the same contributors of the pesticide contamination which points to this are of Morgan County as being highly vulnerable to groundwater contamination with agricultural chemicals.

Arkansas Valley Network

This network of 20 monitoring wells was installed by the Program in 2004 and was last sampled in 2005. The median nitrate-nitrogen concentration was 2.04 ppm with only one well having greater than 10.0 ppm. The third quartile was at 7.3 ppm which signifies that elevated nitrate levels in the Arkansas River alluvial aquifer were not of much concern given that this network spans from just east of Pueblo, CO all the way to Holly, CO. The three wells on the western extent of the network (just east of Pueblo) were all below detectable limits for nitrate.

In 2008, only 19 wells were sampled as one well had been completely wiped out by some large machinery. The current landowner at this site 5.5 miles west of Lamar, CO, does not wish for the Program to re-install a new well and would prefer for us to just properly abandon the damaged well. This will create a bit of a gap between John Martin Reservoir and Lamar, CO, but there is still pretty sufficient coverage of the Arkansas Valley. Samples collected in 2008 were analyzed for 100+ pesticides, nitrate- and nitrite-nitrogen, basic inorganic nutrients, and selenium. Split samples were also collected for CDPHE which analyzed their samples for dissolved metals (unfiltered), basic inorganic nutrients, VOCs, some pesticide compounds, and arsenic speciation. Data from CDPHE is not included in this report, as many of their interests and analytes are outside of the Program's scope.

Results for various parameters of water quality are presented in Table 6 for samples collected in 2008. The median nitrate concentration was about two times higher than it was in 2005 while the third quartile was only slightly higher than it was in 2005. As can be seen in Figure 9 the key difference in the distribution of nitrate concentration in the alluvial aquifer, between 2005 and 2008, is the obvious increase in the number of wells with nitrate-nitrogen concentrations above the EPA Drinking Water Standard, east of Lamar, CO. The median nitrate for these five wells was 4.8, 7.3, and 12.3 in 2004, 2005, and 2008, respectively. The third quartile doubled in 2008, to 15 ppm, compared to values of 7.1 and 7.4 ppm in 2004 and 2005.

Arkansas Valley Network 2008 Water Quality Results

n=19	Nitrate-N	Sulfate	Sodium	Boron	Chloride	Selenium	TDS	SAR
	ppm or mg L^{-1}							
Mean	5.7	946	253	0.5	85	0.022	2164	3.3
Median	4.1	827	165	0.35	56	0.019	1953	2.5
STD	5.6	475	188	0.41	72	0.015	1081	2
Minimum	BDL	94	21	0.06	8	BDL	386	0.6
Q 25%	1.0	605	134	0.22	45	0.012	1441	2
Q 75%	7.7	1362	411	0.64	102	0.031	3206	4.9
Maximum	20.5	1731	655	1.35	306	0.047	3957	7.7

Table 6. Results for various water quality parameters analyzed in samples collected from monitoring wells in the Arkansas Valley network in 2008. BDL is below detection limit. TDS is total dissolved solids (lab calculated). SAR is sodium absorption ratio.

This pattern of higher nutrient concentrations east of Lamar compared to wells lying west of Lamar does not end with nitrate. An obvious gradient is seen in Figures 10 and 11 for a few other select water quality constituents. With respect to these parameters, similar responses were seen in the 2005 data, but nitrate concentrations seem to have followed suit now in the 2008 sampling. It is possible that two factors could be at play in influencing this shift in water quality east of Lamar, CO. One thought could be that irrigation ditch returns are concentrating contaminants and another is that the dense coverage of phreatophytes like Tamarisk could be causing a evapo-concentration effect because of their high transpiration rates. No data is available to support these claims but they logically make sense and are possible.

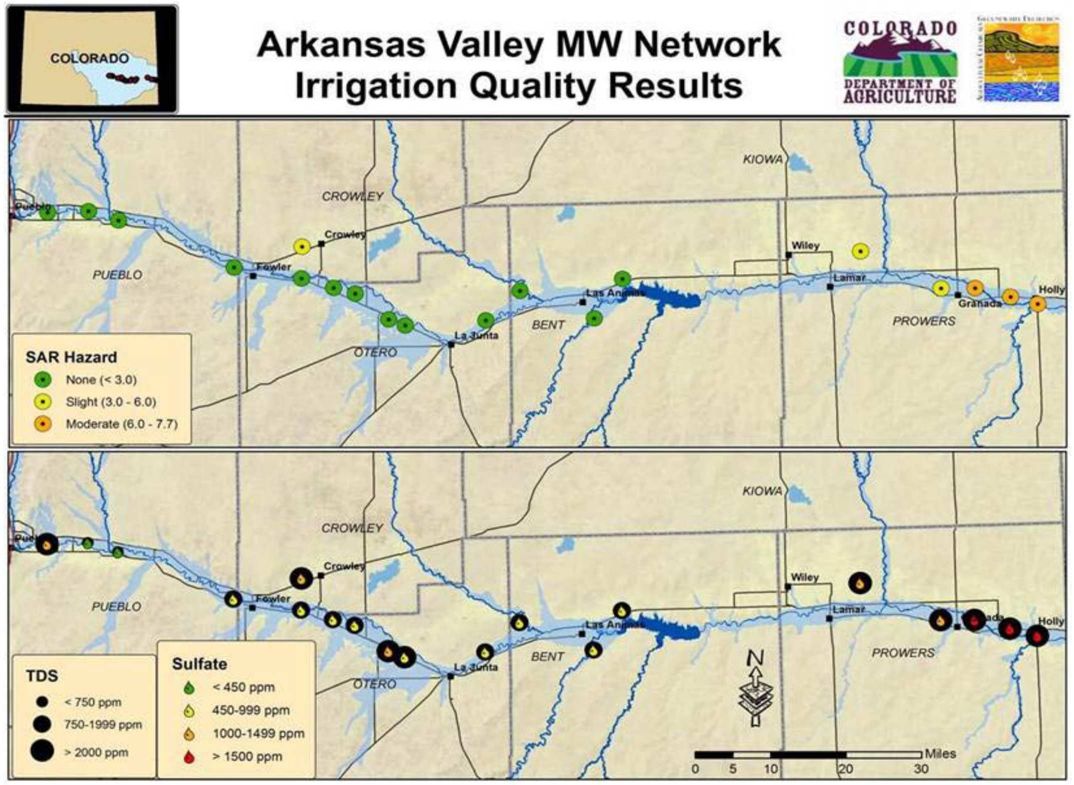

Figure 10. Map showing sodium adsorption ratio (SAR), total dissolved solids (TDS), and sulfate values in samples collected from monitoring wells in the Arkansas Valley Network in 2008.

