Texas AgriLife Research
Texas Water Resources Institute

Groundwater Nitrogen Source Identification and Remediation in the Texas High Plains and Rolling Plains Regions
FY 09 CWA 319(h)
TSSWCB Project No. 09-03


I. Abstract
Work this quarter has focused on the continued collection, analysis and evaluation of soil isotope and irrigation data. The Rolling Plains Summer Cropping Systems Field Day was held at the Chillicothe Demonstration site occurred this quarter. The field day highlighted the N crediting demonstrations being conducted along with other cropping systems information. The N crediting factsheet was completed this quarter and is being distributed widely. Work also continued on a manuscript describing work being conducted and results found to date.

II. Overall Progress and Results by Task

TASK 1: Project Administration

Subtask 1.1: TWRI, with input from Texas AgriLife Research and UT-BEG, will prepare electronic quarterly progress reports (QPRs) for submission to the TSSWCB. QPRs shall document all activities performed within a quarter and shall be submitted by the 15th of January, April, July and October. QPRs shall be distributed to all project partners and posted on the project website developed and hosted by TWRI.

The following actions have been completed during this reporting period:

A. TWRI submitted the 12th Quarter, report to TSSWCB on October 11th, 2012.

94% Complete

Subtask 1.2: TWRI will perform accounting functions for project funds and will submit appropriate Reimbursement Forms to TSSWCB at least quarterly.

The following actions have been completed during this reporting period:

A. Expenditures thus far have totaled $225,325 or roughly 50% of total project funding. Much of the delay in expending project funds can be tied to sample analysis billing. These bills are not completed and paid until analysis is complete, thus disproportionately causing project expenditures to lag behind actual project progress.

55% Complete

Subtask 1.3: TWRI will participate in meetings as appropriate in order to efficiently and effectively achieve project goals, coordinate monitoring efforts and summarize activities and achievements made throughout the course of this project.
The following actions have been completed during this reporting period:
A. No activity to report this quarter.
B. A meeting or conference call will be scheduled for next quarter.

85% Complete

Subtask 1.4: TWRI will work with AgriLife Research and UT-BEG to develop a project final report summarizing the results of the groundwater nitrogen source identification and demonstration of nitrogen remediation strategies for submittal to the TSSWCB and EPA.

The following actions have been completed during this reporting period:
A. A final report format has been developed and will be used as a guide for crafting the final report.

10% Complete

TASK 2: Quality Assurance

Subtask 2.1: TWRI will develop a QAPP for activities in Tasks 3-4 consistent with EPA Requirements for Quality Assurance Project Plans (QA/R-5) and the TSSWCB Environmental Data Quality Management Plan.

All monitoring procedures and methods prescribed in the QAPP shall be consistent with the guidelines detailed in the TCEQ Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment, and Tissue (RG-415) and Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data (RG-416).

The following actions have been completed during this reporting period:
A. No activity to report at this time.

100% Complete

Subtask 2.2: TWRI will submit revisions and necessary amendments to the QAPP as needed.

The following actions have been completed during this reporting period:
A. The annual QAPP revision was approved by EPA on May 17, 2012.

100% Complete

TASK 3: Groundwater Nitrogen Source Identification

Subtask 3.1: To quantify the changes between native rangeland sites and cultivated sites that are in close proximity to each other, UT-BEG will use data from the USDA Bushland site near Amarillo where an area of the research station has been maintained under rangeland
management and is adjacent to cropland.

The following actions have been completed during this reporting period:
A. Analysis of samples sent from profiles has been completed.
B. Result evaluation is currently underway to enable sources to be distinguished.

90% Complete

Subtask 3.2: UT-BEG will quantify organic carbon and total nitrogen in the native and cropland profiles to quantify the reduction in organic carbon from the native to the cropland site. These data will be used to determine if changes in organic carbon and nitrogen can account for the increased nitrate found in profiles under cropland.

The following actions have been completed during this reporting period:
A. Isotope samples are being analyzed by TAMU to further this quantification.

80% Complete

Subtask 3.3: UT-BEG will also examine carbon-13 isotopes on the organic carbon which may provide insights on the impact of the shift from native vegetation to cropland on the relative proportions of soil organic carbon derived the native system versus the cultivated system. Utilization of long-term CRP land may also be employed.

