ANNUAL REPORT
FOR 2004

STATUS OF IMPLEMENTATION OF SENATE BILL 90-126 THE AGRICULTURAL CHEMICALS AND GROUND WATER PROTECTION ACT

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

www.ag.state.co.us/DPI/GroundWater/home.html

GROUNDWATER PROTECTION
AGRICULTURAL CHEMICALS

Colorado Department of Agriculture
Colorado State University Cooperative Extension
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Executive Summary

Status of Implementation of Senate Bill 90-126
The Agricultural Chemicals and Ground Water Protection Act

In the annual report for 2003, several goals for 2004 were identified by the cooperating agencies. The progress made toward each of the goals is detailed in the following pages.

Memoranda of Understanding

Memoranda of Understanding as provided in Section 25-8-205.5 (3) (f) and (g) of the Act have been signed for fiscal year 2005 between the Colorado Department of Agriculture and: 1) Colorado State University Cooperative Extension, and 2) the Colorado Department of Public Health and Environment. The Program objectives for 2005 are stated on pages five through seven.

Colorado Department of Agriculture

Storage Rules

Section 25-8-205.5 (3)(b) of the Agricultural Chemicals and Ground Water 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. Pesticide and fertilizer facility inspections continued in 2004.

Pesticide Management Plan

EPA is developing a program that would require states to produce management plans for pesticides thought to be significant hazards to ground water. If a state wants to allow continued use of any of the pesticides identified, it must produce an EPA-approved management plan specific to that pesticide. EPA concurred on Colorado's Generic Pesticide Management Plan (PMP) in March of 2000. This generic plan will be used as a model to produce the pesticide specific plans.

Waste Pesticide Disposal

MSE Environmental Inc., a private contractor, conducted another "Chemsweep" program in 2004.

Advisory Committee

The Advisory Committee continues to be an integral part of the implementation of this program by providing input from the many facets of the agricultural community and the general public that they represent (Appendix V). The committee met once during 2004.

Legislation

The Program personnel have proposed the need for legislation regarding changing the Program's fee structure. Due to the effects of both drought and the economy, program revenues have declined over the last several years. This has necessitated cuts in both personnel and operating expenses that are adversely affecting the way the Program is operated. After 14 years at the current funding levels, a fee increase is necessary in order to effectively implement this program. The proposed legislation was introduced to the Colorado General Assembly during the 2005 legislative session.

Ground Water Monitoring

In 2004, the Program completed the tenth year of a long-term monitoring effort initiated in the South Platte alluvial aquifer from Brighton to Greeley. From June through August 2004, 82 wells in the long-term network were sampled. Nitrogen analysis indicated that 58% of the monitoring wells, 70% of the irrigation wells, and 40% of the domestic wells exceeded the nitrate drinking water standard of 10 mg/L. Pesticide results for the monitoring well portion of the network revealed three pesticides, Atrazine, Metolachlor, and Clopyralid present in the Weld County monitoring well samples. The breakdown product of Atrazine, Deethyl Atrazine, was also detected. Atrazine was present in three wells and Deethyl Atrazine was present in six wells. Three wells contained both triazine compounds. Metolachlor and Clopyralid were each detected in other wells. The total number of wells with a pesticide detection was eight of the nineteen sampled (42%). Detection levels ranged from 0.16 for Atrazine to 1.96 ug/L (ppb) for DEA. No pesticide was detected at a level that exceeds the applicable standard.

The analysis of existing monitoring data, agricultural chemical use, and aquifer sensitivity and vulnerability models developed by the Program leads to a priority ranking of areas of the state for monitoring. The Arkansas River alluvial aquifer was lacking in monitoring well coverage and ranks third in our areas of concern. This area was selected to receive twenty (20) monitoring wells installed by the Program with a grant from the EPA.

Nitrogen analysis indicated that only one of the nineteen (19) wells sampled (5%) showed nitrate levels in excess of the EPA standard for drinking water (10 mg/L). One well tested below the laboratory detection limit of 0.1 mg/L. The remaining seventeen (17) wells (89%) tested positive for nitrate but were below the EPA standard.

Pesticide data revealed three pesticides, Atrazine, Metolachlor, and 2,4-D present in the well samples. The breakdown product of Atrazine, Deethyl Atrazine, was also present in one well. No pesticide concentration exceeded an applicable water quality standard.

Aquifer Vulnerability Study Summary

In addition to monitoring ground water for the presence of agricultural chemicals, the Program is required to determine the likelihood that an agricultural chemical will enter the ground water. In the process of writing the generic PMP, the staff at CDA, CSU, and CDPHE has studied various types of vulnerability analysis. In 1999, the legislature approved additional funding for a project to develop a method to determine aquifer vulnerability to both pesticides and nitrate statewide. In 2004, work continued toward this goal. Upon completion of the project, the Program will be able to determine ground water vulnerability to agricultural chemicals statewide.

Colorado State University

Education and Communication

Communication is a vital component of the Program. Numerous methods are used to provide information to individuals and organizations using agricultural chemicals. We continue to provide written fact sheets and publications with information on the Program and distribute at meetings, conferences, and trade shows. Also, a display board is being utilized at conferences and trade shows to provide information on the Program. Information on ground water protection is continually being presented to the public through publications, newsletter articles, 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 2004, presentations were made at several major meetings and small local groups throughout the state. We consider this type of outreach an important part of the customer service component of the Program.

Ongoing BMP Development and Education

Colorado State University Cooperative Extension (CSUCE) has worked with the Colorado Department of Agriculture to develop Best Management Practices (BMPs) for Colorado farmers, landowners, and commercial agricultural chemical applicators. Because of the site-specific nature of ground water 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 Program Advisory Committee has recommended that a significant level of input be received at the local level prior to adoption of recommended BMPs.

Demonstration Sites and Field Days

The Ground Water Program at CSUCE works with crop producers, their advisors, fertilizer dealers, USDA NRCS, commodity groups, and local County Extension faculty, to demonstrate and evaluate new and existing production tools that may improve producer profitability and help protect ground water. Field demonstration work continued in 2004 with applied research on nutrient management including a continuing study/demonstration of irrigation water NO_3-N crediting in Weld County. The results of these demonstrations are useful in convincing growers to adopt this BMP when using nitrate enriched ground water. The Ground Water Program also cooperated with other CSU faculty in the Soil and Crop Sciences Department to conduct a study on the potential to save water using cross-linked Polyacrylamide in drybeans.

Colorado Department of Public Health and Environment

During 2004, the Colorado Department of Public Health and Environment (CDPHE) continued to be actively involved with the Agricultural Chemicals and Ground Water Protection Program. The CDPHE continues to review the Program's monitoring data on an annual basis, and provide input on the results. Other activities that the Department has assisted the Program with include final permitting on the new monitoring wells along the Arkansas River, and attending meetings on an as needed basis.

Objectives for 2005 Determined

The following objectives for 2005 have been established:

- Complete production of a report on ground water quality status in Colorado, educational efforts to address water quality problems, and the history of the Program;

- Continue study plots to demonstrate improved nitrogen and water management to farmers;

- Coordinate with other agencies and non-governmental organizations to deal with water quality issues throughout the state;

- Continue BMP education work in vulnerable ground water areas of Colorado;
- Continue to develop and update educational resource materials for ground water education;
- Publish, distribute, and display on the web, urban BMPs to encourage improved agricultural chemical and water management in urban areas;
- Continue to hold in-service training for chemical applicators, agency personnel, etc.;
- Participate in the Certified Crop Advisor program;
- Continue performing inspections of facilities requiring compliance with containment rules;
- Continue to provide information on and enforcement of the containment rules;
- Continue collection and analysis of ground water samples for pesticides and nitrate on a regional scale;
- Continue the long-term monitoring program in Weld County by collecting and analyzing ground water samples for pesticides and nitrate;
- Continue statistical trend analysis on Weld County long-term monitoring data;
- Publish results of the 2001-2002 BMP survey;
- Continue disseminating information on the Act and ground water protection to special interest groups in Colorado;
- Continue revising, publishing, and distributing fact sheets relevant to the Program;
- Improve, update, and continue using the display board to provide information on the Program at trade shows and professional meetings;

- Update the rules for bulk storage and mixing and loading facilities;
- Revise bulletin on pesticide fate and transport;
- Participate in USDA PDP program;
- Complete work on producing a web-based pesticide and ground water quality information tool;
- Revise and reprint the *Pesticide Record Keeping Book*;
- Publish revised bulletin for private wellhead protection; and
- Establish and sample an urban monitoring well network.

APPENDICES

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APPENDIX I

2004 Annual Report
Colorado Department of Agriculture

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

Section 25-8-205.5 (3)(b) of the Agricultural Chemicals and Ground Water 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. The law mandated at least a three year phase-in period for the rules. As a result of comments prior to and at the public hearings, a graduated phase-in schedule was adopted. Regulation of pesticide secondary containment/storage facilities and mixing and loading areas began on September 30, 1997. Regulation of fertilizer secondary containment/storage facilities and mixing and loading areas began on September 30, 1999.

During 2004, 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 2004. A total of 20 pesticide secondary containment structures and 29 pesticide mixing/loading areas were inspected. A total of 14 fertilizer secondary containment structures and 14 fertilizer mixing/loading areas were also inspected. A total of 36 follow-up inspections were also conducted to ensure that problems noted on previous facility inspections were corrected. In addition, one Cease and Desist Order was issued during 2004. Finally, 20 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 2005.

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 Dr. Lloyd Walker, former extension agricultural engineer with Colorado State University Cooperative Extension, produced a set of plans that meet the second criteria. The document is entitled, *Agricultural Chemical Bulk Storage and Mix/Load Facility Plans for Small to Medium-Sized Facilities*. The plans are available from CDA or Colorado State University 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, CSU, or via the internet at www.ag.state.co.us/DPI/GroundWater/home.html.