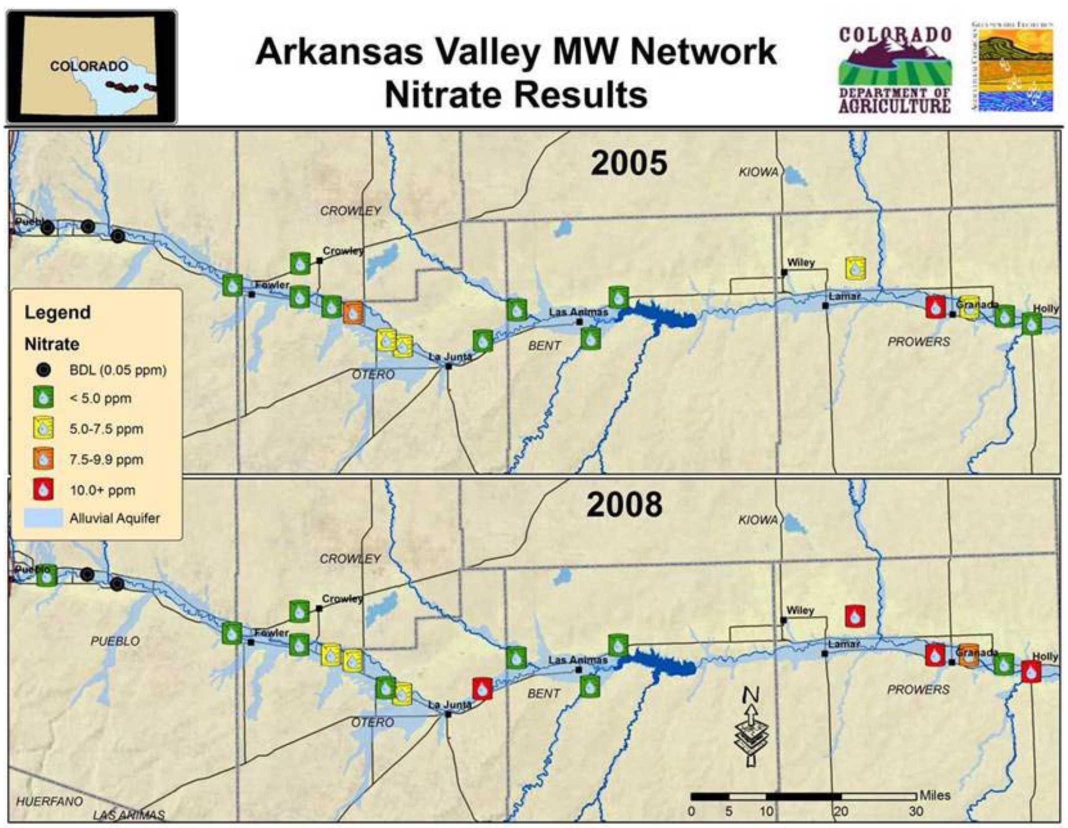

Figure 10. Maps showing distribution of nitrate-nitrogen concentrations in samples collected from monitoring wells in the Arkansas Valley Network in 2005 and 2008. BDL is below detection limit in parentheses.

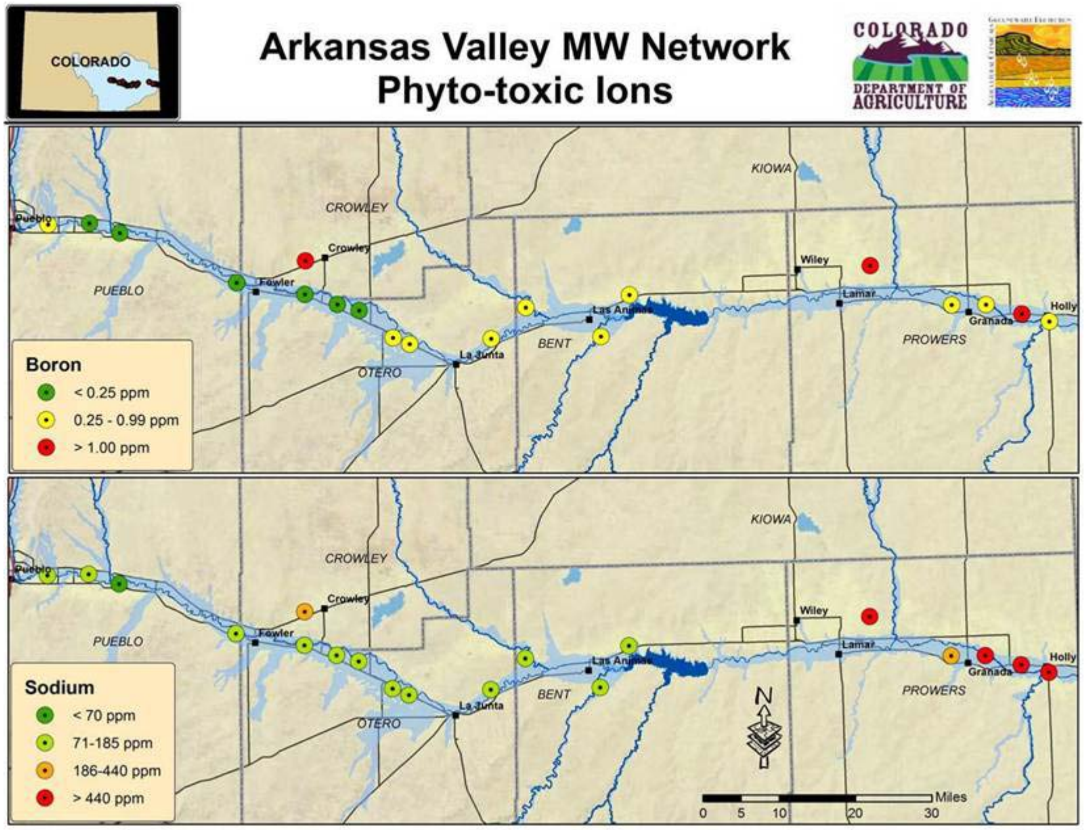

Figure 11. Map showing distribution of boron and sodium concentrations for monitoring wells sampled in the Arkansas Valley Network in 2008.

