RED RIVER VALLEY TILE DRAINAGE WATER QUALITY ASSESSMENT – PHASE II Final Report

Part 1

By

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Section 1.0 Executive Summary

The primary goal of the project is to assess the quality and quantity of water discharged from representative tile drains and surface drains in saline soils in the Red River Valley. As a secondary goal, the project will identify feasible land management options for improving the quality of tile and surface drain effluent. Samples will be collected during the open water periods of 2009 – 2013.

Water samples and precipitation measurements were collected on a weekly basis at eight sites for a period of 5 years. At four of the eight sites additional data was collected including water samples downstream from the outlet and a sample from the overland flow of a nearby comparable un-tiled field, flow measurements from the outlet, and soil samples. Water samples, soil samples, flow measurements and precipitation were all gathered with numerous gaps because of equipment or sampling failure due to natural or manmade causes.

The project period is recorded as 1-1-2009 to 11-30-2013 however it was extended to 1-31-2014 to complete the data analysis and again to October 2014 for the final report. Funding was provided through the North Dakota Department of Health's (NDDH) Section 319 Non-Point Source (NPS) Pollution Management Program which is under US Environmental Protection Agency (EPA) Region 8. Additional funding was provided through the Cass County Soil Conservation District and the North Dakota State Water Commission.

Objectives and tasks realized over the five year period include measurement of water quality (8 sites) and quantity (7 sites) leaving subsurface drains affected by high soil salinity, annual soil sampling to measure decreases of soil salinity in fields at 4 monitoring sites, measurements of water quality leaving the field via surface runoff at 4 sites when flow was apparent and samplers were available, and the presentation of results at local, regional and national meetings and in printed publications and posters.

The most valuable lesson learned from this project is that precipitation events, whether in large single events or accumulations over several days, determine the quantity of water flow from tile systems. Tile flow does not begin in the spring until most of the frost is out of the field. The timing and quantity of rain events determine the mass loading of dissolved minerals in the discharged water. Above average rain amounts during the autumn months (September to December) can affect tile flow the following spring depending on winter snow accumulations and early spring rain events. The portion of rain that flowed from the tile systems ranged from a low of 11 to a high of 30 percent.

Tile flow removes accumulated salts from fields but it may take years to reduce the total dissolved salt (TDS) concentrations to acceptable levels. At six of the sites, the average TDS concentration decreased throughout the project period. There is a significant correlation (R^2 >0.96) between TDS and most of the major cations and anions in the water. At six of the sites, sulfate SO_4) made up over 65% of the TDS in the tile outflow. Average TDS concentrations varied from about 500 to over 11,000 milligrams per liter. The largest flows occurred during the spring and early summer of 2011 where the annual TDS loading to the receiving waterways ranged from a low of 587 to 9627 pounds per acre from the seven flow monitoring sites.

The concentration of nitrate-nitrogen (NO_3-N) in the discharge water is highly variable with the largest amounts occurring in the April to June period. The NO_3-N load to receiving waterways ranged from zero to over 17 pounds per acre. However, the annual averaged site loads ranged from a little over 1 to 11 pounds per acre. These are very low N losses to many farmers and crop consultants. The total load of NO_3-N to receiving waterways for the 4-year project ranged from a low of 900 to 6,390 pounds for the eight sampling sites.

Section 2. Background/Introduction

Throughout the previous fifteen years there has been a significant increase in the acres of agricultural land tile drained in the Red River Valley of eastern North Dakota. There is not an official accounting of acres that are tiled although studies are now being planned to address this issue. The recent tiling in the Red River Valley is primarily due to excessive precipitation received since the early 1990's, and the consequential rise in water tables and movement of salt into the root zone. There is an estimated 1.5 to 2.5 million acres of saline soil in the Red River Valley (Ulmer, 2008). Subsurface drainage is being installed to reduce the effects of soil saturation and soil salinity on crop production by removing the salts in the soil profile. As the salts leave the soil profile the tile drainage effluent may carry high levels of salts that can be detrimental to water quality in the Red River Basin. Salts most likely found in saline soils in North Dakota include calcium sulfate, magnesium sulfate and sodium sulfate (Franzen, March 2008).

Prior data involving water quality of tile drainage effluent include a one-year project (RRVTDWQA – Phase I) that was completed by the same sponsor in 2008 to collect baseline information on water quality at 18 sites in Cass County. Based on data collected in 2008, levels of chloride, nitrate nitrogen, phosphorus, selenium, sulfates, and total dissolved solids in excess of the drinking water standards or state standards for waters of the state were documented; however not all samples at the sites were found to be above either of the standards mentioned.

The Red River Valley Tile Drainage Water Quality Assessment (RRVTDWQA) – Phase II was conducted at 8 tile drainage field sites in counties in eastern North Dakota. Participating landowners were from Cass, Grand Forks, Pembina, Richland, Sargent, Steele, Traill and Walsh counties. Water quality issues relate to saline soils and possible high levels of salts leaving the drains and downstream problematic issues that include downstream neighboring fields and ultimate impacts to the Red River of the North and Lake Winnipeg in Canada. Although all but one site drains into a ditch, the potential water bodies involved in Phase II of the study will be the tributaries that drain into the Red River.

This project has received welcomed support from the Cass, Grand Forks, Walsh, Richland, Sargent, Steel, Traill, and Ransom SCD's, cooperating landowners, tile drain contractors, the Natural Resources Conservation Service (NRCS) and Red River and Lake Agassiz RC&Ds.

Cooperators include: Soil Conservation Districts, the Water Resource District Boards of Cass, Grand Forks, Walsh, Richland, Sargent, Steele, Traill, and Ransom counties. NDSU Agriculture & Biosystems Engineering Department, the Environmental Protection Agency, the North Dakota State Water Commission, the Red River Joint Water Board, the North Dakota Department of Health and the state and county Natural Resources Conservation Service.