The following actions have been completed during this reporting period:
A. Isotope analysis has been completed and results are being evaluated.

90% Complete

Subtask 3.4: Mass balance analyses will also be conducted by UT-BEG, in collaboration with USDA-ARS, to evaluate the relative inputs of nitrogen from different sources. These results should be applicable to the entire Texas High Plains Ogallala and the Rolling Plains Seymour Aquifers.

The following actions have been completed during this reporting period:
A. No new activity to report this quarter.

60% Complete

Subtask 3.5: Nitrate derived from mineralization of native soil organic matter does not constitute a continuous input to the system and should move through the groundwater system as a pulse. UT-BEG will evaluate this process through mass balance analyses.

The following actions have been completed during this reporting period:
A. Nitrate data from the USDA ARS profile analyses has been completed.
B. Results of this task are being written up.

80% Complete
Subtask 3.6: Historical records of agricultural practices will be examined for dryland and irrigated sites by UT-BEG to determine relationships between nitrogen application rates and subsurface inventories. Based on these data and findings from UT-BEG, Texas AgriLife Research will develop recommendations on nitrogen application rates for farmers (Subtask 4.6).

The following actions have been completed during this reporting period:

A. Historical agricultural practice compilation continued at each borehole location.

80% Complete

Subtask 3.7: UT-BEG will assist Texas AgriLife Research with determining BMPs related to nitrogen fertilizer applications for producers.

The following actions have been completed during this reporting period:

A. No activity to report at this time as this will take place after completion of analyses.

0% Complete

Subtask 3.8: UT-BEG will evaluate nitrate input from mineralization of SOM. This mineralization mechanism with subsequent release of nutrients forms the basis of the crop’s nutrient requirements in the northern portion of the Texas High Plains and may contribute substantive amounts of nitrate to the system. UT-BEG will supplement existing data by drilling additional boreholes in Lynn County where extremely high groundwater nitrate contamination is found.

The following actions have been completed during this reporting period:

A. Chemical analysis has been completed and results are being drafted.

80% Complete

**TASK 4: Evaluation and demonstration of Nitrogen Remediation Strategies**

Subtask 4.1: AgriLife Research will establish a 2.5 acre block under subsurface drip irrigation cropped to cotton at the Chillicothe Research Station to demonstrate and document benefits of irrigation water N crediting to area farmers.

The following actions have been completed during this reporting period:

A. The last cotton crop is up and growing well.

B. This task is now complete.

100% Complete

Subtask 4.2: At Chillicothe, AgriLife Research will demonstrate nutrient management strategies based on the crop’s agronomic (1) N requirements, (2) N and P requirements, (3) N requirement minus irrigation N credit, (4) N and P requirement minus irrigation N credit, and (5) control (N from irrigation water only) on plots cropped to cotton under subsurface drip, furrow, and overhead irrigation.
The following actions have been completed during this reporting period:

A. The end of the third growing season is nearing. Data will be collected following harvest and will thus complete this task.

85% Complete

Subtask 4.3: AgriLife Research will collect and analyze soil samples from a depth of 36 inches following each growing season. Soil samples will be analyzed by AgriLife Research at Vernon for nitrate, ammonium, total N, and P. Irrigation water samples will also be collected weekly throughout the irrigation season at demonstration sites and analyzed for nitrate. AgriLife Research will also conduct an economic analysis of different nutrient management practices (Subtask 4.2), demonstrating the most cost-effective BMP.

The following actions have been completed during this reporting period:

A. No new activity to report this quarter. The next soil samples will be collected following the year 3 harvest.

83% Complete

Subtask 4.4: Based on findings from UT-BEG (Subtask 3.6), Texas AgriLife Research will develop recommendations on nitrogen application rates for farmers. Texas AgriLife Research will also work with UT-BEG to determine BMPs related to nitrogen fertilizer applications for producers. Texas AgriLife Research will provide these recommendations on application rates and BMPs via development of a technical report and fact sheet (see Subtasks 4.5 and 4.6 below) to Texas AgriLife Extension Service personnel, local soil and water conservation districts, NRCS personnel, TSSWCB personnel, Texas Water Development Board staff, underground water conservation districts, certified crop advisors, and directly to farmers to ensure delivery of these recommendations.