Pesticide Registration and Ground Water Protection

The Program continues to review products for registration in Colorado which have ground water label advisories and advise the Department's registration program on the merits of registering these products.

Pesticide Management Plan

In October of 1991, the EPA released their *Pesticides and Ground Water Strategy*. The document describes the policies, management programs, and regulatory approaches that the EPA will use to protect the nation's ground water resources from risk of contamination by pesticides. It emphasizes prevention over remedial treatment. The centerpiece of the Strategy is the development and implementation of Pesticide Management Plans (PMPs) for pesticides that pose a significant risk to ground water resources.

The EPA will require a PMP for a specific pesticide if: (1) the Agency concludes from the evidence of a chemical's contamination potential that the pesticide "may cause unreasonable adverse effects to human health or the environment in the absence of effective local management measures;" and (2) the Agency determines that, although labeling and restricted use classification measures are insufficient to ensure adequate protection of ground water resources, national cancellation would not be necessary if the State assumes the management of the pesticide in sensitive areas to effectively address the contamination risk. If the EPA invokes the PMP approach for a pesticide, its legal sale and use would be restricted to states with an EPA-approved PMP.

EPA published the proposed rule for PMP's on June 26, 1996. Comments on the proposed rule were submitted under the signature of the Commissioner of Agriculture, Director of Colorado State University Cooperative Extension, and the Executive Director of the Colorado Department of Public Health and Environment. These comments were printed in the 1996 report. To date, EPA has not published the final rule. It is uncertain when the document will be completed and what will be included based on the comments submitted. However, EPA is still requiring states to produce generic PMPs and is encouraging states to continue with ground water protection programs as outlined in each state's PMP.

In 1996, a complete draft of Colorado's generic PMP was finished and provided to EPA for their informal review. A redrafted plan based on EPA's comments on previous versions was submitted in January 1998. Comments on this version were received from EPA in April 1998, and Colorado then submitted a document final in August 1998 for formal review and concurrence. Two subsequent documents were submitted to EPA based on comments received, the last being in January of 2000. EPA concurred on Colorado's Generic PMP in March of 2000.

One of the more significant issues regarding the PMP involves EPA's demand for a sensitivity analysis/vulnerability assessment map of the state in a Geographic Information System (GIS) format, by which to determine where to focus education and monitoring activities. In late 1995, a small EPA grant was obtained to perform a sensitivity analysis pilot project for the northeastern part of the state. This work was completed in 1996 and provided to EPA. EPA reacted favorably to the project and provided funding for a statewide sensitivity analysis, which was completed in 1998. This information has been published in an eight page fact sheet titled *Relative Sensitivity of Colorado Ground Water to Pesticide Impact*. This publication assesses aquifer sensitivity based on four primary factors: conductivity of exposed aquifers; depth to water table; permeability of materials overlaying aquifers; and availability of recharge for the transport of contaminants. These factors were selected because they incorporate the best data currently available for the entire state and incorporate important aspects of Colorado's unique climate and geology.

In 1999, the Ground Water Program was given spending authority to begin an aquifer vulnerability project to compliment and improve the existing aquifer sensitivity map. Work on one project on aquifer vulnerability to pesticides was completed June 30, 2001 with the Colorado School of Mines. Another related project titled *Probability of Detecting Atrazine/Desethyl-atrazine and Elevated Concentrations of Nitrate in Ground Water in Colorado*, done in conjunction with the United States Geological Survey (USGS) was completed in 2002. The Program is continuing its work in this area and future projects are currently being planned based upon funding availability.

Federal Regulations for Pesticide Containment

The Program continues to work with and monitor EPA's progress toward proposed Federal *Standards for Pesticide Containers and Containment*. EPA proposed these standards in 1994 and has taken public comment twice, in 1994 and 1999. They have once again opened the comment period in 2004 and hope to have these standards finalized by the end of 2005.

Waste Pesticide Disposal

In 1995, CSU Cooperative Extension 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 were 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 currently has 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 EPA and the Colorado Department of Public Health and Environment made the possibility of continuing a waste pesticide disposal program significantly easier by passing the Universal Waste Rule (UWR) in late 1995. The UWR was developed to encourage disposal of products identified as universal wastes by relaxing the regulations in the Resource Conservation and Recovery Act (RCRA) and therefore making it easier to properly dispose of these products. Waste pesticides were defined in the rule as a universal waste.

CDA spoke to 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. Registration for participants was set to begin in early 1997, with a scheduled collection of pesticides set for mid-March 1997. This program was very successful. Over 10,500 lbs. of waste pesticides were 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

Legislation

The Program personnel have proposed the need for legislation addressing the Program's fee structure. Due to the effects of both drought and the economy, Program revenues have declined over the last several years. This has necessitated cuts in both personnel and operating expenses that are adversely affecting the way the Program is operated. After 14 years at the current funding levels, a fee increase is necessary in order to effectively implement this Program.

The first step in this process is asking the Colorado General Assembly to remove the Program fees from statute and allow the Colorado Agricultural Commission to set the fees. Currently, fees for the Department's other pesticide programs are approved by the Agricultural Commission. This includes the pesticide manufacturer's state registration fee of $95 per product, from which the Ground Water Program currently receives $20. Having the Ground Water Program's fee setting structure similar to other related programs is desirable and will give this program more flexibility to deal with future budget issues.

Senate Bill 176 has been introduced during the 2005 Legislative Session that will affect funding for the Ground Water Program. This Bill deals with funding issues for the Inspection and Consumer Services Division of the Colorado Department of Agriculture and was amended to reflect the proposed changes for the Ground Water Program. Progress on this Bill will be followed and reported on in next year's annual report.

Ground Water Monitoring

Summary of Accomplishments

- Continued the long term monitoring project in the Weld County portion of the South Platte River Basin, a high priority watershed for the Program's efforts. This year the Program sampled nineteen (19) monitoring wells and sixty three (63) irrigation and domestic wells. (82)

- Completed the monitoring portion of the comprehensive Program report, a 12 year summary report on all Program work to date.

- Completed the installation of a network of dedicated monitoring wells in the Arkansas Valley in May 2004.

- The new Arkansas monitoring wells were completed in August 2004 and sampled in September 2004.

- Set up an Urban monitoring well network along the Front Range urban corridor utilizing existing monitoring wells, to be used in a water quality study in 2005.

- Developed a long term monitoring plan as a guide to Program sampling efforts for the next five years.

- Completed a statistical analysis on the Weld County monitoring network to look for trends in the nitrate and pesticide data.

- Assisted in the upgrading and refinement of a database for the Program's ground water monitoring data. Assisted in the design for a GIS interactive database.

- Cooperated with the U S Geological Survey, NAQWQA program for Phase II of the South Platte Survey.

- Collaborated with the Department of Agriculture Standards Laboratory to revise and refine the laboratory analysis used on all ground water samples. Evaluated the pesticide survey data to extract information needed to improve laboratory analysis.

- Addressed groups throughout Colorado on the Ground Water Program and issues related to agricultural chemicals and ground water quality. Groups addressed include chemical dealers, ground water management districts, crop and livestock producers, and agency personnel.

- Distributed fact sheets and reports on Colorado ground water quality to interested parties and fielded questions by phone and e-mail from Colorado citizens.

- Cooperated with county Extension agents on disseminating information about Colorado ground water quality.

- Worked to coordinate efforts of the Agricultural Chemicals and Ground Water Protection Program with other state and federal programs in Colorado.

- Cooperated and provided assistance to the South Platte BMP workgroup.

Weld County Long Term Monitoring

In 2004, the Program completed the tenth year of a long term monitoring effort in the South Platte alluvial aquifer from Brighton to Greeley. The long-term monitoring network was established in 1995 and is a combination of three types of wells designed to sample a complete cross-section of the aquifer (Figure 1). The network well types are: a) Twenty (20) dedicated monitoring wells operated by the Central Colorado Water Conservancy District; b) Sixty (60) irrigation wells that were previously sampled in 1989, 1990, 1991, 1994; and c) Eighteen (18) domestic wells first sampled in 1992. The monitoring and irrigation wells are sampled each year, the domestic wells every three years.

