Big Creek Research and Extension Team

University of Arkansas System Division of Agriculture

Quarterly Report – January 1 to March 31, 2014

DEMONSTRATING AND MONITORING THE SUSTAINABLE MANAGEMENT OF NUTRIENTS ON C&H FARM IN BIG CREEK WATERSHED

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Dr. Mark J. Cochran
Vice President for Agriculture

DEMONSTRATING AND MONITORING THE SUSTAINABLE MANAGEMENT OF NUTRIENTS ON C&H FARM IN BIG CREEK WATERSHED

Executive Summary

This is the second Quarterly Report of the Big Creek Research and Extension Team that details progress made from January 1 through March 31, 2014.

1. Permission was obtained and signed Memorandums of Understandings (MOUs) were obtained with the landowners of Fields 1 and 12, to install flumes and piezometers to monitor flow and nutrients in surface runoff and water infiltrating through the soil profile. Instrumentation of Field 1 was completed and Field 12 is ongoing. Permission and signed MOUs were obtained for land above and below the C&H Farm to install flow gauging stations that will be instrumented with continuous and storm flow samplers to monitor nutrient and suspended sediment concentrations.

2. An agreement was obtained to cooperate with U.S. Geological Survey to calibrate and operate the Big Creek gauging stations.

3. An agreement was also reached with C&H to sample a groundwater well adjacent to the slurry holding ponds. Data will be available in the next quarter.

4. Flow monitoring equipment and autosamplers were installed on the culvert draining the subwatershed that contains the C&H livestock operation and holding ponds. A signed Memorandums of Understanding (MOU) and permission to install and access sampling stations was obtained from County Judge to install this equipment on the County-owned culvert.

5. Field 12 was grid sampled in the same manner as Fields 1 and 5, with 40 profiles collected. The surface 0 to 4 inch soil test P concentrations ranged from 17 to 147 mg P/kg, with an average of 63 mg/kg.

6. Base flow sampling of Big Creek continued every two weeks above and below the C&H Farm, and from a spring below monitored Field 1. Dissolved P concentration ranged from 0.006 to 0.010 mg/L at the spring, 0.007 to 0.014 mg/L in Big Creek above the C&H Farm, and 0.007 to 0.015 mg/L downstream of the Farm. E. coli ranged from <1 to 248 MPN/ 100 mL in spring water, 6 to 248 MPN/100 mL upstream of C&H, and 5 to 2620 MPN/100 mL downstream of C&H.

7. A second set of manure samples from Pond 1 and a first set from Pond 2 were collected, which further document the naturally occurring manure solids and nutrient stratification with depth and from the first pond to the second. The resulting difference in manure composition, may allow application of nutrients to more closely match forage nutrient needs.

8. Work has begun on quantifying manure volume and nutrient production. Water meters were installed to measure barn wash water added to the manure. Historical monthly precipitation and evaporation information was also obtained. This information, in conjunction with animal population information, will be used in nutrient application and solids separation calculations.

Big Creek Research Team

Faculty

Andrew Sharpley, Ph.D., TEAM LEADER – Distinguished Professor - Soil science, water quality, soil phosphorus chemistry, agricultural management

Kris Brye, Ph.D., Professor - Effects of land application of poultry litter on in-situ nutrient leaching, effects of land use and management practices on soil physical, chemical, and biological properties related to soil quality and sustainability

Rick Cartwright, Ph.D., Professor – Associate Director of Extension for Agriculture and Natural Resources

Mark Cochran, Ph.D., – Vice President, University of Arkansas System Division of Agriculture.

Mike Daniels, Ph.D., Professor – Extension water quality and nutrient management specialist

Brian Haggard, Ph.D., Professor - Ecological engineering, environmental soil and water sciences, water quality chemistry, water quality monitoring and modeling, algal nutrient limitation, pollutant transport in aquatic systems

Jun Zhu, PhD., Professor - Biological and agricultural engineering, agricultural sustainability, manure treatment technologies

Nathan McKinney, Ph.D., – Assistant Director, Agriculture Experiment Station

Mary Savin, Ph.D. - Structure and function of microbial communities in natural and managed ecosystems, microorganisms in nutrient cycling, contaminant degradation

Karl VanDevender, Ph.D. and P.E., Professor - Extension Engineer, Livestock and poultry manure and mortality management, nutrient management planning

Thad Scott, Ph.D., Associate Professor - Water quality, transport of contaminants to and within water bodies

Adam Willis, M.Sc., Newton County Extension Agent - Agriculture

Field Technicians

The Big Creek Research and Extension Team are ably supported by several excellent Program Technicians based in Little Rock and Fayetteville.

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Introduction

This research project will evaluate the impact and sustainable management of the C&H Farm operation (subsequently referred to as C&H, to include animal facilities and permitted land application fields) on the water quality of Big Creek. The study includes the following major tasks:

1. Monitor the fate and transport of nitrogen (N), phosphorus (P), sediment, and bacteria from land-applied swine effluent to pastures.
2. Assess the impact of farming operations (effluent holding ponds and land-application of effluent) on the water quality of Big Creek below the C&H Farm as well as emerging springs and ephemeral streams.
3. Determine the effectiveness and sustainability of alternative manure management techniques, including solid separation, which may enhance transport and export of nutrients out of the watershed.

The project will measure soil fertility levels of all permitted fields annually, to determine the impact of current manure management on nutrient balances (i.e., any potential accumulation). This combined with nutrient levels in surface runoff and monitored wells on Fields 1 and 12 (an additional Field will be added with landowner permission), will guide adaptive manure management decisions to address field and environmental sustainability concerns. The project will also assess the feasibility of manure treatment, which is regarded as addressing nutrient imbalance concerns on all farms similar to C&H, which has the potential to provide the farm with cost-beneficial alternative for the sustainable use and export of treated manures off the farm and/or out of the watershed.

The plan of research meets the level of funding currently available. Other important methods of investigation, such as the use of dye-tracer tests, will provide valuable information on possible rapid by-pass flow pathways common in karst dominated areas will be conducted.

This information will be a short-term assessment and it must be noted that funds allocated below will not cover long-term monitoring, sample analysis, and assessment of land use impacts on area waters. Additional funds would be needed for sample collection and labor to continue monitoring for a minimum of five years. This time frame is recognized by the Environmental Protection Agency (EPA), Natural Resources Conservation Service (NRCS), and general scientific community to be the minimum required to accurately assess any impacts and overcome annual weather fluctuations.

Soil Sampling and Analysis

Grid soil sampling of Field 12 was conducted as per Figure 1. The grid size is approximately 0.25 acres and seven soil-depths increments were collected to include 0 to 4", 4 to 8", 8 to 12", 12 to 18", 18 to 24", 24 to 30", and 30 to 36" where possible with a Giddings soil probe. A grid network was overlain on each field to determine the point of sampling, which was noted by GPS. Each sample-hole remaining after the soil core was removed was carefully back-filled with commercial top soil (see Figure 1). Where rock stopped the core penetrating below a specific layer, no sample was taken.

The actual analyses of each core sample and depth are given in Appendix (Table 6, 7, 8, 9, and 10) and averages in Table 1. Table 1 contains average values for Fields 1 and 5 already completed in the first quarter of this project. The distribution of soil test P in the surface 4 inches of soil of Fields 1, 5, and 12 are given in Figures 2, 3, and 4, respectively.

Table 1. Average soil test P concentrations in the surface 0 to 4 inches of each field and when sampled during the Comprehensive Nutrient Management Plan (CNMP) development.

Soil depth, inches	Field 1	Field 5	Field 12
	- - - - - - - - -	mg/kg	- - - - - - - - - -
Original NMP	83	65	19
0 - 4	41	54	63
4 – 8	17	32	36
8 – 12	10	28	26
12 – 18	NS †	34	24
18 – 24	NS	6	35
24 – 30	NS	19	NS

† NS is Not Sampled.

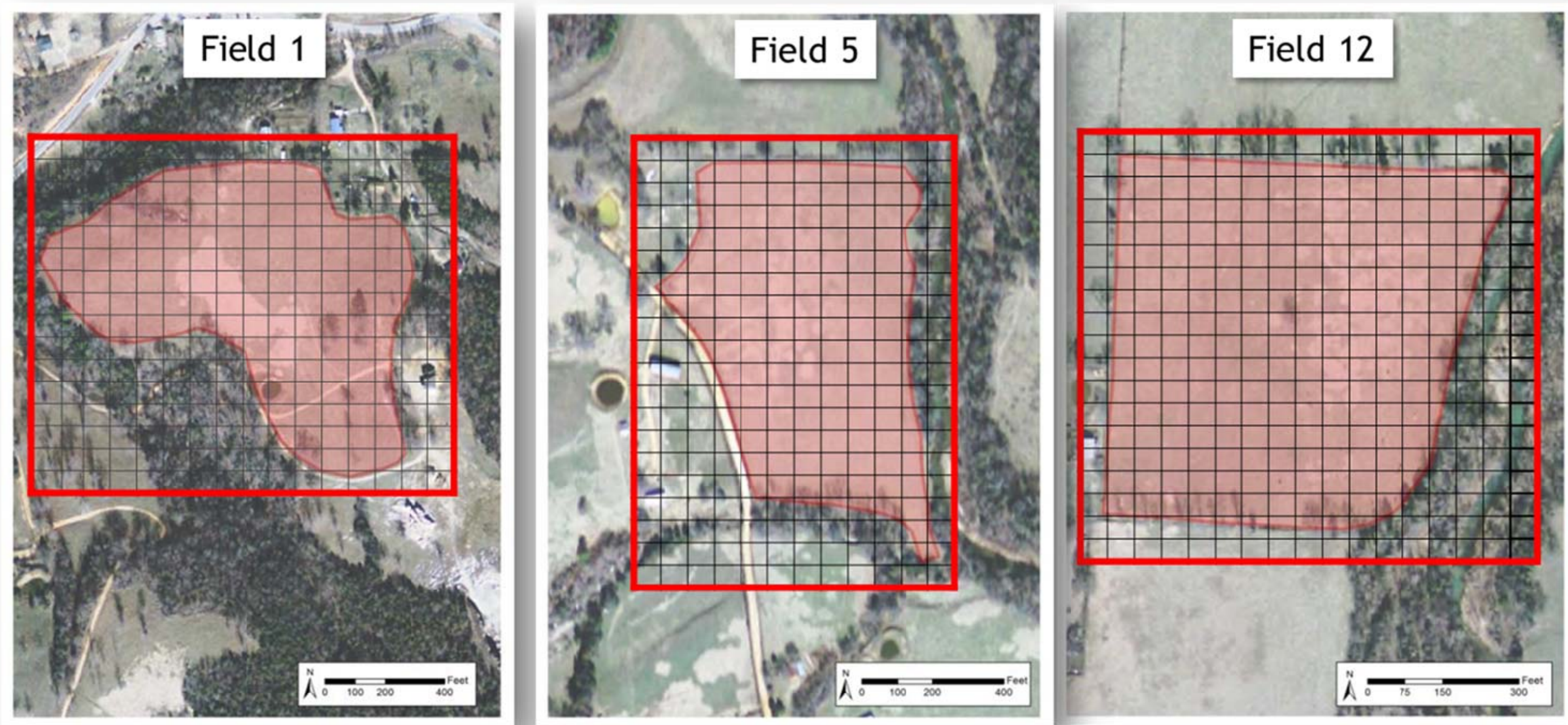

Figure 1. Gridded layout of the sampled Field 1, 5, and 12 on the C&H Farm operation Mt. Judea, Newton County, AR.

