# Idaho

# Eastern Snake River Plain
# Section 319
# National Monitoring Program Project


Figure 9: Eastern Snake River Plain (Idaho) Demonstration Project Area Location

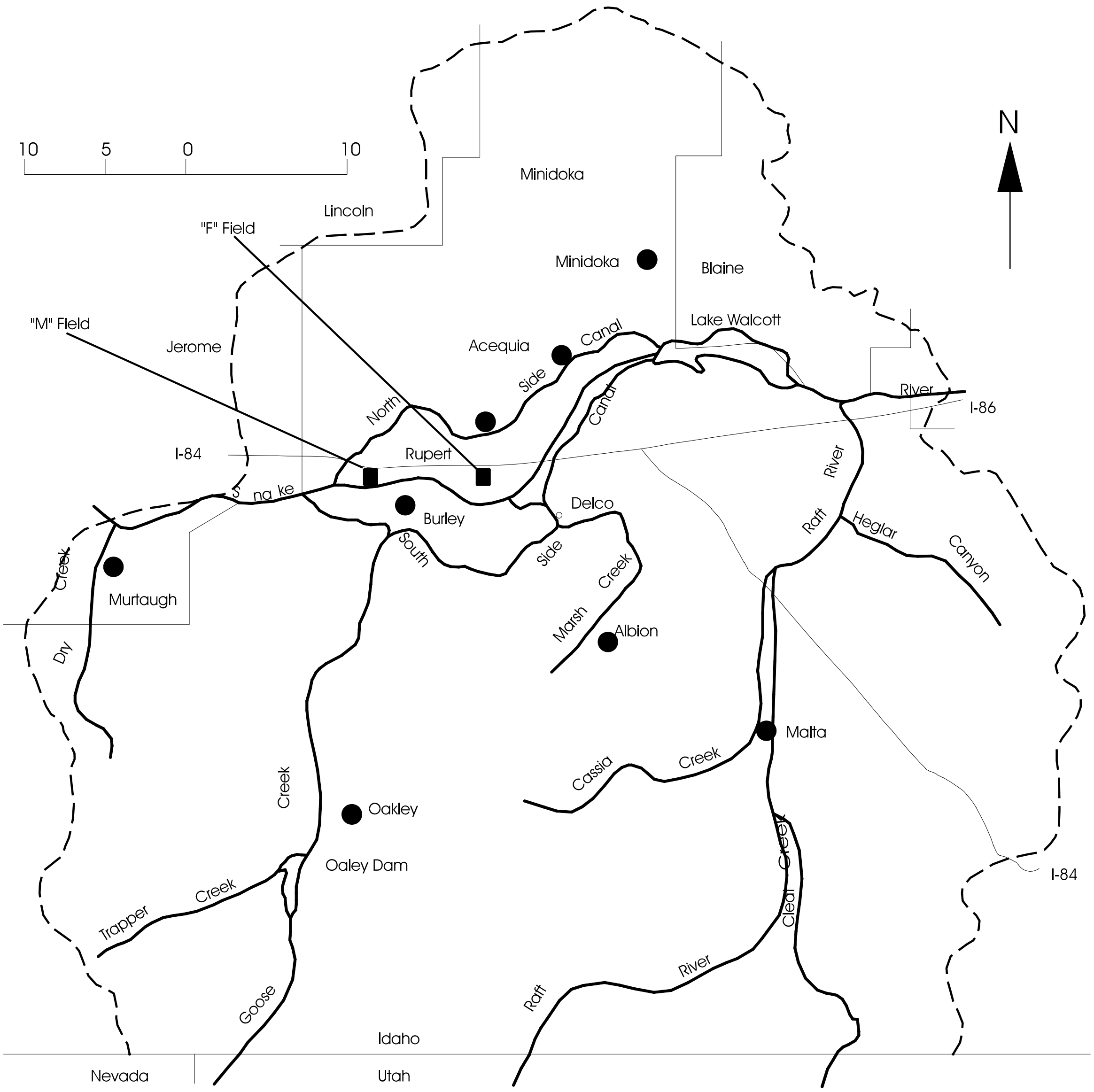


Figure 10: Eastern Snake River Plain (Idaho) USDA Demonstration Project Area

# PROJECT OVERVIEW

The Idaho Eastern Snake River Plain is located in south-central Idaho in an area dominated by irrigated agricultural land (Figure 9). The Eastern Snake River Plain aquifer system, which provided much of the drinking water for approximately 40,000 people living in the project area, underlies about 9,600 square miles of basaltic desert terrain. The aquifer also serves as an important source of irrigation water. In 1990, this aquifer was designated by the U.S. Environmental Protection Agency (USEPA) as a sole source aquifer.