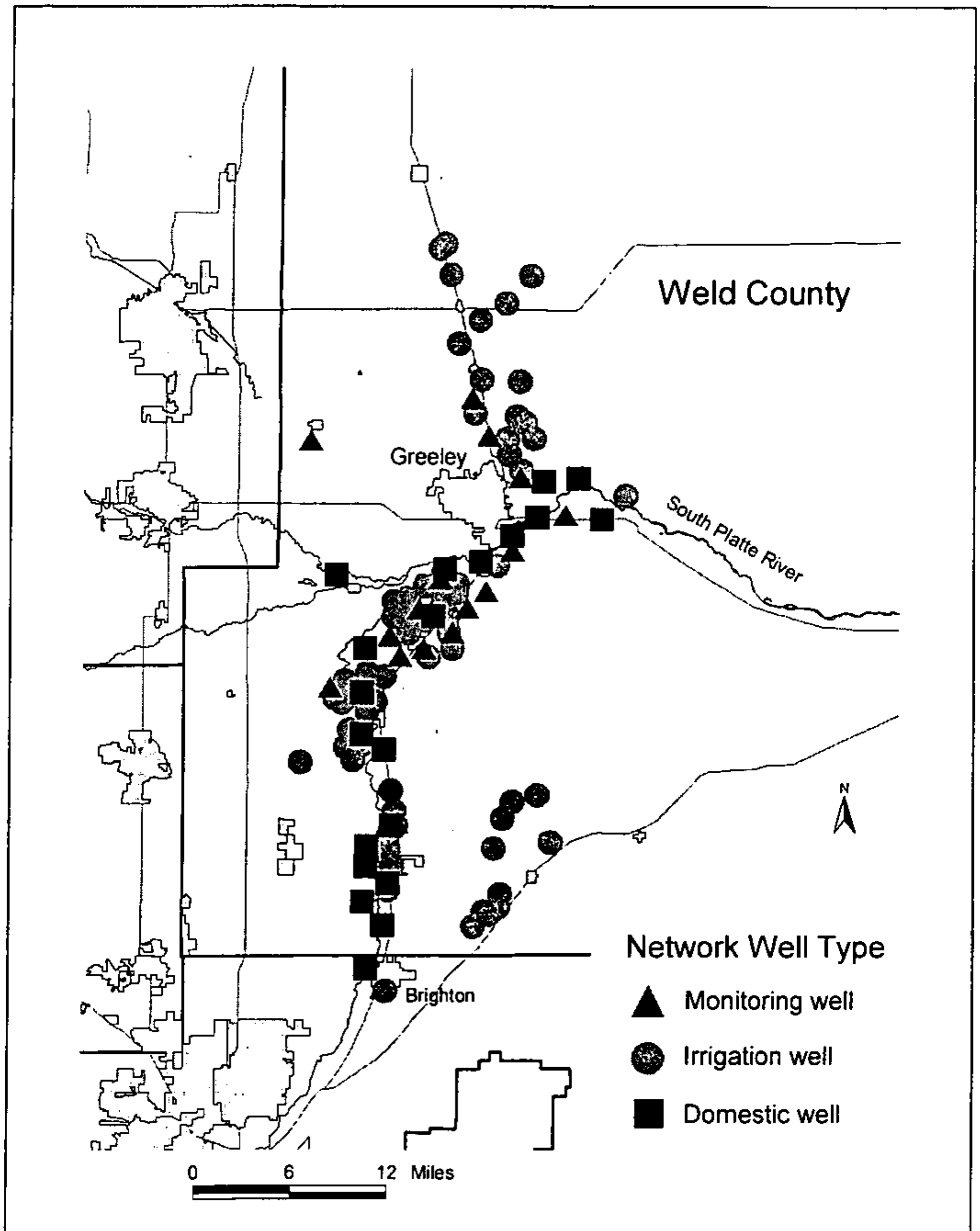


FIGURE 1 - Location and type of well comprising the Weld County, Colorado long term monitoring network.

From June through August 2004, 82 wells in the long-term network were sampled. All wells were analyzed for nitrate-nitrite as nitrogen. The 19 monitoring wells were analyzed for the complete suite of 47 pesticides listed in Table 4. The pesticide analysis for the 53 irrigation and 10 domestic wells was an immuno assay screen for the triazine herbicides.

Nitrogen analysis indicated that 58% of the monitoring wells, 70% of the irrigation wells and 40% of the domestic wells exceeded the nitrate drinking water standard of 10 mg/L. In the monitoring wells, nitrate levels varied over a broader range, with the highest median value. The monitoring wells sample the upper most zone (10 feet) of the aquifer. The irrigation and domestic wells recorded a narrower range in nitrate levels with a smaller median value for the domestic wells. The differences are expected due to the different zones of the aquifer sampled by each well set, as the irrigation wells sample the entire saturated zone, and domestic wells typically sample the lower portion of the aquifer. Table 1, below, lists the summary statistics for each set of wells.

TABLE 1 - Summary statistics for the Weld County nitrate monitoring results, 2004.

Weld County Nitrate Monitoring			
	Monitoring wells	Domestic wells	Irrigation wells
Mean	20.0	11.7	15.9
Median	14.7	9.0	14.3
Standard Deviation	23.2	10.5	9.8
Minimum	3.6	1.6	0.05
Maximum	110	35.3	37.2
# Wells sampled	19	10	53
Note: all values are Nitrate as N (mg/L), except # wells			

Pesticide results for the monitoring well portion of the network revealed three pesticides, Atrazine, Metolachlor, and Clopyralid present in well samples. The breakdown product of Atrazine, Deethyl Atrazine was also detected. Atrazine was present in three wells and Deethyl Atrazine was present in six of the wells. Three wells contained both triazine compounds. Metolachlor and Clopyralid were each detected in other wells. The total number of wells with a pesticide detection was eight of the nineteen sampled (42%). Detection levels ranged from 0.16 for Atrazine to 1.96 ug/L (ppb) for DEA. No pesticide was detected at a level that exceeds the applicable standard.

The triazine herbicide screen used on the irrigation wells detects any pesticide in this family, which includes Atrazine, Simazine, Cyanazine, Deethyl Atrazine, Deisopropyl Atrazine, and Prometone. The results are calibrated in units of Atrazine equivalent but may be actually composed of one or more of the components. In 2004, triazine herbicides were detected in 92% of the irrigation wells and 80% of the domestic wells. Levels ranged from 0.06 ug/L to 0.86 ug/L (ppb) in the irrigation wells and from 0.06 ug/L to 0.18 ug/L in the domestic wells.

Field sampling procedures followed the protocol developed by the ground water quality monitoring working group of the Colorado nonpoint task force.

Arkansas River Monitoring Well Network

The analysis of existing monitoring data, agricultural chemical use, and aquifer sensitivity and vulnerability models developed by the Program lead to a priority ranking of areas of the state for monitoring. The Arkansas River alluvial aquifer was lacking in monitoring well coverage and ranks third in our areas of concern. This area was selected to receive all twenty (20) monitoring wells in 2004, installed by the Program with a grant from the EPA.

The specific monitoring well site selection criteria, used for these final site selections, were similar to the criteria that have guided the monitoring program since its inception. To qualify, an area must have agricultural chemical use in significant quantities, depth to ground water generally less than 50 feet (both a vulnerability and drilling economics factor), a representative array of soil types, and a mixture of irrigated and non-irrigated land use.

Figure 2 shows the final sites selected for the Arkansas River alluvial aquifer monitoring well network.

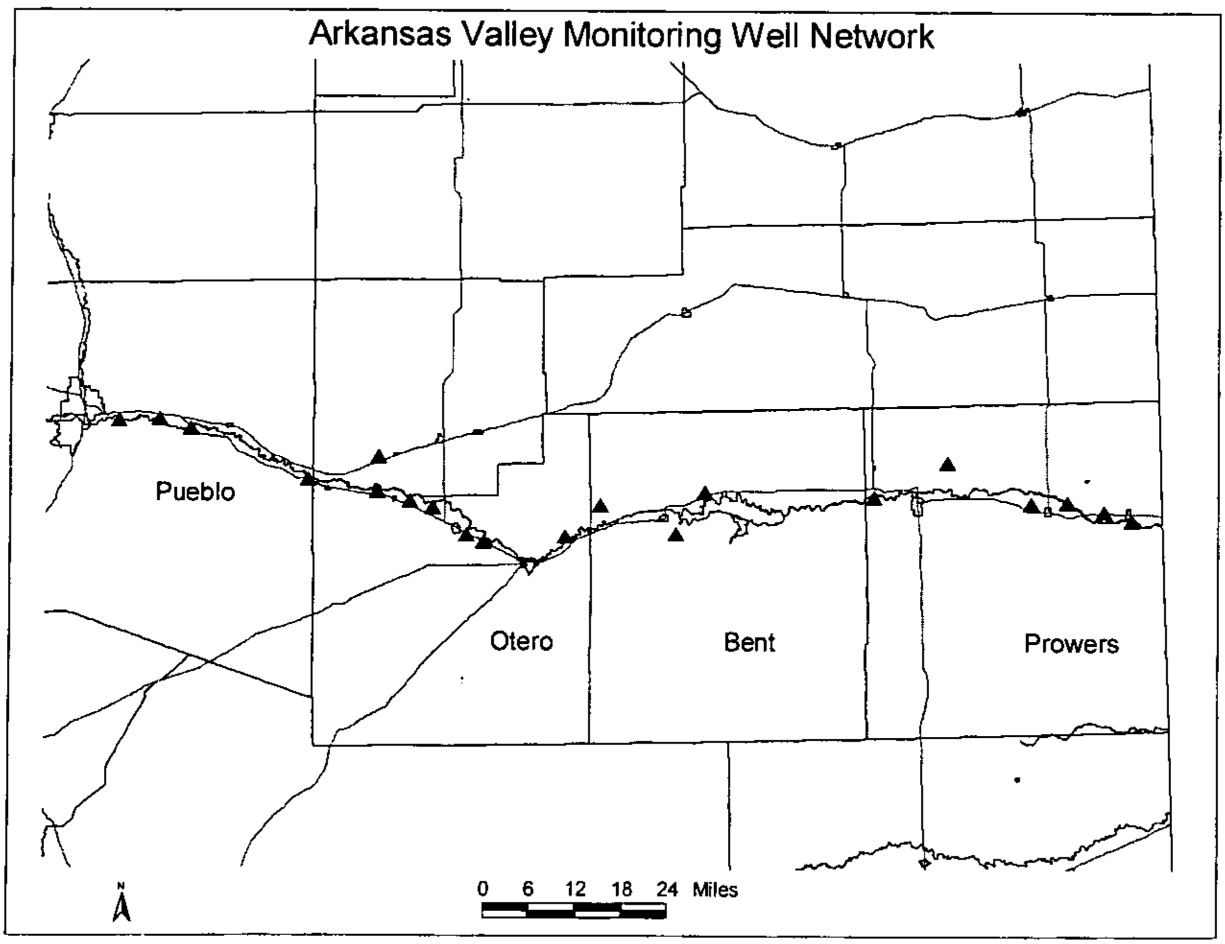


Figure 2 – Monitoring well locations in the Arkansas River alluvial aquifer.