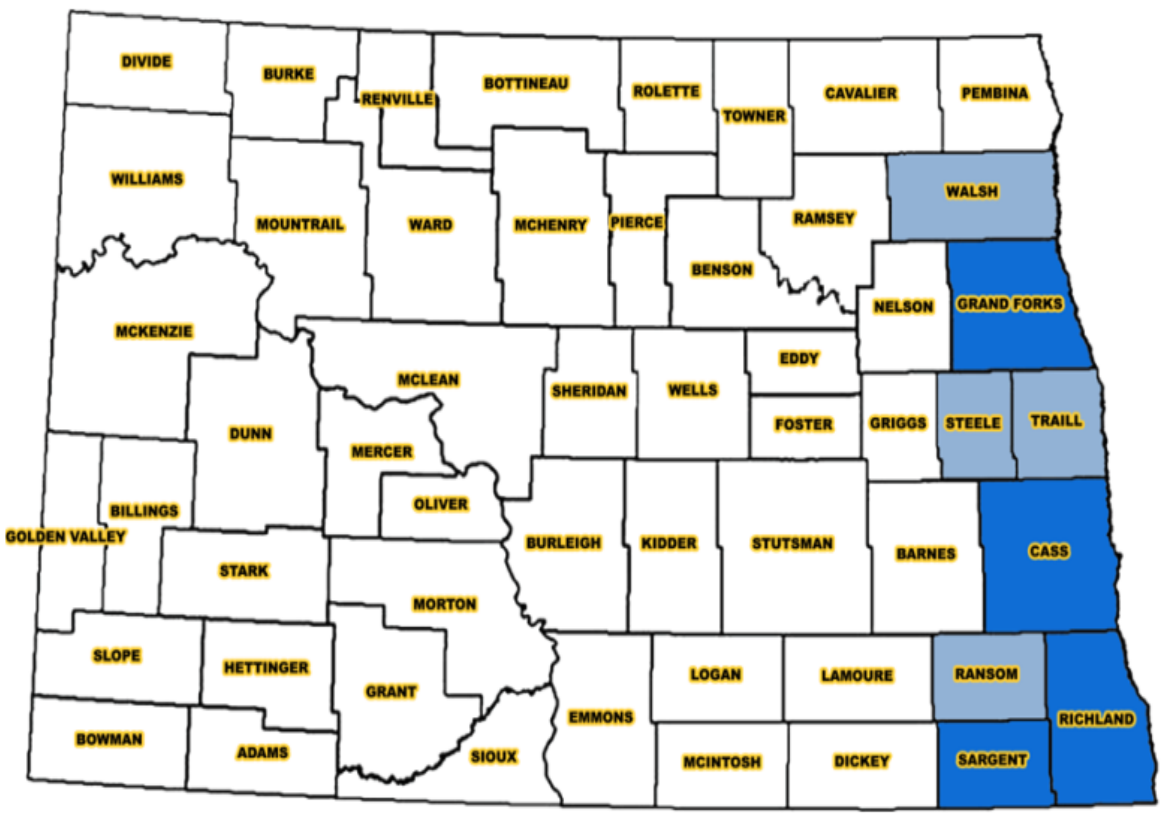

Figure 1. Phase II subsurface drainage sites are highlighted in blue in this map of North Dakota counties. The counties that where water sampling only are highlighted in light blue. The dark blue counties designate sites where soil sampling and additional water samples were collected.

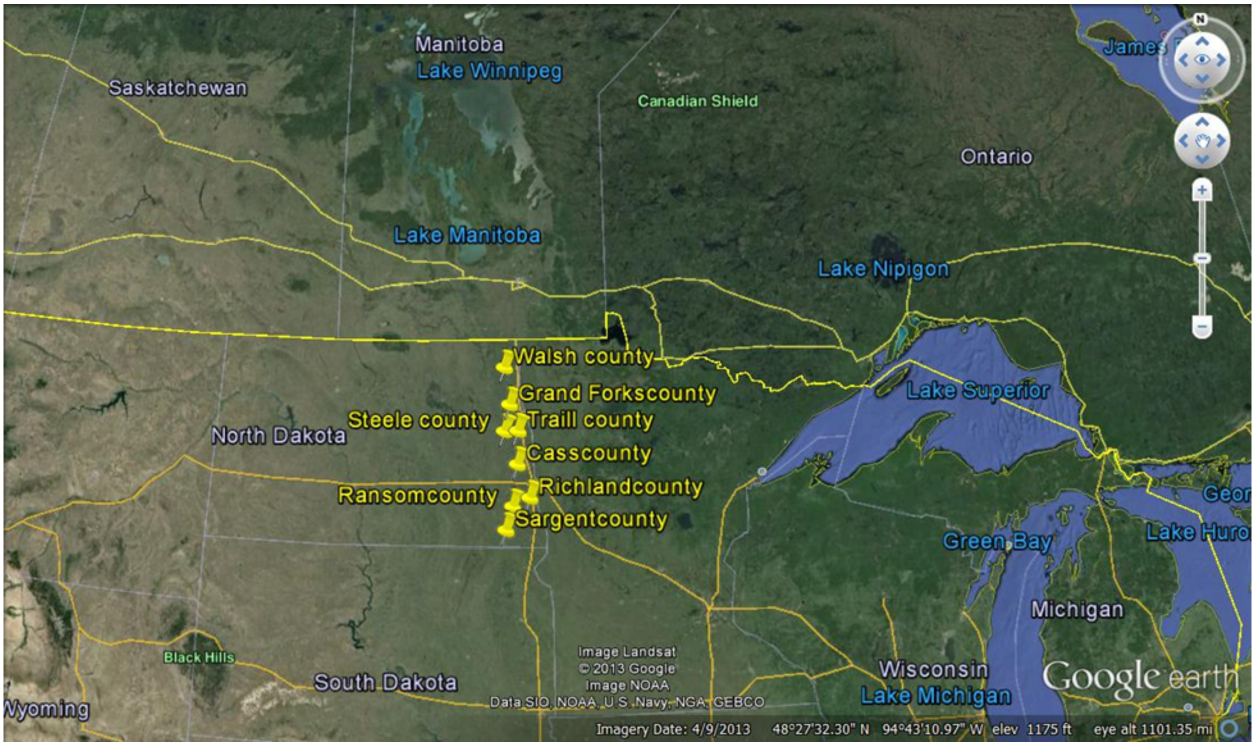

Figure 2. Locations of the Red River Valley Tile Drainage Assessment - Phase II sites. This map shows the locations in relation to Canada and the Great Lakes in the United States.

Section 3.0 Project Goals

The primary goal of the project is to assess the quality and quantity of water discharged from representative tile drains and surface drains in saline soils in the Red River Valley. As a secondary goal, the project will identify feasible land management options for improving the quality of tile and surface drain effluent. Samples will be collected during the open water periods of 2009 – 2013.

To reach these goals the Principal Investigator will: 1) measure the water quality of the outflow from tile drains in the Red River Basin at 8 representative sites; 2) measure the amount of salinity in the outflow of tile drains located on salt affected soils, 3) measure the quantity and quality of water leaving a field via tile and surface runoff at 4 sites to determine mass discharge of mineral constituents, 4) present results at meetings and in printed publications, and 5) use results to help develop best management practices (BMP) for land that is tile drained in North Dakota.