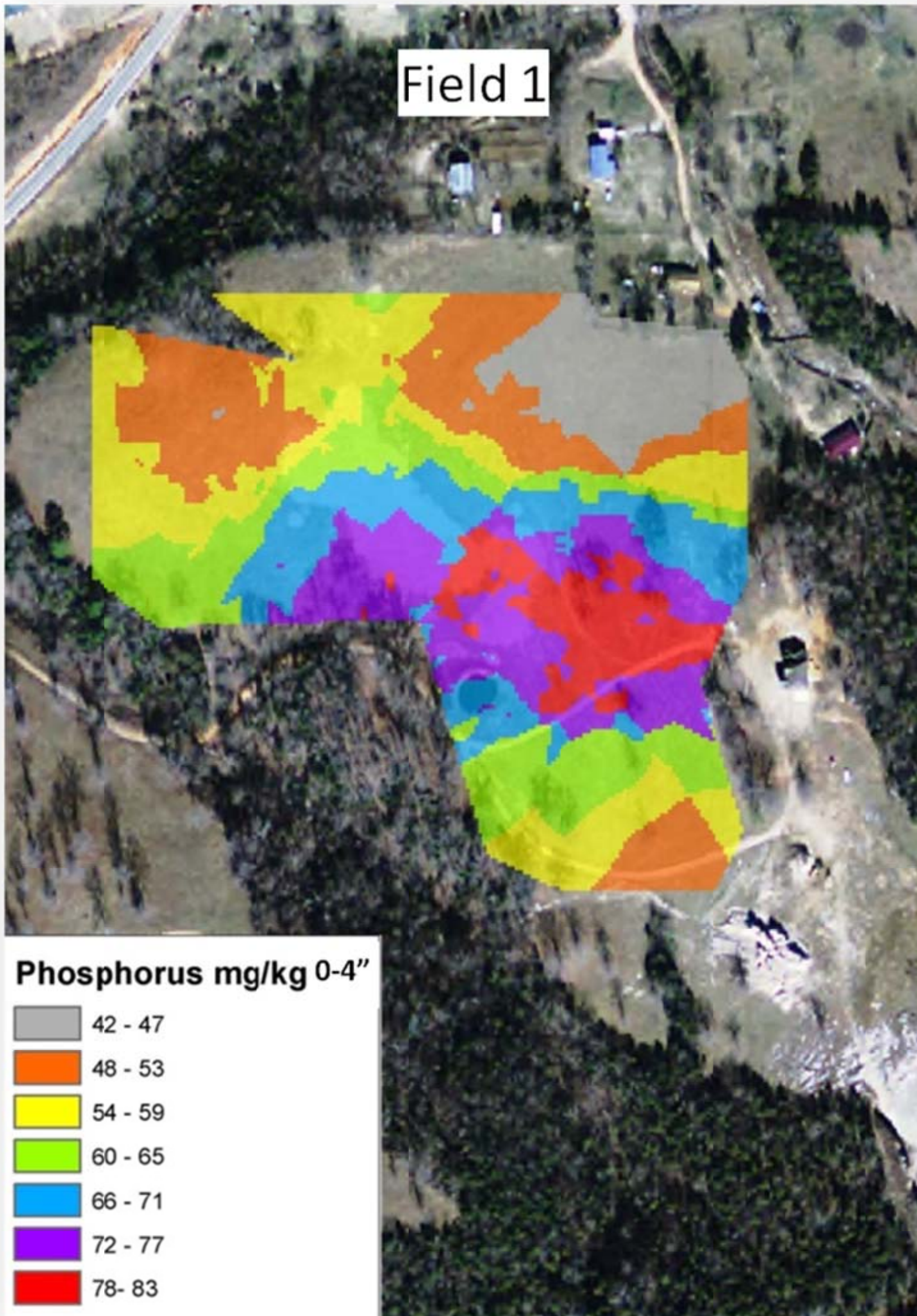

Figure 2. Soil P distribution of the 0 to 4 inch depth for Field 1 on the C&H Farm operation Mt. Judea, Newton County, AR.

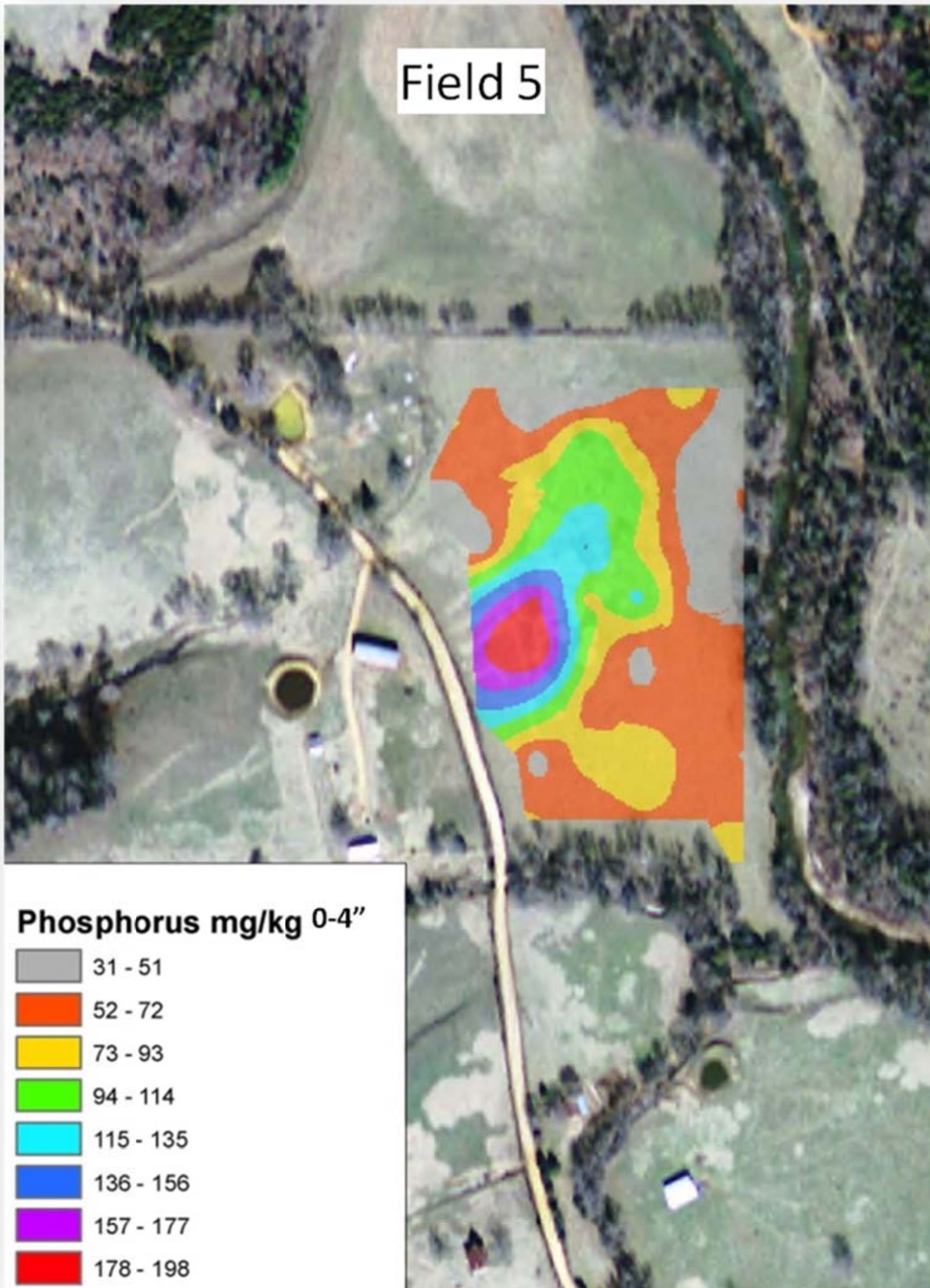

Figure 3. Soil P distribution of the 0 to 4 inch depth for Field 5 on the C&H Farm operation Mt. Judea, Newton County, AR.3.

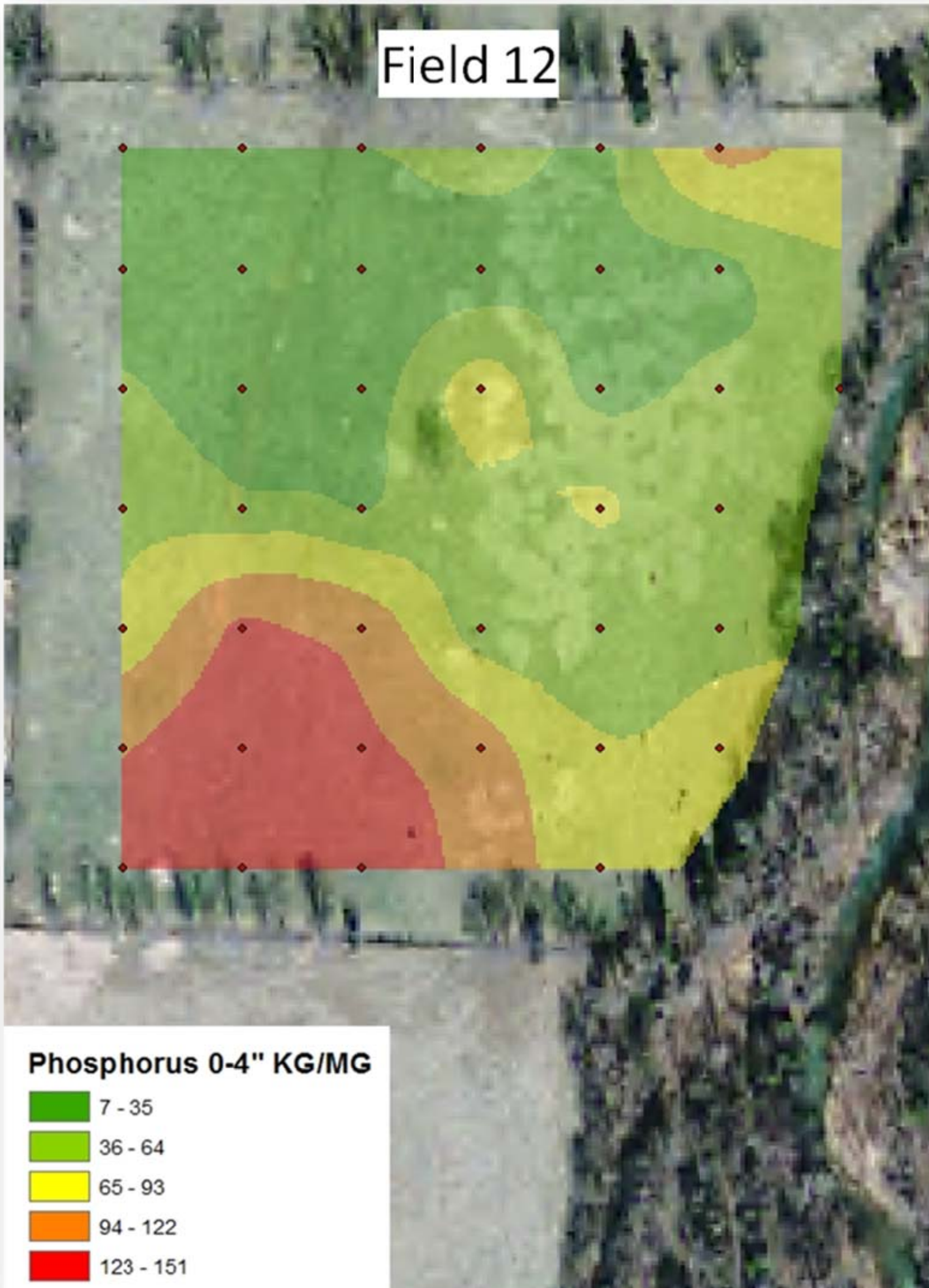

Figure 4. Soil P distribution of the 0 to 4 inch depth for Field 12 on the C&H Farm operation Mt. Judea, Newton County, AR.

Manure Slurry Sampling and Analysis

To provide additional information for the adaptive manure management decision process a second set of manure samples were collected on March 10, 2014. The water level in Pond 1 had reached the point that it flowed across the spill way into Pond 2. Thus, the March 10, 2014 samples were drawn from Ponds 1 and 2

As with the first sampling event, a foot valve liquid manure sampler was used to collect composite samples representing manure from 6 inches below the water surface (top water), from within the settled solids at the bottom of the pond (bottom slurry), and from the water surface to the bottom of the pond including the settled solids (pond profile). Each composite sample was composed of multiple subsamples from various locations around the pond. These subsamples were mixed to compose a sample representing the top water, pond profile, and bottom slurry of Ponds 1 and 2 obtained and hand-delivered on the day of collection to the UofA Agricultural Diagnostics Service Laboratory (Table 2 Figures 5, 6, and 7)

As with the September 24, 2013 samples the March 10, 2014 collection and analysis of manure samples from Ponds 1 and 2, representing the top water, bottom slurry, and entire profile, generated chemical profiles typical of other manure storages associated with swine production. That is, N and P concentrations of the manure increased with water depth (Figures 6 and 7).