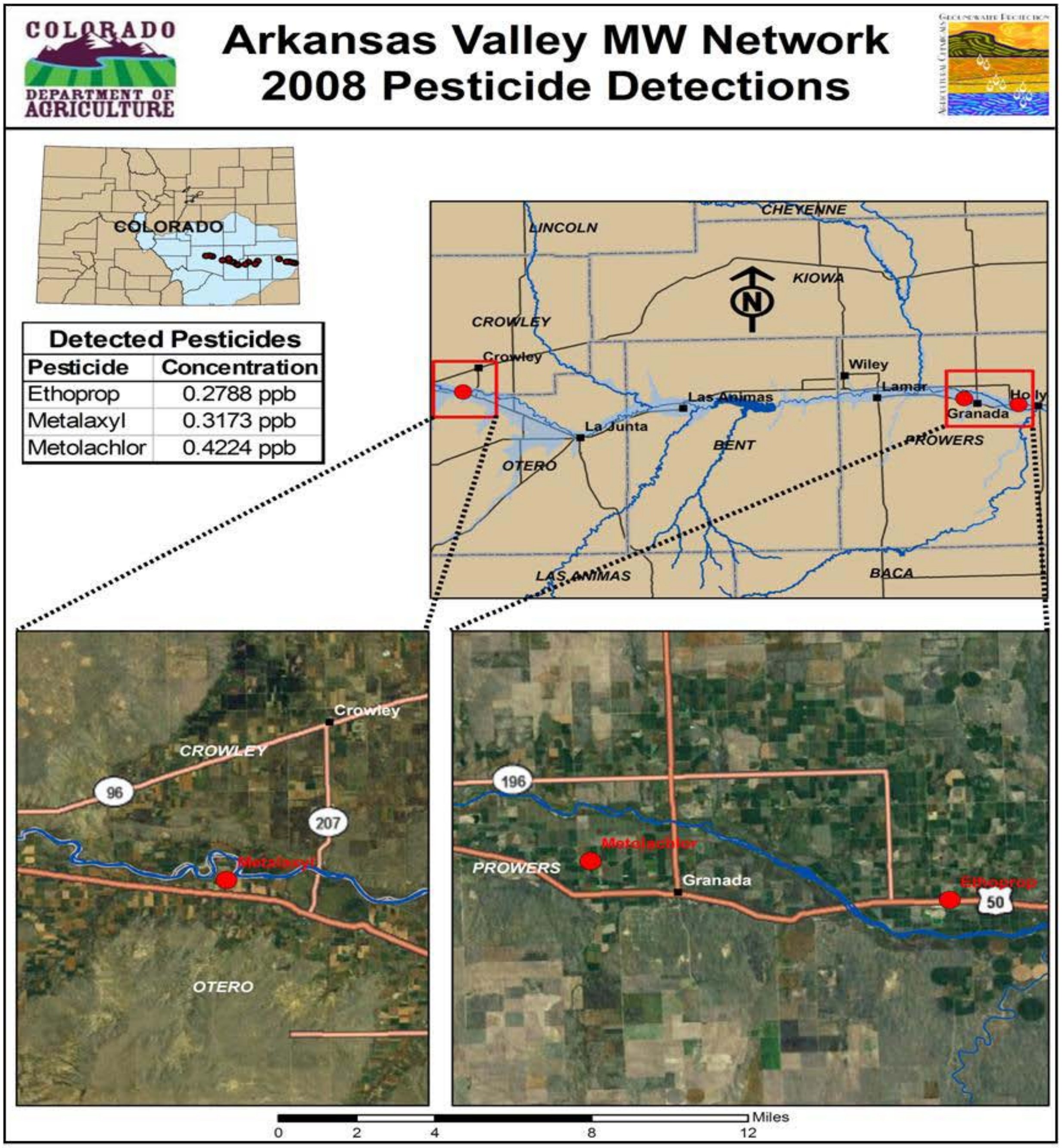

Figure 12. Map showing two areas of the Arkansas Valley network that contain monitoring wells with detected pesticide compounds from samples collected in 2008.

Only samples from three monitoring wells had pesticide detected in 2008. Figure 12 below shows the three well locations with detections of either ethoprop, metalaxyl, or metolachlor. All detected concentrations are well below any established drinking water standards. Metalaxyl and ethoprop were detected for the first time while metolachlor was detected in 2004 and 2005 at the same location as the 2008 detection. The concentrations for metolachlor were 0.580, 0.079, and 0.422 ppb for 2004, 2005, and 2008, respectively. Metolachlor is a commonly detected pesticide in major agricultural land-use areas of Colorado. It has been detected 86 times from samples collected between 1992 and 2007 in the Arkansas, South Platte, and Rio Grande basins. Never has a detected quantity exceeded the Health Advisory Level for metolachlor of 70.0 ppb.

High Plains Monitoring Network

The Program contracted the services and expertise of the United States Geologic Survey (USGS) to assist with reasonable and appropriate placement for 30 monitoring wells within the center section of the Ogallala Formation underlying most of eastern Colorado's High Plains region. Furthermore, USGS personnel conducted geologic logging of boreholes, provided oversight for installation of 20 monitoring wells, and developed the wells to establish a hydraulic connection between the well and the aquifer material. Well drilling and installation services were bid out through the State's competitive bid process which awarded a drilling outfit from Fort Collins, CO with the job.

The High Plains region is unique to Colorado with respect to most other areas that the Program monitors for agricultural chemicals. While the Ogallala Aquifer is primarily an unconfined aquifer, like all alluvial aquifers, it varies greatly in depth to water and is usually greater than 80 ft below the land surface. In comparison, the deepest monitoring well from all other areas sampled by the Program is 80 ft with most of them being 20 to 40 ft below ground surface. Even though the depth to water in the High Plains is much greater – thereby lowering the potential for contamination with agricultural chemicals – the fact that there is key dependence on the aquifer for household and livestock use, and the fact that there is widespread irrigated agricultural land-use on a rather porous soil and vadose zone material, it is important that this area is monitored for agricultural chemicals.

The last sampling event which extended from 1997 to 1998 was conducted primarily with domestic, irrigation, and municipal wells. While these wells provide sufficient information with regards to contaminants in the aquifer, they are not the best wells for accurately determining the mobile fraction of contaminants in groundwater – that fraction which is dissolved in the water or adsorbed onto colloids or mobile sediment particles. Not only is it important to know where contamination with agricultural chemicals may be impacting human and/or animal health, it is also nice to be aware of where contamination may be headed so that forewarning can be provided to 'downstream' well users. Properly located, installed, and sampled monitoring wells help to facilitate this need.

The USGS has a vast knowledge of the geologic and hydrologic characteristics of the Ogallala Formation and was able to utilize various layers of data in a Geospatial Information System (GIS) for visualizing and querying. Several criteria needed to be established for properly locating suitable areas for installing monitoring wells. The Program's goal for the High Plains region is the same as for all other regions of study – to analyze water samples collected from near the top of the water table. It's also important that this monitoring takes place in areas where the land use practices are potentially impacting groundwater quality through the use of agricultural chemicals so only areas of irrigated agriculture were selected.

The Ogallala aquifer can vary greatly in saturated thickness and this can greatly affect both the long-term usability of a monitoring well and accuracy of the well in collecting a representative sample of the aquifer. A criteria was set at 50 ft or greater for saturated thickness. Lastly, a suggested well construction blueprint was decided on, and that in combination with the Program's available budget, resulted in capping the total well depth at 200 ft below ground surface. With long-term use in mind it was decided that the top of a 10-ft section of 2" screened Schedule 40 PVC would need to be set at least 5 ft below the top of the current water table.