The objective of a seven-year United States Department of Agriculture (USDA) Demonstration Project within the Eastern Snake River Plain (1,946,700 acres) (Figure 10) was to reduce adverse agricultural impacts on ground water quality through coordinated implementation of nutrient and irrigation water management. As part of the project, two paired-field monitoring networks (constructed to evaluate best management practices (BMPs) for nutrient and irrigation water management effects) were funded under Section 319 of the Clean Water Act.

The monitoring portion of the project has been completed. Data analysis and findings have been completed. The project has been terminated as of 1999.

# PROJECT BACKGROUND

## Project Area

The USDA Demonstration Project encompasses over 1,946,000 acres. The ground water quality monitoring activities are limited to a 30,000-acre area of south Minidoka County. The 319 National Monitoring Program project consists of two sets of paired five-acre plots (a total of four five-acre plots) located in this 30,000-acre area (Fields “M” and “F,” see Figure 10). The paired fields were located in the eastern and western portions of the area to illustrate BMP effects in differing soil textures. The “M” field soils are silty loams. The “F” field soils are fairly clean, fine to medium sands. Due to the differences in soils and the traditional irrigation methods employed on these fields (flood on “M” and furrow on “F”), the “M” field has a relatively lower spatial variability of existing water quality than the “F” field. The “F” field also shows greater influences of water and nutrient movement from adjacent fields.

## Relevant Hydrologic, Geologic, and Meteorologic Factors

The average annual rainfall is between 8 and 12 inches. Soils in the demonstration area have been formed as a result of wind and water deposition. Stratified loamy alluvial deposits and sandy wind deposits cover a permeable layer of basalt. These soils are predominantly level, moderately deep, and well drained.

Shallow and deep water aquifers are found within the project area. Both study fields are situated over shallow aquifers that extend from a depth of about 3 - 7 feet below the land surface to as much as 25 - 35 feet below the land surface.

## Land Use

Within the 30,000 acre monitored area, 99% of the land is irrigated. Local irrigation systems vary from the historical practice of flood irrigation to more modern techniques of sprinkler irrigation. Of the irrigated cropland, at least 85% is in sprinkler irrigation and the remaining 15% is in furrow. A diversity of crops are grown in the area: beans, wheat, barley, potatoes, sugar beets, alfalfa, and commercial seed. Confined animal feeding operations (CAFOs) are also located in the project area.

## Water Resource Type and Size

In the intensely irrigated areas overlying the Eastern Snake River Plain aquifer, shallow, unconfined ground water systems have developed primarily from irrigation water recharge. Domestic water is often supplied by the shallow systems. Within the project area, the general flow direction of the shallow ground water system is toward the north from the river; however, localized flow patterns due to irrigation practices and pumping effects are very common. This ground water system is very vulnerable to contamination because of the 1) proximity of the shallow system to ground surface, 2) intensive land use overlying the system, and 3) dominant recharge source (irrigation water) of the ground water.

## Water Uses and Impairments

Many diverse crops are produced throughout the Eastern Snake River Plain region. Excessive irrigation, a common practice in the area, creates the potential for nitrate and pesticide leaching and/or runoff. Irrigation return flows drain to local creeks which dissect the area. Ground water monitoring indicates the presence of elevated nitrate levels in the shallow aquifer underlying the project area.

As far back as 1938, elevated nitrate concentrations were documented in the deep regional ground water system underlying the county. Ground water nitrate concentrations exceeding the EPA drinking water standard began to be reported in the 1980s. Increasing trends in ground water nitrate concentrations in shallow ground water were observed from 1985 to 1995. Elevated nitrate concentrations in the ground water impairs the use of the shallow aquifer as a source of drinking water. Low-level pesticide concentrations in the ground water have been detected in domestic wells and are of concern in the project area. Both nitrate and potential pesticide concentrations threaten the present and future use of the aquifer system for domestic water use.