However, P concentrations increased at a greater rate than did N concentrations. The resulting higher N / P ratio of the surface water is closer to the ratio of these nutrients required by pastures on the C&H Farm. Thus, land application of top water from a pond to farm pastures will more likely meet both the N and P needs of the pasture and avoid application of P surplus to plant needs. The higher concentration and lower N / P ratio of bottom slurries will lend to application of that slurry on a manure banking approach, where the slurry would be applied on alternate years to fields more distant from the C&H Farm and Big Creek.

Even without the addition of mechanical and/or chemical separation approaches, the observed natural gravity separation of slurry and its constituents, provides farm nutrient management opportunities to more closely match manure nutrients to crop nutrient needs. In addition, the higher nutrient concentrations of Pond 1 over Pond 2 confirm that Pond 1 is functioning as settling basin, in that it retains a significant portion of the manure solids and nutrients. This provides additional differential manure management opportunities pertaining to land application.

Manure Production Determination

The volume of manure produced by livestock is largely determined by the average animal population characteristics, freshwater additions (if any), spilled drinking water (if any), and pen wash-down water. In addition, any precipitation directly into manure storage or via surface runoff will increase manure volume. Discussions with C&H management revealed that the farm used “wet/dry” feeders so that any animal drinking water spillage would fall into feed troughs to be consumed with the feed. As a result there will be effectively no spilled drinking water adding to manure volume.

Estimates for pen-wash down water were provided in the form of the number of pressure washers, the flow rates in gallons per minute, and the average time spent washing each day. As a more direct determination of pen-wash water additions to the manure was desired, two standard water meters were purchased and installed to measure all the water used by two pressure washers used in the barns (Figure 8 and 9).

Future meter readings and the date of the readings will provide measured information on the amount of water used on a daily basis to wash the animal pens and added to the manure volume. To quantify potential precipitation additions to the manure volume planning is in progress to determine as the built dimensions and elevations of Ponds 1 and 2. This information and historical rainfall information (Table 3) will be included in the information used to estimate potential precipitation additions to the manure volume.

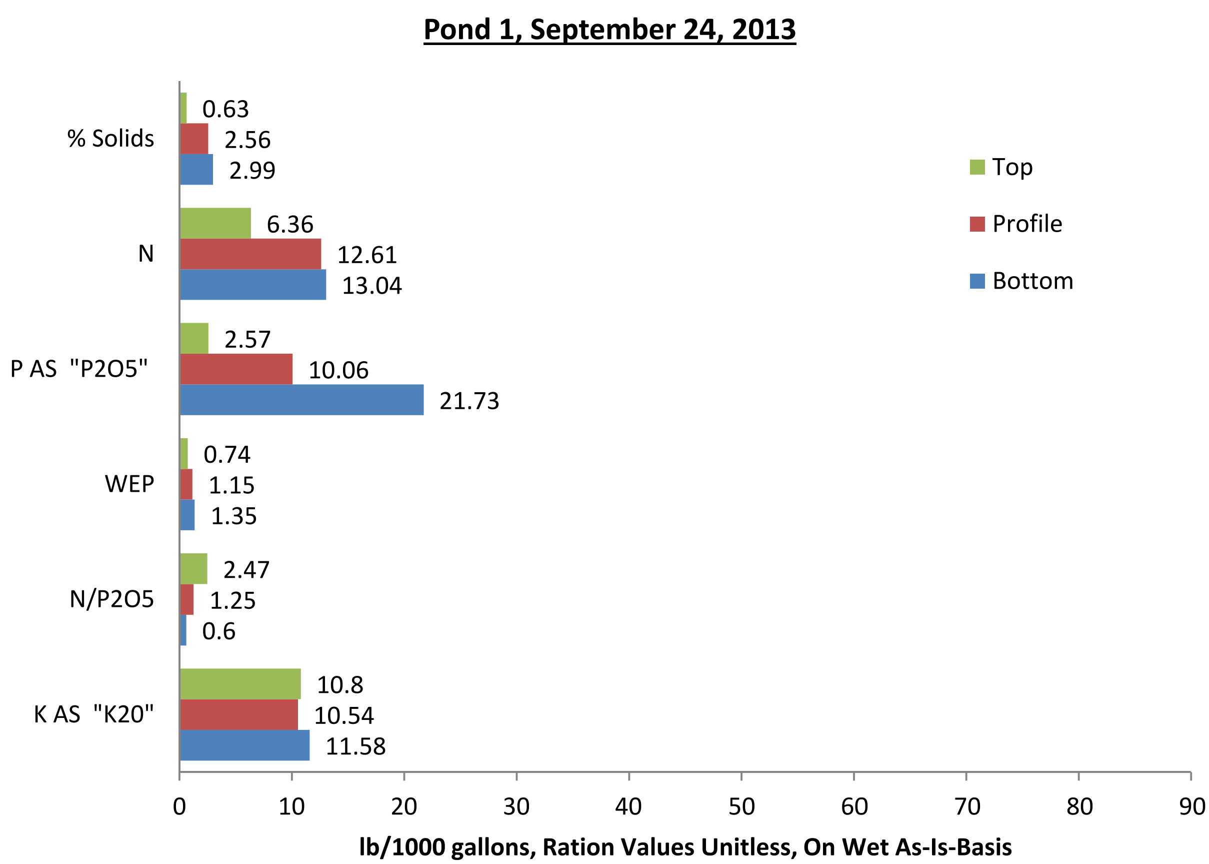

Figure 5. Select Chemical properties of manure samples collected from pond 1 on September 24, 2013.

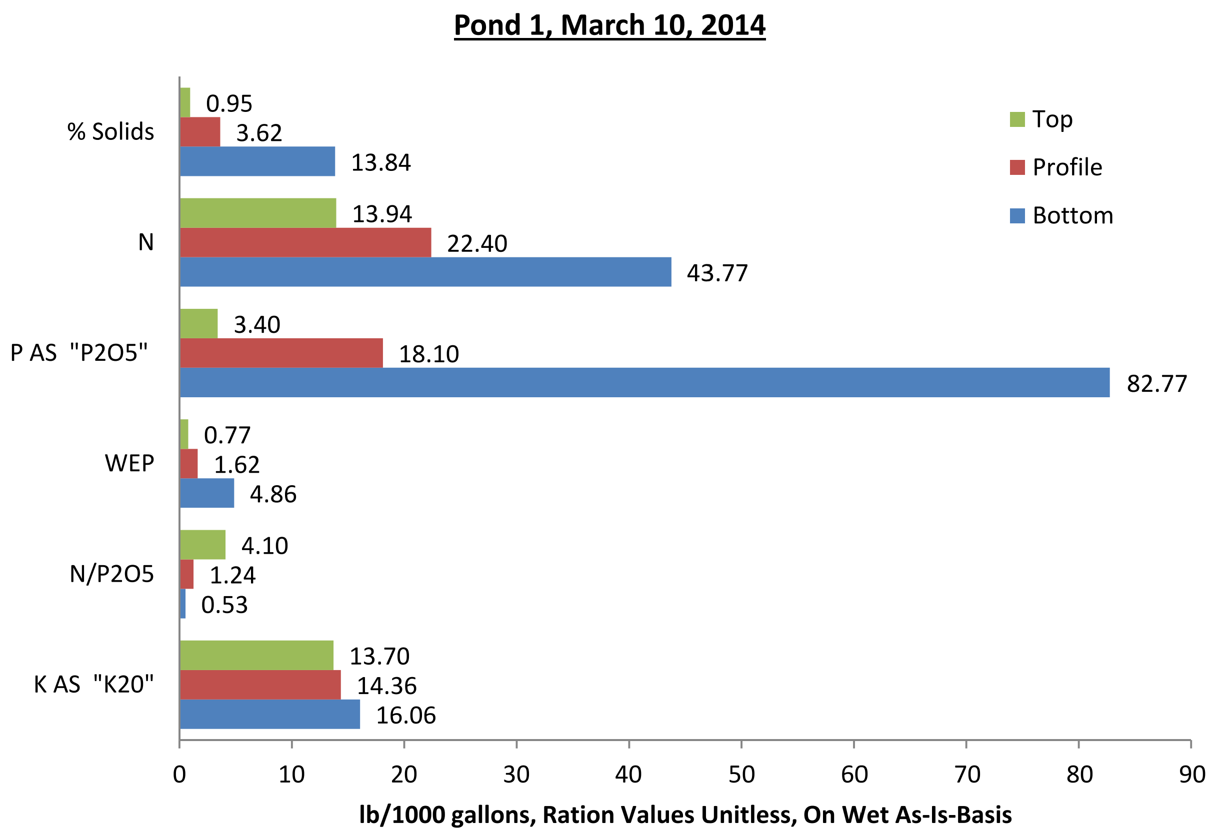

Figure 6. Select chemical properties of manure samples collected from pond 1 on March 10, 2014.

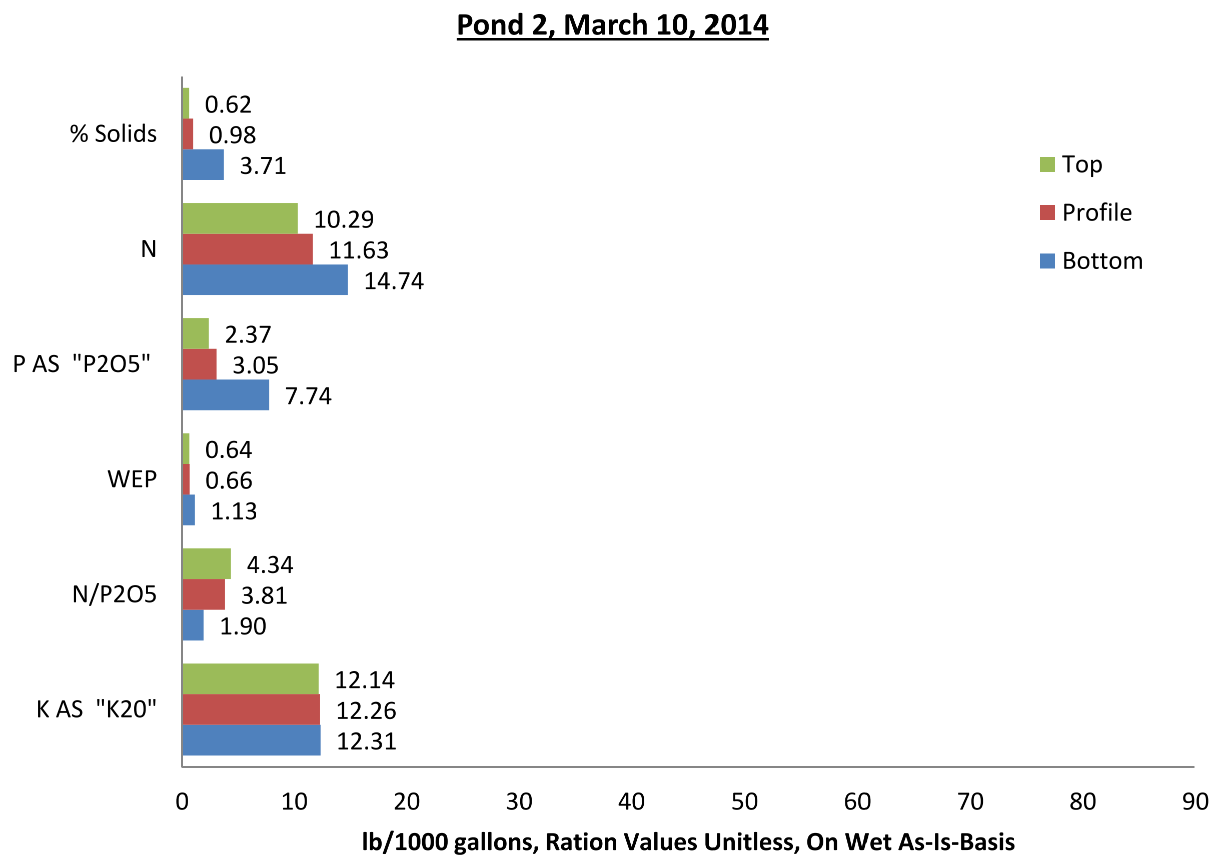

Figure 7. Select Chemical properties of manure samples collected from pond 2 on March 10, 2014.

Table 2. Chemical properties of manure samples collected from ponds 1 and 2 on September 24th, 2013 and March 10, 2014.