Well Installation and Sampling

A hollow-stem continuous flight auger was used to drill all monitoring wells. All down hole drilling equipment was decontaminated following drilling with double steam cleaning, liquinox, and deionized water rinse. During drilling, the cuttings were logged at five (5) foot minimum intervals or whenever a change in lithology was detected. A two (2) foot core sample was taken at each five (5) foot interval, at every monitoring well, from surface to the water table. Borehole sample/cuttings were described and a borehole lithologic log was prepared. Data gathered for each drilled well includes: lithologic description and remarks, color, moisture, consistency, soil type, depth, method of sample collection and identification number, penetration resistance, ground water depth, perched water zones, borehole diameter, date drilled, drilling contractor, project identification, project location, well identification, and well completion data. All measurements and activities are documented in a field logbook. Well casings were constructed of two (2) inch schedule 40 ASTM-approved polyvinylchloride (PVC). Pipe sections were flush threaded to prevent the introduction of contaminants such as glue or solvents into the well. All installed well casing and screens had been pre-cleaned prior to emplacement to ensure that all oils, greases, and waxes have been removed.

Well Construction and Completion Procedures

In the alluvial materials encountered at these sites, the shallower portions of the bolehole would typically fail to stand open as the auger is retracted prior to the construction of the monitoring well. Therefore, all monitoring wells were constructed through the hollow axis of the auger column. When the auger column was used as a temporary casing during well construction, the hollow axis facilitated the installation of the monitoring well casing, intake, filter pack, and annular seal.

In summary the following procedures were adhered to:

The filter pack extended from the bottom of the well screen to no more than two feet above the well screen.

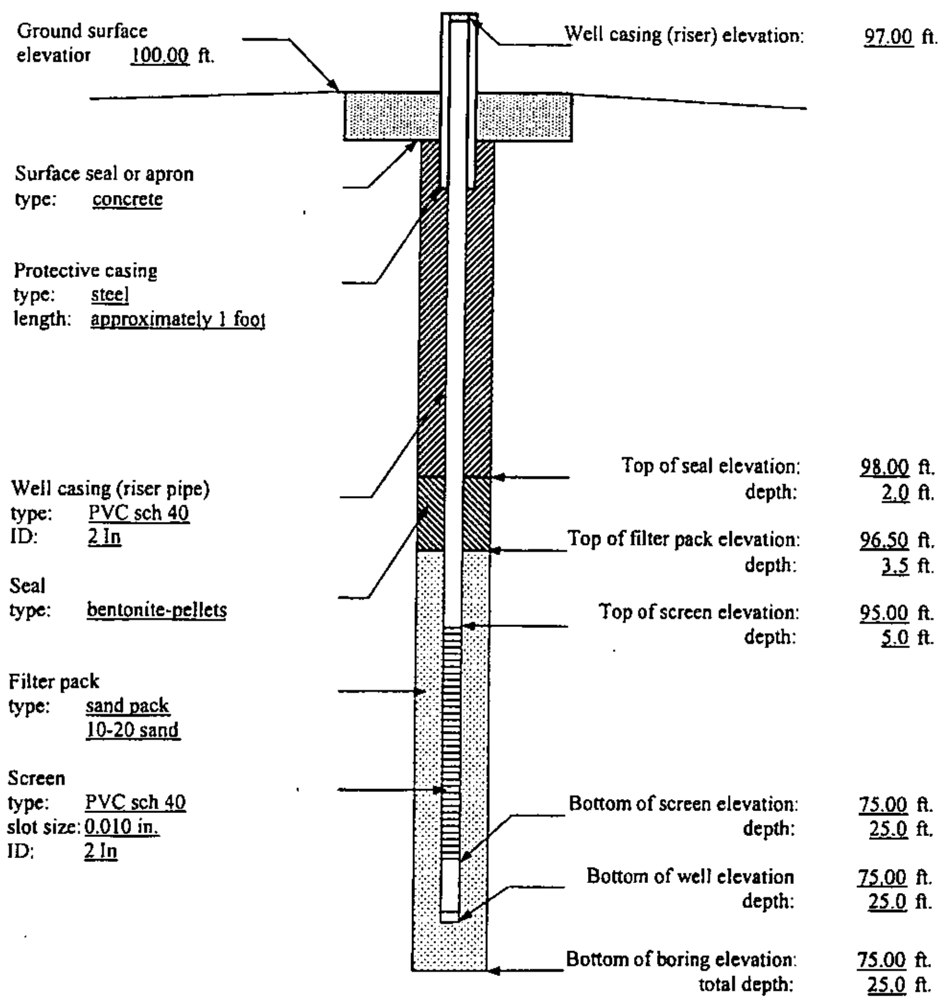
The annular seal was constructed by placing a stable, low permeability material in the annular space between the well casing the borehole wall. The annular seal extends from the top of the filter pack to the bottom of the surface seal. Potable water was added to the bentonite to complete the seal for all locations above the water table. This two (2) foot interval above the filter pack was sealed with untreated sodium bentonite pellets. A bentonite-cement mixture was placed from the top of the bentonite pellet zone to the expanding cement surface seal. Expanding cement was used for the remaining annular space to provide for security and an adequate surface seal.

At completion of the well, a lock was installed to prevent the entrance of foreign material and tampering. Typical well construction is illustrated in Figure 3 below.

CDA - Ag. Chems & GW Protection Program		Well Number: MW-01
DATE DRILLED: 3/4/2004	N1000 E1000	PROJECT: Ark River MW network
INSPECTED BY:		
COMMENTS: North end of Holly Airport, west edge of runway South of Ark River		JOB NO:
		INSTALLED BY: Spectrum

MONITORING WELL CONSTRUCTION DIAGRAM

NTS



DATE COMPLETED: 3/4/04
CASING (RISER) ID: 2 In
SCREEN LENGTH: 20.0 ft.
SCREEN SLOT SIZE: 0.010 in.

ALL ELEVATIONS IN FEET ABOVE MEAN SEA LEVEl

Figure 3 – Typical construction diagram for Arkansas monitoring wells.

Well Development

Following the construction of the monitoring wells, natural hydraulic conductivity of the formation was restored and all foreign sediment removed to ensure turbid-free ground water samples. Well development was completed two weeks after completion of drilling. All development well equipment was decontaminated prior to use with liquinox cleaning, first rinse, and a final dionized water rinse.

Before initiating the well surging, the well was bailed to make sure that water flowed into it. A mechanical method of development, a surge block, was used to force water to flow into and out of the screen. Development began above the screen and moved progressively downward to prevent the tool from becoming sand locked. Surging and cleaning was continued until little or no sediment could be pulled into the well.

Sampling

The Arkansas monitoring well network was first sampled in 2004. Sampling procedure followed the established Program protocol for sampling of ground water.

Prior to purging the well for sampling purposes, the water level was measured and recorded to the nearest +/- 0.01 foot. As a rule of thumb, three times the volume of water in the well casing is purged prior to sampling. Rather than attempt to calculate these volumes, a determination of when fresh formation water has reached the point of sampling was verified by measuring pH, conductivity and temperature. A field portable instrument for measuring conductivity and temperature was used for this purpose at each well site. For each well, the conductivity and temperature were measured at periodic intervals (approximately every 5 minutes) while the well was being purged. Water samples were collected when solution chemistry of the ground water had stabilized such that three consecutive readings were within 5 %. It can be reasonably assumed that a stabilization in the values of these parameters indicates that the casing has been purged and fresh formation water has reached the sampling point.

Negative bias (loss of constituent) is of significant concern in sampling for volatile compounds. Therefore great care was taken in sample collection to minimize degassing by operating the sampling pump at a low volume. Samples for volatile constituents were collected first. Samples for nitrate and inorganic analysis were collected next. Water samples for dissolved metals analysis were filtered with a 0.45 micron size filter.

In addition, the sampling team collected quality assurance samples consisting of field blanks and periodic duplicate samples. Field blanks were utilized for field QA/QC performance and subjected to all conditions to which the samples were exposed. Duplicate samples were prepared for lab calibration checks.

Sample bottles were provided by the lab and were part of the quality control program. All samples were handled and preserved in accordance with the requirements of the laboratory used for that analysis. Calibration and operation of all monitoring equipment followed the manufacturer's instructions.

Ground water samples were protected from undue exposure to light during handling, storage, and transport. Samples were stored on ice to prevent temperature extremes and transported to the CDA and CSU laboratories and analyzed within the recommended holding periods. Documentation of actual sample storage and treatment were handled as part of the chain of custody procedures.

Wells were sampled to minimize the potential for cross contamination. Decontamination procedures were adhered to between each sampling event. All common sampling equipment was decontaminated prior to and between all sampling events by washing with a non-phosphate detergent, rinsing with potable water, rinsing with methanol, and a final rinsing with laboratory grade deionized water.

The sampling team disposed of all wastes produced during the sampling events in accordance with Federal and State regulations. Disposable sampling equipment was bagged, removed from the site, and disposed of as a non-hazardous material. All samples were handled in accordance with standard laboratory chain of custody protocol after collection and identification.

Sampling Results

Well number AKMW-001 which was located at the Holly airport was not sampled due to damage sustained by an unfortunate encounter with a mower. The remaining nineteen (19) wells were sampled in August – September 2004. The 19 monitoring wells were analyzed for nitrate-nitrite as nitrogen and the complete suite of 47 pesticides listed in Table 3.

Nitrogen analysis indicated that only one of the nineteen (19) wells sampled (5%) showed nitrate levels in excess of the EPA standard for drinking water (10 mg/L). One well tested below the laboratory detection limit of 0.1 mg/L. The remaining seventeen (17) wells (89%) tested positive for nitrate but were below the EPA standard.

Figure 4 is a map of the area locating each of the wells and showing their corresponding nitrate result. Wells on the map have been color coded according to the nitrate level measured in the well. The wells in blue have nitrate levels below the laboratory detection level of 0.1 mg/L. The wells in green have nitrate levels above the laboratory detection level of 0.1 mg/L up to one half the drinking water standard (4.9 mg/L). Wells in yellow indicate nitrate present in the sample at or greater than one half the standard (5.0 mg/L) but less than 10 mg/L. Wells presented in red indicate nitrate levels exceeding the EPA drinking water standard.