## Pollutant Sources

Within the USDA project area, there are over 1,500 farms with an average size of 520 acres. Nutrient addition to irrigated crops is intensive. A 1990 USGS study estimated that 93 percent of N inputs in the Snake River Basin come from livestock manure, fertilizer, and legume crops. Heavy nitrogen application and excessive irrigation are the primary causes of water quality problems in the shallow aquifer system. In addition, over 80 different agrochemicals have been used within the project area. Excessive irrigation may cause some leaching of these pesticides into ground water (Idaho Eastern Snake River Plain Water Quality Demonstration Project, 1991).

## Pre-Project Water Quality

Ground water data collected and analyzed within the project area indicate the widespread occurrence of nitrate concentrations that exceed state and federal drinking water standards. In a study conducted from May through October 1991, 195 samples taken from 54 area wells were analyzed for nitrate. Average nitrate concentrations were around 6.5 milligrams per liter (mg/l), with a maximum of 28 mg/l. The federal Maximum Contaminant Level (MCL) for nitrate concentrations of 10 mg/l was exceeded in 16 % of the wells at least once during the sampling period. Five percent of the wells yielded samples that continuously exceeded the MCL during the sampling period.

Ninety-eight samples collected from the same 54 wells were analyzed for the presence of 107 pesticide compounds. Fourteen of the 54 wells yielded samples with at least one detectable pesticide present, but all concentrations measured were below the federal Safe Drinking Water MCL or Health Advisory for that compound. Even though the well water currently meets MCL standards, pesticide concentrations are still believed to be a future concern for the Eastern Snake River Plain Aquifer.

### Water Quality Objectives

The overall USDA Demonstration Project objective was to decrease nitrate and pesticide concentrations through the adoption of BMPs on agricultural lands.

Specific project objectives for the USEPA 319 National Monitoring Program project were to:

- Evaluate the effects of irrigation water management on nitrate-nitrogen leaching to a shallow unconfined aquifer. A paired-field study, referred to as “M” (Figure 10), will allow a comparison of ground water quality conditions between two sprinkler irrigation set durations; 24-hour control and 12-hour “BMP.”
- Evaluate the effects of crop rotation on nitrate-nitrogen leaching to a shallow unconfined aquifer. A paired-field study, referred to as “F” (Figure 10), will allow a comparison of the amount of nitrogen leached to ground water as a result of growing beans after alfalfa, a practice that generates nitrogen, and the amount of nitrogen leached to ground water as a result of growing grain after alfalfa, a practice that utilizes excess nitrogen in the soil.

Source: James Osiensky (Personal communication), 1993; Osiensky, J.L. et al. 1993. Ground Water Monitoring Technical Completion Report. Dept. of Geological Sciences, U. of Idaho, Moscow, ID.

### Project Time Frame

October 1991 to October 1998

## *PROJECT DESIGN*

### Nonpoint Source Control Strategy

The 319 NMP project took place within a larger Idaho Snake River Plain USDA Demonstration Project. The nonpoint source control strategy for the USDA Demonstration Project focused on nitrogen, pesticide, and irrigation water management practices that will reduce the amount of nutrients and pesticides reaching surface water and leaching into the ground water. BMP strategies in the Demo project included fertilizer management, pesticide management, and irrigation water management.

The nonpoint source control strategy for the 319 National Monitoring Program project focused on evaluating BMPs on two test fields.

- The BMP implemented on the "F" field consisted of nutrient management through crop rotation; half of the field continued a traditional alfalfa-beans rotation, while the treatment half initiated a USDA-recommended alfalfa-grain rotation.
- The BMP implemented on the "M" field consisted of nutrient management through reduced irrigation water application, promoting increased nutrient residence time in the soil.

**Project Schedule**

| Site | Pre-BMP Monitoring | BMP Installation | Post-BMP Monitoring |
|---|---|---|---|
| Forgeon Field | 1995-1996 | 5/97 | 6/97-1998 |
| Moncur Field | 1992-4/96 | 5/96 | 6/96-1998 |

## Water Quality Monitoring

The 319 National Monitoring Program portion of the USDA Demonstration Project incorporated two paired-field networks consisting of a total of 24 constructed wells. Of the 12 wells on each paired field, 8 wells were centrally located "permanent" wells and 4 were peripheral "temporary" wells. Wells were installed to a depth of 11 feet and extended 4 to 6 feet below the seasonal water table.