	Sample Date								
	September 24th, 2013			March 10th, 2014					
	Pond 1			Pond 1			Pond 2		
	0 – 6"	Profile	Bottom	0 – 6"	Profile	Bottom	0 – 6"	Profile	Bottom
pH	7.8	7.7	7.6	7.8	7.5	7.3	8.0	7.9	7.8
Electrical conductivity (umhos/cm)	10020	10060	9880	14830	14770	10860	12640	12490	12370
Solids (%)	0.63	2.56	2.99	0.95	3.62	13.84	0.62	0.98	3.71
Total N (lbs/1000 gal)	6.36	12.61	13.04	13.94	22.40	43.77	10.29	11.63	14.74
NH_4-N (lbs/1000 gal)	6.09	7.29	6.31	12.45	13.14	13.44	9.79	10.42	10.28
NO_3-N (lbs/1000 gal)	<0.006 †	<0.006	<0.006	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Total P as "P_2O_5" (lbs/1000 gal)	2.57	10.06	21.73	3.40	18.10	82.77	2.37	3.05	7.74
WEP (lbs/1000 gal)	0.74	1.15	1.35	0.77	1.62	4.86	0.64	0.66	1.13
Total K as "K_20" (lbs/1000 gal)	10.80	10.54	11.58	13.70	14.36	16.06	12.14	12.26	12.31
Total Ca (lbs/1000 gal)	0.29	3.16	7.71	1.26	7.66	41.65	0.66	1.15	3.87
NH_4-N / Total N	0.96	0.58	0.48	0.89	0.59	0.31	0.95	0.90	0.70
WEP / Total P	0.66	0.26	0.14	0.52	0.20	0.13	0.62	0.50	0.33
N / P_2O_5	2.47	1.25	0.60	4.10	1.24	0.53	4.34	3.81	1.90
N:P_2O_5:K_2O ratio	2:1:4	1:1:1	1:2:1	4:1:4	2:1:1	3:5:1	4:1:5	4:1:4	2:1:2

† "<" indicate the NO_3-N value is below detection limits.

Table 3. Historical annual precipitation information for Newton Co. Arkansas. Extracted from NRCS's Animal Waste Management Software program version 2.4.0.

Month	Precipitation	Evaporation
January	2.06	0.72
February	2.75	1.08
March	4.58	2.52
April	3.97	3.60
May	5.06	4.68
June	3.27	4.68
July	2.94	5.40
August	2.74	5.04
September	4.15	3.24
October	3.47	2.88
November	3.88	1.44
December	3.55	0.72
Totals	42.42	36.00

Figure 8. One of the standard water meters with hose adapters and mounting base installed to measure water use during pressure washing to clean animal pens.

Figure 9. Two water meters purchased and installed on March 20th, 2014 to measure pen wash down water additions to manure volume. Initial meters readings were 126.6 and 80.2 gallons for meter 1 and 2.

Water Sampling and Analyses

Sampling Locations

Topographic surveys of permitted Fields 1 and 12 were conducted to determine the appropriate location for edge-of-field surface runoff collection flumes. Figure 10 shows the low point on Field 1 where the flume was sited. The location for a similar flume on Field 12 is shown on Figure 11 and construction will begin as soon as the Field dries to allow construction without damaging or rutting any of the farmed field.

Water quality sampling was initiated on September 24, 2013, prior to the formal start of the project (Figure 12). Since January 1 and reported in the 1st Quarterly Report, installation of edge-of-field surface runoff monitoring equipment was completed and became operational April 2, 2014, as shown in Figure 13. Additionally runoff volume and auto-sampling equipment was also installed on an ephemeral stream draining a sub-watershed in which the C&H Farm operations and swine slurry storage lagoons are located, as shown in Figure 12. These sites are;

Site 1. Edge-of field monitoring on Field 1 permitted to receive slurry – Figure 13.

Site 2. Edge-of field monitoring on Field 5a – still to be determined

Site 3. Edge-of field monitoring on Field 12 permitted to receive slurry – still to be completed

Site 4. Ephemeral stream flow draining a subwatershed containing the production facilities – Figure 14.

Site 5. Spring below Field 1 – Figure 15.

Site 6. Big Creek upstream of the C&H Farm operation – Figure 16.

Site 7. Big Creak downstream of the C&H Farm operation – Figure 17.

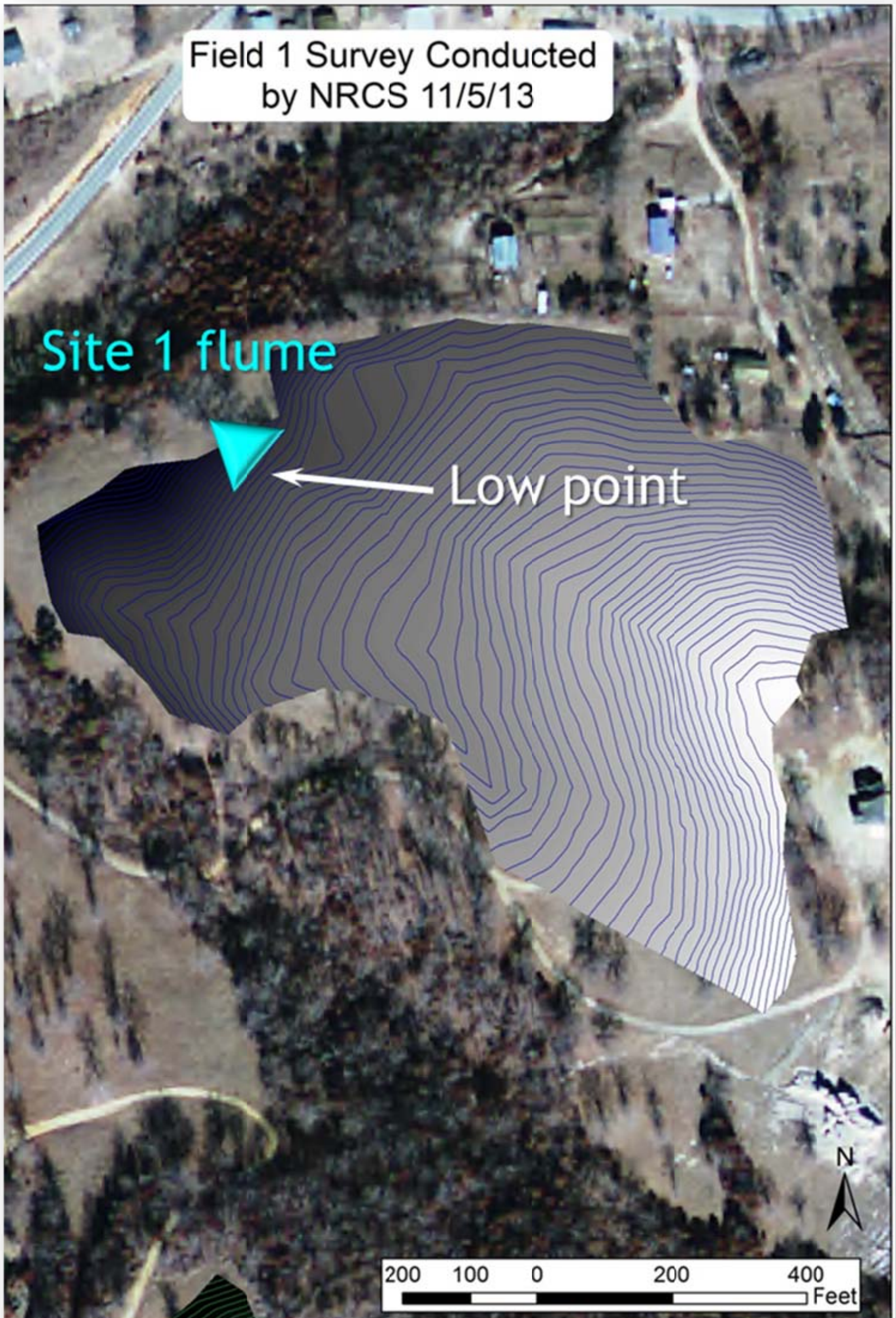

Figure 10. Location of water quality sampling sites on Big Creek and spring below application Field 1.

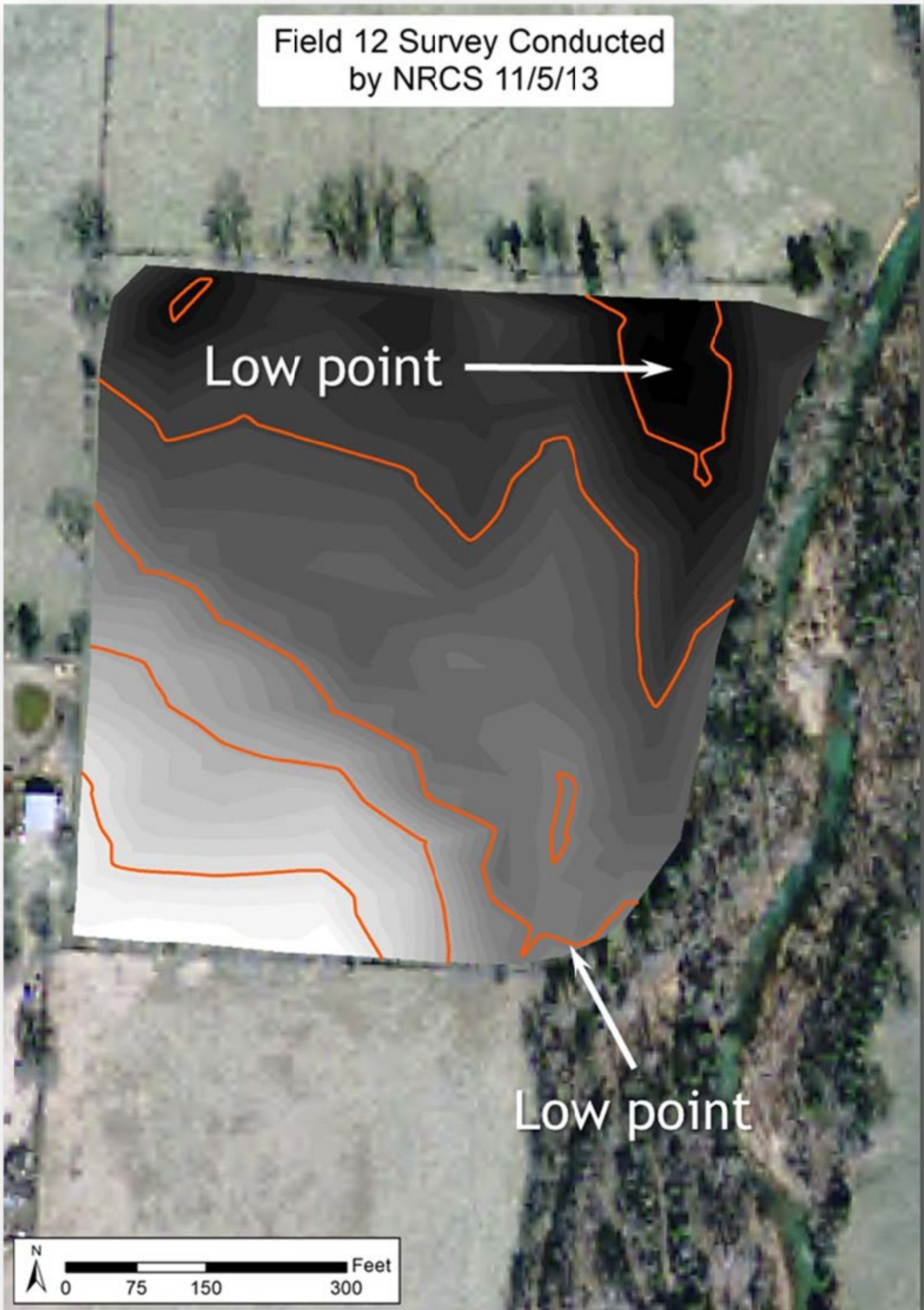

Figure 11. Topographic elevation map showing low point where any surface runoff would leave Field 12 on the C&H Farm.