Additionally, a 5 ft sump was installed at the bottom of the 10 ft screened section to capture sediment. Therefore, the preferred depth to water that would facilitate a total well installation without exceeding a maximum depth of 200 ft, was 180 ft below ground surface.

All the above data layers were compiled in GIS and all area in the High Plains that met the criteria was created. It was then possible to split the area into 30 equal area polygons. As can be seen in Figure 13 there are several contiguous equal area polygons but there are also some that have bits and pieces scattered across several square miles, like '14'. There appears to be two major areas of the Ogallala in Phillips and Yuma Counties which meet our requirements for suitable areas, while some other areas have scattered availability.

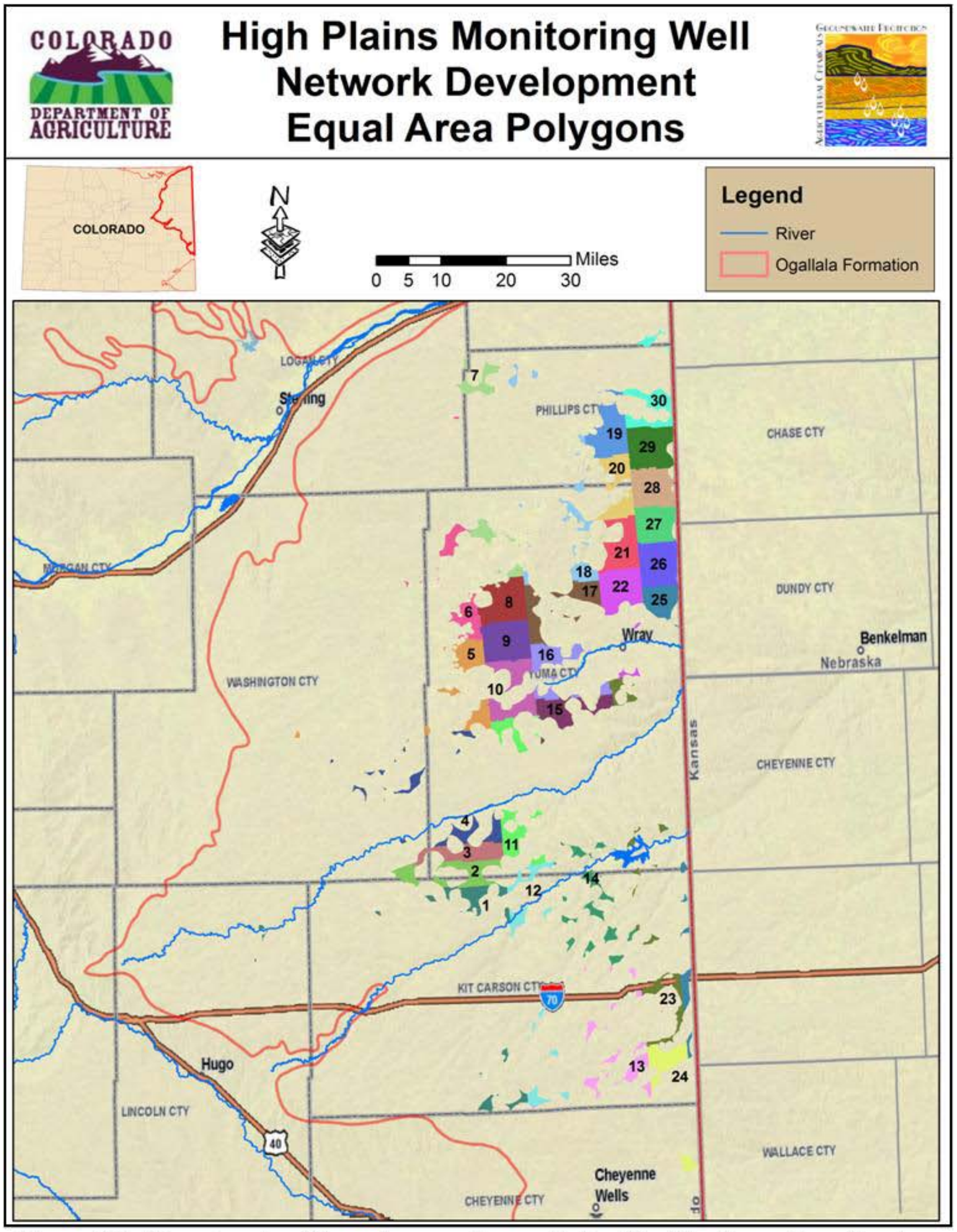

Figure 13. Map showing 30 equal area polygons in the Ogallala Formation of eastern Colorado that meet the following criteria: within area of irrigated agriculture, less than 180 ft to groundwater, and at least 50 ft of saturated thickness.

The next step was to generate a random grid of samples across the 30 equal area polygons so that each polygon had one well location. The program used by USGS for this purpose was ran a total of three times so that there were three options to pick from for each polygon. USGS personnel then visited the landowners in areas around the generated locations to obtain permission for installing a monitoring well.

Due to budgetary constraints only 20 of the 30 polygon areas were able to have a monitoring well installed in 2008. Figure 14 shows the spatial distribution of these 20 monitoring wells. USGS personnel were onsite for geologic logging and oversight of drilling operations. After the installation of monitoring wells, USGS was also responsible for thoroughly developing the wells to remove sediment from the screened portion and establish a hydraulic connection between the well and the water bearing material of the aquifer. A thorough report is being completed by USGS and documents all of the above information to greater detail and provides geologic logs and data acquired during well development activities. At the time of this writing the report had not yet been published.

The 20 well network was sampled in November 2008 and all samples were analyzed for 100+ pesticide active ingredients, nitrate- and nitrite-nitrogen, basic inorganic nutrients, and dissolved metals. Due to well depths, all wells had to be sampled with a Grundfos RediFlo2 pump using conventional sampling methods, and a flow-cell with multi-parameter stabilization, where possible. One well near Joes, CO was not able to be sampled because of inadequate well volume. Two other problematic wells had to be purged dry and allowed to recharge several times before sampling because their productivity was too low to keep up with the withdrawal rate of the Grundfos. With such a large head in these deeper wells, a sufficient column of water in and even above the screened interval is essential, especially if the well is slow to recharge.