## Variables Measured

### Biological

None

### Chemical and Other

Nitrate (NO3)
pH
Temperature
Conductivity
Dissolved oxygen (DO)
Total dissolved solids (TDS)
Total Kjeldahl nitrogen (TKN) and Ammonium (NH+4)
Organic scans for pesticide

### Covariates

Precipitation
Crop
Soil texture
Nutrient content of the irrigation water

**Monitoring Scheme for the Eastern Snake River Plain Section 319 National Monitoring Program Project**

| Design | Site | Primary Parameters | Covariates | Frequency of WQ Sampling | Duration |
|---|---|---|---|---|---|
| Paired field | "M" field | $NO_3$<br>pH<br>Temperature<br>Conductivity<br>DO<br>TDS<br>TKN<br>$NH^+_4$<br>Pesticides | Precipitation<br>Irrigation water amt.<br>Nutrient content of the irrigation water<br>Water table elev<br>Soil texture<br>Crop | Monthly for primary pollutants except Pesticides (sampled)<br><br>and Nitrogen (quarterly) | 4 yrs pre-BMP<br>1 yr BMP<br>2 yrs post-BMP semiannually) |
| Paired field | "F" field | $NO_3$<br>pH<br>Temperature<br>Conductivity<br>DO<br>TDS<br>TKN<br>$NH^+_4$<br>Pesticides | Precipitation<br>Irrigation water amt.<br>Nutrient content of the irrigation water<br>Water table elev<br>Soil texture<br>Crop | | 4 yrs pre-BMP<br>1 yr BMP<br>2 yrs post-BMP |

### Sampling Scheme

A number of covariate monitoring activities have been undertaken by some of the other agencies participating in the project. In addition, vadose zone suction lysimeters were used to monitor NO3 transport. Well monitoring consisted of monthly grab samples. Chemical and other parameters were analyzed monthly, except for NH+4 and TKN, which were analyzed quarterly, and organics, which were analyzed semiannually.

Hydrogeologic variability within and across fields required that a geostatistical approach be developed to evaluate nitrate concentration distribution and BMP effects. Geostatistically-derived maps based on Gaussian simulation and trend surface analysis were compared using a spatial map subtraction technique to evaluate net nitrate changes at each demonstration field.

## Land Treatment Monitoring

Land treatment monitoring consisted of field visits and communication with producers and project personnel.

## Modifications Since Project Start

The design of the project changed since its inception. Originally, the objective of the “M” paired field was to determine the effect of irrigation water management on nitrate-nitrogen leaching into the ground water. One side of the field was to have a sprinkler irrigation system, while the other side was to have furrow irrigation. However, cost share negotiations with the “M” field land owner for project participation led to implementation of the same irrigation water supply system (sprinkler irrigation) in both the BMP test field and the control field.

The type of crops produced and the production methods employed during baseline monitoring changed during the experimental design. The original objective of the “F” paired field was to compare water quality conditions under different cropping regimes (beans after alfalfa vs. wheat after alfalfa). However, scheduled crop rotations were changed to meet commodity market demands on the “F” field. In 1994, potatoes were planted, and in 1995 alfalfa was reestablished. Due to the changes in experimental design, the duration of the monitoring project was extended in order to re-establish baseline water quality data.

The scope of work was increased significantly since the project inception in 1992. The changes were required to facilitate evaluation of the effects of spatial variability within the two paired fields. In addition to the original ground water sample collection scheme for the 12 wells in each field, soil water and additional ground water samples were collected. Geostatistically-based soil water and ground water sampling programs were initiated. Soil water samples, taken with suction lysimeters (soil water samplers), were collected monthly during the growing season at both the “F” and “M” paired fields. Permanent, pressure-vacuum lysimeters (12 inch length) were installed to a depth of one meter below land surface at the “F” field. A seasonal (removed and replaced each growing season) sampling network that includes both vacuum lysimeters (24 inch length) and pressure-vacuum lysimeters (12 inch length) was installed in the “M” field. These lysimeters were installed at a depth of 0.5 meters below land surface. The soil water sampling program provided important information for the interpretation of spatial and temporal variability of the ground water samples collected from in-field monitoring wells.

Twenty-three lysimeters were installed in the “F” field during June, 1994. Six lysimeters were installed in the “M” field during July, 1994. The areal distribution of lysimeters installed in 1994 was based on grain size analyses of soil samples collected in the “F” and “M” fields.