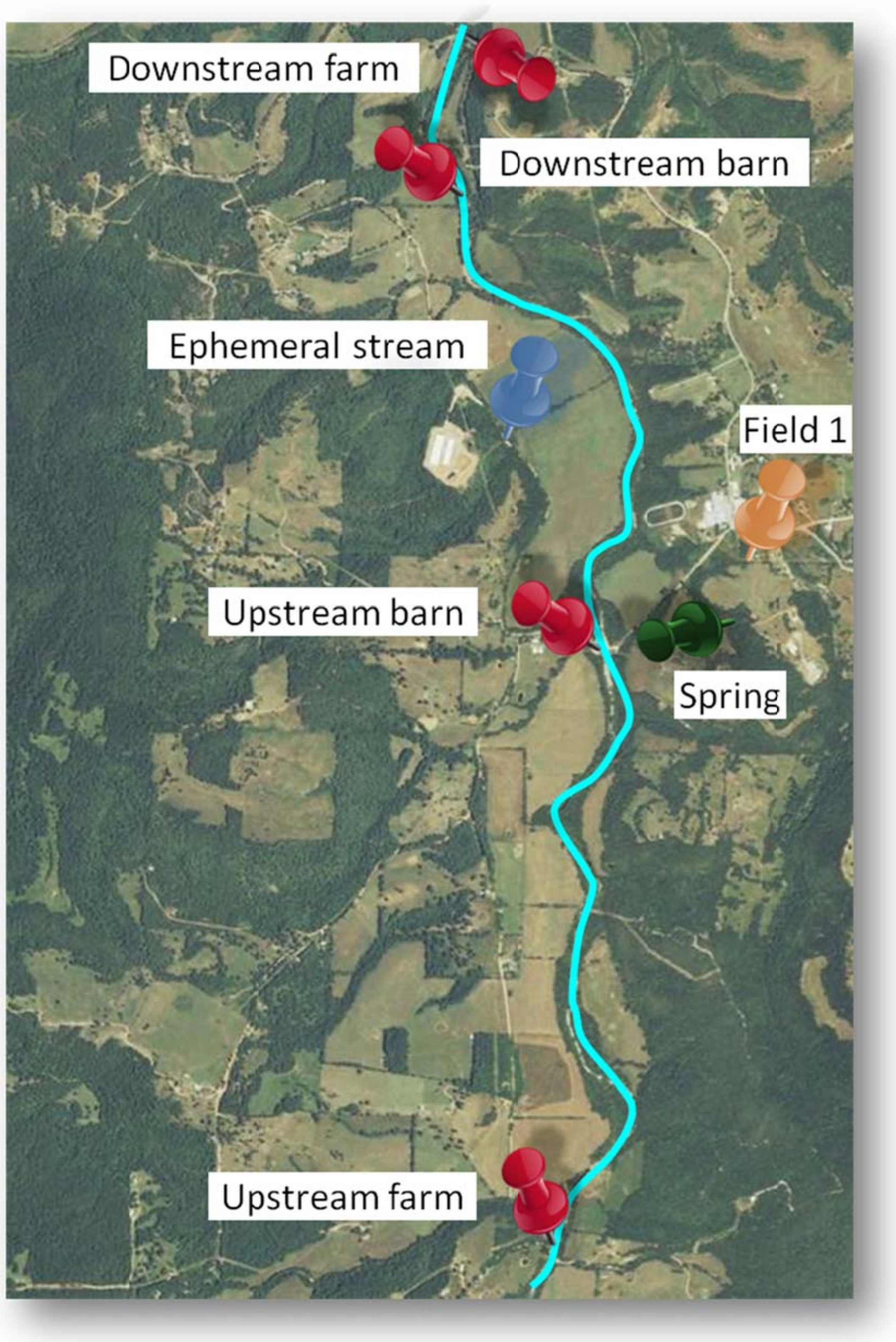

Figure 12. Location of water quality sampling sites on Big Creek and the C&H Farm.

Figure 13. Edge-of-field surface runoff flume on Field 1 on the C&H Farm.

Figure 14. The culvert sampling an ephemeral stream draining a subwatershed containing the C&H Farm operation facilities.

Figure 15. The spring sampled adjacent to Big Creek on the C&H Farm.

Figure 16. The Big Creek sampling site upstream of the C&H Farm during baseflow.

Figure 177. The Big Creek sampling site downstream of the C&H Farm during baseflow.

Sampling Protocols and Analyses

The chemical composition of water samples collected prior to December 31, 2013 is given in Table 4. The following procedure was used to collect, prepare and analyze all water samples;

1. One-liter acid-washed bottles were used to collect the stream samples for nutrient analyses.
2. Water was collected from just beneath the surface where the stream was actively moving and well-mixed.
3. The bottle was rinsed with stream water before collecting the sample.
4. Sterilized specimen cups were used to collect samples for bacterial evaluation.
5. Time of collection was noted.
6. Samples were placed in a cooler on ice to preserve them until processed and were submitted to the Arkansas Water Resources Center Water Quality Lab on the day of collection for analyses.
7. Analyses included Dissolved Phosphorus (EPA 365.2), Total Phosphorus (APHA 4500-P), Ammonia (EPA 351.2), Nitrate (EPA 300.0), Total Nitrogen (APHA 4500-P), Total Suspended Solids (EPA 160.2), E. Coli (APHA 9223, B) and Total Coliforms (APHA 9223, B).

Table 4. Water quality analyses at each sample site. Coliform units are Most Probable Number (MPN) per 100 mL of water.

Date & time sample collected	Date & time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
			- - - - - - - -	- - - - - - - -	- - - - - - - -	mg/L	- - - - - - - -	- - - - - - - -	- - - MPN/100 mL	- - -
9/12/2013	**9/12/2013**	**Base flow**								
10:45	15:30	Upstream farm	0.016	0.030	0.06	0.367	0.50	3.0	6.3	>2420
11:15	15:30	Upstream barn	0.010	0.032	0.05	0.356	0.54	5.8	4.1	4040.0
11:50	15:30	Downstream barn	0.019	0.026	0.05	0.632	0.78	1.2	1.0	488.4
13:00	15:30	Downstream farm	0.010	0.022	0.04	0.396	0.62	1.7	16.0	>2420
9/20/2013	**9/20/2013**	**Base flow**								
10:50	16:08	Spring	0.006	0.020	0.03	0.384	0.50	4.7	72.7	5040
11:15	16:08	Upstream farm	0.009	0.022	0.03	0.247	0.36	1.1	80.9	9870
11:40	16:08	Upstream barn	0.015	0.024	0.04	0.356	0.42	1.2	1203	26130
12:20	16:08	Downstream barn	0.024	0.032	0.06	0.757	0.85	1.3	218.7	2430
12:50	16:08	Downstream farm	0.013	0.022	0.05	0.442	0.53	1.1	548	17230
9/24/2013	**9/24/2013**	**Base flow**								

Date & time sample collected	Date & time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
10:30	16:15	Spring	0.004	0.024	0.00	0.122	0.35	50.0	8.5	>2420
10:45	16:15	Upstream farm	0.011	0.014	0.03	0.444	2.20	17.9	39	1120
11:00	16:15	Upstream barn	0.007	0.024	0.00	0.330	0.41	1.6	42	>2419
12:20	16:15	Downstream barn	0.017	0.032	1.77	0.790	0.82	0.7	42	816
12:40	16:15	Downstream farm	0.007	0.028	0.01	0.511	0.58	1.5	5	>2420
10/1/2013	**10/1/2013**	**Base flow**								
9:45	14:42	Spring	0.001	0.162	0.00	0.108	0.41	89.2	4	920
10:00	14:42	Upstream farm	0.011	0.038	0.02	0.236	0.34	2.2	8	1300
10:15	14:42	Upstream barn	0.006	0.032	0.03	0.235	0.40	6.7	82	5200
10:35	14:42	Downstream barn	0.018	0.032	0.00	0.837	0.92	1.1	19	649
10:55	14:42	Downstream farm	0.009	0.034	0.02	0.514	0.65	3.6	2620	10810
10/9/2013	**10/9/2013**	**Base flow**								
9:00	13:52	Spring	0.011	0.054	0.00	0.088	0.28	29.1	3	1413
9:30	13:52	Upstream farm	0.016	0.034	0.00	0.497	0.73	7.1	11	2419

Date & time sample collected	Date & time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
9:45	13:52	Upstream barn	0.016	0.030	0.00	0.385	0.53	6.2	194	4730
10:00	13:52	Downstream barn	0.017	0.02	0.00	0.868	0.89	0.4	29	1986
10:20	13:52	Downstream farm	0.006	0.038	0.00	0.618	0.77	13.6	28	3450
10/15/2013	**10/15/2013**	**Storm flow**								
11:13	15:47	Spring	0.010	0.250	0.15	0.086	0.58	66.9	1401	19863
12:24	15:47	Upstream farm	0.018	0.026	0.00	1.024	1.03	1.1	759	>2419
12:47	15:47	Upstream barn	0.019	0.036	0.06	0.839	0.99	2.1	472	8664
13:13	15:47	Downstream barn	0.033	0.244	0.12	1.280	1.44	89.2	959	12997
13:34	15:47	Downstream farm	0.067	0.316	0.20	0.677	1.07	101.1	1334	19863
10/22/2013	**10/22/2013**	**Base flow**								
10:10	15:31	Spring	0.005	0.086	0.10	0.307	0.53	36.4	1733	>2419
10:30	15:31	Upstream farm	0.014	0.034	0.00	0.345	0.32	0.3	186	299
10:45	15:31	Upstream barn	0.016	0.024	0.03	0.575	0.60	1.2	411	11190
11:00	15:31	Downstream	0.016	0.022	0.00	0.786	0.77	0.1	150	2419

Date & time sample collected	Date & time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
		barn								
11:20	15:31	Downstream farm	0.012	0.020	0.04	0.723	0.76	0.7	87	292
10/31/2013	**10/31/2013**	**Base flow**								
11:00	15:15	Spring	0.003	0.404	0.14	0.321	1.02	400.9	91	32550
10:45	15:15	Upstream farm	0.012	0.032	0.00	0.242	0.32	1.1	66	1986
10:15	15:15	Upstream barn	0.007	0.044	0.04	0.246	0.38	2.3	261	6310
10:00	15:15	Downstream barn	0.018	0.022	0.11	0.519	0.66	0.9	14	218
10:30	15:15	Downstream farm	0.012	0.024	0.03	0.443	0.45	1.4	Leaked	Leaked
11/6/2013	**11/6/2013**	**Base flow**								
8:35	14:35	Spring	0.013	0.130	0.10	0.062	0.72	21.2	8570	34480
9:00	14:35	Upstream farm	0.032	0.074	0.03	0.432	0.61	4.7	4080	28510
9:10	14:35	Upstream barn	0.020	0.038	0.00	0.184	0.27	2.5	579	13330
9:45	14:35	Downstream barn	0.040	0.164	0.12	0.413	0.67	32.9	3180	36090
10:00	14:35	Downstream farm	0.041	0.154	0.12	0.286	0.60	28.4	3500	43520

Date & time sample collected	Date & time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
11/12/2013	**11/12/2013**	**Base flow**								
10:56	16:28	Spring	0.006	0.022	0.05	2.449	2.61	8.9	48	2750
11:35	16:28	Upstream farm	0.011	0.010	0.00	0.169	0.22	1.0	45	1986
12:15	16:28	Upstream barn	0.012	0.014	0.09	0.221	0.33	1.4	36	1733
13:03	16:28	Downstream barn	0.012	0.012	0.00	0.295	0.34	0.5	21	1046
13:35	16:28	Downstream farm	0.011	0.010	0.00	0.242	0.31	0.0	24	>2419
11/19/2013	**11/19/2013**	**Base flow**								
9:20	14:35	Spring	0.007	0.022	0.02	3.063	3.06	4.4	579	9880
9:45	14:35	Upstream farm	0.010	0.026	0.00	0.123	0.22	0.7	435	2400
10:05	14:35	Upstream barn	0.011	0.028	0.00	0.175	0.32	0.3	172	>2419
10:35	14:35	Downstream barn	0.011	0.028	0.00	0.231	0.34	0.5	238	2419
10:55	14:35	Downstream farm	0.009	0.024	0.02	0.172	0.28	1.0	194	4410
11/26/2013	**11/26/2013**	**Base flow**								
10:35	14:40	Spring	0.007	0.018	0.00	1.69	1.70	4.5	86	1553