The project sponsor hoped to achieve a better understanding of the water (quality and quantity) leaving subsurface sites on salinized fields in eastern North Dakota and to understand how many years before we would see decreases in water quality concentrations. We heard firsthand accounts from farmers who had low-to-no-crop production due to high soil saline levels. They typically saw yield increases after one season following tile installation. This point was demonstrated when we determined we needed to move our Richland county sampling site because the land owner had already had such great "farming" success after his field had been tiled for one year.

Many of the projects monitoring goals were successfully achieved. We have up to five years of water concentration and flow measurements from sites all along the eastern edge of North Dakota (Objective 1, 2 and 3). With the cooperation of the land owners and the assistance of the Soil Conservation Districts we obtained and compiled other relevant and necessary data for the project, including climate data, land use and soils data. Soil samples were taken at four locations in an attempt to associate soil salinity levels with our water concentrations (Objective 4). We presented our project and available results to multitudes of groups and to the landowners over the five-year time period (Objective 5). Tile drainage educational programs were also given to Extension county agents and the public at annual conferences, workshops and tours (see pages 16-18 for list). An annual report was prepared and submitted to the North Dakota Department of Health as per Objective 6 within the QAPP. We were not able to determine the number of acres that have been tiled in North Dakota (Task 15 of Objective 5). A colleague at NDSU is currently undertaking a project that will answer this question. We also have struggled with developing BMPs for land tile drained in North Dakota. We determined that much more studying of a different nature is required to answer that question. Universities in Iowa, Wisconsin, Indiana, Ohio, and Minnesota have research programs that have determined BMPs for nitrogen, but as of this writing South Dakota State University is currently in the first years of working on BMPs for salinity issues.

We believe the benefit of this project is to make others aware of tile drainage in eastern North Dakota. As tile drainage becomes more popular throughout the state we have been able to answer many questions about the pros and cons of drainage and to educate them on drainage design, downstream neighbor conflicts, understanding the permitting process and to answer questions to legislators and water boards as they learn about the practice and ultimately make decisions on permitting. Success of this was measured through surveys at workshops and in personal conversations with members of the water boards and legislature.

Section 4: Project Activities

Objective 1: Evaluate the relationship between land management practices and trends in the quality of the water discharged from 8 tile drains and 16 surface drained systems in the Red River Valley.

Task 1: Establish monitoring sites for up to 8 tile drain systems and 16 surface drain systems and install necessary instrumentation.

Product: Monitoring sites established on 8 tiled fields and 8 un-tiled fields.
A total of eight sites will be studied. Four sites will pull weekly water samples. Four other SCD's (1 in 2009 and 3 in 2010) will obtain weekly samples for a more intensively studied tile drainage system located in their jurisdiction. At each of these sites, flow rate and water quality samples were collected at:

- A drain tile outlet or preferably a lift station
- A downstream location within a mile from the tile outlet
- Surface runoff from the tiled field
- If possible, surface runoff of a comparable field, not tile drained.

Outcomes: *Landowners were contacted and agreed to be a part of this project. All sites were required to have soil salinity concerns. Potential sites were located in Walsh, Steele, Cass, Richland Grand Forks, Ransom, Sargent and Traill counties. Once the tile drainage site was identified we determined surface runoff collection sites for the tiled field, a comparable non-tiled field, and a downstream sample at 4 of the sites. Automated water collection samplers were installed in Cass (2009), Grand Forks (2010) and Richland (2010) counties but were removed after one year due to a lack of value for this large number of samples. We also questioned quality control issues as the auto-samplers were not refrigerated, nor were the samples preserved until we were physically there to add the acids (once a week).*

It is difficult to obtain surface runoff samples due to accessibility at the site or not being in the area when the surface runoff occurs. Two thousand twelve was a very dry year so we have very few samples.

Tipping buckets and rain gauges for precipitation were installed at all sites, as they were determined. Lift stations were equipped with electrical current data loggers to measure flow at sites with lift stations and Stingray flow and velocity measurement devices were installed at the gravity flow sites in Grand Forks and Sargent counties. Steele County was gravity flow and because of its poor location only water samples were collected.

Site	Automated Water Sample Equip	Flow Monitoring	Tipping bucket and Dewey rain gauge	Weekly water collection	Problems
Cass	*2009 & 2010*	*2009-2013* *Current sensor in electric panel*	*2009-2013*	*2009-2013*	*Late start in 2009. Electrical panel failure for most of 2011. Few water samples in 2012.*
Grand Forks	*2010*	*2010 – 2012 HOBO U20 water level logger & barometric pressure loggers* *2011- 2013 Stingray flow and velocity measurement device and data logger*	*2010-2013*	*2010-2013*	*Drought in 2012 resulted in very few water samples.*
Richland	*2010*	*2010-2013* *Current sensor in electric panel*	*2010-2013*	*2010-2013*	*Drought in 2012 resulted in very few water samples.*
Sargent	*NA*	*2011- Stingray flow and velocity measurement device and data logger*	*2010-2013*	*2010-2013*	*2011- Landowner doubled his tile drainage acres that were flowing through this outlet so the project was stalled. 2012 - Drought resulted in very few water samples.*
Walsh	*NA*	*2010-2013* *Current sensor in electric panel*	*2010-2013*	*2010-2013*	*Vandalized in July of 2010. Electrical panel and tipping bucket shot. Drought in 2012 resulted in very few water samples.*
Ransom	*NA*	*2010-2013* *Current sensor in electric panel*	*2010-2013*	*2010-2013*	*2010 Sampling irregularities by district coordinator created gaps in sampling. Drought in 2012 resulted in very few water samples.*
Traill	*NA*	*2010-2013* *Current sensor in electric panel*	*2010-2013*	*2010-2013*	*2012 & 2013 Sampler just quit taking samples. Drought in 2012 resulted in very few water samples.*
Steele	*NA*	*No electricity therefore no current sensor in place.*	*2010-2013*	*2010-2013*	*Drought in 2012 resulted in very few water samples.*

Table 1. Eight sites in eastern North Dakota were equipped with flow measuring and precipitation devices.

Task 2: Document historic, current and planned land management practices on the acres serviced by each drainage system.

Product: Baseline and annual records for crop types and rotations, nutrient/pesticide inputs, yields, soil samples and precipitation.