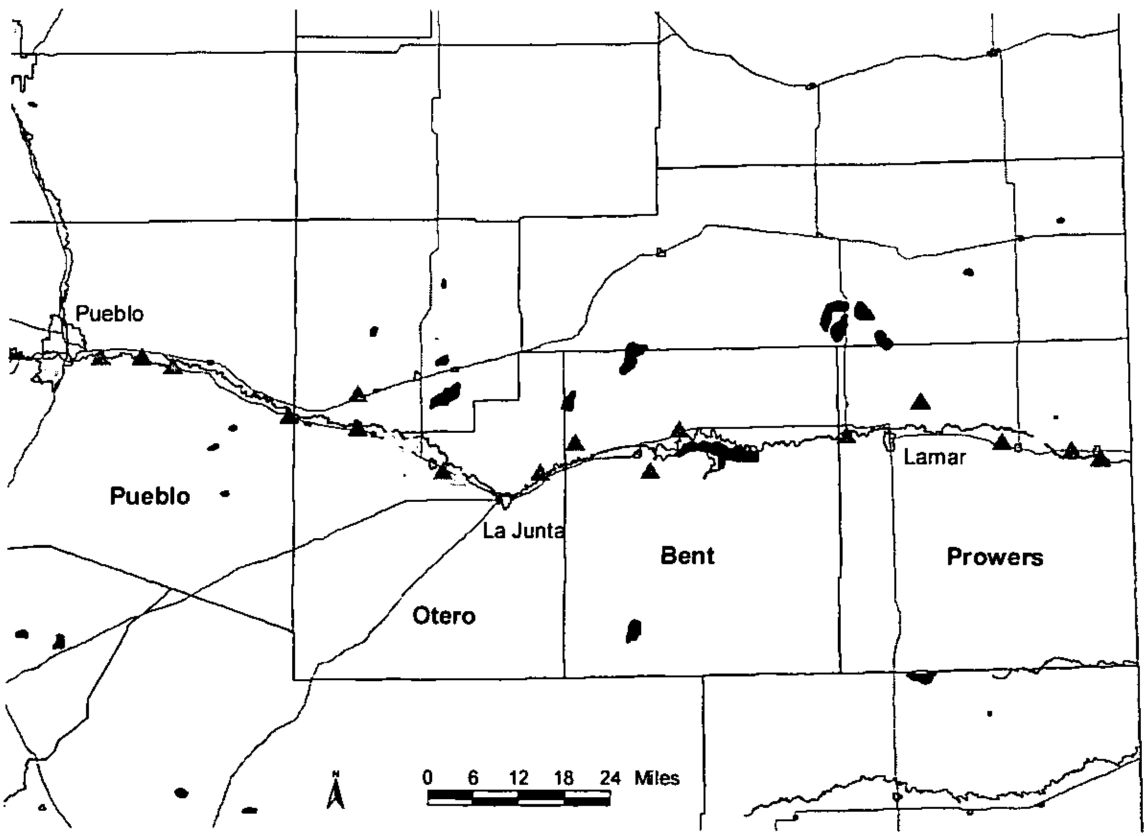


Figure 4 – Map showing nitrate levels in Arkansas monitoring wells, 2004

Pesticide data revealed three pesticides, Atrazine, Metolachlor, and 2,4-D present in the well samples. The breakdown product of Atrazine, Deethyl Atrazine was also present in one well. No pesticide concentration exceeded an applicable water quality standard.

Table 2 provides details on the three different pesticides detected in the Arkansas Valley monitoring wells. In one (1) of the nineteen (19) wells sampled the herbicide Atrazine was detected (5 %). Atrazine is a herbicide commonly used for weed control and often found in ground water in agricultural areas due to its chemical properties of persistence and mobility. Deethyl Atrazine was detected in two (2) wells, one of which also contained Atrazine. Deethyl Atrazine is a breakdown product of Atrazine and when found indicates that Atrazine was present at an earlier time in this area. The detection limit of the laboratory analysis is 0.1 ug/l or ppb for both products. One (1) well (5 %) contained the herbicide Metolachlor and one well detected positive for the herbicide 2,4-D.

TABLE 2 - Results of Pesticide Analysis, Arkansas monitoring wells, 2004.

Pesticide	Detections	Range	DL	MCL
Atrazine	1	0.26	0.07	3
Deethyl Atrazine	2	0.14 - 0.41	0.07	
Metolachlor	1	0.58	0.08	100
2,4-D	1	0.24	0.03	70

Amounts are given in micrograms per liter (ug/L), a unit of measurement for pesticide concentrations in water that is equivalent to parts per billion (ppb).
Detections - The number of wells testing positive for that pesticide.
Range - The range of concentration values for that pesticide in those wells.
DL - Minimum concentration that can be detected by the laboratory.
MCL - The maximum amount allowed in drinking water, if no MCL has been established the number given is the lifetime drinking water health advisory.

The location of the pesticide detections are plotted in Figure 5. Wells plotted in red contained Atrazine and/or Deethyl Atrazine. Of the five (5) detections listed in Table 2, one well contains both compounds, Atrazine in combination with Deethyl Atrazine. The well plotted in yellow tested positive for Metolachlor and the well in magenta contained 2,4-D. In sum total, there are four (4) wells containing five (5) pesticide detections plotted.

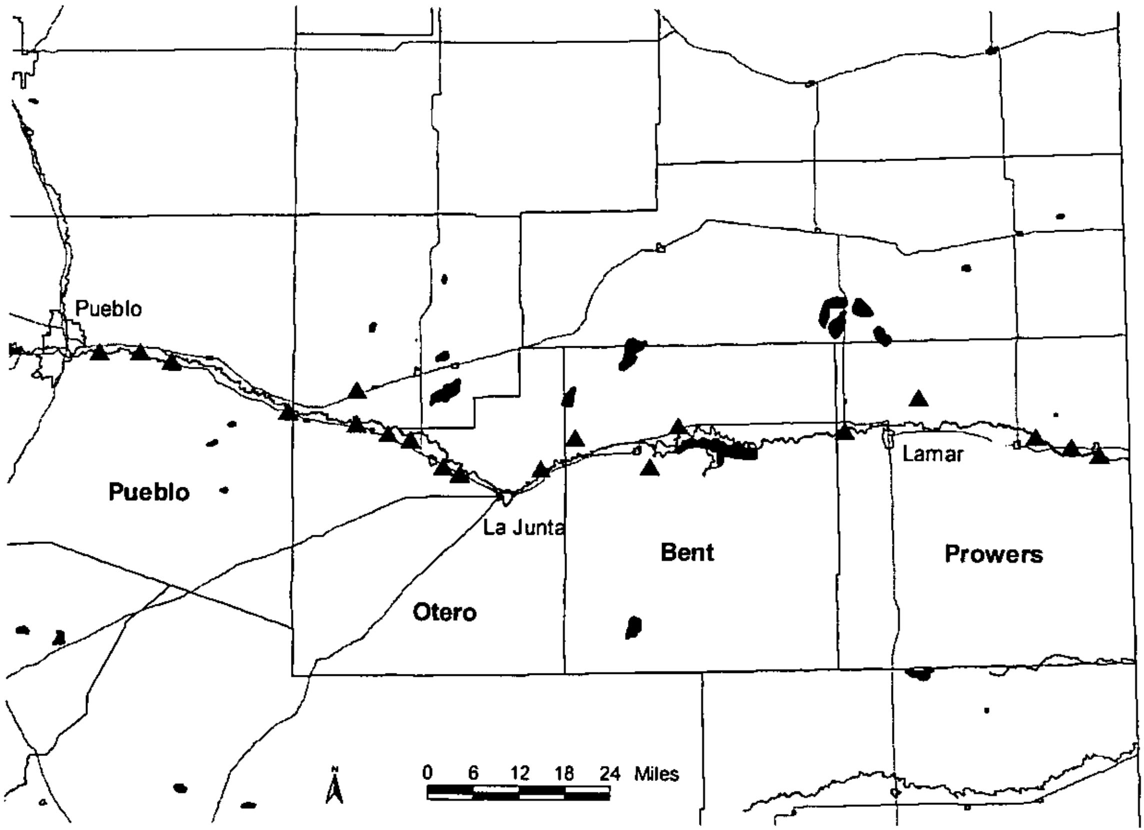


Figure 5 – Map showing locations of pesticide detections in Arkansas monitoring wells, 2004.

Front Range Urban Corridor Monitoring Well Network

The Front Range urban corridor is an area we intend to continue monitoring for agricultural chemicals. The development density of this area creates special considerations and challenges for monitoring. The availability of existing domestic and irrigation wells is very limited. A current project is building a monitoring network from existing monitoring wells. There are currently hundreds of dedicated monitoring wells throughout the metropolitan area. The majority of these wells were installed for site investigations unrelated to agricultural chemicals. We hope to enlist the cooperation of monitoring well owners in this area and avoid the expense of additional drilling. At this time, the Program has contacted several well owners and received the cooperation of a sufficient number to consider the sampling of this area a go for 2005. The results of this effort will be covered in a future report.