Date & time sample collected	Date & time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
10:45	14:40	Upstream farm	0.013	0.018	0.00	0.135	0.14	0.4	77	1203
11:06	14:40	Upstream barn	0.014	0.016	0.00	0.190	0.20	0.7	249	1986
11:30	14:40	Downstream barn	0.014	0.018	0.03	0.300	0.33	1.3	40	613
11:45	14:40	Downstream farm	0.013	0.016	0.00	0.231	0.24	1.2	36	2419
12/3/2013	**12/3/2013**	**Base flow**								
8:30	13:23	Spring	0.007	0.046	0.04	1.048	1.37	26.9	25	1986
8:45	13:23	Upstream farm	0.007	0.012	0.00	0.152	0.25	0.5	27	435
9:00	13:23	Upstream barn	0.009	0.012	0.00	0.210	0.28	0.3	29	548
9:15	13:23	Downstream barn	0.010	0.018	0.00	0.295	0.35	0.6	248	687
9:35	13:23	Downstream farm	0.006	0.012	0.00	0.225	0.28	0.5	12	>2419
12/17/2013	**12/17/2013**	**After snow melt**								
9:35	14:03	Spring	0.007	0.042	0.05	0.367	0.65	2.0	248.1	2419.2
10:00	14:03	Upstream farm	0.010	0.036	0.06	0.180	0.27	1.2	248.1	2419.2
10:10	14:03	Upstream barn	0.011	0.032	0.02	0.379	0.48	0.7	157.6	>2419.2

Date & time sample collected	Date & time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
10:30	14:03	Downstream barn	0.008	0.032	0.03	0.393	0.50	1.6	127.4	2419.2
10:50	14:03	Downstream farm	0.008	0.032	0.00	0.325	0.43	2.1	148.3	>2419.2
1/2/2014	**1/2/2014**	**Base flow**								
10:45	14:19	Spring	0.006	0.024	0.05	3.348	3.24	0.5	ND	ND
10:55	14:19	Upstream farm	0.009	0.022	0.01	0.223	0.25	0.7	ND	ND
11:10	14:19	Upstream barn	0.012	0.024	0.00	0.437	0.47	0.3	ND	ND
11:25	14:19	Downstream barn	0.012	0.024	0.00	0.543	0.58	0.8	ND	ND
11:50	14:19	Downstream farm	0.012	0.036	0.00	0.485	0.54	0.8	ND	ND
1/7/2014	**1/7/2014**	**Base flow**								
10:10	13:43	Spring	0.008	0.024	0.00	2.364	2.32	1.3	20.9	1413.6
10:20	13:43	Upstream farm	0.014	0.022	0.02	0.204	0.27	0.8	66.3	307.6
10:30	13:43	Upstream barn	0.017	0.022	0.00	0.363	0.43	0.3	24.3	344.8
10:50	13:43	Downstream barn	0.015	0.022	0.00	0.497	0.54	1.1	21.1	290.9
11:10	13:43	Downstream farm	0.015	0.028	0.00	0.413	0.46	0.2	18.3	325.5

Date & time sample collected	Date & time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
1/14/2014	**1/14/2014**	**Base flow**								
11:35	15:35	Spring	0.010	0.042	0.00	1.974	2.09	2.3	24.3	1732.9
12:15	15:35	Upstream farm	0.008	0.028	0.01	0.156	0.25	0.3	151.5	980.4
11:50	15:35	Upstream barn	0.008	0.030	0.03	0.211	0.73	0.9	238.2	920.8
12:50	15:35	Downstream barn	0.008	0.028	0.02	0.332	0.43	0.5	156.5	1119.9
13:15	15:35	Downstream farm	0.008	0.026	0.05	0.310	0.39	0.5	95.9	1299.7
1/21/2014	**1/21/2014**	**Base flow**								
8:10	15:00	Spring	0.008	0.006	0.02	2.107	2.10	0.9	5.2	613.1
8:30	15:00	Upstream farm	0.009	0.010	0.00	0.130	0.22	0.0	55.7	290.9
8:20	15:00	Upstream barn	0.010	0.010	0.01	0.211	0.28	0.3	51.2	488.4
8:45	15:00	Downstream barn	0.011	0.012	0.01	0.339	0.45	1.0	49.6	249.9
9:05	15:00	Downstream farm	0.010	0.014	0.01	0.301	0.36	0.5	131.3	410.6
1/29/2014	**1/29/2014**	**Base flow**								
10:20	14:15	Spring	0.009	0.024	0.00	0.851	0.86	1.4	3.1	325.5

Date & time sample collected	Date & time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
10:40	14:15	Upstream farm	0.007	0.028	0.00	0.125	0.15	0.6	10.9	248.1
10:30	14:15	Upstream barn	0.007	0.024	0.01	0.195	0.24	0.0	28.2	290.9
11:00	14:15	Downstream farm	0.007	0.024	0.00	0.282	0.28	0.0	<1	275.0
2/13/2014	**2/13/2014**	**Base flow**								
8:30	13:22	Spring	0.009	0.024	0.00	0.654	0.73	5.1	<1	461.1
8:50	13:22	Upstream farm	0.009	0.016	0.00	0.107	0.15	0.9	68.9	238.2
8:40	13:22	Upstream barn	0.011	0.014	0.00	0.135	0.23	0.9	31.4	260.2
9:10	13:22	Downstream farm	0.009	0.014	0.00	0.241	0.28	0.4	9.8	290.9
2/19/2014	**2/19/2014**	**Base flow**								
9:15	14:36	Spring	0.006	0.020	0.02	0.574	0.62	0.8	1.0	365.4
10:17	14:36	Upstream farm	0.008	0.018	0.00	0.048	0.10	0.4	111.9	325.5
9:30	14:36	Upstream barn	0.009	0.018	0.00	0.070	0.15	0.5	45.5	235.9
11:30	14:36	Downstream farm	0.007	0.016	0.00	0.109	0.17	0.3	8.5	272.3

Date & time sample collected	Date & time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
2/27/14	**2/27/14**	**Base flow**								
10:40	15:10	Spring	0.007	0.106	0.06	0.594	0.82	70	<1	307.6
11:03	15:10	Upstream farm	0.008	0.022	0.02	0.066	0.22	2.1	29.5	209.8
11:40	15:10	Upstream barn	0.008	0.016	0.00	0.084	0.11	0.3	14.8	235.9
12:22	15:10	Downstream farm	0.007	0.014	0.00	0.112	0.16	0.6	2.00	547.5

The water quality data in Table 4 for the monitored spring and Big Creek above and below the boundary of the permitted fields of the C&H Farm only is given in Table 5.

Table 5. Water quality analyses at the spring and in Big Creek upstream and downstream of the C&H Farm boundary of permitted land application fields (see Map 12).

Sample location relative to farm	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
	- - - - - - - - - -	- - - - - - - - - -	mg/L	- - - - - - - - - -	- - - - - - - - - -		- - - MPN/100 mL - - -	
9/12/2013 Base flow								
Upstream	0.016	0.030	0.06	0.367	0.50	3.0	6	>2420
Downstream	0.010	0.022	0.04	0.396	0.62	1.7	16	>2420
9/20/2013 Base flow								
Spring	0.006	0.020	0.03	0.384	0.50	4.7	73	5040
Upstream	0.009	0.022	0.03	0.247	0.36	1.1	81	9870
Downstream	0.013	0.022	0.05	0.442	0.53	1.1	548	17230
9/24/2013 Base flow								
Spring	0.004	0.024	0.00	0.122	0.35	50.0	9	>2420
Upstream	0.021	0.140	0.03	0.444	2.20	17.9	39	1120
Downstream	0.007	0.028	0.01	0.511	0.58	1.5	5	>2420
10/1/2013 Base flow								
Spring	0.001	0.162	0.00	0.108	0.41	89.2	4	920.8
Upstream	0.011	0.038	0.02	0.236	0.34	2.2	8	1300
Downstream	0.009	0.034	0.02	0.514	0.65	3.6	2620	10810
10/9/2013 Base flow								
Spring	0.011	0.054	0.00	0.088	0.28	29.1	3	1413.6

Sample location relative to farm	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
Upstream	0.016	0.034	0.00	0.497	0.73	7.1	11	2419.6
Downstream	0.006	0.038	0.00	0.618	0.77	13.6	28	3450.0
10/15/2013 Storm flow								
Spring	0.010	0.250	0.15	0.086	0.58	66.9	1401	19863.0
Upstream	0.018	0.026	0.00	1.024	1.03	1.1	759	>2419.6
Downstream	0.067	0.316	0.20	0.677	1.07	101.1	1334	19863.0
10/22/2013 Base flow								
Spring	0.005	0.086	0.10	0.307	0.53	36.4	1733	>2419.6
Upstream	0.014	0.034	0.00	0.345	0.32	0.3	186	299.0
Downstream	0.012	0.020	0.04	0.723	0.76	0.7	87	292.0
10/31/2013 Base flow								
Spring	0.003	0.404	0.14	0.321	1.02	400.9	91	32550.0
Upstream	0.012	0.032	0.00	0.242	0.32	1.1	66	1986.3
Downstream	0.012	0.024	0.03	0.443	0.45	1.4	Leaked	Leaked
11/6/2013 Base flow								
Spring	0.013	0.130	0.10	0.062	0.72	21.2	8570	34480.0
Upstream	0.032	0.074	0.03	0.432	0.61	4.7	4080	28510.0
Downstream	0.041	0.154	0.12	0.286	0.60	28.4	3500	43520.0
11/12/2013 Base flow								
Spring	0.006	0.022	0.05	2.449	2.61	8.90	48	2750.0
Upstream	0.011	0.010	0.00	0.169	0.22	1.00	45	1986.3

Sample location relative to farm	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
Downstream	0.011	0.010	0.00	0.242	0.31	0.0	24	>2419.2
11/19/2013 Base flow								
Spring	0.007	0.022	0.02	3.063	3.06	4.4	579	9880.0
Upstream	0.010	0.026	0.00	0.123	0.22	0.7	435	2400.0
Downstream	0.009	0.024	0.02	0.172	0.28	1.0	194	4410.0
11/26/2013 Base flow								
Spring	0.007	0.018	0.00	1.69	1.70	4.5	86	1553.1
Upstream	0.013	0.018	0.00	0.135	0.14	0.4	77	1203.3
Downstream	0.013	0.016	0.00	0.231	0.24	1.2	36	2419.2
12/3/2013 Base flow								
Spring	0.007	0.046	0.04	1.048	1.37	26.9	25	1986.3
Upstream	0.007	0.012	0.00	0.152	0.25	0.5	27	435.2
Downstream	0.006	0.012	0.00	0.225	0.28	0.5	12	>2419.2
12/17/2013 After snow melt								
Spring	0.007	0.042	0.05	0.367	0.65	2.0	248.1	2419.2
Upstream	0.010	0.036	0.06	0.180	0.27	1.2	248.1	2419.2
Downstream	0.008	0.032	0.00	0.325	0.43	2.1	148.3	>2419.2
1/2/2014 Base flow								
Spring	0.006	0.024	0.05	3.348	3.24	0.5	ND	ND
Upstream	0.009	0.022	0.01	0.223	0.25	0.7	ND	ND
Downstream	0.012	0.036	0.00	0.485	0.54	0.8	ND	ND

Sample location relative to farm	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
1/7/2014 Base flow								
Spring	0.008	0.024	0.00	2.364	2.32	1.3	20.9	1413.6
Upstream	0.014	0.022	0.02	0.204	0.27	0.8	66.3	307.6
Downstream	0.015	0.028	0.00	0.413	0.46	0.2	18.3	325.5
1/14/2014 Base flow								
Spring	0.010	0.042	0.00	1.974	2.09	2.3	24.3	1732.9
Upstream	0.008	0.028	0.01	0.156	0.25	0.3	151.5	980.4
Downstream	0.008	0.026	0.05	0.310	0.39	0.5	95.9	1299.7
1/21/2014 Base flow								
Spring	0.008	0.006	0.02	2.107	2.10	0.9	5.2	613.1
Upstream	0.009	0.010	0.00	0.130	0.22	0.0	55.7	290.9
Downstream	0.010	0.014	0.01	0.301	0.36	0.5	131.3	410.6
1/29/2014 Base flow								
Spring	0.009	0.024	0.00	0.851	0.86	1.4	3.1	325.5
Upstream	0.007	0.028	0.00	0.125	0.15	0.6	10.9	248.1
Downstream	0.007	0.024	0.00	0.282	0.28	0.0	<1	275.0
2/13/2014 Base flow								
Spring	0.009	0.024	0.00	0.654	0.73	5.1	<1	461.1
Upstream	0.009	0.016	0.00	0.107	0.15	0.9	68.9	238.2
Downstream	0.009	0.014	0.00	0.241	0.28	0.4	9.8	290.9
2/19/2014 Base flow								

Sample location relative to farm	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	E. coli	Total coliform
Spring	0.006	0.020	0.02	0.574	0.62	0.8	1.0	365.4
Upstream	0.008	0.018	0.00	0.048	0.10	0.4	111.9	325.5
Downstream	0.007	0.016	0.00	0.109	0.17	0.3	8.5	272.3
2/27/14	**Base flow**							
Spring	0.007	0.106	0.06	0.594	0.82	70	<1	307.6
Upstream	0.008	0.022	0.02	0.066	0.22	2.1	29.5	209.8
Downstream	0.007	0.014	0.00	0.112	0.16	0.6	2.00	547.5

ND is no data collected.