Outcomes: *Cropping and fertilizer application was recorded when the information was reported by the landowner. Soil samples were taken from Cass County (2009-2012),* *Sargent County (2011 –2012), Grand Forks County (2010-2012) and Richland County (2010-2012). Table 2 below includes predictor variables by site (soil type, tile spacing, outlets, acres, age of tile). Table 3 indicates variables that changed by the year (crops planted and fertilizer applied). Fertilizer is shown in pounds per acre unless otherwise noted.*

	Cass	Walsh	Grand Forks	Steele	Traill	Ransom	Richland	Sargent
Primary soil type	Fargo silty clay	Overly silty clay loam, level	Wyndmere-Tiffany fine sandy loams	Bearden-Kindred silty clay loams	Fargo silty clay	Divide loam	Bearden silty clay loam, saline	Colvin-Borup, silty loam, saline
Secondary soil type	Fargo silty clay loam	Glyndon silt loam, level	Arveson loam	Colvin silt loam, saline	Fargo-Hegne silty clay	Wyndmere-Tiffany loam	Borup silt loam, saline	Gwinner-Peever silty clay loam complex
Tile diameter	4"	4"	3-8"	3"	3"	4-6"	4"	4"
Tile spacing	60'	50'	50'	40'	40'	80'	40'	60'
Tile depth	3'	3'	2.5-3'	3'	30" minimum	3'	3'	3'
Design Drainage coefficient	3/8"	3/8"	3/8"	3/8"	3/8"	3/8"	3/8"	3/8"
Outlets	1	1	1	4 or 5	1	2	1	
Lift/gravity	Lift Pump	Lift Pump	Gravity	Gravity	Lift Pump	Lift Pumps	Lift Pump	Gravity
Pump Hp & Maximum Flow Rate	10 hp, 1050 gpm	5 hp, 700 gpm			5 hp, 700 gpm	5 hp each, 700 gpm	10 hp, 980 gpm	
Acres	74.7	130/140	150	114.8	154.8	300	142	155
Age of tile (years as of 2009)	1	0	2		2	1		1

Table 2. Predictor variables by site.

	Cass	Walsh	Grand Forks	Steele	Traill	Ransom	Richland	Sargent
2008 crop	Soybeans	Soybeans	Corn/Navy Bean		Soybeans	Corn	Corn	Corn
2009 crop	Sp wheat	Wheat	Navy Bean/Corn		Corn	Soybeans	Beets	Soybeans
2010 crop	Corn	Corn	Corn/Navy Bean		Soybeans	Corn	Corn	Corn
2011 crop	Soybeans	Soybeans	Navy Bean/Corn		Corn	Corn	Corn	Wheat
2012 crop	Corn	Wheat	Corn/Navy Bean		Soybeans	Corn	Beets	
2013 crop	Soybeans	Sugar beets	Navy Bean/Corn		Corn	Corn	Corn	
2008 Nitrogen Applied	No N applied	38 pounds/acre	60/100 N, 10/20 P, 20/20 K, 0/5 gal 3-18-18		No N applied		90 pounds/acre	54N, 46P pounds/acre
2009 Nitrogen Applied	90 pounds/ acre	31 pounds/acre	90/40 N, 10/20 P, 20/20 K, 5gal/0 3-18-18		105 pounds/acre in the fall and 5 gal/acre 10-34 at planting	No N applied	130 pounds/acre	
2010 Nitrogen Applied	86 pounds/ acre	69 pounds/acre	70/80N, 10/20P, 30/25K, 0/5gal 3-18-18		110 pounds/acre	20 pounds/acre potash before planting, 110 N, 20 P2o5 pounds/acre, 4 ton/acre turkey litter	110 pounds/acre	
2011 Nitrogen Applied	No N applied	55 pounds/acre 11-52	100/70N, 20/10P, 20/10K, 5gal/0 3-18-18		No N applied	120 N, 10K, 30 potash pounds/acre	190 pounds/acre	54N, 46P pounds/acre
2012 Nitrogen Applied	120 pounds/ acre	90 pounds/acre 46-0-0	70/130N, 15/20P, 10/20K, 0/5gal 3-18-18		No N applied		120 pounds/acre	
2013 Nitrogen Applied	No N applied					No N applied		

Table 3. Predictor variables that changed each year.

Task 3: Employ student to assist in on site data procurement, data management, website maintenance and clerical support to PI.

Product: Data, reports, and documents.

Outcomes: *Four students have worked on this project and have either graduated or taken other positions. I found that although they may have enthusiasm and are capable of managing data downloading from the sites, they do not know how to organize the large amount of data we have accumulated and it has made for a lot of confusion and* *repetition of processes. With the assistance of a statistician at NDSU and input from the NDDH the analyses are being completed.*

Task 4: Collect and analyze 1 water chemistry sample each week from each site as scheduled in the QAPP (see Section 5.0).

Product: Water quality data to define baseline concentrations and subsequent concentration trends for total nitrogen, total Kjeldahl nitrogen, nitrate-nitrite, ammonia, total phosphorus, ICP metals, cations and anions, dissolved oxygen, temperature, pH, and conductivity.

Outcomes: *With the assistance of the county Soil Conservation District watershed coordinator or appointee, weekly water samples were taken when water was flowing from the tile. Cass, Richland and Grand Forks counties used the automated samplers the first full year but that practice ended when it was determined that it did not meet our expectations or needs. Grab samples from surface runoff were collected when possible, which was less often than expected because the samplers were not in the field on the days when samples could have been gathered. The samplers were instructed to turn the lift station pump on and collect a sample if they could hear water trickling into the holding area of the lift station. This would indicate water was flowing through the tile.*

All samples were collected using methods taught by the NDDH. Three containers, 2-500 ml. and 1-250 ml. were triple rinse and then filled with water. One 500 ml bottle was refrigerated only, one had sulfuric acid added and the 250-ml. containers had nitric acid added. Preservatives were supplied by the NDDH. All samples were then cooled and shipped to the NDDH by the SCD watershed coordinator within the two-week timeframe.

Analysis methods by the NDDH are listed in the QAPP Table 2.

Task 5: Interpret and summarize the water quality sample data, water quantity data, soil samples and land use data collected at each site for inclusion in various informational materials and presentations.

Product: Annual water quality, soil samples and land use data summaries. Final report on water quality trends and the relationship with land management practices.

Outcomes: *Analyses of water quality, flow, soils, and land use will be summarized and reported in Section 2 of this report.*

Objective 2: Quantify the water and pollutant discharges from 4 of the tile drain sites and 4 of the surface drain sites.

Task 6: Install automated samplers to record flows and collect water quality samples. One site will be established in 2009 and 3 additional sites will be established in 2010.

Product: Up to 4 sites for quantifying pollutant loadings and water discharges.