Nitrate samples were collected from the lysimeters for the months of July, August, September, and October, 1994. Basic univariate statistics were computed and a preliminary geostatistical analysis was conducted. Based on these results, the following modifications to the sampling plan were implemented for the 1995 growing season:

- Reduced the length of the shortest lags (distance between samplers)
- Increased the overall number of short lags produced by the sampling configuration
- Included a greater number of the original soil sample locations as lysimeter installation locations

An additional 13 lysimeters were installed in 1995 in the "F" field in addition to Airstone groundwater point samplers at all 36 lysimeter locations. Nineteen lysimters were added to the "M" field network in 1995.

Total Kjeldahl nitrogen was detected in a few wells during the first three years of the project but did not appear to correlate with the nitrate concentrations measured. Nitrate was chosen as the primary constituent of interest as the indicator parameter for evaluation of BMP effectiveness.

# DATA MANAGEMENT AND ANALYSIS

## Data Management and Storage

The Idaho Division of Environmental Quality entered raw water quality data in the USEPA STORET system. Data were also entered into the USDA Water Quality Project's Central Data Base, and the Idaho Environmental Data Management System. Because this is a ground water project, the NonPoint Source Management System (NPSMS) software had limited utility.

This project used geostatistical analysis to evaluate the influence of land use activities on ground water quality. Geostatistics is the branch of applied statistics that focuses on the characterization of spatial dependence of attributes that vary in value over space (or time) and the use of that dependence to predict values at unsampled locations. The usefulness of a geostatistical analysis is dependent upon the adequate characterization of the spatial dependence and of the parameter of interest in the given environment. The degree to which spatial dependence is characterized is a function of the configuration of the sampling locations. Thus, a geostatistic investigation centers around designing an areal distribution of sampling locations which ensures that spatial dependence of the parameter of interest can be recognized if it exists. Geostatistical factors, which must be considered in the design of a sampling plan, include the number of samples and the magnitude and density of separation distances provided by a given configuration.

## NPSMS Data Summary

Not applicable.

## Final Results

At the F site, data suggest that the BMP effects were detectable in groundwater. Probabilistic evaluation suggested a high probability that the crop rotation BMP used at the F field had a positive effect on the ground water quality (reduced nitrate).

- Leaching of nitrate to the ground water in the field was a function of irrigation-precipitation amounts with an approximate 1 to 2 month time lag between increased irrigation-precipitation amounts and increased levels of ground water nitrate.

- The rate and amount of nitrate leached to the ground water in the field were dependent upon the properties of the subsoils. Higher ground water nitrate concentrations were observed in the shallow aquifer within the sandy subsoils area of the field following increased irrigation with an approximate 1 to 2 month time lag.

- The rate and amount of nitrate leached to the ground water in the field were dependent upon the crop grown. Higher ground water nitrate concentrations and higher net nitrate increases were observed in the control half of the field under beans. Lower ground water nitrate concentrations and lower net nitrate increases were observed in the treatment half of the field under grain. These results suggested that the crop rotation BMP implemented at the F field for one year had a positive effect on the ground water quality.

- Crop type had a significant effect on soil water nitrate concentrations during the growing season. Comparatively high soil water nitrate concentrations and larger net nitrate increases occurred under beans compared to low soil water nitrate concentrations and smaller net nitrate increases under grain. This result is significant from the standpoint of reducing the nonpoint source of soil nitrate available to leach to the ground water over time.

- The positive effects of growing grain for a single season were relatively short term. Net changes in the distribution of nitrate in the ground water apparently reversed from July to August 1998, one year after BMP implementation. Crop rotation BMPs must be used on a regular basis to improve the long-term ground water quality significantly in the area.

- Following the crop of potatoes by two years of alfalfa significantly reduced the amount of residual nitrate in the soil water and effectively reduced nitrate concentrations in the shallow ground water.

- Education of farmers on the significance of crop rotation BMPs and work to increase farmer acceptance of BMPs should continue. Results from this study suggest the crop rotation BMP had a positive influence on the soil water and ground water quality.

A reversed trend in net ground water concentrations was observed over the BMP period on the “M” field. These results suggested that irrigation amounts probably influence leaching of nitrate to the ground water.and that the irrigation water management BMP had a positive influence on the ground water quality.