Table 3 - Laboratory Methods and Detection Levels, 2004

Colorado Department of Agriculture Standards Laboratory

PESTICIDE ANALYSIS

Pesticide Trade Name	Pesticide Common Name	Pesticide Use	Chemical Type	EPA Method	MDL (ug/L)
Harness	Acetachlor	Herb	acetoalinide	525.1	0.1
Lasso	Alachlor	Herb	OrganoCL	525.1	0.1
AAtrex	Atrazine	Herb	Triazine	525.1	0.1
	Deethyl Atrazine		Triazine	525.1	0.2
	Deisopropyl Atrazine		Triazine	525.1	0.2
Balan	Benfluralin	Herb	OrganoFL	525.1	0.2
Hyvar	Bromacil	Herb	uracil	525.1	0.4
Captane	Captan	Fungi	carboximide	525.1	1.4
Lorsban	Chlorpyrifos	Insect	OrganoPH	525.1	0.1
Bladex	Cyanazine	Herb	Triazine	525.1	0.2
Dacthal	DCPA	Herb	phthalic acid	525.1	0.1
Dazzel	Diazinon	Insect	OrganoPH	525.1	0.2
Barrier	Dichlobenil	Herb	nitrile	525.1	0.1
Cygon	Dimethoate	Insect	OrganoPH	525.1	0.5
	p,p-DDT	Insect	OrganoCL	525.1	0.4
	Endrin	Insect	OrganoCL	525.1	0.3
	Heptachlor	Insect	OrganoCL	525.1	0.6
	Heptachlor epoxide	Insect	OrganoCL	525.1	0.8
Velpar	Hexazinone	Herb	Triazine	525.1	0.1
Gamma-mean	Lindane	Insect	OrganoCL	525.1	0.1
Malathion	Malathion	Insect	OrganoPH	525.1	0.1
Ridomil	Metalaxyl	Fungi	acylalanine	525.1	0.2
Marlate	Methoxychlor	Insect	OrganoCL	525.1	0.9
Dual	Metolachlor	Herb	acetamide	525.1	0.1
Sencor	Metribuzin	Herb	Triazine	525.1	0.5
Prowl	Pendimethalin	Herb	dinitroaniline	525.1	1.2
Primatol	Prometon	Herb	triazine	525.1	0.1
Princep	Simazine	Herb	triazine	525.1	0.2
Treflan	Trifluralin	Herb	OrganoFL	525.1	0.3
Weed B Gone	2,4-D	Herb	PhenoxyAcid	515.2	0.03
Stinger	Clopyralid	Herb	PicolinicAcid	515.2	0.07
Banvel	Dicamba	Herb	BenzoicAcid	515.2	0.05
Kilprop	MCPP	Herb	PhenoxyAcid	515.2	0.06
Agritox	MCPA	Herb	PhenoxyAcid	515.2	0.02
Tordon	Picloram	Herb	PicolinicAcid	515.2	0.17
Turflon	Triclopyr	Herb	PicolinicAcid	515.2	0.01

Table 3, continued - Laboratory Methods and Detection Levels, 2004

Colorado Department of Agriculture Standards Laboratory

PESTICIDE ANALYSIS

Pesticide Trade Name	Pesticide Common Name	Pesticide Use	Chemical Type	EPA Method	MDL (ug/L)
Temik	Aldicarb	Insect	Carbamate	531.1	1.0
	Aldicarb sulfone		Carbamate	531.1	2.0
	Aldicarb sulfoxide		Carbamate	531.1	2.0
Sevin	Carbaryl	Insect	Carbamate	531.1	2.0
Furadan	Carbofuran	Insect	Carbamate	531.1	1.5
	3-Hydroxycarbofuran		Carbamate	531.1	2.0
	Methiocarb	Insect	Carbamate	531.1	4.0
Lannate	Methomyl	Insect	Carbamate	531.1	1.0
	1-Naphthol		Carbamate	531.1	1.0
DPX	Oxamyl	Insect	Carbamate	531.1	2.0
Baygon	Propoxur	Insect	Carbamate	531.1	1.0

INORGANIC ANALYSIS	EPA Method	MDL (mg/L)
Nitrate/Nitrite as N	300	0.1

Table 3, continued - Laboratory Methods and Detection Levels, 2004

Colorado State University Soils Laboratory

MINERALS AND DISSOLVED METALS ANALYSIS

Basic Water Quality Parameters	Method	Reporting Limit (mg/L)
Boron	EPA 200.0	0.01
Bicarbonate	APHA 2320B	0.1
Calcium	EPA 200.0	0.1
Carbonate	APHA 2320B	0.1
Chloride	EPA 300.0	0.1
Magnesium	EPA 200.0	0.1
Nitrate	EPA 300.0	0.1
pH	EPA 150.1	0.1 pH unit
Sodium	EPA 200.0	0.1
Specific conductance (TDS)	EPA 120.1	1.0 uS/cm
Sulfate	EPA 300.0	0.1
Potassium	EPA 200.0	0.1
Alkalinity, total	Titration	1.0
Solids, Total Dissolved	Gravimetric	10.0
Hardness, total as $CaCO_3$	Calculation	1.0
Dissolved Metals		
Aluminum	EPA 200.0	0.1
Barium	EPA 200.0	0.01
Cadmium	EPA 200.0	0.01
Chromium	EPA 200.0	0.01
Copper	EPA 200.0	0.01
Iron	EPA 200.0	0.01
Manganese	EPA 200.0	0.01
Nickel	EPA 200.0	0.01
Molybdenum	EPA 200.0	0.01
Phosphorous, total	EPA 200.0	0.1
Zinc	EPA 200.0	0.01

APPENDIX II

2004 Annual Report
Colorado State University Cooperative Extension

Summary of Accomplishments

- Conducted educational programs throughout Colorado on issues related to agricultural chemicals and ground water quality. Groups addressed include crop and livestock producers, commercial applicators, chemical dealers, weed districts, crop consultants, crop and livestock producers, agency personnel, real estate professionals, and urban chemical users.

- Produced newsletter articles, press releases, fact sheets, technical papers, and other mass media articles on ground water protection in Colorado.

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

- Published a pocket-sized *Irrigated Field Record Book* (Appendix IV) to help growers improve irrigation water management. We cooperated with the Natural Resources Conservation Service (NRCS) to have over 2,500 copies printed.

- Published a technical bulletin, Center Pivot Irrigation in Colorado as Mapped by LandSat Imagery (Appendix IV). This publication describes and provides the result of efforts to improve irrigation maps in GIS format. This work supports on-going ground water sensitivity/vulnerability mapping in Colorado. Found on the internet at: www.colostate.edu/Depts/AES/pubs_c.html.

- Published article that describes the methodology and results of ground water vulnerability mapping and field assessments (nitrogen leaching index) entitled, *Vulnerability Assessments of Colorado Ground Water to Nitrate Contamination*, in the Journal of Water, Air, and Soil Pollution (Appendix IV).

- Wrote draft report presenting summarized data from returned surveys from a state wide Irrigated Crop Production Survey to assess the current level of BMP adoption by Colorado producers. This should be published in 2005.

- Cooperated with field Extension staff to conduct irrigation management demonstrations on farmer fields throughout Colorado. Demonstrations included: using ET from atmometers and weather stations for improved irrigation scheduling; the affect of sprinkler nozzle height on corn yield, runoff and soil moisture under center pivot irrigation (second year).

- Conducted an applied research study/demonstration on irrigation-water-nitrate crediting in Weld County and cooperated with faculty in the Soil and Crop Sciences Department at CSU to conduct a study on cross-linked Polyacrylamide in drybeans.

- Cooperated with the Colorado Climate Center to improve and promote 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.

- Developed a Colorado curriculum set for physical ground water models that were distributed to County Extension agents around the state to utilize in water festivals and other educational opportunities. These models are primarily used to educate people (primarily youth) about ground water.

- Served on the planning committee for the 2004 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.

- Maintained a CSU Extension Water Quality Website to disseminate BMP information via the Internet and obtained an easy-to-remember web addressed (www.csuwater.info).

- Distributed a revised series of four fact sheets on the web to educate Colorado homeowners on BMPs for urban pesticide and fertilizer use. These fact sheets are entitled:
  Homeowner's Guide to Protecting Water Quality and the Environment XCM-223
  Homeowner's Guide to Pesticide Use Around the Home and Garden XCM-220
  Homeowner's Guide: Alternative Pest Management for the Lawn & Garden XCM-221
  Homeowner's Guide to Fertilizing Your Lawn and Garden XCM-222

- Reprinted and distributed the revised *Pesticide Record Book* for Private Applicators (Appendix IV).

- Worked to coordinate efforts of the Agricultural Chemicals and Ground Water Protection Program with other state and federal programs in Colorado.

- Assisted the Colorado Department of Agriculture in sampling soils from the vadose zone while drilling monitoring wells in the Arkansas Valley.

Ongoing BMP Development and Education

Colorado State University Cooperative Extension (CSUCE) has worked with the Colorado Department of Agriculture to develop Best Management Practices for Colorado farmers, landowners, and commercial agricultural chemical applicators. Because of the site-specific nature of ground water 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 Program 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 (manure was revised in 1999) and expanded to include additional guidelines. Revisions to one chapter in that notebook, *Best Management Practices for Private Well Protection*, were started in 2004.

Cooperative 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.

Evaluation of BMP Adoption

A mailed crop production survey was conducted during the last week of November, 2001 to measure the progress of our educational efforts related to the Program. This survey was mailed to 3,260 irrigating crop producers. To date, 1,298 (40%) producers have responded with 37% of the responses being usable. The primary objective of this survey was to learn the adoption rate of nutrient, pesticide, and irrigation BMPs among Colorado producers. Results from returned surveys were entered into a database in 2002 and were analyzed and summarized in 2003 and 2004. These results will be used to focus the Ground Water Program on the geographical and topical areas that need higher adoption rates to protect water quality. Because we conducted a similar survey in 1997, we can use the 2001 survey to measure progress in our educational efforts since that time. The results of this survey have been summarized in a draft technical report that is currently in review.

Field Demonstration and Research

Field demonstration work in 2004 focused on helping growers improve water and nutrient management. CSUCE loaned atmometers (ETgages) to county agents, consultants, and individual farmers in Weld, Boulder, Kit Carson, and Yuma Counties. ETgages are useful for simple and effective irrigation scheduling. A second year of a center pivot nozzle height (above and below canopy) replicated demonstration was conducted in cooperation with the NE Regional Water Specialist. Nozzle placement can impact water runoff and therefore irrigation uniformity, soil moisture storage and ultimately yield. Results suggested that placing nozzles at a height just above the canopy reduced runoff, improved soil moisture storage, but did not significantly impact yield as compared to nozzles located within the canopy at 14 inches above the ground. Results were published in the *Proceedings for the Center Plains Irrigation Conference and Exposition* (Appendix IV).