Outcomes: *It was determined the automated water samplers were not useful in that we had water standing without preservatives for an extended period. We removed the automated samplers in 2010 and began collecting a grab sample if the lift station pump was running or if there was flow from the gravity outlets. The Cass county site was established in 2009 (late summer because funding was delayed) and the other 7 sites in 2010. In 2010 the Richland county site was moved from the original site because we wanted a field where the tile had been more recently installed. The Walsh county site was not determined until 2010 because the cooperator changed his mind on becoming involved with the project. Because the Walsh, Ransom, and Traill county sites were lift stations we put a current sensor on the electric panels to determine flow (although that was not on the original proposal). The Sargent county site was determined in 2010 but it became apparent that the outlet location was not the best for pulling samples. He then tiled the rest of this field and had to move the tile main outlet to accommodate those acres, thus setting the project behind again. See Task 7 for Grand Forks site information. The number of water samples collected and analyzed varied significantly by site (see table 1 below). The differences in numbers of samples could be due to lack of flow from the tile system, inability to obtain a sample due to flooding or change in conservation district personnel.*

Site Location	Inclusive Sample Dates	Number of Samples Analyzed
Cass County	10/2/2009 to 6/25/2013	81
Grand Forks County	7/7/2009 to 7/2/2013	104
Ransom County	11/5/2009 to 6/4/2013	31
Richland County	4/22/2010 to 7/2/2013	107
Sargent County	8/10/2009 to 5/22/2013	32
Steele County	6/2/2009 to 6/25/2013	30
Traill County	9/17/2009 to 6/10/2013	28
Walsh County	4/12/2010 to 7/6/2013	79
Total for the Project		**492**

Table 4. Number of water samples collected and analyzed in Phase II.

Task 7: Document the water flows/volume and collect and analyze approximately 4 water chemistry samples from each site as scheduled in the QAPP (see Section 5.0).

Product: Continuous hydrologic discharge records and water chemistry data for documenting and evaluating pollutant loadings and trends for total nitrogen, total Kjeldahl nitrogen, nitrate-nitrite, ammonia, total phosphorus, ICP metals, cations and anions, dissolved oxygen, temperature, pH, and conductivity.

Outcomes: *In 2010, the Richland and Cass county sites were equipped with current sensors in the electrical panels of the lift stations to determine how often and how long the pump ran (discharge to ditch). Calculations to determine the flow were made from these measurements. Additional current sensors were installed in 2011 at Ransom and Walsh. The Grand Forks site was equipped with a circular flume and a Hobo U20 water level logger to determine flow. A Stingray flow and velocity measurement device and data logger that uses ultrasonic technology was installed in Sargent County (2011) and Grand Forks County (2012). The Stingray at Sargent County was vandalized in the fall of 2011and replaced in the spring of 2012.The Cass county site was not running the summer of 2012 due to electrical panel failure. Due to less than normal precipitation the cooperators did not see an immediacy to repair the electrical panel.*

Task 8: Obtain and analyze precipitation data from the National Climatic Data Center (NCDC) or other available sources, including rain gauges located within each sampling site and data logging rain gauges. The NCDC has data available for stations in the Red River Valley.

Product: Annual climate data for the sampling sites.

Outcomes: *Tipping buckets and Dewey rain gauges were installed at each of the eight sites. The tipping buckets were equipped with a HOBO pendant event/temp data logger. SCD personnel record rain in the Dewey rain gages each week and the data loggers were downloaded by NDSU personnel at least twice each month. We had a few sites where the pendants were damaged due to sunlight or vandalism. Although they were replaced we lost data at these sites when this occurred. Training was held with the SCD personnel to watch that the tipping buckets were not plugged with bird droppings. Nails or hairpins were attached to the edge of the tipping bucket to discourage birds from sitting on the buckets. When necessary to fill missing data gaps, precipitation amounts were obtained from North Dakota Agricultural Weather Network at http://ndawn.ndsu.nodak.edu/*

Task 9: Obtain and analyze soil samples.

Product: Up to 4 sites for assessing movement of salts through the soil profile and the potential for pollutant loading.

Outcomes: A *commercial agronomist in Cass County took soil samples in 2009, 2010, 2011, and 2012. The Grand Forks and Sargent sites were sampled in 2010, 2011, and 2012. Because the site was moved following 2010 the Richland site was sampled in 2011 and 2012. The NDSU Soils Laboratory on the Fargo campus conducted soil testing.*

Objective 3: Increase knowledge of subsurface drainage effluent impacts and management practices to decrease NPS pollution for landowners and operators, tile contractors, soil conservation districts, legislators and other natural resource managers.

Task 10: Organize and conduct information/education events focusing on subsurface drainage and NPS pollution control.

Product: A minimum of 5 I/E meetings for the public and presentations at a minimum of 5 state, regional or national water quality conferences.

Outcomes: *The following is a list of educational outreach provided through this project:*

National presentations –
Jan. - 2009 Land and Sea Grant National Water Conference, St. Louis, MO
Jan. - 2010 Land and Sea Grant National Water Conference, Hilton Head, SC
Apr. - 2010 Water Quality Monitoring Conference, Denver, CO
Jan. - 2012 Land and Sea Grant National Water Conference, Portland, OR

National posters-
Jan. - 2009 Land and Sea Grant National Water Conference, St. Louis, MO
Jan. - 2010 Land and Sea Grant National Water Conference, Hilton Head, SC
Apr. - 2010 Water Quality Monitoring Conference, Denver, CO
Jan. - 2011 Land and Sea Grant National Water Conference, Washington, DC
Jan. - 2012 Land and Sea Grant National Water Conference, Portland, OR

Local presentations-

2009 – SCD boards in Walsh, Cass, Grand Forks, Richland, Steele, Traill, Ransom, and Sargent counties, Crop Improvement Meetings in Grafton, Oakes, and Valley City

2010 - Red River Basin Land and Water Institute Summit, Grand Forks; Advanced Crop Advisor Workshop, Fargo; Crop Improvement Meeting, Mayville

2011- Minot, ND; Renville County, ND; Langdon, ND; Carrington REC, Carrington, ND; Crop Improvement Meetings in Steele, Grand Forks, Sargent, Cavalier and Pembina Counties; Advanced Crop Advisors and Annual Soybean Council Meetings in Fargo; Watershed Coordinators Workshop, Bismarck; Extension Spring Conference, Fargo; Eastern SD Water Conference – SDSU, Brookings; Soil and Water Conservation Meeting *in Jamestown, Ag Country Insurance; ND Ag Association Meeting; Upper Sheyenne Water Board Mtg. and the Basin Technical and Scientific Advisory Council (BTSAC).*

2012 - ND Water Monitoring Conference, Bismarck, ND; Devils Lake Roundup, Devils Lake, ND; County meetings in Williston, Newburg, Cando, Park River, Hallock, MN, Cavalier and Lamoure; Advanced Crop Advisors, Fargo; Devils Lake; State FSA Office Staff, Fargo; Crosby, ND; NDSU Experiment Station Directors Mtg., Fargo; NDSU Teacher Training Class, Annual FSA Meeting, Bismarck; ND Ag Association Mtg.