Future Plan of Work

1. Instrument Field 12 with piezometers and surface runoff monitoring equipment as on Field 1.
2. Complete installation of automatic flow and water sampling equipment on Big Creek upstream and downstream of the C&H Farm. These sites coordinate with the ongoing weekly baseflow sampling that has been conducted since early September. This is being done in partnership with USGS, who we have funded to have a permanent gauging station downstream of the C&H Farm that provides real-time flow information, to conform with all USGS gauging sites across the State.
3. Deploy sondes at the spring and above permanent USGS gauging stations on Big Creek sampling locations to continuously determine dissolved oxygen (DO), excess partial pressure of carbon dioxide ($EpCO_2$), electrical conductivity (EC), and temperature of the water. Diurnal, seasonal, and storm event fluctuations of water $EpCO_2$, DO, EC, and temperature can be used to examine the rates of respiration and photosynthesis linked to changing nutrient status and organic matter loading and to also identify possible sources of new and old water at these locations. Similarly, a longitudinal survey downstream between upper and lower sampling points in Big Creek under baseflow, can locate potential sites where water is entering the Creek from the surrounding landscape. That is, $EpCO_2$ will increase (and pH will drop), with the input of spring water into Big Creek.
4. Interpret GPR information from Field 12 completed this quarter and present next quarter.
5. Continue to collect runoff, spring, and stream samples after each rainfall event from the autosamplers and manually collect baseflow samples every two weeks from the well, spring, and streams, for analysis of N, P, sediment, and bacteria (E. coli and total coliform from baseflow grab samples).
6. Conduct dye-tracer tests on the C&H Farm in cooperation with a Geologist with experience and training in conducting dye-tracer tests.
7. Periodically determine plant uptake by collecting plant and hay samples for tissue analysis and determine yield (dry-matter mass for a pre-determined area).
8. Determine nutrient application rate by determining nutrient content of swine effluent before land application via manure application and determine volume of effluent being applied to known monitoring area.

Manure Treatment via Solids and Chemical Separation: A Case Study to Evaluate Cost Benefits of Alternative Manure Management Options

Continue current discussions with the owners of the C&H Farm to explore potential long-term, economically viable, options to modify current manure management practices in the general areas of:

1. Separating manure liquids and solids along with their differential management;
2. Retaining sufficient nitrogen to meet crop needs;
3. Exporting excess P off the farm;

4. Mitigating off-site odor;
5. Not exceeding the current physical, economic, labor, and management resources of the farm; and
6. Operating within the constraints of the appropriate environmental regulations.

The project will identify management options to meet the above objectives. It is anticipated that the options will include but not be limited to:

- Mechanical separation manure solids from liquids with or without chemicals as a precursor for off-farm transport of separated solids; and
- Selective application of higher P content slurries and lower P content liquids to different fields that minimizes any loss of nutrient loss.

For the management options identified, their initial and long-term costs will be estimated and an assessment of their implementation impacts made. Available literature and other information resources will be utilized in this process. However, there will be a need for laboratory and onsite tests/trials. This is especially true when evaluating manure solid-liquid separation and/or chemical use. Based on current discussions development of field chemical tests and lab analysis will begin soon. The results of these tests will guide decisions that may lead to additional larger scale implementation trials.

Table 6. Soil analyses of 0 to 4 inch samples collected from Field 12.

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			----------	----------	----------	----------	----------	----------	mg/kg	----------	----------	----------	----------
24422	9	5.9	138	115	776	81	10	18	149	186	1.2	3.2	0.2
24427	10	6.0	143	196	763	79	7	14	138	226	0.9	3.2	0.2
24432	11	5.6	147	88	681	68	13	17	155	245	1.2	2.4	0.1
24438	13	6.0	65	70	1621	98	9	13	128	181	1.4	3.7	0.3
24443	17	5.7	117	117	721	72	10	15	146	187	0.8	2.1	0.1
24449	18	5.9	147	223	726	93	12	17	145	231	0.8	2.7	0.2
24452	19	5.7	126	174	608	94	7	14	154	197	0.8	2.6	0.1
24456	20	5.7	101	96	1169	101	9	17	151	177	1.3	2.7	0.2
24461	21	5.8	61	61	1367	82	10	14	153	168	1.2	2.4	0.2
24466	22	5.3	71	56	734	67	9	13	261	157	0.7	2.5	0.1
24472	25	5.5	60	57	788	62	8	17	107	218	0.8	1.3	0.1
24476	26	5.6	128	202	690	80	7	17	151	172	1.0	2.6	0.1
24480	27	5.8	109	69	956	75	10	16	143	159	0.9	2.1	0.3
24486	28	5.8	45	54	1441	87	12	14	117	170	1.2	1.8	0.2
24491	29	5.6	39	60	993	73	9	12	151	193	1.0	2.1	0.1
24497	30	5.6	53	212	873	69	14	12	155	165	0.7	2.6	0.1
24502	33	5.3	53	29	743	43	9	10	167	131	0.7	2.2	0.0
24508	34	6.1	43	76	1530	83	9	12	134	184	1.4	3.3	0.2
24513	35	6.0	37	81	1207	90	10	13	102	143	1.0	1.9	0.1
24519	37	5.8	63	62	1039	65	13	18	118	190	1.6	2.1	0.1
24524	38	5.8	52	45	828	49	9	15	92	119	0.9	3.0	0.1
24530	41	5.9	43	50	1318	49	14	15	101	185	1.5	1.4	0.2
24535	42	6.0	30	70	1781	105	14	15	102	98	1.6	5.7	0.2
24540	43	6.2	29	67	1767	83	17	14	108	173	1.5	1.5	0.3

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24546	44	5.6	73	88	1048	86	8	15	136	154	1.1	2.2	0.1
24551	45	5.8	30	47	1143	81	19	11	113	149	1.1	2.8	0.2
24557	46	5.8	47	212	820	52	10	13	133	121	0.7	2.0	0.2
24562	47	5.9	42	76	1838	117	11	15	96	96	1.4	2.4	0.3
24563	49	6.1	24	59	1953	84	12	13	83	64	1.5	1.5	0.3
24569	50	5.9	19	54	1758	77	19	12	87	84	1.6	1.1	0.2
24574	51	6.3	17	56	1908	85	17	10	87	96	1.6	1.8	0.2
24580	52	6.3	30	43	1537	55	12	10	100	109	1.5	1.4	0.1
24585	53	6.1	33	54	1416	56	13	10	102	110	1.5	1.8	0.1
24591	54	6.1	32	43	970	57	15	8	115	106	1.2	1.5	0.1
24596	57	6.0	26	53	1120	38	10	8	108	102	1.7	1.5	0.1
24602	58	6.0	36	58	1338	63	9	10	101	78	1.3	1.3	0.1
24607	59	5.9	39	40	853	56	9	9	116	103	1.1	1.5	0.1
24612	60	6.0	52	98	1357	106	12	12	107	88	1.7	1.6	0.2
24617	61	6.0	34	72	1453	85	11	13	118	122	1.3	1.7	0.2
24622	62	6.0	97	282	1723	148	12	16	139	69	1.5	2.6	0.3
Mean, mg/kg		5.86	63	92	1184	77	11	13	127	148	1.2	2.2	0.2
Minimum, mg/kg		5.30	17	29	608	38	7	8	83	64	0.7	1.1	0.0
Maximum, mg/kg		6.30	147	282	1953	148	19	18	261	245	1.7	5.7	0.3
Standard deviation, mg/kg		0.23	40	62	405	21	3	3	32	48	0.3	0.8	0.1
Coefficient of variation, %		3.97	63	67	34	28	27	20	25	32	26.4	37.6	46.6

Table 7. Soil analyses of 4 to 8 inch samples collected from Field 12.

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			------------				mg/kg						------------
24423	9	6.4	47	47	650	26	6	11	94	103	0.7	0.8	0
24428	10	5.8	73	112	663	39	6	11	110	145	0.8	2.2	0.1
24434	11	5.9	81	47	678	38	9	12	123	177	1.1	2.4	0.1
24439	13	6	32	56	1447	58	9	11	117	98	1.4	1.7	0.2
24444	17	5.8	69	64	670	43	8	11	100	119	0.7	0.9	0
24450	18	5.6	102	106	682	51	16	14	128	154	0.8	1.6	0.1
24453	19	5.7	62	127	601	49	9	11	108	105	0.7	1.2	0
24458	20	5.7	36	70	1307	57	10	14	106	72	1.4	1	0.2
24462	21	5.9	27	62	1489	52	15	11	105	82	1.5	1	0.1
24467	22	5.3	62	37	488	28	8	8	160	101	0.5	0.9	0
24473	25	5.8	32	41	713	24	7	12	80	114	0.7	0.4	0
24477	26	5.7	88	115	723	57	7	14	121	111	0.8	1.2	0.1
24482	27	5.9	77	45	879	41	8	12	116	118	0.9	1.1	0.1
24487	28	6.1	13	73	1778	52	12	11	90	64	1.1	0.5	0.2
24492	29	5.8	17	55	1315	40	13	11	119	147	1.3	1.1	0.2
24498	30	5.8	26	45	767	33	10	8	105	78	0.5	0.8	0
24503	33	6	38	27	675	24	6	6	121	81	0.6	1	0
24509	34	6.1	21	54	1670	65	8	9	111	144	1.5	1.7	0.2
24514	35	6.1	17	65	1297	63	11	10	97	117	1.1	2.8	0
24520	37	5.9	47	49	1171	48	13	15	98	112	1.7	9.6	0.1
24525	38	6	23	42	785	29	8	11	73	67	0.6	0.4	0
24531	41	6.3	32	43	1257	32	13	12	90	132	1.7	3.4	0.1
24536	42	5.9	18	77	2257	111	16	15	107	75	2	2.2	0.3
24542	43	6.4	15	59	1681	50	19	11	92	115	1.5	0.8	0.2

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24547	44	5.3	39	82	926	66	9	15	110	106	1.2	1	0
24552	45	5.9	17	54	1404	70	13	11	103	127	1.4	1	0.2
24558	46	6	35	116	630	28	9	9	99	77	0.6	0.7	0
24564	49	6.1	15	67	2386	81	19	14	87	30	1.6	0.8	0.3
24570	50	5.9	12	51	1844	68	17	11	72	44	1.3	0.7	0.2
24575	51	6.3	9	79	2453	105	15	10	92	78	1.8	1.4	0.4
24581	52	6.2	22	49	1419	54	13	9	99	89	1.5	1.1	0.1
24586	53	6.2	16	66	1631	59	11	10	97	81	1.5	0.9	0.1
24592	54	6.2	19	60	1552	47	12	8	113	85	1.6	1.3	0.2
24597	57	6.1	33	63	1375	46	15	9	104	79	1.8	1.8	0.1
24603	58	6.1	28	64	1360	67	10	9	94	53	1.3	0.8	0.1
24608	59	6	24	42	848	36	8	7	108	96	1.2	0.9	0
24614	60	6.1	23	92	1432	102	12	12	101	55	1.6	0.6	0.1
24618	61	6.1	17	60	1440	67	13	11	95	100	1.5	1	0.1
24623	62	5.9	48	202	1841	116	12	14	100	44	1.6	1.1	0.2
Mean, mg/kg		5.96	36	68	1235	54	11	11	104	97	1.2	1.4	0.1
Minimum, mg/kg		5.30	9	27	488	24	6	6	72	30	0.5	0.4	0.0
Maximum, mg/kg		6.40	102	202	2453	116	19	15	160	177	2.0	9.6	0.4
Standard deviation, mg/kg		0.25	24	32	523	23	4	2	16	33	0.4	1.5	0.1
Coefficient of variation, %		4.14	65	47	42	43	32	20	15	34	35.1	104.2	89.1

Table 8. Soil analyses of 8 to 12 inch samples collected from Field 12.