Additionally, 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). As in 2003, selected marketing of these crop water use reports was conducted in Northeastern Colorado to build awareness and adoption of this information for improved irrigation scheduling.

Applied research on nutrient management included a continuing study/demonstration of irrigation water NO_3-N crediting in Weld County in 2004. The results of these demonstrations are useful in convincing growers to adopt this BMP when using nitrate enriched ground water. The Ground Water Program also cooperated with other CSU faculty in the Soil and Crop Sciences Department to conduct a study on the potential to save water using cross-linked Polyacrylamide in drybeans.

Finally, during the Arkansas Valley monitoring well drilling project, CSU worked with CDA to collect soil samples every five feet from the surface to the water table (vadose zone). These were analyzed at CSU for nitrate-nitrogen and phosphorus. Results were presented showing little nitrate in the vadose zone; but some phosphorus movement, which is generally not expected in Colorado's soils. A pesticide analysis may be conducted at the CDA lab at a later date if laboratory time becomes available.

Education and Communication

Communication is a vital component of the Program. Numerous methods are used to provide information to individuals and organizations using agricultural chemicals. We continue to provide written fact sheets and publications with information on the Program and distribute at meetings, conferences, and trade shows. Also, a display board is being utilized at conferences and trade shows to provide information on the Program. Information on ground water protection is continually being presented to the public through publications, newsletter articles, 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 2004, presentations were made at several major meetings and small local groups throughout the state. We consider this type of outreach an important part of the customer service component of the Program.

This past year we continued to make information available over the internet. Several locations including the CSU Cooperative Extension web site (http://www.ext.colostate.edu), the CSU Cooperative Extension Water Quality web site (http://www.csuwater.info), and the Agricultural Chemicals and Ground Water Protection Program web site (http://www.ag.state.co.us/dpi/GroundWater/home.html), provide information on BMPs.

Educational efforts aimed at youth are also conducted. We developed a set of Colorado specific curriculum to accompany four ground water models purchased from the Soil and Water Conservation Society at Iowa State University using non-point source pollution grant funds. Three of the models were distributed to off-campus Cooperative Extension faculty to utilize in educational efforts in ground water. The four curriculum models are: Aquifer Properties, Ground Water Basics, Ground Water Quality and Septic Systems. Although the curriculum was largely developed for a youth audience, it can be used for all ages with some adjustment.

APPENDIX III

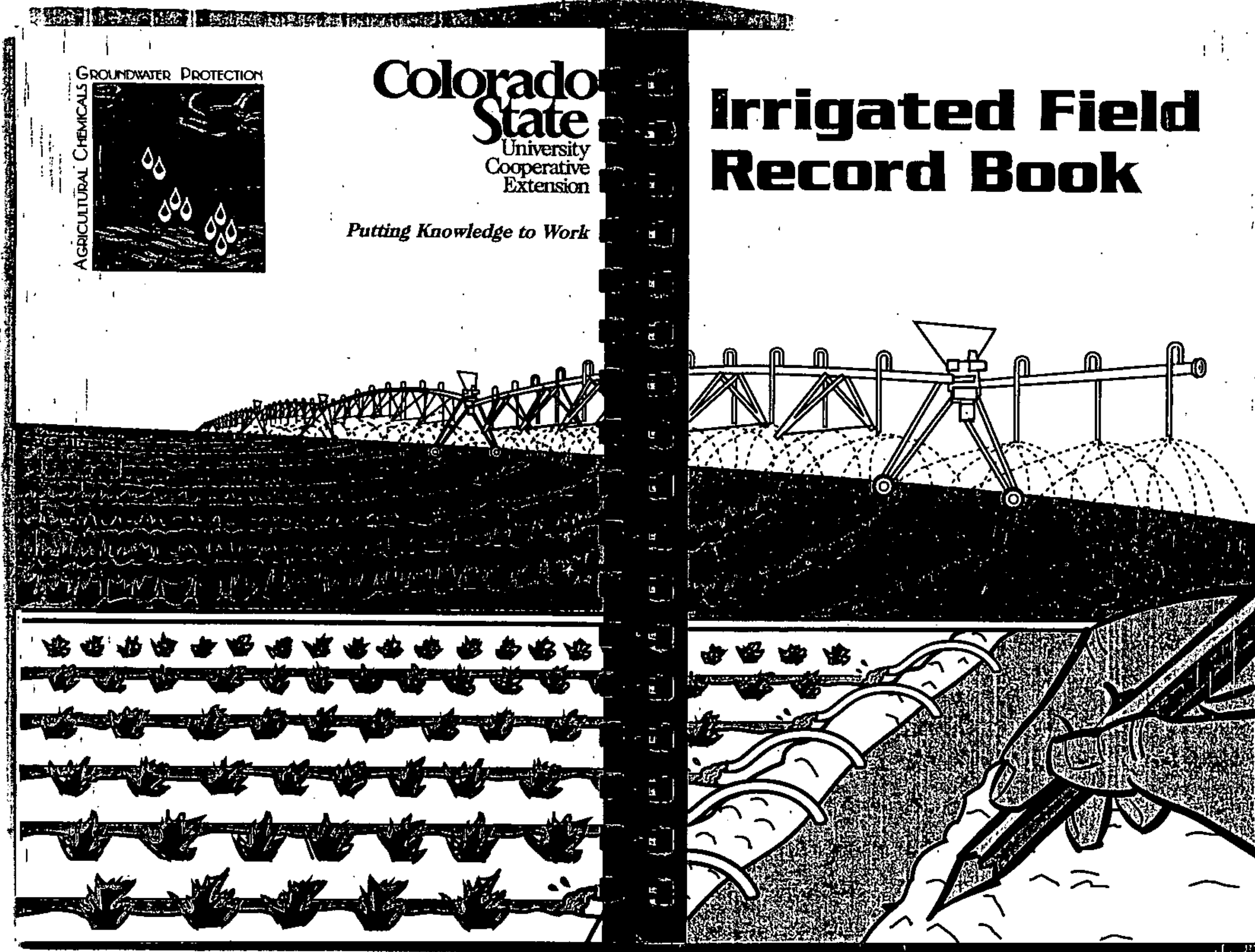
2004 Annual Report
Colorado Department of Public Health and Environment

During 2004, the Colorado Department of Public Health and Environment (CDPHE) continued to be actively involved with the Agricultural Chemicals and Ground Water Protection Program. The CDPHE continues to review the Program's monitoring data on an annual basis, and provide input on the results. Other activities that the Department has assisted the Program with include final permitting on the new monitoring wells along the Arkansas River, and attending meetings on an as needed basis.

The Department has also been actively involved in the Program's plans to develop a Web-based pesticide and ground water information tool. Activities related to this effort included assisting with preparation of the grant, help with the design and functionality of the database, and compilation of ancillary water quality associated metadata.

Finally, the CDPHE continues to support the Program by promoting the Program's activities whenever possible. These activities include communicating the Program's purpose and goals to other State and Federal agencies, interested parties, and private 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 ground water protection.

APPENDIX IV


Groundwater Protection
Agricultural Chemicals
Colorado State University Cooperative Extension
Putting Knowledge to Work
Irrigated Field Record Book

Technical Bulletin TB04-04 November 2004

Agricultural Experiment Station

Colorado State University
Knowledge to Go Places

College of Agricultural Sciences

Department of Soil and Crop Sciences

Cooperative Extension

Center Pivot Irrigation in Colorado as Mapped by Landsat Imagery

VULNERABILITY ASSESSMENTS OF COLORADO GROUND WATER TO NITRATE CONTAMINATION

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Abstract. Nitrate (NO_3-N) contamination of ground water aquifers is an important problem in the United States and throughout the world, particularly as ground water resources become increasingly relied upon to support human needs. Cost effective methodologies are needed to facilitate decision-making for ground water protection. To aid ground water protection organizations, we designed two tools to assess aquifer vulnerability to NO_3-N contamination in Colorado. The first tool is a statewide aquifer vulnerability map (VM) that identifies regions vulnerable to ground water contamination. The VM uses five factors that influence aquifer vulnerability on a regional scale: aquifer locations, depth to water, soil drainage class, land use, and recharge availability. We validated the VM using 576 discrete ground water sample points from throughout the state and found that the VM was able to delineate areas of increased aquifer vulnerability to NO_3-N contamination ($r^2 = 0.78$). The second aquifer assessment tool is a vulnerability matrix (VMX) developed to help practitioners determine relative aquifer vulnerability to NO_3-N contamination on a field scale. The VMX consists of a series of factors that are rated and combined for a particular field. This rating is used to give landowners an index of general aquifer vulnerability to NO_3-N contamination for a specific field, and inform them of changes in management practices to reduce the vulnerability. The VMX can be used in conjunction with the VM to determine NO_3-N contamination potential from intensive agriculture.