2013 - Red River Basin Land & Water Summit, Grand Forks; County meetings in Devils Lake; Maddock; Rugby; Mohall and Langdon; Soil Health Field Day, Grand Forks and Kiwanis Club, Fargo.

Tile Drainage Design Forums, Workshops, Tours and Demonstrations-

2009 – Fargo Drainage Forum (200 registered), Tile Drainage Tour (Emden Discovery Farm, Fairmount and NDSU Campus – 65 attendees)

2010 – Fargo Drainage Forum (130 registered), Tile Drainage Design Workshop (55 registered), Tile Installation Field Day and Demo (75 present), Edmore

2011 – Two Tile Drainage Design Workshops in Wahpeton (55 registered at each), 2-Day tour for Canadian Tile Professionals, Demonstration of Tile Installation and Workshop at Big Iron Farm Show.

2012 – Tile Drainage Design Workshops in Wahpeton, Sioux Falls, SD and Mankato, MN with 165 total registered.

2013 – Tile Drainage Design Workshops in Mankato, MN; Moorhead, MN; and Aberdeen, SD with over 180 total registered.

Regional water quality meetings

2009 - Apr. – Land and Sea Grant meeting Denver, CO
Oct. – Land and Sea Grant meeting Denver, CO
2010 - Oct. – Land and Sea Grant meeting Laramie, WYO
2011 - Jul. – Land and Sea Grant meeting Denver, CO
Nov – Drainage Research Forum, Okoboji, IA
2012 – Tile Contractors Meeting in Mason City, Algona and Lemars, Iowa

NCREA 217 (ADMS)

2011 – Presentations and tour – Fargo
2012 – Presentation - Dundee, MI
2013 – Presentation - Sioux Falls

American Society of Agricultural and Biosystems Engineering Society (ASABE), Regional and International Meetings

2009 - June International ASABE Conference, Reno, NV

NDASCD

Brochures

2011 Tile Drainage brochures (2000 printed and distributed)
http://www.ag.ndsu.edu/waterquality/documents/Tile%20drainage%20brochure%20-14.pdf

Posters

Basics of Tile Drainage – distributed to 17 counties, Carrington and Langdon REC's

Through the legislative process, North Dakota has changed the process for drainage permitting. We have aided local water resource boards to learn about tile drainage equipment, installation and how to avoid issues with neighbors when placing tile outlets. We worked with the International Water Institute, NRCS, and FSA to educate decision makers on tile drainage in North Dakota. In addition, there have been several news releases, TV and radio interviews on tile drainage.

Task 11: Determine number of subsurface drained fields, number of acres and their location in North Dakota.

Product: Document.

Outcomes: *This task is scheduled for 2011 and cannot be accomplished because we have no way to assess the number of acres tiled visually or through permitting. Permitting was initially done through the ND State Water Commission and now through the county Water Boards unless the field is in a closed basin. Currently if the acreage tiled is under 80 acres a permit is not needed which makes this an impossible task. It must also be recognized that many acres are tiled without a permit whether required or not. Colleagues at NDSU are currently working with UND to determine acres drained through subsurface means.*

Task 12: Prepare I/E materials for soil conservation districts, landowners, and the media to promote the project and circulate information on water quality/quantity and NPS pollution.

Product: Minimum of (10) news releases, articles, bulletins, publications or brochures.

Outcomes: *See Task 10.*

<u>Task 13:</u> Facilitate meetings/workshops with cooperating producers and others to identify feasible cropland management options to reduce/prevent pollutant discharges from tile drain systems.

<u>Product:</u> An annual meeting with each cooperator (40) and a minimum of 2 workshops.

Outcomes: *Discussions with producers concerning saline reductions in the field and ways to reduce N losses through farming practices were held via phone or face-to-face at annual meetings. The meetings did not include specific management practices but were focused on water quality and quantity data that was specific to their fields. Until data was fully analyzed it was not practical to make overall observations for changes in farming practices. Landowners did make changes such as reducing N application based on soil tests.*

<u>Task 14:</u> Create and maintain web-based report on the NDSU Water Quality Web Site. The report will be created in April of 2009 and updated each year with new data.

<u>Product:</u> A current web-based report.

Outcomes: *While an NDSU Water Quality website was built and the project was featured on the website, data was not included in the website.*

<u>Task 15:</u> Develop and submit an annual progress report to the ND Department of Health and other project partners.

<u>Product:</u> Annual reports.

Outcomes: *Annual reports were completed as required.*

Section 5: Methodology

Samplers were instructed by the NDDH and NDSU as to correct sampling techniques at the beginning of this project. As required by the NDDH all bottles and caps were rinsed three times prior to sample collection and a preservative (supplied by the NDDH) was added at collection time. Preservatives used were:

- Nitric acid (2 ml.) in a trace metal grade was added to a 250-ml. water sample for testing of cations and trace metals.
- Sulfuric acid (2 ml.) in a 1:5 concentration was added to a 500-ml. water sample for testing of nutrients.
- Refrigeration (no acid) was required in one 500-ml.-water sample for anion testing.

For quality control purposes, duplicate samples were taken following each tenth sample as per the NDDH requirements.

All samples were kept in a cool state (coolers with ice and then refrigerated) and then sent to the Bismarck office of the North Dakota Department of Health in iced coolers, along with the required sample custody report (Appendix C), within two weeks of collection. Water parameters analyzed by the ND Department of Health included:

Cations: Aluminum (Al^{3+}), barium (Ba^{2+}), calcium (Ca^{2+}), copper (Cu^{+}), iron (Fe^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), silver (Ag^{+}), sodium (Na^{+}), and zinc (ZN^{2+}).

Anions: Chloride (Cl^{-}), bromide (Br^{-}), carbonates (CO_3^{2-}), nitrate (NO_3^{-}), nitrite (NO_2^{-}), phosphate (PO_4^{3-}), fluoride (Fl^{-}), and sulfate (SO_4^{2-}).

Trace Metals: Aluminum (Al^{3+}), boron (B), selenium (Se), arsenic (As), zinc (Zn^{2+}), manganese (Mn^{2+}), copper (Cu^{+}), nickel (Ni^{2+}), molybdenum (Mo) and lead (Pb^{4+}).