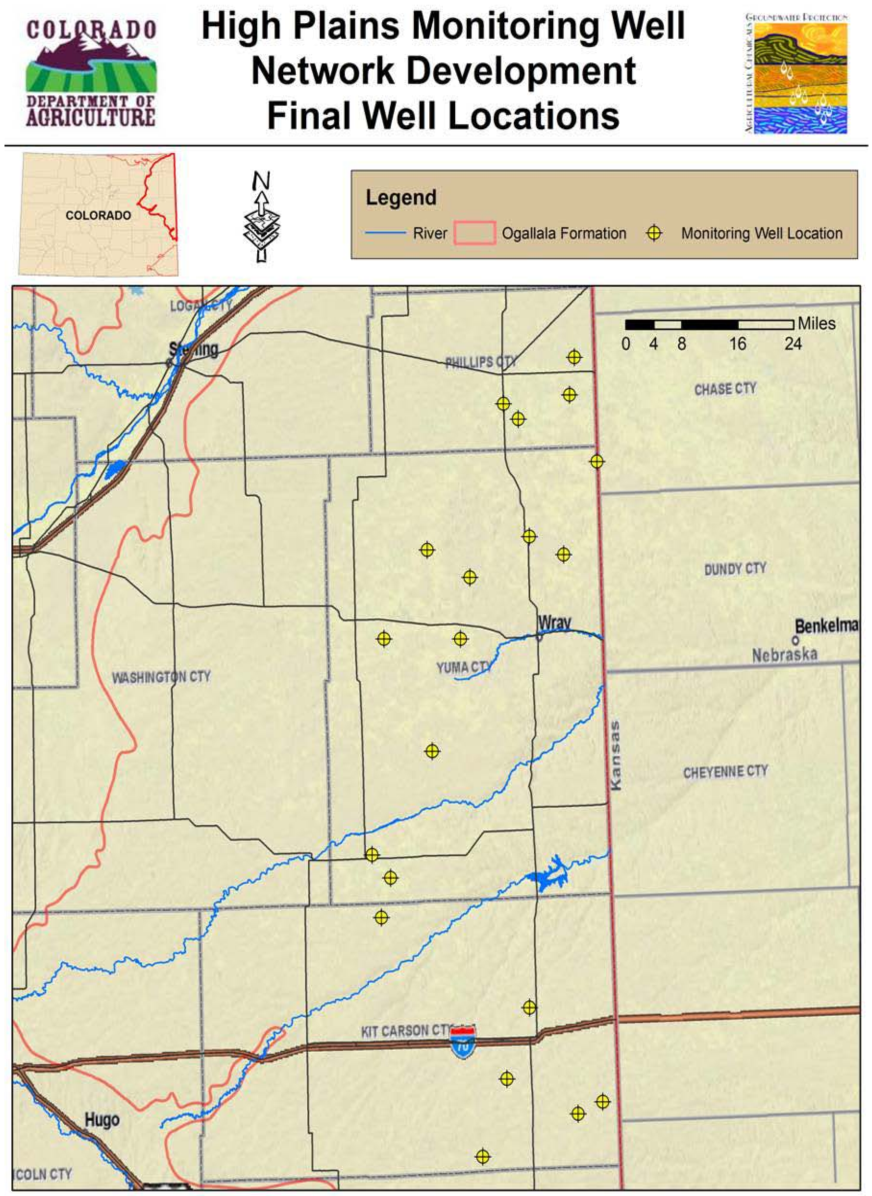

Figure 14. Map showing the distribution of 20 monitoring wells installed by the Colorado Department of Agriculture as part of the High Plains Network.

It is not clear if the well near Joes, CO will gain in volume by the next sampling event, but it is likely this well will have to be sampled with the low-flow bladder pump method.

Nitrate Results

Of the 19 wells sampled in 2008, five were over the EPA Drinking Water Standard for nitrate of 10.0 ppm. The median nitrate-nitrogen value for all wells is 5.84 ppm, the 75th percentile value is 10.31 ppm, and the maximum is 32.91 ppm. As can be seen in Figure 15, there does not seem to be a clear relationship between static water level and nitrate-nitrogen concentration; however, the highest concentration of 32.91 ppm, which is designated by the lone red nitrate symbol, was in a well with the shallowest water table at about 70 ft below ground surface. While depth to groundwater is important in determining vulnerability to nitrate contamination, it is known that other factors are at play in the mechanics of nitrate movement. Data from samples collected in 2008 further demonstrates this.

No groundwater quality concerns were raised due to analysis of the other inorganic nutrients and dissolved metals. All total dissolved solids were less than 800 ppm with a median less than 450 ppm, and all pH values were between 7.2 and 8.0. As baseline data for this newly installed monitoring well network, the results show that water in the Ogallala Aquifer, where we sampled it, is of good quality for both irrigation and drinking except for several locations that had elevated nitrate levels.