Keywords: ground water, nitrate leaching, vulnerability, geographic information systems, GIS

1. Introduction

The protection of ground water resources is a topic of concern throughout the United States (US) and world. In the state of Colorado, located in west central U.S.A., ground water is an important resource as approximately 20% of residents rely on ground water for drinking water supplies. Nitrate (NO_3-N) is a significant contaminant to ground water in many areas (Nolan *et al.*, 1997) and effort is required to minimize future contamination. Nitrate contamination is often associated with anthropogenic activities at the ground surface, such as the fertilization of agricultural crops (Kellogg *et al.*, 1992). Once ground water is contaminated it is difficult

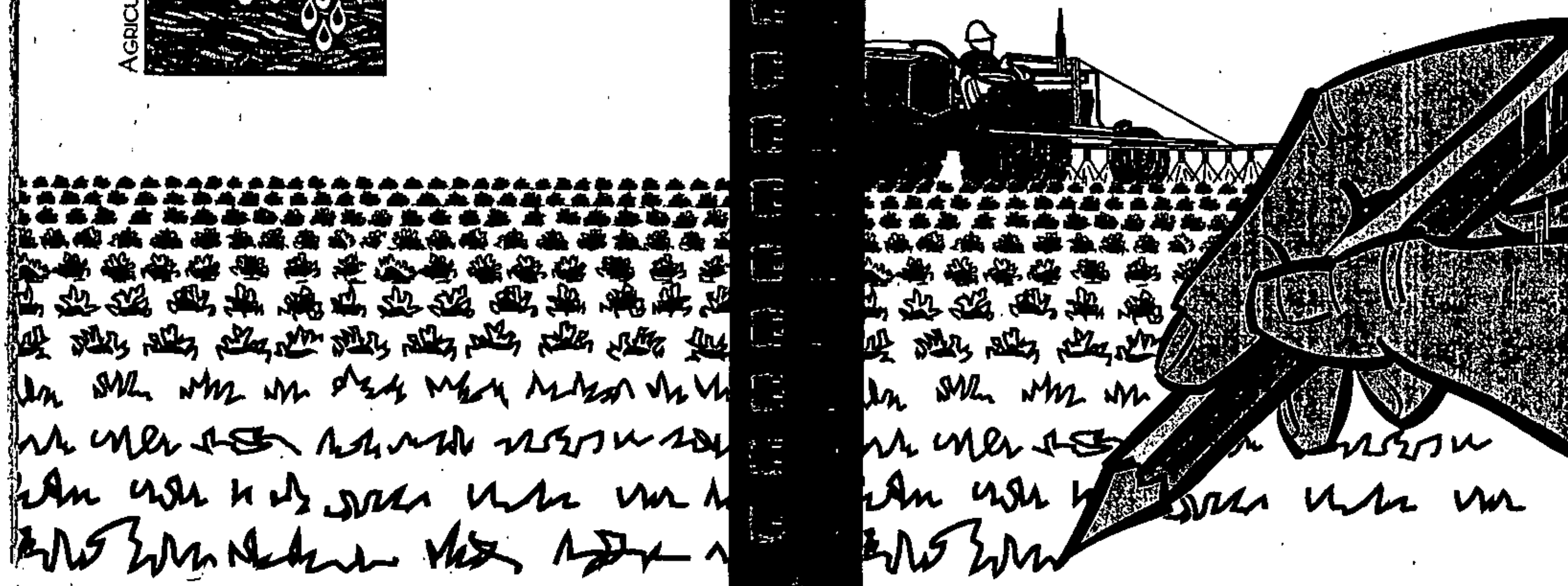
Water, Air, and Soil Pollution **159:** 373–394, 2004.

Colorado State University Cooperative Extension

Putting Knowledge to Work

Groundwater Protection
Agricultural Chemicals

Pesticide Record Book for Private Applicators



INFLUENCE OF NOZZLE PLACEMENT ON CORN GRAIN YIELD, SOIL MOISTURE, AND RUNOFF UNDER CENTER PIVOT IRRIGATION

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Maximizing irrigation efficiency is of enormous importance for irrigators in the Central Great Plains to conserve water and reduce pumping costs. High temperatures, frequently strong winds and low humidity increase the evaporation potential of water applied through sprinkler irrigation. Thus, many newer sprinkler packages have been developed to minimize water losses by evaporation and drift. These systems have the potential to reduce evaporation losses as found by Schneider and Howell (1995). Schneider and Howell found that evaporation losses could be reduced by 2-3% as compared to above canopy irrigation. Many producers and irrigation companies have promoted placing sprinklers within the canopy to conserve water by reducing the exposure of the irrigation water to wind. However, runoff losses can increase as the application rate exceeds the soil infiltration capacity with a reduced wetted diameter of the spray pattern within the canopy. Schneider and Howell (2000) found that furrow dikes were necessary to prevent runoff with in-canopy irrigation.

In 2003 and 2004, a study was conducted comparing sprinkler nozzle placement near Burlington, Colorado in cooperation with a local producer. The objective of this study was to determine the impact of placing the sprinkler devices within the canopy upon soil moisture, runoff and crop yield. A secondary objective was to determine the usefulness of in-season tillage on water intake and preventing runoff.

METHODS

For this study, we utilized the current configuration of a center pivot irrigation system owned by our cooperating farmer. This configuration included drop nozzles with spray heads at approximately 1.5 feet (in-canopy) above the ground surface. The sprinkler heads on the seventh and outside span of the center pivot were raised to approximately 7 feet above ground level (above canopy). This nozzle height allowed for an undisturbed spray pattern for a majority of the growing season. The sprinkler heads on the sixth span of the center pivot remained at the original height (in-canopy). In 2003, the nozzles were raised by

ADVANTAGES AND LIMITATIONS OF ET-BASED IRRIGATION SCHEDULING

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A key ingredient for improving irrigation water management to help conserve water resources is utilizing crop water use information, often referred to as evapotranspiration (ET). This information can be used by growers and their advisers to understand daily crop water use for scheduling irrigations and to determine the amount of water to apply to replenish soil water depletion.

Many resources have been used to develop, promote, and make available ET information for irrigating farmers in Eastern Colorado. Recent survey results suggest that this effort has had some success, but ET-based scheduling has not gained wide acceptance as a primary method for timing irrigations (Figure 1). Rather, a greater number of producers in Eastern reported they use weather station ET as a secondary method of scheduling irrigations, supplemental to

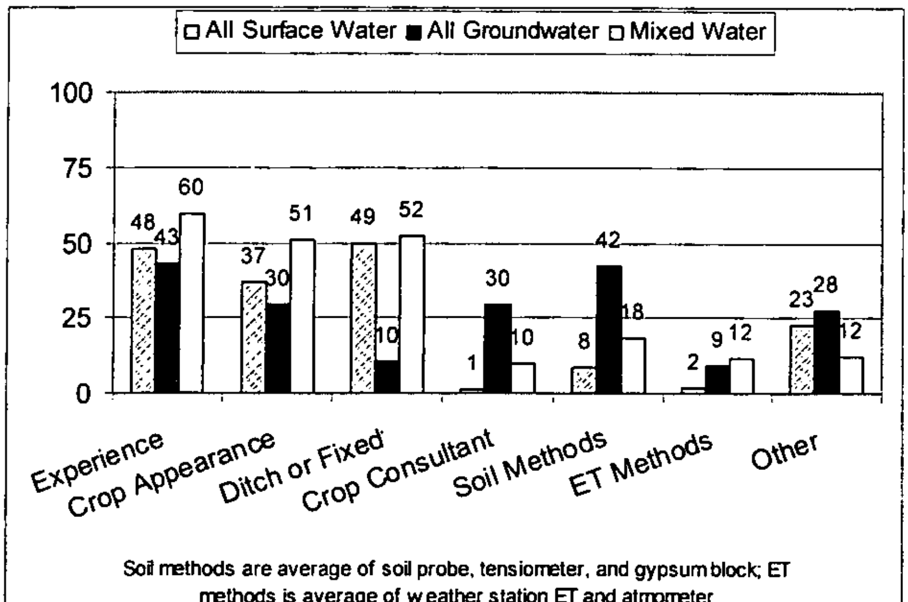

Figure 1. Irrigation scheduling methods chosen by Colorado irrigators in a 2002 mailed survey. Responses are an average of all Colorado regions by primary water source.

APPENDIX V

AGRICULTURAL CHEMICALS AND GROUNDWATER PROTECTION ACT
ADVISORY COMMITTEE
(Revised 2/04)

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(303) 337-6200
sgeist@swingletree.com
Original Appointment: 1994

Mr. Darrel Mertens
Aero Applicators, Inc.
P.O. Box 535
Sterling, CO 80741
(970) 522-1941
aeroapp@kci..net
Original Appointment: 2003

Green Industry

Mr. Eugene Pielin
GMK Horticulture
2768 Crestview Ct.
Loveland, CO 80538
(970) 669-0248
GMKHort@aol.com
Original Appointment: 1999

Mr. John Wolff
Grand Lake Golf Course
P.O. Box 590
Grand Lake, CO 80447
(970) 627-3429
wolffjkce@rkymthi.com
Original Appointment: 1998

Ag Chemical Suppliers

Mr. Anthony Duran
American Pride Coop
P.O. Box 98
Henderson, CO 80640
(303) 659-3643
aduran@americanpridecoop.c
om
Original Appointment: 1998

Mr. Wayne Gustafson
Agland, Inc.
155 Oak Drive
Eaton, CO 80615
(970) 454-4004
Wgustafson@aglandinc.com
Original Appointment: 1991

Producers

Mr. Lanny Denham
2070 57.25 Road
Olathe, CO 81425
(970) 323-5461
pdenham@gwe.net
Original Appointment: 1996

Mr. Steven Eckhardt
343 South 4th St.
La Salle, CO 80645
(970) 539-0443
steckhar@aol.com
Original Appointment: 1997

Mr. John Hardwick
24700 County Road 19
Vernon, CO 80755
(970) 332-4211
(no email address)
Original Appointment: 1991

Mr. Dave Latta
38002 Co. Rd. N
Yuma, CO 80759
(970) 848-5861 x 222
dlatta@conagrabeef.com
Original Appointment: 2001

Mr. Mike Mitchell
1588 E. Rd. 6 N.
Monte Vista, CO 81144
(719) 852-3060
mitch6@amigo.net
Original Appointment: 1991

Mr. Don Rutledge
10639 County Road 30
Yuma, CO 80759
(970) 848-2549
djrutledg@hotmail.com
Original Appointment: 1995

Mr. Max Smith
48940 County Road X
Walsh, CO 81090
(719) 324-5743
cmsmith@rural-com.com
Original Appointment: 1994

Mr. Leon Zimbelman, Jr.
0949 WCR G7
Keenesburg, CO 80643
(303) 732-4662
pufarms@concentric.net
Original Appointment: 1993