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			---	---	---	---	---	mg/kg	---	---	---	---	---
24424	9	6	82	63	713	45	7	14	101	139	1	1.3	0.1
24429	10	6	42	96	607	29	7	9	95	104	0.6	0.9	0
24435	11	6.2	44	49	716	24	8	8	107	117	0.8	0.6	0
24440	13	6.1	22	78	1755	72	20	11	103	73	1.5	1.5	0.2
24446	17	5.8	50	77	681	40	9	9	107	88	0.4	0.9	0
24451	18	5.8	53	65	673	34	6	10	101	91	0.6	0.5	0
24454	19	5.8	45	106	712	39	8	9	99	78	0.6	0.3	0
24459	20	5.9	21	80	1779	56	11	15	104	53	1.4	0.7	0.2
24463	21	5.8	32	72	1493	49	12	13	102	48	1.4	0.4	0.1
24468	22	5.2	39	46	481	23	8	8	126	95	0.6	1.6	0
24474	25	5.9	22	52	781	23	9	9	90	93	0.5	0.2	0
24478	26	5.7	46	128	681	42	9	12	94	70	0.7	0.4	0
24483	27	6.1	34	52	1121	31	8	11	93	72	1.1	0.6	0
24488	28	6.1	13	86	1787	76	13	11	103	90	0.9	0.5	0.2
24494	29	6	10	74	1760	48	15	9	104	96	1.4	3	0.2
24499	30	5.9	11	57	1297	40	13	13	89	49	0.9	0.4	0.1
24504	33	6.1	30	34	720	25	8	5	124	96	0.7	1.6	0
24510	34	6.1	14	70	2050	78	11	9	105	119	1.8	1.5	0.2
24515	35	6.3	10	82	1722	75	16	11	93	71	1.3	0.3	0.1
24521	37	5.9	28	48	1104	44	10	12	88	60	1.4	1.3	0.1
24526	38	6	19	40	643	22	9	7	69	43	0.2	0.5	0
24532	41	6.1	26	52	1505	34	13	12	91	93	2	2.8	0.2
24537	42	5.9	14	79	2443	118	18	15	103	44	1.9	0.9	0.3
24543	43	6.5	12	75	1849	53	18	10	90	63	1.6	0.5	0.1

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24548	44	5.2	18	104	1219	75	12	19	106	73	1.3	1.5	0.1
24554	45	6.1	11	74	1752	79	15	11	108	112	1.5	1.3	0.2
24559	46	6	24	71	936	41	10	10	98	86	1	0.7	0.1
24566	49	6.1	16	63	2099	66	21	15	90	13	1.6	0.6	0.1
24571	50	5.9	10	69	2043	78	22	15	86	21	1.3	0.5	0.1
24576	51	6.3	7	88	2536	104	19	10	98	58	1.7	0.8	0.3
24582	52	6	20	60	1768	77	17	13	100	60	1.6	1.1	0.2
24587	53	6.1	18	71	1493	74	17	9	100	53	1.3	0.7	0.1
24593	54	6.2	13	61	1805	54	11	9	105	55	1.5	1.1	0.2
24598	57	5.9	39	65	1301	51	14	9	99	54	1.5	0.9	0.1
24604	58	6.1	31	76	1468	69	12	9	96	41	1.2	0.5	0.1
24609	59	6.1	25	53	942	42	10	7	120	107	1.3	1.2	0
24615	60	6.2	25	85	1559	108	13	11	105	41	1.3	0.8	0.1
24619	61	6.1	10	71	1899	90	14	13	87	61	1.3	0.9	0.2
24624	62	5.9	19	164	1848	109	12	15	88	25	1.4	0.5	0.1
Mean, mg/kg			5.98	26	73	1378	57	12	11	99	72	1.2	0.9
Minimum, mg/kg			5.20	7	34	481	22	6	5	69	13	0.2	0.2
Maximum, mg/kg			6.50	82	164	2536	118	22	19	126	139	2.0	3.0
Standard deviation, mg/kg			0.24	16	24	562	26	4	3	11	29	0.4	0.6
Coefficient of variation, %			4.08	61	33	41	46	34	26	11	40	37.2	65.6

Table 9. Soil analyses of 12 to 18 inch samples collected from Field 12.

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			----------	----------	----------	----------	----------	mg/kg	----------	----------	----------	----------	----------
24425	9	6.1	50	54	674	29	11	7	107	77	0.5	0.8	0
24430	10	6.1	40	101	656	33	8	7	103	85	0.4	1	0
24436	11	6.3	59	60	817	28	12	6	121	86	0.6	0.3	0
24441	13	6.1	19	88	1909	75	15	12	99	61	1.2	0.8	0.3
24447	17	5.9	57	79	746	39	12	8	113	64	0.2	0.3	0
24455	19	6	61	80	942	43	13	7	103	45	0.3	0.3	0
24460	20	6.1	14	75	1699	57	14	14	93	28	1.2	0.6	0.1
24464	21	5.3	38	80	1308	55	14	16	110	40	1.2	0.4	0
24470	22	5.2	20	87	1151	45	9	16	118	73	1.3	0.6	0.1
24475	25	5.9	28	48	616	26	11	6	89	61	0.1	0.5	0
24479	26	5.8	33	185	646	35	8	11	90	53	0.5	0.3	0
24484	27	6.2	24	62	1349	39	13	10	94	58	1.3	0.7	0.1
24489	28	6.1	23	57	1630	51	11	12	100	89	1.3	1	0.2
24495	29	6.3	12	82	1821	66	16	9	104	76	1.2	0.9	0.1
24500	30	5.7	11	78	1674	55	13	15	93	36	0.8	0.6	0
24506	33	6.1	29	59	1385	42	9	8	144	108	1.3	1.1	0.1
24511	34	6.4	11	78	1934	85	13	10	107	86	1.6	2.6	0.2
24516	35	6.1	11	80	1765	86	24	12	87	41	1.1	0.2	0.1
24522	37	5.8	27	57	1622	61	12	16	87	47	1.5	0.4	0.2
24527	38	5.6	40	56	644	27	13	10	94	33	0.2	2.5	0
24533	41	6	20	50	1832	46	16	12	92	50	1.9	3.9	0.2
24538	42	5.9	11	80	2372	116	19	17	100	25	1.6	0.6	0.2
24544	43	6.6	18	77	1703	57	14	9	89	41	1.3	3.7	0.1
24549	44	5.4	11	85	1457	81	14	17	97	41	1	0.5	0.1

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24555	45	6	9	79	1640	79	16	10	99	67	1.3	1	0.1
24560	46	5.7	16	80	1440	64	13	11	103	81	1.3	0.7	0.1
24567	49	5.8	11	63	1630	46	20	16	91	14	1.1	0.4	0
24572	50	5.9	8	70	1711	70	24	13	87	28	1	0.4	0.1
24578	51	6.2	9	89	2387	100	22	10	98	59	1.7	0.9	0.3
24583	52	5.4	19	63	1671	78	20	17	111	49	1.7	0.9	0.1
24588	53	5.6	18	80	1380	86	25	11	100	45	1.1	0.6	0
24594	54	6.1	12	67	2121	74	15	10	105	35	1.4	0.7	0.2
24599	57	5.9	44	68	1202	61	16	8	101	43	1.2	0.5	0
24605	58	6.3	29	66	1186	54	12	7	85	24	0.6	0.5	0
24610	59	5.9	14	60	1730	72	16	9	119	54	1.5	1.1	0.2
24616	60	5.7	33	84	1334	94	16	12	106	33	1	0.5	0
24620	61	6.1	8	76	1908	97	17	12	87	51	1.1	0.4	0.1
24625	62	6	13	128	1740	104	22	14	84	25	1.3	0.8	0.1
Mean, mg/kg			5.94	23.95	76.61	1458.74	62.00	14.95	11.24	100.26	52.95	1.08	0.89
Minimum, mg/kg			5.20	8.00	48.00	616.00	26.00	8.00	6.00	84.00	14.00	0.10	0.20
Maximum, mg/kg			6.60	61.00	185.00	2387.00	116.00	25.00	17.00	144.00	108.00	1.90	3.90
Standard deviation, mg/kg			0.30	15.16	23.61	477.93	23.68	4.40	3.32	12.17	21.94	0.46	0.85
Coefficient of variation, %			5.13	63.32	30.81	32.76	38.19	29.47	29.58	12.14	41.43	42.41	95.44

Table 10. Soil analyses of 18 to 24 inch samples collected from Field 12.

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
			mg/kg										
24426	9	6.1	63	55	641	33	12	6	117	57	0.3	0.6	0
24431	10	6.3	58	83	761	51	15	6	103	48	0.3	0.5	0
24437	11	6.1	90	71	847	49	16	6	119	44	0.4	1	0
24442	13	6.2	16	83	1586	75	11	11	88	32	0.8	0.4	0.1
24448	17	5.9	62	71	763	41	14	7	104	34	0.1	0.4	0
24465	21	5.2	38	79	1153	56	17	14	112	37	1	0.4	0
24471	22	5.5	13	82	1419	80	11	13	100	40	0.8	0.4	0.1
24485	27	6.3	28	70	1337	43	13	10	94	39	1.1	0.3	0
24490	28	6.1	12	93	1877	89	19	10	95	114	0.7	0.4	0.1
24496	29	6.3	14	86	1857	74	26	8	101	57	1.2	0.9	0.1
24501	30	5.7	17	95	1781	61	19	13	93	22	0.5	0.3	0
24507	33	6.2	20	66	1646	53	10	9	130	104	1.1	0.6	0.2
24512	34	6.1	12	74	1697	81	14	9	92	45	1.1	2.2	0.1
24518	35	5.9	16	86	1608	90	27	14	95	42	1.1	0.5	0.1
24523	37	6	19	62	1479	59	13	19	92	31	1.3	0.7	0.1
24528	38	4.9	46	60	443	30	13	18	102	28	0.2	0.6	0
24534	41	5.9	21	48	1837	50	17	14	90	26	1.6	0.5	0.2
24539	42	6.1	9	79	2005	102	17	17	95	21	1.3	7	0.1
24545	43	6.5	29	85	1659	77	23	7	84	27	1.1	0.3	0.1
24550	44	5.3	13	81	1342	66	17	16	98	28	0.8	2	0
24556	45	6	10	85	1622	82	18	10	95	45	0.9	0.4	0.1
24561	46	5.7	11	99	1700	67	16	9	107	53	1	0.4	0.1
24568	49	5.7	36	100	1682	118	18	15	105	129	1.7	2.2	0.2
24573	50	6	44	62	1867	104	13	14	101	157	1.6	2.9	0.3

Lab Number	Point	pH	P	K	Ca	Mg	Na	S	Fe	Mn	Cu	Zn	B
24579	51	6.2	54	50	1643	87	13	14	117	158	1.5	2.6	0.3
24584	52	5.8	83	71	1329	97	11	14	136	151	1.4	3.4	0.2
24590	53	5.7	54	43	968	91	9	11	154	143	1.3	3	0.2
24595	54	6	35	53	1351	68	10	11	121	142	1.5	2.7	0.2
24600	57	5.9	55	54	1143	78	11	11	114	114	1	2	0.2
24606	58	5.7	70	46	1064	94	9	12	140	138	1.1	3	0.1
24611	59	6.1	101	125	1408	134	9	13	134	131	1.5	3.9	0.3
24621	61	5.8	8	72	1569	66	15	12	91	47	0.7	0.3	0.1
24626	62	5.8	11	98	1558	76	11	14	84	31	0.7	0.3	0
Mean, mg/kg		5.91	35	75	1413	73	15	12	106	70	1.0	1.4	0.1
Minimum, mg/kg		4.90	8	43	443	30	9	6	84	21	0.1	0.3	0.0
Maximum, mg/kg		6.50	101	125	2005	134	27	19	154	158	1.7	7.0	0.3
Standard deviation, mg/kg		0.34	26	18	397	24	5	3	17	48	0.4	1.5	0.1
Coefficient of variation, %		5.70	74	25	28	32	31	29	16	69	43.4	105.4	86.9

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