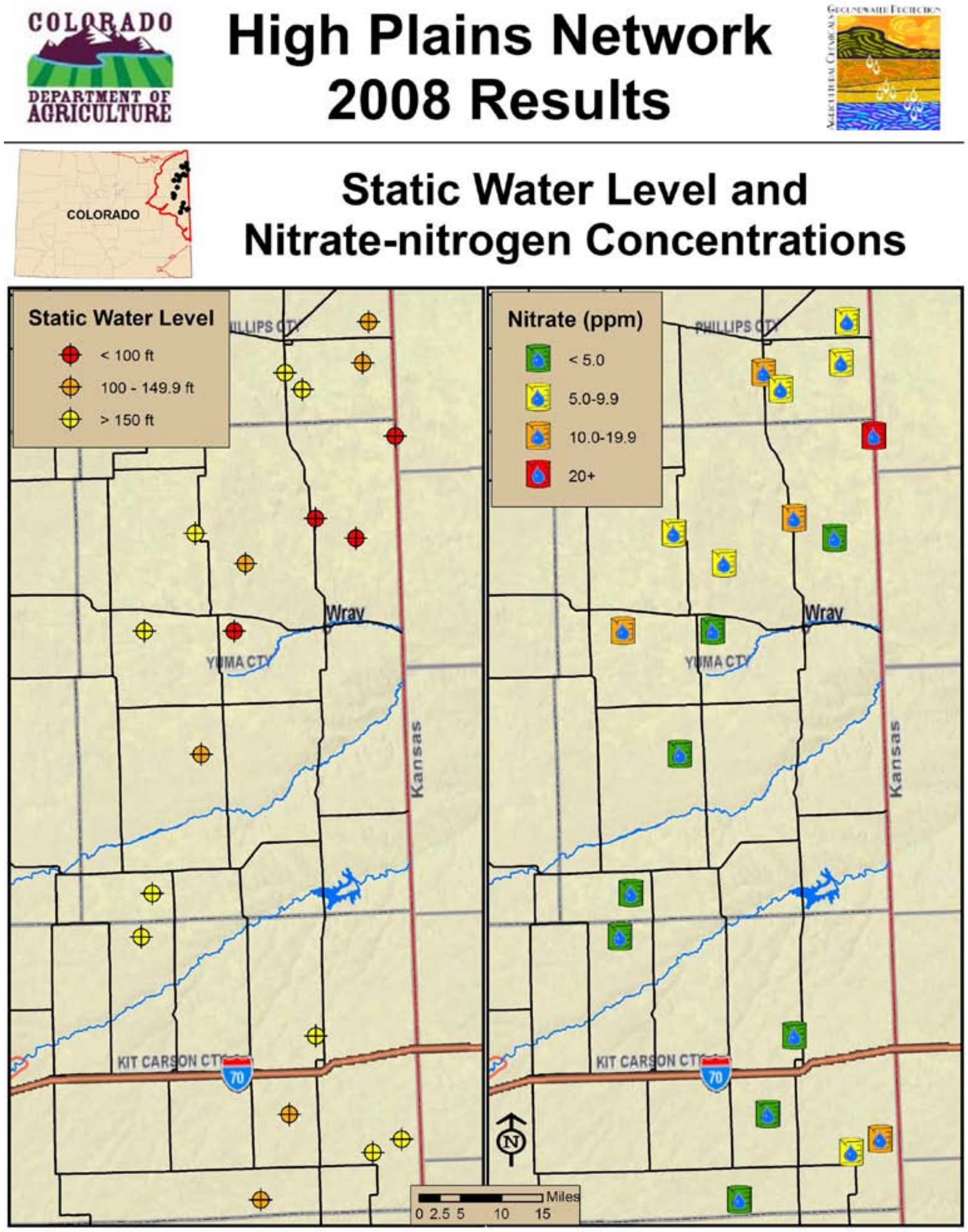

Figure 15. Map showing the static water level and nitrate-nitrogen concentration in monitoring wells sampled in 2008 as part of the High Plains Network.

Pesticide data for the High Plains region resulted in two detections of dicamba at levels of 1.018 and 0.678 ppb. Both amounts are well below the Health Advisory Level of 200 ppb. These were the first ever detections of dicamba by our Program in the Ogallala Aquifer. They were both north of Wray.

During the next sampling event for the High Plains, in 2013, we will collect domestic well samples in areas that do not have a monitoring well and need to be sampled.

Other Notes

The Program encountered several issues with the laboratory with respect to sample load exceedance and analysis inefficiencies in 2008. Many factors were involved with the various issues encountered; however, it is believed that the lengthy pesticide analytes list is somewhat to blame. It is the goal of the Program in 2009 to look over the pesticide analytes list, with sound discretion, to determine which active ingredients we should continue to look for and which we should not. To facilitate this process the Program set up a database housing 200+ pesticide active ingredients (parent and metabolite) along with any known physical and chemical properties, established water standards, and detection history.

From the information in the database it was possible to query out which pesticide active ingredients should be the Program's main focus. About 100 pesticide products were selected as being priority based on the following information:

- Products containing an active ingredient that has a groundwater advisory label. This designates the active ingredient as a potential leacher and a threat to groundwater quality.
- Physical and chemical characteristics of the active ingredient (solubility, adsorption coefficient, half-life, etc.) in addition to leaching index scores (i.e. Groundwater Ubiquity Score) for active ingredients that indicate the chemical has the tendency to leach and potentially impact groundwater quality.
- Historical detection data by the Program using all data from 1992 to present. An active ingredient is declared a priority if it has been detected in groundwater before.
- Pesticide registration information for Colorado. An active ingredient is only declared as priority if it meets one of the above criteria AND it is currently registered or was very recently registered for use in Colorado.

Of the 100 pesticides on this list the CDA laboratory looked for 54 of them in 2008. Some of the active ingredients not currently analyzed for are either altogether new in the manufacturing world, or have not been considered in the past because of infrequency of use or analysis complexity. It is the Program's goal for 2009 to determine which additional active ingredients from the list can be easily incorporated into the analysis procedures without creating further analysis problems.

In 2007, the Program's new chemist changed the analysis protocols employed by the previous two chemists at the groundwater laboratory. One key change was the inflation of the analytes list from 48 analytes to 100+ analytes. This change increased the workload on both the instrumentation and the laboratory personnel and unfortunately, in two years, has not managed to work itself out to be consistently reliable. The inconsistency has come primarily from the inefficiencies of the sample processing procedures and analytical instrumentation that is not thoroughly adept at handling the analysis of 100+ analytes. The increased demand on the laboratory has resulted in a likelihood that less samples can be turned into the laboratory in a given field season which could eventually handicap the Program's ability to monitor around Colorado as according to the Long-Term Sampling Plan.

From the pesticide properties database it was determined that over 100 pesticides do not need to be a priority for analysis in the Program, yet 60 of them were analyzed for in 2008. There are 34 of these active ingredients that have very little if any likelihood of showing up in groundwater due to their properties. The Program is considering the possibility of ceasing further analysis for these 34 active ingredients in an effort to cut down on the analytes list and hopefully increase the laboratory efficiency while maintaining our current annual sample counts outlined in the Long-Term Sampling Plan. A final decision will be made in 2009 and likely discussed in the 2009 Annual Report.

Sampling Plan for 2009 Field Season

The Long-Term Sampling Plan has the Program focusing on the Weld County Long-Term networks, which are sampled annually, the Western Slope, and the San Luis Valley. The Western Slope was sampled in 1998 and utilized primarily domestic and irrigation wells for samples. The Program's focus for the 2009 sample is to develop as extensive a network of monitoring wells as possible, utilizing foremost any existing monitoring wells. The placement of these sample locations will still be based on major land uses on the Western Slope that may be impacting groundwater quality through the use of agricultural chemicals. The two key land uses in areas with shallow, alluvial groundwater are agricultural production and oil and gas development.

The San Luis Valley was last sampled in August and September 2007 as part of a cooperative agreement with the USGS NAWQA program. Split samples were collected for CDA during USGS' sampling events and sent to our laboratory for analysis. Due to complications at our laboratory however, the samples were not analyzed for pesticides. The Program therefore had to rely on data from the USGS' laboratory which does not capture everything we normally look for. The Program is still inquiring with multiple entities about the possibility of establishing our own monitoring network in the San Luis Valley especially since our desired monitoring frequency is every other year, while the USGS only samples once every ten years. Currently, a project being implemented by Colorado Extension will hopefully create an opportunity for the Program to acquire samples from domestic wells for analysis of pesticides and nitrate in 2009. Even though it is the Program's desire to establish a long-term monitoring well network in the San Luis Valley, it is understood that the main purpose of monitoring is for the protection of the environment and the health of humans and animals. For that purpose domestic wells may have to suffice until a monitoring well network comparable to that of the USGS can be established.

2008 Annual Report
Colorado State University Extension

Summary of Accomplishments

- Conducted educational programs throughout Colorado on issues related to agricultural chemicals and groundwater quality. Groups addressed include: crop and livestock producers, commercial applicators, chemical dealers, conservation districts, crop consultants, NRCS agency personnel, homeowners, private well owners, real estate professionals, and urban chemical users.

- Worked to coordinate efforts of the Agricultural Chemicals and Groundwater Protection program with other state and federal programs in Colorado.

- Conducted training related to the Colorado Best Management Practices Manual. Distributed publications to Colorado citizens covering nutrient, pesticide, irrigation, manure, corn, pesticide record keeping, and private water well management.

- Conducted a third year of field demonstration and applied research on limited irrigation under three plant populations and three hybrids for grain corn.