Mineral Chemistry: Bicarbonates (HCO_3), conductivity, pH, potassium (K), sodium adsorption ratio (SAR), total alkalinity, total hardness, total dissolved solids, cadmium (Cd), ammonia nitrogen (NH_3-N), hydroxide (OH).

Rain gauges, provided by the Grand Forks office of the National Weather Service, were installed at each location. Rainfall amounts were recorded on a weekly basis. A log of on-site observations, including precipitation, was kept throughout the season.

Sample Analysis

Samples were analyzed in the laboratory using methods approved by the EPA under Section 304(h) of the Clean Water Act. Methods include inductively coupled plasma mass spectrometry to separate ions on the basis of their mass-to-charge ratio followed by detection with an electron multiplier or Faraday detector (method 200.8), inductively coupled plasma-atomic emission spectrometry (optical spectrometry) to measure characteristic atomic-line emission spectra (method 200.7), automated colorimetry (method 353.2), and semi-automated colorimetry (method 350.1). Data from this project is available from the North Dakota

Department of Health, Bismarck, ND using the Storet numbers provided. Additional information can be obtained in the QAPP.

Site Maps: Sampling locations for tile and surface sampling.

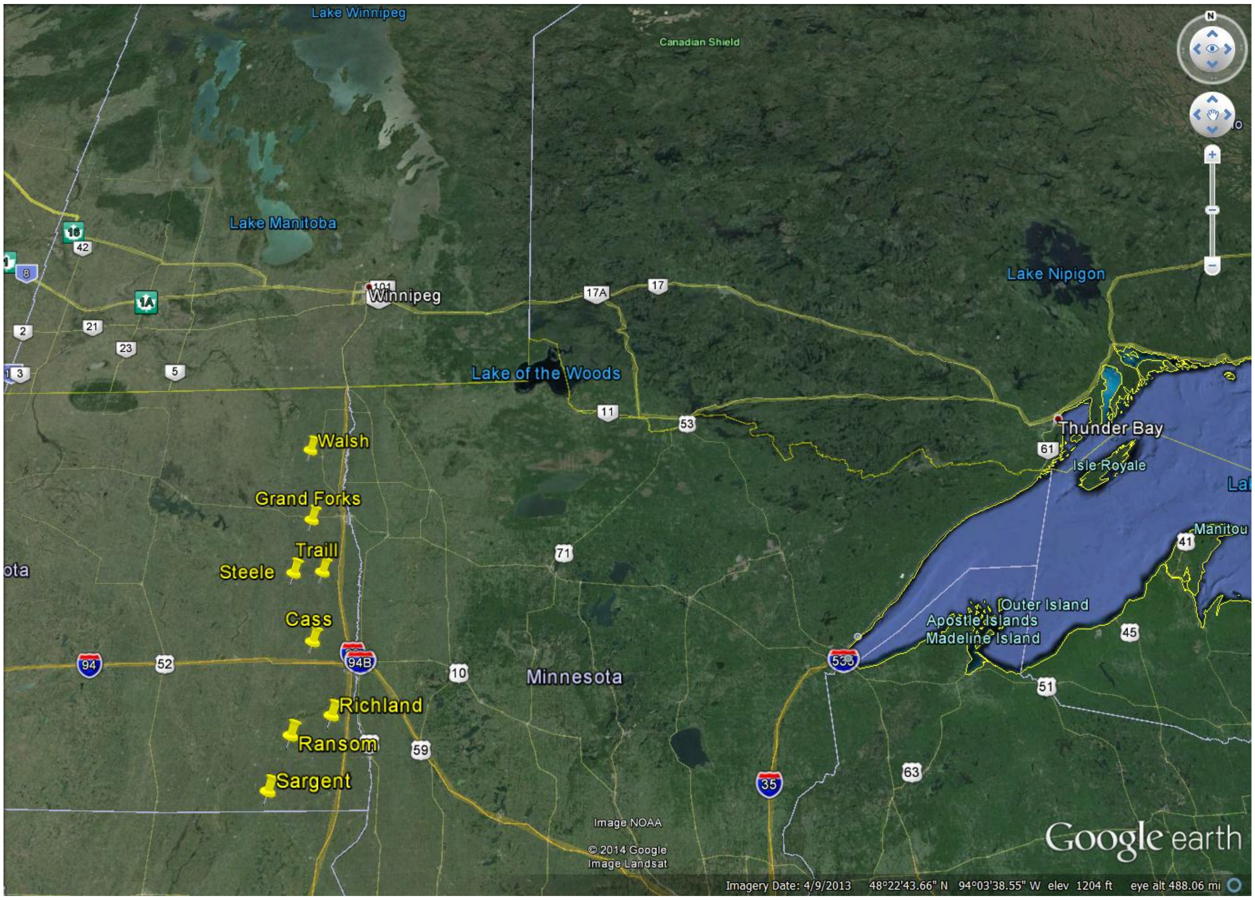

Figure 3. The Phase II water assessment project sampling sites were located in eastern North Dakota.

Figure 4. Cass county water sampling sites.

Figure 5. Grand Forks water sampling sites. This was a gravity-drained outlet into a vegetative area on the edge of a stream.