The following actions have been completed during this reporting period:

A. An AgriLife Extension fact sheet describing N crediting was completed and is being used to expand knowledge of this concept.

50% Complete

Subtask 4.5: AgriLife Research will host a minimum of 1 field day at the demonstration site. Additionally, project results will be presented at the Beltwide Cotton Conference and American Society of Agronomy meetings. The Beltwide Cotton Conferences speed the transfer of new technology to U.S. cotton producers and other industry members. Coordinated by the National Cotton Council (NCC) and its cooperating partners, this annual forum is recognized as the global champion for cotton technology transfer. Regionally, project results will be presented at the annual meetings of the Texas State Support Committee of Cotton Inc. in Lubbock and the Texoma Farm and Ranch Show in Wichita Falls. These regional meetings are well attended by producers, industry, and commodity board members. Finally, at least 3 workshop/stakeholder meetings will be held to discuss nitrate and irrigation strategies. AgriLife Research will work with UT-BEG to develop handouts, presentations, and posters (as appropriate) describing results along with other educational materials for the Texas High Plains and Rolling Plains regions for use at the field day, regional and national meetings, and workshop/stakeholder meetings. Specifically, at least one fact sheet is planned for development on recommendations on
nitrogen application rates and BMPs. These materials will subsequently be made available to AgriLife Extension and others as listed in Subtask 4.4 above for use at other venues in the region and distributed to farmers.

The following actions have been completed during this reporting period:

A. The Rolling Plains Summer Crops Field Day was held at the Chillicothe demonstration site on July 17th. This event highlighted nitrogen crediting demonstrations being conducted through this project among other things.
B. Project personnel also presented an overview of the project at the TSSWCB Board Meeting on September 20th.

85% Complete

Subtask 4.6: AgriLife Research will work with TWRI and UT-BEG to develop a technical report and refereed journal publication summarizing results of the demonstration and groundwater nitrogen source evaluation for further technical transfer and incorporation into the final report submitted to the TSSWCB and EPA.

The following actions have been completed during this reporting period:

A. Efforts continued to develop a written manuscript that describes findings to date.

20% Complete

III. Related Issues/Current Problems and Favorable or Unusual Developments
- The historic drought of the past year adversely effected normal cropping strategies resulting in excessive amounts of irrigation water being applied to crops only to have them fail as a result of extreme heat stress. This foray from the norm may result in legacy effects in crop yields from year to year. Continued sampling will illustrate these impacts in the months to come.
- As a result, a 9 month no-cost extension has been requested on the project to allow for needed data collection and subsequent analysis.

IV. Projected Work for Next Quarter
- Continue to analyze data collected over the last quarter
- Conduct drilling and sampling at field sites where tracers were applied in the Seymour Aquifer area
- Harvest final cotton crop and collect post-harvest data
- Collected additional post-harvest soil samples
- Continue working on a draft manuscript describing findings to date
- Present project findings at ASA International Meetings in Cincinnati, OH
Naturally occurring nitrogen in the form of nitrate in irrigation water helps meet crop N requirements and reduces fertilizer cost for crop production. This nitrogen may be expressed as NO$_3^-$, NO$_3^-$-N, or nitrate-nitrogen—all actual nitrogen. This nitrogen is free and is readily available to the crop. It should be credited 100 percent toward crop needs if applied just before or during crop growth.

This N in irrigation water can:

- Supply varying amounts of timely N during the growing season;
- Be available to the crop immediately;
- Reduce the amount of N fertilizer the producer must buy;
- Be credited toward crop nitrogen needs as a sound economic and agronomic practice;
- Reduce excess nitrates from entering groundwater from percolation or runoff.