- Conducted a second year of on-farm, demonstrative research near Greeley to demonstrate cover crops as a transition to dryland or permanent grass for land that lost irrigation water.

- Conducted irrigation management demonstrations on farmer fields in the Arkansas Valley. Demonstrations included: using crop water use (ET) from the CoAgMet weather stations network and WaterMark® soil moistures for improved irrigation scheduling.

- Helped CDA finish the establishment of a new dedicated urban well monitoring network, primarily through communication with cooperating municipalities and other public entities.

- Presented results from nitrogen management research and demonstrations using the pre-sidedress soil nitrate test (PSNT) for corn when applied with poultry manure in cooperation with Parker Ag Services Company to producers and consultants. Published these results in proceedings of the Great Plains Soil Fertility Conference.

- Continued to cooperate with the Colorado Climate Center to promote and improve the crop water use (ET) reports provided by the Colorado Agricultural Meteorological Network (CoAgMet). See www.CoAgMet.com.

- Served on the Colorado board for the Certified Crop Advisors Program as exam chair responsible for conducting the state exam.

- Maintained a CSU Extension Water Quality Website to disseminate BMP information via the Internet (www.csuwater.info).

- Distributed revised series of four fact sheets on the web to educate Colorado homeowners on BMPs for urban pesticide and fertilizer use.

- Distributed the *Irrigated Field Record Book*.

- Updated the Microsoft Excel® and .pdf versions of the *Pesticide Record books for Private Applicators* and made these products available for download at www.csuwater.info.

- Worked with CDA to refine a web-interactive database utilizing the Integrated Decision Support (IDS) Group at CSU to present the Program's groundwater quality data to the general public and other agencies. See: http://wsprod.colostate.edu/cwis435/WQ/index.html

- Served on the planning committee for the 2008 South Platte Forum. The SP Forum is an interdisciplinary conference that brings together diverse interests in water to communicate and get the latest on water quantity and quality science and policy in the basin.

- Collaborated with CDA to publish a high quality, comprehensive report of the Groundwater Program Activities, Agricultural Chemicals and Groundwater Protection in Colorado. 1990 - 2006. CWRRI Special Report No. 16.

Ongoing BMP Development and Education

Colorado State University Extension (CSUE) has worked with the Colorado Department of Agriculture (CDA) to develop Best Management Practices (BMPs) for Colorado farmers, landowners, and commercial agricultural chemical applicators. Because of the site-specific nature of groundwater protection, the chemical user must ultimately determine the BMPs adopted for use at the local level. The local perspective is also needed to evaluate the feasibility and economic impact of these practices. The SB 90-126 Advisory Committee has recommended that a significant level of input be received at the local level prior to adoption of recommended BMPs. Colorado State University Cooperative Extension has compiled a broad set of BMPs encompassing nutrient, pest, and water management that has been used as a template for local committees. These documents were published in a notebook form in 1995 that are updated as needed (Private Well Protection was revised in 2005) and expanded to include additional guidelines.

CSU Extension piloted the local BMP development process in the San Luis Valley and in the Front Range area of the South Platte Basin. The local working committees consist of a small group of producers, consultants, and chemical applicators. Both of these groups have produced BMPs for nutrient and irrigation management - the most serious problem in their respective areas. In 1995, the Shavano SCD worked with local Extension agents and producers to develop a set of practices appropriate for the West Slope entitled "Best Management Practices for the Lower Gunnison Basin". During 1996, a fourth local BMP work group was initiated in the lower South Platte Basin. They published their findings in a bulletin entitled "Best Management Practices for the Lower South Platte River Basin." Although most of these work groups have not been active since finishing their local BMP publications, these guides continue to be distributed at the local and state level. Building on these efforts, a crop specific BMP, "Best Management Practices for Colorado Corn" was published in 2003 with support from the Colorado Corn Growers. Revision of both the Pesticide and Corn BMP's continued in 2008. Revision of BMPs developed in the process described above will be a major focus of CSUE for the next several years.

Field Demonstration and Research

Field demonstration work in 2008 focused on helping growers improve water and nutrient management. One significant project is the third year of a limited irrigation trial in Weld County where we demonstrated limited versus full irrigation on grain corn using three different plant populations (~20, 25, and 32 thousand plants per acre). WaterMark® soil moisture sensors using a Hansen AM400® visual display and logger along with ET from an atmometer were used to schedule irrigations at this site. This work is supported by a USDA/NRCS Conservation Innovation Grant (CIG) that provides additional visibility through this partnership.

Another nutrient management issue involves residual soil N and P in formerly irrigated fields. Irrigation well curtailments and water transfers have dried up thousands of acres with resultant weed infestation problems - weeds thrive in low water, high nutrient environments. One viable option towards sustainability is to convert formerly irrigated acres to perennial grasslands. This conversion is a process that involves soil nutrient management and weed control to enable perennial grasses to compete in a low soil moisture environment. This marked the second year of demonstrative research conducted at cooperator's farms in Weld County. This research was designed to investigate management strategies utilizing cover crops to transition from an irrigated cropping system to a non-irrigated grassland or dryland cropping system. Cover crops like haymillet, sorghum-sudan, sterile sorghum, winter wheat and triticale were planted during the 2008 growing season. Weed management and N and P soil nutrient management were made possible with these cover crops. This research will be continued in 2009 and possibly extended into 2010 to better understand and demonstrate feasibility and advantages of grassland establishment utilizing cover crops. This work was funded in part by the West Greeley Conservation District.

We continue to improve the awareness and usability of crop ET information provided by the CoAgMet weather network. Cooperating with field CSUCE faculty and Nolan Doesken in the Colorado Climate Center, we upgraded the usability and output of ET reports from weather stations in the CoAgMet network. Specifically, users now have the ability to choose specific crops, weather stations, and planting dates to customize their reports (see "New ET Reports" link at www.CoAgMet.com).

Results from a study in cooperation with Parker Ag Services on using the pre-sidedress soil nitrate test (PSNT) for corn in fields amended with poultry manure were presented and published in 2008. The PSNT has been used successfully in non-manured fields in Colorado, but had not been extensively tested where manure was applied and no work had been done on fields receiving poultry manure. The trial results suggested that the original PSNT calibrated value is valid on manured fields and would allow farmers to eliminate a sidedress application with confidence when soil nitrate levels are above the critical level of 15 ppm nitrate-nitrogen.

Education and Communication

Communication to a wide audience is a vital component of the program. Numerous methods are used to provide information to individuals and organizations using agricultural chemicals as well as the general public. We continue to provide written fact sheets and publications with information on the program and distribute at meetings, conferences, and trade shows. A display booth was used at conferences and trade shows to provide information on the program in 2008. Information on groundwater protection is continually being presented to the public through publications, newsletter articles, mass media, press releases, and presentations at meetings throughout the state. Presentations on how the program works, past and present water quality projects, and plans for future projects with request for local input are made at every opportunity. In 2008, presentations were made at several major meetings and small local groups throughout the state (see table below). Audiences ranged from licensed commercial applicators and Certified Crop Advisors to private well owners and urban homeowners.