Monthly sampling of monitoring wells in the M field have shown no significant increases in ground water nitrate after the planting of potatoes or sugar beets, even though both crops required large amounts of fertilizer. The low variance in ground water nitrate concentrations and lack of significant increases in nitrate concentrations after the growing season for crops requiring heavy fertilization suggest that fertilizer applications over a one year period had very little effect on ground water nitrate concentrations in the M field under sprinkler irrigation. The greatest changes in ground water nitrate concentrations were measured under furrow irrigation. Conversion from furrow to sprinkler irrigation of the fine grained (silty) soils in the M field reduced the leaching of nitrate to the ground water over the period of the investigation. Conversion to sprinkler irrigation is probably the best management practice to reduce ground water nitrate concentrations in fields with predominantly fine grained (silty) soils.

Source: Osiensky, J.L. et al. 1993. Ground Water Monitoring Technical Completion Report. Dept. of Geological Sciences, U. of Idaho, Moscow, ID.

## INFORMATION, EDUCATION, AND PUBLICITY

Information, Education and Publicity (I & E) for the Snake River Section 319 National Monitoring Program project was included in the Snake River Plain Demonstration Project I & E program.

Two Eastern Snake River Plain Demonstration Project brochures have been published. One brochure, targeting the local public, was designed to provide a general explanation of the project. The second explains results from the nitrate sampling of the project area.

The USDA Demonstration Project staff provided the I&E program for this project. University articles were produced on the demonstration project, and project information was disseminated through university and producer conferences. Presentations on the project were also made to the public through local and regional outlets, such as the American Association of Retired Persons, Future Farmers of America, local and regional agricultural producers, local irrigation districts and canal companies, industry representatives, industry supply vendors, and primary and secondary education institutions. In addition, a public information workshop was held annually within the project area for project participants, cooperators, and interested individuals.

Cooperating farm operations that implemented improved management practices for water quality were marked by project display boards to maximize exposure to the local population. These operations weree also visited during the numerous project organized field trips.

Information was also disseminated through local and regional television and radio programs and newspaper articles.

## TOTAL PROJECT BUDGET

Funds budgeted to the State for the Eastern Snake River Plain Section 319 National Monitoring Program project for the period of FY92–98 was approximately $500,000. This figure includes Section 319(h) funds utilized after the National Monitoring Program project monies were suspended, as well as funds provided by the Idaho Division of Environmental Quality and the Idaho Department of Agriculture for additional water quality monitoring.

## IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

None.

## OTHER PERTINENT INFORMATION

The Eastern Snake River Plain Demonstration Project was led by the USDA Natural Resources Conservation Service (NRCS), the University of Idaho Cooperative Extension Service (CES), and the USDA Farm Service Agency (FSA). In addition to the three lead agencies, this project involved an extensive state and federal interagency cooperative effort. Numerous agencies, including the Idaho Division of Environmental Quality, the University of Idaho Water Resource Research Institute, the USDA Agricultural Research Service, the Idaho Department of Water Resources, the U.S. Geological Survey, and the Idaho Department of Agriculture, took on various project tasks.

The Idaho Department of Environmental Quality and the Idaho Water Resource Research Institute were responsible for the 319 National Monitoring Program portion of the project.

An institutional advantage of this project was that the NRCS and the CES are located in the same office.

Three local Soil and Water Conservation Districts, East Cassia, West Cassia, and Minidoka, as well as the Minidoka and Cassia County FSA, county committees, and the Cassia County Farm Bureau made up the USDA Demonstration Project Steering Committee.

A regional well monitoring network consisting of existing domestic sandpoint (driven) wells was established within the Demonstration Project Area. The regional network was intended to augment the paired-field data and provide a means to document the influence of the Demonstration Project on the quality of the area's shallow ground water system. This network consists of 25 wells which have been monitored for nitrogen-nitrate concentrations on a quarterly basis for an average of 12 sampling events.

During implementation of the regional domestic well water quality monitoring portion of the USDA project, agricultural chemicals and nitrate-nitrogen were detected at levels of concern and measured in samples collected from domestic wells. In addition, limited sampling and analysis of ground water drainage systems, irrigation return flows, and injection wells identified nutrients and pesticides in certain surface water bodies within the project area. Nitrate-nitrogen concentrations in subsurface tile drain effluent as high as 8 mg/l were measured. The herbicides MCPA and 2,4-D were detected in return flow irrigation water entering into an injection well. The 2,4-D was measured at levels greater than the allowable Safe Drinking Water MCL of 70 ppb.

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