**Nitrate content in Texas irrigation waters**

Though some waters used for irrigation in Texas contain 20 to 50 ppm nitrate-N, most average 3 to 10 parts per million (ppm) nitrate-N (Fig. 1). Regions that tend to have irrigation water with higher nitrate-N include:

- South of San Antonio
- East of Midland-Odessa and north through most of the Texas South Plains

**Federal Drinking Water Standards**

The public health drinking water standard set by the U.S. Environmental Protection Agency is expressed as 10 ppm NO$_3^-$-N or 10 mg/ml NO$_3^-$-N. A person who endures prolonged consumption of water containing nitrate-N above this level may
become ill. Infants less than 6 months old who consume water above the EPA standard are susceptible to serious illness, and if untreated, may die. Symptoms include shortness of breath and signs associated with methemoglobinemia, or blue baby syndrome.

For more information, see http://water.epa.gov/drink/contaminants/basicinformation/nitrate.cfm

**Terms and conversion factors**

Nitrate in groundwater is most commonly reported as nitrate-nitrogen or NO$_3$-N. Some water and lab reports may report nitrate simply as NO$_3$. The units of concentration are reported as ppm or milligrams per liter (mg/L). These units express the same concentrations: 1 ppm = 1 mg/L.

To convert from nitrate-N (nitrate-nitrogen or NO$_3$-N) to nitrate (NO$_3$) only, multiply by 4.4:

$$10 \text{ ppm NO}_3\text{-N} = 44 \text{ ppm NO}_3$$

To convert nitrate only to nitrate-N, multiply by 0.23 for each 1 ppm of nitrate.

$$10 \text{ ppm NO}_3 = 2.3 \text{ ppm NO}_3\text{-N}$$

**How much N is irrigation really adding to crops?**

For each 1 ppm nitrate-N in water you apply:
- 0.23 pounds of N per acre is applied with each 1 inch of water applied
- 2.7 pounds of N per acre is applied with each foot of water applied

Table 1 shows the amount of nitrate-N applied to crops based on the ppm of nitrate-N in water and the inches of water applied per acre.

**Potential cost savings of credited Nitrate-N**

**Example:** A farmer has an irrigation nitrate-N level of 7 ppm—a modest, but significant level—and plans to apply 10 inches of irrigation to a crop during the growing season. How much N will be applied that can be credited to the crop N requirement?

$$7 \text{ ppm nitrate-N} \times 0.23 \times 10 \text{ inches} = 16 \text{ lb. N per acre}$$

This is enough for 0.3 bale per acre of cotton lint, 800 pounds per acre of grain sorghum, or 13 bushels per acre of wheat.

In 2012, the price per pound of N fertilizer was about $0.60. At this price, the approximate cash value per pound of actual nitrate-N per acre is $9.60.

$$($0.60 \text{ per lb. of N}) \times (16 \text{ lbs. of N per acre}) = $9.60 \text{ per acre}$$

If 1 pound of N per acre is present in irrigation water over a 120-acre center pivot, the farmer will save about $1,150—with no added application costs!

In agricultural production, nitrate-N in irrigation water has essentially the same value as applied N fertilizer. However, the plants may more readily take in N from irrigation water than from forms that are not immediately available to a crop.

**A caveat**

When you pre-water to build soil profile moisture, nitrate-N in irrigation water may not be as available to plants as when it is applied to actively growing crops. If the irrigation levels are 4 inches or more during pre-watering (especially furrow irrigation), the nitrate-N might seep below the root zone of shallow rooted crops such as corn, wheat, and grain sorghum.

Rainfall or further irrigation might push the N even deeper before the crop can capture it. This percolation of water can reduce the otherwise significant increase in available nitrate-N. Producers
should reduce the N credit by half or more in these cases, and especially for irrigation applied 1 month or more before cropping.

**Sample collection and analysis**

Research shows that levels of nitrate-N in irrigation water are consistent throughout the year; a single sample before the growing season should give a good estimate for the upcoming year.

For information on collecting water samples to test for nitrate-N, salinity, and other constituents, see the water sample submittal form at http://soiltesting.tamu.edu/files/waterweb1.pdf.

To have a water sample analyzed, consult your local irrigation or water conservation district, private soil and water testing labs, or the Texas A&M AgriLife Extension Service Soil, Water and Forage Testing Laboratory at http://soiltesting.tamu.edu, (979) 845-4816, or e-mail soiltesting@ag.tamu.edu.

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