A significant accomplishment from collaboration with USDA/NRCS in 2008 was the 2008 Irrigation Water Management Workshop conducted at ARDEC in July. This 3-day workshop trained 25 NRCS and CE field staff using a comprehensive curriculum that included topics from soil-plant-water relationships to irrigation scheduling. Classroom and hands-on sessions allowed students the ability to learn and see concepts presented. Trainers included CSU faculty, NRCS staff, other agency personnel, and USDA/ARS researchers.

This past year, we continued to provide information over the internet. Several locations including the CSU Extension web site (http://www.ext.colostate.edu), and the CSU Extension Water Quality web site (http://www.csuwater.info) provided information on BMPs. The Agricultural Chemicals and Groundwater Protection Database Information System is linked to the CSU Extension Water Quality web site: (http://idsnile.engr.colostate.edu/webkit/Groundwater/). The information tool provides the general public, researchers, and water policy makers over 15 years of the Program's groundwater monitoring data. This data can be queried in a variety of ways. Outcomes of this project include improved accessibility and knowledge of water quality data; improved use of resources to protect vulnerable groundwater; a GIS tool for directing future groundwater management efforts at multiple scales; and increased stakeholder awareness and involvement regarding any potential or identified groundwater contamination.

Cooperation with the USDA/CSREES Water Resources program (http://www.usawaterquality.org/) has become a significant activity for the CSU water quality program. This regional program operates with four primary initiatives: Watershed Management, Production Agriculture Water Quality, Agricultural Water Conservation and Protection, and Drinking Water - Human and Livestock Health. Colorado significantly contributes to the last four mentioned projects. One benefit of this coordination is a significant amount of sharing of expertise, resources and knowledge between the six states. One benefit of this coordination is a significant amount of sharing of expertise, resources and knowledge between the six states. Another outcome is a mini-grant program for CE field and campus faculty to encourage educational programs and extend research information on topics related to water and water quality. In 2008, we primarily focused our money to individuals who have shown successful programs in the past and on our new Extension Regional Water Resource Specialists. Most of the mini-grants focused on private well testing and drinking water education.

The recipients of mini-grants utilize the *Private Well and Septic System Educational Package.* This multi-media package is intended to help CSUCE agents conduct programming that instructs rural residents on methods to preserve and protect water resources and water quality and is further described at http://wsprod.colostate.edu/cwis435/WQ/privatewellpackage.htm . It was distributed on the website and a CD, which includes PowerPoint presentations with accompanying overview and learning objectives. In 2008, we cooperated with Montana State University through the NPM program to help them produce an educational DVD on Private Well Protection and Septic System maintenance. Some of the footage was shot in Colorado. This DVD will be added to the package in 2009.

Summary of outreach activities

Year	Program	Number of times presentation of this type was made	Total no. of participants	% Responsible
2008	Workshops (single and multi-day)	2	~80	75
2008	Presentations	~15	~750	95
2008	Youth (4H) workshop	1	12	33
2008	Field Tours (3 day)	1	25	60
2008	Educational Booth Displays	3	>500	100
2008	Field Days	2	>50	15

Presentations and Publications:

Bauder, Troy. 2008. Irrigation water quality and salinity management. – Central Plains Irrigation Association Workshop and Tradeshow, Greeley CO.

Bauder, Troy. 2008. Grant Update, CoAgMet Pest and Irrigation Management Validation and Promotion Project - Arkansas Valley. NRCS State Technical Committee Meeting

Bauder, T.A., D. Quarles, R.J. Pearson, and S. Van Wychen. 2008. Validation of the Pre-sideress Nitrate Test for Poultry Manured Corn Fields. Proceedings - Great Plains Soil Fertility Conference, March 4-5, 2008, Denver, CO.

Bauder, T.A and J.S. Schneekloth – Editors. From the Ground Up - Agronomy News, Volume 27, Issue 2: July, 2008.

Schneekloth, Joel, Troy Bauder and Neil Hansen. 2008. Limited irrigation research and demonstration in Colorado. Proceedings – Central Plains Irrigation Association, Greeley CO.

Bauder, Troy, Neil Hansen, Brent Esplin, Jim Bauder, Bill Golden, John Eckhart. 2008. Symposia, Agricultural Water Conservation. 2008 USDA-CSREES National Water Conference, Sparks, NV.

Bauder, Troy, Reagan Waskom, Karl Mauch, Greg Naugle and R. Wawrzynski. 2008. Agricultural Chemicals and Groundwater Protection in Colorado. 1990 - 2006. CWRRI Special Report No. 16.

2008 Annual Report
Colorado Department of Public Health and Environment

The Colorado Department of Public Health and Environment (CDPHE) continues to be actively involved with the Agricultural Chemicals and Groundwater Protection Program. The CDPHE reviews the Program's monitoring data on an annual basis, and provides input on the results. The CDPHE participated in the Program's annual water tour, as well as attended other Program related meetings on an as needed basis.

The CDPHE has continued to be involved with the Program's development of a Web-based pesticide and groundwater information tool. Activities this past year related to this effort included assisting with final quality control and functionality testing.

Other activities included continuing assistance with the Program's long-range monitoring plan, which outlines the rationale and proposed schedule for the next ten years of groundwater sampling. Factors that were utilized in developing the long-range plan included historical groundwater sampling data, estimates of pesticide and fertilizer use, and the aquifer sensitivity and vulnerability studies developed by the Program. The long-term monitoring plan also contains allowance to address special sampling situations that may arise through cooperative investigations with other agencies, or due to other special circumstances. Assistance with the short-term monitoring plan has included working with Program staff on locating appropriate monitoring locations, based on local hydrogeologic factors, for the Western Slope monitoring efforts. The CDPHE split water quality samples with the Program on ground water wells in the Arkansas River Basin. The CDPHE worked with CDPHE inspectors to clarify regulations of bulk storage of agricultural chemicals. The CDPHE assisted the Program with surface water sampling and analysis for pesticides. The CDPHE assisted with the Program's drilling efforts to establish a Front Range Metropolitan monitoring network. The CDPHE assisted in the development and editing of the Colorado Water Resources Research Institute Special Report No. 16 (Agricultural Chemicals and Groundwater Protection in Colorado 1990-2006). The CDPHE assisted with the Program's sampling methods study. The CDPHE also provided ongoing technical support to the Program.

The CDPHE also supports the Program by promoting the Program's activities to outside parties. These activities include communicating the objectives of the Program to other State and Federal agencies, interested parties, and Colorado citizens. Reports, educational materials, and other correspondence have been distributed in an effort to develop an awareness of the importance of the Program to the State's efforts in groundwater protection.