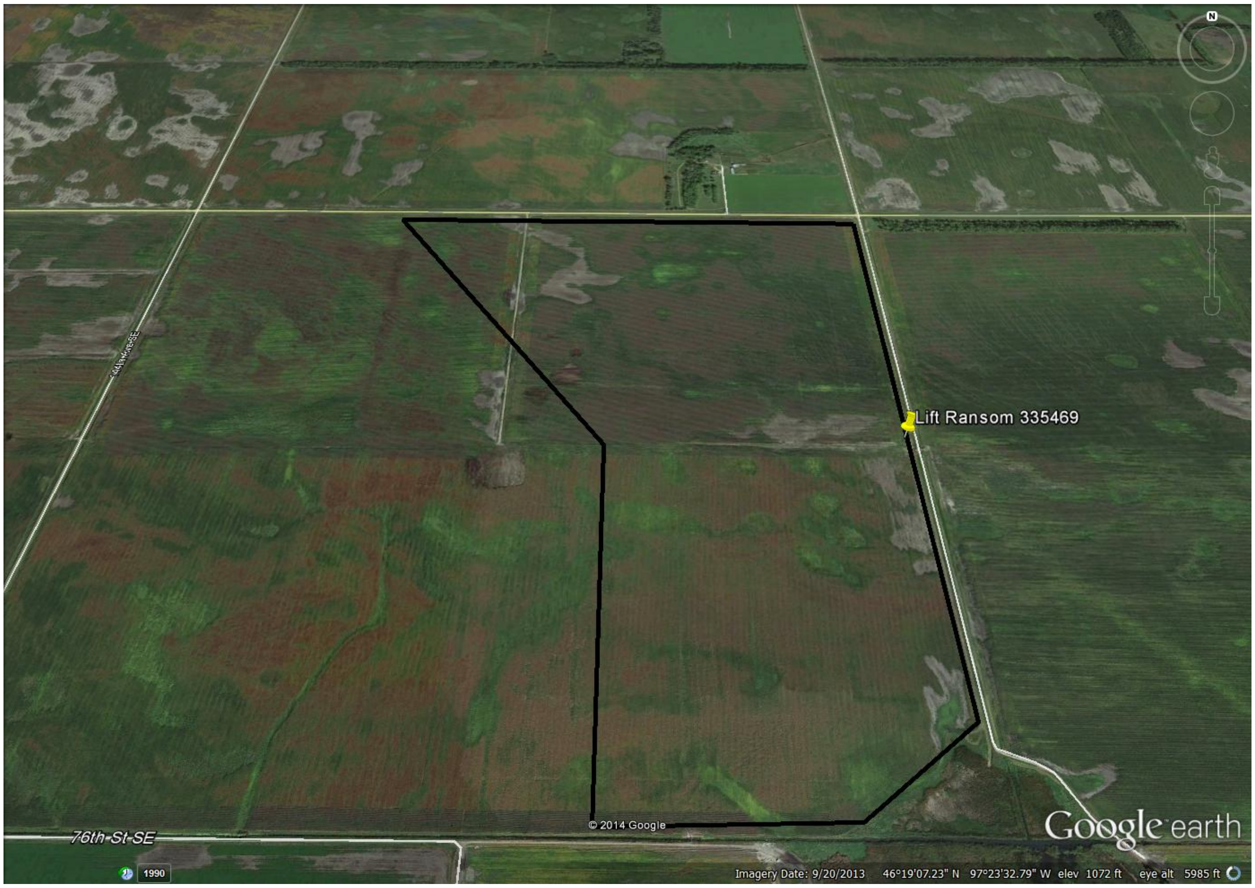

Figure 6. The Ransom county water-sampling site was built with 2 pumps. This site was one of two that was flooded at certain times in the spring and basically recirculated the water as there was nowhere for the water to drain.

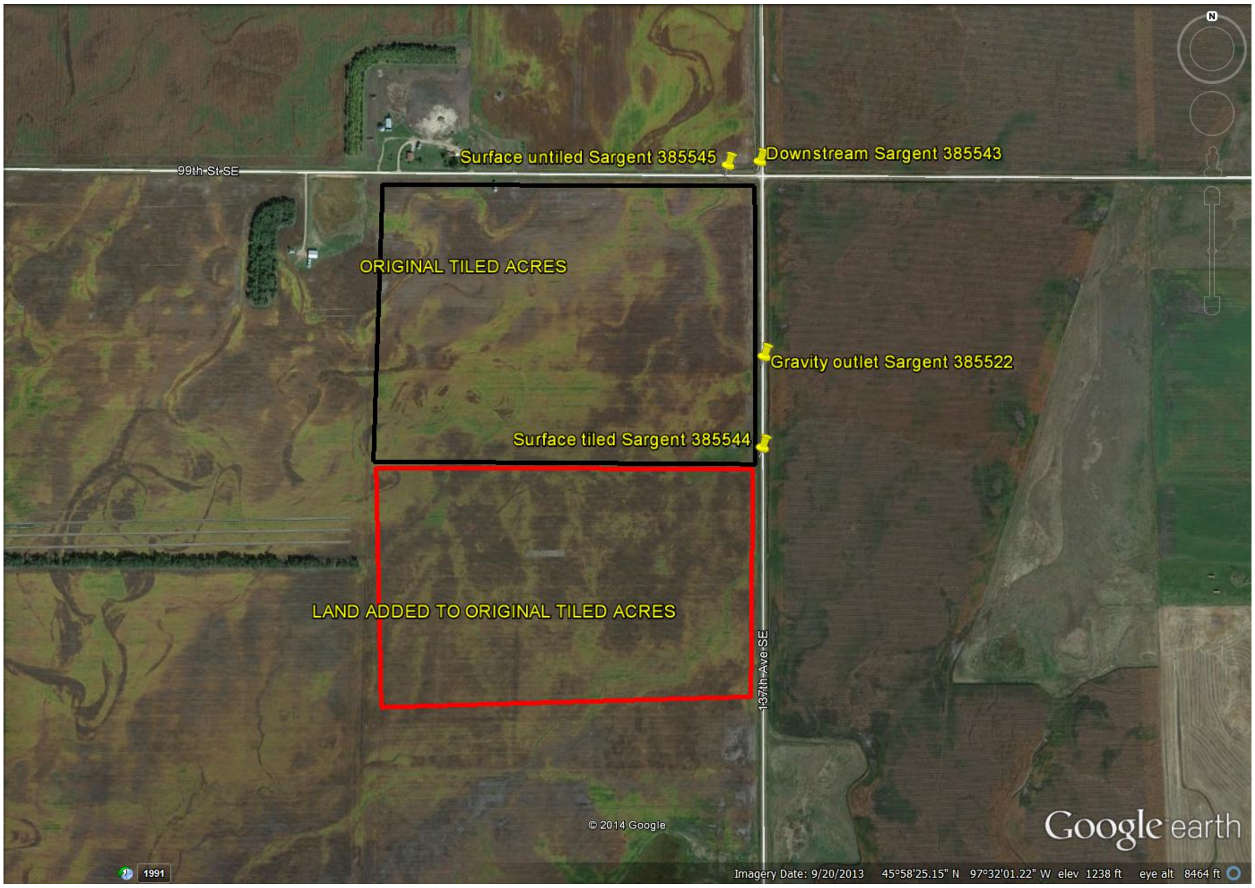

Figure 7. Sargent county site. Water samples were obtained from the tiled acres designated in black. In 2011 the landowner added the orange area to the existing tile main outlet.

Figure 8. Traill county water sampling site. To capture flow volumes, a HOBO current sensor was installed in the electrical panel in the second year of the project.

Figure 9. Richland county site. The lift station emptied into a county drain. We were able to pull upstream and downstream samples in addition to the lift station and surface samples.

Figure 10. This section of the Walsh county site was all tiled but the orange square was in CRP for the first two years of the project and then farmed with the other acres in 2012 and 2013.